WITHDRAWALS AND CONSUMPTIVE USE OF WATER IN PENNSYLVANIA, 1984

By Connie A. Loper, Stephanie D. Lent and Kim L. Wetzel

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CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who prefer metric (International System) units rather than the inch-pound units in this report, the following conversion factors may be used:

Multiply inch-pound units	By	To obtain metric units
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
billion gallons per day (Bgal/d)	0.00004381	cubic meter per second (m^3/s)

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ABSTRACT

Total accountable water withdrawals in Pennsylvania during 1984 were 14,033.66 Mgal/d (million gallons per day); of that total, 5.2 percent (729.53 Mgal/d) was supplied from ground-water sources and 94.8 percent (13,304.12 Mgal/d) was supplied from surface-water sources. Thermoelectric power generation accounted for 71 percent of the total withdrawals (10,010.60 Mgal/d); this was followed by self-supplied industry, 15 percent (2,055.63 Mgal/d); public supply, 11 percent (1,600.02 Mgal/d); mining (147.73 Mgal/d), self-supplied domestic use (131.63 Mgal/d), livestock and poultry (83.52 Mgal/d) and irrigation (4.52 Mgal/d) collectively made up 3 percent. Total consumptive use of water was 615.22 Mgal/d; self-supplied industry is responsible for the greatest consumptive use--185.53 Mgal/d.

Trends in water withdrawals from 1950 to 1984 were examined for public supply, thermoelectric power generation and self-supplied industry. Total population and water withdrawals for public supply gradually increased in those years, whereas withdrawals for self-supplied industry and power generation increased until 1970 and then decreased.

INTRODUCTION

The U.S. Geological Survey's cooperator in the Pennsylvania water-use program is the Pennsylvania Department of Environmental Resources (PaDER). They are responsible for the collection, storage, and maintenance of site specific water-use data in the Water Resources Data System (WARDS). These data are made available to the U.S. Geological Survey for reports and entry into the National Water-Use Data System.

Pennsylvania has about 50,000 miles of streams and rivers. The principal rivers in the State are the Ohio, Allegheny, and Monongahela Rivers in the west and the Susquehanna, Schuylkill, Lehigh, and Delaware Rivers in the east. Although the State has historically been considered water-rich, not only in surface water but also ground water, water supplies in recent years have shown signs of stress due to excessive pumpage, particularly in the southeastern and southwestern parts of the State. These supplies have become critically short in times of extended drought.

Purpose and Scope

The purpose of this report is to document water withdrawals and consumptive use in Pennsylvania in 1984. Data tables and illustrations for water withdrawals and consumptive use in 1984 for public supply, self-supplied domestic use, self-supplied industry, agriculture (irrigation and livestock), mining, and power generation are presented and discussed by county and hydrologic accounting unit. Figure 1 shows the 67 counties in Pennsylvania; figure 2 shows the 13 hydrologic accounting units. Trends of water withdrawals from 1950 to 1984 for public supply, self-supplied industry, and power generation are examined.

Previous Investigations

Water-use data for Pennsylvania were assembled by PaDER for the State Water Plan Series (Pennsylvania Department of Environmental Resources, 1975-83); water-use totals were for public supply, self-supplied industry (mineral, manufacturing), self-supplied power, self-supplied agriculture (livestock, irrigation), self-supplied golf course and institutions, and self-supplied domestic use in 20 designated subbasins.

The U.S. Geological Survey has published water-use reports, at 5-year intervals from 1950 through 1980, that document State water withdrawal totals for several categories of use (MacKichan 1951, 1957; MacKichan and Kammerer, 1961; Murray, 1968; Murray and Reeves, 1972, 1977; Solley, Chase, and Mann, 1983). Information for hydrologic accounting unit or county was not included in these publications, and the water-withdrawal estimates have a wide range of accuracy, inasmuch as they were derived from many sources.

The U.S. Geological Survey established the National Water-Use Information Program in 1977 when a need for uniform and reliable water-use information was recognized. As of 1988, 49 States were participating in this program. The National Water-Use Data System (NWUDS) was developed in 1978 to store these data on a national level.

Acknowledgments

Grateful acknowledgments are made to William Gast and Tom Denslinger of PaDER and to the other individuals in the Pennsylvania Departments of Agriculture and Commerce for their assistance in supplying the data used in this report.

Terminology

The clarification of basic water use terminology is essential for understanding any water-use investigation, as some terms are used differently by individual investigators. "Withdrawal" refers to the volume of water pumped from the source of supply. "Water use" refers to the purpose to which water is put. This report will not evaluate "gross water use" or the greater quantity of water that would be needed if recirculation systems were not in operation.

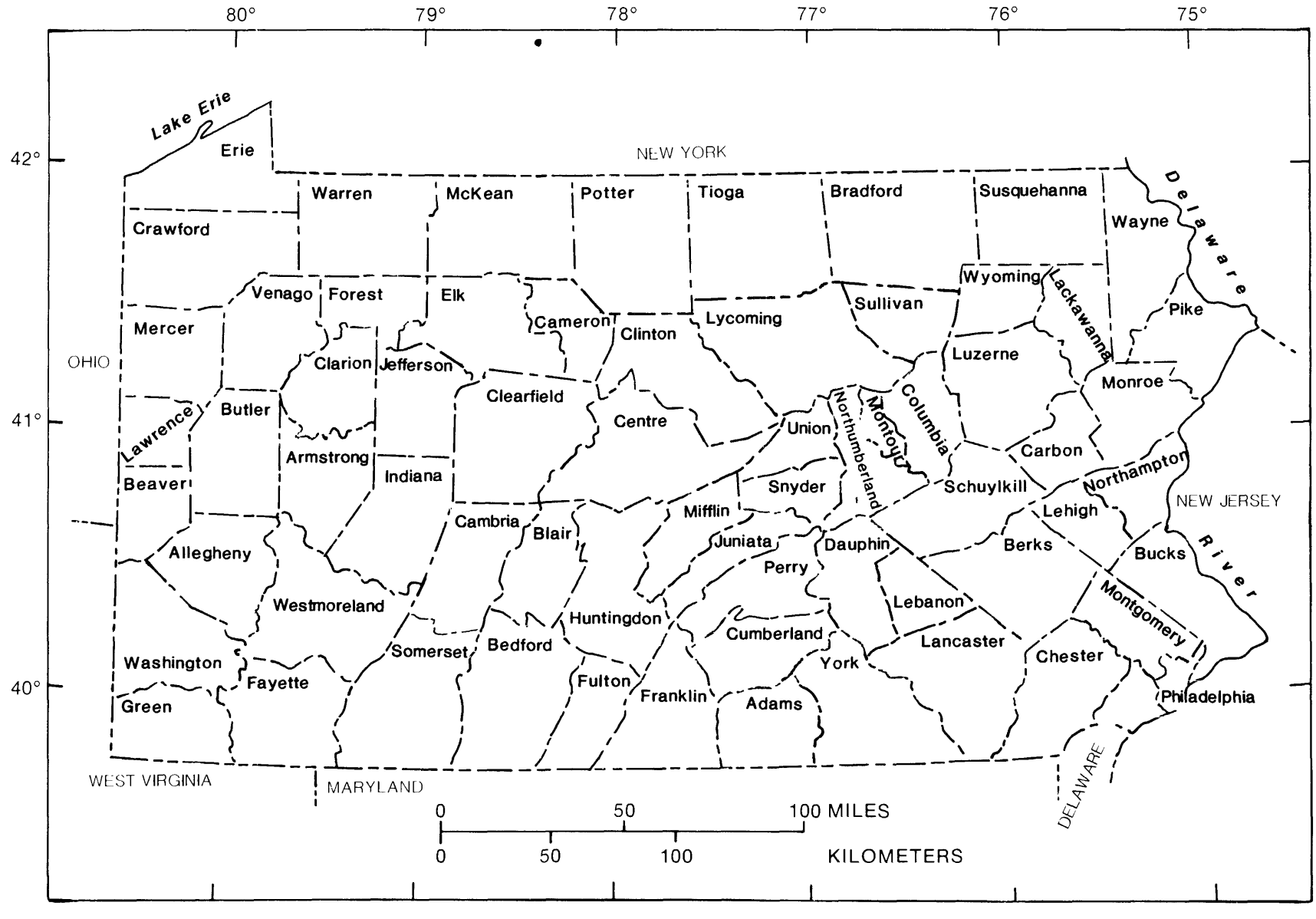


Figure 1.-- Counties in Pennsylvania.

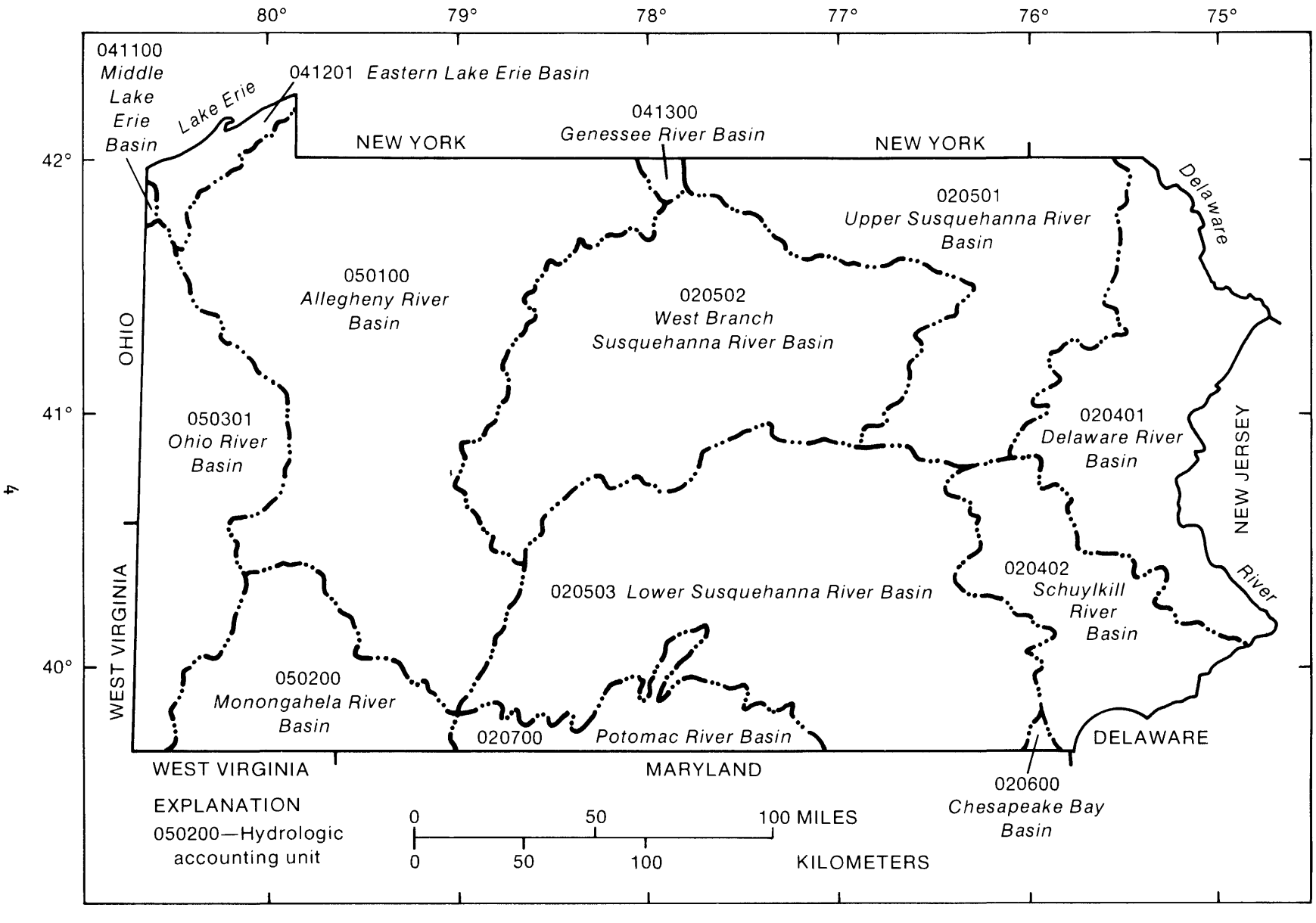


Figure 2.-- Hydrologic accounting units in Pennsylvania.

Actual water usage is the quantity of water received for use by a public supply, industry, irrigator, or rural household. This is equal to the amount of water withdrawn if there is no conveyance loss. A "conveyance loss" is the water lost in transit from a pipe, canal, conduit, or ditch by leakage or evaporation, and generally is not available for further use.

"Non-withdrawal uses" (synonymous to instream or inchannel use) include all uses taking place within the river channel for navigation, fish propagation, and recreation. Water used for hydroelectric power generation is defined as an instream water use.

"Consumptive use" is the difference between the amount of water delivered and the amount released at a facility. Examples of consumptive loss are incorporation into a product and evaporation.

"Ground water" generally is considered to be all subsurface water; this includes water from wells, springs, and quarries. "Surface water" is water from an open body of water, such as a stream, lake, or reservoir. Water is "self-supplied" if a public supply is not used. Industries using their own water supplies are categorized as "self-supplied industry," and individual families not served by a public supply are considered "self-supplied domestic" with respect to water use.

A "community water system" refers to a public water system that serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. A "noncommunity water system" means a public water system that is not a community water system, such as a self-supplied motel or restaurant, where water is provided to the public.

WITHDRAWALS AND CONSUMPTIVE USE OF WATER BY COUNTY AND HYDROLOGIC ACCOUNTING UNIT

Public Supply

Source and Reliability of Data

The State Water Plan Division of PaDER maintains an address file of about 1,350 public suppliers within the State. When the address file was created, a "public supplier" was not defined in strict terms; the list, therefore, includes some institutions, associations, and mobile home parks in addition to public and private water authorities. As of January 1986, this list was increased to over 10,000 names when, by PaDER's Safe Drinking Water Regulation (Pennsylvania Department of Environmental Resources, 1984), a public supplier was defined to be any system that provides water to the public for human consumption and has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. Data only from community systems that have a 200 person service population or withdraw 10,000 gal/d (gallons per day) or more will be entered into WARDS.

PaDER annually collects public supply data through mail surveys and telephone followups; about 85 percent of the suppliers responded to the 1984 survey. Data from public suppliers in the Susquehanna River basin are

entered into the WARDS data base in alternate years from those in the Delaware and Ohio River basins. For this investigation, about 22 percent of the withdrawal data used in calculations were for 1981 and 78 percent for 1983-84. No estimating techniques were needed, inasmuch as withdrawals from 1981 were not significantly different from those for 1983-84.

Withdrawals

Total water withdrawn in 1984 for public supply was 1,600.02 Mgal/d. Of that total, 257.58 Mgal/d (16 percent) was supplied from ground-water sources, and 1,342.44 Mgal/d (84 percent) from surface-water sources.

Population distribution in Pennsylvania is shown in figures 3 and 4 by county and hydrologic accounting unit. About 78 percent of Pennsylvania's total population in 1984 (11,901,000) was served by public supply. Counties containing the cities of Philadelphia (Philadelphia County) and Pittsburgh (Allegheny County) had the greatest withdrawals of water for public supply, 356.3 Mgal/d and 218.8 Mgal/d, respectively (table 1). Most northern-tier and other heavily forested counties had low withdrawals (fig. 5). Forest County in the northwestern part of the state had the least water withdrawn for public supply--0.12 Mgal/d (table 1).

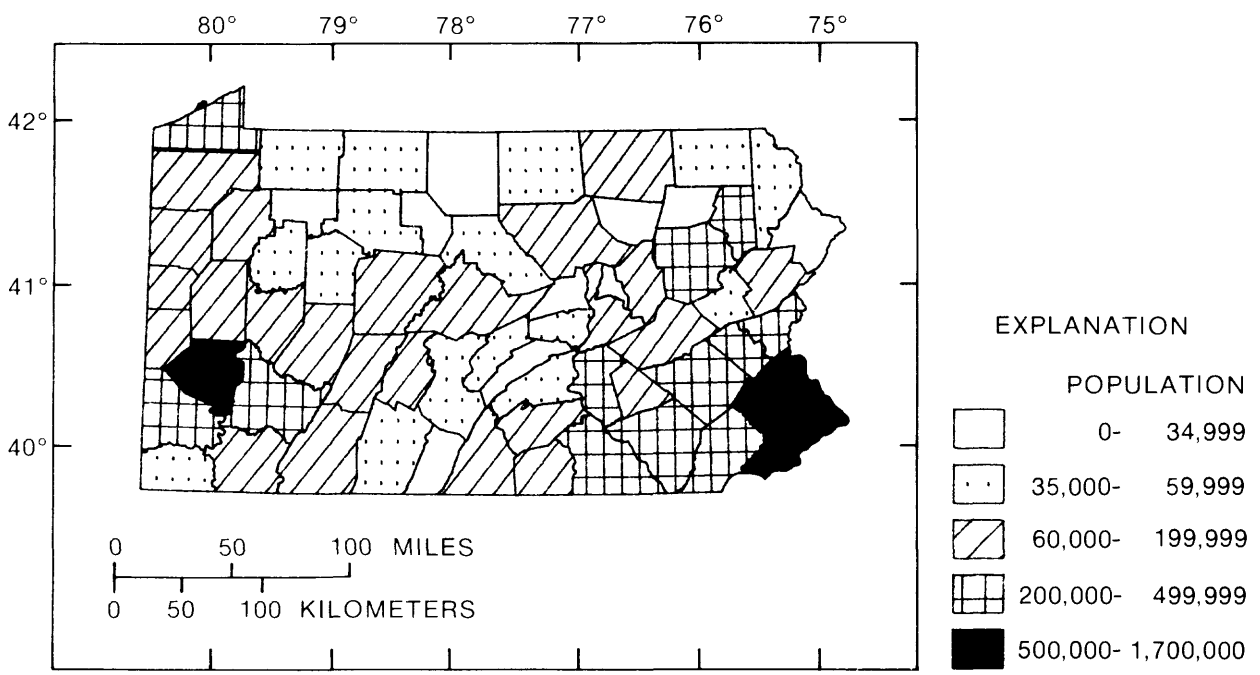


Figure 3.-- Population, by county, 1984

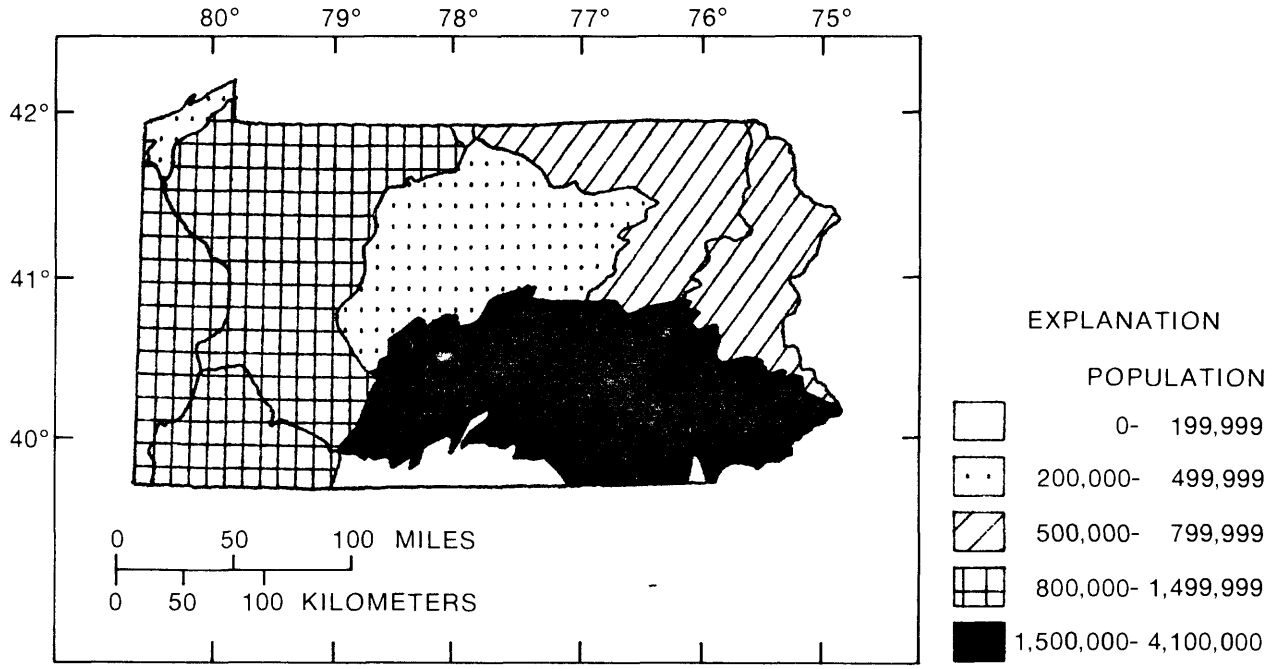


Figure 4.-- Population, by hydrologic accounting unit, 1984.

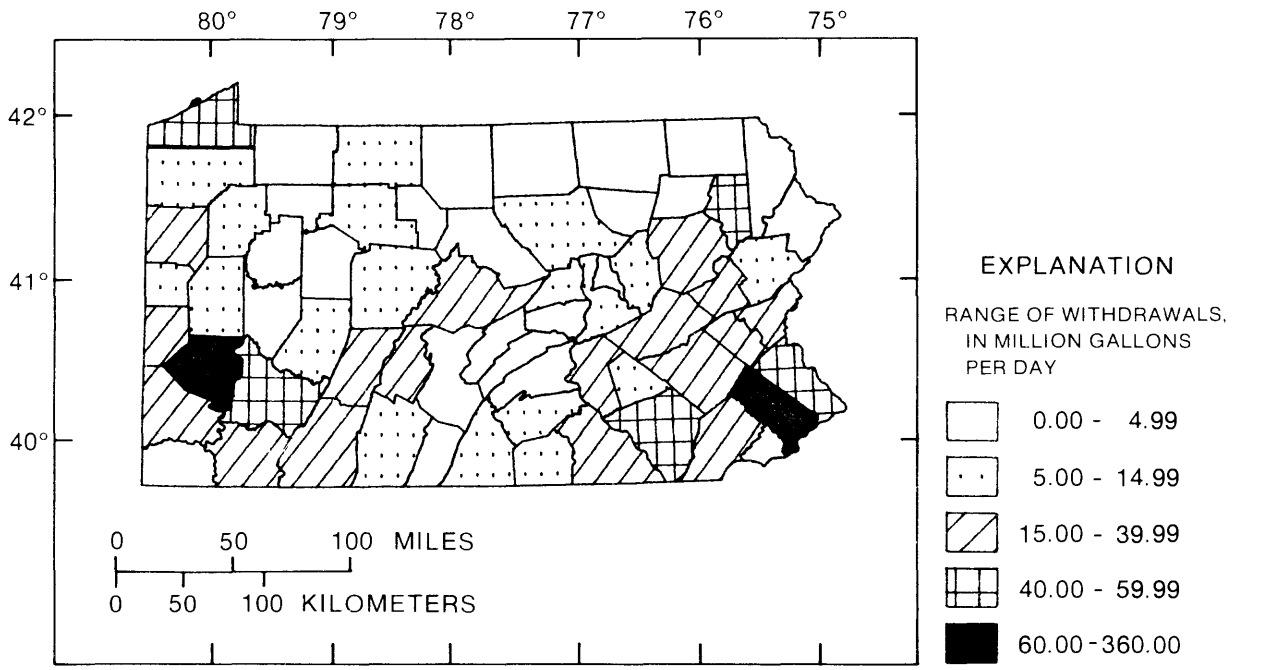


Figure 5.-- Water withdrawals for public supply, by county, 1984.

Table 1.--Water withdrawals for public water supply, by county, 1984
[million gallons per day]

County	Estimated population served	Percentage of population served	Withdrawals			Use		
			Total	Ground water	Surface water	Total[1]	Water to industry	Consumptive use
Adams	29,670	43	9.14	7.85	1.29	2.81	0.27	0.91
Allegheny	1,381,604	98	218.77	16.47	202.30	241.81	14.89	21.88
Armstrong	44,388	54	4.29	2.52	1.77	4.94	.24	.43
Beaver	155,376	78	23.67	10.11	13.56	25.65	7.53	2.37
Bedford	14,911	31	11.15	.40	10.75	10.57	.13	1.12
Berks	222,040	70	36.71	12.81	23.90	37.75	9.05	3.67
Blair	100,800	75	21.06	4.88	16.18	23.24	7.43	2.11
Bradford	27,520	43	3.76	3.54	.22	3.28	.46	.38
Bucks	340,762	67	41.80	15.26	26.54	54.19	5.70	4.18
Butler	62,033	41	9.31	1.13	8.18	9.65	2.44	.93
Cambria	148,764	84	34.43	2.73	31.70	51.83	36.07	3.44
Cameron	4,026	61	.68	<.01	.67	.68	.33	.07
Carbon	39,420	73	34.69	3.58	31.11	8.69	4.86	3.47
Centre	92,745	81	17.05	13.82	3.23	17.01	.41	1.70
Chester	190,779	57	34.71	9.08	25.63	18.24	2.80	3.47
Clarion	20,688	48	2.33	.86	1.47	2.12	.16	.23
Clearfield	54,080	64	6.11	.37	5.74	6.44	.46	.61
Clinton	29,325	75	4.32	.24	4.08	4.47	1.58	.43
Columbia	38,934	65	6.59	3.67	2.92	6.59	1.87	.66
Crawford	40,095	45	7.48	7.12	.36	7.44	2.72	.75
Cumberland	137,270	74	13.70	3.81	9.89	20.74	2.38	1.37
Dauphin	181,566	77	31.03	4.26	26.77	31.30	3.70	3.10
Delaware	529,344	96	4.57	.06	4.51	32.10	11.06	.46
Elk	26,320	70	6.52	.24	6.28	5.75	2.58	.65
Erie	220,038	78	49.07	4.73	44.34	49.63	15.41	4.91
Fayette	132,136	83	32.65	.44	32.21	15.48	1.86	3.26
Forest	1,750	35	.12	.12	--	.12	<.01	.01
Franklin	54,614	47	9.88	1.46	8.42	7.92	1.09	.99
Fulton	2,430	18	.15	.15	--	.16	<.01	.02
Greene	29,664	72	.88	.01	.87	4.36	.32	.09
Huntingdon	21,350	50	4.97	2.95	2.02	3.18	.40	.50
Indiana	51,315	55	5.53	.45	5.08	25.15	.97	.55
Jefferson	28,851	59	1.96	.28	1.68	3.17	.61	.20
Juniata	4,950	25	.38	.18	.20	.43	.05	.04
Lackawanna	194,880	87	52.11	2.19	49.92	35.31	2.63	5.21
Lancaster	240,219	63	55.74	8.03	47.71	28.18	5.66	5.57
Lawrence	74,060	70	12.13	.24	11.89	12.36	3.32	1.21
Lebanon	77,910	70	5.24	2.33	2.91	8.84	.97	.52
Lehigh	223,965	81	38.47	22.06	16.41	37.11	11.84	3.85
Luzerne	289,304	86	34.98	2.53	32.45	58.29	2.86	3.50
Lycoming	83,141	71	11.25	3.24	8.01	11.14	1.98	1.12
McKean	29,520	60	7.76	2.29	5.47	7.78	2.31	.78
Mercer	82,615	65	15.21	1.26	13.95	14.58	4.48	1.52
Mifflin	28,892	62	4.88	.77	4.11	14.41	.89	.49
Monroe	40,916	53	9.67	4.89	4.78	6.34	.65	.97
Montgomery	566,740	86	91.55	40.37	51.18	120.69	8.74	9.15
Montour	7,820	46	2.58	.38	2.20	2.68	.26	.26
Northhampton	186,948	81	15.19	4.53	10.66	40.90	11.53	1.52
Northumberland	76,152	76	9.96	0.38	9.58	15.55	4.24	1.00
Perry	13,912	37	.64	.44	.20	.62	.01	.06
Philadelphia	1,646,700	100	356.30	--	356.30	356.00	35.60	35.63
Pike	7,416	36	1.80	1.80	--	1.62	<.01	.18
Potter	5,888	32	1.26	1.03	.23	1.25	.02	.13
Schuylkill	102,505	65	26.48	2.87	23.61	21.46	4.78	2.65
Snyder	15,576	44	1.48	1.30	.18	1.75	.11	.15
Somerset	45,045	55	34.55	.67	33.88	4.94	.33	3.45
Sullivan	1,054	17	.31	.14	.17	.32	<.01	.03
Susquehanna	11,640	30	1.92	.20	1.72	1.14	.01	.19
Tioga	14,911	37	2.28	.96	1.32	2.38	.41	.23
Union	16,128	48	5.11	.07	5.04	.44	.01	.51
Venango	21,930	34	8.14	7.12	1.02	8.73	1.50	.81
Warren	20,988	44	4.43	4.31	.12	4.71	1.35	.44
Washington	171,588	79	16.56	.18	16.38	20.79	6.24	1.66
Wayne	6,048	16	3.78	.80	2.98	1.74	.16	.38
Westmoreland	336,342	87	43.58	.36	43.22	59.10	6.57	4.36
Wyoming	6,552	24	.69	.59	.10	.71	.01	.07
York	161,200	50	34.53	3.66	30.87	27.48	6.80	3.45
Total	9,268,063		1,600.02	257.58	1,342.44	1,666.23	266.14	160.01

[1]/Differences between withdrawal and use reflect intercounty transfer.

Industrial water use from public supply was calculated by multiplying the percentage supplied to industry (as reported by the supplier) by the total water used (as opposed to withdrawn) within each county or hydrologic accounting unit. Some county withdrawal totals do not equal county use totals because of intercounty or interbasin transfer of water from the supplier to the user, conveyance losses, sanitation, fire fighting, and treatment uses. Public-supplied water used by industry in 1984 totaled 266.14 Mgal/d (17 percent of all water withdrawn); Cambria and Philadelphia Counties had the most industrial water use from public supply, 36.07 Mgal/d and 35.60 Mgal/d, respectively (table 1).

Figure 6 shows the water withdrawals in each hydrologic accounting unit. The Delaware River basin, comprising hydrologic accounting units 020401 and 020402, has the largest population served--4,067,517 (table 2). Eighty percent of these customers are in the Schuylkill River subbasin (020402). The largest withdrawal system in this region is the Philadelphia Water Department. The sources used by this company are predominantly surface waters; 164.3 Mgal/d are withdrawn from the Schuylkill River and 192.0 Mgal/d from the Delaware River. About 75 percent of all withdrawals in the Delaware River basin are used for drinking, sanitation and hygiene; the remaining 25 percent is used in manufacturing and commerce.

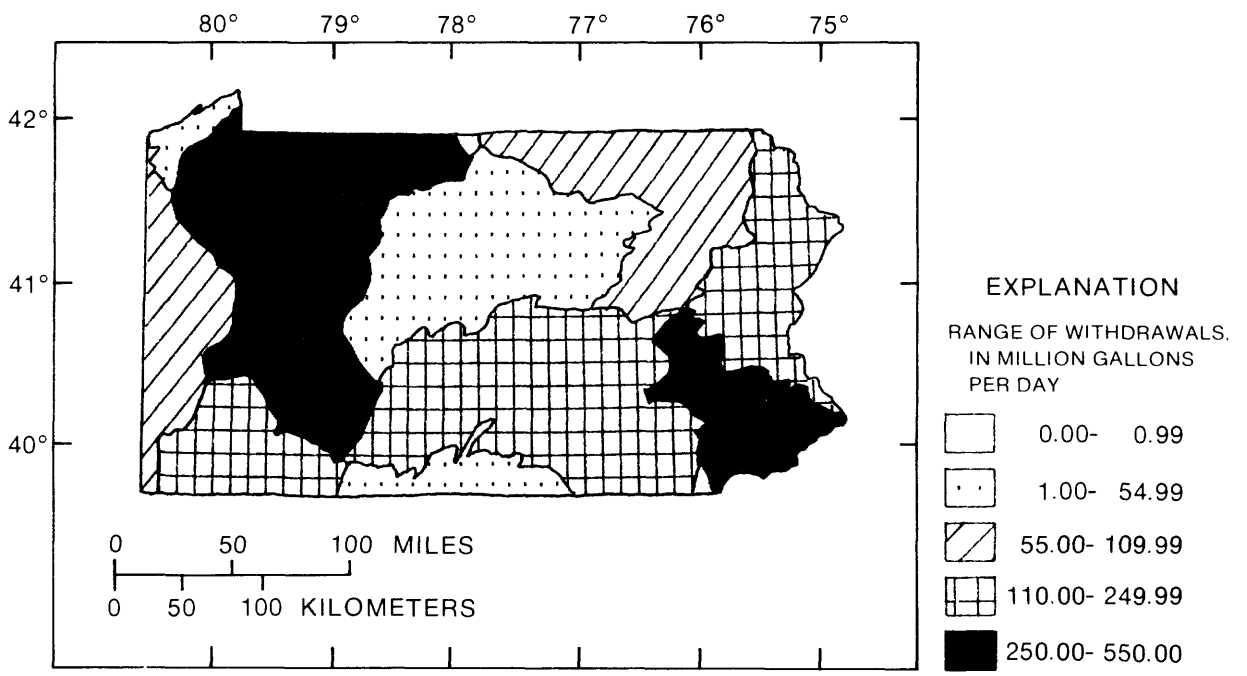


Figure 6.-- Water withdrawals for public supply, by hydrologic accounting unit, 1984.

Table 2.--Water withdrawals for public supply, by hydrologic accounting unit, 1984
[million gallons per day]

Hydrologic accounting unit	Estimated population served	Withdrawals			Use		
		Total	Ground water	Surface water	Total[1/]	Water to industry/ commerce	Consumptive use
020401	776,061	143.35	53.30	90.05	148.72	34.30	14.34
020402	3,291,456	541.65	63.14	478.51	587.44	72.39	54.16
020501	591,304	108.25	14.77	93.48	105.44	7.87	10.82
020502	295,466	50.28	19.43	30.85	48.40	7.63	5.03
020503	1,086,248	199.82	41.06	158.76	176.15	30.60	19.98
020600	5,739	.36	.36	0	.45	.04	.04
020700	84,373	18.96	2.48	16.48	19.13	1.13	1.90
041100	0	0	0	0	0	0	0
041201	194,639	44.53	2.00	42.53	46.45	14.72	4.45
041300	771	.10	.10	0	.10	.01	.01
050100	816,910	268.96	37.92	231.04	166.62	55.93	26.90
050200	946,973	129.25	2.91	126.34	266.13	19.64	12.93
050301	1,178,123	94.51	20.11	74.40	101.20	21.88	9.45
Total	9,268,063	1,600.02	257.58	1,342.44	1,666.23	266.14	160.01

[1/]Differences between withdrawal and use reflect interhydrologic accounting unit transfer.

Consumptive Use

Water is considered to be consumed by public supply when water withdrawn from the source is greater than the amount discharged as effluent from the sewage treatment plant. This is assuming that a type of closed system exists: no conveyance losses (leaks in water lines), no sewage from self-supplied users, and no publically supplied water discharged to septic tanks.

The consumptive use of the system may vary depending on the number of residential, commercial, and industrial users. Some industries consume a considerable amount of water (greater than 90 percent) in the processing of a product; this is either incorporated into the product (ink, paint) or is lost in evaporation (steam-pressing); other industries use the water supplied for cooling, boiler, processing and sanitary purposes and return a major portion to the sewage treatment plant.

The consumptive use data published in this report (tables 1 and 2) were not based on reported totals from individual systems as those data were unavailable. Consumptive use was calculated as 10 percent of the total water withdrawn for public supply. This percentage has been established by the American Water Works Association and has been used for calculating water consumption for public systems in other water use publications (Delaware River Basin Commission, 1981).

Self-Supplied Domestic Use

Source and Reliability of Data

Self-supplied domestic population was calculated by subtracting the number of persons reported to be public supply customers from the total population in each county or hydrologic accounting unit.

Total population in each hydrologic accounting unit was calculated by first adjusting 1982 estimated township population totals (U.S. Department of Commerce, Bureau of the Census, 1984) to reflect changes in county population from 1982 to 1984 (U.S. Department of Commerce, Bureau of the Census, 1985) and then adding the appropriate township totals or percentages of totals corresponding to the area within the accounting unit boundaries.

Withdrawals

About 2,632,937 persons or 22 percent of the total population in Pennsylvania in 1984 were considered self-supplied domestic water users. Water withdrawals in this category were used for hygiene, sanitation, and other domestic purposes. Hand-operated pumps, once commonly used in rural areas, have been largely replaced by submersible pumps placed directly in machine-drilled wells (fig. 7). Self-supplied water used for livestock and irrigation will be discussed in separate sections of this report. Water withdrawn for rural domestic use was considered to be solely from ground-water sources, although a small percentage of the rural population uses water from reservoirs, ponds, and streams.

Self-supplied domestic withdrawals were computed by multiplying the total number of people in each county and hydrologic accounting unit not on a public system by a 50-gal/d per person use factor. This average use factor was determined by PaDER after analyzing usage data from rural customers on public supply systems in many parts of the State.

Rural self-supplied domestic withdrawals totaled 131.63 Mgal/d in 1984, (tables 3 and 4) compared to 147.36 Mgal/d in 1980. Several of the more populated counties in the southeastern part of the State--Bucks, York, Lancaster, and Chester--had total withdrawals greater than 7 Mgal/d from private wells, even though the wells supplied less than 50 percent of the total population in each respective county (table 3 and fig. 8). The larger withdrawals in accounting units 020402 and 020503 (fig. 9) are in these counties.

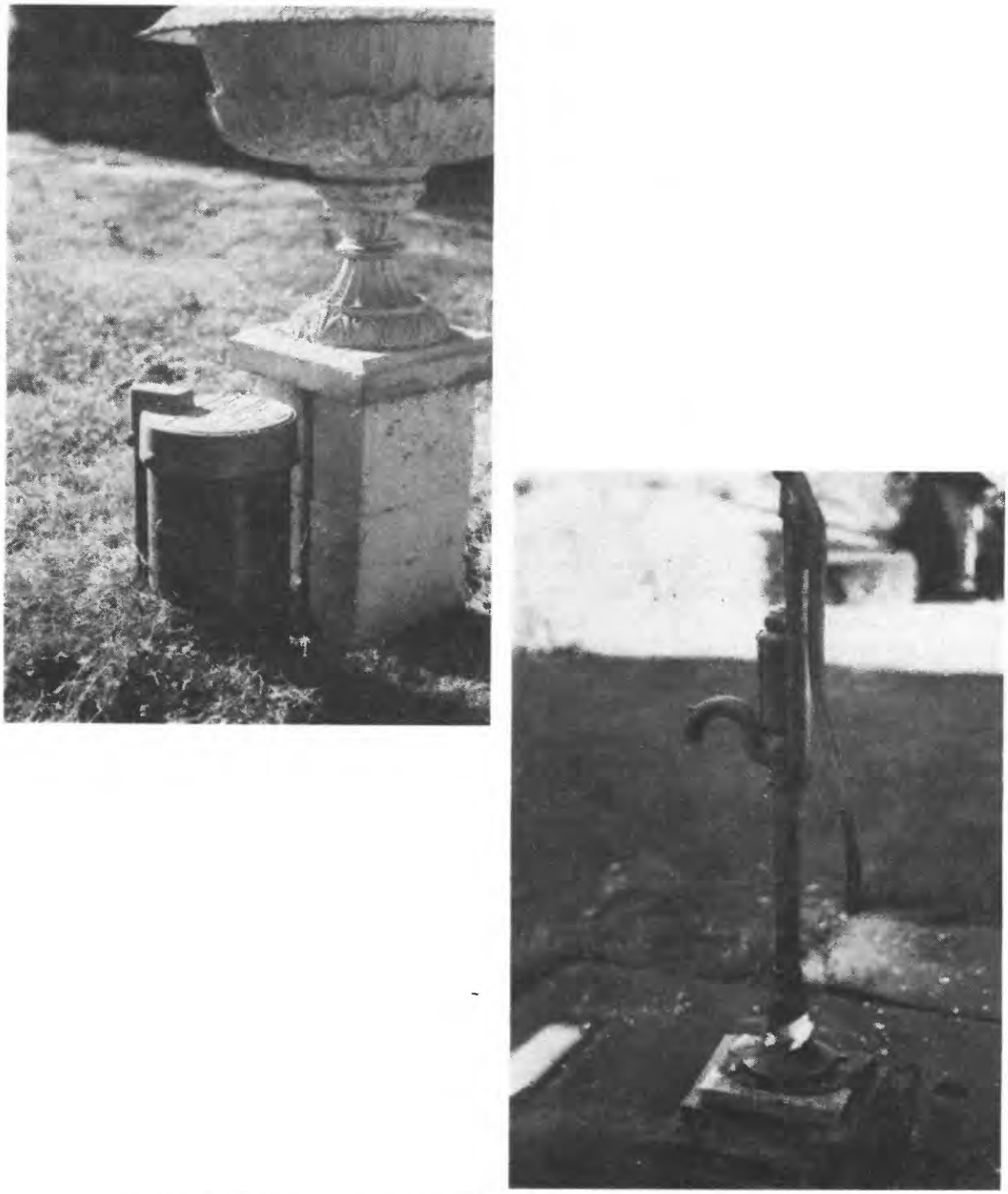


Figure 7.-- Means of withdrawing water for self-supplied domestic use: at present (top) and the past (bottom).

Table 3.--Water withdrawals for self-supplied domestic use, by county, 1984
[million gallons per day]

County	Total population	Rural population	Total[1/] withdrawals	Consumptive use
Adams	69,000	39,330	1.97	0.20
Allegheny	1,409,800	28,196	1.41	.14
Armstrong	82,200	37,812	1.89	.19
Beaver	199,200	43,824	2.19	.22
Bedford	48,100	33,189	1.66	.16
Berks	317,200	95,160	4.76	.48
Blair	134,400	33,600	1.68	.17
Bradford	64,000	36,480	1.82	.18
Bucks	508,600	167,838	8.39	.84
Butler	151,300	89,267	4.46	.45
Cambria	177,100	28,336	1.42	.14
Cameron	6,600	2,574	.13	.01
Carbon	54,000	14,580	.73	.07
Centre	114,500	21,755	1.09	.11
Chester	334,700	143,921	7.20	.72
Clarion	43,100	22,412	1.12	.11
Clearfield	84,500	30,420	1.52	.15
Clinton	39,100	9,775	.49	.05
Columbia	61,800	22,866	1.14	.11
Crawford	89,100	49,005	2.45	.24
Cumberland	185,500	48,230	2.41	.24
Dauphin	235,800	54,234	2.71	.27
Delaware	551,400	22,056	1.10	.11
Elk	37,600	11,280	.56	.06
Erie	282,100	62,062	3.10	.31
Fayette	159,200	27,064	1.35	.13
Forest	5,000	3,250	.16	.02
Franklin	116,200	61,586	3.08	.31
Fulton	13,500	11,070	.55	.05
Greene	41,200	11,536	.58	.06
Huntingdon	42,700	21,350	1.07	.11
Indiana	93,300	41,985	2.10	.21
Jefferson	48,900	20,049	1.00	.10
Juniata	19,800	14,850	.74	.07
Lackawanna	224,000	29,120	1.46	.14
Lancaster	381,600	141,381	7.07	.71
Lawrence	105,800	31,740	1.59	.16
Lebanon	111,300	33,390	1.67	.17
Lehigh	276,500	52,535	2.63	.26
Luzerne	336,400	47,096	2.35	.23
Lycoming	117,100	33,959	1.70	.17
McKean	49,200	19,680	.98	.10
Mercer	127,100	44,485	2.22	.22
Mifflin	46,600	17,708	.89	.09
Monroe	77,200	36,284	1.81	.18
Montgomery	659,000	92,260	4.61	.46
Montour	17,000	9,180	.46	.05
Northampton	230,800	43,852	2.19	.22
Northumberland	100,200	24,048	1.20	.12
Perry	37,600	23,688	1.18	.12
Philadelphia	1,646,700	0	0	0
Pike	20,600	13,184	.66	.07
Potter	18,400	12,512	.63	.06
Schuylkill	157,700	55,195	2.76	.28
Snyder	35,400	19,824	.99	.10
Somerset	81,900	36,855	1.84	.18
Sullivan	6,200	5,146	.26	.03
Susquehanna	38,800	27,160	1.36	.14
Tioga	40,300	25,389	1.27	.13
Union	33,600	17,472	.87	.09
Venango	64,500	42,570	2.13	.21
Warren	47,700	26,712	1.34	.13
Washington	217,200	45,612	2.28	.23
Wayne	37,800	31,752	1.59	.16
Westmoreland	386,600	50,258	2.51	.25
Wyoming	27,300	20,748	1.04	.10
York	322,400	161,200	8.06	.81
Totsl	11,901,000	2,632,937	131.63	13.16

[1/]Assumed to be all ground water.

Table 4.--Water withdrawals for self-supplied domestic use, by hydrologic accounting unit, 1984
[million gallons per day]

Hydrologic accounting unit	Total estimated population	Rural population	Total[1]/ withdrawals	Consumptive use
020401	797,001	20,940	1.05	0.10
020402	4,020,218	728,762	36.44	3.64
020501	778,032	186,728	9.34	.93
020502	447,676	152,210	7.61	.76
020503	1,810,414	724,166	36.21	3.62
020600	11,253	5,514	.28	.03
020700	156,246	71,873	3.59	.36
041100	387	387	.02	<.01
041201	240,295	45,656	2.28	.23
041300	2,030	1,259	.06	.01
050100	1,219,269	402,359	20.12	2.01
050200	1,064,015	117,042	5.83	.58
050301	1,354,164	176,041	8.80	.88
Total	11,901,000	2,632,937	131.63	13.16

[1]/Assumed to be all ground water.

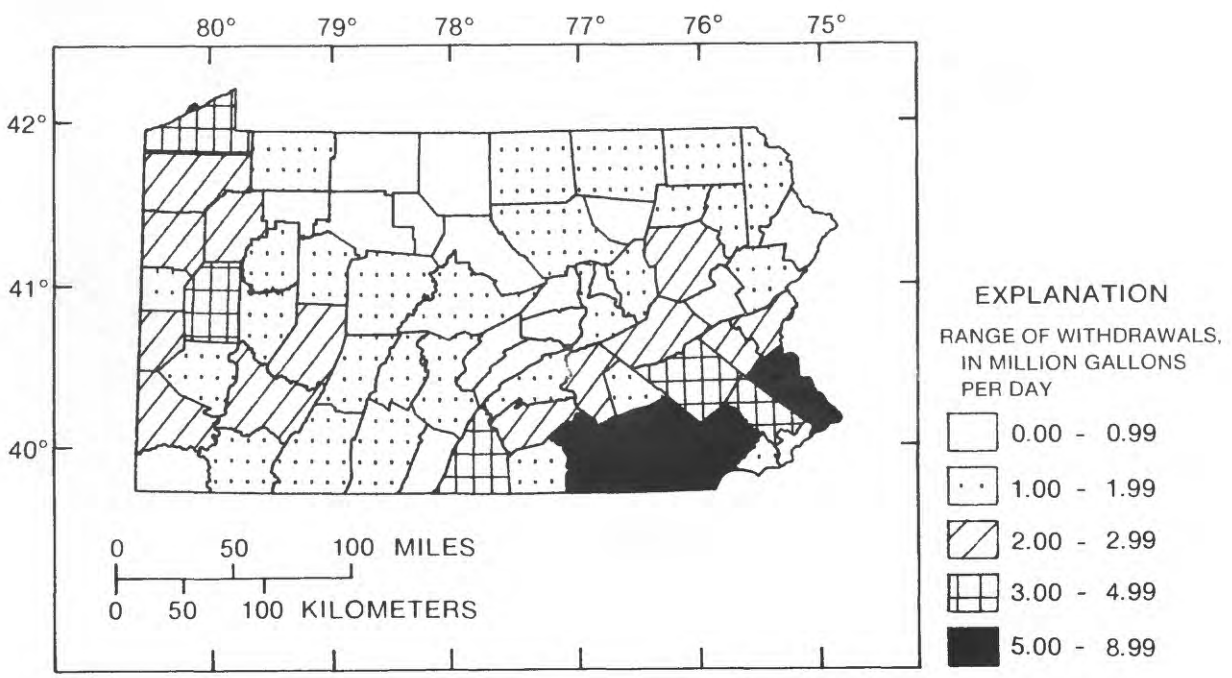


Figure 8.-- Water withdrawals for self-supplied domestic use, by county, 1984.

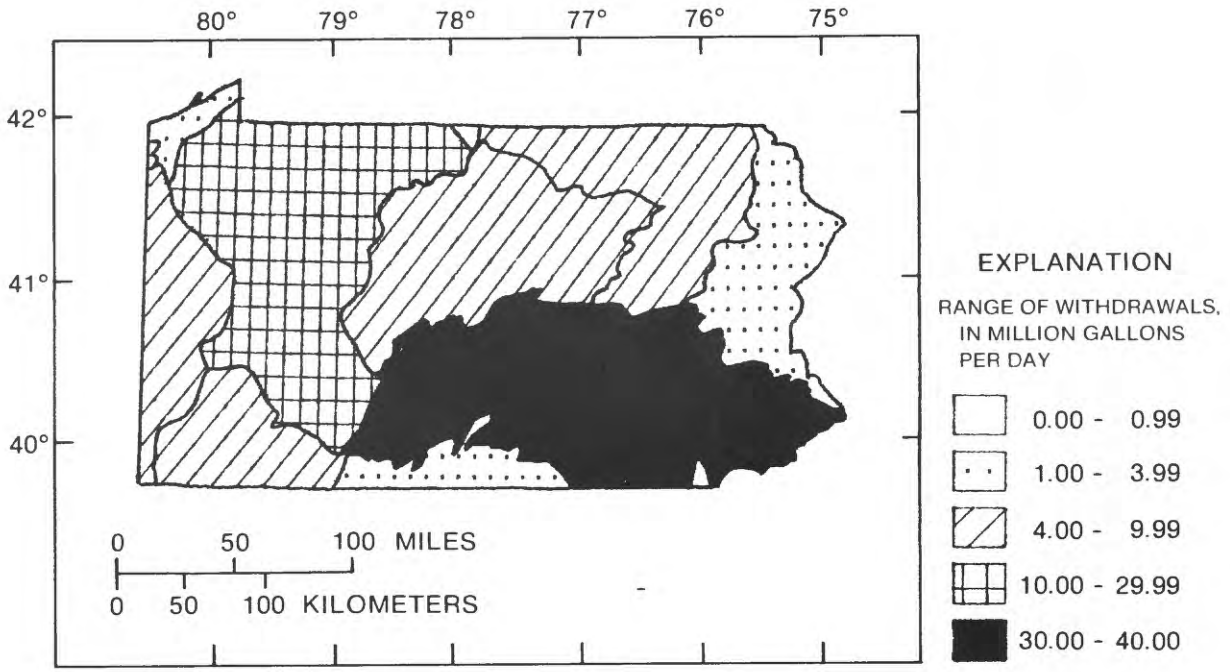


Figure 9.-- Water withdrawals for self-supplied domestic use, by hydrologic accounting unit, 1984.

Consumptive Use

Rural consumptive use is considered to be very low because of the use of septic tanks which return water to the ground water system. No known studies have been done to determine the percentage of consumptive use by septic systems used for waste disposal. For this report, a 10-percent consumptive use factor was assumed (W. Gast, PaDER, oral commun. 1985) and was multiplied by the total withdrawals to obtain the consumptive use for the individual counties or hydrologic accounting units (tables 3 and 4).

Agriculture

In 1983, about 8,700,000 acres, or 30 percent of the total area of Pennsylvania were devoted to agriculture (Pennsylvania Department of Commerce, 1986) Farm land has decreased about 40 percent since 1950 as many small farms were sold for industrial or residential development. Pennsylvania remains one of the top 10 States in the production of milk, mushrooms, chickens, corn, hay, apples, peaches, pears, grapes, and cherries (U.S. Department of Agriculture, Pennsylvania Department of Agriculture, 1985).

Irrigation

Irrigation has been increasing in Pennsylvania. Most systems presently in use are overhead sprinklers such as shown in figure 10, but the use of trickle or drip irrigation systems has been increasing. The trickle system requires about half the water needed by sprinkler systems and commonly requires less manpower. The predominant crops and fruit trees irrigated extensively in Pennsylvania are potatoes, alfalfa, field corn, celery, truck-patch variety vegetables, strawberries and peaches. Water from overhead systems can be used for moisture, frost protection, or, if removed from manure ponds, fertilization.

Figure 10.-- Center-pivot irrigation (photo courtesy of Pennsylvania State University, Agricultural Engineering Department).

Source and reliability of data

The amount of water withdrawn for irrigation depends on several factors, including the amount of rainfall over the course of the growing season (May through October), soil type, crop type, and the type of irrigation system used (center pivot, traveling gun, trickle).

Estimates for this report were made from a 1978 PaDER survey of irrigation withdrawals. For that survey, County Conservation District offices were asked to prepare a mailing list of the farmers within their jurisdictions who used water to sustain and improve crop yields. Questionnaires were sent to those farmers for relevant information; a followup survey was made by conservation officers.

A comparison of PaDER totals for acres irrigated and numbers of farms using irrigation versus totals found in the Census of Agriculture, 1978 (U.S. Department of Commerce, Bureau of the Census, 1982) showed that the 1978 State survey had data for 75 percent of the acres irrigated but for less than 50 percent of the total farms using irrigation. County data available from

the Department of Commerce (U.S. Department of Commerce, Bureau of the Census, 1984) could not be used for estimations because the number of irrigated acres on many farms could not be specified in order to protect the rights of individual growers.

Rainfall for the 1978 growing season was estimated to be 10 percent below normal and, in 1984, 15 percent above normal (National Oceanic and Atmospheric Administration, 1979; 1985). An inverse relation was assumed to exist between precipitation and water used for irrigation; in 1984, because precipitation was 15 percent above normal, irrigation was assumed to be 15 percent lower than normal. This was verified by county extension agents in Franklin, Adams, York, Lancaster and Northampton Counties and through personal communication with grove owners and truck farmers in those areas. Based on this information, a factor of 0.77 was developed and applied to PaDER irrigation data to estimate withdrawals in 1984.

Withdrawals

In 1984, 4.525 Mgal/d was estimated to have been withdrawn to irrigate 8,464 acres in Pennsylvania (table 5). Of that total, 3.791 Mgal/d, or 84 percent, was withdrawn from surface-water sources. Many farmers used ponds on their own property, but other sources included streams and quarries. Beaver and Adams Counties had the greatest withdrawals for irrigation, 0.891 Mgal/d and 0.745 Mgal/d, respectively, followed by Northampton County, 0.323 Mgal/d; and Franklin County, 0.273 Mgal/d, (table 5 and fig. 11). Twenty-eight counties did not report any irrigation of crops or trees; they are generally in the north-central and western parts of the State. Hydrologic accounting unit 020503, which encompasses Franklin and Adams Counties in the Lower Susquehanna River basin, had the highest withdrawals of 1.349 Mgal/d (table 6 and fig. 12).

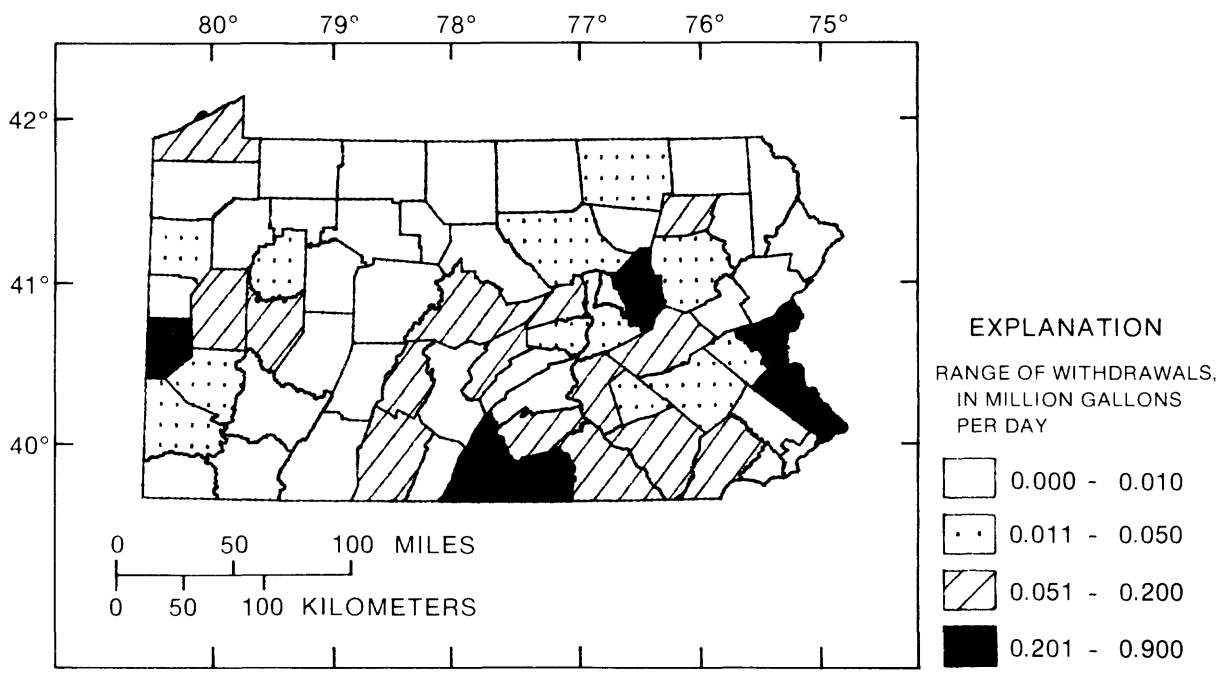


Figure 11.-- Water withdrawals for irrigation, by county, 1984.

Table 5.--Water withdrawals for irrigation, by county, 1984
[million gallons per day; <, less than]

County	Total	Ground water	Surface water	Acres irrigated
Adams	0.745	0.115	0.630	1,394
Allegheny	.022	0	.022	55
Armstrong	.139	.001	.138	43
Beaver	.891	0	.891	113
Bedford	.123	.030	.093	352
Berks	.049	0	.049	179
Blair	.097	.015	.082	323
Bradford	.018	.009	.009	77
Bucks	.232	.214	.018	157
Butler	.079	0	.079	122
Cambria	.009	0	.009	8
Cameron	0	0	0	0
Carbon	0	0	0	0
Centre	.059	.005	.054	100
Chester	.086	.078	.008	94
Clarion	.027	.013	.014	12
Clearfield	0	0	0	0
Clinton	0	0	0	0
Columbia	.226	.086	.140	374
Crawford	.003	0	.003	51
Cumberland	.075	.020	.055	146
Dauphin	.194	.093	.101	198
Delaware	0	0	0	0
Elk	0	0	0	0
Erie	.067	.006	.061	124
Fayette	0	0	0	0
Forest	0	0	0	0
Franklin	.273	.006	.267	1,233
Fulton	0	0	0	0
Greene	0	0	0	0
Huntingdon	0	0	0	0
Indiana	0	0	0	0
Jefferson	0	0	0	0
Juniata	0	0	0	0
Lackawanna	0	0	0	0
Lancaster	0.098	.015	.083	743
Lawrence	<.002	<.001	<.001	6
Lebanon	.047	0	.047	100
Lehigh	.045	.006	.039	94
Luzerne	.012	0	.012	46
Lycoming	.034	0	.034	151
McKean	0	0	0	0
Mercer	.015	0	.015	66
Mifflin	.065	<.001	.064	111
Monroe	.003	.003	0	70
Montgomery	.003	0	.003	5
Montour	0	0	0	0
Northampton	.323	.002	.321	281
Northumberland	.027	<.001	.026	181
Perry	<.002	<.001	<.001	5
Philadelphia	0	0	0	0
Pike	0	0	0	0
Potter	0	0	0	0
Schuylkill	<.143	.002	.141	577
Snyder	.025	0	.025	141
Somerset	0	0	0	0
Sullivan	0	0	0	0
Susquehanna	0	0	0	0
Tioga	0	0	0	0
Union	.078	0	.078	213
Venango	0	0	0	0
Warren	0	0	0	0
Washington	.028	.004	.024	137
Wayne	0	0	0	0
Westmoreland	0	0	0	0
Wyoming	.077	0	.077	87
York	.084	.007	.077	295
Total	4.525	0.734	3.791	8,464

Table 6.--Water withdrawals for irrigation, by hydrologic accounting unit, 1984
[million gallons per day; <, less than]

Hydrologic accounting unit	Total	Ground water	Surface water	Acres irrigated
020401	0.605	0.224	0.381	516
020402	.146	.078	.068	318
020501	.412	.095	.317	957
020502	.110	.005	.105	392
020503	1.349	.236	1.113	3,721
020600	<.001	<.001	0	31
020700	.628	.070	.558	1,607
041100	0	0	0	0
041201	.026	.006	.020	100
041300	0	0	0	0
050100	.214	.014	.200	267
050200	.015	.004	.011	179
050301	1.019	<.001	1.018	376
Total	4.525	0.734	3.791	8,464

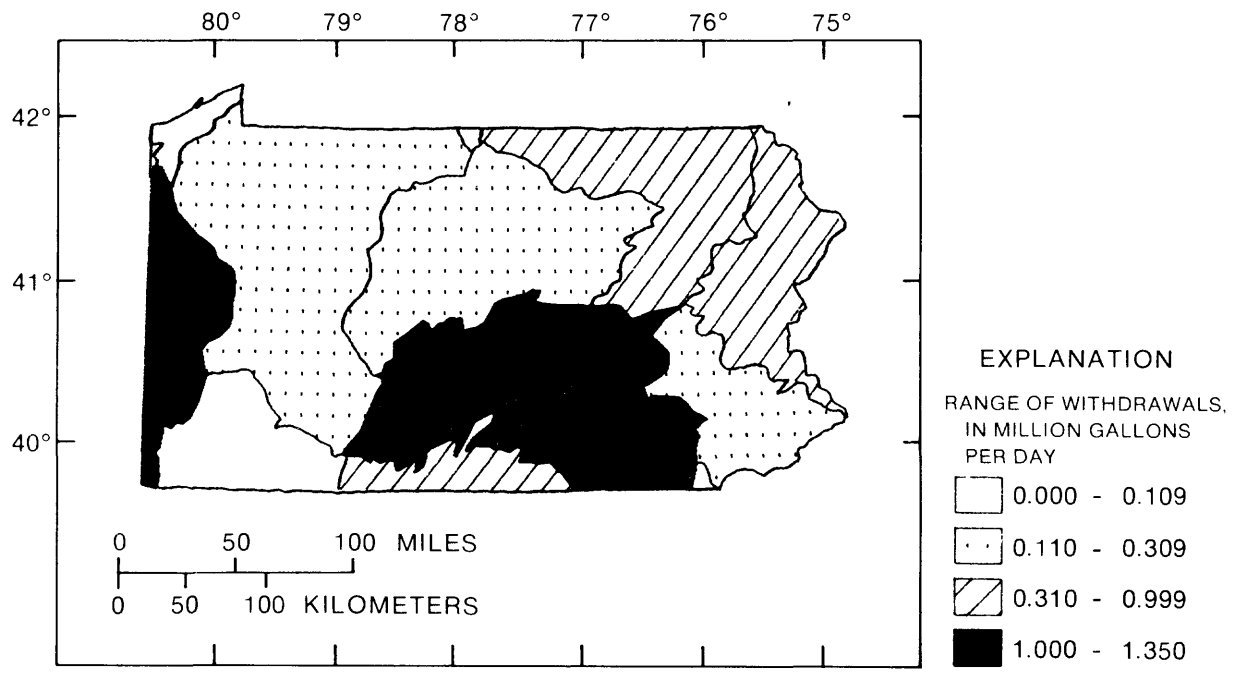


Figure 12.-- Water withdrawals for irrigation, by hydrologic accounting unit, 1984.

Consumptive use

The consumptive use of water withdrawn for irrigation was assumed to be 100 percent (W. Gast, PaDER, oral commun., 1985); that is, all of the water applied was considered lost through evaporation and/or plant transpiration processes and none is returned to the surface or ground-water systems for reuse. As more investigations dealing with estimates of consumption of subsurface irrigational systems are completed, this percentage may decrease.

Livestock

Source and reliability of data

Three of the major livestock types in Pennsylvania are dairy cows, hogs, and poultry. The Pennsylvania Department of Agriculture, in cooperation with the U.S. Department of Agriculture, publishes an annual report that summarizes the numbers of livestock by county (U.S. Department of Agriculture, Pennsylvania Department of Agriculture, 1984; 1985). Totals of livestock and poultry from these censuses were multiplied by the following average daily water use per head (Pennsylvania Department of Environmental Resources, 1975): milk cows, 40 gal/d; cattle, 15 gal/d; hogs, 6 gal/d; sheep, 3 gal/d; and poultry, 0.15 gal/d to estimate water withdrawals, which were then compiled by county and hydrologic accounting units.

Withdrawals

Water withdrawals for livestock and poultry in 1984 were estimated to be 83.52 Mgal/d. Eighty-seven percent of this total, or 72.90 Mgal/d, came from ground-water resources; while 13 percent, or 10.62 Mgal/d, was removed from surface waters. These percentages are from an unpublished 1968 report by the State Soil and Water Conservation Commission, Pennsylvania Department of Agriculture, and were used to derive the estimates shown in tables 7 and 8.

Every county within the State was reported to supply water to livestock and poultry, but most of the high withdrawals are in the southeast (fig. 13). Lancaster County far surpassed all other counties in numbers of livestock and poultry; in 1984, Lancaster County farmers withdrew about 17.6 Mgal/d of water to supply 112,000 milk cows, 270,400 cattle, 304,000 hogs, 6,200 sheep, and 47,908,200 poultry. Even Philadelphia County was reported to have supported 800 hens and pullets; water used for these poultry was supplied from a public supply system and therefore, is not included in table 7.

Like irrigation, livestock and poultry demands for water were the highest in the Lower Susquehanna River basin, hydrologic accounting unit 020503 (fig. 14) where 36.70 Mgal/d was withdrawn in 1984.

Table 7.-- Water withdrawals for livestock and poultry, by county, 1984
[million gallons per day; <, less than]

County	Total	Ground water	Surface water	Consumptive use
Adams	1.45	1.23	0.22	1.09
Allegheny	.13	.12	.01	.10
Armstrong	.55	.52	.03	.41
Beaver	.37	.33	.04	.28
Bedford	1.55	1.55	0	1.16
Berks	3.06	2.90	.16	2.30
Blair	1.06	1.06	0	.80
Bradford	3.09	2.16	.93	2.32
Bucks	.63	.63	0	.47
Butler	.80	.76	.04	.60
Cambria	.33	.32	.01	.25
Cameron	.01	0	<.01	<.01
Carbon	.05	.05	0	.04
Centre	1.07	.91	.16	.80
Chester	2.85	2.85	0	2.14
Clarion	.52	.52	0	.39
Clearfield	.28	.27	.01	.21
Clinton	.37	.18	.19	.28
Columbia	.59	.35	.24	.44
Crawford	1.90	1.90	0	1.42
Cumberland	1.94	1.75	.19	1.46
Dauphin	1.27	1.21	.06	.95
Delaware	.04	.03	.01	.03
Elk	.08	.08	0	.06
Erie	1.42	1.28	.14	1.06
Fayette	3.32	1.99	1.33	2.49
Forest	.04	.03	.01	.03
Franklin	3.42	3.08	.34	2.56
Fulton	.53	.52	.01	.40
Greene	.45	.25	.20	.34
Huntingdon	1.13	1.13	0	.85
Indiana	1.96	1.27	.69	1.47
Jefferson	.44	.35	.09	.33
Juniata	1.66	1.33	.33	1.24
Lackawanna	.28	.14	.14	.21
Lancaster	17.56	17.56	0	13.17
Lawrence	.68	.34	.34	.51
Lebanon	3.52	3.34	.18	2.64
Lehigh	.25	.20	.05	.19
Luzerne	.29	.22	.07	.22
Lycoming	.74	.52	.22	.56
McKean	.20	.15	.05	.15
Mercer	1.02	1.02	0	.76
Mifflin	1.22	1.16	.06	.92
Monroe	.08	.06	.02	.06
Montgomery	.57	.54	.03	.43
Montour	.30	.26	.04	.22
Northampton	.65	.64	.01	.49
Northumberland	1.00	.65	.35	.75
Perry	1.23	1.05	.18	.92
Philadelphia	0	0	0	0
Pike	.02	.02	0	.01
Potter	.51	.23	.28	.38
Schuylkill	.92	.83	.09	.69
Snyder	1.43	.87	.56	1.07
Somerset	1.51	1.49	.02	1.13
Sullivan	.22	.19	.03	.16
Susquehanna	1.63	1.47	.16	1.22
Tioga	1.64	1.07	.57	1.23
Union	.82	.41	.41	.62
Venango	.29	.29	0	.22
Warren	.44	.42	.02	.33
Washington	1.19	1.01	.18	.89
Wayne	1.18	.47	.71	.88
Westmoreland	1.01	.86	.15	.76
Wyoming	.62	.37	.25	.46
York	2.14	2.14	0	1.60
Total	83.52	72.90	10.62	62.63

Table 8.-- Water withdrawals for livestock and poultry, by hydrologic accounting unit, 1984
[million gallons per day]

Hydrologic accounting unit	Total	Ground water	Surface water	Consumptive use
020401	3.21	2.57	0.64	2.41
020402	6.13	5.76	.37	4.60
020501	7.73	5.41	2.32	5.80
020502	4.13	2.89	1.24	3.10
020503	36.70	33.37	3.33	27.52
020600	.28	.28	0	.21
020700	4.10	3.85	.25	3.08
041100	.17	.17	0	.13
041201	.74	.67	.07	.56
041300	.03	.01	.02	.02
050100	9.47	8.52	.95	7.09
050200	5.93	4.74	1.19	4.44
050301	4.90	4.66	.24	3.67
Total	83.52	72.90	10.62	62.63

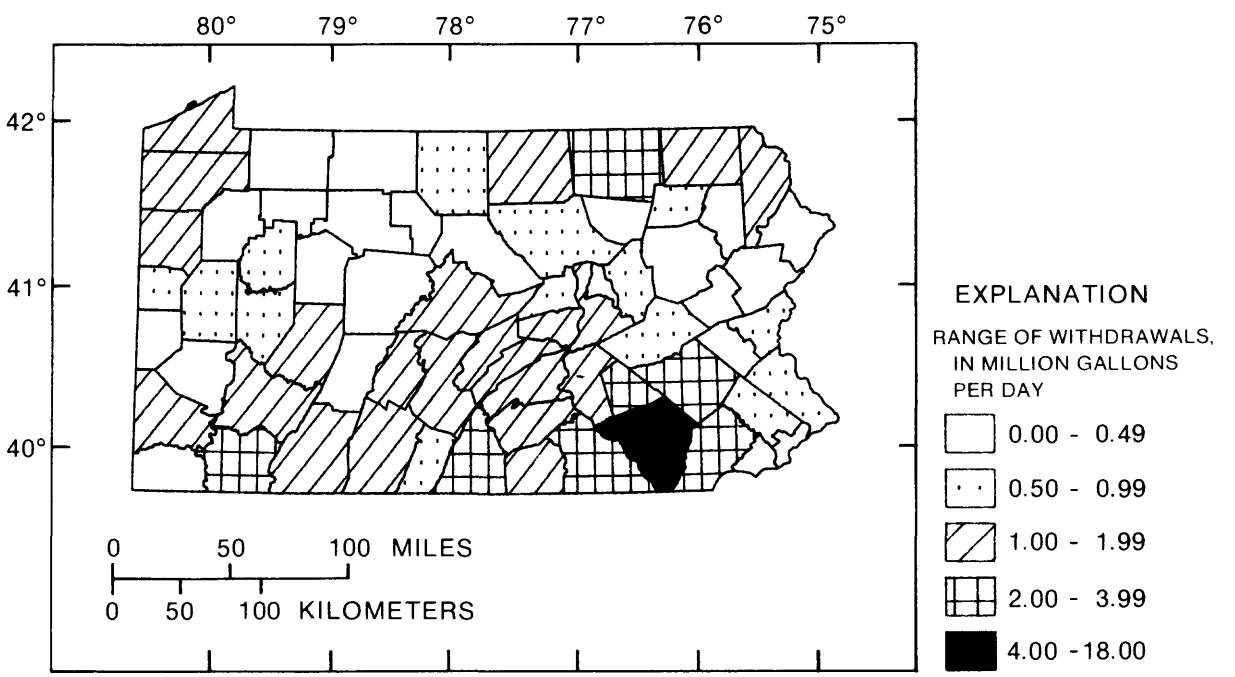


Figure 13.-- Water withdrawals for livestock and poultry, by county, 1984.

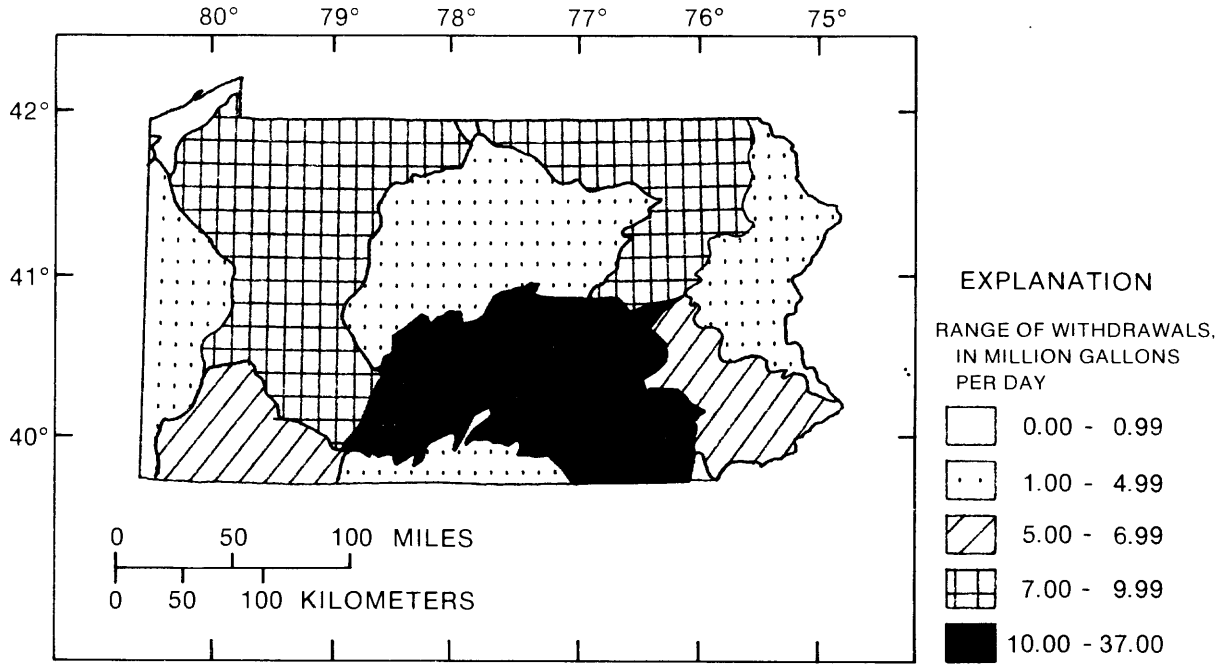


Figure 14.-- Water withdrawals for livestock and poultry, by hydrologic accounting unit, 1984.

Consumptive use

Consumptive use was estimated to be 75 percent of the total water withdrawn for this category (Pennsylvania Department of Environmental Resources, 1975). The remaining 25 percent was assumed to be returned to surface runoff.

Self-Supplied Industry

Source and Reliability of Data

PaDER conducted mail surveys for industrial water withdrawals in 1977 and 1983. About 15,000 industries were contacted in 1977 and 16,600 in 1983; the average response rate was 70 percent. Manufacturers that used only public supplies were not included in this category because that water was included in the total withdrawals for public systems.

WARDS lists 111 industries that withdrew more than 1 Mgal/d from self-supplied sources. These 111 industries used 94 percent of the total water withdrawn in this category. Data stored for 84 of these companies represented withdrawals made in 1977. Because the manufacturing industries significantly changed between 1977 and 1983, updated withdrawal estimates were obtained for the major users. The data were updated either from the 1983 PaDER Survey or by telephone calls to the industries. Water withdrawals of less than 1 Mgal/d were not updated, regardless of report year.

Withdrawals

The manufacturing industries were second only to power generation in the quantity of water withdrawn in Pennsylvania in 1984. Withdrawals totaled 2,055.63 Mgal/d in 1984, of this 1,906.93 Mgal/d (93 percent) were pumped from rivers and streams. Steel companies and to a lesser extent, oil companies were responsible for the greatest industrial use. Most of these industries are near rivers because large volumes of water are required for processing. The Ohio, Monongahela and Allegheny Rivers were used extensively by the steel industries in the western part of the state as were the Delaware and Lehigh Rivers in the east. Steel production has sharply declined since 1977, but, in 1984, five plants withdrawing more than 100 Mgal/d were still in operation.

Allegheny County had the largest withdrawals by self-supplied industry--498.42 Mgal/d. This represented 24 percent of the total withdrawals in this category for the entire State. Five other counties had totals greater than 100 Mgal/d--Beaver (298.47 Mgal/d), Bucks (235.00 Mgal/d), Delaware (233.70 Mgal/d), Northampton (174.58 Mgal/d), and Philadelphia (119.03 Mgal/d). The self-supplied industrial withdrawals for 41 of the 67 counties in Pennsylvania were under 5 Mgal/d (table 9 and fig. 15).

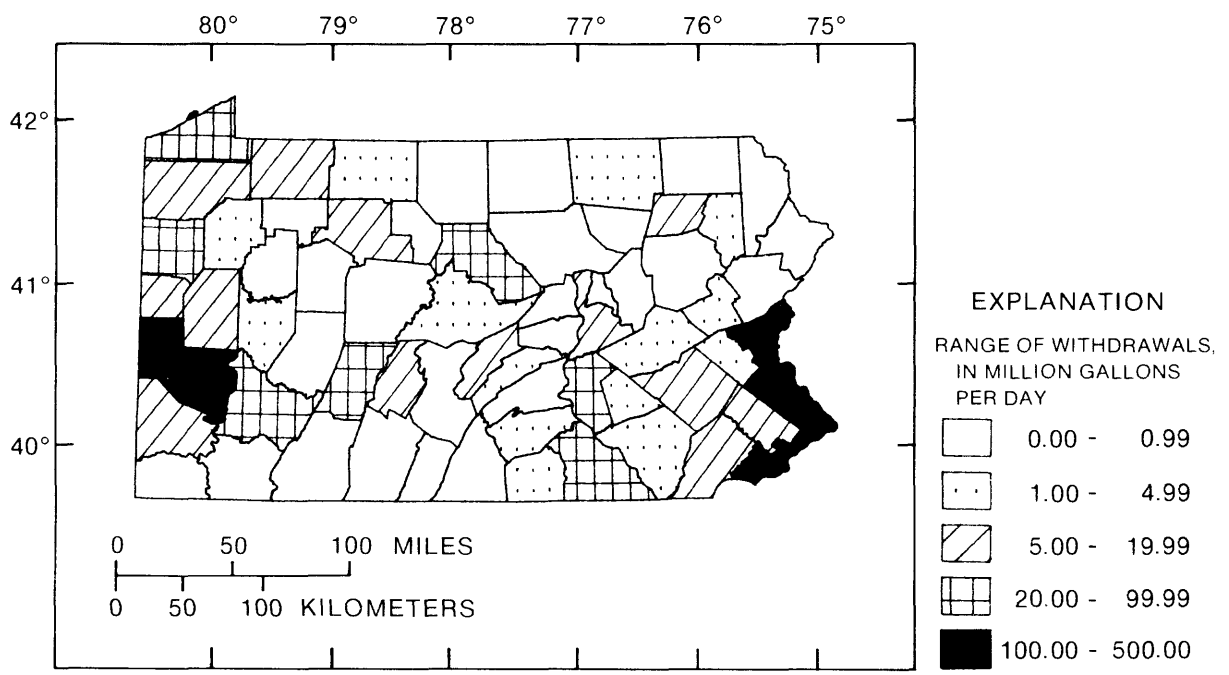


Figure 15.-- Water withdrawals for self-supplied industry, by county, 1984.

Table 9.-- Water withdrawals for self-supplied industry, by county, 1984
[million gallons per day; <, less than]

County	Total	Ground water	Surface water	Consumptive use1/
Adams	1.10	1.03	0.07	0.13
Allegheny	498.42	20.69	477.73	34.98
Armstrong	1.21	.68	.53	.29
Beaver	298.47	9.04	289.43	14.76
Bedford	.01	.01	0	.03
Berks	7.09	6.12	.97	1.86
Blair	9.51	6.83	2.68	3.17
Bradford	1.65	1.65	0	.11
Bucks	235.00	2.77	232.23	12.90
Butler	6.02	1.47	4.55	1.22
Cambria	47.87	.08	47.79	3.26
Cameron	<.01	<.01	0	.01
Carbon	1.09	1.08	<.01	.84
Centre	3.76	3.74	.02	1.35
Chester	12.70	3.39	9.31	1.50
Clarion	.12	.06	.06	.10
Clearfield	.41	.27	.14	.10
Clinton	28.12	.16	27.96	2.24
Columbia	.47	.46	<.01	.15
Crawford	7.63	7.27	.36	.66
Cumberland	3.00	.79	2.21	.34
Dauphin	51.68	14.50	37.18	1.37
Delaware	233.70	.27	233.43	36.04
Elk	11.36	1.68	9.68	.44
Erie	44.95	.38	44.57	4.51
Fayette	.05	.04	.01	.48
Forest	.11	.09	.02	.03
Franklin	.49	.45	.04	.23
Fulton	.29	<.01	.28	.04
Greene	.02	<.01	.01	<.01
Huntingdon	.02	.01	<.01	.06
Indiana	.34	.33	.01	.05
Jefferson	.17	.17	0	.09
Juniata	3.83	3.82	<.01	.06
Lackawanna	1.38	.09	1.29	.41
Lancaster	4.00	3.98	.02	.91
Lawrence	11.14	9.07	2.07	1.64
Lebanon	2.25	1.78	.47	.38
Lehigh	3.23	2.30	.93	1.47
Luzerne	.30	.16	.14	.44
Lycoming	.64	.63	<.01	.23
McKean	4.90	4.90	0	1.35
Mercer	47.09	1.24	45.85	3.63
Mifflin	9.13	.54	8.59	.46
Monroe	.54	.31	.23	.08
Montgomery	9.25	7.43	1.82	1.39
Montour	.05	.05	0	.01
Northampton	174.58	9.24	165.34	22.63
Northumberland	8.26	.72	7.54	.80
Perry	.02	.01	<.01	.49
Philadelphia	119.03	.47	118.56	10.25
Pike	.08	.05	.03	<.01
Potter	.35	.35	0	.01
Schuylkill	1.00	.73	.27	.70
Snyder	.04	.04	0	.01
Somerset	.05	.04	<.01	.49
Sullivan	<.01	<.01	0	<.01
Susquehanna	.25	.25	0	.02
Tioga	.81	.08	.73	.08
Union	.66	.66	0	.07
Venango	3.48	.32	3.16	.94
Warren	8.88	8.85	.03	2.65
Washington	11.50	.05	11.45	1.43
Wayne	.01	.01	0	<.01
Westmoreland	72.18	2.97	69.21	5.45
Wyoming	13.93	.23	13.70	.90
York	35.94	1.78	34.16	2.77
Total	2,055.63	148.70	1,906.93	185.53

1/Based on water from public and self-supplied sources.

Hydrologic accounting units 050200 (Monongahela River basin) and 020401 (Delaware River basin) had the largest withdrawals for this category--539.40 Mgal/d and 441.20 Mgal/d, respectively (table 10 and fig. 16). Because of the high rate of water use in these two river basins, extended droughts in these areas could be economically damaging to major industries within the State.

Table 10.-- Water withdrawals for self-supplied industry, by hydrologic accounting unit, 1984
[million gallons per day]

Hydrologic accounting unit	Total	Ground water	Surface water	Consumptive use1/
020401	441.20	22.39	418.81	41.71
020402	337.85	17.88	319.97	45.92
020501	34.08	3.45	30.63	3.74
020502	30.44	2.32	28.12	5.52
020503	125.25	37.37	87.88	12.02
020600	.18	.18	0	.01
020700	1.29	.63	.66	.33
041100	0	0	0	0
041201	44.47	.20	44.27	5.89
041300	0	0	0	0
050100	108.44	40.28	68.16	14.38
050200	539.40	1.76	537.64	34.36
050301	393.03	22.24	370.79	21.65
Total	2,055.63	148.70	1,906.93	185.53

1/Based on water from public and self-supplied sources.

Consumptive use

A total of 185.53 Mgal/d from self-supplied sources was consumed through evaporation or incorporation into a product. This figure was estimated from data in WARDS, 85 percent of which was 1977 data. Consumptive use totals for individual plants in 1977 were computer calculated on the basis of Standard Industrial Code, whereas consumptive-use estimates were requested on a plant-by-plant basis for the 1983 survey.

Some county consumptive-use totals are greater than withdrawal totals in table 9 and 10 because consumptive use is based on water data from some companies using self-supplied and public-supplied water.

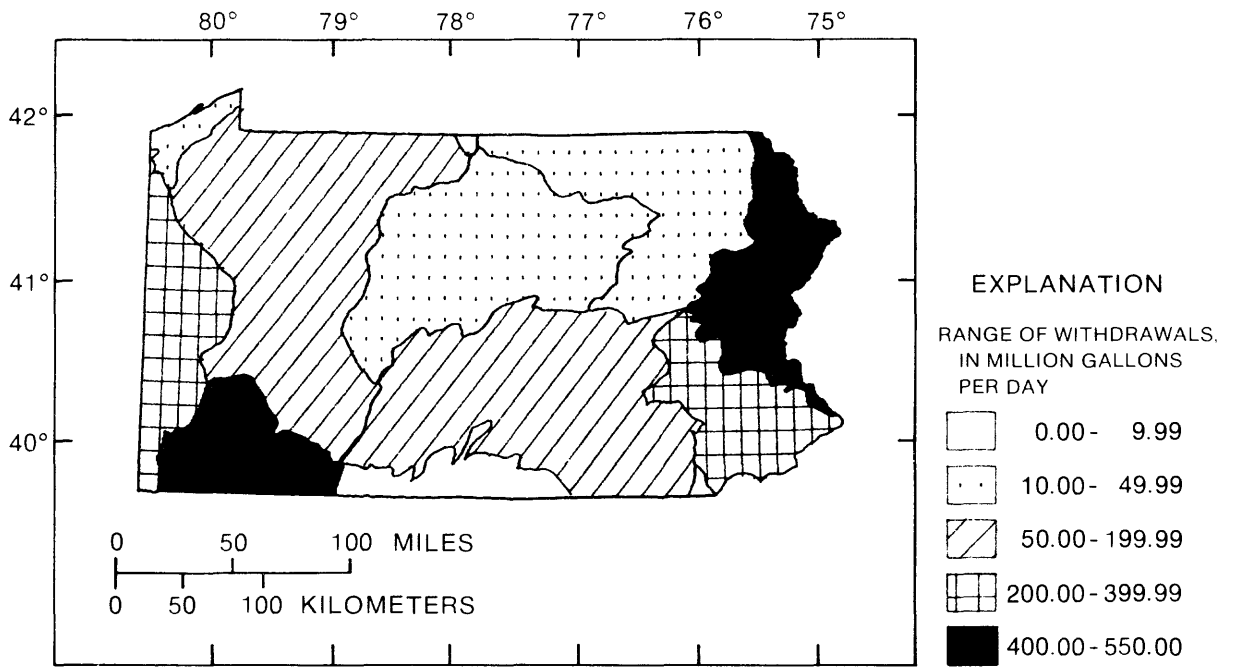


Figure 16.-- Water withdrawals for self-supplied industry, by hydrologic accounting unit, 1984.

Mining

Pennsylvania has always been rich in mineral resources. In 1984, 77,700,111 tons of coal were extracted: 3,893,898 tons was anthracite and 73,806,213 tons was bituminous coal. Anthracite, which is removed primarily through surface mining, is found in northeastern Pennsylvania; bituminous-coal mining is predominantly in western Pennsylvania (fig. 17). Associated with most coal operations is a coal-preparation plant where coal is separated from its impurities. Water is used for dust control, dewatering, cooling and condensing, boiler feed and sanitation; some of these activities are shown in figure 18. Reported noncoal (sand, gravel, limestone) production in 1984 was 56,200,000 tons.

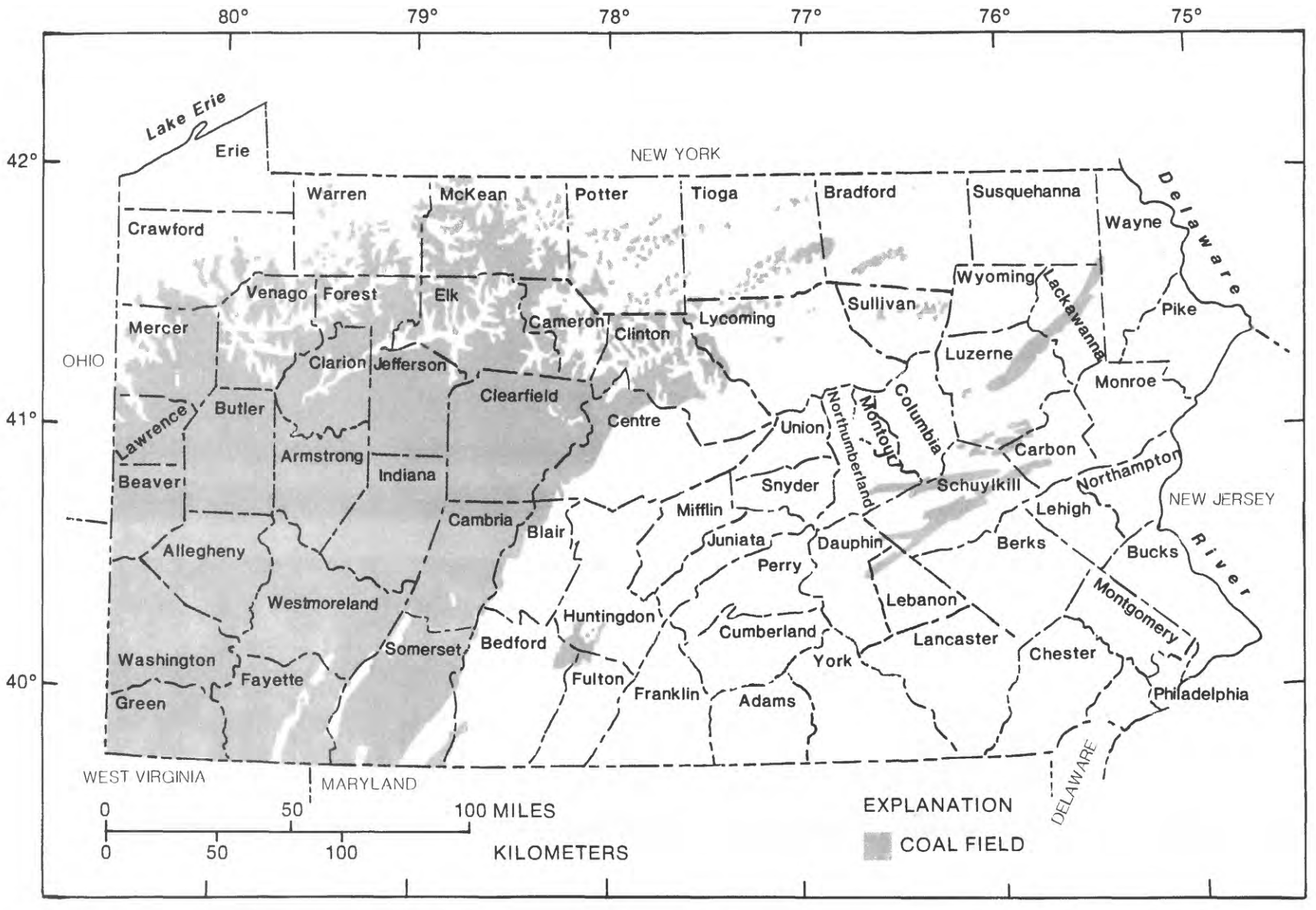


Figure 17.-- Major coal fields in Pennsylvania.

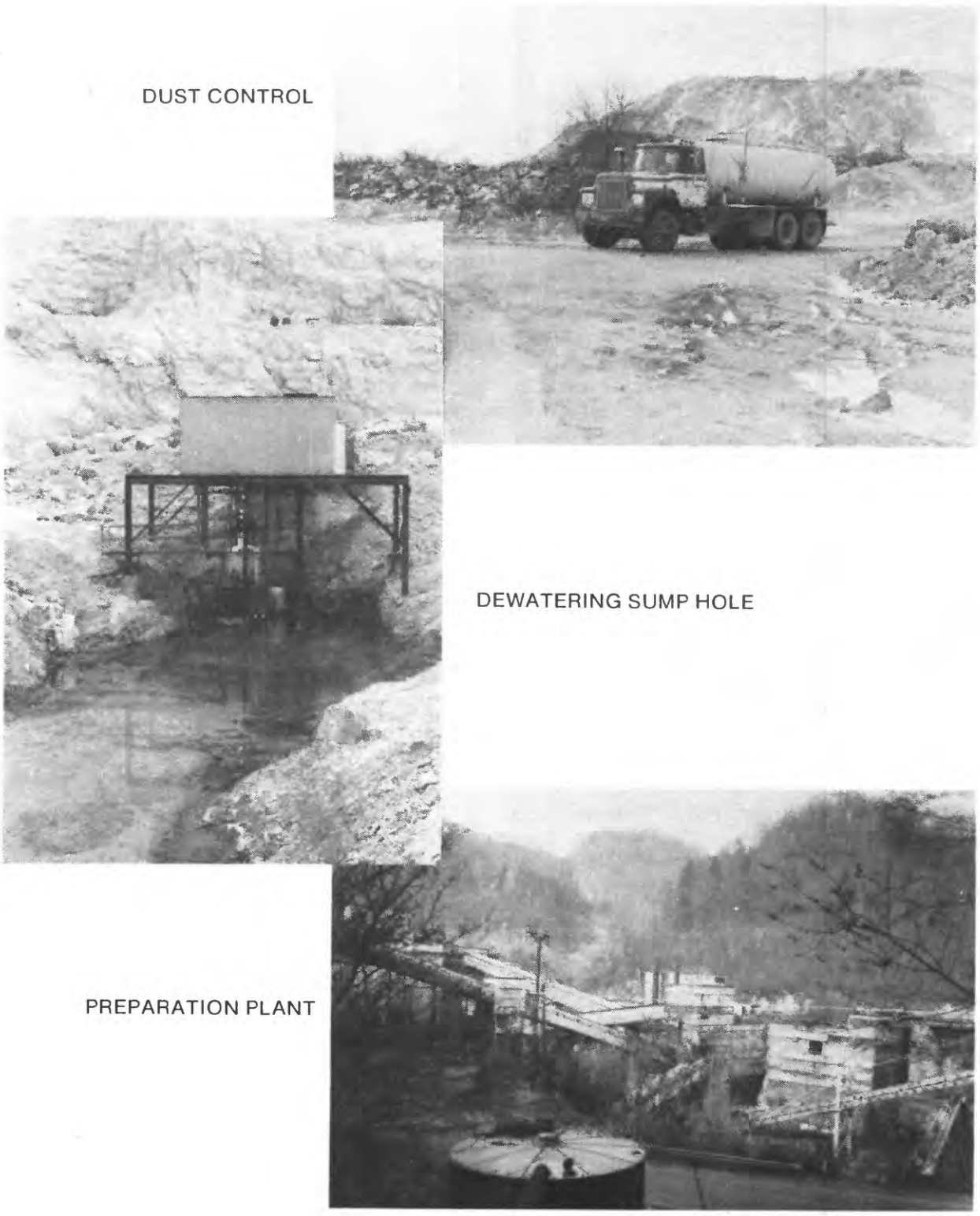


Figure 18.-- Uses of water withdrawn for mining: dust control (top), dewatering sump hole (middle), preparation plant (bottom).

Source and Reliability of Data

The only water withdrawal data for mining activities were collected through a PaDER mail survey in 1978; the response was about 67 percent. Address files from State and private mining agencies were used to create a master listing of about 600 mining operations. It was felt that some mining operations were missed and that the data received were not always too reliable (W. Gast, PaDER, oral commun., 1985). PaDER is, however, the only agency that has collected data on water withdrawals for this category; totals by county and hydrologic accounting unit from that survey were, therefore, used as a base from which estimates were projected.

For this report, mining superintendents of operations that use more than 1 Mgal/d in 1978 were contacted to discuss changes in production and water use between 1978 and 1984. Production information was verified from data for 1978, 1983 and 1984 compiled by PaDER on mining activities, (Pennsylvania Department of Environmental Resources, 1979, 1984, 1985). In those years, noncoal production remained relatively constant, and it was assumed that water withdrawals, many times limited to dewatering and dust control, also remained constant.

Coal production decreased about 10 percent from 1978 to 1984 (Pennsylvania Department of Environmental Resources, 1979, 1985). Changes in water withdrawals were harder to quantify as the U.S. Environmental Protection Agency established new standards in 1983 that required recirculation of wastewater from coal preparation plants and limited discharge to the surface waters, (U.S. Environmental Protection Agency, 1983). Adherence to this regulation has reduced water withdrawals as much as 95 percent for some mining operations (oral communication, several mining superintendents). Unfortunately, coal and noncoal data would be difficult to separate in WARDS and, therefore, different factors were not used for estimating the water use of each. For this reason, a 10-percent assumed reduction was applied to all county and hydrologic accounting unit totals for 1978, although it was realized that noncoal withdrawals remained basically unchanged and withdrawals for some coal operations decreased much more than 10 percent.

Withdrawals

Five counties had water withdrawals of more than 10 Mgal/d: Allegheny, 18.61 Mgal/d; Greene, 17.07 Mgal/d; York, 12.61 Mgal/d; Schuylkill, 11.70 Mgal/d; and Lehigh, 10.16 Mgal/d (table 11 and fig. 19). Very little water is used for mining in the northern half of the State. Coal mining activities in the western part of the State account for the large totals of water withdrawals in accounting units 050100 and 050200--the Allegheny and Monongahela River basins (table 12 and fig. 20); however, the largest water withdrawal was in the 020503 accounting unit where much of the mining was for limestone, sand, and gravel.

Total water withdrawn for mining in 1984 was 147.73 Mgal/d. Eighty percent of this water was ground water, reflecting the influence of dewatering withdrawals.

Table 11.--Water withdrawals for mining, by county, 1984
[million gallons per day; <, less than]

County	Total	Ground water	Surface water	Consumptive use
Adams	7.18	7.15	0.03	0.72
Allegheny	18.61	15.89	2.72	2.16
Armstrong	7.16	7.04	.12	.85
Beaver	.02	<.01	<.01	<.01
Bedford	.73	.27	.46	.02
Berks	2.49	2.47	.02	.57
Blair	.14	.14	0	.12
Bradford	.23	<.01	.22	<.01
Bucks	3.10	2.93	.17	.34
Butler	1.16	1.07	.09	.84
Cambria	4.07	1.22	2.85	1.13
Cameron	0	0	0	0
Carbon	.08	0	.08	.01
Centre	1.96	1.42	.54	.96
Chester	1.38	1.38	0	.07
Clarion	.06	.06	0	.03
Clearfield	.05	.04	.01	.02
Clinton	<.01	0	<.01	<.01
Columbia	<.01	<.01	0	<.01
Crawford	.50	.31	.19	.26
Cumberland	.60	.45	.15	.11
Dauphin	1.82	.56	1.26	.40
Delaware	.05	<.01	.04	<.01
Elk	<.01	<.01	0	0
Erie	.17	.13	.04	.05
Fayette	2.35	2.29	.06	.40
Forest	0	0	0	0
Franklin	.28	.02	.26	.02
Fulton	.41	<.01	.40	.05
Greene	17.07	13.82	3.25	1.91
Huntingdon	3.35	.96	2.39	.13
Indiana	3.52	3.44	.08	.68
Jefferson	.36	.36	0	.06
Juniata	0	0	0	0
Lackawanna	.02	.01	.01	.01
Lancaster	1.96	1.85	.11	.16
Lawrence	2.69	.66	2.03	.58
Lebanon	4.54	4.54	0	.45
Lehigh	10.16	6.89	3.27	.60
Luzerne	6.74	5.79	.95	.70
Lycoming	.72	.72	0	<.01
McKean	0	0	0	0
Mercer	.76	0	.76	.07
Mifflin	<.01	<.01	0	<.01
Monroe	.16	.16	0	.04
Montgomery	.19	.18	<.01	.01
Montour	.08	.08	0	<.01
Northampton	3.94	2.90	1.04	1.12
Northumberland	1.01	.57	.44	.10
Perry	.01	.01	0	<.01
Philadelphia	0	0	0	0
Pike	.07	.07	0	<.01
Potter	0	0	0	0
Schuylkill	11.70	9.77	1.93	1.15
Snyder	.06	.06	0	<.01
Somerset	4.72	3.26	1.46	.33
Sullivan	0	0	0	0
Susquehanna	.02	.01	.01	.01
Tioga	<.01	<.01	0	<.01
Union	.34	.34	0	.03
Venango	.14	.12	.02	.03
Warren	.92	.15	.77	.04
Washington	5.09	3.64	1.45	1.40
Wayne	0	0	0	0
Westmoreland	.11	.10	<.01	.05
Wyoming	.02	0	.02	<.01
York	12.61	12.61	0	1.02
Total	147.73	117.99	29.74	19.94

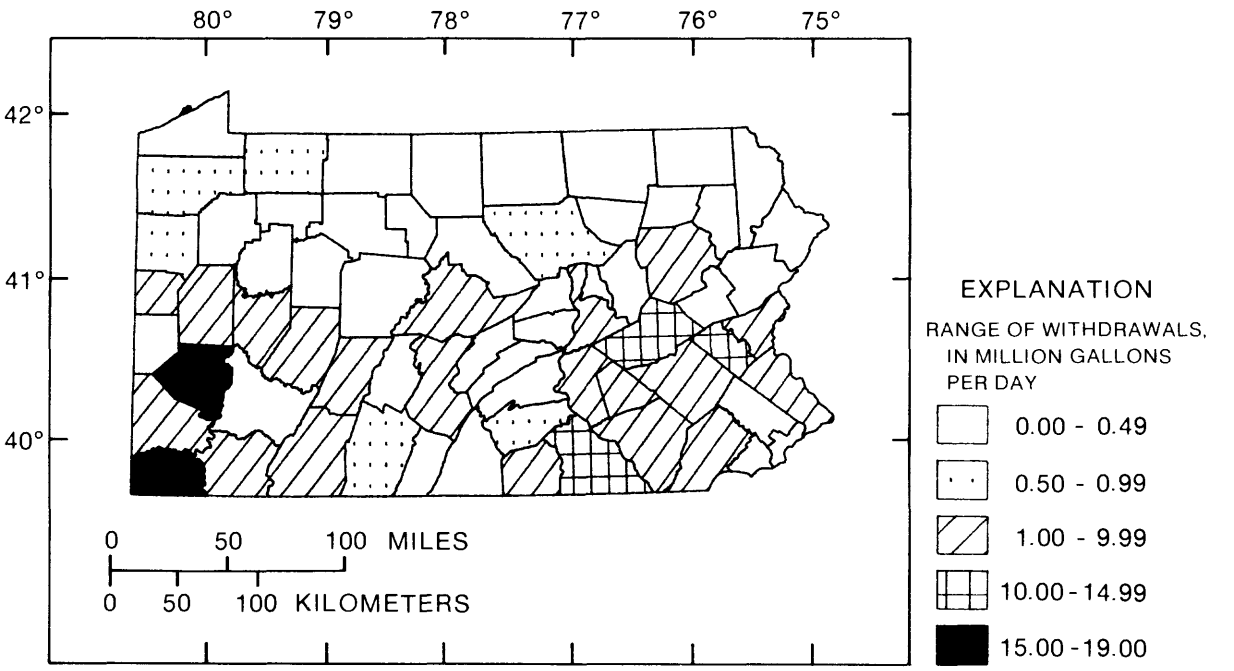


Figure 19.-- Water withdrawals for mining, by county, 1984.

Table 12.--Water withdrawals for mining, by hydrologic accounting unit, 1984
[million gallons per day]

Hydrologic accounting unit	Total	Ground water	Surface water	Consumptive use
020401	22.48	16.68	5.80	2.21
020402	8.90	5.70	3.20	.71
020501	5.59	4.19	1.40	.67
020502	5.42	3.20	2.22	1.68
020503	40.16	35.40	4.76	4.17
020600	0	0	0	0
020700	.75	.04	.71	.13
041100	0	0	0	0
041201	.04	.02	.02	.01
041300	0	0	0	0
050100	33.48	30.69	2.79	4.90
050200	25.57	20.29	5.28	3.86
050301	5.34	1.78	3.56	1.60
Total	147.73	117.99	29.74	19.94

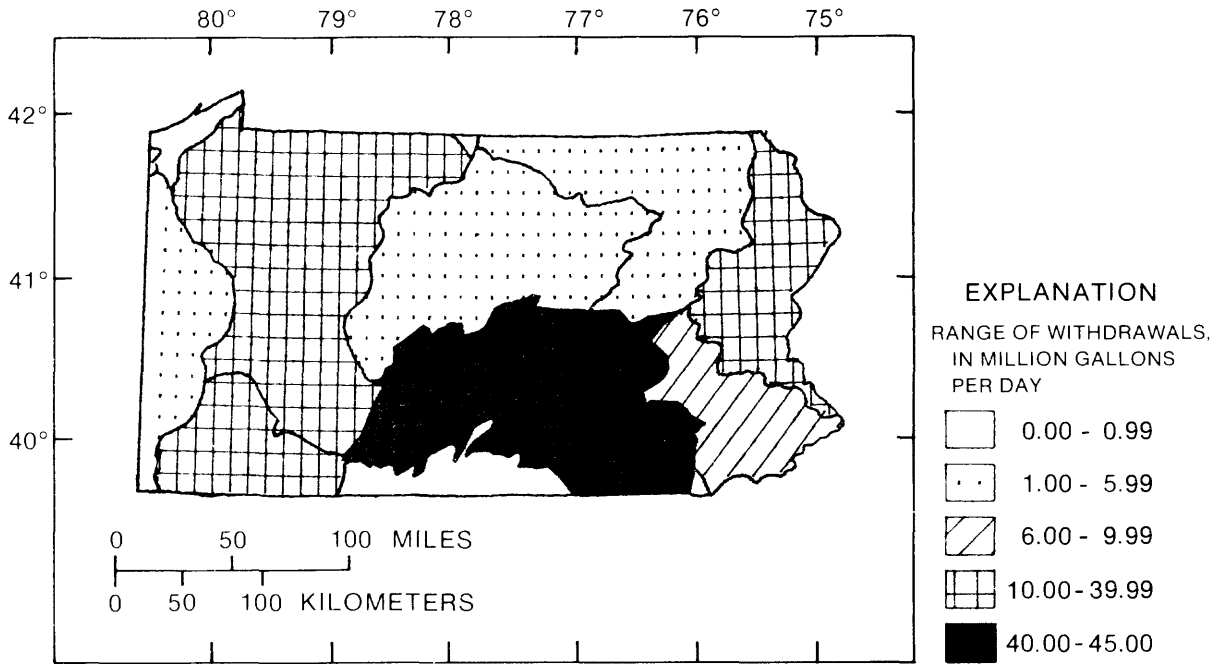


Figure 20.-- Water withdrawals for mining, by hydrologic accounting unit, 1984.

Consumptive use

The consumptive use of water as a percentage of the total water withdrawn varied considerably, by county. Part of this variation reflects the evaporative losses estimated by the mining companies that responded to the survey and their methods of estimation. Total consumptive use was 19.94 Mgal/d, or 13.5 percent of the total withdrawn.

Power Generation--Thermoelectric and Hydroelectric

Source and Reliability of Data

The electric utility companies of Pennsylvania have been requested by PaDER, under Section 1904-A of Act No. 275, to compile annual data for existing and proposed water-related power-generating facilities within the State. The information is presented in the report, "The Pennsylvania Master Siting Study" (Electric Utility Companies of Pennsylvania, 1984), which lists the water withdrawal at rated capacity (WWRC) and the consumptive water use for all nuclear and fossil-fueled facilities. WWRC is the rate at which cooling water will be withdrawn when the plant facilities are operated at rated capacity. These data do not, therefore, include the relatively small amount of water used for boiler operations or sanitary purposes. PaDER uses these plant totals for direct input into their Water Resources Data System. The reliability of these data is considered very good.

Data on water diverted for hydroelectric power generation were obtained from several sources. PaDER, Bureau of Water Quality Management, Hydropower

Section, records the design maximum flow associated with each facility. This information was used for only one plant where no better quantitative data could be obtained. Usually representatives of the generating facilities reported design average flow or calculated total usable flow, which is considered more valid than design maximum flow for the purposes of this report.

Withdrawals and Instream Use

In 1984, Pennsylvania had 43 active thermoelectric and hydroelectric generating facilities (table 13 and fig. 21). Of these 43 plants, 8 were hydroelectric (pumped storage or conventional), 1 plant had both hydroelectric turbine and coal-fired steam units, 31 had either coal-, oil-, or gas-fired steam units, and 3 had nuclear reactors. Three Mile Island, the nuclear plant made famous by the accident in 1979, was inactive in 1984. Photographs of typical hydroelectric and thermoelectric plants are shown in figure 22.

Methods of cooling used by the individual thermoelectric power-generation facilities affects the amount of water required and consumed. Methods of cooling are classified as once-through (with no recycling), once-through with "helper" towers, or closed loop. In the closed-loop method, water is recycled after being diverted through evaporative cooling towers. About 57 percent of all thermoelectric plants in Pennsylvania have cooling towers; these plants withdraw significantly less water but consume slightly more water through evaporation.

In 1984, water withdrawn for thermoelectric power generation totaled 10,010.60 Mgal/d; 60,713.38 Mgal/d was passed through the turbines at the hydroelectric power-generating stations. Water was assumed to be solely from surface-water sources. Thermoelectric power-generation totals are shown by county (fig. 23) and by hydrologic accounting unit (fig. 24).

Lancaster County diverted the most water for hydroelectric power generation--47,743.07 Mgal/d (table 14). Three facilities accounted for this large total: the Safe Harbor and Holtwood hydroelectric plants on the Susquehanna River, and the Muddy Run pumped-storage plant.

Three of the twenty-four counties with thermoelectric facilities--York, Delaware, and Allegheny--withdrew more than 1 billion gallons of water per day. Withdrawals for these counties were 2,907.00 Mgal/d, 1,410.00 Mgal/d, and 1,095.00 Mgal/d, respectively. Service areas for these plants include some of the densely populated areas of the southeastern and southwestern parts of the state. Not all the generating capacity of the facilities was devoted to Pennsylvania customer needs--utility companies throughout the State also supply electricity to parts of New York, Ohio, Virginia, West Virginia, most of New Jersey, and all of Delaware.

The Lower Susquehanna River basin, accounting unit 020503, far exceeded other basins in water withdrawn for thermoelectric power generation (3,303.40 Mgal/d) and instream use for hydroelectric power generation (55,594.22 Mgal/d) (table 15). The lower Delaware River basin, 020402, had the next largest withdrawal for this category, 2,750.60 Mgal/d. Seven thermoelectric power-generating plants are located in the lower Delaware River basin. Six of these plants are operated by the Philadelphia Electric Company to supply power to

the metropolitan area. The Allegheny River basin, 050100, had the second largest instream use for this category, 3,893.16 Mgal/d. The Piney generating station, located on the southern bank of the Clarion River, is the only instream hydroelectric plant in the Allegheny basin. The other hydroelectric facility in the basin, the Seneca Power Station, is a pumped-storage type. This plant is at the base of the Allegheny River Dam constructed by the Army Corps of Engineers for flood control and low-flow augmentation of the Allegheny Valley region.

Table 13.--Water-related electric generating stations (active) in Pennsylvania, 1984

Figure number	Station name	Utility	Fuel type
1	Wallenpaupack	Pennsylvania Power & Light Co.	Hydroelectric-conventional
2	Portland	General Public Utilities System	Steam turbine-(bituminous)
3	Martins Creek	Pennsylvania Power & Light Co.	Steam turbine (bituminous) & oil-fired steam
4	Titus	General Public Utilities System	Steam turbine-(bituminous)
5	Cromby	Philadelphia Electric Co.	Steam turbine-(bituminous) & oil-fired steam
6	Schuylkill	Philadelphia Electric Co.	Oil-fired steam
7	Richmond	Philadelphia Electric Co.	Oil-fired steam
8	Delaware	Philadelphia Electric Co.	Oil-fired steam
9	Southwark	Philadelphia Electric Co.	Oil-fired steam
10	Eddystone	Philadelphia Electric Co.	Steam turbine-(bituminous) & oil-fired steam
11	Hunlock	Luzerne Electric Div-UGI	Steam turbine-(anthracite)
12	Sunbury	Pennsylvania Power & Light Co.	Steam turbine (anthracite and bituminous)
13	Three Mile Island (out of service 1984)	General Public Utilities System	Nuclear-fueled steam
14	York Haven	General Public Utilities System	Hydroelectric-conventional
15	Brunner Island	Pennsylvania Power & Light Co.	Steam turbine (bituminous)
16	Safe Harbor	Safe Harbor Water Power Corp.	Hydroelectric-conventional
17	Holtwood	Pennsylvania Power & Light Co.	Hydroelectric & steam turbine, (anthracite)
18	Muddy Run	Philadelphia Electric Co.	Hydroelectric--pumped storage
19	Peach Bottom	Philadelphia Electric Co.	Nuclear-fueled steam
20	Susquehanna	Pennsylvania Power & Light Co.	Nuclear-fueld steam
21	Montour	Pennsylvania Power & Light Co.	Steam turbine (bituminous) & oil-fired steam
22	Shawville	General Public Utilities System	Steam turbine (bituminous)

Table 13.--Water-related electric generating stations (active) in Pennsylvania, 1984--Continued

Figure number	Station name	Utility	Fuel type
23	Williamsburg	General Public Utilities System	Steam turbine (bituminous)
24	Front Street	General Public Utilities System	Steam turbine (bituminous)
25	Warren	General Public Utilities System	Steam turbine (bituminous)
26	Seneca	Cleveland Electric Illuminating Co. Pennsylvania Electric Co.	Hydroelectric--pumped storage
27	Piney	Pennsylvania Electric Co.	Hydroelectric, conventional
28	Armstrong	Allegheny Power System, Inc.	Steam turbine (bituminous)
29	Keystone	General Public Utilities System	Steam turbine (bituminous)
30	Homer City	General Public Utilities System	Steam turbine (bituminous)
31	Conemaugh	General Public Utilities System	Steam turbine (bituminous)
32	Seward	General Public Utilities System	Steam turbine (bituminous)
33	Springdale	Allegheny Power System, Inc.	Oil-fired steam
34	Cheswick	Duquesne Light Co.	Steam turbine coal (general)
35	New Castle	Pennsylvania Power Co.	Steam turbine (bituminous)
36	Beaver Valley	Duquesne Light Co.	Nuclear-fueled steam
37	Bruce Mansfield	Pennsylvania Power Co.	Steam turbine coal (general)
38	Phillips	Duquesne Light Co.	Steam turbine coal (general)
39	Brunot Island	Duquesne Light Co.	Combined-cycle (gas & steam turbines)
40	Elrama	Duquesne Light Co.	Steam turbine coal (general)
41	Mitchell	Allegheny Power System, Inc.	Oil-fired steam & steam turbine (bituminous) (bituminous)
42	Hatfields Ferry	Allegheny Power System, Inc.	Steam turbine (bituminous)
43	Musser's Dam	American Hydropower	Hydroelectric, conventional
44	Patterson Dam	Beaver Valley Power Co.	Hydroelectric, conventional

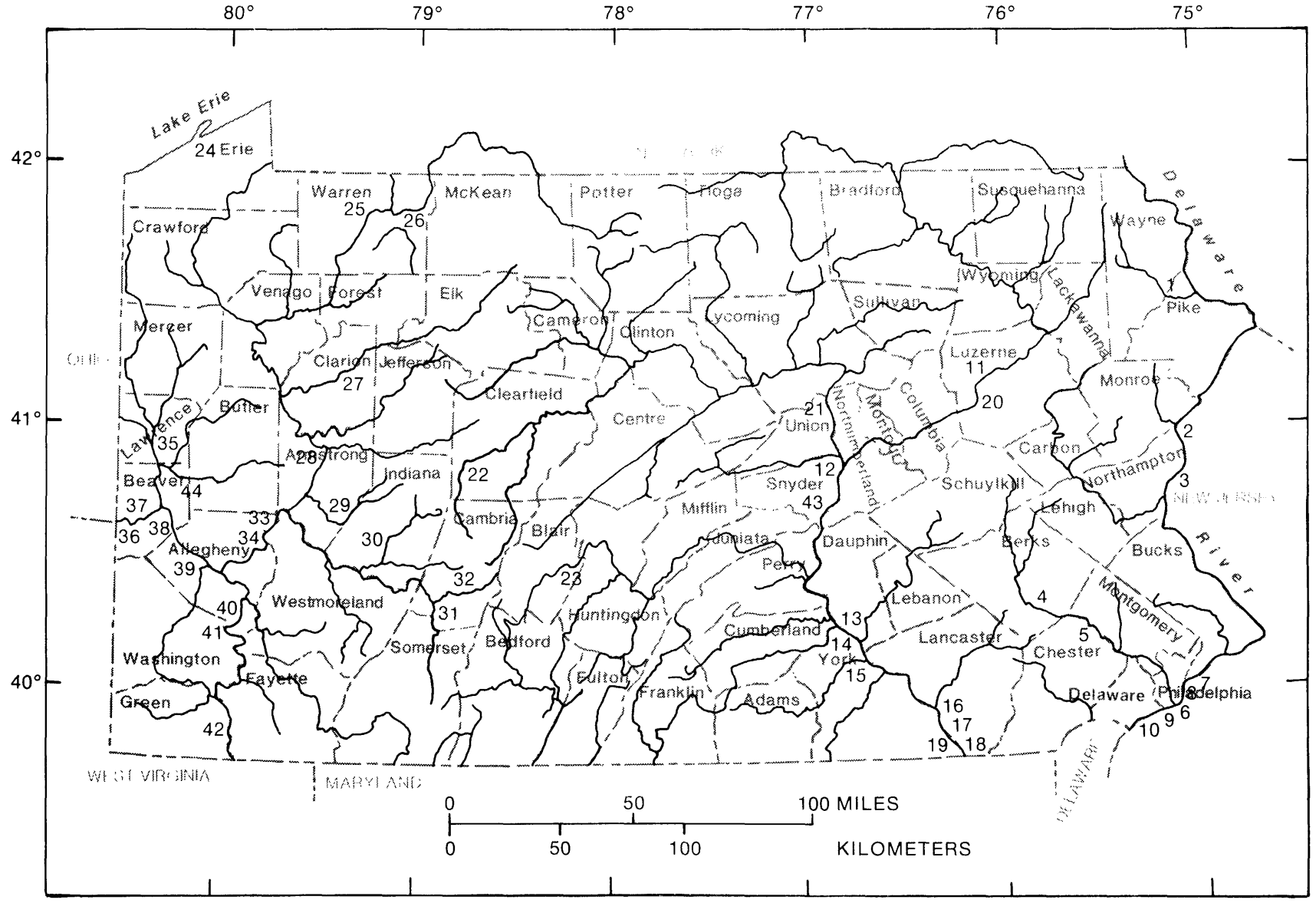
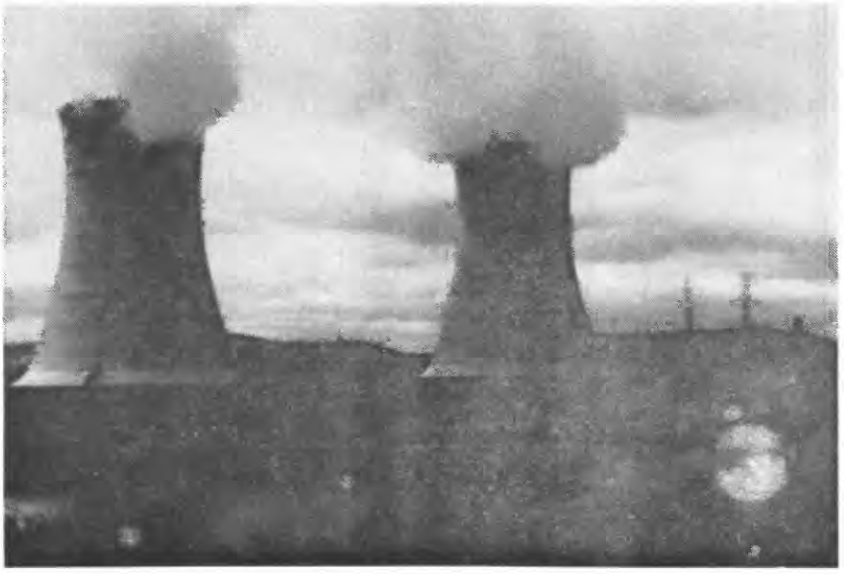


Figure 21.-- Locations of thermoelectric and hydroelectric power plants in Pennsylvania.



THERMOELECTRIC

HYDROELECTRIC

Figure 22.-- Thermoelectric and hydroelectric power-generation plants.

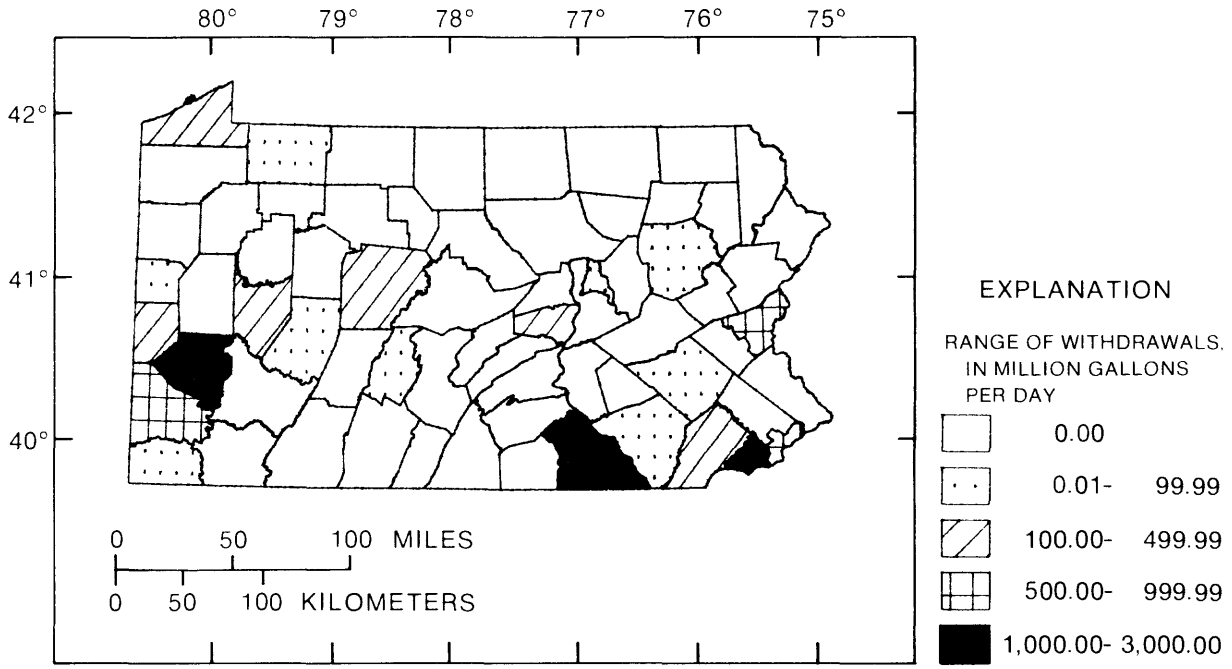


Figure 23.-- Water withdrawals for thermoelectric power generation, by county, 1984.

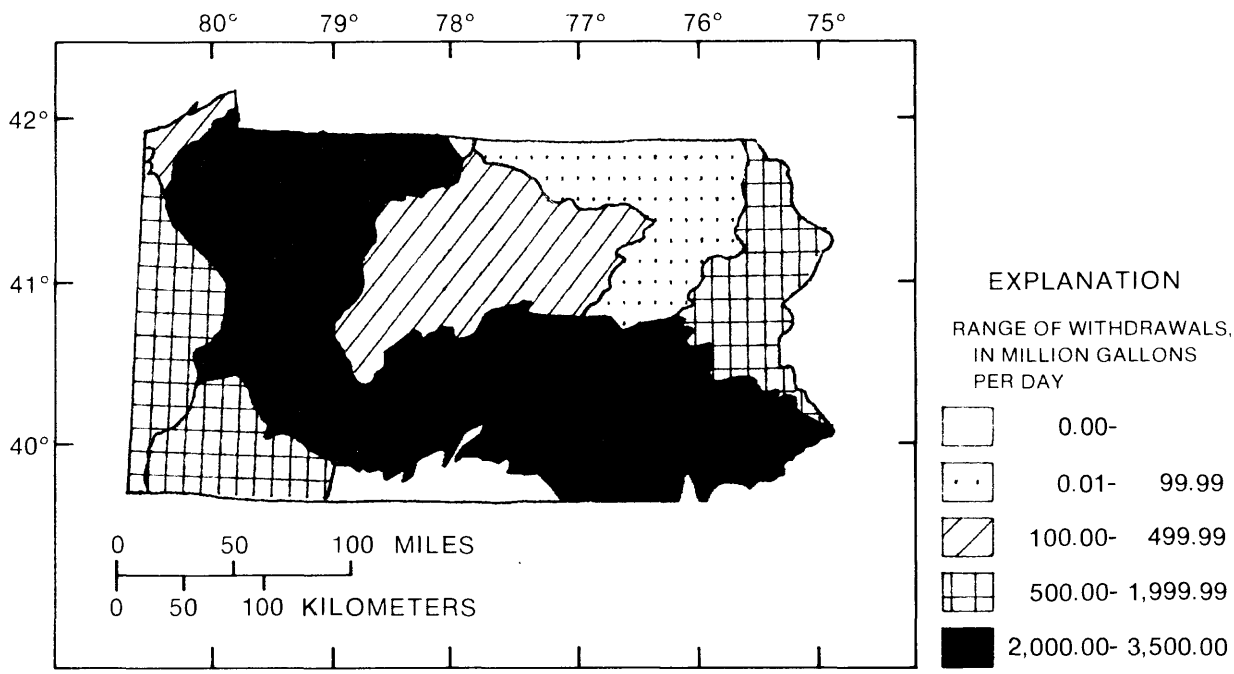


Figure 24.-- Water withdrawals for thermoelectric power generation, by hydrologic accounting unit, 1984.

Table 14.--Water withdrawals and instream use for power generation, by county, 1984
[million gallons per day]

County	Total[1/]	Consumptive use
Thermoelectric:		
Allegheny	1,095.00	1.10
Armstrong	234.80	21.20
Beaver	122.30	51.20
Berks	26.60	1.87
Blair	31.70	.10
Chester	324.00	1.43
Clearfield	425.00	3.96
Delaware	1,410.00	2.79
Erie	300.10	.03
Greene	31.90	8.20
Indiana	58.60	29.36
Lancaster	73.70	.60
Lawrence	31.50	.09
Luzerne	60.00	.80
Montour	33.00	14.60
Northampton	511.40	8.21
Philadelphia	990.00	1.03
Snyder	291.00	2.10
Warren	89.00	.21
Washington	964.00	1.44
York	2,907.00	19.10
Total	10,010.60	169.42
Hydroelectric:		
Beaver	910.00	0.00
Clarion	436.16	0
Lancaster	47,743.07	0
Snyder	95.89	0
Warren	3,457.00	0
Wayne	316.00	0
York	7,755.26	0
Total	60,713.38	0.00

[1/]All surface water.

Table 15.--Water withdrawals and instream use for power generation, by hydrologic accounting unit, 1984
[million gallons per day]

Hydrologic accounting unit	Total[1/]	Consumptive use
Thermoelectric:		
020401	511.40	8.20
020402	2,750.60	7.10
020501	60.00	.80
020502	458.00	18.60
020503	3,303.40	21.90
020600	0	0
020700	0	0
041100	0	0
041201	300.10	.02
041300	0	0
050100	942.40	51.10
050200	995.90	9.60
050301	688.80	52.10
Total	10,010.60	169.42
Hydroelectric:		
020401	316.00	0.00
020503	55,594.22	0
050100	3,893.16	0
050301	910.00	0
Total	60,713.38	0.00

[1/]All surface water.

Consumptive Use

Generally, less than 1 percent of the total water withdrawn for power generation is consumed by evaporation at individual thermoelectric plants through the cooling towers. According to estimates provided by cooling tower manufacturers, the total consumption of water by evaporation in 1984 was 169.42 Mgal/d.

Total Withdrawals and Consumptive Use of Water for State

In 1984, withdrawals for all categories totaled 14,033.66 Mgal/d. Seventy-one percent of this water was used at the thermoelectric power-generating plants throughout the State. Self-supplied industry was the next largest user, with 15 percent, followed by public supply, 11 percent. The smaller use categories--mining, self-supplied domestic use, irrigation, and livestock and poultry--collectively made up less than 2 percent. Ninety-nine percent of all water withdrawn came from surface-water sources.

Combined withdrawals are shown in table 16 and figure 25 by county and in table 17 and figure 26 by hydrologic accounting unit. Heaviest use of water is in the southwestern and southeastern parts of the State. York County had the highest total withdrawals (3,000.36 Mgal/d), followed by Allegheny County (1,832.36 Mgal/d), Delaware County (1,649.46 Mgal/d), and Philadelphia County (1,465.33 Mgal/d). More than one half of the counties in Pennsylvania used less than 50 Mgal/d. Forest County, in the northwestern part of the State, had the lowest population and the lowest combined withdrawals--0.43 Mgal/d.

Twenty-seven percent of the 14,033.66 Mgal/d withdrawn in 1984 was taken from the lower Susquehanna River basin, hydrologic accounting unit 020503. Power production accounted for 88 percent of the withdrawal in this unit; the remaining 12 percent was accounted for in the other use categories.

Water consumed from ground and surface-water sources totaled 615.22 Mgal/d. Industry was estimated to have consumed 185.53 Mgal/d, followed by power generation (169.42 Mgal/d), public supply (160.01 Mgal/d), livestock and poultry (62.63 Mgal/d), mining (19.94 Mgal/d), self-supplied domestic use (13.16 Mgal/d) and irrigation (4.52 Mgal/d).

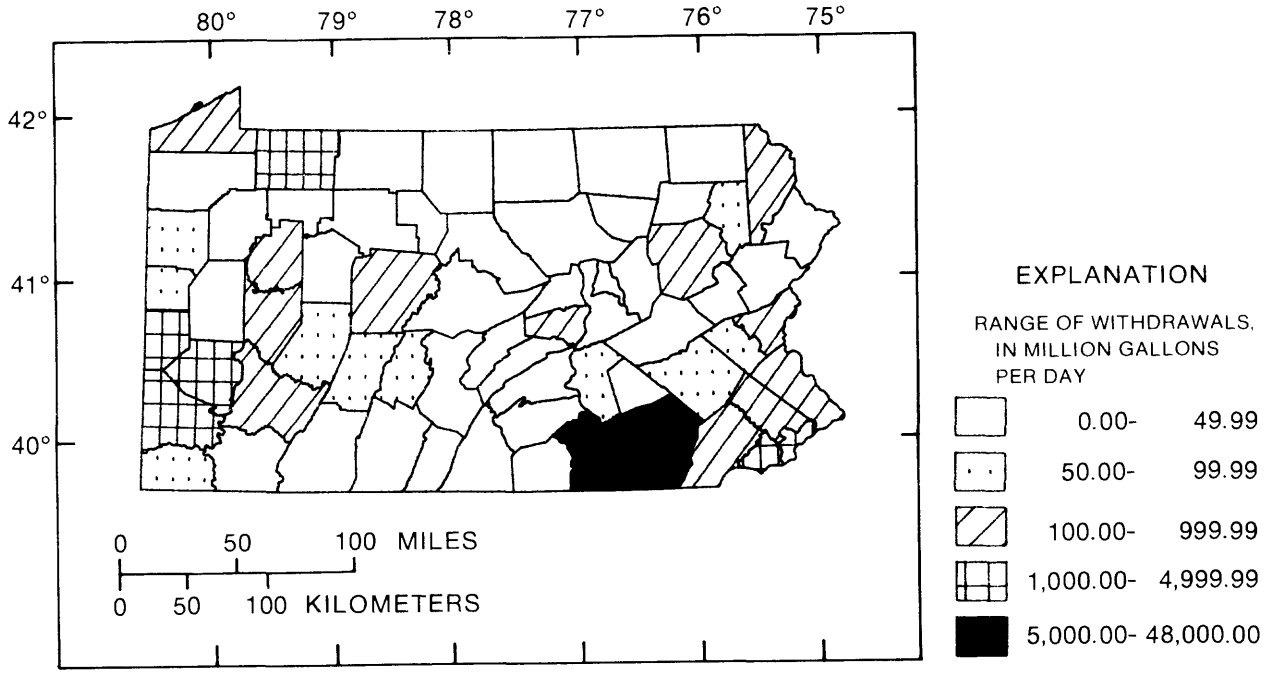


Figure 25.-- Total water withdrawals, by county, 1984.

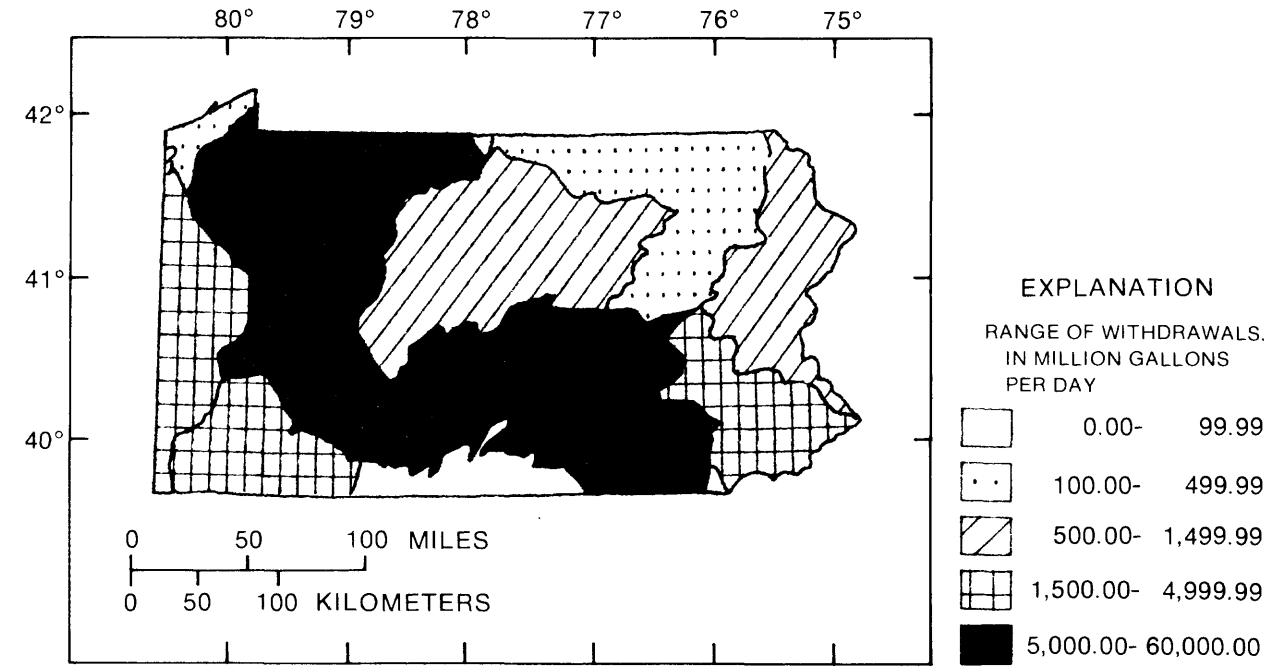


Figure 26.-- Total water withdrawals, by hydrologic accounting unit, 1984.

Table 16.--Total water withdrawals and consumptive use in Pennsylvania, by county, 1984
[million gallons per day; <, less than]

County	Total population	Combined withdrawals			Withdrawals, by category of use							Estimated total consumptive use all categories
		Total	Ground water (percent)	Surface water (percent)	Public supply	Self-supplied domestic	Irrigation	Livestock and poultry	Self-supplied industry	Mining	Power generation	
Adams	69,000	21.59	89.6	10.4	9.14	1.97	0.745	1.45	1.10	7.18	0	3.80
Allegheny	1,409,800	1,832.36	3.0	97.0	218.77	1.41	.022	.13	498.42	18.61	1,095.00	60.38
Armstrong	82,200	250.04	5.1	94.9	4.29	1.89	.139	.55	1.21	7.16	234.80	23.51
Beaver	199,200	447.91	4.8	95.2	23.67	2.19	.891	.37	298.47	.02	122.30	69.73
Bedford	48,100	15.22	25.8	74.2	11.15	1.66	.123	1.55	.01	.73	0	2.61
Berks	317,200	80.76	36.0	64.0	36.71	4.76	.049	3.06	7.09	2.49	26.60	10.80
Blair	134,400	65.25	22.4	77.6	21.06	1.68	.097	1.06	9.51	.14	31.70	6.57
Bradford	64,000	10.57	86.9	13.1	3.76	1.82	.018	3.09	1.65	.23	0	3.02
Bucks	508,600	289.15	10.4	89.6	41.80	8.39	.232	.63	235.00	3.10	0	18.96
Butler	151,300	21.83	40.7	59.3	9.31	4.46	.079	.80	6.02	1.16	0	4.12
Cambria	177,100	88.13	6.5	93.5	34.43	1.42	.009	.33	47.87	4.07	0	8.23
Cameron	6,600	.83	18.1	81.9	.68	.13	0	.01	<.01	0	0	.10
Carbon	54,000	36.64	14.8	85.2	34.69	.73	0	.05	1.09	.08	0	4.43
Centre	114,500	24.99	84.0	16.0	17.05	1.09	.059	1.07	3.76	1.96	0	4.98
Chester	334,700	382.93	6.3	93.7	34.71	7.20	.086	2.85	12.70	1.38	324.00	9.42
Clarion	43,100	4.18	63.1	36.9	2.33	1.12	.027	.52	.12	.06	0	.89
Clearfield	84,500	433.37	.6	99.4	6.11	1.52	0	.28	.41	.05	425.00	5.05
Clinton	39,100	33.31	3.2	96.8	4.32	.49	0	.37	28.12	<.01	0	3.01
Columbia	61,800	9.03	63.3	36.7	6.59	1.14	.226	.59	.47	<.01	0	1.60
Crawford	89,100	19.96	95.5	4.5	7.48	2.45	.003	1.90	7.63	.50	0	3.33
Cumberland	185,500	21.72	42.5	57.5	13.70	2.41	.075	1.94	3.00	.60	0	3.60
Dauphin	235,800	88.70	26.3	73.7	31.03	2.71	.194	1.27	51.68	1.82	0	6.28
Delaware	351,400	1,649.46	.1	99.9	4.57	1.10	0	.04	233.70	.05	1,410.00	39.44
Elk	37,600	18.53	13.9	86.1	6.52	.56	0	.08	11.36	<.01	0	1.21
Erie	282,100	398.88	2.4	97.6	49.07	3.10	.067	1.42	44.95	.17	300.10	10.94
Fayette	159,200	39.72	15.4	84.6	32.65	1.35	0	3.32	.05	2.35	0	6.76
Forest	5,000	.43	93	7.0	.12	.16	0	.04	.11	0	0	.09
Franklin	116,200	17.42	46.5	53.5	9.88	3.08	.273	3.42	.49	.28	0	4.38
Fulton	13,500	1.93	64.6	35.4	.15	.55	0	.53	.29	.41	0	.56
Greene	41,200	50.90	28.8	71.2	.88	.58	0	.45	.02	17.07	31.90	10.61
Huntingdon	42,700	10.54	58.1	41.9	4.97	1.07	0	1.13	.02	3.35	0	1.65
Indiana	93,300	72.05	10.5	89.5	5.53	2.10	0	1.96	.34	3.52	58.60	32.32
Jefferson	48,900	3.93	55.0	45.0	1.96	1.00	0	.44	.17	.36	0	.78
Juniata	19,800	6.61	91.8	8.2	.38	.74	0	1.66	3.83	0	0	1.41
Lackawanna	224,000	55.25	7.0	93.0	52.11	1.46	0	.28	1.38	.02	0	5.98
Lancaster	381,600	160.13	24.0	76.0	55.74	7.07	.098	17.56	4.00	1.96	73.70	21.22

Table 16.--Total water withdrawals and consumptive use in Pennsylvania, by county, 1984--Continued
[million gallons per day; <, less than]

County	Total population	Combined withdrawals			Withdrawals, by category of use							Estimated total consumptive use all categories
		Total	Ground water (percent)	Surface water (percent)	Public supply	Self-supplied domestic	Irrigation	Livestock and poultry	Self-supplied industry	Mining	Power generation	
Lawrence	105,800	57.73	19.9	80.1	12.13	1.59	<.002	0.68	11.14	2.69	31.50	4.19
Lebanon	111,300	17.27	79.1	20.9	5.24	1.67	.047	3.52	2.25	4.54	0	4.21
Lehigh	276,500	54.79	62.2	37.8	38.47	2.63	.045	.25	3.23	10.16	0	6.42
Luzerne	336,400	104.67	10.6	89.4	34.98	2.35	.012	.29	.30	6.74	60.00	5.90
Lycoming	117,100	15.08	45.2	54.8	11.25	1.70	.034	.74	.64	.72	0	2.12
McKean	49,200	13.84	60.1	39.9	7.76	.98	0	.20	4.90	0	0	2.38
Mercer	127,100	66.32	8.7	91.3	15.21	2.22	.015	1.02	47.09	.76	0	6.22
Mifflin	46,600	16.20	20.8	79.2	4.88	.89	.065	1.22	9.13	<.01	0	2.03
Monroe	77,200	12.26	59.0	41.0	9.67	1.81	.003	.08	.54	.16	0	1.33
Montgomery	659,000	106.17	50.0	50.0	91.55	4.61	.003	.57	9.25	.19	0	11.45
Montour	17,000	36.47	3.4	96.6	2.58	.46	0	.30	.05	.08	33.00	15.14
Northampton	230,800	708.27	2.8	97.2	15.19	2.19	.323	.65	174.58	3.94	511.40	34.51
Northumber-land	100,200	21.46	16.4	83.6	9.96	1.20	.027	1.00	8.26	1.01	0	2.80
Perry	37,600	3.08	87.4	12.6	.64	1.18	<.002	1.23	.02	.01	0	1.60
Philadelphia	1,646,700	1,465.33	<.1	99.9	356.30	0	0	0	119.03	0	990.00	46.91
Pike	20,600	2.63	98.9	1.1	1.80	.66	0	.02	.08	.07	0	.28
Potter	18,400	2.75	81.5	18.5	1.26	.63	0	.51	.35	0	0	.58
Schuylkill	157,700	43.00	39.4	60.6	26.48	2.76	.143	.92	1.00	11.70	0	5.61
Snyder	35,400	295.03	1.1	98.9	1.48	.99	.025	1.43	.04	.06	291.00	3.46
Somerset	81,900	42.67	17.1	82.9	34.55	1.84	0	1.51	.05	4.72	0	5.58
Sullivan	6,200	.80	75.0	25.0	.31	.26	0	.22	<.01	0	0	.23
Susquehanna	38,800	5.18	63.5	36.5	1.92	1.36	0	1.63	.25	.02	0	1.58
Tioga	40,300	6.01	56.4	43.6	2.28	1.27	0	1.64	.81	<.01	0	1.68
Union	33,600	7.88	29.8	70.2	5.11	.87	.078	.82	.66	.34	0	1.40
Venango	64,500	14.18	70.4	29.6	8.14	2.13	0	.29	3.48	.14	0	2.21
Warren	47,700	105.01	14.4	85.6	4.43	1.34	0	.44	8.88	.92	89.00	3.80
Washington	217,200	1,000.65	.7	99.3	16.56	2.28	.028	1.19	11.50	5.09	964.00	7.08
Wayne	37,800	6.56	43.7	56.3	3.78	1.59	0	1.18	.01	0	0	1.43
Westmoreland	386,600	119.39	5.7	94.3	43.58	2.51	0	1.01	72.18	.11	0	10.87
Wyoming	27,300	16.38	13.6	86.4	.69	1.04	.077	.62	13.93	.02	0	1.62
York	322,400	3,000.36	.9	99.1	34.53	8.06	.084	2.14	35.94	12.61	2,907.00	28.83
Total	11,901,000	14,033.66	5.2	94.8	1,600.02	131.63	4.525	83.52	2,055.63	147.73	10,010.60	615.22

Table 17.--Total water withdrawals and consumptive use in Pennsylvania, by hydrologic accounting unit, 1984
[million gallons per day; <, less than]

Hydrologic accounting unit	Total population	Combined withdrawals			Withdrawals, by category of use							Total consumptive use all categories
		Total	Ground water (percent)	Surface water (percent)	Public supply	Self-supplied domestic	Irrigation	Livestock	Self-supplied industry	Mining	Power generation	
020401	797,001	1,123.30	8.6	91.4	143.35	1.05	0.605	3.21	441.20	22.48	511.40	69.58
020402	4,020,218	3,681.72	3.5	96.5	541.65	36.44	.146	6.13	337.85	8.90	2,750.60	116.28
020501	778,032	225.40	16.5	83.5	108.25	9.34	.412	7.73	34.08	5.59	60.00	23.17
020502	447,676	555.99	6.4	93.6	50.28	7.61	.110	4.13	30.44	5.42	458.00	34.80
020503	1,810,414	3,742.89	4.9	95.1	199.82	36.21	1.349	36.70	125.25	40.16	3,303.40	90.56
020600	11,253	1.10	100.0	0	.36	.28	<.001	.28	.18	0	0	.29
020700	156,246	29.32	36.4	63.6	18.96	3.59	.628	4.10	1.29	.75	0	6.43
041100	387	.19	100.0	0	0	.02	0	.17	0	0	0	.14
041201	240,295	392.19	1.3	98.7	44.53	2.28	.026	.74	44.47	.04	300.10	11.19
041300	2,030	.19	89.5	10.5	.10	.06	0	.03	0	0	0	.04
050100	1,219,269	1,383.08	9.9	90.1	268.96	20.12	.214	9.47	108.44	33.48	942.40	106.59
050200	1,064,015	1,701.89	2.1	97.9	129.25	5.83	.015	5.93	539.40	25.57	995.90	65.78
50301	1,[illegible],164	1,196.50	4.8	95.2	94.51	8.80	1.019	4.90	393.03	5.34	688.80	90.37
Total	11,901,000	14,033.66	5.2	94.8	1,600.02	131.63	4.525	83.52	2,055.63	147.73	10,010.60	615.22

TRENDS IN WATER USE, 1950-84

Trends in withdrawals of water for public supply, self-supplied industry, and thermoelectric power generation for 1950-84 can be seen in table 18. Data were derived from the U.S. Geological Survey estimated-water-use reports by MacKichan (1951, 1957), MacKichan and Kammerer (1961), Murray (1968), Murray and Reeves (1972, 1977) and by Solley, Chase, and Mann (1983). Total withdrawal data for the 1950 and 1955 reports (MacKichan, 1951 and 1957) did not include all the categories included in the later publications.

Population increased by 13.4 percent between 1950 and 1984. Public supply also increased but the magnitude of the increase was greater--45.8 percent. Larger fluctuations were observed in withdrawals by thermoelectric power generation and self-supplied industry than in withdrawals by public supply.

Table 18.--Water withdrawals and total population in Pennsylvania, 1950-84
[A double dash means no data available]

Year	Total population	Water withdrawals, in millions of gallons per day			
			Selected categories		
		[1]/Total withdrawals	Public supply	Self-supplied industrial	Thermoelectric power generation
1950	10,498,012	[2]/ 7,000	1,070	5,800	--
1955	10,814,000	[3]/11,000	1,420	9,040	
1960	11,319,000	13,000	1,310	4,400	6,600
1965	11,583,000	15,000	1,430	4,850	8,800
1970	11,794,000	20,000	1,750	5,400	12,000
1975	11,828,000	18,000	1,650	4,750	11,200
1980	11,824,000	16,000	1,540	3,650	10,100
1984	11,901,000	14,000	1,560	2,050	10,000

[1]/Excludes water used for hydroelectric power generation.

[2]/Total includes water withdrawn for rural (domestic and livestock), municipal, irrigation and self-supplied industrial categories.

[3]/Total includes water withdrawn for rural (domestic and livestock), municipal, irrigation and self-supplied industrial (includes thermoelectric power categories).

Published totals for withdrawals by self-supplied industry in 1955 included water used for thermoelectric power generation (MacKichan, 1957); regional data were used to estimate withdrawals by self-supplied industry and thermoelectric power generation.

Self-supplied industrial water use steadily declined after 1970, chiefly because the steel industry in Pennsylvania also declined. Decreases in this category are also due to enhanced efforts to recycle wastewater to avoid costly treatment, relocation of some industries to other States, and a shift to public systems.

Withdrawals for thermoelectric power generation increased steadily from 1955 to 1970, but declined since then, in spite of the construction of new facilities. Part of this decline reflects the gradual replacement of the once-through cooling systems by water-recirculating closed-loop cooling towers. This has resulted in less water withdrawn for the amount of power produced.

SUMMARY

Withdrawals and consumptive use of water in Pennsylvania in 1984 were examined for seven categories. Combined water withdrawals in 1984 totaled 14,033.66 Mgal/d. Thermoelectric power generation was the largest use category, followed by self-supplied industry, public supply, mining, self-supplied domestic use, livestock and poultry, and irrigation.

Water withdrawn in 1984 for public supplies totaled 1,600.02 Mgal/d. Sixteen percent was taken from ground-water sources, while the remaining 84 percent was derived from surface-water sources. Public systems supplied water to 78 percent of Pennsylvania's total population in 1984.

A total withdrawal of 131.63 Mgal/d from ground-water sources was estimated for the 2,632,937 persons considered to be self-supplied domestic water users in 1984; this represents an 11 percent decrease in withdrawals between 1980 and 1984.

Climatological data show that rainfall in 1984 was 15 percent above normal. This greatly reduced water withdrawals for irrigation. Some water was withdrawn for frost protection and fertilization and to supply the needs of some truck crops. An estimated 4.525 Mgal/d was used to irrigate 8,464 acres; 84 percent of these withdrawals were made from surface waters.

Livestock and poultry are concentrated in six counties in southeastern Pennsylvania; withdrawals for livestock and poultry were greatest in Lancaster County. Total withdrawals in 1984 were estimated to be 83.52 Mgal/d.

Industrial withdrawals totaled 2,055.63 Mgal/d from self-supplied sources. Only 7 percent of the water used was from ground-water sources.

Mining accounted for withdrawals of 147.73 Mgal/d, including water used for dust control, dewatering, preparation-plant processing, cooling and condensing, boiler feed, and sanitation. Allegheny and Greene Counties had the largest total withdrawals.

Pennsylvania had 43 active thermoelectric and hydroelectric power-generation facilities in 1984. Approximately 60,713.38 Mgal/d was used at the hydroelectric facilities; 10,010.60 Mgal/d was withdrawn for use at the thermoelectric plants. The lower Susquehanna River basin, hydrologic accounting unit 020503, far exceeded other basins for water withdrawn for thermoelectric power generation (3,303.40 Mgal/d) and water used for hydroelectric power generation (55,594.22 Mgal/d).

Water consumed through evaporation or incorporation into a manufactured product totaled 615.22 Mgal/d. Self-supplied industry was responsible for 30 percent of the total consumptive use followed by power generation (28 percent), public supply (26 percent), livestock (10 percent), mining (3 percent), self-supplied domestic use (2 percent), and irrigation (less than 1 percent).

Examination of trends in withdrawals from 1950 through 1984 for public supply, self-supplied industry, and thermoelectric power generation showed that while population increased by 13.4 percent since 1950, public-supply with-

drawals increased by 45.8 percent. This increase reflects increased use of public systems, technological advances of that period, which placed more water-using appliances in most homes, and generally increased water use related to the increased standard of living. There has been a pronounced decrease in self-supplied industrial withdrawals since 1970, predominantly because of the depressed condition of the steel industries in the State. Since 1970, withdrawals for power generation have decreased because of the transition from once-through cooling systems to closed-loop cooling systems, which reduce the amount of water withdrawn but increase the amount of water consumed.

REFERENCES CITED

Delaware River Basin Commission, The Delaware River Basin Comprehensive (Level B) Study, May 1981, 140 p.

Electric Utility Companies of Pennsylvania, 1984, Pennsylvania Master Siting Study, Major Electric Generating Projects 1984-1998, 34 p.

MacKichan, K. A., 1951, Estimated water use in the United States, 1950: U.S. Geological Survey Circular 115, 13 p.

-----1957, Estimated water use in the United States, 1955: U.S. Geological Survey Circular 398, 18 p.

MacKichan, K. A. and Kammerer, J. C., 1961, Estimated use of water in the United States, 1960: U.S. Geological Survey Circular 456, 26 p.

Murray, C. R., 1968, Estimated use of water in the United States, 1965: U.S. Geological Survey Circular 556, 53 p.

Murray, C. R. and Reeves, E. B., 1972, Estimated use of water in the United States in 1970: U.S. Geological Survey Circular 676, 37 p.

-----1977, Estimated use of water in the United States in 1975: U.S. Geological Survey Circular 765, 37 p.

National Oceanic and Atmospheric Administration, 1979, 1978 Climatological Data, Annual Summary, v. 83, no. 13, 15 p.

-----1985, 1984 Climatological Data, Annual Summary, v. 89, no. 13, 34 p.

Pennsylvania Department of Agriculture, State Soil and Water Conservation Commission, (unpub) State-wide Water Resources Investigation (Agricultural Water Resources), 1968 survey.

Pennsylvania Department of Commerce, 1986, 1986 Pennsylvania Abstract, 28 ed., 266 p.

REFERENCES CITED--Continued

Pennsylvania Department of Environmental Resources, 1975-1983, State Water Plan Series, SWP 1-20.

-----1979, Annual Report on Mining, Oil, and Gas, and Land Reclamation and Conservational Activities-1978, 387 p.

-----1984, Annual Report on Mining Activities--1983, 490 p.

-----1984, Safe Drinking Water Regulation, Chapter 109, 25 p.

-----1985, Annual Report on Mining Activities--1984, 384 p.

Solley, W. B., Chase, E. B., and Mann, IV, W. B., 1983, Estimated use of water in the United States in 1980: U.S. Geological Survey Circular 1001, 56 p.

U.S. Department of Agriculture, Pennsylvania Department of Agriculture, 1984, 1983 Crop and Livestock Annual Summary, 85 p.

-----1985, 1984 Crop and Livestock Annual Summary, 75 p.

U.S. Department of Commerce, Bureau of the Census, 1982, 1978 Census of Agriculture, v. 4, Irrigation, AC 78-IR, 330 p.

-----1984, 1982 Census of Agriculture, v. 1, Part 38--Pennsylvania State and County Data, 365 p.

-----1984, Current Population Reports, Local Population Estimates, Series P-26, No. 82-38-SC, 41 p.

-----1985, Current Population Reports, Local Population Estimates, Series P-26, No. 84-52-C, p. 16-17.

U.S. Environmental Protection Agency, 1983, Protection of the Environment, Title 40, Part 434, pp. 240-250.