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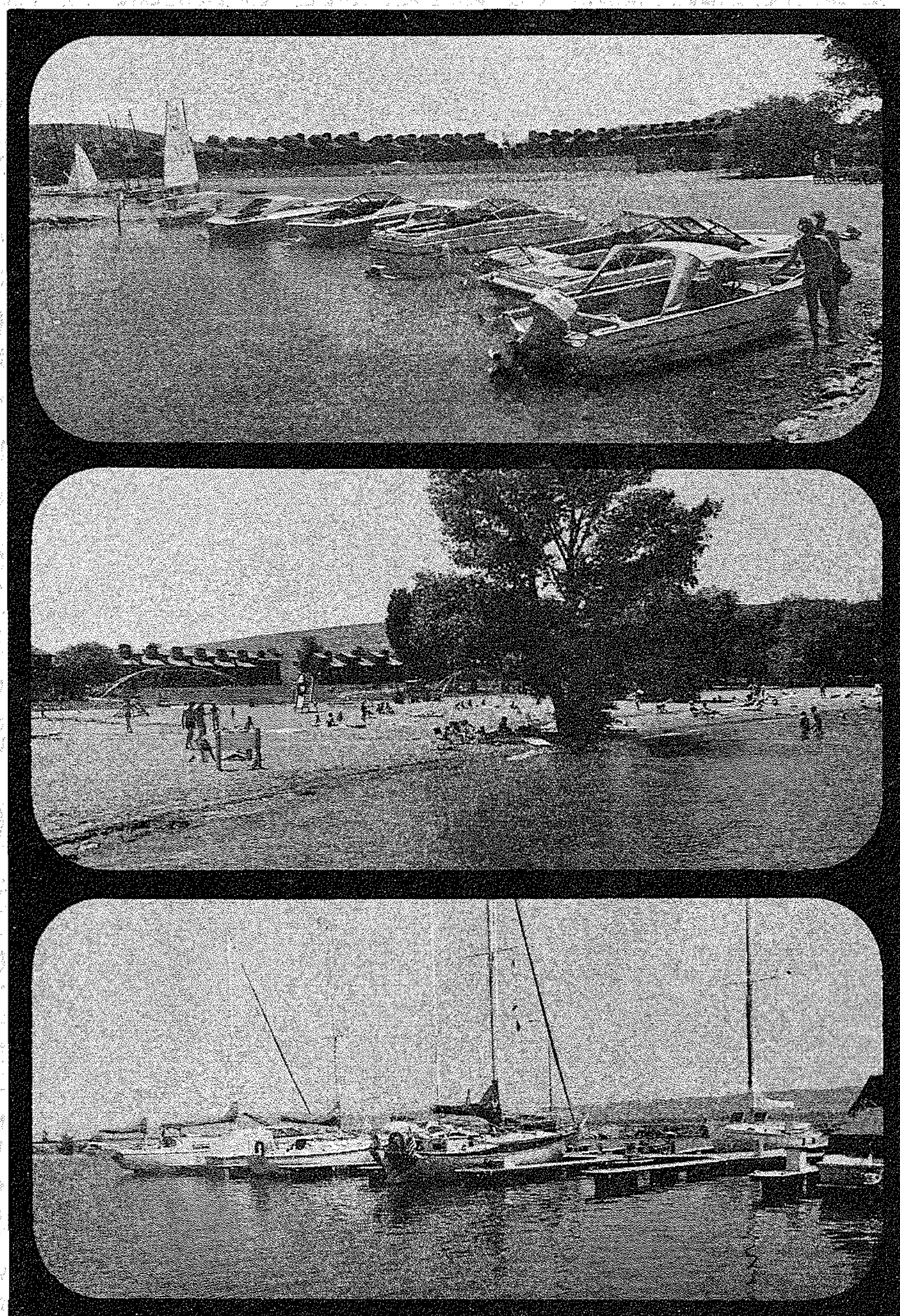

Utah Water Research Laboratory
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December 1980

WATER RESOURCES PLANNING SERIES
UWRL/P-80/06

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ABSTRACT

Design criteria for drinking water systems at recreation developments, particularly summer home type, cause frequent confrontations with regulatory agencies. Developers claim extremely low water use rates due to low occupancy rates, but regulatory agencies are concerned about changes over time from essentially weekend use to more permanent residency and also about occasional peak day water demands similar to those of municipal systems. Little empirical data have been available to resolve such questions. This study included the gathering and analysis of both historic water use measurements and additional daily and instantaneous measurements during peak seasons at 11 Utah and one Wyoming recreation development. The water demand parameters studied included average, peak month, peak day, and instantaneous events at mountain cabins, resort condominiums, marinas, and recreation vehicle campgrounds. The results are compared to existing design criteria of the Utah Division of Environmental Health.

ACKNOWLEDGMENTS

The authors are indebted to Kurt Gernerd for his work in gathering data for this study. Gratitude is also expressed to water system operators and managers at the 12 recreation developments who assisted in providing data from files and also in allowing the research team access to system instrumentation during the study. Finally, a special thanks to the black bear at Pine Mountain for its restraint in not eating Kurt Gernerd prior to completion of his data gathering.

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INTRODUCTION

Municipal Versus Recreation Design Criteria

State regulatory agencies are with increasing frequency being confronted with questions related to appropriate design criteria for systems supplying water to recreation developments. For example, developers of second homes or "summer" homes in mountain environments often propose water supply systems too small to meet existing standards for such systems (which are often identical to standards for municipal systems). The developer may have access to a spring source or propose facilities such as pipes and reservoirs as adequate for this "special" use even though they are too small to meet accepted standards for domestic water supply to municipal users. Developers have sought to justify proposed systems providing less than the normally required capacity by citing reasons which include:

1) Low occupancy rates relative to permanent residences.

2) Little or no landscaping.

3) Providing capacity for fire flows is useless because no fire department serves the area.

4) When people are on vacation, they use less water by avoiding car washing, cooking less, etc.

State regulatory agencies, such as the Department of Health, in trying to protect the public against low pressure periods and infiltration of polluted water into the public supply, may respond with the following defense of using standards similar to municipal to supply recreation dwellings:

1) Despite other periods of low occupancy, peak period uses such as on weekends and holidays may equal or exceed use rates in permanent residences. For example, several generations of a family may enjoy meeting at grandfather's cabin on nonworking days.

2) Despite spartan type life styles portrayed by original developers, mountain cabins tend to become more and more permanent residences over time. Eventually, yards are landscaped--sometimes as a fire protection. Replacement of natural vegetation, such as tall grass which becomes dry, with planted grass which is cut and watered, substantially reduces expected damage from forest fires.

In Utah, the State Division of Health enforces design standards for capacities of supply and distribution facilities for both municipal and recreational systems. Since so little empirical data have been available upon which to base standards in recreational areas, the Division has required essentially municipal type capacities for new "summer home" type developments and somewhat lower capacities for condominiums and campgrounds. However, developers often request continued operation of water systems as the number of users at recreation developments grows beyond what the Division of Health believes permissible. In such situations, particularly if the source capacity is hydrologically limited such as with fixed spring capacities, the agency may require the developer to justify his claim of adequacy of the system by measuring water use over an extended period. Some of the data presented in this report were acquired in this manner.

Clearly, additional data are needed to identify differences in water demand functions between municipal and recreation type developments. The data need to cover uses during various time intervals such as annual average, peak season, peak day, and instantaneous peaks.

Scope and Objectives

This report presents the results of a study on water use of recreation developments in Utah. The state funded UWRL project received cooperation and support from the waterworks office of the Division of Health which is the regulatory agency for all public water systems in Utah. The objective was to define reasonable flow rate design standards for drinking water systems at various types of recreation developments.

The first task was to identify various categories of recreation developments to study. The following list was selected:

a. Single family residence mountain cabins.

b. Resort condominiums with both summer use peaks and winter use peaks.

c. Marinas with overnight camping facilities.

d. Recreation vehicle campgrounds.

Twelve locations were selected for gathering data on water use (Figure 1). Four of these were in the summer cabin category because it has generated the greatest controversy. Four condominium resorts were included (two with summer peaks and two with winter peaks) and two sites in each of the remaining categories were selected.

The project scope was further defined by selecting the following list of water use parameters to study:

a. Peak season and month (referred to as long term data).

b. Peak day (to be estimated from daily data).

c. Instantaneous peaks (referred to as short term data).

It was not possible within the time and money limitations of this study to assemble or collect all water use data necessary to characterize the demand parameters in all three time frames for all four types of recreation development. Fortunately, in response to urgings by Division of Health

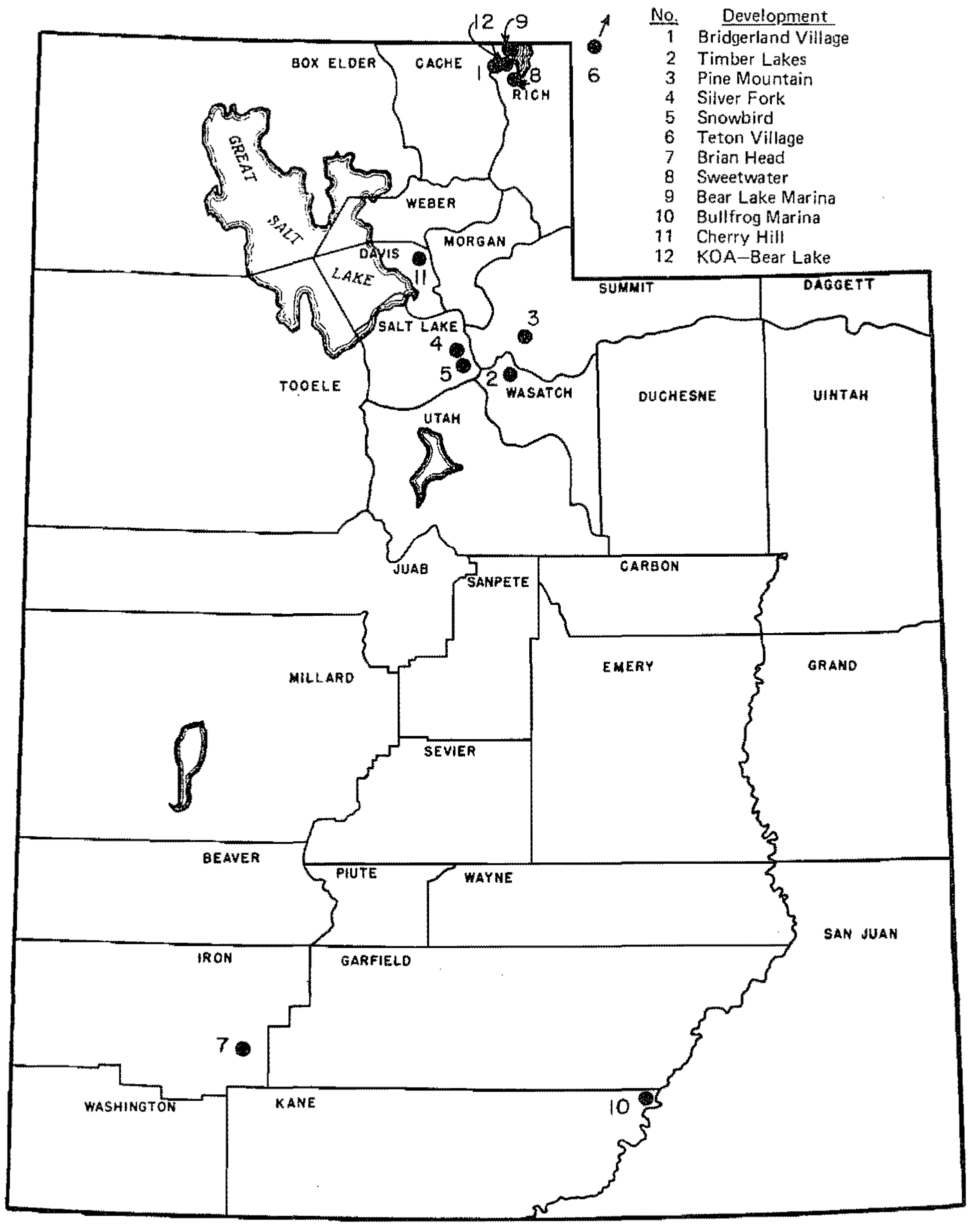

Figure 1. Location of developments included in the study.

personnel, a significant amount of monthly and daily water use data recorded by developers became available and permitted a more thorough analysis than would have been possible otherwise. These data were supplemented by measurements made by the research team during the summer of 1979. Both daily and instantaneous measurements were obtained wherever suitable master meters were available.

One of the difficult aspects of determining unit water use levels at some recreation sites is defining the units which should be used to estimate water needs. For example, should water facilities at marinas be sized according to number of boat slips, number of camping sites, or some combination of both? The unit definition selected for each type of development will be given later with the description of each resort.

REVIEW OF LITERATURE

There has been almost no research on water demand at recreation developments reported in the literature. With the exception of one report, this section will be limited to a discussion of design standards followed by western U.S. state regulatory agencies in approving water systems at recreation sites.

Research Reports

A report entitled "Design of Water and Wastewater Systems for Rapid Growth Areas and Resorts" (Flack 1976) is devoted mainly to a discussion of growth rates in boom towns and resort areas and suggesting design innovations for these sites; however, it does include some unit water use data at major ski resorts, such as the following discussion of water use at Vail, Colorado:

> Monthly per capita water usage at Vail, Colorado, a typical large destination ski resort, is not notably different from that which occurs in a typical suburban area. The pattern of total monthly water usage, however, is noticeably dissimilar from that of ordinary residential communities.... Both Vail and Meeker show considerable irrigation usage, with Vail's peak period being slightly later due to its higher elevation, but Vail shows high usage during the winter months due to the winter sport activities. Average water use in 1973 at Vail was about 200 gpcd during the summer and 100 gpcd during the winter. These values are indicative of a low occupancy rate and heavy irrigation during the summer and a high occupancy rate with no irrigation during the winter ski season.
>
> Forecasting future water usage in destination resorts is usually related directly to the forecasted population, but must be adjusted for the percentage of the housing which is actually occupied. Maximum occupancy generally occurs during the Christmas holidays. The housing units at Vail have been estimated to be only 45 percent occupied in May.
>
> Per capita water usage, based on number of skiers, at day-type ski areas is considerably less than at destination resorts. Average uses are found to be about 8 gpcd at Winter Park, a large Colorado day-type area. At Wolf Creek Pass ski area, rates as high as 12 gpcd have been observed during weekdays when skier usage is normally well below the weekend levels.

The U.S. Forest Service and other agencies have accumulated data on water flows and characteristics in certain public recreation and camping areas. When site specific data are not available, design flow suggested by the Forest Service (Flack 1976) is as given in Table 1.

Utah Design Standards

The Utah regulatory agency concerned with drinking water system design standards is the Department of Health. This agency's design standards are included in a document called "State of Utah Public Drinking Water Regulations" (Utah Dept. of Health 1979b). Some recreation related standards are detailed in separate pamphlets such as one entitled, "Recreation Camp Sanitation Regula-

Table 1. Developed for use in Region 2, U.S. Forest Service.

Type of Establishment	gal/day/person
Resident Occupant:	
Seasonal use	75
Year round	100
Camper:	
No flush toilets or showers provided	10
Flush toilets, but no showers provided	40
Flush toilets and showers provided	45
Picnicker:	
No flush toilets provided	5
Flush toilets provided	10
Swimmer:	
No bathhouse, flush toilets or showers provided	2
Flush toilets in bathhouse, but no showers	5
Flush toilets and showers provided	10
Picnic and Swim Area Participant:	
No bathhouse, flush toilets, or showers provided	5
Flush toilets in bathhouse, but no showers	10
Flush toilets and showers provided	15
Boat Launch Area Participants:	
No flush toilets provided	5
Flush toilets provided	10

tions" (Utah Dept. of Health 1979a). Utah has by far the most detailed regulations in regards to minimum flow and storage capacities for both municipal and recreation type systems. The recreation categories for which design standards are specified are summarized in Table 2.

Other States

No other western U.S. state has quantitative standards for recreation type water systems, in fact, very few specify quantities for municipal systems. Several western states (Idaho, Wyoming, and Montana) have adopted the "Ten State Standards" (Great Lakes-Upper Mississippi River Board of State Sanitary Engineers 1976) as their standard. That document does not differentiate between municipal and recreation type systems. It includes only a general statement on quantities required for municipal systems such as:

> The quantity of water at the source shall:
>
> a. Be adequate to meet the projected water demand of the service area as shown by calculations based on the extreme drought of record.
>
> b. Provide a reasonable surplus for anticipated growth.
>
> c. Be adequate to compensate for all losses such as silting, evaporation, seepage, etc.

Pipe diameters are required to be 6 inches minimum for fire flows or "Any departure from minimum requirements shall be justified by hydraulic analysis and future water use, and can be considered only in special circumstances."

California does specify minimum quantities for both source and storage capacities (a nonlinear function of number of connections) but does not differentiate between municipal and recreation development (California Dept. of Health Service 1979).

The Colorado regulatory agency does not have authority to approve or disapprove plans and specifications. Rather, this responsibility is given to the licensed consulting engineer engaged for each project (Colorado Dept. of Health 1978).

New Mexico has no mandatory requirement for minimum water quantity. The regulatory agencies use the "Manual of Septic-Tank Practices" of Health, Education and Welfare as guidelines when reviewing plans and specifications for noncommunity water systems. The figures that are related to this study are listed on Table 3.

Oregon has a general requirement for building a system that is capable of delivering water to all users without exhausting the source of supply. If that source is surface water, the quantity available must be determined from the low flow record. The reservoir must also be sized to supply a sufficient amount of water during peak demand periods (Oregon Health Division 1977). Instantaneous demand values of design parameters are recommended by the state and are listed on Table 4. The peak day recommended minimum supply is 1000 gal/residence.

Table 2. Design standards for the State of Utah.

Type of Development	Source Capacity	Storage Capacity	Distribution System Capacity
Summer Home (Mountain Cabin)	800 gpd/unit	400 gal/unit	$10.8\ N^{.64}$ gpm
Condominium	250 gpd/bedroom	125 gpd/bedroom	$10.8\ N^{.64}$ gpm
Recreation Vehicle Campground	100 gpd/vehicle space	50 gpd/vehicle space	4 N for $N \leq 60$ gpm $80 + 20\sqrt{N}$ $60 < N < 240$ gpm 1.6 N $240 < N$ gpm

N = Number of units for summer homes or condominiums
or Number of vehicle spaces for recreation vehicle campgrounds

Table 3. Recommended design standards by HEW.

Type of Establishment	gal/day/person
Camps:	
Campground with central comfort station	35
With flush toilet, no shower	25
Resort camp (night and day) with limited flushing	50
Luxury camp	100
Cottage and small dwelling with seasonal occupancy	50

Table 4. Design standards for the State of Oregon.

Number of Residences	gpmu
4	7.5
10	6.0
20	5.0
30	4.7
40	4.2
50	4.0
75	3.3
100	3.0
200	2.0

RESORT DESCRIPTIONS AND SCOPE OF DATA

Mountain Cabins

The homes being built on mountain lots vary from small A frame structures with a small kitchen and single bathroom to large structures which are physically indistinguishable from permanent residences. The design of water systems to supply these mountain "cabins" generates most of the confrontations between the Division of Health and Utah developers over issues of water supply to recreational areas, therefore, four developments in this category were studied. The developments are ordered below with the numbers shown on Figure 1.

1-Bridgerland Village

This expanding subdivision of mountain lots in Rich County above Bear Lake obtains its water from a spring which it shares with a small municipality. The site is at about 7,000 feet elevation. The property is planned for the eventual development of 182 lots. During the summer of 1979, 30 lots had cabins in use. Of this total, six were using the water system for irrigation of landscaping.

The data obtained include:

a. Long term: Individual meter readings at the beginning and end of the summer seasons of 1977, 1978, and 1979.

b. Daily: Daily values on all individual meters during the July 4th and four other weekends during 1979. Also, total system inflow during July 1979, at 3 to 4 day intervals (by recording reservoir levels before and after each pumping period).

c. Short term: No instantaneous data could be measured because no master meter exists.

2-Timber Lakes

This is a mountain subdivision 7 miles east of Heber City located at approximately 7,000 feet elevation. The water source is a spring which is shared with other, lower elevation users. The development had 83 cabins in use during 1979, none of which appeared to be irrigating any landscaping.

The data obtained include:

a. Long term: Individual meter readings approximately monthly from October 1978 to September 1979.

b. Daily: Individual meter readings during five mostly peak period weekends and one 5 day period during the summer of 1979.

c. Short term: No data at less than daily intervals were obtainable because of no master meter.

3-Pine Mountain

This mountain subdivision is located in Summit County, 8 miles east of Oakley, at an average elevation of 7,500 feet. The water sources include a small spring and two wells. A master meter available below the reservoir allows measurement of instantaneous water demand during periods when the pumps are off. No irrigation of landscaping was observed. There were 55 cabins in use in 1976 and 115 in 1979.

The data obtained include:

a. Long term: Various spot checks during 1976 and 1979.

b. Daily: Peak weekends and/or full weeks during the summers of 1976 and 1979.

c. Short term: Master meter was read at approximately 15 minute intervals (except late night) during an August 1979 weekend.

4-Silver Fork

This mountain subdivision is located in Big Cottonwood Canyon near the Solitude ski resort above Salt Lake City. The approximate elevation is 8,000 feet. The water source is a spring. Some yards are irrigated. There were 155 cabins in use during 1977 and 160 during 1979. A master meter below the reservoir allowed short term data collection.

The data obtained include:

a. Long term: Weekly data from October 1976 to June 1977 plus spot checks during July 1977 and July 1979.

b. Daily: Only two weekends one each during July of 1977 and 1979.

c. Short term: Readings during July 4th weekend 1979 plus a July weekend in 1979.

Resort Condominiums

5-Snowbird

This major Utah ski resort is located in Little Cottonwood Canyon, immediately east of Salt Lake Valley. The facilities include 470 condominium units, all with kitchens and many with two bathrooms. There is a restaurant in each of the three major condo buildings, and several more restaurants and bars are in the resort center building. Also food and toilet service is provided at a restaurant at the midpoint of the ski run area. The alpine environment is also popular in the summer, and convention business brings year round use but at an occupancy rate much lower than in winter.

The dimension selected for characterizing per unit water use was the number of condo units (470 each).

Data obtained include:

a. Long term: November 1979 to April 1980.

b. Daily: December 1979 to April 1980.

c. Short term: Correlation of continuous record of reservoir level, pump capacity, and daily master meter record allowed one month of instantaneous use analysis (January 1980).

6-Teton Village

This ski resort is located in Wyoming but provided water use data which should be similar to that expected at Utah resorts. It had 532 condominium and/or hotel units in use during the period of analysis. The resort has many restaurants and shops including a mountain top facility which serves the resort. Summer recreation at Teton Village is also very extensive, and in fact water use peaks in the summer despite higher occupancy rates during the ski season. One master meter measures water use of the entire resort.

Data obtained include:

a. Long term: 1974-1979.

b. Daily: 1974-1979 (including some with errors due to reservoir overflow).

c. Short term: None.

7-Brian Head

This southern Utah ski resort is located northeast of Cedar City. It has 133 condominium type units in three separate buildings. The water is metered separately to each of the three buildings and this allows calculation of water use by overnight guests (information not possible to obtain at Snowbird or Teton Village). The condominiums are served by the municipal water system. Other uses within the town are excluded from these data.

Data obtained include:

Daily only: 1 1/2 months during season peak period, 1978-79.

8-Sweetwater

This large summer resort on Bear Lake served the following overnight facilities during 1979: a) 163 condominium units; b) 200 mountain cabins; and c) 83 mobile homes. Unfortunately, only one master meter exists, and there was no way to accurately separate water use among these three groups of units. However, the condominium units are the heaviest users because of essentially 100 percent occupancy during the summer. The mobile homes and cabins on the other hand, are single owner facilities which experience much lower occupancy rates (31 percent occupancy of mobile homes on July 4th weekend for example). If use rates for other nearby mountain cabins are used as an estimate of cabin and mobile home water use at Sweetwater, the balance should be an approximately correct use rate for the condominiums.

Data obtained include:

a. Long term: None recorded.

b. Daily: July 1979.

c. Short term: Hourly during a peak weekend of July 1979.

Marinas

9-Bear Lake State Park

This is the major marina for large sailboats on Bear Lake (6,000 feet elevation). It has 141 boat slips, including 26 with pressure water connections to the boats. Boats at the other 115 slips obtain water from a standpipe in the boat slip area. All except 25 slips are rented by the season, and all are in such demand that they are rented each year on the first day they are available. The marina is used by many smaller boats which utilize the boat ramp on a daily basis. The permanently docked boats are almost all large enough to have a galley, toilet and beds, and are used extensively for overnight living accommodations.

The adjacent camping area has spaces for 60 recreation vehicles which do not have individual water hookups, but use five standpipes. The restroom facilities include seven toilets and four basins but no showers.

Rather than attempting to base water demand estimates on artificial units taken as some weighted average of boat slips plus camping spaces, the number of boat slips alone was used. A boating-day basis could not be used because no records of number of boating days could be found. Information was not available to determine how many of the vehicles in the camping area were owned by boat slip renters, how many were owned by smaller boat launchers, or how many were simply nonboating campers. Furthermore, it was impossible to separate water use between marina and camping area users since only one master meter was available.

Data obtained include:

a. Long term: Seasonal or monthly readings from 1976 to 1979.

b. Daily: All of July 1979.

c. Short term: Hourly use for one weekend in July 1979.

10-Bullfrog Basin

This is a major marina on Lake Powell. Because of its remote location (70 miles from the nearest town) Bullfrog Marina provides grocery, restaurant, service station, and camping facilities in addition to boat launching and refueling services. One of the most popular ways to see Lake Powell is by house boat and 77 of these large boats which have flush toilet, pressurized kitchen, and bathroom taps are based at Bullfrog. They are used essentially every day during the summer season. These boats mostly have beds for 10 people, but they commonly carry more than that with use of sleeping bags on the flat roof deck. Because of the hot climate (summer daytime temperatures usually exceed 100°F) high water use per person should be expected.

The park service occupancy data indicate from 400 to 600 boats per day use the boat launch facilities during summer months and the marina operator's records indicate that 100 to 300 boats are actually refueled there.

In addition to the boat facilities, 82 overnight camping facilities (without pressure water hookups) are operated by the Park Service; and 16 spaces (with pressure water hookups) are operated by the commercial marina operator. Also, substantial water demand is represented by the 103 mobile home units in which employees live. A single master meter serves all of the commercial operations, including the marina, service station, and mobile homes. The units used for converting total water use to a per unit dimension were the Park Service's "boating day" records. This contrasts with the Bear Lake unit basis of number of boat slips. Neither type of unit is adequate for characterizing water use at Bullfrog because they both exclude any measure of support facility water use. However, since there is almost no relation between number of boat slips and water use at Bullfrog, boating days were selected as the unit.

Data obtained include:

a. Long term: Monthly use--1978-1980.

b. Daily: September 1978 to June 1980.

c. Short term: None.

Recreation Vehicle Campgrounds

11-Cherry Hill

This overnight campground is located just off Interstate 15 near Kaysville, Utah. It has 168 spaces with water hookups, a swimming pool, laundry with 9 washers, 12 showers, 12 toilets, and 20 basins. All irrigation of landscaping is from a separate nonpotable water system.

Data obtained include:

a Long term: None.

b. Daily: All of August 1979.

c. Short term: Hourly or less during one weekend in August 1979.

12-KOA

This overnight campground on the shore of Bear Lake has 130 spaces with water hookups, but on peak days serves many more recreational vehicles in an open space which has 110 picnic tables. A rather arbitrary assumption was made that the units without water hookups would use about half as much water as those with hookups. Therefore, the campground capacity was calculated as 130 + 0.5 (110) = 185 units.

In addition to the camp spaces, the water using facilities include a swimming pool, 16 showers, 16 toilets, 16 basins, and a small grocery store.

Data obtained include:

A meter was installed for the first time on June 28, 1979. It was read at hourly intervals for 30 hours and then was destroyed by the campground owner (it was located on his property). No further data could be collected.

RESULTS

Data Presentation Format

The data displayed and analyzed here include a mixture of routine and special measurements recorded by resort owners or water wholesalers and special measurements made by the research team over varying time intervals, and at a large number of different types and sizes of resorts. The variability in water using activities (even within similar resort categories) and the very limited number of replications of some of the data make statistical analysis difficult and somewhat limit the precision of predictions. Nevertheless, these data are the most extensive collection of water use information at recreation facilities in the Utah region and represent a substantial addition to a data base which has previously been almost nonexistent. They should provide an initial empirical basis for recreational water supply facility design.

This section of the report presents all of the water use measurements for a given resort in order of decreasing time interval (seasonal, monthly, daily, etc.), repeats this process for other resorts in that same category, and repeats the presentation for the other categories of resorts. The statistical analysis and discussion of their design implications follows in order to make comparisons between resorts. The single exception to this is the frequency distribution figure showing flow rates as a function of percent of units at a development which will be included in this section.

Because of the large amount of data collected, the presentation will be almost entirely graphic in nature in order to assist the reader in visualizing the orders of magnitude of variations over time. All the collected data are tabulated in appendices.

The following conventions will be used for presentation of data: 1) All daily, monthly, or seasonal flow rates will be given as gallons per day (gpd) or gpd per unit (gpdu). 2) All short term flow rates will be expressed as gallons per minute (gpm) or gpm per unit (gpmu). 3) Flow rates will often be given both as rates per total number of units and per number of units occupied during the period metered. Unless designated as per unit occupied, such flows should be interpreted as per total number of units.

Mountain Cabin Data

1-Bridgerland Village

The seasonal (and monthly) water use patterns during recent years for this development is shown in Figure 2. The average use during the Bear Lake summer season (July-September) is 137 gallons/month/unit. Nonsummer use averages 77 gallons/month/unit.

The Bridgerland data were acquired by individual meter readings at each completed cabin. It was therefore possible to determine the distribution of water use among cabins for one peak season month, for the peak 2-day period, and for the peak day of the period during which these special data were recorded. These cumulative distributions and the average values for each distribution are shown in Figure 3. The distributions show that on a monthly basis the highest water use was about four times the average while the ratio is about 10 during 1 and 2 day periods. For these short periods, only about 30 percent of the connections are making above average water use. The peak weekend use rate was 431 gallons per day per unit (gpdu) based upon only those units which were occupied during that particular period (60 percent of the total units). This compares to 258 gpdu based upon total number of units available. The Bridgerland water use data are summarized as follows in Table 5.

Table 5. Summary of water demand for Bridgerland Village.

Time Period	Total Units (gpdu)	Occupied Units (gpdu)	Percent Occupancy
Annual Average	93	-	-
July - Sept.	137	-	-
Oct. - June	77	-	-
Peak Month (Aug.)	157	176	90[a]
Peak Day	324	540	60

[a]Percent occupied at least one day during month, not monthly average occupancy.

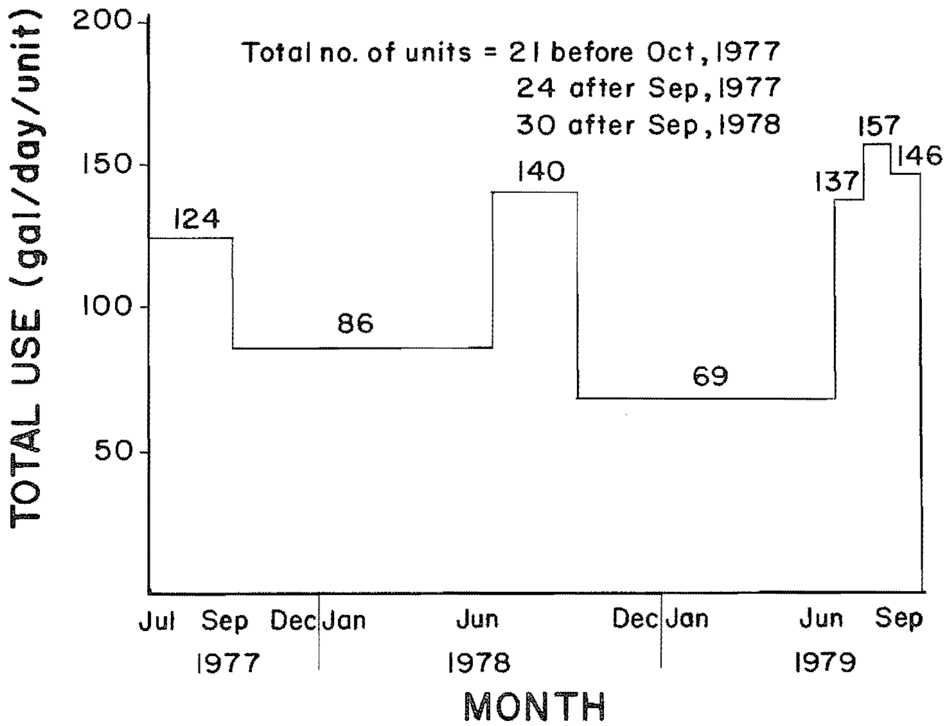

Figure 2. Seasonal water demand for Bridgerland Village.

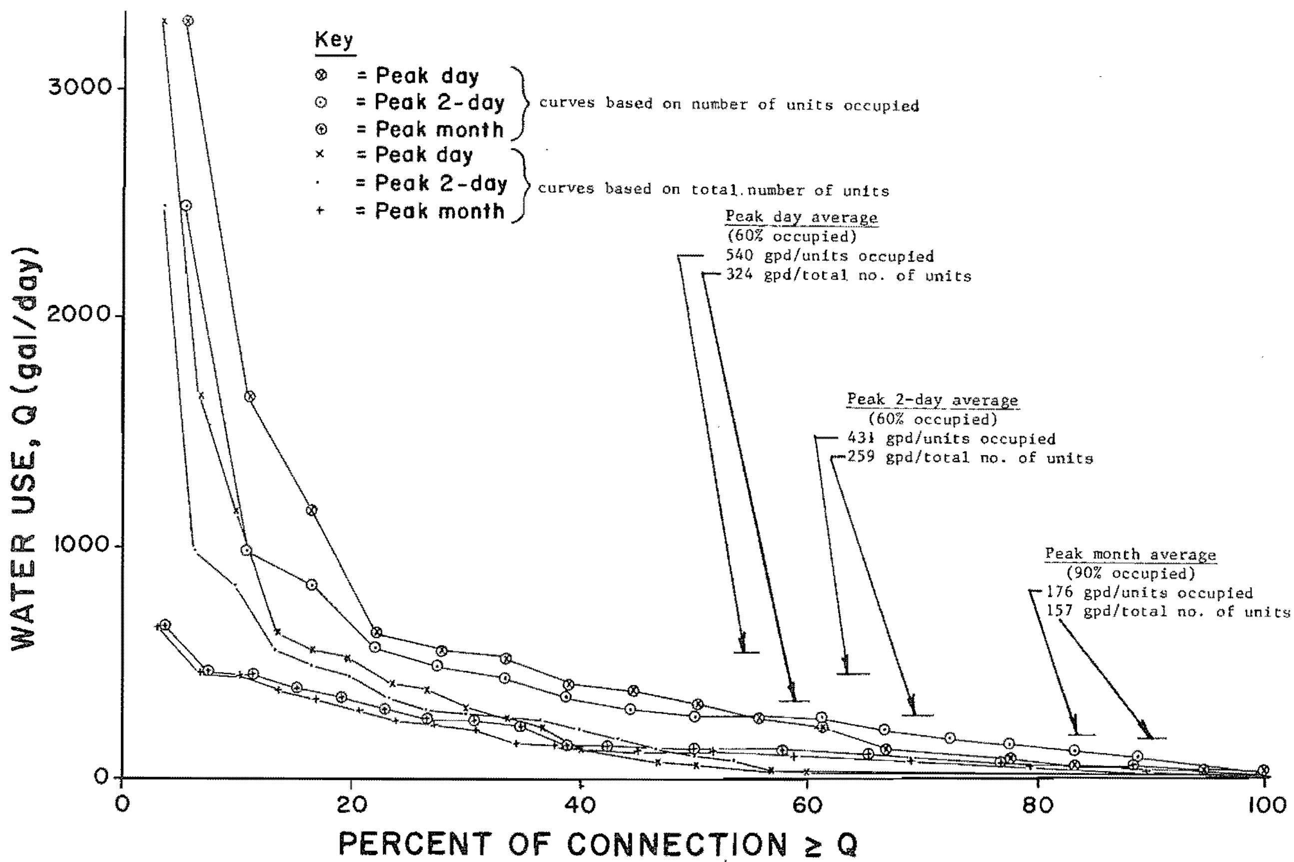

Figure 3. Distribution of water demand among users at Bridgerland Village.

2-Timber Lakes

Figure 4 shows the seasonal and monthly averages for two peak months (1979) along with measurements during several peak (holiday) weekends. Since Timber Lakes has no master meter, these data were acquired by reading each meter at individual connections. As was the case with Brigerland Village, these readings allowed analysis of variations among units. The cumulative distribution functions are shown in Figure 5. The Timber Lakes water use data are summarized in Table 6.

The extremely low use rates (in comparison with all the other data collected) may be due to hydrologic and hydraulic constraints that limit use to less than the actual demand. Timber Lakes has an unusual (and undesirable) mode of operation in that no reservoir exists and certain flows must be moved through this system to other water users. This causes low pressures during peak periods and limits the water available to Timber Lakes users.

Table 6. Summary of water demand for Timber Lakes.

Time Period	Total Units (gpdu)	Occupied Units (gpdu)	Percent Occupied
June-Aug.	39.9	-	-
Peak Month	43.5	45.7	95[a]
Peak Day	83.0	246	34

[a]Percent occupied at least one day during month, not monthly average occupancy.

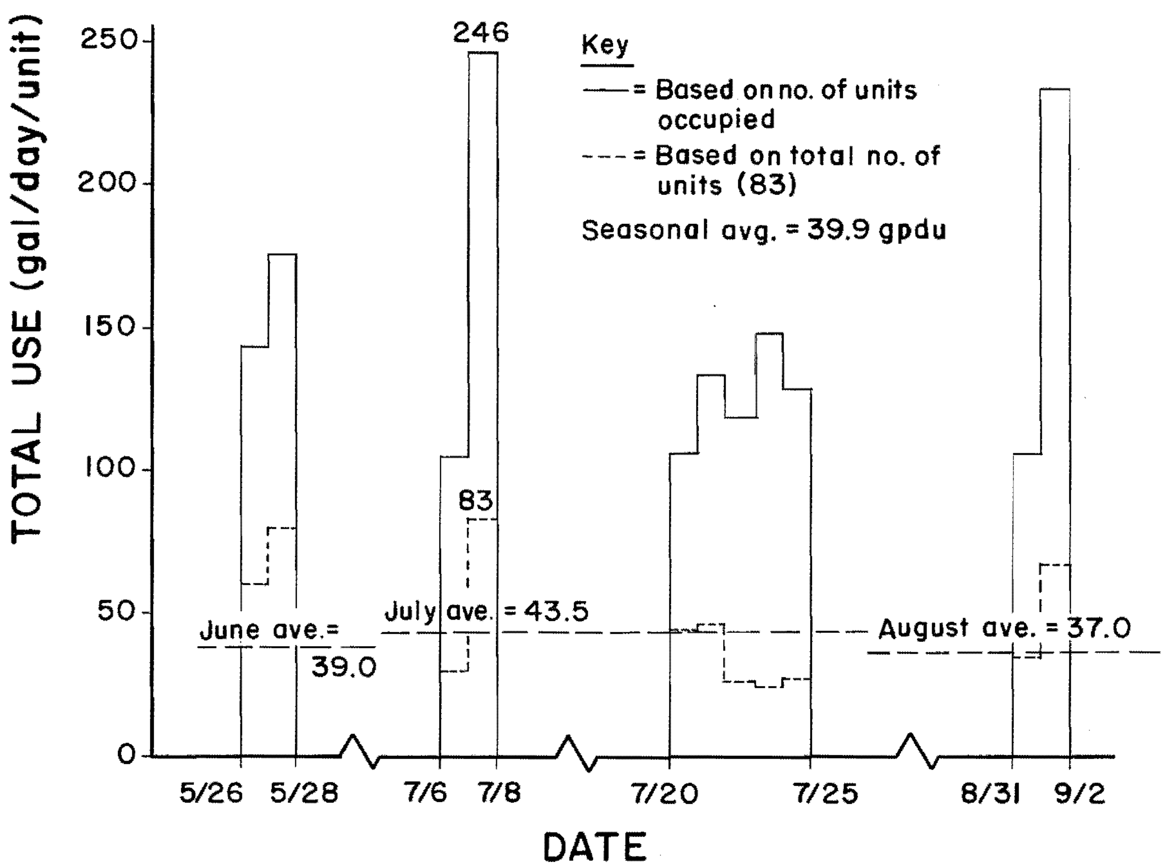

Figure 4. Daily water demand during peak holidays (weekends) for Timber Lake.

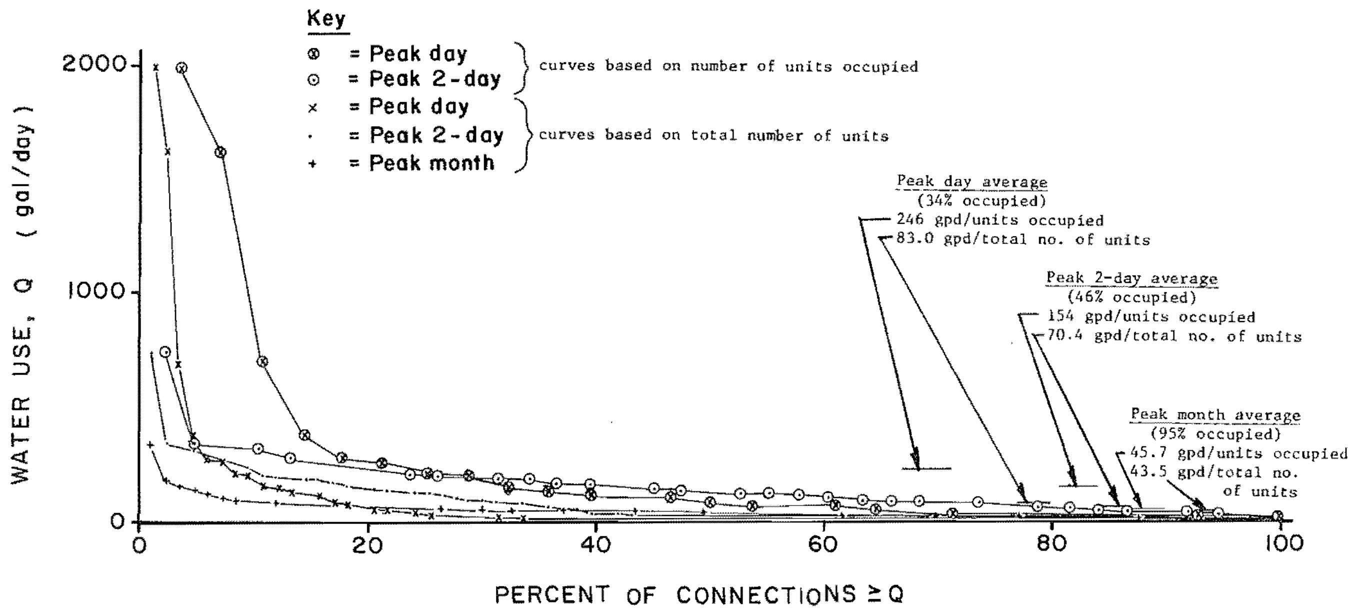

Figure 5. Distribution of water demand among users at Timber Lake.

3-Pine Mountain

The monthly and daily water use data at Pine Mountain during the summer of 1976 are displayed in Figure 6. Use was recorded every day during part of the time and only on weekends during other weeks; therefore, the straight lines connecting weekends are averages for those periods.

The master meter at Pine Mountain (below the reservoir) allowed instantaneous water use calculations during periods when the pumps were off. This type of data was obtained during a weekend in August 1979, and is shown in Figure 7. The peak measured flow of 0.995 gpm per connection is a little less than one would expect in a municipal system but of about the same order of magnitude. Hughes and Gross (1979) report levels of 1.29 gpm for a similarly sized municipal system (average of daily peak events during summer). The Pine Mountain data are summarized in Table 7.

Table 7. Summary of water demand for Pine Mountain.

Time Interval	Total Units (gpdu)	Occupied Units (gpdu)	Percent Occupied
June-Aug. avg.	90.6 gpdu	-	-
Peak Month (July)	117 gpdu	-	-
Peak Day	435 gpdu	614	71
Peak Instantaneous	0.995 gpmu	-	-

4-Silver Fork

The available data include weekly or shorter readings of a master meter during October to May 1976, 77 which are displayed in Figure 8 and very short term measurements during a 2-day July 4th holiday period in 1979 (displayed in Figure 9). Use according to the data on Figure 8 peaks during the ski season, but the lack of summer data prevents verification that this is actually the annual peak.

The instantaneous data show use about one-half that of Pine Mountain (0.47 gpmu). The Silver Fork data are summarized in Table 8.

Table 8. Summary of data for Silver Fork.

Time Interval	Water Use (Total Units)
Oct.-May avg.	259 gpdu
Peak Month (Jan.)	343 gpdu
Peak Day	-
Instantaneous Peak	0.47 gpmu

Resort Condominiums

5-Snowbird

Daily water use during a peak winter three-month period is shown in Figure 10.

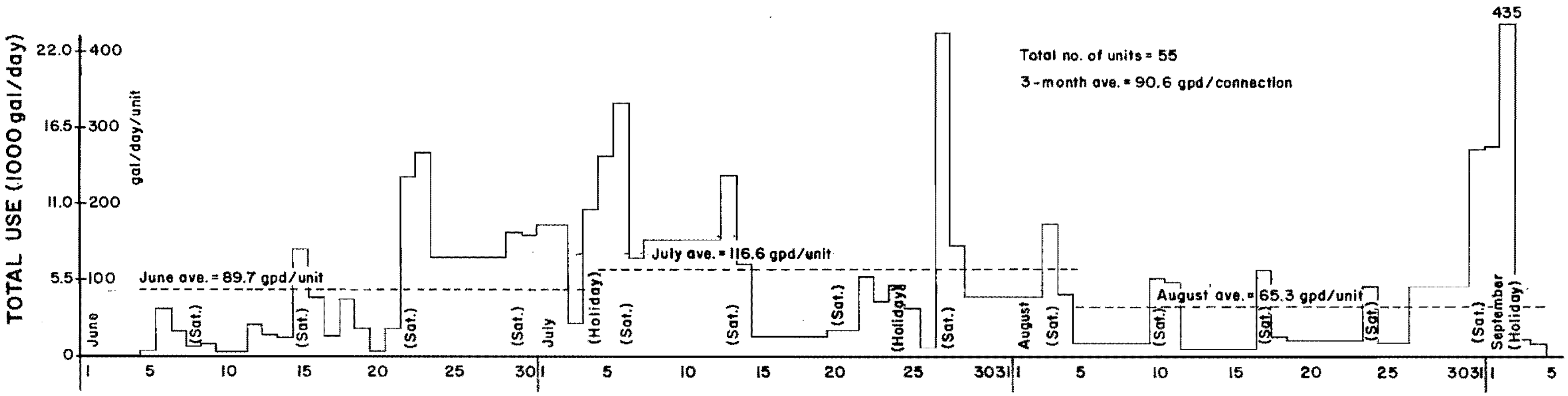

Figure 6. Daily water demand for Pine Mountain.

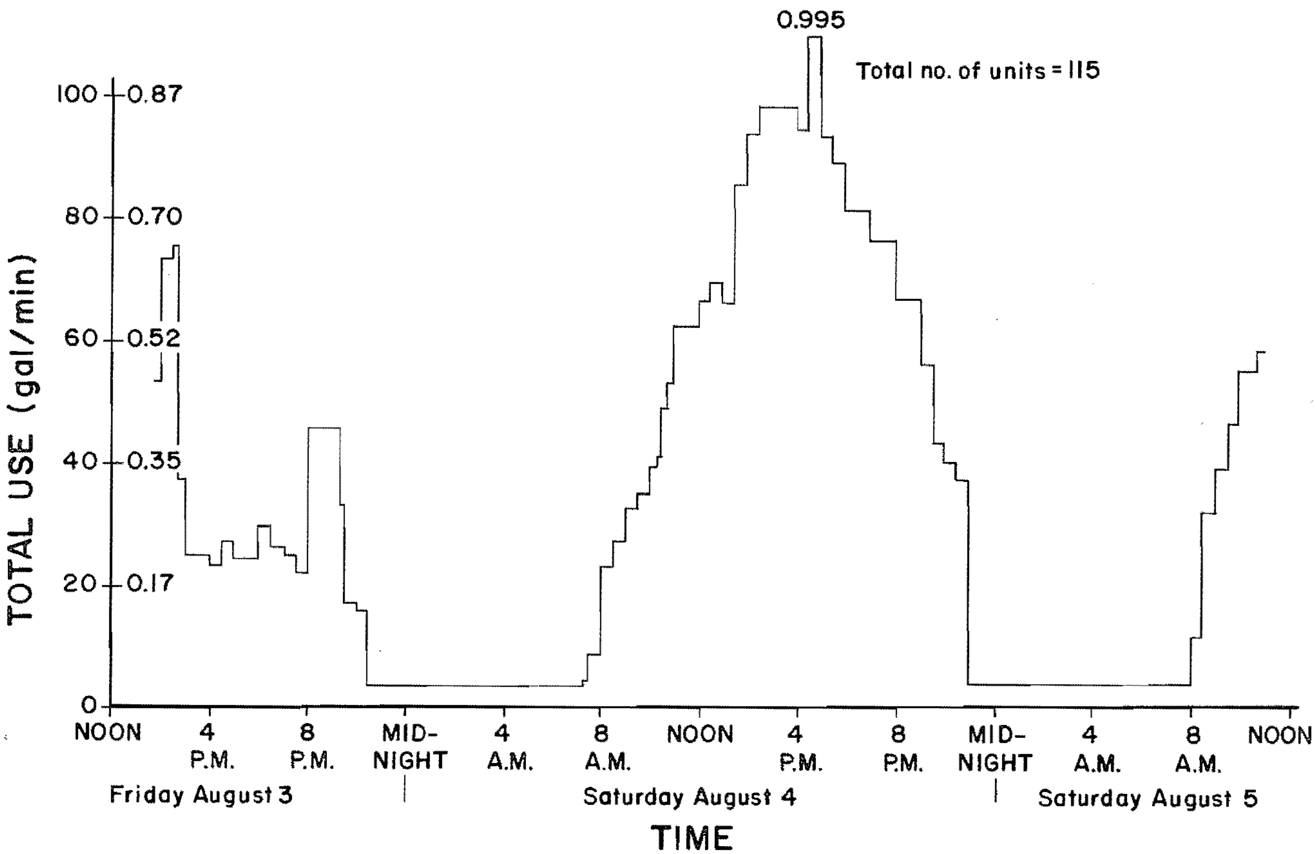

Figure 7. Short term water demand hydrograph for Pine Mountain.

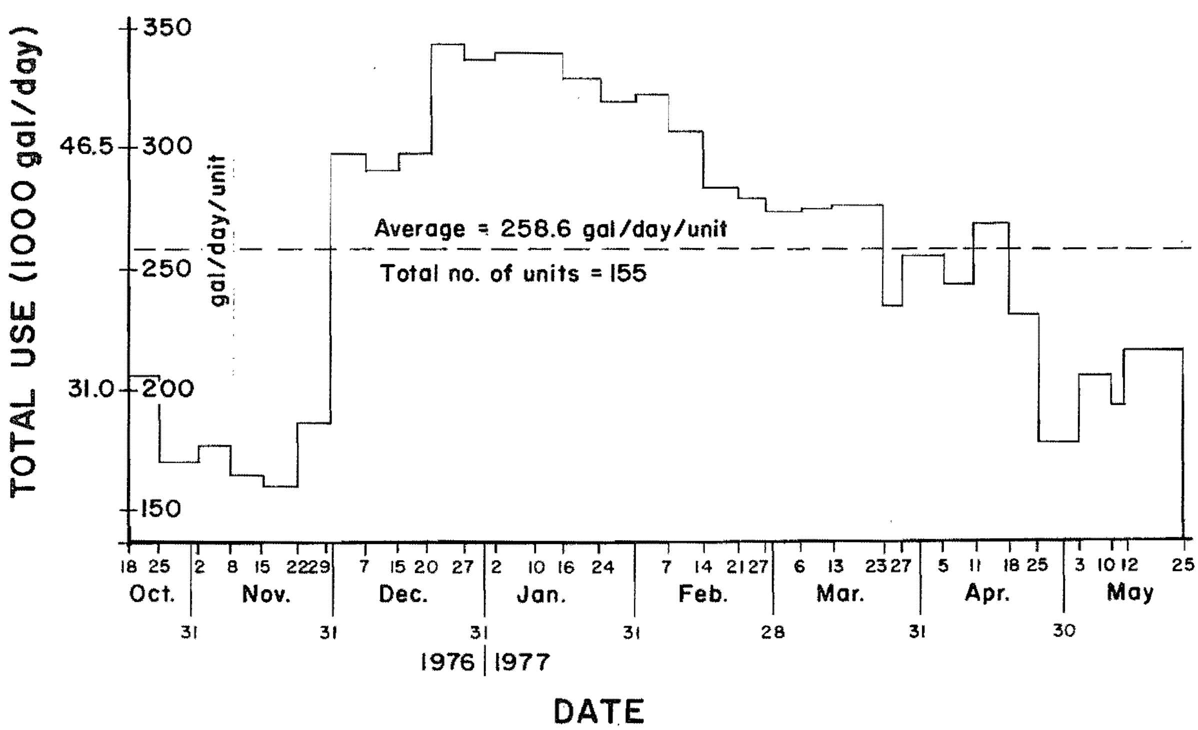

Figure 8. Weekly water demand for Silver Fork.

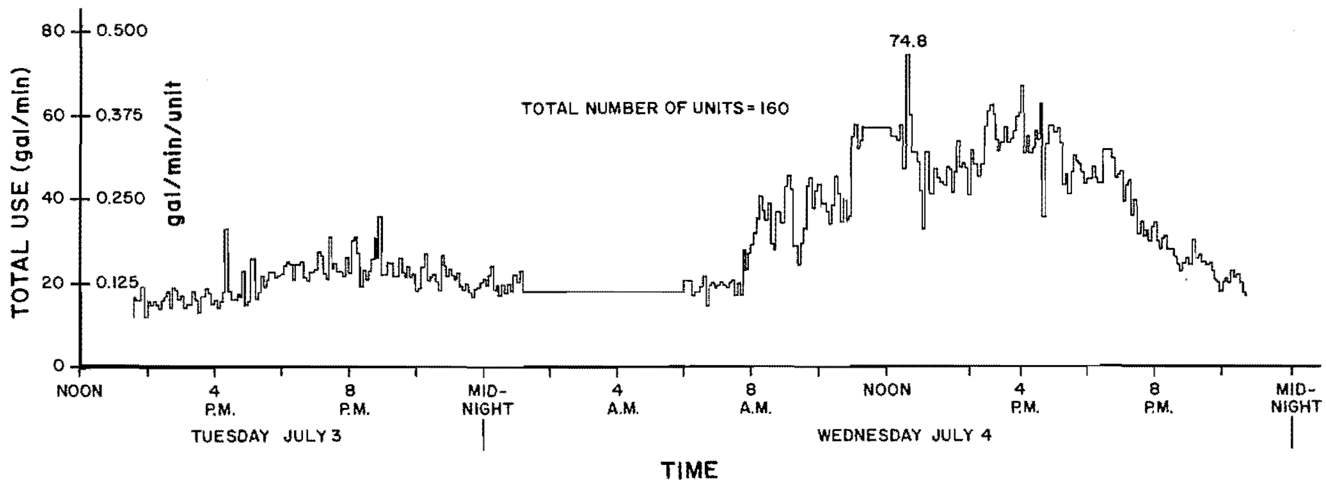

Figure 9. Short term water demand hydrograph for Silver Fork.

The busy Christmas week shows the expected high water use, but the peak day occurred during January and the peak month was February. Shorter interval data during Christmas week are shown in Figure 11. These data were calculated by correlating a known pump capacity with changes in slope on a continuous circular chart record of reservoir water level. The highest instantaneous flow observed during the three-month period was 0.534 gpmu on January 15. The Snowbird data are summarized in Table 9.

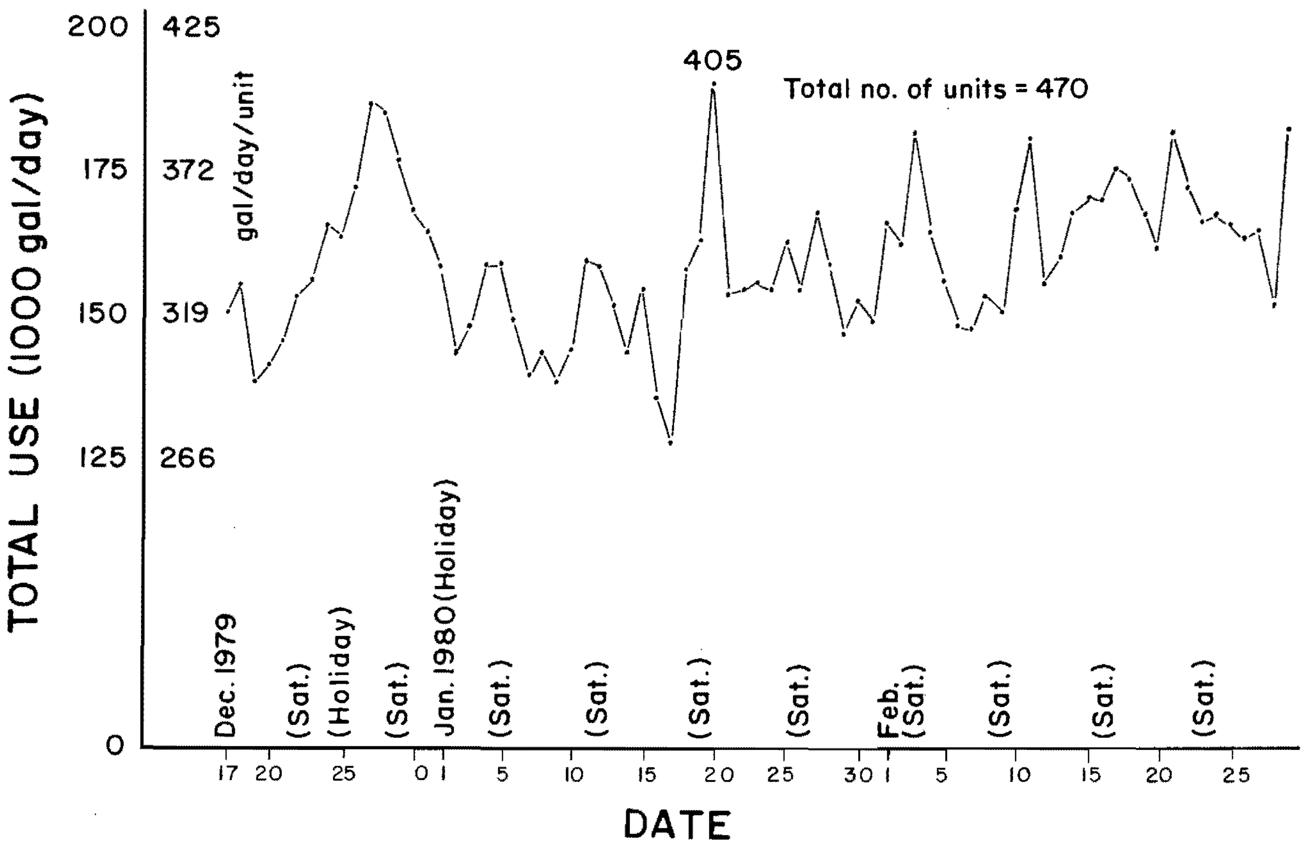

Figure 10. Daily water demand for Snowbird.

Table 9. Summary of water demand for Snowbird.

Time Interval	Water Use		
	Total Units	Occupied Units	Percent Occupied
Dec. - Feb.	324 gpdu	-	-
Peak Month (Feb.)	352 gpdu	-	-
Peak Day	405 gpdu	462 gpdu	90%
Instantaneous Peak	0.534 gpmu	0.60 gpmu	-

6-Teton Village

Two years of monthly data shown in Figure 12 indicate that despite the peak occupancy rate during the ski season, the peak water demand period is during the summer. This is probably due to the summer landscaping component of demand.

Figure 12 indicates a major increase in demand during July and August 1978 as compared to 1977. There was no significant increase in number of units available during that summer nor do climatic records suggest any explanation for this dramatic increase in demand. Average temperatures were almost identical during both years and July 1978 had much less rainfall than in 1977, but the reverse was true in August.

Figure 13 shows daily water use at Teton Village for about one year. No short term measurements were possible because of the master meter location in relation to pumps and reservoirs. The Teton Village data are summarized in Table 10.

Table 10. Summary of water demand for Teton Village.

Time Interval	Water Use (Total Units)
1978 Annual Average	250 gpdu
Peak Month (July)	383 gpdu
Peak Day	624 gpdu

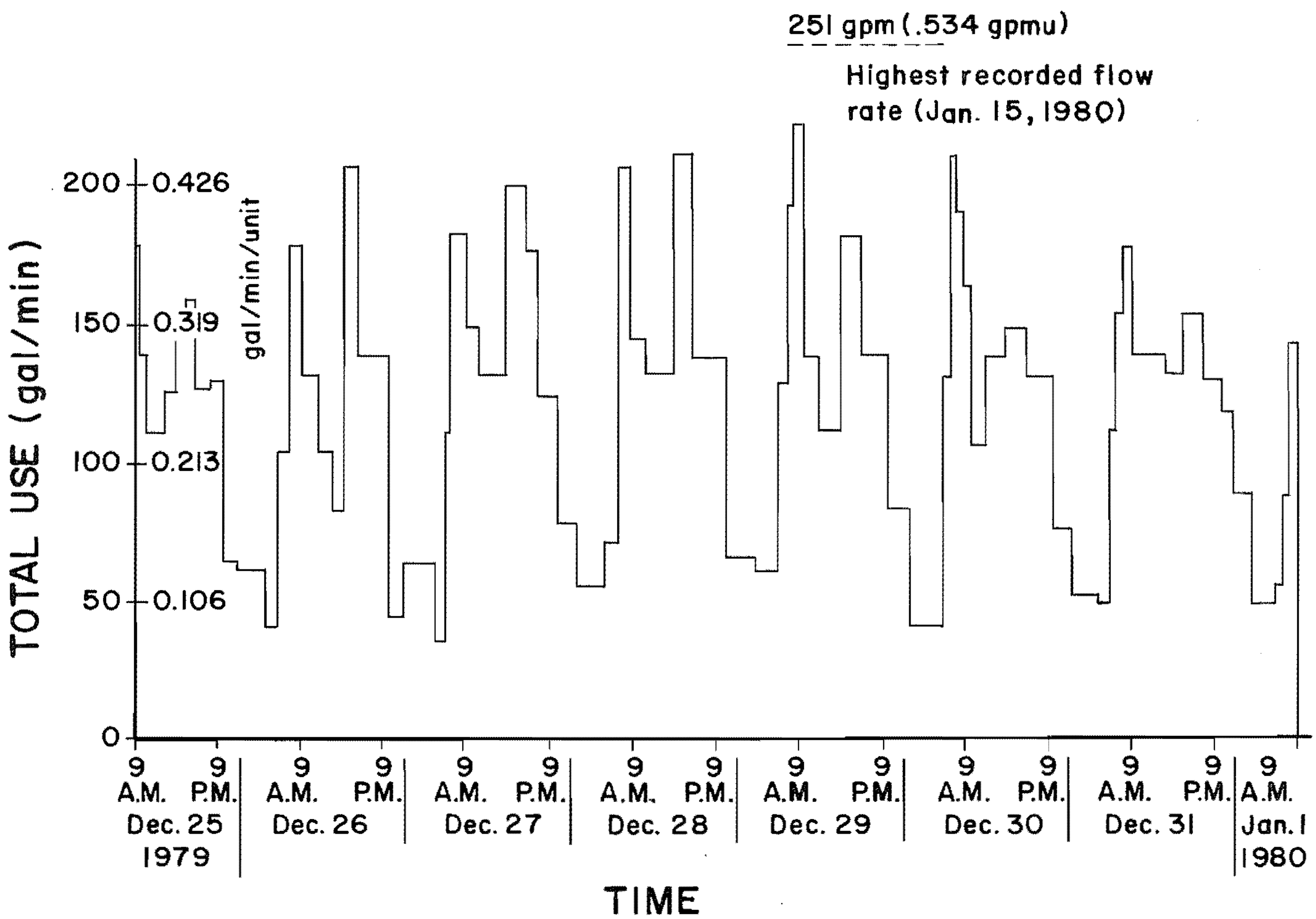

Figure 11. Water demand hydrograph during Christmas week for Snowbird.

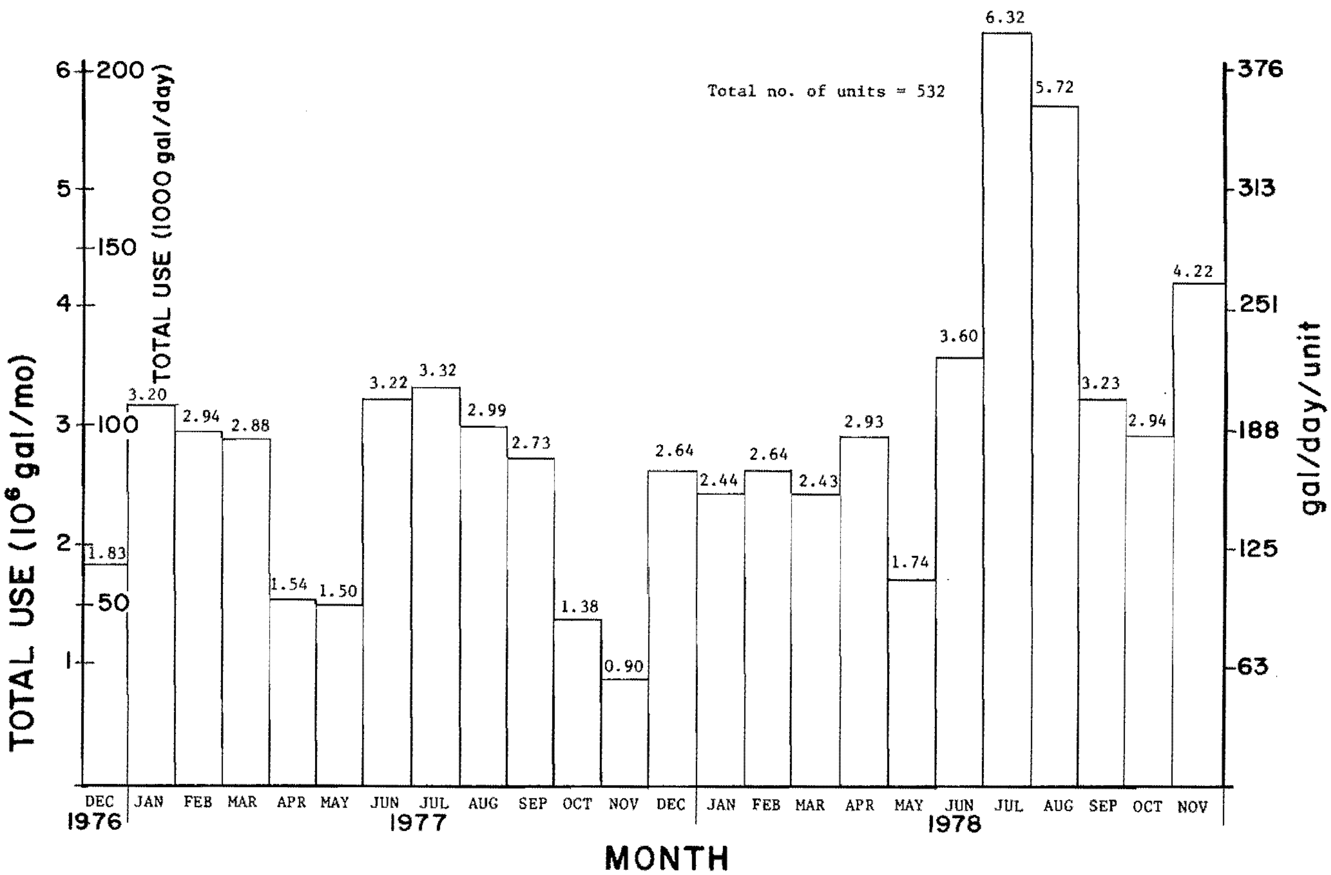

Figure 12. Monthly water demand for Teton Village.

7-Brian Head

The only data available at Brian Head are daily measurements during December and half of January 1979 (Figure 14). The Christmas week peak use is very apparent in the figure. One of the desirable aspects of the Brian Head data is that each of three condominium buildings is metered separately. This permits analysis of indoor water use as a function of overnight occupancy, something that was not possible at any other condominium type development. This analysis will be reported in a later section. The Brian Head data are summarized in Table 11.

Table 11. Summary of water demand for Brian Head.

Time Interval	Water Use (Total Units)
1½ Months (Dec.-Jan.)	128 gpdu
Peak 30 Days (Dec.-Jan.)	164 gpdu
Peak Day	276 gpdu

8-Sweetwater

The total daily water use at Sweetwater (not including landscaping and golf course irrigation which are provided from separate systems) during July 1979 is shown in Figure 15. The combined use by condominiums, mobile homes, and mountain cabins is included in the data shown. The Sweetwater data are summarized in Table 12.

Table 12. Summary of water demand for Sweetwater.

Time Interval	Water Use (Total Units)
Peak Season (July-Aug.)	363 gpdu
Peak Month (July)	395 gpdu
Peak Day	865 gpdu

Marinas

9-Bear Lake State Park

Monthly water use during a 3-year period (1977-79) is shown in Figure 16. The July

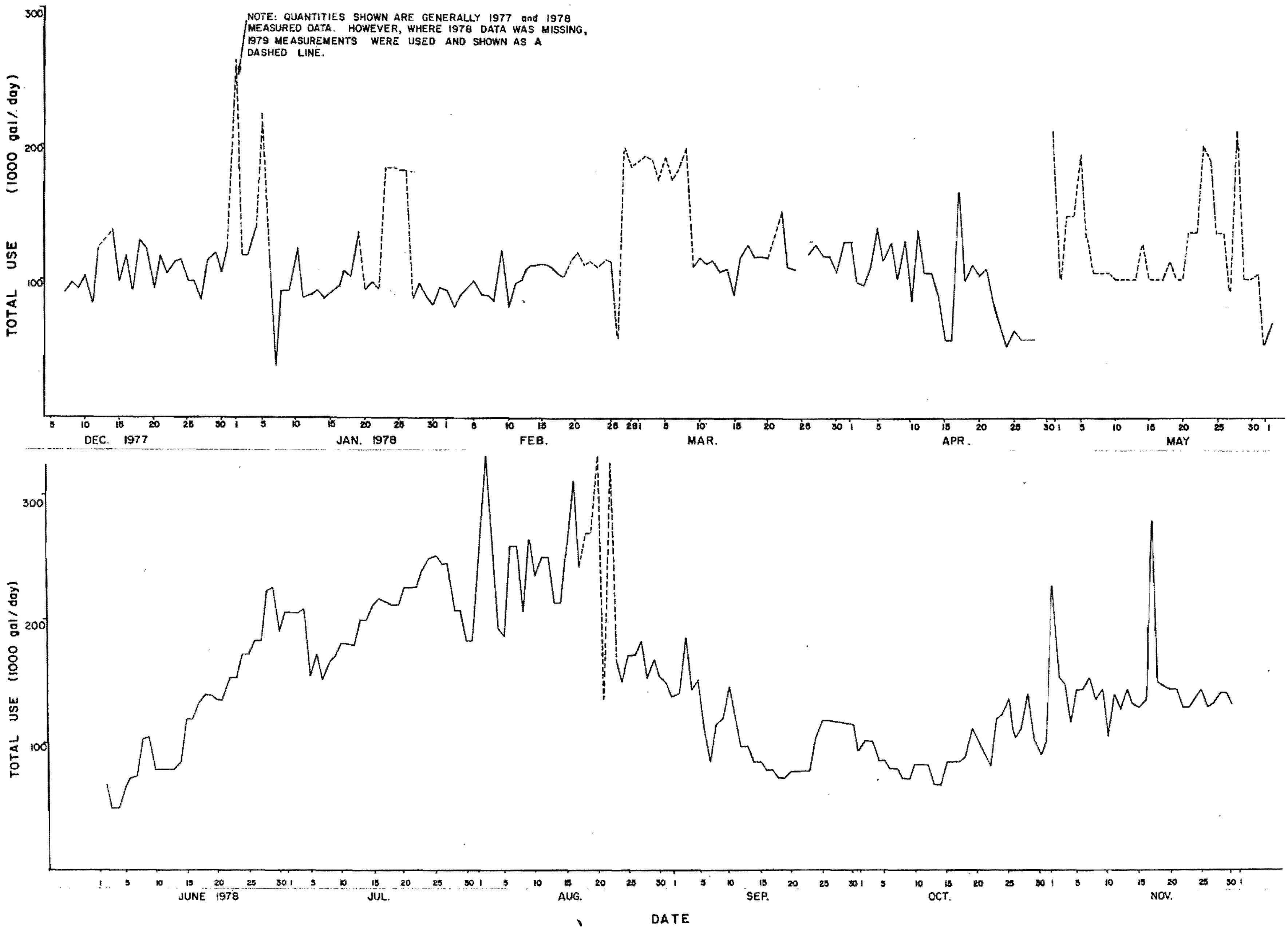

Figure 13. Daily water demand for Teton Village

1978 quantity is more than double that of any other month during the 3-year period. It is believed that substantial water use was associated with construction to expand the marina facilities during that month, and the measured amount does not reflect normal marina demand. The only daily and instantaneous meter readings were taken during July of 1979 (Figures 17 and 18). Unfortunately, this was a period of lower demand than were the peak summer months in 1977 and 1979 (even if July 1978 is ignored). Therefore, the available peak day and peak hour data probably measured demands substantially lower than the true peak values for these periods. For that reason, both sets of data will be included in Table 13.

Table 13. Summary of water demand for Bear Lake Marina.

Time Interval	3-yr Period (Total Units)	1979 Only (Total Units)
Summer Season (June-Aug.)	48.7 gpdu	35.4 gpdu
Peak Month (July)	110	36.9 gpdu
Peak Day	-	65.9 gpdu
Peak Instantaneous	-	0.055 gpmu

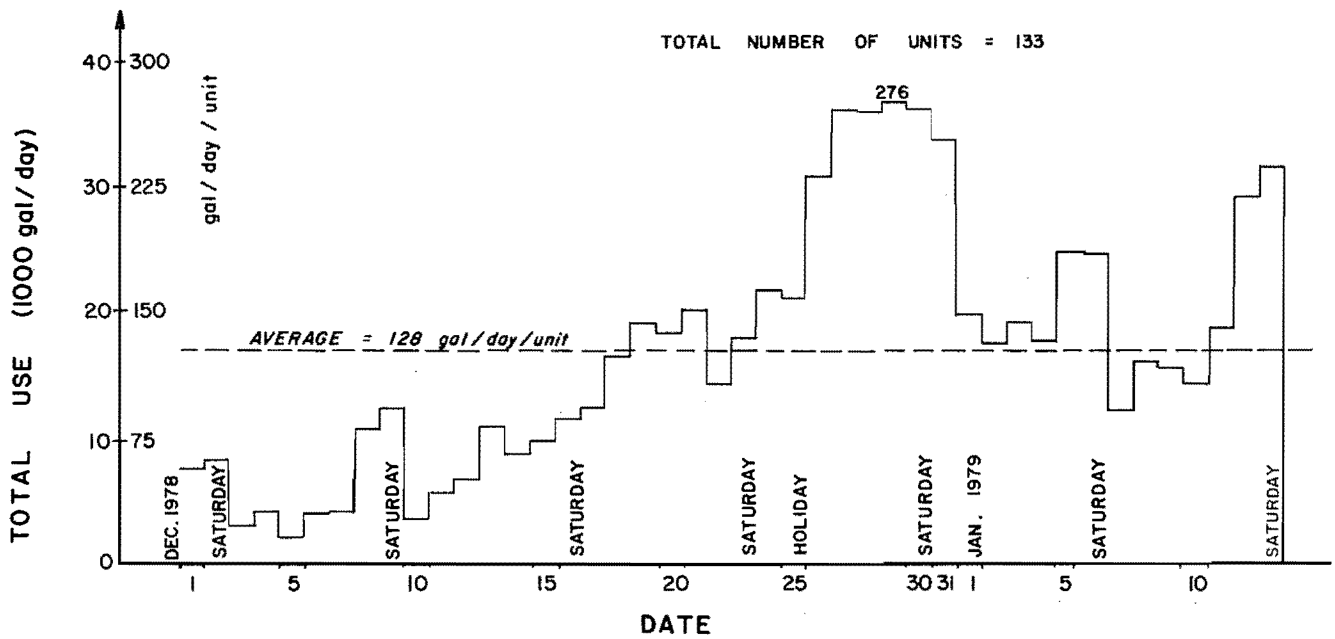

Figure 14. Daily water demand for Brian Head.

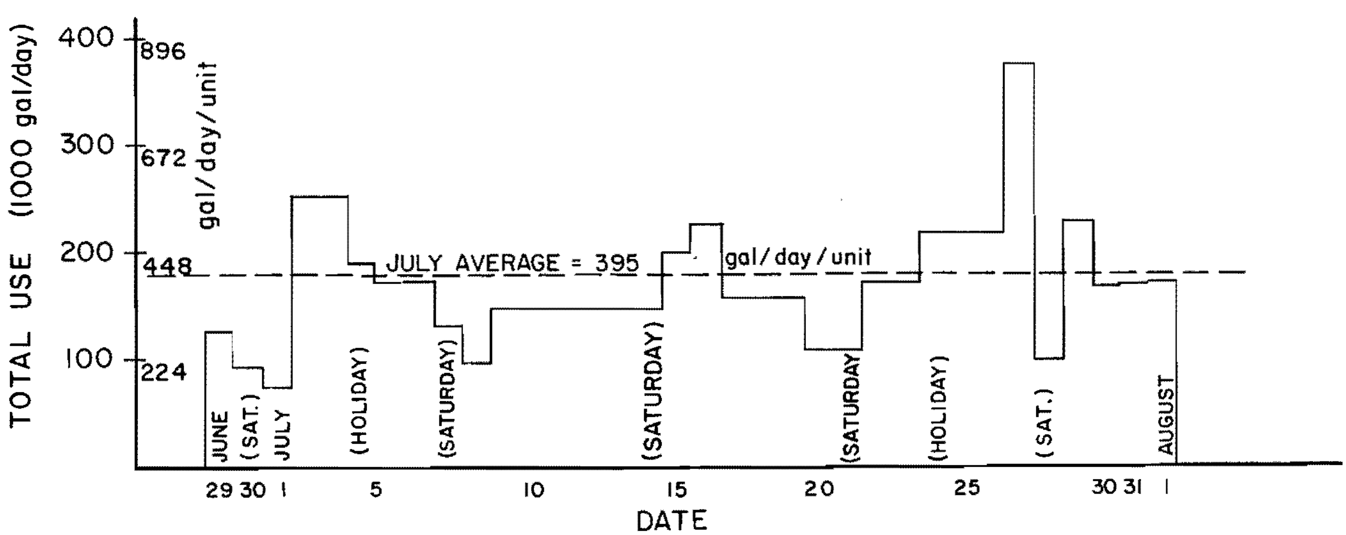

Figure 15. Daily water demand for Sweetwater.

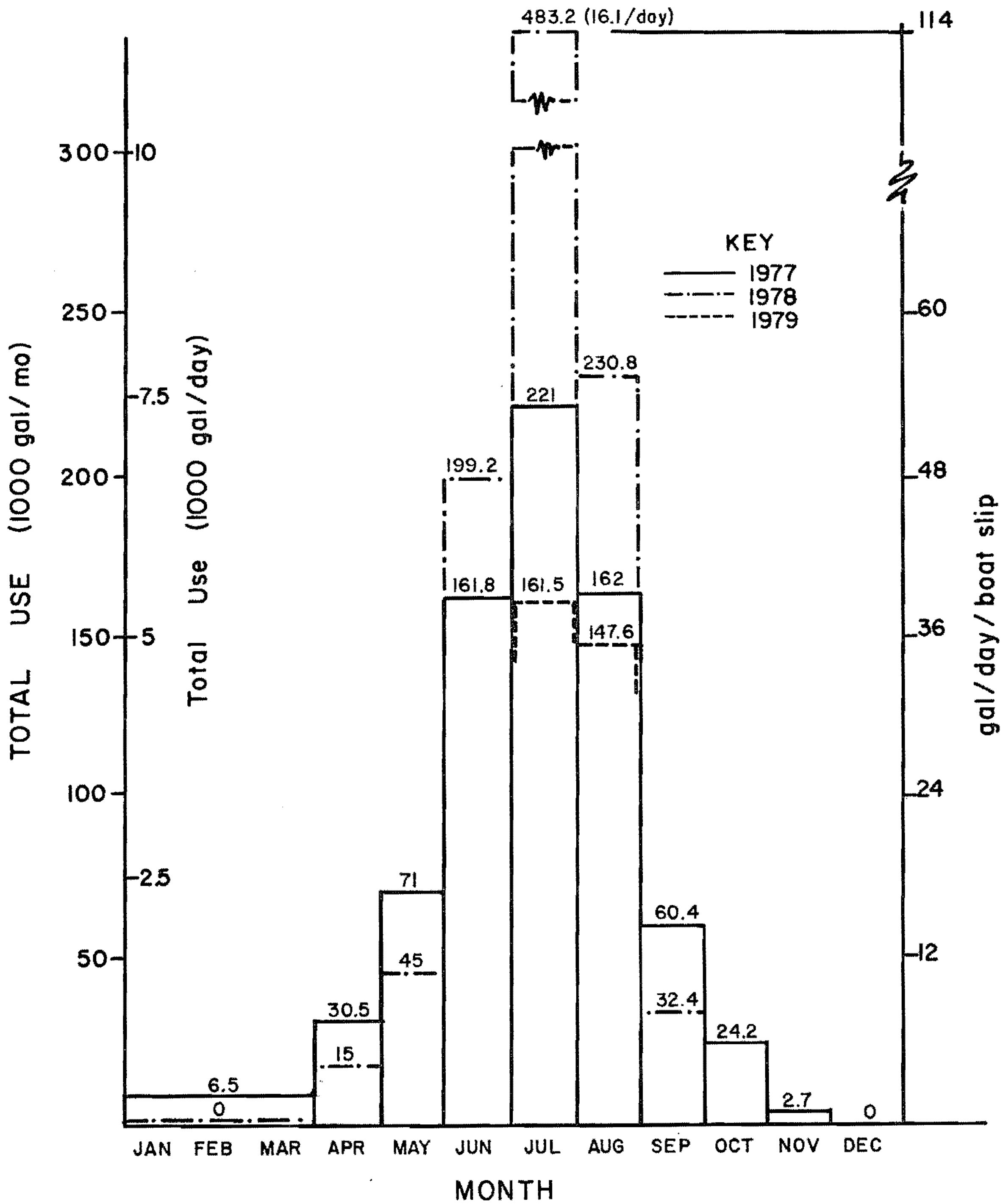

Figure 16. Monthly water demand for Bear Lake State Marina.

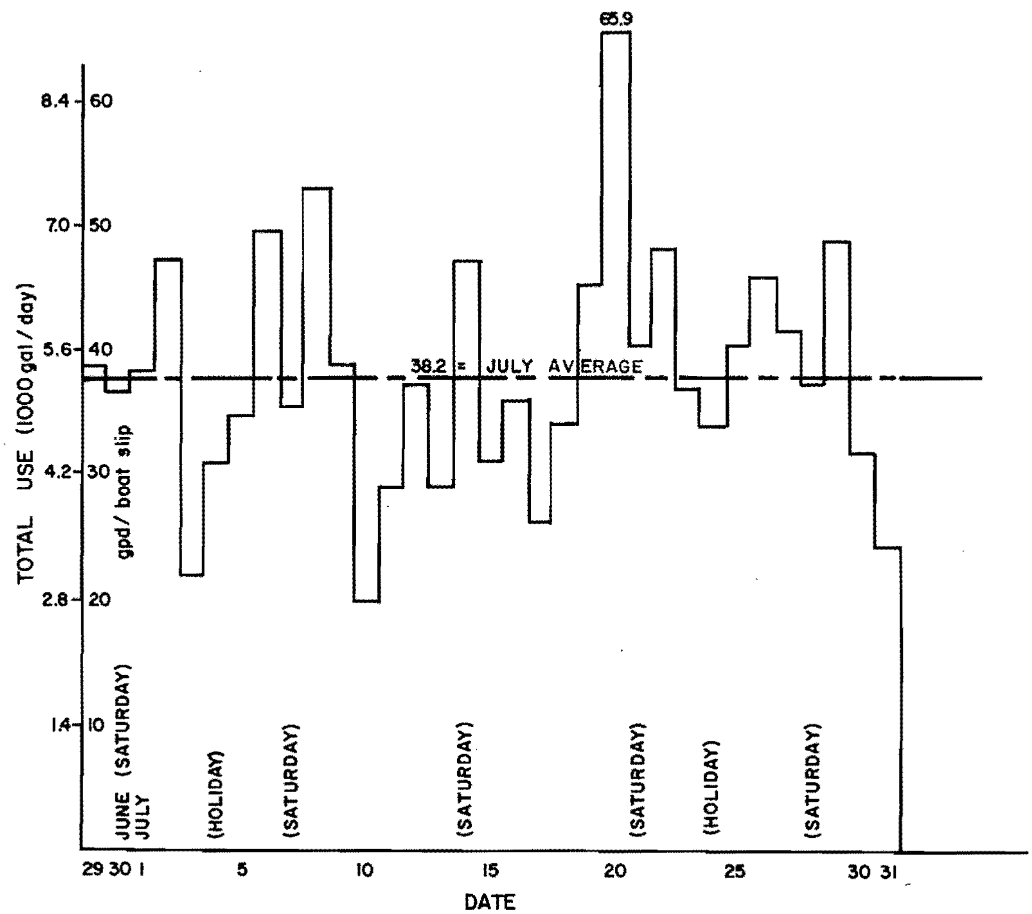

Figure 17. Daily water demand for Bear Lake State Marina.

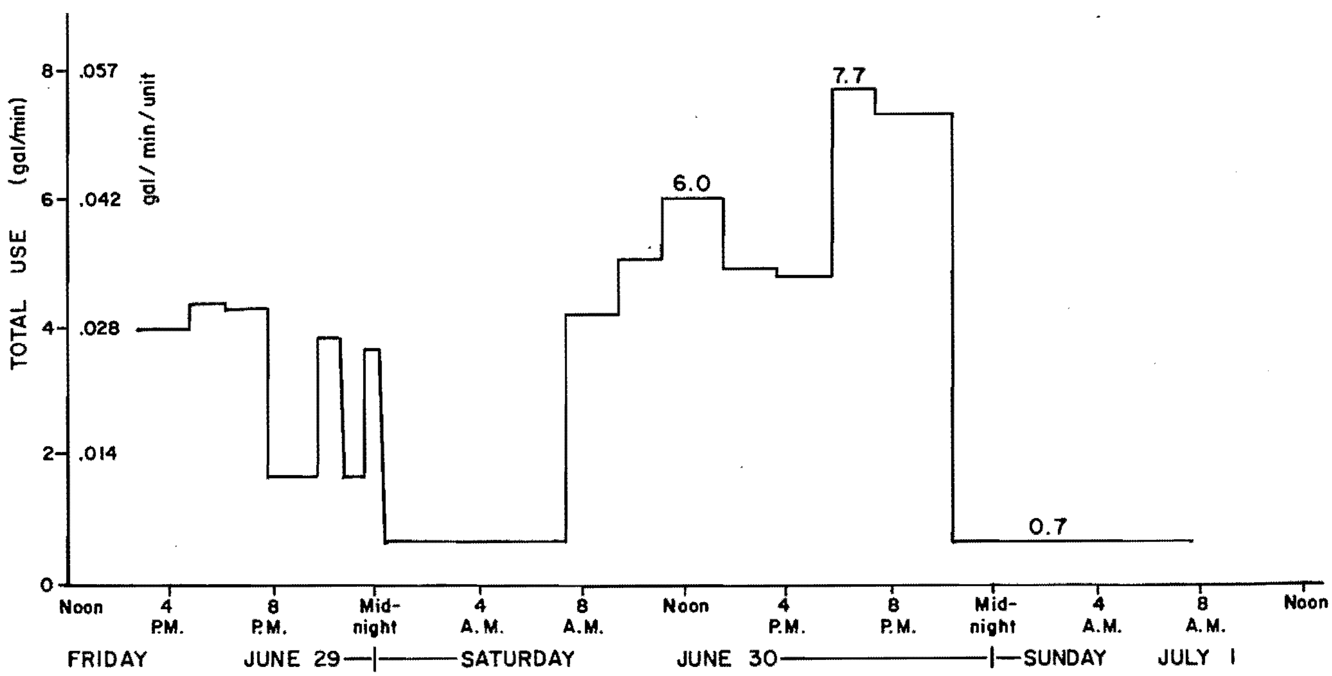

Figure 18. Short term water demand hydrograph for Bear Lake State Marina.

10-Bullfrog Marina

Two years of monthly water use and one summer season (June-August) of daily water use are shown in Figures 19 and 20 respectively. Since data on number of boating days were also available, a regression analysis of water use as a function of boating days was performed. This will be given in a later section. The Bullfrog data are summarized in Table 14.

Table 14. Summary of water demand for Bullfrog Marina.

Time Interval	Water Use (Gallons Per Boating Day)
Peak Season (June-Aug.)	408
Peak Month	425
Peak Day	823

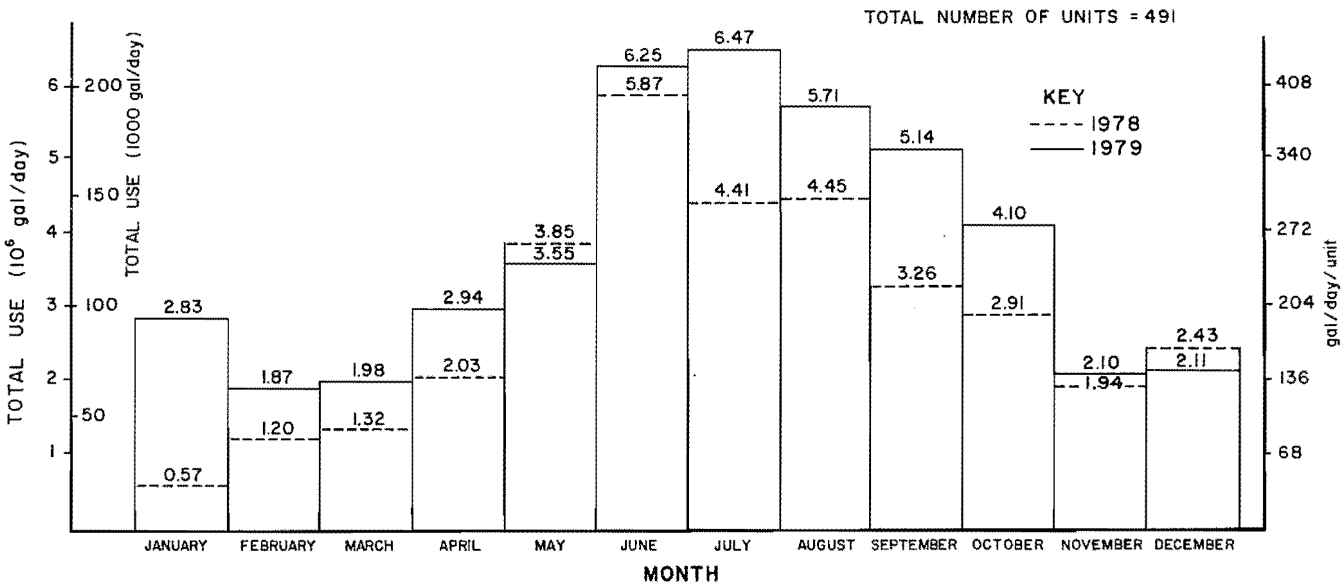

Figure 19. Monthly water demand for Bullfrog Marina.

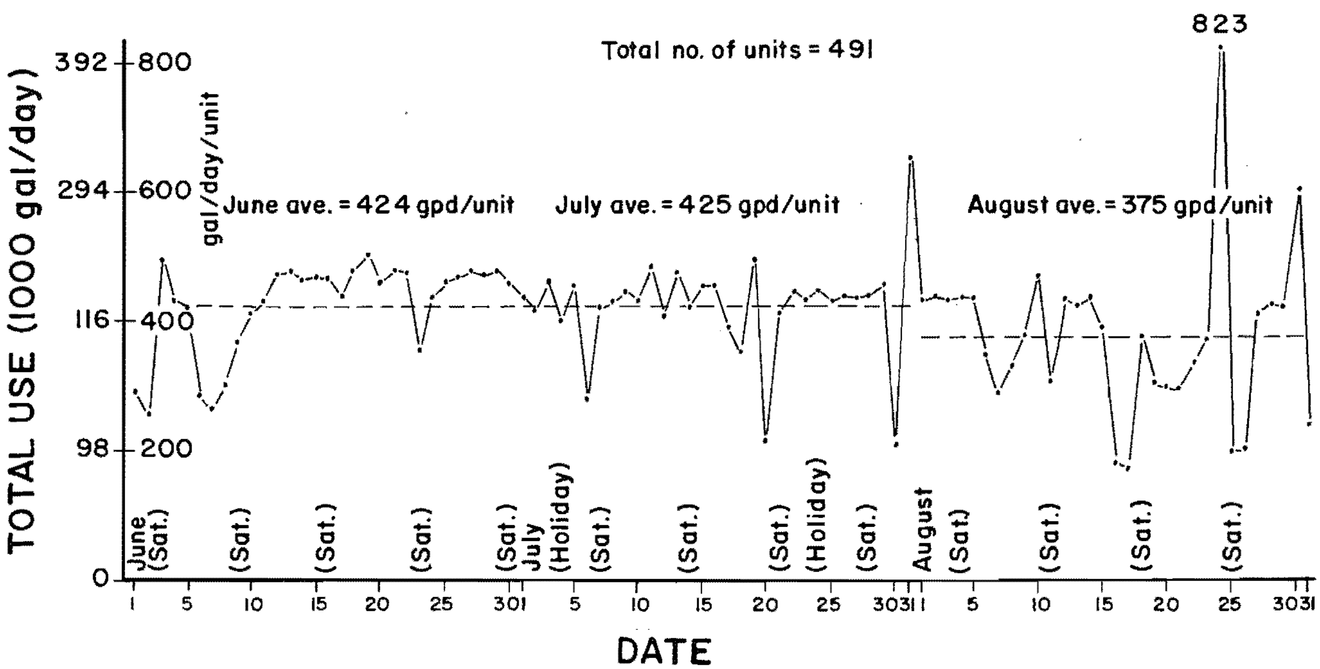

Figure 20. Daily water demand for Bullfrog Marina.

Recreation Vehicle Campgrounds

11-Cherry Hill

Daily meter readings were taken during August 1979, and short term measurements were recorded during one weekend of that month. These data are displayed in Figures 21 and 22 respectively. The Cherry Hill data are summarized in Table 15.

Table 15. Summary of water demand for Cherry Hill.

Time Interval	Water Use		
	Total Units	Occupied Units	% Occupied
August	87.3 gpdu	128 gpdu	68
Peak Day	137.5 gpdu	155 gpdu	89
Peak Hour	0.186 gpmu	0.321 gpmu	
Instantaneous Peak (12 min.)	0.308 gpmu	0.438 gpmu	

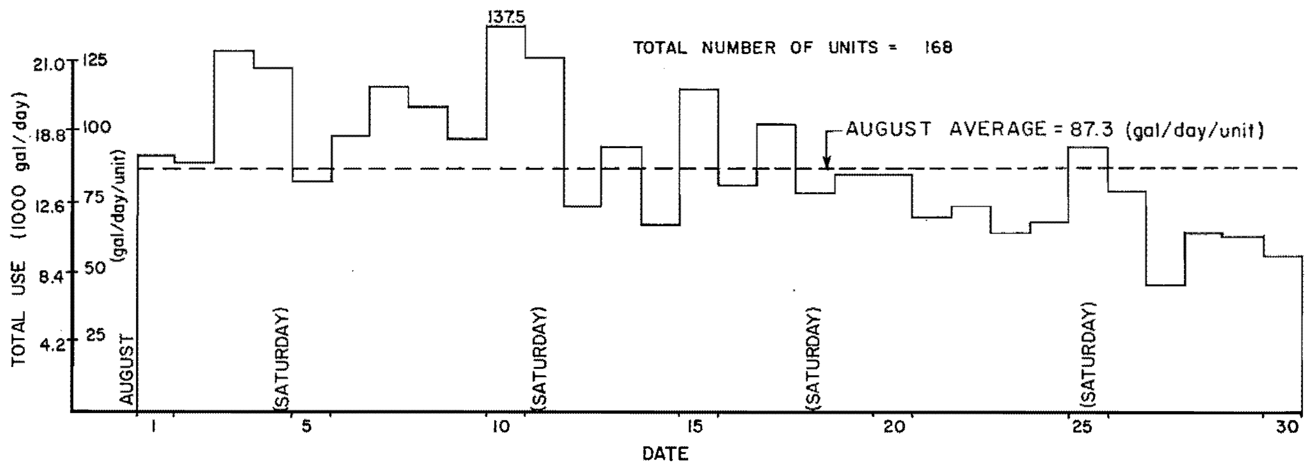

Figure 21. Daily water demand for Cherry Hill Campground.

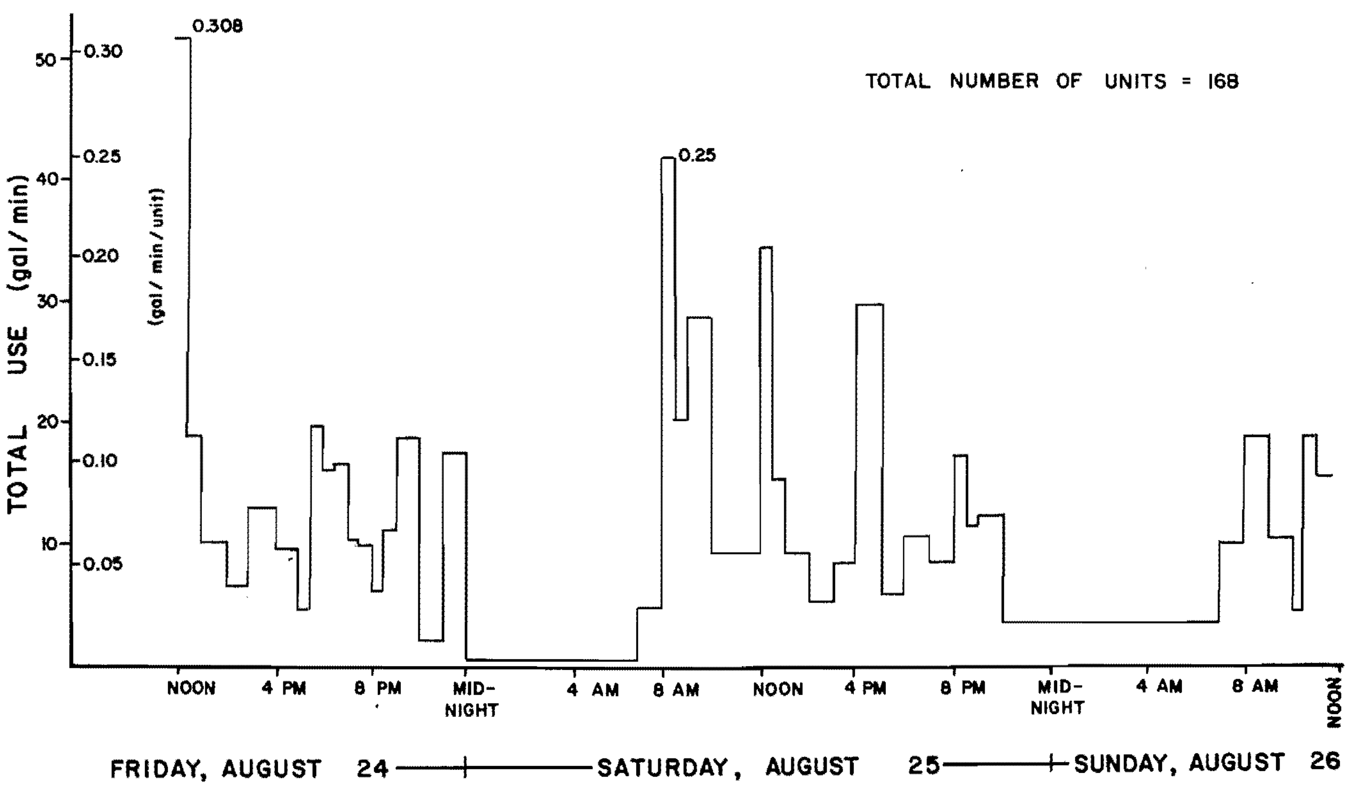

Figure 22. Short term water demand hydrograph for Cherry Hill Campground.

12-KOA (Bear Lake)

Only 30 hours of data were recorded before the meter was destroyed; but since this period was a peak holiday weekend (July 4th), the data should approximate peak values. The data are shown in Figure 23. The KOA data are summarized in Table 16.

Table 16. Summary of water demand for KOA (Bear Lake).

Time Interval	Water Use		
	Total Units	Occupied Units	% Occupied
One Day	78.3	128	61
Peak Hour	0.12 gpmu	0.20	61

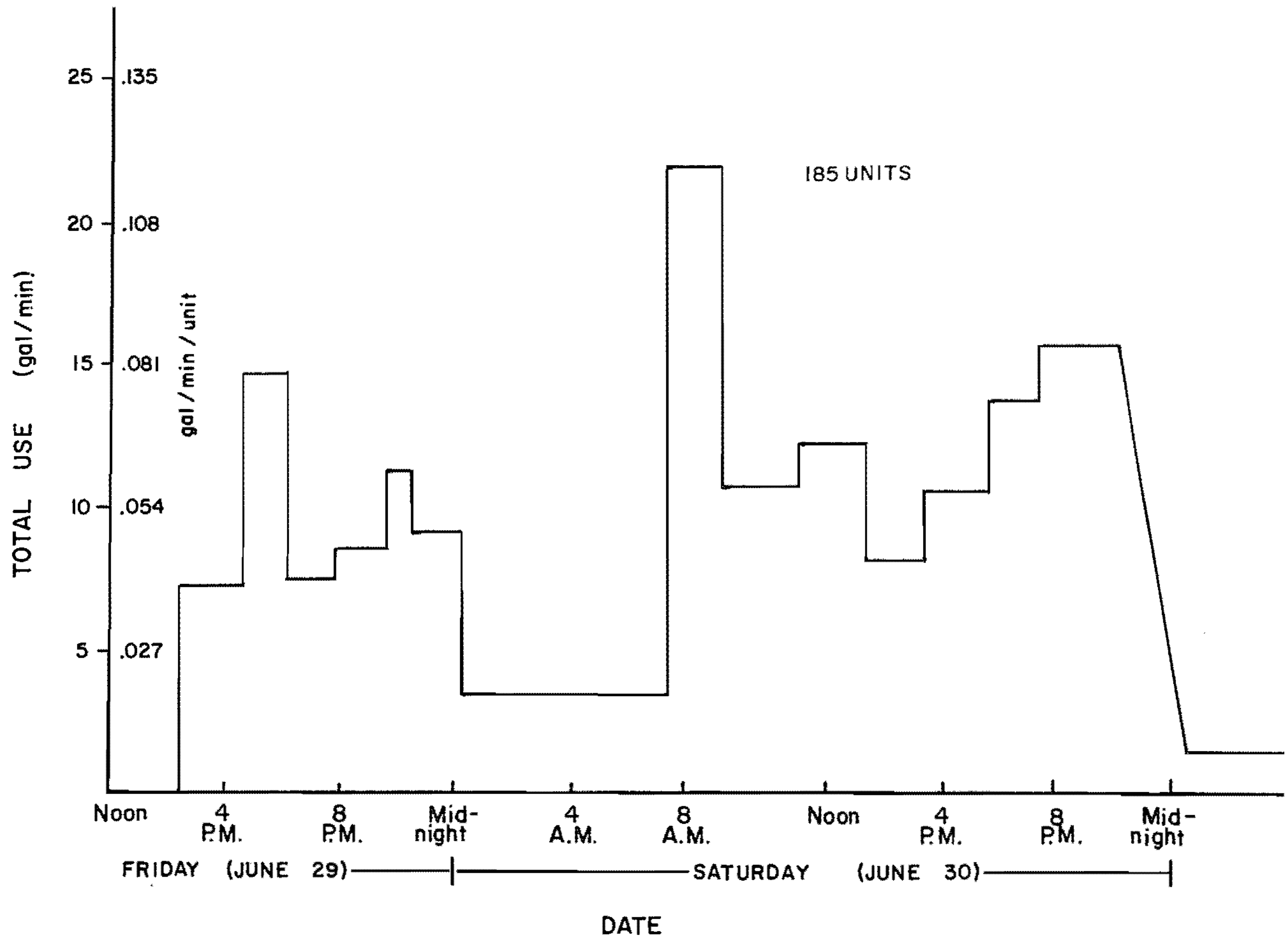

Figure 23. Short term water demand hydrograph for KOA Campground.

Frequency Analysis on Daily and Instantaneous Demand

In many hydrologic studies, historic data are used to predict the probability of future events using frequency analysis. In this section, frequency analysis is used to estimate water use levels with a probability P of being equaled or exceeded during a certain time period. This time period will be the period for which data are available. This probability is often alternately expressed in terms of a recurrence interval, $T_r (= 1/P)$. In this analysis, however, the recurrence interval concept could be misleading. For example, data are available from most of the resorts only during the peak season. Use of frequency analysis of such data to calculate events with recurrence intervals longer than 1 year implies some knowledge (or assumption) concerning use rates during the portion of the year without data and an appropriate adjustment of the plotting position equation to expand the data base to the entire year. Such an adjustment was used, for example, by Hughes and Gross (1979) for analysis of municipal water use measured only during summer months. Sufficient reliable data were not available for this sort of expansion in this study where many different lengths of data base exist, where the lengths of "peak season" may or may not be well defined, and where the data base may vary from covering most of the peak season to only a small part of it.

In order to simplify interpretation of the probability analyses, the approach will be to associate probability statements directly with whatever data base was used. That is, if 2 months of daily data were recorded during what was assumed to be the peak season (say July and August at a particular resort), the probability of various water use rates during future peak seasons will be calculated. However, no multiple year recurrence interval use levels will be presented except for one development where year around data were available.

A discussion of peak day frequency analysis based upon subsets of the data--namely weekends and holidays only, will be given in a later section.

A review of the data indicate that the daily and instantaneous data can be approximated by a normal distribution. Using the method of moments, the mean and standard deviation of each data set are computed and used as estimates of the population parameters. If the normal probability function is used for estimation of the demand,

$$X = \overline{X} + SK$$

where

- X = the estimate of demand given a probability of exceedance, P
- $\overline{X}$ = the mean of the data sample
- S = the standard deviation of the data sample
- K = the number of standard deviation from the mean for a normal distribution, which is associated to the probability, P

This probability function requires an assumption that the mean and standard deviation of the data sample equal the true mean and standard deviation of the population. Little error will be introduced if the data sample is large. If the data sample is small, the student t-distribution is more desirable than the normal distribution. The student t-distribution assumes a normal distribution with allowance in the point estimates of the mean and standard deviation. This is accomplished by allowing a function of degree of freedom of that sample. The difference in estimates between using t-distribution and normal distribution becomes smaller as the degree of freedom increases. The estimates using t-distribution are more conservative (estimates are higher) because of the randomness allowance in the mean and standard deviations. The estimated demand at a given probability of exceedance, P, using the t-distribution is

$$X = t^{1-\alpha,N-1} \; S\sqrt{\frac{N+1}{N}} + \overline{X}$$

where

- t = student t value associated with (probability) and (degree of freedom)
- α = P
- N = number of data in the sample

In the study, except for Teton Village where a normal probability function was used because of the large quantity of data points, estimates of the demand at a given probability level are based on the t-distribution. The expected demand for various probabilities for developments with available data is summarized in Table 17. Since data obtained from different developments are from different time periods, the period to which the estimates can apply also vary among developments. This time period is listed in the table under the term of "Period Applicable."

Risk of Exceedance Analysis

Each result in Table 17 defines the expected daily total and peak demands at given probabilities during a certain time period. However, in order to define a confidence limit that the daily demand will not exceed a certain magnitude during a particular time period, further analysis is required. An equation which estimates the probability of an event with probability of exceedance, P, will be exceeded exactly K times during a given time period (Linsley et al. 1975) is:

$$J = 1 - \binom{N}{K} (1 - P)^{N-KpK}$$

where

- N = number of time intervals (days) in a given time interval
- K = number of times (days) the given value of event will be exceeded
- P = probability of exceedance of the event with the given value
- J = probability that the value of the event will be exceeded exactly K times in N time intervals

For K = 0, that is the largest event ever within the time interval of N days, the equation is reduced to

$$J = 1 - (1 - P)^N$$

A 95 percent assurance (or confidence) level is frequently used in most statistical analysis. Table 18 gives the values for the expected demand and the 95 percent assurance level for several probabilities of exceedance for each development.

Frequency Analysis of Weekend and Holiday Data

The quantities given in Tables 17 and 18 are based upon analysis of all the peak season data available. An interesting question is whether excluding nonholiday weekdays would lower or raise the estimate of peak day demand. That parameter is a function of both mean and standard deviation. One would expect the weekend mean to be higher at most resorts, but the standard deviation may well decrease due to exclusion of weekday data which may be very different than the presumably higher weekend events. This section will include frequency analysis of data from weekends and holidays only, and will compare the results to the related

Table 17. Frequency distribution of daily and instantaneous water demand.

Probability of Exceedance		0.25	0.01	0.005	0.0005
Developments	Period Applicable				
		Daily Total Demand (gpdu)			
Mountain Cabin					
Pine Mountain	June - Aug.	173	351	384	468
(data are insufficient for other sites in this category)					
Condominium - Ski Area					
Snowbird	Mid-Dec. - Feb.	358	406	413	435
Teton Village	Jan. - Dec.	318	485	510	577
Brian Head	Dec. - mid-Jan.	179	312	333	397
Condominium - Water Based					
Sweetwater	July	493	750	793	926
Marinas					
Bear Lake	July	44.8	62.2	64.9	73.9
Bullfrog	June - Aug.	475	636	660	730
Campground					
Cherry Hill	Aug.	106	147	154	176
		Instantaneous Demand (gpmu)			
Condominium - Ski Area					
Snowbird	Mid-Dec. - Jan.	0.446	0.544	0.559	0.605

Table 18. Water demand at 95 percent assurance level.

Probability of Exceedance		0.10		0.01		0.005		0.001	
Developments	Period Applicable	Expected Value	95% Exceedance Value	Expected Value	95% Exceedance Value	Expected Value	95% Exceedance Value	Expected Value	95% Exceedance Value
				Daily Total Demand (gpdu)					
Mountain Cabin									
Pine Mountain	June - Aug.	238	379	351	467	384	497	447	547
Condominium - ski area									
Snowbird	mid-Dec. - Feb.	375	412	406	438	413	441	429	459
Teton Village	Jan. - Dec.	379	509	485	582	510	601	562	642
Brian Head	Dec. - mid-Jan.	227	332	312	396	333	414	378	454
Condominium - water based									
Sweetwater	July	543	785	750	915	793	963	887	1039
Marina									
Bear Lake	July	50.9	64.4	62.2	72.9	64.9	75.9	71.0	80.8
Bullfrog	June - Aug.	534	660	636	730	660	748	711	789
Campground									
Cherry Hill	Aug.	119	153	147	174	154	182	169	194
				Instantaneous Demand (gpmu)					
Condominium - ski area									
Snowbird	mid-Dec. - Jan.	0.481	0.554	0.544	0.595	0.559	0.616	0.591	0.629

quantities based upon all of the data. The objective here is to determine the validity of the question posed above and also to provide some basis for data collection in future studies.

Analysis was made on five different resorts where an adequate number of data points are available: Pine Mountain, Snowbird, Teton Village, Brian Head, and Bullfrog Marina. The other resorts have such limited amounts of daily data that weekend only analysis was not possible. Table 19 shows that weekend-holiday mean water use was higher than the overall mean, except at Teton Village and Bullfrog Marina. However, the difference is significant only at Pine Mountain (the only mountain cabin development analyzed). The standard deviation was also higher at Pine Mountain and at two of three ski resorts, but the differences are relatively small. Except for Pine Mountain, the combination of mean and standard deviation differences between using all data and using only the weekend and holiday data are insignificant.

Table 19. Mean and standard deviation of daily demand for various developments using only weekend and holiday data and using all data.

Developments		Weekend and Holiday Data	All Data
Pine Mountain	No. of Data	29	38
	Mean	155.5 gpdu	103.8 gpdu
	s.d.	115.1 gpdu	101.8 gpdu
Snowbird	No. of Data	22	75
	Mean	350 gpdu	33.9 gpdu
	s.d.	22.7 gpdu	24.7 gpdu
Teton Village	No. of Data	106	353
	Mean	249 gpdu	250 gpdu
	s.d.	108.6 gpdu	101.0 gpdu
Brian Head	No. of Data	15	44
	Mean	136 gpdu	128 gpdu
	s.d.	78.0 gpdu	75.3 gpdu
Bullfrog Marina	No. of Data	28	92
	Mean	398 gpdu	408 gpdu
	s.d.	78.1 gpdu	98.0 gpdu

As in the previous section, the t-distribution is used to predict the demand at various probabilities of exceedance, and the results are shown on Table 20. Pine Mountain has a large difference in results using the two sets of data. Clearly, weekend only data at mountain cabins would produce higher estimates of peak day water use than data sets including weekdays. However, the Snowbird analysis shows that there is essentially no difference between peak day estimates of the two data sets. Both Brian Head and Teton Village have also shown only small differences, but difference tends to increase with smaller probability for Brian Head because of a smaller number of data points (15 dates). A surprising result is indicated by the analysis of Bullfrog data where estimates using weekends and holiday data are less than using all data (though the difference is small).

Table 20. Frequency distribution of daily water demand, comparison between using only weekend and holiday data and using all data.

Probability of Exceedance	0.25		0.01		0.005	
Development	W&H	All	W&H	All	W&H	All
	Daily Demand (gal/day/unit)					
Pine Mountain	235	173	444	352	479	384
Snowbird	366	358	408	406	416	413
Teton Village	323	318	507	485	536	510
Brian Head	191	179	347	312	375	333
Bullfrog Marina	453	475	597	636	621	660

Note: W&H = weekend and holiday data
All = all available data

From results shown in Tables 19 and 20, one would conclude that for ski resorts and marinas, the water use does not depend on whether the day is a weekend (holiday) or weekday. This should not be surprising in the case of major ski resorts where rooms are rented by the week to "fly in" skiers, who may actually leave the resort for other activities in nearby cities on weekends in order to avoid the long lines created by local skiers on Saturdays and Sundays.

The mountain cabin results, however, indicate that weekend/holiday data would be a more conservative (higher) and therefore better estimator of possible future peak day water demands. The difference in results between categories of resorts can be explained by the occupancy rate of the development. Ski areas and marinas are usually filled to near capacity all the time during the season, regardless of the date. Mountain cabin development has a much higher occupancy rate during weekends. An analysis of occupancy rate for mountain cabins will be given in a later section.

Peak Flow Duration Analysis

The instantaneous peak demands estimated in previous sections of this report are based on average flowrates in time intervals between two meter readings (except for Snowbird, where it is based on the reservoir elevation difference and pumping status). This time interval varies from development to development depending on the available data. The time interval where peak demand occurs for each of the developments are given in Table 21.

Table 21. Time intervals where recorded peak instantaneous demands occurred.

Development	Peak Demand (gpmu)	Minimum Time Interval Measured
Pine Mountain	0.995	30
Silver Fork	0.468	5
Snowbird	0.534	30
Cherry Hill	0.308	12

It should be noted that these "peak demands" are not the absolute maximum instantaneous demands (which are always greater than the values measured over discrete intervals).

Instantaneous flowrates for various durations of time for each of the four developments are plotted in Figures 24, 25, and 26. Figure 24 shows the patterns for the two mountain cabin developments, Pine Mountain and Silver Fork. Variation of demand is much larger in Pine Mountain than in Silver Fork, which has an almost constant flowrate for over 80 percent of time (which may be mostly leakage). As can be seen in the figure, the absolute maximum demand (as time approaches zero) is unknown.

Figure 25 shows the flowrate vs time duration from the peak day and an average day during January at Snowbird. The sparseness of data points results from the nature of the continuous reservoir level record. A new data point occurs only when the slope of the record changes sufficiently to become measurable. Figure 25 shows that the two curves follow approximately the same pattern, except that the variation is higher for the peak day. The peak flows occur during a 75-minute and a 2-hour interval for the peak day and average day respectively. Variation of flowrates in such a comparatively long time interval should be very large. The absolute maximum demand will be much larger than the peaks indicate in the figure.

Data on Cherry Hill are plotted on Figure 26. It follows the pattern for the most time duration curves, i.e., flowrate decreases drastically for the first one or two hours of duration, then levels off (still decreasing) for longer time durations. Unlike the other developments, Cherry Hill had very little water usage for a duration of 7 hours (time duration between 17 and 24

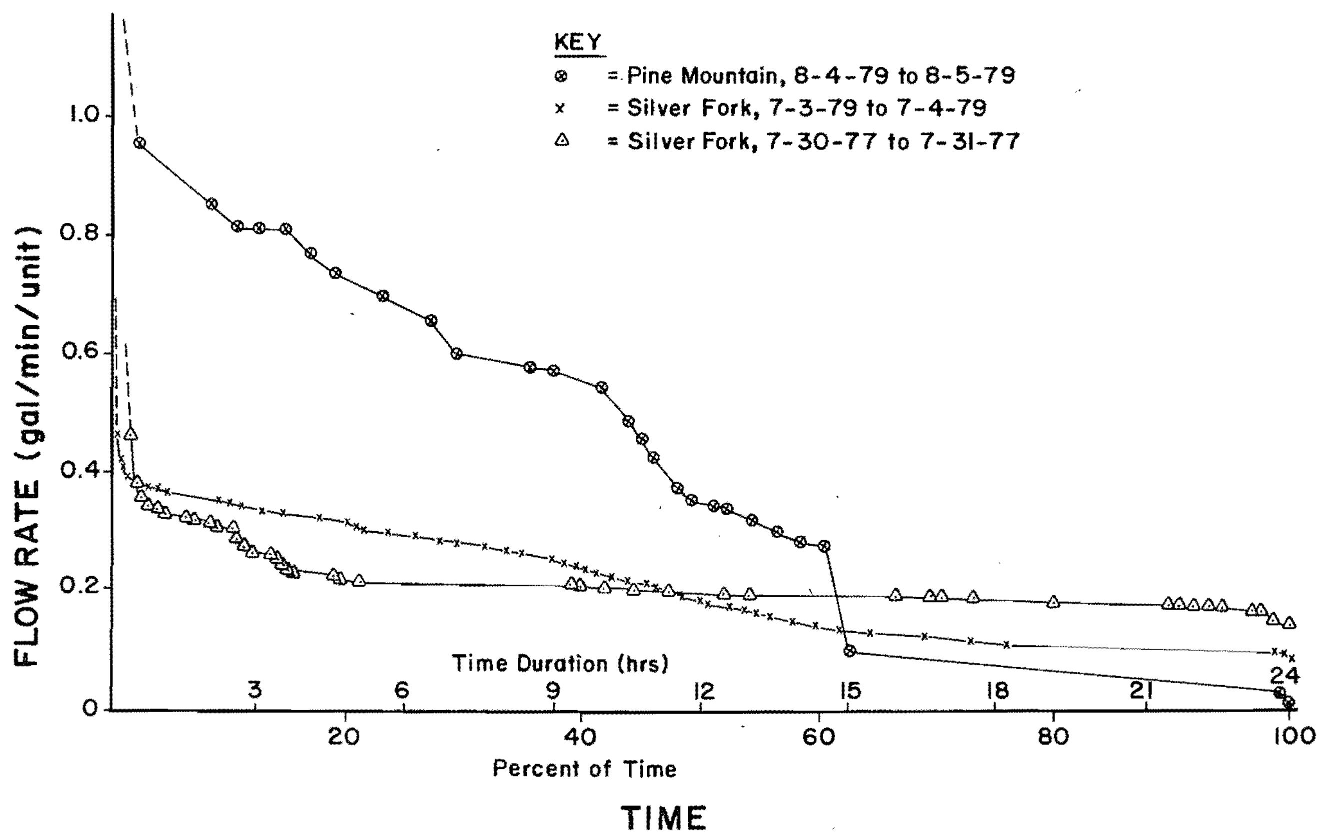

Figure 24. Time duration curves for Pine Mountain and Silver Fork.

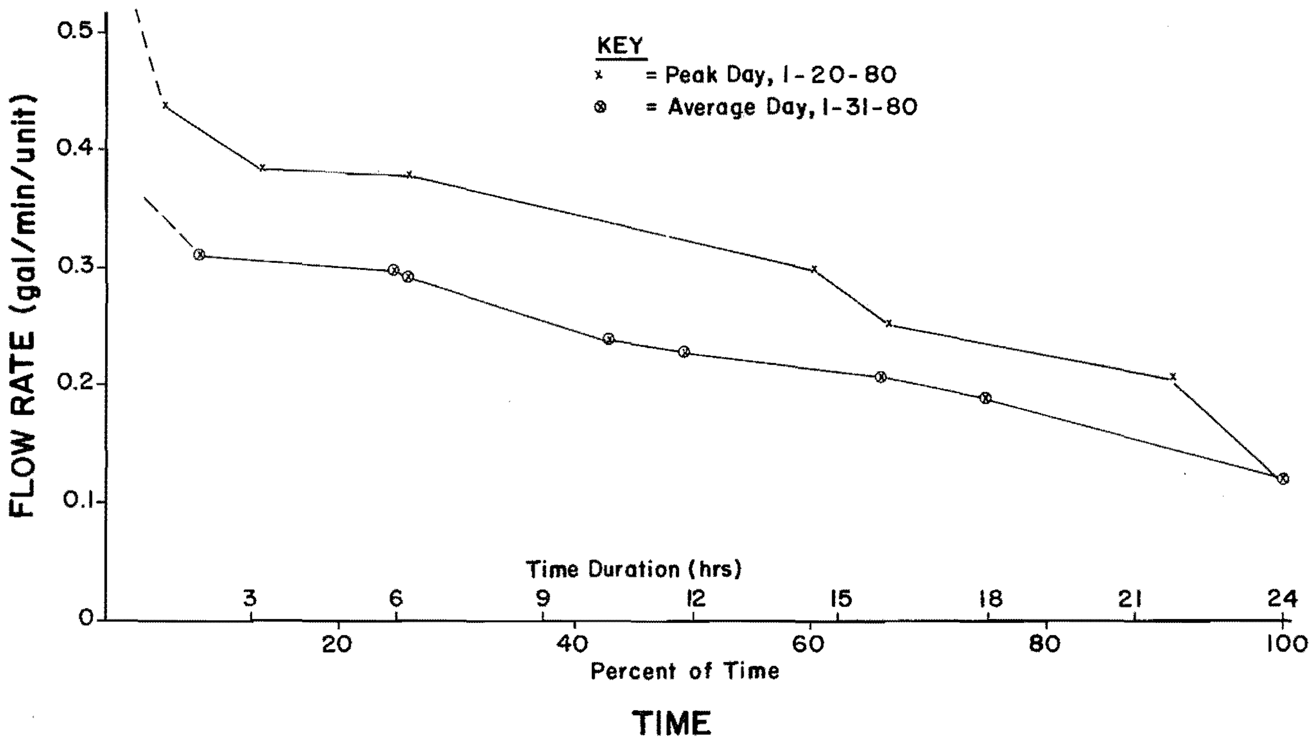

Figure 25. Time duration curves for Snowbird.

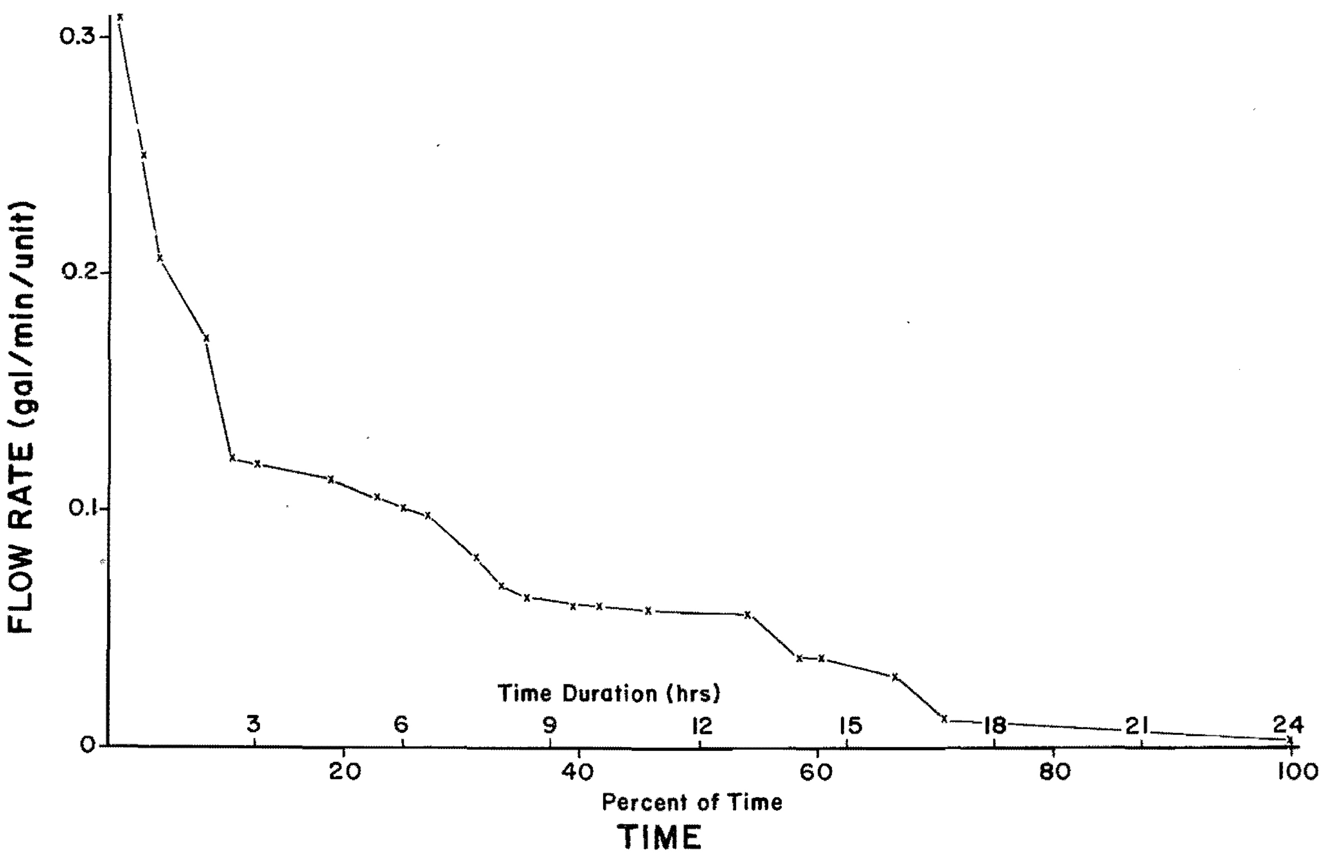

Figure 26. Time duration curve for Cherry Hill Campground.

hours). For other developments, a small but still significant flowrate is observed for long durations of time, even during late night hours.

Water Use--Occupancy Regression Analysis

One important determinant of the differences between municipal and recreation development water demand is the occupancy pattern. Occupancy rates are high for permanent residences regardless of season of the year or day of the week. Recreation development occupancy rates, on the other hand, vary dramatically seasonally and in some cases with day of the week even during peak seasons. Occupancy or visitor day data were available for some of the resorts. The functional relationship between water use and occupancy at those sites is analyzed in this section in an attempt to better quantify differences between municipal, residential, and recreational water demands.

Brian Head

This water system has master meters at each of the three condominium buildings. Daily water demand was regressed against daily occupancy in each building, for the 1 1/2 months with data available. Extremely high correlation coefficients were obtained for each of the three buildings (see Table 22). Unlike other developments, the occupancy record here gives the number of guests in each building instead of the number of units occupied. Results in Table 22 show that the per capita use for the three different buildings vary over a large range. There is no clear explanation for this wide variation between buildings since they each have similar facilites; however, examination of the regression coefficients in Table 22 indicates that most of the variation between buildings is due to the intercept coefficient (the constant a) rather than the per capita coefficient (b). This suggests that a constant leakage approaching 286 gpd may exist in the building #3 plumbing system. The extremely high correlation between water use and occupancy in each individual building suggests that some "adjustment" of data may have occurred. These historic data were reported by the water system manager and were not measured by the research team. The relationship for one of the buildings is shown graphically in Figure 27.

Bullfrog Marina

Six months of use data (boating days) are available for each year at this development. Monthly water demand was regressed against the number of boating days in each month. The result yields a correlation coefficient of 0.74 (Table 22 and Figure 28) and indicates a degree of dependence.

Cherry Hill

Daily water use for a period of one month is regressed against number of vehicles in the development each day. Since this is a vehicle campground, the number of vehicles inside the development is assumed to be the number of units used. The result shows a correlation coefficient of 0.75 (Table 22 and Figure 29) which is in the same level as Bullfrog Marina.

Table 22. Water use/occupancy regression analysis.

Regression Equation $Q = a + bX$		Regression Coeff. a	Regression Coeff. b	Concl. Coeff. r
Brian Head				
Q = daily water usage (gallons)	Building #1	-74.0	79.8	0.9996
X = no. of occupants (persons)	#2	8.6	53.4	0.9980
	#3	285.9	86.4	0.9972
Bullfrog				
Q = monthly water use (10^3 gallons) X = monthly boat visitations (boat days)		1440	248	0.74
Cherry Hill				
Q = daily water use (gallons) X = no. of occupancy (vehicles)		880	120	0.75

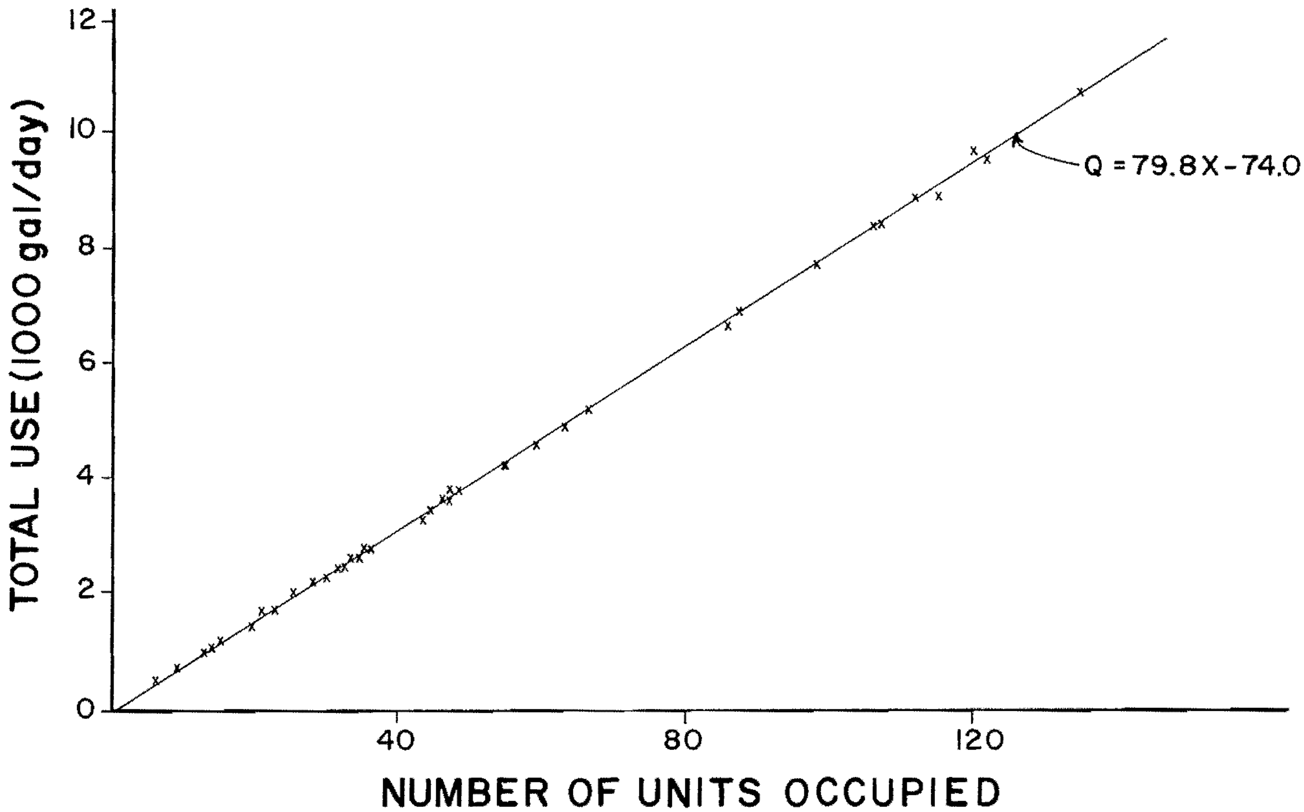

Figure 27. Regression between water demand and occupancy for Brian Head.

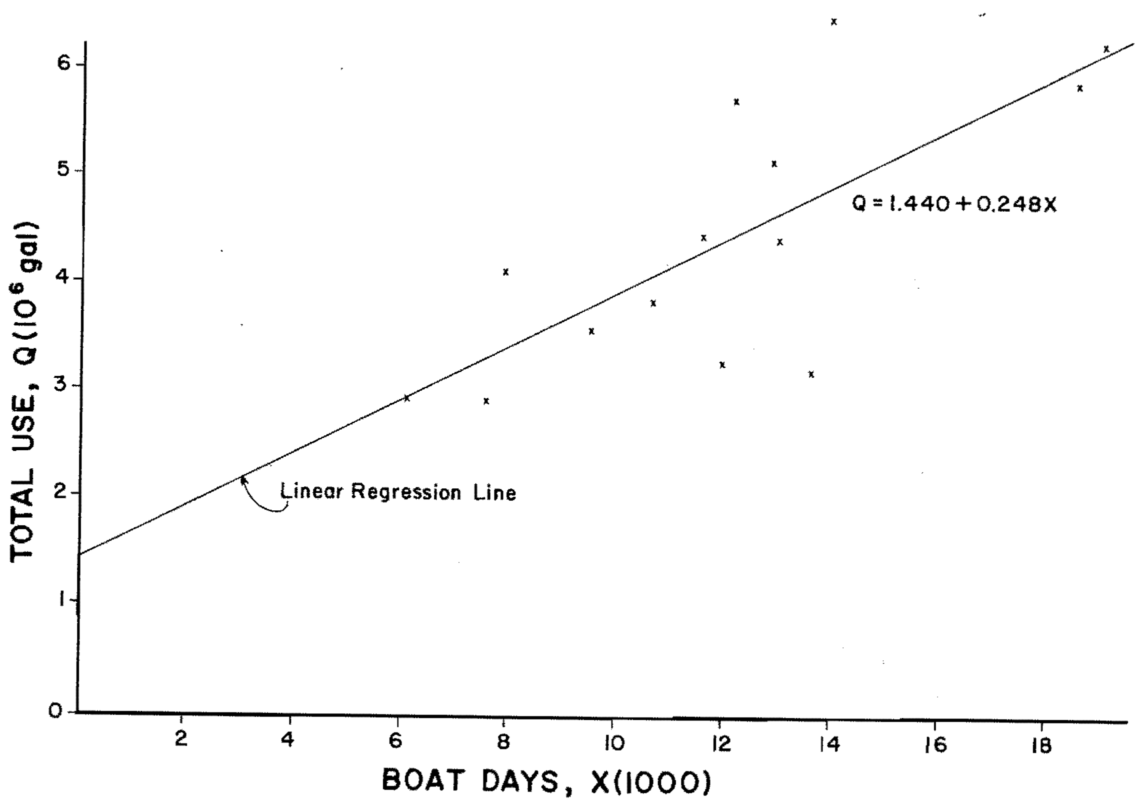

Figure 28. Regression between water demand and boat visitations for Bullfrog Marina.

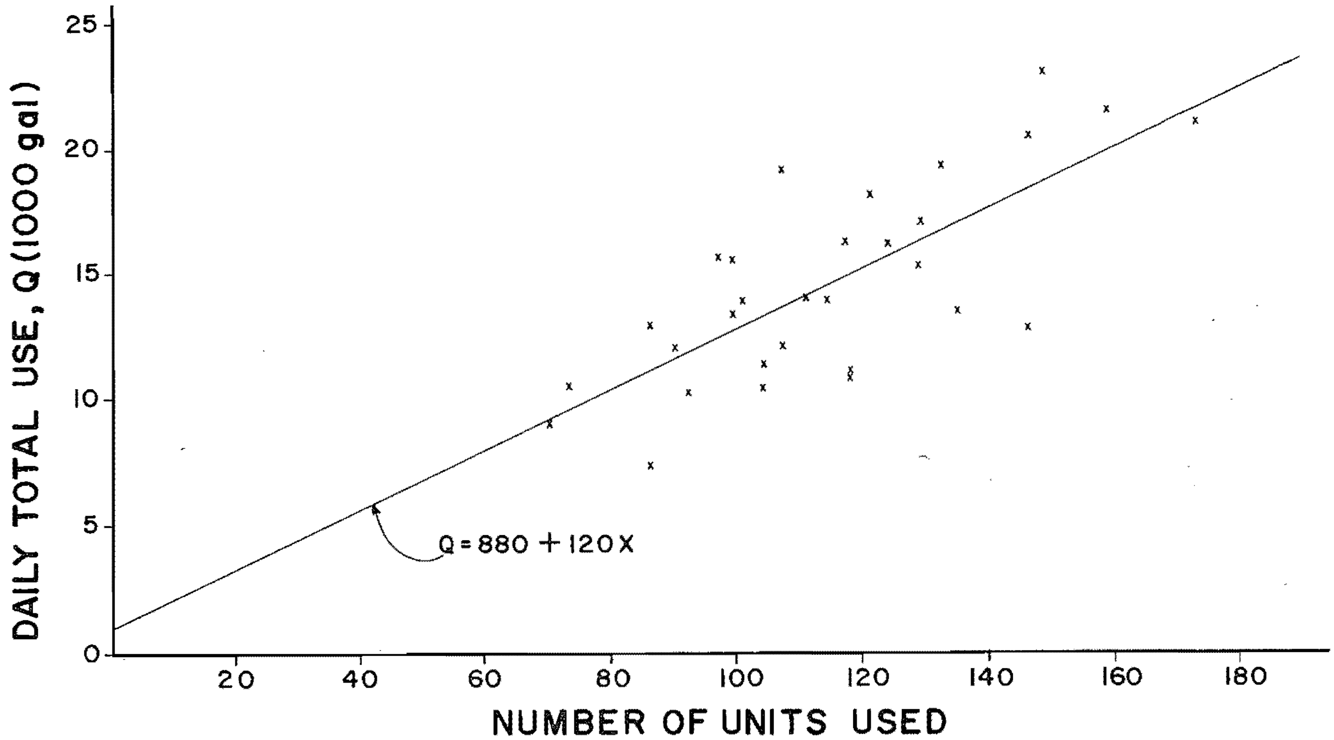

Figure 29. Regression between water demand and occupancy for Cherry Hill Campground.

Summary

The high correlation coefficients obtained at Brian Head indicate a strong dependency between water demand and occupancy. The regression coefficients estimate a use per unit occupied. The high correlation and unit values indicate a per person water use of 53 to 86 gpd. Although the correlation is much better than expected, a relatively high correlation compared to other resorts is logical since Brian Head has three meters connected into three individual buildings and water use outside of the buildings is not included.

Results in Bullfrog Marina and Cherry Hill have lower correlation coefficients because the meter records are not the same type in that they are important determinants of water use besides the independent variable. For example, the water in Bullfrog Marina is consumed not only by boaters though they are the major users (their number explains about 75 percent of the use) but by campers, mobile homes, and other support facilities. If longer data records were available and included measurements of numbers of these other users, multiple regression techniques could be used to derive regression coefficient "b's" indicating use per each type of unit.

Occupancy Rate of Mountain Cabins

A previous section analyzed the correlation between water use and occupancy in various types of resorts. This analysis is concerned rather with the probability of occupancy itself exceeding any given level at mountain cabin developments. A review of the State of Utah Public Drinking Water Regulation indicates that the design standards of summer homes (mountain cabins) are essentially the same as that of a community water system. A claim often made by developers of mountain cabin developments is that they experience very low occupancy rate relative to permanent residences; thus a smaller source capacity should be allowed. Occupancy records (not complete) can be obtained from three of the four mountain cabin developments included in this study (Bridgerland Village, Timber Lake, and Pine Mountain). Analyses of these data follow. The analyses include two very different kinds of statistics as follows: 1) Indicators of probability of "at least one day" occupancy during periods longer than one day; and 2) probability of occupancy levels on a particular day (which are much lower quantities than the former).

Bridgerland Village

Occupancy data were obtained from meter readings of individual units. A change in meter readings during a certain time interval indicates there was occupancy of at least one day within that period in that unit. Only six daily occupancy records, during the July 4th week, could be obtained in this manner. This 6-day period is considered one of the peak periods in the season. The highest recorded occupancy rate (on a single day) is 60 percent (18 units occupied) and the lowest is 40 percent (12 units). During the 6 day interval, 80 percent (24 units) of the cabins had at least a 1-day occupancy. In a similar time period, a 5-day interval during the Pioneer Day holiday week, only 56.7 percent (17 units) of the cabins had at least a 1-day occupancy. On a monthly basis, the "at least 1-day" occupancy rate is 83.3 percent (25 units) in July and 90 percent (27 units) in August in 1979.

Timber Lake

Eleven daily occupancy records are obtained in the same manner as those in Bridgerland Village. Of the 11 periods, 9 are for weekends or holidays. The highest recorded occupancy rate is 45.8 percent (38 units) on a Saturday and the lowest is 16.9 percent (14 units) on a weekday. During the same 5-day period within the Pioneer Day holiday week, Timber Lake had a "at least 1 day" occupancy rate of 42.2 percent (35 units) compared to 53.3 percent for Bridgerland Village. On a monthly basis, the "at least 1-day" occupancy rates are 92.8, 95.2, 88.0 percent for June, July, and August respectively in 1979.

Pine Mountain

Occupancy records of 50 days are available during a 3-month period in 1976. The records include all the weekends and holidays (29 days) in that period. Distinct differences in occupancy rates are found between weekends (holidays) and weekdays. Weekends and holidays have an average occupancy rate of 51.5 percent compared to 19.7 percent on weekdays. The 19.7 percent may still be overstated because of two weekdays in the July 4th week having occupancy rates of 52.7 percent and 60 percent. If those two days are excluded in the computation of the average, 15.9 percent is the average occupancy rate on nonholiday weekdays. The highest recorded occupancy rate is 70.9 percent (39 units) while the lowest is 5.5 percent (3 units). The occupancy percentage here is based on the total of 55 units in 1976, but since then Pine Mountain has expanded to 115 units in 1979.

Frequency Analysis on Occupancy Rate of Mountain Cabins

In this section, frequency analysis is used to predict the probability of a mountain cabin development having a certain level of occupancy. The variable considered, number of occupants, is a discrete variable, therefore the binomial distribution is considered to be an appropriate distribution for probability analysis:

$$P = \binom{n}{x} \theta^{x} (1 - \theta)^{n-x}$$

where

- P = probability that there is x occupancy in n units on any given day
- n = total number of units
- x = number of units occupied
- θ = probability that a unit is occupied on any given day (this parameter is estimated from data available)

Because n is relatively large ($\geq$ 30) for each of the three developments, computation of $\binom{n}{x}$ will become very tedious. Normal distribution is often used to approximate the binomial probabilities in these cases (Freund 1971). Also, as discussed in an earlier section, student-t distribution is favored over normal distribution when number of data points is limited. All three developments have less than 30 data points of occupancy record and student-t distribution is therefore used. Pine Mountain originally had 50 data points but that is not complete for a whole season. All weekends and holidays during the 3-month period are included and only about one-third of the weekdays record are available. The nonholiday weekdays and weekends (and holidays) records are analyzed separately to decrease bias of the results. This yielded two sets of data for Pine Mountain, one with 29 dates, another with 19 dates (two extremely high weekday records are excluded to prevent bias), data for Timber Lake are reduced from 11 to 9 for analysis of weekend and holidays only.

Figure 30 shows that normal distribution is a good approximation to the models. The occupancy level for various probabilities of exceedance are summarized on Table 23 based on both normal and student-t distribution. The result shows that all three developments have little chance of reaching 80 percent occupancy level on any single day. Differences between results of t distribution and normal distribution for Bridgerland Village are very significant because of the small sample of six data points. Still the result is considered overstated because that 6-day period is one of the peak periods during the season.

Timber Lake has a low occupancy rate compared to the other two--there is very little chance of the occupancy level reaching 60 percent. Pine Mountain has a high variance on occupancy during weekends and holidays. It has approximately a 1 percent probability that occupancy will be over 80 percent, but that is only applicable to the weekends and holidays during a season. There are approximately 30 days of weekends and holidays in one season, thus it would be expected to reach that level of occupancy approximately once in 3 years. The differences in occupancy level between holidays (weekends) and nonholiday weekdays are very significant as can be shown in Figure 30 for Pine Mountain. Occupancy level for weekdays seldom reach 30 percent--1 percent probability which is equivalent to approximately twice every 3 years.

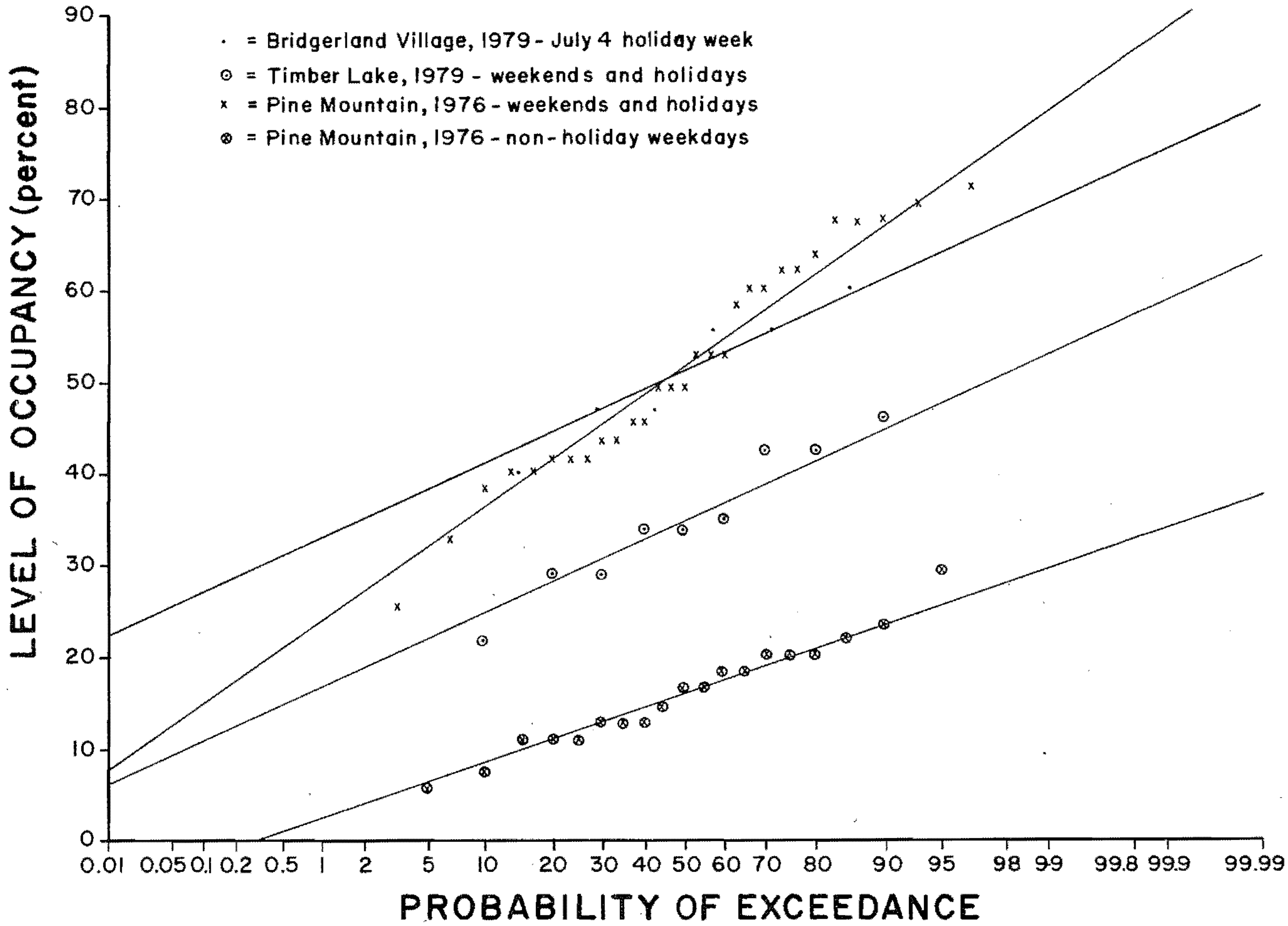

Figure 30. Frequency analysis of occupancy at Mountain Cabins.

Table 23. Summary of occupancy levels for various probabilities of exceedance.

Probability of Exceedance		0.1	0.05	0.01	0.005
Development	Distribution	Level of Occupancy (Percent)			
Bridgerland Village	Normal	61.1	63.9	69.2	71.2
	Student-t	63.5	68.1	79.5	85.1
Timber Lake	Normal	44.6	47.4	52.6	54.5
	Student-t	46.0	49.7	58.1	61.9
Pine Mountain (weekends and holidays)	Normal	66.8	71.1	79.2	82.2
	Student-t	67.4	72.0	81.3	84.9
Pine Mountain (nonholiday weekends)	Normal	23.4	25.6	29.6	31.0
	Student-t	23.9	26.3	31.3	33.2

Table 24. Summary of water use and comparison to municipal levels and state standards.

Development Type and Location	Number of Units	Total Season Measured (gpdu)	Peak Month (gpdu)	Peak Day: Recorded (gpdu)	Peak Day: Avg Prob=.01 (gpdu)	Peak Day: Avg Prob=.0005 (gpdu)	Peak Day: 95 Percent Assurance of Prob. = .01 (gpdu)	Instantaneous Peak flow (gpmu)	(Peak Month / Season Avg)	(Peak Day / Season Avg)
1. Municipal Reference										
a. Salt Lake City	63,000	974	2365	2466				-	2.42	2.53
b. Bountiful	6,340	444	528	598				-	1.18	1.21
c. Utah Municipal Sample Avg.	5,340	608	1085	1256				1.5	1.78	2.06
2. Mtn. Cabin Development										
Present state requirement				800				1.76-1.96		
a. Bridgerland Village	30	147	157	324					1.06	2.20
Rec./Mun. Ratio[1]		(.24)	(.15)	(.26)						
Rec./DOH Ratio[2]				(.41)						
b. Timber Lakes	83	40	-	83						2.08
Rec./Mun. Ratio		(.06)		(.07)						
Rec./DOH Ratio				(.10)						
c. Pine Mountain	115	91	117	435	351	468	467	.995	1.29	4.78
Rec./Mun. Ratio		(.16)	(.11)	(.35)				(.66)		
Rec./DOH Ratio				(.54)				(.50)		
d. Silver Fork	155	259	343	-				.47	1.32	
Rec./Mun. Ratio		(.43)	(.32)					(.31)		
Rec./DOH Ratio								(.27)		
3. Resort Condominiums										
Present state requirement				500[3]						
a. Snowbird	470	324	352	405	406	435	438	1.18	1.09	1.25
Rec./Mun. Ratio		(.53)	(.32)	(.32)				(.36)		
Rec./DOH Ratio				(.81)				(.45)		
b. Teton Village	532	250	383	624	485	577	582		1.53	2.5
Rec./Mun. Ratio		(.41)	(.35)	(.50)						
Rec./DOH Ratio				(1.25)						
c. Brian Head	133	128	164	276	312	397	396		1.28	2.16
Rec./Mun. Ratio		(.21)	(.15)	(.22)						
Rec/DOH Ratio				(.55)						
d. Sweetwater	446	363	395	856	750	926	915		1.09	2.36
Rec./Mun. Ratio		(.60)	(.36)	(.68)						
Rec./DOH Ratio				(1.71)						

Table 24. Continued.

4. Marinas										
a. Bear Lake State Park	141	49	–	–	62	74	73	.06		
Rec./Mun. Avg		(.08)	(.10)					(.04)		
b. Bullfrog Basin	400-600	408	425	823	636	730	730		1.04	2.02
Rec./Mun. Avg.		(.67)	(.39)	(.65)						
5. Recreation Vehicle Parks										
Present State Requirements										
a. Cherry Hills	168	-	87	138	147	176	174	.31		
Rec./Mun. Ratio			(.08)	(.11)						
Rec./DOH Ratio				(1.38)						
b. KOA	185	-	-	71						
Rec./Mun. Ratio				(.06)						
Rec./DOH Ratio				(.71)						

[1]Recreation System/Utah Municipal Average.

[2]Measured Peak Event/Utah Division of Health Requirement.

[3]Assuming 2 bedrooms per unit.

Table 25. Summary of design standards for State of Utah.

Type of Water System	Source Capacity (Peak Day)	Distribution Capacity (Instantaneous Peak)
Municipal	800 gpdu	gpmu = $10.8N^{-.36}$
Summer Homes	800 gpdu	gpmu = $10.8N^{-.36}$
Recreational Condominiums	250 gpd/bedroom	gpmu = $10.8N^{-.36}$
Recreational Vehicle Parks	100 gpdu	Not Specified
Marinas	Not Specified	Not Specified

N = Number of units served.

ANALYSIS SUMMARY AND RECOMMENDATIONS

General

There are several significant differences between water demand levels and patterns at municipal systems and recreation type developments. It is not possible to calculate water demand functions which are directly comparable to those of municipal systems because of differences in demand determinants. For example, Hughes and Gross (1979) developed well correlated demand functions for average and peak month periods in which the independent variables were price of water and an outdoor use index. Most recreation developments, however, do not meter individual users and charge them on a per unit basis, and therefore price is not a demand determinant (except for some mountain cabin developments).

Also, an outdoor use index (which accounts for relative magnitude of landscape irrigation) for recreation systems would have to be structured differently for each of the four categories of recreation developments (leaving an insufficient data base for statistical inferences within each category). The outdoor use index therefore is not a productive concept except perhaps for the mountain cabin category.

Municipal demand functions in Utah were also developed for peak day as a function of average day. This approach is potentially usable for recreation utilities. However, there are some difficulties. One is that average annual water use is not a very stable parameter at many resorts. Some resorts are open year around but experience extremely low occupancy during off seasons. Others are closed part of the year. Others have peak seasons which vary in length, depending upon the weather, and this distorts annual average water use levels. It appears that calculation of peak day demand as a function of average daily use might be useful if the average parameter were based upon the period a resort is open rather than having an annual time base. The present data base for Utah recreation sites is, however, inadequate for developing functions of this sort.

What can be presented from the data available for this study are ratios comparing the water use at various time intervals and various recreation sites to municipal use levels and to existing design criteria.

Since water demand varies greatly among municipal systems, the comparisons made here will be made with an average system (computed from a sample of Utah communities) and also with two systems which essentially span this range (Hughes and Gross 1979). Salt Lake City provides all of the indoor and outdoor demand of its residences through a single domestic system at a very low unit cost. It therefore has a relatively high demand (214 gpd per person or 974 gpdu average). Bountiful City experiences a much lower water demand for its moderately priced municipal water because a separate system serves all outdoor irrigation (101 gpd per person or 444 gpdu).

Table 24 summarizes the water use for each recreation development and allows comparisons to use levels in Salt Lake City, Bountiful, and a hypothetical "average" municipal system which represents the mean of a Utah municipal and rural 14 system sample developed by Hughes and Gross (1979). The table presents two kinds of ratios: 1) the recreation development water use divided by the average municipal parameter, 2) the recreation development water use divided by the Utah Division of Health requirement as given in the State of Utah Public Drinking Water Regulations. These requirements were given in the Review of Literature, but are summarized in Table 25 in revised form--instantaneous peak requirements are expressed as per unit quantities rather than total flow.

Mountain Cabin Summary

Seasonal and Monthly Demand

The seasonal average and peak month demands were both highest for Silver Fork. This was surprising since the data for Silver Fork are for the winter season only. One explanation may be the large late night flow which suggests substantial leakage (see Figure 24). The very low levels shown for Timber Lakes may be distorted by the inadequate system pressures. Bridgerland Village and Pine Mountain appear to best represent flows expected at future well designed and maintained water systems supplying mountain cabin developments. The peak season averages are 147 and 91 gpdu respectively and the peak month quantities are 157 and 117 respectively. These are all much lower than demands experienced at an average municipal system where 608 and 1085 gpdu are the respective numbers. Thus, the (rec/mun) ratios vary from 0.11 to 0.24. These data suggest that during periods as long as one month (including peak month) the water use at mountain cabin developments is not more than one-fourth that of an average municipality.

Peak Day Demand

The peak day water use at Bridgerland and Pine Mountain were 324 and 435 gpdu respectively. The peak to average ratio was very high at Pine Mountain (more than double that of Bridgerland). Compared to peak days in municipal water systems, the mountain cabin systems are still relatively low (ratios of 0.26 and 0.35) but higher than the longer term parameters. The State Division of Health presently requires 800 gpdu capacity at mountain cabin developments.

The measured flows were never more than 435 gpdu and the probability of an extremely rare event (P = 0.0005) is only 468 gpdu. However, it may be desirable to keep the standard as high as 600 until the data at representative developments such as Pine Mountain and Bridgerland Village can be extended to at least three peak seasons.

Instantaneous Peaks

The only short term data obtained were at Pine Mountain and Silver Fork. The measured peak events were two-thirds and one-third respectively of the peaks expected in a municipal system and one-half and one-fourth respectively of the state requirement. The relatively higher rec/mun ratios show that very short term peaks in recreational systems approach the order of magnitude of those experienced in municipal systems. The design standard should not be lowered, particularly since the physical capacities involved are pipelines which usually are governed by fire flows anyway thereby preventing any cost reduction. The claim by some developers that fire flows are useless in the absence of local fire equipment and personnel is very shortsighted in rapidly developing areas where the property owners may soon be interested in forming their own fire department.

Resort Condominium Summary

Seasonal and Monthly Demand

The highest flows at any of the four condo resorts were at Sweetwater, which is a water based summer peaking development. The lowest were at Brian Head, a ski resort which has a rather limited source of spring water that may be restricting flow or at least discouraging excess use. The use rates (except at Brian Head) are considerably higher than at the mountain cabin developments. The rec/mun ratios vary from 0.21 to 0.60 seasonally and 0.15 to 0.36 for peak month. Very little difference exists between peak season and peak month.

Peak Day Demand

Sweetwater experiences the highest demand (856 gpdu) followed by Teton Village (624) which is basically a ski resort, but the summer occupancy and additional warm weather demands are such that water use at Teton Village peaks during the summer. These two highest peak day rec/mun ratios are 0.68 and 0.50, suggesting that peak day flows at such resorts approach the order of magnitude of municipal systems. The State Department of Health requirements for this category are for 250 gpd per bedroom. Most of the condos at each resort have one separate bedroom and also a bed in the living room. Therefore, 500 gpdu were used as the required capacity. This appears to be too small since two of the four sites studied are exceeding this amount--Teton Village is 25 percent higher than the standard and Sweetwater is 70 percent higher. The same standard as municipal (800 gpdu) appears to be adequate for the ski resorts but rare peaks at Sweetwater can be expected to exceed 900 gpdu.

Instantaneous Peaks

None of the resorts had master meter-pump locations suitable for measuring instantaneous flow rates. However, Snowbird had a continuous record of reservoir water level which allowed such computations. The measured peak was 0.53 gpmu which is about one-third the expected level for municipal systems and 45 percent of the capacity required by the State Department of Health regulations. Although this is well below the standard, other resorts undoubtedly experience much higher peaks. The peak day parameters for example at Sweetwater are double that of Snowbird. A similar ratio for short term peaks suggests a level approaching the state standard. The standard therefore appears to be about right.

Marina Summary

Peak Season and Peak Month

The two very different marinas were purposely selected to determine the range over which water use varies. The Bear Lake Marina has no support facilities other than public restrooms, while Bullfrog includes a restaurant, service station, and housing for many employees. The summer season use rates are 49 and 408 gpdu respectively at these marinas. The peak month water use at Bear Lake is unknown but likely approaches 70 gpdu while Bullfrog is at 425 gpdu.

Peak Day Demand

The daily peak for the holiday weekend measured at Bear Lake was 66 gpdu; however, this was apparently significantly lower than peaks during previous years (based upon peak month data). At Bullfrog the peak day use was 823 gpdu. This startling figure suggests that peak day use per boat at Bullfrog (if all support facility demand is included in the per boat figure) is higher than that per residence in a city such as Bountiful. There are no established state standards for marinas, and the data presented here demonstrate the difficulty inherent in making such standards. Clearly the design of a system for a major self-contained development like Bullfrog requires separate analysis of the water needs of each use to be supplied and should be done by an experienced engineer. Standards for smaller marinas such as Bear Lake should be determined after additional data are gathered to resolve the anomalies in the data available at present. The very low levels of recorded water use, however, suggest a modest design is in order.

Recreation Vehicle Parks Summary

Very few data are available for this category. The meter which was purposely destroyed by the KOA owner prevented all except 30 hours of peak weekend data there. The daily August data at Cherry Hill indicate a monthly demand of 87 gpdu (only 8 percent of municipal level) and 138 gpdu on peak day (11 percent of municipal). The instantaneous peak of 0.31 gpmu, however, is 21 percent of that expected at a municipal system. The peak day flow at Cherry Hill was 138 gpdu which was 38 percent above the state requirement of 100 gpdu source capacity. It appears therefore that the standard is too low.

Duration of Short Term Peaks

The time duration curves show the percentage of the time flows are above any particular level. However, the data base for the curves is not sufficient to draw firm conclusions about the duration of extremely short term peaks. The Silver Fork data cover intervals of considerably less than 1 hour and suggest very high peaks for durations of 5 to 10 minutes relative to longer durations. The time duration curves appear to be steeper than those for municipal systems (Hughes and Gross 1979), the values somewhat lower during short periods and becoming progressively more lower at longer durations. This is precisely the trend one would expect. The same statements hold for the Cherry Hill data, but Snowbird data did not allow inferences about durations shorter than 1 hour.

A general conclusion is that recreation developments experience instantaneous peaks very high compared to average daily flows (higher ratios than municipal) but not so high as municipal in absolute value.

Regression of Water Use vs Occupancy

The incredibly good correlation of the Brian Head data (R = 0.999) suggests that water use inside ski resort condominium buildings is about 53 to 86 gallons/day/person. The much higher total uses at other ski resorts, however, indicate that either there are major uses in addition to the condominium building demands or the in-building uses at other sites are much higher than at Brian Head. Interviews with the Snowbird water system manager did not resolve this question; however, Snowbird plans to install additional meters, some of which would allow separation of individual building demand. Future analysis of these data will resolve the question.

The Bullfrog Marina data were not so well correlated (R = 0.74) because the system serves a variety of support functions, but use was regressed against boating days only. The linear function, however, suggests a monthly demand of 1.44 million gallons independent of boating days plus an additional 248 gallons per boat per day.

The campground data at Cherry Hill (R = 0.75) indicate a base flow independent of occupancy of 880 gallons plus 120 gallons per recreation vehicle.

Conclusions and Recommendations

1. In order to better define demand at recreation developments, an ongoing data gathering effort should be conducted. One way of doing this would be to include recreation sites in the current program the State Division of Water Rights is conducting to assist and encourage measurement of water use by municipal and rural systems. Several years of monthly data plus several months of daily data during peak months at many resorts will be needed to firm up design recommendations. Instantaneous peak data are extremely expensive to obtain and do not seem to represent an important need because most resorts construct distribution pipeline of more than adequate size. The more important questions are usually related to source capacities as determined from peak day water demands.

2. The data available from this study indicate some changes of state minimum design standards are in order. The present standard requires water systems at mountain cabin developments to have water source capacity of 800 gpd per unit, the same as in municipal systems. Some systems studied experience much lower peak day demands (and perhaps should be permitted to operate as special documented cases), but the state standard should not presently be lower than 600 gpd until the data base is improved.

The reverse situation is true for resort condominiums and recreation vehicle campgrounds--existing resorts are exceeding the state standard. The condominiums (both ski and water based type) produce higher demands per unit than the mountain cabins, yet the state standard is only 250 gpd/bedroom or 500 gpd/unit for most units. The condominium standard should be increased to at least 800 gpd per unit. The recreational vehicle campgrounds are experiencing peak day uses as high as 138 gpdu while the state requirement is only 100. This standard should be increased to at least 150 gpdu, and additional data should be gathered to determine the final standard.

3. The reason for lower than anticipated water use by mountain cabins and higher than expected by condominiums and recreation vehicle campgrounds can be explained by the huge difference in occupancy rates even on peak days because the former are single owner properties which are usually not rented to others. Condominiums on the other hand, tend to approach 100 percent occupancy for entire seasons because they are either time share operations or are rented as hotel units when owners are not at the site.

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APPENDIX A

DAILY DEMAND FOR THE DEVELOPMENTS

Table A-1. Daily water demand, Bridgerland Village.

Date	Water Use (gpd)	Occupancy (units)
June 30, 1979	9730	18
July 1	4910	14
2	6980	17
3	4630	12
4	6230	14
5	9280	17

Table A-2. Daily water demand, Timber Lake.

Date	Water Use (gpd)	Occupancy (units)
May 27, 1979	5000	35
28	6690	38
July 7	2510	24
8	6890	28
21	3740	35
22	3860	29
23	2260	19
24	2080	14
25	2320	18
Sept. 1	2970	28
2	5590	24

Table A-3. Daily water demand, Pine Mountain.

Date	Water Use (gpd)	Occupancy (units)
June 5, 1976	350	6
6	3550	3
7	1800	11
8	700	23
9	900	14
10	250	6
11	250	7
12	2400	4
13	1610	11
14	1390	9
15	7790	27
16	4160	22
17	1430	8
18	4140	6
19	2080	7
20	300	7
21	2100	16
22	13000	34
23	14700	29
29	8970	33
30	8810	27
July 3	2400	29
4	10600	37
5	14400	33
6	18370	37
7	7070	25
13	13080	37
14	6680	27
20	2000	32
21	1900	18
22	5810	10
23	4010	11
24	5130	23
25	3480	12
26	480	13
27	23360	38
28	8000	23
Aug. 3	9540	34
4	4470	24
10	5530	29
11	5260	21
17	6200	35
18	1300	22
24	5000	25
25	1480	24
31	14930	33
Sept. 1	15070	29
2	23950	39
3	1090	10
4	760	9

Table A-4. Daily water demand, Snowbird.

Date	Water Use (kgpd)	Occupancy (units)
Dec. 17, 1979	150.7	346
18	156.2	341
19	137.9	340
20	141.8	333
21	145.7	337
22	153.4	391
23	157.3	403
24	165.6	395
25	163.4	404
26	172.2	466
27	187.1	464
28	185.6	469
29	176.6	446
30	168.4	422
31	164.8	434
Jan. 1, 1980	158.3	361
2	143.1	347
3	148.1	344
4	158.3	354
5	158.9	407
6	148.8	339
7	134.8	325
8	143.5	327
9	138.4	375
10	144.0	384
11	159.4	375
12	157.9	471
13	151.7	453
14	143.2	442
15	154.9	418
16	135.4	383
17	127.5	377
18	157.9	419
19	163.8	436
20	190.3	412
21	153.3	403
22	154.5	392
23	155.2	444

Table A-4. Continued.

Date	Water Use (kgpd)	Occupancy (units)
24	154.5	460
25	162.4	469
26	154.3	462
27	167.4	456
28	158.1	419
29	147.0	442
30	152.3	457
31	148.6	451
Feb. 1, 1980	166.4	467
2	162.3	439
3	182.2	402
4	164.5	390
5	156.5	372
6	147.9	383
7	147.6	399
8	153.1	401
9	150.2	466
10	168.6	473
11	181.0	471
12	156.6	468
13	161.5	459
14	168.9	467
15	171.5	460
16	171.0	474
17	176.5	477
18	173.5	476
19	167.4	476
20	161.7	476
Feb. 21	181.7	477
22	172.5	450
23	166.8	464
24	167.5	466
25	165.6	467
26	163.3	471
27	164.9	470
28	151.1	470
29	182.0	466

Table A-5. Daily water demand, Brian Head.

Date	Water Use (kgpd)	Occupancy (person)
Dec. 1, 1978	7.6	101
2	8.2	111
3	3.0	37
4	4.2	53
5	2.2	30
6	4.0	53
7	4.1	54
8	10.7	140
9	12.4	164
10	3.6	48
11	5.7	70
12	6.8	86
13	10.9	137
14	8.7	106
15	9.7	124
16	11.5	142
17	12.4	146
18	16.5	203
19	19.2	239
20	18.3	226
21	20.1	248
22	14.2	180
23	18.0	230
24	21.8	278
25	21.2	264
26	30.7	388
27	36.1	452
28	36.0	460
29	36.7	463
30	36.1	472
31	33.9	427
Jan. 1, 1979	19.8	255
2	17.5	218
3	19.2	229
4	17.8	213
5	24.8	305
6	24.7	307
7	12.2	148
8	16.1	191
9	15.7	185
10	14.3	171
11	18.8	219
12	29.2	356
13	31.7	390

Table A-6. Daily water demand, Sweetwater.

Date	Water Use (kgpd)	Date	Water Use (kgpd)
June 29, 1979	121.0	July 19, 1979	#154.6
30	86.1	20	*106.2
July 1	66.9	21	*106.2
2	*200.9	22	*170.0
3	*250.9	23	*170.0
4	186.3	24	#214.9
5	168.7	25	#214.9
6	170.0	26	#214.9
7	124.2	27	381.7
8	93.6	28	110.3
15	196.6	29	226.2
16	221.7	30	162.2
17	#154.6	31	163.0
18	#154.6	Aug. 1	163.6

Note: * Average for 2 days.
Average for 3 days.

Table A-7. Daily water demand, Bear Lake State Marina.

Date	Water Use (kgpd)	Date	Water Use (kgpd)
June 29, 1979	5500	July 16, 1979	5100
30	5200	17	3700
July 1	5400	18	4800
2	6700	19	6400
3	3100	20	9300
4	4400	21	5700
5	4900	22	6800
6	7000	23	5200
7	5000	24	4800
8	7500	25	5700
9	5500	26	6500
10	2800	27	5900
11	4100	28	5300
12	5300	29	6900
13	4100	30	4500
14	6700	31	3400
15	4400		

Table A-8. Daily water demand, Bullfrog Marina.

Date	Water Use (kgpd)	Date	Water Use (kgpd)	Date	Water Use (kgpd)
June 1, 1979	142	July 1, 1979	214	Aug. 1, 1979	211
2	124	2	205	2	215
3	244	3	229	3	211
4	211	4	197	4	213
5	207	5	225	5	214
6	138	6	138	6	169
7	129	7	208	7	142
8	147	8	213	8	161
9	179	9	220	9	185
10	201	10	213	10	232
11	211	11	238	11	149
12	230	12	200	12	212
13	232	13	235	13	208
14	227	14	207	14	214
15	231	15	224	15	192
16	230	16	224	16	87
17	215	17	192	17	85
18	235	18	173	18	184
19	245	19	243	19	150
20	224	20	105	20	148
21	234	21	203	21	146
22	232	22	219	22	164
23	173	23	214	23	181
24	214	24	220	24	404
25	225	25	212	25	97
26	229	26	217	26	99
27	234	27	214	27	202
28	231	28	217	28	210
29	235	29	226	29	208
30	225	30	102	30	295
		31	322	31	118

Table A-9. Daily water demand, Cherry Hill.

Date	Water Use (kgpd)	Occupancy (No. of Vehicles)	Date	Water Use (kgpd)	Occupancy (No. of Vehicles)
Aug. 1, 1979	15.3	129	Aug. 16, 1979	13.4	99
2	14.0	114	17	17.1	129
3	21.6	159	18	12.9	146
4	20.5	146	19	*14.0	101
5	13.6	135	20	*14.0	111
6	16.4	117	21	11.5	104
7	19.4	132	22	12.1	90
8	18.2	121	23	10.5	104
9	16.3	124	24	11.1	118
10	23.1	149	25	15.7	97
11	21.1	173	26	13.0	86
12	12.2	107	27	7.4	86
13	15.6	99	28	10.5	73
14	11.0	118	29	10.3	92
15	19.2	107	30	91.0	70

Note: * Average for 2 days.

APPENDIX B

SHORT TERM FLOWRATE RECORDS

Table B-1. Short term flowrate record, Pine Mountain.

Time	Flow-rate (gpm)	Time	Flow-rate (gpm)
1:45 p.m., 8-3-79	53.3	12:00 noon, 8-4-79	66.6
2:00	73.3	12:30 p.m.	69.2
2:30	75.6	1:00	66.0
2:45	37.0	1:30	85.0
3:00	24.5	2:00	93.6
4:00	23.0	2:30	98.0
4:30	27.0	4:00	94.2
5:00	24.0	4:30	109.8
6:00	29.4	5:00	93.0
6:30	26.0	5:30	88.5
7:00	24.6	6:00	80.6
7:30	21.6	7:00	76.0
8:00	46.0	8:00	66.6
9:20	33.0	9:00	56.0
9:30	16.5	9:30	43.4
10:00	15.5	10:00	40.0
10:30	4.2	10:30	37.0
7:30 a.m., 8-4-79	8.8	11:00	3.8
8:00	23.0	8:00 a.m., 8-5-79	11.8
8:30	27.0	8:30	32.0
9:00	32.6	9:00	39.2
9:30	35.0	9:30	46.5
10:00	41.0	10:00	55.2
10:30	49.0	10:45	58.0
10:45	53.0	11:00	
11:00	62.7		

Note: The flowrate shown is the average during the time interval between the two specified times.

Table B-2. Short term flowrate record, Bear Lake State Marina.

Time	Flow-rate (gpm)	Time	Flow-rate (gpm)
2:43 p.m., 6-29-79	4.0	7:25 a.m., 6-30-79	4.1
4:47	4.4	9:27	5.1
6:17	4.3	11:05	6.0
7:49	1.7	1:35 p.m.	4.9
9:47	3.9	3:37	4.8
10:38	1.7	5:42	7.7
11:36	3.7	7:25	7.3
12:03 a.m., 6-30-79	0.7	10:22	0.7
		7:42 a.m., 7-1-79	

Note: The flowrate shown is the average during the time interval between two specified times.

Table B-3. Short term flowrate record, Cherry Hill.

Time	Flow-rate (gpm)	Time	Flow-rate (gpm)
12:18 p.m., 8-24-79	52.0	10:00 a.m., 8-25-79	9.5
12:30	19.0	12:00 p.m.	34.6
1:00	10.3	12:30	15.5
2:00	6.6	1:00	9.5
3:00	13.4	2:00	5.5
4:00	9.8	3:00	8.5
5:00	5.0	4:00	30.0
5:30	20.0	5:00	6.0
6:00	16.3	6:00	10.7
6:30	17.0	7:00	8.8
7:00	10.5	8:00	17.3
7:30	10.0	8:30	11.5
8:00	6.3	9:00	12.3
8:30	11.5	10:00	3.6
9:00	19.0	7:00 a.m., 8-26-79	10.0
10:00	2.2	8:00	19.0
11:00	17.8	9:00	10.3
12:00 a.m., 8-25-79	0.5	10:00	4.3
7:00 a.m.	5.0	10:30	19.0
8:00	42.0	11:00	15.3
8:30	20.3	11:30	
9:00	28.9		

Note: The flowrate shown is the average during the time interval between two specified times.

Table B-4. Short term flowrate record, KOA (Bear Lake).

Time	Flow-rate (gpm)	Time	Flow-rate (gpm)
2:37 p.m., 6-29-79	7.3	9:23 a.m., 6-30-79	10.8
4:41	14.7	11:05	12.2
6:13	7.5	1:30 p.m.	8.1
7:43	8.6	3:34	10.6
9:43	11.3	5:38	13.8
10:35	9.1	7:22	15.7
12:07 a.m., 6-30-79	3.5	10:16	1.4
7:22	22.0	7:30 a.m., 7-1-79	

Note: The flowrate shown is the average during the time interval between two specified times.

APPENDIX C

DAILY PEAK INSTANTANEOUS DEMAND FOR THE DEVELOPMENTS

Table C-1. Daily peak instantaneous demand, Snowbird.

Date	Peak Flow (gpm)	Date	Peak Flow (gpm)	Date	Peak Flow (gpm)
Dec. 1979		Jan. 1980		Feb. 1980	
		1	147	1	183
		2	178	2	214
		3	156	3	211
		4	175	4	211
		5	165	5	183
		6	147	6	170
		7	165	7	178
		8	156	8	176
		9	172	9	178
		10	185	10	230
		11	185	11	206
		12	172	12	201
		13	222	13	178
		14	151	14	189
		15	251	15	195
		16	144	16	233
17	178	17	144	17	223
18	189	18	184	18	210
19	165	19	172	19	250
20	154	20	206	20	222
21	178	21	164	21	244
22	193	22	192	22	219
23	202	23	151	23	216
24	193	24	178	24	211
25	178	25	177	25	219
26	208	26	189	26	189
27	200	27	244	27	193
28	212	28	172	28	246
29	222	29	159	29	222
30	211	30	185		
31	178	31	189		