WATER CLOSET PEFORMANCE TESTING

Prepared for

Seattle Public Utilities and
East Bay Municipal Utility District

by

NAHB RESEARCH CENTER℠

Upper Marlboro, Maryland

September 2002

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Report No.: P01-1660902

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The NAHB Research Center is the not-for-profit research arm of the National Association of Home Builders, and is located in Upper Marlboro, MD. In its nearly 40 years of service to the home building industry, the Research Center has provided product research and building process improvements that have been widely adopted by home builders in the United States. Through testing and certification services, the NAHB Research Center seal is recognized throughout the world as a mark of product quality and an assurance of product performance.

EXECUTIVE SUMMARY

In the interest of fostering water conservation initiatives in their respective water service areas, Seattle Public Utilities, Seattle, WA, and the East Bay Municipal Utility District, Oakland, CA, engaged the NAHB Research Center, Inc.,[1] to undertake a series of performance tests and evaluations on a variety of residential and commercial toilet fixtures.

The objectives of the study were to:

- Develop information on product performance, water savings reliability, and physical characteristics that will assist the consumer in evaluating products and making purchase choices.

- Evaluate the NAHB Research Center's flush performance test protocol as a potential supplement to existing ASME/ANSI A112.19.2 pass/fail protocols for the purpose of developing discriminatory data on toilet fixture performance.

A variety of commonly available toilets and newly developed fixtures were tested to determine flushing performance, flush volume, trap diameter, water spot area, and other characteristics. While the majority of tested fixtures were designed to flush at the standard 1.6 gallons per flush (gpf), a few possessed design volumes significantly less than the standard. A total of 52 different models were tested. Three were older fixtures removed from residential dwellings because of performance problems, while the remaining 49 being new fixtures of current vintage.

The 49 new models tested in this study were, to the extent possible, obtained from retail outlets or commercial plumbing distributors. To evaluate any differences from unit to unit of like models, two units of each model were obtained and, when possible, from different sources. The testing included nominal 1.6 gpf gravity, pressure-assist and vacuum-assist models, as well as a few special models such as dual-flush, flapperless, and air-assist units.

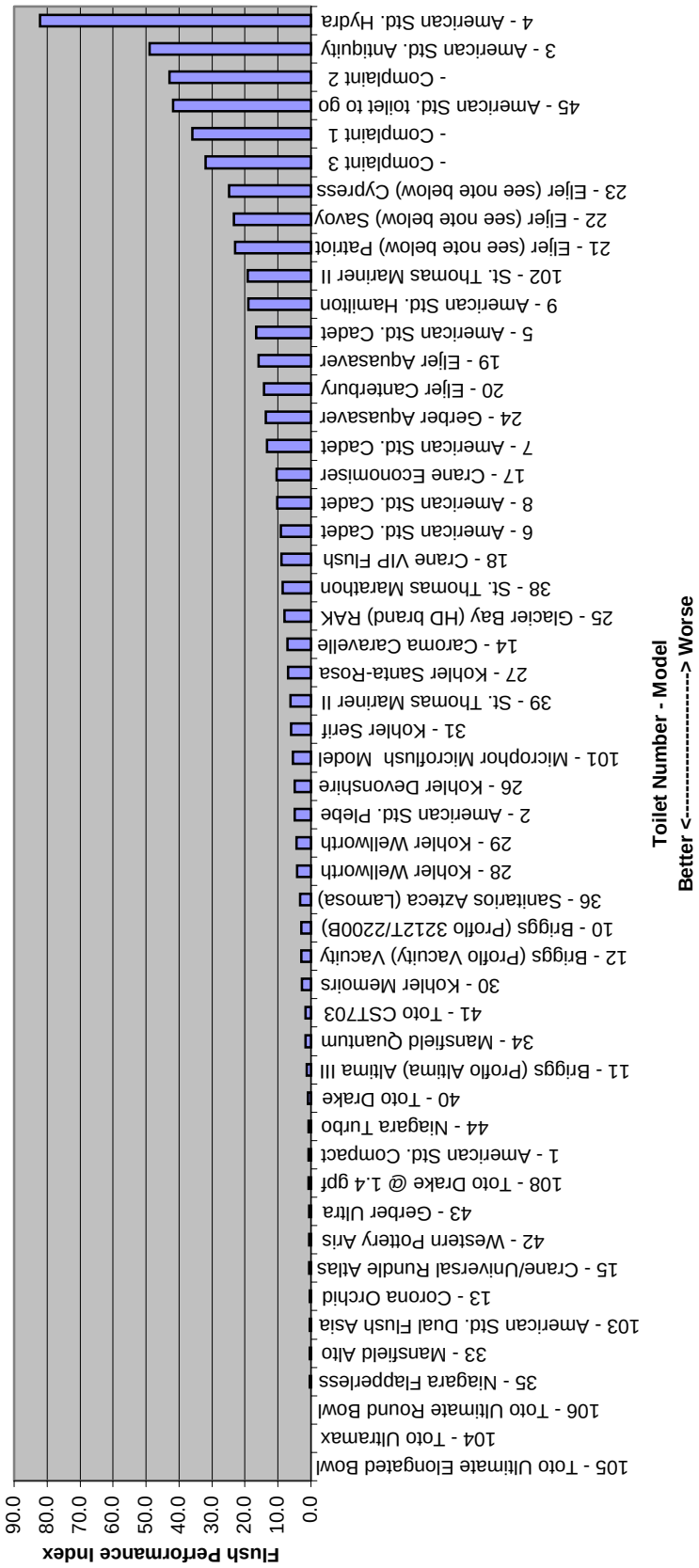
The flushing performance testing utilized a series of floating or sinking sponges as well as paper wads to simulate the waste loading in the toilet. Five different levels of loading were used ranging from a substantial challenge to a minimal load. Each toilet was flushed a number of times at each loading level until a stable value was reached that represented the average of how many of the test media remained in the bowl after each flush. The results from each loading level of both the "floaters" and "sinkers" were summed to calculate a Flush Performance Index. Also measured were the "out of the box" flush volume, flush volume with a replacement flapper, and trap diameter.

The tested models had average Flush Performance Index numbers ranging from 0 to 82 with lower numbers indicating better performance. Figure 1 shows the results of the flush performance testing. Several complaint toilets, removed from consumers' homes, were tested to gain a benchmark as to what index value might be expected from a toilet that performed poorly in actual use. Most of the tested models performed better than the complaint toilets. The performance indexes may be used as a general indication of the expected performance, but cannot be used to precisely predict performance of one model compared to another in a particular individual's home. The difference between actual use and the simulated testing requires that the results be interpreted with an understanding of the testing variability and limitations.

The report also compares the retail price of most of the tested fixtures with the Flush Performance Index. There appears to be little correlation between fixture price and flushing performance.

[1]The NAHB Research Center is a wholly-owned, independent, not-for-profit subsidiary of the National Association of Home Builders.

FIGURE 1
FLUSH PERFORMANCE INDEX



Technicians measured “out-of-the-box” flush volumes after the toilet fixtures were set up in accordance with the manufacturers’ written instructions. Subsequently, the original equipment flapper was replaced with a generic “standard” replacement flapper and the flush volume was measured for a second time. The distributions of the results of these measurements are shown in Figure 2. Out-of-the-box flush volumes of nominal 1.6 gpf toilets ranged from 1.45 to 1.89 gpf. The average flush volume of those toilets that exceeded 1.6 gpf was 1.68 gpf.

After replacement of the original flapper with a generic flapper, the flush volume for the 1.6 gpf fixtures that could be retrofit with a standard flapper ranged from 1.03 to 4.66 gpf. Twenty-eight of the 33 models that could be retrofit with a standard flapper used more than 1.6 gpf after flapper replacement and averaged 2.91 gpf. This is consistent with the results of an earlier study wherein similar flapper replacements were performed.[2] Because flapper valves typically require replacement several times during the useful life of a toilet fixture and the likelihood that the consumer will install a generic replacement flapper, water efficiency of many of the tested models could significantly degrade over time.

[2]Metropolitan Water District of Southern California, “After-Market Toilet Flappers: A Study of Compatibility and Flush Volumes,” 1998.

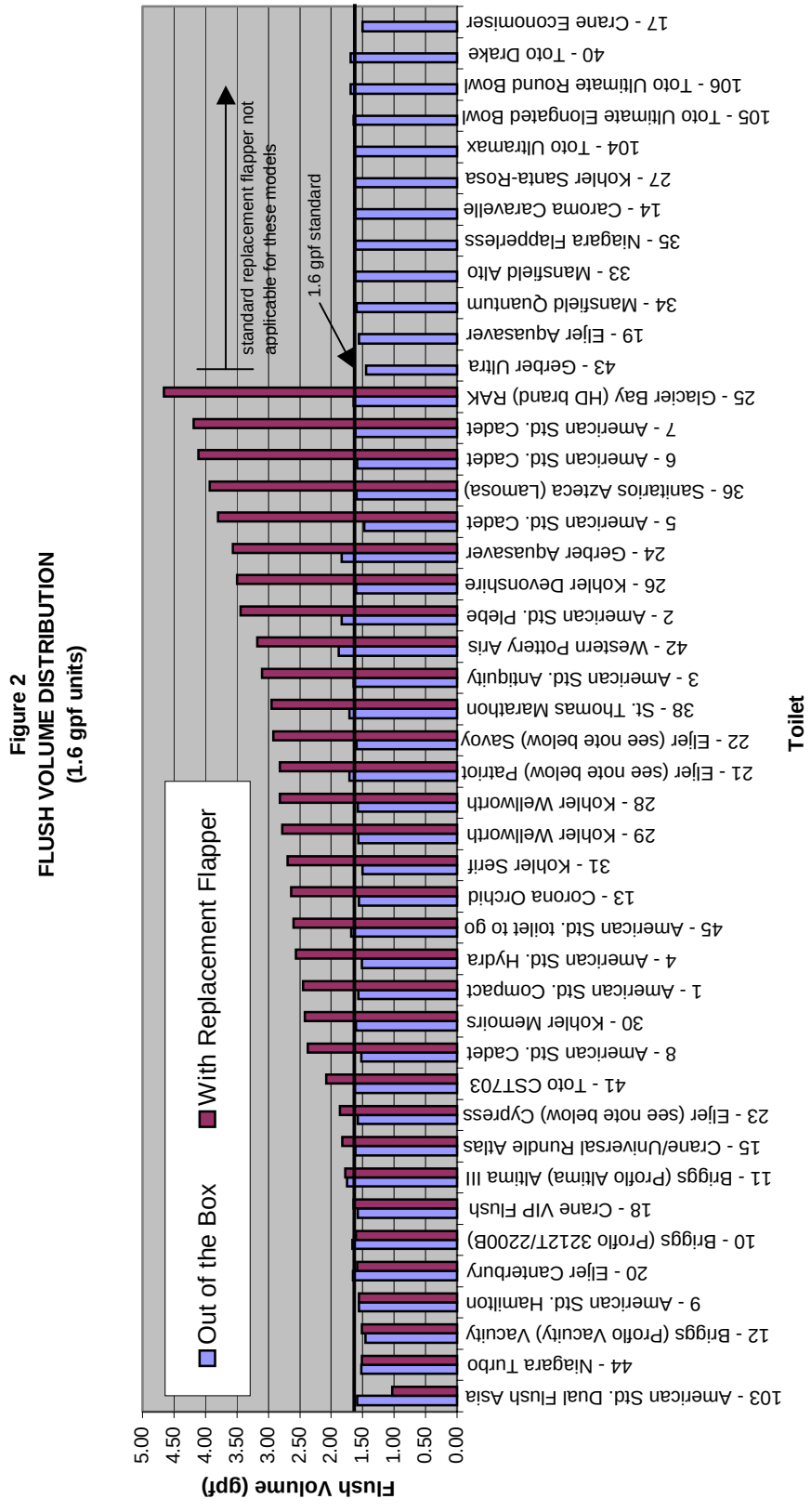


Figure 2
FLUSH VOLUME DISTRIBUTION
(1.6 gpf units)
Flush Volume (gpf)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Out of the Box
With Replacement Flapper
1.6 gpf standard
standard replacement flapper not applicable for these models
Toilet
103 - American Std. Dual Flush Asia
44 - Niagara Turbo
12 - Briggs (Profio Vacuity) Vacuity
9 - American Std. Hamilton
20 - Eljer Canterbury
10 - Briggs (Profio 3212T/2200B)
18 - Crane VIP Flush
11 - Briggs (Profio Altima) Altima III
15 - Crane/Universal Rundle Atlas
23 - Eljer (see note below) Cypress
41 - Toto CST703
8 - American Std. Cadet
30 - Kohler Memoirs
1 - American Std. Compact
4 - American Std. Hydra
45 - American Std. toilet to go
13 - Corona Orchid
31 - Kohler Serif
29 - Kohler Wellworth
28 - Kohler Wellworth
21 - Eljer (see note below) Patriot
22 - Eljer (see note below) Savoy
38 - St. Thomas Marathon
3 - American Std. Antiquity
42 - Western Pottery Aris
2 - American Std. Plebe
26 - Kohler Devonshire
24 - Gerber Aquasaver
5 - American Std. Cadet
36 - Sanitarios Azteca (Lamosa)
6 - American Std. Cadet
7 - American Std. Cadet
25 - Glacier Bay (HD brand) RAK
43 - Gerber Ultra
19 - Eljer Aquasaver
34 - Mansfield Quantum
33 - Mansfield Alto
35 - Niagara Flapperless
14 - Caroma Caravelle
27 - Kohler Santa-Rosa
104 - Toto Ultramax
105 - Toto Ultimate Elongated Bowl
106 - Toto Ultimate Round Bowl
40 - Toto Drake
17 - Crane Economiser

BACKGROUND

The Energy Policy Act of 1992 required that gravity tank type toilets manufactured in the US after January 1, 1994, have a maximum water usage of 1.6 gpf. The maximum flushing volume requirements and acceptable testing variations are specified in ASME/ANSI A112.19.6 for hydraulic performance. Major plumbing codes adopted by state and local governments require all toilets to comply with this standard. This standard required that each toilet flush a certain percentage of plastic granules and 0.75-inch diameter polypropylene balls out of the bowl. As the industry converted their models to 1.6 gpf from the previous standard 3.5 gpf, issues with flushing performance began to be recognized as a problem by homeowners, builders, and the plumbing industry.

Water conservation is the key driver that mandated the change to 1.6 gpf. However, a poor performing 1.6 gpf toilet will not necessarily provide the expected water conservation as plumbers and end-users adjust their fixtures to consume more water, install incorrect after-market parts in their fixtures, and increase water consumption by holding down the flush handle on the fixture or by double flushing.

In 1999, in order to address this performance concern, the NAHB Research Center endeavored to develop a more rigorous test protocol and to evaluate the flushing performance of a number of toilets on the market at that time. This research led to the development of a test protocol that yielded a Clog Potential Index (see Appendix E).

Seattle Public Utilities (Seattle) and the East Bay Municipal Utility District (EBMUD) are both committed to more effective water conservation measures. These utilities recognized a need for better consumer information about the performance of specific 1.6 gpf toilets. Of particular interest to both utilities was the flushing volume of the toilets upon replacement of the original flapper with a “universal” replacement available at hardware stores and home centers. Accordingly, they co-sponsored a major toilet fixture testing program with the NAHB Research Center. This report is the result of the testing sponsored by the two utilities.

SELECTION OF TOILET FIXTURES

The list of candidate toilet models was prepared by Seattle and EBMUD to include all the popular models available on the west coast of the U.S. at the large do-it-yourself home improvement centers and at plumbing supply stores, as well as those models frequently purchased by water utilities for water conservation programs. Where feasible, similar models available in both round front and elongated bowls were included on the candidate list.

Representatives of Seattle and EBMUD purchased the majority of the toilet fixtures at Home Depot and Lowes. Some units were purchased from plumbing supply houses, and a few were provided directly by the manufacturer. In nearly all cases, two of each toilet model were purchased and tested. When practical, the same model was purchased from two different sources.

In some instances, several models used the same tank with different bowls or the same bowl was used with different tanks. In these instances, tanks and bowls were used in common rather than purchasing multiple tanks or bowls (beyond the two replicates).

For tracking purposes, the toilets were assigned a number and a letter designation (e.g., 17B). The number corresponded to a particular manufacturer and model while the letter (A or B) distinguished the replicates. Each tank and bowl was labeled with a number and letter that was referenced throughout the testing. A complete listing of all fixtures subjected to testing is shown in Appendix A.

The after-market replacement flappers (see Figure 3) used were manufactured by Coast Foundry & Manufacturing of Pomona, California. They were considered typical of a standard flapper that a homeowner might use to replace a worn/leaky flapper. These flappers were provided directly by the manufacturer. Each "A" unit received a brand new replacement flapper. The "B" unit received a flapper that had been used once.

FIGURE 3
REPLACEMENT FLAPPER

TEST SET-UP

FIXTURE MEASUREMENTS

Prior to beginning the flush performance testing, fixtures were measured in several key dimensions, including trap diameter (see Figure 4), footprint, wallprint, bowl height, and other important dimensional features. Fixture characteristics and dimensions are shown in Appendix B.

FIGURE 4
TRAP DIAMETER MEASUREMENT

The trap diameter of each fixture model was estimated by rolling a series of plastic balls through the trap. The balls varied in size in 1/8-inch increments. The largest ball that would freely pass completely through the trap was noted as the trap diameter for that unit, although it is possible that the actual trap diameter is up to 1/8-inch larger than the diameter of the largest ball passed through the trap.

Subsequent to fixture set-up, the water spot (surface of the water in the bowl) area was also determined. A digital photograph was taken of each unit for estimating the water spot area. Figure 5 shows a typical photo. A section of tape measure floating in the water was used to provide a scale to estimate the area. The total water spot area was estimated by constructing perpendicular lines on the photograph at one-inch intervals, measuring the width of the water spot at each line, calculating the area of each interval, and summing to approximate the area of the water spot.

FIGURE 5
WATER SPOT MEASUREMENT

TANK TRIM IDENTIFICATION

In addition to fixture measurements, the tank trim (parts other than china regularly supplied with a fixture, for example, tank flush valves) within each of the tested models was identified and recorded. It is also shown in Appendix B.

FIXTURE SET-UP

Each toilet fixture to be tested was removed from the packaging and set up according to the manufacturer's written instructions contained in the packaging. Most fixtures came pre-adjusted to the correct flush volume but some required adjusting the water level in the tank to a water line on the overflow tube or tank wall.[3]

FIGURE 6
TEST STAND

The toilet was connected to the water supply line through a 3/8" diameter shut off valve and a 3/8" diameter, 20" long flexible stainless steel supply line typical of current home construction. The static water supply pressure was kept between 50 and 55 psi, typical of many municipalities. Each unit was mounted on the test stand (Figure 6) using a 3-inch diameter standard toilet flange attached to a PVC elbow. A rubber gasketed bowl ring was used to seal each unit to the drain line.

PERFORMANCE TESTS

FLUSH VOLUME DETERMINATION

Once the fixture set-up was complete, the flush volume was measured by catching and weighing the outflow of the toilet. (In each flush, the outflow from the fixture was collected for a period of two minutes after the tank refilled.) Three measurements were taken and the average reported.

FLUSH PERFORMANCE TEST

Appendix C includes the test protocol used to determine each fixture's flush performance. The test media involved various numbers of synthetic open cell polyurethane sponges (0.8 x 0.8 x 1.1 inches). Two types of sponges were used as test media. The sinking media ("sinkers") were created by inserting and gluing into the sponge a 0.125" dia x 0.875" stainless steel dowel pin. This resulted in a sponge that, when fully saturated, sank to the bottom of the bowl. The unweighted sponges which float when fully saturated are referred to as "floaters". Each flush loading also included four water-saturated wads of a single 7.5" x 6" sheet of Kraft anti-tarnish paper.

Ten different levels/types of media loading were tested on each unit:

60 sinkers + 4 paper wads	60 floaters + 4 paper wads
50 sinkers + 4 paper wads	50 floaters + 4 paper wads
30 sinkers + 4 paper wads	30 floaters + 4 paper wads
20 sinkers + 4 paper wads	20 floaters + 4 paper wads
15 sinkers + 4 paper wads	15 floaters + 4 paper wads

Each toilet fixture was loaded with the media for a specific level of testing and flushed by depressing the handle for approximately one second. The number of pieces of that media were remaining in the bowl after each flush and trapped in the trap were recorded. The flushing was repeated at each level until a

[3]In attempting to duplicate the actions of a typical consumer in setting up and installing a new toilet fixture, manufacturers' instructions were followed. This sometimes required an adjustment of the water level in the tank to a specified line marked on the overflow tube or the tank wall. The lab technician did NOT attempt to adjust the fixture to 1.6 gpf; however, given that the average consumer would not be able to perform such an adjustment in the home.

stable value for the running average of the remaining media pieces was reached (see Appendix C for details). Each level was flushed at least five times. Once the stable running average was reached, another loading level was tested. The results from all the levels were combined to calculate the flush performance index discussed in the Test Results section.

FIGURE 7
TESTING SEQUENCE

SPONGES READY TO LOAD

MEDIA READY TO FLUSH

MEDIA REMAINING IN BOWL

Many of the flushes left sponges and/or paper wads remaining in the bowl; however, the vast majority of bowls would clear completely upon a second flush. In very few instances, a toilet would clog and require plunging after a second flush attempt. Instances of clogs were also noted and adjustments were made to the performance index as noted in Appendix C.

TEST RESULTS

As noted in Appendix C, the Flush Performance Index is calculated by summing the running average of test media remaining in the bowl over all 10 loading levels. Appendix D contains the average flush performance index, flush volume, trap diameter, and water spot area results for each of the models tested.

PERFORMANCE BENCHMARKS

Three NAHBRC "complaint toilets" were also included in the test program and evaluated for comparison purposes. These toilets had originally been installed in homes and were the subject of numerous complaints by the occupants.[4] The primary complaint was frequent clogging, but complaints about the need to double flush were also prevalent.

As part of a previous NAHBRC study, these toilets had been removed from a residence and replaced with a new fixture; then they were delivered to the NAHBRC and sanitized prior to testing. These toilets are

[4]The complaint toilets were originally installed between 1991 and 1993 and had been removed from single-family residences because of unsatisfactory performance. The primary complaint was frequent clogging but double flushing was also a concern. The precise causes of that unsatisfactory performance were not determined and could be attributed to faulty installation or other user-induced factors, rather than to the design or manufacture of the fixtures. However, the replacement toilets performed satisfactorily, suggesting that the drain line problems were not the cause of the initial unsatisfactory performance.

identified as Complaint 1, Complaint 2, and Complaint 3 in this study.[5] These were tested using the same protocol (Appendix C) and the same performance index was calculated.[6]

The majority of the models tested performed better than the Complaint units. Establishing a threshold value for the Flush Performance Index that would represent satisfactory performance in a typical home was not included in the scope of this work.

TEST DATA

Table 1 shows the average result for the two units tested for each model. The information is sorted alphabetically by manufacture and model. Results shown in Appendix D are sorted by Flush Performance Index, by water spot area, by "out-of-the-box" flush volume, and by after-market replacement flapper flush volume. All results reported are the average of the two units tested.[7]

The reader is encouraged to consider the discussion in the Variability of Test Results section before making any conclusion from the tabulated results. It is recommended that the results be interpreted only as an approximate indication of performance. Although the Complaint toilets provide some indication of the index levels where performance problems could be anticipated, there is no assurance that user complaints will not occur with other of the tested units.

It was a rare instance when a toilet did not completely clear the test media at the loading levels of 15 or 20 sponges, and generally at 30 sponges as well. As expected, the results at the 60 sponge level were worse than at the 50 sponge level and both of these levels contributed the most to the value of the indexes.

[5]Since the complaint models are no longer on the market, disclosure of the manufacturer and model is not included to avoid any confusion by the reader.
[6]When Complaint 2 was originally tested during the previous study, it had been incorrectly installed at the home with a flush volume of only 1.2 gpf. When adjusted to a setting of 1.6 gpf in a previous study, its performance improved significantly. However, for this study, it was again tested at 1.2 gpf since that was known to have caused the originally unsatisfactory performance.
[7]Only one fixture was available for testing for toilet numbers 101 and 103.

TABLE 1
AVERAGE RESULTS
(listed in alphabetical order)

Fixture Number	Brand	Model	Flush Performance Index	Out of Box Flush Volume Gpf	Replacement Flapper Flush Volume gpf
3	American Std.	Antiquity	*48.9**	1.64	3.10
5	American Std.	Cadet	*16.6**	1.48	3.80
6	American Std.	Cadet	*9.1**	1.59	4.12
7	American Std.	Cadet	*13.3**	1.62	4.19
8	American Std.	Cadet	*10.3**	1.53	2.37
1	American Std.	Compact	0.8	1.57	2.45
103	American Std.	Dual Flush Asia Model	0.4	1.59	1.03
9	American Std.	Hamilton	19.1	1.56	1.56
4	American Std.	Hydra	*82.1**	1.51	2.56
2	American Std.	Plebe	4.9	1.84	3.44
45	American Std.	toilet to go	41.8	1.69	2.60
10	Briggs (Proflo 3212T/2200B)	Abingdon III	2.9	1.66	1.60
11	Briggs (Proflo Altima)	Altima III	1.3	1.75	1.78
12	Briggs (Proflo Vacuity)	Vacuity	2.9	1.45	1.52
14	Caroma	Caravelle	*7.2*	1.62	n/a
	Complaint 1		36.0	1.64	NM
	Complaint 2		42.9	1.20	NM
	Complaint 3		32.0	1.65	NM
13	Corona	Orchid	0.4	1.56	2.64
17	Crane	Economiser	*10.4**	1.50	n/a
18	Crane	VIP Flush	9.0	1.58	1.64
15	Crane/Universal Rundle	Atlas	0.5	1.61	1.82
19	Eljer	Aquasaver	15.9	1.56	n/a
20	Eljer	Canterbury	*14.3**	1.66	1.59
23	Eljer (see note below)	Cypress	24.9	1.58	1.86
21	Eljer (see note below)	Patriot	*23.0**	1.71	2.82
22	Eljer (see note below)	Savoy	23.4	1.60	2.92
24	Gerber	Aquasaver	*13.7**	1.84	3.57
43	Gerber	Ultra	0.6	1.45	n/a
25	Glacier Bay (HD brand) RAK thailand	Westminster	*8.0**	1.65	4.66
26	Kohler	Devonshire	5.0	1.61	3.50
30	Kohler	Memoirs	2.7	1.61	2.42
27	Kohler	Santa-Rosa	7.0	1.63	n/a
31	Kohler	Serif	6.0	1.50	2.69
28	Kohler	Wellworth	4.3	1.58	2.82
29	Kohler	Wellworth	4.3	1.57	2.77
33	Mansfield	Alto	0.4	1.62	n/a
34	Mansfield	Quantum	1.7	1.60	n/a
101	Microphor	Microflush Model LF210	5.5	0.66	n/a
35	Niagara	Flapperless	0.3	1.62	n/a
44	Niagara	Turbo	0.8	1.52	1.52
36	Sanitarios Azteca (Lamosa)	Sahara	3.2	1.60	3.94
38	St. Thomas	Marathon	*8.6**	1.72	2.95
39	St. Thomas	Mariner II	6.2	0.95	n/a
102	St. Thomas	Mariner II Flushmate 4	19.2	1.18	n/a
40	Toto	Drake	0.9	1.70	n/a
108	Toto	Drake @ 1.4 gpf	0.7	1.39	n/a
105	Toto	Ultimate Elongated Bowl	0.0	1.64	n/a
106	Toto	Ultimate Round Bowl	0.1	1.69	n/a
104	Toto	Ultramax	0.0	1.63	n/a
41	Toto	CST 703	1.7	1.63	2.08
42	Western Pottery	Aris	0.5	1.89	3.18

Key: NM - Not measured; n/a - not applicable as in pressure assist or generic flapper did not fit unit.
*Flush Performance Index values where the results of the A and B units differed by more than 5 index units.

FLUSH VOLUME REDUCTION

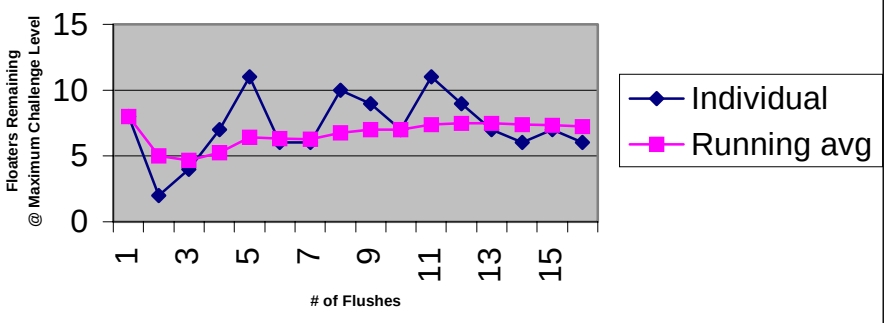
Some of the standard gravity-fed fixtures are known to be capable of flushing at volumes below 1.6 gpf.[8] Therefore, at the request of the sponsors, in addition to measuring flush performance on the toilet fixtures at their design flush volume (water level set per the manufacturer's instructions), the water level in the tank of one 1.6 gpf fixture was lowered such that the flush volume would be reduced. The fill valve on the Toto Drake (No. 40) fixtures was removed, adjusted, and re-installed to yield 1.4-gpf, at which time the fixture was re-tested for its flush performance index. This modified unit was identified as fixture #108.

As shown in Appendix D, the flush performance index of #108 (0.8) was essentially unchanged from the original #40 (0.9), leading one to hypothesize that the flush volume could be reduced even further without sacrificing performance. But, reducing the flush volume on #108 below 1.4-gpf was not possible due to the physical configuration and operating characteristics of the flush valve (flapper). It is possible, however, that other of the better-performing 1.6 gpf toilet fixtures listed in Appendix A could be modified to flush satisfactorily at 1.4-gpf or less.

VARIABILITY OF TEST RESULTS

By the very nature of their use, there is a significant degree of randomness and chaos associated with toilet loading and flushing in actual use. Despite reasonable efforts to minimize any variability introduced by the testing, the data show that there is still a considerable amount of variation from flush to flush on the same toilet. Figure 8 illustrates an example of this variability on one toilet at the most challenging loading level and how the running average changed until the stability criteria was met. This variability is due to the random and chaotic nature of the flushing event as well as variability associated with the test method in preparing, loading, and flushing.

FIGURE 8
INDIVIDUAL FLUSH VARIABILITY



Although the use of a stable running average reduces the variation in the Flush Performance Index, the remaining variation is significant enough that the results must be interpreted with some recognition of the amount of variation.

A number of factors could influence the results of the testing including placement/arrangement of the media, level of media saturation, and the rate at which and length of time the fixture's flush handle is depressed. These variations are also common in actual fixture usage.

[8] A few toilet fixtures listed in Appendix A are designed and specified to flush at 1.5-gpf, rather than the maximum of 1.6.

A complete error and uncertainty analysis was beyond the scope of this study.[9] Table 2 shows the results of repeat tests on the same units. These results can give the reader a general idea of the uncertainty associated with the Flush Performance Index value. Fifty percent of the replicate tests yielded a flush performance index within 1 unit from the initial test, while 75 percent were less than 5 units. However, there were several instances were the index values differed by more than 5 units. The largest unit difference was seen with the toilet fixture that had the highest index in the study. The reader is again cautioned to use the reported values as a general indication of relative performance, as small differences in the Flush Performance Index could be attributed to limitations of the testing protocol.

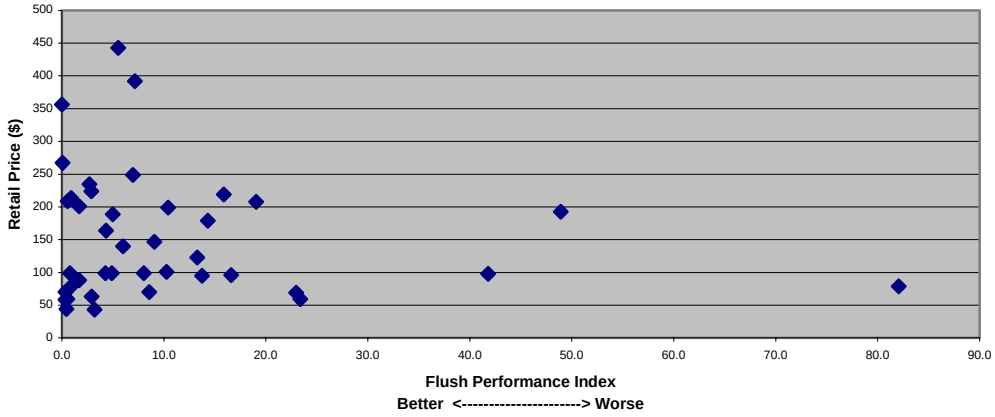
TABLE 2
FLUSH PERFORMANCE INDEX: INITIAL, AND REPLICATE TEST RESULTS[10]

Toilet Number	Initial Test	Replicate Test[11]	Index Value Difference
4A	112.8	*88.4*	24.4
5B	5.8	8.1	2.3
6A	16.9	17.8	0.9
6B	1.3	2.2	0.9
8A	19.6	15.5	4.1
17B	4.1	11.4	7.3
19A	14.7	10.5	4.2
28B	4.9	4.0	0.9
38A	14.7	*8.7*	6.0
38B	2.5	*2.8*	0.3
41A	2.6	*1.7*	0.9
104A	0.0	*0.0*	0.0

PRICE VS. PERFORMANCE

To determine whether more costly fixtures perform better than lower-cost fixtures, the retail price was compared to the Flush Performance Index. Figure 9 is a scatter plot of the average flush performance vs. toilet price. The price used was the average retail cost incurred to obtain a fixture model for this test. There is no apparent correlation of price with performance.

FIGURE 9
PRICE VS. PERFORMANCE



[9]A complete statistical error and variability analysis were beyond the scope of this study and no confidence interval or uncertainty estimate has been established. The client requested that repeat testing be performed on the best, worst, and two randomly chosen units. Repeat tests were also performed in several instances when the results of the A and B units differed significantly. In each instance when repeat testing was performed on both A and B models, the difference in the units was confirmed. This finding suggests that the testing protocol identified variations in performance between two fixtures of the same model.
[10]Values in italics represent replicate testing by a different technician as requested by the client for the replicate tests.
[11]The average results reported in Table 1 and the results in Appendix D include only the initial test results.

RECOMMENDATIONS

While this report provides significant information about the performance of a wide variety of toilets, there is still is a need for further work. The results of this study lead to the following recommendations:

1) A sample of the tested units should be installed in homes to provide verification that this test protocol will correlate with actual performance in a variety of use situations.
2) A formal variability and error analysis should be done to quantify the error associated with the test and to identify opportunities to reduce it.
3) The results of recommendations 1 and 2 should be used to establish a performance benchmark for acceptable performance.
4) The plumbing industry in cooperation with the water utility industry, should develop a parts identification and distribution system for flush valve flappers that will assure that the consumer will purchase the appropriate replacement flapper to maintain the 1.6 gpf that the fixture was designed for.
5) To ensure consistent performance over time as manufacturing processes and fixture design improves, there should be on-going periodic testing of fixtures to verify continued flushing performance and water usage.

DISCLAIMERS

The information in this report is believed to be an accurate description of the units tested and the results obtained. Every effort was made to ensure the accuracy of the findings including, but not limited to, preparation of a detailed test protocol, careful selection and procurement of the products to be tested, and third-party oversight of testing protocol implementation. However, because only two units of each model were tested, these results should not be considered as fully representative of the typical or average production of the models tested.

The reader is also encouraged to consider the obvious differences between this testing with sponges compared to human waste. The test media differ in size, uniformity, consistency, surface characteristics, and amount and type of paper compared to actual toilet usage. All of these variables affect the flushing performance in actual use.

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This report was prepared and submitted by:

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Director, Laboratory Services

September 30, 2002
Date

APPENDIX A
TOILET FIXTURE LIST

TOILETS TESTED - SEATTLE PUBLIC UTILITIES							
Fixture Number	**Manufacturer**	**Flush System***	**Model Name**	**Model Number or Tank/Bowl Number**	**Type Fixture**	**Bowl: Round Front or Elongated**	**Mfr's Rated Flush Volume**
1	American Std.	Gravity	Compact	4010-012-020/3027-012-020	2-piece	Elong	1.6G
2	American Std.	Gravity	Plebe	4392.312.020/3344.312.020	2-piece	Elong	1.6G
3	American Std.	Gravity	Antiquity	4094-0150-20/3093.013.20	2-piece	RF	1.6G
4	American Std.	Gravity	Hydra	4036-017-020/3038-011-020	2-piece	RF	1.6G
5	American Std.	Gravity	Cadet	4112-016-020/3454-016-020	2-piece	RF	1.6G
6	American Std.	Gravity	Cadet	4112-016-020/3417.016.020	2-piece	RF/ADA	1.6G
7	American Std.	Gravity	Cadet	4112-016-020/3459-016-020	2-piece	Elong	1.6G
8	American Std.	Gravity	Cadet	4010 tank, 3454 bowl	2-piece	RF	1.6G
9	American Std.	Gravity	Hamilton	2092-0170-20	1-piece	Elong	1.6G
10	Briggs (Proflo)	Gravity	Abingdon III	4229 = 4440t/4875b	2-piece	RF	1.6G
11	Briggs (Proflo)	Gravity	Altima III	4232 = 4430t/4320b	2-piece	RF	1.6G
12	Briggs (Proflo)	Vacuum	Vacuity	4200	2-piece	Elong	1.6G
13	Corona	Gravity	Orchid	8510	2-piece	RF	1.6G
14	Caroma	Gravity	Caravelle	270 Suite - DUAL FLUSH	2 pc/2flush	RF	1.6/0.8G
15	Crane/Universal Rundle	Gravity	Atlas	4490 tank, 4295 bowl	2-piece	RF	1.6G
17	Crane	Pressure	Economiser	3612 tank,3824 bowl	2 -piece	RF	1.6G
18	Crane	Vacuum	VIP Flush	3995	2-piece	RF	1.6G
19	Eljer	Pressure	Aquasaver	1417-00000/131-7025-00	2-piece	Elong	1.6G
20	Eljer	Gravity	Canterbury	0811-63000	1-piece	RF	1.6G
21	Eljer (see note below)	Gravity	Patriot	141-2120-00/131-2120-00	2-piece	RF	1.6G
22	Eljer (see note below)	Gravity	Savoy	141-0220-00/131-2120-00	2-piece	RF	1.6G
23	Eljer (see note below)	Gravity	Cypress	141-0230-00/131-2120-00	2-piece	RF	1.6G
24	Gerber	Gravity	Aquasaver	21-712	2-piece	Elong	1.6G
25	Glacier Bay (HD brand) RAK thailand	Gravity	Westminster	263-014 tank, 263-019 bowl	2 piece	RF	1.6G
26	Kohler	Gravity	Devonshire	4619-0/4269-0	2-piece	Elong	1.6G
27	Kohler	Gravity	Santa Rosa	3386-0	1-piece	RF	1.6G
28	Kohler	Gravity	Wellworth	4620-0/4277-0	2-piece	RF	1.6G
29	Kohler	Gravity	Wellworth	4620-0/4276-0	2-piece	Elong	1.6G
30	Kohler	Gravity	Memoirs	4454-0/4254-0	2-piece	Elong	1.6G
31	Kohler	Gravity	Serif	4608 tank, 4277 bowl	2-piece	RF	1.6G
33	Mansfield	Gravity	Alto	130-160	2-piece	RF	1.6G
34	Mansfield	Pressure	Quantum	150-100	2-piece	Elong	1.6G
35	Niagara	Gravity	Flapperless	N2216	2-piece	RF	1.6G
36	Sanitarios Azteca (Lamosa)	Gravity	Sahara	411	2-piece	RF	1.6G
38	St. Thomas	Gravity	Marathon	6201.010	2-piece	RF	1.6G
39	St. Thomas	Pressure	Mariner II	6207.020	2-piece	Elong	**1.0G**
40	Toto	Gravity	Drake	CST744S	2-piece	Elong	1.6G
41	Toto	Gravity	CST703	CST703	2-piece	RF	1.6G
42	Western Pottery	Gravity	Aris	822	2-piece	RF	1.6G
43	Gerber	Pressure	Ultra	21-302	2-piece	RF	1.6G
44	Niagara	Gravity	Turbo	N2220	2-piece	RF	1.6G
45	American Std.	Gravity	All-in-one-box	4028/3338	2-piece	RF	1.6G

TOILETS TESTED - EAST BAY MUNICIPAL UTILITY DISTRICT							
Fixture Number	**Manufacturer**	**Flush System***	**Model Name**	**Model Number or Tank/Bowl Number**	**Type Fixture**	**Bowl: Round Front or Elongated**	**Mfr's Rated Flush Volume**
101	Microphor	Air-assist	Microflush	LF-210	1-piece	RF	**0.5G**
102	St. Thomas	Pressure	Mariner II	6207.020	2-piece	RF	**1.0G**
103	American Std.	Gravity	Dual Flush	unknown - **DUAL FLUSH**	2-piece/2-flush	RF	1.6/1.0G
104	Toto	Gravity	Ultramax	MS854114S	1-piece	Elong	1.6G
105	Toto	Gravity	Ultimate	MS854114	1-piece	Elong	1.6G
106	Toto	Gravity	Ultimate	MS853113	1-piece	RF	1.6G
108	Toto	Gravity	Drake	CST744S **(Note: Flush volume modified in laboratory to 1.4-gpf)**	2-piece	Elong	**1.6G**

*See definitions of flush systems in Appendix B.
NOTES:
1) All models white fixtures, unless otherwise noted.
2) Three Eljer models all use the same bowl.
3) ProFlo is manufactured by Briggs and is private labeled for Ferguson-Familian; ProFlo units are identical in design to the Briggs products with the same names.
4) East Bay Municipal Utility District also sponsored the testing of the 3 complaint toilets referenced in the report.
5) The toilets on this list and the information included here were compiled by the sponsors.

APPENDIX B
DIMENSIONAL DATA ON TESTED

Fixture Number	Manufacturer	Flush System (see Definitions below)	Model Name	Bowl	Mfr's Rated Flush Volume	Siphon Jet Design?	Bowl Footprint Dimensions (L x W) inches	Bowl Height and Width (H x W) inches	Extent of Trapway Glazing (see below)	Bowl Inside Dimension (L x W) inches	Exposed or Concealed Trapway	Rough-In Dimension inches	Installed Height inches	Installed Width (wallprint) inches	Manufacturer of Internal Tank Trim Components	Height: Water Line above Discharge inches	Presence of Required Labeling ASME 112.19.2	Mfr Name on Toilet?	Flapper brand or designation	Float on Flapper or Chain?	1.6-gpf marked on toilet per ASME std?	Water Spot Area Estimate (in^2)
1	American Standard	Gravity	Compact	Elong	1.6G	No	16.5 x 9.5	15 x 14 3/4	FB	14.5 x 10.5	Exposed	12	29.25	19.00	A. Standard	7.00	Yes	Yes	Undetermined	Yes	Yes	28
2	American Standard	Gravity	Plebe	Elong	1.6G	Yes	20.1 x 9.25	15.25 x 14.25	FI	14.5 x 10.75	Exposed	12	29.50	20.25	A. Standard	7.50	Yes	Yes	Plant 72	Yes	Yes	77
3	American Standard	Gravity	Antiquity	RF	1.6G	Yes*	19.5 x 9.5	15.1 x 16.0	F	13 x 11.25	Exposed	12	30.25	18.50	A. Standard	7.50	Yes	Yes	738003	Yes	Yes	45
4	American Standard	Gravity	Hydra	RF	1.6G	Yes*	16.4 x 9.0	14.75 x 15.0	F	12.5 x 10.9	Exposed	12	27.50	19.00	A. Standard	7.00	Yes	Yes	Plant 72	Yes	Yes	48
5	American Standard	Gravity	Cadet	RF	1.6G	Yes	19.5 x 9.5	15.0 x 15.0	P	11.5 x 11.25	Exposed	12	30.25	19.00	AS (smrtvlve?)	7.50	Yes	Yes	Undetermined	Yes	Yes	65
6	American Standard	Gravity	Cadet	RF/ADA	1.6G	Yes	19.0 x 9.25	16.5 x 14.4	FI	14.0 x 11.1	Exposed	12	31.25	19.00	AS (smrtvlve?)	7.50	Yes	Yes	Undetermined	Yes	Yes	70
7	American Standard	Gravity	Cadet	Elong	1.6G	Yes	19.0 x 9.1	14.6 x 14.1	P	14.1 x 11.0	Exposed	12	30.00	19.00	AS (smrtvlve?)	7.50	Yes	Yes	Undetermined	Yes	Yes	78
8	American Standard	Gravity	Cadet	RF	1.6G	Yes	19.25 x 9.25	15.0 x 14.75	F	11.4 x 11.0	Exposed	12	30.00	19.13	A. Standard	6.75	Yes	Yes	Undetermined	Yes	Yes	60
9	American Standard	Gravity	Hamilton	Elong	1.6G	No	16.75 x 10.0	14.75 x 15.0	F	14.75 x 11.0	Exposed	12	24.50	18.75	A. Standard	4.50	Yes	Yes	Undetermined	No	Yes	26
10	Briggs (Proflo)	Gravity	Abingdon III	RF	1.6G	No	18.5 x 10.0	14.1 x 14.25	N	12.5 x 11.25	Exposed	12	28.13	19.00	Hoov-R-Line	5.00	Yes, sticker	Yes	Hoov-R-Line	No	Yes	46
11	Briggs (Proflo)	Gravity	Altima III	RF	1.6G	No	18.4 x 9.25	14.9 x 14.5	N	13.25 x 10.9	Exposed	12	29.00	18.00	Hoov-R-Line	6.00	Yes	Yes	Hoov-R-Line clear	No	Yes	51
12	Briggs (Proflo)	Vacuum-assist	Vacuity	Elong	1.6G	No - vacuum	23.0 x 9.6	14.6 x 14.6	N	14.6 x 10.5	Exposed	12	31.00	17.50	Fluidmaster	Not avail	Yes	Yes	Blue	Yes	Yes	75
13	Corona	Gravity	Orchid	RF	1.6G	Undetermined	15.25 x 9.1	14.5 x 14.25	FP	12.75 x 10.75	Exposed	12	26.50	19.00	Grivel	5.63	Yes	Yes	Grivel	No	Yes	44
14	Caroma	Gravity	Caravelle/Tasman	RF	1.6/0.8G	Wash down	23.75 x 10.0	14.9 x 14.1	N	13.6 x 11.4	Concealed	Variable	32.25	16.50	Caroma/Fluidmstr	Not avail	No	Yes	Undetermined	No	No	14
15	Crane/Universal Rundle	Gravity	Atlas	RF	1.6G	Undetermined	19.1 x 10.4	15.4 x 14.25	NG	13.0 x 11.4	Exposed	12	28.00	18.38	CRN 203	4.75	Yes	Yes	Clear	No	No	46
17	Crane	Pressure-assist	Economiser	RF	1.6G	Yes	17.4 x 9.6	14.1 x 14.1	FI	13.0 x 11.0	Exposed	12	28.63	19.50	Flushmate	-	Yes, sticker	Yes	Not applicable	Not applicable	No	70
18	Crane	Vacuum	VIP Flush	RF	1.6G	No - vacuum	20.0 x 9.0	14.5 x 15.0	N	12.75 x 10.5	Exposed	12	29.50	18.00	Fluidmaster	Not avail	Yes, sticker	Yes	Hoov-R-Line clear	Not available	Sticker	83
19	Eljer	Pressure-assist	Aquasaver	Elong	1.6G	Yes	18.4 x 9.75	14.6 x 14.75	N	14.25 x 11.0	Exposed	12	28.25	19.50	WC Technology	Not applicable	Yes	Yes	Not applicable	Not applicable	Yes	60
20	Eljer	Gravity	Canterbury	RF	1.6G	No	19.1 x 10.25	14.1 x 17.0	P	13.5 x 10.75	Exposed	12	23.50	19.00	Coast MM IV	3.50	Yes, sticker	Yes	Coast Blue	No	Yes	42
21	Eljer (see note below)	Gravity	Patriot	RF	1.6G	No	18 x 9.5	14.25 x 14.5	NG	12.5 x 10.5	Exposed	12	27.75	20.75	Coast MM IV	6.75	Yes	Yes	Coast Blue	No	Yes	61
22	Eljer (see note below)	Gravity	Savoy	RF	1.6G	No	18 x 9.5	14.25 x 14.5	NG	12.5 x 10.5	Exposed	12	28.00	20.75	Coast MM IV	6.75	Yes	Yes	Coast Blue	No	Yes	58
23	Eljer (see note below)	Gravity	Cypress	RF	1.6G	No	18 x 9.5	14.25 x 14.5	NG	12.5 x 10.5	Exposed	12	Undetermined	Undetermined	Coast	Undetermined	Yes	Yes	Coast Blue	No	Yes	58
24	Gerber	Gravity	Aquasaver	Elong	1.6G	Yes	20.25 x 9.25	14.5 x 14.5	N	14.75 x 11.5	Exposed	12	28.50	19.25	Hoov-R-Line	7.00	Yes	Yes	Hoov-R-Line clear	No	Yes	63
25	Glacier Bay (HD brand) RAK thailand	Gravity	Westminster	RF	1.6G	No	18.25 x 10.0	14.75 x 14.4	P	12.5 x 11.25	Exposed	12	30.00	18.50	Coast MM IV	8.00	Yes	Yes	Undetermined	Yes	Yes	34
26	Kohler	Gravity	Devonshire	Elong	1.6G	Yes	21.4 x 9.6	14.9 x 14.5	PB	14.6 x 11.6	Exposed	12	32.00	18.75	Fluidmaster	7.50	Yes	Yes	see below	Yes	Yes	61
27	Kohler	Gravity	Santa Rosa	RF	1.6G	Yes	21.9 x 9.25	15.0 x 14.75	PB	13.6 x 10.9	Exposed	12	25.50	19.00	Fluidmaster	5.25	Yes	Yes	Red (see note)	No	Yes	52
28	Kohler	Gravity	Wellworth	RF	1.6G	Yes	20.4 x 10.0	14.4 x 14.5	FS	12.5 x 11.0	Exposed	12	27.50	20.00	Ingenium 400	6.25	Yes	Yes	Coast Blue	Yes	Yes	62
29	Kohler	Gravity	Wellworth	Elong	1.6G	Yes	29.9 x 10.0	14.0 x 14.5	FS	14.0 x 10.9	Exposed	12	27.50	19.38	Ingenium 400	6.50	Yes	Yes	Undetermined	Yes	Yes	70
30	Kohler	Gravity	Memoirs	Elong	1.6G	Yes	21.0 x 10.1	14.1 x 14.5	FB	14.0 x 11.0	Exposed	12	31.50	17.63	Ingenium 400	6.50	Yes, sticker	Yes	Coast 400		Yes	71
31	Kohler	Gravity	Serif	RF	1.6G	Yes	20.4 x 10.0	14.4 x 14.5	FS	12.5 x 11.0	Exposed	12	30.50	20.25	Fluidmaster	7.25	Yes	Yes	Coast Blue	Yes	Yes	63
33	Mansfield	Gravity	Alto	RF	1.6G	Yes	17.25 x 9.4	15.1 x 14.0	F	11.75 x 10.75	Exposed	12	29.25	18.50	Mansfield/Lavelle	8.25	Yes	Yes	Lavelle	No	Yes	53
34	Mansfield	Pressure-assist	Quantum	Elong	1.6G	Yes	18.25 x 9.5	14.25 x 14.75	N	14.25 x 10.5	Concealed	12	27.25	19.00	Sloan Flushmate	Not applicable	No	Yes	Not applicable	Not applicable	No	92
35	Niagara	Gravity	Flapperless	RF	1.6G	No	20.0 x 10.4	15.0 x 14.75	F	12.9 x 11.25	Exposed	12	28.75	19.25	Niagara/Fluidmstr	Not applicable	Yes	Yes	Not applicable	Not applicable	Yes	37
36	Sanitarios Azteca (Lamosa)	Gravity	Sahara	RF	1.6G	No	17.25 x 9.1	14.5 x 14.5	NG	13.25 x 11.25	Concealed	12	29.50	18.00	Hoov-R-Line	8.50	Yes	Yes	Clear (see note)	No	No	38
38	St. Thomas	Gravity	Marathon	RF	1.6G	No	18.0 x 9.25	14.75 x 14.75	N	12.75 x 11.1	Exposed	12	29.00	19.38	Hoov-R-Line	7.50	No	No	Hoov-R-Line clear	No	No	45

Fixture Number	Manufacturer	Flush System (see Definitions below)	Model Name	Bowl	Mfr's Rated Flush Volume	Siphon Jet Design?	Bowl Footprint Dimensions (L x W) inches	Bowl Height and Width (H x W) inches	Extent of Trapway Glazing (see below)	Bowl Inside Dimension (L x W) inches	Exposed or Concealed Trapway	Rough-In Dimension inches	Installed Height inches	Installed Width (wallprint) inches	Manufacturer of Internal Tank Trim Components	Height: Water Line above Discharge inches	Presence of Required Labeling ASME 112.19.2	Mfr Name on Toilet?	Flapper brand or designation	Float on Flapper or Chain?	1.6-gpf marked on toilet per ASME std?	Water Spot Area Estimate (in^2)
39	St. Thomas	Pressure-assist	Mariner II	Elong	**1.0G**	Yes	18.1 x 9.1	15.0 x 14.75	N	15.0 x 11.75	Exposed	12	28.50	19.50	Flushmate 4	Not applicable	Yes	Yes	Not applicable	Not applicable	Yes	58
40	Toto	Gravity	Drake	Elong	1.6G	Yes	24.0 x 9.4	14.9 x 14.1	N	14.9 x 11.0	Exposed	12	28.50	19.50	Lavelle	6.75	Yes	Yes	Lavelle red	No	Yes	65
41	Toto	Gravity	CST703	RF	1.6G	No	17.0 x 9.25	14.75 x 14.4	F	13.1 x 11.0	Exposed	12	29.13	16.63	Coast	7.75	Yes	Yes	Coast blue	No	Yes	38
42	Western Pottery	Gravity	Aris	RF	1.6G	Yes	17.0 x 9.5	14.75 x 14.6	FB	13.25 x 10.5	Exposed	12	29.75	16.25	Western Enduro	8.50	Yes	Yes	Undetermined	No	Yes	51
43	Gerber	Pressure-assist	Ultra	RF	1.6G	Yes	18.5 x 9.0	14.25 x 14.5	N	13.5 x 11.5	Exposed	12	28.25	19.50	Sloan Flushmate	Not applicable	Yes	Yes	Not applicable	Not applicable	Yes	112
44	Niagara	Gravity	Turbo	RF	1.6G	No	20.0 x 10.25	15.0 x 14.6	F	12.75 x 11.25	Exposed	12	30.25	19.00	Coast	5.38	Yes	Yes	Coast blue	No	Yes	35
45	American Standard	Gravity	All-in-one-box	RF	1.6G	Yes	18.5 x 9.5	15.5 x 14.6	NG	12.5 x 11.5	Exposed	12	29.00	19.25	A. Standard	7.00	Yes	Yes	Black, part # 738003-301	Yes	Yes	55
101	Microphor	Air-assist	Microflush	RF	0.5G	No	23.0 x 16.0	15.25 x 14.5	Not applic.	12.75 x 11.0	Concealed	Not available	18.50	16.00	Microphor	Not applicable	Undetermined	No	Not applicable	Not applicable	Not a 1.6 unit	82
102	St. Thomas	Pressure-assist	Mariner II	RF	**1.0G**	Yes	18.0 x 9.5	13.75 x 14.5	N	13.0 x 11.5	Exposed	12	28.50	19.50	Flushmate 4	Not applicable	Undetermined	No	Not applicable	Not applicable	Not a 1.6 unit	72
103	American Standard	Gravity	Dual Flush	RF	1.6/1.0G	Wash down	16.5 x 8.75	15.25 x 13.75	N	10.75 x 11.75	Concealed	Unknown	29.75	15.25	Fluidmaster	Not applicable	Not applicable	Yes	Not available	No	Not a requirement	9
104	Toto	Gravity	Ultramax	Elong	1.6G	Yes	24.5 x 10.0	14.9 x 14.75	F	15.0 x 10.75	Exposed	12	27.50	16.00	Lavelle	7.00	Yes	Yes	Lavelle red	No	Yes	63
105	Toto	Gravity	Ultimate	Elong	1.6G	Yes	25.0 x 10.0	15.0 x 14.75	F	15.0 x 10.75	Exposed	12	27.50	16.00	Lavelle	5.00	Yes	Yes	Coast blue	No	Yes	63
106	Toto	Gravity	Ultimate	RF	1.6G	Yes	23.6 x 10.0	14.9 x 14.25	N	13.1 x 10.9	Exposed	12	28.00	16.00		6.00	Yes	Yes	Unknown	No	Yes	63
108	Toto	Gravity	Drake	Elong	1.6G **(see note)**	Yes	24.0 x 9.4	14.9 x 14.1	N	14.9 x 11.0	Exposed	12	28.50	19.50	Lavelle	6.75	Yes	Yes	Lavelle red	No	Yes	68

Notes:
1) All model numbers are for white fixtures, unless otherwise noted.
2) Three Eljer models use the same bowl.
3) ProFlo is manufactured by Briggs and is private labeled for Ferguson-Familian; ProFlo units are identical in design to the Briggs products with the same names.
4) The American Std. Antiquity and Hydra do not possess a true siphon jet and instead use a wide discharge at the bottom of the bowl.
5) Fixture No. 108 was a modified Toto Drake (Fixture No. 40); laboratory reduced the flush volume to 1.4-gpf by adjusting the fill valve setting.
6) Information in this table was compiled and provided by the sponors and included in the report as reference information to make the document more useful.
The only information in this appendix that was measured by the NAHB Reseach Center was the water spot estimate.

Definitions - Flush System:
Gravity: Relies upon the weight of the water and related head pressure to activate the flush.
Pressure-assist: Relies upon air pressure within a cannister or vessel inside the toilet tank to create the flush. Air pressure is created in the cannister as water refills it after a flush.
Vacuum-assist: Relies upon a vacuum created by the water falling from an enclosed vessel (inside the toilet tank) when the flush lever is actuated. This vacuum is transmitted to the trapway of the fixture to assist in "pulling" the waste from the bowl.
Air-assist: Relies upon air pressure created by a separate source (pump) to create the flushing action.

Key:
1) Siphon-jet design: Toilet bowl uses a jet-opening at the bottom of the bowl to deliver water into the trapway in order to assist in creating the siphonic action needed to evacuate the bowl.
2) Bowl footprint dimensions: measurement of the widest point and the longest point on the base of the bowl.
3) Bowl height and width: measurement of the bowl height from the base (as it would be installed and without a toilet seat) and the exterior width at the top of the rim.
4) Extent of trapway glazing: visual assessment of inside and bottom of bowl as to how thoroughly the trapway is glazed.
F = Full (generally thick)
I = Incomplete coverage
NG = Not glazed
S = Small areas of incomplete coverage
B = Bottom coverage incomplete
N = No glazing on base
P = Partial coverage throughout
5) Exposed or concealed trapway: whether or not the trapway contour is visible from the external side view.
6) Rough-in dimension: distance from the centerline of the bolts to the back of the tank (use manufactures specification).
7) Installed height: the height from the base of the toilet to the top of the tank lid, as it would be installed.
8) Installed width (wallprint): width of the tank, or the bowl, if it is wider than the tank.
9) Manufacturer of internal trim parts: brand of internal tank trim components.
10) Height of water line in the tank above the tank discharge point: distance from the internal base of the tank (flush valve opening) to the marked water line inside the tank.
11) Presence of required labeling: yes/no as to whether the fixture is marked as 1.6-gpf or 6-liter per ASME A112.19.2.
12) Name on toilet: yes/no as to whether the brand/manufacturer is marked permanently on the toilet per ASME A112.19.2; indicate if a removable sticker is used.
13) Float on flapper or chain: yes/no as to whether the flapper or the chain connecting the flush lever to the flapper use a float mechanism to govern the closing of the flapper.

Flapper Notes:
Kohler Devonshire has a rigid flapper (Coast 400 CertainSeal).
Kohler Santa Rosa flapper appears non-standard.
The Corona Orchid has a flexible chain on the flapper.
The Universal Rundle Atlas has a flexible chain on the flapper.
The Lamosa Sahara has a rubber chain on the flapper.

APPENDIX C
RESEARCH CENTER TOILET TESTING PROTOCOL AND PROCEDURES

1. The toilet to be tested should be mounted on the toilet test rack. Assemble the bowl, tank, and flushing mechanism per manufacturer's instructions.

2. The water supply pressure shall be adjusted to 50 psi (+5/-0 psi) and the toilet supplied thru a standard 3/8" diameter shut off valve and a 3/8" diameter by 20 " long flexible stainless steel fill tube.

3. The toilet is set up and flush volume adjusted per the manufacturer's instructions. If no instructions or water line are provided, the unit shall be tested as it comes from the box. The flush volume will be measured 3 times and averaged. The flush volume will be determined by catching the water discharged during the flush and for 2 minutes after the flow meter indicates that refilling has stopped. Any unit that is outside of the range 1.4 to 2.0 gpf will not be tested without consulting with the client. The toilet will be operated with the lid on the tank.

4. After the flush volume has been determined, mount the toilet to a flange with a 3" diameter by 6" inch long drop followed by a 3", 90 degree elbow. Use a rubber gasket to seal the toilet to the flange.

5. The test media consists of sponge floaters, sponge sinkers, and paper balls. The sponges are synthetic open cell polyurethane sponges, white, 0.8 x 0.8 (+-0.04) x 1.1 (+/-0.12) inches having a density of 1.1 +/- 0.11 lb/ft3 when new. A single sheet of Kraft anti-tarnish paper (7.5 x 6 inches, 15 lb, 486 sheets/ream) is crinkled between the palms of the hands to form each ball approximately 1 inch in diameter. The sinker sponges are weighted in the center with a 0.875" long x 0.125" diameter stainless steel pin (approximately 1.37 g). The pin is adhered into the sponge with some urethane adhesive.

6. The sponges are stored in an 8" diameter pail full of water in a completely saturated condition. Prior to testing the appropriate number of sponges are placed in an 8" diameter strainer setting in the pail full of water. A second 8" diameter strainer is used to squeeze the sponges under water and then pressure is slowly released allowing the sponges to expand (while still below the surface of the water) and to saturate with water. The strainer is then used to immediately transport the sponges to the bowl and gently dump them so as to land generally on the center of the water spot. The media pieces can be reused until deterioration is apparent at which time they should be replaced.

7. The following loading levels are tested for each unit.

    60 floater sponges and 4 paper wads
    50 floater sponges and 4 paper wads
    30 floater sponges and 4 paper wads
    20 floater sponges and 4 paper wads
    15 floater sponges and 4 paper wads
    60 sinker sponges and 4 paper wads
    50 sinker sponges and 4 paper wads
    30 sinker sponges and 4 paper wads
    20 sinker sponges and 4 paper wads
    15 sinker sponges and 4 paper wads

8. After the saturated sponges have been placed in the bowl, place the four saturated paper wads on top of the sponges spaced approximately uniformly apart.

9. Flush the toilet by activating the lever and holding it down for approximately one second and then releasing.

10. After the flush has completed, count the number of media pieces remaining visible in the bowl and the number that have cleared the trap. Record these numbers on the data sheet.

11. Flush the toilet again to remove any remaining media. Be sure all media are out of the trap and accounted for. If the toilet has clogged requiring the use of a plunger or more than one additional flush to clear all media, then the number of media that initially remained in the trap will be added to the number remaining in the bowl to determine the contribution running average. A notation of the clog will be made on the data sheet.

12. After the tank and bowl have refilled, reload the bowl with the same media level. Repeat steps 6-11 until 5 consecutive flushes result each in a change of less than 5 percent in the running average of media remaining in the bowl for the loading level. If the running average is less than 2.0 then the flushing will stop when five consecutive flushes result in an average change of less the 10 percent. Once this criterion for 5 consecutive flushes has been achieved then proceed to the next media level.

13. Calculate the “Flush Performance Index” by summing the final running average for each of the media levels.

TRAP DIAMETER MEASUREMENT

The trap diameter of each unit will be measured by passing plastic balls through the trap. The toilet will be placed upside down, and a ball will be placed in the trap exit and allowed to fall into the toilet. The toilet will be rotated to facilitate the ball traveling through the trap and exiting the bowl. The largest ball that will freely pass through the trap will be recorded as the trap diameter. Balls will be used in 1/8” diameter increments from 1-1/2” to 2-1/8”.

APPENDIX D
DETAILED TEST RESULTS

APPENDIX D1
AVERAGE RESULTS SORTED BY FLUSH PERFORMANCE INDEX

FIXTURE NUMBER	BRAND	MODEL	FLUSH PERFORMANCE INDEX	OUT-OF-BOX FLUSH VOLUME gpf	REPLACEMENT FLAPPER FLUSH VOLUME gpf	TRAP DIAMETER in	WATER SPOT in^2
104	Toto	Ultramax	0.0	1.63	n/a	2.00	63
105	Toto	Ultimate Elongated Bowl	0.0	1.64	n/a	2.00	63
106	Toto	Ultimate Round Bowl	0.1	1.69	n/a	2.00	63
35	Niagara	Flapperless	0.3	1.62	n/a	1.88	38
33	Mansfield	Alto	0.4	1.62	n/a	1.50	53
103	American Std.	Dual Flush Asia Model	0.4	1.59	1.03	NM	9
13	Corona	Orchid	0.4	1.56	2.64	1.50	44
15	Crane/Universal Rundle	Atlas	0.5	1.61	1.82	1.94	46
42	Western Pottery	Aris	0.5	1.89	3.18	1.75	51
43	Gerber	Ultra	0.6	1.45	n/a	1.94	112
108	Toto	Drake @ 1.4 gpf	0.7	1.39	n/a	2.00	69
1	American Std.	Compact	0.8	1.57	2.45	1.63	28
44	Niagara	Turbo	0.8	1.52	1.52	1.88	35
40	Toto	Drake	0.9	1.70	n/a	2.00	65
11	Briggs (Proflo Altima)	Altima III	1.3	1.75	1.78	2.00	51
34	Mansfield	Quantum	1.7	1.60	n/a	1.88	92
41	Toto	CST703	1.7	1.63	2.08	1.81	38
30	Kohler	Memoirs	2.7	1.61	2.42	1.88	71
12	Briggs (Proflo Vacuity)	Vacuity	2.9	1.45	1.52	2.06	75
10	Briggs (Proflo 3212T/2200B)	Abingdon III	2.9	1.66	1.60	1.75	46
36	Sanitarios Azteca (Lamosa)	Sahara	3.2	1.60	3.94	1.63	38
28	Kohler	Wellworth	4.3	1.58	2.82	1.88	62
29	Kohler	Wellworth	4.3	1.57	2.77	1.81	70
2	American Std.	Plebe	4.9	1.84	3.44	1.94	78
26	Kohler	Devonshire	5.0	1.61	3.50	1.81	61
101	Microphor	Microflush Model LF210	5.5	0.66	n/a	1.50	82
31	Kohler	Serif	6.0	1.50	2.69	1.88	63
39	St. Thomas	Mariner II	6.2	0.95	n/a	NM	58
27	Kohler	Santa-Rosa	7.0	1.63	n/a	1.75	52
14	Caroma	Caravelle	7.2	1.62	n/a	NM	28
25	Glacier Bay (HD brand) RAK Thailand	Westminster	8.0	1.65	4.66	1.94	35
38	St. Thomas	Marathon	8.6	1.72	2.95	1.88	45
18	Crane	VIP Flush	9.0	1.58	1.64	1.81	83
6	American Std.	Cadet	9.1	1.59	4.12	1.81	70
8	American Std.	Cadet	10.3	1.53	2.37	1.94	60
17	Crane	Economiser	10.4	1.50	na/	1.63	70
7	American Std.	Cadet	13.3	1.62	4.19	1.88	78
24	Gerber	Aquasaver	13.7	1.84	3.57	1.75	64
20	Eljer	Canterbury	14.3	1.66	1.59	1.50	42
19	Eljer	Aquasaver	15.9	1.56	n/a	2.00	60
5	American Std.	Cadet	16.6	1.48	3.80	1.94	65
9	American Std.	Hamilton	19.1	1.56	1.56	1.50	26
102	St. Thomas	Mariner II Flushmate 4	19.2	1.18	n/a	1.75	72
21	Eljer (see note below)	Patriot	23.0	1.71	2.82	1.88	61
22	Eljer (see note below)	Savoy	23.4	1.60	2.92	1.88	58
23	Eljer (see note below)	Cypress	24.9	1.58	1.86	1.88	58
	Complaint 3		32.0	1.65	NM		
	Complaint 1		36.0	1.64	NM		
45	American Std.	toilet to go	41.8	1.69	2.60	2.00	56
	Complaint 2		42.9	1.20	NM		
3	American Std.	Antiquity	48.9	1.64	3.10	1.75	45
4	American Std.	Hydra	82.1	1.51	2.56	1.75	48

Note:
For trap diameter NM indicates the trap was not measured as it was larger than the 2-1/8" ball. Numbers 14 and 103 had substantially larger traps.
For Replacement Flapper Volume, n/a indicates that the replacement flapper did not fit or was not applicable as in pressure assist units.
This testing was performed at the NAHB Research Center laboratory during March, April, May, and June 2002.

APPENDIX D2
AVERAGE RESULTS SORTED BY OUT OF THE BOX FLUSH VOLUME

FIXTURE NUMBER	BRAND	MODEL	FLUSH PERFORMANCE INDEX	OUT-OF-BOX FLUSH VOLUME gpf	REPLACEMENT FLAPPER FLUSH VOLUME gpf	TRAP DIAMETER in	WATER SPOT in^2
101	Microphor	Microflush Model LF210	5.5	0.66	n/a	1.50	82
39	St. Thomas	Mariner II	6.2	0.95	n/a	NM	58
102	St. Thomas	Mariner II Flushmate 4	19.2	1.18	n/a	1.75	72
108	Toto	Drake @ 1.4 gpf	0.7	1.39	n/a	2.00	69
43	Gerber	Ultra	0.6	1.45	n/a	1.94	112
12	Briggs (Proflo Vacuity)	Vacuity	2.9	1.45	1.52	2.06	75
5	American Std.	Cadet	16.6	1.48	3.80	1.94	65
31	Kohler	Serif	6.0	1.50	2.69	1.88	63
17	Crane	Economiser	10.4	1.50	na/	1.63	70
4	American Std.	Hydra	82.1	1.51	2.56	1.75	48
44	Niagara	Turbo	0.8	1.52	1.52	1.88	35
8	American Std.	Cadet	10.3	1.53	2.37	1.94	60
19	Eljer	Aquasaver	15.9	1.56	n/a	2.00	60
13	Corona	Orchid	0.4	1.56	2.64	1.50	44
9	American Std.	Hamilton	19.1	1.56	1.56	1.50	26
1	American Std.	Compact	0.8	1.57	2.45	1.63	28
29	Kohler	Wellworth	4.3	1.57	2.77	1.81	70
18	Crane	VIP Flush	9.0	1.58	1.64	1.81	83
23	Eljer (see note below)	Cypress	24.9	1.58	1.86	1.88	58
28	Kohler	Wellworth	4.3	1.58	2.82	1.88	62
6	American Std.	Cadet	9.1	1.59	4.12	1.81	70
103	American Std.	Dual Flush Asia Model	0.4	1.59	1.03	NM	9
34	Mansfield	Quantum	1.7	1.60	n/a	1.88	92
22	Eljer (see note below)	Savoy	23.4	1.60	2.92	1.88	58
36	Sanitarios Azteca (Lamosa)	Sahara	3.2	1.60	3.94	1.63	38
26	Kohler	Devonshire	5.0	1.61	3.50	1.81	61
30	Kohler	Memoirs	2.7	1.61	2.42	1.88	71
15	Crane/Universal Rundle	Atlas	0.5	1.61	1.82	1.94	46
7	American Std.	Cadet	13.3	1.62	4.19	1.88	78
33	Mansfield	Alto	0.4	1.62	n/a	1.50	53
35	Niagara	Flapperless	0.3	1.62	n/a	1.88	38
14	Caroma	Caravelle	7.2	1.62	n/a	NM	28
27	Kohler	Santa-Rosa	7.0	1.63	n/a	1.75	52
41	Toto	CST703	1.7	1.63	2.08	1.81	38
104	Toto	Ultramax	0.0	1.63	n/a	2.00	63
3	American Std.	Antiquity	48.9	1.64	3.10	1.75	45
105	Toto	Ultimate Elongated Bowl	0.0	1.64	n/a	2.00	63
25	Glacier Bay (HD brand) RAK Thailand	Westminster	8.0	1.65	4.66	1.94	35
20	Eljer	Canterbury	14.3	1.66	1.59	1.50	42
10	Briggs (Proflo 3212T/2200B)	Abingdon III	2.9	1.66	1.60	1.75	46
45	American Std.	toilet to go	41.8	1.69	2.60	2.00	56
106	Toto	Ultimate Round Bowl	0.1	1.69	n/a	2.00	63
40	Toto	Drake	0.9	1.70	n/a	2.00	65
21	Eljer (see note below)	Patriot	23.0	1.71	2.82	1.88	61
38	St. Thomas	Marathon	8.6	1.72	2.95	1.88	45
11	Briggs (Proflo Altima)	Altima III	1.3	1.75	1.78	2.00	51
24	Gerber	Aquasaver	13.7	1.84	3.57	1.75	64
2	American Std.	Plebe	4.9	1.84	3.44	1.94	78
42	Western Pottery	Aris	0.5	1.89	3.18	1.75	51

Note:
For trap diameter NM indicates the trap was not measured as it was larger than the 2-1/8" ball. Numbers 14 and 103 had substantially larger traps.
For Replacement Flapper Volume, n/a indicates that the replacement flapper did not fit or was not applicable as in pressure assist units.

APPENDIX D3
AVERAGE RESULTS SORTED BY FLUSH VOLUME WITH A REPLACEMENT FLAPPER

FIXTURE NUMBER	BRAND	MODEL	FLUSH PERFORMANCE INDEX	OUT-OF-BOX FLUSH VOLUME gpf	REPLACEMENT FLAPPER FLUSH VOLUME gpf	TRAP DIAMETER in	WATER SPOT in^2
103	American Std.	Dual Flush Asia Model	0.4	1.59	1.03	NM	9
44	Niagara	Turbo	0.8	1.52	1.52	1.88	35
12	Briggs (Proflo Vacuity)	Vacuity	2.9	1.45	1.52	2.06	75
9	American Std.	Hamilton	19.1	1.56	1.56	1.50	26
20	Eljer	Canterbury	14.3	1.66	1.59	1.50	42
10	Briggs (Proflo 3212T/2200B)	Abingdon III	2.9	1.66	1.60	1.75	46
18	Crane	VIP Flush	9.0	1.58	1.64	1.81	83
11	Briggs (Proflo Altima)	Altima III	1.3	1.75	1.78	2.00	51
15	Crane/Universal Rundle	Atlas	0.5	1.61	1.82	1.94	46
23	Eljer (see note below)	Cypress	24.9	1.58	1.86	1.88	58
41	Toto	CST703	1.7	1.63	2.08	1.81	38
8	American Std.	Cadet	10.3	1.53	2.37	1.94	60
30	Kohler	Memoirs	2.7	1.61	2.42	1.88	71
1	American Std.	Compact	0.8	1.57	2.45	1.63	28
4	American Std.	Hydra	82.1	1.51	2.56	1.75	48
45	American Std.	toilet to go	41.8	1.69	2.60	2.00	56
13	Corona	Orchid	0.4	1.56	2.64	1.50	44
31	Kohler	Serif	6.0	1.50	2.69	1.88	63
29	Kohler	Wellworth	4.3	1.57	2.77	1.81	70
28	Kohler	Wellworth	4.3	1.58	2.82	1.88	62
21	Eljer (see note below)	Patriot	23.0	1.71	2.82	1.88	61
22	Eljer (see note below)	Savoy	23.4	1.60	2.92	1.88	58
38	St. Thomas	Marathon	8.6	1.72	2.95	1.88	45
3	American Std.	Antiquity	48.9	1.64	3.10	1.75	45
42	Western Pottery	Aris	0.5	1.89	3.18	1.75	51
2	American Std.	Plebe	4.9	1.84	3.44	1.94	78
26	Kohler	Devonshire	5.0	1.61	3.50	1.81	61
24	Gerber	Aquasaver	13.7	1.84	3.57	1.75	64
5	American Std.	Cadet	16.6	1.48	3.80	1.94	65
36	Sanitarios Azteca (Lamosa)	Sahara	3.2	1.60	3.94	1.63	38
6	American Std.	Cadet	9.1	1.59	4.12	1.81	70
7	American Std.	Cadet	13.3	1.62	4.19	1.88	78
25	Glacier Bay (HD brand) RAK Thailand	Westminster	8.0	1.65	4.66	1.94	35
101	Microphor	Microflush Model LF210	5.5	0.66	n/a	1.50	82
39	St. Thomas	Mariner II	6.2	0.95	n/a	NM	58
102	St. Thomas	Mariner II Flushmate 4	19.2	1.18	n/a	1.75	72
108	Toto	Drake @ 1.4 gpf	0.7	1.39	n/a	2.00	69
43	Gerber	Ultra	0.6	1.45	n/a	1.94	112
19	Eljer	Aquasaver	15.9	1.56	n/a	2.00	60
34	Mansfield	Quantum	1.7	1.60	n/a	1.88	92
33	Mansfield	Alto	0.4	1.62	n/a	1.50	53
35	Niagara	Flapperless	0.3	1.62	n/a	1.88	38
14	Caroma	Caravelle	7.2	1.62	n/a	NM	28
27	Kohler	Santa-Rosa	7.0	1.63	n/a	1.75	52
104	Toto	Ultramax	0.0	1.63	n/a	2.00	63
105	Toto	Ultimate Elongated Bowl	0.0	1.64	n/a	2.00	63
106	Toto	Ultimate Round Bowl	0.1	1.69	n/a	2.00	63
40	Toto	Drake	0.9	1.70	n/a	2.00	65
17	Crane	Economiser	10.4	1.50	N/a	1.63	70

Note:
For trap diameter NM indicates the trap was not measured as it was larger than the 2-1/8" ball. Numbers 14 and 103 had substantially larger traps.
For Replacement Flapper Volume, n/a indicates that the replacement flapper did not fit or was not applicable as in pressure assist units.

APPENDIX D4
AVERAGE RESULTS SORTED BY WATER SPOT AREA

FIXTURE NUMBER	BRAND	MODEL	FLUSH PERFORMANCE INDEX	OUT-OF-BOX FLUSH VOLUME gpf	REPLACEMENT FLAPPER FLUSH VOLUME gpf	Trap Diameter in	Water Spot in^2
103	American Std.	Dual Flush Asia Model	0.4	1.59	1.03	NM	9
9	American Std.	Hamilton	19.1	1.56	1.56	1.50	26
1	American Std.	Compact	0.8	1.57	2.45	1.63	28
14	Caroma	Caravelle	7.2	1.62	n/a	NM	28
44	Niagara	Turbo	0.8	1.52	1.52	1.88	35
25	Glacier Bay (HD brand) RAK Thailand	Westminster	8.0	1.65	4.66	1.94	35
36	Sanitarios Azteca (Lamosa)	Sahara	3.2	1.60	3.94	1.63	38
35	Niagara	Flapperless	0.3	1.62	n/a	1.88	38
41	Toto	CST703	1.7	1.63	2.08	1.81	38
20	Eljer	Canterbury	14.3	1.66	1.59	1.50	42
13	Corona	Orchid	0.4	1.56	2.64	1.50	44
3	American Std.	Antiquity	48.9	1.64	3.10	1.75	45
38	St. Thomas	Marathon	8.6	1.72	2.95	1.88	45
15	Crane/Universal Rundle	Atlas	0.5	1.61	1.82	1.94	46
10	Briggs (Proflo 3212T/2200B)	Abingdon III	2.9	1.66	1.60	1.75	46
4	American Std.	Hydra	82.1	1.51	2.56	1.75	48
11	Briggs (Proflo Altima)	Altima III	1.3	1.75	1.78	2.00	51
42	Western Pottery	Aris	0.5	1.89	3.18	1.75	51
27	Kohler	Santa-Rosa	7.0	1.63	n/a	1.75	52
33	Mansfield	Alto	0.4	1.62	n/a	1.50	53
45	American Std.	toilet to go	41.8	1.69	2.60	2.00	56
39	St. Thomas	Mariner II	6.2	0.95	n/a	NM	58
23	Eljer (see note below)	Cypress	24.9	1.58	1.86	1.88	58
22	Eljer (see note below)	Savoy	23.4	1.60	2.92	1.88	58
8	American Std.	Cadet	10.3	1.53	2.37	1.94	60
19	Eljer	Aquasaver	15.9	1.56	n/a	2.00	60
26	Kohler	Devonshire	5.0	1.61	3.50	1.81	61
21	Eljer (see note below)	Patriot	23.0	1.71	2.82	1.88	61
28	Kohler	Wellworth	4.3	1.58	2.82	1.88	62
31	Kohler	Serif	6.0	1.50	2.69	1.88	63
104	Toto	Ultramax	0.0	1.63	n/a	2.00	63
105	Toto	Ultimate Elongated Bowl	0.0	1.64	n/a	2.00	63
106	Toto	Ultimate Round Bowl	0.1	1.69	n/a	2.00	63
24	Gerber	Aquasaver	13.7	1.84	3.57	1.75	64
5	American Std.	Cadet	16.6	1.48	3.80	1.94	65
40	Toto	Drake	0.9	1.70	n/a	2.00	65
108	Toto	Drake @ 1.4 gpf	0.7	1.39	n/a	2.00	69
17	Crane	Economiser	10.4	1.50	na/	1.63	70
29	Kohler	Wellworth	4.3	1.57	2.77	1.81	70
6	American Std.	Cadet	9.1	1.59	4.12	1.81	70
30	Kohler	Memoirs	2.7	1.61	2.42	1.88	71
102	St. Thomas	Mariner II Flushmate 4	19.2	1.18	n/a	1.75	72
12	Briggs (Proflo Vacuity)	Vacuity	2.9	1.45	1.52	2.06	75
7	American Std.	Cadet	13.3	1.62	4.19	1.88	78
2	American Std.	Plebe	4.9	1.84	3.44	1.94	78
101	Microphor	Microflush Model LF210	5.5	0.66	n/a	1.50	82
18	Crane	VIP Flush	9.0	1.58	1.64	1.81	83
34	Mansfield	Quantum	1.7	1.60	n/a	1.88	92
43	Gerber	Ultra	0.6	1.45	n/a	1.94	112

Note:
For trap diameter NM indicates the trap was not measured as it was larger than the 2-1/8" ball. Numbers 14 and 103 had substantially larger traps.
For Replacement Flapper Volume, n/a indicates that the replacement flapper did not fit or was not applicable as in pressure assist units.

APPENDIX E
COMPARISON TO THE NAHB RESEARCH CENTER WATER CLOSET SURVEY

A summary of the previous NAHB Research Center toilet testing can be found on the Research Center's web site at www.nahbrc.org by searching for "water closet survey". The "Clog Potential Index" from the previous study is similar to "Flush Performance Index" of this report. The results of this previous testing and the current study cannot be directly compared, as the test protocol was modified for this study. The major difference was that the current study used 1.1" long sponges vs. 2.2" sponges in the previous study. The volume of sponges was kept essentially the same and the number at each level was doubled for the current study. There were also other minor differences in the two test protocols. Because the indices are based on counting the number of test media pieces left in the bowl, the values from the previous study would need to be doubled to compare to this study. In general, it appears that the industry has made considerable progress in improving the performance of the toilets on the market since the 1999 study. However, it also appears that cutting the sponges in half made the media easier to flush and the index values lower.