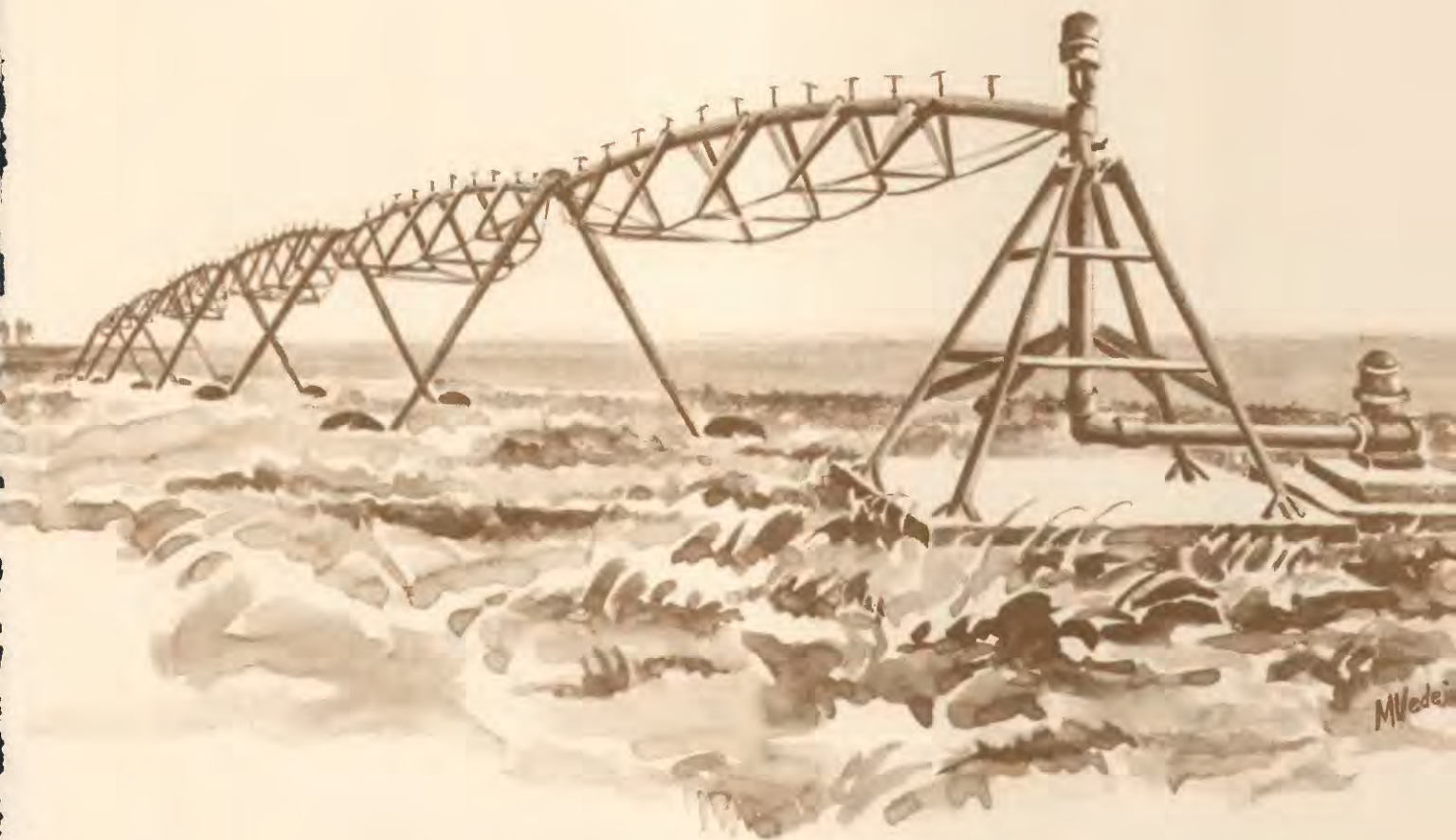


# ESTIMATED USE OF GROUND WATER FOR IRRIGATION IN WISCONSIN, 1984



*Prepared by* United States Department of the Interior, Geological Survey

*In cooperation with the* University of Wisconsin-Extension, Agricultural Engineering Department

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*By*

J. T. Krohelski, B. R. Ellefson, and C. A. Storlie

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Madison, Wisconsin  
1987

**UNITED STATES DEPARTMENT OF THE INTERIOR  
DONALD PAUL HODEL, *Secretary***

**GEOLOGICAL SURVEY  
Dallas L. Peck, *Director***

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## FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

For the use of readers who prefer the International System of Units (SI),  
the conversion factors for the terms used in this report are listed below.

<u>Multiply inch-pound units</u>	<u>By</u>	<u>To obtain SI unit</u>
gallon (gal)	0.003785	cubic meters (m <sup>3</sup> )
gallon per minute (gal/min)	0.003785	cubic meter per minute (m <sup>3</sup> /min)
million gallons per year (Mgal/yr)	0.003785	million cubic meters per year (Mm <sup>3</sup> /yr)

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## ABSTRACT

The flow from a sample of 143 irrigation wells from 6 irrigation areas in Wisconsin was measured using an external flowmeter during the 1983–84 irrigation seasons. The measured pumpages were correlated with reported pumpages. The equation that describes this correlation is:

$$Q_m = 0.86 \times Q_r$$

where  $Q_m$  is the measured pumpage and  
 $Q_r$  is the reported pumpage.

This equation was used to adjust all reported irrigation pumpage, yielding a more accurate estimate of total irrigation water use. The maximum total irrigation pumpage for 1984 was estimated to be 31,700 million gallons by using the equation and accounting for both reported and unreported pumpage.

From 1979 to 1984, irrigation pumpage increased a maximum of 25 percent and the maximum number of irrigation wells increased 32 percent.

## INTRODUCTION

Irrigation is used in Wisconsin to increase the quantity and quality of crop yields, to protect against crop loss during dry periods, and to maintain the quality of recreational facilities. Sloggett (1985) estimated that irrigation increased 72 percent in Wisconsin between 1974 and 1983, based on an increase in the State's irrigated acreage. The largest increase in irrigation was during 1976 and 1977 (based on irrigation-well permit applications). This increase was undoubtedly due to a drought beginning in 1976 (Tom

Calabresa, Wisconsin Department of Natural Resources, oral commun., 1985). After 1977 the installation rate of new irrigation systems declined. Ground water accounts for approximately 97 percent of the water used for irrigation in Wisconsin (Lawrence and Ellefson, 1982, p. 98).

An accurate assessment of current irrigation practices largely depends on the analyses of an accurate data base. Irrigators using 70 gal/min or more from a well or a combination of wells on one property are required to report pumpage to the Wisconsin Department of Natural Resources (DNR). In addition to these data, the Soil Conservation Service and the University of Wisconsin-Extension have compiled data on system type, water sources, power sources, and irrigated soil types (Soil Conservation Service, 1977).

Determining the accuracy of reported pumpages is useful to both irrigators and scientists. It is becoming increasingly important to know how much water is being applied to a field. Water applied in excess of plant requirements can promote leaching of fertilizer and pesticide from the soil to the ground-water reservoir and increase the cost of pumping. Storlie (Agricultural Engineering, University of Wisconsin-Madison, written commun., 1985) reports that many Wisconsin irrigators overwater their crops, some by as much as 100 percent of the crop demand.

## Purpose and Scope

The purpose of this report is to present a more accurate estimate of statewide ground-water use for irrigation than previously made. Irrigators generally calculate (and report) their pumpage based on rated pump capacity and the number of hours the system was running. Pumpage estimates can be incorrect if pump efficiency, pump capacity, or total pumpage hours are in error.

In this study pumpage from a statistical sample of irrigation wells was measured, correlated with reported pumpage, and the relationship was applied to statewide reported pumpage data. The report does not include information on irrigation from sources other than ground water, or nonagricultural irrigation. Reported pumpage data were assembled by DNR during the spring of 1985. These data are entered into a computer file that is maintained by DNR.

## Methods of Study

The flow rate from irrigation wells was measured using a ClampIttron Model 240 flowmeter<sup>1</sup>. This flowmeter uses ultrasonic waves to measure flow and is both noninvasive and nondestructive. Transducers are mounted on opposite sides of an irrigation pipe. A signal is passed through the pipe and fluid, and returned to the electronic assembly where it is translated into a flow rate. The ClampIttron meter was calibrated at known flow rates ranging from 100 to 1,200 gal/min. An accuracy of about plus or minus 5 percent was obtained at flow rates less than 130 gal/min. At flow rates greater than 300 gal/min an accuracy of plus or minus 3 percent was obtained. Storlie (1985, p. 31) presents a complete description of the flowmeter.

The State was divided into six irrigation areas to ease data collection and interpretation (fig. 1). The five major areas are groups of counties that have the highest concentration of irrigators. Irrigation areas include: the northwest, northeast, central sands, lower sands, south, and "other" (which contains irrigation wells not located in the five major areas). It was determined that 230 wells should be measured to obtain a Statewide statistical sample having a confidence interval of plus or minus 10 percent (the number 230 was derived from a regression analysis using 33 measured wells). A random-number generator was used to select approximately 14 percent of the irrigation wells from each irrigation area, for a total of 350 wells. This number allowed wells that could not be measured for various reasons (such as a temporarily unused well or wells for which permission to measure could not be obtained) to be dropped from the sample.

About half of the irrigation wells in the State are located in the central sands irrigation area. Most measured wells are in the central sands irrigation area because the area contains a large number of wells and because it is readily accessible from Madison. Measurements in more distant areas were difficult to obtain because unpredictable storms would shut down irrigation.

Measurements of flow from 143 irrigation systems were made during the 1983 and 1984 irrigation seasons. Regression techniques were used to determine the correlation between measured flow and reported flow at the measured sites.

<sup>1</sup> The use of the brand name in this report is for identification purpose only and does not imply endorsement by the U.S. Geological Survey.

Attempts were made to correlate irrigation area and type of irrigation system to measured flow. Although the age of the irrigation-system components may be a factor in the accuracy of reported pumpages, it was not considered in this study.

Statewide irrigation-water use estimated in this report has been incorporated into the State Water-Use Data System (SWUDS). SWUDS was created in 1984 as part of a national effort to quantify water use and is maintained by the U.S. Geological Survey. SWUDS is updated annually and will provide data for estimating annual water use.

## Acknowledgments

Appreciation is expressed to the many irrigators who allowed measurement of their wells. DNR provided a listing of reported pumpages used in this report. Appreciation is also given to Rick Stowell, an agricultural engineering student, who measured wells during the 1984 irrigation season, and to Kraig Rury, for writing the computer programs that aided in analyzing and plotting data.

## ESTIMATED USE OF GROUND WATER FOR IRRIGATION

Estimates of total ground-water pumpage were improved by using the relationship between measured and reported pumpage.

## Correlation Between Measured and Reported Pumpages

The discharge from 143 irrigation wells was measured. Table 1 shows the location, irrigation area, system type, reported pumpage, and measured pumpage for each of these wells. There is a strong correlation between measured and reported pumpages (STD ERROR = 130.1). The equation that describes this correlation is:

$$Q_m = 0.86 \times Q_r \quad (1)$$

where  $Q_m$  is the measured pumpage and

$Q_r$  is the reported pumpage.

Statistical analysis also indicates a difference in the correlation of pumpage between central-pivot and traveling-gun-irrigation systems. Where data are available on system type, accuracy of reported pumpages may be slightly improved by applying one of the following equations (STD ERROR = 125.):

$$Q_m = 0.84 \times Q_c \quad (2)$$

where:  $Q_m$  is measured pumpage for a central-pivot system,  
 $Q_c$  is the reported pumpage for a central-pivot system, and

$$Q_m = 0.98 \times Q_t \quad (3)$$

where  $Q_m$  is measured pumpage for a traveling-gun system and  
 $Q_t$  is the reported pumpage for a traveling-gun system.

An attempt was made to correlate reported pumpage to measured pumpage within each of the irrigation areas. Because of the lack of data in most irrigation areas, the validity of the regression equations is questionable and they are not presented in this report.

### Adjusted Pumpages

Equation 1 was used to adjust 1984 reported pumpages. Table 2 shows reported irrigation pumpage and adjusted pumpage by township and range. Table 3 summarizes these data by county. Note that the adjusted total pumpage is lower than the reported pumpage.

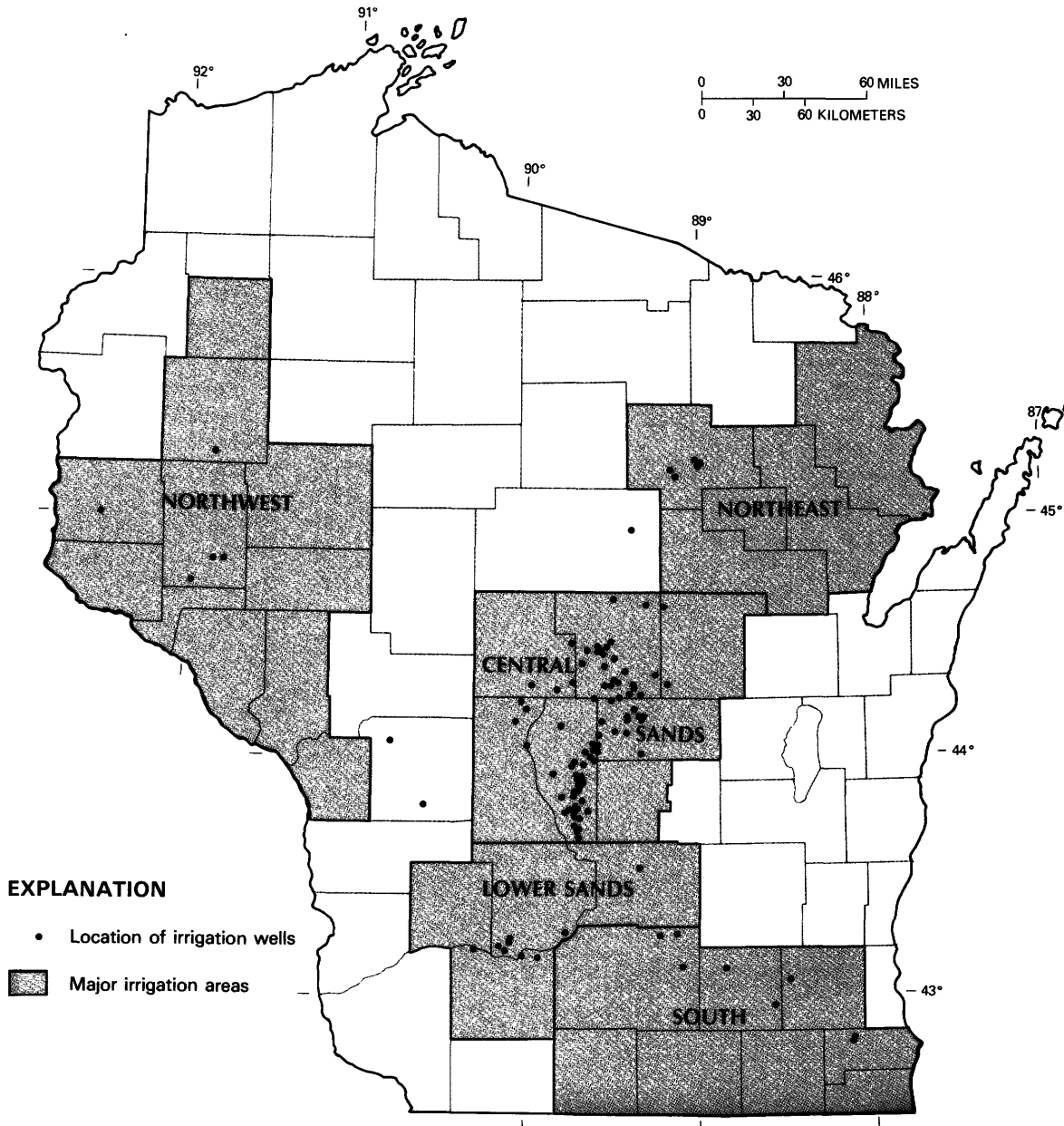


Figure 1. Location of irrigation wells measured for this study.



The adjusted total pumpage shown in tables 2 and 3 is a minimum value (18,182 Mgal/yr) because 43 percent of the irrigators did not report pumpage to DNR. Only those wells in the DNR file of high-capacity irrigation wells that had a completion date and monthly pumpage values are shown in tables 2 and 3, and on plate 1. Wells that either did not have a completion date or did not have pumpage values were excluded.

A maximum total pumpage for the State was calculated by including estimates for these wells without reported data. The average adjusted pumpage per irrigation well with reported data is 11.6 Mgal/yr. Multiplying 11.6 Mgal/yr times 1,162 (the number of irrigation wells without reported data) equals 13,500 Mgal/yr; the estimated additional pumpage from wells without reported data. This value, added to the adjusted total pumpage from tables 2 and 3, should approximate the maximum total pumpage. Based on these procedures the minimum total irrigation pumpage for 1984 was 18,182 and the maximum was 31,700 Mgal/yr.

### **Increase in Irrigation Pumpage**

Irrigation pumpage in Wisconsin increased by 25 percent between 1979 and 1984. In 1979 Lawrence and Ellef-

son (1982, p. 98) reported that 29,600 Mgal were pumped for irrigation, based on the DNR file. Using equation 1 to adjust the 1979 pumpage so that it is comparable to adjusted 1984 pumpage yields 25,337 Mgal in 1979.

In 1979 and 1984 there were 2,065 and 2,733 irrigation wells, respectively (the totals include both wells with reported and unreported pumpage data). This represents a 32-percent increase in the number of irrigation wells for the 5-year period from 1979 to 1984.

### **REFERENCES**

- Lawrence, C. L., and Ellefson, B. R., 1972, Water use in Wisconsin, 1979: U.S. Geological Survey Water-Resources Investigations 82-444, 98 p.
- Soil Conservation Service and University of Wisconsin-Extension, 1977, 1977 Irrigation Data Survey.
- Sloggett, G., 1985, Draft of Energy and U.S. Agriculture: Irrigation pumping, 1974-83: U.S. Department of Agriculture, Economic Research Service.
- Storlie, C. A., 1985, Irrigation pumping plant and water use evaluation: Madison, University of Wisconsin-Agricultural Engineering master's thesis, 163 p.

**Table 1.** Location, irrigation area, system type, and pumpage for measured irrigation wells

County	Location Township Range		Measured (gal/min)	Reported (gal/min)	Irrigation area	Type of system
Adams	14N	06E	560	368	Central Sands	Center pivot
Adams	14N	06E	509	550	Central Sands	Center pivot
Adams	14N	07E	672	700	Central Sands	Center pivot
Adams	14N	07E	608	850	Central Sands	Center pivot
Adams	15N	06E	701	950	Central Sands	Center pivot
Adams	15N	06E	486	600	Central Sands	Traveling gun
Adams	15N	06E	705	800	Central Sands	Center pivot
Adams	15N	06E	551	650	Central Sands	Center pivot
Adams	15N	06E	531	700	Central Sands	Center pivot
Adams	15N	06E	548	700	Central Sands	Center pivot
Adams	15N	06E	695	725	Central Sands	Center pivot
Adams	15N	06E	486	750	Central Sands	Center pivot
Adams	15N	07E	650	1,000	Central Sands	Center pivot
Adams	15N	07E	519	1,000	Central Sands	Center pivot
Adams	15N	07E	775	775	Central Sands	Center pivot
Adams	15N	07E	515	1,000	Central Sands	Center pivot
Adams	15N	07E	775	1,000	Central Sands	Center pivot
Adams	15N	07E	800	1,000	Central Sands	Center pivot
Adams	15N	07E	450	500	Central Sands	Center pivot
Adams	16N	06E	789	1,000	Central Sands	Center pivot
Adams	16N	06E	672	700	Central Sands	Center pivot
Adams	16N	06E	946	800	Central Sands	Center pivot
Adams	16N	07E	780	1,000	Central Sands	Center pivot
Adams	16N	07E	822	1,000	Central Sands	Center pivot
Adams	16N	07E	780	1,000	Central Sands	Center pivot
Adams	16N	07E	793	1,000	Central Sands	Center pivot
Adams	16N	07E	788	1,000	Central Sands	Center pivot
Adams	17N	06E	660	700	Central Sands	Center pivot
Adams	17N	06E	1,036	1,100	Central Sands	Center pivot
Adams	17N	07E	660	1,000	Central Sands	Center pivot
Adams	17N	07E	619	650	Central Sands	Center pivot
Adams	17N	07E	936	1,000	Central Sands	Center pivot
Adams	17N	07E	598	900	Central Sands	Center pivot
Adams	17N	07E	810	900	Central Sands	Center pivot
Adams	17N	07E	707	900	Central Sands	Center pivot
Adams	17N	07E	548	1,000	Central Sands	Center pivot
Adams	17N	07E	614	800	Central Sands	Center pivot
Adams	17N	07E	598	800	Central Sands	Center pivot
Adams	17N	07E	964	900	Central Sands	Center pivot
Adams	17N	07E	740	850	Central Sands	Center pivot
Adams	17N	07E	872	1,000	Central Sands	Center pivot
Adams	17N	07E	747	850	Central Sands	Center pivot
Adams	17N	07E	766	900	Central Sands	Center pivot
Adams	18N	07E	728	800	Central Sands	Center pivot
Adams	18N	07E	423	450	Central Sands	Center pivot
Adams	18N	07E	901	900	Central Sands	Center pivot
Adams	18N	07E	872	900	Central Sands	Center pivot
Adams	18N	07E	942	1,000	Central Sands	Center pivot
Adams	18N	07E	295	650	Central Sands	Center pivot
Adams	18N	07E	800	875	Central Sands	Center pivot

**Table 1.** Location, irrigation area, system type, and pumpage for measured irrigation wells—Continued

County	Location Township	Range	Measured (gal/min)	Reported (gal/min)	Irrigation area	Type of system
Adams	18N	07E	722	1,100	Central Sands	Center pivot
Adams	18N	07E	506	500	Central Sands	Center pivot
Adams	19N	06E	568	700	Central Sands	Center pivot
Adams	20N	07E	1,197	1,100	Central Sands	Center pivot
Barron	32N	12W	640	800	North West	Center pivot
Barron	34N	11W	651	800	North West	Traveling gun
Columbia	12N	10E	520	600	Central Sands	Center pivot
Dane	05N	09E	592	775	Southern	Center pivot
Dane	08N	12E	419	450	Southern	Traveling gun
Dane	09N	11E	678	900	Southern	Center pivot
Dane	09N	11E	661	800	Southern	Center pivot
Dunn	26N	13W	728	1,000	North West	Center pivot
Dunn	27N	11W	756	1,000	North West	Center pivot
Dunn	27N	11W	636	1,000	North West	Center pivot
Dunn	27N	12W	680	700	North West	Center pivot
Iowa	08N	02E	790	900	Lower Sands	Center pivot
Iowa	08N	03E	505	525	Lower Sands	Traveling gun
Iowa	08N	05E	455	500	Lower Sands	Traveling gun
Jefferson	06N	16E	1,978	1,750	Other	Traveling gun
Jefferson	08N	14E	323	450	Other	Traveling gun
Juneau	19N	04E	445	750	Central Sands	Center pivot
Juneau	20N	04E	630	800	Central Sands	Center pivot
Juneau	20N	04E	670	1,000	Central Sands	Center pivot
Juneau	20N	04E	774	1,000	Central Sands	Center pivot
Kenosha	01N	19E	350	520	Other	Hand-moved
Langlade	31N	11E	614	650	North East	Center pivot
Langlade	31N	11E	825	800	North East	Center pivot
Langlade	32N	12E	1,010	975	North East	Center pivot
Langlade	32N	12E	382	400	North East	Traveling gun
Langlade	32N	12E	382	400	North East	Traveling gun
Monroe	18N	04E	479	450	Other	Traveling gun
Portage	21N	08E	299	500	Central Sands	Center pivot
Portage	21N	08E	893	950	Central Sands	Center pivot
Portage	21N	08E	544	800	Central Sands	Center pivot
Portage	21N	08E	778	800	Central Sands	Center pivot
Portage	21N	09E	596	700	Central Sands	Center pivot
Portage	21N	09E	565	600	Central Sands	Center pivot
Portage	21N	09E	868	800	Central Sands	Center pivot
Portage	21N	09E	680	775	Central Sands	Center pivot
Portage	21N	09E	507	600	Central Sands	Center pivot
Portage	21N	10E	697	800	Central Sands	Center pivot
Portage	22N	07E	522	475	Central Sands	Traveling gun
Portage	22N	07E	624	800	Central Sands	Center pivot
Portage	22N	08E	561	900	Central Sands	Center pivot
Portage	22N	08E	842	900	Central Sands	Center pivot
Portage	22N	08E	680	800	Central Sands	Center pivot
Portage	22N	08E	551	1,000	Central Sands	Center pivot
Portage	23N	07E	1,175	1,250	Central Sands	Center pivot
Portage	23N	08E	806	900	Central Sands	Center pivot
Portage	23N	08E	664	900	Central Sands	Center pivot

**Table 1.** Location, irrigation area, system type, and pumpage for measured irrigation wells—Continued

County	Location Township Range		Measured (gal/min)	Reported (gal/min)	Irrigation area	Type of system
Portage	23N	08E	708	708	Central Sands	Center pivot
Portage	23N	08E	398	550	Central Sands	Traveling gun
Portage	23N	08E	583	700	Central Sands	Center pivot
Portage	23N	08E	970	1,000	Central Sands	Center pivot
Portage	23N	08E	892	775	Central Sands	Center pivot
Portage	23N	08E	980	950	Central Sands	Center pivot
Portage	23N	08E	883	800	Central Sands	Center pivot
Portage	23N	08E	582	800	Central Sands	Center pivot
Portage	25N	09E	863	1,000	Central Sands	Center pivot
Portage	25N	10E	693	750	Central Sands	Center pivot
Portage	25N	10E	551	560	Central Sands	Traveling gun
Racine	04N	20E	701	700	Other	Traveling gun
Racine	04N	20E	429	450	Other	Traveling gun
Sauk	08N	03E	1,016	1,100	Lower Sands	Traveling gun
Sauk	08N	03E	908	1,000	Central Sands	Center pivot
Sauk	08N	03E	1,176	1,000	Lower Sands	Center pivot
Sauk	09N	03E	947	1,000	Central Sands	Center pivot
Sauk	09N	06E	1,093	1,100	Lower Sands	Traveling gun
St. Croix	29N	17E	648	1,050	North West	Center pivot
Waukesha	07N	17E	623	766	Other	Center pivot
Waupaca	21N	11E	393	550	Central Sands	Traveling gun
Waupaca	25N	11E	764	775	Central Sands	Center pivot
Waushara	18N	08E	892	900	Central Sands	Center pivot
Waushara	18N	08E	765	850	Central Sands	Center pivot
Waushara	18N	08E	872	925	Central Sands	Center pivot
Waushara	18N	10E	577	900	Central Sands	Center pivot
Waushara	19N	08E	890	675	Central Sands	Center pivot
Waushara	19N	08E	553	750	Central Sands	Center pivot
Waushara	19N	08E	485	625	Central Sands	Center pivot
Waushara	19N	08E	812	800	Central Sands	Center pivot
Waushara	19N	08E	975	1,000	Central Sands	Center pivot
Waushara	19N	09E	851	1,000	Central Sands	Center pivot
Waushara	19N	09E	721	750	Central Sands	Center pivot
Waushara	20N	08E	606	700	Central Sands	Center pivot
Waushara	20N	08E	784	1,000	Central Sands	Center pivot
Waushara	20N	09E	740	800	Central Sands	Center pivot
Waushara	20N	09E	800	950	Central Sands	Center pivot
Waushara	20N	09E	362	600	Central Sands	Traveling gun
Waushara	20N	09E	575	700	Central Sands	Center pivot
Waushara	20N	09E	339	420	Central Sands	Traveling gun
Wood	21N	05E	850	900	Central Sands	Center pivot
Wood	21N	05E	715	900	Central Sands	Center pivot
Wood	21N	06E	508	800	Central Sands	Center pivot

**Table 2.** Distribution of 1984 ground-water pumpage for irrigation in Wisconsin, by township and range

Township <sup>1</sup>	Range	Reported pumpage (1000's of gallons)	Adjusted pumpage (1000's of gallons)	Township <sup>1</sup>	Range	Reported pumpage (1000's of gallons)	Adjusted pumpage (1000's of gallons)
1	2E	0	0	7	9E	29,216	25,008
1	3E	0	0	7	13E	61,607	52,735
1	9E	76,734	65,684	7	14E	0	0
1	10E	9,883	8,459	7	16E	0	0
1	11E	20,952	17,934	7	17E	128,524	110,016
1	12E	49,965	42,770	7	19E	3,343	2,861
1	13E	0	0	7	20E	7,234	6,192
1	14E	0	0	8	1W	15,624	13,374
1	19E	1,341	1,147	8	2W	0	0
1	21E	2,701	2,312	8	1E	10,368	8,875
2	1E	0	0	8	2E	66,679	57,077
2	2E	0	0	8	3E	354,125	303,130
2	6E	0	0	8	4E	550,820	471,501
2	9E	56,626	48,471	8	5E	81,273	69,569
2	10E	6,912	5,916	8	6E	88,396	75,667
2	12E	7,194	6,158	8	11E	791	677
2	13E	86,350	73,915	8	12E	20,254	17,337
2	14E	40,401	34,583	8	14E	4,500	3,852
2	20E	15,776	13,504	8	15E	0	0
3	9E	7,396	6,331	8	16E	22	18
3	10E	25,200	21,571	8	17E	77,760	66,562
3	11E	50,122	42,904	8	20E	20,778	17,786
3	12E	32,454	27,780	8	21E	15,223	13,030
3	13E	483	413	8	22E	22,655	19,392
3	14E	14,100	12,069	9	2W	0	0
3	15E	0	0	9	2E	14,010	11,992
3	16E	0	0	9	3E	187,950	160,885
3	17E	576	493	9	5E	11,127	9,524
3	20E	0	0	9	6E	145,048	124,161
3	21E	19,196	16,431	9	11E	52,239	44,716
3	22E	0	0	9	19E	0	0
4	8E	3,415	2,923	9	21E	5,586	4,781
4	9E	0	0	10	5E	0	0
4	10E	14,257	12,204	10	6E	110,847	94,885
4	12E	0	0	10	7E	0	0
4	13E	0	0	10	10E	13,950	11,941
4	15E	0	0	11	8E	0	0
4	16E	15,369	13,155	11	10E	8,424	7,210
4	20E	34,849	29,830	11	12E	1,416	1,212
5	7E	85	72	11	13E	1,680	1,438
5	8E	0	0	11	22E	540	462
5	9E	0	0	12	6E	44,212	37,845
5	10E	0	0	12	7E	0	0
5	11E	4,440	3,800	12	9E	15,144	12,963
5	12E	0	0	12	10E	17,131	14,664
5	14E	0	0	12	11E	2,812	2,407
5	15E	0	0	12	12E	360	308
5	16E	0	0	12	13E	4,608	3,944
5	20E	0	0	12	16E	0	0
5	21E	0	0	12	19E	0	0
5	22E	0	0	12	22E	0	0
6	9E	1,008	862	13	7E	10	8
6	11E	0	0	13	9E	0	0
6	13E	10,305	8,821	13	10E	0	0
6	15E	19,800	16,948	13	11E	292	250
6	16E	0	0				
6	17E	271	232				
6	19E	0	0				
6	21E	0	0				
7	8E	0	0				

<sup>1</sup> Townships with no pumpage are listed because they have irrigation wells without reported pumpage.

NOTE: Figures may not add to totals because of independent rounding.

**Table 2.** Distribution of 1984 ground-water pumpage for irrigation in Wisconsin, by township and range—Continued

Township <sup>1</sup>	Range	Reported pumpage (1000's of gallons)	Adjusted pumpage (1000's of gallons)	Township <sup>1</sup>	Range	Reported pumpage (1000's of gallons)	Adjusted pumpage (1000's of gallons)
13	12E	960	821	18	7E	493,854	422,733
13	13E	0	0	18	8E	423,148	362,214
14	5E	7,410	6,343	18	9E	228,620	195,693
14	6E	113,297	98,982	18	10E	45,794	39,193
14	7E	114,500	98,012	18	11E	117,374	100,472
14	8E	0	0	18	15E	0	0
14	9E	0	0	18	16E	4,050	3,466
14	10E	2,152	1,842	19	1W	1,020	873
14	12E	1,944	1,664	19	3W	0	0
14	13E	0	0	19	4W	0	0
14	14E	0	0	19	5W	0	0
14	15E	0	0	19	9W	0	0
15	7W	0	0	19	3E	0	0
15	3E	6,023	5,155	19	4E	145,464	124,517
15	5E	34,200	29,275	19	5E	22,320	19,107
15	6E	290,577	248,733	19	6E	31,816	27,234
15	7E	202,937	173,714	19	7E	141,722	121,314
15	8E	0	0	19	8E	1,339,462	1,146,573
15	9E	66,210	56,675	19	9E	457,161	391,329
15	10E	0	0	19	10E	344	294
15	13E	6,993	5,986	19	11E	14,760	12,634
15	14E	2,700	2,311	19	12E	1,344	1,150
15	17E	3,814	3,264	19	19E	0	0
15	23E	4,133	3,537	19	23E	5,960	5,101
16	6W	0	0	20	4W	80	68
16	7W	45	38	20	6W	0	0
16	2E	2,708	2,318	20	12W	188,898	161,696
16	3E	2,811	2,406	20	3E	0	0
16	4E	0	0	20	4E	657,036	562,422
16	5E	0	0	20	5E	154,320	132,097
16	6E	48,359	41,395	20	6E	117,396	100,491
16	7E	45,504	38,951	20	7E	569,670	487,637
16	9E	11,427	9,781	20	8E	1,560,771	1,336,019
16	10E	1,440	1,232	20	9E	1,095,721	937,937
16	12E	0	0	20	10E	0	0
16	13E	5,197	4,448	20	11E	0	0
16	14E	9,140	7,823	20	12E	0	0
16	21E	8,678	7,428	20	16E	1,826	1,563
17	4W	4,558	3,901	20	17E	0	0
17	8W	0	0	20	18E	8,097	6,931
17	3E	19,260	16,486	20	19E	216	184
17	5E	0	0	21	6W	0	0
17	6E	84,759	72,553	21	9W	0	0
17	7E	352,074	301,375	21	11W	0	0
17	8E	0	0	21	12W	12,000	10,272
17	9E	48,000	41,088	21	4E	61,080	52,284
17	10E	0	0	21	5E	159,835	136,818
17	13E	26,748	22,896	21	6E	57,024	48,812
17	15E	0	0	21	7E	358,400	306,790
18	1W	675	577	21	8E	701,180	600,210
18	2W	0	0	21	9E	617,514	528,591
18	4W	0	0	21	10E	63,765	54,587
18	6W	12,894	11,037	21	11E	109,542	93,767
18	7W	0	0	21	12E	0	0
18	8W	89,007	76,190	21	14E	0	0
18	9W	75,593	64,707				
18	3E	218	186				
18	4E	35,424	30,322				
18	5E	206,801	177,021				
18	6E	9,290	7,952				

<sup>1</sup> Townships with no pumpage are listed because they have irrigation wells without reported pumpage.

NOTE: Figures may not add to totals because of independent rounding.

**Table 2.** Distribution of 1984 ground-water pumpage for irrigation in Wisconsin, by township and range—Continued

Township <sup>1</sup>	Range	Reported pumpage (1000's of gallons)	Adjusted pumpage (1000's of gallons)	Township <sup>1</sup>	Range	Reported pumpage (1000's of gallons)	Adjusted pumpage (1000's of gallons)
21	16E	8,212	7,029	26	11W	46,432	39,745
21	17E	541	463	26	12W	104,625	89,559
21	22E	125	107	26	13W	0	0
22	4W	0	0	26	14W	23,760	20,338
22	6W	0	0	26	6E	5,856	5,012
22	8W	8,025	6,869	26	9E	0	0
22	6E	3,468	2,968	26	10E	0	0
22	7E	1,120,593	959,227	27	8W	6,372	5,454
22	8E	407,443	348,771	27	9W	12,864	11,011
22	9E	433,452	371,034	27	10W	0	0
22	10E	74,952	64,158	27	11W	374,876	320,893
22	11E	55,745	47,717	27	12W	104,400	89,366
22	12E	0	0	27	18W	8,597	7,359
22	18E	2,892	2,475	27	19W	0	0
22	19E	0	0	27	20W	0	0
23	10W	0	0	27	6E	8,400	7,190
23	13W	0	0	27	7E	17,640	15,099
23	14W	0	0	27	9E	0	0
23	15W	0	0	27	10E	0	0
23	7E	286,336	245,103	27	11E	0	0
23	8E	749,485	641,559	27	20E	828	708
23	9E	276,790	236,932	27	26E	9,960	8,525
23	10E	83,702	71,648	28	8W	0	0
23	11E	2,400	2,054	26	9W	720	616
23	12E	9,360	8,012	28	10W	1,332	1,140
23	21E	0	0	28	11W	18,945	16,216
24	4W	0	0	26	12W	31,528	26,988
24	6W	0	0	28	17W	9108	7796
24	7W	0	0	28	18W	300	256
24	8W	0	0	28	19W	0	0
24	9W	10	8	28	20W	0	0
24	10W	0	0	28	10E	0	0
24	13W	30,882	26,435	28	18E	0	0
24	18W	0	0	28	19E	24,240	20,749
24	8E	77,256	66,131	28	26E	412	352
24	9E	372,245	318,641	29	8W	18,993	16,258
24	10E	3,168	2,711	29	9W	1,075	920
24	11E	47,000	40,232	29	11W	0	0
24	12E	15,577	13,333	29	12W	66,040	56,530
24	16E	0	0	29	15W	0	0
24	18E	360	308	29	16W	0	0
24	19E	4,020	3,441	29	17W	1,900	1,626
24	20E	0	0	29	18W	20,414	17,474
24	22E	732	626	29	19W	11,697	10,012
24	23E	7,020	6,009	29	11E	0	0
25	5W	4,200	3,595	29	17E	0	0
25	8W	0	0	29	18E	68,832	58,920
25	13W	8,364	7,159	30	7W	0	0
25	14W	4,228	3,619	30	8W	12,900	11,042
25	17W	0	0	30	9W	4,277	3,661
25	8E	79,590	68,129	30	12W	0	0
25	9E	103,894	88,933	30	13W	11,745	10,053
25	10E	29,865	25,564	30	14W	8,035	6,878
25	11E	0	0	30	17W	3,000	2,568
25	15E	0	0	30	18W	6,048	5,177
25	16E	210	179				
25	19E	0	0				
26	7W	0	0				
26	9W	0	0				
26	10W	13,320	11,401				

<sup>1</sup> Townships with no pumpage are listed because they have irrigation wells without reported pumpage.

NOTE: Figures may not add to totals because of independent rounding.

**Table 2.** Distribution of 1984 ground-water pumpage for irrigation in Wisconsin, by township and range—Continued

Township <sup>1</sup>	Range	Reported pumpage (1000's of gallons)	Adjusted pumpage (1000's of gallons)	Township <sup>1</sup>	Range	Reported pumpage (1000's of gallons)	Adjusted pumpage (1000's of gallons)
30	19W	0	0	33	18W	0	0
30	10E	4,500	3,852	33	19W	14,700	12,583
30	11E	36,796	31,497	33	10E	2,925	2,503
30	12E	2,220	1,900	33	30E	0	0
30	18E	0	0	34	11W	131,813	112,831
30	19E	0	0	34	12W	7,626	6,527
31	10W	5,280	4,519	34	16W	0	0
31	11W	14,700	12,583	34	11E	15,900	13,610
31	12W	0	0	34	29E	0	0
31	13W	0	0	34	30E	0	0
31	15W	0	0	35	5W	0	0
31	16W	0	0	35	10W	0	0
31	17W	48,103	41,176	35	11W	68,428	58,574
31	18W	3,580	3,064	35	13W	0	0
31	10E	17,641	15,100	35	18W	0	0
31	11E	73,754	63,133	35	6E	0	0
31	12E	0	0	35	7E	0	0
31	13E	8,892	7,611	35	12E	10,140	8,679
31	14E	8,169	6,992	36	10W	0	0
31	18E	202	172	36	11W	10,512	8,998
31	20E	0	0	36	6E	0	0
31	28E	714	611	36	8E	0	0
32	9W	11,610	9,938	37	7W	3,780	3,235
32	10W	13,122	11,232	37	12W	9,360	8,012
32	11W	0	0	37	7E	0	0
32	12W	6,672	5,711	37	10E	0	0
32	13W	0	0	38	11W	9,612	8,227
32	15W	0	0	38	14W	0	0
32	17W	0	0	38	10E	0	0
32	18W	0	0	39	9W	0	0
32	19W	0	0	39	10W	0	0
32	8E	0	0	39	11W	0	0
32	10E	0	0	39	12W	7,965	6,818
32	11E	86,544	74,081	39	13W	0	0
32	12E	48,100	41,173	39	6E	0	0
32	14E	11,400	9,758	40	11W	0	0
32	15E	8,100	6,933	40	13W	0	0
32	19E	293	250	40	10E	19,368	16,576
32	20E	12,960	11,093	40	18E	2,520	2,157
33	7W	0	0	40	19E	3,567	3,057
33	9W	32,580	27,888	41	8W	0	0
33	10W	127,555	109,187	41	9W	6,984	5,978
33	11W	201,096	172,138	41	8E	7,429	6,359
33	14W	0	0				
33	15W	0	0				
					TOTAL	21,240,608	18,181,956

<sup>1</sup> Townships with no pumpage are listed because they have irrigation wells without reported pumpage.

NOTE: Figures may not add to totals because of independent rounding.



Table 3. Distribution of 1984 ground-water pumpage for irrigation in Wisconsin, by county

County	1984 reported pumpage <sup>1</sup> (1000's of gallons)	1984 adjusted pumpage (1000's of gallons)	County	1984 reported pumpage <sup>1</sup> (1000's of gallons)	1984 adjusted pumpage (1000's of gallons)
Adams	2,873,676	2,459,866	Marquette	129,229	110,620
Ashland	0	0	Menominee	0	0
Barron	566,824	485,201	Milwaukee	37,878	32,423
Bayfield	0	0	Monroe	6,253	5,352
Brown	4,752	4,067	Oconto	102,202	87,484
Buffalo	231,780	198,403	Oneida	0	0
Burnett	0	0	Outagamie	12,005	10,276
Calumet	8,313	7,115	Ozaukee	6,126	5,243
Chippewa	56,187	48,096	Pepin	12,592	10,778
Clark	0	0	Pierce	8,597	7,359
Columbia	60,499	51,787	Polk	14,700	12,583
Crawford	0	0	Portage	5,839,630	4,998,722
Dane	257,176	220,142	Price	0	0
Dodge	6,288	5,382	Racine	54,045	46,262
Dor	11,086	9,489	Richland	80,689	69,069
Douglas	0	0	Rock	358,273	306,681
Dunn	805,086	689,153	Rusk	32,580	27,888
Eau Claire	36,756	31,463	St. Croix	104,150	89,152
Florence	6,087	5,210	Sauk	833,393	713,384
Fond du Lac	15,654	13,399	Sawyer	10,764	9,214
Forest	10,140	8,679	Shawano	210	179
Grant	15,624	13,374	Sheboygan	12,811	10,966
Green	144,171	123,410	Taylor	0	0
Green Lake	40,882	34,995	Trempealeau	143,674	122,984
Iowa	590,110	505,134	Vernon	0	0
Iron	0	0	Vilas	26,797	22,938
Jackson	80	68	Walworth	15,945	13,648
Jefferson	96,234	82,376	Washburn	26,937	23,058
Juneau	1,036,074	886,879	Washington	0	0
Kenosha	19,818	16,964	Waukesha	237,910	203,650
Kewaunee	7,020	6,009	Waupaca	239,624	205,118
La Crosse	41,900	35,866	Waushara	5,284,499	4,523,530
Lafayette	0	0	Winnebago	5,876	5,029
Langlade	323,861	277,224	Wood	281,407	240,884
Lincoln	0	0			
Manitowoc	6,085	5,208			
Marathon	36,396	31,155			
Marinette	13,253	11,344			
			Total	21,240,608	18,181,956

<sup>1</sup> Zero pumpage indicated that no pumpage was reported.

NOTE: Figures may not add to totals because of independent rounding.