

# Canada Mortgage and Housing Corporation Dual-flush Toilet Project

*Evaluating –*

- *Public perception, acceptance, and satisfaction,*
- *Water Savings, and*
- *Cost-Effectiveness*



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## 1.0 INTRODUCTION

As the strain on municipal water systems continues to increase, demand-side management (DSM) has quickly been recognized as being a cost-effective alternative ‘source’ of water to expanding supply infrastructure (supply-side management or SSM). Effectively implementing water efficiency measures can extend the life of both water and wastewater treatment plants by allowing larger populations to be serviced with existing infrastructure and, thereby, ultimately reducing the costs to customers.

It is for this reason that in 1996 the Ontario Building Code began mandating the installation of toilets that flushed with only six litres of water (ULF toilets) in new construction. The same 6-litre flush requirement is mandated across the entire USA. In Australia, where the lack of fresh water is even more of a concern, the use of dual-flush toilets is required by code.

Along the same lines, many municipalities across Canada have subsidized toilet replacement programs in an attempt to increase the natural market penetration of water efficient toilets. It is important to these municipalities that the expected water savings are achieved, i.e., that the municipality gets what it paid for.

Measures that do not achieve the intended water savings goal cost the municipality in two ways – the cost associated with implementing a failed program, and the cost of a lost water savings opportunity. It is necessary, therefore, that water efficiency programs are properly monitored.

With this in mind, in 2001 the Canada Mortgage and Housing Corporation (CMHC) led a national project involving 13 agencies/participants in 7 provinces to evaluate dual-flush toilet technology in Canada with regards to:

1. public perception, acceptance, and satisfaction with dual-flush toilets;
2. water savings compared to 6L or 13L toilets; and
3. cost-effectiveness compared to 6L or 13L toilets.

### 1.1 Dual-flush Toilets

Although ULF toilets have had their share of “bumps and bruises” during their evolution, their overall performance continues to improve and new and innovative technologies are still emerging.

Caroma Industries Pty Ltd. is a recognized leader in dual-flush toilet technology, having developed the world’s first two-button model over 15 years ago. *Theoretically*, a toilet using 3 litres for liquid waste and 6 litres for solid waste would flush with an average of about 3.8 litres<sup>1</sup> - a savings of almost 37% more than the design flush volume of a standard 6-litre toilet. Data collected as part of this project was analyzed to determine *actual* savings.



Figure 1: Dual-flush Toilet & Flush Selection

<sup>1</sup> Based on a ratio of approximately three ‘short’ flushes for every ‘long’ flush.

## 2.0 PROJECT OBJECTIVES

The three primary objectives associated with this project were to:

1. determine public perception, acceptance, and satisfaction with dual-flush toilets;
2. field-test effectiveness of dual-flush toilets compared to 6L or 13L toilets; and
3. determine cost-effectiveness of dual-flush toilets compared to 6L or 13L toilets.

### 2.1 Public Perception, Acceptance, and Satisfaction with Dual-flush Toilets

The first objective was achieved by having participants complete survey questionnaires – participants included end users as well as lead contacts for each site.

### 2.2 Effectiveness of Dual-flush Toilets Compared to 6L or 13L Toilets

The relative effectiveness of the dual-flush toilet was determined by physically measuring the two parameters that contribute to the total water demands related to toilet flushing:

1. Flush Volume - flush volumes of the existing toilets and ‘long’ and ‘short’ flush volumes of the dual-flush toilets were measured using an inline water meter (*Figure 2*). Note that the meter was only installed temporarily to determine the flush volumes of existing and replacement toilets and was removed prior to the toilets being used by participants.
2. Number of Flushes – electronic flush counters were installed in the existing toilets and two counters were installed in the dual-flush toilets to count both ‘long’ and ‘short’ flushes (*Figure 3*). A significant increase in the total number of flushes at any site would indicate an increased incidence of ‘double-flushing’. The monitoring program was to include one month of ‘pre-monitoring’ existing toilet and between one and two months of ‘post-monitoring’ replacement toilet (depending upon the type of site).



*Figure 2: Measuring Flush Volumes*



*Figure 3: Electronic Flush Counter*

### 2.3 Cost-effectiveness of Dual-flush Toilets vs. 6L or 13L Toilets

The relative cost-effectiveness was determined by comparing the associated water savings with the relative costs of both dual-flush and conventional toilets (6-litre and 13-litre models).

### 3.0 COMPARISON WITH OTHER ULF TOILETS

Caroma dual-flush toilets use a ‘washdown’ flush action vs. the more common (in North America) siphonic flush action. In washdown toilets the waste is ‘pushed’ out of the bowl by the flush, while in siphonic toilets the waste is ‘pulled’ or siphoned out of the bowl by the flush.

A small number of other ULF toilet models were also installed as part of this project to serve as a comparison. These additional models included six TOTO Drakes, four Niagara Flapperless, two Vitra Wellingtons<sup>2</sup>, and one Western Potteries Aris.

The Aris toilet flushes in a conventional manner, while the Flapperless and Drake models both incorporate innovative flushing mechanisms.

- The Niagara Flapperless uses a tipping bucket rather than a flapper to provide water for flushing. The bucket is situated near the top of the toilet tank and is designed to hold a volume of water only slightly greater than 6 litres. When the handle is depressed, the bucket ‘tips’ and the water is discharged into to bowl.
- The TOTO Drake uses a proprietary 3-inch flapper. The toilet, therefore, flushes approximately twice as quickly as toilets using a standard 2-inch flapper. TOTO calls this system of flushing the GRAVITY MAX system.

All toilets used in this project were provided at no cost from the manufacturers/suppliers.

### 4.0 SITE SELECTION

A total of 70 toilets were installed as part of this project by 13 different program participants – 56 Caroma dual-flush toilets<sup>3</sup>, nine TOTO Drakes, four Niagara Flapperless, and one Western Potteries Aris<sup>4</sup>. The sites included single-family homes, municipal offices, a small apartment building, schools, golf courses, and a commercial site (Second Cup Coffee restaurant). As such, parts of the data analysis have been delineated to reflect the various sectors involved.

The following list identifies participants in the program:

- Calgary, Alberta
- Durham, Ontario
- GVRD, British Columbia
- Halton, Ontario
- Minto Property Management, Ontario
- Quebec City, Quebec
- Regina, Saskatchewan
- St. Johns, Newfoundland
- Toronto, Ontario
- Vernon, British Columbia
- Victoria, British Columbia
- Waterloo, Ontario
- Manitoba

Participant details, e.g., phone numbers, email addresses, etc., are attached as Appendix 4.

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<sup>2</sup> The Vitra toilets were added to the project to replace two toilets that were broken during shipping. No data was collected regarding the Vitra toilets.

<sup>3</sup> 15 dual-flush toilets were installed in a single low-rise apartment building in Toronto.

<sup>4</sup> It is expected that data from the 56 dual-flush installation sites is accurate to within approximately  $\pm 13\%$  with a 95% confidence level. These sites were responsible for greater than 400 flushes per day.

## 5.0 PROJECT RESULTS

### 5.1 Public Perception, Acceptance, and Satisfaction with Dual-Flush Toilets

As stated earlier, the first objective was achieved by having participants complete survey questionnaires (Appendix 1). A total of 158 surveys were submitted as part of this project, as follows:

- Caroma 121 surveys
- TOTO 11 surveys
- Niagara 13 surveys
- Western Potteries 13 surveys

The results of the customer satisfaction surveys are summarized in the following tables. Charts illustrating comprehensive survey results are presented in Appendix 2.

**Table #1**

| Toilet                   | Average Rating out of 10 | Additional cost participants would be willing to pay for toilet |
|--------------------------|--------------------------|---|
| <b>Caroma</b>            | 7.8                      | \$46  |
| <b>TOTO</b>              | 7.6                      | \$45  |
| <b>Niagara</b>           | 7.9                      | \$25  |
| <b>Western Potteries</b> | 7.2                      | \$23  |

**Table #2**

| Toilet                   | Appearance |            |         | Clear Solids |                 |         | Clear Liquids |                 |         | Recommend |            |       | Like vs. Existing toilet |         |         |
|--------------------------|------------|------------|---------|--------------|-----------------|---------|---------------|-----------------|---------|-----------|------------|-------|--------------------------|---------|---------|
|                          | Good, %    | Average, % | Poor, % | Good, %      | Satisfactory, % | Poor, % | Good, %       | Satisfactory, % | Poor, % | Yes, %    | Perhaps, % | No, % | More, %                  | Same, % | Less, % |
| <b>Caroma</b>            | 64         | 34         | 2       | 61           | 27              | 12      | 77            | 16              | 7       | 66        | 26         | 8     | 60                       | 28      | 12      |
| <b>TOTO</b>              | 64         | 36         | 0       | 56           | 33              | 11      | 91            | 9               | 0       | 56        | 36         | 9     | 25                       | 50      | 25      |
| <b>Niagara</b>           | 38         | 62         | 0       | 67           | 33              | 0       | 75            | 25              | 0       | 62        | 38         | 0     | 27                       | 73      | 0       |
| <b>Western Potteries</b> | 23         | 69         | 8       | 54           | 31              | 15      | 77            | 15              | 8       | 38        | 38         | 24    | 28                       | 36      | 36      |

#### 5.1.1 Additional Observations

- 100% of the 92 responses received stated that they liked the dual-flush option.
- 82% of respondents gave the Caroma a rating of 7 or more out of 10
- The Second Cup restaurant stated that their existing toilet (in the patron's restroom) required plunging almost every day and that it frequently overflowed. They had no occurrences with plugging, plunging, or overflowing with the dual-flush toilet and they were extremely happy with its performance.
- The 15-unit apartment building installed efficient showerheads and aerators as well as dual-flush toilets and reduced its water demands by 360 litres per suite per day (slightly more than 50%). Savings directly related to toilet installation equate to 124 litres per

suite per day (approximately 35% of the total savings). Savings related to reduced toilet leakage equate to 176 litres per suite per day<sup>5</sup>. (See Appendix 3 for complete details of savings achieved at this site.)

- Bowl streaking was the largest single complaint (one site stated that although they supported the dual-flush option they felt that they had to remove the toilet after the project due to severe streaking problems).

**Acceptance:** Participants overwhelmingly accept and support the dual-flush technology.

**Satisfaction:** Program participants expressed a range of satisfaction with the Caroma dual-flush toilets. While most comments were very positive, others expressed a strong dislike of the toilet. Significant bowl ‘streaking’ was the most common complaint, even among participants that expressed support for the toilet.

## 5.2 Water Savings Compared to 13-Litre and Conventional 6-Litre Toilets

**Table #3 – Average Flush Volumes**

| Toilet            | Flush Volume, L         |
|-------------------|-------------------------|
| Existing Toilets  | 14.1                    |
| Caroma            | 3.4 ‘short’, 6.0 ‘long’ |
| TOTO              | 6.1                     |
| Niagara           | 6.2                     |
| Western Potteries | 7.5                     |

**Table #4 – Changes in Average Flushes per Day**

| Site              | Flushes/Day Pre | Flushes/Day Post         | Changes in Flushes/Day <sup>6</sup> |
|-------------------|-----------------|--------------------------|-------------------------------------|
| Caroma            | 16.6            | 10.6 ‘short’, 6.8 ‘long’ | 5% increase                         |
| TOTO              | 14.0            | 12.0                     | 14% decrease                        |
| Niagara           | 13.0            | 7.9                      | 39% decrease                        |
| Western Potteries | 10.9            | 15.0                     | 37% increase                        |

**Table #5 – Comparison of Caroma Savings in Different Sectors<sup>7</sup>**

| Sector           | ‘Short’ Flushes per Day | ‘Long’ Flushes per Day | Ratio ‘Short’ to ‘Long’ | Increase in Flushes per day | Savings, % |
|------------------|-------------------------|------------------------|-------------------------|-----------------------------|------------|
| Single-Family    | 9.0                     | 4.1                    | 1.6 to 1                | 5%                          | 68%        |
| Office (overall) | 7.9                     | 4.6                    | 1.7 to 1                | 6%                          | 56%        |
| Office (female)  | 12.8                    | 4.8                    | 2.7 to 1                | -1%                         | 64%        |
| Office (male)    | 4.5                     | 4.2                    | 1.1 to 1                | 12%                         | 50%        |
| Coffee Shop      | 82                      | 61                     | 1.3 to 1                | 12%                         | 52%        |

While data from the *Office* (female) sector shows that there are approximately 2.7 ‘short’ flushes

<sup>5</sup> Note that it is likely that this reduction in leakage would have been achieved by installing any non-leaking toilet, or perhaps even by replacing the existing toilet flappers (flush valves).

<sup>6</sup> Outliers and erroneous data have been removed. Analysis includes 30 Caroma, 7 TOTO, 3 Flapperless, and 1 Aris; Caroma value is expected to be accurate to  $\pm 18\%$  at 95% confidence, other values are significantly less accurate and are presented for illustration purposes only.

<sup>7</sup> Similar analysis for schools, golf courses, etc., was not included because of insufficient data.

to every one ‘long’ flush, data from the *Office* (male) sector indicates that the number of ‘short’ and ‘long’ flushes are similar. This result suggests that less water savings should be expected if dual-flush toilets are installed in washrooms where urinals are available.

It also appears that in applications where a low ratio of ‘short’ to ‘long’ flushes would be expected (e.g., in a mens restroom where urinals are available) there may be a corresponding increase in the number of flushes per day (*possibly* indicating an increased frequency of double-flushing). Although this result is not conclusive, it is not unexpected as clearing solids is a more difficult task for a toilet than clearing liquids. Again, dual-flush toilets seem better suited to environments where urinals are not available.

The ratio of ‘short’ to ‘long’ flushes was also relatively low at the Coffee Shop, however, this may be more related to customer curiosity about the toilet than to flush performance (i.e., a changing customer base may continue to be curious about the novelty of a dual-flush toilet and experiment with the different flushes).

The *effective* flush volume of a dual-flush toilet (i.e., the *total* volume of water used divided by the *total* number of flushes, both ‘long’ and ‘short’) depends upon the location where it is installed, i.e., the effective flush volume decreases as the ratio of ‘short’ flushes to ‘long’ flushes increases and vice versa. The *overall* effective flush volume identified in this project was 4.4 litres per flush<sup>8</sup>. It should be reiterated, however, that the effective flush volume is dependent on the installation location, i.e., the effective flush volume appears to be lower in ladies restrooms than in mens restrooms equipped with urinals. This said, the effective flush volume of dual-flush toilets appears to be about 32% less than that of conventional ULF toilets in ladies restrooms, 27% less in single-family applications, and 23% less in mens restrooms where urinals are installed.

The data also showed a small increase in the average number of flushes per day at sites where dual-flush toilets were installed (5% more flushes), and a decrease at sites where TOTO Drakes and Niagara Flapperless toilets were installed (14% and 39% fewer flushes respectively<sup>9</sup>). There is insufficient data, however, to ascertain whether the increase in flush rates at dual-flush sites is related to flush performance or simply to participant curiosity about the toilet.

**Table #4 – Avg. Savings per Flush** (based on replacing existing toilet flushing with 14.1 litres)

| Toilet                                     | Savings per Flush | Savings per Flush |
|--|-------------------|-------------------|
| Caroma (based on ‘effective flush volume’) | 9.7 L             | 69%               |
| TOTO                                       | 8.1 L             | 57%               |
| Niagara                                    | 7.9 L             | 56%               |
| Western Potteries                          | 6.6 L             | 47%               |

### 5.3 Cost-Effectiveness of Dual-Flush Toilets

<sup>8</sup>  $(3.4 \text{ L/flush} * 10.6 \text{ flushes/day} + 6.0 \text{ L/flush} * 6.8 \text{ flushes/day}) \div (10.6 \text{ flushes/day} + 6.8 \text{ flushes/day}) = 4.4 \text{ L/flush.}$

<sup>9</sup> Outliers and erroneous data have been removed from calculation.

The cost-effectiveness of a toilet reflects the relationship between the cost and the water savings associated with the toilet. To avoid misinterpretation it should be pointed out that:

- toilets are often selected for a variety of reasons – design, water savings, flush performance, cost, colour, etc.,
- cost-effectiveness calculations consider only the cost and flush volume,
- the cost of a toilet is not related to the flush volume.

The following tables identify approximate costs of toilets included in this study as well as other makes and models. The tables also includes the payback period for each toilet assuming the following conditions:

- an existing toilet flushing at 14.1 litres is replaced,
- a non-dual-flush toilet will save 8.0 litres/flush,
- a dual-flush toilet will save 9.7 litres/flush,
- each toilet is flushed 10 times per day,
- the combined water/sewer cost is \$1.00 per m<sup>3</sup>.

**Table #5 – Approximate Retail Cost of Toilets in Program**

| 6-Litre Toilet Make/Model | Cost  | Payback Period in Years |
|---------------------------|-------|-------------------------|
| Caroma Tasman             | \$300 | 8.5                     |
| Caroma Caravelle          | \$400 | 11.3                    |
| TOTO Drake                | \$300 | 10.3                    |
| Niagara Flapperless       | \$169 | 5.8                     |

**Table #6 – Sample Retail Costs of 13-Litre Toilets\***

| 13-Litre Toilet Make/Model  | Cost  | Payback Period in Years |
|-----------------------------|-------|-------------------------|
| Briggs Altima               | \$97  | 3.3                     |
| Briggs Abingdon Elongated   | \$119 | 4.1                     |
| American Standard Plebe     | \$175 | 6.0                     |
| American Standard Cadet III | \$189 | 6.5                     |

**Table #7 – Sample Retail Costs of 6-Litre Toilets\***

| 6-Litre Toilet Make/Model    | Cost  | Payback Period in Years |
|------------------------------|-------|-------------------------|
| Komet International Deco 611 | \$78  | 2.7                     |
| American Standard Marina     | \$116 | 4.0                     |
| Komet Deco 614               | \$118 | 4.0                     |
| Komet Albany                 | \$198 | 6.8                     |
| Briggs Millennium one piece  | \$248 | 8.5                     |
| Komet International Bohemian | \$290 | 9.9                     |
| Briggs Kingsley one piece    | \$298 | 10.2                    |

\*prices from 'The Building Box' flier, Book 3/02, 03/16/02, pages 28 & 29

As can be seen in Tables 5, 6, and 7, there is a range of toilet costs and, therefore, there is also a range in respective payback periods. Based on the criteria outlined above, however, it appears that the additional savings achieved in this program by employing dual-flush technology were not significant enough to completely offset the additional costs of the Tasman or Caravelle toilets. Again, it is important to note that maximizing water savings is often not the primary consideration for persons purchasing new toilets.

## 6.0 CONCLUSIONS

1. 100% of the participants were pleased with having the option of being able to choose between a ‘short’ or ‘long’ flush (even though not all participants were fully satisfied with the Caroma Tasman/Caravelle in particular).
2. There are additional water savings associated with the dual-flush option vs. 6-litre only flush toilets. The amount of additional savings, however, is dependant upon the type of application. Additional savings ranged from a high of about 32% in ladies restrooms, to about 23% in mens restrooms equipped with urinals. The additional savings including all sectors was 26%.
3. Any additional water savings achieved by utilizing a dual-flush option would be offset if the cost of the dual-flush toilet is greater than about 130% the cost of a 6-litre only flush toilet. It should be noted, however, that water savings is only one of many criteria considered by home-owners and facility managers choosing to install new toilets.
4. The Caroma ‘long’ flush, the TOTO Drake, and the Niagara Flapperless all flushed with average flush volumes of between 5.9 and 6.2 litres<sup>10</sup>.
5. It is difficult to generalize the expected savings from installing water-efficient toilets since the savings calculations must consider both the flush volumes and number of flushes per day of both the existing toilet and the new toilet. Water savings are also related to the type of application, i.e., a greater *volume* of savings would be expected in ‘high use’ applications.
6. All toilet models received similar scores on surveys. All toilets (regardless of make and model) had average rating of between 7.2 and 7.9 points out of 10.
7. Nearly all participants rated the appearance of Tasman/Caravelle, Drake, Flapperless, and Aris as either Good or Average.
8. Major concerns with the Caroma Tasman/Caravelle are related to bowl streaking (cleaning) and, secondly, to the physical size of the toilet. A significant number of respondents also expressed that the plastic tank looked ‘cheap’.
9. Several comments were made about the comfort of the toilet seat, however, this is not considered significant as seat comfort is a personal issue and seats can be easily changed.
10. Participants generally liked the Caroma better than their existing toilet.
11. The ratio of ‘short’ to ‘long’ flushes varies depending upon whether the toilet is installed in a residential or non-residential site, and whether it is installed in a mens restroom (where there is an option to use a urinal) or ladies restroom. The *overall* ratio was approximately 1.56 short flushes to every long flush (i.e., 10.6 ‘short’ flushes to every 6.8 ‘long’ flushes).

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<sup>10</sup> Although the Western Potteries Aris flushed with 7.5 litres it was later confirmed that a large number of Aris toilets were shipped with the wrong flapper – a flapper that caused the toilet to flush with too great a volume. It is expected that the toilet included as part of this study was one of those toilets. A flush volume of 7.5 litres, therefore, may not be indicative of what would be expected in further tests of Aris toilets.



# **Appendix 1**

## **Participant Surveys**

### Customer Satisfaction Survey: Caroma Toilet

This new toilet is called a Caroma Toilet. It incorporates a ‘dual-flush’ technology designed to save water by allowing the user to select a ‘short flush’ for liquid waste (3 litres) and a ‘long flush’ for solid waste (6 litres).

Please help us by taking a minute to answer the following questions. Thank you.

Date \_\_\_\_\_

1. How would you rate the appearance of this toilet?

- |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| Pleasing                 | Average                  | Poor                     |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

2. How do you like the option of selecting either the ‘short’ flush or ‘long’ flush?

- |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| Like It                  | Don’t Like It            | Don’t Use It             |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

3. How well did this toilet clear bowl of solids? Liquids?

- |         |                          |                          |                          |
|---------|--------------------------|--------------------------|--------------------------|
|         | Good                     | Satisfactory             | Poor                     |
| Solids  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Liquids | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

4. Would you recommend this toilet to others wishing to purchase a water efficient toilet?

- |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| Yes                      | Perhaps                  | No                       |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

5. How do you like the Caroma toilet compared to other toilets?

- |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| More                     | Same                     | Less                     |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

6. If there was one thing you could have the manufacturer change, what would it be?

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7. On a scale of 1 to 10, with “1” totally unsatisfactory and “10” excellent, how would you rate the Caroma?

- |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        | 10                       |
| <input type="checkbox"/> |

8. What additional cost would you be willing to pay to purchase a dual-flush toilet vs. a conventional toilet?

- |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| \$0                      | \$50                     | \$100                    | \$150                    |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Comments

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### Customer Satisfaction Survey

This new toilet is designed to flush better than standard toilets and to use only 6 litres of water per flush - older toilets flush with between 13 and 20 litres. It is installed as part of a program to determine how much water these toilets save and also the public's opinion of these toilets.

Please help us by taking a minute to answer the following questions. Thank you.

Date \_\_\_\_\_

Type of toilet installed:                      TOTO Drake                      Western Potteries Aris                      Flapperless

1. How would you rate the appearance of this toilet?

Pleasing                      Average                      Poor  
                                           

2. How well did this toilet clear bowl of solids? Liquids?

   Good                      Satisfactory                      Poor  
Solids                                                                    
Liquids                                                                 

3. Would you recommend this toilet to others wanting to purchase a water efficient toilet?

Yes                      Perhaps                      No  
                                           

4. How do you like this toilet compared to other toilets?

More                      Same                      Less  
                                           

5. If there was one thing you could have the manufacturer change, what would it be?

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6. On a scale of 1 to 10, with "1" totally unsatisfactory and "10" excellent, how would you rate this toilet?

1    2    3    4    5    6    7    8    9    10

7. What additional cost would you be willing to pay to purchase an efficient toilet vs. a conventional toilet?

\$0                      \$50                      \$100                      \$150  
                                                                 

Comments

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## Participant Satisfaction Survey

This is a Caroma Toilet - it incorporates a ‘dual-flush’ technology designed to save water by allowing the user to select a ‘short flush’ for liquid waste (3 litres) and a ‘long flush’ for solid waste (6 litres). Most efficient toilets flush with 6 litres.

Date: \_\_\_\_\_

1. How many Caroma toilets did you install?
2. How would you rate the appearance of the Caroma?  

|                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| Pleasing                 | Average                  | Poor                     |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
3. How do you like the option of selecting either the ‘short’ flush or ‘long’ flush?  

|                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| Like It                  | Don’t Like It            | Don’t Use It             |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
4. How does the Caroma clear bowl of solids? Liquids?  

|         |                          |                          |                          |
|---------|--------------------------|--------------------------|--------------------------|
|         | Good                     | Satisfactory             | Poor                     |
| Solids  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Liquids | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
5. Compared to your old toilet, the Caroma:  

|                             |                          |                          |                          |
|-----------------------------|--------------------------|--------------------------|--------------------------|
|                             | More                     | Same                     | Less                     |
| Clogs...                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Requires double flushing... | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Requires bowl cleaning...   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
6. Would you recommend Caroma toilets?  

|                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| Yes                      | Perhaps                  | No                       |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
7. Who installed your Caroma?  

|                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| Self                     | Plumber/Contractor       | Other                    |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
8. How do you like the Caroma vs. your old toilet?  

|                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| More                     | Same                     | Less                     |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
9. If there was one thing you could have the manufacturer change, what would it be?  


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10. On a scale of 1 to 10, with “1” totally unsatisfactory and “10” excellent, how would you rate the Caroma?  

|                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        | 10                       |
| <input type="checkbox"/> |
11. What additional cost would you be willing to pay to purchase a dual-flush toilet vs. a conventional toilet?  

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| \$0                      | \$50                     | \$100                    | \$150                    |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**Please complete the next section only if you also installed a TOTO or Flapperless toilet.**

12. What other type of toilet did you install?  

|                          |                          |
|--------------------------|--------------------------|
| TOTO                     | Flapperless              |
| <input type="checkbox"/> | <input type="checkbox"/> |
13. How many did you install?
14. How would you rate the appearance of this toilet?  

|                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| Pleasing                 | Average                  | Poor                     |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
15. How well does toilet clear bowl of solids? Liquids?  

|         |                          |                          |                          |
|---------|--------------------------|--------------------------|--------------------------|
|         | Good                     | Satisfactory             | Poor                     |
| Solids  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Liquids | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
16. Compared to your old toilet, this toilet:  

|                             |                          |                          |                          |
|-----------------------------|--------------------------|--------------------------|--------------------------|
|                             | More                     | Same                     | Less                     |
| Clogs...                    | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Requires double flushing... | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Requires bowl cleaning...   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
17. Would you recommend this toilet?  

|                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| Yes                      | Perhaps                  | No                       |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
18. If there was one thing you could have the manufacturer change, what would it be?  


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19. On a scale of 1 to 10, with “1” totally unsatisfactory and “10” excellent, how would you rate this toilet?  

|                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        | 10                       |
| <input type="checkbox"/> |
20. What additional cost would you be willing to pay to purchase an efficient toilet vs. a conventional toilet?  

|                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| \$0                      | \$50                     | \$100                    | \$150                    |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Comments

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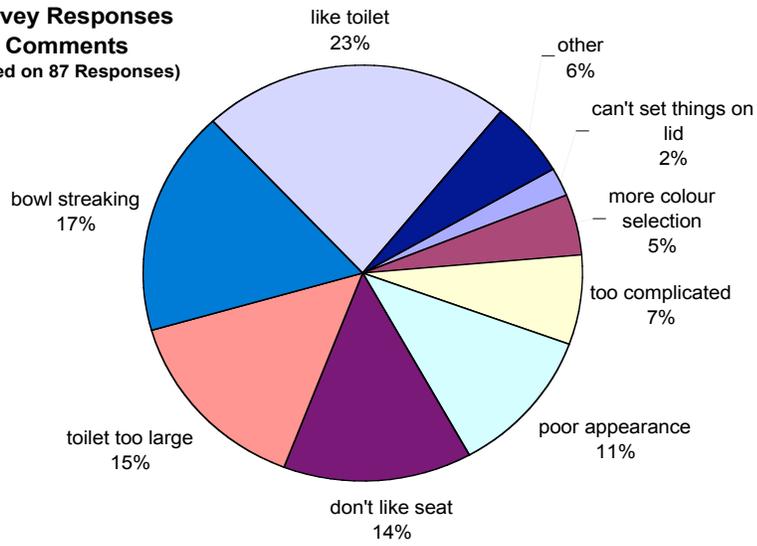


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# **Appendix 2**

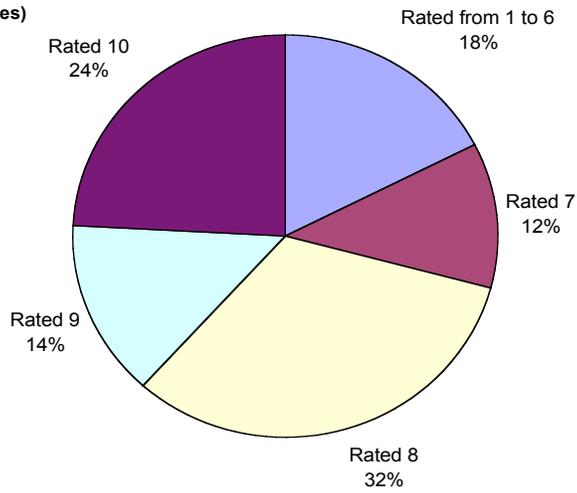
## **Charts Illustrating Survey Responses**

**Survey Responses  
Comments**  
(Based on 87 Responses)

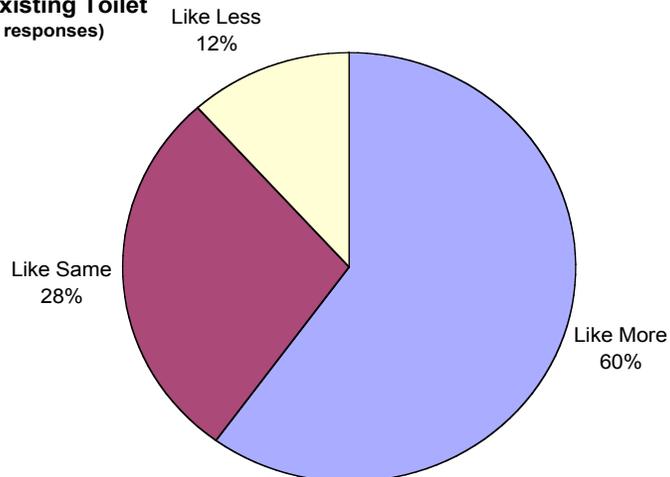


**Survey Responses  
Rating from 1 to 10**  
(based on 120 responses)

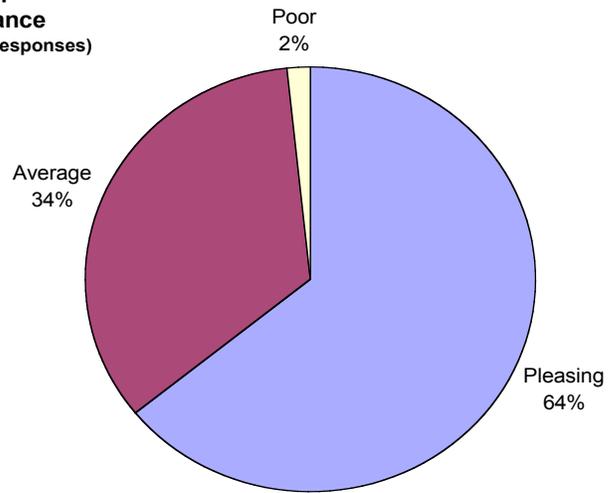
Average Rating of 7.8



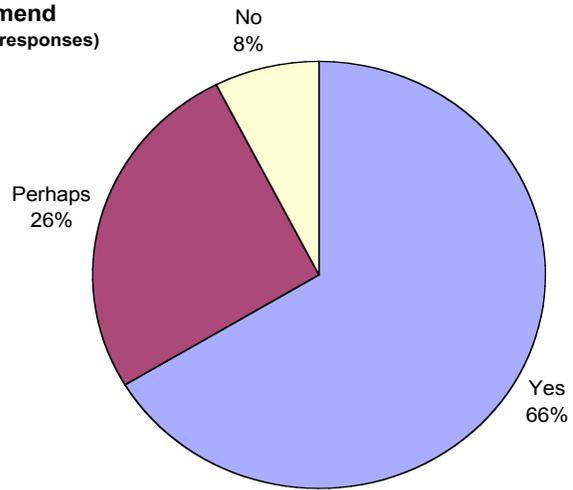
**Survey Responses  
Compared to Existing Toilet**  
(based on 120 responses)



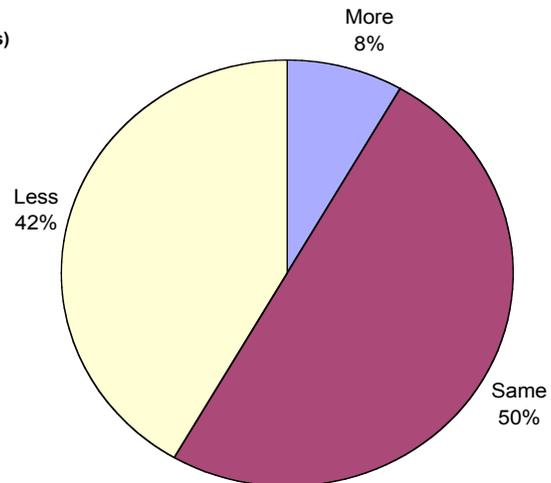
**Survey Responses  
Appearance**  
(based on 120 responses)



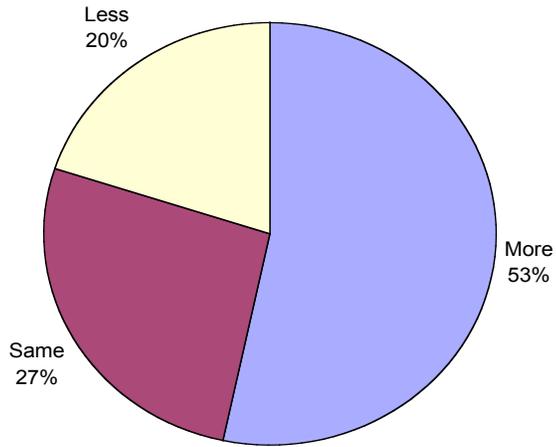
**Survey Responses  
Recommend**  
(based on 119 responses)



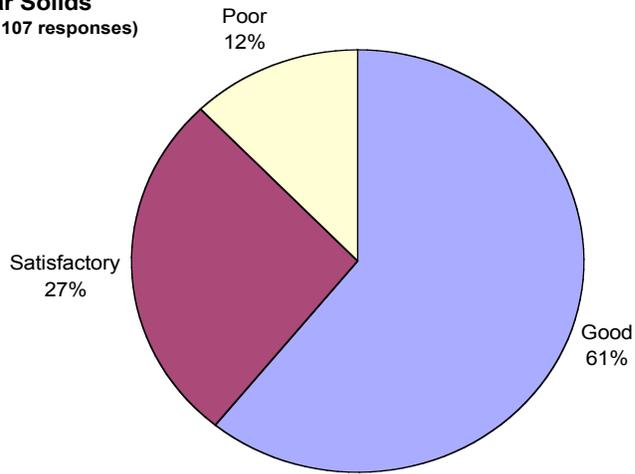
**Survey Responses  
Double Flushing**  
(based on 12 responses)



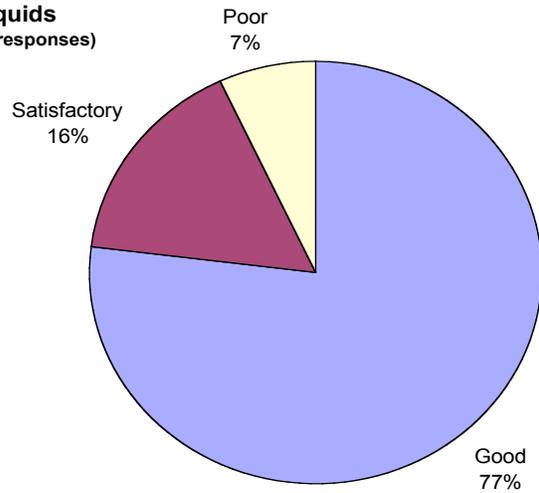
**Survey Responses  
Cleaning**  
(based on 15 responses)



**Survey Responses  
Clear Solids**  
(based on 107 responses)



**Survey Responses  
Clear Liquids**  
(based on 117 responses)



## **Appendix 3**

**Water Demand Reductions  
15-Unit Apartment Bldg.,  
39 Harcourt Ave., Toronto**

## **Water Demand Reductions, 15-Unit Apartment Bldg., 39 Harcourt Ave., Toronto**

### **Introduction**

As part of Toronto's involvement in the CMHC Dual-Flush Toilet Evaluation Project, all of the toilets in the public housing apartment building located at 39 Harcourt Avenue were replaced with Caroma dual-flush models. The new toilets are designed to flush with both a 'long' flush of 6 litres (for solid waste) and a 'short' flush of 3 litres (for liquid waste).

In addition to replacing the toilets in this 15-unit apartment building the program also involved evaluating the effectiveness (i.e., water savings) resulting from installing efficient showerheads and aerators. Because most multi-residential toilet replacement programs typically include replacing showerheads and faucet aerators at the same time as the toilets are changed-out only the aggregate water savings is known, i.e., the individual water savings directly related to replacing toilets, showerheads, or aerators cannot be quantified. Because the toilets, showerheads, and aerators were each replaced at different times during this project it was possible to identify the water savings associated with the replacement of each of these fixtures.

### **Monitoring**

The program included installing a data logger on the building's ¾" Rockwell SRII water meter to record water demands over the entire monitoring period. The data logger was installed on May 23<sup>rd</sup> – before any changes to the building's plumbing was initiated – to collect 'pre' data. The following illustrates the milestone dates of the program:

- May 23 – Start of 'pre' data collection
- June 14 – Dual-flush toilets installation completed
- July 10 – Water efficient showerheads installed
- July 24 – Water efficient aerators installed
- July 26 – Data logger removed

### **Results**

The fixture replacement program achieved an overall water savings of slightly more than 50% based on data collected during the monitoring period - a significant water demand reduction.

During the 'pre' monitoring period (before any change to the building's plumbing fixtures) the average water demand was 716 litres per apartment suite per day. Data collected by the monitoring equipment identified a constant leakage of approximately 1.83 litres per minute – this leakage was later identified as being related to leaking toilets.

After the existing toilets were replaced with the new Caroma dual-flush toilets the per suite water demand was reduced to 416 litres. The 300 litres per suite water savings during this phase of the program could be broken down into 124 litres savings related to lower flush volumes and to 176 litres related to eliminating the toilet leak(s)<sup>1</sup>.

Replacing the existing showerheads with new water efficient units resulted in an additional savings of

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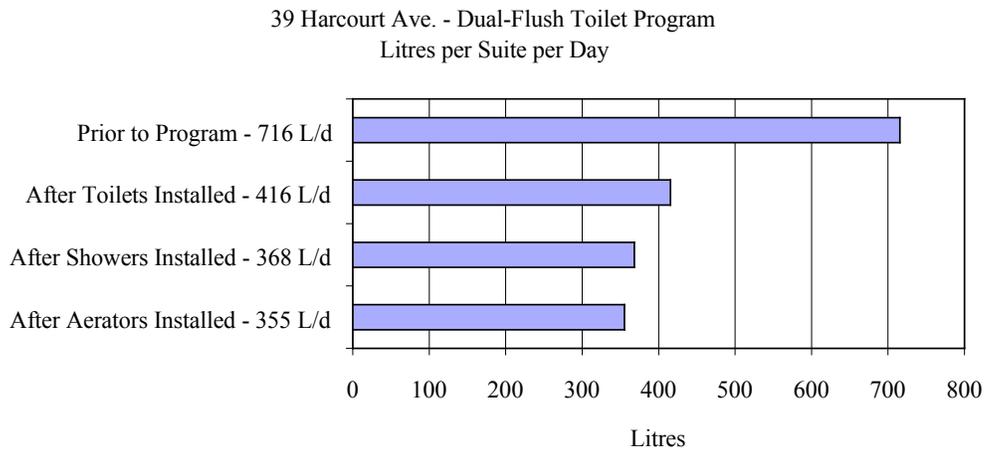
<sup>1</sup> Data logging revealed an immediate cessation in leakage after the new toilets were installed.

47 litres per suite per day, while installing new aerators saved about 13 litres per suite per day. The following table summarizes the savings.

| Fixture           | Savings, L/suite/d | Reduction in Demand |
|-------------------|--------------------|---------------------|
| Dual-flush toilet | 124                | 17.4 %              |
| Leakage           | 176                | 24.5 %              |
| Showerhead        | 47                 | 6.6 %               |
| Aerator           | 13                 | 1.8 %               |
| <b>Total</b>      | <b>360</b>         | <b>50.3%</b>        |

The aggregate water savings achieved in multi-residential buildings by installing water efficient toilets, showerheads, and aerators has typically been between 25-35% (including reduced leakage). A savings of greater than 50% is, therefore, substantial. This high level of savings may be due in part to the installation of dual-flush water efficient toilets vs. the more conventional 6-litre per flush units<sup>2</sup>. It should also be noted, however, that a significant portion this savings was from reducing toilet leakage.

The chart below helps to illustrate the savings achieved at each phase of the program.



<sup>2</sup> A study completed in Seattle identified an additional savings of 26% when using dual-flush vs. conventional 6-litre toilets.

## Estimation of Flush Volume Savings

An analysis of the collected 'pre' data identified the average flush volume of the existing toilets was approximately 14.8 litres. A similar analysis of the 'post' data identified that the average volume of the 'long' flush was approximately 6.2 litres and the average of the 'short' flush was 3.7 litres.

### ***'Pre' Toilet Change-Out***

Estimated per suite toilet demand before toilet change-out can be calculated as follows:

Per suite water demand (excluding leakage)  
 $716 \text{ litres/suite} - 176 \text{ litres leakage} = 540 \text{ litres/suite}$   
Toilet use of approximately 30%  
 $30\% * 540 \text{ litres/suite} = 162 \text{ litres/suite toilet demand}$   
Flushes per suite per day  
 $162 \text{ litres/suite per day} \div 14.8 \text{ litres/flush} = 10.95 \text{ flushes/suite/day}$

### ***'Post' Toilet Change-Out***

Estimated per suite toilet demand after toilet change-out can be calculated as follows:

Assume ratio of 4 'short' flushes to every 1 'long' flush, i.e., 80% of flushes are 'short'.  
Total number of flushes per suite per day = 10.95  
Number of 'short' flushes  
 $80\% * 10.95 = 8.76 \text{ 'short' flushes/day/suite}$   
Flush volume associated with 'short' flushes  
 $8.76 \text{ 'short' flushes} * 3.7 \text{ litres/flush} = 32.4 \text{ litres/suite/day}$   
Number of 'long' flushes  
 $20\% * 10.95 = 2.19 \text{ 'long' flushes/day/suite}$   
Flush volume associated with 'long' flushes  
 $2.19 \text{ 'long' flushes} * 6.2 \text{ litres/flush} = 13.6 \text{ litres/suite/day}$   
Per suite water demand associated with toilet flushing  
 $32.4 \text{ litres ('short' flush)} + 13.6 \text{ litres ('long' flush)} = 46 \text{ litres/suite/day}$

Savings Associated with toilet change-out equals the difference between 'pre' and 'post' toilet demands per suite –

$162 \text{ litres/suite 'pre'} - 46 \text{ litres/suite 'post'} = 116 \text{ litres/suite savings}$

The calculated water savings using the above methodology identifies a water savings associated with installing the new dual-flush toilets of approximately 116 litres per suite per day. The savings based on data logging is equal to 124 litres per suite per day. The small difference between these two values (approximately 6.7%) verifies that the assumptions used to calculate flush volume savings are fundamentally sound, i.e., that the 'short' flush is used for approximately 80% of the flushes. The following table summarizes these results.

|                                     |             |
|-------------------------------------|-------------|
| Average 'Pre' flush volume          | 14.8 litres |
| Average 'Long' flush volume         | 6.2 litres  |
| Average 'Short' flush volume        | 3.7 litres  |
| Number of flushes per suite per day | 10.95       |
| 'Short' flush duty factor           | 80%         |
| 'Long' flush duty factor            | 20%         |

### Additional Water Savings vs. Installing Conventional 6-Litre Toilets

The water savings directly related to installing the dual-flush toilets was 124 litres per suite per day. The expected savings using conventional 6-litre toilets can be estimated as follows<sup>3</sup>:

$$10.95 \text{ flushes/day} * (14.8 \text{ litres/flush 'pre'} - 6 \text{ litres/flush 'post'}) = 96.4 \text{ litres/suite/day}$$

The additional water savings achieved by installing the dual-flush toilets is, therefore:

$$124 \text{ litres/suite/day} - 96.4 \text{ litres/suite/day} = 27.6 \text{ litres/suite/day}$$

This additional water savings equates to an additional 28.6%, i.e.,

$$27.6 \text{ litres}/96.4 \text{ litres} = 28.6\%$$

### Conclusion

The high level of detail pertaining to the water savings specifically related to the replacement of the different types of plumbing fixtures at 39 Harcourt is rare and was only achievable because:

1. detailed monitoring and data logging was performed, and
2. the toilets, showerheads, and aerators were replaced at different times.

This study has shown that installing water-efficient plumbing fixtures in multi-residential apartment buildings can result in significant water savings – greater than 50% of the water demand was saved in the building at 39 Harcourt Ave.

This study has also shown that greater than 80% of the water savings achieved was either directly or indirectly related to the installation of water-efficient toilets. Even if the reduced leakage is not considered toilets still account for more than 67% of the total savings<sup>4</sup>.

The additional water savings that has been achieved by installing dual-flush toilets vs. conventional 6-litre toilets in this building has been estimated to be approximately 28.6%.

<sup>3</sup> Assuming that the new toilet flushes with exactly 6.0 litres.

<sup>4</sup> 124 litres per unit per day saving from toilets and a total savings of 184 litres (without leakage).

## **Appendix 4**

### **Contact and Site Information for Program Participants**

| <b>Participant in CMHC Dual Flush Toilet Program</b>  | <b>Number of Caroma Toilets</b> | <b>Number of Other Toilets</b> |
|---|---------------------------------|--------------------------------|
| <p><b>City of Calgary, Alberta</b><br/> Contact: Marnie McMillan<br/> Phone: (403) 268-2539<br/> Fax: (403) 268-5709<br/> Email: marnie.mcmillan@gov.calgary.ab.ca</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 2 Caromas in residential applications</li> <li>• 2 Caromas in Waterworks office</li> </ul>   | 4                               | 0                              |
| <p><b>Quebec City, Quebec</b><br/> Contact: Michel Lagacé<br/> Phone: (418) 623-9738<br/> Fax: (418)<br/> Email: mlagace@ville.quebec.qc.ca</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 4 Caromas in municipal office</li> </ul>  | 4                               | 0                              |
| <p><b>City of St. Johns, Newfoundland</b><br/> Contact: Gerri King<br/> Phone: (709) 576-8613<br/> Fax: (709) 576-8625<br/> Email: Gking@city.st-johns.nf.ca</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 1 Caroma in Eastern Water Treatment Plant, 1 in Western Plant</li> </ul>   | 2                               | 0                              |
| <p><b>Region of Durham, Ontario</b><br/> Contact: Glen Pleasance<br/> Phone: (905) 668-7721, ext. 5391<br/> Fax: (905) 668-2051<br/> Email: Glen.Pleasance@region.durham.on.ca</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 2 Caromas in municipal office building</li> <li>• 1 Drake, 1 Flapperless, and 1 Aris in municipal office building</li> </ul> | 3                               | 3                              |
| <p><b>Region of Halton, Ontario</b><br/> Contact: Cassandra Bach<br/> Phone: (905) 825-6123, ext. 7787#<br/> Fax: (905) 825-8822<br/> Email: Bachc@region.halton.on.ca</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 1 Caroma in Landfill Site office</li> <li>• 1 Drake in Landfill Site office</li> </ul>   | 1                               | 1                              |
| <p><b>City of Regina, Saskatchewan</b><br/> Contact: Randy Burant<br/> Phone: (306) 777-7819<br/> Fax: (306) 777-6806<br/> Email: rburant@cityregina.com</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 5 Caromas in school</li> <li>• 1 Caroma in municipal office bldg</li> <li>• 1 Drake in municipal office bldg.</li> </ul>                           | 8                               | 3                              |

|  |   |   |
|--|---|---|
| <ul style="list-style-type: none"> <li>• 1 Caroma in golf course</li> <li>• 2 Drakes in golf course</li> <li>• 1 Caroma in residence</li> </ul>  |   |   |
| <p><b>Greater Vancouver Regional District, British Columbia</b><br/> Contact: Andrew Doi<br/> Phone: (604) 436-6825<br/> Fax: (604) 436-6970<br/> Email: andrew.doi@gvrd.bc.ca</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 2 Caroma in residential</li> <li>• 1 Caroma in commercial</li> <li>• 1 Drake in commercial</li> <li>• 1 Caroma in institutional</li> <li>• 1 Drake in institutional</li> </ul>  | 4 | 2 |
| <p><b>Region of Waterloo, Ontario</b><br/> Contact: Roger D’Cunha<br/> Phone: (519) 575-4423<br/> Fax: (519) 575-4452<br/> Email: droger@region.waterloo.on.ca</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 2 Caromas at Waste Management Centre at Waterloo Landfill</li> <li>• 1 Drake at Waste Management Centre at Waterloo Landfill</li> </ul>   | 2 | 1 |
| <p><b>Province of Manitoba</b><br/> Contact: Lisbeth Liebgott<br/> Phone: (204) 945-8980<br/> Fax: (204) 945-1211<br/> Email: lliebgott@env.gov.mb.ca</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 2 Caromas in public washrooms of seniors apartment bldg.</li> <li>• 2 Caromas Gimli's heritage Town Hall office</li> <li>• 1 Caroma - Gimli High School - female bathroom</li> <li>• 1 Caroma - Single mothers' assistance office</li> <li>• 1 Flapperless - Single mothers' assistance office</li> <li>• 1 Drake - Single mothers' assistance office</li> <li>• 1 Flapperless - Gimli High School - female bathroom</li> <li>• 1 Drake - Gimli High School - female bathroom</li> </ul> | 6 | 4 |
| <p><b>City of Toronto, Ontario</b><br/> Contact: Roman Kaszczij<br/> Phone: (416) 392-4967<br/> Fax: (416) 392- 2974<br/> Email: roman_kaszczij@city.toronto.on.ca</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 1 Caroma in Second Cup restaurant</li> <li>• 1 Caroma in 15-unit apartment building</li> </ul> <p>Note: Toronto is purchasing additional 14 Caroma toilets required to replace all of the existing toilets in the 15-unit apartment building.</p>   | 2 | 0 |
| <p><b>City of Victoria, British Columbia</b><br/> Contact: Deborah Walker<br/> Phone: (250) 474-9683<br/> Fax:<br/> Email: dwalker@crd.bc.ca</p> <p>Installation Sites:</p>  | 4 | 0 |

|   |   |   |
|---|---|---|
| <ul style="list-style-type: none"> <li>• 2 Caromas in single-family houses</li> <li>• 2 Caromas in municipal office</li> </ul>  |   |   |
| <p><b>City of Vernon, British Columbia</b></p> <p>Contact:<br/> Phone:<br/> Fax:<br/> Email:</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 2 Caroma in firehall</li> <li>• 2 Caroma residential</li> <li>• 1 Caroma commercial</li> </ul> <p>Note: The project contact, Eric Jackson is no longer employed by the City of Vernon and there has been no replacement assigned to the project.</p> | 5 | 0 |
| <p><b>Minto Property Management, Ontario</b></p> <p>Contact: Andrew Pride<br/> Phone: (416) 977-0777<br/> Fax: (416) 596-3444<br/> Email: apride@minto.com</p> <p>Installation Sites:</p> <ul style="list-style-type: none"> <li>• 1 Caroma in apartment suite</li> </ul>   | 1 | 0 |