Santa Clara County Residential Water Use Baseline Survey

Final Report

Prepared for
Santa Clara Valley Water District
by M. Cubed
in association with
Farrand Research, Inc.
Western Wats, Inc.
ConserVision Consulting, LLC.

August 2004

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This report is the result of a collaborative effort between four firms and staff of Santa Clara Valley Water District's Water Use Efficiency Unit. Over the course of one year a vast amount of data on residential water-using fixtures, devices, landscapes, attitudes, and knowledge was collected, analyzed, and summarized. None of this could have been accomplished without the dedication to the project shown by the staffs of Farrand Research, Inc., Western Wats, Inc., ConserVision, LLC., and Santa Clara Valley Water District. Special acknowledgement is owed to Shicha Chander of Santa Clara Valley Water District, whose continuous assistance with management and coordination of all aspects of this project has been a tremendous help. Finally, a debt of gratitude is owed to the residents of Santa Clara County for their willingness to participate in the surveys that provided the foundation for everything that follows.

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1. Executive Summary

1.1 Purpose of Study

This study surveyed single- and multi-family residences in Santa Clara County to determine the distributions of water-using appliances, fixtures, and landscapes in the residential sector. The study also assessed Santa Clara County residential customer knowledge and attitudes about water use and conservation. Table E1 lists the types of information developed by the study.

Table E1. Types of Data Compiled by Santa Clara County Residential Water Use Baseline Survey

Demographic • Persons per household • Length of residence • Age of housing stock • Proportion of single- v. multi-family housing units	Knowledge & Attitudes • Awareness of household water use • Knowledge of conservation practices • Awareness of regional and local conservation programs • Willingness to participate in conservation programs
Indoor • Toilets per household (& % ULFT) • Showers per household (& % low-flow) • Faucets per household (& % aerator) • Prevalence of dishwashers (& frequency of use) • Washers per household (& % high-efficiency & frequency of use) • Prevalence of water softeners (& % with auto recharge) • Prevalence of home water treatment (RO) • Prevalence & magnitude of indoor leaks	Outdoor • Prevalence of pools & spas • Prevalence of pressure reducing valve • Prevalence & magnitude of outdoor leaks • Size and type of landscape • Inventory of irrigation systems • Assessment of irrigation system function • Statistics on irrigation system efficiency

The information compiled by this study will enable Santa Clara Valley Water District to estimate the types and quantities of water-using hardware within the residential sector of Santa Clara County and to establish a baseline from which future residential water savings potential can be measured. Study results will be useful for service area demand forecasting, conservation program marketing and design, BMP program evaluation, and BMP program implementation.[1] Survey results will allow the District to determine the present level of ULFT penetration (relevant to BMPs 1 and 14), the level of low-flow showerhead penetration (relevant to BMPs 1 and 2), the prevalence of high-efficiency washing machines

[1] BMP is short for Best Management Practice and refers to the 14 BMPs listed in the Memorandum of Understanding Regarding Urban Water Conservation in California.

(relevant to BMP 6), and characteristics of outdoor water use, landscaping, and irrigation systems (relevant to BMPs 1 and 5).

1.2 Study Findings

1.2.1 Indoor Appliances and Fixtures

The study collected information on household characteristics and the number of bathrooms, toilets, showers, clothes washers, dishwashers, faucets, and water softeners. Where appropriate it recorded the type of device and measured its flow rate. It also identified and measured indoor water leaks. Table E2 summarizes demographic and fixture count findings based on this data.

Table E2. Residential Indoor Water-using Fixture Counts for Santa Clara County

	SINGLE-FAMILY	MULTI-FAMILY
Avg. Persons Per Household	3.2	2.4
Median Construction Year	1965	1972
% Built before 1992	92%	83%
Avg. Fixtures Per Housing Unit		
Toilets	2.3	1.4
Showers	1.5	1.1
Faucets	3.7	2.4
% of Households/Units With		
Clothes Washers		
Owned	97%	32%
Shared[1]	NA	65%
Dishwashers	87%	70%
Water Softeners	17%	3%

Notes:

1. 65% of inspected multi-family housing units had access to one or more shared washers. Based on a comparison of the number of shared washers and the number of housing units per multi-family housing complex there were approximately 0.06 shared washers per multi-family housing unit in the sample. This quantity was used to estimate the total number of shared washers in multi-family housing complexes located in Santa Clara County.

Table E3 summarizes the proportion of indoor water using devices measured as high-efficiency for single- and multi-family housing. The estimates for toilets and showerheads are limited to housing constructed before 1992 because households constructed after this date are subject to code requirements that result in the installation of toilets and showerheads with high-efficiency ratings.

Table E3. Proportion of Water Efficient Indoor Devices

PROPORTION OF WATER EFFICIENT DEVICES	SINGLE-FAMILY	MULTI-FAMILY
Toilets (residences constructed before 1992)	42%	31%
Showerheads (residences constructed before 1992)	59%	51%
Clothes Washers (Energy Star or Front-load)		
Owned	26%	29%
Shared[1]	NA	44%

Notes:
1. This percentage is calculated by dividing the number of shared washers in the sample that were either Energy Star or front-load models by the total number of shared washers in the sample.

Water-savings potentials from replacing remaining non-water-efficient residential toilets, showerheads, and clothes washers in Santa Clara County were calculated by combining information collected from the on-site surveys with unit-water savings estimates from empirical studies and data on housing population from Census 2000. The results, shown in Table E4, are expressed in acre-feet-per-year (AFY) of water savings.

Table E4. Remaining Water Savings Potential for Toilets, Showerheads, and Clothes washers

WATER-USING DEVICE	SINGLE-FAMILY (AFY)	MULTI-FAMILY (AFY)	TOTAL (AFY)
Toilets (residences constructed before 1992)	9,890	5,671	15,561
Showerheads (residences constructed before 1992)	1,293	458	1,751
Clothes Washers[1] (Energy Star or Front-load)	4,320	511	4,831
Eliminate household leaks	2,500	NA[2]	2,500
Total	18,003	6,640	24,643

Notes:
1. Estimate only accounts for retrofit of existing population of clothes washers. It does not account for water savings potential associated with future growth in the population of clothes washers.
2. Leaks were measured only for single-family residences. Leak estimates for multi-family households are not included in the totals.

1.2.2 Outdoor Uses

Table E5 shows the prevalence of outdoor water-using devices and landscape for single- and multi-family housing.

Table E5. Prevalence of Residential Outdoor Water-using Devices and Landscape

WATER-USING DEVICE/LANDSCAPE	SINGLE-FAMILY HOMES	MULTI-FAMILY COMPLEXES
Pool	15.4%	25.7%
With Cover	33.0%	4.0%
Without Cover	67.0%	96.0%
Spa	18.5%	20.3%
With Cover	62.0%	13.0%
Without Cover	38.0%	87.0%
Pressure Reduction Valve	27%	30%
Landscape (irrigated and non-irrigated)	97.3%	79.0%
Irrigation System (for residences with landscape), including hose	95.4%	97.1%

Table E6 summarizes average landscape area for single- and multi-family residences in Santa Clara County. This information along with population counts of single-family residences and multi-family housing complexes was used to estimate the total residential landscape area in Santa Clara County. The wide range for this estimate reflects the substantial variation in landscape area for both single- and multi-family housing.

Table E6. Residential Landscape Area in Santa Clara County

	SINGLE-FAMILY HOMES	MULTI-FAMILY COMPLEXES
% With Landscape (irrigated and non-irrigated)	97.3%	79.0%
Mean Landscape Area (for sites w/ landscapes)	3,681 sq. ft.	30,333 sq. ft.
95% Confidence Interval of Mean	±1,040 sq. ft.	±13,391 sq. ft.
Mean Area Planted to Turf (for sites w/ landscape)	1,546 sq. ft.	6,404 sq. ft.
95% Confidence Interval of area planted to turf	±258 sq. ft.	±1,929 sq. ft.
Sample Size	410	187
Est. Total Residential Landscape in County	21,891 – 40,207 acres	13,827 – 35,686 acres
Est. Total Residential Turf in County	10,676 – 14,955 acres	2,256 – 4,201 acres

Most single- and multi-family residences have automatic in-ground irrigation systems (Table E7). Only 4.6% of single-family and 2.9% of multi-family residences have no irrigation system at all.

Automatic, in-ground, systems with pop-up spray heads are the most common type of system for both single- and multi-family housing. About one-in-five single-family households use a drip system for at least some of their irrigation requirements. In the multi-family sector, only about one-in-fourteen complexes use a drip system.

Table E7. Distribution of Residential Irrigation Systems

IRRIGATION SYSTEMS	SINGLE-FAMILY HOMES	MULTI-FAMILY COMPLEXES
% of Inspected Sites[1]		
No Irrigation System	4.6%	2.9%
Hose Irrigation	33.8%	14.0%
Manual In-Ground	18.3%	16.2%
Automatic In-Ground	60.9%	70.6%
Manual Drip	3.8%	1.5%
Automatic Drip	18.5%	5.9%
Number of Landscapes Inspected	394	136
Avg. # Stations per System	5.2	7.8
Notes: 1. Some residences had more than one irrigation system. Therefore the sum of % of Inspected Sites exceeds 100%.		

The study measured irrigation system performance in three ways:

- First, problems with irrigation system design and operation were identified;
- Second, catch-can tests were used to assess system distribution uniformity (DU)[2]; and
- Third, catch-can tests were used to assess system precipitation rate (PR).[3]

Table E8 summarizes irrigation system performance findings. Most irrigation systems inspected had at least one problem affecting its water use efficiency. Single-family residences average close to two problems per irrigation station while multi-family residences averaged one-and-a-half. Overspray was the most common problem, with 49% of the single-family and 35% of the multi-family systems experiencing overspray. Average distribution uniformity was below 50% for both types of housing, indicating that most systems are not optimally designed. Well-designed systems relying primarily on pop-up spray

[2] Distribution uniformity (DU) measures how evenly water is applied by the irrigation system. DU is typically used in landscape audits to assess irrigation system performance. DU = Average catch in the low quartile x 100 / Average catch overall. To implement the test catch-can readings are ranked from low to high. The average of the lowest 25 percent of the catch-can readings is then computed and divided by the average of all the catch-can readings. The result is multiplied by 100 to express it as a percentage.

[3] Precipitation rate refers to the amount of water a sprinkler head delivers over a period of time, generally given in "inches per hour."

heads should have a distribution uniformity of 65%-70%.[4] On average, precipitation rates were in the moderate range and not excessive. Anything over 2 inches per hour will be too fast to soak into the ground and will result in excessive runoff. About one-in-six of the systems had rates exceeding this threshold.

Table E8. Residential Irrigation System Performance Indicators

Performance Indicator	SINGLE-FAMILY HOMES	MULTI-FAMILY COMPLEXES
Avg. No. of Problems per Irrigation Station	1.9	1.5
Avg. Distribution Uniformity (DU) (%)	46%	45%
Avg. Precipitation Rate for Pop-Up Sprinklers (PR) (in/hr)	1.4	1.5

1.2.3 Water Leaks

Leaks were detected in approximately 6% of single-family residences.[5] Leak rates showed little central tendency, ranging from a low of 2 gallons per day to a high of 860 gallons per day. The average leak rate for the sample was 100 gallons per day while the median was 39 gallons per day. Given the current stock of single-family residences in the county, this implies that single-family leaks consume nearly 2,500 acre-feet (AF) each year.

The on-site inspections also checked for specific sources of water leaks indoors and outdoors. Outdoor water leaks were identified in 3% of single-family residences and 4% of multi-family residences. Toilets were a primary source of indoor water leaks. Approximately 7.5% of all inspected toilets had leaks. Toilets in multi-family housing showed a slightly higher prevalence of leaks (8.3%) than toilets in single-family housing (7.2%). Of the 1,072 showerheads inspected for this study, only 1.6% had measurable leaks. Leaking showerhead diverters for bathtubs were more common. Approximately 9% of the inspected bathtubs with showerhead diverters leaked water. Faucet leaks were negligible.

1.2.4 Residential Water Use Knowledge and Attitudes

The study implemented a telephone survey to illicit household information on the following topics.

- Concern about future supply
- Knowledge/attitudes about household water use
- Knowledge/attitudes about how to save water around the house
- Economic relevance of household water use

[4] Low DU can result in excessive water application when irrigation times are lengthened to ensure that the areas receiving the lowest amount of water receive adequate irrigation.
[5] Leak detection tests were not part of the inspections of multi-family residences.

- Knowledge of local water utility conservation programs

Results of the survey may be useful in guiding conservation program design, marketing, and information programs. Key results for each subject area were as follows.

- Most households are somewhat or extremely concerned about the County's future water supply. Households identifying themselves as very knowledgeable about local water issues were most likely to express significant concern about future supply reliability.
- Most households consider their water use to be typical of similar households. Only a small fraction of households, especially among multi-family households, consider their use above average. Multi-family households are likely to believe their water use is below average.
- Households identifying themselves as very knowledgeable about local water issues also are more likely to be proactive about improving household water use efficiency. Conservation information programs may be able to exploit this link between knowledge about local supply issues and household conservation.
- Households save water to avoid waste and help out during shortages. Economic considerations rank below these two primary motivations. The survey clearly showed that most households do not consider water to be a major household expense.
- Single-family households are likely to think they can save more water indoors than outdoors. However, the chance a household thinks it can save more water outdoors than indoors increases with the household's knowledge about its water use. Those households that considered themselves somewhat or very knowledgeable about their water use were much more likely to believe they could save more water outdoors than indoors. This result also reinforces the general conclusion that education and information programs about household water use should play a prominent role in the region's overall demand management strategy.
- Most households rank the price and features of a water-using appliance above its efficiency as a primary purchase consideration. Only about one-third of surveyed households indicated that water efficiency was of first importance when purchasing a new water-using appliance. This suggests that conservation messages directed at new appliance purchase decisions should emphasize features and cost-effectiveness of water-efficient appliances in addition to their water saving potential.
- About eight-in-ten surveyed households were familiar with Energy Star appliance labeling and low-flow toilets. Only about one-third of surveyed households were aware of newer

devices, such as dual-flush toilets and ET irrigation controllers. About half of surveyed households were familiar with drought-tolerant landscaping and the term xeriscape.

- Household awareness of utility-sponsored water conservation programs is mixed. Table E9 shows the percent of surveyed households having heard of each listed conservation program. Survey respondents had the least familiarity with residential survey programs. Awareness of device distribution programs is higher, especially among single-family households. Only in the case of toilet replacement programs, however, were a majority of surveyed households familiar with the program.

Table E9. Awareness of Regional or Local Residential Water Conservation Programs

HOUSEHOLD HAD HEARD OF LOCAL UTILITY PROGRAM	SINGLE-FAMILY RESIDENTS	MULTI-FAMILY RESIDENTS	ALL RESPONSES
Toilet Replacement Program	68%	42%	60%
SCVWD's In-Store/Internet Washing Machine Rebate Program	44%	32%	40%
Showerhead and Faucet Aerator Giveaway Programs	32%	23%	29%
Water Wise House Call Program[1]	17%	15%	16%
Water Watcher Home Water Survey Program[2]	7%	5%	6%

Notes:
1. The District actively markets to the top 20%- 30% water users throughout the County except San Jose Water Company customers.
2. The Water Watcher Home Water Survey Program is a water survey program specific to San Jose Water Company and therefore it is not surprising that Countywide results show a low level of awareness. However, the proportion of San Jose residents indicating awareness of the program is not statistically different than for the county as a whole.

1.3 Implications for Conservation Program Design and Focus

Results from the *Santa Clara County Residential Baseline Water Use Study* have implications for the design and focus of regional conservation programs. Some key implications drawn from study results are as follows:

- Conservation programs addressing indoor water use should focus on washing machine and toilet conversions. These two appliances offer the largest amount of indoor residential water savings potential to the region.
- Washing machine savings potential is significantly larger for single-family households than for multi-family households. Washer rebates that reduce cost differentials between

conventional and high-efficiency washers are likely to be an effective way to accelerate conversion to high-efficiency appliances.

- While toilet savings potential is higher for single-family than for multi-family households, it is probably the case that more cost-effective toilet replacement programs can be implemented for the multi-family sector. Direct installation toilet replacement programs should be emphasized over rebate programs. Recent research by the California Urban Water Conservation Council shows conclusively that toilet rebate programs suffer from high rates of program freeridership, especially within the single-family sector.[6]
- Study results do not support continuation of showerhead distribution programs. The remaining savings potential is small. Moreover, rates of natural replacement implied by the study suggest that the region will achieve the BMP 2 coverage requirement through natural replacement of showerheads by 2006 for the single-family sector and by 2010 for the multi-family sector.
- Significantly reducing single-family household water leaks could save up to 2,500 acre-feet/year for the region. Study data show that leaks are not uniformly distributed across households, but rather concentrate within a small subset of water users. Identifying and targeting these customers will present the largest challenge to a successful leak reduction initiative. The AWWARF *Residential End Uses of Water* study found that there was a 76% probability that a single family home having winter water use exceeding 400 gpd has a major leak problem exceeding 130 gpd (nearly 1/3 of total winter use) and recommended water utilities target single family accounts with winter water use exceeding 400 gpd to receive a high consumption notice accompanied by information on how to detect and repair household leaks.
- Study results indicate that most residential irrigation systems are not well maintained and have design and/or performance issues that could result in overwatering of landscape. Residential outdoor water use offers a significant reservoir of potential water savings and should be a major focus of regional conservation initiatives.
- Study results indicate that most households believe they can save more water indoors than outdoors. However, households knowledgeable about their water use tend to believe the

[6] A program freerider is someone that would have taken the same action with or without the program. Toilet rebate programs attract people already in the market to replace a broken toilet or people replace toilets for a remodel. Because of energy code requirements, these people will replace their old toilets with ULFTs whether or not a rebate is present.

opposite. This suggests residential customer information programs should focus on educating customers about household water use and how to identify and implement water savings opportunities, particularly with respect to outdoor water use.

1.4 Future Research

The *Santa Clara County Residential Baseline Water Use Study* has provided the District with a rich and extensive data set about residential demographic characteristics, indoor water using fixtures and devices, outdoor landscaping characteristics and irrigation systems, prevalence and size of residential water leaks, and information about household water conservation knowledge and attitudes. This report has presented an initial analysis and summary of this data. Much more, however, could be and should be done with the data. Possible future uses of the data are discussed below.

- *Residential demand modeling* – households participating in the on-site inspections were asked to sign a release allowing the District to obtain water-billing records from the household's water service provider. Combing data from the on-site inspections with data on historical water use and weather would allow the District to explore relationships between household characteristics and demand for water.
- *Regional demand forecasting* – the data developed by the *Santa Clara County Residential Water Use Baseline Survey* will facilitate use of models such as IWR-MAIN or DSS commonly used by water utilities to forecast water demand and conservation program savings.[7]
- *Conservation potential assessments* – the data summarized in this report can be used to estimate the water savings potential, especially for outdoor water use. Savings associated with changes in landscape sizes, characteristics, or irrigation system efficiencies are possible using the data developed by the study.
- *Conservation program marketing assessments* – the data also provide insight into what conservation messages are most likely to resonate with Santa Clara County households, which segments of the residential sector are most responsive to conservation messages, and the extent of understanding about conservation programs and household willingness to participate in them.

[7] DSS is the model acronym for Demand Side Management Decision Support System.

2. Introduction to the Study

2.1 Study Purpose

This study implemented a two-part survey of a representative sample of single- and multi-family residences in Santa Clara County. The purpose of the survey was to gather baseline information about residential water-using devices, appliances, irrigation systems, and landscapes. Survey techniques were also used to assess residential attitudes and knowledge about water use, conservation practices, and water agency conservation program offerings. Table 1 shows the types of baseline information developed by the study.

Table 1. Types of Data Compiled by Santa Clara County Residential Water Use Baseline Survey

Demographic • Persons per household • Length of residence • Age of housing stock • Proportion of single- v. multi-family housing units	Knowledge & Attitudes • Awareness of household water use • Knowledge of conservation practices • Awareness of regional and local conservation programs • Willingness to participate in conservation programs
Indoor • Toilets per household (& % ULFT) • Showers per household (& % low-flow) • Faucets per household (& % aerator) • Prevalence of dishwashers (& frequency of use) • Washers per household (& % high-efficiency & frequency of use) • Prevalence of water softeners (& % with auto recharge) • Prevalence of home water treatment (RO) • Prevalence & magnitude of indoor leaks	Outdoor • Prevalence of pools & spas • Prevalence of pressure reducing valve • Prevalence & magnitude of outdoor leaks • Size and type of landscape • Inventory of irrigation systems • Assessment of irrigation system function • Statistics on irrigation system efficiency

The information compiled by this study will enable Santa Clara Valley Water District to estimate the types and quantities of water-using hardware within the residential sector of Santa Clara County and to establish a baseline from which future residential water savings potential can be measured. Study results will be useful for service area demand forecasting, conservation program marketing and design, BMP

program evaluation, and BMP program implementation.[8] Survey results will allow the District to determine the present level of ULFT penetration (relevant to BMPs 1 and 14), the level of low-flow showerhead penetration (relevant to BMPs 1 and 2), the prevalence of high-efficiency washing machines (relevant to BMP 6), and characteristics of outdoor water use, landscaping, and irrigation systems (relevant to BMPs 1 and 5).

2.2 Study Approach

The study implemented both telephone and on-site surveys. Survey participants were selected using random sampling techniques to ensure a representative sample that would allow inferences to the general population. The telephone survey was used to recruit households for on-site surveys and to administer the water use knowledge and attitudes questionnaire. On-site inspections were used to catalog water-using appliances, landscape area and plant types, irrigation systems, and other household characteristics. In total, 835 telephone interviews and 611 on-site inspections were completed. Table 2 shows the breakdown of completed telephone and on-site surveys by residence classification.[9]

Table 2. Completed Residential Baseline Surveys by Residence Classification

SURVEY INSTRUMENT	SINGLE-FAMILY COUNT	MULTI-FAMILY COUNT	MOBILE HOME COUNT	TOTAL COUNT
Telephone	543	270	22	835
On-Site	410	187	14	611

2.3 Research Team Composition

Implementation of the surveys required significant effort, involving coordination between four firms and the water use efficiency staff of Santa Clara Valley Water District. Table 3 shows the responsibilities of each member of the research team.

[8] BMP is short for Best Management Practice and refers to the 14 BMPs listed in the Memorandum of Understanding Regarding Urban Water Conservation in California.

[9] Mobile homes are excluded from the analysis of data collected through on-site inspections due to the low sample count. According to Census 2000 figures, mobile homes and other non-standard housing, such as live-in boats, account for only 3% of Santa Clara County's housing stock.

Table 3. Project Tasks and Participant Roles

STUDY TASK	PARTICIPANT
Design Sample	M.Cubed Farrand Research, Inc.
Design Survey Instruments	M.Cubed Farrand Research, Inc. ConserVision Consulting Santa Clara Valley Water District
Implement Telephone Survey	Farrand Research, Inc. Western Wats, Inc.
Implement On-site Survey	ConserVision Consulting Santa Clara Valley Water District
Data Entry	M.Cubed Santa Clara Valley Water District
Data Analysis	M.Cubed Santa Clara Valley Water District
Project Management/Coordination	M.Cubed Santa Clara Valley Water District

2.4 Review of Previous Research

In recent years several studies to develop residential water device profiles and/or assess residential knowledge and attitudes about water use and conservation have been undertaken by California water supply agencies and others. Notable examples include survey studies conducted by the City of San Jose (1999), East Bay Municipal Water District (1995, 1998, 2002), Marin Municipal Water District (1997), Metropolitan Water District of Southern California and Municipal Water District of Orange County (2002), and California Municipal Utilities Association (1998). Thus, this present study adds to a growing body of information about indoor and outdoor residential water devices and uses, attitudes about water conservation, and knowledge or awareness of water agency conservation programs.

In addition to adding to this growing knowledge base, this study benefited directly from the approaches developed by earlier research. In particular, the overall study design and sampling methods used for this project closely follow those developed for the *Orange County Saturation Study* (Metropolitan Water District of Southern California, et al. 2002). That study used telephone and on-site surveys to develop a representative profile of the type of water using devices found in the typical Orange County home. The sampling methods, survey techniques, and project management strategies developed for that study were instrumental to this present research.[10]

[10] We are particularly indebted to Metropolitan Water District of Southern California for its early assistance with study design and its willingness to share management software developed for the Orange County study.

The telephone survey instrument benefited substantially from earlier attitudinal surveys conducted by East Bay Municipal Utility District (2002), Marin Municipal Water District (1997), and California Municipal Utilities Association (1998). Likewise, the on-site survey instrument benefited from previous work. The questionnaire and forms used for Santa Clara Valley Water District's Water Wise House Calls residential survey and device distribution program provided the foundation for the on-site survey instrument used for the baseline study. Only minor modifications and additions to the Water Wise House Calls forms were needed to adapt them for use by this project.

In a like manner, it is hoped that the methods and tools employed for this study may serve as a reference point for similar research in other parts of California.

3. Method of Research

3.1 Target Sample Sizes

3.1.1 On-Site Survey

The process of selecting a sample size requires determination of an acceptable range of uncertainty, given time and cost constraints of the study. In most cases, survey researchers choose a 95% level of confidence with a margin for error not to exceed ±10%.[11] It is generally desirable to reduce the margin of error as much as possible. Doing so, however, necessarily increases the sample size and thus the cost and time required to complete the study.

Given the resources available for this study and the costly procedures to obtain a truly representative random sample, it was determined that a maximum of 600 on-site inspections could be completed. Two alternative splits between multi-family and single-family surveys were considered. The first alternative was to sample in proportion to the population of housing units. Based on California Department of Finance housing statistics for Santa Clara County, this would require allocating 70% of the sample to single-family and 30% to multi-family residences. While this sampling approach would preserve the population proportions between single-family and multi-family residences, it would also result in a higher margin of error for the multi-family survey relative to the single-family survey. An alternative to proportional sampling would be to stratify the sample between single- and multi-family residences and equally sample from both populations. This would have the benefit of equalizing the margins of error between the two populations, but would result in a higher margin of error for single-family residences compared to the first approach. It would also cost more to implement because of higher recruitment costs associated with multi-family residences. After consulting with Santa Clara Valley Water District it was decided that given the importance of single-family water use to overall water demand in the County, equalizing the margins of error between the two housing categories did not merit the sacrifice in margin of error for the single-family survey. Therefore, the first sampling alternative was selected. Table 4

[11] This means that for any given random sample there is a 95% chance that the true value x being measured will fall within the interval x^ ± 10%, where x^ is the estimate of x derived from the sample data. More generally, the relationship between sample size, confidence level, and margin of error when data are given in terms of proportions is described by the following formula:

$$n = \left(\frac{Z_\alpha \sqrt{p(1-p)}}{C_p} \right)^2$$

where n is the sample size, Z_α is the standard normal value for confidence level α, C_p is the margin of error and p is the population proportion. The true population proportion is unknown. The standard way to handle this is to set the value of p to the proportion that would result in the largest sample size. This occurs when p = 0.5.

shows the on-site survey target sample sizes adopted for the study and their associated margins of error. As shown in Table 2, a total of 611 on-site inspections ultimately were completed.

Table 4. On-Site Survey Target Sample Sizes

HOUSING TYPE	SURVEYED HOUSEHOLDS	MARGIN OF ERROR (AT 95% CONFIDENCE LEVEL)
Single-Family	420	± 4.8%
Multi-Family	180	± 7.3%
Total Sample	600	± 4.0%

3.1.2 Telephone Survey

The experience of the *Orange County Saturation Study* suggested that up to 25% of the recruited households would not be successfully scheduled for an on-site inspection. Therefore, the target sample size for the telephone survey was set to 125% of the on-site target sample size. Table 5 shows the target sample sizes and margins of error for the telephone survey. As shown in Table 2, in the actual event, a total of 835 telephone surveys were ultimately required to meet the on-site target sample size.

Table 5. Telephone Survey Target Sample Sizes

HOUSING TYPE	SURVEYED HOUSEHOLDS	MARGIN OF ERROR (AT 95% CONFIDENCE LEVEL)
Single-Family	525	± 4.3%
Multi-Family	225	± 6.5%
Total Sample	750	± 3.6%

3.2 Sample Selection and Survey Procedure

3.2.1 Telephone Recruitment

The sample of households for the *Santa Clara County Residential Water Use Baseline Survey* was obtained using a telephone recruitment survey.[12] The sample for the telephone survey was generated from a master list of randomly generated residential telephone numbers for Santa Clara County.[13] The master list of 17,920 telephone numbers was randomly divided into seven equally sized subsets, or replicates. The purpose of dividing the master list into replicates was to minimize the likelihood of geographical bias

[12] The telephone recruitment process for this study was based on the one developed for the *Orange County Saturation Study* and the description of this process closely follows a similar description found in Metropolitan Water District of Southern California, et al. (2002).

[13] The list of telephone numbers was purchased from Scientific Telephone Sample, a company that specializes in developing telephone sample frames for survey research. The list was generated by identifying all assigned telephone exchanges for Santa Clara County, screening out exchanges reserved for non-residential use, and then randomly generating the last four digits to form a complete number.

that might be caused by telephone numbers from proximate areas being dialed sequentially. A starting replicate was randomly selected and used to begin the telephone survey. Each telephone number in the starting replicate was called up to seven times. The time and day of calls made to each number were varied systematically to maximize the chances of contact. If contact was not made by the seventh attempt, the telephone number was dropped from the sample and randomly replaced with another number from the same replicate. This process was repeated until all numbers in the replicate had been called at least seven times. After that, a new replicate was randomly selected and the entire process was repeated. This continued until the target sample sizes for the on-site survey in Table 4 were achieved.[14]

Every call attempt to every dialed number was given a call disposition. Call disposition categories included: complete interview with agreement to participate in the on-site component; complete interview with no agreement to participate in the on-site component; incomplete interview; refusal; communication barrier, including language; non-eligible contact, with reason for non-eligibility specified; dead number, with reason specified. The date and time each call was made was also recorded. The total number of calls made to each telephone number and all dispositions for all call attempts was recorded and included in weekly status reports. Appendix C contains the final call disposition report from the telephone survey.

Prior to implementation of the telephone survey, interviewers were trained in the use of the CATI[15] system, proper interviewing techniques, strategies for developing rapport with respondents, and the use of "fallback" statements and explanations in the event respondents had questions about the survey or the purpose of the study. The call center had the capability to conduct the surveys in English, Spanish, and Vietnamese.

Quality control procedures during the telephone survey included pre-testing the survey instrument on 20 households, supervisor monitoring of interviewers while calls were in progress, and supervisor callbacks to at least 10% of all completed interviews to verify that respondents had been interviewed.

During the survey, standard screening procedures were employed to ensure that survey questions were asked of a knowledgeable respondent. Respondents were asked several additional screening questions to determine individual eligibility (respondents were required to be at least eighteen years old) as well as household eligibility (e.g., place of residence, year their residence was built and/or length of residence, owning or renting, questions needed to classify the housing unit).

[14] The target sample for single-family residences was achieved before multi-family residences. Therefore, towards the end of the telephone survey the procedure had to be modified to terminate calls if the household was identified as single-family. Because multi-family households tended to be harder to recruit this necessity was anticipated and single- and multi-family sample yields were monitored throughout the recruitment phase of the survey to determine when to start terminating single-family calls.

[15] CATI stands for Computer Assisted Telephone Interviewing.

Eligible households were asked to participate in the on-site inspection component of the survey. To increase acceptance rates, the importance of the study to the region was reiterated and participants were informed that after completing the in-home portion of the study they would be entered into a District-sponsored drawing where they could win a $500 gift certificate to a local store of their choice. Households who agreed to participate received a letter on District letterhead thanking them and reminding them that an on-site surveyor would be contacting them and that they were eligible for the $500 gift certificate.[16]

A procedure was adopted to verify addresses for the on-site inspection. During the recruitment interview, once the respondent agreed to the home inspection survey, a Western Wats supervisor would speak with the respondent and verify the address. Farrand Research would later check the address in the U.S. Postal Service online database. If the address failed to appear in the USPS database, Farrand Research noted this when delivering the recruitment data to M.Cubed; however, the number of addresses failing to appear in the USPS database was insubstantial.[17]

Appendix A includes a copy of the interviewer script and questionnaire.

3.2.2 On-site Scheduling

Twice each week the names, telephone numbers and addresses of households agreeing to participate in the on-site inspection phase of the study were sent to the on-site inspection team. To increase the likelihood of contact and successful appointment scheduling, the on-site survey firm employed one, and often two, schedulers days, evenings, and weekends during the on-site survey phase of the project.[18] Appointment confirmation letters on District letterhead were mailed once the inspection visit was successfully scheduled. These letters reiterated the importance of the study and advised what the technicians would be doing on the customer's premises. The letters also included the name and number of a person at the District who could be contacted if people wanted additional reassurances about the

[16] In an effort to increase on-site survey participation, letters encouraging participation were also sent to single-family participants who completed the telephone survey but then subsequently refused the on-site inspection. Letters were also left by on-site inspectors for owners of multi-family dwellings to encourage their participation. These steps were taken in order to reduce non-response bias in the sample.

[17] Only a very small percentage of recruit addresses in each batch could not be verified through the database. In most of these instances the contact information was accurate but simply not represented in the database. During the telephone interview, interviewers were instructed to ask the recruits to spell out their address information to avoid incorrect entry of contact information. These precautions were suggested by the experience of the *Orange County Saturation Study.* See Metropolitan Water District of Southern California et al. (2002).

[18] Capacity to schedule during evenings and weekends proved critical to successfully scheduling appointments and one scheduler was, during peak periods, insufficient. Likewise, not allowing too much time to pass from the date a residence was recruited to the time it could be contacted by the on-site inspection firm also was an important factor in successfully scheduling appointments. During this study, several adjustments to the rate of recruitment were required until the right balance was found.

study's legitimacy. Finally, the letter reminded people that they would be eligible for participation in the prize drawing after completing the on-site inspection.

Because of the experience from the *Orange County Saturation Study*, it was anticipated that the target sample size should be increased by a factor of 1.25 to allow for recruited households that could not be successfully scheduled for the on-site inspection or subsequently refused the on-site inspection. This turned out to be a slight underestimate. The ratio of recruited to inspected households ended up being 1.36:1 rather than 1.25:1. The practical significance of this was the need to continue the telephone recruitment process longer than anticipated.[19]

3.2.3 On-Site Surveys

The same firm used by the District to run its Water Wise House Calls program was retained to conduct the on-site inspections. Thus, only surveyors with prior residential survey experience and familiarity with the region were used for the study. Prior to going into the field for this study, surveyors were provided additional training by the District in landscape measurement, irrigation system assessment and testing, and leak measurement.

A multi-part form addressing indoor and outdoor water devices and household characteristics was developed for the on-site inspections. Separate forms were developed for single- and multi-family residences. On-site surveys could be conducted in English, Spanish or Vietnamese. Appendix B includes a copy of the on-site inspection forms.

Because of the quantity of information the on-site inspection would collect and the desire to keep visits to no more than 45 minutes, two surveyors were assigned to each inspection. This allowed the indoor and outdoor components of the inspection to be performed at the same time.

3.2.4 Coordinating Data Collection Activities

Coordinating information flows between the telephone and on-site surveys and keeping track of appointment call dispositions presented significant logistical challenges. Fortunately, the *Orange County Saturation Study*, confronting many of the same issues, developed a database application to handle the transfer of data from the call center to the on-site scheduler and to keep track of on-site scheduling. This software was modified and employed for this study as well, making data management much simpler and less susceptible to human error.

[19] Ideally, the on-site appointment would be scheduled as part of the telephone recruitment process. It is believed this would substantially reduce the ratio of recruited to inspected households. The *Orange County Saturation Study* reached a similar conclusion. However, because of the scheduling logistics involved, in most circumstances this would be possible only if the same entity was responsible for both telephone recruitment and on-site inspections.

3.2.5 Data Entry

Data collected by the telephone survey was automatically logged into a database by the CATI system during the interview. At the conclusion of the telephone survey phase of the study, the data was provided to M.Cubed for analysis. Because the survey was administered through a CATI system, no secondary data entry was required for the telephone survey data.

The same was not the case for data collected through the on-site inspections. Information from the inspections was recorded on paper forms. To put this information into an electronic format, a database was developed with data entry screens that replicated the paper forms. Interns under the supervision of District staff used the database to key-in the form data. The District then provided the data in electronic format to M.Cubed for analysis.

4. Sample Quality Benchmarks

4.1 Population Characteristics

Several population benchmarks were used to assess the adequacy of the sample obtained by the methods previously described. These were:

- Geographic distribution of the housing stock
- Age distribution of the housing stock
- Distribution of years of occupancy
- Distribution of persons per household

Data from the Census 2000 Summary File 3 were used as population benchmarks from which to assess the quality of the baseline sample. While Census data are generally considered to provide the most reliable estimates of underlying population characteristics, it should be noted that data from Census 2000 Summary File 3 is itself derived from sampling and therefore subject to sampling error. Assuming the baseline and Census samples are truly random, sampling errors should tend to cancel out and the sampling distributions should closely match. While small discrepancies between the benchmark values and baseline sample values should be expected, large discrepancies would suggest possible bias in one or both samples. As will be shown below, with few exceptions, the baseline sample data closely matches the population benchmarks from Census 2000, indicating the baseline sample provides a reasonable representation of the underlying population of housing units.

4.1.1 Geographic Distribution

Geographic representation can be assessed by comparing the proportion of sampled residences from each city or town in the County with the proportion of County housing stock in each city or town as estimated by Census 2000. Figure 1 shows the comparison. It is seen that the sample closely matches the distribution of housing derived from Census 2000 data with few exceptions. The magnitudes of the differences are consistent with normal sampling error.

4.1.2 Housing Stock Age

In a similar fashion, the sample distribution of housing stock age was compared to Census 2000 data. The comparison is shown in Figure 2. As with the geographic representation, there is generally a good match between the sample distribution and the Census 2000 data. The largest discrepancy is for the age class "1999 and after" where the County sample proportion is just about twice that of the Census. Part of

this discrepancy is due to the fact that Census housing counts terminated in March 2000 whereas the County sample is based on the housing stock as of 2002/2003. Thus one would expect a higher proportion of housing in the age class "1999 and after" for the County sample compared to the Census due to housing construction occurring since March 2000. For the other age categories the magnitudes of the differences between the two estimates are within the bounds of normal sampling error.

4.1.3 Years of Occupancy

Figure 3 compares the distribution of years of occupancy exhibited by the baseline sample to the Census 2000 benchmark. The largest discrepancy is in the category "Less than 2" where it appears the County sample may have somewhat over-sampled households from this category, though the discrepancy may simply be due to sampling error.

4.1.4 Persons per Household

The distribution of persons per household is shown in Figure 4. The largest discrepancies between the Census benchmark and the County sample are at each tail of the distribution. The County sample appears to have under-sampled households with "one occupant" or "seven or more occupants". This is not too surprising. Single occupant households may be less likely to agree to an on-site inspection for several plausible reasons. The proportion of time the house is unattended is likely to be greater for single occupant households, making scheduling more difficult. Likewise, single occupant households may be less inclined to agree to a home visit because of concerns about personal safety. Single occupant households also may have a higher proportion of older or infirm individuals with less willingness or ability to undertake the inspection.

The apparent under-sample in the category "seven or more occupants" can mostly be attributed to sampling error. If one takes the Census value to represent the true population value, then almost 80% of the discrepancy can be explained by normal sampling error. Recognizing that the Census value itself is drawn from a sample, it becomes possible that all of the discrepancy is due to sampling error.

The mean number of persons per household for single- and multi-family residences produced by the County sample is nearly identical to that derived from Census data. There remains some discrepancy in the "other" category[20], but this can be explained by sampling error caused by the small number of observations in the baseline survey for this category. The comparison is shown in Figure 5.

[20] The "other" category includes mobile homes and houseboats.

4.2 Other Data Quality Issues

On the whole, Figures 1-5 suggest the County sample is reasonably representative of the underlying population of housing units and that the sampling method did not result in any serious under- or over-sampling of key population benchmarks. Nonetheless, survey research of the type conducted for this study is always subject to possible selection bias. Metropolitan Water District of Southern California, et al. (2002) explains the issue of selection bias as follows:

> Any study that depends on the voluntary participation of randomly selected subjects (i.e., households) must consider the possible occurrence and effects of *self-selection bias*. Simply stated, the occurrence and adverse effects of selection bias are a source of concern whenever there are systematic differences between those who agree and those who decline to participate in a study. People with an interest in conservation, for example, are more likely to willingly participate in a telephone survey dealing with conservation-related attitudes and behaviors than those who are less interested in the issue. The effect of this type of selective participation will be that the survey results will disproportionately reflect the opinions of those from whom conservation is a salient issue. For this reason, there are *a priori* reasons for suspecting that the opinions and behaviors reported by the sample of willing study participants may not provide an accurate portrayal of those held by the larger population. The dilemma here is that the absence of information from those who declined to participate makes it impossible to know if these types of differences actually exist. The best that can be done in most cases is to try to identify disproportionate rates of non-participation among identifiable segments of a randomly selected sample, and then to try to anticipate if, and how, their exclusion from the study may limit the generalizability of study findings.

In the case of the *Orange County Saturation Study* various surveying strategies were employed in an effort to minimize this source of bias. A carefully worded script was developed to elicit participation from the broad population. Interviewers were trained in methods to elicit participation should respondents initially indicate an unwillingness to continue with the interview. Sample replicates were used to avoid under- or over-sampling particular areas and each phone number in a sample replicate was called seven times before being dropped. Calls were systematically varied by time of day and day of week to maximize contact. Finally, survey participation in the on-site portion of the survey was incentivized by use of a prize drawing.[21] These same techniques were used for this study.

The *Orange County Saturation Study* also used probit regression techniques to look for systematic differences in housing characteristics – such as number of bathrooms, persons per household, and age of household -- between households agreeing to on-site inspections and those refusing.[22] The results of this

[21] The purpose of the prize drawing was to (1) increase overall willingness to participate in the on-site inspection and (2) to offset the expected tendency of households with an interest in water conservation and regional water issues more generally to self-select themselves for participation. It should be noted, however, that presence of the prize drawing itself could introduce possible sources of sample bias.

[22] Probit (and logit) regression models are used to help explain dichotomous or categorical choices, such as to vote or not to vote, or to participate in an activity or not to participate. In the simplest sense, probit regression is a way to statistically evaluate variables thought to influence the odds of a dichotomous outcome.

analysis indicated no significant differences.[23] The conclusion drawn from the probit regression analysis was that the surveying methods did not result in obvious or detectable sources of selection bias. The telephone survey for the Orange County study included questions about housing characteristics – such as number of bathrooms, persons per household, and age of household -- used in the probit regression analysis that were not included in the telephone survey for this study. These questions were removed from this study's telephone survey instrument for two reasons. First and foremost, to allow time for the water use knowledge and opinion questions, which were not part of the Orange County study. Second, the Orange County study provided strong evidence that self-reported information obtained by telephone about household characteristics, especially as they relate to plumbing, was unreliable and frequently wrong. A decision was made early in this study to collect this information only through the on-site inspections. Therefore, it was not possible to do a similar probit analysis for this study. Given the similarity in survey methods employed, however, it is generally expected that similar results would have been obtained.

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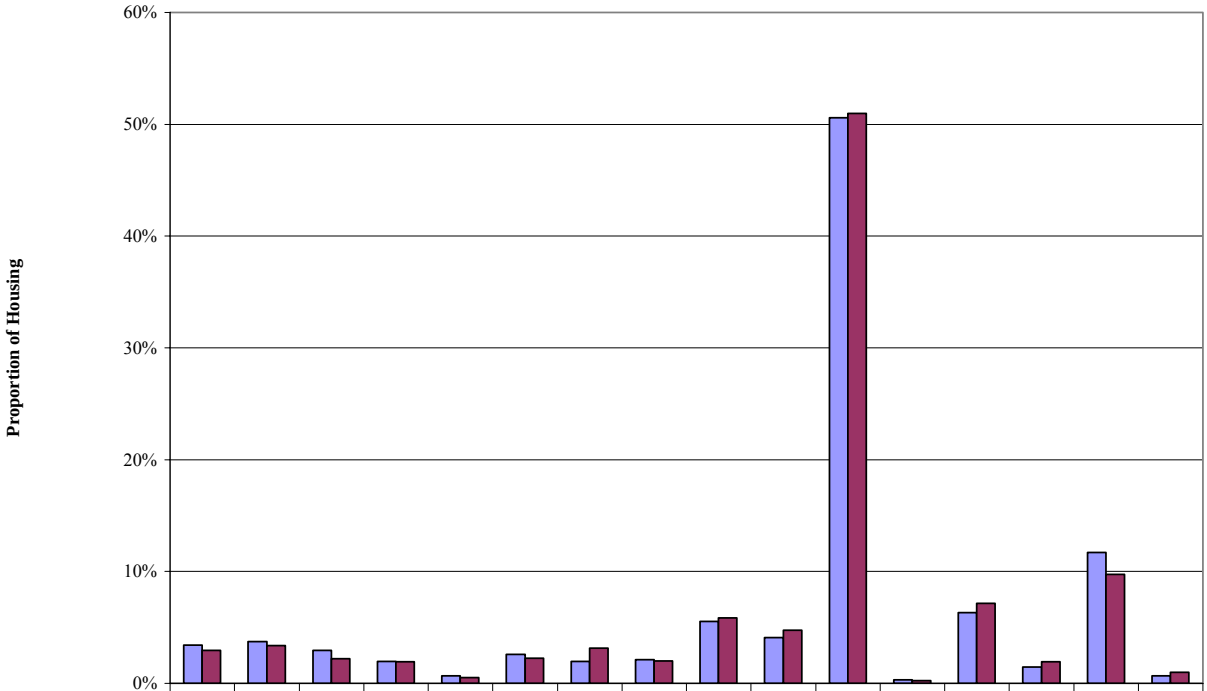
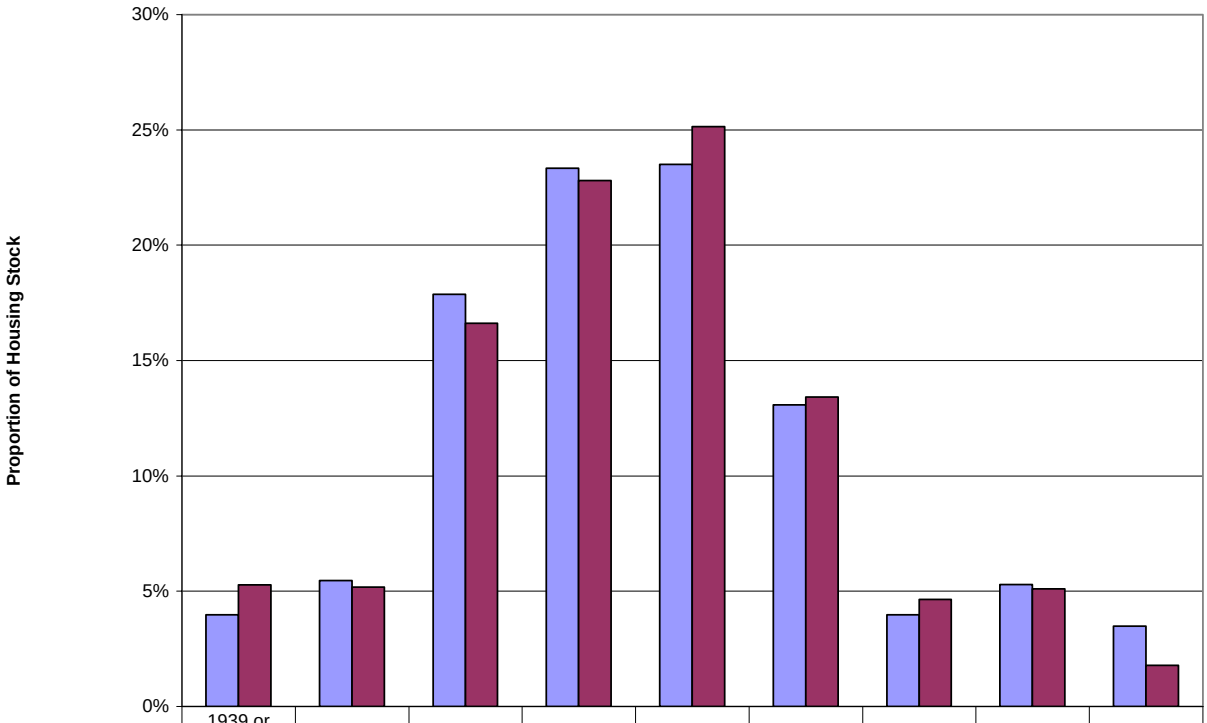
[23] See Appendix H of Metropolitan Water District of Southern California, et al. (2002).



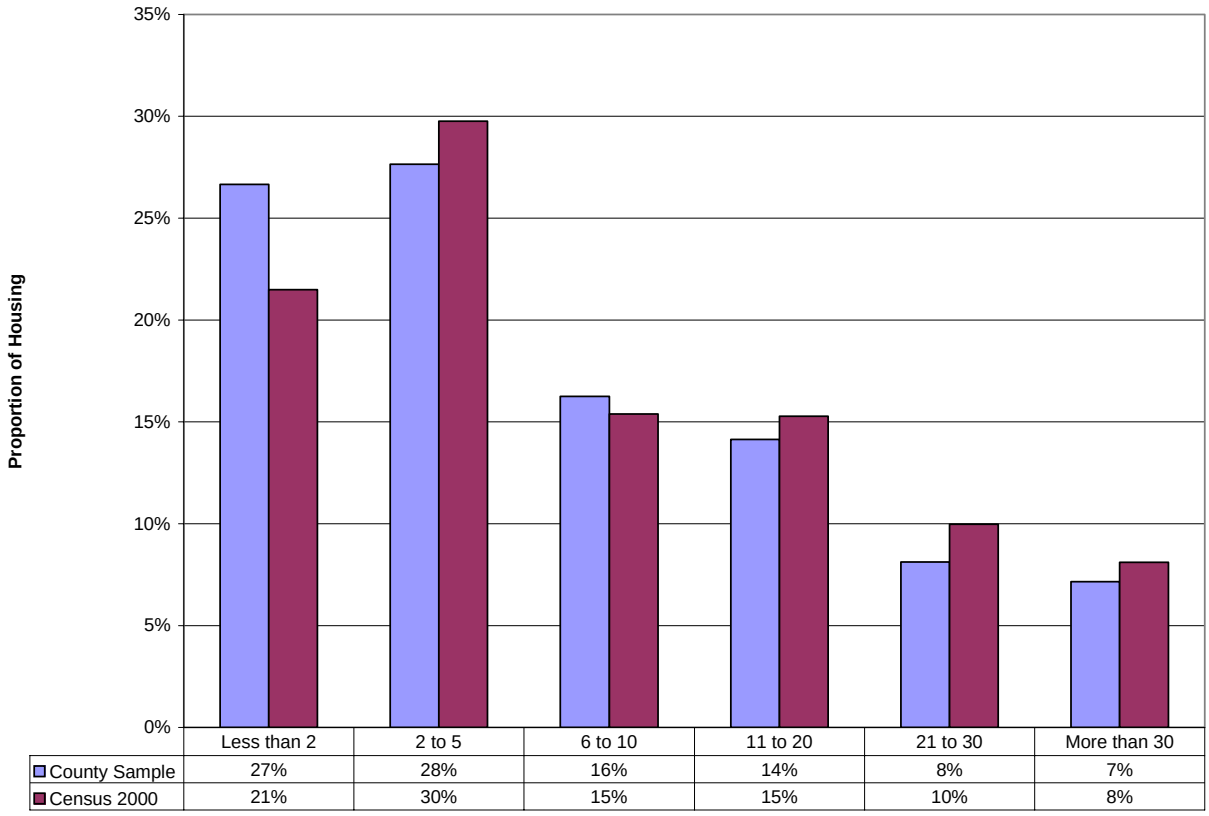
	Camp bell	Cuper tino	Gilroy	Los Altos	Los Altos Hills	Los Gatos	Mil pitas	Morgan Hill	Mt. View	Palo Alto	San Jose	San Martin	Santa Clara	Sara toga	Sunny vale	Other
County Sample	3.4%	3.7%	2.9%	2.0%	0.7%	2.6%	2.0%	2.1%	5.5%	4.1%	50.6%	0.3%	6.3%	1.5%	11.7%	0.7%
Census 2000	3.0%	3.4%	2.2%	1.9%	0.5%	2.2%	3.1%	2.0%	5.9%	4.7%	51.0%	0.2%	7.2%	1.9%	9.7%	1.0%

Figure 1. Comparison of Sample Geographic Dispersion to Underlying Population



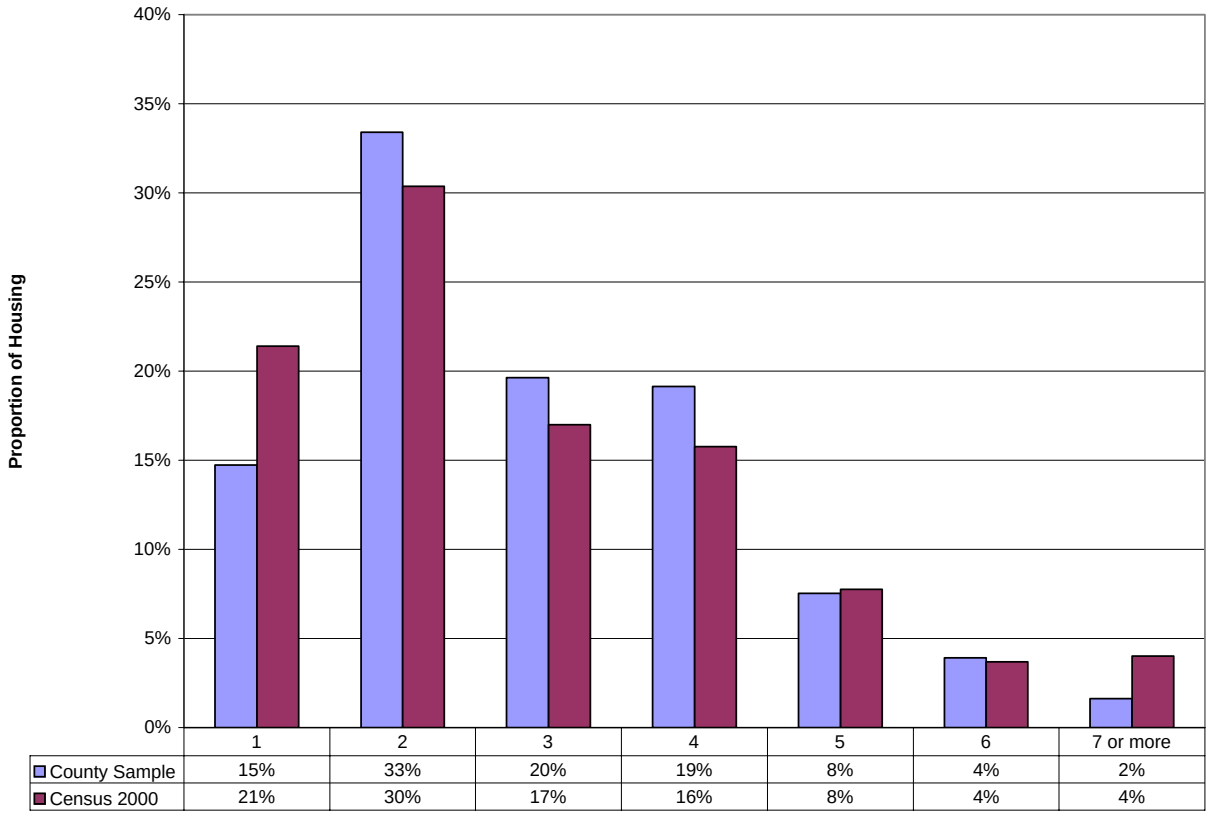
	1939 or earlier	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1994	1995-1998	1999 or after
County Sample	4.0%	5.5%	17.9%	23.3%	23.5%	13.1%	4.0%	5.3%	3.5%
Census 2000	5.3%	5.2%	16.6%	22.8%	25.2%	13.4%	4.7%	5.1%	1.8%

Figure 2. Comparison of Sample Distribution of Housing Stock Age to Underlying Population



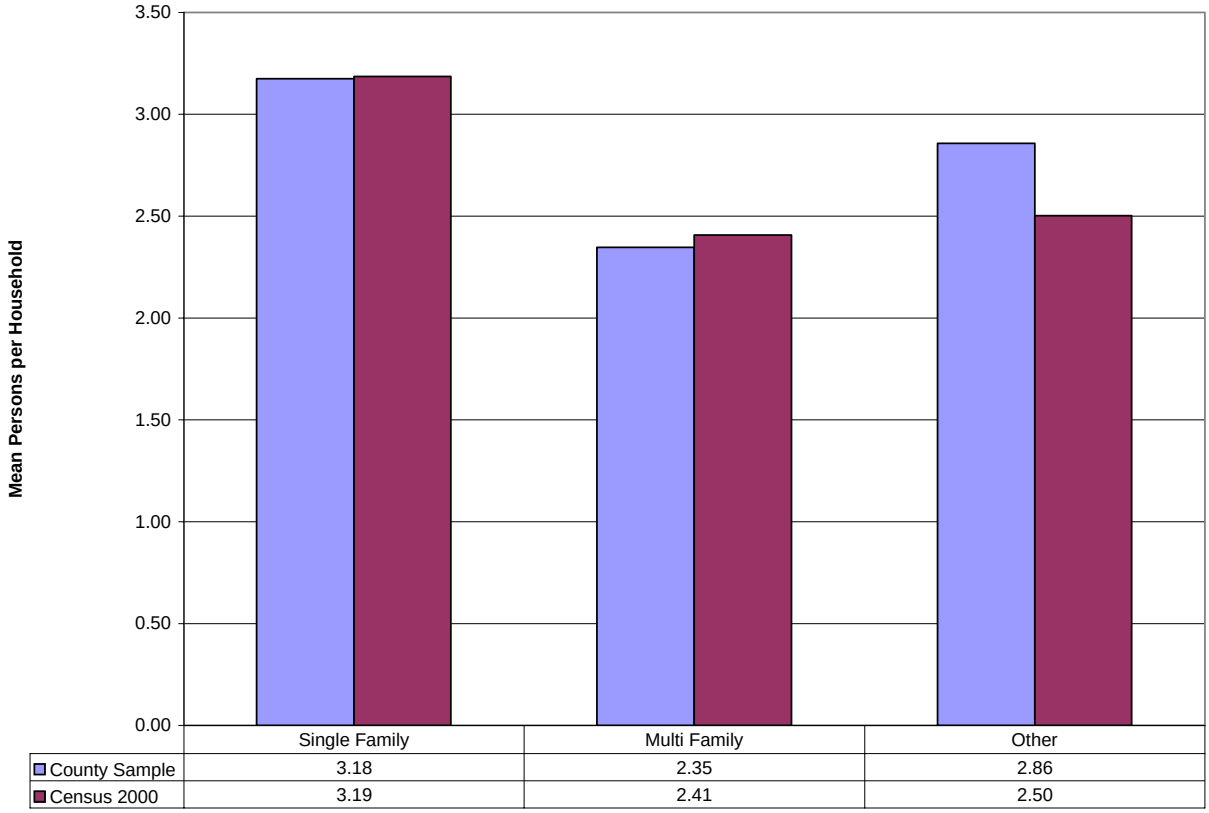
	Less than 2	2 to 5	6 to 10	11 to 20	21 to 30	More than 30
County Sample	27%	28%	16%	14%	8%	7%
Census 2000	21%	30%	15%	15%	10%	8%

Figure 3. Comparison of Sample Distribution of Years of Occupancy to Underlying Population



	1	2	3	4	5	6	7 or more
County Sample	15%	33%	20%	19%	8%	4%	2%
Census 2000	21%	30%	17%	16%	8%	4%	4%

Figure 4. Comparison of Sample Distribution of Persons per Household to Underlying Population



	Single Family	Multi Family	Other
County Sample	3.18	2.35	2.86
Census 2000	3.19	2.41	2.50

Figure 5. Comparison of Mean Persons per Household to Underlying Population

5. Housing Demographics

Basic housing statistics for Santa Clara County are shown in Table 6. The underlying distribution of construction year for the County's housing stock is shown in Figure 2. Likewise, the underlying distributions for years resided and persons per household are shown in Figures 3 and 4, respectively.

Table 6. Santa Clara County Count of Housing Units and Other Basic Statistics

	SINGLE-FAMILY	MULTI-FAMILY	MOBILE HOMES	TOTAL
Occupied Housing Units [1]	371,052	175,785	19,026	565,863
% Housing Units	66%	31%	3%	100%
Mean Construction Year	1965	1972	NA	
Median Construction Year	1965	1972	NA	
% Constructed before 1992	92%	83%	NA	89%
95% Confidence Interval [2]	±3%	±5%		±3%
Mean Years Resided	12.0	3.6	NA	
Median Years Resided	7.0	1.5	NA	
Mean Persons Per Household	3.2	2.4	2.5[1]	2.9
Median Persons Per Household	3.0	2.0	NA	NA

Notes:
1. From Census 2000 Summary Tape 3.
2. See footnote 22 on next page for explanation of confidence interval calculation.
NA – Insufficient number of observations from County sample; data not available from Census.

6. Indoor Water Use Devices

The indoor portion of the on-site inspections cataloged the quantity and type of water appliances and plumbing fixtures, including the following:

- Counts and flow measurements of toilets, showerheads, and faucets;
- Prevalence of in-unit and on-premise washing machines, and proportion that were Energy Star or front-loading;
- Prevalence of dishwashers and water softeners; and
- Prevalence and magnitude of indoor water leaks.

Data from the indoor inspections are summarized in the following subsections.

6.1 Toilets

6.1.1 Mean Toilets per Household

Table 7 shows the mean number of toilets per household for single- and multi-family residences. The table also shows the 95% confidence interval for the mean number of toilets.[24]

Table 7. Mean Number of Toilets by Type of Residence

	SINGLE-FAMILY	MULTI-FAMILY
Mean # Toilets	2.3	1.4
Sample Size	410	187
95% CI of Mean	± 0.07	± 0.11

6.1.2 Toilet Flush Volume Measurement

Toilet flush volume was measured using the dimensions of the toilet tank. The formula to estimate gallons per flush used by the surveyors was as follows:

[24] For interval scale variables, such as mean toilets per household, the 95% confidence interval uses the formula:

$$C_{.05} = \pm 1.96 \frac{S}{\sqrt{n}},$$

where S is the sample standard deviation and n is the sample size. For proportional variables, such as percent of households with a ULFT, the 95% confidence interval uses the formula:

$$C_{.05} = \pm 1.96 \sqrt{\frac{P(1-P)}{n}},$$

where P is the sample proportion and n is the sample size. Interpretation of the 95% confidence intervals so described is as follows: with repeated sampling, one should expect that 95% of the intervals thus constructed would contain the true population mean or proportion.

$$\frac{L \times W \times D}{231} + 0.5,$$

where L is tank length, W is tank width, and D is the distance between the height of the water line when the tank is full and fully flushed. The scalar 231 in the denominator converts cubic inches to gallons. One-half gallon is added to the tank volume to account for water in the bowl of the toilet. Schematically, the measurement is shown in Figure 6.[25]

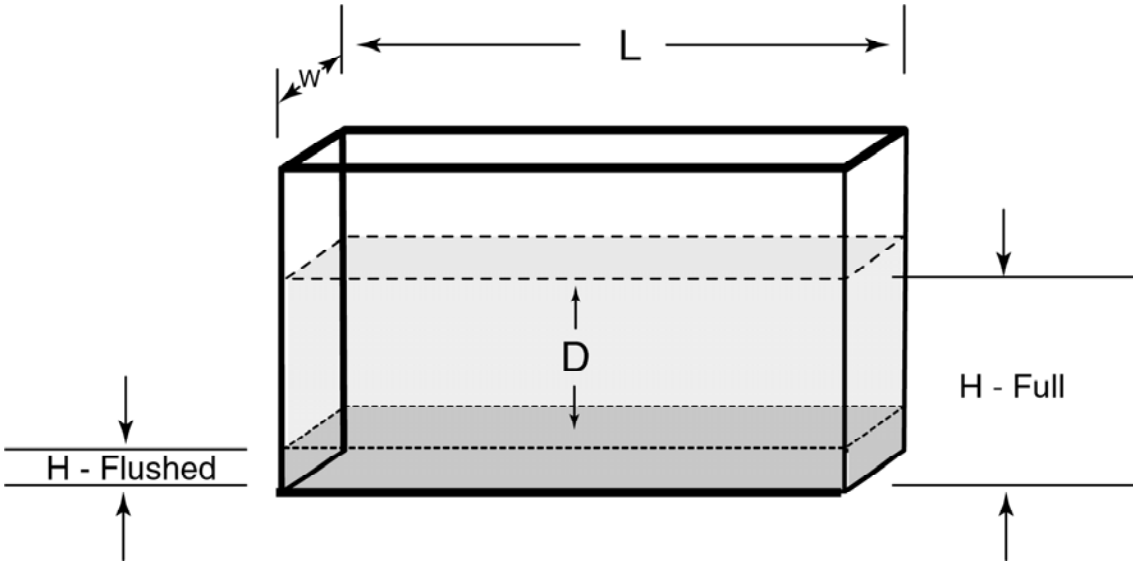


Figure 6. Schematic of Toilet Flush Volume Measurement

According to ConserVision, which performed the measurements, a calculated flush volume of 2.2 gallons per flush (gpf) or less using the above formula is indicative of an ultra-low-flush toilet (ULFT). This conclusion is based on field-testing of installed toilets rated 1.6 gpf by the manufacturer.[26]

6.1.3 Measured Flush Volumes for Post-1991 Housing Construction

Figures 7 and 8 show the distribution of calculated flush volumes for single- and multi-family residences, respectively. These figures divide sampled housing units between those constructed before 1992 and those constructed after. This is done because of the 1992 change in California's plumbing code which required installation in new construction and retail sale of toilets rated 1.6 gpf or less (ULFTs). Given this change in the plumbing code, one would expect nearly all toilets in residences constructed after 1991 to be ULFTs. Figures 7 and 8 indicate otherwise. In Figure 7, for example, it is seen that only slightly more than 60% of the sampled toilets in single-family residences constructed after 1991 have

[25] Figure 6 is taken from Metropolitan Water District of Southern California et al. (2002), Appendix F.
[26] Memorandum from ConserVision to Santa Clara Valley Water District May 5, 2003.

flush volumes of 2.2 gpf or less. The proportion for multi-family residences constructed after 1991 is just over 50%, as shown in Figure 8. These proportions are surprisingly low. There are several possible explanations.

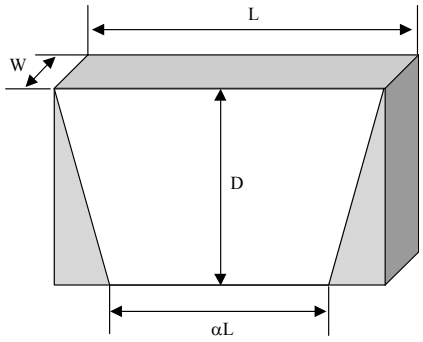
- One possibility is that during the first couple years following the change in plumbing code, non-ULFTs continued to be installed until inventories of the old models were eliminated. If this were the case we would expect measured flush volumes to decrease with time. That is, residences constructed in 1992 or 1993 would be more likely to have a non-ULFT than residences constructed in 1997 or 1998. The sample data show no such tendency. Regressing flush volume against construction year shows no downward trend. In fact, the data exhibit a very slight upward trend, though not one that is statistically significant.
- Another possibility is that households are replacing ULFTs installed at the time of construction with higher flow toilets obtained outside the normal retail sales channel. There is anecdotal evidence that this is occurring to some extent nationwide, though to what extent is unknown. A stretch of the imagination is required to believe that by itself it can explain the results in Figures 7 and 8.
- Leaky flapper valves may also account for the higher than expected flush volumes.[27] It has been shown that flapper valves may malfunction for several reasons. First, they may degrade due to normal wear or from the use of in-tank bowl cleaners. Second, a faulty flapper may be replaced with one that is incompatible with the flush valve, leading to excessive flush volume.
- Another credible reason is measurement formula inaccuracy and measurement error. The measurement formula used to estimate flush volume assumes a rectangular tank. If the tank is prismoidal (i.e., a trapezoidal face) instead of rectangular the formula will overestimate flush volume.[28] Likewise, if the tank face is somewhat bowed, the formula may overstate or

[27] John Koeller (2000), "*Toilet Flappers: A Weak Link in Water Conservation.*"
[28] If the tank is prismoidal as shown in the figure below, then the overstatement of volume is equal to $0.5 \times D \times W \times L \times (1-\alpha)$. For typical values of L, W, and D, an α of 0.8 can result in errors of 10% or more.

understate the volume depending on where the width measurement is taken. Tanks with Trapezoidal faces are fairly common, particularly for newer toilets. In addition, the formula does not account for displacement caused by internal tank apparatus. Finally, the assumption that the toilet bowl volume is a constant 0.5 gallons for all toilet brands and models is another possible source of measurement error. It seems unlikely that bowl volumes would be uniform, particularly when comparing ULFTs to non-ULFTs. Non-ULFT bowls tend to be larger than ULFT bowls, suggesting the 0.5 gallons assumption could cause the flush volume for ULFTs to be overstated. In addition to these physical issues, human measurement errors are inevitable in such calculations. If these errors were randomly produced then their effects would tend to cancel out. On the other hand, if there is a tendency to over- or understate particular parameters, formula results will be biased.

- Finally, the water level for ULFTs may be set above the line recommended by the manufacturer, thus flushing more than the stated 1.6 gpf.

The mean flush volume for toilets in residences constructed after 1991 is shown in Figure 9. This figure also shows the 95% confidence interval around the average flush volume. It is seen that for both single- and multi-family residences constructed after 1991 the two-sided confidence interval for the mean includes the hypothesized value of 2.2 gpf for ULFTs.[29]



[29] P-values were calculated to determine if the observed distribution of flush volumes for residences constructed after 1991 were consistent with an underlying population average flush volume of 2.2 gpf. The p-value is the probability that the sample mean would be as large as measured assuming the underlying population mean is 2.2 gpf. The p-values for single- and multi-family residences constructed after 1991 are 62% and 7%, respectively. In other words, assuming the true population mean is 2.2 gpf, there is a 62% probability of observing a sample mean at least as large as the one calculated for single-family residences. Thus, while there are a large number of toilets in single-family residences constructed after 1991 in the sample with measured flush volumes greater than 2.2 gpf, the data are not inconsistent with the hypothesis that the underlying population mean is 2.2 gpf.

The case for multi-family residences constructed after 1991 is less compelling. Here we observe that the probability of obtaining the calculated sample mean assuming the true population mean is 2.2 gpf is only 7%. This casts greater doubt on the hypothesis, assuming the measurements are accurate, or causes one to question the validity of the measurements, assuming the hypothesis is correct.

6.1.4 T5 Flush Volume Measurements

Because of concern that the approach to measuring flush volume in the original survey may have introduced systematic bias in the flush volume estimates, a sub-sample of toilets was randomly selected for re-measurement using a T5 flushmeter.[30] T5 measurements were made on 59 randomly selected toilets and the results were compared to the original flush volume estimates. Figure 10 shows a plot of the T5 measurements against the original volume estimates. Regression analysis of the data indicated that the discrepancy between the two measurements is largely random. The analysis did not suggest that the original survey methodology for estimating flush volume was biased. The T5 analysis also showed

- When toilets are categorized by period of manufacture, the two measurement approaches yield similar average flush volumes for the categories. This is shown in Table 8. For example, the average flush volume of toilets manufactured after 1993 is about 2.2 gallons for each measurement approach. Average flush volumes depart most for older toilets; the T5 estimates for older toilets tend to be somewhat lower than the original survey estimates.

- Flush volume for Kohler brand toilets are more likely to be mis-measured using the original survey measurement approach than other brands.

- The T5 analysis supports using 2.2 gpf as the cutoff for categorizing toilets as ULF or non-ULF.

- Most sampled toilets manufactured after 1993 flush more than 1.6 gpf. 76% of the sampled toilets manufactured after 1993 had flush volumes greater than 1.6 gpf. Toilets that actually flush 1.6 gallons are a rarity. The average flush volume for toilets manufactured after 1993 was 2.2 gpf.

Table 8. Average Flush Volume by Toilet Manufacture Year

Mfg Category	N	Average of T5 (gal)	Average of Estd. Volume (gal)
Unknown	8	2.8	2.8
Pre 1978	7	2.9	3.3
1978 to 1993	11	3.0	3.2
Post 1993	33	2.2	2.2
Grand Total	59	2.5	2.6

[30] The T5 Flushmeter was not on the market at the time the original survey was conducted. For a description of the T5 Flushmeter, see http://www.t5flushmeter.com/meter.html.

6.1.5 Measured Flush Volumes for Pre-1992 Housing Construction

Figures 7 through 10 also show the distribution and mean flush volumes for residences constructed before 1992. Figure 7 shows that approximately 42% of the toilets in single-family residences constructed before 1992 had measured flush volumes at least as small as 2.2 gpf. For multi-family residences, shown in Figure 8, the value is 31%.

These data allow an estimate of the average rate at which non-ULFT toilets are being converted to ULFT toilets in residences constructed before 1992. This is useful for projecting future residential water demand for the County. If we assume that 100% of toilets in 1991 were non-ULFT and note that over the past eleven years 40% of the single-family and 30% of multi-family toilets have been converted to ULFTs, the average annual rate of replacement would be 3.6% per year for single-family residences and 2.7% per year for multi-family residences.

The assumption that 100% of the toilets in 1991 were non-ULFT is obviously wrong. By 1991 ULFTs had been in the market for several years and undoubtedly some toilets had been converted before 1991. However, the market penetration of ULFTs in 1991 was not extensive and it is very unlikely that more than 5% of installed toilets were ULFTs in 1991. Adopting the assumption that 95% of the toilets in 1991 were non-ULFT yields average annual rates of replacement for single- and multi-family residences constructed before 1992 of 3.2% and 2.3%, respectively.

These two estimates provide plausible lower and upper bounds for the average annual rates of toilet replacement over the period 1992-2002.

Table 9 shows the measured penetration of ULFTs and the calculated average annual rate of replacement of toilets in pre-1992 housing for Santa Clara County. The table also compares these results to estimates for Orange County and East Bay Municipal Utility District (EBMUD)[31] obtained by similar survey research. In broad terms, Table 9 suggests that for the regions studied between 34% and 50% of the toilets in pre-1992 single-family housing are ULFTs, and for multi-family housing the range is currently between 30% and 40%. Over the past decade annual rates of replacement have averaged around 4% for single-family residences and 3.5% for multi-family housing. Rates of replacement appear to be higher in Orange County than in either Santa Clara County or EBMUD's service area (which encompasses parts of Alameda and Contra Costa Counties).

[31] EBMUD's service area covers much of Alameda and Contra Costa Counties.

Table 9. Percent ULFTs in Pre-1992 Housing: Comparative Results from Three Studies

REGION	% ULFTS IN PRE-1992 HOUSING		AVG. ANN. REPLACEMENT RATE [1]	
	Single-family	Multi-family	Single-family	Multi-family
Santa Clara Co. [2]	42%	31%	3.6%	2.3%
EBMUD [3]	34%	37%	2.5%	3.3-3.5%
Orange Co. [4]	49%	38%	5.4%	4.2%

Notes:
1. Average annual rate of replacement estimates based on assumption that 100% of toilets in 1991 were non-ULFT. Therefore estimates should be viewed as upper-bound estimates.
2. Through 2002
3. Through 2001
4. Through 2000

Sources for Orange Co. and EBMUD are Metropolitan Water District of Southern California, et al. (2002) and East Bay Municipal Utility District (2002)

6.1.6 Toilet Leaks

The prevalence of toilet leaks is shown in Table 10. It is clear that toilet leaks constitute a potentially significant source of water loss. Based on this data, planning studies may assume that between 5% and 10% of toilets in the County leak. According to data in California Urban Water Conservation Council (2000b), a typical toilet leak rate is 8 gallons per day (gpd). The data in Tables 6 and 7 indicate there are approximately 853,000 toilets in single-family housing and 246,000 toilets in multi-family housing. Thus, leaking single-family toilets may account for up to 535 AFY of residential water use in Santa Clara County. Similarly, leaking multi-family toilets may account for 198 AFY of residential water use. Malfunctioning flappers are assumed to be the principle cause of toilet leaks.

Table 10. Percent of Inspected Toilets with Leaks

	SINGLE-FAMILY	MULTI-FAMILY
% of inspected toilet with leaks	7.2%	8.3%
Potential Annual Loss (AFY)	535 AFY	198 AFY

6.1.7 Reasons for Toilet Replacement

For each toilet inspected, the household was asked if it had been replaced since 1991. Those answering yes were then asked the primary reason for replacing the toilet. Table 11 shows the results of this question sequence. It is clear from Table 11 that the dominant reason for replacing a toilet is bathroom remodeling. The second most common reason is to replace a broken toilet. Saving water and

participating in utility ULFT programs are third and fourth, respectively. Table 11, however, should not be interpreted as a measure of utility program participation. It is possible that those replacing a broken toilet or remodeling a bathroom also participated in a utility program, but did not state such participation as the primary reason for replacing the toilet. Therefore, utility program participation could be higher than indicated by Table 11.

By the same token, however, Table 11 suggests utility toilet programs in Santa Clara County could be plagued with program free-riders. A program free-rider is a program participant that would have replaced their toilet with or without the program. In effect, they do not help the program produce water savings because the same savings would have occurred in the absence of the program. Households with broken toilets are prime candidates for program free-ridership. If a toilet is broken to the extent that it significantly compromises its function it is highly likely the household will replace the toilet. If participating in a utility ULFT program can lower the cost of toilet replacement simple self-interest will push such households to these programs. For the same reason, households in the market for a new toilet because they are remodeling a bathroom are also likely ULFT program participants.

Table 11. Reasons Stated by Households for Toilet Replacements Occurring Since 1991

REASON FOR REPLACEMENT	% OF TOILETS
Remodel	67%
Broken	15%
Save water	9%
Utility program	3%
Unknown	6%
Total	100%

6.1.8 Future Potential Water Savings from Toilets

The data on housing demographics and toilet characteristics can be combined to estimate potential reductions in residential water use assuming the remaining non-ULFT toilets in pre-1992 housing were converted to ULFT toilets. From Table 6 we note that 92% of the single-family housing units in Santa Clara County were constructed before 1992. For multi-family housing, the figure is 83%. Multiplying these percentages by the total housing units shown in Table 6 gives an estimate of total housing units built before 1992. Total toilets in pre-1992 housing are determined by multiplying housing units by the average number of toilets per household listed in Table 7. To get the number of non-ULFT toilets we multiply the total number of toilets by the percent of non-ULFT toilets shown in Table 8. Water savings per toilet are calculated using the toilet water savings estimates in Exhibit 6 of California Urban Water Conservation Council (2000b). The last step is to multiply the count of non-ULFT toilets by the water

savings per toilet and then convert the result to acre-feet per year (AFY). These calculations are shown in Table 12.

Table 12. ULFT Water Savings Potential for Santa Clara County

	SINGLE-FAMILY	MULTI-FAMILY
Total housing units	371,052	175,785
% built before 1992	92%	83%
Pre-1992 housing units	341,368	145,902
Avg. toilets per household	2.3	1.4
Total toilets in pre-1992 housing	785,146	204,263
% non-ULFT	58%	69%
Non-ULFTs in pre-1992 housing	455,385	140,941
Savings per ULFT[1]	19.4 GPD	35.9 GPD
Remaining ULFT Savings Potential[2]	9,890 AFY	5,671 AFY

Notes:
1. Estimated savings per day are from CUWCC (2000a)
2. Calculation uses the conversion 1 AF = 325,900 gallons.

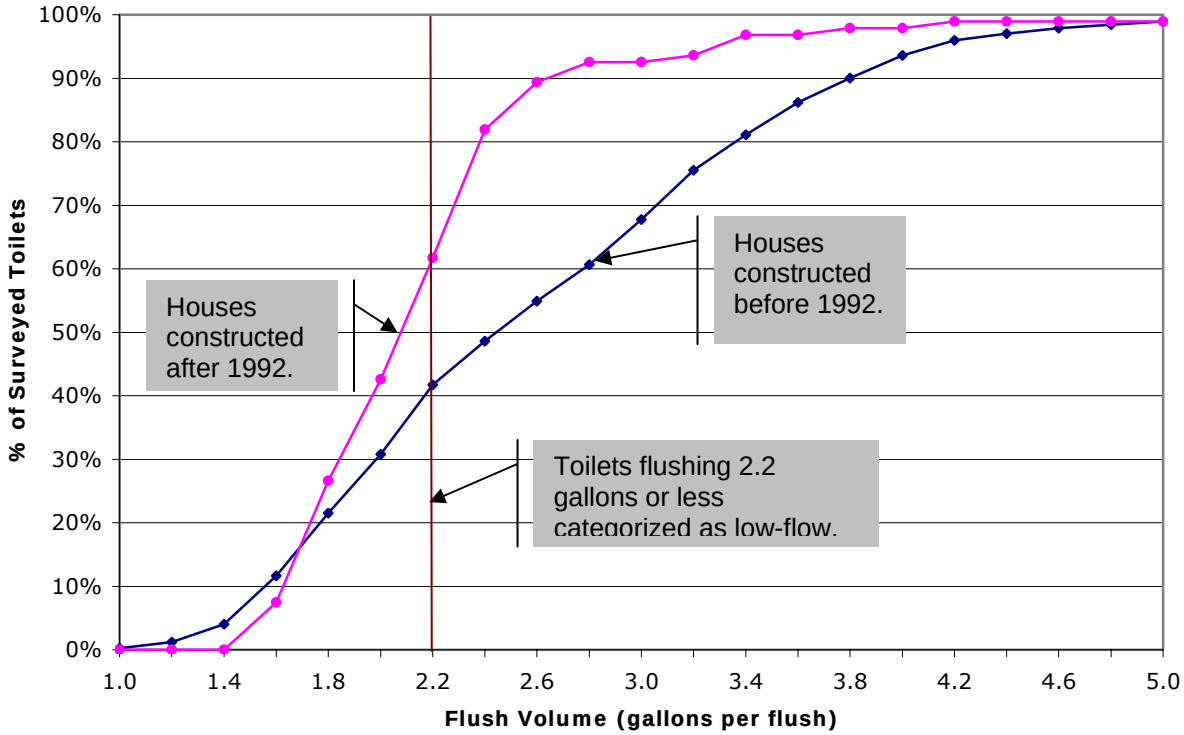


Figure 7. Cumulative Distribution of Calculated Toilet Flush Volume: Single-Family Residences

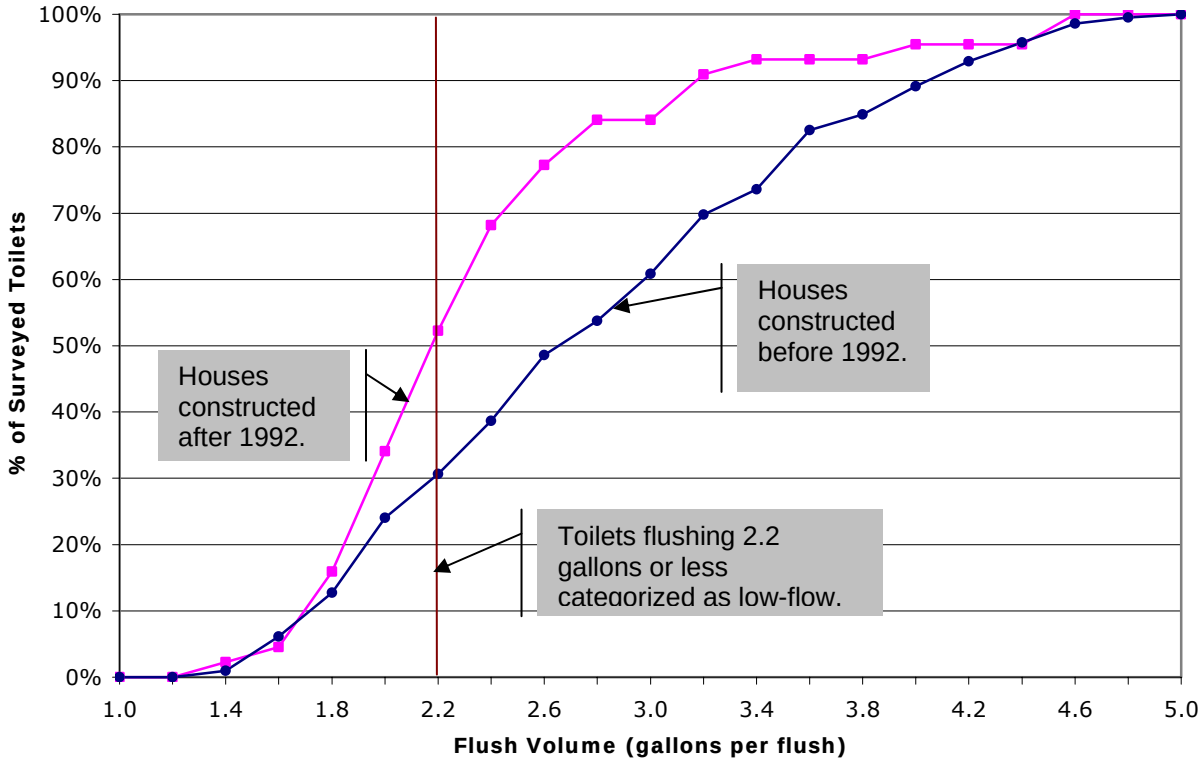


Figure 8. Cumulative Distribution of Calculated Toilet Flush Volume: Multi-Family Residences

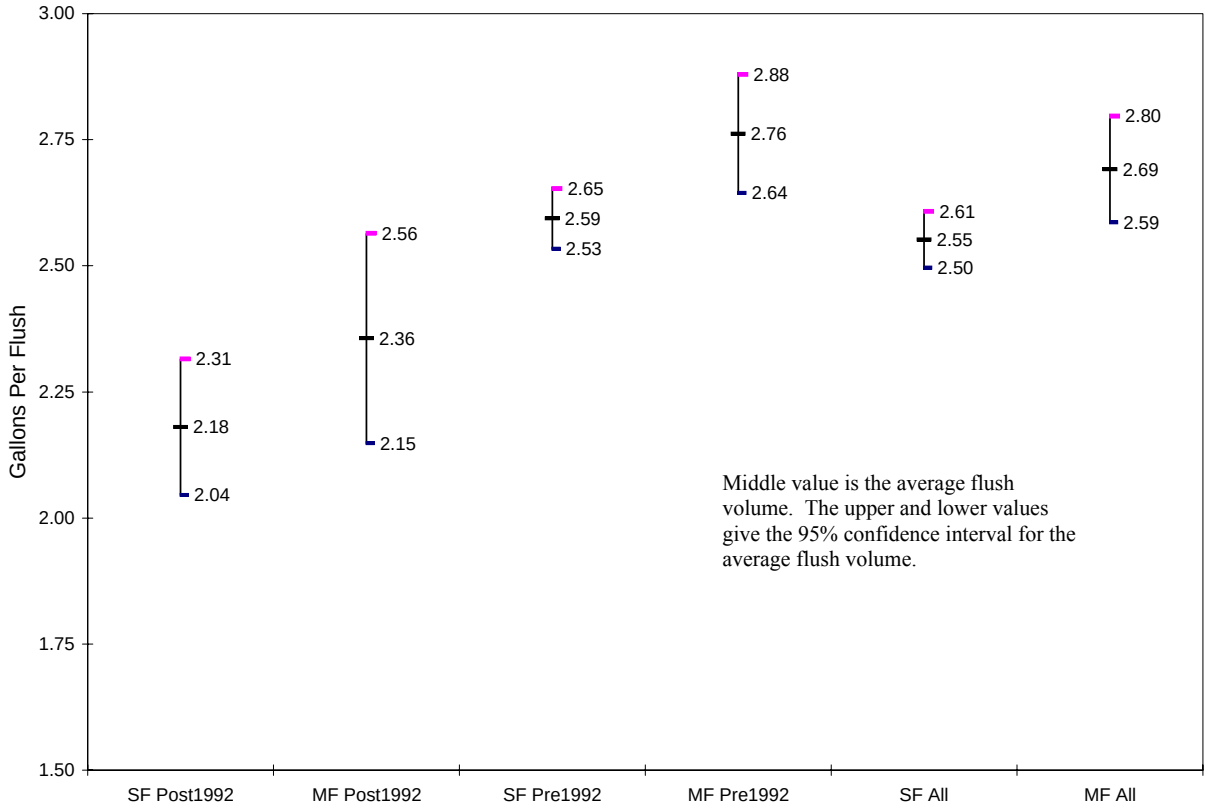


Figure 9. Average Flush Volume by Residential Classification

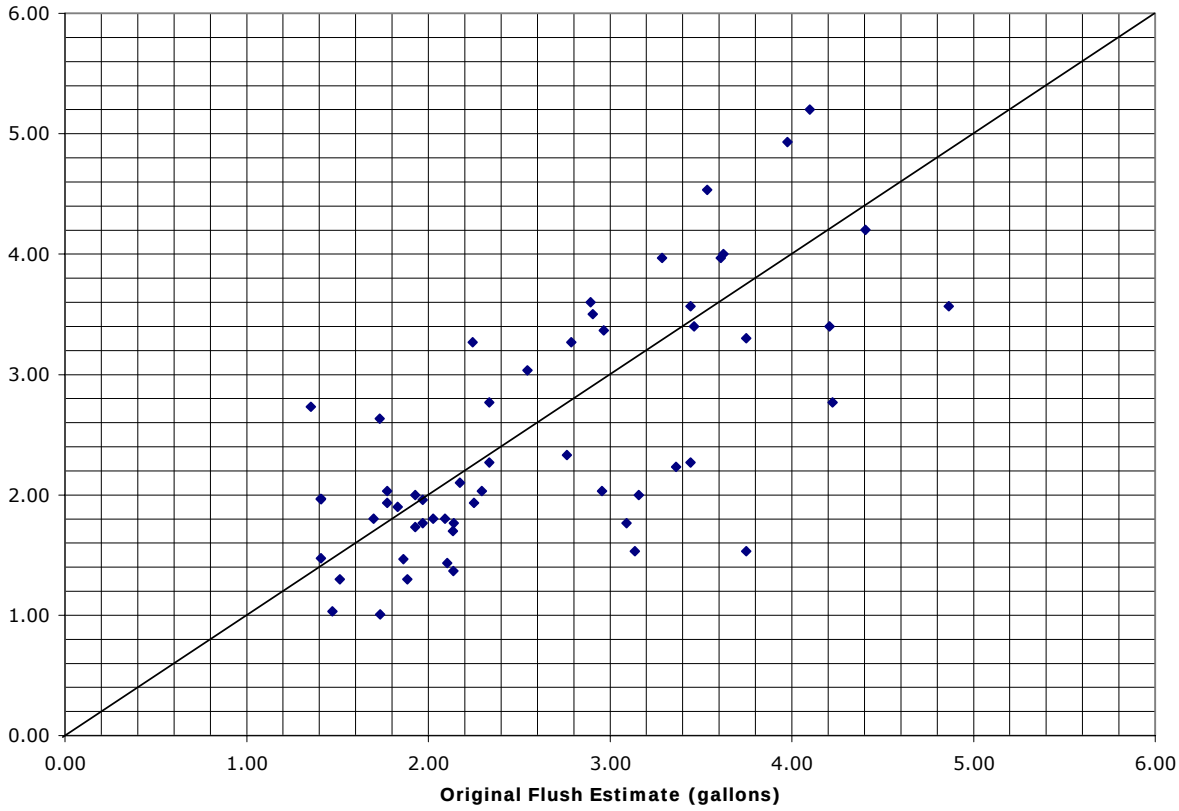


Figure 10. T5 and Original Survey Flush Volume Estimates

6.2 Showers

6.2.1 Mean Showers per Household

Table 13 shows the mean number of showerheads per household for single- and multi-family residences. The table also shows the 95% confidence interval for the mean number of showerheads.

Table 13. Mean Number of Showerheads by Type of Residence

	SINGLE-FAMILY	MULTI-FAMILY
Mean # Showerheads	1.5	1.1
Sample Size	410	187
95% CI of Mean	± 0.05	± 0.05

6.2.2 Measured Showerhead Flow Rates for Single- and Multi-Family Residences

Figures 11 and 12 show the distribution of measured showerhead flow rates for single- and multi-family residences, respectively. As for toilets, the figures divide the sample between housing units constructed before 1992 and those constructed after to account for the 1992 change in the plumbing code requiring only the installation and retail sale of showerheads rated 2.5 gallons per minute (gpm) or less.

Figure 11 shows that approximately 80% of the showerheads in single-family residences constructed in 1992 or after had measured flow rates at least as small as 2.5 gpm, whereas for single-family units constructed before 1992 only 60% of the showerheads had flow rates of 2.5 gpm or less. Figure 12 shows a similar comparison for multi-family housing units. In this figure it is seen that slightly less than 60% of the showerheads in multi-family housing units built after 1991 had flow rates of 2.5 gpm or less while approximately 50% of the units built before 1992 had flow rates this low.

Because of the 1992 change in the plumbing code there was the expectation that a large majority of showerheads in housing units built after 1991 would have flow rates of 2.5 gpm or less. Figure 11 shows that this is largely the case for single-family housing. For multi-family housing, however, the proportion of showerheads with flow rates of 2.5 gpm or less in housing units built after 1991 is lower than expected – slightly less than 60%. There are several possible explanations:

- Showerhead flow rates are sensitive to water pressure levels. High water pressure could increase measured flow rates beyond the showerhead rating. Thus there could be a marked difference between the showerhead's rating and its actual performance.
- Showerheads with flow ratings of 2.5 gpm or less are being replaced with showerheads with higher flow rates, or the low-flow showerheads are being tampered with to allow higher flow

rates. Evidence from the District's Water Wise House Calls survey program suggests this is happening to some extent.

6.2.3 Saturation of Low-Flow Showerheads in Pre-1992 Housing Units

The proportion of showerheads in pre-1992 housing with flow rates of 2.5 gpm or less is a key question for implementation of Best Management Practice 2 under the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU). Water suppliers implementing BMP 2 are required by the MOU to continue showerhead distribution programs unless they can show that the proportion of showerheads with flow ratings of 2.5 gpm or less in pre-1992 housing is at least 75%. The MOU specifies a statistical test by which this can be judged. The statistical test requires the water supplier to construct a 95% confidence interval around the percent of showerheads rated 2.5 gpm or less with a margin of error of ±10%. Showerhead rating is frequently not observable on the showerhead at the time of inspection. Typically to enact this test the showerhead flow measurement is used as a proxy for the rating (Metropolitan Water District of Southern California, et al., 2002).

Table 14 shows the 95% confidence intervals for the proportion of showerheads in housing constructed prior to 1992 with flow measurements of 2.5 gpm or less. In the table two different 95% confidence intervals are given. The first is based on the full sample of showerheads, which results in a smaller margin of error than specified by the MOU test. The second is based on 97 randomly selected sample observations, which results in a 10% margin of error, as specified by the test. In both cases, however, the hypothesis that at least 75% of the showerheads in pre-1992 housing have flow rates of 2.5 gpm or less is rejected.

Table 14. 95% Confidence Intervals for Proportion of Showerheads in Pre-1992 Construction with Measured Flow Rates of 2.5 GPM or Less

	MARGIN OF ERROR BASED ON FULL SAMPLE		±10 % MARGIN OF ERROR	
	Lower	Upper	Lower	Upper
Single-Family	55%	62%	48%	68%
Multi-Family	44%	57%	45%	65%

Table 15 compares low-flow showerhead saturation rates measured in Santa Clara to estimates for Orange County and East Bay Municipal Utility District (EBMUD)[32] obtained by similar survey research.

[32] EBMUD's service area covers much of Alameda and Contra Costa Counties.

Table 15. Percent Low-flow Showerheads in Pre-1992 Housing: Comparative Results from Three Studies

REGION	% SHOWERHEADS IN PRE-1992 HOUSING WITH FLOW ≤ 2.5 GPM	
	Single-family	Multi-family
Santa Clara County [1]	59%	51%
EBMUD [2]	67%	64%
Orange County [3]	67%	60%

Notes:
1. Through 2002; mid point of ranges shown in Table 14.
2. Through 2001
3. Through 2000

Sources for Orange Co. and EBMUD are Metropolitan Water District of Southern California, et al. (2002) and East Bay Municipal Utility District (2002)

The low-flow showerhead saturation data imply an average showerhead replacement rate for pre-1992 housing stock of about 8.5%/yr for single-family households and about 6.9%/yr for multi-family households in Santa Clara County. At these rates, the region will reach the 75% coverage requirement by around 2006 for single-family households, and by around 2010 for multi-family households.

6.2.4 Showerhead & Showerhead Diverter Leaks

Of the 1,072 showerheads inspected for this study, only 1.6% had measurable leaks. The distribution of leaks for inspected showerheads is shown in Table 16.

Table 16. Distribution of Showerhead Leaks

LEAK RATE (GALLONS PER DAY)	% OF INSPECTED SHOWERHEADS
No Measurable Leak	98.4%
≤ 10 GPD	0.8%
10.1 - 50 GPD	0.4%
50.1 - 100 GPD	0.0%
> 100 GPD	0.4%
Total	100.0%

Showerhead diverter leaks are more common than showerhead leaks. Approximately 9% of the inspected bathtubs with showerhead diverters leaked water.

6.2.5 Future Potential Water Savings From Showerheads

Future potential water savings from converting remaining high-flow showerheads in pre-1992 housing units to low-flow showerheads rated 2.5 gpm or less is shown in Table 17. These estimates were developed in the same manner as those for toilets in Table 12. Water savings per showerhead are from California Urban Water Conservation Council (2000b).

Table 17. Low-flow Showerhead Water Savings Potential for Santa Clara County

	SINGLE-FAMILY	MULTI-FAMILY
Total housing units	371,052	175,785
% built before 1992	92%	83%
Pre-1992 housing units	341,368	145,902
Avg. showers per household	1.5	1.1
Total showers in pre-1992 housing	512,052	160,492
% with flow rates > 2.5 gpm	41%	49%
High-flow Showerheads in pre-1992 housing	209,941	78,641
Savings per Low-Flow Showerhead[1]	5.5 GPD	5.2 GPD
Remaining Showerhead Savings Potential[2]	1,293 AFY	458 AFY

Notes:
1. Estimated savings per day are from CUWCC (2000b)
2. Calculation uses the conversion 1 AF = 325,900 gallons.

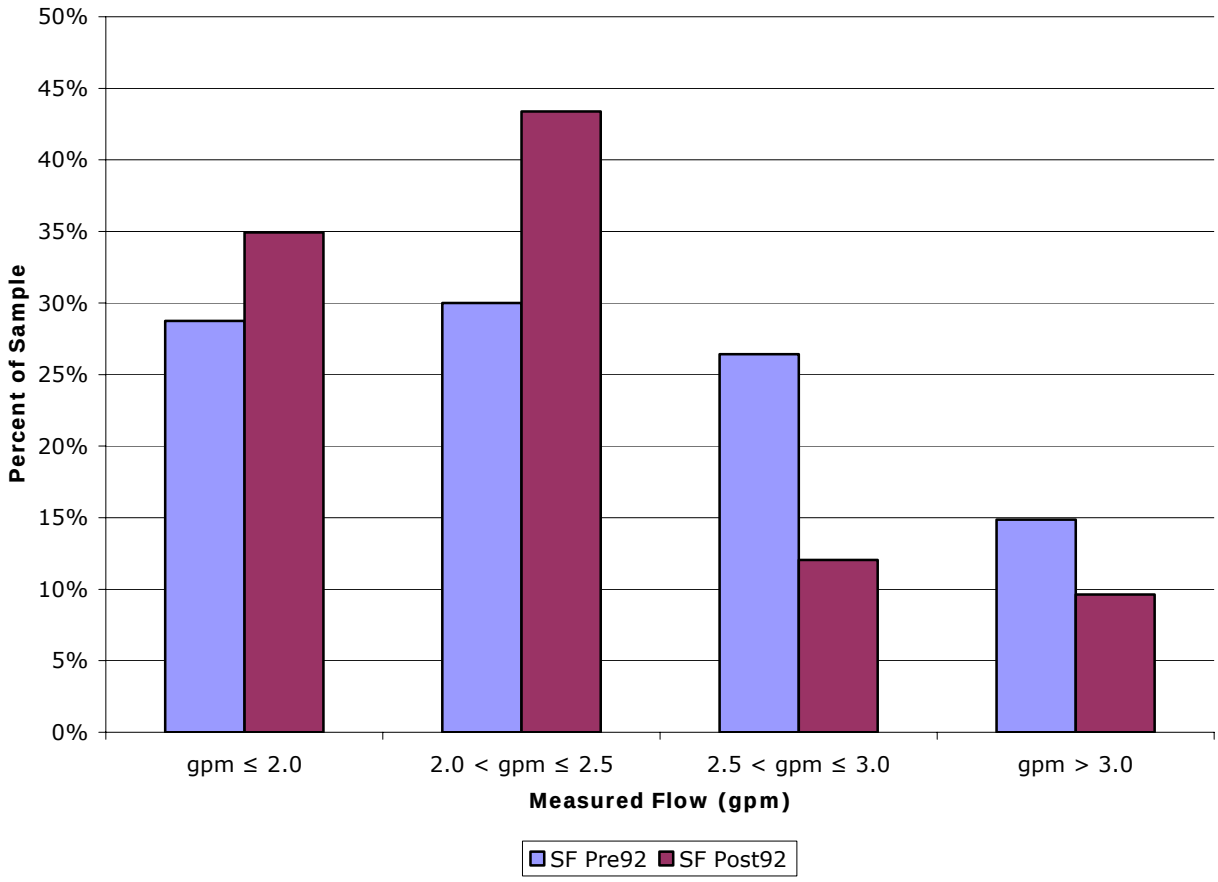


Figure 11. Distribution of Showerhead Flow Rates: Single-Family Residences

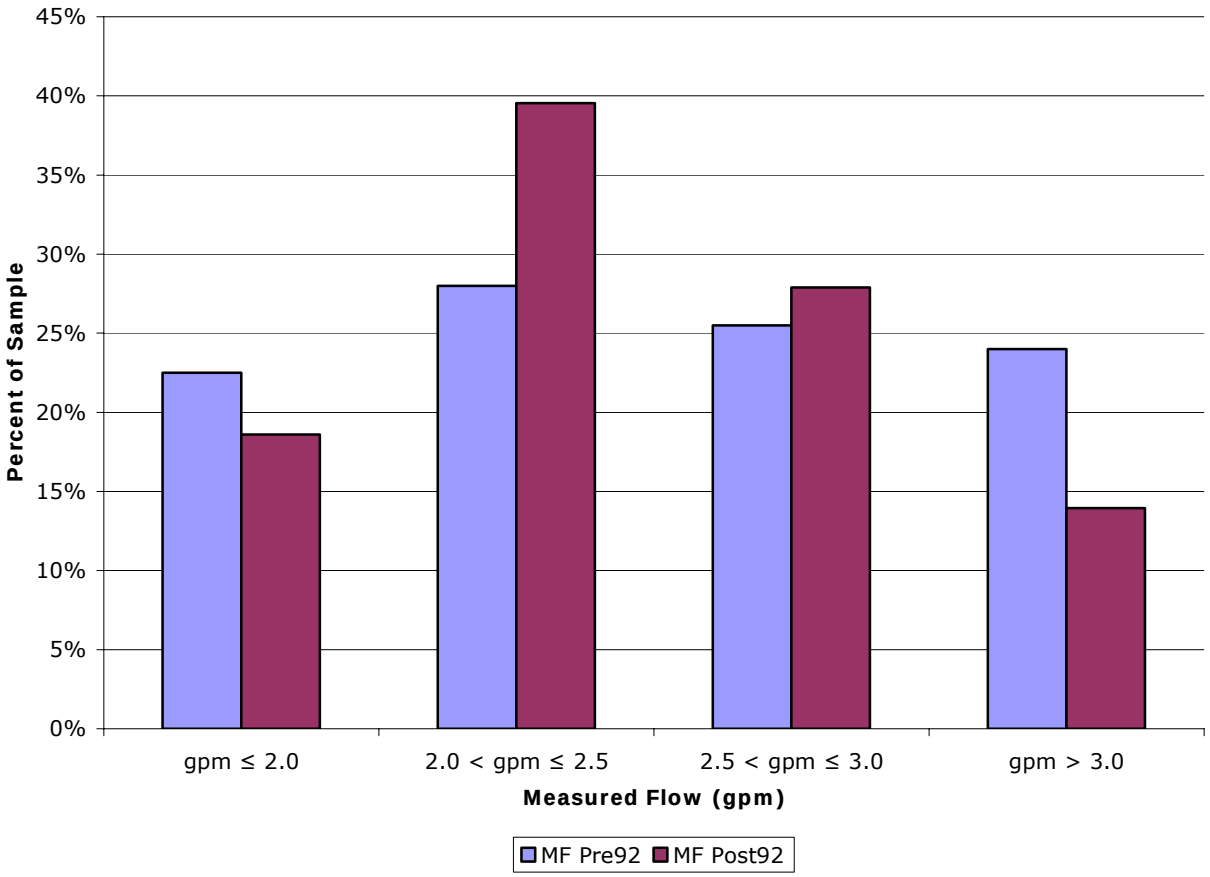


Figure 12. Distribution of Showerhead Flow Rates: Multi-Family Residences

6.3 Faucets

6.3.1 Mean Faucets per Household

Table 18 shows the mean number of faucets per household for single- and multi-family residences. The table also shows the 95% confidence interval for the mean number of faucets.

Table 18. Mean Number of Faucets by Type of Residence

	SINGLE-FAMILY	MULTI-FAMILY
Mean # Faucets	3.7	2.4
Sample Size	410	187
95% CI of Mean	± 0.1	± 0.1

6.3.2 Presence of Aerators

Table 19 lists the percent of faucets fitted with aerators for single- and multi-family residences.

Table 19. Prevalence of Faucets Fitted with Aerators

	SINGLE-FAMILY	MULTI-FAMILY
% of Faucets	93.6%	94.9%
Sample Size (faucets)	1504	450

6.3.3 Faucet Flow Rates

Table 20 shows the average measured flow rate in gallons per minute for sampled faucets for single- and multi-family residences. The table also shows the 95% confidence interval for the mean flow rate.

Table 20. Mean Faucet Flow Rate (GPM) by Type of Residence

	SINGLE-FAMILY	MULTI-FAMILY
Mean Flow Rate (GPM)	2.06	2.2
Sample Size	1,504	450
95% CI of Mean	± 0.04	± 0.12

The distribution of faucet flow rates for single- and multi-family houses is shown in Figure 13. The figure clearly shows there is no appreciable difference in the dispersion of faucet flow rates between single- and multi-family housing.

6.3.4 Faucet Leaks

The study inspected 2,009 faucets. Of these, 99.6% did not have measurable leaks.

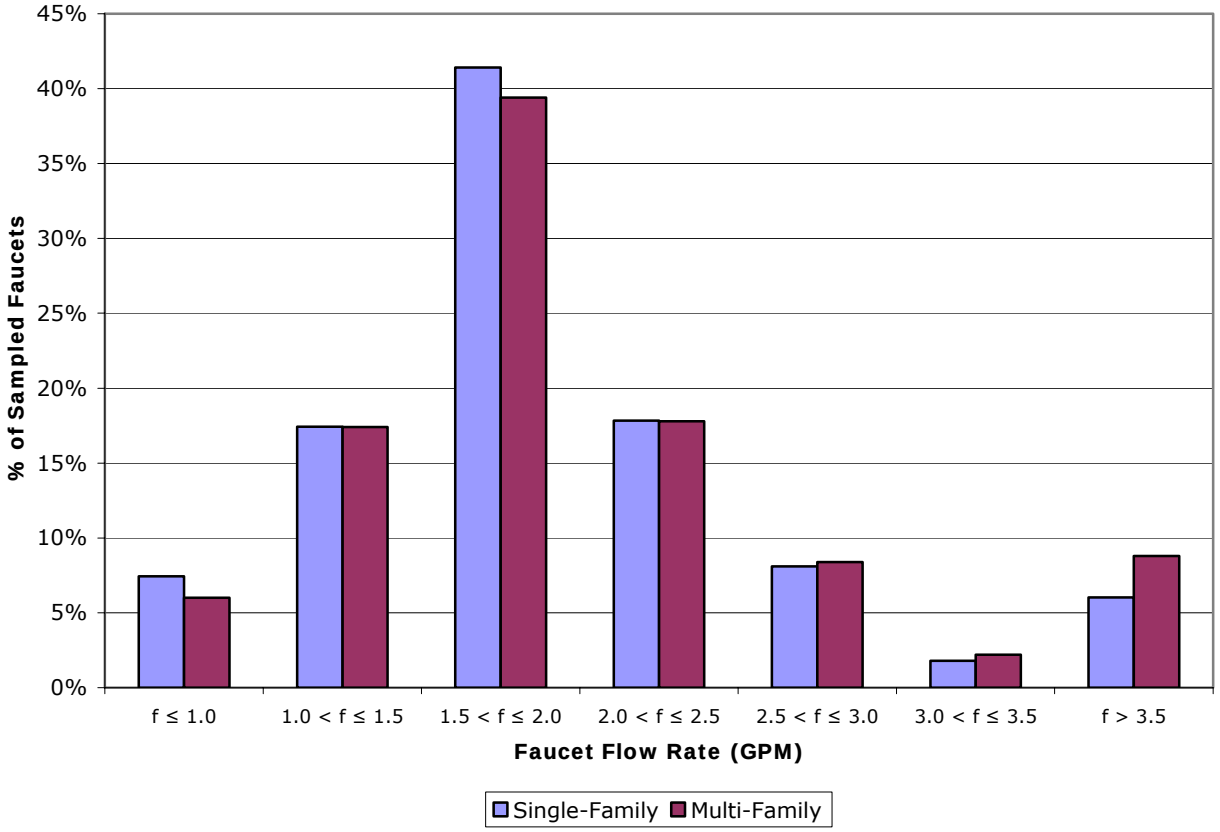


Figure 13. Distribution of Faucet Flow Rates (GPM) By Type of Residence

6.4 Clothes Washers

6.4.1 Clothes Washer Ownership by Housing Category

Table 21 shows the percent of surveyed households either owning a clothes washer, having access to a shared washer on premise, or having no washer on premise. The proportions are similar to those measured in other recent studies of residential water-using appliances (East Bay Municipal Utility District 2002; Metropolitan Water District of Southern California, et al. 2002).

Table 21. Proportion of Households with Clothes Washer on Premise by Type of Residence

	SINGLE-FAMILY	MULTI-FAMILY
Own Clothes Washer	97%	32%
Shared Clothes Washer	0.7%	64.2%
No Clothes Washer	2.7%	4.3%
Sample Size	410	187

6.4.2 Energy Star or Front-loading Clothes Washers

Table 22 shows the proportion of clothes washers in the sample identified as Energy Star or front-loading clothes washers. It should be noted that water use efficiency for Energy Star and front-loading clothes washer models can widely vary. While Energy Star and front-loading models in general use less water per load of laundry than conventional vertical-axis clothes washers, this study made no attempt to measure efficiency differences in the models sampled.

Table 22. Proportion of Washers that are Energy Star or Front-loading by Type of Residence

	SINGLE-FAMILY	MULTI-FAMILY
% Energy Star or Front-loading		
Owned (in-unit)	25.5%	29.3%
Shared (on-premise)	Insufficient Observations to Calc.	44.0%
Sample Size	399	179

6.4.3 Potential Water Savings from Existing Conventional Clothes Washers

To calculate water savings potential of high-efficiency clothes washers in Santa Clara County the following results from empirical studies were used to determine average water savings per washer in single-family, in-unit multi-family, and shared (common area) multi-family settings. In each case, water savings estimates were derived from field-based studies using controlled data collection on laundry practices and machine operation over long time periods.

- Single-family - California Urban Water Conservation Council (2000b) estimates that the typical high-efficiency clothes washer will use 5,250 gallons less water per year than a

conventional washer in a single-family residence. The empirical basis for this estimate is reported in M.Cubed (2000).

- Multi-family In-unit - Water savings associated with high-efficiency clothes washers for in-unit multi-family housing settings were evaluated by Oak Ridge National Laboratories (2001). This study estimated that an in-unit high-efficiency clothes washer used, on average, 2,037 gallons less water per year than a conventional washer.
- Multi-family Shared (common area) – Two analyses of water savings of high-efficiency clothes washers in common area settings have been conducted by Battelle Pacific Northwest Laboratory (BPNL) (2000a; 2000b). The first study by BPNL was conducted at Fort Hood, Texas, using common laundry facilities for three barracks. This study estimated average annual water savings of 38,780 gallons/machine/year. The second study was located in a multi-family complex called Leisure World in Laguna Woods, California. In this study three different high-efficiency washer models were tested. Water savings ranged between 8,430 and 18,070 gallons/machine/year. Two of the models tested significantly outperformed the third. The average savings for the two high-performers was 17,425 gallons/machine/year whereas savings for the low-performer was 8,430 gallons/year/machine. The simple average for all three tested machines is 14,427, gallons/year/machine. The results from the Fort Hood study represent a unique setting that is not generally reflective of urban or suburban multi-family settings. The findings from the Leisure World study are considered to better reflect multi-family conditions in Santa Clara County. Moreover, it is useful that the Leisure World study contained a mixture of lower and higher performing high-efficiency machines. As discussed previously, water savings can vary widely across Energy Star and front-loading washer brands. Because the Residential Baseline Study did not directly measure water use efficiency of the washers inspected but only recorded if they were Energy Star or front-loading, a prudent water savings assumption is to use the average savings of 14,427 gallons/year/machine for the three machines tested in the Leisure World Study.

To calculate residential clothes washer waters savings potential it is also necessary to have an estimate of the number of conventional washers still in use in Santa Clara County. For single-family housing units this is easily obtained from the information in Tables 6 and 22. For multi-family housing units the calculation requires estimating the average number of in-unit and shared washers per housing unit. The average number of in-unit washers can be calculated from Table 22 and is 0.316. The average number of shared washers per housing unit was calculated by dividing the total number of shared washers reported in the sample by the total number of multi-family housing units associated with these shared

washers and then adjusting this estimate to account for the percentage of multi-family housing units that do not have access to an on-premise washer. This produced an estimate of 0.059 washers per multi-family housing unit.

Using the above information, Table 23 computes the clothes washer water savings potential for Santa Clara County assuming the existing population of non-Energy Star and non-Front-loading washers were replaced with high-efficiency models. It is important to note that the estimates in Table 23 only account for savings potential associated with existing washers. It does not account for potential savings associated with new washers installed in the region to accommodate population growth.

Table 23. High-efficiency Washing Machine Water Savings Potential for Santa Clara County

	SINGLE-FAMILY	MULTI-FAMILY
Total housing units[1]	371,052	175,785
% with In-unit Washers[2]	97%	32%
Total In-unit Washers	359,992	56,251
% Conventional (low-efficiency)	74.5%	70.7%
Total Conventional Washers	268,141	39,769
Savings per Washing Machine[3]	5,250 GPY	2,037 GPY
In-unit Savings Potential	4,320 AFY	249 AFY
Shared Clothes Washers	NA	
Avg. Washers per Housing Unit[4]	NA	0.06
Total Shared Washers	NA	10,547
% Conventional (low-efficiency)[5]	NA	56%
Total Shared Conventional Washers	NA	5,906
Savings per Washing Machine[6]	NA	14,427 GPY
Shared Washer Savings Potential	NA	262 AFY
Total Washing Machine Savings Potential	4,320 AFY	511 AFY

Notes:
The sample included only 3 instances of single-family residences with shared washers. This prevented analysis of shared savings potential for single-family residences. Given the very low percentage of single-family housing with a shared washer it is not thought that this potential would amount to more than a few AF per year.

1. Census 2000 Summary File 3.
2. Derived from on-site sample data.
3. For single-family source is M.Cubed (2000); for multi-family source is Oak Ridge National Laboratories (2001)
4. Derived from on-site sample data
5. Derived from on-site sample data
6. Savings estimate for shared washers from Battelle Pacific Northwest Laboratory (BPNL) (2000a; 2000b)

6.5 Other Indoor Appliances

6.5.1 Dishwashers

Table 24 lists the proportion of sampled households with dishwashers and the average number of dishwasher loads per week.

Table 24. Proportion of Households with In-Unit Dishwasher by Type of Residence

	SINGLE-FAMILY	MULTI-FAMILY
% with a Dishwasher	87%	70%
Sample Size	410	187
95% CI of Mean	± 3.2%	± 6.6%
Average Loads Per Week	3.3	2.4

Notes:
1. Average dishwasher loads per week is based on estimated loads per week reported by survey respondents.

6.5.2 Water Softeners

The proportion of sampled households with water softeners is shown in Table 25. The table also indicates the proportion of water softeners that are self-regenerating models.

Table 25. Proportion of Households with Water Softeners by Type of Residence

	SINGLE-FAMILY	MULTI-FAMILY
% with a Water Softener	17%	3%
Sample Size	410	187
95% CI of Mean	± 3.6%	± 2.3%
% Self-regenerating	71.4%	40.0%

7. Residential Outdoor Water Use Characteristics

The outdoor portion of the on-site inspection cataloged a variety of information related to residential outdoor water use. This included:

- Presence of pools and spas;
- Presence of pressure reduction valves;
- Size of landscaped area;
- Type of plants in landscaped area;
- Presence and type of irrigation system; and
- Performance and efficiency of irrigation system.

Results of the outdoors inspections are summarized in the subsections that follow.[33]

7.1 Pools & Spas

Table 26 lists the proportion of surveyed households with pools and spas. The table also shows the percentage of pools and spas that have covers.

Table 26. Prevalence of Residential Pools & Spas in Santa Clara County

	SINGLE-FAMILY	MULTI-FAMILY
% with Pool	15%	26%
% with Spa	19%	20%
% of Pools with Cover	33%	4%
% of Spas with Cover	62%	13%
Sample Size	410	187

7.2 Prevalence of Pressure Reduction Valves

Table 27 shows the proportion of households with pressure reduction valves. It also indicates the average measured water pressure for systems with and without pressure reduction valves.

[33] Readers should note that outdoor water use results for multi-family refer to multi-family complexes rather than individual housing units, as was the case for indoor water use.

Table 27. Prevalence of Pressure Reduction Valves

	SINGLE-FAMILY	MULTI-FAMILY
% With Pressure Reduction Valve	27%	30%
Average Water Pressure		
Valve	69.7	62.8
No Valve	63.8	57.2
Number of Households Inspected	410	187

7.3 Landscape

7.3.1 Landscape Area

The mean total landscape area (all areas except "hardscape", such as concrete, walkways, etc.) and mean landscape area planted to turf are shown in Table 28. The sample of residential landscape area exhibits substantial dispersion, especially in the case of multi-family residences. The distribution of sampled landscape areas is shown in Figure 14. Note that in Figure 14, landscape area is expressed in acres for multi-family and square-feet for single-family residences.[34] As seen in Table 28 the large variance in measured landscape area results in wide confidence intervals around the mean.

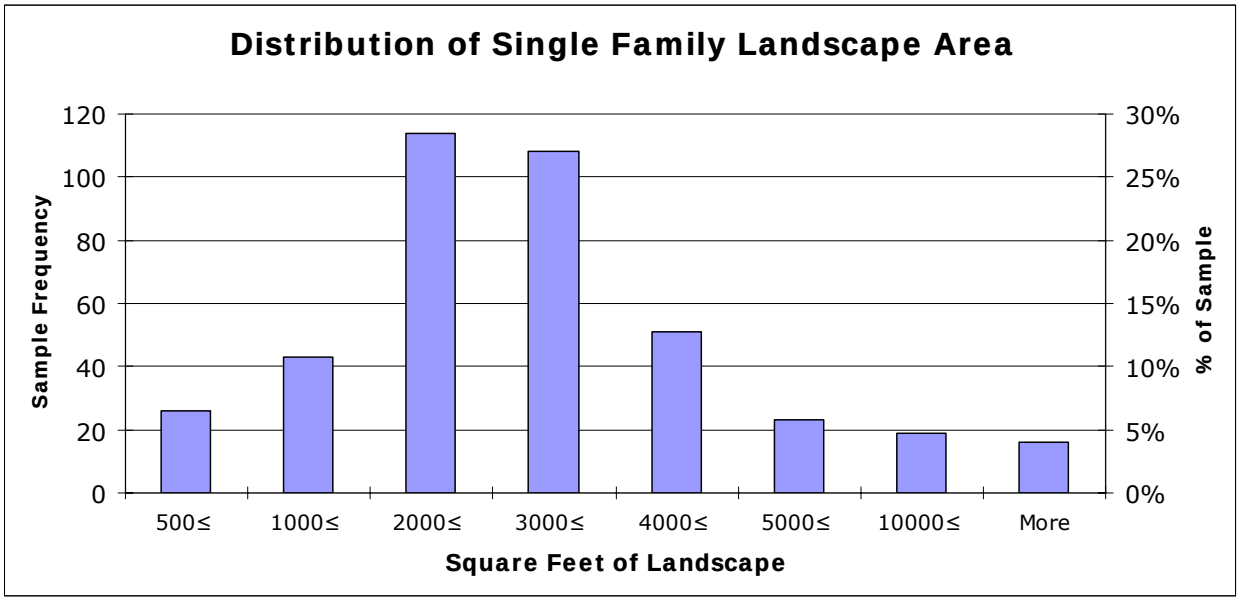
Table 28 also estimates the total residential landscape area (in acres) for Santa Clara County. To make this calculation we multiplied the upper and lower bounds for mean landscape area by the total number of residential structures with landscape in the County. Total number of residential structures in the County was estimated from Census 2000 data.[35] The proportion of residential structures with landscape was based on the sample proportions from the County survey. For single-family residences, approximately 97% had landscape while for multi-family structures approximately 79% had landscape. The same procedure was employed to calculate the total amount of residential landscape area (in acres) planted to turf.

[34] One acre is equivalent to 43,560 square-feet.

[35] Census 2000 does not directly count the number of multi-family structures. Rather it counts the total number of housing units within a structure category. The categories are 2 units, 3 to 4 units, 5 to 9 units, 10 to 19 units, 20 to 49 units, and 50 or more units. To estimate the corresponding number of structures we divided a category's number of housing units by the mid point number of units per structure in the category. For example, for housing units in structures with 3 to 4 units we divided the number of housing units by 3.5 to estimate the corresponding number of structures. For the category 50 or more units it is not possible to take a mid point. Therefore we divided the number of housing units by 50 to get an upper-bound estimate of the number of structures in this category.

Table 28. Mean Landscape Area by Housing Category

	SINGLE-FAMILY	MULTI-FAMILY COMPLEXES
% With Landscape[1]	97.3%	79.0%
Mean Landscape Area (for sites w/ landscapes)	3,681 sq. ft.	30,333 sq. ft.
95% CI of Mean	±1,040 sq. ft.	±13,391 sq. ft.
Mean Area Planted to Turf (for sites w/ landscape)	1,546 sq. ft.	6,404 sq. ft.
95% CI of area planted to turf	±258 sq. ft.	±1,929 sq. ft.
Sample Size	410	187
Est. Total Residential Landscape in County	21,891 – 40,207 acres	13,827 – 35,686 acres
Est. Total Residential Turf in County	10,676 – 14,955 acres	2,256 – 4,201 acres



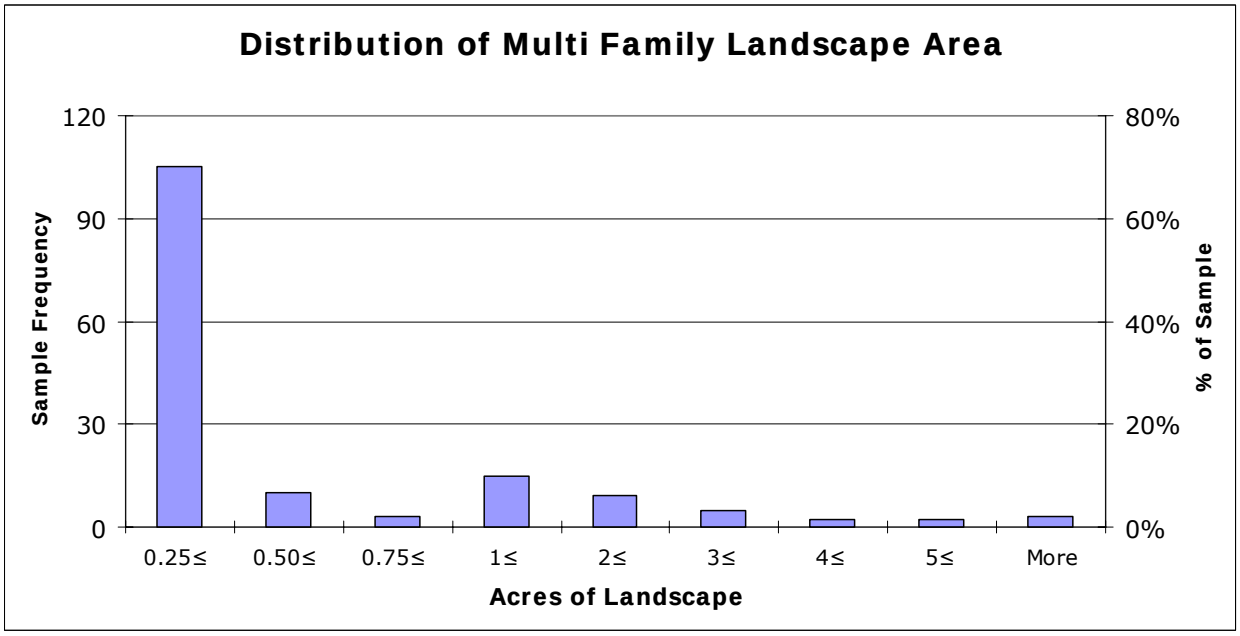


Figure 14. Distribution of Landscape Area by Housing Category

Landscape area for single-family residences does not show significant correlation with the age of the house. There is a slight upward trend in landscape area, but this is largely caused by outlier data. Likewise, while the percent of landscape area planted to turf is negatively correlated with the year the residence was built (e.g. older houses have a higher proportion of landscape area planted to turf) the correlation is slight. Neither of the correlations is large enough to provide a useful predictive relationship. The amount of variation in the data explained by the regressed variable, as indicated by the adjusted r-squares, is less than 5% in both instances.

7.3.2 Plant Types

Other than turf, landscape areas for specific types of plants were not measured during the inspections. However, the types of plants served by individual irrigation stations were recorded, as shown in Table 29. This gives some indication of the prevalence of particular plant categories in Santa Clara County residential landscapes.

Table 29. Percent of Irrigation Stations by Plant Type

	SINGLE-FAMILY	MULTI-FAMILY COMPLEXES
Cool season turf	32.2%	34.4%
Ornamental plants	16.5%	11.9%
Drought tolerant plants	14.3%	20.3%
Mixture of plants	10.0%	6.1%
Trees with mulch	9.3%	14.7%
Warm season turf	7.8%	4.0%
Ground cover	4.8%	4.3%
Dichondra plants	2.9%	3.8%
Vegetables	2.2%	0.6%

7.4 Irrigation Systems

7.4.1 Types of Irrigation Systems and Stations

The prevalence of particular types of irrigation systems used for residential landscapes in Santa Clara County is shown in Table 30. The table shows two types of information: (1) the proportion of inspected landscape sites with a given type of irrigation system; and (2) the proportion of inspected irrigation stations of a given type. A single inspected property can have more than one irrigation system. For example, part of the property could be irrigated with an in-ground system and part could be irrigated with a hose. Therefore, adding the % of Inspected Sites will total to more than 100%. Also, a single irrigation system may have multiple stations. For example, an in-ground system may have one station to irrigate lawns, one to irrigate shrubs, and one to irrigate flowers.

The data in Table 30 show that most single and multi-family sites have irrigation systems of some sort. Approximately 5% of single-family and 3% of multi-family sites had no irrigation system of any kind. The majority of residential irrigation systems are in-ground. Most of these are operated with automatic controllers. Approximately one-third of single-family residences rely on hose irrigation to some extent. Hose irrigation is less common for multi-family residences. Only 14% of inspected multi-family sites used hose systems. Drip irrigation is also more common with single-family than with multi-family irrigation systems. 23% of inspected single-family sites has drip irrigation whereas only 8% of multi-family sites did. Multi-family irrigation systems are predominantly in-ground with pop-up spray heads. Pop-up spay valves account for 80% of all irrigation stations inspected at multi-family residences.

Table 30. Types of Irrigation Systems used for Residential Landscapes

IRRIGATION SYSTEMS	SINGLE-FAMILY	MULTI-FAMILY
% of Inspected Sites[1]		
No Irrigation System	5%	3%
Hose Irrigation	34%	14%
Manual In-Ground	18%	16%
Automatic In-Ground	61%	71%
Manual Drip	4%	2%
Automatic Drip	19%	6%
Number of Landscapes Inspected	394	136
Avg. # Stations per System	5.2	7.8
IRRIGATION STATIONS[2]		
Pop-up	66%	80%
Drip	12%	3%
Rotor	7%	6%
Microspray	7%	3%
Hose	5.0%	4.7%
Hose with sprinkler	2.4%	0.7%
Impact	1.4%	1.7%
Bubbler	0.8%	1.2%
Number of Stations Inspected	1,478	423

Notes:
1. Sites with irrigation systems may have more than one. Therefore the sum of % of Inspected Sites exceeds 100%.
2. An irrigation system may have multiple irrigation stations. For example, an in-ground system may have a station for a front lawn, a station for a back lawn, and a station for shrubs.

7.4.2 Irrigation System Performance

Irrigation system performance was evaluated in three ways.

- First, problems with irrigation system design and operation were noted and recorded;
- Second catch-can tests were used to assess system distribution uniformity (DU) [36]; and
- Third, catch-can tests were used to assess system precipitation rate (PR).[37]

[36] Distribution uniformity (DU) measures how evenly water is applied by the irrigation system. DU is typically used in landscape audits to assess irrigation system performance. DU = Average catch in the low quartile x 100 / Average catch overall. To implement the test catch-can readings are ranked from low to high. The average of the lowest 25 percent of the catch-can readings is then computed and divided by the average of all the catch-can readings. The result is multiplied by 100 to express it as a percentage.

[37] Precipitation rate refers to the amount of water a sprinkler head delivers over a period of time, generally given in "inches per hour."

Table 31 shows the prevalence of sprinkler system design and operation problems for single- and multi-family residences. Note that the percentages in Table 31 add to more than 100% because an individual irrigation station could have had more than one problem identified. The last row of the table shows the average number of problems identified per irrigation station. Several observations from Table 31 suggest themselves:

- It is quite common for residential sprinkler systems to fall into some amount of disrepair. Single-family residences averaged about 1.9 problems per sprinkler station while multi-family residences averaged about 1.5.
- Overall, sprinkler systems for multi-family residences appear to be better designed and/or maintained than do single-family systems. Multi-family sprinkler stations had 21% fewer identified problems (1.5 problems per station compared to 1.9). The difference cannot be explained by sampling error alone. One explanation for the difference is that a greater proportion of multi-family irrigation systems are professionally installed. Moreover, the County survey clearly show that multi-family residences with landscaping are more likely to use a professional landscape maintenance service than are single-family residences: 66% of surveyed multi-family residences compared to only 22% of single-family residences. These two factors likely contribute to the difference. Nonetheless, as will be seen in Tables 33, 34, and 35, other measures of system performance do not suggest that multi-family systems perform better than single-family systems. If anything, they suggest the opposite.
- Overspray is the predominant problem for both single- and multi-family sprinkler systems. 49% of sprinkler stations in single-family residences had overspray problems. For multi-family the problem was less prevalent (35% of sprinkler stations) but still significant when compared to other identified problems.

Table 31. Prevalence of Sprinkler System Design & Maintenance Problems

	TYPES OF PROBLEMS FOR STATIONS WITH PROBLEMS	
PROBLEM	SINGLE-FAMILY	MULTI-FAMILY
Over spray	49%	35%
Spray pattern blocked or misdirected	39%	21%
Broken or clogged heads	26%	36%
Low head drainage	14%	0%
Incorrect spray arc	12%	14%
Heads not vertical	10%	10%
Uneven head spacing	8%	8%
Unequal pressure/unequal discharge rate	6%	6%
Misting due to high pressure	6%	8%
Sunken heads	6%	5%
Broken/leaking valve or pipe	6%	4%
Heads/nozzles not matched	6%	6%
Low pressure	3%	1%
Avg. Number of Problems Per Station	1.9	1.5
Number of Stations in Sample	1,219	382

Table 32 provides a similar problem assessment for drip irrigation systems. Overall, drip systems exhibited fewer design/maintenance problems per station than did sprinkler systems. For single-family residences, drip systems averaged 0.9 problems per station. Multi-family drip systems averaged 0.5 problems per station, though the small sample size of multi-family drip irrigation stations greatly reduces the reliability of population inferences and comparative statements. The predominant problem for both housing categories is high pressure. For single-family residences, missing or broken emitters and pulled off tubing are also common problems.

Table 32. Prevalence of Drip Irrigation System Design & Maintenance Problems

	% OF DRIP SYSTEM STATIONS WITH PROBLEM	
PROBLEM	SINGLE-FAMILY	MULTI-FAMILY
High pressure	21%	31%
Missing/broken emitters	18%	
Tubing pulled off emitters	16%	
Pinched or broken tubing	13%	
Emitters too close to plant	10%	8%
Clogged emitters	8%	
Low pressure causes flow vs. drip	3%	8%
Avg. Number of Problems Per Station	0.9	0.5
Number of Stations in Sample	173	13

The prevalence of general problems associated with plant irrigation is shown in Table 33.

Table 33. Prevalence of Plant Irrigation Problems

	% OF STATIONS WITH PROBLEM	
PROBLEM	SINGLE-FAMILY	MULTI-FAMILY
Dry spots	14%	22%
Soil Compaction - need to aerate	12%	15%
Area over-watered	12%	11%
Valves not separated by plant water requirement	11%	11%
Improper design	9%	7%
Ponding near plants	7%	13%
Run-off	6%	13%
Needs mulch	6%	10%
Excess grass thatch	6%	3%
Valves not separated for sun exposure	3%	5%
Avg. Number of Problems per Station	0.9	1.1
Number of Stations in Sample	1,478	423

Table 34 shows the distribution of DU for pop-up spray head systems in which catch-can tests were performed. A well-designed system using modern equipment and primarily using pop-up spray heads should have a distribution uniformity of 0.65-0.70. Lower uniformity indicates a problem with the irrigation system that may lead to inefficient water use. A DU below 0.5 indicates poor system performance and requires attention. As shown in Table 34, average DU for both single- and multi-family housing is below 0.5. Fully, 60.2% of single-family and 62.7% of multi-family irrigation systems tested had DU values of 0.5 or less.

Table 34. Irrigation System Distribution Uniformity (DU)

	SINGLE-FAMILY	MULTI-FAMILY
Average DU	46%	45%
Sample Size	327	59
DU Histogram	% of Systems with DU	% of Systems with DU
0.0 – 0.1	0.3%	5.1%
0.1 – 0.2	4.0%	5.1%
0.2 – 0.3	11.6%	11.9%
0.3 – 0.4	15.6%	13.6%
0.4 – 0.5	28.7%	27.1%
0.5 – 0.6	25.7%	18.6%
0.7 – 0.8	10.1%	10.2%
0.8 – 0.9	3.4%	6.8%
0.9 – 1.0	0.6%	1.7%

Table 35 summarizes PR results for tested irrigation systems. PR refers to the amount of water a sprinkler head delivers over a period of time, generally given in "inches per hour." PR values greater than 2.0 inches per hour are considered high; 1.0 to 2.0, moderate; and less than 1.0, low. Anything over 2 inches per hour will be too fast to soak into the ground and will result in excessive runoff. As shown in Table 35, 15.6% of single-family and 16.9% of multi-family systems tested had PR values exceeding 2.0.

Table 35. Irrigation System Precipitation Rates (PR) – Pop Ups

	SINGLE-FAMILY	MULTI-FAMILY
Average PR (in/hr)	1.4	1.5
Sample Size	327	59
PR Histogram	% of Systems with PR	% of Systems with DU
0.0 - 0.5	5.8%	1.7%
0.5 - 1.0	22.0%	18.6%
1.0 - 1.5	33.9%	37.3%
1.5 - 2.0	22.6%	25.4%
2.0 - 2.5	8.6%	8.5%
2.5 - 3.0	4.6%	5.1%
More than 3.0	2.4%	3.4%

8. Residential Water Leaks

8.1.1 Meter Read Leak Test

Water leaks in single-family housing units were checked using sequential meter reads with all indoor and outdoor water using appliances and fixtures turned off. The proportion of inspected single-family housing units with leaks is shown in Table 36.

Table 36. Proportion of Single-Family Households with Indoor & Outdoor Water Leaks

	SINGLE-FAMILY
% of Sampled Households with Leaks	6.2%
Number of inspected residences	385
95% Confidence Interval	± 2.4%

The magnitude of leaks showed very little central tendency and substantial dispersion, ranging from a low of 2 gallons per day to a high of 860 gallons per day. The average magnitude was 100 gallons per day while the median was only 39 gallons per day.

8.1.2 Outdoor Leak Inspection

The outdoor part of the survey also inspected for leaks. Table 37 shows the proportion of inspected housing units where outdoor leaks were identified.

Table 37. Proportion of Households with Outdoor Water Leaks

	SINGLE-FAMILY	MULTI-FAMILY
% of Sampled Households with Outdoor Leaks	3%	4%
Number of inspected residences	410	187
95% Confidence Interval	±2%	±3%

9. Residential Water Use Attitudes and Knowledge

During the telephone portion of the survey, households were asked a series of questions to assess their attitudes and knowledge about residential water use, conservation, and water utility conservation programs. The questions were divided into four broad categories:

- Economic relevance of household water use
- Concern about future supply
- Knowledge/attitudes about household water use
- Knowledge/attitudes about how to save water around the house
- Knowledge of and willingness to participate in local water utility conservation programs

9.1 Economic Relevance of Household Water Use

9.1.1 Proportion of Households that Directly Pay for Water Service

Survey respondents were asked whether their household received and paid a water bill. As shown in Table 38, approximately 89% of single-family households directly receive and pay a water bill. By comparison, only about 34% of multi-family households directly pay for water service.

Table 38. Does Household Directly Pay for Water Service

	SINGLE-FAMILY	MULTI-FAMILY
Yes	88.9%	33.7%
No	10.4%	63.0%
Don't Know/Refused	0.7%	3.3%
Sample Size	565	270

9.1.2 Proportion of Bill Paying Households that View Water Service as a Major Expense

Bill paying households were asked whether they considered the cost of water service to be a major household expense. The results to this question are shown in Table 39. Responses indicate that for the majority of single-family households in Santa Clara County (55.8%), the cost of water is not considered a major household expense. This is even more the case for multi-family households, where only 16.5% considered water a major expense.

Table 39. Is Water Service a Major Household Expense
[Bill Paying Households Only]

	SINGLE-FAMILY	MULTI-FAMILY
Yes	38.5%	16.5%
No	55.8%	69.2%
Don't Know/Refused	5.8%	14.3%
Sample Size	502	91

To probe further into the relative economic importance households in Santa Clara County assign to the cost of water service, water bill paying survey respondents were asked to choose which among a variety of common household bills they would have somebody else pay if possible. Table 40 tabulates their responses. For single-family households, the cost of energy service clearly dominates other typical household bills. Water service, phone service, and cable service were distant seconds by comparison. Similarly for multi-family households energy service was clearly the first choice followed by cable and phone service. Internet and water service were distant thirds.

Table 40. Which Bill Would Household Choose to Have Somebody Else Pay if Possible
[Bill Paying Households Only]

	SINGLE-FAMILY	MULTI-FAMILY
Energy bill	64.3%	40.7%
Water bill	11.0%	9.9%
Phone bill	8.8%	19.8%
Cable TV bill	8.6%	20.9%
Internet service bill	4.4%	7.7%
Don't Know/Refused	3.0%	1.1%

Tables 39 and 40 suggest strongly that water service, at its present level of cost, is not a pressing economic issue for most households in Santa Clara County. While a minority of households in Santa Clara County considers water service a major household expense, most do not.

9.2 Concern about Future Supply

9.2.1 Level of Concern about Adequacy of Future Water Supply

Surveyed households were asked to state the degree of concern they felt about having an adequate water supply in the future. Responses are shown in Table 41. The data do not show any appreciable differences in attitude between single- and multi-family households. In both cases, a large majority of households are either somewhat or extremely concerned about future water supply for the County.

Table 41. Degree of Concern about Adequacy of Future Water Supply

	SINGLE-FAMILY	MULTI-FAMILY
Extremely concerned	35.2%	36.3%
Somewhat concerned	48.7%	42.6%
Not concerned	14.2%	16.7%
Don't Know/Refused	1.9%	4.4%
Sample Size	565	270

9.2.2 Effect of Water Use Knowledge on Concern about Future Water Supply

Households were also asked to assess their level of knowledge about household water uses and ways to save water. When responses to this question are cross-tabulated with responses about future supply concern an interesting result emerges. The cross-tabulation is shown in Table 42. The chi-square test[38] for independence between the categorical responses is strongly rejected. Households that consider themselves very knowledgeable about water use and conservation are more likely to express extreme concern about the adequacy of future water supply, whereas households that consider themselves less knowledgeable are more likely to express less concern.[39]

Table 42. Cross-tab of Concern about Future Supply and Household Water Use Knowledge

	Level of Concern about County's Future Water Supply				
Level of knowledge about water use	Not concerned	Somewhat concerned	Extremely concerned	Don't know/refused	Row Total
Don't know/refused	9%	9%	18%	64%	100%
Not knowledgeable	18%	45%	31%	6%	100%
Somewhat knowledgeable	13%	52%	33%	2%	100%
Very knowledgeable	17%	40%	43%	0%	100%
All Responses	15%	47%	36%	3%	100%
All responses: Chi-square p-value << 0.01 Excluding Don't know/refused: Chi-square p-value < 0.02 Sample Size is 835 (565 single-family and 270 multi-family residences)					

[38] The chi-square value is used to test for statistical independence of categorical variables. The test is implemented by setting up a contingency table, such as Table 42, between two categorical variables. If the column variable is not contingent on the row variable, then the row and column frequencies are independent. The statistical test of whether the columns are contingent on the rows is called the chi-square test of independence. The null hypothesis is that there is no relationship between row and column frequencies. The chi-square p-value shows the probability of observing the row and column frequencies assuming this hypothesis is true. The lower the chi-square p-value the lower the likelihood that the row and column frequencies would occur if the two variables were truly independent. The independence hypothesis is typically rejected for p-values below 0.05.

[39] Thereby validating the age-old truism that ignorance is bliss. It is clear from the table that the chi-square statistic is being strongly influenced by the "Don't know/refused" category. That is, respondents with no opinion about their knowledge of household water use were also very likely to have no opinion about their concern for the County's future water supply. This strong dependency virtually guarantees rejecting the hypothesis that the categorical responses are independent based on the chi-square statistic. However, elimination of the "Don't know/refused" category from the table doesn't alter the result. The hypothesis that the responses are independent is still rejected at the 98% level of confidence.

9.3 Knowledge/Attitudes about Household Water Use

Households were asked to state whether they considered themselves very knowledgeable, somewhat knowledgeable, or not knowledgeable about their household's water use and ways it could save water. Responses to this question are tabulated in Table 43. Results indicate that the majority of households consider themselves somewhat knowledgeable. Multi-family households are more likely to state they are not knowledgeable about their household's water use while single-family households are more likely to state they are very knowledgeable. As shown by the chi-square p-value, the likelihood that the responses shown in Table 43 would have occurred if opinions about household water use knowledge were completely independent from housing category is less than 1%. This is not surprising. Water service constitutes a larger share of household expense for single-family homes and a greater proportion of single-family homes pay directly for water service. Also, water conservation messages are more frequently directed at single-family homes. Thus, it is not unexpected they would have more knowledge about how water is used around the house and how to conserve water.

Table 43. Knowledge about Household Water Use

LEVEL OF KNOWLEDGE ABOUT WATER USE	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Don't know/refused	1.1%	1.9%	1.3%
Not knowledgeable	11.9%	20.4%	14.6%
Somewhat knowledgeable	57.2%	52.6%	55.7%
Very knowledgeable	29.9%	25.2%	28.4%
Sample Size	565	270	835
Chi-square p-value < 0.01			

Households were also asked to state whether compared to similar households they considered their water use to be below average, average, or above average. Going into the survey, the expectation was that most households would consider their use to be about average. This was borne out by the results, which are tabulated in Table 44. The results also indicate that multi-family households are less likely to consider they have above average water use and more likely to consider they have below average water use compared to single-family households.

Table 44. How Does Household's Water Use Compare to Similar Households

LEVEL OF WATER USE	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Don't Know	5.0%	5.6%	5.1%
Below Average	22.7%	31.9%	25.6%
Average	57.9%	59.3%	58.3%
Above Average	14.5%	3.3%	10.9%
Sample Size	565	270	835
Chi-square p-value << 0.01			

9.3.1 Effect of Water Use Knowledge on Estimate of Level of Use

Household assessment of level of water use was also cross-tabulated with assessment of water use knowledge. The results are shown in Table 45. The data suggest that household's considering themselves very knowledgeable about water use also believe their use of water is below average. Whereas households indicating they are somewhat knowledgeable or not knowledgeable about water use assume their water use is typical of other households. The results suggest that households that are more knowledgeable about water use also may be more proactive about reducing use.[40] If so, this reinforces the importance of water use education and information programs as part of an overall demand management strategy.

Table 45. Cross-tab of Concern about Future Supply and Household Water Use Knowledge

	Household's Assessment of Water Use			
Level of knowledge about water use	Don't know/refused	Below Average	Average	Above Average
Don't know/refused	27.3%	27.3%	27.3%	18.2%
Not knowledgeable	7.4%	21.3%	64.8%	6.6%
Somewhat knowledgeable	4.7%	20.4%	63.2%	11.6%
Very knowledgeable	3.8%	38.0%	46.8%	11.4%
All Responses	5.1%	25.6%	58.3%	10.9%
Chi-square p-value << 0.01 Sample Size is 835 (565 single-family and 270 multi-family residences)				

[40] An additional area of research suggests itself. It would be highly useful to compare attitudes about levels of water use with actual household water use records. Such an investigation is beyond the scope of this study, but is one that the data collected for this study would enable.

9.4 Knowledge/Attitudes about Saving Water Around The House

9.4.1 Primary Reasons Stated to Conserve Water

From among a list of reasons for conserving water around the house, survey respondents were asked to identify their primary reason for doing so.[41] The results are shown in Table 46. Avoiding waste is the most frequently stated primary reason for conservation, but results also show that no one reason clearly stands out. The top three themes are: (1) avoid waste; (2) respond to shortages; and (3) save money. Because these themes relate to one another, conservation messages should incorporate all three. For example, avoiding waste saves money and prevents shortages. Especially multi-family households also frequently cited protecting the environment. This theme also ties into avoiding waste and thus messages could be tailored to emphasize how reducing waste also provides environmental benefits.

Table 46. Primary Reason to Conserve Water Around House

	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Avoid waste	28%	39%	31%
Respond to shortages/drought	25%	17%	22%
Save money	22%	11%	19%
Protect the environment	17%	21%	5%
Help the community	4%	6%	18%
Don't know/refused	5%	6%	5%
Sample Size	565	270	835

9.4.2 Single-Family Attitudes about Saving Water Indoors Versus Outdoors

Single-family survey respondents were asked if they thought their household could save the most water by changing how it uses water indoors or outdoors. Responses, cross-tabulated by assessment of household water use knowledge, are shown in Table 47. Overall, single-family households are more likely to believe they can save more water indoors than outdoors. However, as knowledge about household water use increases the likelihood that a household believes it can save more water outdoors increases. The results suggest that many single-family households have a limited understanding about relative magnitudes between indoor and outdoor uses and consider many indoor uses to be more discretionary than outdoor uses.

[41] Whenever questions with lists of possible responses were used in the telephone survey, the order of the list was randomly rotated to avoid response bias caused by particular orderings.

Table 47. Can Household Save More Water Indoors or Outdoors [Single-family Households Only]

	KNOWLEDGE ABOUT HOUSEHOLD WATER USE		
COULD SAVE MOST WATER	DON'T KNOW/NOT KNOWLEDGEABLE	SOMEWHAT/VERY KNOWLEDGEABLE	ALL RESPONSES
Indoors	64%	47%	49%
Outdoors	25%	39%	37%
Don't know/refused	11%	14%	14%
Chi-square p-value < 0.02 Sample Size is 835 (565 single-family and 270 multi-family residences)			

9.4.3 Attitudes about Savings Water by Changing Habits Versus Changing Appliances

Households were also asked if they thought they could save more water around the house by changing their water use habits or by changing some of their water-using appliances and plumbing fixtures. Responses to this question are shown in Tables 48 and 49. Table 48 shows the responses by housing category while Table 49 cross-tabulates the responses with knowledge about household water use.

Results in Table 48 suggest that compared to single-family households multi-family households are more likely to believe they could save more water by changing appliances. This makes sense when one considers that the proportion of household water use dictated by appliance requirements is likely to be substantially greater in multi-family households, where outdoor water use is not a factor. Likewise, it may be the case that appliances in multi-family housing units, which are primarily rental units, are older and less efficient than their counterparts in single-family housing units. Overall, though, the households are nearly evenly split between whether more water could be saved by changing habits or appliances.

Table 48. Can Household Save More Water by Changing Habits or Appliances

CAN SAVE MOST WATER BY	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Change appliances	43%	46%	44%
Change habits	41%	31%	38%
Don't know/refused	16%	23%	18%
Sample Size	565	270	835
Chi-square p-value < 0.015			

Results in Table 49 show that knowledge about household water use has little bearing on a household's opinion about whether it could save more water by changing its habits or appliances. The chi-square p-value indicates that category dependencies are unlikely.

Table 49. Cross-tab of Knowledge about Use with Save More Water by Change Habits or Appliances

CAN SAVE MOST WATER BY	Don't know/refused	Not Knowledgeable	Somewhat Knowledgeable	Very Knowledgeable	All Responses
Change appliances	27.3%	49.2%	43.7%	42.6%	27.3%
Change habits	36.4%	33.6%	39.1%	36.7%	36.4%
Don't know/ refused	36.4%	17.2%	17.2%	20.7%	36.4%
Chi-square p-value < 0.49 Sample Size is 835 (565 single-family and 270 multi-family residences)					

9.4.4 Relative Importance of Water Efficiency When Selecting New Appliances

Households were asked when shopping for a new water-using appliance, such as a washing machine or dishwasher, to rank in order of importance the following three purchase considerations:

- Price of the appliance compared to other models
- Features of the appliance compared to other models
- Water efficiency of the appliance compared to other models

Table 50 shows the proportion of respondents ranking water efficiency first, second, or third in order of importance. Overall, respondents were roughly evenly divided in their ranking of water efficiency between first, second, and third order of importance. Multi-family households were more likely than single-family households to not know or refuse the question. This is not unexpected given that multi-family households are less likely to purchase and own major water-using appliances. If non-responses are excluded from the sample, then differences in responses between single- and multi-family households are not statistically significant, as indicated by the chi-square p-value in Table 48.

Table 50. Relative Importance of Water Efficiency When Purchasing Appliances

RANKED	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Don't Know/refused	5%	12%	7%
First	34%	34%	34%
Second	33%	24%	30%
Third	28%	30%	29%
Sample Size	565	270	835
All Responses: Chi-square p-value << 0.01 Excluding Don't Know/Refused: Chi-square p-value < 0.15			

9.4.5 Household Awareness of Conservation Measures and Concepts

Households were asked to indicate if they were familiar with a variety of water conservation measures and concepts, ranging from Energy Star appliances to graywater plumbing systems. Responses are tallied in Table 51. The data suggest that, overall, single-family households have broader awareness of the conservation measures listed in Table 51 than do multi-family households. The results also indicate that there is a broad level of awareness among Santa Clara County households of Energy Star branded appliances and UFLTs. On the other hand, a large majority of the population is unaware of newer technologies such as ET irrigation controllers and dual flush toilets. Likewise, only a minority of households has heard of graywater plumbing.

Table 51. Household Awareness of Conservation Measures & Concepts

CONSERVATION MEASURE OR CONCEPT	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Ultra-low Flush Toilets	89%	70%	83%
Energy Star or Front Loading Clothes Washer	80%	69%	77%
Xeriscaping or Drought-tolerant Landscaping	63%	36%	54%
ET Irrigation Controllers	32%	37%	34%
Graywater Plumbing	31%	30%	31%
Dual-flush Toilets	25%	26%	25%
Sample Size	565	270	835
Chi-square p-value << 0.01			

9.4.6 Past Actions Taken by Households to Reduce Water Use

Households were read a list of conservation actions and asked if they had undertaken any of them. Table 52 summarizes the responses. As is to be expected, single-family households have been more proactive in their actions to save water around the house. Some responses are unexpected, however. For example, the proportion of single-family households indicating they have replaced one or more older toilets with a ULFT is 50%. Likewise, 38% have indicated they have replaced an older washing machine with a high-efficiency model. The veracity of these responses is questionable if one compares them to the on-site inspection results for UFLTs and washing machines, which suggest a lower level of saturation than implied by the responses.

Table 52. Past Conservation Actions Households Reported Taking

HOUSEHOLD HAS TAKEN ACTION IN PAST	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Used washing machine only with full loads	79%	74%	78%
Adjusted water schedule to use less water in spring/fall	72%	16%	54%
Checked for leaks and made repairs if any discovered	70%	52%	64%
Replaced old showerhead with low-flow	54%	34%	48%
Replaced old toilet with ULFT	50%	26%	42%
Replaced old wash. mach. with high-efficiency model	38%	15%	31%
Installed aerators	36%	23%	32%
Installed toilet dam	35%	20%	30%
Replaced grass or other plants with landscaping using less water	31%	10%	24%
Upgraded irrigation system to use less water	22%	7%	17%
Sample Size	565	270	835
Chi-square p-value << 0.01			

9.5 Local Water Utility Conservation Programs

9.5.1 Awareness of Local Water Conservation Programs

Households were read a list of local water utility conservation programs and asked if they had heard of any of them. Responses are tallied in Table 53. As with awareness about conservation measures and concepts the data summarized in Table 53 suggest that, overall, single-family households have a broader awareness of local water utility conservation programs than do multi-family households. This is especially the case for toilet, washing machine, and showerhead/aerator programs. Again, the result is not unexpected given the high proportion of multi-family households that do not own or maintain their own water appliances.

Table 53. Awareness of Local Water Utility Conservation Programs

HOUSEHOLD HAD HEARD OF LOCAL UTILITY PROGRAM	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Toilet Replacement Program	68%	42%	60%
SCVWD's In-Store Washing Machine Rebate Program	44%	32%	40%
Showerhead and Faucet Aerator Giveaway Programs	32%	23%	29%
Water Wise House Call Program	17%	15%	16%
Water Watcher Home Water Survey Program [1]	7%	5%	6%
Sample Size	565	270	835
Chi-square p-value << 0.01			

Notes:
1. The Water Watcher Home Water Survey Program is local to the San Jose area and therefore it is not surprising that Countywide results show a low level of awareness. However, the proportion of San Jose residents indicating awareness of the program is not statistically different than for the county as a whole.

9.5.2 Information Households Would Find Useful for Saving Water

Households were read a list of topics about household water use efficiency and asked which, if any, they would find useful in their efforts to save water. Reponses are summarized in Table 54. It is clear from the table that single-family respondents had a tendency to say yes to every topic. Multi-family households, as would be expected, were much less likely to be interested in topics addressing landscape water uses. Perhaps of most interest is the fact that for both single- and multi-family households, information about how to check for and repair leaks and information about typical amounts of water used for common household activities ranked highest.

Table 54. Information about Water Conservation Households Find Useful

HOUSEHOLDS INDICATING THEY WOULD FIND INFORMATION ON TOPIC USEFUL	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Amount of water typically used for common household activities	86%	81%	84%
Checking for leaks and making repairs	83%	77%	81%
Efficient landscape irrigation	79%	52%	70%
Selecting water efficient appliances and plumbing	78%	71%	76%
Water-efficient irrigation systems	75%	43%	65%
Selection and care of low-water-use plants	74%	60%	69%
Sample Size	535	270	835
Chi-square p-value << 0.01			

9.5.3 Willingness to Participate in Utility Plumbing Fixture Programs

Households were read a list of devices and asked if they were to receive them free of charge from their water utility would they install them. The devices listed were as follows:

- ULFT, which require tools to install and may require help from a plumber
- Water and energy saving faucet aerators, which can be installed without tools
- Water and energy saving showerheads, which require a wrench to install

Responses are tabulated in Table 55. The results suggest three things. First, households like free stuff or, alternatively, there is a natural tendency to express a willingness to accept things that are offered for free. Second, there is no statistically discernable difference in responses between single- and multi-

family households. Even in the case of ULFTs, where multi-family households have less discretion in replacing major plumbing fixtures, the proportion of households indicating they would install a free toilet is not much lower than for single-family households. Third, and not unexpectedly, a substantial minority of households balk at expressing a willingness to replace a major plumbing fixture such as a toilet, even if offered free of charge. Simply put, the cost to replace a toilet goes beyond just the fixture and frequently includes a plumber's or one's own labor costs plus the inconvenience and disruption associated with removing an old toilet and installing a new one.

Table 55. Proportion of Households Willing to Install Devices Received Free from Utility

WOULD INSTALL DEVICE IF RECEIVED FREE FROM UTILITY	SINGLE-FAMILY	MULTI-FAMILY	ALL RESPONSES
Faucet aerators	85%	83%	85%
Low-flow showerhead	76%	76%	76%
ULFT	59%	51%	57%
Sample Size	565	270	835
Chi-square p-value < 0.30			

Finally, households were asked if they would replace an older high-flow toilet with a ULFT if their water utility provided a financial incentive. The interviewer started at $50 and only continued to the next level of incentive if the respondent indicated they would be unwilling to replace the toilet at the lower level. Incentives were increased by $25 increments to a maximum of $125. If a respondent indicated they would be unwilling to replace the toilet given a $125 incentive they were then asked if they would replace it assuming the utility covered the entire purchase and installation cost. Responses to this question sequence are summarized in Table 56.

In reviewing Table 56, the reader should note that percentage responses for incentive levels are cumulative. Thus, the percent of respondents indicating they would accept at least $75 includes those respondents that required at least $50 plus those that required at least $75. This was done to indicate the percent of households that might be willing to replace a toilet at different incentive levels.

The other point to note about Table 56, one that casts substantial doubt on the veracity of the responses, is the apparent inconsistency with the responses in Table 55. In Table 5, a full 41% of single-family households and 49% of multi-family households indicated an unwillingness to replace their toilets even if a ULFT were provided free of charge. However, in Table 56 we see that only 18% of single-family and 30% of multi-family households report an unwillingness to replace an old toilet with a ULFT if given a financial incentive of at least $100, the approximate cost a typical utility would have to pay for a new toilet provided through a free distribution program. Thus there is a potentially significant

discrepancy in stated preferences. The results in the two tables are inconsistent and suggest respondents have limited conception of relative costs involved in replacing an existing toilet. Therefore it seems reasonable to assume these responses could substantially depart from actual behavior of households when presented with such offers and choices by their local utilities.

Table 56. Percentage of Total Respondents Willing to Replace Old Toilet with ULFT for Given Incentive Levels

WOULD REPLACE TOILET WITH ULFT IF GIVEN	SINGLE-FAMILY	MULTI-FAMILY
At least $50	67%	59%
At least $75	74%	64%
At least $100	82%	70%
At least $125	85%	72%
All costs of replacement	90%	82%
Unwilling to replace toilet even if all costs covered	10%	18%
Sample Size	565	270

Table 56 also shows the proportion of respondents indicating unwillingness to replace their existing toilet with a ULFT even if the utility covered all costs. For single-family households, 10% of the respondents indicated they would be unwilling to replace their toilet even if the utility covered all expenses. For multi-family households, the response rate was 18%. These respondents were asked their primary reason for this unwillingness. The question was asked in an open-ended format and then responses were matched to the categories shown in Table 57. For multi-family respondents the fact that most households rent the property and do not have ownership of major appliances and fixtures is clearly the primary reason for an unwillingness to replace a toilet even if the utility covered all expenses. This result is both expected and has little import on the ability of utility programs to influence replacement of toilets in multi-family settings. Such programs are marketed to the property owner/manager and decisions to replace plumbing fixtures are generally made at this level rather than at the household level. For single-family households, on the other hand, the primary reason is concern that the toilets do not function well. Either stories in the media about ULFT toilet performance issues or personal experience have persuaded these households that ULFTs are inferior to older, higher flush volume toilets. Overall, the proportion of single-family households in the sample with this attitude is small, about 5%, suggesting that for most households in the County, concerns about ULFT performance may not be a significant issue. Nonetheless, it is probably an issue about which the District and other water utilities in the region should continue to provide information and education.

Table 57. Primary Reason Given for Unwillingness to Replace Existing Toilet with ULFT Even if All Replacement Costs Covered by Utility

STATED REASON	SINGLE-FAMILY	MULTI-FAMILY
Don't work well/don't flush properly	57%	13%
Don't want the hassle	11%	0%
Rent/don't own	9%	76%
Can't get desired color or style	6%	3%
Sounds too expensive	4%	5%
Want to wait until remodel	4%	0%
Current toilet works fine	2%	0%
Don't know	2%	0%
Other	6%	3%
Sample Size	565	270

10. Future Research and Uses of the Data

The *Santa Clara County Residential Baseline Water Use Study* has provided the District with a rich and extensive data set about residential demographic characteristics, indoor water using fixtures and devices, outdoor landscaping characteristics and irrigation systems, prevalence and magnitude of residential water leaks, and information about household water conservation knowledge and attitudes. This report has presented an initial analysis and summary of this data. Much more, however, could be and should be done with the data. Possible future uses of the data are discussed below. The reader should note this discussion by no means exhausts possible uses of the data developed by this study.

- *Residential demand modeling* – households participating in the on-site inspections were asked to sign a release allowing the District to obtain water-billing records from the household's water service provider. Combing data from the on-site inspections about persons per household, type and number of plumbing devices, size and type of landscape, type and performance of irrigation systems, prevalence of pools and spas, prevalence and magnitude of leaks, and attitudes about conservation with data on historical water use and weather would allow the District to econometrically explore relationships between household characteristics and demand for water to a degree seldom before attained. Such models could be used by the District and local water utilities to forecast and plan for residential water demand.

- *Regional demand forecasting* – the data developed by the *Santa Clara County Residential Water Use Baseline Survey* will greatly facilitate regional demand and supply requirement forecasting using models such as IWR-MAIN or DSS.[42] These models implement end-use modules to estimate the conservation water savings potential and benefits of different conservation program portfolios. Often implementation of the models is hampered by insufficient data about end uses. Alternatively, the models are implemented using non-region specific estimates and default values. The data developed for this study would eliminate, at least for Santa Clara County, many of the data bottlenecks often encountered.

- *Conservation potential assessments* – the data summarized in this report can be used to estimate the remaining water savings potential of various plumbing fixtures and devices. Tables 12 and 17 provide examples of this sort of quantification for toilets and showerheads. Additional analysis of this kind is possible, especially with respect to landscape water use.

- *Conservation program marketing assessments* – the data should also provide insight into what conservation messages are most likely to resonate with Santa Clara County households,

[42] DSS is the model acronym for Demand Side Management Decision Support System.

which segments of the residential sector are most responsive to conservation messages, and the extent of understanding about conservation programs and household willingness to participate in them.

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12. Appendix A – Telephone Screening Survey Instrument

Hello, this is _____ calling on behalf of the Santa Clara Valley Water District. I would like to ask you a few questions about water usage in your home. Your answers will help us decide how to best meet Santa Clara County's future water needs. Please be assured we are not selling anything and all your answers will remain confidential. This call will only take about ten minutes. When we are finished, you may be invited to participate in the second part of the study which would take place at a later date.

SAMPLE REPLICATE NUMBER:___

LANGUAGE: ENGLISH:___ SPANISH:___ VIETNAMESE:____

READ ONLY ON 5TH ATTEMPT IF ANSWERING MACHINE: Hello, I'm calling on behalf of the Santa Clara Valley Water District. We are conducting a telephone survey of homes in your area about residential water use. We will try again during the next several days. Thank you.

SCREENER = *Q. A through Q. I*

A. Would you have ten minutes to answer these few questions now?

Yes ___ Proceed to B.
No ___ When may we call back? Day _____ Time _____
Refused ___ (THANK AND TERMINATE)

If respondent objects, read: 50% of Santa Clara County's water is imported, which makes it a critical resource. The purpose of this study is to help local water agencies plan for what they will need to do to meet the area's future water needs. Your answers to our questions will help us do that.

If respondent asks about sponsors, read: The Santa Clara Valley Water District is a public agency that obtains water from both our local watersheds as well as outside our area and distributes it to local water agencies in the county, including the one that supplies your water. If you wish further information about this public agency or about this study, you may call
Ms. Shicha (she-cha) Chander at the Santa Clara Valley Water District at (408) 265-2607 ext. 3114.

If respondent asks about how his/her phone number was obtained, read: Your number was chosen at random from among all the residential phone numbers in your area.

If respondent asks about interviewer or call center, read: Farrand Research was retained by the District to conduct this survey; it is a research firm that specializes in studying the public's opinions. They are located in Long Beach, California. (*Only if necessary):* We are calling from a telephone facility located in central Utah.

B. May I verify that I have reached XXX-XXX-XXXX (phone number)?
Yes, correct phone number _____ - continue
No, incorrect phone number _____. I'm sorry, I've dialed the wrong telephone number. (THANK AND TERMINATE)
Ref ___ - (THANK AND TERMINATE)

C. Since your number was chosen at random, I need to start with a few questions about your household. Is this a residence?
Yes _____ - continue
No _____. We are only interviewing to residences for this survey. Thank you for your time. (THANK AND TERMINATE)
Ref ___ - (THANK AND TERMINATE)

D. Are you 18 years or older and a resident in this home?
Yes _____ - continue
No _____ - ask to speak to a resident at least 18 years old. IF NOT AVAILABLE, CATI SCHEDULES CALLBACK.
Ref ___ - (THANK AND TERMINATE)

E. Do you generally pay the bills for your household?

Yes ____ - continue

No ____ QG1. May I speak to the person who does generally pay the bills?
(INTERVIEWER: If bill payer is not available, continue with next question (QH).
If respondent asks why you want to speak with the bill payer, say "Some of the questions in this survey may be easier for the bill payer to answer, but it is not critical that we speak to that person".)

Ref ___ - (THANK AND TERMINATE)

F. In what town or city is your home located?
_____

Alviso	Los Altos	Morgan Hill	Palo Alto	Saratoga
Campbell	Los Altos Hills	Mount Hamilton	San Jose	Stanford
Cupertino	Los Gatos	Mountain View	San Martin	Sunnyvale
Gilroy	Milpitas	Onizuka Air	Santa Clara	Willow Glen
	Monte Sereno	Force Base		

Other _____. Is (CITY RESPONDENT MENTIONS) in Santa Clara County? IF "YES" RECORD RESPONSE AND CONTINUE. IF NOT, SAY: "I'm sorry we are only including residences in Santa Clara County in this survey. Thank you for your time.

Refused _____. (THANK AND TERMINATE)

H. Which of the following best describes the building in which you live?" (READ LIST. MARK ONE ONLY)

A single-family house detached from any other house. _____
(Clarification, if necessary: a single house with open space on all sides; that is, not attached to another house.)

A single-family house attached to one or more other houses such as a condominium or townhouse _____

A building with two to four units _____

A building with five or more units _____

A mobile home or trailer ____

Other ___ - DESCRIBE AND CATEGORIZE INTO ABOVE CATEGORIES IF POSSIBLE, OTHERWISE MARK AS OTHER – TERMINATE IF NOT ABLE TO CODE INTO ABOVE CATEGORIES. SAY: "We are only interviewing specific types of households. Thank you for your time."

Don't know _____ We are only interviewing specific types of households. Thank you for your time.

Refused _____ (THANK AND TERMINATE)

I. Is there a separate residence located on a floor directly above or below yours?

Yes _____
No _____

Dwelling unit status is determined from combination of Q.J and Q.K. (i.e., if Yes to Q.K – then unit is multi-family. If no to Q.K – then unit is single-family. See grid below for proper classification of dwelling types based on responses to Q.J and Q.K.
This will be an overquota terminate question for sample after meeting quota for higher incidence dwelling type.

		Q.H Response					
		SF-detached	**SF-attached**	**2-4 units**	**5+ units**	**DK**	**Ref**
Q.I Responses	**Yes**	Incompatible	Multi-family	Multi-family	Multi-family	Not eligible	Not eligible
	No	Single-Family	Single-Family	Single-Family	Single-Family	Not eligible	Not eligible
	DK	Not eligible	Not eligible	Not eligible	Not eligible	Not eligible	Not eligible
	Ref	Not eligible	Not eligible	Not eligible	Not eligible	Not eligible	Not eligible

INTERVIEWER: IF "INCOMPATIBLE" RESPONSE ABOVE, ASK FOLLOW UP TO Q.I BELOW:

Just to help me clarify the type of building you live in, is there a separate residence located above or below the one you live in?

Yes _____ = Multi-family classification

No _____ = Single-family classification

I1. Dwelling unit type (as determined from QH and QI):

Single-family

Multi-family

K. Based on the information you've given me, your residence is the type we need for our study. This involves asking you a few more questions about your household and then having our surveyors visit your home at no cost to you to measure performance of water-using devices in your home and your irrigation system, if you have one. Knowing this will allow your local water agency to estimate how much water households like yours will need in the future.

(Single-family) This visit will only take about 45 minutes.

(Multi-family) This visit will only take about 30 minutes.

After completing the in-home portion of the survey you will receive a complementary water saving kit. You will also be entered into a drawing. Ten winners will receive a $500 gift certificate from their choice of three different local stores. Your chances of winning are good since this study only includes 600 households.

Interviewer: If respondent asks how many people are eligible for the drawing: Only 600 households in Santa Clara County will be eligible.

Interviewer: If respondent asks what local stores will be in the drawing: You would have a choice of gift certificate from a local grocery, home improvement, or garden supply store.

If you agree to this visit, you will receive an official confirmation letter from the Santa Clara Valley Water District. This letter will include the name of someone you can talk to at the water district office if you have any questions about the study.

Can I have a surveyor contact you to schedule a convenient time to visit your home for this part of the study?

Yes ___ - continue

No ___ - See below for appropriate response before terminating.

Must check with landlord/manager ___ (Name:_____; Phone:_____), or

Must check with responsible person in household _____ (Name: _____, Relation: _____)
Name of person who completed phone survey (Name: _____, Relation _____)
(*be sure to record both respondent's name and name of responsible person in household if someone else in household completed phone interview and indicated someone such as the parent as the person to contact for in-home inspection). (Obtain respondent's name here, as opposed to very end of survey, only if we need to contact someone other than respondent to schedule the on-site appointment.)*

Refused ___

Interviewer: If respondent asks why the site visit is necessary:
Our ability to estimate future water needs and plan the facilities and programs to reliably meet these demands depends critically on knowing what types of water using devices "households like yours" have. We are surveying a random sample of households like yours so that we can accurately forecast residential water use in Santa Clara County.

Interviewer: If respondent objects to the interview, please read the appropriate information from the material here:

- All our staff carry I.D., so you can verify that they represent the Santa Clara Valley Water District.
- We will schedule your appointment for a convenient time when you, or someone you designate, will be home and available, 6 days a week, during the day or in the evenings.
- All the information gathered in our survey is strictly confidential; no one outside our staff will ever see your individual responses.
- If you want to verify this research, you may call Ms. Shicha (she-cha) Chander at the Santa Clara Valley Water District—the number is (408) 265-2607 ext. 3114. Also, you will receive a formal letter from the Water District office.
- *(For single-family residents)* The surveyors will need only about 45 minutes to complete the inspection.
- *(For multi-family residents)* The surveyors will need only about 30 minutes to complete the inspection.

L. What are the best days and times to call you (*or the "responsible" person)* to schedule this appointment? (OBTAIN A WINDOW OF TIME OF ABOUT 1 TO 3 HOURS, IF POSSIBLE.)

Days _____ Hours _____ **Interviewer: Day should be at least 4 days from today.**

M. May I please have your name so that the surveyors know whom to ask for when they call?

(Mr__ Ms__) First _____Last _____) (SPELL BACK TO CONFIRM)

N. Is the phone number I called today the best number to use for scheduling the on-site survey? _____Yes _____No [IF NO, THEN ASK N.1]

N.1. What number is best to use for scheduling the on-site survey? _____ - _____ - _____

O. What is you address? VERIFY WITH RESPONDENT THAT THE ADDRESS THEY GIVE IS THE ADDRESS OF THE DIALED RESIDENCE.

Street Address _____ (SPELL BACK TO CONFIRM)
City _____, CA SPELL BACK TO CONFIRM
Zip Code _____

[IF MULTI-FAMILY RESIDENCE, ASK THE FOLLOWING QUESTIONS:]
O1. To help us schedule the outdoor portion of the on-site survey, we need to get more information from you. Does your building or housing complex have a name?

[RECORD BUILDING OR COMPLEX NAME:]_____

O2. Does your building or housing complex have an owner or manager that we should call to schedule the outdoor portion of the on-site survey? Do you have his/her name and phone number?

[RECORD NAME:]_____
[RECORD PHONE NUMBER:]_____

For All Respondents Agreeing to On-Site Inspection

1. Does your house receive and pay a water bill?
   Yes _____
   No _____ if No, skip to Question 3.
   Don't know _____
   Refused _____

2. [Bill Paying Households Only] Do you consider the amount of money your household spends for water service to be a major household expense?
   ___ yes ___ no ___ don't know

2A. [Bill Paying Households Only] If you could have somebody else pay <u>one</u> of the following bills for your household, which would you select? [ROTATE LIST. READ LIST. MARK ONE ONLY.]

___ water bill
___ phone bill
___ energy (gas & electricity) bill
___ Cable TV bill
___ Internet service bill

3. Would you say that you are [extremely concerned, somewhat concerned, or not at all concerned] about having an adequate water supply in the future?

___ extremely concerned
___ somewhat concerned
___ not concerned

4. Do you consider that you are [very knowledgeable, somewhat knowledgeable, or not knowledgeable] about your household's water use and ways it could save water (LIST AND RECORD ANSWER)

___ very knowledgeable
___ somewhat knowledgeable
___ not knowledgeable

5. Compared to households similar to yours, would you say that water use by your household is (READ LIST AND MARK ONLY ONE)

___ above average
___ average
___ below average
___ don't know

6. [Single-family Only] If you were to divide your household's water use between indoor uses and outdoor uses, what percent would you estimate is for [ROTATE LIST BETWEEN INDOOR AND OUTDOOR USES.]

- Indoor uses

Record % _____ Continue

Don't know _____ Continue
Refused _____ Continue

- Outdoor uses

Record % _____ Continue
Don't know _____ Continue
Refused _____ Continue

7. When your household conserves water is it primarily to [ROTATE LIST, READ LIST, MARK ONE]

___ Save money
___ Avoid waste
___ Protect the environment
___ Help the community
___ Respond to water shortages/drought

8. [Single-family Only] Do you think your household could save the most water by changing how it uses water indoors or outdoors? (MARK ONLY ONE)

____ Indoors
____ Outdoors
____ Don't know
____ Refuse

8A. What are three things your household could do differently to save water?

1._____
2._____
3._____

9. Do you think your household could save more water by changing its water use habits **or** by changing some of its water-using appliances and plumbing fixtures?

_____Change Habits
_____Change Appliances/Fixtures
_____Don't know

10. Of the following three items, which is the most important when shopping for a new water-using appliance, such as a washing machine or dishwasher? [ROTATE ORDER. READ ENTIRE LIST THEN SAY: "Which is the second most important?" Rank 1, 2, 3]

____ Price of the appliance compared to other models

____ Features of the appliance compared to other models

____ Water efficiency of the appliance compared to other models

11. Are you familiar with any of the following water conservation measures? [ROTATE LIST. REPEAT THE FOLLOWING PHRASE BEFORE EACH RESPONSE OPTION: "Are you familiar with..."]

- Energy Star or Front Loading clothes washing machines that have been designed to save both water and energy.
  ___ yes ___ no ___refuse

- Ultra-low-flush toilets that flush no more than 1.6 gallons of water per flush?
  ___ yes ___ no ___refuse

- Dual-flush toilets that offer two water volume options for flushing?
  ___ yes ___ no ___refuse

- Graywater plumbing systems which recycle water from sinks and showers for use outdoors.
  ___ yes ___ no ___refuse

- ET, or Evapotranspiration, irrigation system timers which turn sprinklers on and off based on actual weather conditions and plant water requirements?
  ___ yes ___ no ___refuse

- Xeriscaping (zera-scaping), or drought-tolerant landscaping, which is landscaping with drought-tolerant plants and/or plants with low water requirements?
  ___ yes ___ no ___refuse

12. Have you heard of any of the following local water conservation programs? [READ LIST AND MARK ALL RESPONSES. ROTATE LIST. REPEAT THE FOLLOWING PHRASE BEFORE EACH RESPONSE OPTION: "Have you heard of..."]

- The "Water Wise" House Call Program in which a technician visits your house to help you save water?
  ___ yes ___ no ___refuse

  - The "Water Watcher" Home Water Survey Program?
  ___ yes ___ no ___refuse

- Toilet replacement and rebate programs?
  ___ yes ___ no ___refuse

- The District's In-Store Energy Star Clothes Washing Machine Rebate Program?
  ___ yes ___ no ___refuse

- Free Showerhead and Faucet Aerator giveaway programs?
  ___ yes ___ no ___refuse

  If yes, has your household participated in any of these showerhead giveaway programs?
  ___ yes ___ no ___ don't know

13. Would you consider general information on the following topics helpful to your household's efforts to save water: [ROTATE LIST. REPEAT THE FOLLOWING PHRASE BEFORE EACH RESPONSE OPTION: "Would you consider... AND THE FOLLOWING PHRASE AT THE END OF EACH RESPONSE OPTION: "...to be helpful."]

- Information about how to select water-efficient appliances and plumbing fixtures, such as washing machines, dishwashers, or toilets
  ___yes ___no

- Information about how to check for plumbing leaks and make simple repairs
  ___yes ___no

- Information about how much water is typically used for common household activities, such as dishwashing, clothes washing, bathing, or outdoor watering.
  ___yes ___no

- Information about how to select and care for drought-tolerant, low water-use plants, shrubs, and trees
  ___yes ___no

- Information about how to efficiently water lawns and other landscaping
  ___yes ___no

- Information about water-efficient irrigation hardware and sprinkling systems
  ___yes ___no

14. Which of the following actions have you taken in the past to decrease the amount of water your household uses? [READ LIST AND MARK ALL THAT APPLY. ROTATE LIST. REPEAT THE FOLLOWING PHRASE BEFORE EACH RESPONSE OPTION: "Have you..."]

___ Installed something in the toilet tank to reduce toilet water use

___ Replaced any older toilets with ultra-low-flush toilets

___ Installed aerators on bathroom and/or kitchen faucets

___ Used washing machine only with full loads

___ Replaced an older washing machine with an Energy Star or front-loading washing machine.

___ Replaced any older showerheads with low-flow showerheads.

___ Replaced an older irrigation system with a newer one designed to use less water

___ Replaced grass or other plants with landscaping requiring less water

___ Adjusted your watering schedule to irrigate less during the Spring and Fall

___ Check for plumbing leaks and repair them as soon as they are located

15. If you were to receive <u>free</u> water-saver devices from your water utility, which of the following would you install in your home: [ROTATE LIST. REPEAT THE FOLLOWING PHRASE BEFORE EACH RESPONSE OPTION: "Would you install..."]

- Ultra-low-flush toilets, which require tools to install and may require help from a plumber?

___ yes ___ no ___ don't know

- Water and energy saving faucet aerators, which can be installed without tools?
  ___ yes ___ no ___ don't know

- Water and energy saving showerheads, which require a wrench to install?
  ___ yes ___ no ___ don't know

16. Let me remind you that we are not selling anything, and that this interview is for research purposes only. It costs about $150, on average, to replace a toilet. Would you replace an older high-flow toilet in your household with an ultra-low-flush toilet if your water utility paid you …. (REREAD QUESTION EACH TIME FOR NEXT DOLLAR AMOUNT IF NO TO PREVIOUS DOLLAR AMOUNT)

$50 towards the purchase and installation cost? Yes___ No___ if no, continue to next $
$75 towards the purchase and installation cost? Yes___ No___ if no, continue to next $
$100 towards the purchase and installation cost? Yes___ No___ if no, continue to next $
$125 towards the purchase and installation cost? Yes___ No___ if no, continue to next $
The entire purchase and installation cost? Yes___ No___

Ask 16a only if respondent answered "No" to all of Q.16.

16a. What is the primary reason you would be unwilling to replace an older high-flow toilet with a new low-flow toilet even if it were done free of charge?

_____[Open ended response. Mark the one that mostly closely matches response]

__Sounds too expensive
__Don't want the hassle
__Our current toilets work fine
__*I've heard the toilets don't work*
__I don't want to install a new toilet until I remodel
__I don't think I can get a color or style I like
__Rent/don't own the home
__They don't flush well
__Other [specify]
__Don't know

That's all of our questions. A surveyor will contact you during the next week to schedule an appointment to come out to your home for this Santa Clara Valley Water District study. After we schedule the appointment, you will receive an official confirmation in the mail directly from the Santa Clara Valley Water District. Thank you very much for your time and for agreeing to participate in this important study.

13. Appendix B – On-site Inspection Form

Santa Clara Valley Water District

Customer Information & Water Consumption

Residential Baseline Study 1

Tracking ID: _____

Complex/Site Name: _____ Retailer: _____

Type of Dwelling

- Single Family Detached ◯
- Single Family Attached (condo / townhse) ◯
- Multi Family (2-4 Unit Bldg) ◯
- Multi Family (5+ Unit Bldg) ◯
- Total Units in Complex _____
- Mobile Home / Trailer ◯

Residence Year Constructed: _____ Years at Site: _____

Number of Residents: _____ Bathrooms: _____

Ownership Own ◯ Rent ◯

Survey Conducted in English ◯ Spanish ◯ Vietnamese ◯

Appliances

ITEM	Use Patterns	Characteristics
Clothes Washer	Yes◯ No◯	_____ # Loads per week
	Own Washer◯ Share Washer◯	
	Energy Star or Front Load ? Yes◯ No◯	
Coin Operated	Yes◯ No◯	_____ # Loads per week
		_____ *Total # Coin-Op Machines*
		_____ *# Energy Star or Front Load*
Dish Washer	Yes◯ No◯	_____ # Loads per week
Softener	Yes◯ No◯	*Auto Recharge?* Yes◯ No◯
Reverse Osmosis	Yes◯ No◯	*On/Off Switch?* Yes◯ No◯
Pool	Yes◯ No◯	*Cover?* Yes◯ No◯
Hot Tub/Spa	Yes◯ No◯	*Cover?* Yes◯ No◯

Meter Calculations

Last Read (from bill if avail.) _____

Date of Last Reading _____

Today's Meter Reading _____ hcf

5 Minute Leak Check

Meter Second Reading _____

Meter First Reading − _____

Total hcf = _____

Conversion to (gpd) (hcf X 215,568)

Leak Rate (gpd) = _____

Surveyors: _____ **Date:** _____ **House Leak?** Yes◯ No◯

Santa Clara Valley Water District

Indoor Section

Location ID Options

MB:	*Master Bathroom*	*OB:*	*Other Bath*
GB:	*Guest Bath*	*KT:*	*Kitchen*
KB:	*Kids Bath*	*LR:*	*Laundry Room*
HB:	*Hallway Bath*	*GR:*	*Garage*
BB:	*Bedroom Bath*	*OT:*	*Other*

Residential Baseline Study 2

Tracking ID: ____________________

Showers

Loc.ID	gpm	Leak Rate	Diverter Leak	SH Replaced while customer has lived there?	If yes, # of years ago?	If yes, reason replaced	If low flow, free or discounted through Program?
		gpd	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○
		gpd	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○
		gpd	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○
		gpd	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○
		gpd	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○

Faucets

Location ID	Gpm	Leak Rate	Aerator Present?	Location ID	Gpm	Leak Rate	Aerator Present?
		gpd	Yes○ No○			gpd	Yes○ No○
		gpd	Yes○ No○			gpd	Yes○ No○
		gpd	Yes○ No○			gpd	Yes○ No○
		gpd	Yes○ No○			gpd	Yes○ No○

Toilets

Loc.ID	Tank Measurements	Leaks?	Brand / Manuf. Yr.	Bowl Clnr	Toilet Replaced while customer has lived there?	If yes, # of years ago?	Reason Replaced	If ULFT, rec'd free or discounted through Program
	L: ____ F: ____ W: ____ E: ____	Yes○ No○	Br: ____ Yr: ____	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○
	L: ____ F: ____ W: ____ E: ____	Yes○ No○	Br: ____ Yr: ____	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○
	L: ____ F: ____ W: ____ E: ____	Yes○ No○	Br: ____ Yr: ____	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○
	L: ____ F: ____ W: ____ E: ____	Yes○ No○	Br: ____ Yr: ____	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○
	L: ____ F: ____ W: ____ E: ____	Yes○ No○	Br: ____ Yr: ____	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○
	L: ____ F: ____ W: ____ E: ____	Yes○ No○	Br: ____ Yr: ____	Yes○ No○	Yes○ No○		Broken○ Remodel○ Other ________	Yes○ No○ Don't Know○

Santa Clara Valley Water District

Outdoor Section

Residential fddd **Baseline Study 3**

Tracking ID: _____

Present Irrigation Schedule

This schedule is for: Spring ○ Summer ○ Fall ○

Location	Type*	Minutes /Cycle	Cycles/ Day	Days/ Week	Total Minutes

Total # of Valves: _____

Landscape Area: _____ sq.ft.

Turf Area: _____ sq.ft.

Landscape. Service: Yes ○ No ○

How Often is the Schedule Adjusted Now? _____

Water Pressure	Pressure Red. Valve		Outdoor Leak	
_____ psi	Yes ○	No ○	Yes ○	No ○

*Sprinkler Type: **P**=Pop-up **R**=Rotor **I**=Impact **B**=Bubbler **D**=Drip **MS**=Microspray **H**=Hose **HS**=Hose w/Sprinkler

Irrigation System (check all that apply)

Automatic In-Ground ○ Drip, Automatic ○

Manual In-Ground ○ Drip, Manual ○

Hose ○ None ○

Controller Brand/Model _____

Controller Type

Mech ○ Hybrid. ○ Elec/Dig ○ Other ○ None ○

Catch can test location:

Catch Can Test

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

10 _____

Reason Incomplete

Rain ○ Broken ○ N/A ○

Unable ○ Wind ○ Denied ○

Irrigation System & Landscape Description	Irrigation Area / Stations											
	1	2	3	4	5	6	7	8	9	10	11	12
Plants												
Plant type: WS = Warm Season **CS**=Cool Season **M**=Mix **D**=Dichondra **O**=Ornamental **DT**=Drought Tolerant **V**=Vegetables **T**=Trees w/mulch **GC**=Ground Cover												
Valves not separated by plant water requirement												
Valves not separated for sun exposure												
Area over-watered												
Dry spots												
Soil compaction - need to aerate												
Excess grass thatch												
Needs mulch												
Sloped area												
Run-off												
Ponding near plants												
Improper design												
System Type: R=Rotor **I**=Impact **B**= Bubbler **D**=Drip **MS**=Microspray **H**=Hose **HS**=Hose w/Sprinkler												
Sprinkler Systems	1	2	3	4	5	6	7	8	9	10	11	12
Broken or clogged heads												
Heads/nozzles not matched												
Uneven head spacing												
Low head drainage												
Spray pattern blocked or misdirected												
Incorrect spray arc												
Over spray												
Sunken heads												
Heads not vertical												
Unequal pressure/unequal discharge rate												
Misting due to high pressure												
Low pressure												
Broken/leaking valve or pipe												
Drip Systems	1	2	3	4	5	6	7	8	9	10	11	12
Pinched or broken tubing												
Tubing pulled off emitters												
Emitters too close to plant												
Low pressure causes flow vs. drip												
Missing/broken emitters												
Clogged emitters												
High pressure												
Comments:												

14. Appendix C – Telephone Survey Call Disposition Report

	Ratios	Category totals
Call statistics		
Total telephone numbers dialed (at least once)		55,738
Total calls made		185,292
Total interviews completed		2,362
Total "willing" participants identified		835
Key call ratios		
Average calls per dialed number	3.32	
Average calls per completed interview	78.45	
Average calls per "willing" participant	221.91	
Cooperation rate	35.35%	
Key sample characteristics		
Single-family		565
Multi-family		270