

High-Efficiency Plumbing Fixture Direct Install Water Savings Analysis

for

Sonoma County Water Agency

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Santa Rosa, California

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By

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INTRODUCTION

The purpose of this study was to evaluate the results of a multi-faceted water conservation 'direct installation' program developed and managed by the Sonoma County Water Agency (Water Agency)¹, a water wholesaler in northern California that is also responsible for flood protection services, distribution of recycled water, recreational opportunities and wastewater treatment.

The program encompassed the replacement of older water-using fixtures and fixture fittings in both domestic (residential) and non-residential applications with new high-efficiency products. Qualified, licensed plumbers were used to install all such items, which included toilet fixtures, urinals, showerhead, and faucet aerators. It should be noted that the analysis and this report focus almost entirely upon the water use reductions resulting from toilet fixture replacements and does not assess savings associated with showerhead and faucet aerators.

The program was implemented in several service areas:

- Airport/Larkfield/Wikiup Sanitation Zone
- Geyserville Sanitation Zone
- Occidental County Sanitation District
- Penngrove Sanitation Zone
- Russian River County Sanitation District
- Sea Ranch Sanitation Zone
- Sonoma Valley County Sanitation District

Only two of the above service areas were included in this study as inclusion depended upon the availability of customer water use data. The areas and program time frame where data was available were as follows:

- Sonoma Valley County Sanitation District² (City of Sonoma³)
- Installations from June 2009 through April 2010

- Sonoma Valley County Sanitation District (Valley of the Moon Water District⁴)
- Installations from June 2009 through February 2010

- Airport/Larkfield/Wikiup Sanitation Zone⁵ (Town of Windsor⁶)
- Installations from November 2009 through April 2010

In this report, service areas are further broken out by retail water provider as note above in parenthesis.

¹ <http://www.scwa.ca.gov/quick-facts/>

² <http://www.scwa.ca.gov/lower.php?url=svcscd>

³ <http://www.sonomacity.org/>

⁴ <http://www.vomwd.com/index.html>

⁵ <http://www.scwa.ca.gov/lower.php?url=airport-larkfield-wikiup-sanitation-zone>

⁶ <http://www.ci.windsor.ca.us/>

PROGRAM BACKGROUND

Schedule

The subject program was executed over a period of about 11 months, beginning with a pilot program in June 2009 expanding to full fledged program from September 2009 through April 2010. During the eight months of the full program, more than 5,000 fixtures were installed.

Fixtures and Fixture Fittings

This study focused on the replacement of approximately 1,776 aging toilet fixtures⁷ with high-efficiency models⁸, divided as follows:

Table 1. Toilet fixture replacements

| Service Area | Residential | Commercial | Total |
|-------------------------------|-------------|------------|-------|
| City of Sonoma | 266 | 451 | 717 |
| Valley of the Moon Water Dist | 874 | 18 | 892 |
| Town of Windsor | 0 | 164 | 164 |
| Total | 1140 | 633 | 1773 |

The program installed 1.28 gpf HETs through December 2009. Beginning in January 2010, the program requirements were modified to require 1.1 gpf or less HETs for tank-type toilets; it also allowed the replacement of 1.6 gpf ULFTs if at least one non-efficient (greater than 2.0 gpf) toilet was to be replaced at the same participating property.

Urinals, showerheads and faucet aerators were also replaced through the program as well:

Table 2. Urinal fixture replacements

| Service Area | Properties | Urinals |
|-------------------------------|------------|---------|
| City of Sonoma | 3 | 23 |
| Valley of the Moon Water Dist | 0 | 0 |
| Town of Windsor | 19 | 59 |
| Total | 22 | 82 |

Table 3. Showerhead replacements

| Service Area | Residential | Commercial | Total |
|-------------------------------|-------------|------------|-------|
| City of Sonoma | 44 | 51 | 95 |
| Valley of the Moon Water Dist | 52 | 1 | 53 |
| Town of Windsor | 0 | 1 | 1 |
| Total | 96 | 53 | 149 |

⁷ A total of 1,954 toilet fixture installations were evaluated for this study, however, 178 fixtures could not be included as part of the analysis due to a lack of or inconsistent water use data. Other toilets (3) were excluded for other reasons. In addition, 82 urinal fixtures were replaced as well.

⁸ High-efficiency toilet (HET) fixtures are defined as those with an effective flush volume 20 percent less than the Federal maximum of 1.6 gallons per flush (gpf). As such, all HETs flush (on average) at 1.28 gallons or less. The first HET fixtures were introduced to the North American marketplace in 1999. Since that date, over 1,000 different HET models from dozens of manufacturers exist in the U.S. marketplace. The U.S. EPA's WaterSense program endorses HETs and labels those models that perform to a high set of standards.

Table 4. Faucet aerator replacements

| Service Area | Residential | Commercial | Total |
|-------------------------------|-------------|------------|-------|
| City of Sonoma | 191 | 163 | 354 |
| Valley of the Moon Water Dist | 113 | 5 | 118 |
| Town of Windsor | 0 | 118 | 118 |
| Total | 304 | 286 | 590 |

Participating Properties

A total of 1,740 sanitation customer properties participated and are benefitting from the program. Included in this study are 364 properties, divided by retail water service providers as follows:

Table 5. Properties participating in the program

| Service Area | Residential | Commercial | Total |
|-------------------------------|-------------|------------|-------|
| City of Sonoma | 79 | 44 | 123 |
| Valley of the Moon Water Dist | 215 | 5 | 220 |
| Town of Windsor | 0 | 21 | 21 |
| Total | 294 | 70 | 364 |

Plumber Participation

Any licensed plumber could participate in the program provided they agreed to Water Agency's terms and conditions and met certain insurance requirements. Participating plumbers were paid through a set rate schedule for materials and labor. A total of thirteen (13) plumbers participated in the program. Seven (7) of those plumbers participated in the toilet installations analyzed for this report.

The participating plumbers verified eligibility, performed a water audit of the property⁹, provided and installed the fixtures, invoiced the customer for any upgrades, and invoiced SCWA for the base price of materials, recycling, and labor.

Data Collection

For the purpose of assessing water use reductions achieved through the program, the Water Agency collaborated with its retail water service providers to secure water meter readings for the 364 properties for a minimum of one year following fixture installation. These meter readings were then compared to meter reads from periods prior to installation of from 24 to 36 months.

In addition to metered water consumption and property location, each data set for an individual participant (property) contained information on type of property occupancy, the number and type of fixtures and fixture fittings within the property, listing of which of those items were replaced, the flush volume and technology¹⁰ of the replaced toilets, the date of replacement, and the licensed plumber name.

⁹ The on-site audit included: an inventory of all toilets, urinals, showerheads, faucets, and clothes washers at the property; a recording of flush volumes and design of the toilets, flow rates of the faucets, and the efficiency of the clothes washers – standard or Energy Star rated; a 5-minute “whole-house” leak check at the water meter; and a post-installation inventory of the replacement fixtures and fixture fittings.

¹⁰ Toilet fixtures were identified either as gravity-fed, pressure-assist, or flushometer valve/bowl combinations.

STUDY RESULTS

Methodology

Metered water consumption data furnished by the retail water service providers was used to assess demand reductions, if any, due to fixture and fitting replacements. Sub-metering or other fixture-specific monitoring of uses within homes and businesses was not performed. All results relied entirely upon data from utility meters and reports from the installing plumbers.

To reduce the effect of seasonal variations in climate (and, hence, water demand variances) from year to year, only demand over the six fall and winter months was considered. Because all of the participating water utilities are programmed for bimonthly billing, and therefore all water consumption was measured in two-month increments, it was impractical to use a period any shorter than six months for the 'winter analysis'. Moreover, the installations of the high-efficiency products occurred largely during the 2009-2010 winter period. As such, the analyses of the 'before' and 'after' cases compared the 2008-09 winter period with that of the identical 2010-11 period.

Where possible, properties where only toilets were being replaced were isolated from those with mixed installations. For example, many of the installations involved replacement of an array of different products at the same property, e.g., toilets and urinals; toilets, showerhead and aerators; or toilets, urinals, showerheads, and aerators.

In some cases, the information provided by the installation plumbers or the water consumption data from meter readings was such that certain properties (and the associated fixture replacements) had to be removed from our analyses. The remainder of the installations (1,776) were each evaluated individually and some further removals occurred because of extraordinary changes in post-installation water consumption when compared to pre-installation¹¹.

Findings

Water savings achieved through toilet fixture replacement were assessed for several different categories of end-user, type of toilet, and the flush volume of the old and new toilets. A further analysis was made for replacement activities where the plumber replaced a variety of plumbing items in a single site visit. Finally, a similar analysis was made for urinal replacements.

Overall water savings

The replacement of toilet fixtures and all other devices¹² resulted in the following:

Table 6. Savings from all toilet fixture and fixture fitting replacements¹³

| | Residential | Commercial | Total |
|---|-------------|-------------|-------------|
| No. of Properties | 294 | 70 | 364 |
| No. of Toilets | 1140 | 633 | 1773 |
| Daily Water Savings per Toilet (gallons) | 54.7 | 58.9 | 56.2 |

¹¹ These were cases where a substantial increase or decrease in water use was not warranted solely by the reported fixture and fixture fitting replacements.

¹² Includes instances where other plumbing items (urinals, showerheads, aerators) were replaced at the property at the same time as toilet replacement.

¹³ Represents a mixture of aging toilets replaced: 1.6 gpf, 3.5 gpf, and higher. Replacement toilets all qualified as HETs. Some properties and toilet installations are left out of this summary, due to lack of water use data or data inconsistencies.

Water savings by end use category – Residential

(Single-family housing vs. Multi-family housing)

In total, 1,140 new HETs were installed in 294 residential applications, replacing an equal number of non-efficient 1.6 gpf and 3.5 gpf rated fixtures. Refer to Table 7.

Table 7. Residential installs

| Service Area | <u>Residential Installations</u> | | |
|-------------------------------|----------------------------------|--------------|-------|
| | Single Family | Multi-Family | Total |
| City of Sonoma | 89 | 177 | 266 |
| Valley of the Moon Water Dist | 337 | 537 | 874 |
| Total | 426 | 714 | 1140 |

Water savings associated with toilet installs in the single and multi-family categories were divided into two further categories, those installs where only toilets were replaced and those installs involving toilets and other fixtures or fixture fittings. Of the total of 1,140 toilets replaced in residential, 813 were installs involving no other such items. Table 8 displays the water savings per toilet achieved for both single and multi-family for both scenarios.

Table 8. Water savings – residential installations¹⁴

| | No. of | <u>Water Savings (gal/day)</u> | |
|-------------------------------------|---------|--------------------------------|--------------|
| | Toilets | Single Family | Multi-Family |
| Toilets 'alone' | 813 | 27.6 | 59.4 |
| Toilets combined with other devices | 327 | 36.0 | 70.8 |

Water savings per residential household

A secondary analysis was performed to determine water savings by participating household. In the case of multi-family installs, the participating plumber reported on the number of apartment units within the property being retrofitted.¹⁵ Table 9 displays household water use reductions reported as per installed toilet basis.

Table 9. Water savings per household

| Service Area | Dwelling Units | Toilets Replaced | Avg Water Savings per Dwelling Unit (gal/day) |
|---|----------------|------------------|---|
| <u>Single-Family Dwellings</u> | | | |
| City of Sonoma | 49 | 89 | 109.5 |
| Valley of the Moon Water Dist | 190 | 337 | 53.5 |
| Combined | 239 | 426 | 65.0 |
| <u>Multi-Family Dwelling Units</u> | | | |
| City of Sonoma | | 177 | |
| Valley of the Moon Water Dist | 412 | 537 | 86.1 |
| Combined | 412 | 714 | |
| All Dwelling Units | 651 | 1140 | |

¹⁴ Toilets 'alone' category excludes those instances where toilets were installed along with urinals, showerheads, or aerators. However, the category includes instances where 3.5 gpf and 1.6 gpf toilets were installed together in the same property.

¹⁵ Dwelling unit counts are for actual living units, regardless of the number of dwelling units in a given multi-unit apartment building. For example, 537 toilets were replaced in 412 apartments in the Valley of the Moon Water District. It should be noted that the unit information was not available for the multi-family properties located in the City of Sonoma.

Water savings by end use category – Non-residential
(Commercial and institutional applications)

Commercial and institutional replacements of toilets were similarly broken into two categories, i.e., installs where the toilet alone was replaced without any additional plumbing replacements on the same property and installs where the toilet was accompanied by installs of one or more of the following: urinal fixture, showerhead, or faucet aerator. Savings as disclosed by the billing data is summarized in Table 10.

Table 10. Water savings – non-residential installations¹⁶

| | Properties | Toilets Replaced | Average Water Savings per Toilet (gal/day) |
|--|------------|------------------|--|
| Toilets 'alone' | 32 | 164 | 132.0 |
| All non-residential toilet installations | 64 | 633 | 64.6 |

Non-residential installations fell into seven categories, most participating properties being in the office and retail/services classifications as noted in Table 11.

Table 11. Water savings by commercial-institutional category

| Non-Residential Category | Properties | Toilets Replaced | Average Water Savings per Toilet (gal/day) |
|------------------------------------|------------|------------------|--|
| Office (incl medical offices) | 21 | 96 | 34.6 |
| Retail & Services | 20 | 57 | 194.3 |
| Hospitality: Lodging & Restaurants | 7 | 366 | 45.0 |
| Warehouse | 4 | 29 | 35.9 |
| Light Manufacturing | 4 | 52 | 7.6 |
| Religious Institutions | 4 | 19 | 150.8 |
| Mobile Home Park | 3 | 2 | 197.3 |
| Health Club - Spa | 1 | 12 | 443.8 |
| Combined | 64 | 633 | 64.6 |

It is important to note that all of the office building toilet replacements were accompanied by aerator installations as well. As a result, there was no reliable method to isolate the savings resulting from toilet replacement from that derived from aerators.

Conversely, retail and service installations were isolated because installations were not accompanied by other fixtures or fittings. Half of the hospitality (lodging and restaurants) installations and half of the religious installations were accompanied by aerator installs. Interestingly, however, only one of the five lodging institutions that received replacement toilets were also provided with new showerheads. This would indicate that those remaining four hotels were already equipped with efficient showers in the guest rooms or that hotel management declined the offer of replacement showerheads.

The health club-spa installation of 12 toilets was accompanied by the installation of three high-efficiency urinals (HEUs) as well. Eight of the 12 toilets replaced were reported as likely 3.5 gpf

¹⁶ The majority of the 164 toilet installations made 'alone' replaced 3.5 gpf fixtures in high-volume locations, resulting in large per-toilet water savings.

or greater. The sample size for health club-spa and for the mobile home park are such that the savings data may not be representative of such facilities and cannot be applied with confidence to other similar end uses.

Water savings by replaced toilet
(1.6 gallons per flush vs. 3.5 gallons per flush)

Plumbers were required to record and report the flush volume of the toilets they replaced at each participating property. That report indicated whether the replaced fixtures were functioning at 2.0 gallons or less¹⁷; all others were reported to be flushing at 2.1 gallons or more (assumed to be 3.5 gpf fixtures). However, plumbers were not required to physically measure toilet flush volumes, relying instead upon their observation and experience. As a result, it cannot necessarily be assumed that all of the recorded information is fully accurate; but it is sufficient to provide a general picture of what was removed and replaced within the participating properties.

In many properties, installing plumbers replaced both types of older fixtures, i.e., 2.0 gpf or less and 3.5 gpf. However, it was those installations where only one or the other was replaced that could be used for developing the savings data shown in Table 12.

Table 12. Water savings by replaced toilet

| Category | Properties | Toilets Replaced | Average Water Savings per Toilet (gal/day) |
|--------------------|------------|------------------|--|
| Residential | | | |
| Replace 1.6 gpf | 17 | 19 | 27.1 |
| Replace 3.5 gpf | 165 | 504 | 41.8 |
| Commercial | | | |
| Replace 1.6 gpf | 8 | 335 | 25.8 |
| Replace 3.5 gpf | 45 | 235 | 102.8 |
| Combined | | | |
| Replace 1.6 gpf | 25 | 354 | 25.9 |
| Replace 3.5 gpf | 210 | 739 | 61.2 |
| TOTAL | 235 | 1093 | 49.8 |

Water savings by replacement toilet design/technology
(Gravity-fed vs. pressure-assist vs. flushometer valve combination)

Another area in which building managers and water efficiency practitioners are interested is that related to the design of replacement product. For example, will a standard gravity-fed HET (at 1.28 gpf) yield a savings similar to that of the pressure-assist HET (at 1.1 gpf)?

In this Water Agency program, installed HETs were fairly evenly divided between the two designs. However, most commercial installs of one or the other technology were accompanied by installs of showerheads, aerators, or urinals, therefore excluding them from a 'toilet only'

¹⁷ It is likely the fixtures recorded as 2.0 gpf or less were designed and originally rated at 1.6 gpf, complying with the EPA's 92 Federal maximum. Based upon other studies, we know that many of these aging fixtures were likely to be flushing at something other than 1.6 gallons. This includes those adjusted to higher flush volumes as well as those with lower flush volumes. In the latter case, reduced flush volumes on these aging fixtures frequently degrades flush performance and, thus, results in double flushing by the customer.

water savings analysis. Analyzing only 'discrete' installations¹⁸, Table 13 displays the water savings yield from 911 such toilet replacements¹⁹.

Table 13. Water savings by type of replacement toilet

| | Residential | Commercial | Combined |
|--|-------------|--------------|-------------|
| Pressure-assist toilets | 269 | 43 | 312 |
| Daily water savings/toilet (gal) | 94.9 | 153.4 | 120.6 |
| Gravity-fed toilets | 478 | 121 | 599 |
| Daily water savings/toilet (gal) | 39.7 | 124.3 | 56.8 |
| Combined savings (gal/toilet/day) | 59.5 | 132.0 | 72.6 |

Water savings by installation plumber

For the toilet replacements evaluated in this study, seven (7) different licensed plumbers performed the installations. Documentation provided by the Water Agency showed those plumbers as installing a total of 1,954 toilet fixtures²⁰, 82 urinal fixtures, 149 showerheads, and 590 faucet aerators (refer to Tables 1 through 4) as replacements for existing fixtures and fixture fittings.

Table 14 displays the total water savings²¹ attributed to each of the seven plumbers shown on a per toilet basis:

Table 14. Water savings by installation plumber

| Plumber | Properties Served | Toilets Replaced | Average Daily Water Savings |
|-----------------|-------------------|------------------|-----------------------------|
| A | 217 | 1269 | 52.9 |
| B | 53 | 167 | 13.6 |
| C | 59 | 183 | 54.3 |
| D | 20 | 111 | 36.6 |
| E | 1 | 8 | 89.7 |
| F | 3 | 44 | 11.7 |
| G | 2 | 7 | 115.1 |
| Combined | 355 | 1789 | 47.8 |

Differences in average daily water savings among the seven (7) plumbers are largely attributable to the types of properties and replacements made, since, in some cases, replacements of showerheads, faucet aerators, or urinals were made at the same time as the

¹⁸ 'Discrete' installations are defined as a pressure-assist or gravity-fed toilet install that is not accompanied by an installation (replacement) of a urinal, showerhead, nor aerator. For example, a gravity-fed toilet is not accompanied by the concurrent installation of pressure-assist toilets, urinals, showerheads or aerators. It should also be noted that the pressure-assist toilets installed in this program were rated at 1.0 gpf, whereas the gravity-fed toilets used as replacements were rated at 1.28 gpf. This difference resulted in the savings from pressure assist fixtures to be significantly greater than those resulting from gravity-fed toilet replacements.

¹⁹ The 911 'discrete' installs represents two-thirds of the 1,371 toilet replacements that took place without urinal, showerhead or aerator replacements at the same property. The difference of 455 installs occurred at properties where both pressure-assist and gravity-fed toilets were installed at the same time.

²⁰ A total of 1,773 toilet installs were evaluated in this study; refer to footnote 7.

²¹ Savings derived from all sources: toilets, urinals, showerheads, and aerators.

toilet replacements. The reader should not infer that one plumber is necessarily 'better' than another plumber based upon the water savings data in this table.

Water savings – urinal replacements

A total of 82 urinals in 22 properties were replaced with HEUs as part of this Water Agency program (Table 2). Of the 82, only 12 urinals (in two properties) were installations unaccompanied by the replacement of other fixtures or fixture fittings. The water use data from this small sample and those two properties was inconclusive; it could not be used for developing any general water savings metrics.

SUMMARY AND CONCLUSIONS

The Water Agency program covered within this study was directed largely at toilet fixture replacements, although urinals, showerheads, and faucet aerators were also replaced in a large number of the participating properties. The primary goal of this study was to derive water savings per toilet fixture based upon a total of 1,954 such replacements²². While this represents an adequate sample from which to draw some general water savings metrics to be applied elsewhere, the parsing of this number into smaller and smaller increments for more sector-specific metrics leads to less reliable data. However, the resulting water savings metrics for these sectors is still generally useful for projections of likely water use reductions when conservation programs are being developed or evaluated.

Key water savings findings from the study were as follows:

Table 15. Water savings summary

| | Number of Properties | Toilets Replaced | Average Daily Water Savings (gallons) |
|---|-------------------------|---------------------|--|
| <i>ALL Fixtures & Fittings Combined...</i> | | | |
| Overall | 364 | 1773 | 56.2 |
| Residential | 294 | 1140 | 54.7 |
| Non-Residential (commercial) | 70 | 633 | 58.9 |
| <i>Toilet Fixtures alone...</i> | | | |
| Residential | 199 | 813 | 56.1 |
| Non-Residential (commercial) | 32 | 164 | 132.0 |
| Replace a 1.6 gpf | 25 | 354 | 25.9 |
| Replace a 3.5 gpf | 210 | 739 | 61.2 |
| Replace with a pressure-assist | 58 | 312 | 120.6 |
| Replace with a gravity-fed | 171 | 599 | 56.8 |

Installations of the high-efficiency fixtures and fixture fittings were performed by seven different licensed plumbing companies. Nearly 97 percent of those installations were performed by four of the companies.

The program documents counted the installation of 82 high-efficiency urinals, however in 70 of those instances, toilet fixtures or other devices were installed at the same time. Water use records for the remaining 12 urinals were not sufficient to draw any savings conclusions.

²² As noted in the report, however, this number was reduced a bit as certain properties were removed from the analysis due to missing or inconsistent data.