IDENTIFYING RESIDENTIAL WATER USE

Survey Results and Analysis of Residential Water Use for Thirteen Communities in Utah

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SUMMARY

This report outlines the process used to identify residential indoor water use in 13 communities throughout the state of Utah and statistical results for each of the surveyed communities. By implementing the basic procedure outlined herein, any community should be able to identify possible conservation goals available to their situation.

During 1999 and 2000, the Division of Water Resources investigated the difference between indoor and outdoor water use. The division surveyed over 2000 residents in 13 communities throughout the state. Once the surveys were inventoried, billing records were obtained from the local water providers. Statistical analysis indicates that the amount of water used indoors varies little throughout the state. The survey's primary finding shows the average indoor water use is approximately 68 gpcd (gallons per capita day), with the most influential factor being the number of persons per household. The statewide average is estimated to be closer to 70 gpcd.

Survey information supports the following estimates:

- Indoor water use is approximately 68 gpcd.
- Outdoor water use is approximately 115 gpcd.
- Yearly average residential water use is 183 gpcd.
- Evaporative coolers use about 41 gallons per day per household during the summer months (approximately 6 gpcd year round).
- Indoor conservation devices save about 20 gallons per day per household throughout the year (roughly 6 gpcd).
- Indoor water use rises slightly with income.
- Outdoor irrigation practices greatly influence residential water use.
    - Hose irrigation practices apply water under the estimated net irrigation requirement (volume required to maximize growth).
    - Sprinkler systems without control timers water at the estimated net irrigation requirement.

    - Sprinkler systems with timers water close to 44 percent over the estimated net irrigation requirement.
- Estimations from meter reading records indicate that typical residents over irrigate their yards by 18 percent of the net irrigation requirement.

Appendix B contains information on a multi-family housing indoor water use study that was conducted subsequent to the initial printing of this report. Conclusions from that study are included here as a quick reference.

- Apartment indoor water use in Utah is 125 gallons per unit per day, or 55 gpcd.

- Multi-family (general) indoor water use in Utah is 150 gallons per unit per day, or 60 gpcd.

Research in Salt Lake City indicates that potential water conservation outdoors is approximately 25,000 gallons per household per year (24 gpcd), simply by watering at the consumptive use requirements of the turf. Based on survey-wide results, potential conservation indoors is estimated to be 20,000 gallons per household per year (16 gpcd). These volumes will vary from community to community based on climate conditions, lot sizes, age of development, and persons within the home.

To meet the growing needs of the state, communities will need to develop new water sources and set strong conservation goals. Both development and conservation of our water resources are necessary to maintain the lifestyle we enjoy.

INTRODUCTION

It is imperative that utility departments, and others responsible for water service, recognize their leadership roles in the proper use of water. Combined planning for both development and conservation programs will enable utilities to optimize the value of their water resources now and in the future. The purpose of this report is to illustrate how utility records were used to identify indoor water use. By implementing these procedures, water managers can make better decisions concerning their development and conservation efforts.

The Division of Water Resources shares with local providers the responsibilities of timely development and the wise use of Utah's water. Limited supplies and constant growth of the state's economy has led the division to place additional emphasis on water use research and on modeling the water use characteristics of present and projected populations. The results have created a sense of urgency in promoting strong water education and conservation programs. With proper planning, Utah water providers can supply sufficient water to the state's growing citizenry well into the 21st century without significant lifestyle changes.

Under current law, water retailers must prepare comprehensive water management and conservation plans. These plans help provide a methodical course of action to enable the appropriate use of the state's water resources. To assist in this endeavor, the Division of Water Resources is conducting research into the water use habits of residents. A strong focus of this research is the irrigation of residential turf areas. In the summer of 1998, division staff began investigating indoors versus outdoor water use.

In Bountiful City, the division investigated meter readings of over 100 homes. Primary analysis indicated significant outdoor watering during the fall and spring months before secondary water was made available for irrigation. In November 1999, the division paid Bountiful City to read the meters of the same study residences. Meter readings were

again collected during the first week of March 2000. The analysis and comments of this data are attached in Appendix A.

Though the results of the Bountiful City surveys were interesting, the division wanted to conduct a broader study that could be patterned more like a random survey. This report presents the processes and procedures used to derive indoor water use rates across the state.

Subsequent to the initial release of this report, a study was conducted on the indoor water use of multi-family housing. Considering the multi-family housing study to be a refined consequence of this study, it has been included as Appendix B. Thus, all current division study information on residential water use in Utah is incorporated into this one reference.

PROCESSES AND PROCEDURES

This section discusses the methodologies used in determining indoor and outdoor uses from the water records of various communities. Typical comparison of municipal water use is done on a per-person basis, often expressed as gallons per capita day (gpcd) or gallons per day per household (GPD). In order to arrive at per capita values, division staff obtained both population and water volume data for various households. Public surveys and individual meter readings were used to gather necessary information. Within this section, various items will be addressed concerning the development and implementation of the survey method. Topics that will be discussed include selection of study areas, sample size, generation of random samples, and formulation of the survey. Also discussed are data entry and analysis, and interpretation of the results. Each of the following subsections will address these key issues.

Selection of Study Areas

The Division of Water Resources has established methods for determining municipal and industrial water use. Computer modeling with the Wasatch Front Water Demand/Supply Model (WFWDSM) of municipal and industrial water use for the most populated part of the state continues to be the primary method of identifying water use. Outside the Wasatch Front, the division gathers actual yearly water volume records to identify municipal and industrial water use. Results of these studies are published in the *Municipal and Industrial Water Supply and Uses* reports for each hydrological basin within the state. Because additional information was desired for model calibration, the Wasatch Front became the focus of survey efforts. However, additional towns were included in the survey to identify a rural component. Staff at the Division of Water Resources identified over 40 communities as possible candidates for inclusion in the survey study. An overwhelming positive response was indicated by the cities invited. Due to manpower and financial constraints, staff at the division picked 13 communities for inclusion in the study. Selection of communities was based on availability of data, scheduling of city personnel,

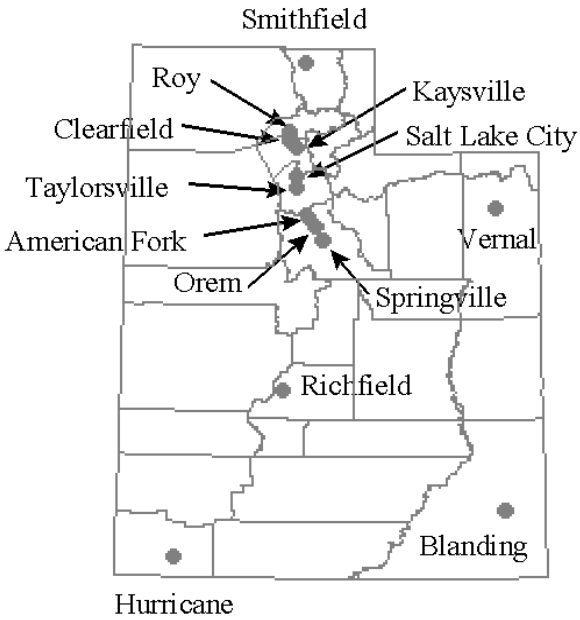

Figure 1. Communities included in Residential Survey Study

and geographic location. The distribution of cities participating in the survey is illustrated in Figure 1.

Sample Size

The number of surveys sent to each community was based on the number of residential connections reported to the Division of Water Rights. Approximately one percent of the reported residential connections were targeted for survey within each of the 13 communities. However, a minimum of 100 surveys was sent to rural communities regardless of the number of connections within their service boundaries. Survey response rates are shown in Table 1. Response rates were consistently higher than 36 percent, with the exception of Salt Lake City.

Random Selection of Residents

The Division of Water Resources tried to reduce the workload of the billing clerks for the surveyed communities. Therefore, all mailing lists were generated from phone listings for each city rather than billing records. Because mailing boundaries are different than the city utility service boundaries, some communities had more than one water supplier. For example, in Davis County, the Clearfield Area included households in Clearfield, Sunset, Clinton and West Point. The Kaysville Area included some households in Kaysville and Fruit Heights. The Vernal area included households serviced by Vernal City and the Ashley Valley Service District.

Table 1. Survey Response Rates

Communities	Number of Connections	Desired Results	Number of Surveys Mailed	Number of Surveys Returned	Return Rate(%)
Salt Lake County					
Salt Lake City	70,362	700	2,500	734	29.4
Taylorsville	14,821	150	500	210	42.0
Davis County					
Clearfield Area	4,739	50	250	96	38.4
Kaysville Area	5,500	50	250	123	49.2
Utah County					
American Fork	5,100	50	250	139	55.6
Orem	17,332	170	600	231	38.5
Springville	4,940	50	250	105	42.0
Weber County					
Roy	8,278	80	400	159	39.8
Other Counties					
Smithfield	1,909	20	100	50	50.0
Richfield	2,000	20	100	38	38.0
Blanding	1,109	10	100	38	38.0
Hurricane	1,226	10	100	54	54.0
Vernal Area	2,300	20	100	41	41.0
Totals	**139,616**	**1,380**	**5,500**	**2,018**	**36.7**

Additional difficulties were encountered in regional phone listings. For example, phone listings in Salt Lake County often list residents as living within Salt Lake City itself. To separate out households in Taylorsville and Salt Lake City proper, each utility service district was contacted and a utility service boundary map requested. Using a GIS database, homeowners were randomly selected within the given service boundaries. Households were randomly selected by zip code areas (e.g., Salt Lake City) or by a specified distance from the geographic center of the service district boundaries (e.g., in Taylorsville).

Formulation of Survey

The Division of Water Resources wanted a survey that was simple and user friendly. To increase survey response rate, the division focused on a survey that could be completed in less than ten minutes. Survey questions were identified which relate to water use both inside and outside the home. The original list of questions was reduced to a single page, and questions were asked in a multiple-choice format. A tracking number was assigned to each survey to indicate which household supplied the information. Finally, respondents were given the opportunity to place their names on the survey. An illustration of the survey is shown in Figure 2.

Surveying organizations sometimes send a preliminary letter before the actual survey to inform the respondents they have been selected as part of a study group. This is done to increase response rates. To test the effectiveness of a preliminary letter, the division used the Clearfield Area as a pilot study. One week in advance, 125 preliminary letters were mailed out. A week later, all 250 surveys were mailed out. The division found the response rate for the households that received a preliminary letter was 46 percent, while the response rate for households without a preliminary letter was 33 percent. Because the response rate without the preliminary letter was high enough to maintain division goals, the division opted not to send out preliminary letters to the other communities.

Bulk mailing was employed to insure a lower mailing rate. Generally, a three-week grace period was given to receive survey responses. Approximately 93 percent of all surveys returned were within the three-week response period. Residents who responded within the three-week period were sent a thank you post card from the division. After thank you cards were mailed, formalized lists of survey respondents were created and sent to the individual cities for retrieval of meter readings. Surveys received after the three-week grace period were not included in the study. Results of the surveys were logged as they were received.

Data Entry and Analysis

Survey responses were entered along with location, year, and water volume information. The number of years available varied from household to household and from one to five years. Winter results were determined by subtracting the fall and spring meter readings. Typical fall meter reading dates were between October and November. Spring meter readings were typically between March and early May. The sum of the readings during the summer months became the summer use. Outdoor water use was calculated by subtracting the winter total daily use from the summer total daily use.

Use rates for each household were calculated and organized by community. Outliers (extreme values) of winter water use were eliminated to insure only indoor water use was measured and not early spring and late fall irrigation and also to insure broken meters were not included. Outliers were eliminated based on quartiles and the distribution of data points. Data outside the outer quartiles were removed.

The following guidelines are listed to help aid the identification of outliers for removal:

1. Individual communities are analyzed one at a time.
2. All data points were sorted by household population groupings. (Only one-person households are compared with one-person households, etc.)
3. Entries are ranked by calculated gpcd.
4. Data set reviewed by staff, and low water use data points were eliminated. (Below 20 gpcd was considered as either a faulty meter or incorrect data entry).
5. Median value of gpcd is identified.
6. Clustering 50 percent of the entire data set nearest the median value identifies inner quartile.

Instructions:
The Division of Water Resources is grateful for your help. **Please circle the appropriate answer** to the questions below. **If any of the questions make you feel uncomfortable or you do not know the answer, please skip that question.**

How many toilets are in your home? **1 2 3 4 MORE**

Is the size of your livable floor space **MORE** than or **LESS** than 2000 square feet?

Does your home have a "swamp cooler"? **YES** or **NO**

Is your home a **HOUSE** or an **APARTMENT** or **CONDO** or **OTHER**?

Is your home **MORE** than or **LESS** than 7 years old?

IMPORTANT (please answer): How many people lived in your home during the following years? (Please be aware of births; seasonal visitors; children moving in or out; etc.). Fractional numbers are acceptable if applicable.

Year	Persons
1999	
1998	
1997	

Year	Persons
1996	
1995	
1994	

What is your family's gross yearly income?
Under $25,000 **$25,001-$50,000** **$50,001-$75,000** **$75,001-$100,000** **MORE**

How large is your lot (if you live in an apartment or condominium you need not answer this question)?
Under 1/4 acre **1/4 to1/3 acre** **1/3 to 1/2 acre** **Larger than 1/2 acre**

How do you irrigate your yard (if your yard is irrigated by a landlord or an association you need not answer this question)?
FLOOD **HOSE** **SPRINKLER w/ timer** **SPRINKLER w/o timer**

Do you have a separate source of water for irrigating your yard? **YES** or **NO**

We thank you for your time. Please return this survey to the Division of Water Resources in the enclosed envelope.

_____
(Please print your name)

Figure 2. Residential Survey

7. Range of the inner quartile is identified for the community.
8. Range of inner quartile was added and subtracted from boundaries of the inner quartile to identify boundaries of outer quartiles.
9. Data outside of outer quartile boundaries are eliminated.
10. Next group of persons-per-household is selected.
11. Process completed for community.
12. All communities are joined into new data set.

A histogram of the winter water use and the cutoff points for the outliers is shown in Figure 3. No data points were removed in the summer records. Removal of outliers from winter records was to insure inflated water use values for early spring and late fall irrigation was not included in indoor water use estimates. These outliers may indicate system leaks during the winter months. The group of data points removed from the winter reading data set would be an ideal starting point for a leak detection program.

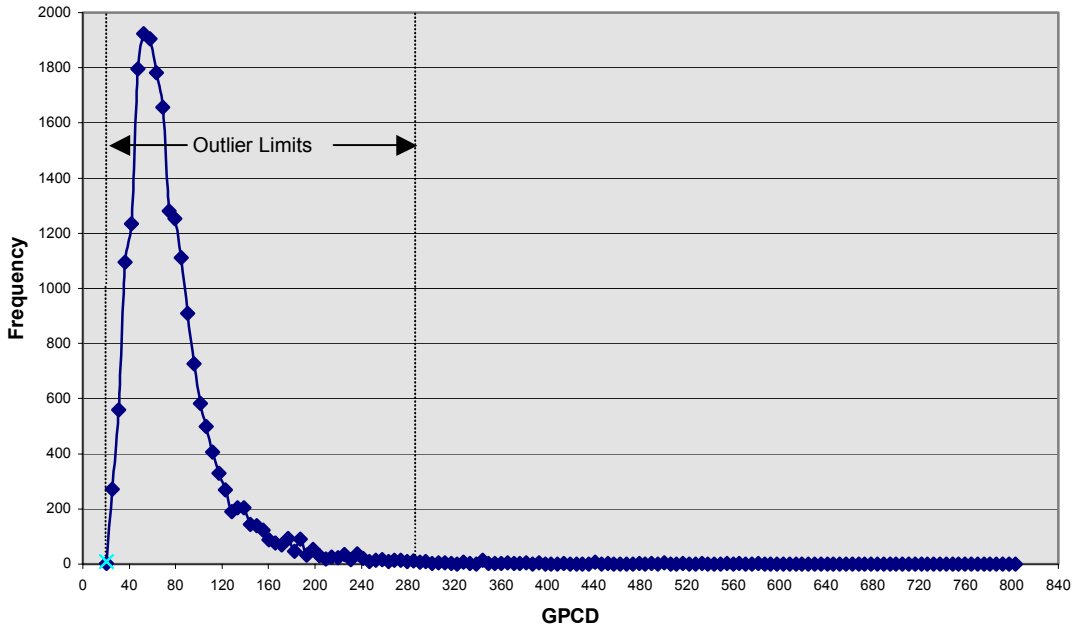

Figure 3. Frequency Distribution of Winter Water Use for Survey Study

All summer use included both indoor and outdoor water use and leakage. Typical summer meter reading dates were between March and November; however, some meters were not read until May or were not read beyond October. Average duration of the summer metering period was 229 days.

After all the information was processed, each city was analyzed separately and also aggregated for statewide representation. These results will be presented later in the section entitled "Community Results".

With the data in a workable form, it was possible to make various comparisons of the entire data set to see what results the survey could supply. The number of persons in the home is the single most influential factor in determining the per capita use rate. It was imperative that indoor water use be compared based on similar persons per household. Regression curves were drawn for each category based on the water use values in gallons-per-household per day. From these curves, the water use values were determined based on the same number of persons per household.

Six Residential Questions Answered

During the process of analysis and evaluation, six questions dealing with residential water use were addressed. The information collected on the surveys was substantial enough to answer the following questions:

1. What is the average per capita water use of the survey respondents?
2. How much water does an evaporative cooler use?
3. How much water is conserved due to mandatory conservation devices since 1992?
4. How much does indoor water use change with household income?
5. How much water do different irrigation practices use?
6. How much do people typically over irrigate their yards?

Each of these questions is answered hereafter, based on survey responses. A short explanation of how the data points were analyzed follows each question.

Average gpcd:

Indoor: 68 gpcd
Outdoor: 115 gpcd
Year : 183 gpcd

Rates shown are the average gallons per capita day for the winter and summer months. Each data set in the analysis was compared on an equal persons-per-household basis using regression curves, as indicated above. Yearly weighted average is determined by the number of days in the winter and summer metering periods.

Evaporative coolers: Estimated 41 gpd per household throughout summer season. (Summer billing season averaged 190 days). 6 gpcd based on yearly use requirement.

Water use for evaporative coolers was determined by analyzing all household residents who claimed they used secondary water for irrigation. This was done to insure metered drinking water was not being used on lawns and gardens. First, the winter water use for homes with evaporative coolers was compared with that of homes without, to determine if there were other factors affecting water use. No significant differences occurred. The average household with an evaporative cooler used 331 gpd during the summer months. The average household without an evaporative cooler used 290 gpd during the summer months. All data sets in the analysis were compared on an equal persons-per-household basis by using regression curves, as indicated above.

Interestingly, the estimated usage of evaporative coolers can range from 26 to 62 gpd in Utah, as determined by manufacturers. Estimates are based on size of home, temperature, and humidity. Further studies by Karpiscak, and others in Phoenix, Arizona, indicate the average water use for evaporative coolers is approximately 66 gpd

(1998). Due to the harsher environment in Arizona, a lower water use in Utah would be expected.

Indoor conservation devices: 20 gpd per household throughout the year. 6 gpcd based on population data.

Conservation savings from indoor plumbing fixtures were determined by comparing the average "old" (seven years or older) home's winter water use to the average "new" home's (newer than seven years) winter water use. Both data sets in the analysis were compared on an equal persons-per-household basis, using regression curves as indicated above. No questions were asked concerning the type of fixtures within the home. However, since 1993, low flush toilets (1.6 gallons per flush) have been a standard construction requirement. Also, faucet aerators and low flow showerheads have become increasingly popular since 1993.

Indoor use vs. income: Increases 0.1 gpcd per $1,000 of gross family income.

A comparison of the winter water use by various income levels determined the average winter water use for $0-$25,000; $25,001-$50,000; $50,001-$75,000; $75,001-$100,000; and incomes greater than $100,000. The rate of water use increase was determined by dividing the difference between the winter use of the $25,001-$50,000 and the $75,001-$100,000 gross income range by 50. The other ranges were not used because the data could not be categorized in finite bounds. All data sets in the analysis were compared on an equal persons-per-household basis by using regression curves, as indicated above. The net result did not show a substantial difference in winter water use among the different income categories.

Water use vs. irrigation type: Based on 180 day irrigation season:
Hose: 502 gpd per household.
Sprinkler w/o timer: 620 gpd per household.
Sprinkler w/ timer: 969 gpd per household.

Data points were separated into categories of irrigation method. All mixed irrigation methods were eliminated from the analysis. Average water use per household was determined for each irrigation method. Average indoor water use was subtracted from each of the totals to identify only water used outdoors. Volumes of water were standardized to a 180-day summer irrigation season.

Typical landscape overwatering: Based on Salt Lake City data:
Hose: 33 percent under net irrigation requirement.
Sprinkler w/o timer: 96 percent of net irrigation requirement.
Sprinkler w/ timer: 44 percent over the net irrigation requirement.

Salt Lake City was selected as the study area. First, the average landscaped area per lot was determined by referencing the Water Check Program conducted by the Utah State University Extension Service and Jordan Valley Water Conservancy District during the summer of 1999.

The error reflected in the 95 percent confidence interval was added to the total to give a conservative estimate of irrigated lot size. The net irrigation requirement for turf, using Salt Lake City Airport weather data for years 1994-1998, was used to determine the volume of water required. This volume was then adjusted with an average distribution uniformity of 54 percent (also from Water Check information in Salt Lake City). The distribution uniformity was estimated to be close to the application efficiency.

The average volume of water applied was determined from each of the irrigation methods, based on the average gallons-per-day used and the number of days the water was applied for surveyed residents from 1994-1998. This process yielded average volume of water applied outdoors for each month. All volumes were adjusted to represent a 180-day irrigation period. The percentage of overwatering was then determined by dividing the amount applied by the amount required.

It should be noted residents who irrigate with a hose might have smaller yards than those with in-ground sprinkler systems. The survey results could not indicate a difference in lawn size (based on owners' responses). However, watering 33 percent below the consumptive use requirement could lead to a reduction of landscape aesthetics. Please refer to the section below entitled "Outdoor Water Use Comparison".

Statistical Validity

Use of survey data to project true social characteristics is dependent on the information gathered, how it was gathered, and whether a significant sample size was surveyed. Furthermore, success is dependent on what characteristic is being defined. The original purpose of the survey was to investigate the per capita indoor use of residences. Once this rate is defined, then volumes of water used indoors can be subtracted from the total volumes yielding an estimation of outdoor water use. To get residential per capita use rates, it is necessary to know how many people are in a home and how much water they use. The survey was successful in determining these facts. However, additional information contained in the survey is of great interest, yet the statistical validity may be weaker. Nevertheless, all of the data is worth noting and adding to the general understanding of municipal and industrial water use. Information in this report will be presented with 95 percent confidence intervals and correlation coefficients where applicable. Please note that these measures of validity are traditionally low for municipal and industrial water use studies when compared to other statistical investigations. Residential water use is partly dependent on social behavior and not a cause-and-effect relationship. The wide scatter in residential water use is a reflection of the social influences in society to use water regardless of "need".

Winter data includes information from 1,612 households. Because many of the communities could supply more than one year of information, 6,293 data points were analyzed. The mean gallons per capita day is 68.03 $\pm$0.33 (based on 3.51 persons per household). This accuracy is well within the error of the individual meter reading process

and validates the assumption that it represents statewide indoor water use. Summer data includes information from 1,246 households and 5,069 data points.

Each community is addressed individually and collectively in the next section. Statistical boundaries are presented where applicable.

COMMUNITY RESULTS

A generalized comparison among the communities' water use is included for the following communities: American Fork, Blanding, Clearfield, Hurricane, Kaysville, Orem, Richfield, Roy, Salt Lake, Smithfield, Springville, Taylorsville and Vernal.

Statistical Results

Statistical results of the surveyed communities are shown in Table 2 and Table 3. Though the values for indoor water use (winter use category) are quite similar, the outdoor water use varies from location to location. Higher indoor water use cities (e.g., Orem and Richfield) read meters in the mid-to-late spring. Therefore, the high figures may be a result of outdoor watering during the early spring.

Indoor Water Use

A total of 1,612 households were represented throughout the state. The communities supplied water use records from 1994-1999. There are a total of 6,293 data points within the set.

Estimating community-wide indoor water use for communities throughout Utah can be done with Figure 4 and Figure 5. Both figures represent the same data; however, Figure 4 is in gallons-per-residential connection per year whereas Figure 5 is in gallons-per-capita day. Since the study results were only focused on single-family dwellings, it must be assumed that multi-family dwellings typically use the same amount of water indoors as their counterpart.

Table 2. Winter (Assumed all Indoor) Water Use Statistics

Cities	Households	N	GPCD			GPD			PPH		
				95% C.I.	STD		95% C.I.	STD		95% C.I.	STD
American Fork	71	366	64.4	1.0	25.1	280.6	11.0	127.1	4.36	0.18	2.10
Blanding	29	129	58.6	2.1	30.0	244.0	18.8	128.8	4.16	0.42	2.88
Clearfield area	83	309	67.2	1.5	30.3	228.7	10.8	114.9	3.40	0.18	1.92
Hurricane	34	55	68.5	3.3	29.0	262.7	32.4	143.6	3.84	0.52	2.30
Kaysville area	102	401	61.1	0.9	22.4	255.4	9.5	115.0	4.18	0.15	1.88
Orem	193	817	70.7	0.8	29.4	323.7	8.4	145.0	4.58	0.13	2.28
Richfield	31	90	82.5	3.7	39.5	283.1	20.5	116.9	3.42	0.35	2.02
Roy	146	430	68.3	1.3	31.2	237.0	8.3	103.9	3.47	0.14	1.75
Salt Lake City	577	2623	68.7	0.6	31.5	195.7	3.2	101.1	2.85	0.05	1.66
Smithfield	37	166	66.0	2.0	29.2	228.4	16.6	129.3	3.46	0.24	1.87
Springville	93	339	66.8	1.2	26.1	259.5	10.0	111.8	3.88	0.17	1.88
Taylorsville	185	526	71.8	1.1	30.2	263.8	8.6	120.0	3.67	0.13	1.88
Vernal	30	42	61.5	3.1	23.8	231.6	26.5	102.0	3.77	0.42	1.62
Total	1612	6293	68.0	0.3	29.8	238.5	2.6	123.2	3.51	0.04	1.99

Table 3. Summer (Indoor and Outdoor) Water Use Statistics [1]

Cities	Secondary Use? [2]	Households	N	Days	GPCD			GPD			PPH		
						95% C.I.	STD		95% C.I.	STD		95% C.I.	STD
American Fork	N	66	297	214	228.3	6.0	133.3	1016	44	464	4.46	0.20	2.02
Blanding	N	25	122	229	237.6	17.2	231.5	952	80	533	4.01	0.43	2.88
Clearfield area	N	48	175	189	245.0	11.5	163.9	773	43	348	3.16	0.23	1.79
Hurricane	Y	22	39	213	97.8	18.4	60.0	416	193	298	4.26	1.74	2.68
Kaysville area	Y	98	409	178	69.6	1.3	32.6	289	11	137	4.15	0.15	1.87
Orem	N	183	683	188	316.9	6.0	205.6	1458	49	783	4.60	0.14	2.30
Richfield	N	26	89	182	306.1	19.5	204.6	1045	74	422	3.42	0.38	2.15
Roy	Y	100	294	178	73.0	1.7	32.7	244	11	118	3.34	0.16	1.65
Salt Lake City	N	575	2808	249	257.0	3.6	190.5	728	13	406	2.83	0.05	1.67
Smithfield	N	16	61	173	236.0	19.5	185.9	962	105	492	4.08	0.46	2.17
Springville	N	72	210	232	247.0	8.2	145.2	994	53	461	4.02	0.21	1.85
Taylorsville	N	175	518	237	203.5	4.5	120.1	756	22	307	3.71	0.14	1.88
Vernal	N	19	42	209	219.1	19.0	155.6	855	118	482	3.90	0.39	1.58
Total	N	1246	5069	229	253.0	2.3	183.6	863	12	540	3.41	0.05	2.00

Notes:

1. For cities that have partial secondary coverage of community system the group represented in **Table 3** represents the majority of surveys returned.
2. Secondary use is based on responses to survey questions by home owners not secondary supplier records.
3. Annual Values are the summer water use standardized over the entire year (365 days).

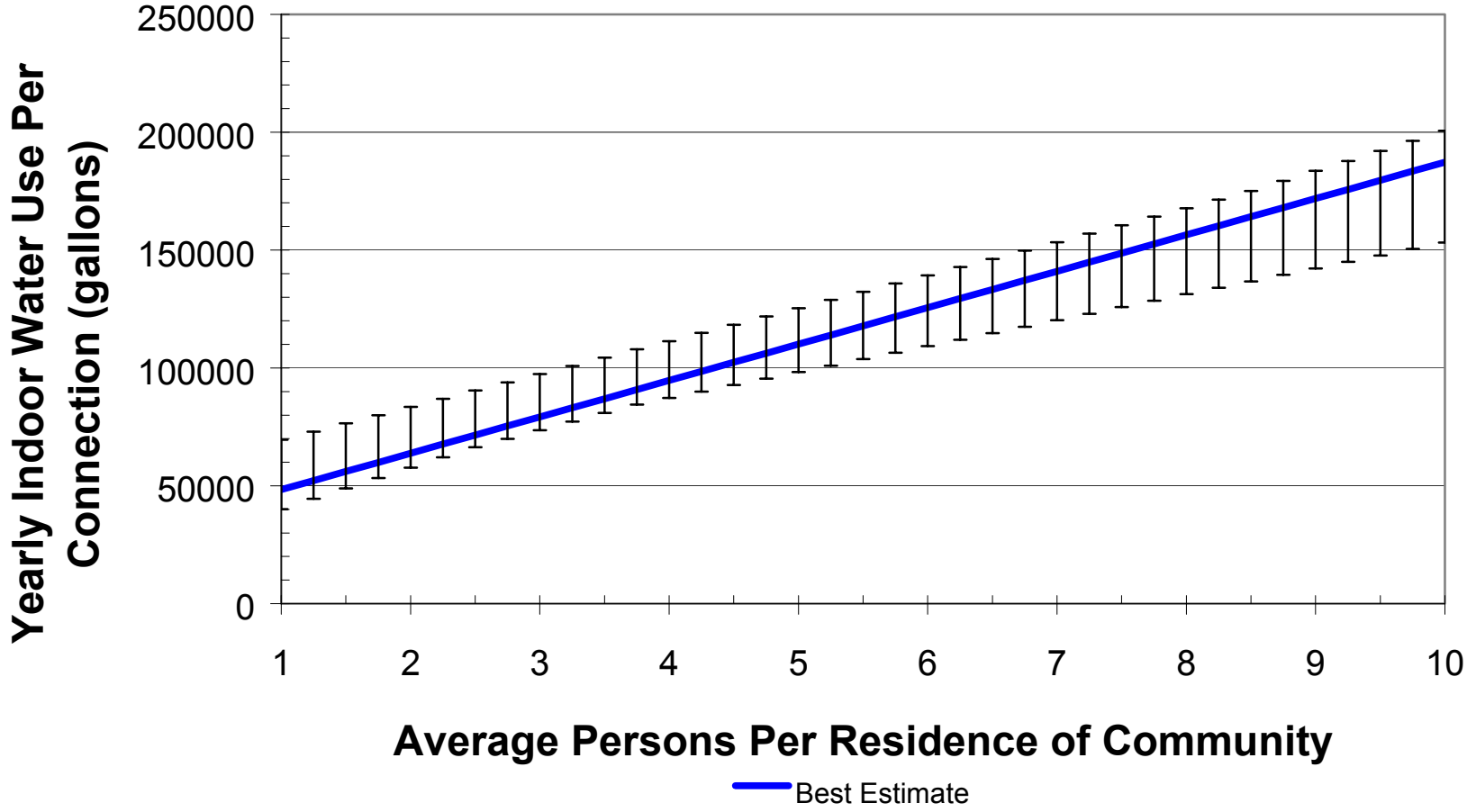

Figure 4. Yearly Indoor Water Use for Survey Respondents

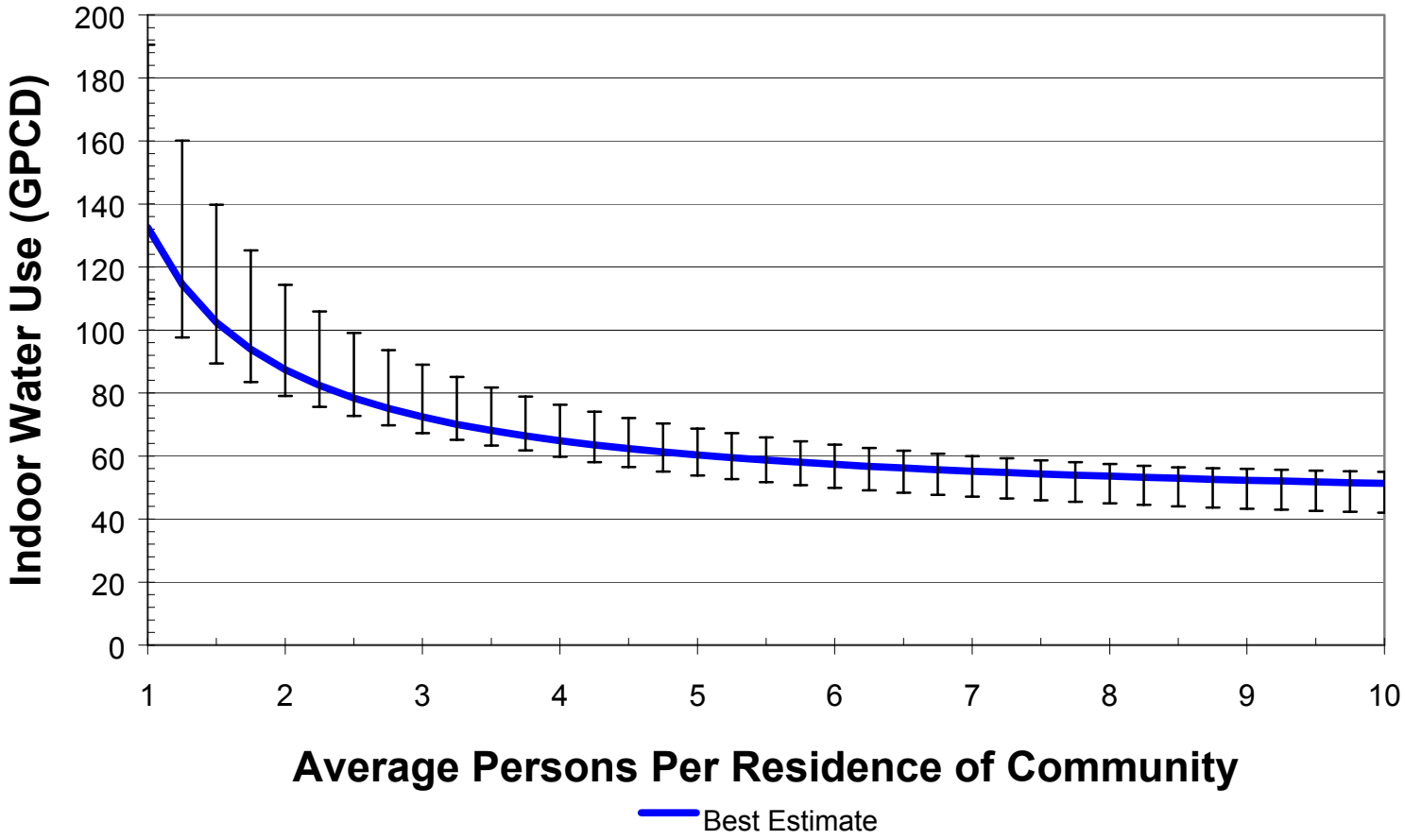

Figure 5. Per-capita Use Rates for Single Family Dwellings for State of Utah

The following equations define the curves in Figure 4 and Figure 5:

$GPD_{Indoor} = 42.3\ P_{PH} + 90.3$ Correlation Coefficient $R^2 = 0.468$ (1)

$GPCD_{Indoor} = \frac{90.3}{P_{PH}} + 42.3$ (derived from equation 1) (2)

Where:

GPD_{Indoor}	=	Gallons per Household per Day (culinary indoor use only)
P_{PH}	=	Persons Per Household
$GPCD_{Indoor}$	=	Gallons per Capita Day Water Use (culinary indoor use only)

Survey results indicated the average indoor use to be 68 gpcd (pph of 3.51). Because the survey did not include apartments, the persons-per-household (pph) rate was higher than the state average. If Equation 2 is used to determine a statewide indoor water use rate with the pph of 3.15 (from the 1990 Census), the indoor water use for the state is approximately 70 gpcd.

To test the validity of Equations 1 and 2, they were applied to the communities surveyed and the percent error shown. See Table 4 for results. To compare the variability of the indoor water use results, please refer to Figure 6.

Outdoor Water Use Comparison

Outdoor water use is estimated by subtracting the indoor water use figures from the total water use during the summer months. It should be noted that communities with secondary water systems show an increase in “indoor” water use during the summer months. Many of the surveyed households in Kaysville and Roy indicated that they had a “separate source of water for irrigating.“ These two communities alone represented over half of the secondary water users surveyed. Kaysville showed 13 percent increase in indoor” water use from winter to summer, while Roy showed a 6 percent increase. It is assumed these increases are due to outdoor irrigation or other uses.

Table 4. Comparison of Mathematical Approach and Actual Survey Data

Community	Surveyed Volume (Gallons)*	Estimated Volume (Gallons)	Percent Error $\%E=(V_0-V_1)/V_0$
American Fork	37,273,000	36,600,000	1.8
Blanding	11,074,000	12,500,000	-13.1
Clearfield	25,964,000	26,400,000	-1.6
Hurricane	5,283,400	5,060,000	4.2
Kaysville	37,361,000	39,100,000	-4.5
Orem	96,507,000	84,600,000	12.3
Richfield	9,368,000	7,710,000	17.7
Roy	37,165,000	37,163,000	0.005
Salt Lake City	187,262,300	202,000,000	-7.9
Smithfield	9,186,000	9,768,000	-6.3
Springville	31,764,000	31,500,000	0.8
Taylorsville	50,676,000	47,100,000	7.1
Vernal	3,584,000	3,820,000	-6.7
Totals	566,326,000	548,000,000	3.3

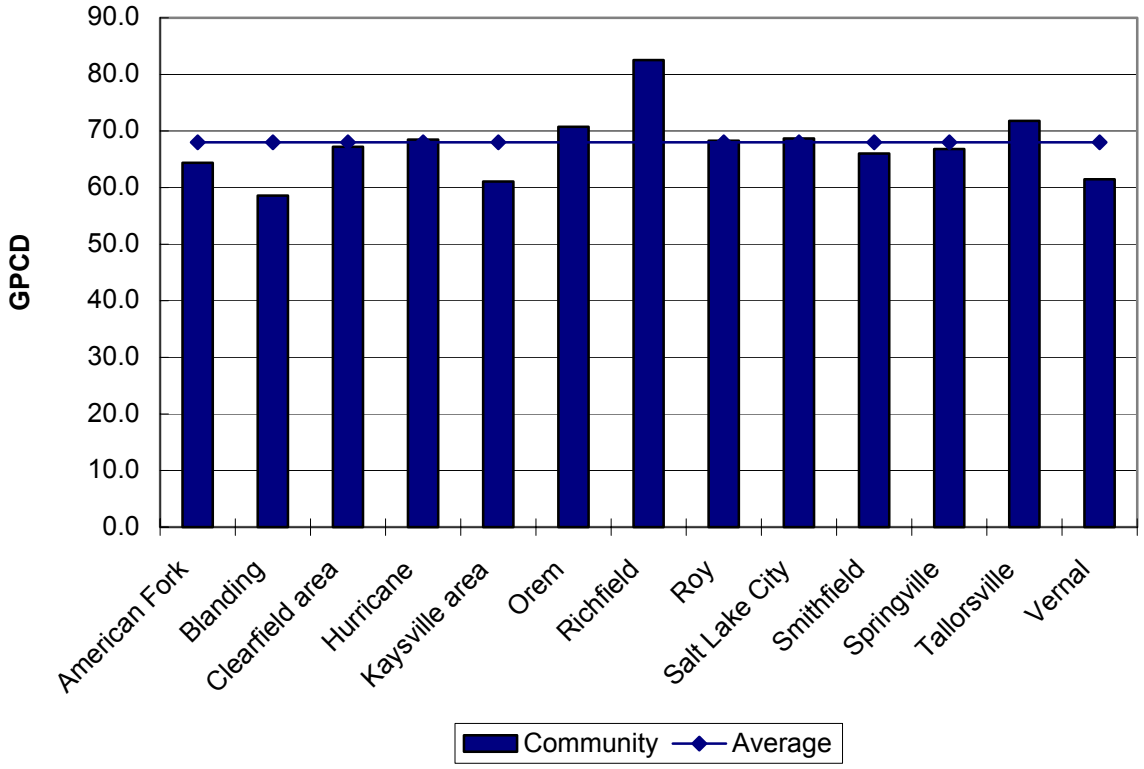

Figure 6. Indoor Water Use Comparison in GPCD of Study Areas

This subsection will describe outdoor water use and how it correlates with the net irrigation required from community to community. Selected communities, based on their locations in the state, are compared below. These communities include: Clearfield, Salt Lake City, Orem, Richfield and Vernal. Unfortunately, the two communities on opposite ends of the state (Smithfield and Hurricane) could not be compared because they use secondary water systems for outdoor irrigation.

Salt Lake City was able to provide monthly water use that was analyzed to prepare Figure 7. Please note that some assumptions were made to estimate the net irrigation requirement of Salt Lake City. Primarily, conveyance efficiencies are assumed to be 100 percent, while the application efficiency of the irrigation system is assumed to be 54 percent efficient. This leads to an overall efficiency of 54 percent. This efficiency is typical of residential sprinkler systems for Salt Lake City (Jackson, 2000). Figure 7 illustrates the typical use pattern for outdoor use from 1994-1998. Also, the irrigation requirements by month have been added for Salt Lake City. Estimations of irrigation requirements were based on data supplied by Hill (1998) and Jackson (2000). During the early summer months of May and June, Figure 7 suggests Salt Lake City residents irrigate approximately 34 percent less than the net irrigation requirement. This suggests one of two things: Either soil moisture is being stored and carried over from month to month during the rainy season, or residents are maintaining aesthetically pleasing lawns without meeting the consumptive use requirements.

Independent research indicates that Kentucky bluegrass can be stressed below the potential evapotranspiration level (or unrestricted consumptive use requirement). Erik Ervin and Anthony Koski (1998) concluded acceptable season-long Kentucky bluegrass quality could be maintained by irrigating at approximately 75 percent of the potential evapotranspiration (or 60 percent of the ETr for alfalfa). The Department of the Interior funded studies in both Colorado and Wyoming (1979) to help determine the water requirements for urban lawns. The Colorado portion of the test identified that the turf would need approximately 70 percent of the potential evapotranspiration to maintain an acceptable aesthetic rating, The Wyoming results indicated: “Homeowners who applied

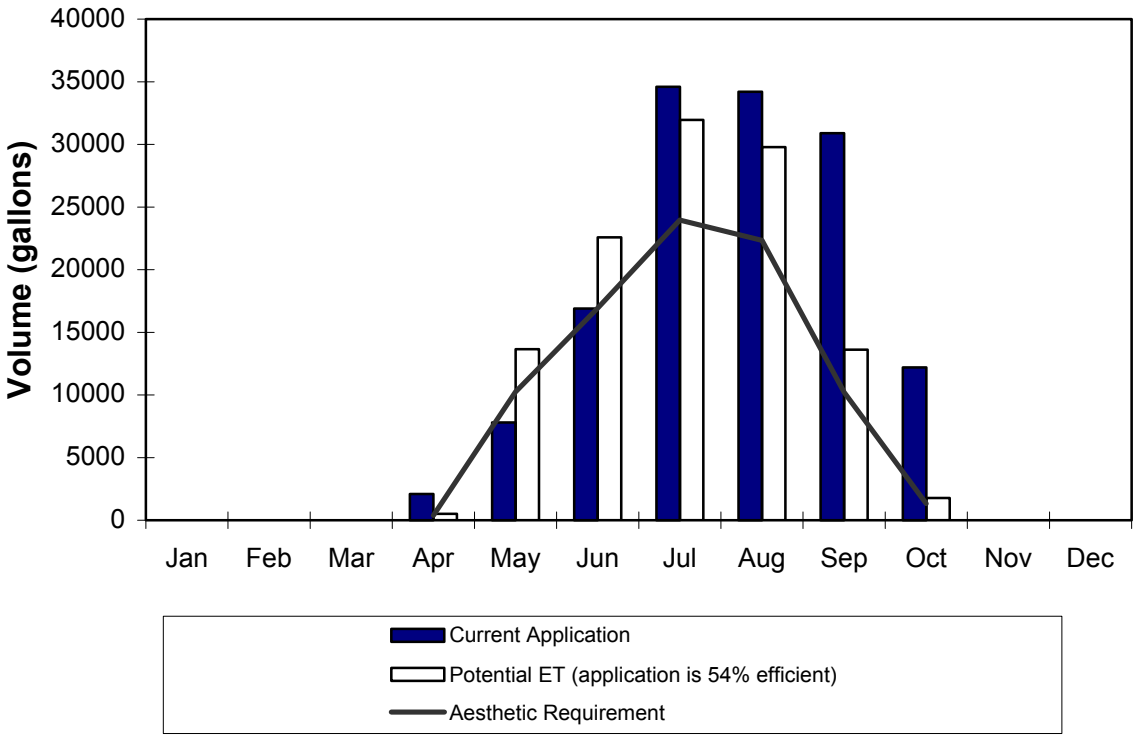

Figure 7. Outdoor Water Required Versus Volume Applied in Salt Lake City

water at a rate near the (potential) ET rate of the grass could maintain aesthetically acceptable lawns as readily as those homeowners who applied much greater amounts of water." However, the same results warn the aesthetics begin to decline rapidly upon stressing the turf. For further analysis of the survey data collected in Utah, it will be assumed the maximum stress level that can be sustained is 75 percent of the unrestrictive consumptive use requirement.

Multiplying the consumptive use requirement by 0.75 produces the aesthetic requirement curve in Figure 7. The current monthly application volumes indicate typical residents employ very conservative methods in watering lawns throughout the early summer months, but the application of water surpasses the needs of turf during the hot months of July and August. This tendency of over watering continues into the fall months

when the outdoor irrigation season ends. In fact, the large drop in water use between September and October indicates the irrigation season ends abruptly. This pattern typifies the use of automated sprinkler systems in the survey group.

Table 5. Annual Culinary GPCD Averages

Cities	Secondary Use?	Annual GPCD Potable Water
American Fork	N	161
Blanding	N	169
Clearfield Area	N	156
Hurricane	Y	86
Kaysville Area	Y	65
Orem	N	198
Richfield	N	194
Roy	Y	71
Salt Lake City	N	197
Smithfield	N	153
Springville	N	183
Taylorsville	N	158
Vernal	N	153
Average	N	183

Efforts to curtail overwatering may provide large dividends. If typical residents in Salt Lake City irrigate their lawns to meet the potential evapotranspiration, then outdoor water saving of 18 percent would occur. This corresponds to 25,000 gallons saved per household (24 gpcd on a 2.85 pph basis). Furthermore, for every percentage point increase in the application efficiency, the water saving increases proportionally (i.e., if overall efficiency was adjusted from 54 percent to 60 percent, outdoor water saving would increase to almost 25 percent). The 60 percent efficiency level was recognized as a minimum: "As an absolute minimum, no sprinkler should be operated so a (distribution uniformity) of less than 60 percent is achieved" (Dept. of Interior, 1979). Proper maintenance and inspection of automated sprinkler systems can help insure distribution uniformity is adequate.

If each resident applied water at the aesthetic water requirement (see Figure 7), outdoor water saving of 38 percent would occur. This corresponds to approximately 53,000 gallons saved per household (51 gpcd based on a 2.85 pph basis).

Annual Water Use Averages

By taking a weighted average of usage between the indoor and outdoor water use rates for the summer and winter meter-reading period shown in Table 2 and Table 3, the annual gpcd values were determined as shown in Table 5.

COMPARISON WITH OTHER STUDIES

Indoor, outdoor, and total residential water use for single family dwellings have been studied by various researchers. The common thread in all studies is data variability. Though averages are similar, the standard deviations are high and correlation coefficients are low. This wide scatter in the data set is due to the social influences of residential water use. Typical engineering studies model physical laws of nature. However, residential water use seems to be social behavior rather than natural law.

Two major studies will be addressed in this report: (1) a massive study by the American Water Works Association (1999) surveyed some 12,000 homes in 12 cities throughout the nation to identify indoor water use, and (2) the results from *Municipal – Residential Water Use Study of Salt Lake County,* by Kirkpatrick (1976), will be compared to the results presented herein.

The American Water Works Association attempted to identify how much water could be conserved indoors. Their study indicated: "Indoor residential water use per capita is quite stable in the United States." The average indoor water use of the 12 cities surveyed was 69.7 gpcd. Furthermore, 58.1 percent of the total water use was for outdoor irrigation. Percentage of outdoor water use ranged from 22.3 percent (Waterloo, Ontario) to 76.2 percent (Las Virgenes, California). The survey in Utah indicated that 63 percent of water used throughout the year is used outdoors. These results emphasize the fact that outdoor water use is affected by climate. The AWWA also estimates that by employing maximum conservation methods, indoor water use could be reduced to 52 gpcd. Maximum conservation methods include:

- Installing ultra-low flush toilets, showerheads and faucet heads.
- Replace agitator-type clothes washing machines with tumbler-type machines.

- Practice routine common sense leak detection and control methods by residents.

Kirkpatrick estimated the typical indoor water use for Salt Lake City residences by investigating an apartment complex within the valley:

> The figure of 70 gpcd is arrived at as being a reasonable minimum for culinary-sanitary uses in the Salt Lake Valley. Comparing this figure to the 74 gpcd found in Seattle . . . shows that the basic culinary-sanitary water demand is very likely the same in urban areas of opposite climates. (1976)

These estimates are remarkably close to the average indoor water use presented herein. It is expected the values for indoor water use are slightly higher by Kirkpatrick for two reasons: (1) His study was not focused on indoor water use and, therefore, this method of determining such values was only based on assumptions and relationships; and (2) water use prior to the early 1990s did not include conservation devices within the home.

CONCLUSIONS

Indoor water use can be estimated based on the aforementioned equations. However, estimations will commonly be ±10 percent of the actual volumes. Outdoor water use is much more difficult to estimate based on empirical equations. Ambiguity of outdoor use is due to the variety of different social and physical characteristics that affect outdoor water use.

Utah's indoor water use is approximately 70 gpcd. Due to the variety of influences affecting outdoor water use, based on the data gathered, outdoor use could not be modeled on a statewide basis given the current information. However, the following guidelines when estimating outdoor water use are of interest:

1. Residents typically over water their lawns by as much as 18 percent of the net irrigation requirement.
2. Lawns can be watered at about 75 percent of their net irrigation requirement and still be aesthetically pleasing.
3. Water volumes actually used outdoors for irrigation are not closely related to the consumptive use of turf.

Outdoor watering is often applied based on personal habit rather than system efficiency or the irrigation needs of turf. Therefore, outdoor irrigation is the perfect arena for educational type programs and incentive pricing.

Research in Salt Lake City indicates potential water conservation outdoors is over 25,000 gallons per household per year (24 gpcd). Based on survey-wide results, potential conservation indoors is estimated at 20,000 gallons per household per year (16 gpcd). These volumes will vary from community to community based on climate conditions, lot sizes, age of development, and persons within the home. Before a community makes a conservation goal, a detailed audit must be made of existing records to help identify what the potential for savings is between indoor and outdoor water use.

RECOMMENDATIONS

The information presented herein is a valuable step toward understanding municipal and industrial water use. The purpose of this study was to identify residential indoor water use and explain how the data was analyzed. These ends have been met. However, substantial variability still exists in the determination of outdoor water use. This study suggests outdoor water use is an area of utmost importance to the water conservation arena. Further studies to correlate outdoor water use with growing seasons, lot sizes, and developmental stages of communities should be investigated. Also, investigation of pricing structures on statewide outdoor water use could be explored. Future municipal and industrial water use studies could include:

1. Multi-family dwelling usage.
2. Conservation possibilities with institutional water use.
3. Residential irrigation efficiencies.
4. Efficiencies of secondary water systems.
5. Maximizing industrial water use efficiency.
6. Actual costs of providing water now and into the future.
7. Billing processes used by water providers to meet the actual costs mentioned above and insure appropriate utilization of water resources.

The collection and investigation of municipal water use can aid in the following: Efficient water development of current and future supplies, baseline information to monitor effectiveness of conservation programs, clearer information for educational efforts, better economic strength in community services, proper evaluation of educational program effectiveness, and base data for modeling and planning for future growth. Data can be used to develop interactive web sites, publish brochures, identify possible leaks in individual residences, develop billing rate structures, and educating the public on wiser use of their resources. The current ease of water delivery has heightened society's lifestyles. However, this same ease has removed the comprehension of how much water we use.

Since municipal water use is inseparably connected with human behavior and attitude, the arena of conservation must focus on education in order to find lasting effects.

Utility providers should conduct studies to insure information obtained is representative of their service areas. Water utilities must read individual meters for system auditing in conjunction with billing purposes. Effective water auditing can only be accomplished if the following criteria are met:

1. *All* connections should be metered, read and recorded, whether or not the connections are billed.
2. Meters should be replaced and maintained according to the manufacturer's recommendations on meter life expectancy.
3. Meters should be read monthly from spring to fall. (Additional readings in the winter can be useful).
4. Meters should be read in early spring and late fall (to eliminate outdoor water influence).
5. Metering records should be held for a minimum of five years and, possibly, five-year summary records kept thereafter.
6. All meter readings should be stored as computer files in database-type format so analyses can be done easily and efficiently.

Surveys can be done for each community as outlined in this study. However, based on our experience, some guidelines are appropriate: First, rural areas may need additional questions concerning livestock use throughout winter months. Wording of secondary water use questions should be phrased according to local terms (secondary, irrigation, gray water, etc.), so residents understand survey questions. Finally, additional questions concerning age grouping within each home may allow better correlation of water use.

Residential outdoor water use is different than its agricultural counterpart. The evidence of socio-economic influences on residential water use indicates typical consumptive use procedures may underestimate applied volumes.

The Division of Water Resources believes the state of Utah can meet the needs of its growing population if wise planning and implementation of conservation practices are employed. Wise planning should include progressive development of current available sources and strong conservation goals on the community level. To meet future growth, the Division of Water Resources has suggested a 25 percent reduction of water use for public community systems by 2050. The bulk of this reduction will be made up in the residential water use category.

SINGLE FAMILY RESIDENTIAL WATER USE STUDY

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APPENDIX A

BOUNTIFUL CITY WATER USE STUDY

Bountiful City Water Use Study

Background

In 1998, the Division of Water Resources began an investigative study of residential water use rates. Bountiful City was asked to help in the preliminary study because of their extensive historical database (14 years). Personnel at the division identified 108 homes in the service area of Bountiful City. Areas of investigation were clustered into five major study groups, identified as neighborhoods of division personnel. Historical meter records were supplied by the city, while division personnel within each of the neighborhoods made population counts. All of the homes investigated had access to secondary water sources for outdoor irrigation. The secondary sources were available from approximately April 15 to October 15 each year. Due to the availability of irrigation sources, the preliminary assumption was that potable water used at each residence was for indoor water use. Though some incidental use outside would occur in the summer, the volume was not significant.

Preliminary Results

The preliminary results for Bountiful City are provided in Table A-1. Individual investigation of each year's record revealed a reoccurring pattern of water use for smaller households (one and two persons). As with many larger cities, the procedure of collecting meter readings and billing for the water used is often performed by different agencies. Accounting procedures in Bountiful automatically inserts the minimum use allotted for homes whose meter readings are less than 5,000 gallons per month. Though this practice reduces workload for billing departments and results in no billing changes, the historical records for water use were not exact for smaller households.

Table A-1. Preliminary Results of Bountiful City Billing Records.

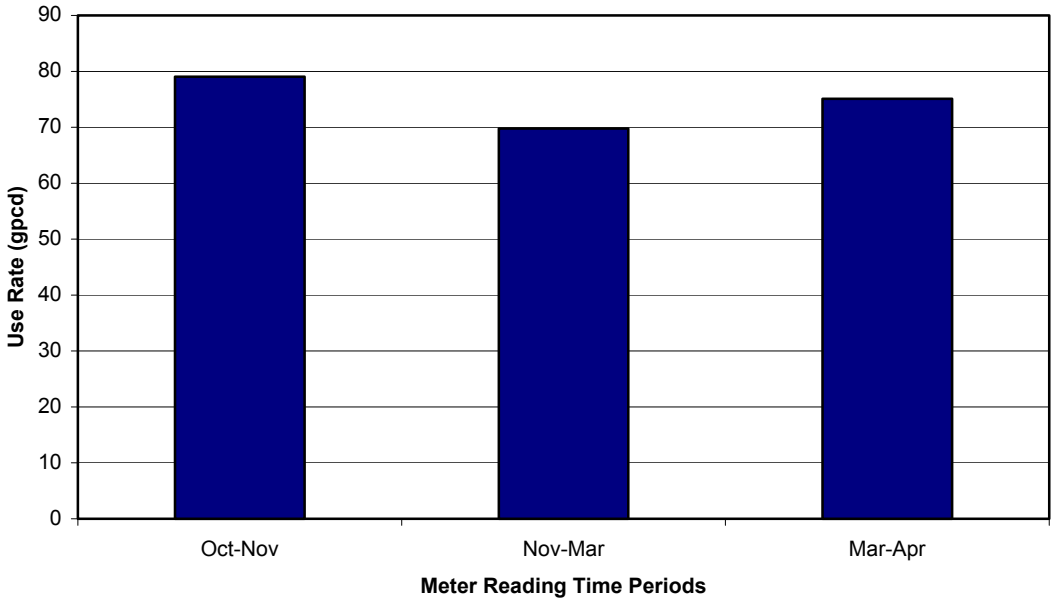
Category	Mean	
	Winter	Summer
Gallons Per Capita Day (GPCD)	74.7 +/-1.7	80.2 +/-2.0
Gallons Per Household	48440 +/-1200	51959 +/-1270
Persons Per Household (PPH)	3.55 +/-0.1	3.55 +/-0.1

Note: 95% confidence levels are included.

Final Results

During the winter of 1999-2000, the division contracted with Bountiful City to provide actual meter reading data for the 108 homes previously selected for the investigative study. Meter readings were provided for the typical citywide reading of October 1999. Then a special meter reading of the 108 homes was done on November 15, 1999, after the first frost of the year. Meters of the same 108 homes were read again on March 8, 2000. Finally, the citywide readings on April 5, 2000 were added to the data list. The average gallons per capita day (gpcd) for each of the three time periods are presented in Figure A-1.

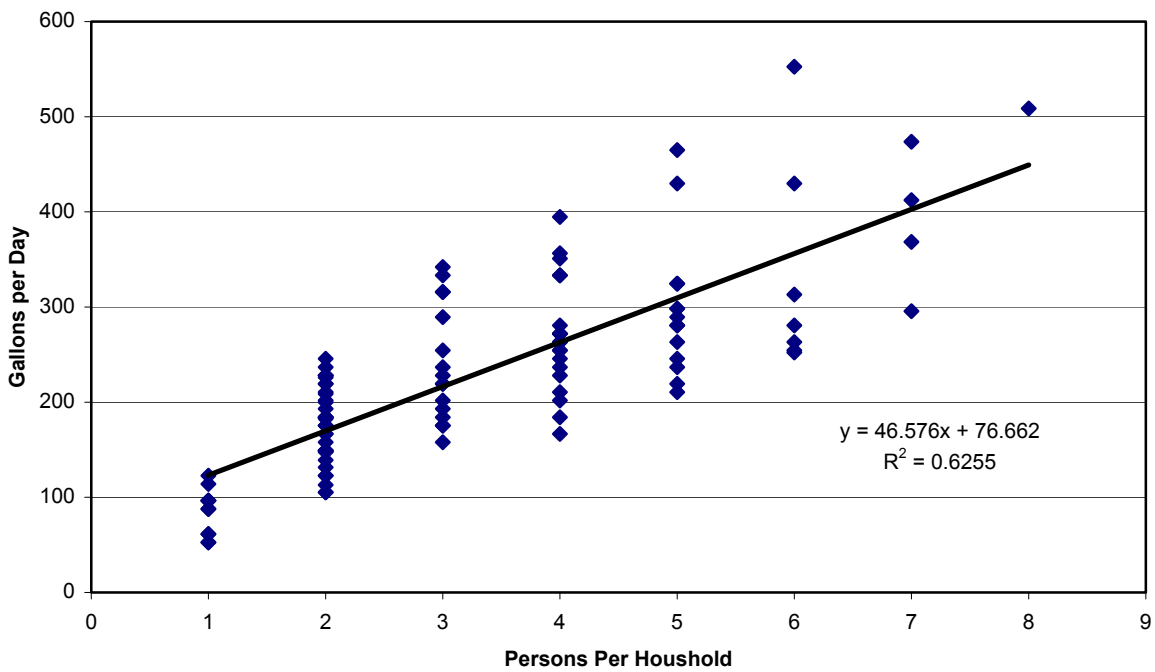
Figure A-1
Bountiful Winter Water Use



From Figure A-1, it is evident potable water use during the fall and early spring shows a 14 percent and 9 percent increase respectively (compared to the winter water use figure). Though this increase was expected, the volume was assumed to be insignificant.

A plot of gallons per day (gpd) verses persons per household (pph) is shown in Figure A-2 for the November–March use period. A linear fit cure is drawn through the data to aid in estimating use as pph changes over time. This equation can be modified to provide the same information in gpcd.

Figure A-2
Indoor Water Use for Bountiful



GPD = 46.576 PPH + 76.662 (Equation A-1)

GPCD = 76.662 $(PPH)^{-1}$ + 46.576 (Equation A-2)

Conclusions

Though a secondary source of water is available, potable water use outdoors during the summer months is substantial. If readings are not taken during the frost season, estimating indoor water use by subtracting the last fall meter reading and the first spring meter reading overestimates indoor water use. Average indoor water use can be approximated for Bountiful, according to Equation A-2, as 70 gpcd (assumed pph of 3.25).

APPENDIX B

MULTIFAMILY HOUSING INDOOR WATER USE STUDY

ACKNOWLEDGEMENTS

The data summarized in this report was collected under the general direction of Lloyd H. Austin, P.E., assistant director of the Utah Division of Water Resources, and supervised by Eric K. Klotz, P.E., chief, Resources Inventories and Special Studies Section. Data analysis and preparation of this report was performed by Gregory E. Williams, P.E., senior engineer.

Gratitude is expressed to the many organizations that made information available for this report, including but not limited to the following: United States Census Bureau, United States Geological Survey, American Water Works Association, American Water Works Association Research Foundation, Water Management, Inc., and the Utah State Office of Planning and Budget.

Appreciation is also expressed to the managers of the living complexes in Salt Lake County that provided information on tenant population. The division is especially appreciative of the time and effort taken by the employees of Granger-Hunter Improvement District, Jordan Valley Water Conservancy District and Salt Lake City Public Utilities in providing specific water use records of the selected facilities.

SUMMARY

The most commonly used data for planning and comparative purposes in the water industry is water use expressed as a per capita number in the units of gallons per capita per day (gpcd). There are many studies and an abundance of data for general gpcd water use for cities, suburban and rural areas, and each of the states.

The majority of the gpcd water use information is a compilation of all water use, in all types of residences. Some of this information is separated into outdoor and indoor water use. However, this information still includes all types of residences. In order to better understand and plan for the growing trend of multiple family dwellings and planned unit developments, it was determined that more specific information of indoor water use of differing housing was needed. This study specifically addresses the gpcd indoor water use of multiple family dwellings.

The following table summarizes the gpcd indoor water use findings of this study. The National category is multi-family dwellings outside the state of Utah. The WVC, SLC category is dwellings in West Valley City and Salt Lake City. Old Farm is a large living complex in Salt Lake County that includes apartments, condominiums, and townhouses. The weighted average numbers are the product of the gallons per unit per day (gpud) of each complex times the number of units, then divided by the total number of units in the category.

	Weighted Average	Range	Mean
National	60	43 – 65	54
WVC, SLC	63	45 – 67	56
Old Farm	51	49 – 55	52

The recommended figures for estimating general multifamily indoor daily water use are 60 gpcd and 150 gpud. For apartments only, the recommended figures are 55 gpcd and 125 gpud.

Recent studies have mostly agreed that the *general* average per capita daily indoor residential water use is approximately seventy gallons. The division study *Identifying Residential Water Use* concluded the figure to be 68 gpcd, with a range of 58.6 gpcd in Blanding, Utah, to 71.8 gpcd in Taylorsville, Utah. A comprehensive study released in 1999 by the American Water Works Association, entitled *Residential End Uses of Water,* determined that the national average indoor water use was 69.3 gpcd, with a range of 57.1 gpcd in Seattle, Washington, to 83.5 gpcd in Eugene, Oregon.

The overall gross average gpcd water use in multi-family dwellings of this study is 54 gpcd. This figure is twenty-three percent *lower* than the above- mentioned general figure of 70 gpcd. Possible reasons for this difference will be discussed later in this report. Suffice it to say, in summary, there not only is a difference in the gpcd water use of residents of multi-family dwellings from those of single family homes, but also a relatively significant difference if one is dealing with only multi-family dwellings.

INTRODUCTION

The Utah Division of Water Resources has the responsibility of completing investigations, studies and plans for the purpose of the effective and efficient use of the water resources of the state of Utah. In 1990, the division completed the *Utah State Water Plan*, providing the foundation and overall direction of the establishment and implementation of statewide water management. Detailed plans for each of the hydrologic basins of the state have since been completed and published as part of the ongoing and evolving *Utah State Water Plan*.

In recognition of the increasing demand of municipal and industrial (M&I) water uses, in 1992 the division began the collection of detailed M&I data for each hydrologic basin. Beginning in 1994, as data collection was completed for each of the basins, reports have been prepared and published for each hydrologic basin. These reports supplement the *Utah State Water Plan*, providing comprehensive data on M&I water use for water managers, planners and policy makers.

In 1998, the division began to specifically address residential uses of water. A preliminary survey of residential water use in Bountiful City indicated that the differential between indoor and outdoor water use was more significant than had been expected. A more comprehensive survey entitled "Identifying Residential Water Use" was then conducted, using thirteen selected communities throughout the state. As the *Identifying Residential Water Use* study targeted single-family houses, it came into question whether multi-family housing indoor per person water use would differ. With the recent trend of a larger overall percentage of multi-family housing, the division decided to specifically study the indoor per person water use of apartment, condominium and townhouse developments. This study is an investigation into the indoor water use patterns of multi-family housing residents.

METHODOLOGY

For comparative purposes, it was determined that the most current available data should be acquired for states other than Utah. The indoor water use figures for these "national" facilities were collected from various studies conducted specifically for multi-unit apartment complexes. The results of these studies determined a per living unit indoor water use rate, with most also determining a per person indoor water use rate.

The indoor water use figures for local facilities were determined by contacting both the property managers of the facility and the agency, or agencies, providing water service to the property. Monthly meter reading records were obtained for all service meters to each of the properties. These records were carefully reviewed for consistency, accuracy and applicability in determining only the winter season water use. This winter water use amount was then assumed to be all indoor usage.

Available tenant records were discussed with each of the property managers. These facility tenant records were used, when complete enough, to determine the facility population during the time period of the meter readings. Otherwise, the 2000 Census persons per rented unit figures for the applicable area were used for population data. Using the water use and population data, the gallons per unit per day and the gallons per capita per day numbers were then calculated.

For the Fox Point Apartments, Wayland Station Townhouses, and Lexington Village Condominiums, on site interviews and inspections along with facility records were used to determine population figures. As with the other local complexes, monthly water use records were obtained for all water meters serving the buildings. In general, the water use from November through February was used to insure that only indoor water use figures were being utilized.

SUMMARY OF THE RESULTS

The following table shows the resulting gpcd indoor water use of several multi-family complexes scattered throughout the United States. As can be seen, the results are fairly consistent and closely clustered around the mean value of 54 gpcd. No site specific population figures were available for the complexes of the indicated states and/or cities. Therefore, the average persons per rented unit figure of the 2000 Census, for the state the complex is in, was used to calculate the gpcd for that particular study complex or complexes.

NATIONAL STUDIES RESULTS

LOCATION	UNITS	GPUD	PPU	GPCD
Maryland	911	152	2.34	65
Virginia	4,675	139	2.36	59
Washington, D.C.	1,076	114	2.07	55
Chicago, Ill.	1,145	155	2.38	65
Nashville, Tenn.	106	116	2.27	51
Pennsylvania	308	130	2.13	61
Boston, Mass.	412	122	2.18	56
San Pablo, Calif.	NA	148	2.79	53
Houston, Texas	NA	109	2.53	43

Notes: gpud = gallons per unit per day
ppu = persons per unit
gpcd = gallons per capita (person) per day

The next table shows the resulting gpcd indoor water use of multi-family housing complexes in Salt Lake County. The first seven (up to and including Compass Court Townhouses) are located in West Valley City. The U of U (University of Utah) married student housing is located in Salt Lake City. The last three complexes are all within the larger complex called Old Farm, which is in Salt Lake County, near the city of Murray.

Of the West Valley City complexes, only the Compass Court Townhouses population could not be closely estimated and/or was not available from the management. For this complex, the 2000 Census figure for persons per rented unit of 3.05 was used in the calculation of the gpcd numbers. The U of U complex had fairly accurate records of population, dating back several years. The Old Farm complex was surveyed on site. The managers of each of the three areas were interviewed and population information gathered. Additionally, the information given was verified through canvassing individual units.

SALT LAKE COUNTY RESULTS

LOCATION	UNITS	GPUD	PPU	GPCD
Balmoral Townhouses	81	148	3.29	45
Crossroads Apartments	240	166	2.52	66
Somerset Village Apartments	486	186	3.00	62
Scottsdale Apartments	437	129	2.00	64
Homestead Farms Condos	152	268	4.00	67
Three Lanterns Apartments	42	200	4.00	50
Compass Court Townhouses	56	168	3.05	55
U of U Married Student Apts.	1,094	180	2.77	65
Fox Point Apartments	398	124	2.53	49
Waylan Station Townhouses	282	160	3.05	53
Lexington Village Condos	77	166	3.05	55

Notes: gpud = gallons per unit per day
ppu = persons per unit
gpcd = gallons per capita (person) per day

CONCLUSIONS AND RECOMMENDATIONS

The results of this study clearly show that the per person indoor water use in a multiple family dwelling is significantly less than that in a single-family house. The actual difference may be even greater as more accurate population figures are available for multiple family housing. This can be seen by the generally lower gpcd figures for those complexes where the population per unit was more accurately determined and/or verified. Additionally, when using the 2000 Census figures of persons per rented unit, it must be realized that a "unit" can be any rented living quarter from a single room to a three-story, five bedroom house.

The reasons for this difference can be as varied as the living quarters. One possible reason is the demographics. That is, rental units tend to house a more mobile population. The tenants, particularly of apartments, are usually younger or older, single, with no children. These people are less "tied down" to their living quarters, travel more, and are often visiting and/or staying with other friends or family. Additionally, there is generally less physical space per person in rental units. If nothing else, there would be less "maintenance" water used for the unit. Another reason could be the difference in the appliances. Rental units tend to have smaller water-using appliances. In fact, rental units may not even have comparable appliances. That is, apartments many times have common laundry facilities and may not have dishwashers. These two appliances alone can account for twenty percent of the overall water use of a unit.

In conclusion, the following water use figures are recommended:

Apartments only:	125 gpud
	55 gpcd
Multi-family:	150 gpud
(General)	60 gpcd

MULTI-FAMILY HOUSING INDOOR WATER USE STUDY

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