Retrofitting Showerheads in Dalhousie University Residences: A Cost-Benefit Analysis

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Abstract

With the human population expected to double by 2027, resource depletion has increasingly becoming a cause for concern. Only 2.5 percent of the earth's water supplies are classified as fresh, and even less is accessible. Water conservation, through demand management, is therefore an essential element to sustainable communities. According to Environment Canada, retrofitting inefficient water fixtures can reduce consumption by 40 percent (Environment Canada, 2008). For this study a cost-benefit analysis was conducted to determine the feasibility of replacing the existing showerheads in two of Dalhousie University's residence buildings, Howe Hall and Shirreff Hall, with low-flow models. Both the economic and environmental implications of such a retrofit were taken into account. Three main research tools were used to gather information for the cost-benefit analysis: face-to-face interviews, direct measurement, and document analysis. The study found that Howe Hall would save $8,371.66 in the first year and $9,929.93 in subsequent years by switching to low-flow showerheads with a flow rate of 5.7 lpm. The payback period would be less than 2 months. In addition, 6,276,822 litres of water would be saved per school year. Shirreff Hall would save $11,915.92 in the first year following the retrofit and $12,784.69 in subsequent years, with a payback period of less than 1 month. Meanwhile, 8,081,344.13 litres of water would be saved per school year. These results indicate that the benefits of replacing existing showerheads in these buildings would noticeably outweigh the costs. It is therefore recommended that both Howe and Shirreff switch to low-flow showerheads as soon as possible. It is also hoped that the findings of this study will contribute to a campus wide effort to reduce water consumption at Dalhousie, and thus be an integral part of the Greening the Campus movement.

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1.0 Introduction

1.1 Background

With the current rate of human population growth, essential resources are quickly becoming depleted. Water is one such resource that is easily taken for granted. Though 70 percent of the earth is covered in water, only 2.5 percent is classified as freshwater and less than one percent of the world's freshwater supplies are available for human consumption (Environment Canada, 2008). This precious and important resource is vital to human existence, yet it is being contaminated and wasted with reckless abandon.

The human population continues to increase and is expected to double by the year 2027 (Pinnacle Environmental Technologies Inc., 2008). It is therefore becoming increasingly urgent to mitigate freshwater deterioration and depletion in order to support our growing population (Pinnacle Environmental Technologies Inc., 2008). Water conservation is one solution to the depletion of our freshwater resources. Water conservation means "doing the same with less, by using water more efficiently or reducing where appropriate, in order to protect the resource now, and for the future" (Environment Canada, 2008).

1.2 Research Problem

Between 1972 and 1996, Canada's rate of water withdrawals increased by almost 90 percent, to 45 billion m^3/yr (Environment Canada, 2008). Restoring water quality to acceptable standards for public use is an expensive and energy intensive process. Rather than expanding current systems, or searching for new water supplies to meet increasing demands, municipal governments across Canada are now taking a different approach towards the issue of water waste. According to Environment Canada, "*demand* *management*, incorporating water efficient applications, is rapidly gaining popularity as a low cost, effective way to get more service out of existing systems, thus delaying or deferring the need for constructing new works" (Environment Canada, 2008). By retrofitting, or replacing, existing water fixtures with water-efficient models, a typical household can reduce water consumption by 40 percent with no effect on lifestyle (Environment Canada, 2008).

Dalhousie University has demonstrated dedication to sustainability by signing three sustainability-related international declarations, including the Talloires Declaration; and by creating a sustainability office that is led by a full-time director. There are also a number of student groups, such as SustainDal, that are addressing sustainability issues on campus. However, despite such efforts Dalhousie received an overall grade of C+ in the 2009 college sustainability report card (Sustainable Endowments Institute, 2008). It is thus evident that steps must be taken for Dalhousie to meet its environmental goals (Sustainable Endowments Institute, 2008).

This study sought to address one possible step Dalhousie could take to further sustainability on campus by reducing water consumption. A cost-benefit analysis was conducted to determine the feasibility of replacing existing showerheads in Dalhousie residence buildings with water-efficient models, also known as low-flow showerheads. The scope of this analysis was limited to two campus residence buildings, Howe Hall and Shirreff Hall. One particular low-flow showerhead model was chosen and compared to those presently installed in these two residences. Both the economic and environmental impacts of installing low-flow showerheads were taken into account to provide a thorough and well-rounded analysis of possible costs and benefits. By outlining the benefits of replacing current water fixtures with low-flow models, it is hoped that this study will help to convince university officials that switching to water-efficient fixtures will significantly reduce the amount of water wasted on campus, thus saving the university money and helping Dalhousie meet its Greening the Campus goals.

1.3 Relevant Community

1.3.1 Howe Hall

Howe Hall was chosen because it is the largest residence on campus, and therefore uses the highest volume of water, and has showerheads with flow rates comparable to those of most other residence buildings. Completed in 1960, Howe Hall is located on the Studley campus, at 6230 Coburg Road. This residence provides accommodation for approximately 711 Dalhousie students in six different houses: Bronson, Fountain, Henderson, Smith, Cameron, and Studley (Dalhousie University Archives and Special Collections).

While the building's newest addition, Fountain House, had low-flow showerheads in place when it opened in 2002, water-efficient fixtures have yet to be installed in Howe's older houses: Bronson, Smith, Henderson, and Cameron, in which there are 113 showers with a flow rate of 9.5 litres per minute (lpm).

1.3.2 Shirreff Hall

Shirreff Hall was chosen because it is the oldest residence on campus and has water fixtures with the highest flow rates of all Dalhousie residences. Completed in 1923, the residence is located on the Studley campus, at 6385 South Street. Shirreff provides accommodation for 442 students in four houses: New Eddy, Old Eddy, Newcombe and the Annex (Dalhousie University Archives and Special Collections). Shirreff Hall has a total of 63 showers: 45 with a flow rate of 15.2 lpm and 18 with a flow rate of 9.5 lpm.

1.4 Significance for Campus Sustainability

Reducing natural resource use, including water consumption, is listed as one of Dalhousie's key sustainability goals (Office of Sustainability, 2008). Since low-flow showerheads can help reduce water consumption, a thorough consideration of installing these fixtures throughout the Dalhousie campus is important. Due to time and financial constraints, this study only considered the implementation of such fixtures in two campus communities: Howe Hall and Shirreff Hall residences. However, these residences collectively reflect the water consumption habits of over 1,000 Dalhousie students, thus making this study a valuable step towards reducing water consumption at the university.

Greening the Campus projects help raise awareness on sustainability issues affecting university communities. Specifically, this project addressed the effects of water consumption habits and one of the strategies available to decrease this consumption. This assessment also offers a framework that can be applied to future studies assessing the feasibility of installing low-flow fixtures in different buildings on campus. This study can therefore be a significant contribution to the Greening the Campus movement, as water conservation is an essential element of a sustainable community.

2.0 Research Methods

This section will describe the methods used to conduct this cost-benefit analysis of installing low-flow showerheads in Dalhousie University's Howe Hall and Sherriff Hall residences. The cost-benefit analysis considered both the economic and ecological implications of retrofitting showerheads in Dalhousie's residences. The advantages and disadvantages of both the current and low-flow showerheads were weighed using a variety of quantitative and qualitative methods.

Triangulation was used to ensure the overall reliability and validity of this study. Triangulation consists of using multiple data sources to gain information that is as accurate as possible (Palys and Atchison, 2008: 42). According to Palys and Atchison (2008: 427), reliability is "the degree to which repeated observation of a phenomenon…yields similar results." Validity refers to "whether research measures what the researcher thinks is being measured" (Palys and Atchison, 2008: 430). Specifically, the information for this project was gathered using three main research tools: face-to-face interviews, direct measurement, and document analysis. Within each method of analysis, measures were taken to further guarantee reliability and validity.

2.1 Research Tools

2.1.1 Face-to-Face Interviews

Face-to-face interviews were conducted with two key stakeholders in relation to the project. These primary actors were selected based on their knowledge and decision-making power concerning residence showerheads. The interviewees were Rochelle Owen, Director of Dalhousie's Office of Sustainability, and Mateo Yorke, Facilities Building Manager for Shirreff Hall.

The decision to conduct face-to-face interviews, rather than other interview techniques, was chosen to cut back on time and costs, to ensure the completion of the interviews, and to maintain the clarity of both the questions asked, and the answers provided (Palys and Atchison, 2008: 157). Allowing for the clarification of questions and answers helped to ensure the reliability and validity of the information gathered. Combinations of open-ended and structured questions were used. Open-ended questions were used to obtain the respondent's opinion on a given subject; this was the main type of questioning used. Closed questions were used less frequently, but allowed for more specific responses. The interview questions generally followed a funnel approach. For any given topic, broad, open-ended questions were asked first, followed by more specific, structured questions. According to Palys and Atchison (2008: 173), beginning an interview with open-ended questions allows the respondent to explain their thoughts and concerns in their own words. The addition of structured questions then allows the researcher to focus in on key points of interest. See Appendixes A-E for details on the interview process.

2.1.2 Direct Measurement

The flow rates of the currently installed showerheads in Howe Hall and Shirreff Hall were compared to the flow rate of the Earth Massage Low-Flow Showerhead, the model chosen for this assessment, to determine the accuracy of advertised flow rates. Flow rates, in litres per minute (lpm), were calculated (see Appendix F for calculations) using a bucket of computable dimensions, a ruler, and a stopwatch. After turning on the shower, the bucket was placed under the stream of water. The bucket collected water for ten seconds, as measured by a stopwatch. After ten seconds, the bucket was removed from under the stream and the shower was turned off. The volume of water collected was then calculated. To ensure reliability, this method was repeated five times to obtain an average. The following formula was used to calculate flow rate:

$$\frac{\text{Ave. Calculated Volume of Water } (\text{cm}^3)}{10 \text{ seconds}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{1 \text{ litre}}{1000 \text{ cm}^3} = \text{Flow Rate (in lpm)}$$

The Earth Massage Low-Flow Showerhead was chosen based on its availability and the fact that it was recommended by Dalhousie's Office of Sustainability, the Ecology Action Center, and the Halifax Water Commission. Reliability was guaranteed by testing each bathroom facility multiple times and by using the facilities in Howe Hall and Sherriff Hall, the residences in question.

2.1.3 Document Analysis

The documents analyzed included both scholarly sources and grey material. Scholarly sources included peer-reviewed studies and papers related to this project. The review of other academic papers, whose goals aligned with those of this study, helped to determine which methods and measurements would be best suited for this study. A variety of grey material was also examined, including the websites of government and environmental organizations. For instance, the Halifax Water Commission provided information on water rates and fees, which add up to $1.5820 per m3, or $.0015820 per L. To ensure reliability, the flow rates of the currently installed showerheads and of the low-flow model were collected from a variety of sources. Rochelle Owen provided an audit, consisting of the total number of showerheads currently in each of Dalhousie's residences and their respective flow rates. The flow rate of the low-flow showerhead was inscribed on the fixture itself, which was purchased for $6.00 + HST at the Halifax Water Commission's office (450 Cowie Hill Rd., Halifax, NS).

Collection and analysis of these documents was primarily carried out using *a priori* analytical methods, as most of the research material was analyzed with specific data and/or information of interest in mind. However, *a posteriori* analytical methods was also used to extrapolate the key themes that emerged in literature examining the environmental costs and/or benefits of reducing water consumption.

2.2 Cost-Benefit Analysis

The three methods described above provided enough information to produce a comprehensive cost-benefit analysis of retrofitting showerheads in Howe Hall and Shirreff Hall residences. The numerical and statistical data collected was inserted into a series of equations that determined the cost and water savings associated with retrofitting these showerheads (see Appendix G for calculations). The following assumptions were made for the water and cost saving calculations:

- People aged 18-34 shower for an average of 9.6 minutes (CNW Group Ltd, 2008)
- Each resident showers once per day
- Howe Hall has 711 residents and Shirreff Hall has 442 residents
- There are 242 days in a school year, from September 1st – May 1st
- Each resident showers in their building's facilities for the entire 242 days of the school year
- Each showerhead would take 10 minutes to install
- Dalhousie would buy 500 showerheads at a time, at the reduced cost of $4.49/unit

From these assumptions, calculations were made to compare the current rate of water consumption and price paid per school year to the amount of water consumed and associated costs if low-flow showerheads were to be installed. Cost and water savings were then determined, as well as the payback period (see Appendix G for a break down of the calculations).

The average flow rates obtained by direct measurement were not used for this calculation. Instead, the Earth Massage's advertised flow rate, of 5.7 lpm, and the flow rates calculated by the previous showerhead audit were used. The following equation was used to determine the price paid for shower water per school year:

(Shower time) x (Flow rate) = L per shower

(L per shower) x (# of Students) = L per day
(L per day) x ($.0015820 per L) = $ per day
($ per day) x (242 days) = Total $ on showers each school year

Once labour and material costs were taken into account, the cost savings on water bills was determined for the first year following the retrofit, and then for subsequent years. A second equation was used to determine the amount of water consumed for showering purposes per school year:

(Shower time) x (Flow rate) = L per shower
(L per shower) x (# of Students) = L per day
(L per day) x (242 days) = L of water per school year

2.3 Delimitations

Due to time constraints, certain delimitations were set prior to commencing this project. First, only two out of a possible ten residences were chosen for investigation. This allowed for a more focused and detailed study, and more time to ensure the reliability of the direct measurements taken in these two residences. Second, showerheads were specifically targeted for this study, instead of gathering data on all water fixtures in residences. This allowed for a more comprehensive account of one specific factor contributing to both the financial and ecological costs of water consumption. Finally, only one low-flow showerhead model was chosen for comparison with the currently installed models, as the Earth Massage showerhead was recommended by a number of sources.

2.4 Limitations

A number of limitations arose throughout the process of gathering and analyzing data. During the direct measurement of flow rates, it was noted that water pressure, and therefore flow rates, varied unpredictably. Consequently, the flow rates advertised on both the current showerheads and on the low-flow model often conflicted with the flow rates observed during the direct measurement process. Using the flow rates obtained from direct measurement would therefore have compromised the study's reliability. In addition, the majority of the showerheads currently installed in Shirreff Hall are structured in a way that does not allow for easy removal. These showerheads are connected to a square base, rather than simply screwed onto a pipe. Therefore, the researchers were not able to install the low-flow model in these particular showers. Finally, a number of emails were sent out to potential interviewees, but many did not respond. Repeated attempts were made to contact these primary actors, yet only two interviews were conducted. This hindered the study, as further insights into the benefits and barriers of retrofitting showerheads in residences would have been beneficial.

3.0 Results

3.1 Research Tools

3.1.1 Face-to-Face Interviews

The Director of Dalhousie's Office of Sustainability, Rochelle Owen

Rochelle Owen recommended using the Earth Massage low-flow showerhead for the cost-benefit analysis, as this is the model she is currently considering for installation in residences. Rochelle's goal is to have all residence showerheads retrofitted at the same time, as the fixtures would be purchased in bulk from Flapperless Inc. at the cost of $4.49 per unit, for 500 units. According to Rochelle, one drawback of low-flow showerheads is that students complain about them. For this reason, she recommends switching to low-flow showerheads in the summer months, when there are no students in the residences. Since the Office of Sustainability has limited resources, Rochelle gives energy issues greater priority than water conservation, due to the immensity of the energy problem and the challenges in addressing them.

Facilities Building Manager for Shirreff Hall, Mateo Yorke

Mateo did not know when the current showerheads were last updated. He has, however, discussed the possibility of installing low-flow showerheads, and has said that "it is not a question of if; it is a question of when". There is a possibility that low-flow showerheads will be installed this summer. Mateo did not see any social barriers to making the switch to low-flow showerheads, except for the possibility of student dissatisfaction with the new fixtures. For this reason, he also recommended that the switch be done in the summer. The main factor that will influence how soon this project goes through is money. The residences allocate their budget in the summer, so whether they make the switch will depend on financial feasibility. In terms of financial barriers, Mateo said that labour costs were the biggest constraint – not material costs.

3.1.2 Direct Measurement

The average flow rate of the current showerhead tested in Fountain House was 5.035 litres per minute (lpm) while the low-flow showerhead had an average flow rate of 7.016 lpm (see Table 1). The average flow rate of the current showerhead tested in Bronson House was 9.161 lpm while the low-flow showerhead had an average flow rate of 6.487 lpm. The average flow rate of the current showerhead tested in Cameron House was 8.509 lpm while the low-flow showerhead had an average flow rate of 7.614 lpm. The average flow rate of the current showerhead tested in Smith House was 7.261 lpm while the low-flow showerhead had an average flow rate of 7.207 lpm. The average flow rate of the current showerhead tested in Henderson House was 8.632 lpm while the low-flow showerhead had an average flow rate of 6.949 lpm. Finally, the average flow rate of the current showerhead tested in Old Eddy was 9.866 lpm while the low-flow showerhead had an average flow rate of 7.424 lpm. See Appendix F for calculations.

Table 1. Observed average flow rates (in litres per minute) of current and low-flow showerheads tested in 5 houses in Howe Hall (Fountain, Bronson, Cameron, Smith, and Henderson) and 1 house in Shirreff Hall (Old Eddy).

Type of showerhead	**House**					
	Fountain	**Bronson**	**Cameron**	**Smith**	**Henderson**	**Old Eddy**
Current	5.035	9.161	8.509	7.261	8.632	9.866
Low-Flow	7.016	6.487	7.614	7.207	6.949	7.424

3.1.3 Document Analysis

Documents were analyzed to assess the environmental costs and benefits associated with installing low-flow showerheads. The following is a summary of the environmental benefits associated with retrofitting water fixtures:

- Reduced demand on municipal water supply systems, which may help to avoid any expansion of supply systems and water treatment facilities (Engineering Technologies Canada Ltd, 2001).
- Reduced energy use and, therefore, lower GHG emissions (Nova Scotia Power, 2005).
- Approximately 18 percent of residential energy use goes towards heating water (NRCAN, 2008).
- Reduced waste water, which can significantly reduce energy consumption because less energy is needed to run wastewater pumps (Dillon Consulting Ltd., 2005).
- Reducing waste water will also help to reduce the contaminants that enter the environment through wastewater (Clean Nova Scotia, 2009).
- As demand continues to increase, freshwater resources are becoming depleted (Environment Canada, 2008). Reducing water consumption will help to preserve Canada's precious freshwater resources.

3.2 Cost-Benefit Analysis

The resultant cost and water savings if each residence building were to switch to the Earth Massage low-flow showerheads are below. For a breakdown of the calculations see Appendix G.

3.2.1 Howe Hall

Material Costs: $507.37
Labour Costs: $1,050.90
Cost Savings the First Year (Includes Installation Costs): $8,371.66
Cost Savings Subsequent Years: $9,929.93 (see Figure 1)
Water Savings per School Year: 6,276,822 litres (see Figure 2)
Payback Period: less than 2 months

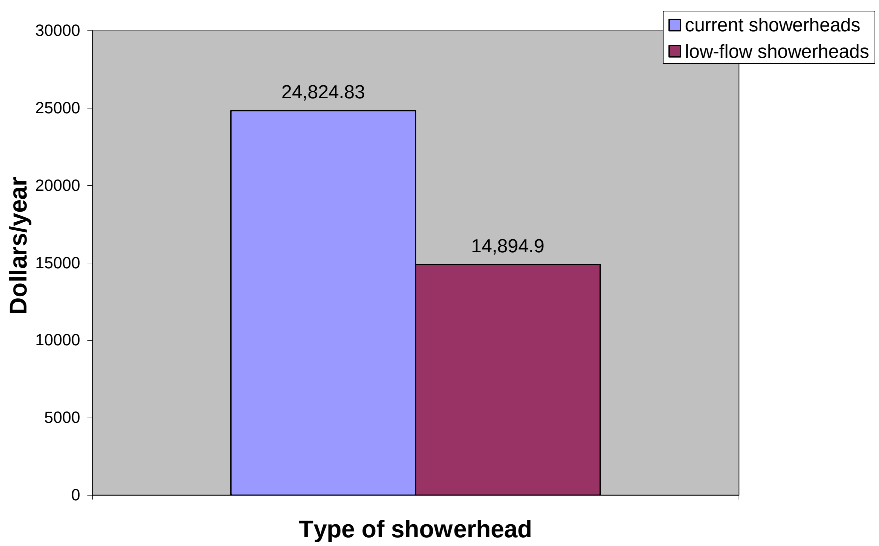

Figure 1: The price paid for shower water each school year in Howe Hall, with existing showerheads (blue) and if low-flow showerheads were installed (purple). Cost savings on water bill is $9,929.93 per school year.

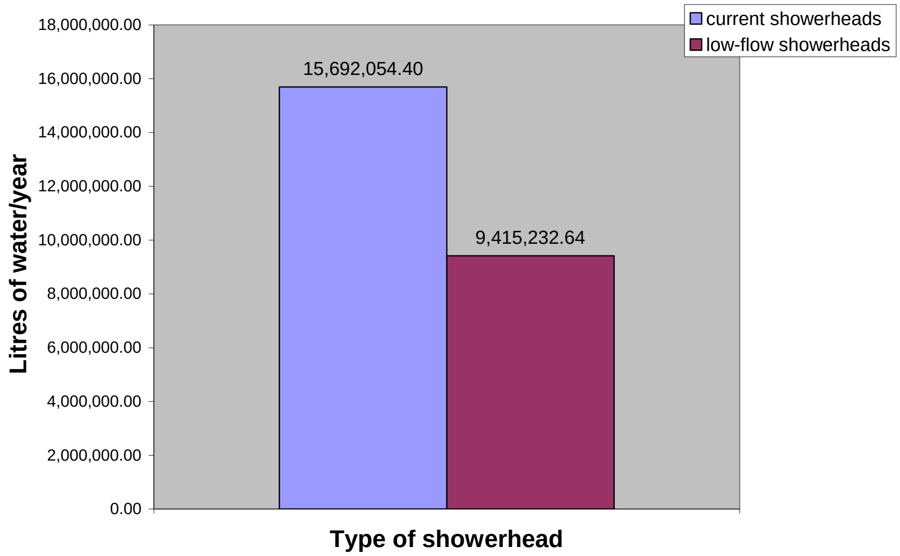

Figure 2: The amount of water (in litres) consumed by showers in Howe Hall each school year. The blue column represents water consumed by existing showerheads each year while the purple column represents the projected rate of water consumption each year if low-flow showerheads were installed. Water savings is an estimated 6,276,822 litres per school year.

3.2.2 Shirreff Hall

Material Costs: $282.87
Labour Costs: $585.90
Cost Savings the First Year (Includes Installation Costs): $11,915.92
Cost Savings Subsequent Years: $12,784.69 (see Figure 3)
Water Savings per School Year: 8,081,344.13 litres (see Figure 4)
Payback Period: less than 1 month

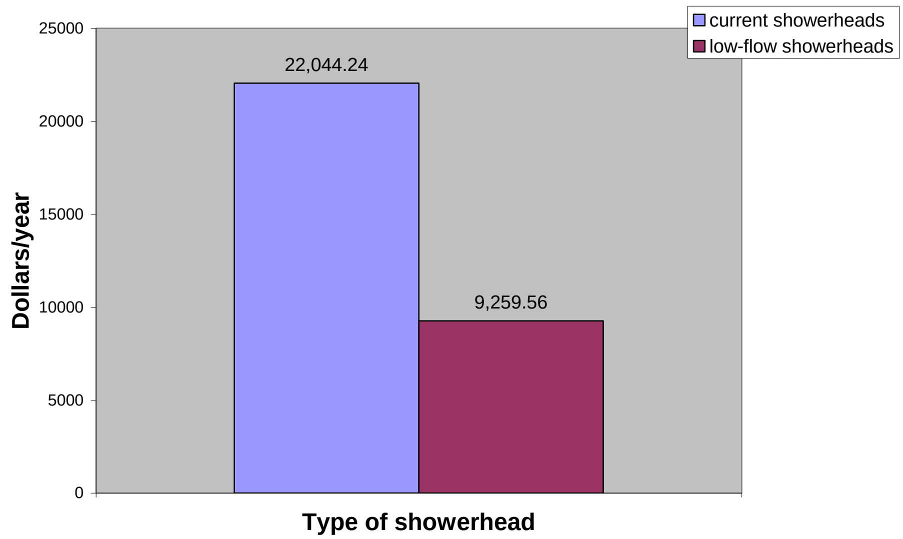

Figure 3: The price paid for shower water each school year in Shirreff Hall, with existing showerheads (blue) and if low-flow showerheads were installed (purple). Cost savings on water bill is $12,784.69 per school year.

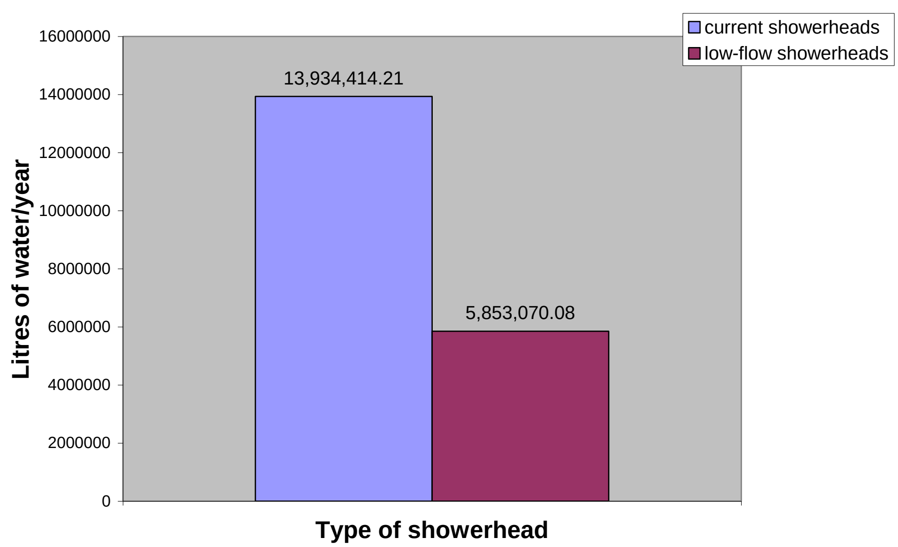

Figure 4: The amount of water (in litres) consumed by showers in Shirreff Hall each school year. The blue column represents water consumed by existing showerheads each year while the purple column represents the projected rate of water consumption each year if low-flow showerheads were installed. Water savings is an estimated 8,081,344.13 litres per school year.

4.0 Discussion

The purpose of conducting this study was to weigh the costs of installing low-flow showerheads in Dalhousie residences against the benefits of doing so, in hopes that it would provide incentive for water conservation efforts on the Dalhousie campus. The results of this study point to numerous benefits, both environmental and economic, that noticeably outweigh the costs. The significant findings of this study are summarized and described below.

The flow rates tested demonstrated variation from the advertised flow rates. This suggests that other factors, such as water pressure, influence flow rates. This raises concern over the accuracy of the water and cost savings calculations, since they were based on advertised flow rates. However, since the variation was not substantial, and the cost and water savings were so great, it is unlikely that a slight change in flow rates would significantly change the undertone of the results found in this study.

This study revealed that both residence buildings would considerably decrease their water consumption each year as a result of switching to low-flow showerheads. Howe could potentially save 6,276,822 litres of water per school year while Shirreff could save 8,081,344.13 litres. As a result, both residences also stand to benefit from substantial cost savings if they make this switch. Howe Hall would save approximately $8,371.66 in the first year following the retrofit and $9,929.93 in subsequent years. Meanwhile, Shirreff Hall would save $11,915.92 in the first year and $12,784.69 in subsequent years. The fact that Shirreff Hall will experience significantly greater water and cost savings compared to Howe Hall speaks to the difference a low-flow showerhead can make. Because Sherriff Hall has 45 showerheads with a flow rate of 15.2 lpm, in contrast to Howe Hall's 9.5 lpm showerheads, this residence will receive higher savings. It is also important to note that both residences will experience cost savings within the first year following the retrofit, even when taking into account the installation costs, which include both labour and materials. It is anticipated that the payback period would be less than two months for Howe Hall and less than one month for Shirreff Hall (for a breakdown on how this was calculated see Appendix G). This makes the installation costs practically inconsequential.

It is also important to note that the cost-benefit analysis did not include in its calculations the energy savings that would be gained by reducing water consumption. This is a significant oversight, although intentional due to feasibility limitations, seeing as how approximately 18 percent of residential energy use is for heating water (NRCAN, 2008). Furthermore, Nova Scotia Power (2005) recommends switching to low-flow fixtures because they will yield substantial energy savings. Considering the energy savings, both residences will experience even greater cost savings as a result of installing low-flow showerheads.

The document analysis further adds to a long list of benefits that would be gained by installing low-flow showerheads. Literature and previous studies reveal significant environmental benefits from reducing water consumption, waste water and energy use. Meanwhile, environmental costs were not encountered in the literature review. It is important, however, to recognize that low-flow showerheads require additional materials and energy to produce, and that replacing working showerheads will produce unnecessary waste. While this is important to consider, the long list of environmental benefits associated with low-flow showerheads surely outweigh the costs.

While it had been expected that the interviews would reveal significant barriers to installing low-flow showerheads in residences, they instead revealed minimal barriers and indicated that a switch to low-flow showerheads will likely take place soon, perhaps even this summer. This will depend on the allocations of residence budgets. The interviews therefore pointed to financial constraints as opposed to social constraints that will influence how long it will take to implement a low-flow shower initiative. It is hoped that this study will erode these perceived financial constraints, since it has been demonstrated that residences will experience financial gain well within the first year upon installing low-flow showerheads.

Similar results were found in a previous study that examined low-flow fixtures in the Dalplex fitness centre (Richardson-Prager *et al.*, 2004). This study found that installing low-flow showerheads in the Dalplex would substantially reduce water consumption and result in significant cost savings, with a very short payback period. Richardson-Prager *et al.* (2004: 33) recommended and used a low-flow showerhead with a flow rate of 7.5 lpm in their study. This is a higher flow rate than that of the showerhead recommended and used in this study (5.7 lpm), supporting the notion that switching to lower-flow showerheads will result in significant cost and water savings. This further adds to the argument that Dalhousie has a lot to gain by installing low-flow fixtures on campus.

The results of this study also align with the results of studies conducted on other university campuses. Cambridge University, for instance, carried out retrofits of various types of water fixtures, including showerheads. As a result, they saved approximately 121 million litres of water and $282,000 each year, with a payback period of only 1.8 years (Richardson-Prager *et al.*, 2004: 40). While this is a longer payback period than what this study found, it is likely because the initiative was of a much larger scale and included the installation of more expensive fixtures, such as ultra-low-flush toilets. Cambridge University's retrofits provide a concrete example of the benefits available if low-flow fixtures are installed, and therefore support the results of this study, which overwhelmingly favour a switch to low-flow fixtures in Dalhousie residences.

The findings of this study, supported by the results and conclusions of similar research, support the promotion of low-flow showerheads. The results further suggest that other water conservation measures on campus could yield tremendous cost savings and contribute to a more sustainable campus, and should therefore be pursued.

5.0 Recommendations and Conclusions

The results of this project indicate that it would be both economically and ecologically beneficial for Shirreff Hall and Howe Hall to replace their current showerheads with low-flow models. It is therefore recommended that both these residences replace their current showerheads with the low-flow Earth Massage model. It is also recommended that the results and methods of this study be applied to other residences on campus to promote further water, cost, and energy savings. Furthermore, the results and methods of this project should be used to encourage and inform future studies surrounding water conservation on the Dalhousie campus and on other university campuses.

While water conservation is a topic that should be explored and considered throughout the Dalhousie campus, focusing on residences, such as Howe Hall and Shirreff Hall, is an important first step and will provide a valuable framework for future studies in this area. It is hoped that this project will contribute to a campus wide effort to reduce water consumption at Dalhousie, and thus be an integral part of the Greening the Campus movement.

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7.0 Appendixes

7.1 Appendix A – Recruitment Letter Sent to Interviewees

Dear Interviewee,

I am writing to request your time for an interview at your earliest convenience. I am a member of a group project for a third year environmental science class at Dalhousie University. Our group is conducting a cost-benefit analysis of installing low-flow showerheads and aerators in two Dalhousie Residences: Howe Hall and Sheriff Hall. The findings of the study will be compiled into a final report that will be submitted to the appropriate individuals at Dalhousie University. It is our hope that this study will demonstrate the advantages of switching to low-flow water fixtures and thereby contribute to efforts towards a more sustainable campus.

Having the opportunity to interview you will add valuable insight and information to the benefits and drawbacks of installing these fixtures in the two aforementioned residence buildings. If you agree to be interviewed two members of the group would meet with you to conduct the interview. Prior to conducting the interview we would ask that you read an information letter about the study. If you agree to be interviewed then you must sign the consent form. The interview can be completed in half an hour. Wse are flexible as to the time and location of the interview, so both can be decided upon to best accommodate your needs.

Please contact me at _____ if you have any questions or concerns or to set up an interview.

We greatly appreciate taking the time to read this letter and we look forward to hearing from you,

Thank you

7.2 Appendix B –Information and Cover Letter

Dear Interviewees,

To begin with, we would like to sincerely thank you for lending us your time and participation for our research project. By taking the time to answer our questions you will be providing valuable information and insight into our research topic. The project for which you are answering questions is for a Dalhousie University third year Environmental Science class. We are conducting a cost-benefit analysis of installing low-flow showerheads in two Dalhousie residence buildings: Sherriff Hall and Howe Hall. The results from this analysis will be compiled into a final report to be submitted to the appropriate individuals at Dalhousie. It is our hope that this project will demonstrate the advantages of such retrofits to existing water infrastructures on campus. The project would, therefore, contribute to the Greening the Campus movement here at Dalhousie University.

During this interview you will be asked questions pertaining to your specific area of expertise and knowledge. The questions will be geared towards gaining a better understanding of existing water infrastructure in Howe Hall and Sherriff Hall, existing incentives and barriers to installing low-flow water fixtures and the benefits and drawbacks of different low-flow water fixtures. Your answers will then guide our project design and help to determine the issues/areas that the project will focus on to effectively address water use and efficiency in these two residences. Your answers will also add personal insight into the benefits and costs of installing low-flow fixtures that are harder to access from existing data.

We ask you to please answer each question with honesty and to the best of your knowledge. Should you at any time feel that answering a particular question makes you feel uncomfortable or that the question is inappropriate please inform the interviewer and refrain from answering the question. Your input is valuable for designing future interviews. Constructive criticism is always helpful and the decision to answer each question is always at your discretion. Should you choose, your name does not have to be mentioned in the final report. The location of the interview can also be chosen to best accommodate your schedule and needs.

We thank you so much for your time and welcome any questions or concerns at any stage of the process,

Sincerely,

Lara Green
Brent Adams
Julie Quance
Tippy Scott
Renée Huntley

7.3 Appendix C – Interview Questions

Facilities Building Manager for Shirreff Hall (Mateo Yorke)

1. When were the current showerheads installed or last updated?

2. Do you have any plans to update your current showerheads?

3. Have you considered installing low-flow showerheads? Why/Why not?

4. If you have considered low-flow showerheads, why has it not yet been done?

5. What do you think are the major constraints to installing low-flow fixtures in Dalhousie residences?

6. To what extent have Dalhousie students and/or staff been calling for the installation of low-flow water fixtures? Please explain:

Director of Dalhousie's Office of Sustainability (Rochelle Owen)

1. Is there any specific brand of showerhead that you would recommend for water conservation?

2. What are the benefits and/or drawbacks of different types of low-flow showerheads?

4. To your knowledge, what is the largest factor preventing the transition to low-flow showerheads on Dalhousie campus?

5. Would Dalhousie purchase showerheads from a supplier (in bulk)? At what cost?

6. Dalhousie has many improvements to make for the Greening the Campus movement. In your opinion, considering the areas Dalhousie needs to improve in, where does water conservation rank on a scale of 1-10, 1 being not needed and 10 being immediate attention necessary? Please explain your answer.

7.4 Appendix D – Informed Consent Form

Dalhousie University
Researchers: Tippy Scott, Julie Quance, Brent Adams, Renée Huntley, and Lara Green
Supervisor: Dr. Tarah Wright

Dear Participant,

You are being asked to participate in a student project for a course entitled "Campus as a Living Laboratory" at Dalhousie University in the Department of Environmental Science. We are interested in your knowledge and perspective regarding the water fixtures and water conservation in Dalhousie University's Howe Hall and Sherriff Hall residences. We are conducting a cost-benefit analysis to determine the feasibility of installing low-flow water fixtures in Howe Hall and Sherriff Hall residences. We are conducting these interviews with residence staff and environmental actors because you have the knowledge regarding the current water fixtures, low-flow models, and what is involved in decision-making regarding the installation of new fixtures. With your permission, we plan to audio-record the interview. Please note the following:

1) Participants' anonymity will be protected if so desired: names will be used unless the participant chooses to be anonymous. Please check below if you do not want your name to be revealed in our report.

    I wish to remain anonymous ____

2) Participation in the interview is entirely voluntary and participants can withdraw from the interview at any point.

3) The interview will be conducted in a location of the participant's choosing.

Your knowledge and perspective regarding the water fixtures in Dalhousie residences is a valuable asset to our research project, and to the Greening the Campus Movement. By participating in this research you are helping to improve knowledge about water fixtures and conservation on campus.

When you sign this consent form you are agreeing to allow us to record our interview and include the findings of the interview in our research project. Thank you for contributing your time and expertise to improve the understanding of the water fixtures and conservation in Dalhousie University residences. Should you have any further questions about the research project or your involvement in it, please contact Dr. Tarah Wright at Dalhousie University via email at tarah.wright@dal.ca.

I have read the consent form and I understand it. I consent to participate in this interview and to have it recorded.
Signature of Student Researcher ____
Signature of Participant ____
Date____

7.5 Appendix E – Interviewees' Consent

Rochelle Owen's consent:

------ Forwarded Message
From: Rochelle Owen <rjowen@dal.ca>
Date: Tue, 24 Mar 2009 11:32:15 -0300
To: 'Lara Green' <lr422634@dal.ca>
Subject: RE: Consent Form

Please use this email as my formal consent. Let me know when your presentation is. I may have meetings but might be able to make it.

Rochelle Owen
Director - Office of Sustainability
Dalhousie University
1226 LeMarchant St.
Halifax, N.S.
B3H 3P7
902-494-7448 (ph)
902-494-1334 (fax)
rjowen@dal.ca
sustainability.dal.ca

Mateo Yorke's Consent:

------ Forwarded Message
From: Mateo Yorke <myorke@hcasmail.housing.dal.ca>
Date: Mon, 06 Apr 2009 09:31:24 -0300
To: Lara Green <lr422634@dal.ca>
Subject: Re: Consent Form

Hi Lara,

You can pick up the form anytime today at Risley (I'll be there after 10:30 or so). Otherwise, you may take this e-mail as my consent for participating in the interview and using my voice recording in your project.

Best of luck!

Mateo

7.6 Appendix F – Flow Rate Calculations (Direct Measurement Results)

Table 1. Height of water (in cm) collected in a bucket when current and low-flow showerheads were tested in Fountain House (Howe Hall).

Fountain House	
Current Showerhead (h in cm)	Low-Flow Showerhead (h in cm)
7.60	10.5
7.50	10.5
7.40	9.80
7.30	10.5
7.30	10.4
Avg = 7.42	Avg = 10.34

$$\frac{\text{Ave. Calculated Volume of Water (cm}^3\text{)}}{\text{10 seconds}} \times \frac{\text{60 seconds}}{\text{1 minute}} \times \frac{\text{1 litre}}{1000 \text{ cm}^3} = \text{Flow Rate (in lpm)}$$

Volume (in cm^3) = $\pi r^2 h$, where h is the average height of water collected in a bucket over a 10 seconds period (in cm) and r is the radius of the bucket (r = 6 cm).

Flow Rate of Current Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6 \text{ cm})^2(7.42 \text{ cm})$
Volume = 839.2 cm^3
Flow Rate (in lpm) = $(839.2 \text{ cm}^3/10 \text{ s}) \cdot (60\text{s}/1 \text{ min}) \cdot (1\text{L}/1000 \text{ cm}^3)$
Flow Rate = 5.035 lpm

Flow Rate of Low-Flow Showerhead:
Volume = $\pi r^2 h$
Volume = $\pi(6 \text{ cm})^2(10.34 \text{ cm})$
Volume = 1169.4 cm^3
Flow Rate (in lpm) = $(1169.4 \text{ cm}^3/10\text{s}) \cdot (60 \text{ s}/1 \text{ min}) \cdot (1\text{L}/1000 \text{ cm}^3)$
Flow Rate = 7.016 lpm

Table 2. Height of water (in cm) collected in a bucket when current and low-flow showerheads were tested in Bronson House (Howe Hall).

Bronson House	
Current Showerhead (h in cm)	Low-Flow Showerhead (h in cm)
13.0	9.50
14.0	9.50

13.6	9.70
13.2	9.60
13.7	9.50
Avg = 13.5	Avg = 9.56

$$\frac{\text{Ave. Calculated Volume of Water (cm}^3)}{\text{10 seconds}} \times \frac{\text{60 seconds}}{\text{1 minute}} \times \frac{\text{1 litre}}{\text{1000 cm}^3} = \text{Flow Rate (in lpm)}$$

Volume (in cm^3) = $\pi r^2 h$, where h is the average height of water collected in a bucket over a 10 seconds period (in cm) and r is the radius of the bucket (r = 6 cm).

Flow Rate of Current Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6\ cm)^2(13.5\ cm)$
Volume = 1526.8 cm^3
Flow Rate (in lpm) = (1526.8 cm^3/10 s) · (60s/1 min) · (1L/1000 cm^3)
Flow Rate = 9.161 lpm

Flow Rate of Low-Flow Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6\ cm)^2(9.56\ cm)$
Volume = 1081.2 cm^3
Flow Rate (in lpm) = (1081.2 cm^3/10 s) · (60s/1 min) · (1L/1000 cm^3)
Flow Rate = 6.487 lpm

Table 3. Height of water (in cm) collected in a bucket when current and low-flow showerheads were tested in Cameron House (Howe Hall).

Cameron House	
Current Showerhead (h in cm)	Low-Flow Showerhead (h in cm)
13.0	11.5
12.4	11.0
12.6	11.1
12.3	11.4
12.4	11.1
Avg = 12.54	Avg = 11.22

$$\frac{\text{Ave. Calculated Volume of Water (cm}^3)}{\text{10 seconds}} \times \frac{\text{60 seconds}}{\text{1 minute}} \times \frac{\text{1 litre}}{\text{1000 cm}^3} = \text{Flow Rate (in lpm)}$$

Volume (in cm^3) = $\pi r^2 h$, where h is the average height of water collected in a bucket over a 10 seconds period (in cm) and r is the radius of the bucket (r = 6 cm).

Flow Rate of Current Showerhead:
Volume (in cm^3) = $\pi r^2 h$

Volume = $\pi(6\ cm)^2(12.54\ cm)$
Volume = 1418.2 cm^3
Flow Rate (in lpm) = $(1418.2\ cm^3/10\ s) \cdot (60s/1\ min) \cdot (1L/1000\ cm^3)$
Flow Rate = 8.509 lpm

Flow Rate of Low-Flow Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6\ cm)^2(11.22\ cm)$
Volume = 1268.95 cm^3
Flow Rate (in lpm) = $(1269.0\ cm^3/10\ s) \cdot (60s/1\ min) \cdot (1L/1000\ cm^3)$
Flow Rate = 7.614 lpm

Table 4. Height of water (in cm) collected in a bucket when current and low-flow showerheads were tested in Smith House (Howe Hall).

Smith House	
Current Showerhead (h in cm)	Low-Flow Showerhead (h in cm)
10.6	10.6
10.6	10.6
10.6	10.7
10.5	10.7
11.2	10.5
Avg = 10.70	Avg = 10.62

$$\frac{\text{Ave. Calculated Volume of Water } (cm^3)}{10 \text{ seconds}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} \times \frac{1 \text{ litre}}{1000\ cm^3} = \text{Flow Rate (in lpm)}$$

Volume (in cm^3) = $\pi r^2 h$, where h is the average height of water collected in a bucket over a 10 seconds period (in cm) and r is the radius of the bucket (r = 6 cm).

Flow Rate of Current Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6\ cm)^2(10.70\ cm)$
Volume = 1210.1 cm^3
Flow Rate (in lpm) = $(1210.1\ cm^3/10\ s) \cdot (60s/1\ min) \cdot (1L/1000\ cm^3)$
Flow Rate = 7.261 lpm

Flow Rate of Low-Flow Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6\ cm)^2(10.62\ cm)$
Volume = 1201.1 cm^3
Flow Rate (in lpm) = $(1201.1\ cm^3/10\ s) \cdot (60s/1\ min) \cdot (1L/1000\ cm^3)$
Flow Rate = 7.207 lpm

Table 5. Height of water (in cm) collected in a bucket when current and low-flow showerheads were tested in Henderson House (Howe Hall).

Henderson House	
Current Showerhead (h in cm)	Low-Flow Showerhead (h in cm)
12.8	10.2
13.0	10.4
12.8	10.4
12.9	10.0
12.1	10.2
Avg = 12.72	Avg = 10.24

$$\frac{\text{Ave. Calculated Volume of Water (cm}^3\text{)}}{\text{10 seconds}} \times \frac{\text{60 seconds}}{\text{1 minute}} \times \frac{\text{1 litre}}{1000\text{ cm}^3} = \text{Flow Rate (in lpm)}$$

Volume (in cm^3) = $\pi r^2 h$, where h is the average height of water collected in a bucket over a 10 seconds period (in cm) and r is the radius of the bucket (r = 6 cm).

Flow Rate of Current Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6\text{ cm})^2(12.72\text{ cm})$
Volume = 1438.6 cm^3
Flow Rate (in lpm) = $(1438.6\text{ cm}^3/10\text{ s}) \cdot (60\text{s}/1\text{ min}) \cdot (1\text{L}/1000\text{ cm}^3)$
Flow Rate = 8.632 lpm

Flow Rate of Low-Flow Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6\text{ cm})^2(10.24\text{ cm})$
Volume = 1158.1 cm^3
Flow Rate (in lpm) = $(1158.1\text{ cm}^3/10\text{ s}) \cdot (60\text{s}/1\text{ min}) \cdot (1\text{L}/1000\text{ cm}^3)$
Flow Rate = 6.949 lpm

Table 6. Height of water (in cm) collected in a bucket when current and low-flow showerheads were tested in Old Eddy (Shirreff Hall).

Old Eddy	
Current Showerhead (h in cm)	Low-Flow Showerhead (h in cm)
14.0	11.2
14.5	10.7
15.0	10.7
15.0	10.9
14.2	11.2
Avg = 14.54	Avg = 10.94

$$\frac{\text{Ave. Calculated Volume of Water (cm}^3\text{)}}{\text{10 seconds}} \times \frac{\text{60 seconds}}{\text{1 minute}} \times \frac{\text{1 litre}}{\text{1000 cm}^3} = \frac{\text{Flow Rate}}{\text{(in lpm)}}$$

Volume (in cm^3) = $\pi r^2 h$, where h is the average height of water collected in a bucket over a 10 seconds period (in cm) and r is the radius of the bucket (r = 6 cm).

Flow Rate of Current Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6\ cm)^2(14.54\ cm)$
Volume = $1644.4\ cm^3$
Flow Rate (in lpm) = $(1644.4\ cm^3/10\ s) \cdot (60s/1\ min) \cdot (1L/1000\ cm^3)$
Flow Rate = 9.866 lpm

Flow Rate of Low-Flow Showerhead:
Volume (in cm^3) = $\pi r^2 h$
Volume = $\pi(6\ cm)^2(10.94\ cm)$
Volume = $1237.3\ cm^3$
Flow Rate (in lpm) = $(1237.3\ cm^3/10\ s) \cdot (60s/1\ min) \cdot (1L/1000\ cm^3)$
Flow Rate = 7.424 lpm

7.7 Appendix G – Cost-Benefit Analysis Calculations

Results for Howe Hall:

113 Showers @ 9.5 lpm
Current Showerheads
(9.6 min) x (9.5 L/min) = 91.2 L/shower
(91.2 L/shower) x (711 showers/day) = 64843.2 L/day
(64843.2 L/day) x ($.0015820/L) = $102.58/day
($102.58/day) x (242 days) = $24,824.83/year
Low-flow Showerheads
(9.6 min) x (5.7 L/min) = 54.72 L/shower
(54.72 L/shower) x (711 showers/day) = 38,905.92 L/day
(38905.92 L/day) x ($.0015820/L) = $61.55/day
($61.55/day) x (242) = $14,894.90/year
Cost Savings on Water Bill
$24,824.83 - $14,894.90 = $9929.93
Labour Costs
(10 min/showerhead) x (113 showerheads) = 1130 mins
(1130 mins) / (60 mins/hr) = 18.8333 hours
(18.8333 hrs) x ($55.80/hr) = $1050.90
Material Costs
(113 showers) x ($4.49/showerhead) = $507.37
Cost Savings First Year (Includes Installation Costs)
($9929.93) – ($1050.90) – ($507.37) = $8371.66
Payback Period
$8371.66/8 month = $1,046.46 is saved each month of the school year
Total installation costs = $1050.90 + $507.37 = $1,558.27
Payback period is less than two months.
Cost Savings Subsequent Years
$24,824.83 - $14,894.90 = $9929.93
Water Savings
Current Showerheads: (64,843.2 L/day) x (242 days) = 15,692,054.4 L/year
Low-flow Showerheads: (38,905.92 L/day) x (242 days) = 9,415,232.64 L/year
Water Savings: (15,692,054.4 L/year) – (9,415,232.64 L/year) = 6,276,821.76 L/year

Results for Sherriff Hall:

63 showers in total
- 18 @ 9.5 lpm
- 45 @ 15.2 lpm
- Average = (9.5 x (18/63)) + (15.2 x (45/63))
  = 13.57 lpm

Current Showerheads
(9.6 min) x (13.57 L/min) = 130.272 L/shower
(130.272 L/shower) x (442 showers/day) = 57580.224 L/day
(57580.224 L/day) x ($.0015820/L) = $91.0919/day

($91.0919/day) x (242 days) = $22,044.24/year

Low-flow Showerheads

(9.6 min) x (5.7 L/min) = 54.72 L/shower

(54.72 L/shower) x (442 showers/day) = 24186.24 L/day

(24186.24 L/day) x ($.0015820/L) = $38.2626/day

($38.2626/day) x (242 days) = $9,259.56/year

Cost Savings on Water Bill

$22,044.24 - $9,259.56 = $12,784.69

Labour Costs

(10 min/showerhead) x (63 showerheads) = 630 mins

(630 mins) / (60 mins/hr) = 10.5 hours

(10.5 hrs) x ($55.80/hr) = $585.90

Material Costs

(63 showers) x ($4.49/showerhead) = $282.87

Cost Savings First Year (Includes Installation Costs)

($12,784.69) – ($585.90) – ($282.87) = $11,915.92

Payback Period

$11,915.92/8 months = $1,489.49 is saved each month of the school year

Total installation costs = $585.90 + $282.87 = $868.77

Payback period is less than one month.

Cost Savings Subsequent Years

$22,044.24 - $9,259.56 = $12,784.69

Water Savings

Current Showerheads: (57580.224 L/day) x (242 days) = 13,934,414.21 L/year

Low-flow Showerheads: (24186.24 L/day) x (242 days) = 5,853,070.08 L/year

Water Savings: (13,934,414.21 L/year) – (5,853,070.08 L/year) = 8,081,344.13 L/year