DALPLEX WATER AUDIT

ENVS 3502/ Dr. T. Wright

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ABSTRACT

Based on the premise that the Dalplex is wasting water, our group set out to identity problems with the plumbing system located within the facility. We focused on four main fixtures for this study; toilets, urinals, faucets and shower heads. After direct observations of fixtures backed our original hypothesis of water waste we researched alternative fixtures that will reduce water usage. An installation of these fixtures would save Dalhousie University thousands of dollars and millions of litres of fresh water each year. The methodology behind our research will be covered in this report – this includes descriptions of the assessment, interview, research and cost analysis process, and the overall reliability of the report. Cost analysis figures for each type of fixture will be listed, along with case studies that validate our research. A list of alternatives will be provided, as well as future recommendations for not only the facility, but other buildings across campus.

DALPLEX WATER AUDIT

INTRODUCTION

OVERVIEW OF RESEARCH PROBLEM

The intention of this study is to become knowledgeable about the practice of water management on the Dalhousie University Campus, specifically in older buildings. A water audit was performed for the Dalplex facilities, which then lead us to construct a feasibility assessment for alternative fixtures that could be installed to reduce the amount of water wasted.

The Studley Campus of Dalhousie University lies in the heart of Halifax, Nova Scotia. Covering several city blocks it is comprised of 52 buildings which can be further split into several distinct wings and departments. Situated in the South-West corner of campus is the Dalhousie Dalpex, a multi-story athletic complex that serves students, staff, faculty, and the surrounding community. Built in the late 1970s, it was officially opened on October 19th, 1979. At the time it was the largest, most advanced and comprehensive athletics facility in Eastern Canada. Under 180,000 square feet of floor space it houses an International sized swimming pool, 50,000 square feet of courts and weight rooms, a full sized track, and multi-purpose rooms for classroom activities (Dalhousie News, 2004). Because it is an athletics facility that serves a large volume of people daily it has a vast array of plumbing fixtures.

There are several reasons as to why the Dalplex was chosen for our water audit and feasibility assessment. These include its age, accessibility, number and diversity of fixtures. When these qualities are combined we feel that a larger impact (in terms of water conservation) can be made with the results of our study in comparison to other buildings on campus. It is also our hope that this assessment will serve as a future blueprint for other structures including those that have been built, are in the process of construction, and those that are planned for future use.

For the purpose of the study, the Dalplex itself has been divided into six distinct zones. They include the academic wing, change rooms, pool deck, field house, family change rooms and the cardio wing. Within these zones fixtures studied were showerheads, urinals, toilets and faucets; the make, water flow rate (measured in litres per minute or flush) and physical integrity of each was recorded. Based on external research gathered from literature and expert knowledge we will attempt to provide alternative fixtures and a comprehensive analysis of both water and monetary savings.

The academic wing is located on the main floor and houses two generic washrooms for use by facilities staff and students. On the same floor the main change rooms are located. These are the largest and most diverse studied during the audit, and are the most frequently used each day. Directly beside the main change rooms are common use family change rooms. This area includes showers, toilets and faucets. Branching off from the change rooms on the lower level are the male and female pool decks, these contain simple showers for use before entering and after leaving the pool. Situated on the top floor is the field house, containing both male and female washrooms, these contain toilets, urinals and faucets only. The final area of study is the male and female washrooms located beside the cardio facilities.

Based on our preliminary observations water is being wasted at the Dalplex in three ways. Many of the fixtures are outdated and use larger amounts of water than newer counterparts on the market. Secondly, there are several leaks and / or broken fixtures. This puts into question the ability of the Dalhousie Facilities Management to locate, identify, and remediate problems. Thirdly, some fixtures are missing critical water saving components completely. There are several options available to increase the effectiveness of water conservation management within the Dalplex ranging from the replacement of older fixtures to ones that maximize reduction of water use and the implementation of proactive maintenance checks. The underlying goal of the audit is to identify areas where significant improvements can be made and provide a list of alternatives that can be implemented to counteract water waste problems. The monetary costs associated with these changes must be kept in mind in order for the study to remain effective. The solutions suggested must have a short payback period in order to be effective for the university.

WHY IS WATER CONSERVATION SUCH A CONCERN?

As with any other natural resource, the availability of fresh water reserves for human use declines as the population increases. According to the United Nations the annual growth rate of the human population is projected at 1.9%. In undeveloped areas this is occurring at a higher rate, as much as 2.4% (UN, 2004). By 2005, the amount of individuals on the planet will exceed 7 billion (UN, 2004). What is troubling is that the current population increase is having a direct effect on the amount of water used. Between 1995 and 2000 the global consumption of fresh water rose 15%, from 3,790km cubed to 4,430km cubed (UNEP, 2004). As there are no conclusive results, it is estimated that per-capita use, especially in developing nations rose during this same period (UNEP, 2004). Canadians are not exempt from the problem; in the last 20 years the average per-capita water use in the country has risen by 30%, placing Canada a dismal 28th out of 29 nations ranked for water usage by the Organization for Economic Cooperation and Development (OECD, 2004).

Before the 1970s, concern over the increasing consumption of water was not an issue. Natural resources were viewed as limitless; therefore there was little regulation over the flow rates of fixtures in residential, commercial and industrial environments. According to the sustainable building magazine, *Environmental Design & Construction:* “Only when shortages started to become significant did actions to conserve start. Two kinds of shortages appeared -- insufficient water availability, and where water was not short, inadequate waste treatment capacity” (Martin, 2004). Ethics pertaining to water use had not always been this way. During the 1920s, North American toilets did not exceed a flush capacity of 7.5 litres per flush (LPF) (Martin, 2004). This changed as preferences for aesthetics took precedence. Flow rates for one-piece toilets (such as those found in the Dalplex) reached anywhere between 18.9 LPF to 26.5 LPF during the 1950s to 1970s. Some models even exceeded a staggering 45 LPF (City of Auburn, 2004). As long as water was cheap and available in large quantities nothing would change the way it was used.

During the 1960s droughts hit many areas in the Western United States. As the demand for water use began to reach existing capacities two things began to occur. The number of construction moratoriums and availability of low flow fixtures rose (Martin, 2004). The first fixture to be radically modified was the toilet. By the late 1970s flow rates had been reduced to 13.25 LPF with the introduction of new technology (Martin, 2004).

Today, the leaders of water conservation in North America reside in those areas first affected in 1960. Institutions such as universities have taken the initiative and reduced their water use significantly. A prime example is a new water conservation program implemented at the University Of Colorado in Boulder, Colorado. Under the new plan, the university saves approximately 250,000,000 litres of water a year, resulting in a monetary saving of over $400,000 CAD (University of Colorado, 2004). Building codes in California require that fixtures with the lowest possible flow be installed in new buildings and old buildings that are being renovated (Creighton, 2001). In Iowa, the University of Northern Iowa replaced aging 22.7 litres per minute (LPM) showerheads with new 7.5 LPM models. The costs of the change were covered within six weeks (Creighton, 2001). A campus water audit for Rice University in Houston, Texas was performed in 1998. Recommendations in the audit included the replacement of 17 LPF toilets with 13.25 LPF toilets, resulting in savings of $3,200 CAD and 3.5 million litres of water per month (Neuman, 2004). In conjunction with economic surpluses there are many environmental benefits associated with a reduction in water use;

- Reduced output of sewage to septic tanks and septic field systems may prevent hydraulic overloading / rupture and increase the longevity of the network.

- Lower Rates of groundwater extraction from individual wells may avoid problems with aquifer depletion – we are not the only organisms that depend on these natural ground-water reserves.

- Reduced output of sewage to municipal sewage treatment plants may prevent overloading of treatment facilities and prevent future expansion to meet increasing sewage outputs.

- Reduced demand on municipal water supply systems may avoid expansion of supply systems and water treatment facilities. (as stated in: Engineering Technologies Canada, 2001)

Where does Dalhousie fit into the picture? Dalhousie University is not located in an area affected either historically or presently by drought, and face what seems to be an abundance of fresh water for our immediate use. Each year the university consumes approximately 1 billion litres of fresh water. Economically this translates to $2,300,000 in expenditures (Howitt, 2004). For 2003, the Dalplex used 23 million litres of water at a cost of $54,000 (Howitt, 2004). Given these numbers and the state of fixtures at the Dalplex it is safe to assume that improvements can be made. Not only will the use of a valuable resource be curbed, but the economic returns will be beneficial to the university. Perhaps Dalhousie should follow the lead of schools in the Western States and adopt a water conservation strategy that sets new standards, making the university a leader in Canadian water conservation. If there is room for improvement, then there should be an obligation to make proactive changes.

MEMBERS OF THE ACTOR SYSTEM

Throughout the duration of our assessment there were several actor systems that we encountered. An actor system defines the social roles that individuals directly related to a situation fill. 'Primary' actors are the key actors – they are directly related to the issue at hand and play the largest role in decision making processes (Palys, 2003). Primary actors identified during the assessment include members of our research group, and top levels of Facilities Management. As researchers we will provide the assessment to Facilities Management Directors, who in turn will decide the true feasibility of the project (table 1). 'Supporting' actors are the next group in the actor system. Like primary actors they are directly involved with the issue but do not have as large a role in the final decision making process (Palys, 2003). Supporting actors in our study are the lower levels of Facilities Management; members of the maintenance staff who directly take care of fixtures (maintenance checks and repairs), and Dalplex Staff members. Supporting actors may also include external sources of information – such as expert knowledge in the field of plumbing. This information is essential in order to draft a proper assessment (table 1). The third group in the actor system are 'should be' actors. These individuals are directly related to the issue and immediately affected by any decision made. They usually play no role in the decision making process initiated by primary and supporting actors (Palys, 2003). Should be actors in this issue are students, staff, faculty and members of the community who use the Dalplex, but are not involved in the decision making processes (table 1).

Table 1: Actor System of Dalhousie Water Conservation Project

PRIMARY	SUPPORTING	SHOULD BE
Researchers	*Maintenance Staff*	*Students*
Facilities Management Directors	*Dalplex Staff*	*Staff (General)*
	Plumbers	*Faculty*
		Community

LOW FLOW OPERATIONALIZATIONS & MAINTENANCE OVERVIEW

As stated earlier, the primary goal of the assessment is to identify fixtures in use at the Dalplex, and to provide a list of alternatives and their respective benefits. But what exactly constitutes normal water flow and low water flow? Values for each change over time. In the late 1970s a low flow toilet was considered to be 13.25 LPF. Today this has dropped to 6 LPF (Martin, 2004). In essence, the description of 'low flow' can be applied to any fixture that surpasses current water conservation guidelines. Normal flow therefore, is any fixture that meets current guidelines. Guidelines for new equipment are usually set by the Canadian Standards Association (Canadian Standards Association, 2004), and then adopted as law by levels of government whose jurisdiction covers the area of concern. The CSA is a non profit membership association whose main purpose is to serve business, industry, government and consumers through the development of standards that improve public health and safety, energy consumption, quality of life and the preservation of the environment (Canadian Standards Association, 2004). CSA guidelines for the fixtures sampled in the Dalplex are covered under several acts (table 2).

Table 2: CSA Guidelines for commercial fixtures

FIXTURE	GUIDELINE	STANDARD FLOW	RECOMMENDED FLOW
Toilet	B4	13.25 LPF	6 LPF
Urinal	B4	3.8 LPF	1.9 LPF
Faucet	B125-98	8.3 L/min	1.9 L/min
Shower head	A112.18.1M	9.5 L/min	7.5 L/min

While fixtures at the Dalplex meet CSA guidelines mentioned above, there has been no action to meet recommended flow rates listed. Across campus there are examples of better fixtures (closer to recommended flow rates) than those located at the Dalplex, but there is no continuity amongst buildings (Appendix B).

All toilets found in the Dalplex are classified as ‘single piece’, meaning they do not have an external tank that holds water (Martin, 2004). To conserve water with a single piece toilet one must install a flushometer. A flushometer acts as a coupling between the toilet itself and internal plumbing which provides water from the municipality. Since municipal water is under pressure and hard to regulate, the purpose of the flushometer is to restrict flow rates. Developed in the early 1980s for commercial toilets they were responsible for converting most fixtures from 18.9 LPF to 26.46 LPF to 13.25 LPF (Martin, 2004). By restricting flow rates a flushometer can pressurize pre-determined amounts of water, and then release them when the toilet flushes, thereby increasing the effectiveness of a flush and reducing the amount of water needed to clear the bowl (Howitt, 2004). In order to increase the effectiveness of a flushometer, modern low flow toilet designs have a wider bowl and pipes and use clearance and gravity to assist in a flush rather than volume of water (Martin, 2004).

New generation ultra-low flow (ULF) toilets have a flush rate of 6 LPF. Introduced in the early 1980s these toilets had poor performance records; the plugging of toilets and septic fields were a large problem. ‘Plugging’ is best defined in an evaluative report of ULF toilets as “the complete blockage in the toilet or piping leading to the septic system, which requires the use of a plunger or snake to correct” (Engineering Technologies Canada, 2001). A second problem was ‘double’ flushing; where in some cases two or three flushes are required to clear the bowl. The main concern of users is that if more than one flush is needed then the point of conserving water is negated (Engineering Technologies Canada, 2001). Because of this many plumbers and maintenance staff have biased views of these systems even though improvements have been made in the last two decades (Engineering Technologies Canada, 2001).

By 1992, seventeen US states passed laws requiring that any toilet installed in a new building or during a renovation must be a 6 LPF model. The same year the American Energy Policy Act laid out a proposal to slowly phase out the manufacture of 13.25 LPF toilets and their associated parts; the first phase of this act was initiated in 1994 (Engineering Technologies Canada, 2001). In Canada, two provinces abide to the 6 LPF standards; Ontario and British Columbia (Engineering Technologies Canada, 2001). Individuals in all states and provinces associated with the 6 LPF acts have agreed that when these toilets are installed with proper plumbing systems and certified parts there is little chance of problems occurring. Recent case studies in Prince Edward Island elementary schools with 6 LPF toilets (instead of 13.25 LPF models) have shown measured water savings of 46-60% (Engineering Technologies Canada, 2001).

A low flow urinal uses a variation of a flushometer to conserve water, although other features can be added in conjunction with the device to increase overall effectiveness. Many older models of urinals flushed once every 5 minutes throughout the day. A simple device called a ‘snubber’ can be installed in the timing mechanism in order to increase the flush interval (Howitt, 2004). Many snubbers however, cannot be programmed to shut-off during certain times of the day. An electronic control panel is needed in order to program a urinal. With one installed a urinal can automatically shut itself off when a facility closes, and then turn itself on again when the facility opens. In order to meet sanitary guidelines it can be programmed to flush more frequently during peak hours, or less frequently during slow hours (Howitt, 2004). A variation of the timer is a motion sensor panel installed just above the urinal. These can be programmed to flush after each visit or after a predetermined number of visits (while still retaining the ability to shut off during the evening) (Howitt, 2004).

Urinal conservation can be taken to the next level with the installation of a waterless urinal. This is a system that does not flush water, but uses bio-degradable chemicals to move urine out of the urinal and into a plumbing system (Appendix C). As urine enters the bowl it passes through a liquid chemical layer that has a density less than that of water. This allows the urine to sink to the bottom of the bowl and into a filtration system where sediments are collected. Once treated, the urine enters the standard plumbing system assisted by gravity (Howitt, 2004). The only costs associated with the operation of a waterless urinal are to replace the chemical sealant and the filtration system – if done correctly the costs of these combined should be less than the cost of water and regular maintenance of parts (per year) (Falcon, 2004).

The most common shower head available on the market at the moment allows 9.5 litres per minute (LPM) of water to be used. Models that restrict the flow of water to a larger degree are available, but more costly than their counterparts. Showerheads with flow rates of 7.5 LPM can be purchased for larger institutions. Prices for these low flow showerheads range between $10-50 CAD (Snow, 2004). The best way to conserve shower water is to regulate the amount of time spent showering; timed showers are an effective way of accomplishing this. Users push a spring-loaded button on the wall which is set to a timer. After a predetermined amount of time the shower will shut off. To turn it back on a user simply pushes the button again (Howitt, 2004). These mechanisms are simple to install and cost effective in the long run, they also prevent the habit of leaving a shower on after use, either on purpose or through forgetfulness.

There are two methods available which conserve water use through a faucet. These are the addition of an aerator and the application of a sensor (much like those found on urinals, as mentioned previously). An aerator is a circular ring of metal that fits onto the threaded end of a faucet. In the center of the ring is either a wire mesh or plastic disc that restricts the flow of water (PBS Home, 2004). A standard aerator will provide a user with approximately 8.3 LPM. A low flow aerator will lower this to 1.9 LPM without affecting performance (Energy Federation Incorporated, 2004). A sensor placed underneath a faucet will detect hand movement, turning on water flow when hands are placed in the sink and shutting off automatically when they are removed.

Simply replacing fixtures with models that are more efficient is only half of the water conservation battle. Members of Facilities Management need to ensure that spot-checks are completed on a regular basis. A commercial toilet that leaks water into the bowl can waste 200 litres of water each day, while a faucet with a steady drip can waste almost 800 litres of water in a week (Creighton, 2001). Although costs are negligible on a short term basis they can add up in the long run, especially when dealing with multiple fixtures. Custodians and building staff should be able to quickly identify leaks and their associated problems and pass information onto maintenance staff to ensure a speedy repair. Students should also be made aware of the consequences of water waste and made to feel that they can easily report leaks to management.

DALPLEX WATER AUDIT

METHODS

METHODS & MATERIALS

To adequately represent the problem of water mismanagement our report utilized three areas of study, consisting of expert information (interviews), text analysis and case study analysis, and cost analysis examination in order to determine the feasibility of retrofitting toilets, urinals, faucets, and showerheads with lower flow models. The interview process involved the owner of a plumbing fixture company, a member of Facilities Management at Dalhousie University, and an employee of the Dalplex facility. Text analysis of water conservation technologies and case studies related to water conservation were researched in order to determine past successes and failures. Water use at the Dalplex facility was also studied directly. This was done through direct observations and a comparison of the present cost of water usage at the Dalplex versus the possible savings that can occur with the installation of low flow fixtures.

SAMPLING & INTERVIEWS

Based on the nature of our study we chose to use a non-probabilistic, purposive sampling method, which is ideal sampling frame is not available. It is also best used when the objectives of the research being conducted would be best fulfilled by a pre-determined, strategically chosen sample (Palys, 2003). As stated previously, actively seeking expert knowledge on water use at the Dalplex and water conservation strategies provides us with a report that has more validity.

The specific type of non-probabilistic sampling that we used is purposive sampling. Interviewees are sought on purpose because they meet criteria that have been set by researchers. Because they meet certain criteria these interviewees are more likely to reaffirm a study, rather than challenge it (Palys, 2003). Researchers should be careful about relying on these opinions; information should also be gathered from archival sources to check for verification or to triangulate information (Palys, 2003). We kept this in mind, and chose to perform several interviews and consult case studies.

Three in-person interviews were done, which allowed direct contact with the candidate and ensured that data collected was of high quality. As well, the interviewee and interviewers could ask for clarification of questions and responses, and follow-up questions of unexpected answers could be asked (Palys, 2003).

The first interview occurred on Thursday, March 25, 2004 at 6355 Lady Hammond Road, Halifax. The respondent was Ray Snow, the manager of Sumner Wholesale Plumbing Fixtures. Questions covered during the span of the interview included the monetary cost of both conventional and water conserving plumbing fixtures (Appendix D). The interview was planned over the telephone and a consent form was signed before any questions were asked; this allowed us to use Ray Snow's information and name in the project. The interview was conducted by Lance Richardson-Prager and took approximately 20 minutes to complete.

The second interview occurred on Friday, March 26, 2004 at the Facilities Management Building on 1326 Henry St in Halifax. The respondent was Peter Howitt, the Building and Utilities Services Assistant Director of Dalhousie University. Mr. Howitt oversees zone maintenance and repairs and heads energy conservation projects across the Dalhousie campus. Questions covered during the interview included the present financial costs of water use on campus and at the Dalplex, and past pilot studies of water conserving fixtures (Appendix D). The interview was planned through a verbal agreement. Verbal consent was also given to use names and information acquired during the interview in the final report. The interview was conducted by Courtney Shaffer and Evan McMaster, and took approximately 45 minutes to complete.

The third interview was conducted on Friday, March 26, 2004 at the Killam Library on the Dalhousie Campus in Halifax. The respondent was an anonymous employee of the Dalplex. Questions asked during the interview covered daily attendance figures at the Dalplex. As with the previous two interviews, the meeting was arranged through a verbal agreement. A consent form was signed that allowed information acquired during the interview to be used in the final report, but names to be kept confidential. The interview was conducted by Dan Sturby and took approximately 40 minutes to complete.

The specific nature of the water conservation project meant that discussing the matter with local experts was ideal. Given that the interviews were free, their cost-effectiveness cannot be disputed, and the data provided was substantial for the moderate amount of time needed to conduct them. For a study such as this it is ideal to seek expert knowledge based on the following;

- Sampling Dalplex users is impractical; it is much more productive to talk to facilities staff that have direct knowledge of visitor rates.
- Because of the commercial and economic aspects of the project it is advisable to speak to those involved in the business aspects of water conservation.
- Specific financial information related to water use at the Dalplex is not openly available. Interviews with the right individuals can provide this information.

- Because we are interviewing experts, the nature of the questions can be more specific and direct, thereby leading to a more credible report. The respondent can also direct us to other sources of information which may be beneficial to the study, or encourage research in another direction (Palys, 2003).

TEXT ANALYSIS (ELECTRONIC SOURCES)

Electronic sources are up-to-date banks of information which adequately describe the constantly changing water conservation industry. Because technology is continuously moving forward, sources of information found in literary sources such as journals may be outdated; therefore not applicable to our study. Electronic sources provide reliable data to researchers and are easily accessible at any given time, an important quality given the time restrictions of the study. Electronic Case studies also assisted in the research process of this report. Having data provided by these reports can help a researcher draw parallels or back claims they have made in their study. As with previous electronic sources, these case studies were ideal due to their high accessibility.

Due to the nature of low flow plumbing appliances, much of the data collected was procured from commercial websites. Case studies were also consulted for their parallels to the water consumption issues at the Dalplex.

There were many websites used to gather information on specific fixtures during our study. These sites include; American Standard, Falcon Waterfree Technologies, the Energy Federation, the Environmental Development & Construction Magazine, and PBS Home (See Bibliography for complete web addresses).

CASE STUDIES

In conjunction with information gathered from commercial sources, we looked at case studies which covered water audits and pilot projects in North American institutions ranging from university campuses to elementary school districts.

- *University of Cambridge*

  (www.energyvortex.com/pages/headlinedetails.cfm?id=1089)

  A water audit conducted at the University of Cambridge which provided recommendations that in turn lead to an eventual retrofit of plumbing fixtures on campus.

- *Rice University*

  www.ruf.rice.edu/~enviclub/envi490/watercons.html

  A campus water audit was performed by an Environmental Science and Engineering class at Rice University. Flow rates for fixtures were studied across campus and recommendations were made to Facilities Management.

- *PEI Dept. of Fisheries, Aquaculture and Environment, Evaluation of Ultra-low Flow Gravity Toilets in Two Schools*

  www.gov.pe.ca/photos/original/fae_6L_toilet.pdf

  This pilot study was conducted within two elementary schools on Prince Edward Island. Researchers tested the effectiveness of low flow toilets (6 Litres per flush) in the school environment.

- *Socorro School District, Texas*

  www.falconwaterfree.com/pdf/socorro_CaseStudy.PDF

  Waterless urinals were installed in multiple facilities throughout the Socorro School District in Texas in an effort to conserve water. The retrofit had many positive results (maintenance, money).

COST ANALYSIS

Cost analyses of proposed fixtures were performed to determine the economic feasibility of these retrofits. This was accomplished by calculating the present cost of water use at the Dalplex and comparing figures obtained to potential savings achieved through the installation of low flow fixtures.

Data was collected for fixtures located in the Dalplex. These observations were completed on the 15th of March by all members of the group.

- Type of fixture and their respective number in each room
- The manufacturer (American Standard, Crane, Moen etc)
- Fixture specifications (flow rates measured in litres / min or litres / flush)
- Physical integrity of each fixture.

A list of alternative fixtures was compiled based on information collected from our Dalplex study and text analysis. By knowing the manufacturer and actual flow rates of each fixture studied we were able to research alternatives made by those same manufacturers that could conserve larger amounts of water. We then consulted the data from text sources and interviews to determine the installation costs of new fixtures.

Alternative fixtures studied included ultra low flow aerators, toilets, shower heads, and waterless urinals.

RELIABILITY

Reliability is the accuracy and reproducibility of a project’s procedures to lead to a comparable result (Palys, 2003). The report increased its reliability by containing a step-by-step description of all our research methods, and a complete break-down of the final cost analysis (Appendix E). To enhance the project’s reproducibility and accuracy we specified which fixtures we would study (toilets, urinals, showerheads, and faucets) in the Dalplex. Reliability of our interviews was assured due to the fact that if they were to be done by another student, and asked the same questions (Appendix D) the same responses would be given.

VALIDITY

The validity of our results was another priority for this project. Validity is obtained when the desired issue is measured by the research conducted (Palys, 2003). This feasibility assessment performed in this study used three sources of information: interviews of experts, a cost analysis of water conserving retrofits at the Dalplex, and electronic text sources such as case studies. Each diversified the research and allowed for the triangulation of data (comparing data from multiple sources to validate information) (Wright, 2004). Another way to increase the validity of the report was to increase the number of people interviewed, and in turn, the number of questions asked though time was a limiting factor. The examination of case studies similar to our project increased the validity of our report as they gave us information to compare our data from the cost analysis to. The also outlined past successes and failures, so we could avoid making the same mistakes.

CATALYTIC VALIDITY

Catalytic validity can be defined as "the extent to which research empowers people by enhancing 'self-understanding' and facilitating social transformation" (Palys, 2003, 2001).

This report's high catalytic validity comes from its financial concerns: an implementation of water conserving fixtures would have economic savings for Dalplex (and by proxy Dalhousie University); savings which could then be passed on to the patrons of the facility or the university community. The options presented are practical, with both short term and long term benefits. Implementation of projects at Dalhousie are only considered it the have a short payback period. Typifying our study economically increased it meaning for those who are responsible for making the changes proposed.

The catalytic validity of this study is also enhanced by asking the respondents to either sign or give verbal consent. This protects the researcher and the respondent due to the fact that any study will have a level of risk present. For example, by giving confidentiality to the Dalplex employee, his/her job security was protected.

LIMITATIONS

Limitations to a study are factors out of the researcher's control that for whatever reason, inhibit or prevent the acquirement of information (Wright, 2004). There were several limitations that we encountered while completing this report. The first was the short time frame provided to complete the study. Since this project is part of an Environmental Science course, the project had to be completed within a three month period (starting on the 10th of February and running until the 13th of April, 2004). If the research period had been extended there would have been time to conduct more interviews and consult further case studies. The relatively low number of people in the group combined with financial shortcomings created yet another limitation for the project. This meant that we had to minimize our research to only interviews and text analysis. If more financial resources had been at our disposal we could have utilized electronic monitoring equipment to gather exact flow rates for individual fixtures (instead of relying on information from the manufacturer.

BOUNDARIES

A system is a "set of components and interrelationships that can encompass smaller subsystems" (Wright, 2003). The system we studied for our report was the plumbing fixtures (toilets, urinals, showerheads, and faucets) in the Dalplex. The study also possesses delimitations, which are temporal, spatial, and geographical boundaries on our system (Wright, 2004). The time established by Dr Wright to complete this project is a temporal boundary. We were given from February 10, 2004 to April 13, 2004 to complete this project. A spatial boundary to this system is the Dalplex itself and its 108 plumbing fixtures. The group chose to assess water consumption only at the Dalplex. This was to minimize over-complexity and/or over-generalization of a study. If a system is too large, then fine details are overlooked and resources become limited. The last boundary placed upon this study was a geographical boundary. The group chose to do a water conservation project in Nova Scotia, where access to cheap water is available. This excess supply of water generally means that people take a narrow view towards any substantial changes in their plumbing systems.

DALPLEX WATER AUDIT

RESULTS & DISCUSSION

Each fixture will be reviewed independently in this section, with Data / Interview results provided first, followed by respective case studies.

TOILETS

Data / Interview Results

Current models of toilets installed in the Dalplex have been in place since the building was built in 1979 (Howitt, 2004). These toilets fulfill the minimum degree of water conservation required by the CSA (table 2). Flush volume is approximately 13.25 litres for the 25 public toilets found in the Dalplex (Howitt, 2004; Appendix A). The CSA recommends that ultra low flow (ULF) toilets with a flush volume of 6 litres be installed (table 2).

When asked about ultra low flow toilets being implemented at Dalhousie, Facilities Management expressed frustration towards the installation of the fixtures due to failures in the past. When the Eliza Ritchie Residence was opened in 1987, it was equipped with 6 litres per flush (LPF) toilets. Over the next few years, $20,000 in damages was spent due to the clogging and subsequent flooding of these toilets. Floors and ceiling had to be repaired and replaced (Howitt, 2004).

The MacMechan bathroom on the main floor of the Killam Library has also recently been equipped with ULF toilets. These toilets are not being used properly, and unless this changes they will more than likely be uninstalled. To date, there have been six floods (Howitt, 2004).

CASE STUDY

PEI Dept. of Fisheries, Aquaculture and Environment, Evaluation of Ultra-low Flow Gravity Toilets in Two Schools, November 2001

The purpose of this case study was to calculate how much water could be saved by installing ULF toilets instead of 13 litres per flush (LPF) toilets in a commercial or institutional setting. The two models tested were the 6 litre Drake toilets by Toto USA and the 6 litre American Standard Cadet. In a 4 week period, these toilets' net water savings totalled 46-60% of that previously used by the 13 LPF models (Engineering technologies Canada, Ltd., 2001).

Additionally, the toilets were monitored to determine any maintenance problems that may be associated with the two models. No incidences of plugging or double flushing were reported, and no flooding occurred. User satisfaction was high enough that both models in both schools remain installed to date, even after the completion of the study (Engineering technologies Canada, Ltd., 2001).

Negative perceptions of ULF toilets are reported in this case study, which are based on first generation models that were poorly designed (Engineering technologies Canada, Ltd., 2001). This seems to be the case in Facilities Management as they were skeptical of their beneficence due to their failure in Eliza Ritchie Residence over 10 years ago (Howitt, 2001). This study shows that ULF toilets are better designed, and can result in large water savings without increased maintenance.

URINALS

Data / Interview Results

The 8 urinals in place at Dalplex adhere to the lowest standard flow rate of 3.8 LPF set by the CSA (table 2). Efforts by Facilities Management have been made to reduce the volume of water wasted by placing a snubber which increases the time span between flushes from every five minutes to once an hour. However, these urinals flush every hour, even during the night when the facility is not in use (Howitt, 2004).

The CSA recommends a flow volume of 1.9 LPF (table 2), however, there are now waterless urinals on the market in which no water is used, but instead a chemical layer facilitates the flushing of the urine (Falcon Waterfree). Waterless urinals have been pilot tested at Dalhousie in the Facilities Management building. The model tested, the Water Matrix, has proven to be unsatisfactory with regards to performance and may be more expensive to maintain than the current models that use water (Appendix C). Specific problems with performance include excess odours and poor hygienic quality (Howitt, 2004).

CASE STUDY

There are models of waterless urinals that have been reported to correct for the problems usually associated with them. Once again, failures of first generation models are the cause of negative perceptions of the fixtures in general.

We suggested to Facilities Management a model that has a reputation to have solved many of the problems that other waterless urinals have. Peter Howitt was very enthusiastic and told us he would look into it.

Socorro Texas School District – Case study of Falcon Waterfree urinals

Schools in Texas were outfitted with 14 Falcon Waterfree urinals. Users reported that they were almost completely odour free and very hygienic. The maintenance staff at the schools reported that they were low maintenance, possibly even lower than those that use water because there is no plumbing to become clogged (Falcon WaterFree).

There was a reduction of 15-20 % total water use for the schools. The urinals paid for themselves within about 2 years of their installation (Falcon WaterFree). The payback period would be expected to be much longer in Atlantic Canada, as water is more abundant and therefore cheaper.

FAUCETS

Interview Results

There were great inconsistencies in the flow rate of faucet fixtures throughout the campus (Appendix B) as well as within Dalplex (Appendix A). Some faucets were not installed with faucet aerators to restrict the flow rate, making the flow rate a minimum of 8.3 LPM (table 2). Most were equipped with aerators of 7.5 LPM. There are approximately 20 faucets in the public bathrooms at Dalplex (Appendix A). In the Sir James Dunn building, there are aerators as low as 1.9 litres per minute (Appendix B). Installing these would reduce the amount of faucet water by 75%. When Peter Howitt was informed about these aerators, he was interested in exploring them further and considering installing them in the Dalplex (Howitt, 2004).

Facilities Management expressed concern about theft of aerators based on past experiences (Howitt, 2004). There are now vandal proof aerators which restrict flow to

1.9 LPM on the market. These aerators require the use of a key in order to unscrew them (AM Conservation Group, Inc. 2004).

SHOWERS

Interview Results

Currently installed on the 51 showers in Dalplex are showerheads that restrict the water flow rate to 9.5 LPM (Appendix A). This is the minimum requirement made by the CSA (table 2). There are only timers on the showers on the pool deck (appendix A).

To reduce water consumption it is suggested that showerheads be replaced with ones that allow a flow rate of 7.5 LPM (table 2). Additionally, timers should be installed on the 39 showers located in the changing rooms. Both Dalplex staff members and Facilities Management reported that showers are left on by users after they are finished showering, sometimes even for hours (Anonymous, 2004; Howitt, 2004). Timers would reduce or eliminate this form of water wastage. If the timers were set so the water would turn off after five minutes, a maximum of only 40 litres would be wasted. Facilities Management expressed an interest in installing timers when informed of this problem (Howitt, 2004). It is our hopes as well that timers will force patrons to become aware of how long they have been in the shower and possibly encourage them to take a shorter shower.

ADDITIONAL INTERVIEW DATA

Patron Behaviour

Facilities Management also stressed the importance of patrons' behaviours when it comes to water conservation. The low flow fixtures can work if used properly, but they often are not. For example, low volume toilets are not made for disposal of sanitary napkins and tampons, but it is very hard to control the behaviour of the users. They can be told not to do so, but even if a minority do choose to abuse the fixtures, this can result in large damages and costs to Dalhousie (Howitt, 2004).

Leaky Fixtures

When asked about maintenance of leaky fixtures, Peter Howitt said that in theory there is a routine check for leaks, but it is becoming increasingly difficult. The number of maintenance staff has remained stable, although several new buildings have been added to the campus. More often they have to rely on complaints and reports from patrons and staff to become aware of problematic leaks, which may occur after a considerable amount of water has been wasted (Howitt, 2004).

Statistical Information from interviews

- Litres of water per year used at Dalhousie: 1,000,000,000 litres/year
- Money spent on water each year: $2,300,000
- Litres of water used at the Dalplex in 2003: 23,421,000 litres
- Cost of water annually at Dalplex: $53,800
- Cost of water per litre: $0.0023

COST ANALYSIS AND FEASIBILTY

From the data we obtained from the expert interviews and literature review, we were able to do a cost analysis outlining how much water and money could be saved if the proposed water conserving fixtures were retrofitted, how much it would cost to install these fixtures, and the estimated payback periods for each, as well as the payback period for all the fixtures combined. Dalhousie works on a five year budget, so realistically, for a project to be undertaken the payback period must be less than five years.

ASSUMPTIONS AND SOURCES OF ERROR

To complete the cost analysis, we had to make a number of assumptions, so our calculations may contain some degree of error. To calculate the amount of water used by patrons each day (and then for one academic year) for each fixture we had to make an educated estimate. It would not have been ethical for us to observe each fixture and count the number of users daily. Devices can be purchased to count the number of flushes per toilet per day, but money was a limiting factor for our study (Engineering technologies Canada, Ltd., 2001).

We assumed that:

-2/3 of daily Dalplex patrons flush a toilet once

-2/3 of daily Dalplex patrons turn on a faucet for 30 seconds

-1/3 of daily Dalplex patrons have a five minute shower

No assumptions had to be made about the urinals, as they flush automatically once and hour (Howitt, 2004).

Data on number of patrons using the Dalplex per day were estimated based on the information given by the anonymous Dalplex employee. They stated that busy times were between 11am and 1pm, and 4pm and 7pm, and that about 10 people per minute enter the facility during these times. About one person per minute enters in the non-buy times (Anonymous, 2004). From these numbers we calculated the daily number of patrons using the facilities in the Dalplex to be about 3700 people (appendix E).

Another source of error in our calculations is that it was not possible to factor in the labour costs for installation of fixtures as it varies with the contract (Snow, 2004). Discounts are offered to institutions when they are buying many fixtures at once, but this could not be included in the cost analysis as well because the specific figures are negotiated for each contract (Snow, 2004).

COST ANALYSIS RESULTS

Table 3. *Summary of water use at Dalplex for each fixture type studied in an 8 month period.* ***Assumptions made****: 3700 patrons per day, 2466 (2/3) patrons use toilets once, 2466 (2/3) patrons use faucet for 30 seconds, 12433 (1/3) patrons use shower for 5 minutes. This includes summary of cost analysis for water conservation fixtures, and pay back period for each one. Calculations can be found in appendix E.*

	Water Used/8months (L)	**Water Saved (L)**	**Cost of water/8months ($)**	**Money Saved ($)**	**Installation Costs ($)**	**Pay-back period**
Toilets						
Now (13.25LPF)	7,841,760 L	N/A	$ 18,036	N/A	N/A	N/A
LV (6LPF)	3,551,040 L	4,290,720 L	$ 8,167	$ 9,868	$ 10,000	244 days
Urinals						
Now (3.8LPF)	175,104 L	N/A	$ 402	N/A	N/A	N/A
Waterless	0 L	175,104 L	$ 0	$ 402	$ 6,400	10 years
Faucets						
Now (7.5LPM)	2,219,400 L	N/A	$ 5,104	N/A	N/A	N/A
LF (1.9LPM	562,248 L	1,657,152 L	$ 1,293	$ 3,811	$ 79	5 days
Showerheads						
Now (9.8LPM)	14,500,080 L	N/A	$ 33,350	N/A	N/A	N/A
LF (7.5LPM)	11,096,880 L	3,403,200 L	$ 25,522	$ 7,827	$ 2,500-6,450	78-198 days
Total		**9,526,176 L**		**$21,910**	**$ 18,979-22,929**	**251 days**

GLOSSARY
LPF: Litres per flush
LPM: Litres per minute
LF: Low flow
L: Litres

FEASIBILITY

Toilets

If all 25 public toilets in the Dalplex were replaced with ultra low flow toilets the net water savings annually is calculated to be 55% compared to current models. This translates to economic savings of $9,868 for an academic school year (8 month period). The cost to replace each of these toilets with an ULF model would be approximately $10,000. The return period for the retrofits would be slightly more than one school year (table 1). This is much less than the five year minimum so toilet retrofits are deemed to be feasible.

Our calculations were confirmed by the aforementioned case study on the installation of ULF toilets in two PEI schools. The net savings from each of the toilets installed was measured and calculated to be in the range of 46-60%.

The pay back period for the installation of ULF toilets was calculated to be approximately 2 years by students in the Environmental Science and Engineering 490 course at Rice University. This is a longer payback period compared to our cost analysis (twice as long) but installation costs were not taken into account in our analysis. A two year payback period would even be feasible since Dalhousie works on a five year budget.

Urinals

Currently, 3.8 litres of water are flushed every hour per urinal. There are 8 public urinals in the Dalplex, so this translates to about 175,000 litres in an academic year, costing Dalhousie only about $402. The installation of waterless urinals would completely eliminate this cost. However, there is a cost associated with the chemical cartridges. Installing and maintaining 8 waterless urinals at Dalplex would cost $6,400.

The payback period is approximately 10 academic years (108 month period). The relatively small amount of money spent on water for these fixtures, in addition to the fact that the retrofit does not comply with the five year return policy may make the installation of waterless urinal retrofits unfeasible.

In the case study of the installation of Falcon WaterFree toilets in Texas Schools, the payback period is estimated to be about 2 years; five times less than the payback period calculated for Dalplex. As was mentioned before, this is probably due to the difference in the price of water in Texas than in Nova Scotia.

Faucets

The cheapest and most effective way to reduce water use from faucets is to restrict the flow rate with an aerator. The lowest the rate can be restricted to without compromising user satisfaction is 1.9 litres per minute. An average aerator costs about $4 each and can reduce water use by 75% compared to the 7.5 LPM aerators currently installed. There are 20 faucets in the public bathrooms at Dalhousie. At a cost of about $80, all faucets could be retrofitted with vandal proof aerators, saving over 550,000 litres of water and $3000 in one academic year. The payback period would be approximately 5 days, making the retrofit feasible. In fact, it is the most cost effective water conserving fixture we have studied.

Facilities Management informed us that they have had problems with people taking off the aerators when they are installed. If all the aerators on all the faucets in the Dalplex were replaced 45 times, the payback period for this would still be under one academic school year!

Shower Heads

For showerhead retrofits we looked at two possibilities that would be most effective if used collectively. Currently, the average flow rate for the 51 showerheads at Dalplex is 9.5 litres per minute. Only the showers on the pool deck have timers installed. If the current showerheads were replaced with those that allow a reduced flow rate of 7.5 litres per minute, approximately 3 million litres of water and $7,000 would be saved. The installation of timers on the showers would reduce the amount of water wasted when the shower are left on after being used. This behaviour was observed by both staff members (anonymous, 2004) and Facilities Management (Howitt, 2004). The cost to install the timers to the 39 showers in the changing rooms is approximately $3,900. Together the installation costs would total $6,450. The payback period would be at the most ~230 days (less than 8 months), making the retrofits feasible. The elimination of the water wasted by those that leave the showers running after use due to the proposed retrofits could not accurately be calculated as data on the amount of water wasted from this behaviour could not be gathered. So, total water saved would be even greater than calculated.

Cumulative Feasibility

Although the payback period for the installation of waterless urinals is longer than the recommended five year payback period, when looked at collectively, the water and economic savings of the other types of fixtures makes up for this. The total volume of water saved by our proposed retrofits is approximately 9 million litres (~40% of current water use), which would save $21 thousand per academic year. Total installation costs are estimated to be $22 thousand, resulting in a payback period of just over one academic year.

We compared our study to a similar study of water savings in Cambridge University. This university has approximately the same number of students, so is assumed to be of comparable size. In this case, however, the retrofits were actually carried out. ULF toilets, low flow showerheads, and faucet aerators were installed campus wide. An estimated $282,000 and 121 million litres of water are saved annually. The payback period was 1.8 years; almost double that of our study. However, the labour costs that were not included in our study may be the cause of this. Even if the payback period is about 2 years for our proposed retrofits, this is still feasible, as it is less than the five year suggested payback period given by Dalhousie. (Cambridge 2003)

DALPLEX WATER AUDIT

RECOMMENDATIONS

Based on the successes, failures, and limitations of our study we have compiled a number of recommendations for Facilities Management as well as future ENVS 3502 classes.

1) It is our hope that fixtures recommended previously in the report be taken into consideration by Facilities Management. An ideal study on the true effectiveness of these fixtures in the environment they are destined for needs to take place. It is therefore ideal that trial fixtures be installed in the Dalplex (beside current fixtures) and several aspects of their function be looked at in a comprehensive pilot study. These include;

- Total water consumption on a monthly basis for both existing fixtures and pilot fixtures.
- Total cost of the water consumption (dollars / L) for both existing fixtures and pilot fixtures.
- Difference in costs for water use between existing / pilot fixtures
- Effectiveness to eliminate waste (in the case of urinals / toilets) for both existing fixtures and pilot fixtures.
- Cost of chemical treatments for cleaning and functionality for both existing fixtures and pilot fixtures (critical for comparing waterless urinals to existing urinals), while taking into account how much these chemical treatments cost.
- Maintenance costs (if applicable) for both existing fixtures and pilot fixtures.
- Total costs for each individual fixture (water + chemical + maintenance)
- Based on the above results, the calculated pay-back period for each individual fixture.

It should be noted that an ideal trial period for such a pilot project is at least one month. A longer period of time will allow those running the pilot study to average random variables associated with water use per fixture on a day to day basis. A longer length of time will also increase the validity of the cost-analysis, perhaps the most important part of the study. A second factor that will determine the outcome of a pilot study is the plumbing located within the Dalplex. In order to be completely effective many low flow fixtures must have the appropriate plumbing (wide drains with a long vertical slope) and certified parts (Martin, 2004). Without this combination the true measure of a fixtures water saving potential can never be recorded.

2) Because the amount of maintenance staff has not increased with the addition of new buildings on campus, the amount of time that can be spent checking for leaks in the Dalplex has decreased. When not actively checking plumbing and fixtures, Facilities Management must rely on staff or members of the community to submit reports of problems. Without standards set (as to what constitutes a 'problem'), a problem might go unreported for as long as it is not 'deemed' a problem by an individual. A set of standards pertaining to the functionality of each fixture should be drafted by Facilities Management. If it is not economically feasible to hire new maintenance staff or designate increased spot checks under their authority, then perhaps responsibility should be partially shifted to Dalplex staff. These individuals are at the Dalplex on a daily basis; therefore they would be able to identify problems the minute they surface. Students might also be able to help in this situation. With increased knowledge and understanding of the impacts associated with wasted water they might feel obligated to submit reports to staff, which in turn can pass this information on to Facilities Management. Education initiatives can be as simple as posting informative signs in appropriate areas of the Dalplex.

3) Because of time restraints, we were only able to accomplish so much. It would be ideal to have future groups pick up where we have left off, filling in missing answers to

questions and study other areas of water use at the Dalplex which we missed. Water cooling systems and the pool were not studied during the course of our audit; these are two other systems where the potential to save water on a yearly basis is high. Groups can research to see if water in cooling systems is recycled, or if a pool cover is used at night to prevent evaporation. As mentioned earlier, user education is a large issue. Members of the Dalhousie community need to realize the limitations of low flow fixtures and how to use them properly. Problems in the past associated with flooding and plugged fixtures are directly attributed to user habits (Howitt, 2004). If this can be prevented through awareness and education campaigns undertaken by future environmental science students, then water conservation techniques can be implemented on a larger scale; not only in the Dalplex, but across campus.

For example, Mr. Howitt informed us that the ULF toilets in the MacMechan bathroom on the main floor of the Killam Library may be uninstalled. We propose that they remain installed for the next year, and perhaps the next class of Greening the Campus students launch an awareness program as to how these facilities should be used properly. This may increase the effectiveness of the fixtures to the point where they remain installed permanently, and the university can save water and the economic cost associated with this resource.

DALPLEX WATER AUDIT

APPENDICES

APPENDIX (Anatomy): A worm-shaped process projecting from the blind end of the caecum.

APPENDIX A
DALPLEX FIXTURE SUMMARY
** See below for section glossary*

- The following is a list of fixtures gathered early on in the water audit from the main bathrooms / change rooms at the Dalplex. Six areas were sampled in the building – these are the academic wing, main floor change rooms, family change rooms, field house, pool deck, and the cardio bathrooms.
- Each section is broken into title, description of room, a complete list of fixtures, their make and physical integrity.

ACADEMIC WING
- *Contains one male and female washroom, each consisting of a toilet and faucet.*
  Toilets: American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Faucets: American Standard Waltec 12 / No leaks / No aerators.

MAIN FLOOR CHANGE ROOMS (Men)
- *Contains a mixture of faucets, showers (not running on timers), toilets and urinals.*
  Toilets (x3): American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Faucets (x4): Moen Commercial / No leaks / 3.78L aerators.
  Urinals (x4): American Standard / No leaks / Timed flush / 3.8LPF
  Shower heads (x18): American Standard Bradley / 8 steady leaks / 9.5LPM aerators

MAIN FLOOR CHANGE ROOMS (Women)
- *Contains a mixture of faucets, showers (not running on timers) and toilets.*
  Toilets (x6): American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Faucets (x4): American Standard Waltec 12 / No leaks / 8.3LPM aerators
  Shower heads (x18): American Standard Bradley / 2 steady leaks / 9.5LPM aerators

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POOL DECK (Men)
- *Contains showers running on a timer system.*
  Shower heads (x6): American Standard Bradley / No leaks / 9.5LPM aerators

POOL DECK (Women)
- *Contains showers running on a timer system.*
  Shower heads (x6): American Standard Bradley / No leaks / 9.5LPM aerators

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FIELD HOUSE (Men)

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets (x3): American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Urinals (x3): American Standard / No leaks / Timed flush / 3.8LPF
  Faucets (x3): American Standard Waltec 12 / No leaks / 7.5LPM aerators

FIELD HOUSE (Women)

- *Contains a mixture of toilets and faucets.*
  Toilets (x9): American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Faucets (x5): American Standard Waltec 10 / No leaks / 7.5LPM aerators

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FAMILY CHANGE ROOM

- *Contains a mix of faucets, toilets and showers (not running on timers).*
  Toilets (x1): American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Faucets (x1): American Standard Waltec 12 / No leaks / No aerator
  Shower heads (x3): No name / No leaks / 9.5LPM aerators

CARDIO BATHROOM (Men)

- *Contains a mixture of toilets, faucets and urinals.*
  Toilets (x1): American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Urinals (x1): American Standard / Constantly flushing / Timed Flush / 3.8LPF
  Faucets (x1): American Standard Waltec 12 / No leaks / 7.5LPM aerator

CARDIO BATHROOM (Women)

- *Contains a mixture of toilets and faucets.*
  Toilets (x1): American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Faucets (x1): American Standard Waltec 12 / No leaks / 7.5LPM aerator

---

GLOSSARY

LPF: *Litres per flush.*
LPM: *Litres per minute.*
No leaks: *The fixture is in complete working order, with no visible leaks or damage.*
Steady leaks: *The fixture is emitting a steady stream of water when turned off.*
Constantly flushing: *The fixture is constantly flushing, without a break in the cycle.*
Timed Flush: *Fixture flushes every hour during the day.*

APPENDIX B

DALHOUSIE FIXTURE SUMMARY

** See below for section glossary*

- The following is a list of bathrooms sampled across the Dalhousie Studley campus.
- These figures were gathered as supplemental material only – used to compare fixtures across campus to those located within the Dalplex.
- The intent of this study was to find out if there is any continuity in fixtures across campus, or if there are existing low flow water fixtures installed in other buildings.
- Only male bathrooms were sampled.
- Twelve buildings were sampled – a brief description of the rooms, the make of the fixtures within, and the physical integrity of each will be listed. The total number of fixtures in each room was not recorded.

LIFE SCIENCES CENTRE (LSC) – BIO 6th FLOOR
- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Urinals: American Standard / No leaks / Timed flush / 3.8LPF
  Faucets: American Standard Waltec 12 / No leaks / 7.5LPM aerator

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CHASE BUILDING – LOWER FLOOR
- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: American Standard / External tank (no volume reading) / No leaks
  Urinals: American Standard / Teck II flushometer / Timed flush / 3.8LPF
  Faucets: American Standard Waltec 40 / No leaks / 7.5LPM aerator

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CHEMISTRY BUILDING – LOWER FLOOR
- *Contains a mixture of toilets and faucets.*
  Toilets: American Standard / External tank (no volume reading) / No leaks
  Faucets: No name / Steady leak / No aerator

ARTS AND ADMINISTRATION – LEVEL 0
- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: Canadian Potteries / Crane flushometer / No leaks / LPF N/A
  Urinals: Canadian Potteries / No leaks / Timed flush / LPF N/A
  Faucets: No Name / No leaks / No aerators

ARTS AND ADMINISTRATION – LEVEL 3

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: Canadian Potteries / Crane flushometer / No leaks / LPF N/A
  Urinals: Canadian Potteries / No leaks / Timed flush / LPF N/A
  Faucets: No Name / No leaks / No aerators

KILLAM MEMORIAL LIBRARY – MACMECHAN WASHROOM

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: N/A
  Urinals: N/A
  Faucets: Kindred Commercial / No leaks / 8.3LPM aerators

STUDENT UNION BUILDING – SECOND FLOOR

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: American Standard / Waltec II flushometer / No leaks / 13.25LPF
  Urinals: American Standard / No leaks / Timed Flush / 3.8LPF
  Faucets: Delta / No leaks / 7.5LPM aerators

DUNN ENGINEERING – THIRD FLOOR

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: Crane / Crane flushometer / No leaks / 13.25LPF
  Urinals: Crane / No leaks / Timed Flush / 3.8LPF
  Faucets: Aristaline / No leaks / 1.9LPM aerators

FASS BUILDING – THIRD FLOOR

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: Crane / Crane flushometer / No leaks / 13.25LPF
  Urinals: Crane / No leaks / Timed flush / 3.8LPF
  Faucets: Aristaline / No leaks / 7.5LPM

DALHOUSIE ARTS CENTRE – BOTTOM FLOOR

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: American Standard / Waltec Quiet Flush flushometer / No leaks / 13.25LPF
  Urinals: American Standard / No leaks / Timed flush / 3.8LPF
  Faucets: American Standard Waltec 12 / No leaks / 2/3 have 8.3LPM aerators

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COMPUTER SCIENCE – MAIN FLOOR

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: American Standard / Zurn flushometer / No leaks / 13.25LPF
  Urinals: American Standard / No leaks / Sensor flush / 3.8LPF
  Faucets: Aristaline / No leaks / 7.5LPM aerator

WELDON LAW BUILDING – SECOND FLOOR

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: American Standard / Zurn flushometer / No leaks / 13.25LPF
  Urinals: American Standard / No leaks / Timed flush / 3.8LPF
  Faucets: American Standard Waltec 12 / No leaks / 8.3LPM aerators

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TUPPER BUILDING – THEATRE BATHROOMS

- *Contains a mixture of toilets, urinals and faucets.*
  Toilets: American Standard / Zurn flushometer / No leaks / 13.25LPF
  Urinals: American Standard / No leaks / Timed flush / 3.8LPF
  Faucets: American Standard Waltec 12 / ½ have steady leak / 8.3LPM aerators

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GLOSSARY

LPF: *Litres per flush.*
LPM: *Litres per minute.*
No leaks: *The fixture is in complete working order, with no visible leaks or damage.*
Steady leaks: *The fixture is emitting a steady stream of water when turned off.*
Timed Flush: *Fixture flushes every hour during the day.*
External Tank: *Toilet fixture has an external tank instead of a flushometer.*

APPENDIX C
WATERLESS URINAL EVALUATION / FUNCTION

- The following is a brief report completed by Facilities Management on a waterless urinal constructed by Water Matrix, a Canadian fixture company.
- Information on Water Matrix fixtures can be found at; http://www.watermatrix.com/waterless/
- The urinal was tested within the Facilities Management building on 1326 Henry St, during 2003-2004 (Howitt, 2004).
- The costs associated with the waterless urinal were compared to costs associated with a traditional 3.8LPF urinal (as seen throughout campus)

	Waterless Unit	**Traditional Unit**
Chemical Cost per year	$227.00	$109.00
Cartridge Cost per year	$57.00	*N/A*
Labour Cost per year	$126.00	$63.00
Water Cost per year	*N/A*	$131.00
Overall Satisfaction	Poor	Good
Total Costs per year	$410.00	$303.00

FUNCTION OF A WATERLESS URINAL

- Since waterless urinals do not use water to flush urine into a plumbing system, they must rely on a cartridge to accomplish this. According to Falcon Waterfree Technologies (www.falconwaterfree.com), the cartridge performs four main functions;
    - *Acts as a funnel, allowing liquid from the bowl to flow into the cartridge.*
    - *It holds a liquid sealant that acts as a boundary between the urine and the air, eliminating odours.*
    - *It acts as a trap for uric sediment. Much of the sediment that can cause drainage pipe corrosion is trapped at the bottom of the cartridge.*
    - *It allows the remaining urine to be freely disposed down the drain.*

- Sealant liquids are less dense than water; therefore they remain at the top of the cartridge, allowing urine to pass through to the bottom of the cartridge and into the drain.

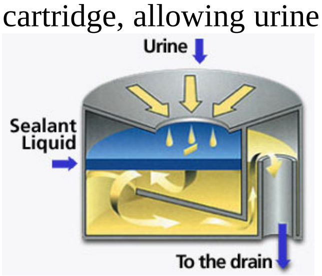

Diagram of cartridge / sealant

- A typical cartridge needs to be replaced after approximately 7,000 uses.

APPENDIX D
INTERVIEW QUESTIONS / ANSWERS

** The three interviews that we completed will be looked at in this appendix. Each question asked will be illustrated along with its answers.*

Interview 1 (Ray Snow plumbing fixture company manager)

What is the most popular plumbing fixture company?
- American Standard and Crane

What is the cost of an average commercial urinal?
- Crane $400 American Standard $550

Are there any waterless urinals sold in Nova Scotia?
- Not that he knew of.

Are many customers concerned with water conservation when buying plumbing fixtures?
- Not usually in Nova Scotia, but some new apartment buildings are installing low flow toilets (less then 6 litres).

What is the average volume of water used per flush with urinals?
* Normal urinals use 5-6 litres per flush.
* Low Flow urinals use 3.8 litres per flush and cost $500.
* American Standard sensor low flow urinals use 1.9 litres per flush and cost $1000.

How much do waterless urinals cost?
- Don't know.

In Nova Scotia are there any special standards that plumbing fixtures must adhere to?
- Yes, they must adhere to CSA (Canadian Standard Association) and national building codes. They must also adhere to the guidelines governing the American Disabilities act and ANSI A117.1 requirements for the physically challenged.

How much do commercial toilets cost? How do they (price wise) compare with low flow toilets?
- Price wise, they both cost about the same ($400-$700) with the cheapest being $300.

What is a low flow toilet?
- A low flow toilet is a toilet with 6 litres or less in its tank.

What is a pressure powered toilet? And how does it compare with a gravity fed toilet?
- A pressure powered toilet uses pressure to push water thru pipes. In comparison to gravity fed all it needs is another fixture attached to the toilet.

What would you estimate the labour cost to be for installing a toilet?
- It would cost $50 dollars an hour and it usually takes 2-3 hours to install a toilet.

How much do commercial faucets cost?
- They cost $200 and have a flow of 8.3 litres a minute.

How much are faucets with sensors?
- They range in price between $200-$400 dollars with the American Standard being $470.

What is a low flow faucet?
- A low flow faucet is a faucet that uses less than 8.3 litres of water a minute.

What are aerators?
- Low-flow aerators work by restricting water flow and increasing pressure.

Would the university save money by buying plumbing fixtures in bulk?
- Yes

Is clogging a problem with low flow toilets?
- At first in the original models it was an issue, but the newer models have bigger pipes so there isn't much of a clogging problem anymore.

Do you sell low flow showerheads?
- Yes now all showerheads are low flow because of low flow water guidelines. All showers must be less than 2.5 gallons a minute (ASME A112.18.1M).

Can you get low flow showerheads in less then 2.5 gallons per minute?
- No, all company's just make 2.5 gallon per minute showerheads. You need a special restrictor to go lower.

What is the average cost of a commercial low flow showerhead?
- $25

Is there any other water saving techniques that you can think of that will save water with the plumbing fixtures?
- Changing toilet parts from brass to plastic would save water as they don't rust.

Interview 2 (Dalplex Employee)

Do you have an environmental background (have you ever taken an environmental studies class)?
- No

What would you classify you environmental awareness as?
- I know enough to know that there is a problem.

In an hour of work how many people would you say visit the Dalplex?
- During busy times 10 a minute; during non-busy times 1 a minute.

When would you classify the busy and non-busy times to be?
- Busy times would be between 11-1 and 4-7 and non-busy would be everything else.

Do you have regular rounds (times in which you have to check each area of the building)?
- No

How often do you go through the change room?
- 5-6 times a shift.

During these times have you noticed any water waste (water being used but for no reason)?
- Yes, showers are left on all the time when no one is using them. Faucets are left on as well, but not as much.

How many towels do you give out during busy and non-busy times?
- During busy times 50 (2 to each person) every ten minutes. During non busy times 10-20 every ten minutes.

Who would you say wastes the most water in the Dalplex (leaves on showers and taps)?
- Kids do, but there are always exceptions.

Interview 3 (Peter Howitt)

Has Dalhousie ever considered a change to water conserving fixtures? Urinals?
- Water conservation fixtures have been pilot tested at Dalhousie (many in the facilities management building, for example waterless urinals). They were found to be unsatisfactory and more expensive in the long run (we suggested a model that has a reputation to have solved many of the problems that other waterless urinals have. He was very enthusiastic and told us that he would look into it).

Toilets?
- Low volume toilets have recently been tried and have proved frustrating. Low volume toilets placed in the library have consistently become clogged and overflowed (6 major floods since their installation, causing the possibility that they may be uninstalled in the near future). Low volume toilets were installed in Eliza Ritchie a few years ago but have since been replaced. Due to floods, floors and ceilings had to be repaired. Damages totalled $20,000 over a few years (there models are now outdated, technology has improved since then and the problems have been eliminated.

Faucets?
- Mr. Howitt indicated that he was very interested in installing on a large scale 0.5GPM aerators (Dalplex's toilets and faucet fixtures date back to 1979, when the building was constructed).

Showers?
- He expressed an interest in installing timers on the showers in the change rooms. Patrons (children in particular), tend to leave the showers on after they are finished. Sometimes a shower will run for hours at a time. (The benefits of having timed showers could not be quantified in our cost analysis, as there is no data for how much water is wasted as a result of the showers being left on after their use. However, we believe that the benefits are great both environmentally and economically. Timed showers allow people to be more aware of how long they have been in the shower, and may encourage them to take shorter showers.

Do patron's behaviours affect Dalplex water waste?
- It was stressed that the major problem with water wastage is the habits of the patrons. The fixtures can work if used properly, but often they aren't. For example, low volume toilets aren't made to handle the disposal of sanitary napkins and tampons, but it is very hard to control the behaviour of the users. They can be told not to do so, but even if a minority do choose to abuse the fixtures, this can result in large damages and costs to Dalhousie.

Permission Form *(used for select interviews to obtain signed consent)*
Respondent must sign statement for interview to occur

I Ray Snow agree with the following stipulation to this interview:

I understand my right to choose whether to participate in the project and that the information obtained will be handled confidentially if required by respondent and I am aware that the results of the interview may be used for the purposes of publication in a class project.

APPENDIX E
DALPEX COST ANALYSIS

- The following are cost analysis calculations for each fixture studied at the Dalplex, and the alternatives suggested.
- Assumptions for each set of calculations made will be listed, as well as the step by step process taken to reach our final conclusions.

GENERAL FIGURES *(Associated with Calculations)*
- Number of daily visitors (based on interview results): *3,700*
- Price of water / Litre: *$0.0023*

TOILET COST ANALYSIS

- There were a couple of assumptions made to complete these calculations. The first is that on average, 3700 people will use the Dalplex each day. Based on this figure it is assumed that approximately 2/3 of these visitors will use a toilet once during their visit. This sets the number of daily flushes at 2,466.
- To calculate the amount of water used presently by toilets we take the total number of flushes in a day and multiply it by the flush rate of Dalplex toilets (13.25 Litres per flush). To calculate the cost we multiply the amount of water used per day by the price of water per litre.
  - ***2,466 x 13.25L = 32,674 L / day***
  - Daily cost: ***32,674 L / day x $0.0023/L = $75 / day***
- To calculate the amount of water used if low flow toilets were installed (6 litres per flush) we multiply the daily flush amount by 6. To calculate the cost we multiply the amount of water used per day by the price of water per litre.
  - ***2,466 x 6L = 14,796 L / day***
  - Daily cost: ***14,796 L / day x $0.0023/L = $34 / day***
  - The difference is: ***32674 L – 14,796 L = 17,878 L / day***
  - Total savings per day is: ***$75 - $34 = $41***
- The amount of money saved during an 8 month period (standard school year) if low flow toilets (6 litres per flush) are used is calculated by multiplying daily savings by 240 days (the average number of days in an 8 month period). The amount of litres saved during the same 8 month period is calculated by multiplying total savings per day by 240 days.
  - ***$41/ day x 240 days = $9,840 / 8 months***
  - Litres saved: ***17,878 L / day x 240 days = 4,290,720 L***
- To calculate the pay-back period for the installation of low flow toilets, we must first find the installation cost. We then take this number and divide by the total savings for each 8 month period. Labour costs will not be included as they cannot be adequately calculated.
  - ***$10,000*** (total installation cost for 25 toilets) ***/ $9,840 = 244 days***

URINAL COST ANALYSIS

- We did not have to make any assumptions based on visitor rates with urinals, as they flush once every hour regardless of how many patrons use them.
- To calculate the amount of water used each day by the urinals in the Dalplex we must calculate the amount of water used by each individual urinal, and then multiply it by the total amount of urinals. During each flush a urinal will consume 3.8 litres of water. To calculate the amount of water consumed during an 8 month period, we will multiply the amount of water used per day by 240 days.
  - ***3.8 L / hr x 24 hr / day = 91.2 L / day***
  - ***91.2 L / day x 8 urinals = 729.6 L / day***
  - Water used in an 8 month period: ***729.6 L / day x 240 days = 175,104 L***
- Since waterless urinals do not use water, we do not need to calculate the amount of water saved during an 8 month period. To find out how much money can be saved every 8 months through the installation of waterless urinals we will need to find the amount of money spent each day on urinal water, and the total amount spent every 8 months.
  - ***729.6 L / day x $0.0023 / L = $1.67 / day***
  - ***$1.67 / day x 240 days = $402.74 / 8 months***
- Before we can make final calculations there are several other monetary variables associated with waterless urinal use. These are installation and maintenance costs.
  - Unit Price: ***$498 x 8 urinals = $3,984***
  - Cartridge Price: ***$75 x 8 urinals = $600 / 8 months***
  - Chemical Costs: ***$227 x 8 urinals = $1,816 / 8 months***
  - Total costs: ***$3,984 + $600 + $1,816 = $6,400***
- As with the low flow toilets, the pay-back period is calculated by dividing total installation costs by total savings.
  - ***$3,984 / 402.74 = 3,813 days (10 years)***

FAUCET COST ANALYSIS

- The main assumption with faucet calculations is that based on 3700 patrons each day, approximately 2/3 of them will wash their hands for 30 seconds. This puts the number of uses at 2,466 per day.
- To calculate the amount of water used each day we must multiply the number of uses per day by the flow rates of the faucets at the Dalplex (which are 7.5 litres per minute - divided by half to account for 30 seconds of use). To calculate the daily cost of faucet use we will multiply the amount of litres used each day by the price per litre.
  - ***2,466 x (7.5/2) = 9,247 L / day***
  - Daily Cost: ***9,247 L / day x $0.0023 / L = $21.27 / day***
- To calculate the costs if low flow aerators were installed (1.9 litres per minute) we must multiply the number of daily uses by the flow rates of the low flow aerators.
  - ***2,466 x (1.9/2) = 2,342 L / day***
  - Daily Cost: ***2,342 L / day x $0.0023 / L = $5.38 / day***
  - The difference is: ***9,247 L / day – 2,342 L / day = 6,905 L / day***

  - Total savings per day: ***$21.27 – $5.38 = $15.89***
- The amount of money saved during an 8 month period (standard school year) if low flow aerators are used is calculated by multiplying daily savings by 240 days (the average number of days in an 8 month period). The amount of litres saved during the same 8 month period is calculated by multiplying total savings per day by 240 days.
  - ***$15.89 x 240 days = $3,813 / 8 months***
  - Litres saved: ***6,905 L / day x 240 days = 1,657,200 L / 8 months***
- To calculate the pay-back period for the installation of low flow aerators, we must first find the installation cost. We then take this number and divide by the total savings for each 8 month period. Labour costs will not be included as they cannot be adequately calculated.
  - ***$79*** (cost to install 20 aerators) ***/ $3,813 = 5 days***

SHOWER HEAD COST ANALYSIS

- Assumptions made to calculate the pay-back period for shower heads are that 1/3 of the 3700 daily patrons will take a 5 minute shower. This works out to 1233 showers daily.
- To calculate the amount of water used presently by showers we take the total number of uses in a day and multiply it by the flow rate of Dalplex shower heads (9.5 Litres per minute x 5 (to account for a 5 minute shower)). To calculate the cost we multiply the amount of water used per day by the price of water per litre.
  - ***1,233 x 5 min x 9.5 L / min = 58,567 L / day***
  - Daily cost: ***58,567 L / day x $0.0023 / L = $134.46 / day***
- To calculate the amount of water used if low flow shower heads were installed (7.5 litres per minute) we multiply the daily use by the flow rate of low flow shower heads (7.5 litres per minute x 5(to account for a 5 minute shower)). To calculate the cost we multiply the amount of water used per day by the price of water per litre.
  - ***1,233 x 5 min x 7.5 L / min = 46,237 L / day***
  - Daily Cost: ***46,237 L / day x $0.0023 / L = $106.34 / day***
  - The difference is: ***58,567 L / day – 46,237 L / day = 12,330 L / day***
  - Total Savings per day: ***$134.46 / day – 106.34 / day = $28.12***
- The amount of money saved during an 8 month period (standard school year) if low flow shower heads are used is calculated by multiplying daily savings by 240 days (the average number of days in an 8 month period). The amount of litres saved during the same 8 month period is calculated by multiplying total savings per day by 240 days.
  - ***$28.12 x 240 days = $6,748 / 8 months***
  - Litres saved: ***12,330L / day x 240 days = 2,959,320 L / 8 months***
- To calculate the pay-back period for the installation of low flow shower heads, we must first find the installation cost. We then take this number and divide by the total savings for each 8 month period. Labour costs will not be included as they cannot be adequately calculated.
  - ***$2,550*** (cost to install 51 shower heads) ***/ $6,748 = 88 days***

TIMED SHOWER COST ANALYSIS

- This is in addition to the costs associated with the installation of low flow shower heads. A timed shower system costs approximately $100 to install. Because 12 of the showers we studied in the Dalplex already have timers, 39 remaining shower heads would need to be retrofitted. To calculate the total cost of such a retrofit (excluding labour) we multiply the number of shower systems by the cost of a timer.
    - ***39 shower heads x $100 = $3,900***
- The cost of installing timed showers is then added to the total costs for installing low flow shower heads.
    - ***$3,900 + $2,550 = $6,450***
- The pay-back period for the installation of the timed shower system and low flow shower heads can now be calculated. To do so we take the installation costs and divide by the savings for an 8 month period.
    - ***$6,450*** (cost to install timers / heads) ***/ $6,748 = 227 days***

COMPLETE TOTALS

- The complete water savings for an 8 month period are;
    - **9,082,296 L** (approximately **40%** in savings)
- The amount of money saved during the same 8 month period is;
    - **$20,889**
- The installation costs range between;
    - **$18,979 - $22,929**
- Therefore, the total pay-back period will range between;
    - **218 – 263 days.**

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