EVALUATION OF ULTRA-LOW FLOW (6 LITRE) GRAVITY TOILETS IN TWO SCHOOLS

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The donation of sample 6 litre toilets by Toto USA and American Standard were greatly appreciated.

EXECUTIVE SUMMARY

Engineering Technologies Canada Ltd. (ETC) has carried out an evaluation of ultra-low flow (ie., 6 litre) gravity toilets in two Prince Edward Island schools. The objectives of the study were to calculate how much (if any) water can be saved in schools by using 6 litre instead of conventional (13.2 litre) gravity toilets and to determine if there is a higher rate of plugging or "double flushing" in 6 litre toilets.

The previous experience of the PEI Eastern School District with 6 litre toilets has not been positive. Therefore, a formal study was deemed necessary to in order to allow for an objective evaluation of 6 litre toilets in the challenging school environment.

Six litre toilets theoretically require only 46 per cent of the water that 13.2 litre models require. The potential water savings afforded by 6 litre toilets would reduce the output of sewage to septic tank and disposal field systems and may prevent hydraulic overloading of these systems and increase their longevity.

During Phase I of the study, three conventional (13 litre) toilet stalls in each school were monitored. For Phase II, the same stalls were retrofitted with either Toto USA Drake or American Standard Cadet 6 litre toilets. The daily flushes per day and any incidents of clogging or plugging for the toilet stalls were tracked during each phase.

There was a 6 to 13 percent increase in the average total number of flushes per day for the stalls retrofitted with 6 litre toilets at each school. However, when the results for individual stalls were examined, there was no clear connection between increased flushing frequency (double flushing) and the use of the 6 litre toilets. The measured net water savings for 6 litre toilets over toilets designed to flush with 13.2 litres ranged from 46 to 60 percent.

The 6 litre toilets tested in this study did not cause an increase in the frequency of routine toilet plugging. There were no additional maintenance problems caused by a possible increased level of

"double flushing".

The 6 litre gravity toilet models tested in this study are considered suitable for use in public schools, recreational and commercial facilities and residential homes.

The flushing performance and water consumption of other 6 litre models should be investigated before specifying their use in schools and other demanding environments. Another study recently completed for the Canadian Water and Wastewater Association by Veritec Consulting Inc. (see Appendix A) showed that despite being CSA certified, the actual consumption of some ultra-low flow toilet models was considerably more than 6 litres per flush. Toilet models should be specified or selected which have been independently confirmed to flush effectively using 6.5 litres of water or less.

The Veritec study also found that many 6 litre toilet models (including the American Standard Cadet) use considerably more water when fitted with commonly available, universal replacement flappers. Therefore, to ensure water savings are maintained in the long term, plumbers servicing 6 litre toilets in schools and other government buildings should be directed to use only genuine manufacturer replacement parts.

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1 INTRODUCTION

Engineering Technologies Canada Ltd. (ETC) was retained by the PEI Department of Fisheries, Aquaculture and Environment to carry out an evaluation of ultra-low flow (6 litre) gravity toilets in two schools.

There is a significant difference of opinion among plumbers, engineers and maintenance personnel as to the performance and plugging frequency of modern 6 litre gravity toilets. Many believe all 6 litre toilet models experience an unacceptable frequency of plugging, clogging, rootering (plugging of the building sewer piping) compared to older, less water-efficient models. Others are of the opinion that actual water savings are much less than theoretical water savings due to a perceived higher rate of "double flushing" in 6 litre toilets.

Some maintenance personnel and plumbers have had bad experiences with poorly designed or first generation 6 litre models and assume all modern brands and models will perform just as poorly. This negative perception continues to be reinforced in the media and popular press. As a result, there is often strong resistance to the use of 6 litre toilets in spite of the potential water saving benefits.

The PEI Department of Fisheries, Aquaculture and Environment currently promotes the use of water conserving fixtures on private sector as well as government building projects such as office complexes and schools. However, the previous experience of other government departments with 6 litre toilets has not been positive.

The PEI Eastern School District had retrofitted some of its schools with early 6 litre toilet models and found they resulted in an unacceptable increase in the frequency of plugging and maintenance (J. Miodowski, personal communication). Therefore, in spite of strong recommendations by the Department and ETC to "go low flow" at the new Elementary School in Donagh, 6 litre toilets were rejected out of concern that the fixtures would result in similar maintenance problems, and that the projected water savings would not be realized due to "double flushing". ETC estimated the hydraulic loading to the school's new on-site sewage system would be 40 percent to 50 percent less if 6 litre toilets could be successfully employed. This would have resulted in a reduced capital cost of the on-

site sewage system due to a lower design flow. The reduced sewage output would have also reduced the possibility of overloading of the system and site.

There may be other existing schools with on-site sewage systems that are currently at or beyond capacity. In some cases, retrofitting the school with effective, 6 litre toilets may solve a hydraulic overloading problem and avoid costly remedial work on the septic system.

A formal study was deemed necessary in order to allow for a proper objective evaluation of the relative performance of 6 litre toilets in the challenging school environment. The study was designed so as to ensure that the analysis of and conclusions reached from the data were consistent with the application of the scientific method.

There were two main objectives of this study:

1. Calculate how much (if any) water can be saved in elementary and secondary schools by using 6 litre instead of conventional (13 litre) gravity toilets;

2. Determine if there is a higher rate of ***plugging*** or ***double flushing*** in 6 litre versus 13 litre gravity toilets.

For the purposes of this study ***"plugging"*** is defined as a ***blockage in the toilet or toilet piping which requires the use of a plunger or snake to restore the toilet to normal flushing operation***.

Prior to commencing the study, custodians at the two schools involved in the study were asked what sort of plugging frequency was typical or normal in the conventional (ie., non-six litre) toilets. Custodians indicated that the frequency of plugging is highly variable ranging from none to several incidents per week. Overall they gave the impression that plugging is not normally a regular occurrence with non-six litre toilets.

"Double flushing" refers to a case where the user flushes the toilet more than once during a single

visit. Double flushing is usually carried out in order to correct an actual or perceived problem with proper evacuation of waste from the bowl. Double flushing may be carried out by the primary user of the toilet to ensure the bowl is clean before leaving the stall, or it may be done by the next user of the toilet to clear the bowl prior to using it themselves.

Theoretically, a poorly performing 6 litre toilet that requires two or more flushes per visit will use more water than a 13 litre toilet that requires only one flush. Therefore, the incidence of double flushing is an important consideration when maximum water savings is the goal.

This report describes the methodology used and the results obtained from the study. Conclusions and recommendations have been presented regarding the acceptability and application of gravity 6 litre toilets in schools and other buildings.

2 BACKGROUND

2.1 Rationale and Benefits of Ultra-low Flow Toilets

Over the past few decades, North American manufacturers have re-designed toilets to use less water and introduced ultra-water conserving models under pressure from the USEPA. First generation toilets used in excess of 20 litres to flush the bowl. Second generation "water saver" toilets were designed to use 13.2 litres per flush (for convenience rounded off to 13 litres in this report) and are still the most common type of gravity toilet in Canada. Third generation, 1.6 usgal (6 litre) toilets have been marketed in the USA since the early1980s. By 1992, seventeen States had established a standard of 1.6 gallons per flush (gpf) for replacement toilets and those installed in new construction. The USA's Energy Policy Act of 1992 established a national manufacturing standard of 1.6 gpf for most toilets, the initial stage of which took effect on January 1, 1994. In Canada, only Ontario and British Columbia have mandated 6 litre toilets on all new and retrofit construction.

Six litre toilets theoretically require only 46 per cent of the water that 13 litre models require. The water used to flush toilets typically comprise approximately 40 percent of all water used in the home. In commercial or institutional buildings (including schools) toilet water usage can comprise

a much larger portion of the overall water demand. The potential water savings afforded by 6 litre toilets and other water conserving fixtures benefit the environment in several ways:

- Reduced output of sewage to septic tank and disposal field systems may prevent hydraulic overloading of these systems and increase system longevity;

- Lower rates of groundwater extraction from individual wells may avoid problems with aquifer depletion;

- Reduced output of sewage to municipal sewage treatment plants may prevent overloading of treatment facilities and avoid or defer expansion of these facilities;

- Reduced demand on municipal water supplies may avoid expansion of water supply systems and water treatment facilities.

There are also significant potential economic benefits where users pay significant unit rates for every litre of water they consume and sewage they produce. These benefits do not currently provide much of an incentive in the Maritimes where most users are charged either a flat fee or a very low unit rate for municipal water and sewer services.

2.2 Previous Studies

Some manufacturer's (G. Baldwin, personal communication) have carried out their own in-house studies which compared the relative performance of various 6 litre toilet models using simulated human waste. *Customer satisfaction surveys* (Westat, 1996) have also been carried out which investigated homeowner, landlord and plumber's relative satisfaction with various 6 litre toilet models following a retrofit program. However, none of these studies attempted to quantify the relative frequency of clogging, plugging and double flushing in an actual commercial or institutional setting. The Ontario Ministry of Education has carried out studies of 6 litre ***flush valve*** toilets in schools but not 6 litre gravity toilets (B.Gauley, personal communication).

Veritec Consulting Inc. has carried out several water efficiency studies in which potential water savings from the use or retrofit of 6 litre toilets have been projected and confirmed after the retrofit program (B. Gauley, personal communication). Veritec (2001) also recently completed an evaluation of 31 different models of 6 litre toilets for the Canadian Water and Wastewater Association (CWWA) and the Canada Mortgage and Housing Corporation (CMHC). This results of this study have recently been made public and a copy of the report is included Appendix A. Highlights of the report were as follows:

- Approximately 37 percent of the toilets tested flushed properly using 6.5 litres of water or less;

- Approximately 50 percent of the toilets tested with the manufacturer supplied (proprietary) flapper used more than 6.0 litres per flush (up to 8 litres in some cases);

- When the toilets were retested with commonly available universal replacement (standard) flappers, the majority used more water, with many jumping to 10 -16 litres per flush.

The results of this study were forwarded to the CSA B45 technical committee on plumbing fixtures.

2.3 CSA Certification

CSA tests and certifies toilets for compliance with the CAN/CSA-B45 standard. This standard requires a water closet to achieve a minimum of 9 out of 15 possible points in testing to be certified. However, the scores are not made public and toilets are rated as either ***pass or fail***. Consumers have no way of comparing the relative flushing performance of various toilet models.

Last year, the B45 technical committee approved a proposal to amend the standard so that 6 litre toilets would be retested and classified into one of four categories determined by how high the toilet scored in testing. The four proposed classifications (listed in order of increasing rating or score) were as follows:

1. Single and multi-unit home residential, generally low volume use;
2. Commercial transient medium traffic locations such as hotels, motels, resorts, restaurants;
3. Commercial-institutional-industrial use such as schools, military facilities.
4. High traffic and occupancy public facilities such as airports, bus depots, correction facilities.

A rating or classification system would allow consumers, designers and owners to select or specify toilet models which are most appropriate for the type of facility. Unfortunately, CSA's plans to switch to a classification system have since been abandoned (B. Gauley, personal communication).

The CSA B45 Committee on plumbing fixtures is currently conducting an investigation into why some of the toilet models tested in the CWWA/CMHC study failed to meet their certification criteria. The CSA has formed a task force to investigate some of the findings stated in that report. Changes to the B45 standard may be recommended by the task force.

3 METHODOLOGY

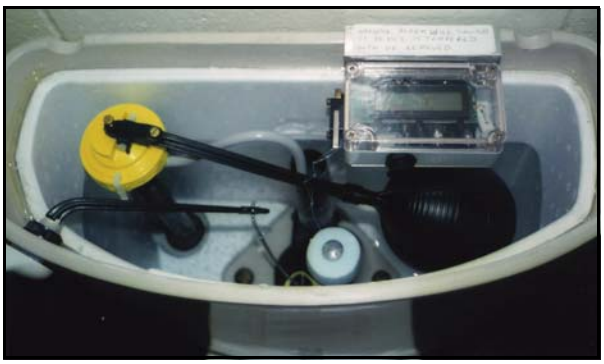
3.1 Informal Study

The Eastern School District had already begun an informal evaluation of 6 litre toilets at two local schools when ETC received approval to proceed with a formal study. At Stone Park Intermediate (grades 7 to 9), two 6 litre *Drake* toilets manufactured by Toto USA had been installed in a handicapped stall in a girl's washroom, and in one of the boys toilet stalls.

At Elliot River Elementary (grades 4 to 6), a Toto *Drake* was installed in one of the two stalls in the boys washroom. A 6 litre American Standard *Cadet* was installed in the handicapped stall of the girl's bathroom.

Preliminary telephone interviews (B. Shaw / K. Galloway and S. MacAusland / K. Galloway) were made with custodial staff in charge of keeping the records. Almost a month into the informal study, neither custodian found that the 6 litre toilets clogged or plugged at all. However, both felt that the 6 litre toilets were installed in locations which were used relatively infrequently. They expressed

concern the toilets were not being subjected to a true test.



ETC Flush Counter installed under tank lid of American Standard Cadet 6 litre toilet.

To determine if there was significant variability in toilet usage among the different stalls, *ETC's Electronic Flush Counters* (see photo on left) were installed inside the tanks of selected handicapped and non-handicapped toilets in boys and girls washrooms. This device records a "flush" every time the water level in the tank drops below a predetermined level. After monitoring various stalls for a period of several days, it was found that the boy's toilets and the handicapped toilets were only being used half to one quarter as often as other toilets. Therefore, to maximize fixture usage and hence exposure to potential clogging incidents, it was decided to monitor only non-handicapped toilet stalls in the girl's washrooms during the formal study described in the next section.

3.2 Formal Study

The formal study consisted of monitoring three (3) girls toilet stalls (the *study stalls*) in the Stone Park (SP) and Elliot River (ER) schools. There were two phases of monitoring and data collection.

During Phase I, the existing (13 litre) toilets were monitored for a period of 3 to 6 weeks. Daily flush totals were recorded using ETC Flush Counters. Custodial staff were asked to record any incidents of clogging or plugging that occurred in the toilets. The water consumption of two of the existing toilets was checked by reading a water meter before and after flushing the toilet

Typical 13.2 litre conventional toilet.

several times. The actual consumption of both toilets was 11.8 litres or 11 percent less than their design consumption of 13.2 litres.

For Phase II, the study stalls were retrofitted with either Toto USA Drake or American Standard Cadet 6 litre toilets and monitored for another period of approximately 4 weeks. The Drake toilets were donated by the manufacturer for the study. The American Standard Cadet toilets were donated through a local plumbing wholesaler. Table 1 summarizes which toilet stalls were studied and the Phase I and II fixtures.

During both phases of the study, site visits were made at least bi-weekly to ensure the flush counters had not been removed or tampered with, download flush counter data, interview custodians and to ensure toilets were functioning properly (ie., no leaks, etc.).

Toto USA Drake 6 litre toilet

American Standard Cadet 6 litre

The water consumption of two of each model of 6 litre toilet was checked by reading a water meter before and after flushing the toilet several times. Both models were flushing with 12 to 17 percent less than their design consumption of 6.0 litres. The manufacturer and/or the plumbers were contacted to get information and advice on how to adjust the toilets so they would use the full 6.0 litres of water. In spite of following their advice, we were unsuccessful in adjusting the toilets to use more than the amounts indicated in Table 2.

Independent testing carried out by Veritec Consulting Inc. (2001) showed a similar flush volume for the Toto USA Drake, but a higher volume (between 6.5 and 7.0 litres) for the American

Standard Cadet toilet tested in that study.

Table 1 Summary of toilet stalls and fixtures used in study.

School	Toilet Identifier	Stall Location Description	Phase I (13 litre) Toilet Fixture	Phase II (6 litre) Toilet Fixture
Stone Park Junior High	SP-G1	Main floor Girl's 1st stall	Crane bowl and tank (unlined)	American Standard Cadet
Stone Park Junior High	SP-G2	Main floor Girl's 2nd stall	Crane Cranada bowl, tank 3-592 (lined)	Toto USA Drake
Stone Park Junior High	SP-G3	Main floor Girl's 3rd stall	Crane bowl, tank 3-576 (lined)	Toto USA Drake
Elliot River Elementary	ER-G2	Upper floor Girl's 2nd stall	Crane bowl, Amer. Std. tank 4055 (lined)	American Standard Cadet
Elliot River Elementary	ER-G3U	Upper floor Girl's 3rd stall	Crane bowl, tank 3-574 (lined)	American Standard Cadet
Elliot River Elementary	ER-G3L	Lower floor Girl's 3rd stall	Crane bowl, tank 3-574 (unlined)	Toto USA Drake

Table 2 Actual measured water consumption of 6 litre study toilets.

Manufacturer/Model	Flush Volume	
Toto USA Drake	SP-G2 5.0 L (17% less)	SP-G3 5.0 L (17% less)
American Standard Cadet	ER-G2 5.3 L (12% less)	ER-G3U 5.0 L (17% less)

Zero flush counts on weekends and holidays and other anomalies were eliminated from the raw data sets prior to calculating means or doing other statistical analyses on the adjusted data sets. The number of actual days (ie., the sample size) ranged from 15 to 25 days and 19 to 20 days for the Toto Drake stalls, before and after the 6 litre retrofits respectively. For the American Standard stalls, the sample size ranged from 25 to 28 days and 18 to 19 days, before versus after the retrofits respectively. Raw and adjusted data sets are included in Appendix B.

4 RESULTS AND DISCUSSION

4.1 Flushing Frequency

As indicated in Figure 1, after the 6 litre retrofits, there was a 6 percent increase in the average total number of flushes per day for the three stalls at Stone Park School. There was a 13 percent increase in the average total flushes per day for the three stalls at Elliot River School. Detailed data is included in Appendix B. These results seem to indicate a slightly higher frequency of "double flushing" with the 6 litre toilets. However, the increase in usage may have been caused by other reasons not related to the performance of the toilets. For example, some students may have preferred to use the 6 litre toilets because they were new.

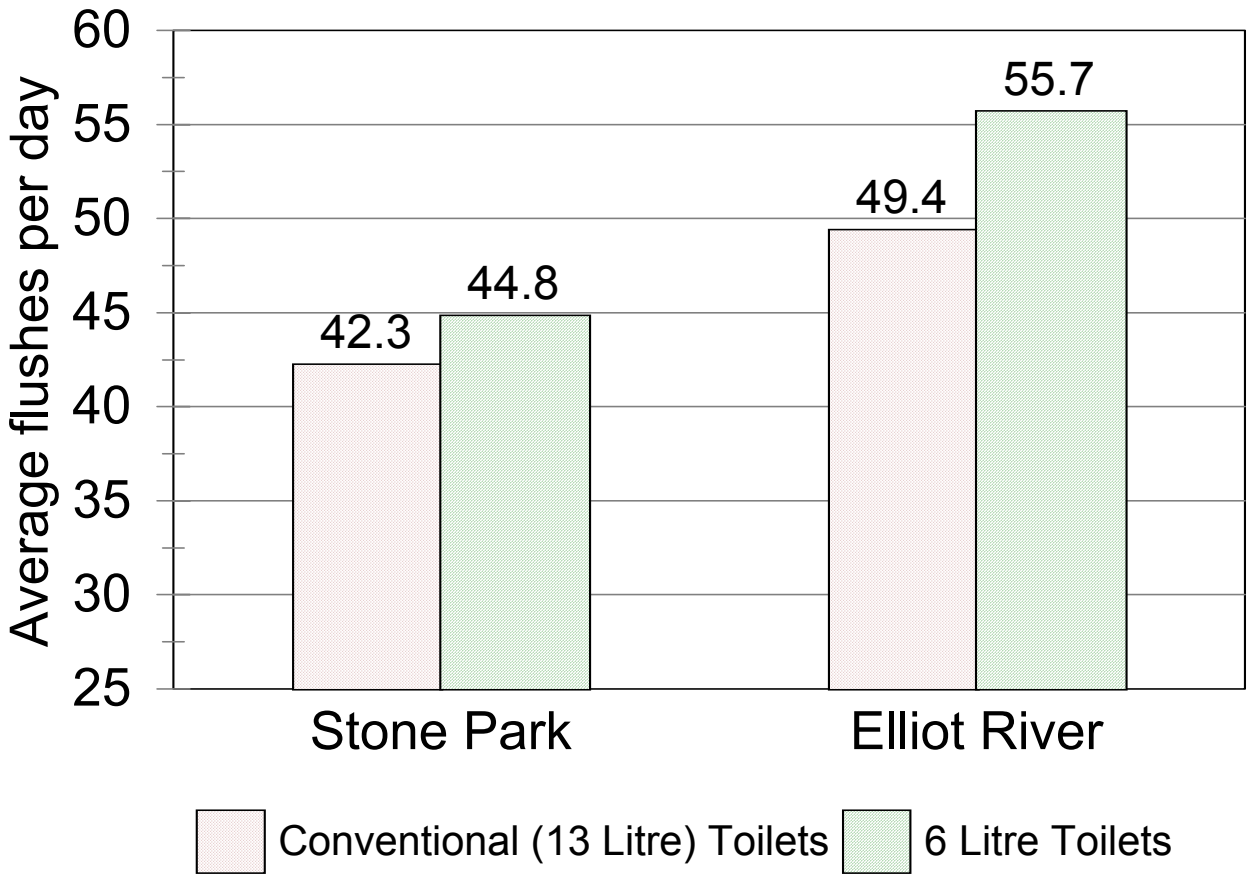
The change in flushing frequency for stalls retrofitted with the two different models of 6 litre toilets is summarized in Tables 3 and 4 and shown graphically in Figures 2 and 3.

Table 3 Change in flushing frequency after retrofit with Toto Drake 6 litre toilets.

Stall	13 Litre Ave/day	6 Litre Ave/day	Percent Change	Statistical Significance
SP-G2	6.4	4.2	-34.2 %	Second mean is significantly less than first (P = 0.025)
SP-G3	16.4	22.3	35.8 %	Second mean is significantly greater than the first (P=0.0004)
ER-G3L	14.9	17.7	18.5 %	Second mean is moderately significantly greater than the first (P=0.06)

After the 6 litre retrofits, one of the Toto and one of the American Standard toilet stalls showed a significant increase in the average number of daily flushes. One of the Toto toilet stalls showed only a moderately significant increase and the other Toto stall experienced a significant decrease in flushing frequency. The average flushing frequency of the other two American Standard toilet stalls did not change significantly after the retrofits. Therefore, overall, there was no clear connection between increased flushing frequency (double flushing) and the use of the 6 litre toilets.

Average Flushes/day by School
Before Versus After 6 Litre Retrofits



Engineering Technologies Canada Ltd.	**Evaluation of Ultra-low Flow (6 Litre) Gravity Toilets in Two Schools**	Figure No.
	Average Flushes/day by School Before Versus After 6 Litre Retrofits	**1**

Table 4 Change in flushing frequency after retrofit with American Std. Cadet 6 litre toilets.

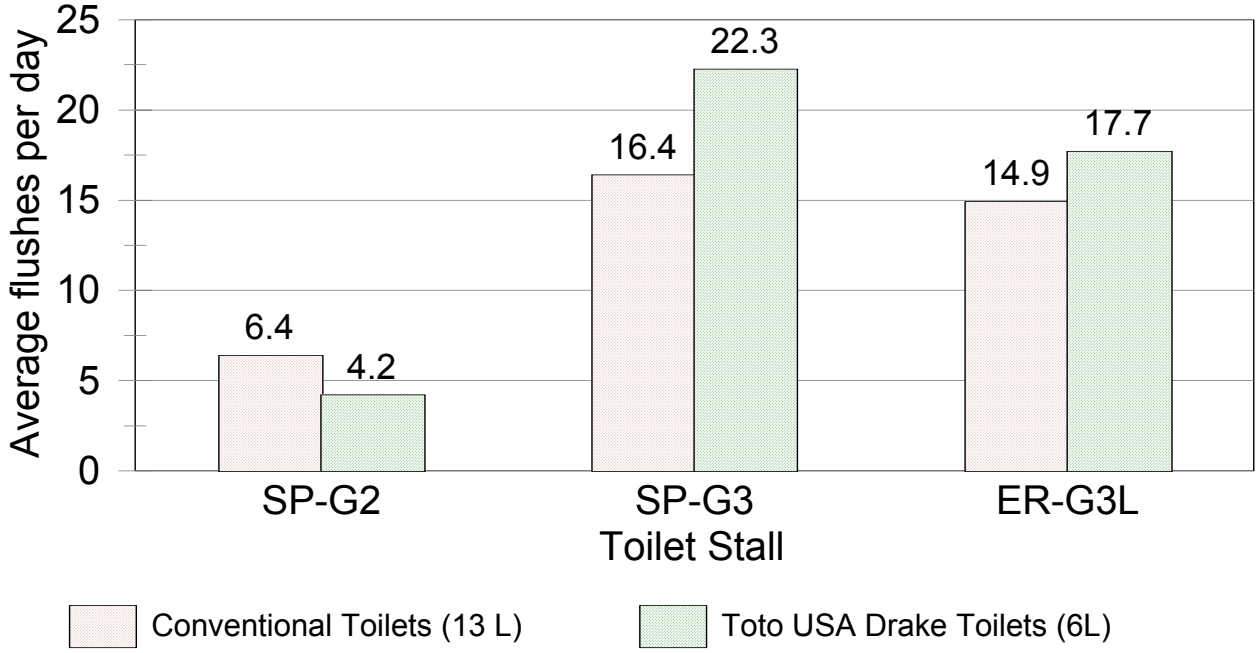
Stall	13 Litre Ave/day	6 Litre Ave/day	Percent Change	Statistical Significance
SP-G1	19.9	18.4	-7.6 %	Means are not significantly different (P = 0.28)
ER-G2	13.6	14.8	8.6 %	Means are not significantly different (P = 0.30)
ER-G3U	19.5	23.1	18.5 %	Second mean is significantly greater than the first (P=0.01)

4.2 Water Savings

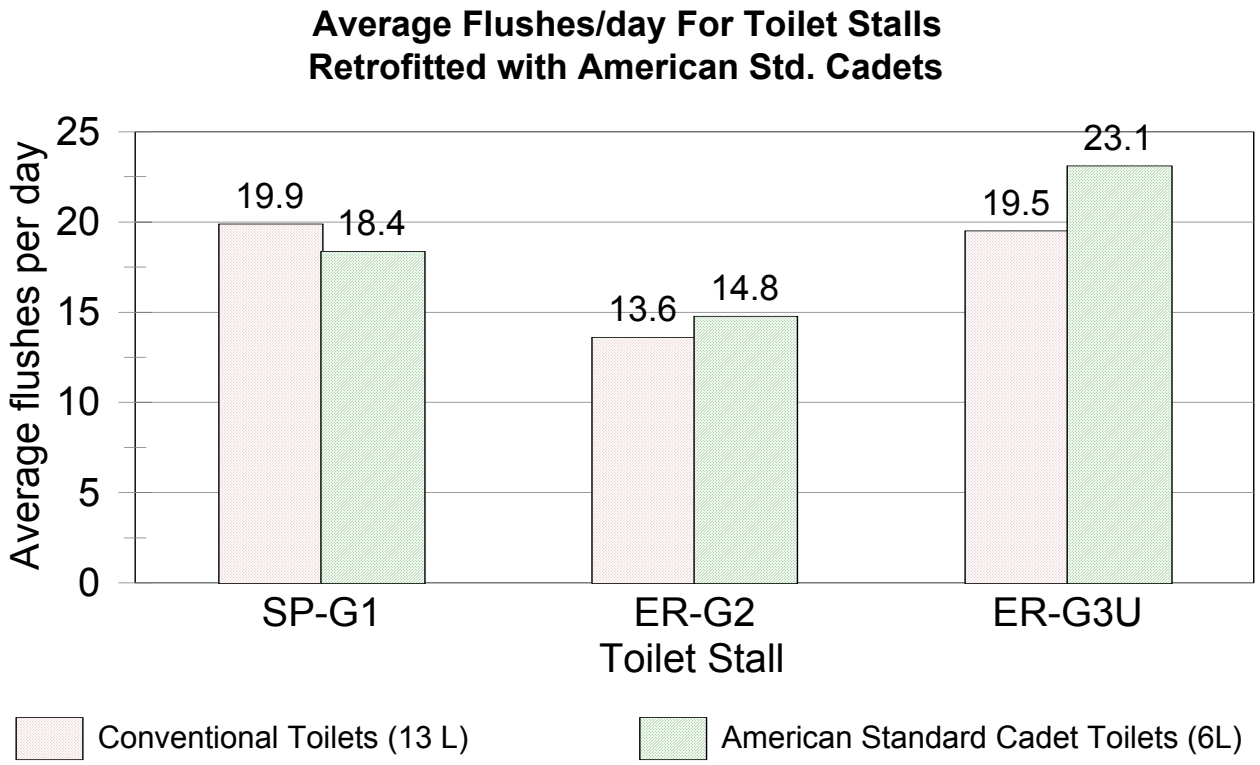
The net water savings achieved by using 6 litre versus 13 litre toilets is indicated in Tables 5 and 6. Although the average daily usage increased in four of the study stalls after the 6 litre retrofits, this was offset by the fact that the retrofit toilets were using less than half the amount of water per flush. Therefore, the net water savings over a toilet that flushes with 11.8 to 13.2 litres were still quite considerable (average low to high end water savings of 46 percent to 60 percent).

It is noted that in some older schools, very high water consumption (approximately 20 litres per flush), first generation toilets may still be in use. Therefore, retrofitting these schools with 6 litre toilets would have result in even greater water savings of around 70 percent.

Average Flushes/day For Toilet Stalls Retrofitted with Toto USA Drakes



Engineering Technologies Canada Ltd.	**Evaluation of Ultra-low Flow (6 Litre) Gravity Toilets in Two Schools**	Figure No.
	Average Flushes/day for Toilet Stalls Retrofitted with Toto USA Drakes	**2**



Engineering Technologies Canada Ltd.	**Evaluation of Ultra-low Flow (6 Litre) Gravity Toilets in Two Schools**	Figure No.
	Average Flushes/day for Toilet Stalls Retrofitted with American Standard Cadets	**3**

Table 5 Net water savings after retrofit with Toto Drake 6 litre toilets.

Stall	13 Litre Ave/day	6 Litre Ave/day	Measured/assumed water used per flush	Net Water Savings Over 13 Litre Toilets*
SP-G2	6.4	4.2	5.0 litres	67 % to 75 %
SP-G3	16.4	22.3	5.0 litres	31 % to 48 %
ER-G3L	14.9	17.7	5.0 litres (assumed)	40 % to 55 %
			Average:	46 % to 60 %

*High and low end estimates based on measured/assumed versus design water consumption for both toilets.

Table 6 Net water savings after retrofit with American Standard Cadet 6 litre toilets.

Stall	13 Litre Ave/day	6 Litre Ave/day	Measured/assumed water used per flush	Net Water Savings Over 13 Litre Toilets*
SP-G1	19.9	18.4	5.3 litres (assumed)	53 % to 63 %
ER-G2	13.6	14.8	5.3 litres	45 % to 56 %
ER-G3U	19.5	23.1	5.0 litres	40 % to 55 %
			Average:	46 % to 58 %

*High and low end estimates based on measured/assumed versus design water consumption for both toilets.

4.3 Plugging

The other objective of the study was to determine what effect the use of 6 litre toilets had on the relative incidence of toilet plugging. During both the 13 litre and 6 litre monitoring periods, custodial staff were asked to keep a record of any incidents of plugging which required the use of a plunger or snake to restore a toilet to normal flushing operation. No incidents were recorded during Phase I and only a single case of plugging was reported during Phase II in which one of the toilets had a pencil jammed sideways in the trapway. The custodian considered this an act of vandalism which would have caused any toilet to plug.

The 6 litre toilets in both schools were left in service upon completion of Phase II of the formal study. A follow-up interview was made in late November 2001 with custodians at both schools. They were of the opinion the 6 litre toilets were still performing well and stated there have been no

maintenance problems in the first three months of the Fall 2001 school term.

Therefore, the 6 litre toilets tested in this study did not cause an increase in the frequency of routine toilet plugging. There were no additional maintenance problems caused by a possible increased level of "double flushing".

5 CONCLUSIONS AND RECOMMENDATIONS

Several conclusions and recommendations can be made from the study:

1. There was no clear connection between increased flushing frequency and the use of 6 litre toilets.

2. The average net water savings achieved with 6 litre toilets over a toilet which flushed with approximately 13 litres were 46 to 60 percent, even after taking into account possible increases in "double flushing".

3. The 6 litre toilets tested in this study did not cause an increase in the frequency of routine toilet plugging. There were no additional maintenance problems caused by a possible increased level of "double flushing".

4. The 6 litre gravity toilet models tested in this study are considered suitable for use in public schools, recreational and commercial facilities and residential homes. We wish to caution that water savings may not be maintained in the long term if the American Standard Cadet toilets are refitted with commonly available universal replacement flappers. Toto Drake toilets will only accept the manufacturer's proprietary flapper.

5. Boy's and handicapped toilets only receive half to one quarter of the usage of conventional (ie., non-handicapped) girl's toilets. To maximize water savings in school retrofit programs, conventional girl's toilet stalls should be the priority for 6 litre toilet replacement.

6. The flushing performance and water consumption of other 6 litre models should be investigated before specifying their use in schools and other demanding environments. The CWWA/CMHC study recently completed by Veritec Consulting Inc. (Appendix A) could be used to help identify other appropriate 6 litre toilet models. Despite CSA certification, this study showed actual consumption of some ultra-low flow toilet models are considerably higher than their intended design consumption of 6 litres per flush. Toilet models should be specified or selected which have been independently confirmed to flush effectively using 6.5 litres of water or less.

7. The Veritec study found that many 6 litre toilet models (including the American Standard Cadet) use considerably more water when fitted with commonly available, universal replacement flappers. Therefore, to ensure water savings are maintained in the long term, plumbers servicing 6 litre toilets in schools and other government buildings should be directed to use only genuine manufacturer replacement parts.

   For private sector building projects where permanent, effective water conservation measures are required as a condition of permitting, it may be prudent to recommend only toilet models which either: (a) maintain low flush volumes even with a universal flapper; or (b) will only accept the manufacturer's proprietary flapper.

Sincerely,

ENGINEERING TECHNOLOGIES CANADA LTD.

Kelly Galloway, P.Eng.
Principal

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APPENDIX A

Independent Toilet Testing Program report
by Veritec Consulting Inc.

Independent Toilet Testing Program

Background

In 1996 the Ontario Building Code introduced the mandatory installation of water efficient 6-litre (6L) toilets in all new construction[1]. The Code does not require the installation of 6L units when replacing existing toilets, however, many municipalities provide incentives towards the installation of 6L toilets over 13L toilets in an effort to reduce water consumption, defer capital expansions, and to be environmentally responsible.

Each model of 6L toilet available in Ontario is expected to pass certain testing requirements for certification, i.e., it is expected to meet the Canadian Standards Association (CSA) requirements. Currently, the test scores are confidential, however, each model must achieve a minimum score of 9 out of 15 points to be certified. The testing protocol includes measuring the toilet's flush volume and evaluating the toilet's performance. Toilets must flush with an average volume of no more than six litres based on five flushes at each of 20, 50, and 80 psi, and each toilet is evaluated based on water-change capability, flushing surface, and three different carry-out capability tests.

In spite of the certification process, however, independent field tests have identified a number of toilet models that flush with considerably more than six litres of water, and others that have an inferior flush performance.

It is believed that *all certified toilets* should flush satisfactorily (i.e., clear and clean the bowl in a satisfactory manner) and use approximately six litres or less per flush. Field-testing results have indicated that certification does not guarantee that a toilet will perform to these standards. Field-testing is designed to simulate what a homeowner would experience from purchasing a toilet "off the shelf". It also seems that the poor performance of some models of 6L toilets are casting all 6L toilets in a bad light – a clear case of having 'a few bad apples spoiling the whole bunch'. Many 6L toilets tested in the field do, in fact, flush at six litres and perform quite well.

Program Goal

In the interest of assessing how certified 6L toilets function 'in the field', the Canadian Water and Wastewater Association, The Canada Mortgage and Housing Corporation, the Region of Durham, the Region of Halton, the Region of Waterloo, and the City of Toronto initiated an independent toilet testing program. Municipalities and homeowners need to be assured that the 6L toilets they are subsidizing or purchasing are saving water and performing well.

[1] Certain types of buildings were exempt from this requirement, e.g., hospitals, jails, historic sites, airports, etc

Scope of Independent Toilet Testing

It is important to note that this independent toilet testing program (as performed by Veritec Consulting Inc.) was **not intended to duplicate CSA testing.**

The method of determining toilet *flush volumes* is virtually the same for both the CSA and the independent testing program. The independent *performance testing* procedures, however, vary from those of the CSA. The CSA performance testing uses sponges, crumpled paper balls, paper sheets, sawdust, polyethylene granules, and blue dye to measure flush performance. The independent performance testing uses blue dye (food colouring) to test liquid carry out, Kool-Aid powder to test wash down, and toasted oat O's breakfast cereal as a floating media to test solid carry out. Together, these materials seem to provide a good measure of flush performance.

Both the CSA and independent performance testing protocols are *comparison* tests, i.e., they compare the ability of *different* toilet models to clear the *same* test materials under the *same* conditions. It is important to note that *none* of the testing materials used by either the CSA or the independent testing accurately simulate the toilet's ability to clear human waste.

In most cases a single toilet of each selected make and model was tested – a total of thirty-one different toilet models were tested.

Notes and Considerations

It should be noted that the testing of only one specimen of each toilet does not provide a statistically valid sample size. The results shown in this report should be viewed only as an indication of expected 'field' results.

The selection of toilets tested as part of this program is in no way intended to represent all of the various makes and models available, nor is it intended to provide a comprehensive list of all toilets that might be expected to perform either well or poorly in the field. Toilets selected however, represent a broad range of designs, styles and price ranges available in the Ontario market.

The results obtained during this testing program are not a guarantee of performance.

The following section outlines observations made during the testing program, and ***Table 1*** summarizes the results of the flush volume and performance testing based on the criteria identified in ***Flush Volume/Performance Results*** section**.**

Observations

1. There is a significant difference in the performance and flush volumes of different toilets.
2. Approximately 50% of the toilets tested flushed with greater than 6.0 litres.
3. Toilets with larger tanks tend to flush with between 10-16 litres if the proprietary flapper is replaced with a standard flapper[2]. This is a significant problem because many proprietary flappers aren't commonly found in retail stores.
4. Toilets with smaller tanks tend to flush with less than 10 litres when standard flapper is used.
5. Toilets with standard flappers tend to flush with the same volume even if the proprietary flapper is replaced.
6. Because white or clear rubber chains can transmit forces to the flapper causing it to close prematurely or to stay open longer than required, their use can lead to highly variable flush volumes. Link chains can also get twisted or 'hung up'. Metal bead chains appeared to perform best during testing. See Figure 1 and Figure 2.
7. The flush volume of toilets equipped with adjustable float flappers can be relatively easily adjusted by home-owners or installers by moving position of float on flapper chain.
8. Toilets equipped with adjustable float flappers or standard flappers are more susceptible to flush volume changes due to changes in the tank water level (i.e., because the minimum volume of water remaining in the tank during a flush stays constant, raising the top water level in the tank will increase the flush volume).
9. Adjustable float flappers may be 'set up' incorrectly at factory or by the installer, thereby increasing or decreasing the designed flush volume and either reducing water savings or reducing the flush performance.
10. Toilets equipped with air-bleed flappers are *less* susceptible to flush volume changes due to changes in the tank water level because flappers tend to close after a distinct period of time determined by the rate at which air leaves the flapper bulb.
11. The flush volume of toilets equipped with air-bleed flappers cannot be significantly adjusted by the home-owner or installer unless the proprietary baffle is replaced[3] or removed.
12. Improper baffles can be easily substituted by factory or installer thereby increasing or decreasing design flush volume and reducing either water savings or flush performance.
13. Typical 'float-style' fill valves (ballcocks), e.g., Coast Foundry, were generally more affected by changes in supply water pressures than 'needle-valve-style', e.g., Fluidmaster.
14. Trap size did not appear to significantly affect flush performance or flush volume.
15. Refill tubes that are inserted into the overflow tube and extend below the tank water level may cause siphoning of the tank water down the overflow tube into the bowl (and eventually to sewer). This problem can be corrected by preventing the refill tube from being inserted too far into the overflow tube (e.g., by attaching the refill tube to the overflow tube via a 'clip').
16. Increasing the supply water pressure tends to decrease the flush volume of toilets fitted with air-bleed flappers, while increasing the flush volume of toilets fitted with buoyant flappers[4].

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[2] Toilet flappers deteriorate over time (most are warranted for five years). If proprietary flappers are replaced with commonly available (and less expensive) standard flappers the toilet may flush with considerably more water.

[3] Statement does not include changing the water level in the tank, holding the handle down, etc.

[4] The CSA currently conducts all of its performance testing using a pressure of 20 psi, however, using such a low test pressure actually helps the performance of air-bleed flappers which flush with more water at lower pressures.

Flush Volume / Performance Results

Table 1 on the following page summarizes the results of the flush volume/performance testing. The following classification system has been used:

Flush Volume: Flush volumes of 6.0 litres or less were classified as Very Good, flush volumes between 6.0 and 6.5 litres were classified as Good; flush volumes between 6.5 and 7.0 litres were rated as Fair, and flush volumes greater than 7.0 litres are classified as Poor. Note that these scoring criteria have been selected arbitrarily.

Dye: Largely a subjective test; a rating of Good was given if virtually no blue dye was visible in bowl after flush, a rating of Fair was given in a small amount of dye was visible after the flush, a rating of Poor was given if a significant amount of dye was visible after the flush.

Washdown: A rating of Good was given if virtually no powder was visible on bowl after flush, a rating of Fair was given if a small amount of powder was visible after the flush, a rating of Poor was given if a significant amount of powder was visible after the flush.

Floating Media: Toilets that routinely removed 100% of the floating media received two black stars (i.e., Very Good), while toilets that left an average of between 1-5 media were rated as Good, toilets that left 6-10 units were rated as Fair, and toilets that left greater than 10 were rated as Poor (note: approximately 100 toasted O's were used in each test and some toilets left as much as 50% in the bowl).

Standard Flapper: Toilets that flush with less than 8.0 litres when the proprietary flapper was replaced with a standard flapper were rated as Good, those that flushed with between 8.1 – 10.0 litres were rated as Fair, and those that flushed with greater than 10.0 litres were rated as Poor.

Figure 1 - Rubber Flapper Chain & Metallic Bead Flapper Chain

Table 1 – Summary of Testing Results

Make/Model	Flapper Type	Chain Type	Flush Volume	Dye Test	Washdown Test	Floating Media	Standard Flapper
A.S. Cadet	adjustable float	bead	○	○	★	○	●
A.S. Hamilton	standard	bead	★★	○	★	★★	★
A.S. Marina	adjustable float	bead	●	★	★	○	●
A.S. Plebe	adjustable float	bead	●	★	★	○	●
A.S. Revue	adjustable float	bead	★	★	★	○	○
Briggs Abingdon III	standard	rubber	○	★	○	★	★
Briggs Altima III	standard	rubber	★	★	★	★★	★
Briggs Vacuity	adjustable float	bead	★	★	○	●	★
Caroma Caravelle	proprietary	-	★★	○	★	●	-
Ceralux Mancesa	air-bleed	rubber link	★★	★	★	★	★
Crane Cranada	air-bleed	rubber	★★	●	★	●	●
Eljer Patriot	air-bleed	link	★★	★	★	●	○
Gerber Aqua Saver	air-bleed	rubber	●	○	★	★	●
Gerber Pressure Assist	-	-	★★	★	○	★	-
Kohler Rialto	proprietary	link	★★	★	★	●	-
Kohler Santa Rosa	Buoyant Bulb	link	★	★	★	○	-
Kohler Wellworth	standard	bead	★★	★	★	★	★
Mansfield Alto	Plunger	-	★★	○	★	★	-
Niagara Flapperless	-	-	★	★	★	★★	-
Orion Jupiter	adjustable float	rubber link	★★	●	★	●	●
Orion Novara	adjustable float	link	★★	★	★	★★	●
TOTO 703	air-bleed	link	★★	★	★	★	○
TOTO Drake	proprietary	link	★★	★	○	★	-
TOTO Ultimate	proprietary	link	●	★	○	★	-
TOTO Ultramax	proprietary	link	★★	★	○	★	-
Vitra Atlantis	air-bleed	link	★★	★	★	★	
Vitra Ecosaver	air-bleed	rubber	○	★	○	★	●
Vitra Wellington	air-bleed	rubber	★	★	○	★	●
Vortens L.C. Vienna 2	air-bleed	link	★★	★	★	●	●
Vortens Lamosa Sahara (GTA)	air-bleed	link	★	★	★	★	●
Western Potteries, Aris	air-bleed	link	●	★	★	★	●

Key: Very Good ★★ Good ★ Fair ○ Poor ●

Notes

1. Two samples of the Ceralux Mansesa were tested (the second unit was shipped to the testing lab in error). When the first unit was installed on the test rig it was leaking so badly that it could not be tested. The results in ***Table 1*** refer to the second unit tested.
2. Three other models that were purchased and installed on the test rig but are not included in ***Table 1***.
   a) A sample Foremost toilet could not be tested as the flapper was binding against the side of the insulated tank and could not be made to close.
   b) A sample Komet Deco flushed at 14 litres when adjusted to the waterline. The unit could not be adjusted to flush with less than 8 litres.
   c) A sample Style Line SA26720WH could not be tested as the flapper was leaking too much.

Conclusion

As can be seen in ***Table 1***, there are significant variations in the flush volumes and performance of the toilets tested as part of this independent testing program. Some of the toilet models performed very well and exceeded expectations, while others, unfortunately, did not. It should be noted that toilets currently tested by the CSA are supplied by the manufacturers, while toilets tested as part of this program were purchased from suppliers and retail outlets.

The results of this testing have been forwarded to the CSA B45 Committee on plumbing fixtures, and they have responded that they intend to conduct their own investigations to ascertain why some of the toilet models tested in this program failed to meet their certification criteria. The CSA has formed a Task Force to investigate some of the results stated in this report. Changes to the CSA B45 Series-99 Plumbing Fixtures Standard may be made based on the recommendations put forth by the Task Force.

APPENDIX B

Raw and Adjusted Data

APPENDIX B

Raw and Adjusted Data

RAW DATA

Toto Retrofitted Stalls

	Stall - 13 L toilets				Stall - 6 L toilets				
Date	**SP-G2**	**SP-G3**	**ER-G3L**	**Notes:**	**Date**	**SP-G2**	**SP-G3**	**ER-G3L**	**Notes:**
April 6		12			May 25	10	19		
April 9		19			May 28	1	21	15	
April 10		15			May 29	9	19	26	
April 11		25			May 30	7	20	17	May 31: 3 SP toilets had
April 12		16			May 31	14	44	18	double normal counts
April 17		20			June 1	8	12	7	June 1: SP/ER Orientation
April 18		16			June 4	0	24	22	many classes out
April 19		23			June 5	7	22	19	
April 20		19			June 6	4	28	19	
April 23		16			June 7	5	20	14	
April 24	13	18			June 8	6	30	31	
April 25	6	13	14		June 11	5	38	22	
April 26	6	15	17		June 12	8	20	22	
April 27	6	24	17		June 13	5	31	9	
April 30	6	14	21		June 14	1	22	12	
May 1	3	10	8		June 15	0	26	8	
May 2	5	12	19		June 18	2	15	21	
May 3	7	13	15		June 19	5	27	8	
May 4	6	12	16		June 20	2	15	21	June 20-22: ER Grade
May 8	9	18	0	May 8: No Explanation	June 21	1	12	12	6 classes away on trip
May 9	9	23	15	anomaly, rain?	June 25	2	14	19	Ommitted June 22
May 10	5	18	16		June 26			19	
May 11	11	10	12						
May 14	3	17	9						
May 15	1	12	0	May 15: No Explanation					
May 16			12	anomaly, rain?					
May 17			22						
May 18			11						
Total # flushes:	96	410	224			102	479	361	
Total # days:	15	25	17			21	21	21	
Average/day:	**6.4**	**16.4**	**13.2**			**4.9**	**22.8**	**17.2**	
Std. Dev:	3.1	4.3	6.2			3.7	8.2	6.3	

RAW DATA

American Standard Retrofitted Stalls

	Stall - 13 L toilets				Stall - 6 L toilets				
Date	**SP-G1**	**ER-G2**	**ER-G3U**	**Notes:**	**Date**	**SP-G1**	**ER-G2**	**ER-G3U**	**Notes:**
April 6	12	11	29		May 25	19			
April 9	21	9	6		May 28	27	15	20	
April 10	12	11	24		May 29	15	13	18	
April 11	22	7	20		May 30	18	20	26	May 31: 3 SP toilets had
April 12	21	13	24		May 31	46	22	22	double normal counts
April 17	17	11	12		June 1	16	8	12	June 1: SP/ER Orientation
April 18	20	9	15		June 4	25	9	27	many classes out
April 19	20	16	23		June 5	13	12	26	
April 20	23	11	21		June 6	12	13	31	
April 23	20	12	22		June 7	22	18	28	
April 24	21	15	21		June 8	14	14	26	
April 25	24	22	15		June 11	17	16	23	
April 26	28	11	15		June 12	18	17	25	
April 27	17	18	19		June 13	23	14	29	
April 30	30	17	15		June 14	23	15	18	
May 1	19	14	16		June 15	21	15	16	
May 2	14	19	18		June 18	23	12	25	
May 3	18	14	17		June 19	19	9	13	
May 4	19	8	19		June 20	16	2	1	June 20-22: ER Grade
May 8	20	17	16		June 21	14	7	9	6 classes away on trip
May 9	18	18	18		June 25	10	21	18	
May 10	26	14	18		June 26		11	25	
May 11	16	12	23						
May 14	22	13	19						
May 15	17	12	23						
May 16		15	24						
May 17		16	30						
May 18		16	24						
Total # flushes:	497	381	546			411	283	438	
Total # days:	25	28	28			21	21	21	
Average/day:	**19.9**	**13.6**	**19.5**			**19.6**	**13.5**	**20.9**	
Std. Dev:	4.3	3.6	5.0			7.5	4.9	7.5	

Adjusted Data

Toto Retrofitted Stalls

	Stall - 13 L toilets				Stall - 6 L toilets		
Date	**SP-G2**	**SP-G3**	**ER-G3L**	**Date**	**SP-G2**	**SP-G3**	**ER-G3L**
April 6		12		May 25	10	19	
April 9		19		May 28	1	21	15
April 10		15		May 29	9	19	26
April 11		25		May 30	7	20	17
April 12		16		May 31			18
April 17		20		June 1			
April 18		16		June 4	0	24	22
April 19		23		June 5	7	22	19
April 20		19		June 6	4	28	19
April 23		16		June 7	5	20	14
April 24	13	18		June 8	6	30	31
April 25	6	13	14	June 11	5	38	22
April 26	6	15	17	June 12	8	20	22
April 27	6	24	17	June 13	5	31	9
April 30	6	14	21	June 14	1	22	12
May 1	3	10	8	June 15	0	26	8
May 2	5	12	19	June 18	2	15	21
May 3	7	13	15	June 19	5	27	8
May 4	6	12	16	June 20	2	15	21
May 8	9	18		June 21	1	12	12
May 9	9	23	15	June 25	2	14	19
May 10	5	18	16	June 26			19
May 11	11	10	12				
May 14	3	17	9				
May 15	1	12					
May 16			12				
May 17			22				
May 18			11				
Total # flushes:	96	410	224		80	423	354
Total # days:	15	25	15		19	19	20
Average/day:	**6.4**	**16.4**	**14.9**		**4.2**	**22.3**	**17.7**
Std. Dev:	3.1	4.3	4.1		3.1	6.6	6.0
				% increase in average/day:	**-34.2%**	**35.8%**	**18.5%**

RAW DATA

American Standard Retrofitted Stalls

	Stall - 13 L toilets				Stall - 6 L toilets		
Date	**SP-G1**	**ER-G2**	**ER-G3U**	**Date**	**SP-G1**	**ER-G2**	**ER-G3U**
April 6	12	11	29	May 25	19		
April 9	21	9	6	May 28	27	15	20
April 10	12	11	24	May 29	15	13	18
April 11	22	7	20	May 30	18	20	26
April 12	21	13	24	May 31		22	22
April 17	17	11	12	June 1			
April 18	20	9	15	June 4	25	9	27
April 19	20	16	23	June 5	13	12	26
April 20	23	11	21	June 6	12	13	31
April 23	20	12	22	June 7	22	18	28
April 24	21	15	21	June 8	14	14	26
April 25	24	22	15	June 11	17	16	23
April 26	28	11	15	June 12	18	17	25
April 27	17	18	19	June 13	23	14	29
April 30	30	17	15	June 14	23	15	18
May 1	19	14	16	June 15	21	15	16
May 2	14	19	18	June 18	23	12	25
May 3	18	14	17	June 19	19	9	13
May 4	19	8	19	June 20	16		
May 8	20	17	16	June 21	14		
May 9	18	18	18	June 25	10	21	18
May 10	26	14	18	June 26		11	25
May 11	16	12	23				
May 14	22	13	19				
May 15	17	12	23				
May 16		15	24				
May 17		16	30				
May 18		16	24				
Total # flushes:	497	381	546		349	266	416
Total # days:	25	28	28		19	18	18
Average/day:	**19.9**	**13.6**	**19.5**		**18.4**	**14.8**	**23.1**
Std. Dev:	4.3	3.6	5.0		4.7	3.8	4.9
				% increase in average/day:	**-7.6%**	**8.6%**	**18.5%**

Combined Daily Totals by School

Before Versus After 6 litre Retrofits

Stone Park School

Day	Date	Stall - 13 L toilets SP-G2	SP-G3	SP-G1	Daily Totals
1	April 24	13	18	21	52
2	April 25	6	13	24	43
3	April 26	6	15	28	49
4	April 27	6	24	17	47
5	April 30	6	14	30	50
6	May 1	3	10	19	32
7	May 2	5	12	14	31
8	May 3	7	13	18	38
9	May 4	6	12	19	37
10	May 8	9	18	20	47
11	May 9	9	23	18	50
12	May 10	5	18	26	49
13	May 11	11	10	16	37
14	May 14	3	17	22	42
15	May 15	1	12	17	30
16					
17				Ave/day:	42.3
18				Std. Dev:	7.6

Date	Stall - 6 L toilets SP-G2	SP-G3	SP-G1	Daily Totals
May 25	10	19	19	48
May 28	1	21	27	49
May 29	9	19	15	43
May 30	7	20	18	45
June 4	0	24	25	49
June 5	7	22	13	42
June 6	4	28	12	44
June 7	5	20	22	47
June 8	6	30	14	50
June 11	5	38	17	60
June 12	8	20	18	46
June 13	5	31	23	59
June 14	1	22	23	46
June 15	0	26	21	47
June 18	2	15	23	40
June 19	5	27	19	51
June 20	2	15	16	33
June 21	1	12	14	27
June 25	2	14	10	26
			Ave/day:	44.8
			Std. Dev:	8.8
			% increase:	6.1%

Elliot River School

Day	Date	Stall - 13 L toilets ER-G2	ER-G3U	ER-G3L	Daily Totals
1	April 25	22	15	14	51
2	April 26	11	15	17	43
3	April 27	18	19	17	54
4	April 30	17	15	21	53
5	May 1	14	16	8	38
6	May 2	19	18	19	56
7	May 3	14	17	15	46
8	May 4	8	19	16	43
9	May 9	18	18	15	51
10	May 10	14	18	16	48
11	May 11	12	23	12	47
12	May 14	13	19	9	41
13	May 16	15	24	12	51
14	May 17	16	30	22	68
15	May 18	16	24	11	51

Date	Stall - 6 L toilets ER-G2	ER-G3U	ER-G3L	Daily Totals
May 28	15	20	15	50
May 29	13	18	26	57
May 30	20	26	17	63
May 31	22	22	18	62
June 4	9	27	22	58
June 5	12	26	19	57
June 6	13	31	19	63
June 7	18	28	14	60
June 8	14	26	31	71
June 11	16	23	22	61
June 12	17	25	22	64
June 13	14	29	9	52
June 14	15	18	12	45
June 15	15	16	8	39
June 18	12	25	21	58