FINAL TECHNICAL COMPLETION REPORT

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OKLAHOMA WATER RESOURCES RESEARCH INSTITUTE

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IMPROVED DESIGN AND OPERATING CRITERIA FOR RURAL WATER DISTRICTS (PHASE II)

by

James E. Garton
Richard C. Peralta

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The authors are respectively, Professor, Agricultural Engineering Department, and Graduate Research Associate, Agricultural Engineering Department, Oklahoma State University

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ABSTRACT

Rural Water District design depends on expected usage amounts and rates, which in rural areas, is often season-dependent. An "average" rural water district in Oklahoma was monitored for consumptive use, peak use rates, and temporal distribution of water use.

Monthly usage amounts per tap were significantly higher for June, July, and August than for the rest of the year. (12,799 gallons or 48,431 liters versus 8,219 gallons or 31,101 liters). The average monthly use per residential tap was 8258 gallons (31,248 liters) and the average monthly use per person was 2,796 gallons (10,501 liters).

The period of time when water use was lowest was found to be from 11:00 pm - 6:30 am.

The criteria of 85% adequacy was used in presenting the following information. (This means that only 15% of the daily demands or daily peak flow rates exceeded these values). The daily demand per tap in July - August was 620 gallons (2,346 liters) as compared with 365 gallons (1,381 l) for the other months. The peak demands values were .74 gpm (2.8 lpm) per person and 1.3 gpm (4.9 lpm) per tap.

OBJECTIVES

The objectives of the project were to develop criteria for the design and operation of rural water districts in Oklahoma. Specifically the following information bits were sought:

- -monthly usage rates (in order to be able to predetermine contractual needs for the rural water systems)
- -daily water use per person or per tap (to appropriately select the storage tank volume)
- -peak use rates (to determine proper pipe sizes)
- -temporal distribution of demand (to determine available pump operating periods for filling of storage with a minimum of interference and to properly choose pump and pipe sizes)

METHODOLOGY

The System

Rural Water District Number 3, Payne County, Oklahoma (Figure 1) consists primarily of a storage tower and three main lines which service approximately 140 residences. Taps on the system were differentiated according to residence; dairies; or unclassified taps (farm operations, pastures, business establishments, etc.) The monthly water use of each tap on the district were obtained from the water district manager's logs of water sales. Other data were obtained from three water meters, one on each lateral, and from a printing impulse counter associated with each of these three meters. The counter recorded the cumulative number of seconds after midnight of each successive 100 gallons (378 l) of water usage. Error introduced by the measuring and timing instrumentation was estimated to be less than 5%.

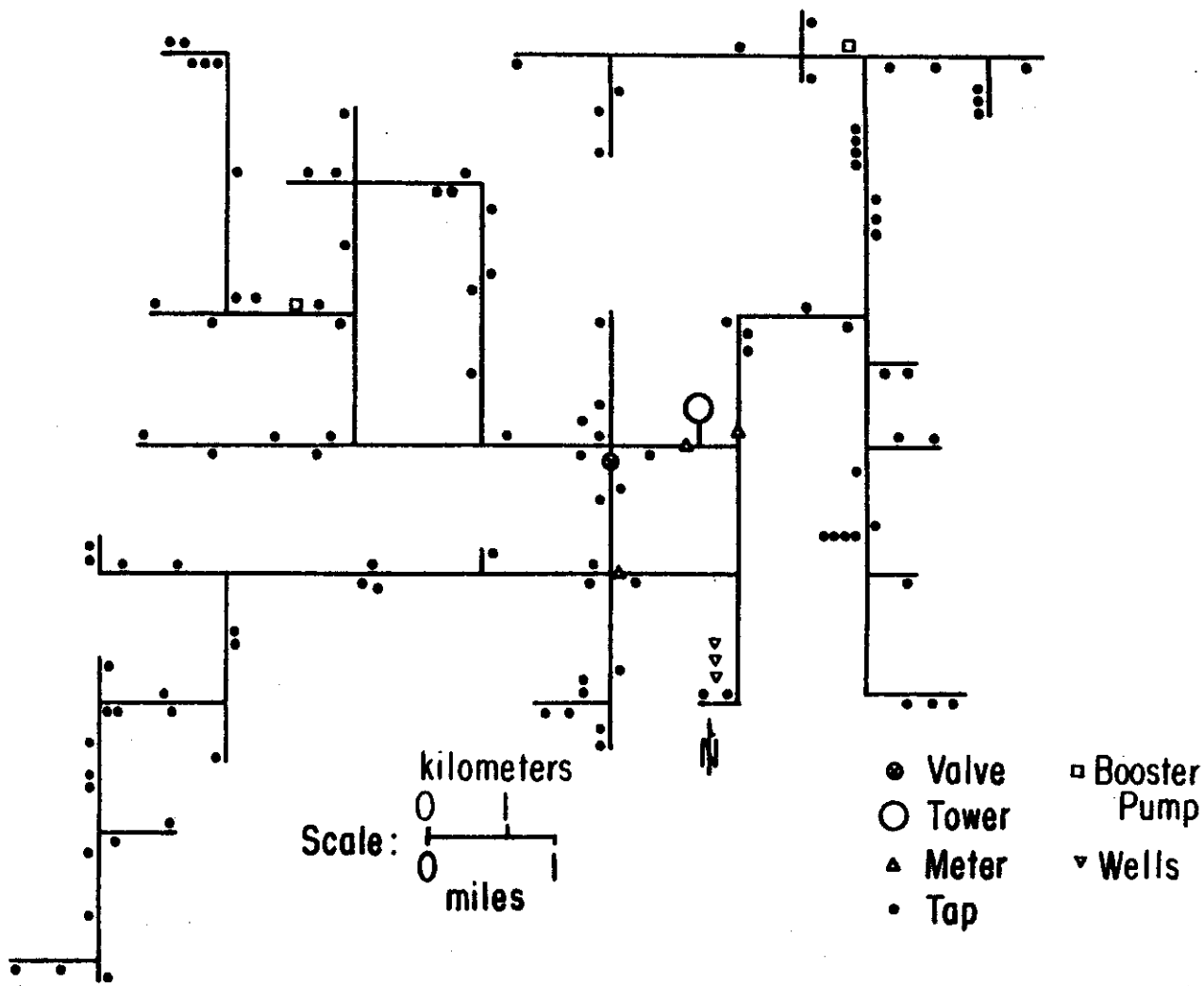

Figure 1. Payne County Rural Water District No. 3
(Not all residences are shown)

USAGE VOLUMES

The monthly average use per tap was calculated as shown below. The results are graphically displayed in Figure 2.

$$\text{Average Monthly Use per Tap} = \frac{\text{Total Monthly Use of the District}}{\text{\# of Taps Using Water}}$$

The average monthly use per residential tap is shown on Figure 3 and was calculated as follows:

$$\text{Average Monthly Use Per Residential Tap} = \frac{\text{Total Monthly Use of District} - \text{Use by Unclassified Taps} - \text{Use by Dairies}}{\text{\# of Residential Taps}}$$

The average monthly use per person living on its district is shown on Figure 4 and was determined thusly:

$$\text{Average Monthly Use Per Person} = \frac{\text{Total Monthly Use of the District} - \text{Use by Unclassified Taps} - \text{Use by Dairies}}{\text{\# of people residing on the district}}$$

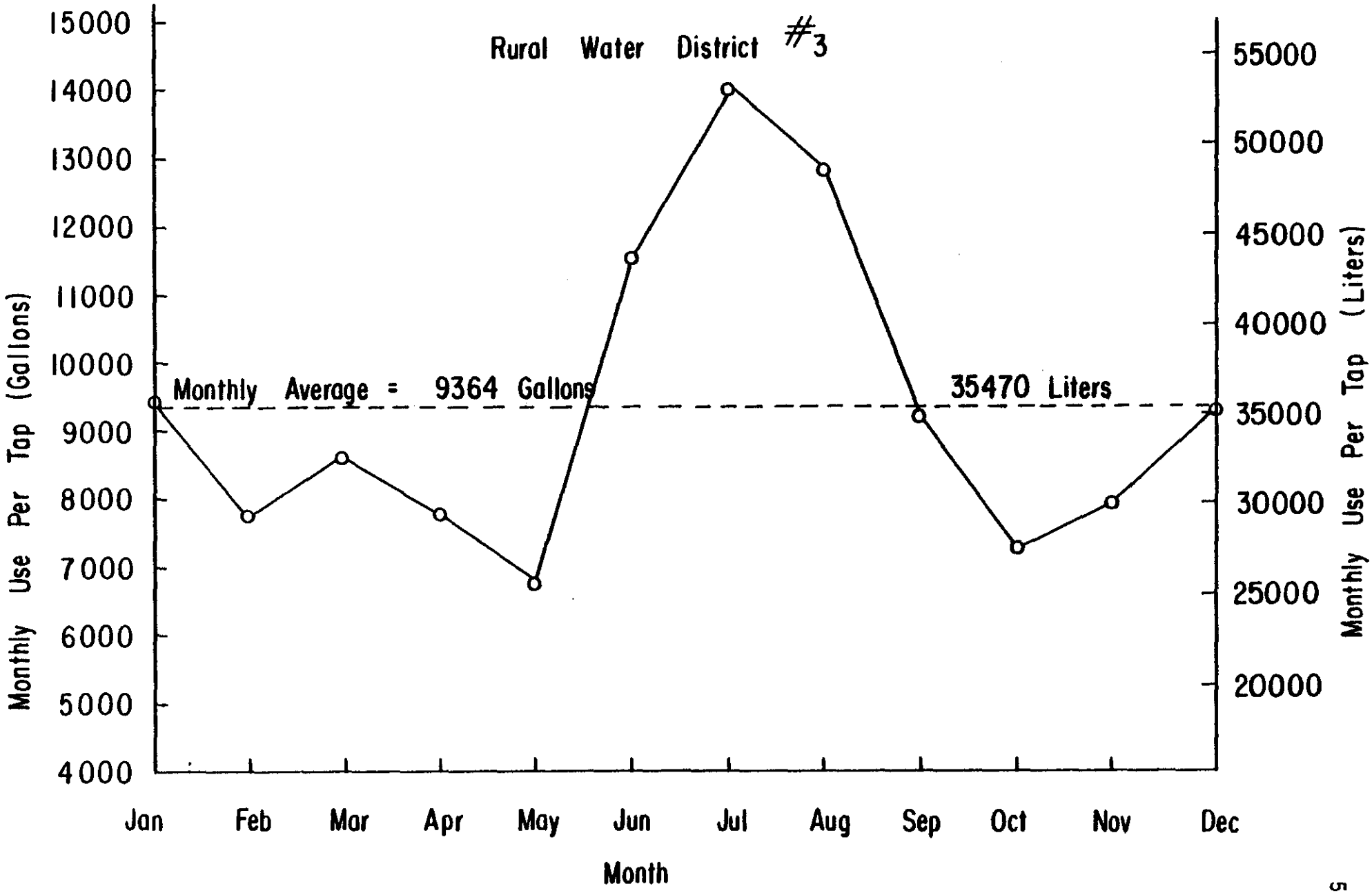

Figure 2. Monthly Use Per Tap for the Months of the Year.

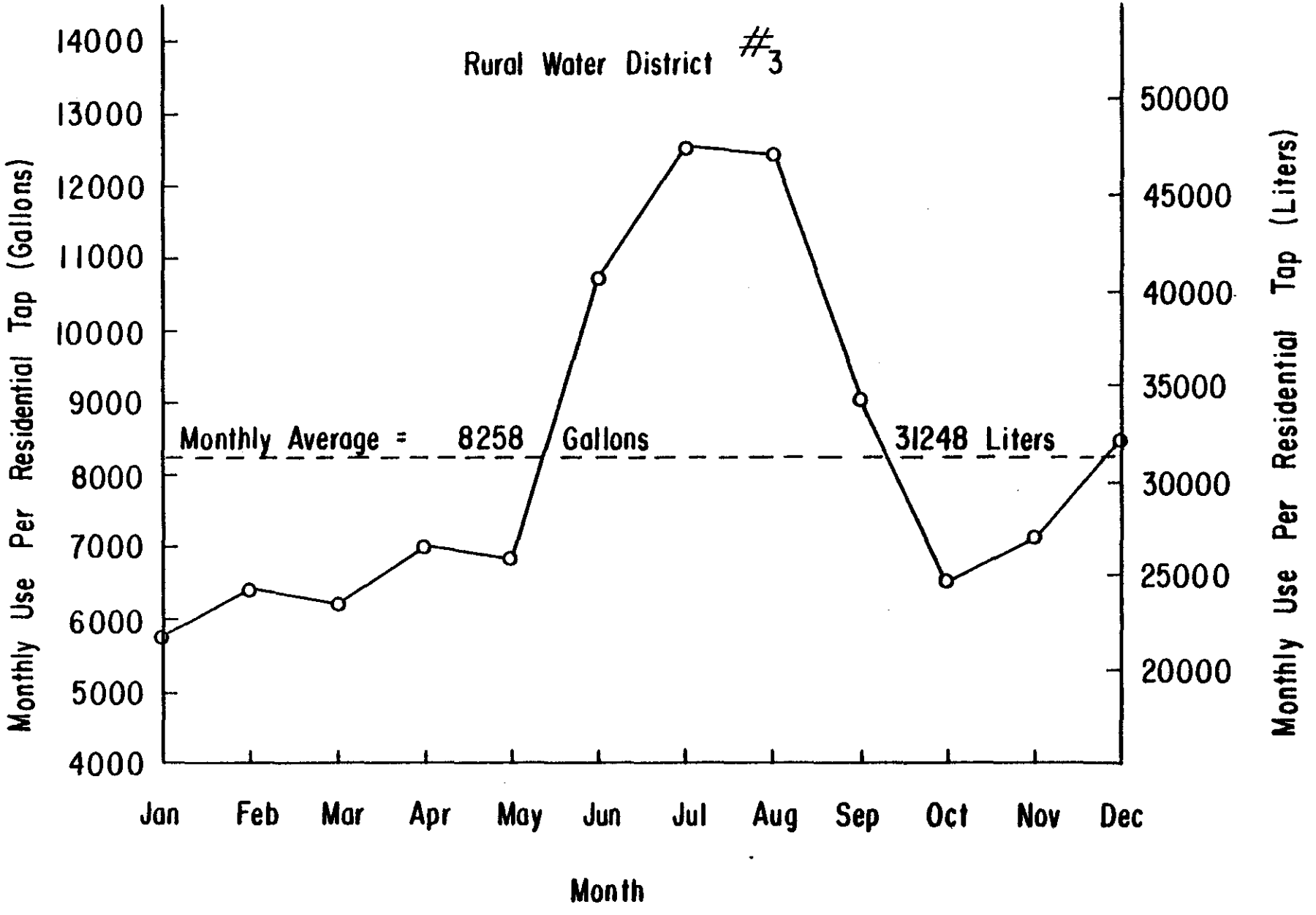

Figure 3. Monthly Use Per Residential Tap for the Months of the Year.

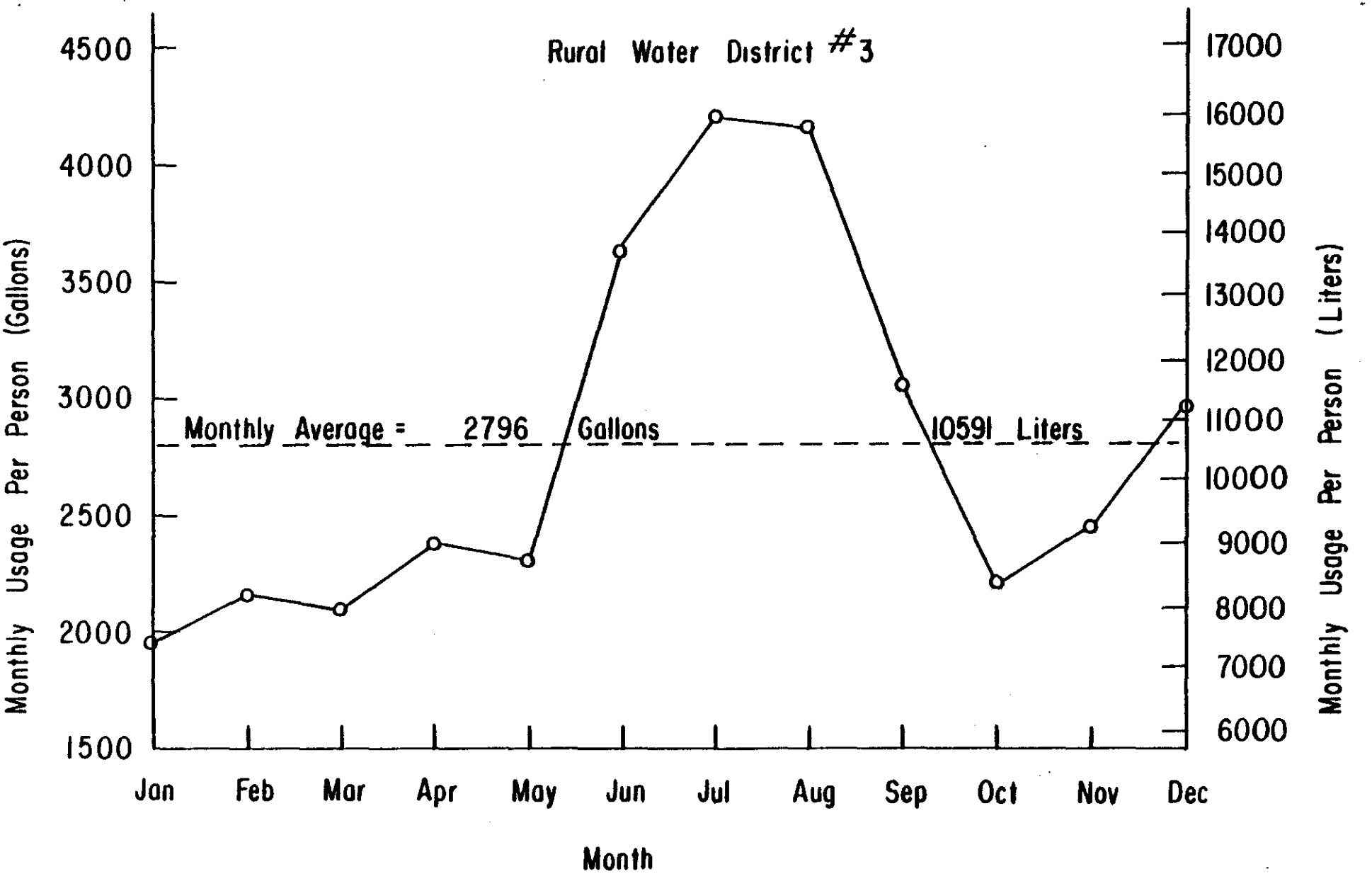

Figure 4. Monthly Use Per Person for the Months of the Year.

The daily demand was calculated from the printed output of the impulse counters and was compared for accuracy with the meter dial readings. The average daily demand per tap and per person on each of the three main lines was determined. Cumulative frequency histograms were prepared for each of the lines and for the rural water district as a whole (Figure 5-8). South Downey had the lowest use of the three main lines. It is difficult to assign a specific cause for this, since individual rural taps vary greatly in the application of their water. Table 1 shows the basic composition of the different main lines.

In order to determine the effect of seasonality on daily water use, Fig. 9-12 were prepared. Scrutiny of the curves verified that June, July, and August usage differed significantly from the rest of the year. Figures 13 and 14 express this result for the different lines and the entire system. The effect of the day of the week on daily demand is considered not to be especially influential from a design viewpoint. Table 2 provides an example of data used to reach this conclusion.

TABLE 1
APPROXIMATE MAIN LINE COMPOSITIONS

	Frye	North Downey	South Downey	Total
# Dairy Taps	0	1	2	3
# Residential Taps	27	23	33	83
# Unclassified Taps	24	11	8	43
# Taps	51	35	43	129
# People	84	58	95	237
# Dairy Cows	0	150	200+	

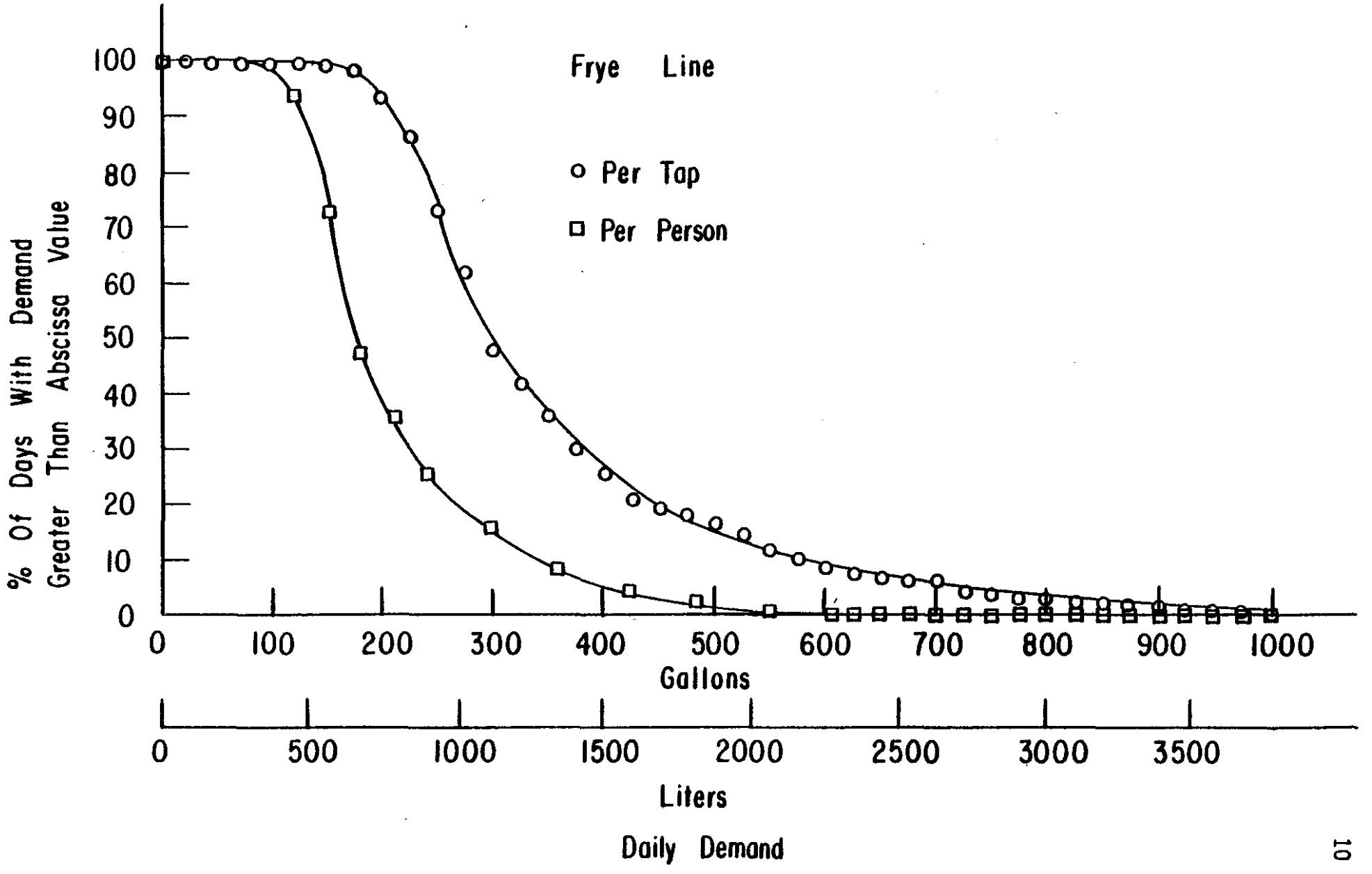

Figure 5. Percent of the Observed Days which had an Average Daily Use Greater than the Amount Shown.

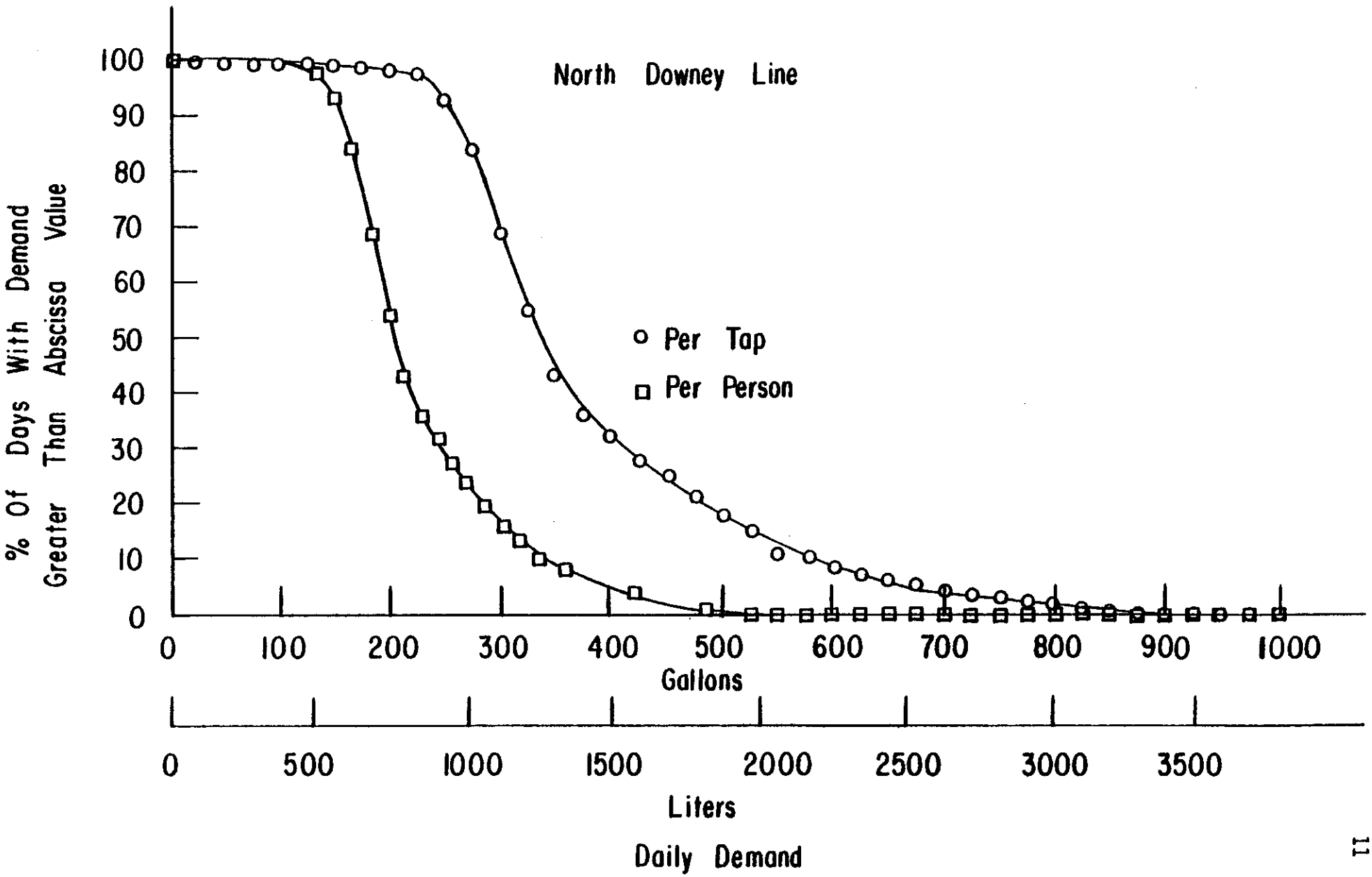

Figure 6. Percent of the observed days which had an average daily use greater than the amount shown.

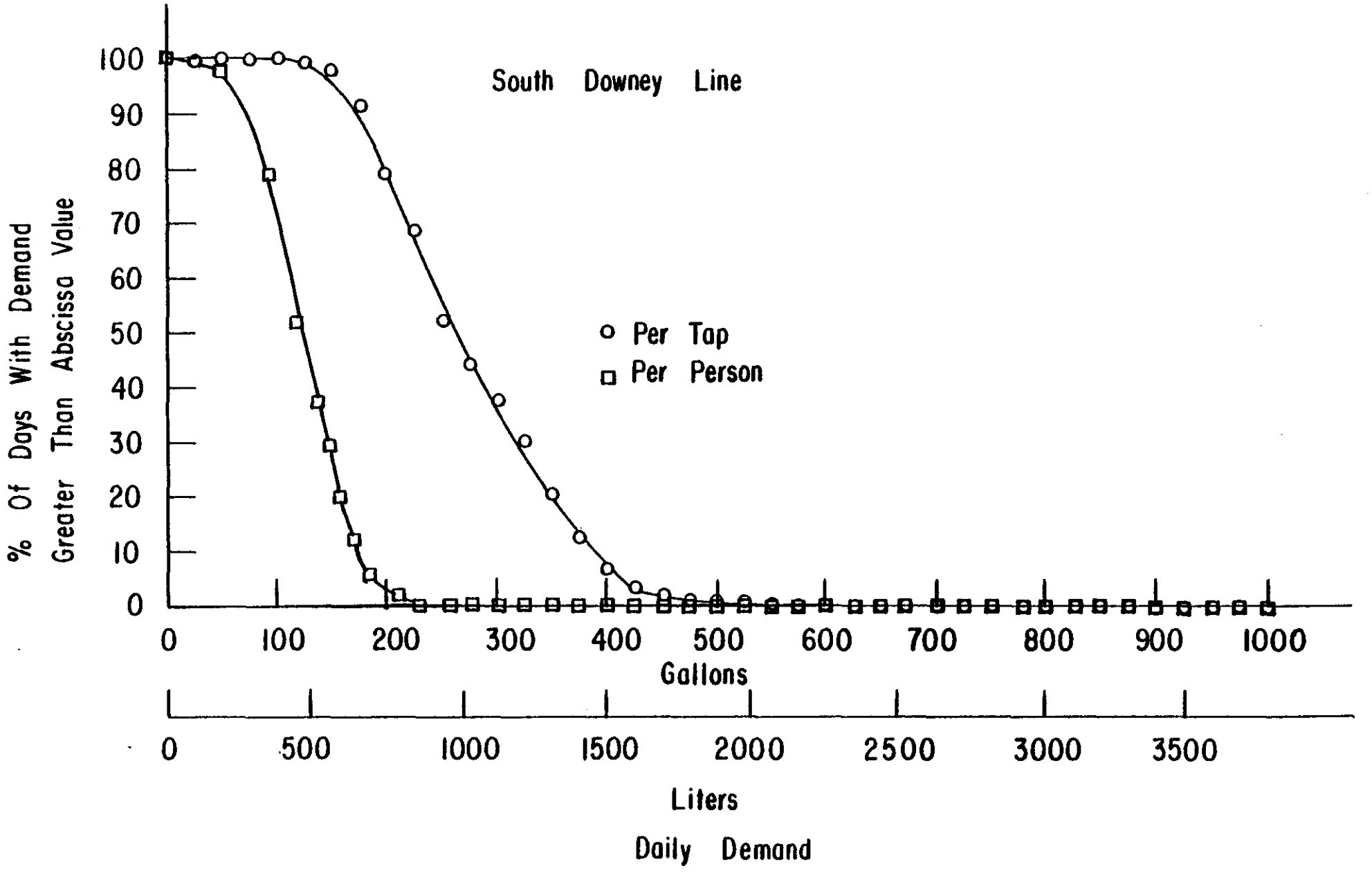

Figure 7. Percent of the observed days which had an average daily use greater than the amount shown.

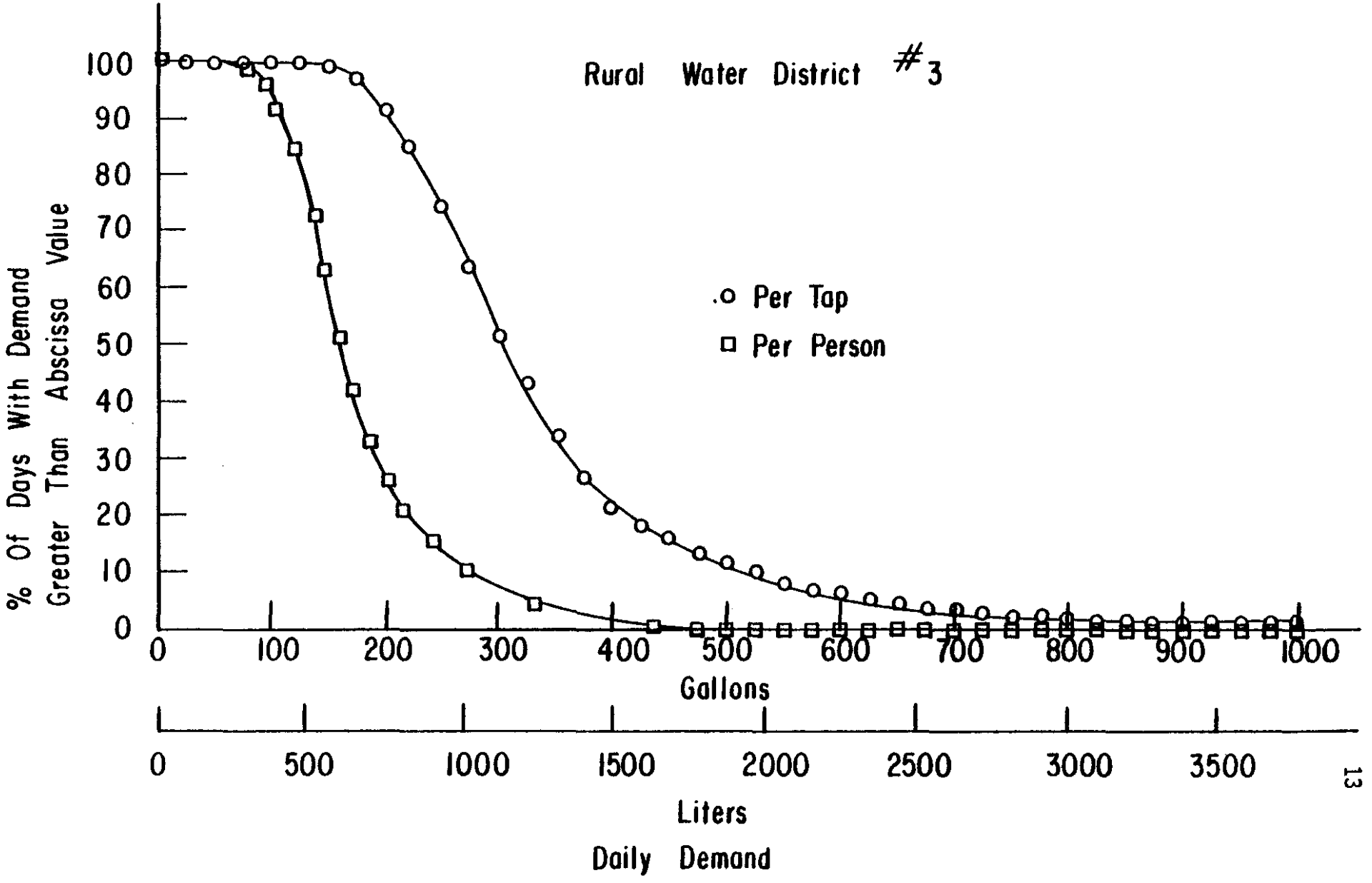

Figure 8. Percent of the observed days which had an average daily use greater than the amount shown.

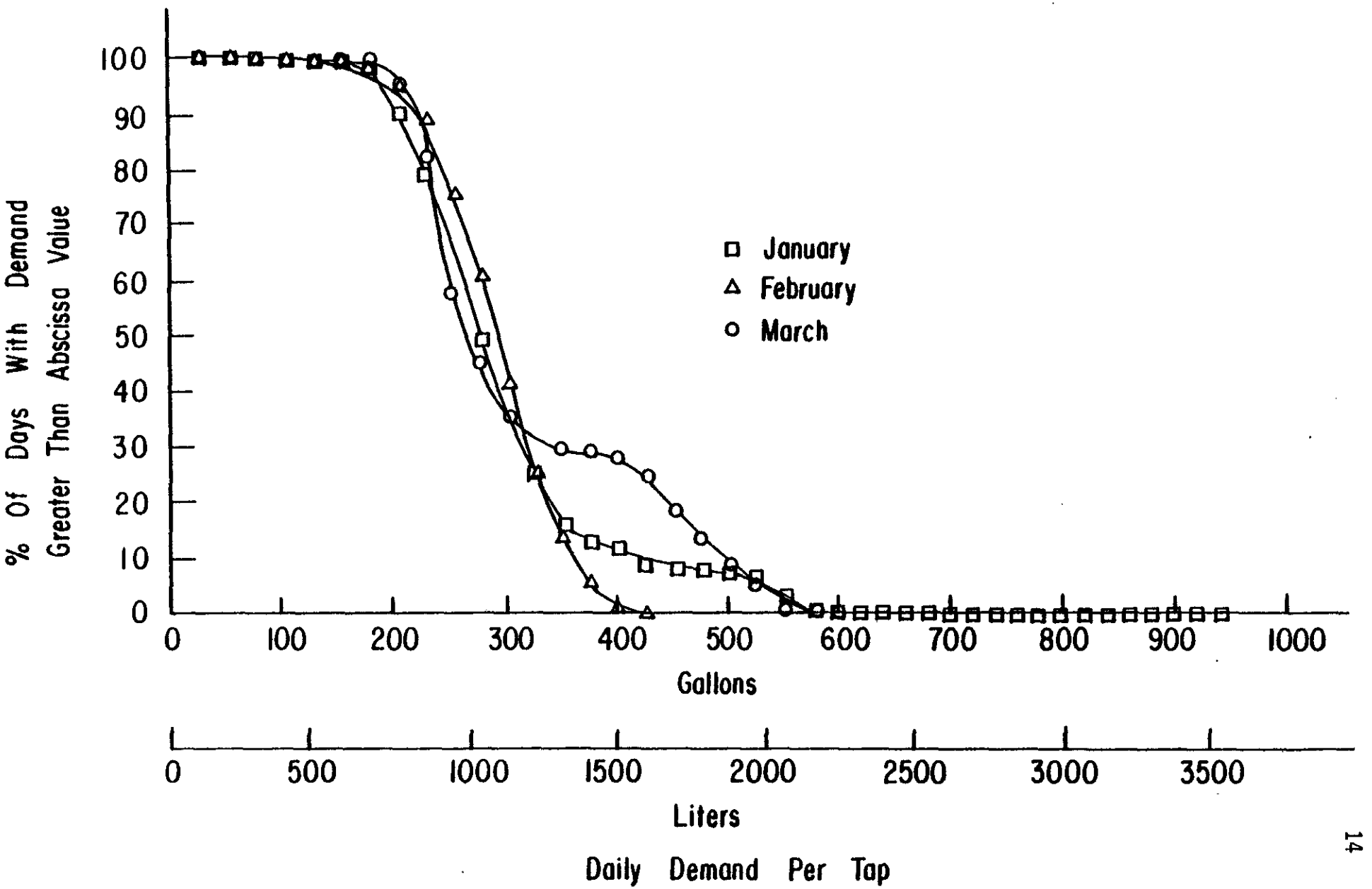

Figure 9. Frequency distribution of daily demand per tap for Rural Water District #3 for the months of January, February, and March.

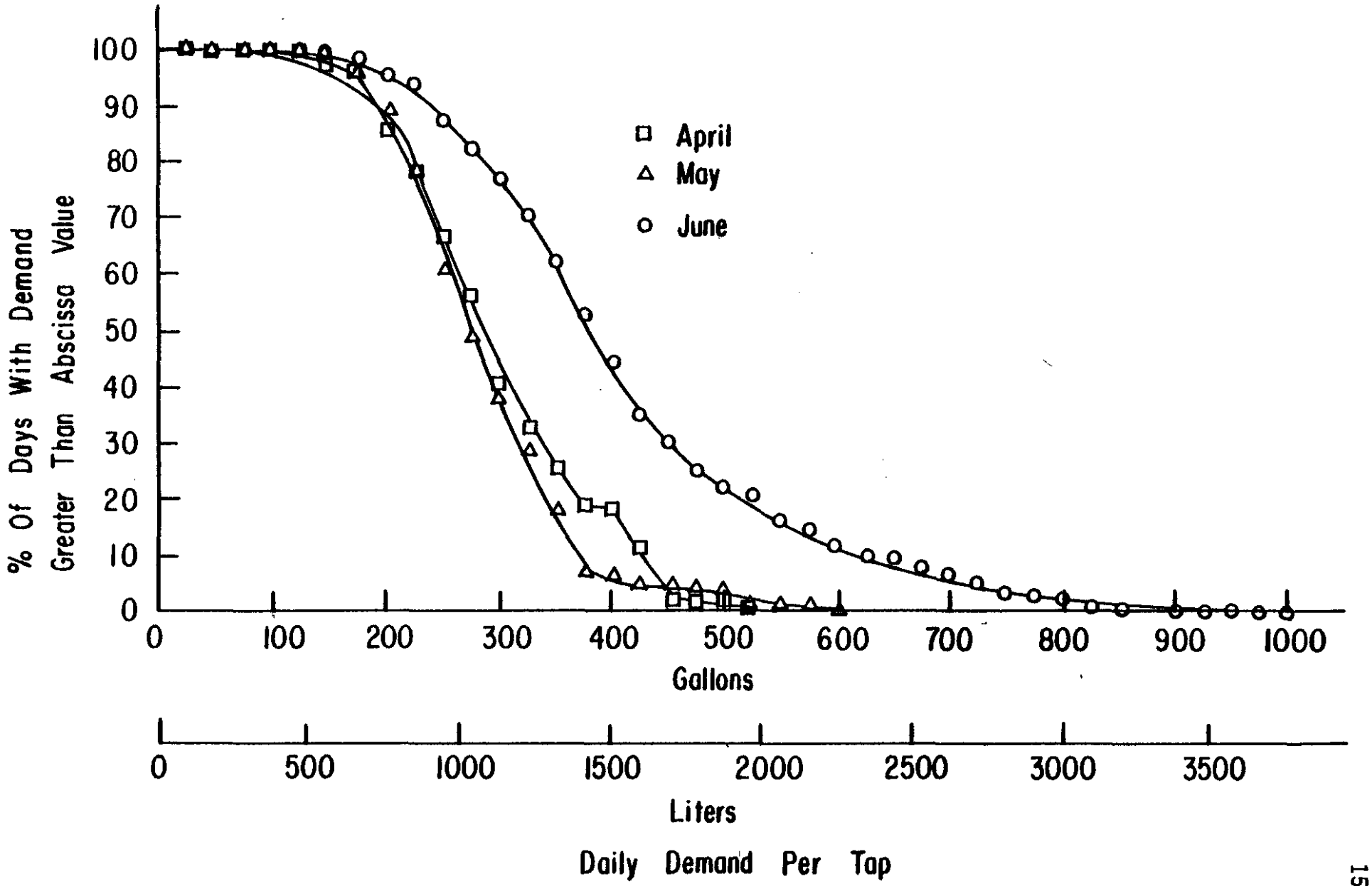

Figure 10. Frequency distribution of daily demand per tap for Rural Water District #3 for the months of April, May and June.

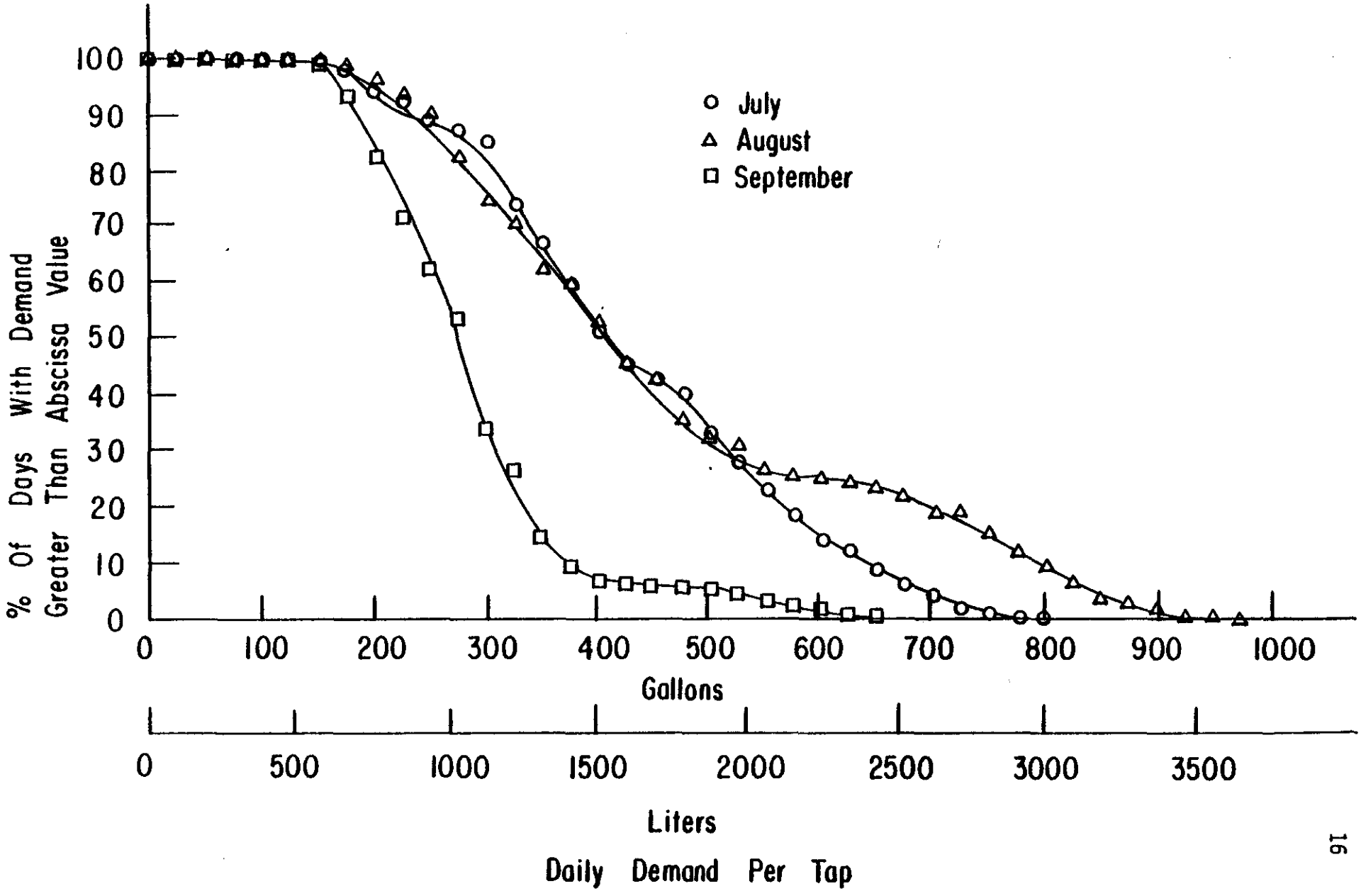

Figure 11. Frequency distribution of daily demand per tap for Rural Water District #3 for the months of July, August, September.

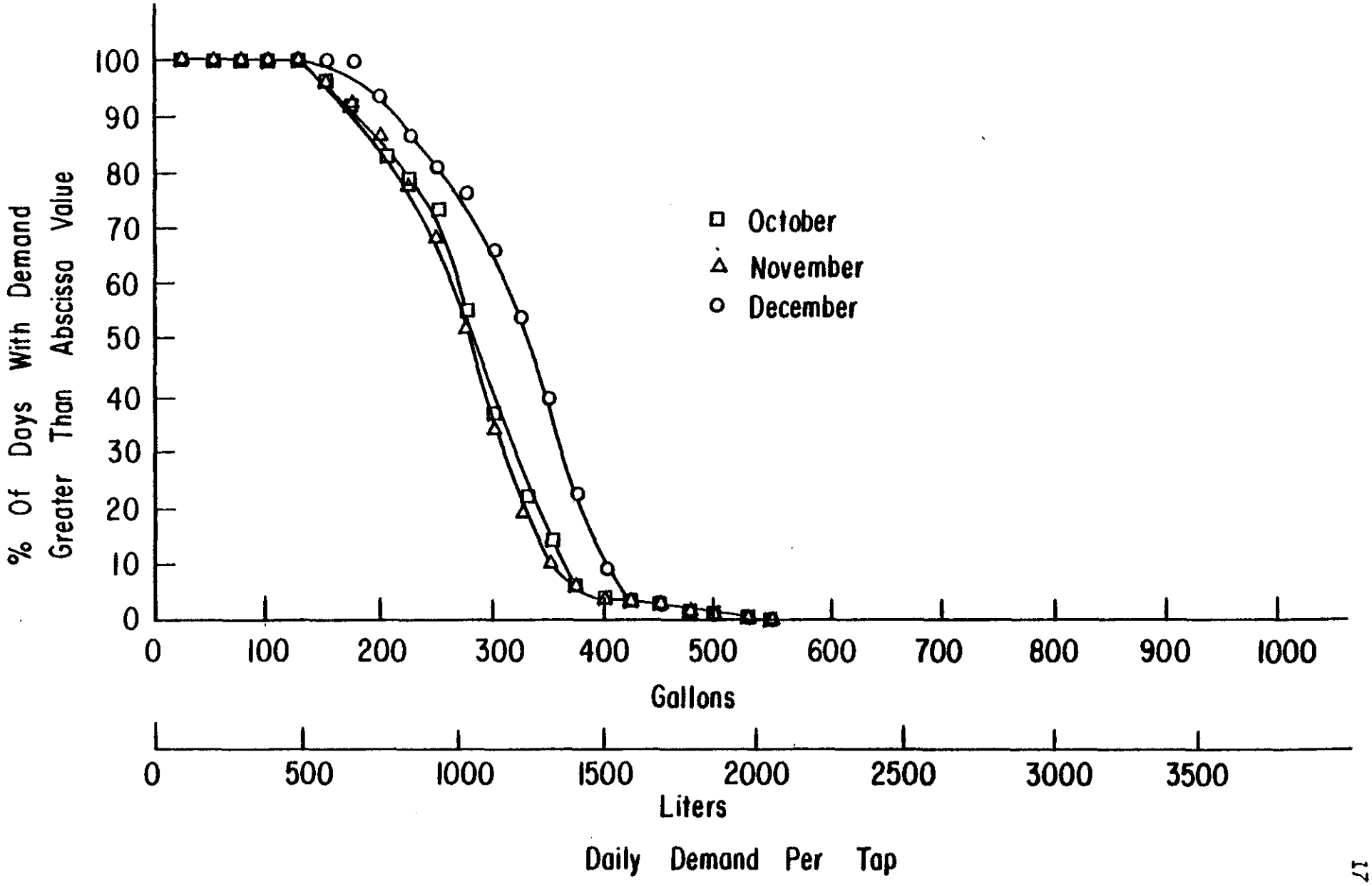

Figure 12. Frequency distribution of daily demand per tap for Rural Water District #3 for the months of October, November, and December.

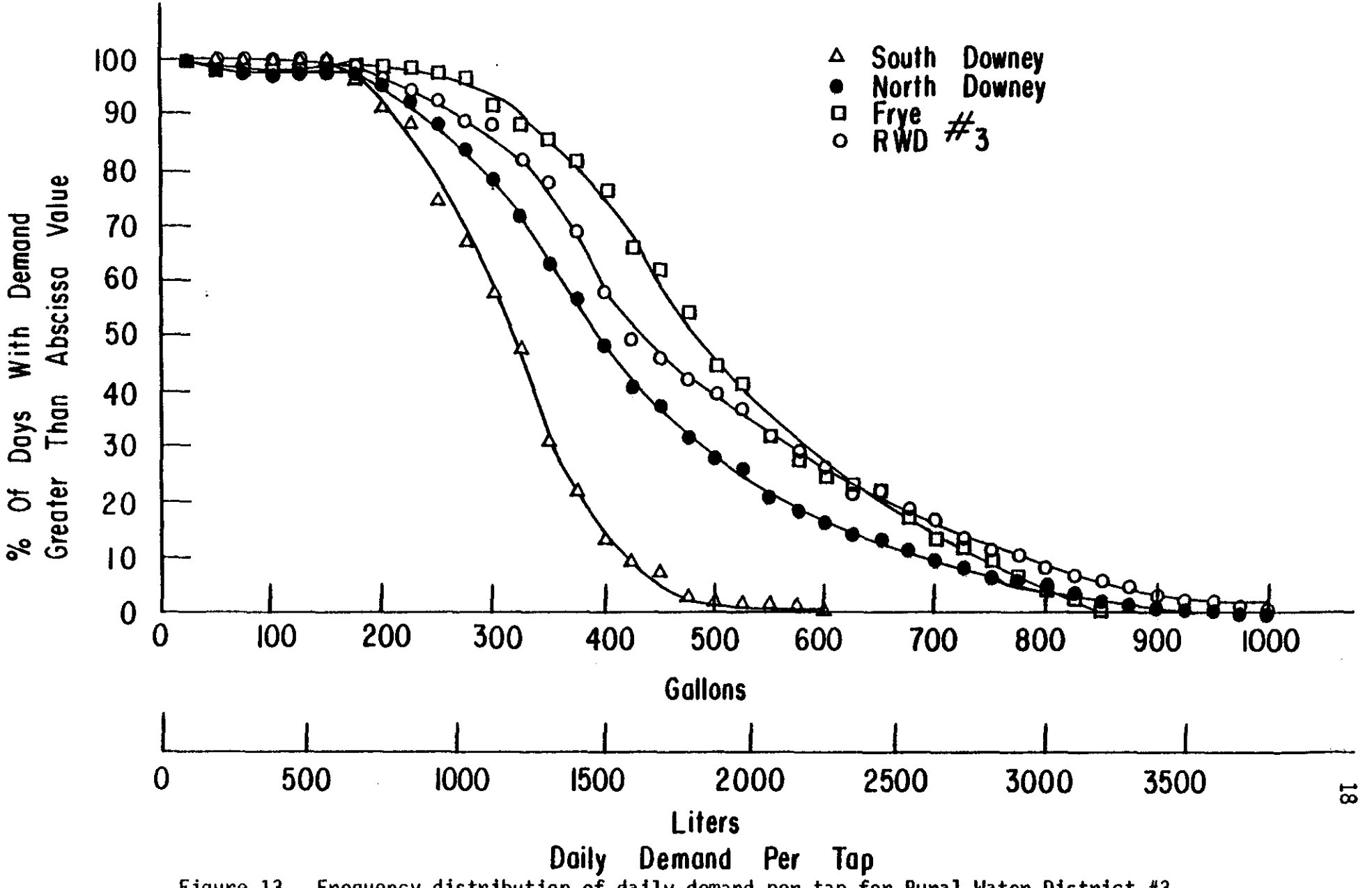

Figure 13. Frequency distribution of daily demand per tap for Rural Water District #3 for the months of June, July, and August.

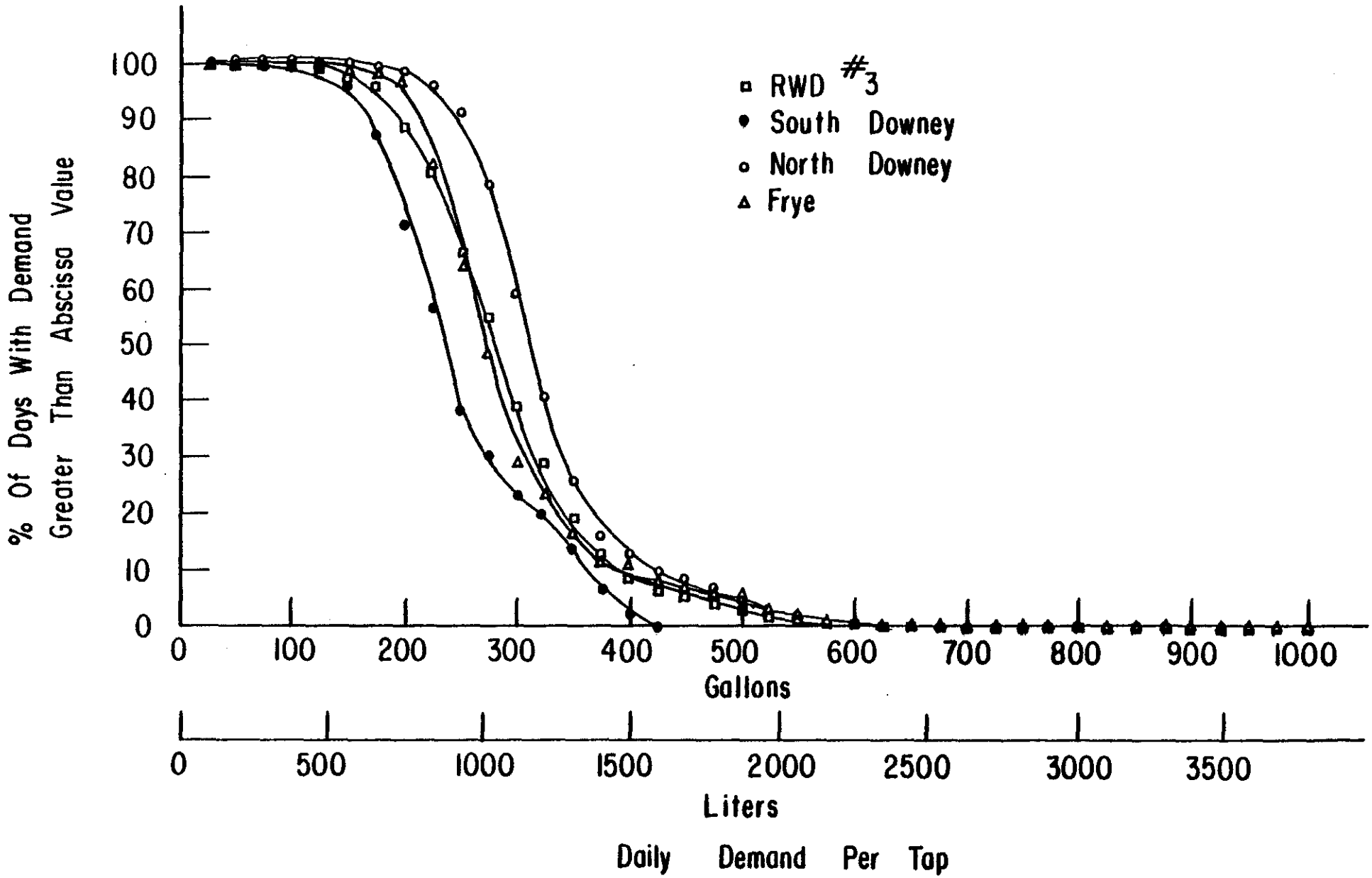

Figure 14. Average of all months except June, July and August.

TABLE 2
AVERAGE USE PER DAY OF WEEK FOR FRYE LINE
April 1976 - May 1977

Day of Week	MON.	TUES.	WED.	THURS.	FRI.	SAT.	SUN.
Avg. Use per day:							
(Gallons)	17,039	15,063	14,641	16,426	14,531	15,205	17,536
(Liters)	64,476	56,998	55,402	62,156	54,985	57,536	66,356

PEAK DEMAND RATES

The impulse counter printed the time after each 100 consecutive gallons (378 l) of flow passed through the meter. The volume of flow divided by the difference in time between any two prints yields the demand rate. The printed tapes for each day were examined and the shortest time between any two prints was used to determine the peak demand rate per 100 gallons (378 l) interval. A similar technique yielded the peak demands per 200, 300, 400 and 500 gallon (757, 1135, 1514, and 1892 l) intervals. The data were used only when there was exact correlation in the number of gallons used as recorded by the water meters and the impulse counters. The peak demand per tap and per person was used to prepare Figures 15 and 16. Since the figure representing peak demand includes unclassified and dairy taps, the calculated peak demand per person is higher than the actual demand.

Analysis of the time of day when peak demands most often occurred yielded the histogram of Figure 17.

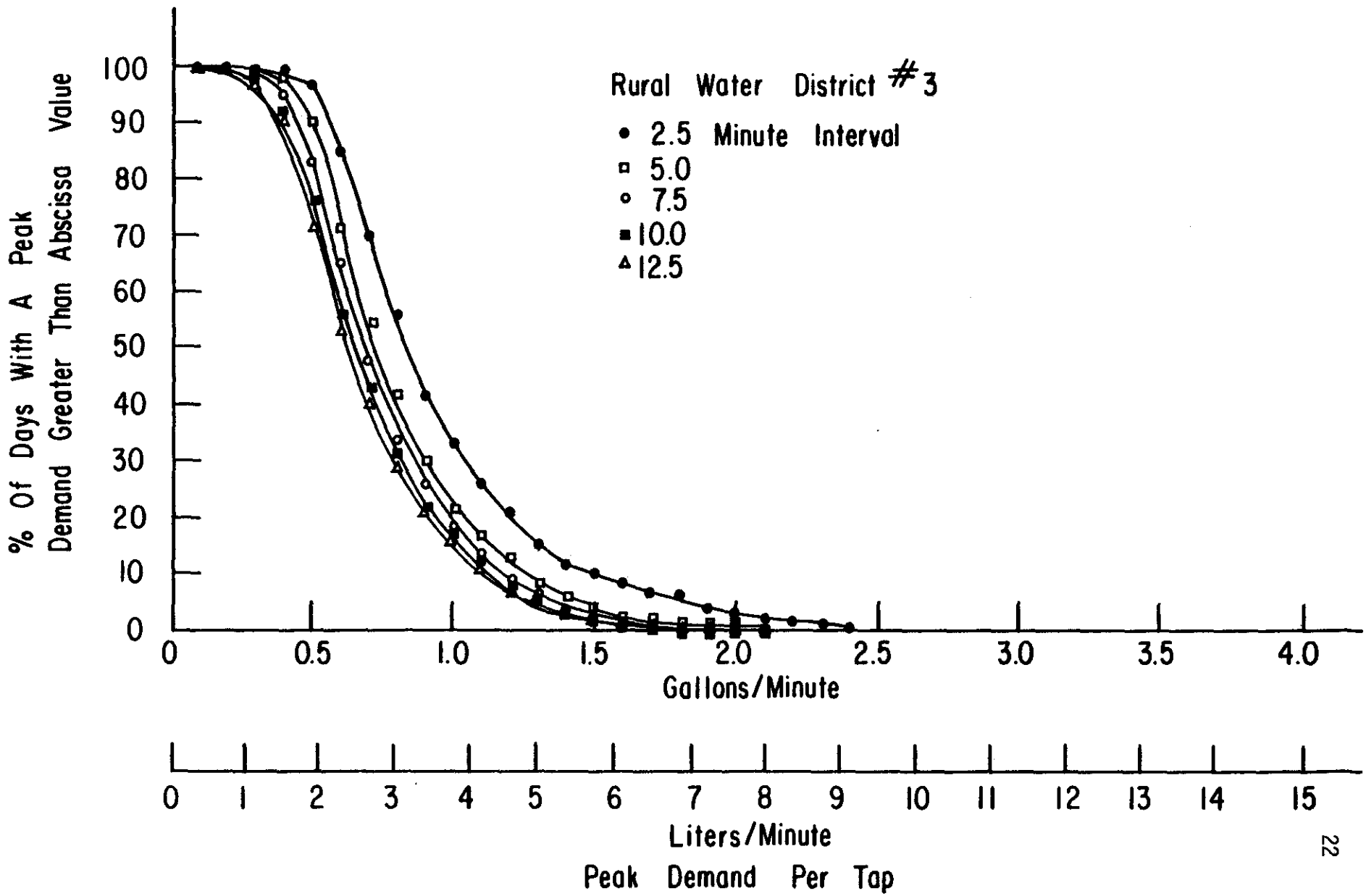

Figure 15. Percent of days having a demand in excess of the indicated flow rate for different periods of time.

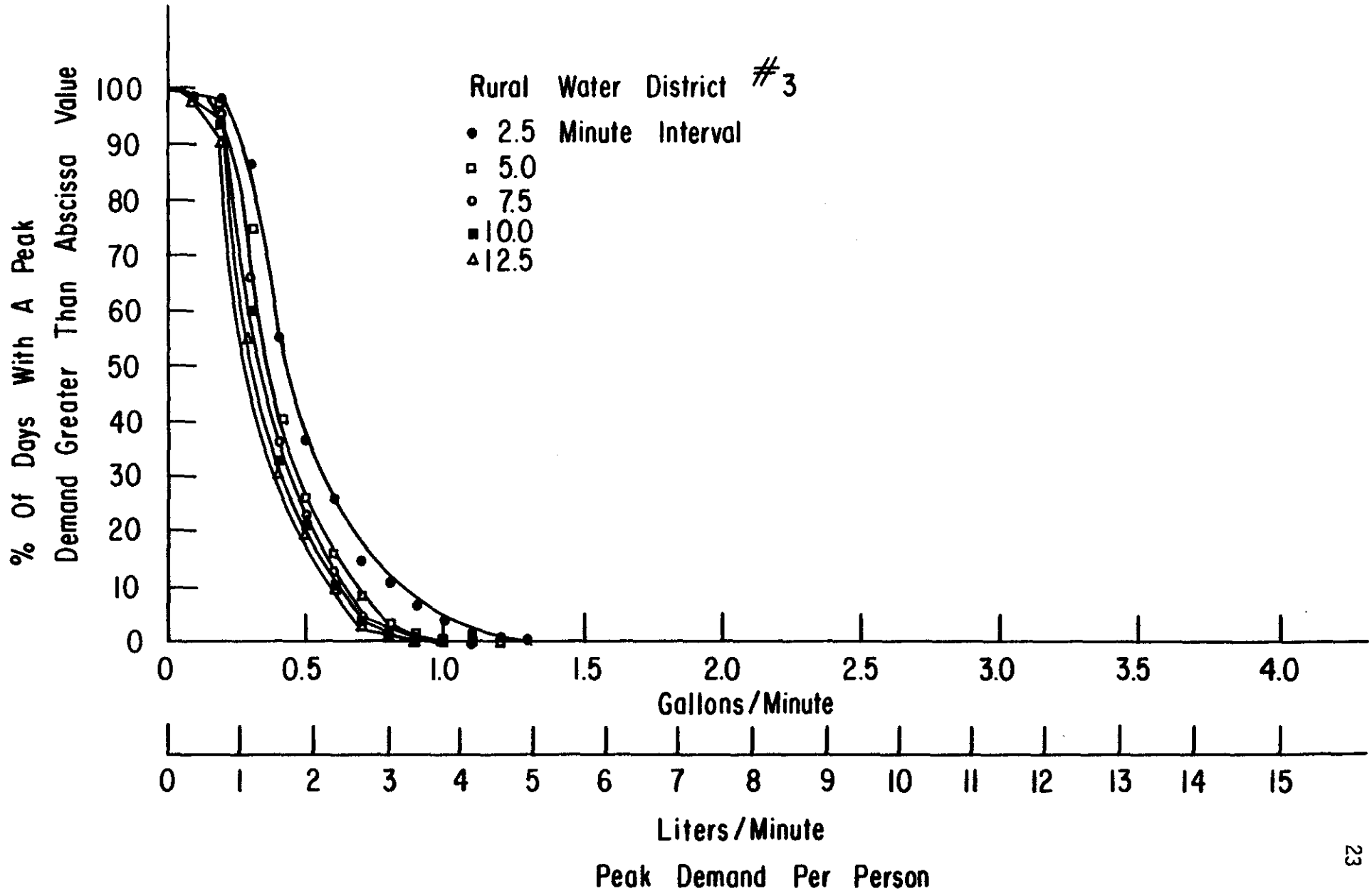

Figure 16. Percent of days having a demand in excess of the indicated flow rate for different periods of time.

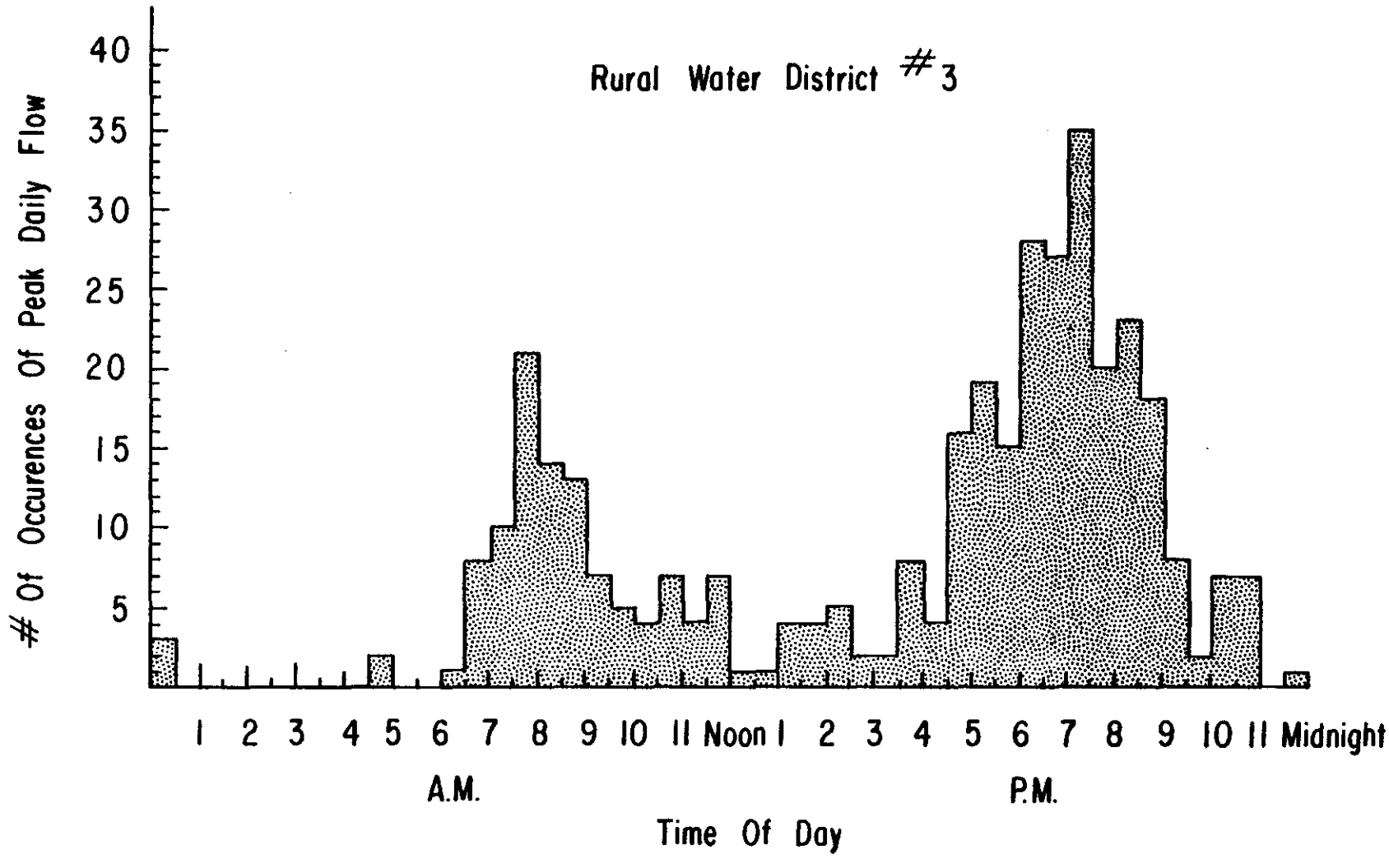

Figure 17. Histogram of time of occurrence of peak flows.

SUMMARY AND CONCLUSIONS

Average monthly usage rates for Rural Water District No. 3, which is assumed to be representative of rural water districts in Oklahoma, are found in Table 3.

TABLE 3
MONTHLY WATER USE

	Gallons	Liters
Average Monthly use per tap	9,364	35,470
Average Monthly use per tap: (June, July and August)	12,799	48,431
Average Monthly use per tap of all months except June, July and August	8,219	31,101
Average Monthly use per Residential tap	8,258	31,248
Average Monthly use per Person	2,796	10,501

The cumulative frequency curves of Figure 8 were used to estimate a daily demand design value which one would expect to be exceeded on only 15% of the days. Accordingly, the design daily demand would be 187 gallons (708 l) per person or 455 gallons (1,722 l) per tap. Utilizing the results of Figures 13 and 14 as well, one obtains the results shown in Table 4.

TABLE 4
85% ADEQUACY DAILY DEMAND VALUES

	Gallons	Liters
Daily demand per tap	455	1,722
Daily demand per tap: (June, July, August)	620	2,346
Daily demand per tap: (Average of all months except June, July and August)	365	1,381

The general rule of thumb for this district when comparing use volumes per person to use volume per tap is 1.84 people per tap. This varied from 1.65 to 2.2 on the different main lines.

Figures 15 and 16 were utilized to prepare Table 5.

TABLE 5
85% ADEQUACY PEAK DEMAND VALUES

	GPM	LPM
Peak demand per person	.71	2.8
Peak demand per tap	1.3	4.9

The optimal period to pump to refill storage in the standpipes (i.e. when use is lowest) is from 11:00 pm to 6:30 am.

Rural water districts generally have great potential for future expansion. Estimates of the number of taps to be added during the next 10-20 years should be a part of any design procedure, and appropriate allowances should be made in system design.

The demand for water should have some relationship to price. During the design of the district the average bill was estimated at $13.00 per month , which may be high in relation to urban water services. The average monthly use of 9364 gallons per tap calculates to $16.18 per month using the pricing schedule for the district as listed in Table 6. The summer usage in excess of 12,000 gallons per month, which is about 3 times the design value, does not appear to be severly limited by price. The June, July, and August usage of 12,799 gallons calculates to a bill of $17.90 per month.

TABLE 6
RATE SCHEDULE FOR RURAL WATER DISTRICT #3

First 2,000 gallons - $9.00
Next 2,000 gallons @ $1.50 per 1,000 gallons
Next 2,000 gallons @ $1.00 per 1,000 gallons
Next 2,000 gallons @ $0.75 per 1,000 gallons
All over 8,000 gallons @ $0.50 per 1,000 gallons

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