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Mr. Glen Pleasance
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August, 2001

Re: ULF Toilet Performance Monitoring Program

Dear Glen,

Veritec Consulting Inc. is pleased to provide the following report outlining the results of Durham's ULF Toilet Performance Monitoring Program.

1.0 Background

The initial purpose of this program was to verify the flush volumes of approximately 400 of the ultra-low-flush (ULF) toilets installed during the past five years as part of Durham Region's overall water efficiency program¹. The project was partially prompted by a published report showing that the water savings achieved by installing ULF toilets in Tucson were eroding slightly over time². Durham retained Veritec to determine the actual flush volumes of toilets installed as part of the Regional water efficiency program.

Because it was expected that the information gathered as part of this study would be significant to all Canadian municipalities interested in improving water efficiency, this project was completed as a joint effort between the Region of Durham and the Canada Mortgage and Housing Corporation (CMHC).

The project was to involve physically measuring toilet flush volumes on site (i.e., in participant's homes) using either a proprietary toilet flush volume meter, an inline meter installed on the toilet's water supply, or the home's own water meter. As well as recording the flush volumes Veritec personnel were to note improperly adjusted tank water levels, floats, flappers, etc., and record any comments or concerns raised by the program participants during the site visit.

After about half of the monitoring program was complete, however, it was apparent that not only were many toilet flushing with more than six litres of water, many of the toilets were actually flushing with considerably *less* than six litres. Conversations with homeowners revealed that many of them resolved the 'low flush volume problem' by routinely 'holding the handle down' or double flushing when disposing of solid waste. Some participants stated that they understood this to be the 'normal practice' when using water

¹ Durham's toilet replacement program includes approximately 6,000 households to date.

² This report, *Flushing of Aging Low-Consumption Toilets in Tucson*, however, could not verify that the toilets were properly functioning and flushing at the time they were installed.

efficient toilets and some even imparted to their house guests the need to ‘hold the handle down’ when flushing.

At this point the initial scope of work for the project was changed to incorporate the detailed monitoring of five homes with extremely low flushing toilets by data logging household water meters (Phase II). The data logging would identify the actual flush volumes being practiced by the participants vs. the flush volumes that can be measured when the handle is simply ‘depressed and released’.

This report outlines the results of both phases of the program.

2.0 Phase I – Physically Measuring Toilet Flush Volumes on Site

Durham Region retained Parmac Relationship Marketing Inc. to make the initial contact with residents that had participated in the Region’s various toilet replacement programs over the years. Parmac was to screen and qualify the residents and provide a list of potential monitoring participants to Veritec.

Parmac provided 227 contacts representing approximately 382 toilets. Using these contacts Veritec was able to successfully schedule 108 appointments equating to 148 toilets – the remaining homes deciding not to participate³. There were a variety of participant comments recorded by both Parmac (during the phone contact) and by Veritec (during both the phone and site contacts). A copy of the telephone script used by Parmac is attached at the end of this report – no specific script was used by Veritec⁴. A complete list of the recorded comments is attached at the end of this report. Table 1 below categorizes these comments⁵.

Table 1: Summary of Participant’s Comment – 148 Toilets

	Satisfied	Performance Issues	Leaks	No Comment	Totals
American Standard	15 (31%)	24 (49%)	2 (4%)	8 (16%)	49 (33%)
Crane	21 (37%)	24 (42%)	1 (2%)	11 (19%)	57 (39%)
Mansfield	4 (44%)	3 (33%)	0 (0%)	2 (22%)	9 (6%)
Western Pottery	15 (45%)	2 (6%)	1 (3%)	15 (45%)	33 (22%)
Totals	55 (37%)	53 (36%)	4 (3%)	36 (24%)	148 (100%)

Given that Durham staff receive very few complaints about the ULF program it appears that although a significant number of participants are unhappy with the program, only a small number of them actually take the time and effort to complain to the Region. This does not mean, however, that they do not complain to friends and neighbours.

³ Inspecting a *random* sample of 108 homes out of a total population of approximately 6,000 equates to a 95% confidence level that the results are accurate to within approximately $\pm 10\%$.

⁴ It is interesting to note that although neither Parmac nor Veritec specifically asked questions related to quality issues during phone conversations, many participants readily volunteered related comments.

⁵ Note that the number of comments gathered for each toilet is not statistically valid, this is especially true for the Mansfield where only 9 responses were collected.

2.1 Participant Comments vs. Flush Volume

For the purposes of comparing participant comments to measured flush volumes the groups *Satisfied* and *No Comment* were combined (it was assumed that participants making no comments were generally satisfied with their toilet). For the same reason the groups *Performance Issues* and *Leaks* were also combined.

The correlation between participant comments and flush volumes are illustrated in the Figure 1 and Figure 2.

2.1.1 Satisfied/No Comment Group

The average flush volume of the *Satisfied/No Comment* group was found to be equal to 6.4 litres; 46% of these toilets flushed with more than 6.5 litres.

In this group 11 of the 23 American Standard toilets and 20 of the 32 Crane toilets flushed below 6 litres, while 24 of the 28 Western Pottery toilets and all 4 Mansfield toilets tested flushed with greater than 6 litres.

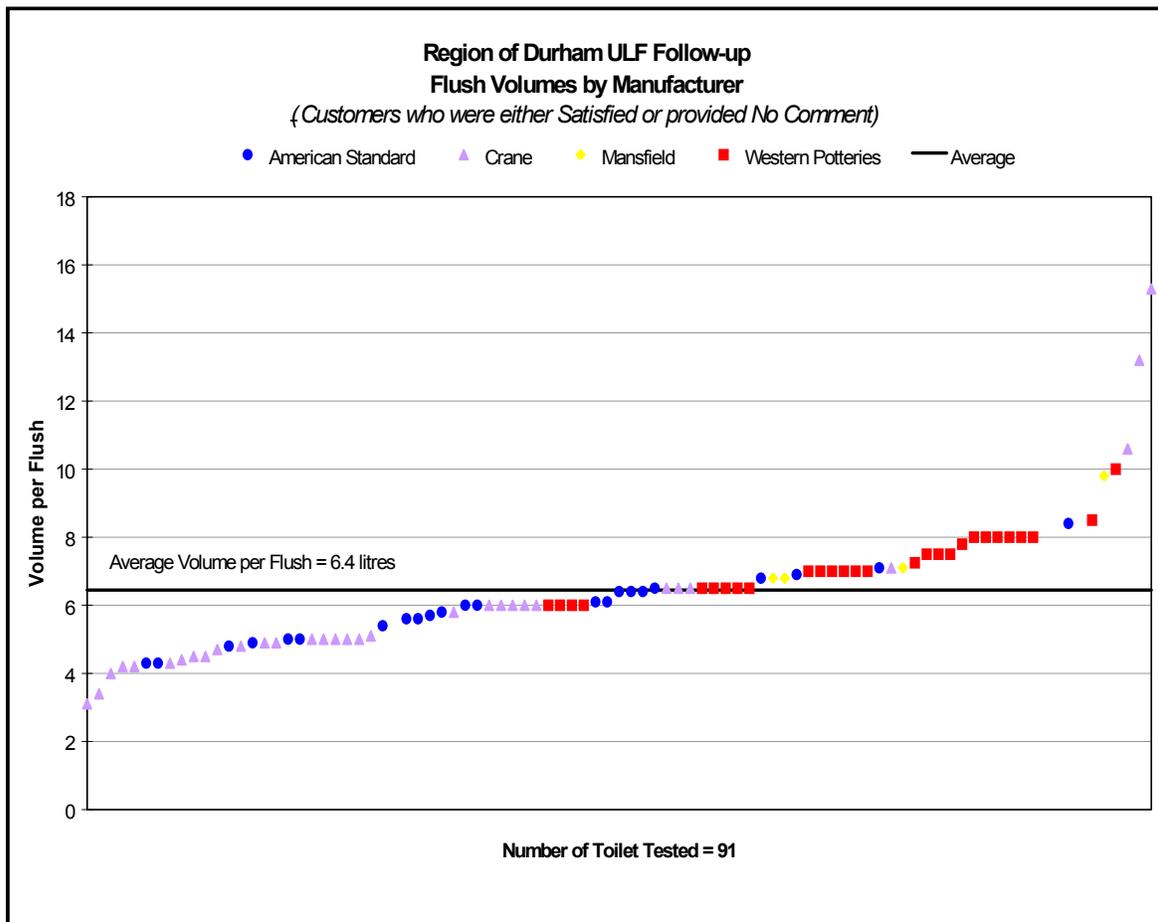


Figure 1 - Satisfied/No Comment Groups vs. Toilet Flush Volume

2.1.2 Performance Issues/Leaks Group

The most common “performance-related issues” identified included clogging, double flushing, and the need to hold the handle down during flushing. Figure 2 illustrates the measured flush volumes of this group of toilets.

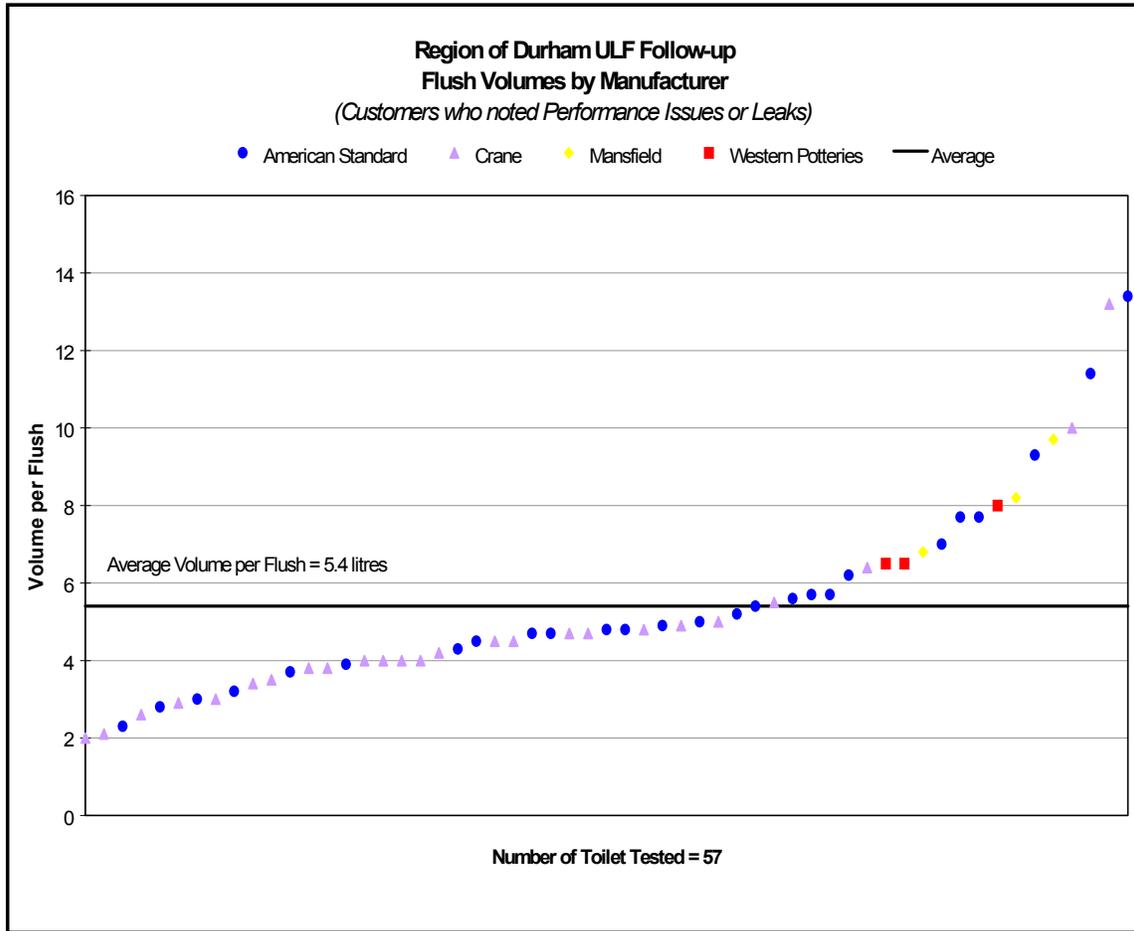


Figure 2 - Performance Issues/Leaks Groups vs. Toilet Flush Volume

In this group 19 of the 26 American Standard toilets and 22 of the 25 Crane toilets flushed below 6 litres, while all 3 Western Pottery toilets and all 3 Mansfield toilets tested flushed with greater than 6 litres. The average volume per flush recorded in this group equals 5.4 litres; 72 % of these toilets flushed with less than 6 litres and approximately one third of the toilets “flushed” with less than 4 litres.

The toilets in this second group do not appear to be flushing properly at these low flush volumes. Double-flushing and holding the handle down are commonplace based on the participant comments. Note that ‘holding the handle down’ can result in discharging the entire tank volume during a flush – approximately 13 litres of water. Therefore, it appears that the flush volumes being measured in participant homes (i.e., the flush volumes resulting from depressing and releasing the handle) may differ from the actual flush volumes being practiced by the participants.

2.1.1 Toilet Flush Volumes vs. Tank Water Level

Site inspections revealed extreme variations in flush volumes. Despite these variations, however, the tank water levels were generally adjusted to the proper level, indicating that these variations in flush volumes were related more to the operation of the flapper than to variations in the tank water level. All of the toilets in the program were originally fitted with a proprietary early-closing flapper supplied by the manufacturer. These flappers are often not readily available in retail stores, however, which can lead to a significant problem when the toilet stock begins to age and the proprietary early-closing flappers are replaced with standard non-early-closing flappers⁶.

2.1.2 Effects of Participant's Flushing Technique on Flush Volumes

As well as improperly operating flappers it was also observed that the different techniques used by participants to flush the toilet had some effect on the flush volumes. For instance, the following observations were recorded by field technicians –

- A toilet with a *measured* flush volume of 2.8 litres used 6.7 litres when the handle was held until the bowl was cleared.
- A toilet with a *measured* flush of 6 litres used 10 litres when the homeowner demonstrated their “normal flush” to the inspector.

2.1.4 Phase I Conclusion

The Phase I field testing of approximately 200 toilets indicated that although all of the toilets installed as part of Durham's toilet replacement program were designed to flush with 6 litres, there was actually a significant variation in flush volumes when measured in the field and, furthermore, that this variation was likely related more to flapper operation rather than improperly adjusted tank water levels.

Phase I also identified that many participants (especially those with extremely low flushing toilets) are routinely altering the natural flush cycle of their toilets, i.e., they often ‘hold the handle down’ and, in effect, flush with considerably more than the volume recorded if the handle is simply ‘depressed and released’.

To verify this suspicion the original scope of work was altered to include data logging the water demands of five households with low flushing toilets for seven days. This monitoring would become Phase II of the project.

⁶ Some of the toilets flushing with greater than 10 litres had had their original early-closing flappers replaced a regular, non-early closing flapper.

3.0 Phase II

The results of Phase I indicated that many participants were experiencing performance problems with their ULF toilets - requiring them to either double flush or to hold the handle down during the flush to properly clear the bowl.

To determine the effect of participants ‘holding down the handle’ it was decided a number of homes with extremely low flushing toilets would be included in a detailed water demand monitoring program. Five homeowners accepted an offer to have the Region replace their ULF toilets at no cost after participating in a one-week monitoring program requiring them to have a small data-logging device installed on their existing Regional water meter.

The collected data allowed Veritec to complete a water use analysis of each of the five homes and to identify toilet flush volumes when participants ‘held the handle down’ or double-flushed.

3.1 Range of Flush Volumes

The following table highlights the range (i.e., the maximum, minimum, and average) of flush volumes of the eight ULF toilets installed in the five participating households.

Table 2: Maximum, Minimum, and Average Flush Volumes of ULF Toilets

Toilet #	<i>Maximum</i>	<i>Minimum</i>	<i>Average</i>
T1	11.0	3.7	5.3
T2	9.9	3.9	4.5
T3	11.4	2.8	6.2
T4	8.3	2.6	4.4
T5	8.7	5.0	5.4
T6	12.2	3.4	3.9
T7	9.4	3.2	4.9
T8	13.5	4.8	9.2

A total of 584 toilet flushes were identified in the data analysis⁷ with a range of flushes of between 2.6 and 13.5 litres – a significant range of flush volumes for 6-litre toilets. The average of the data logged flush volumes is 4.8 litres. Figure 3 illustrates the variation in flush volumes recorded with the data loggers.

⁷ Flushes that may have been masked by “simultaneous events”, e.g., during shower or clothes washer operation, were not identified in the data analysis.

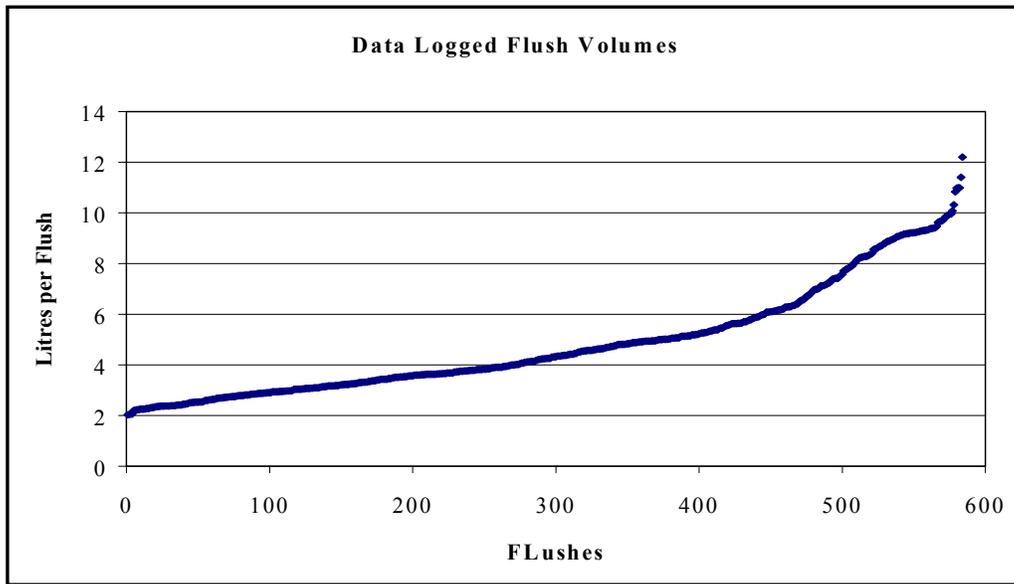


Figure 3: Range of Recorded Flush Volumes

The range of flush volumes was determined by whether or not the handle was held down during the flush and, if so, to how long it was held down. As can be seen in Figure 3, the recorded flush volumes are relatively evenly distributed between about 2.6 litres and 10 litres, indicating that participants may depress the handle for different durations depending upon how much water they feel is required to clear the bowl.

This ‘flush volume variation’ is wholly at the participant’s discretion and is illustrated further in Figure 4 below. This figure shows three very different flush profiles (and volumes) for a single toilet in one of the participating homes.

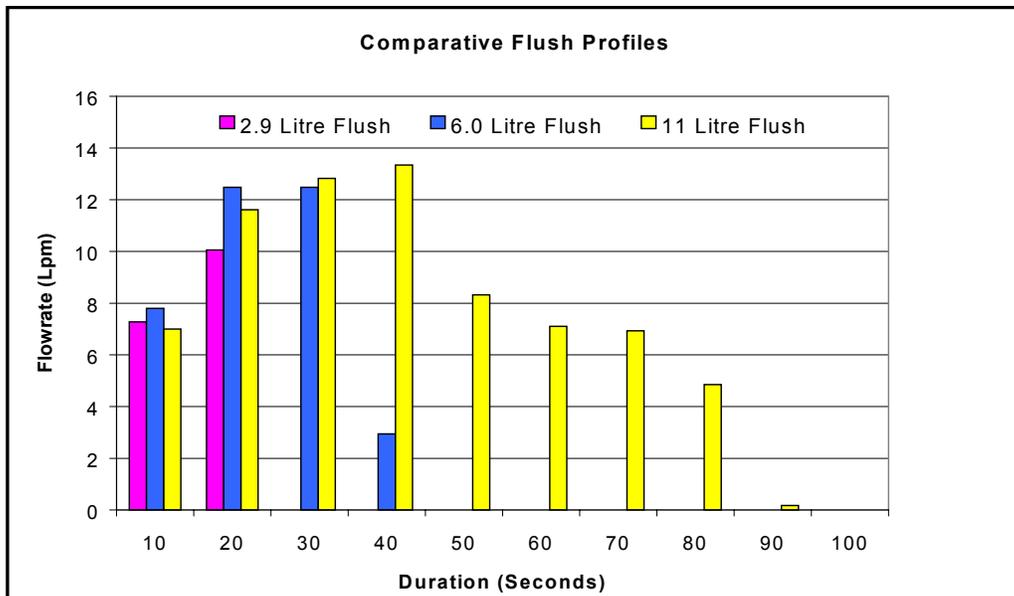


Figure 4: One Toilet and Three Flush Volumes

- The first flush volume of 2.9 litres in Figure 4 suggests the flapper closes almost instantly – as was the case when the toilet was originally tested and the measured flush volume equaled 2.8 litres.
- The second flush of 6 litres represents what would be considered a “proper” flush profile.
- And the third illustrates the additional consumption when the handle is held down – likely until the bowl is cleared.

The average flush volume of these toilets based on physical measurements (i.e., when the handle is simply depressed and then released) was 3.6 litres, while the average flush volume during the data logging period was 4.8 litres. The difference between these two values is additional verification that participants feel that it is necessary to ‘hold down the handle’ to successfully clear the bowl. The flush volumes identified in Table 2 also indicate that many participants sometimes hold down the handle until the tank is emptied.

3.2 Double Flushing

The recorded data was also analyzed to determine if there were a high incidence of double-flushing. For the purposes of this analysis double flushing was defined as a second distinct flush within approximately one minute of the first - it did not include events where the toilet may have been flushed again before the original flush was completed as this was considered a variation of ‘holding the handle down’.

Using this methodology 23 out of 584 flushes appeared to be double-flushes. This represents slightly less than 4% of the total number of flushes. However, if one considers that double-flushing is generally only required to remove solid waste, and solid waste flushing constitutes only about 20% of the total number of flushes, then double-flushing to remove solid waste may occur approximately 20% of the time.

4.0 Conclusions

The results of Durham Region’s ULF Follow-up Program are significant in terms of both toilet performance and customer satisfaction.

Testing in Phase 1 highlighted a significant variability in toilet flush volumes despite all of the toilets being 6-litre ULF models. Site inspections also revealed that most of the toilets had properly adjusted tank water levels, indicating that the high or low flush volumes were related to improperly adjusted or manufactured flappers, or to some other quality control problems.

Phase I also revealed that there is significant percentage of customer dissatisfaction with the performance of 6-litre toilets. In fact, because of their own experiences, many participants believe that all water efficient toilets offer the same poor performance. Because this follow-up monitoring program did not contact all of the residents that have participated in Durham’s toilet replacement program it is likely that there are additional dissatisfied participants that have not been contacted yet.

It is interesting to note that some of the participants contacted by Parmac related that they had no concerns or problems with their ULF toilets, yet when these same participants were contacted by Veritec they expressed some level of dissatisfaction with their fixtures.

It is possible that the reason for these disparate comments is related to the amount of time the participant was given to consider the question. For example, when a homeowner is asked a completely unexpected question (e.g., about a toilet they may have installed more than a year earlier) they may have some difficulty immediately collecting all of their thoughts regarding the subject, but when they are given more time to think (e.g., the length of time between the phone calls made by Parmac and Veritec) they have had time to consider the questions and are able to provide a more accurate assessment of their feelings.

If this is correct then the results of follow-up phone surveys completed ‘out of the blue’ may be skewed, i.e., there may be more ‘no comment’ responses than would otherwise occur if the participant had additional time to consider (this is important especially if ‘no comment’ replies are considered tantamount to a positive comment. Based on this view, the Region may wish to consider different methods of conducting follow-up customer satisfaction surveys.

Testing in Phase II indicated that as a result of poorly performing toilets many participants have developed non-water-efficient habits such as holding the handle down (and to a lesser extent double flushing) to clear the bowl.

It was also discovered that several of the toilets installed as part of Durham’s toilet replacement programs were improperly ‘set up’ by the installer (e.g., floats set to the wrong level). This was surprising given that all of the toilets were installed by professional contractors and not by the homeowners themselves. Improperly adjusted toilets can lead to customer dissatisfaction and a loss of water savings, as well as casting a negative light on water efficiency in general and water efficient toilets in general.

The results of Phase II illustrated that the potential of participants ‘holding down the handle’ introduces an additional variation in flush volumes, i.e., if the toilets are not functioning well there is a tendency for the homeowner to adjust their flushing technique rather than replacing the toilet (or in some cases, rather than complaining). A small number of participants, however, had replaced the proprietary early-closing flapper with a standard flapper (thus eliminating much of the expected water savings) because of dissatisfaction with the flushing performance.

5.0 Recommendations

Based on the results gathered in both Phase I and Phase II of this study, there are several recommendations that may help improve the effectiveness of Durham's water efficient toilet replacement programs in the future.

1. Need to have installers properly trained to install ULF toilets.
2. Need to conduct post-installation inspection of toilets.
3. Need to provide sufficient information to participants about the program, e.g., they should be informed that the new toilets should perform satisfactorily and not require an increase in the need to double flush or to hold the handle down.
4. Need to ensure that Region is made aware of problems participants may encounter with their new fixtures, i.e., need to give participants a clear method of communicating problems.
5. Need to use only high quality toilets that can be expected to perform well in the field and achieve expected water savings.
6. The Region may wish to follow up with more participants regarding their satisfaction in the program.
7. The Region may also wish to work with retailers to ensure that proper toilet replacement components for the various types of toilets being installed in the Region are in stock and available to the homeowner.

Please call me if there are any questions concerning the above.

Sincerely,
Bill Gauley, P.Eng., Principal



Veritec Consulting Inc.