SEATTLE PUBLIC UTILITIES
STUDY OF MARKET PENETRATION OF
WATER EFFICIENT FIXTURES

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EXECUTIVE SUMMARY

The Seattle Market Penetration Study was designed to enable Seattle Public Utility (SPU) to assess the effectiveness of their water conservation programs and the extent to which their customers have reduced water consumption through behavioral changes and conversion to water conserving fixtures and appliances. Data were collected with both surveys and data-logging and the results were compared for consistency. Results from previous studies were available that showed usage patterns on homes that were known to have few if any water conserving fixtures. Even more useful, were data from a group of homes known to be totally retrofit with the high efficiency fixtures and appliances. These two data sets provided a good framework for looking at the use patterns for the Market Penetration study. The availability of these data allowed the results from this study to be placed on a line between no retrofits and complete retrofits, to see where this random sample of 100 homes lies, and how far Seattle must go to capture all of the water savings available from this important customer group.

A survey was developed using previous SPU surveys in an effort to elicit detailed information from a random sample of 1,500 customers regarding the types and numbers of water using fixtures, penetration of low flow fixtures and appliances and customers' efforts at reducing water use indoors. Questions regarding participation in various rebate programs, outdoor reduction and demographics were also included in the survey.

A smaller random sample of 125 customers developed from the survey was chosen for data-logging. This provided SPU with accurate water use patterns over a period of time without relying on reporting from customers to determine the penetration of low flow fixtures. It also helped SPU to determine the accuracy that could be achieved from survey information.

Data-logging analysis using Trace Wizard software also provided SPU with another level of detail that would be difficult to obtain with a survey. In addition to determining the penetration of low flow and water efficient devices Trace Wizard could be used to determine the frequency, volume and duration of each type of end use. Customers with high leak rates were also identified from the flow trace analysis.

Table 1 shows a summary of the average daily indoor use in gallons per household for each of the identified end uses of water. Data are presented for the market study group, and the homes in the Seattle Home Conservation before and after their retrofits. The first thing that

stands out about is that the indoor use for the market group is nearly identical to the pre-retrofit home conservation study group. The market study group used an average of 153 gpd compared to the 92 gpd used by the home conservation study group after they were fully retrofit. On a household basis, then, this implies there are still approximately 60 gpd of potential savings available. Houses using 60 gpd for indoor uses would only require a total 22 kgal per year indoors.

Table 1 Summary comparison of end uses

	Seattle Market Penetration Study - 2004 (gpd)	Seattle Home Cons. Study (pre-retrofit) – 2000 (gpd)	Seattle Home Cons. Study (post-retrofit) - 2000 (gpd)
Dishwasher	2.0	3.3	3.0
Other	7.4	0.5	0.2
Leak	6.9	16.8	4.9
Faucet	26.3	21.2	17.4
Shower	29.4	22.1	19.9
Bath	4.1	7.8	6.3
Clothes Washer	36.5	34.2	21.2
Toilet	40.0	45.4	19.2
Total	152.6	151.3	92.1

The results show that the category for which the best measurable savings appear in the market penetration group is toilet use, which lies at 40 gpd. This is clearly lower than the pre-retrofit group use of 45 gpd for toilets, but still not to the potential of 19 gpd for a fully retrofit home. The clothes washer daily use of 36.5 gpd was higher than the average use prior to the retrofits. We know that homes with high efficiency washers should be using around 21 gpd for clothes washing. So, there is still a long way to go in this category as well. If one looks at the total use for faucets and showers we see that was around 56 gpd in the market group compared to 37 gpd for the post retrofit group. So, there are savings to be had in these categories, but it appears that in order to capture them it requires use of faucets with lower flow rates than 2.0-2.6 gpm used for standard retrofit. Leakage remains an important category. The post retrofit homes had rates down at 5 gpd. Experience has shown that leakage rates this low require toilets that do not leak. Based on the results of these studies it appears that an excellent goal for indoor water use would be 90 gpd as the mark of a fully retrofit home.

INTRODUCTION

In 2003 Aquacraft, Inc. joined with Seattle Public Utility (SPU) to assist them in evaluating the impact of their approach to water conservation education and rebate programs. The SPU had been conducting residential water conservation programs for several years, and they wanted to know the extent to which high efficiency water fixtures and appliances had penetrated the single family sub-class of customers in their service area. Thus this project has been referred to as the Seattle Market Penetration study, or market penetration study.

In order to collect the information needed to answer the question two sources of information were tapped. Surveys were mailed to 1,500 SPU customers and the data from 480 respondents was tabulated into a Microsoft Access database. The purpose of these surveys was to obtain information from the customers about the types of fixtures and appliances present in their homes, and whether they had done any retrofits. In addition to the surveys a random sample of 125 homes was chosen from the 1500 home sample for data logging. Data logging was an attractive option to SPU because it offered the potential to obtain the needed information on market penetration without having to rely on a survey response from the customer. The Seattle City Council wanted to reduce the frequency of surveys in order to avoid imposing on their citizens, and this was seen as a possible way to do this. Seattle's previous experience with data logging had shown that by using flow trace data from data loggers it was possible to obtain surprisingly detailed breakdowns of household water use according not just to whether it was indoor our outdoor, but down to the level of identifying the water used for individual fixtures and appliances at the event level.

This report presents the findings of the study and shows the extent to which the households in the study are employing high efficiency fixtures and appliances. By comparing their water use to that from other study groups for which the penetration of efficient fixtures was known it was possible to gauge how far this random sample of customers has taken advantage of water conserving technology.

METHODOLOGY

A brief description of each of the tasks required for this study is provided in this section of the report. A detailed description of the data logging methodology is available in the Seattle Home Water Conservation Study (Mayer, DeOreo, Lewis, 2000) and the Residential End Uses of Water Study (REUWS) (Mayer, DeOreo, 1999).

Task 1: Survey and Q1500 Selection

Aquacraft, Inc. and Seattle Public Utilities (SPU) developed a cover letter and survey that contained 13 questions relating to household water use. The full survey can be found in Appendix A. Responses from these questions were tabulated and used to draw conclusions about the respondents' water use patterns. A summary of the questions asked in the survey is provided in Table 2.

Table 2 : Summary of survey questions

Question	Subject
1	Number of toilets, bathtubs, showers, sinks, dishwashers and other in-home water using devices
2	Year and brand of toilets
3	Make and model and age of clothes washer
4	Replacement of shower head, faucet aerators or toilets with low flow fixtures
5	Presence of leaking fixtures
6	Conservation measures such as fewer toilet flushes, leak repair, less faucet use, and fuller clothes washer and dishwasher loads
7	Participation in utility sponsored promotions and rebates
8	Lawn watering frequency
9	Outdoor conservation such as thatch removal, aeration, hose timers and soil amendments.
10	Lawn and garden watering reduction
11	Lawn and garden watering system
12	Rent or own
13	Demographics

Some of the information obtained, for example a count of the number of fixtures such as toilets, showers, and sinks, can only be acquired directly from a survey of the residents, or from an on-site inspection. Likewise, the makes and models of devices require direct inspection and

direct responses. However, if what is required is knowledge of the presence of the types of products or their efficiencies in terms of gallons per use then the information can be obtained from the flow traces, as will be described in this report. From the standpoint of the water provider, knowing the makes and models, while perhaps of interest, is not as essential as knowing the types of fixtures and appliances present and the volume of water that is used by each.

Task 2: Prepare Database & Print Mailing Labels

Historical billing data and address information was provided in electronic form by SPU. Aquacraft generated a random sample of 1500 regional customers from this database and surveys were sent to 1000 Seattle customers and 500 wholesale customers.

Task 3: Tabulate Survey Responses

Aquacraft recorded and tabulated the responses from the surveys in an MS Access database. There were 337 responses from Seattle Public Utility customers and 143 responses from ten wholesale customers. Summaries of SPU responses, all purveyors and combined responses are provided in Appendix B of this report. Responses from individual purveyors are provided in Appendix D.

Task 4: Study Group Selection

Aquacraft worked with the SPU staff to develop a study group of 125 homes from the Seattle survey respondents for data logging, which is referred to as the market penetration study group. The selected group was a random sample that reflects the current state of water use and the penetration of water conserving fixtures in Seattle homes. Data from the market penetration study group could be compared with data from the REUWS and the pre and post retrofit homes from the Seattle Home Conservation study to show both their similarity and differences.

Task 5: Data Logging

After SPU replaced the water meters on the homes to be logged Aquacraft personnel came to Seattle and installed data loggers. It took three trips to cover all 125 homes. During each trip the loggers were retrieved and downloaded and replaced in the field until all 125 homes

had been logged. The SPU staff was responsible for retrieving the data log equipment from the third and final installation phase.

The data loggers were used to collect continuous high resolution flow traces from the water meters of the selected homes. The goal was to obtain good data of at least ten days duration from a minimum of 100 homes. Aquacraft obtained 101 accurate flow traces of at least ten days duration during the three phases.

Task 6: Flow Trace Analysis and Database Development

Aquacraft analyzed the record from each data logger using the Trace Wizard software program. Each flow trace was disaggregated and the various end uses such as toilets, showers, clothes washers and dishwashers were identified. Water use data were imported into a MS Access database and queries were run to summarize key results. The data were used to identify the penetration of water conserving toilets, showerheads, faucets and clothes washers.

Data were also available from two other studies, which was used to compare the results of the market penetration study in order to judge the degree to which high efficiency devices are in use by single family customers. The first set was from the 100 homes selected for the Residential End Uses of Water Study, done in 1996-97. This was a random set of homes chosen for baseline measurement of end uses of water in single family customers. A retrofit study was done in Seattle in 1999, which measured water use patterns by end use in 37 homes both before and after the toilets, showerhead, clothes washers and faucet aerators were replaced. This was a very useful set of data because it showed the end uses of water in a group of homes which were known to have no high efficiency clothes washers and not more than one or two ULF toilets (among the entire group) prior to the retrofit, and then to have all ULF toilets, high efficiency clothes washers, new faucet aerators and showerheads after the retrofit. By comparing the results from the market penetration group to these other data sets it was possible to obtain precise estimates of the percentage of the potential water conservation that the existing customers have captured.

Task 7: Identify Customers with High Leakage Rates

In both the REUWS and the pre-retrofit groups the average household leakage rates were relatively high. Typically, these averages were greatly influenced by a few homes with very high

leakage rates. The SPU requested that they be notified of any customers in the market study that had high leak rates. These customers could then be contacted by the utility in an effort to reduce their water consumption. These customers are identified in Appendix C of this report.

RESULTS FROM LOGGING ANALYSES

Flow trace analysis was used to determine both average daily household use and a disaggregation of daily use by end-use. Fixtures of particular interest were toilets, clothes washers, showers and faucets. Leakage rates, as they are affected by retrofits, were also of interest. This study and previous studies have shown these uses account for over 80 percent of daily indoor household use and therefore have the greatest potential for water savings. Also, these are the fixtures that have products readily available for retrofit testing.

As discussed below, comparison of trace analysis data from the current Seattle market penetration study with the previous Seattle Home Conservation post-retrofit study confirm that much of the indoor water savings have yet to be captured. In addition, survey data confirm that many SPU customers still have old fixtures, particularly clothes washers and toilets and few have taken advantage of the rebates that were designed to encourage customers to upgrade their old fixtures with water conserving models.

Logged Home Analysis

Data from the logged Seattle homes was used to determine the daily average household water use, average volume of each end use, daily per capita water use (from the 28 logged homes that responded to the mail survey), and the penetration of low flow fixtures and appliances.

Daily Household Use

Figure 1 is a histogram of the distribution of average daily water use for the Seattle market penetration study. Sixty five percent of households use between 60 and 180 gallons per household per day, however thirty one percent of households use 200 or more gallons per day. Thirteen percent of households use 300 or more gallons of water per day. The histogram shows one outlier with average water consumption over 620 gallons per day.[1] The average daily water use per household for the logged homes was 153 gallons per day. Statistical data for the average household use is shown in Table 3.

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[1] This home had a high leakage rate of 82 gallons per day. Analysis of the trace indicates a high occupancy rate for this home. There was an average of 1.3 baths, 4.9 showers, 4.8 clothes washer loads, 34.3 non-ULF toilet flushes and 17.8 ULF toilet flushes per day during the 13 day logging period.
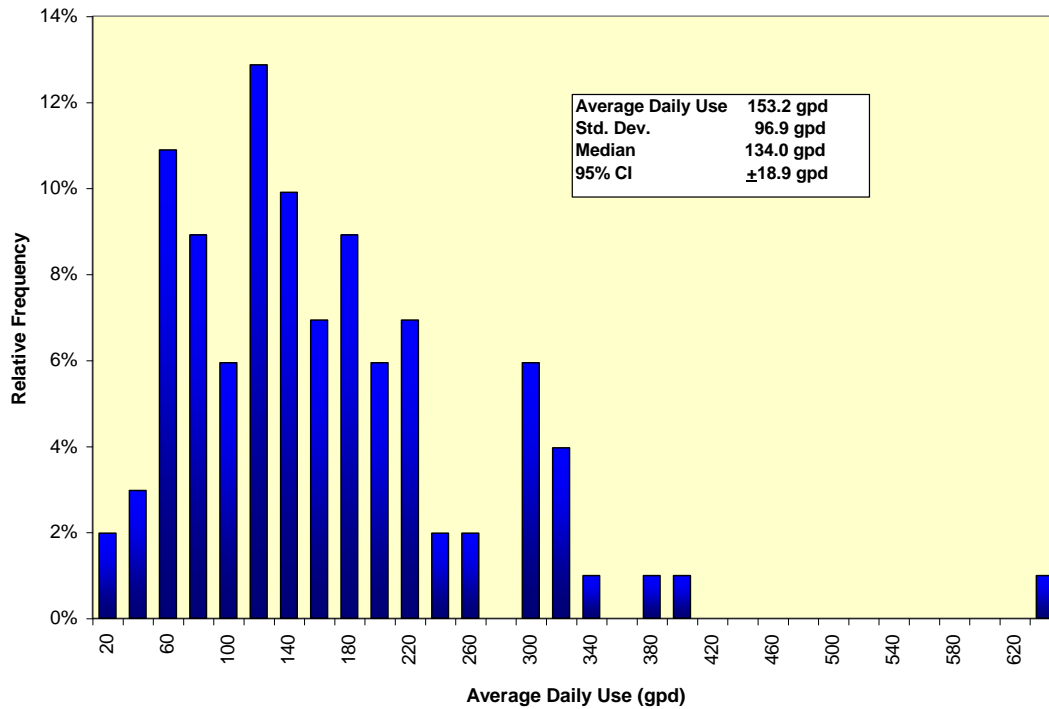
Figure 1 Daily per household indoor water use distribution for market group

Table 3 Statistical data for average household use

Stats	Gallons per Day
Average Daily Use	153
Standard Deviation	97
Median	134
95% Confidence Interval	±19

When the daily use distributions are plotted for the market group along with the pre and post retrofit groups the differences between the market group and the retrofit group stand out clearly. In Figure 2 these distributions show that the market penetration group is much more similar to the pre-retrofit group than the post retrofit group. Figure 3 confirms this. It compares average daily indoor use with data from the previous Seattle studies discussed above. It is interesting to note that the daily average water use in the Seattle market penetration study group is 153 gpd, which is nearly identical to that of the Seattle REUWS and the Seattle Home Conservation study pre-retrofit homes, which are both 151 gpd.
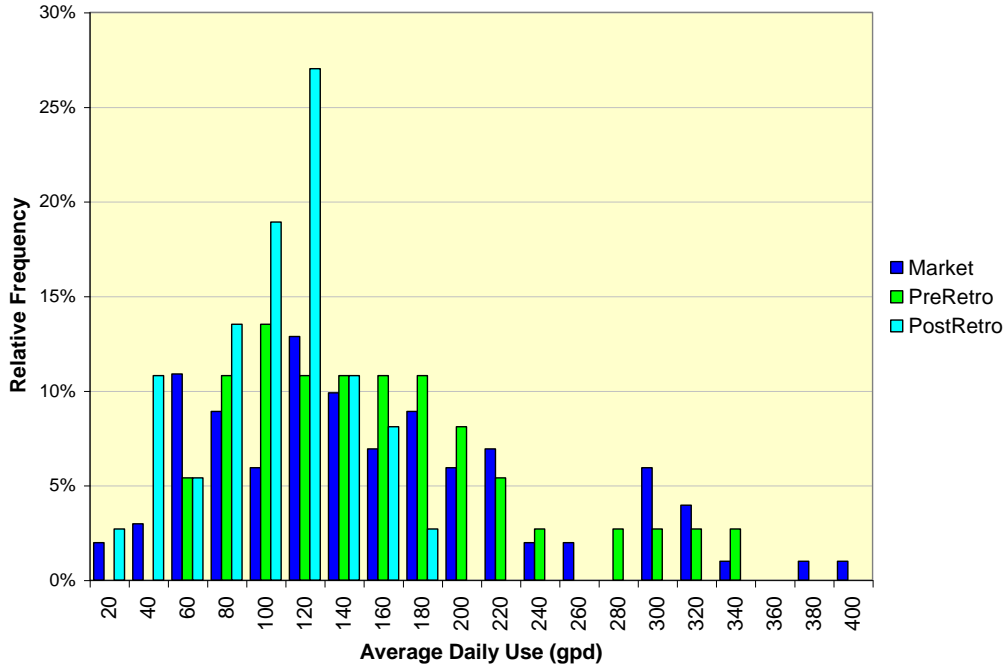
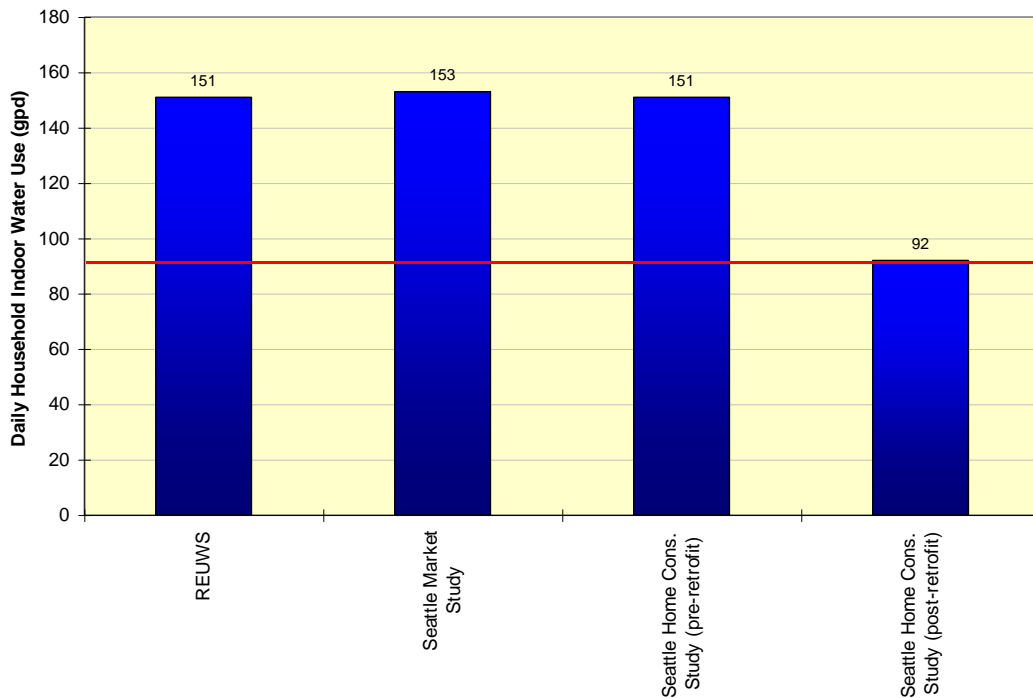**Figure 2 Comparison of household use patterns**

Figure 3 Comparison of total household water consumption from four Seattle studies

Household Use by Fixture

The data from the market study shows an average household indoor use of approximately 153 gallons of water per day under baseline conditions. Toilet flushing and clothes washers account for approximately half of all household use and another forty percent is used for showers, bathing and faucets. Households average 40 gallons per day for toilet use, 37 gallons per day for the clothes washer, 34 gallons per day for showers and baths and 28 gallons per day for faucets. The volume used for each fixture type can be seen in Figure 4. In this group, leakage rates averaged only 7 gpd per household.
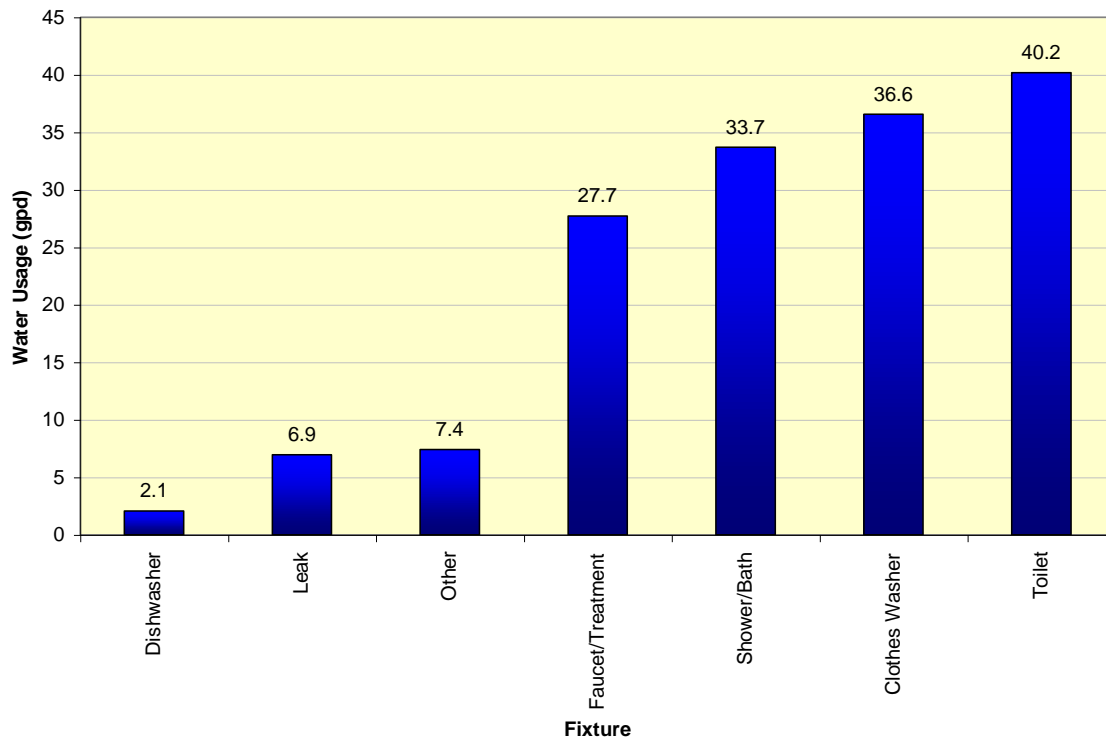
Figure 4 Seattle Market study average daily household use by fixture

Household use by fixture from the Seattle market penetration study was been compared to three previous Seattle studies and the results are shown in Figure 5. Although there are some differences in the amount of water used by fixture, overall daily household use is very similar for the Seattle Market study, REUWS and the pre-retrofit study. It is interesting to note however, that the daily household use for three of the four highly water consumptive fixtures is higher for the Seattle Market study than for the REUWS and pre-retrofit study. Only leaks and dishwashers use less water than in these two studies. What is clearly demonstrated on the graph is the

potential for water savings that still exists. The post-retrofit study shows the average amount of water used for each fixture when high water use fixtures were replaced with water conserving fixtures.
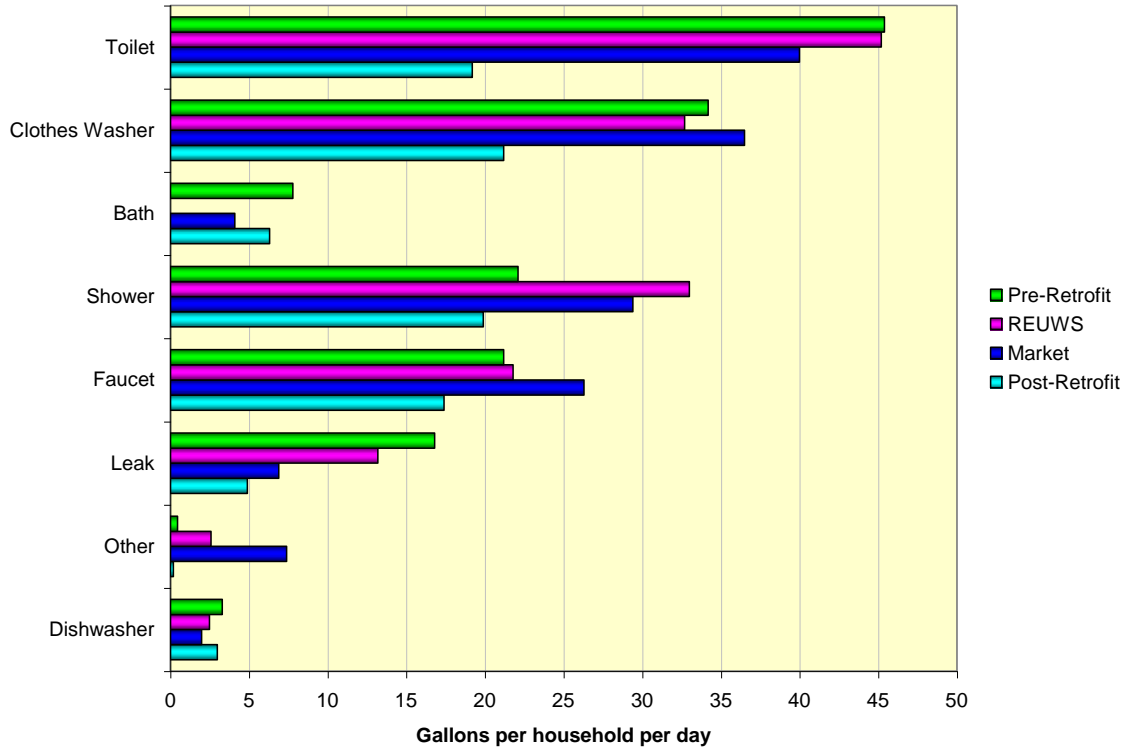
Figure 5 Comparison of average daily fixture usage from four Seattle studies[2]

The pie chart shown in Figure 6 shows that nearly 50 percent of the average daily indoor household use was for toilets and clothes washers. Bathing and faucet use comprise another 40 percent of indoor use. The remaining ten percent is for all other uses, such as water treatment and dishwashers.

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[2] The REUWS combines shower and bath in one category. These data are broken out for the other three studies.
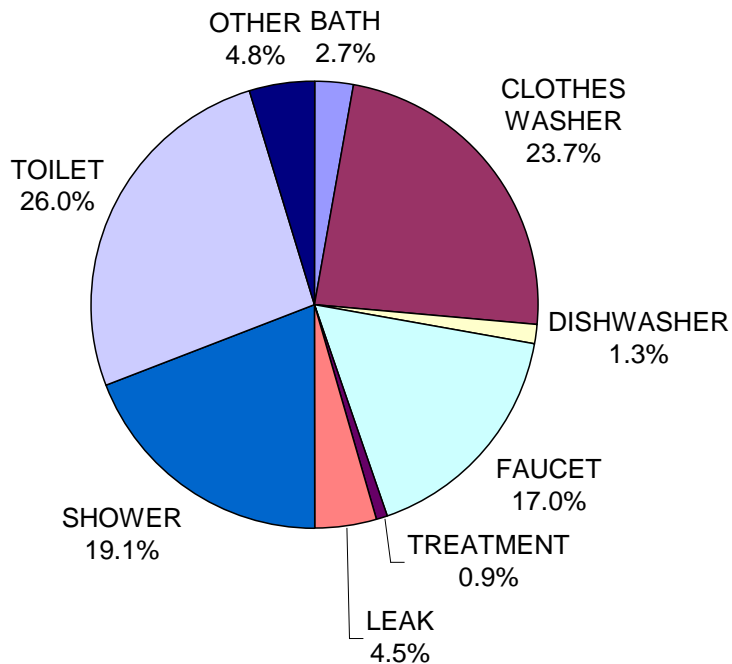
Figure 6 Percent of daily household use by fixture

Daily Per Capita Use

Surveys were mailed to 1,000 SPU customers in order to gather information regarding water use, water conservation efforts and demographics. The number of residents reported from the mail survey and data obtained from flow trace analysis was then used to calculate daily per capita water use. There were only 28 customers who responded to the survey that also had data loggers installed on their water meters. The distribution of average daily per capita use is shown in Figure 7.

This small sample size prevents making general statements about per capita use from these results, but the results are still of interest. Table 4 shows the statistical data for average daily per capita use. While the average per capita use shown in Table 3 is lower than that found in the REUWS, which was 57.1, the median use of 54.0 was identical to that of the REUWS group.

Avg. per capita use 51.9 gpcd
Std. Dev.   22.6 gpcd
Median   54.0 gpcd
95% CI   ±8.4 gpcd
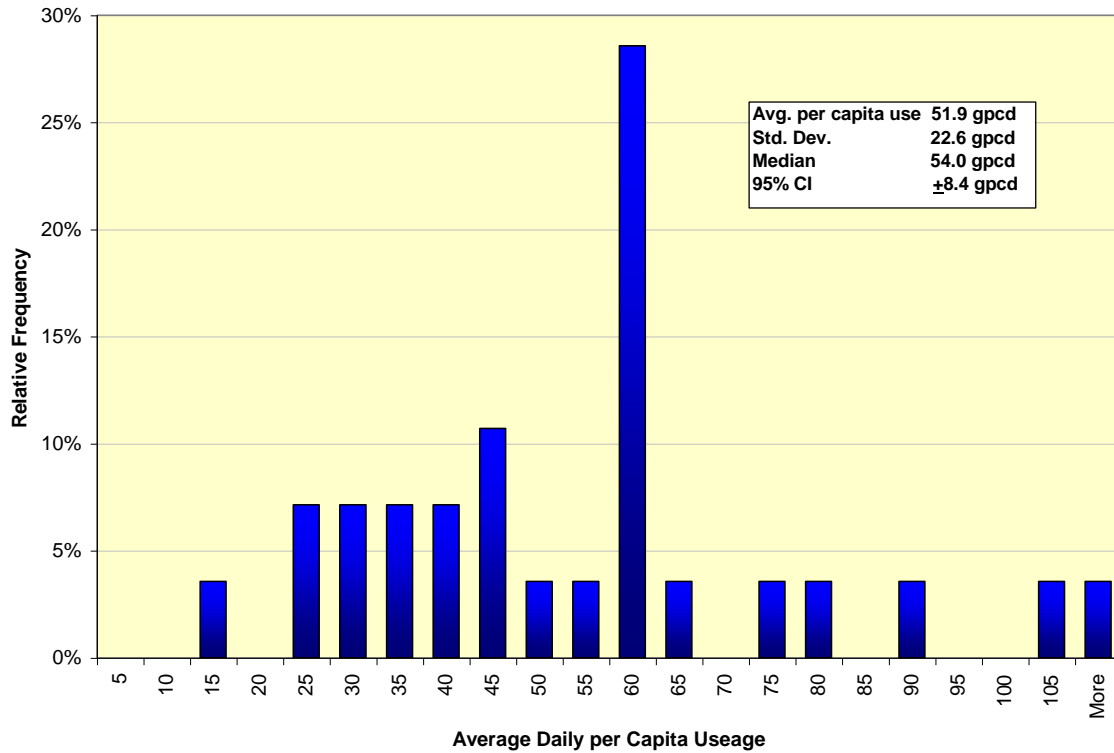
Figure 7 Average daily use per capita distribution of 28 logged and surveyed Seattle customers

Table 4 Statistical data for average daily per capita use

Statistic	GPCD
Average Daily per Capita Use	51.9
Standard Deviation	22.6
Median	54.0
95% Confidence Interval	± 8.4

Water Use by Fixture

        Analysis of the logged homes using Trace Wizard allows each flow trace to be disaggregated into specific end uses. Individual fixtures are identified, separated, and analyzed for flow rate, volume and duration. The data are then used to determine penetration rates of ULF toilets, low flow faucets and showerheads, and water conserving clothes washers.

Average Toilet Volume

        There were 15,307 toilet flushes during the logging period with an average of 152 flushes per household. The ULF toilet flushes are clearly evident in the bimodal distribution of toilet flushes shown in Figure 8. While there is a wider range of flush volumes among the non-ULF toilets, another peak is evident between the 3 to 5 gallon range.

        Twenty-five households had 200 or more toilet flushes during the logging period. Of these 25 homes 15 of them used non-ULF toilets at least 90 percent of the time. Twenty-eight homes had toilets that were at least 50 years old. Table 6 shows the statistical data for the average toilet flush volume in the Seattle Market study.

        The logging data showed that there was at least one ULF toilet in 42 percent of the homes logged, but only five of the homes had only ULF toilets. Twenty-six homes used their ULF toilets at least 50 percent of the time. Table 5 shows the number and percentage of homes with ULF toilets and the percentage of toilet flushes attributed to the ULF toilet for each.

Table 5 Number of logged homes with ULF toilets and percent of ULF toilet flushes

Percent of Time ULF Toilet Used	100 %	90 %	80 %	70 %	50 %
No. of homes[3]	5	11	17	19	26
Percent	4.9	10.9	16.9	18.8	25.7

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[3] The previous count of homes is included in each of the number of homes given, i.e. 11 homes includes the five homes that use their ULF toilet 90% of the time as well as an additional 6 home that use their ULF 80% of the time.
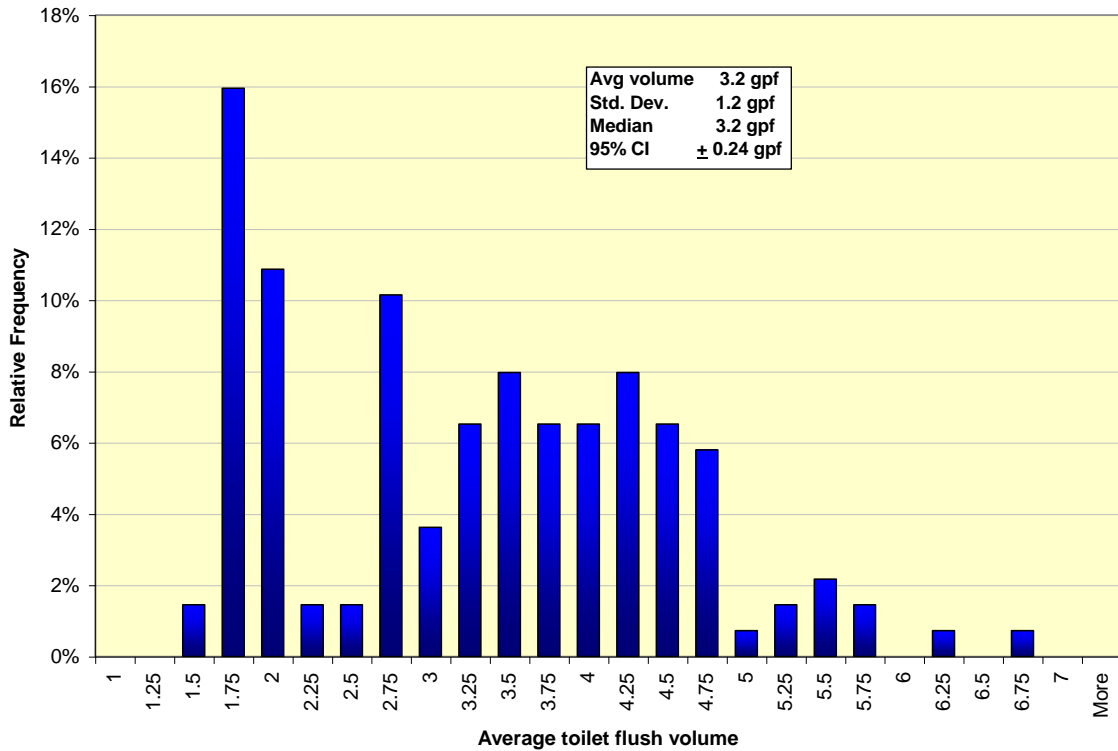
Figure 8 Average toilet flush volume diagram of logged Seattle customers

Table 6 Statistical data for average toilet flush volume

Statistic	Gallons per flush
Average Toilet Flush Volume	3.2
Standard Deviation	1.2
Median	3.2
95% Confidence Interval	± 0.2

The average total flush volume from the market penetration study was compared with the results from two previous Seattle studies, pre and post-retrofit and shown in Table 7. The data show that only around 18 percent of the possible savings have been achieved to date.

Table 7 Average toilet flush volume from three Seattle studies

	Seattle Home Cons. Study Pre-Retrofit	Seattle Market Study	Seattle Home Cons. Study Post-Retrofit
Average toilet flush volume (gpf)	3.6	3.2	1.4

Non-ULF Toilets

Eighty seven percent of toilet flushes ranged between 2.75 and 5 gallons per flush (gpf) but nearly 10 percent of the toilets used more than 5 gpf as shown in Figure 9. Survey responses indicated that there were a number of homes with toilets that were more than 50 years old.
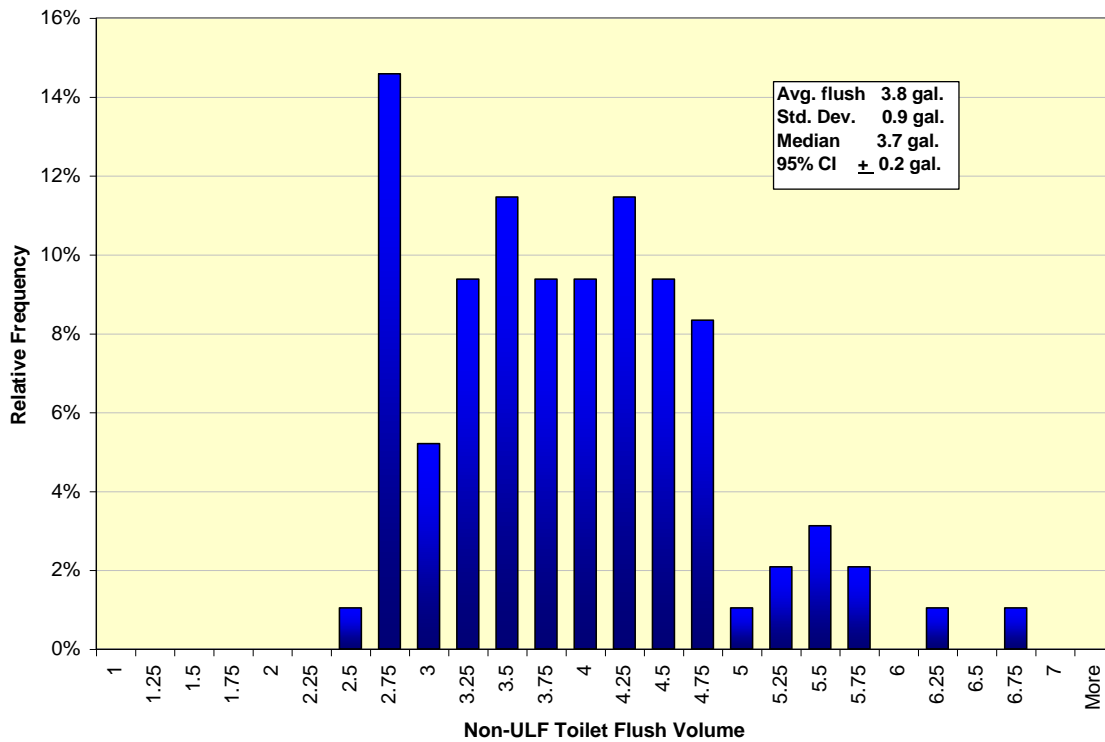
Figure 9 Average non-ULF toilet flush volume diagram of logged Seattle customers

Table 8 Statistical data for average flush volume in non-ULF toilets

Statistic	Gallons per flush
Average Non-ULF Flush Vol.	3.8
Standard Deviation	0.9
Median	3.7
95% Confidence Interval	± 0.2

ULF Toilets

Unlike non-ULF toilets there is a very narrow range of flush volumes for ULF toilets as shown in Figure 10. Ninety three percent of the ULF toilets used 2 gallons or less per flush. The statistical data for the ULF toilets in the Seattle Market study is shown in Table 9.
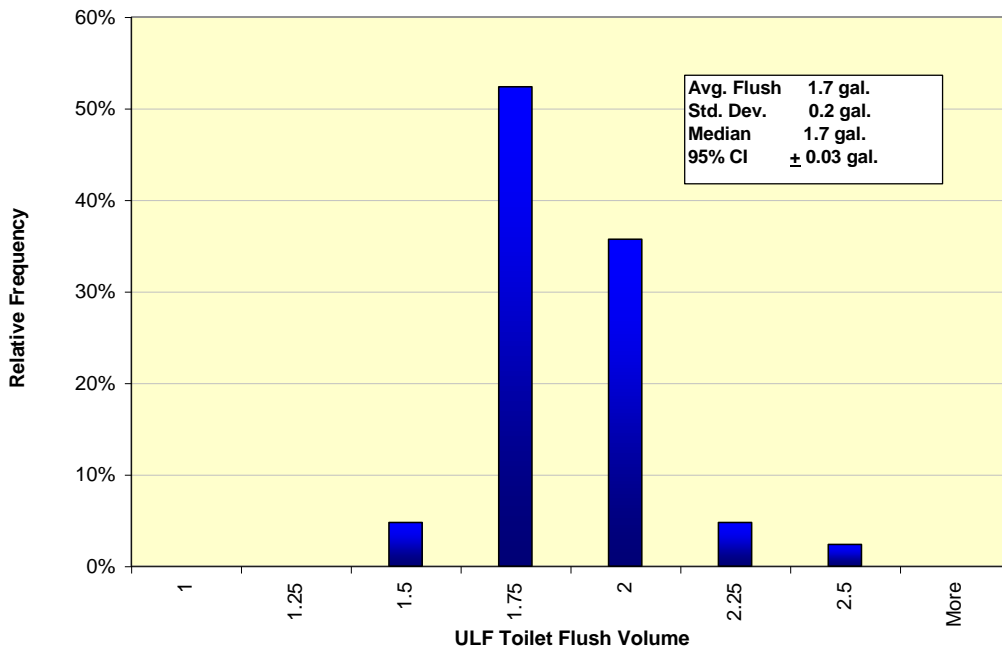
Figure 10 Average ULF toilet flush volume distribution of the logged Seattle customers

Table 9 Statistical data for average flush volume in ULF toilets

Statistic	Gallons per flush
Average ULF Flush Vol.	1.7
Standard Deviation	0.2
Median	1.7
95% Confidence Interval	± 0.0

Average Clothes Washer Volume per Load

After toilets, the next most important device for potential water conservation is the clothes washer. There were 94 homes that used a clothes washer during the logging period. Figure 11 shows that nearly 50 percent of logged homes used an average of 45 gallons per load or more, while only sixteen of the 94 homes (17 percent) had clothes washers that averaged less than 30 gallons per load. There were 21 homes (22 percent) that used clothes washers that averaged more than 50 gallons per load.
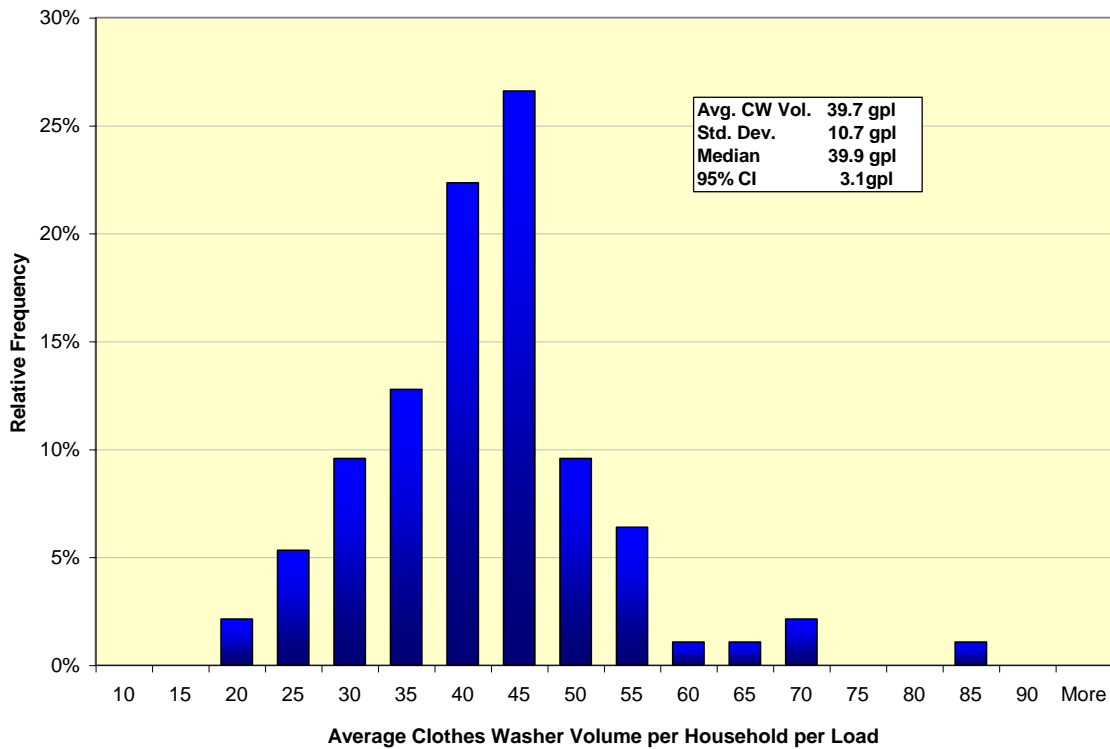
Figure 11 Average clothes washer volume distribution of logged Seattle customers

The statistical data for the average clothes washer volume in the Seattle Market study is shown in Table 10.

Table 10 Statistical data for average clothes washer load

Statistic	Gallons per load
Average CW Vol.	39.7
Standard Deviation	10.5
Median	39.9
95% Confidence Interval	± 2.1

Despite the fact that efficient clothes washers were found in 17 percent of the homes in the market study, the average clothes washer volume per clothes washer load in the Seattle Market study is nearly identical to that of the REUWS and the Seattle Home Conservation pre-retrofit study where no particular effort had been made to target homes for conservation. Examination of the histogram of all clothes washer volume per load data shown in Figure 12 shows that a slightly higher percentage of REUWS and pre-retrofit customers had high volume clothes washers than did those in the market study. In addition, because some of the newer, top-loading models have adjustable fill levels it is possible that the average volume for some of these clothes washers may look like that of an efficient model particularly if it is located in a home with a small number of residents.

The distribution of clothes washer volume per load data show that the Market Penetration study group is slightly lower than either the pre-retrofit or REUWS groups in the distribution of volume per load, but it is nothing like the low rates of gallons per load seen in the post retrofit group. This implies that the current inventory of clothes washers in the Seattle service area look a lot more like conventional machines than new, high efficiency machines.
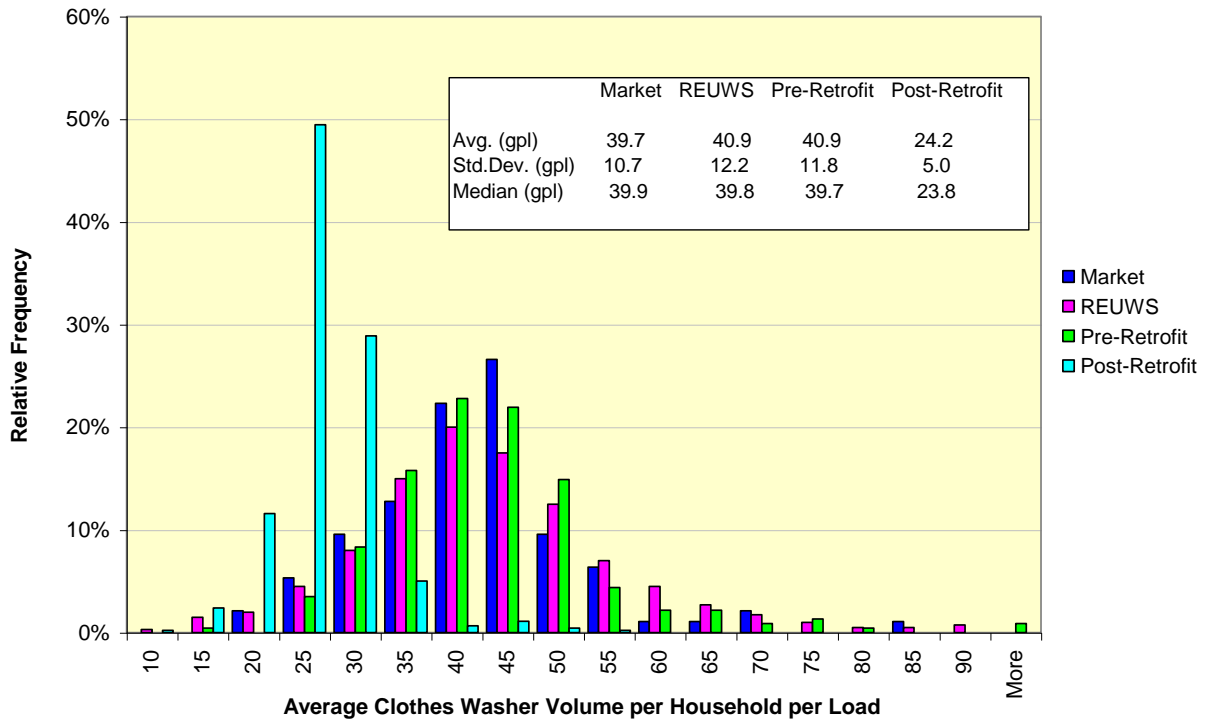
Figure 12 Distribution on clothes washer volumes per load for four Seattle studies

Table 11 shows a potential water saving of 15.4 gallons per load with a retrofit of water conserving clothes washer models. The data indicate that at this time Seattle has captured less than 10% of the potential savings available from high efficiency clothes washers.

Table 11 Comparison of clothes washer water use from three Seattle studies

	Seattle Home Cons. Study Pre-Retrofit	Seattle Market Study	Seattle Home Cons. Study Post-Retrofit
Average clothes washer use (gpl)	40.9	39.7	24.3
Std. Deviation (gpl)	11.8	10.7	5.0
Median (gpl)	39.7	39.9	23.8

Shower Flow Rates

There were 2,215 shower events recorded in 98 homes during the logging period. Eighty-two percent of the logged homes had showers with flow rates of 2.5 gpm or less as shown in Figure 13. Only one home had a flow rate of nearly 6 gpm. This home had an average shower duration of 5.2 minutes but due to the high flow rate the average shower volume for this customer was over 30 gallons – nearly double that of the average shower volume of 16.9 gallons as shown in Figure 14.

Five percent of logged homes had average shower volumes that exceeded 30 gallons. Three of the customers had high shower volumes due to the high flow rate of the showers. Two of the customers had high shower volumes due to the average length of the shower that was nearly double the average duration of 8.2 minutes as shown in Figure 15. Only 11 percent of homes took showers that averaged 5 minutes or less.

Avg. Flow Rate	2.2 gpm
Std. Dev.	0.7 gpm
Median	2.0 gpm
95% CI	± 0.1 gpm
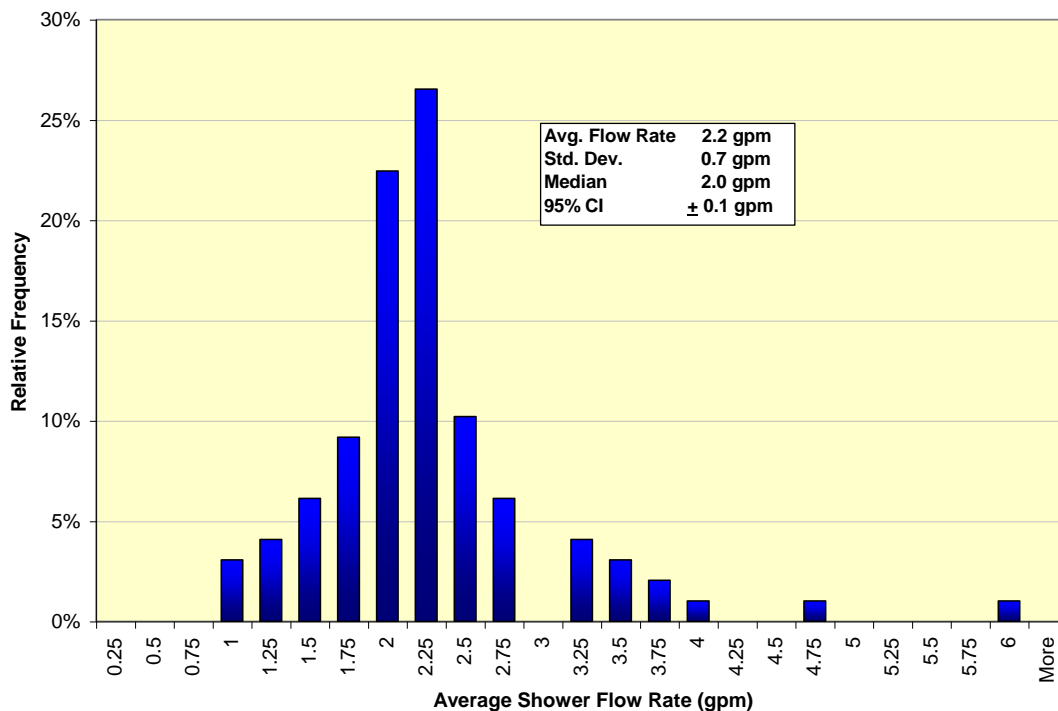
Figure 13 Average shower flow rate distribution

Table 12 shows the statistical data for the average shower flow rate in the Seattle Market study.

Table 12 Statistical data of average shower flow rate

Statistic	Gallons per minute
Average Shower Flow Rate	2.2
Standard Deviation	0.7
Median	2.0
95% Confidence Interval	± 0.1

Avg. Shower Volume	16.9 gal.
Std. Dev	6.1 gal.
Median	15.8 gal.
95% CI	+1.2 gal.
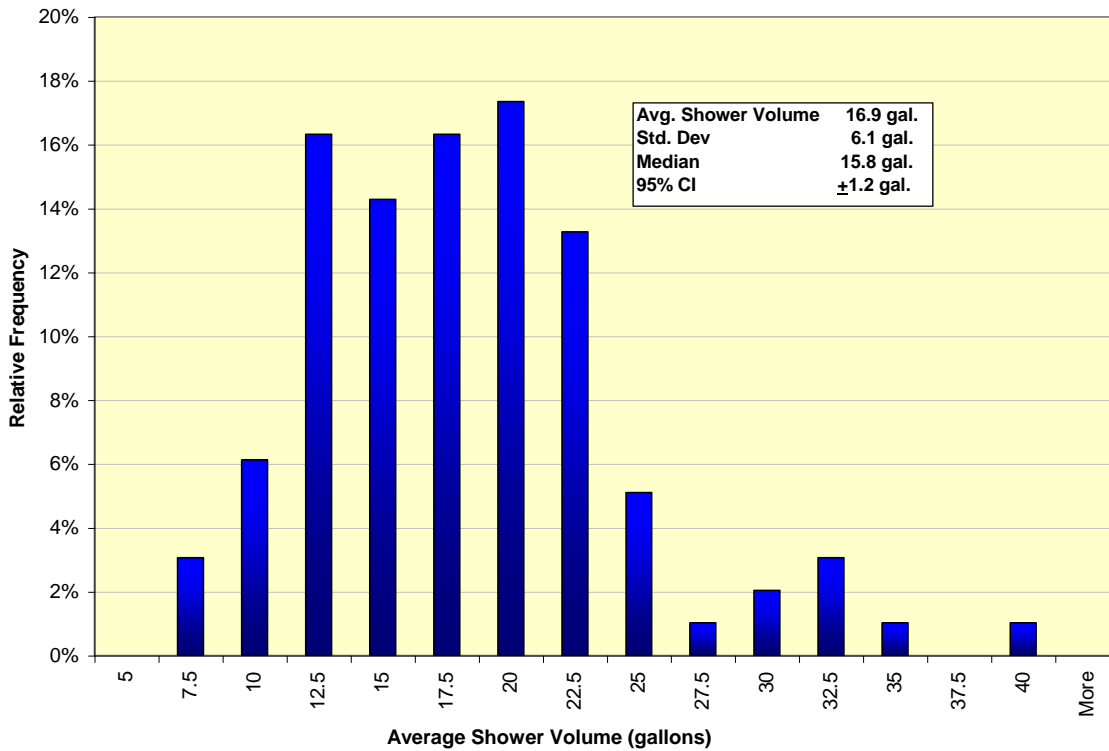
Figure 14 Average shower volume distribution

Table 13 shows the statistical data for the average shower volume for the Seattle Market study.

Table 13 Statistical data for average shower volume

Statistic	Gallons
Average Shower Vol.	16.9
Standard Deviation	6.1
Median	15.8
95% Confidence Interval	±1.2
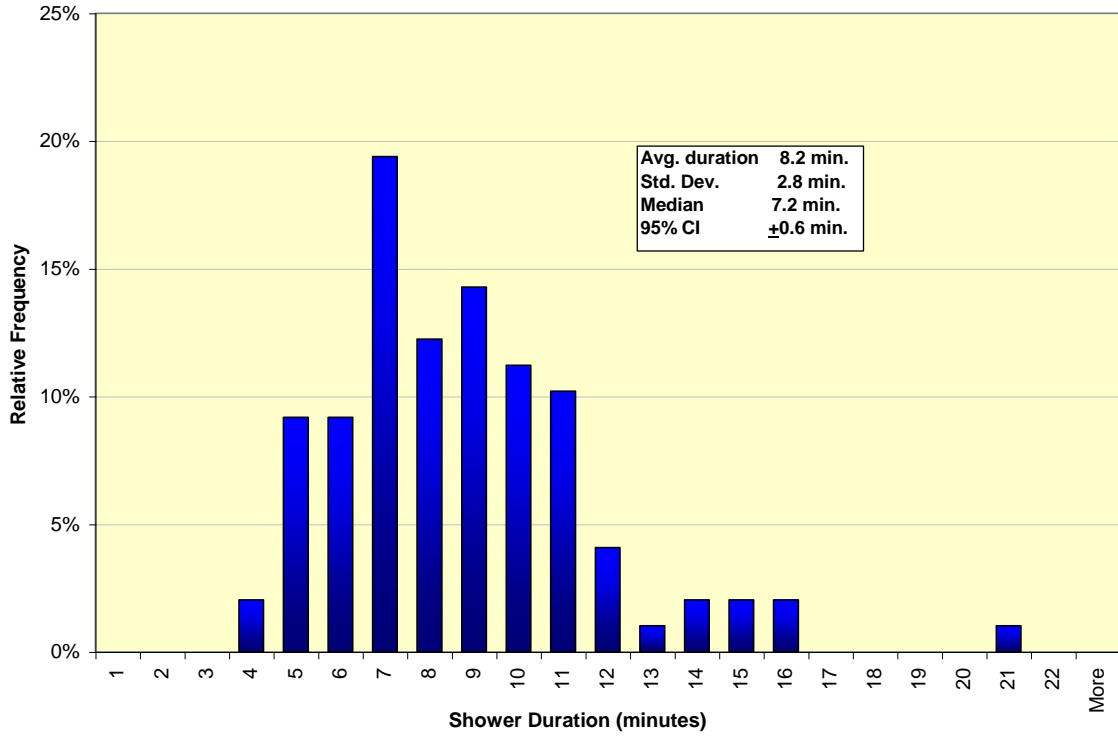
Figure 15 Average shower duration distribution

Table 14 shows the statistical data for the average shower duration for the Seattle Market study.

Table 14 Statistical data for average shower duration

Statistic	Minutes
Average Duration	8.2
Standard Deviation	2.8
Median	7.2
95% Confidence Interval	± 0.6

Faucet Flow Rates

Figure 16 shows the distribution of the faucet mode flow rates (gpm) of the logged homes. Eighty-three percent of the homes had flow rates of 1.1 gpm or less and only one percent of the homes had an average flow rate that exceeded 1.5 gpm. All of the homes had mode flow rates less than 2.2 gpm and none of the homes had average peak flows that exceeded 2.2 gpm. The maximum average peak flow of the logged homes was 1.6 gpm.
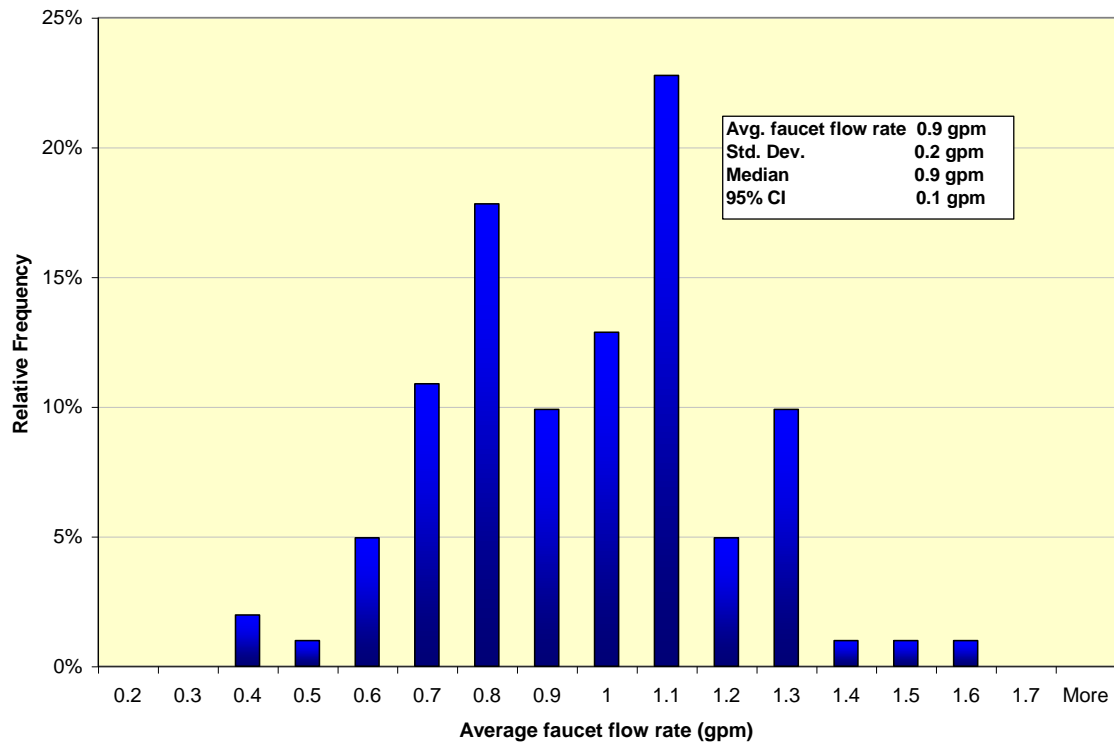
Figure 16 Average faucet mode flow rate distribution

The statistical data for the average faucet flow rate in the Seattle Market study is shown in Table 15.

Table 15 Statistical data for average faucet flow rate

Statistic	Minutes
Average Faucet Flow rate	0.9
Standard Deviation	0.2
Median	0.9
95% Confidence Interval	$\pm\,0.1$

Leakage

Figure 17 shows the average daily leak rate from each of 101 logged Seattle homes. The high leak rate was affected by two outliers who had an average leak rate over 80 gpd. Trace analysis of the first home showed a one-gallon leak that repeated at 15 minute intervals and persisted throughout the trace. This type of leak is consistent with that of a leaking toilet flapper. The second home had a continuous leak that typically ran at 0.15 gpm throughout the entire trace. This leak is typical of a shower or faucet valve that is incompletely closed but may be caused by a toilet flapper leak or other system leak. Nine of the 101 homes logged had leak rates over 20 gallons per day. Despite the high leak rate in a small percentage of the homes that were logged for this study the average leak rate of Seattle homes is lower than that found from the REUWS study (Mayer, DeOreo, 1999) where the average leak rate was 21.9 gallons per day per home.

The statistical data for the average daily leak rate in the Seattle Market study is shown in Table 16. As is normally the case, these data are highly skewed with a mean value of 7.0 but a median value of only 1.7. As shown in Figure 5 the leakage rate in the market study group was significantly less than that in either the REUWS or the Pre-retrofit group. This is due mainly to the random nature of the selection process, but also at least partially due to the fact that the breakpoint between a leak and a faucet was changed for this analysis which caused more events to be classified as faucets and fewer as leaks.

Table 16 Statistical data for average daily leak rate

Statistic	Gallons per day
Average Faucet Flow rate	7.0
Standard Deviation	15.0
Median	1.7
95% Confidence Interval	± 2.9
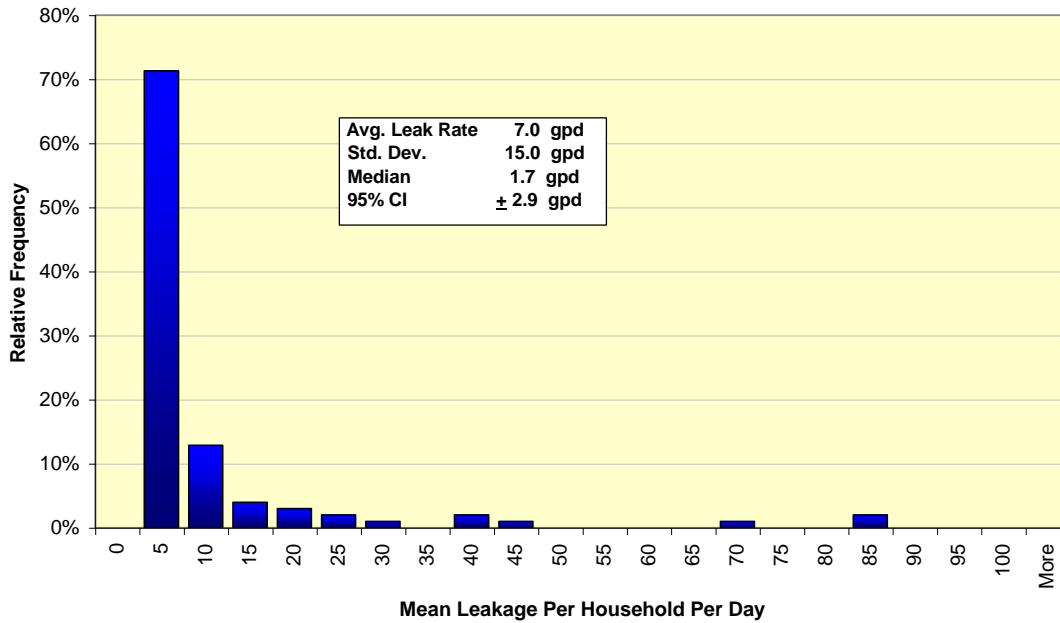
Figure 17 Average daily leak rate distribution

Summary of Logging Results

The average daily water use for various household fixtures and end uses is summarized in Table 17. For all end uses except dishwashers and baths (end uses which are not retrofit) water use is lower in the post-retrofit study than in the current market study. The data clearly show the potential for savings by retrofitting fixtures that are typically included during a retrofit; namely showers, faucet aerators, toilets and clothes washers.

Table 17 Comparison of daily water consumption for three Seattle studies by end use

	Seattle Market Study (gpd)	Seattle Home Cons. Study (pre-retrofit) (gpd)	Seattle Home Cons. Study (post-retrofit) (gpd)
Dishwasher	2.0	3.3	3.0
Other	7.4	0.5	0.2
Leak	6.9	16.8	4.9
Faucet	26.3	21.2	17.4
Shower	29.4	22.1	19.9
Bath	4.1	7.8	6.3
Clothes Washer	36.5	34.2	21.2
Toilet	40.0	45.4	19.2
Total	152.6	151.3	92.1

Survey Response Analysis

The responses to the surveys have been summarized and presented in this section. Responses were used to determine both the customers' efforts at water conservation and the correlation between reported penetration of low flow fixtures and the actual penetration found from data-logging.

Actual vs. Reported Penetration Rates of Efficient Fixtures

Surveyed customers were asked to report whether they had replaced showerheads, faucet aerators, or toilets in their homes since 1993. Forty five percent of customers reported replacing toilets, seventy three percent of customers reported replacing showerheads and 65 percent reported replacing faucet aerators.

ULF Toilets

The penetration of ULF toilets in the logged Seattle homes correlates closely with the reported penetration of ULF toilets in homes surveyed. The results from the surveys showed that 41 percent of survey respondents reported having one or more toilets that were less than ten years old. This matches very closely with the results from the logging that showed at least one ULFT in approximately 40% of the homes. The logging results do provide a note of caution in interpreting the survey results in that when people indicate that their homes are equipped with ULFT's they don't mean that they are completely retrofit, since we know that only 5% of the homes had exclusively ULFT's.

Clothes washers

Seventeen percent of the logged customers had water efficient clothes washers that used 30 gallons per load or less. Sixty-eight percent of the Seattle Utility respondents indicated that their machine was less than 13 years old, however only 14 percent had front-loading machines. Seventy-nine percent of the Seattle purveyor respondents indicated that their machine was less than 13 years old, although only 16 percent had front-loading machines. The survey thus indicates that front-loading clothes washers are present in 14% to 16% of the homes while the logger data indicate that 17% of the homes had machines that use less than 30 gallons per load[4]. This is a very close agreement, however, the survey results would lead one to expect that daily household use for clothes washing should be somewhere in between 35 and 21 gpd, which is the range in the pre and post retrofit groups. The fact that household clothes washing use was greater in the Market Study group than the pre retrofit group makes one pause a bit in declaring that high efficiency clothes washers have made as large an impact in this group as the survey would lead one to expect.

Low flow showers

Low flow showers (less than 2.5 gpm) were found in 81 percent of the logged Seattle homes. However only 73 percent of survey respondents reported replacing their showerheads after 1993. Given the accuracy of survey responses this is a fairly good match. It is probable that many of the houses were equipped with 2.5 gpm showerheads when the owners moved in,

and there was no need to replace them. Clearly, low flow shower heads have made a major penetration into the market. The retrofit study done in Tampa showed that in order to get statistically significant savings from shower retrofits one needs to use newer models that deliver only 1.7 gpm.

Low flow faucets

As with showerheads, the reported penetration of low flow faucets was lower than the percentage of logged homes found to have low flow faucets. In other words, most homes were equipped with faucet aerators delivering around 2 gpm to start with, and whether the owners replaced them had no bearing on the faucet use patterns in the homes. Only 65 percent of survey respondents reported having replaced their faucets since 1993 but 100 percent of the logged homes showed average mode flow rates below 2.2 gpm. There are many different models of faucet aerators, however, and some deliver flows of less than 1.0 gpm. In addition, irrespective of the type of aerator many times the faucets are not opened all of the way, and their flow rates are less than the maximum possible rate for the aerator. In order to get savings from faucets it appears necessary to use aerators that deliver substantially less than 2.2 gpm.

The retrofit results in Tampa showed that in order to get savings from faucet replacements required using 1.0 gpm aerators in bathrooms and 1.5 gpm devices in kitchens. In Tampa several houses were also equipped with hands free electronic activation.

Leaks

Only 10 percent of homes surveyed reported some kind of leak. More than half of the leaks reported were thought to be from faucets; almost all other reported leakage was thought to be due to the showers, baths or toilets. The percentage of homes that reported leaks is considerably lower than the number of logged homes that were found to have leaks however, 41 logged homes had leaks that averaged less than one gallon per day. Small volume leakage could be difficult to detect thereby contributing to underreporting. It is likely that many people miss leaks in their toilets, which are believed to be the main source of leakage in single family homes. This study group had lower leakage rates than either the REUWS or pre retrofit Home

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[4] It should be noted that the survey may not have included top-loading clothes washers models that are efficient and logging data may include clothes washers that had average volumes under 30 gpl due to variable fill levels (but do not meet the strict criteria of efficient clothes washers).

Conservation study groups. This may be partially the luck of the draw and partially the fact that more leaks were classified as faucet use in this study because of the way the logging analysis parameters were set. In any case, the leakage pattern followed the same skewed pattern with a few large leakers contributing to most of the leakage. Leakage is also probably associated with toilets more than any other device.

Indoor Conservation Practices

A high percentage of SPU customers reported some type of indoor conservation practices. Repairing leaks, fuller clothes washer loads and reduced car washing are reported by at least 85 percent of the respondents. Table 18 shows the percentage of participants in all of the indoor conservation activities from the survey.

Table 18 Percentage of SPU respondents participating in indoor conservation practices

Activity	Seattle %	Purveyor %
Reduce shower time	64.4	71.3
Device in toilet	25.2	21.7
Repair leaks	92.3	95.8
Reduce faucet use	87.8	83.2
Flush less	67.7	58.7
Disposal less	47.5	51.7
Fuller dish washer loads	73.0	84.6
No pre-rinse	30.6	37.1
Fuller clothes washer loads	89.6	88.1
Reduce car washing	85.8	92.3

Survey respondents indicate that they have made an effort to reduce the duration of showers and faucet use, but Table 19 indicates that the average duration of these activities has not decreased and in fact average shower duration is slightly higher than the three other studies. The average shower volume however is similar to that of the pre-retrofit studies. As with showers, the longer faucet duration in the Market group has not resulted in a higher average faucet volume than in the pre-retrofit studies.

Table 19 Results of shower and faucet use from four Seattle studies

Study Group	Shower Vol.(gal)	Shower Duration (min.)	Faucet Vol. (gal.)	Faucet Duration (min.)
Market Study group (n=28)	16.9	8.2	8.5	10.6
Seattle Home Water Cons. Baseline (n=37)	18.1	7.9	9.2	8.4
Seattle Home Water Cons. Post-Retrofit (n=37)	14.9	7.8	8.0	8.9
Seattle REUWS (n=12)	16.2	7.9	8.7	6.9

Utility Sponsored Activities

Several rebates and promotions aimed at water and energy savings were available for Seattle customers. Forty five percent of Seattle customers and fifty seven percent of Purveyor customers had not participated in any rebate activity or promotion as shown in Table 20. Of the customers that did respond, the free compact fluorescent bulb and aerator was requested most frequently. Customers had received rebates for the other activities 15 percent of the time or less.

Table 20 Percent of participants in utility sponsored activities

Activity	Seattle %	Purveyor %[5]
No rebate participation	44.8	57.3
Yard days	7.4	6.3
Discounted Compost Promotion	10.7	7.7
Discounted Soaker Hose Promotion	3.3	4.9
WashWise clothes washer rebate	7.7	15.4
Toilet Round-up Event Rebate	3.9	2.8
Mailing of free CFL & Faucet Aerator	50.4	25.2

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[5] Percent of participation totals greater than 100 percent since it was possible for customers to participate in more than one activity or receive more than one rebate.

Lawn Watering

  Seattle survey respondents were asked whether or not they have a lawn and if so how frequently they watered. Forty-one percent of respondents indicated that they either had no lawn or never watered; another 21 percent said that they only watered once a month. Only twenty eight percent of Purveyor respondents indicated that they either had no lawn or never watered and another 16 percent said that they only watered once a month. Results are shown in Table 21.

Table 21 Lawn watering frequency percentages

Activity	SPU %	Purveyor %
No lawn	6.8	9.2
Never water	33.8	19.1
Water 1x/month	20.8	15.6
Water weekly	27.0	36.2
Water every other day	10.4	15.6
Water every day	0.0	4.3

Outdoor Water Reduction

  Seattle and Purveyor customers were asked about several practices designed to reduce outdoor water use and lawn watering. Their responses are shown in Table 22. More than half of the respondents said that they used soil amendments, planted xeric plants or mulched their planting beds. Respondents were least likely to check soil moisture levels before watering or use a timer to turn their hoses off. While nearly 70 percent of Seattle respondents reduced outdoor water use by not watering their lawn area regularly or by reducing the size of the lawn area that was watered only 57 percent of Seattle purveyor customers did so.

Table 22 Percentage of utility respondents that participate in activities that reduce outdoor water consumption

Activity	SPU %	Purveyor %
Remove thatch	38.0	49.0
Aerate lawn	26.1	37.8
Hose timer	23.3	34.3
Soaker hose or drip irrigation	18.7	41.3
Check soil moisture levels	30.3	23.8
Amend soil	57.3	53.8
Xeric plants	59.6	53.8
Mulch	56.4	59.4
Reduce lawn area watered	25.2	25.9
Stop regular watering	43.6	31.5
No reduction in lawn watering	20.5	34.3

Irrigation System

The type of irrigation system used and how well that system is maintained can effect outdoor water consumption. Table 23 shows that about 6 percent of Seattle Utility customers irrigate with a portable sprinkler system. The low response rate to questions about inspection, sensors and settings is likely due to the fact that fewer than 15 percent of respondents use an in-ground sprinkler system.

Table 23 Type of irrigation used by respondents

Activity	SPU %	Purveyor %
Soaker hose/drip irrigation	15.7	25.9
Portable sprinklers	61.1	60.1
In-ground irrigation no controller	3.3	1.4
In-ground irrigation w/controller	5.3	13.3
Professional inspection	5.0	11.9
Rain sensor	1.5	5.6
Override settings	4.5	11.2

Demographic Information

Demographic information was obtained from the survey analysis of Seattle Utility and Seattle Purveyor customers and is shown in Table 24. Of the 337 completed surveys from Seattle Utility customers, seven customers failed to indicate the number of residents in the household. Of the 143 responses received from Seattle purveyors, one customer failed to indicate the number of residents in the household.

Table 24 Demographics of SPU residential customers, SPU Purveyors and logged customers

	Seattle Utility Customers (n=330)		Seattle Purveyor Customer (n=142)		Seattle Customers Logged & Surveyed (n=28)	
	Count	Percent	Count	Percent	Count	Percent
Adults	666	83.6	235	77.6	61	81.3
Teens	50	6.3	26	8.6	2	2.7
Children	81	10.2	42	13.9	12	16.0
Total	797	100	303	100	75	100
Avg. number of residents/household	2.42		2.13		2.7	

Property Type

A large majority of survey respondents from the Seattle Utility and Seattle purveyors owned their own homes. All of the Seattle Purveyor customers indicated whether they owned or rented their home and 333 Seattle Utility customers responded to this question on the survey. Results are shown in Table 25 below.

Table 25 Property type of surveyed customers

	Seattle Utility Customers (n=333)		Seattle Purveyor Customers (n=143)	
	Number of customers	Percent	Number of customers	Percent
Own	310	93	138	97
Rent	23	7	5	3
Total	**333**	**100**	**143**	**100**

Comparison of Full Logged Sample (n=101) with Logged Survey Respondents (n=28)

The average use per household of the small sample of logged and surveyed homes was nearly 20 gallons per day less than that of the larger sample as seen in Table 26. The higher daily use of the 101 logged homes was affected by 11 homes that all had higher daily use than the home with the maximum daily use in the sample of 28 homes. In fact, one of the 101 homes had more than twice the daily usage found in any of the homes from the smaller sample.

There was very little difference in the average daily household use of the fixtures and household uses evaluated for this study. The larger leak rate (gpd) found in the larger sample of logged homes is a result of several outliers in the group with very high leak rates. The larger clothes washer volume (gpl) found in the smaller sample is likely due to the slightly smaller percentage of homes that have water conserving clothes washers.

Generally, the sample of 28 homes is too small to provide statistically reliable water use data, or to use for reliable comparison. The results are presented as a matter of interest.

Table 26 Avg. Daily Use and Fixture Use comparison of Logged (n=101) vs Logged & Surveyed Homes (n=28)

Average Usage Rate	Average		Standard Deviation		Median		95% CI	
	Logged	*Logged & Surveyed*	*Logged*	*Logged & Surveyed*	*Logged*	*Logged & Surveyed*	*Logged*	*Logged & Surveyed*
Daily Use (gpd)	153.2	133.7	96.8	71.3	134.0	120.6	18.9	26.4
Non-ULF Toilets (gpf)	3.8	3.9	0.9	1.0	3.7	3.7	0.2	0.4
ULF Toilets (gpf)	1.7	1.7	0.2	0.1	1.7	1.6	0.03	0.05
Clothes Washers (gpl)	39.7	40.9	10.5	11.1	39.9	40.5	2.1	4.1
Shower flow rate (gpm)	2.2	2.2	0.7	0.7	2.0	2.0	0.1	0.3
Faucet flow rate (gpm)	0.9	0.9	0.2	0.2	0.9	0.9	0.1	0.1
Faucets (gpd)	26.8	21.6	23.2	17.1	20.4	17.9	0.04	0.1
Leak rate (gpd)	7.0	5.6	14.9	13.1	1.7	0.8	2.9	4.9

CONCLUSIONS

Seattle Public Utility has made an on-going effort to reduce residential water consumption through customer education and rebate programs. These efforts have been designed to encourage the reduction of water use through behavior modification and installation of water conserving devices. Results from the Market Penetration Study show that Seattle Public Utility customers have an awareness of the importance of water conservation and report an effort to reduce water use.

SPU has participated in several residential household end use studies. These results are summarized in Figure 3. The Market Penetration study group had a daily indoor use of 153 gpd while both the REUWS (1997), and the pre-retrofit groups (2000) showed average daily household use of 151 gpd. When one compares this to the post-retrofit use of only 92 gpd it is hard to avoid the conclusion that there is still considerable potential for further reduction in daily indoor water consumption in the Seattle service area.

The results concerning showerheads and faucet aerators indicate that these two types of devices are thoroughly saturated with 2.2 gpm faucets and 2.5 gpm showerheads. If further savings are desired from faucets and showers it will be necessary to move to 1 gpm in bathrooms and 1.5 gpm in kitchens, and 1.7 gpm showers. All of these should be equipped with quick shut off devices. With these types of devices, however, it is possible to obtain significant savings from the faucet and shower categories of use, but it appears of little use to have active programs providing the traditional showerheads and faucets since these appear to be ubiquitous already.

Toilet replacements have made the biggest reduction in household water use, but if the figures summarized in Table 17 are examined they show that that at this time only around 20% of the total potential savings from toilet replacements have been captured. Likewise, while around 14% of the homes report having front loading clothes washers the household use data indicate that water savings from this category has not really begun to be significant. Savings from leakage will continue to be important and are clearly linked to having toilets that do not leak. This suggests greater use of flapperless or pressure assisted toilets over flapper models.

This study has demonstrated that in order to obtain data on the penetration of high efficiency fixtures and appliances it is probably more accurate to use flow trace analysis than surveys. The results from the surveys would lead one to over estimate the degree to which ULF

toilets and high efficiency clothes washers had penetrated the market. The customers reported that 40% of the homes had ULFT's, but the logger data showed that this referred to homes with at least one ULFT, and that only 5% of all homes had ULFT's as their only type of toilet. The survey results would also tend to over estimate the penetration rate of high efficiency clothes washers. The survey respondents reported that around 15% of homes are equipped with high efficiency clothes washers. But the logging results, especially as shown in Figure 12 show a much more modest shift in the volume distribution.

SPU could use the results of this study to set targets for household consumption. Presently, the average household is using approximately 150 gpd for indoor household uses, but if the best available technology were used, (including 1.7 gpm shower heads, 1.0 gpm bathroom faucets, 1.5 gpm kitchen faucets, quick faucet shutoff devices, 1.1 gpf pressure assisted toilets and clothes washers using less than 20 gallons per load) it is reasonable to expect indoor residential uses to drop to 90 gpd or less. This would represent a savings of approximately 60 gpd, or 22 kgal per year per single family home. Assuming that Seattle serves approximately 340,000 single-family accounts this would amount to an annual savings of 7.48 billion gallons of water or 22,960 acre-feet of reduced demand. This would represent approximately a 14% reduction in total demand.

APPENDIX A

PLEASE circle or fill in the answers to the following questions. Thank you!

1. **How many of the following water-using devices do you have in your home?**

	(Circle one number for each item)				
Toilet	0	1	2	3	4+
Bathroom Sink	0	1	2	3	4+
Shower with no bathtub	0	1	2	3	4+
Bathtub with shower	0	1	2	3	4+
Bathtub without shower	0	1	2	3	4+
Whirlpool bathtub with jets	0	1	2	3	4+
Dishwasher	0	1	2	3	4+
Kitchen faucet	0	1	2	3	4+
Indoor utility sink (basement, garage, laundry)	0	1	2	3	4+
Pressure regulator on main house service line	0	1	2	3	4+
Hot tub	0	1	2	3	4+
Swimming pool	0	1	2	3	4+
Water feature (fountain, pond etc)	0	1	2	3	4+

2. **For each toilet in your home, please write in the BRAND NAME and YEAR it was made. Look for the year of manufacture stamped under the tank lid or inside the wall of the tank. If you can't find the year, please estimate the age. If you have more than one toilet, list up to four, from the most used to least used.**

	BRAND	YEAR MADE OR ➔	(Circle estimated age)	
Toilet 1 (most used)			Under 10 years	10+ Years
Toilet 2			Under 10 years	10+ Years
Toilet 3			Under 10 years	10+ Years
Toilet 4			Under 10 years	10+ Years

3. **Do you have a clothes washer in your home? (Circle one answer)**

1   **No (Skip to Question 4)**

2   **Yes (Complete 3a and 3b)**

⬇

3a. If YES: What is the BRAND NAME, MODEL NUMBER, and YEAR your washer was made?

BRAND	MODEL NUMBER	YEAR MADE OR ➔	(Circle estimated age)
			12 years old or less **13 or more years**

Please continue to the next page ☞

⬇

3b. If YES: What type of clothes washer is it? (Circle one answer)

1   A top loading clothes washer

2   A front loading clothes washer

4. Have any of the following fixtures been replaced in your home since 1993?

	(Circle one answer for each item)	
Shower head	**No**	**Yes**
Faucet Aerator	**No**	**Yes**
Toilet	**No**	**Yes**

5. Do you currently have any water leaks in your home that need repair?

1   No (Skip to Question 6)

2. Yes ➜ What leaks do you have that need repair? (Circle all that apply)

> **1   A toilet that keeps running**
>
> **2   A shower that drips**
>
> **3   A faucet that drips**
>
> **4   An irrigation system that leaks**
>
> **5   A water heater that leaks**
>
> **6   A pipe or valve in your plumbing system that leaks**

6. Does your household usually take any of the following steps to reduce water use?

	(Circle one answer for each item)	
Reduce shower time	**No**	**Yes**
Keep a jar or other water displacement device in toilet	**No**	**Yes**
Repair toilet and faucet leaks	**No**	**Yes**
Reduce faucet use **(such as turn faucet off while shaving or brushing teeth)**	**No**	**Yes**
Flush toilet less often	**No**	**Yes**
Use garbage disposal less often	**No**	**Yes**
Run fuller loads in dishwasher	**No**	**Yes**
Put dishes in dishwasher without pre-rinsing them	**No**	**Yes**
Run fuller loads in washing machine	**No**	**Yes**
Wash car less often or used a shut off nozzle while washing it	**No**	**Yes**

7. Has your household taken part in any of these utility sponsored activities?

	(Circle one answer for each item)	
Northwest Natural Yard Days	No	Yes
Discounted Compost Promotion	No	Yes
Discounted Soaker Hose Promotion	No	Yes
WashWise clothes washer rebate	No	Yes
Toilet Round-Up Event rebate	No	Yes
Mailing of a free Compact Fluorescent Light (CFL) & Faucet Aerator	No	Yes

8. How often do you water your lawn <u>during the warm summer months</u>? (Circle one answer) Don't have a lawn

1 **Don't have a lawn**

2 **Never water my lawn**

3 **Water my lawn about 1 time a month or less**

4 **Water my lawn weekly or every other week**

5 **Water my lawn about every other day week**

6 **Water my lawn about every day**

9. Does your household usually take any of the following steps to reduce water use outdoors?

	(Circle one answer for each item)	
Remove lawn thatch (dead stems) when needed to improve water absorption	No	Yes
Aerate your lawn (extract soil plugs) when needed to reduce soil compaction	No	Yes
Use a water timer to turn off your hose or soaker hose	No	Yes
Use a soaker hose or drip irrigation system	No	Yes
Check moisture levels below the surface of your soil before watering	No	Yes
Amend your soil with compost when creating a new garden or planting area	No	Yes
Put in plants that need little water once they are established	No	Yes
Maintain a layer of mulch on planting beds	No	Yes

10. In the past 5 years, have you reduced lawn watering by: (Circle one)

1 **Yes, reducing the size or area regularly watered?**

2 **Yes, stopped regular watering of the same size lawn?**

Please continue to the next page ☞

11. What watering system do you use to water most of your lawn and garden? (Circle one)

1   A soaker hose or drip irrigation system (Skip to Question 12)

2   Hoses and portable sprinklers connected to a hose (Skip to Question 12)

3   In-ground irrigation system that you manually turn off and on (no controller) (Skip to Question 12)

4   An in-ground irrigation system with an automatic start-stop controller   (Complete 11a, 11b, 11c)

⬇

11a. Do you usually have the system professionally inspected once a year for leaks and broken heads?   (Circle one)
1   No

2   Yes

11b. Do you have a rain sensor (a device that automatically turns the system off if it rains)? (Circle one)
1   No

2   Yes

11c. Do you change or override the controller setting (watering times) more than once during the watering season? (Circle one)
1   No

2   Yes

Finally, please answer these questions about your household. These are very important questions for projecting how much water various types of households use and for helping to plan our programs.

12. Do you own or rent your home? (Circle one)
  1   Own
  2   Rent

13. How many people, including yourself, live in your home year-round? (Fill in numbers)
  Adults (age 18+)   _____
  Teenagers (age 13-17)   _____
  Children (under 13)   _____

14. Would you like to receive summary of the results of this study?   ☐   Yes   ☐   No

Thank you for taking part!
Return your completed questionnaire in the postage-paid envelope to:

Seattle Public Utilities Resource Conservation
700 5th Ave Suite 4900
Seattle, WA 98104-5004

Appendix B

Customer Responses

		Seattle	All Purveyors	Combined Customers
Demographics	Number of responses	**337**	**143**	**480**
	% Adults	84%	78%	82%
	% Teens	6%	9%	7%
	% Children	10%	14%	11%
	% Rent	7%	3%	6%
	% Own	93%	97%	94%
Fixtures	# Toilets	2.07	2.57	2.22
	# Bath Sinks	2.08	2.79	2.29
	# Showers no bath	0.62	0.96	0.72
	# Baths w/shower	1.08	1.18	1.11
	# Baths no shower	0.12	0.23	0.15
	# Whirpools	0.00	0.21	0.06
	# Dishwashers	0.76	0.93	0.81
	# Kitchen faucets	1.09	1.12	1.10
	# Indoor util sinks	0.66	0.55	0.63
	# Pressure reg	0.19	0.37	0.23
	# Hot tub	0.06	0.16	0.08
	# Swimming pool	0.01	0.03	0.02
	# Water feature	0.05	0.14	0.07
Toilets	Total number	673	366	1039
	Avg # per residence	2.00	2.56	2.16
	% Older than 1993	59%	61%	60%
Clotheswashers	Total number	334	140	474
	Older than 1991	107	30	137
	%Older than 1991	32%	21%	29%
	# Front loading	45	22	67
	% Front loading	13%	16%	14%
Fixture replacement	Showerhead	254	98	352
	% replaced	75%	69%	73%
	Faucet	220	90	310
	% replaced	65%	63%	65%
	Toilet	156	58	214
	% replaced	46%	41%	45%
Leaks	% w/ leaks	10%	24%	11%
	% w/ toilet leaks	2%	6%	3%
	% w/shower or bath leak	3%	4%	3%
	% w/faucet leak	5%	11%	7%
	w/irrigation leak	0%	0%	0%
	% w/water heater leak	0%	0%	0%
	% w/other leak	1%	0%	1%

		Seattle	All Purveyors	Combined Customers
Indoor reduction	% shower reduction	64%	71%	66%
	% Device in toilet	25%	22%	24%
	% Repair leaks	92%	96%	93%
	% faucet reduction	88%	83%	86%
	% Flush less	68%	59%	65%
	% Disposal less	47%	52%	49%
	% Fuller DW loads	73%	85%	76%
	% No pre-rinse	31%	37%	33%
	% Fuller CW loads	90%	88%	89%
	% Reduce car-washing	86%	92%	88%
Utility activities	Yard days	7%	6%	7%
	Compost	11%	8%	10%
	Soaker hose	3%	5%	4%
	Clothes washer	8%	15%	10%
	Toilet Round-up	4%	3%	4%
	CFL & aerator	50%	25%	43%
Lawn watering	No lawn	7%	9%	8%
	Never water	34%	19%	29%
	Water 1x/month	21%	15%	19%
	Water weekly	27%	36%	30%
	Water every other day	10%	15%	12%
	Water every day	0%	4%	1%
Outdoor reduction	Remove thatch	38%	49%	41%
	Aerate	26%	38%	30%
	Timer	19%	34%	23%
	Soaker/drip	30%	41%	34%
	Soil moisture	22%	24%	23%
	Amend soil	57%	54%	56%
	Xeric plants	60%	54%	58%
	Mulch	56%	59%	57%
	Reduce Area Watered	25%	26%	25%
	Stopped Regular Watering	44%	31%	40%
	No	20%	34%	25%
Watering system	Soaker hose/drip	16%	26%	19%
	Portable sprinklers	61%	60%	61%
	In-ground irrigation no controller	3%	1%	3%
	In-ground irrigation w/controller	5%	13%	8%
	Professional Inspection	5%	12%	7%
	Rain Sensor	1%	6%	3%
	Override Settings	4%	11%	6%

Appendix C

Customers with High Leak Rates[6]

Key Code	Leak rate (gpd)	Name	Street Address					Zip Code
40058	83.08	ANNA M ZITKOVICH	720	N	62ND	ST		98103-5622
40022	82.39	TRINA JACOBS	5009	S	51ST	AVE	S	98118-2053
40043	67.71	RALPH A FRAGALE	2522	S	30TH	AVE	S	98144-5518
40008	44.30	ROSANN RUTH COLLINS	2601	S	MYRTLE	ST		98108-3646
40045	37.47	HELEN L ANDERSON	10214	SW	MARINE VIEW	DR	SW	98146-1082
40054	37.32	TOBY TOUSLEE PHENIX	331	N	84TH	ST		98103-4219
40029	29.01	MICHAEL L FINN	300	W	MC GRAW	PL		98119-2654
40089	24.54	LEROY PENNER	1917	NE	NORTHGATE	WAY		98125-6557
40061	22.37	MARGARET RASMUSSEN	5011	NE	8TH	AVE	NE	98105-3602

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[6] Customers with leak rates greater than 20 gallons per day

Appendix D

Individual Purveyor Responses

	Bellvue	Bothell	Cedar River	Coal Creek	Highline	Kirkland	Soos Creek	WD119	WD20	Woodinville
Number of responses	55	7	2	3	28	10	9	3	9	17
% Adults	80%	94%	100%	100%	85%	76%	65%	86%	83%	59%
% Teens	9%	6%	0%	0%	5%	8%	10%	0%	8%	16%
% Children	12%	0%	0%	0%	11%	16%	25%	14%	8%	25%
% Rent	4%	0%	0%	33%	0%	0%	0%	0%	11%	6%
% Own	96%	100%	100%	67%	100%	100%	100%	100%	89%	94%
# Toilets	2.78	2.43	3.00	2.63	2.07	2.60	2.78	2.67	2.11	2.94
# Bath Sinks	3.04	2.57	3.50	2.86	2.07	2.90	2.89	3.00	2.33	3.41
# Showers no bath	1.06	1.00	1.50	1.00	0.63	1.20	0.89	0.67	0.75	1.18
# Baths w/shower	1.20	1.43	1.50	1.21	1.04	1.10	1.33	1.33	1.11	1.29
# Baths no shower	0.23	0.25	0.00	0.20	0.13	0.11	0.33	0.33	0.29	0.38
# Whirpools	0.17	0.00	0.00	0.12	0.08	0.22	0.29	0.67	0.22	0.40
# Dishwashers	0.98	1.00	1.00	0.94	0.93	0.90	0.89	0.67	0.56	1.06
# Kitchen faucets	1.11	1.14	1.00	1.04	1.07	1.10	1.11	1.00	1.22	1.24
# Indoor util sinks	0.52	0.17	0.00	0.42	0.62	0.40	0.89	0.33	0.44	0.71
# Pressure reg	0.33	0.00	0.00	0.27	0.41	0.43	0.50	0.67	0.22	0.46
# Hot tub	0.22	0.33	0.00	0.22	0.12	0.10	0.00	0.00	0.11	0.19
# Swimming pool	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.33	0.00	0.06
# Water feature	0.02	0.00	0.00	0.02	0.24	0.00	0.00	0.00	0.33	0.35
Total number	152	17	6	6	57	26	25	8	19	50
Avg # per residence	2.76	2.43	3.00	2.00	2.04	2.60	2.78	2.67	2.11	2.94
% Older than 1993	66%	53%	100%	100%	63%	65%	48%	0%	53%	66%
Total number	53	7	2	3	28	10	9	3	8	
Older than 1991	9	0	0	3	8	2	3	0	3	2
%Older than 1991	17%	0%	0%	100%	29%	20%	33%	0%	38%	12%
# Front loading	14	1	0	0	2	0	1	0	1	3
% Front loading	26%	14%	0%	0%	7%	0%	11%	0%	13%	18%
Showerhead	37	4	2	2	22	6	6	2	6	11
% replaced	67%	57%	100%	67%	79%	60%	67%	67%	67%	65%
Faucet	36	5	2	2	20	5	6	1	6	7
% replaced	65%	71%	100%	67%	71%	50%	67%	33%	67%	41%
Toilet	25	2	1	3	9	2	5	1	4	6
% replaced	45%	29%	50%	100%	32%	20%	56%	33%	44%	35%

	Bellvue	Bothell	Cedar River	Coal Creek	Highline	Kirkland	Soos Creek	WD119	WD20	Woodinville
% w/ leaks	4%	14%	50%	0%	11%	30%	11%	0%	33%	18%
% w/ toilet leaks	4%	0%	50%	0%	4%	20%	22%	0%	11%	6%
% w/shower or bath leak	2%	0%	0%	0%	7%	10%	11%	0%	11%	0%
% w/faucet leak	0%	14%	100%	0%	0%	10%	11%	0%	11%	12%
w/irrigation leak	0	0	0	0	0	0	0	0	0	0
% w/water heater leak	0	0	0	0	0	0	0	0	0	0
% w/other leak	0	0	0	0	0	0	0	0	0	0
% shower reduction	69%	100%	50%	100%	71%	80%	78%	67%	78%	53%
% Device in toilet	1%	14%	25%	33%	3%	8%	9%	22%	9%	3%
% Repair leaks	98%	100%	100%	100%	96%	100%	89%	100%	89%	88%
% faucet reduction	84%	86%	100%	100%	79%	90%	89%	67%	78%	82%
% Flush less	64%	43%	50%	67%	54%	80%	67%	67%	56%	41%
% Disposal less	60%	57%	100%	33%	39%	40%	78%	67%	22%	47%
% Fuller DW loads	93%	71%	100%	67%	86%	80%	78%	67%	44%	35%
% No pre-rinse	47%	0%	50%	33%	32%	20%	56%	33%	22%	22%
% Fuller CW loads	93%	100%	100%	100%	79%	80%	78%	100%	78%	94%
% Reduce car-washing	96%	100%	100%	100%	86%	80%	100%	100%	89%	88%
Yard days	5%	14%	50%	33%	7%	0%	0%	0%	0%	6%
Compost	9%	14%	0%	33%	7%	10%	0%	0%	11%	0%
Soaker hose	4%	14%	0%	0%	7%	0%	22%	0%	0%	0%
Clothes washer	22%	0%	0%	0%	7%	0%	11%	0%	22%	29%
Toilet Round-up	4%	0%	0%	0%	0%	0%	0%	0%	0%	12%
CFL & aerator	22%	29%	0%	33%	32%	20%	33%	167%	0%	29%
No lawn	16%	14%	0%	0%	7%	10%	0%	0%	0%	0%
Never water	13%	14%	50%	33%	21%	10%	11%	67%	44%	18%
Water 1x/month	16%	14%	0%	0%	21%	20%	11%	0%	22%	6%
Water weekly	25%	29%	50%	67%	25%	40%	78%	33%	33%	59%
Water every other day	20%	14%	0%	0%	21%	20%	0%	0%	0%	12%
Water every day	7%	0%	0%	0%	4%	0%	0%	0%	0%	6%

	Bellvue	Bothell	Cedar River	Coal Creek	Highline	Kirkland	Soos Creek	WD119	WD20	Woodinville
Remove thatch	51%	43%	50%	0%	43%	50%	67%	0%	33%	59%
Aerate	42%	29%	50%	33%	25%	50%	67%	33%	0%	47%
Timer	42%	14%	50%	67%	32%	20%	44%	33%	11%	29%
Soaker/drip	44%	29%	0%	67%	32%	70%	78%	33%	33%	29%
Soil moisture	25%	43%	100%	0%	21%	20%	22%	0%	0%	41%
Amend soil	55%	43%	0%	100%	46%	60%	78%	67%	44%	53%
Xeric plants	53%	43%	50%	67%	54%	70%	67%	67%	33%	53%
Mulch	62%	43%	50%	67%	57%	50%	78%	67%	22%	76%
Reduce Area Watered	22%	29%	100%	33%	25%	30%	22%	33%	11%	35%
Stopped Regular Watering	33%	43%	0%	33%	29%	10%	44%	33%	44%	29%
No	35%	14%	0%	33%	39%	50%	33%	33%	22%	35%
Soaker hose/drip	18%	0%	0%	33%	14%	10%	0%	33%	0%	12%
Portable sprinklers	51%	71%	100%	67%	71%	60%	78%	0%	78%	59%
In-ground irrigation no controller	0%	0%	0%	0%	4%	0%	11%	0%	0%	0%
In-ground irrigation w/controller	18%	0%	0%	0%	7%	20%	0%	33%	0%	24%
Professional Inspection	15%	0%	0%	0%	7%	10%	0%	33%	0%	29%
Rain Sensor	5%	0%	0%	0%	4%	10%	0%	33%	0%	12%
Override Settings	16%	0%	0%	0%	0%	20%	0%	33%	0%	24%