High-Efficiency Showerhead Performance Study

Final Report

Study completed at the University of Waterloo, Ontario, Canada

Study Sponsors:

Canadian Municipal Water Efficiency Network (CMWEN)

Alliance for Water Efficiency (AWE)

Report Issued: January 2010

(Revised December 2011)

Authors

Bill Gauley, P.Eng., Principal, Veritec Consulting Inc., Mississauga, ON

Dr. James E. Robinson, P.Eng., Associate Professor, University of Waterloo, ON

Kurtis Elton, M.E.S. Candidate, University of Waterloo, ON

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1.0 Introduction

Many studies have shown that showering accounts for between 20% and 30% of all indoor residential water demands. An "efficient" showerhead should not only save water but also the energy used to heat the water (thus reducing greenhouse gas emissions[1]). But, what constitutes an efficient showerhead? Traditionally, flow rate was considered the prime indicator of showerhead efficiency, but clearly there is a relationship between flow rate and performance.

The purpose of this project was to establish and test a protocol that could be used to identify an "efficient" showerhead based on the following three criteria: minimum flow rate, minimum hot water (energy) requirement, and maximum level of performance as perceived by 23 student volunteers. It was also hoped that the results of this project would aid the development of the ASME/CSA standards and the U.S. EPA WaterSense specifications.

Each student participant in the study took 12 separate showers using 12 different showerheads. The test rig used in this project could accommodate four showerheads at one time so the 12 fixtures were tested in three groups of four. After completing each group of four showers, participants were asked to answer a set of questions regarding their perceptions on each showerhead's spray, rinsing ability, quietness, aesthetic appeal, etc. Participants were also timed for each "step" of their shower, e.g., shampooing, body washing, etc. Each participant session took about two hours.

2.0 Methodology

Testing was conducted in a locker room in a sports complex building at the University of Waterloo, Ontario, Canada. The shower area in the locker room had four showers, each controlled by a single lever. In the original configuration, the levers are pulled out to activate the shower and pushed in to turn the shower off. Temperature is controlled by rotating the lever to the right (colder) or to the left (hotter). The original configuration was modified using copper piping, valves, flow meters, and pressure gauges to produce two identical control units, each fitted with two showerheads as identified in figure 2.1. Participants were asked to adjust the control valves to produce an appropriate water temperature for each shower, but the flow rates and water temperatures were recorded remotely and the participants had no knowledge of actual flow rates or water temperatures. A set of ball valves were used to toggle between each of the two showerheads connected to each control unit.

[1] The extent of Greenhouse Gas emission savings varies from area to area depending on how the energy used to heat the water is produced. The average savings across Canada is about 20 kg of CO_2 equivalent for every cubic meter of hot water saved. The average savings across the USA is about 36 kg of CO_2 equivalent for every cubic meter of hot water saved.

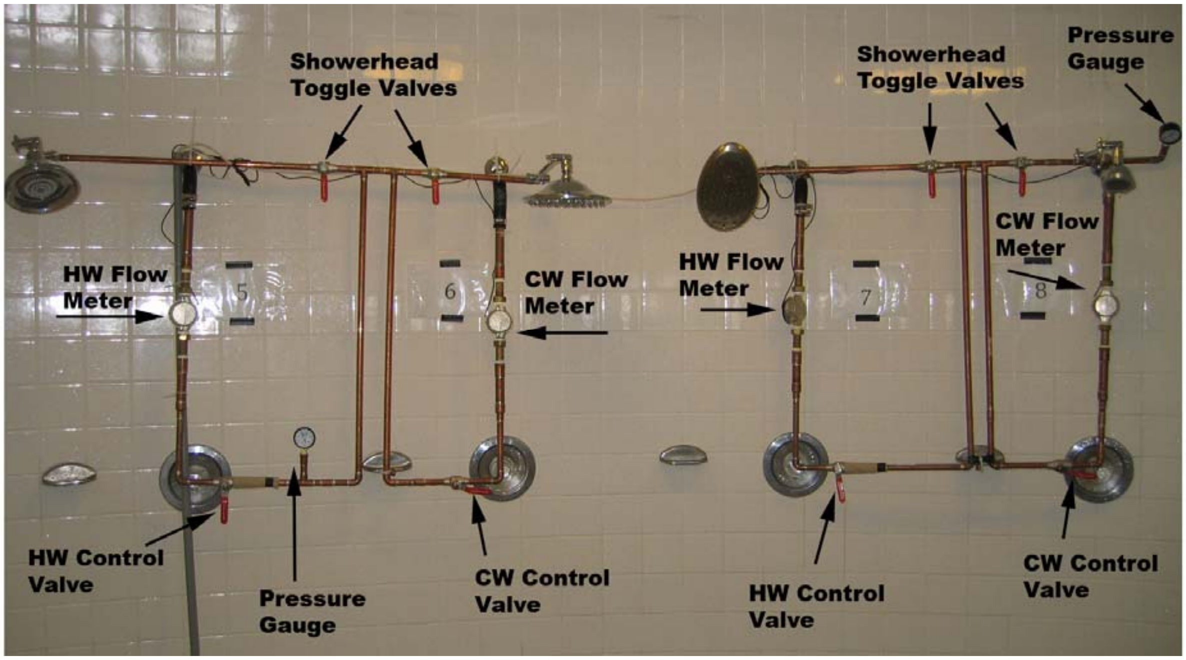


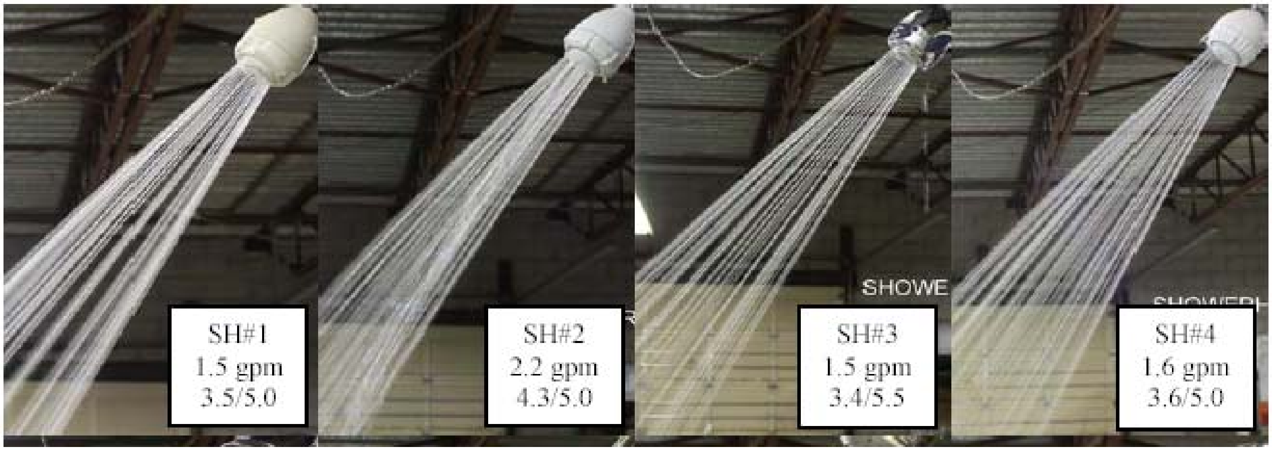
Figure 1 - Setup of Test Rig

After testing each group of four showerheads, participants were asked to answer questions regarding their perceptions of each showerhead on a laptop computer setup in another area of the locker room. . Questions included “How would you rate the overall performance of each showerhead?”; “How would you rate overall appeal of spray for showerhead x?”, etc. A copy of the survey is provided in Appendix A.

The study used twelve different showerheads, listed below along with their rated flow rate and measured flow rates during testing:

Table 1: Showerheads Included in Study			
No.	**Make and Model**	**Rated Gpm / Lpm**	**Measured Gpm / Lpm**
1	Niagara Earth	2.0 / 7.6	1.5 / 5.7
2	AM Conservation Spoiler	2.5 / 9.5	2.2 / 8.3
3	Niagara Earth (silver colour)	1.5 / 5.7	1.5 / 5.7
4	NRG, LM 39709	2.0 / 7.6	1.6 / 6.0
5	Kohler, Forte K-10240	1.75 / 6.6	1.6 / 6.0
6	Delta 8” Brass (rain style)	2.5 / 9.5	1.5 / 5.7
7	Waterpik AquaScape (rain style)	2.5 / 9.5	2.0 / 7.6
8	Bricor Elite B150	1.25 / 4.7	1.5 / 5.7
9	Delta H2Okinetic RP46384	1.5 / 5.7	1.4 / 5.3
10	Bricor B125-AM-GT	1.25 / 4.7	1.6 / 6.0
11	Niagara Conservation 800831-8383	2.5 / 9.5	1.7 / 6.4
12	Niagara – brass aerating	2.4 / 9.1	1.7 / 6.4

The following photos show each showerhead, the type of spray pattern, the flow rate, and the overall score assigned by the participants out of 5.0.



Each participant took three sets of four showers - a total of twelve showers – wearing bathing suites. The showerheads were always tested in the same order (an aspect that would be changed if further study is undertaken), starting with SH-1 and ending with SH-12. Each participant was asked what “steps” they normally take during a typical shower (e.g., rinse hair, apply shampoo, scrub body, etc.) and then they were asked to repeat these steps for each showerhead. Each step was timed by a researcher of the same gender as the participant. Participants were also encouraged to make comments while showering to help communicate their perceptions.

Since participants would essentially be “clean” after testing the first showerhead, it was decided that participants should be made “dirty” prior to testing each showerhead (except for their first test). As such, the participants were sprayed with a mild oil and water mixture (one part canola oil to seven parts water) for about four to five seconds using a battery operated spray mister. For consistency, participants were also asked to repeat the first shower at the end of their session, this time after being sprayed with the oil/water mixture.

After each set of four showers, participants answered questions while the researchers installed the next set of four showerheads. This also gave the participant a break prior to testing the next set of showerheads.

3.0 Results

A total of 23 participants participated in the project - 13 female and 10 male (note that the sample size is considered too small to be considered statistically significant). The mean age of the participants was 22 and the mean height was 5 feet 7 inches[2]. The mean hair length of all participants was 9.4 inches.

Survey responses indicated that study participants (all University Students) take an average of 6.2 showers per week - 59% in the morning and 41% in the evening.

Participants were asked to rate the importance of specific shower characteristics - the following table identifies the most frequent response.

Table 2: Importance of Various Showerhead Attributes

Category	Level of Importance
Strength of spray	**Extremely Important**
Hair rinsing ability	
Overall appeal of spray	**Very Important**
Spray coverage / width of spray	
Distribution of spray	
Face rinsing ability	**Quite Important**
Body rinsing ability	
Noise level	
Size of showerhead	**Only Slightly Important**
Variety of sprays provided	
Attractiveness of showerhead	**Not at all Important**

The participants were also asked to provide their *individual overall rating* (IOR) for each showerhead. As illustrated below, the results for the IOR tend to mirror the “Level of Importance” ratings.

[2] The showerheads were installed at approximately 2 metres (80 inches) from the floor.

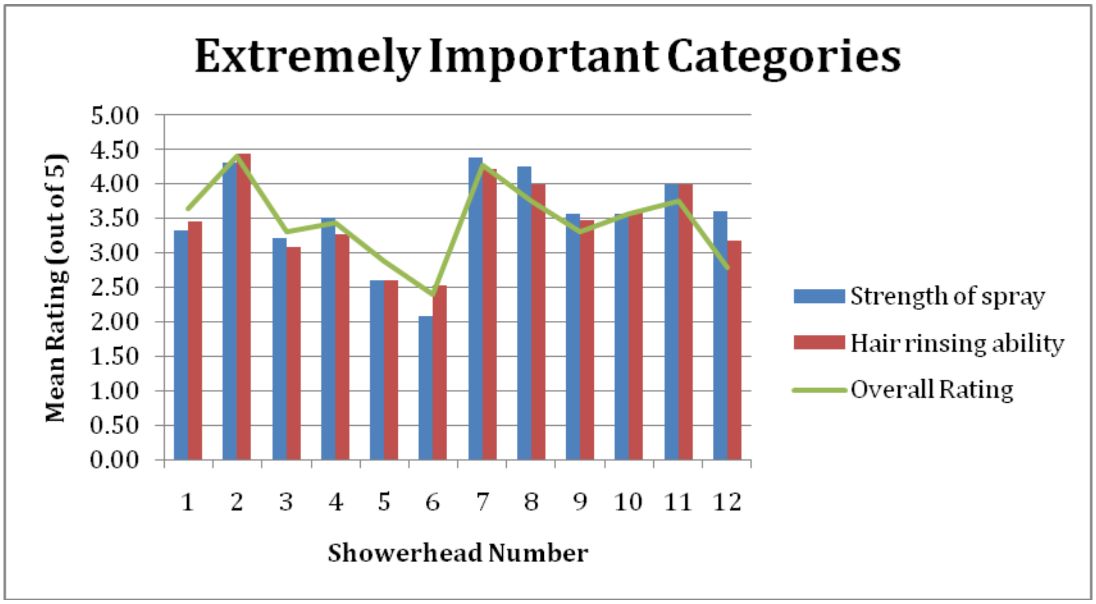


Figure 2 - Extremely Important Categories

3.1 Replacement of Home Showerhead

Participants were asked whether they would replace their current household showerhead with any of the test showerheads. Only three showerheads earned a "yes" from more than 50% of participants (#2 AM Conservation Spoiler, #7 Waterpik, and #11 Niagara) – and all of these had rated flow rates of 2.5 gpm / 9.5 Lpm. Figure 3.2 shows a summary of the answers given, with IOR shown for reference purposes.

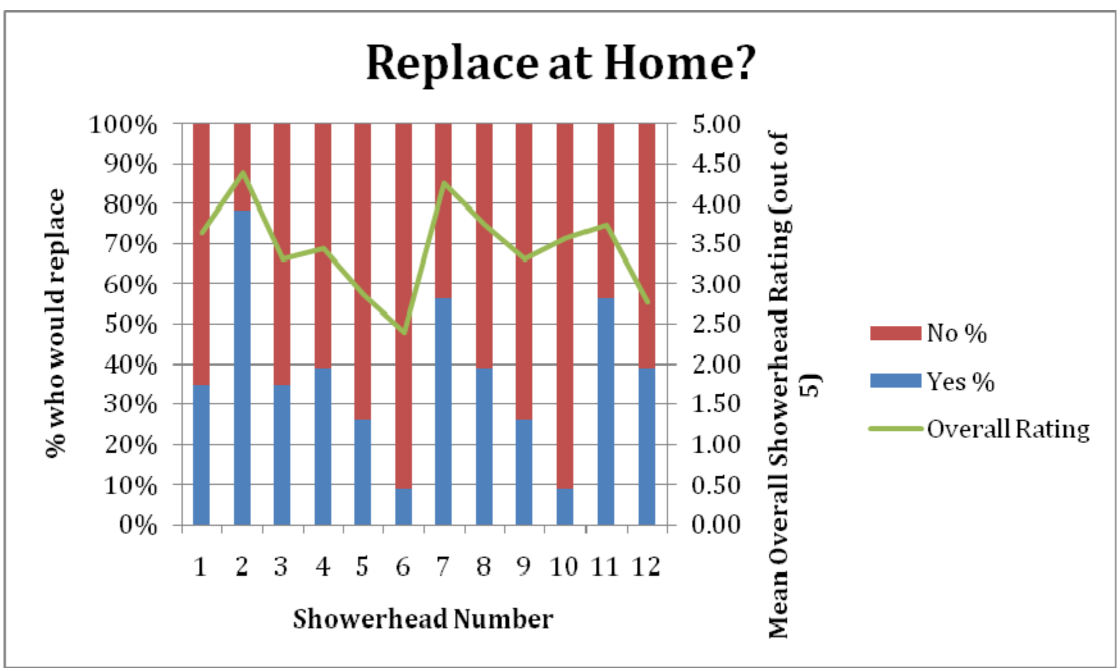


Figure 3 - Replace existing showerhead at home?

It is interesting to note that that a high IOR was no guarantee that participants would consider the showerhead as a replacement for their existing showerhead – for example, showerhead #10 scored 3.5 out of 5 for IOR but less than 10% of the participants would replace their existing showerhead with this model.

It is important to note that participants answered all survey questions without specific knowledge regarding the attributes of the test showerheads, e.g., flow rates, costs of showerheads, etc.

3.2 Flow Data

Showerhead flow rates during testing ranged from a maximum of 8.3 Lpm/2.2 gpm (showerhead 2) to a minimum of 5.3 Lpm/1.4 gpm (showerhead 9). Note that these are actual flow rates vs. rated or advertised flow rates. Figure 3.3 shows flow rate data for each showerhead with IOR overlaid for reference purposes. In general, showerheads with a relatively large gap between IOR and flow rate (e.g. SHs 9, 3, 8, and 1) might be considered to have a relatively high acceptance while also having relatively low flow rates.

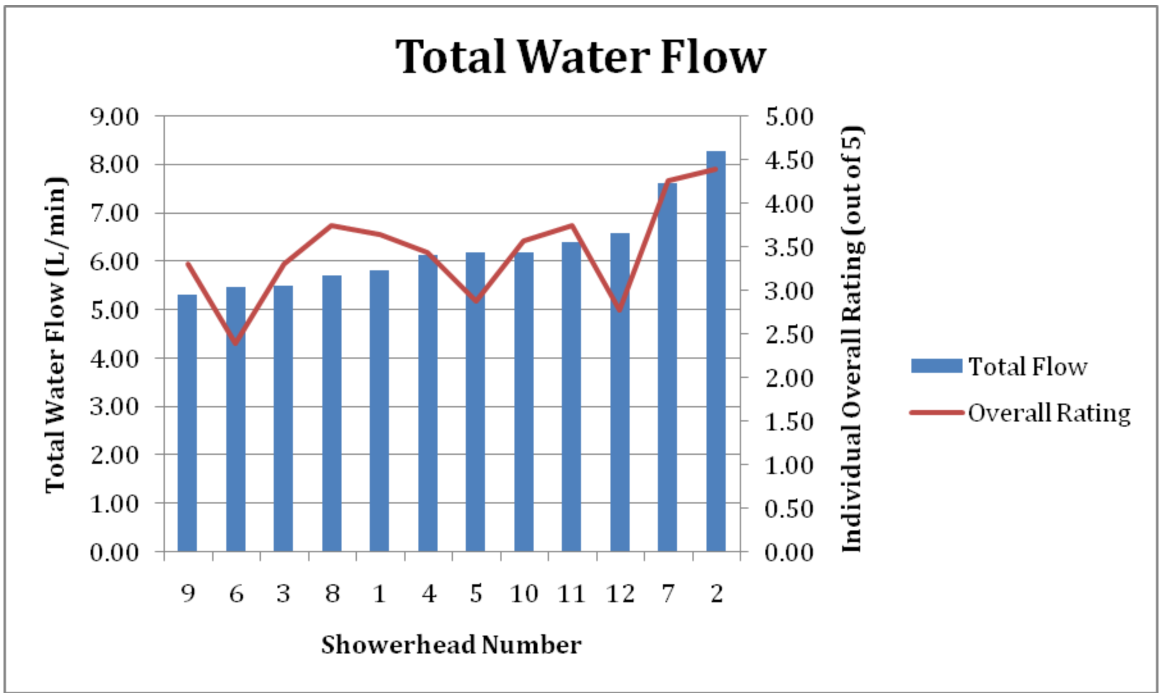


Figure 4 - Flow Rate vs. Rating

3.3 Timing Data

A researcher of the same gender as the participant recorded the time it took participants to complete each “step” of their shower. Unfortunately, the results of the timing data analysis were not conclusive – possibly due to the unnatural aspects of the testing, such as having an observer present – and they are not included in this report.

3.4 The Effect of Hair Length

Self-reported hair length was checked against shampooing times and conditioning times for possible correlations. In both cases, virtually no correlation was found. It is possible that hair thickness is a more important factor than length with regard to rinsing times, since individuals who claimed to have “thick” hair sometimes complained about showerheads being too “weak”.

3.5 Shower Water Temperature

The average temperature of all showers (measured immediately after discharging from showerhead) was 38C with a standard deviation of 3.1C (100.3F with a standard deviation of 3.5 F), i.e., only slightly greater than body temperature.

4.0 Conclusions

Participants in this study tended to prefer showerheads with higher flow rates. The showerheads with the highest overall rating were showerhead #2 (AM Conservation Spoiler flowing at 8.3 Lpm/2.2 gpm) and showerhead #7 (Waterpik AquaScape flowing at 7.6 Lpm/2.0 gpm). Note that the style of these two types of showerheads is quite different - showerhead #2 is typical adjustable showerhead and #7 is a rain-style showerhead. The rated flow rate of both of these models is 9.5 Lpm/2.5 gpm. The lower flow rates achieved during testing were due to the relatively low pressures available in the test facility (approximately 45 psi).

Showerheads #1, 3, 8, and 9 all scored a relatively high rating while having relatively low flow rates. The first two of these models are typical adjustable units (tested in the ‘stream’ mode), showerhead #8 is a non-adjustable ‘stream’ unit, and showerhead #9 provides a somewhat chaotic flow pattern.

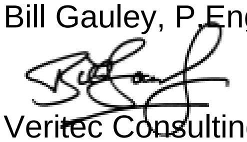
The showerheads scoring the lowest overall ranking were showerheads #5, 6, and 12. Showerhead #5 is a ‘stream’ model with a large number of streams, showerhead #6 provides a rainfall-type spray, and showerhead #12 is an aerating model.

More expensive showerheads did not perform better than lower cost models.

Strength of spray and hair rinsing were the two most important factors identified by the participants.

As one of the co-authors of this report, I would be pleased to answer any questions you may have regarding this study.

Sincerely,
Bill Gauley, P.Eng., Principal



Veritec Consulting Inc. (bill@veritec.ca)

Showerhead Study - Post-Shower Survey

1. Group 1

1. How would you rate the overall performance of each showerhead?

	Very poor	Poor	Satisfactory	Good	Excellent
SH 1	○	○	○	○	○
SH 2	○	○	○	○	○
SH 3	○	○	○	○	○
SH 4	○	○	○	○	○

2. For Showerhead 1, how would you rate the following:

	Very poor	Poor	Satisfactory	Good	Excellent	N/A
Overall appeal of spray	○	○	○	○	○	○
Strength of spray	○	○	○	○	○	○
Spray coverage/width of stream	○	○	○	○	○	○
Face rinsing ability	○	○	○	○	○	○
Body rinsing ability	○	○	○	○	○	○
Hair rinsing ability	○	○	○	○	○	○
Distribution of spray	○	○	○	○	○	○
Size of showerhead	○	○	○	○	○	○
Attractiveness of showerhead	○	○	○	○	○	○
Quietness of showerhead	○	○	○	○	○	○
Variety of spray types available	○	○	○	○	○	○

6. Would you replace the showerhead you currently have at home with any of these showerheads?

	Yes	No
SH 1	○	○
SH 2	○	○
SH 3	○	○
SH 4	○	○

7. Which showerhead is the best of this group?

- SH 1
- SH 2
- SH 3
- SH 4

4. Last Couple of Questions

22. For each of the categories below, please indicate how important each one is for the making of a comfortable shower:

	Not at all important	Only slightly important	Quite important	Very important	Extremely important
Overall appeal of spray					
Strength of spray					
Spray coverage/width of stream					
Face rinsing ability					
Body rinsing ability					
Hair rinsing ability					
Distribution of spray					
Size of showerhead					
Attractiveness of showerhead					
Quietness of showerhead					
Variety of spray types available					

23. Please rank your top three showerheads from the twelve that were tested today:

	Ranking
SH 1	
SH 2	
SH 3	
SH 4	
SH 5	
SH 6	
SH 7	
SH 8	
SH 9	
SH 10	
SH 11	
SH 12	

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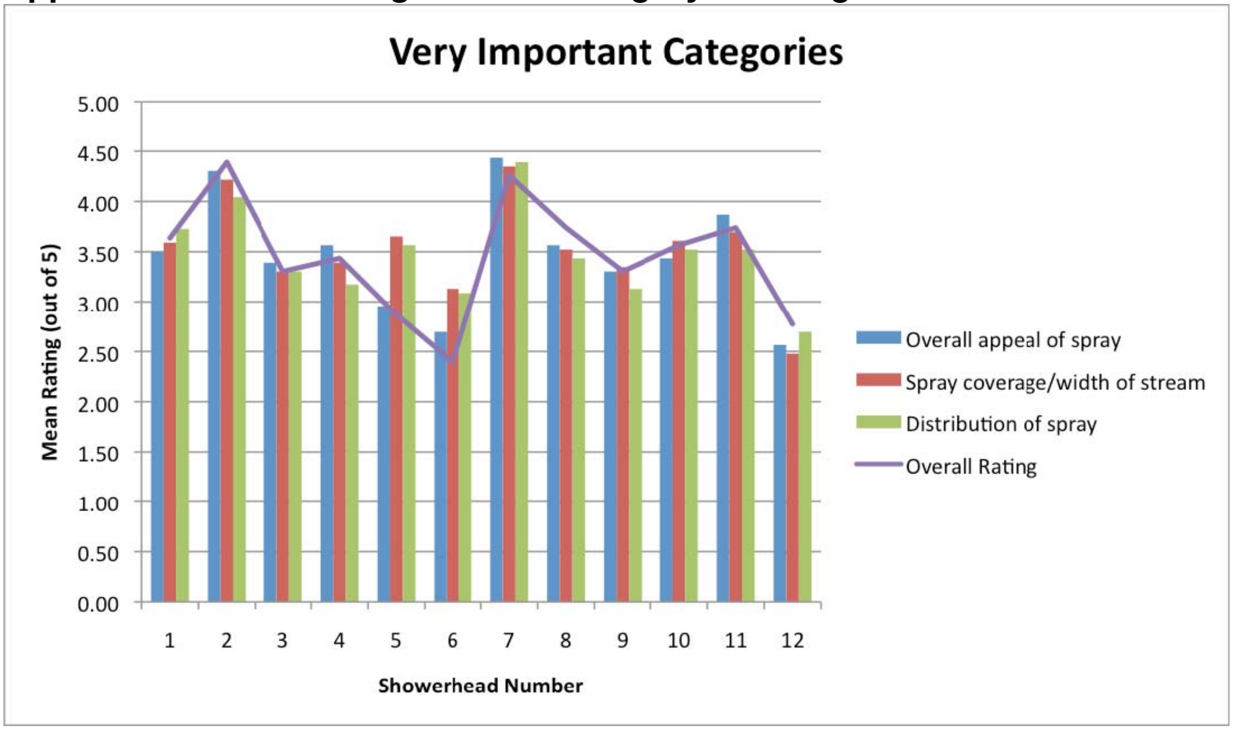
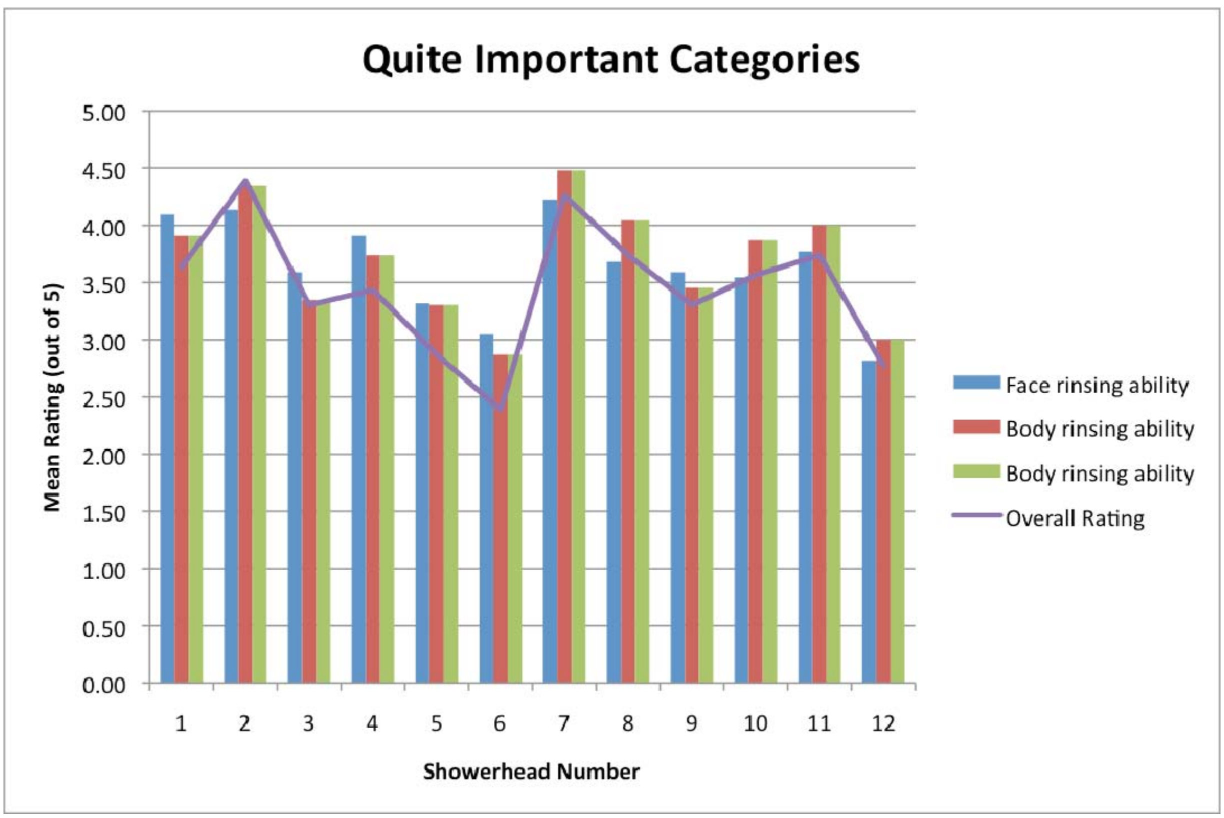
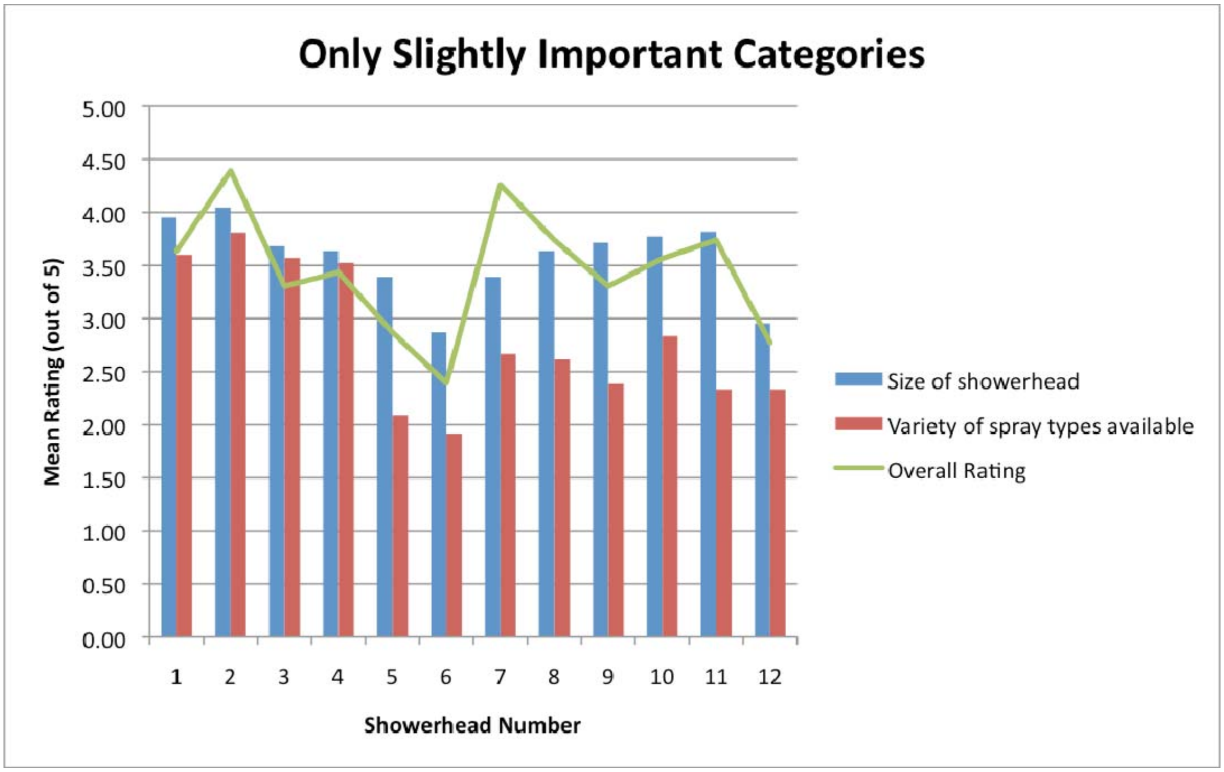
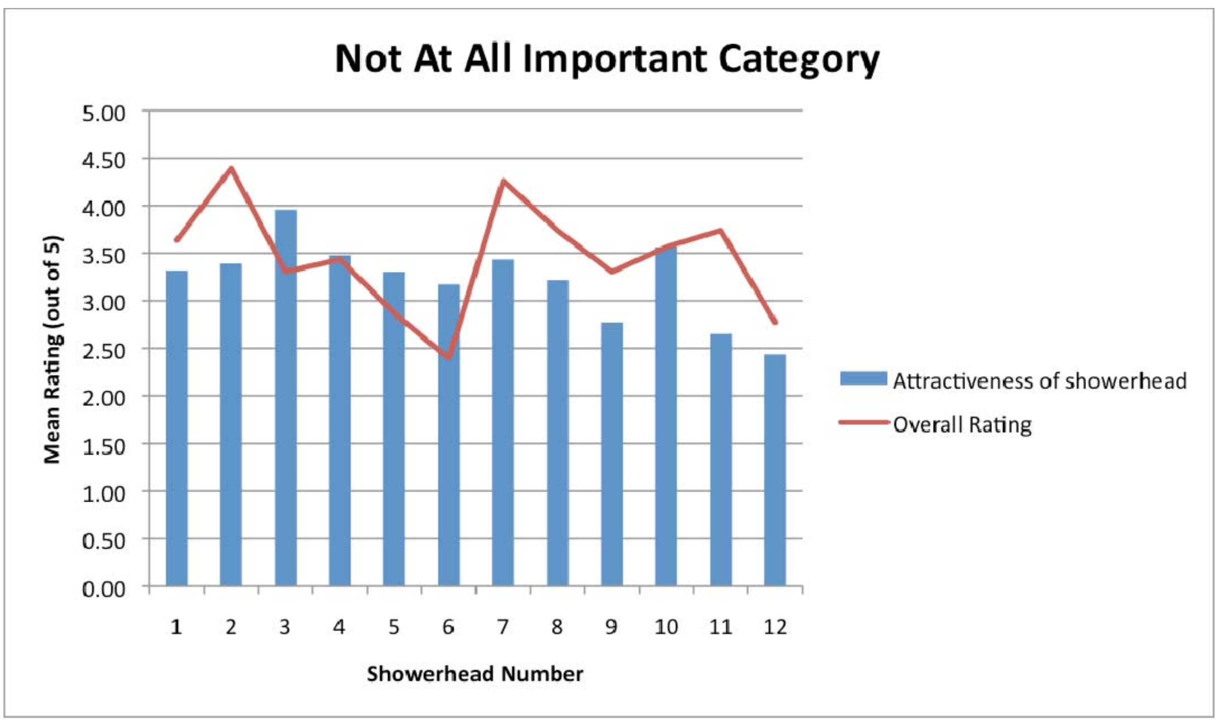
Appendix B – Remaining Shower Category Rankings






Only Slightly Important Categories
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Mean Rating (out of 5)
1
2
3
4
5
6
7
8
9
10
11
12
Showerhead Number
Size of showerhead
Variety of spray types available
Overall Rating


Not At All Important Category
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Mean Rating (out of 5)
1
2
3
4
5
6
7
8
9
10
11
12
Showerhead Number
Attractiveness of showerhead
Overall Rating