RESEARCH

WATER CONSERVATION: OBSERVATIONS FROM A HIGHER EDUCATION FACILITY MANAGEMENT PERSPECTIVE

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ABSTRACT

Sustainable or green building practices have been adopted by most higher education institutions for their new campus buildings, major renovations and daily operations. This paper provides a synthesis of opinions and existing practices related to water conservation in institutional green buildings of member institutions of APPA (formerly the Association of Physical Plant Administrators). A specific focus regarding waterless urinals and their operation was attempted. A web-based survey and follow-up one-to-one interviews were utilized to extract information and data from these industry professionals. The survey evaluated the institution's use of policy related to sustainable building practices and focused on their approaches to water conservation. Regional preferences are provided and barriers to some water conservation practices and approaches have been identified. Operational challenges are evident, particularly as they relate to waterless urinals. It is clear that higher education institutions are engaging in water conservation practices across Canada and the United States. This work contributes to a foundation for future research and analysis related to best-management practices for water conservation in the higher education sector.

KEYWORDS

water conservation, higher education, LEED®, rainwater harvesting, waterless urinals, policy

INTRODUCTION

All levels of the Canadian government have focused almost exclusively on increasing water supply rather than on reducing demand. Although Canada has a relatively abundant amount of fresh water, the country must come to terms with the fundamental fact that there is not an endless supply of fresh water and water laws and policies must evolve to reflect this reality (Boyd, 2003). Despite Canada's strong environmental values, a 2001 report from the

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Eco-Research Chair at the University of Victoria found that Canada's environmental performance was one of the weakest of all countries in the Organization for Economic Cooperation and Development (OECD) (Boyd, 2001).

Independent evaluations by the OECD and the Canadian Commissioner of Environmental and Sustainable Development indicate that the major factor explaining Canada's substandard environmental performance is poor public policy (Gunton, 2005). Others have concluded that current Canadian laws and policies are often barriers to innovation and new technology (Boyd, 2003). Conversely, many studies have shown that the adoption of new environmental technologies can be accelerated by appropriate regulatory action or even by the anticipation of future regulatory actions (Steinberg et al 2000; Rondinelli and Berry; 2000; Khanna et al. 2009). In addition, widely accepted theories of innovation diffusion postulate that adoption decisions are aided when decision-makers believe that the innovation is not too complex for them to understand or operate successfully, and when they can personally observe the new technology in successful operation (Rogers, 2003).

As ongoing pressure from economic growth continues, concerns will be introduced regarding the reduced reliability of the water supply and water management. The results of these concerns may include policies relating to the development and adaptation of innovative technologies and processes (Horbulyk, 2005). There is a growing recognition for the need to reduce water demand through conservation and efficiency that may result in lower supply costs, less environmental damage and more rapid implementation (Brandes and Maas 2006). In many cases, the adoption of these technologies will challenge the *status quo* and will require decision-makers to break with long-standing design practices.

The sustainability movement in higher education has been emerging from its early stages and has seen significant progress over the past ten years or more. Most of the tangible indicators have occurred in campus operations, particularly in energy conservation, renewable energy, water conservation and sustainable building designs (Elder 2008). Green buildings, often referred to as sustainable buildings, are a common trend on higher education campuses across Canada and the United States. These facilities are being constructed as universities and colleges strive to incorporate into their campuses a built environment that reflects the movement to sustainability and "green" facilities. Senior facility management professionals, by the very nature of their position and their corresponding autonomy and authority, provide leadership and play a key role during the planning, design and construction of new buildings and major renovations at their respective campuses. They have the most strategic impact and influence on the achievement of sustainable outcomes for these new facilities and are charged with the ongoing operation and maintenance of the building after the construction process (Cupido et al. 2010). Utilizing a case study methodology to determine factors contributing to institutions achieving environmental sustainability, James and Card (2011) recognized that institutions need facility management leaders that are highly progressive, persistent and environmentally knowledgeable.

The lead author is a member of APPA (formerly the Association of Physical Plant Administrators), the association serving higher education facility management professionals. This organization represents facility professionals from coast-to-coast in Canada and the United States.

To date, no comprehensive, formal research initiative has been performed with APPA as it relates to water conservation policy, methods, regional differences, barriers and related operational challenges. Research through this organization and its members would provide a broad geographic perspective on water conservation approaches in higher education.

The primary purpose of this paper is to provide a synthesis of opinions and existing practices related to water conservation in institutional green buildings of member institutions of APPA. The relationship between water conservation importance and institutional policy is discussed. A specific focus regarding waterless urinals and their operational concerns is attempted. Barriers to waterless urinals and rainwater harvesting (with treatment to potable water standards) are investigated. The paper illustrates an innovative rainwater harvesting system that is capable of producing potable water for building occupants. The operational outcomes and challenges are identified. This paper concludes with opportunities for future research within the higher education sector regarding water conservation.

BACKGROUND

Many Canadian and American higher educational institutions have now adopted a policy, guideline, standard, law or goal to ensure that green buildings or green practices will form part of the built environment on their respective campuses (Cupido et al 2010). These approaches typically utilize a formal green building or sustainable building rating assessment system to validate that their efforts actually produce a "green" building. Whether a policy or non-policy (i.e. guideline, standard, law or goal) is used by the institution, the most commonly identified building rating assessment system is the Canadian Green Building Council's (CaGBC) or the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED®) standard.

LEED® and Higher Education

Developed in the United States and now commonly utilized in Canada, LEED® is a nationally accepted benchmark for the design, construction and operation of high performance green buildings. LEED® was created to transform the built environment to sustainability by providing the building industry with consistent, credible standards for what constitutes a green building. Several assessment rating systems are used throughout the building industry to evaluate designs, however, in the North American market LEED® is the most dominant system and is being adapted to worldwide markets (Fowler and Rauch 2006). LEED® has also shown to be a commonly referenced metric within many existing U.S. policies (Pearce et al. 2005). Higher educational institutions that have implemented sustainable policies for their new buildings are exhibiting policy compliance and meeting their LEED® targets (Cupido et al. 2010). LEED® is not without some shortcomings and in some instances can result in unintended consequences. Building professionals can recognize that any rating system should not be blindly followed (Bray 2006).

Green buildings have many features that make them far superior to conventional buildings and are more cost-effective to operate and are more adaptive to alternate uses. Characteristics include: optimal site selection, improved building envelope, efficient electrical light fixtures, and efficient water supply and wastewater fixtures, including rainwater and waste water recycling systems (Cole 2005). A major practice in LEED® buildings is water conservation and institutions are focusing on specific approaches that may assist with their water conservation needs including rainwater harvesting (Cupido et al. 2012).

From an institutional perspective, green buildings may be an opportunity to showcase innovation and attract incoming students and faculty (Richardson and Lynes 2007). As it relates to higher education, many universities have become better environmental stewards, but are still faced with difficult challenges. Specific actions are necessary to address these challenges. These actions include the development of a strategy for limiting water use to a reasonable allocation of the locally available supply (Graedel 2002, Beringer et al. 2008). Wright (2002), recognized the importance of green campus physical operations as a common theme in institutional policies as well as in national and international declarations. Various initiatives of sustainable campus operations categorized by Kosnik (2007) included building construction and renovation, energy management, transportation and water use. McIntosh et al (2008) recognized that the greening of day-to-day campus operations as the most successful aspect addressed by higher education institutions.

Water Conservation and Higher Education

In a broader perspective across various Canadian and American higher education institutions, several examples of water conservation attitudes and practices are provided along with barriers or perceived barriers to attaining these sustainable practices:

- Following a study of sustainability in higher education in the Atlantic Provinces, it was determined that water conservation and awareness regarding water use was not an issue or of little issue in approximately two-thirds of the institutions studied. A precipitation-rich area such as Atlantic Canada was likely a factor in these results (Beringer et al. 2008).
- A cohort of Canadian facilities management directors was asked to identify perceived barriers to implementing sustainable initiatives in their institutions and the majority of the respondents felt that they did not have the adequate financial resources to complete some or all of the planned sustainable initiatives. Other barriers included attitudes, staffing resources, government, lack of university cohesion and lack of leadership and sustainability policy (Wright and Wilton 2012).
- Many regions in the United States have been facing water shortages and drought and have been forced to improve water resources management. A popular method for demand management has been water conservation which has been identified as a critical issue for higher education across the state of Texas (Zellner 2014). Building-use conservation methods on the campuses of higher education in Texas include; low-flow urinals, toilets, faucets, showers and waterless urinals.
- The Medical Sciences building at the University of Victoria in British Columbia now uses recycled wastewater from a nearby marine research lab on campus to provide treated water for urinals and toilets and thus requires no potable water for flushing (Leach 2005).
- At a proposed, innovative mixed-use development designed to create a low-impact housing community on more than 200 acres on the University of California, Davis (UC Davis) campus, the objective was achieving net-zero water use in which annual potable water use is no greater than annual rainfall (Olmos and Loge 2013).
- Despite the widespread use of LEED® in green building policies, many cite the cost as a major disadvantage to using the system (Retzlaff 2009). This fact invariably impacts the implementation of any water conservation measures in the LEED® certification process for Higher Education institutions.

RESEARCH METHODOLOGY

A comprehensive quantitative web-based survey was developed by the lead author to poll members of APPA on their use of policies or non-policies for sustainable development and the use of LEED® applications for new construction and major renovations on their campuses (Cupido et al. 2010). A specific focus was undertaken on the importance of water as an essential natural resource that needs to be conserved in the institutional environment.

The overall intent of the survey was to determine if institutional policies are an important criterion for their sustainable building practices and their use of LEED®. Survey questions were tailored through two streams. One set of questions was provided if the participant's institution had a green building policy in place and a separate set of questions was provided for a participant whose institution did not have a policy in place. However, all participants were asked several survey questions to identify water conservation practices and uses for harvested rainwater, if practiced. Each participant was asked if they wished to be contacted for a follow-up qualitative telephone interview. For the purposes of this paper, only the principal findings and outcomes related to the water conservation component of the survey and interviews are identified and discussed. Outcomes of the survey regarding institutional use of policy or non-policies were reported in related research by Cupido et al (2010).

Following Research Ethics Board approval at McMaster University, and consent from participants, the web-based survey was distributed to the designated institutional representatives of APPA's member institutions and was completed over a four week period commencing in May 2008. The total number of member institutions with designated institutional representatives approaches 1,100. These representatives are typically the senior facility management official at their respective institution and are responsible for the management of higher education facilities across Canada and the United States. These individuals generally have a professional designation such as a Professional Engineer or an Architect. The survey did not request participants to compromise their anonymity. This research was initiated and performed in cooperation with APPA's Center for Facilities Research (CFaR). The Center was established to engage in a deliberate search for knowledge critical to policy making in education.

Follow-up telephone interviews were conducted with a subset of respondents from the web-based survey who agreed to participate in this second phase. The interviews provided an opportunity for the researcher to qualitatively explore and supplement the water conservation components of the web-based survey and to gain greater insight as to the strategic application of water-based sustainable initiatives at their respective institutions. APPA is divided into six geographic regions encompassing Canada and the United States as shown in Figure 1. Four participants were selected from each region to provide a geographical balance across each country.

Interview questions regarding water conservation and rainwater harvesting practices are shown in Table 1. The total duration of each interview was 30 to 45 minutes and all answers and dialogue were transcribed for later review and analysis and will remain confidential. This mixed-methods approach provided valuable information beyond what is available from published sources, and was an essential ingredient to the research performed.

Following the survey and interviews, the lead author undertook two initiatives to supplement the findings and outcomes: 1) an operational review by the lead author of waterless urinals at the David Braley Athletic Center (DBAC) on the McMaster campus; and 2) the lead author's investigation of the early performance outcomes of a unique rainwater-to-potable water treatment system at McMaster's Engineering Technology Building (ETB).

FIGURE 1. APPA's six geographical regions ([Geographical Regions Map] 2007). [Reproduced by permission]

TABLE 1. Interview questions regarding institutional water practices.

Q11. Tell me more about how you rate the importance of water conservation with the conservation of electricity and natural gas?
Q12. Do you feel your local water authority and/or the state or provincial authorities would allow you to harvest rainwater and treat it to drinking water standards? What barriers to this approval are you aware of?
Q13. Are you in favor of waterless urinals? Has your institution had experience with them? If yes, was the experience a positive one? If no, please elaborate.

Waterless urinals were further explored due the number of comments (generally negative) during the interview phase. The issue of rainwater harvesting is a growing municipal requirement in many jurisdictions and many APPA institutional members have explored or commenced the implementation of this requirement through LEED® certification. The water treatment system provided an opportunity to expand on that specific issue and understand if any other APPA member institutions are considering or undertaking this innovative approach to water conservation.

RESULTS AND DISCUSSION

A total of 218 participants accessed the survey and 213 participants completed the survey. Twenty-four individuals participated in the follow up interviews. One individual agreed to participate in the interview and then declined to be interviewed at the time it was scheduled to commence. It shall be acknowledged that there may be a potential for respondent bias in evaluating their own roles and responsibilities in their water conservation practices and use of harvested rainwater.

Demographics

The web-based survey was predominately received by senior facility management (n=186), including several facility planners (n=7) and sustainability officers (n=8). It is not clear whether or not these individuals (the planners and sustainability officers) and their respective roles are within the Facility Services/Physical Plant department, however the assumption is made that they had sufficient departmental knowledge and information to adequately respond to the survey.

The distribution of institution size was well-balanced and generally was evenly distributed from small institutions with a size up to 500,000 square feet (n=15) to the largest with greater than 10 million square feet (n=20). The most common sized institution ranged from 1 million to 2 million square feet (n=51). It is estimated that the respondents represented almost 700 million square feet of campus space that they would have the responsibility to manage and operate. The total number of buildings in each institution indicated a random distribution of responses and subsequent ranges with the most common being 50 to 75 (n=36) or greater than 100 buildings (n=50) on one main campus and other locations where applicable. For reference, the lead author's university has 60 buildings with over 5 million square feet on one main campus.

Water Conservation Importance

When the survey respondents were asked to rank the importance of water conservation with the conservation of electricity and natural gas, almost two-thirds (n=120) felt it was equally as important. Approximately one-third (n=59) felt it was less important and several (n=11) thought it was more important. These findings were supported by the dialogue in the follow-up interviews. As illustrated in Table 2, there appeared to be no specific regional indicator of those interviewed who felt that water conservation was more important or equally important. The interviewees from the western-most region of APPA (PCAPPA), indicated they have a policy or state legislation to guide them in all cases and their water conservation rating was mixed. In the RMAPPA region however, two of the four from this region did rate it as *more important* and this region was the only region to have more than one interviewee rate water conservation as such. In the MAPPA region, three of four felt it was less important and one felt it was equally important. All of those three acknowledged an abundance of municipally available water. One comment that perhaps reinforced this fact was noted; "it is the least of our concerns in this part of the country." Research on the state of sustainability in higher education in Atlantic Canada revealed similar apathy to water conservation and water awareness in that precipitation-rich area (Beringer et al. 2008).

Of the ten institutions that either had an institutional policy or state legislation to guide them for their sustainable practices (Cupido et al 2010a), nine acknowledged that water conservation was equally or more important with only one indicating it was less important. Of the fourteen institutions that did not have an institutional policy or state legislation to guide them for their sustainable practices, eleven acknowledged that water conservation was equally or *less important (n=7)*.

TABLE 2. Ratings of Water Importance in APPA Regions.

Interview No.	APPA Region	Policy (Yes/No)	Government (Prov./State) Legislation (Yes/No)	Water Conservation Rating More, Equally, Less (Important)
5	CAPPA	No	Yes	Equally
4	CAPPA	No	No	Less
6	CAPPA	Yes	No	Equally
7	CAPPA	Yes	Yes	Equally
1	ERAPPA	No	No	More
2	ERAPPA	No	No	Equally
3	ERAPPA	No	No	More
14	ERAPPA	No	No	Less
8	MAPPA	No	No	Less
9	MAPPA	No	No	Less
23	MAPPA	No	No	Equally
15	MAPPA	No	No	Less
16	PCAPPA	Yes	Yes	Less
22	PCAPPA	Yes	Yes	More
24	PCAPPA	Yes	Yes	Less
18	PCAPPA	Yes	Yes	Equally
11	RMAPPA	No	No	Less
12	RMAPPA	No	Yes	More
13	RMAPPA	No[1]	Yes	More
25	RMAPPA	Yes	Yes	Equally
19	SRAPPA	No	No	Equally
21	SRAPPA	No	No	Less
17	SRAPPA	Yes	No	Equally
20	SRAPPA	Yes	No	Equally

Notes:: 1. Interviewee 13 is with an institution that does not have a formal policy but treat their state legislation as if it were a policy for their institution and department.

Rainwater Harvesting

When asked what method is used to harvest rainwater as a component of their green building, approximately two-thirds of the survey respondents (n=109) indicated that they do not harvest rainwater. Of those who do harvest rainwater, the most common approach (n=33) was to utilize roof water collection and storage into a cistern, tank, pond, etc.; other institutions utilized holding pond retention (n=19), swales or bioswales (n=16) and parking lot collection (n=16). Other methods included a groundwater recharge system (n=1), and constructed and restored wetlands (n=2). Two respondents acknowledged that the State of Colorado does not permit rainwater harvesting.

In the interview portion of the survey, interviewees were asked if their local water authority and/or the provincial or state authority would allow their institution to harvest rainwater and treat it to drinking water standards. In addition, they were asked if they are aware of any barriers to rainwater harvesting at their respective campus. Ten of the 24 interviewees were not sure if their water authority would allow or approve rainwater harvesting. Seven were certain that it was not allowed and the remainder indicated that it was allowed or they believed it was allowed. Four interviewees acknowledged that their campus does harvest rainwater for irrigation purposes, although the interview question did not specifically ask them if their campus did harvest rainwater or not.

Several individuals identified barriers, that they were aware of, to harvesting rainwater and treating it to drinking water standards. These barriers included; state/provincial restrictions on the operations (i.e. legislation) (n=17), capital costs to install the system (n=3), operating costs (n=3), public concerns for risk (n=2) and staff training challenges (n=1). These barriers are consistent with barriers identified by Leidle (2008), from stakeholder interviews with municipal representatives, building professionals and product suppliers in the rainwater harvesting industry. However, rainwater harvesting can be advanced by policy initiatives that must be tailored to local initiatives (Farahbakhsh et al. 2009).

The majority of campuses are serviced with a municipal supply of water (n=175) and approximately 53% (n=101) meter or submeter their campus buildings. No metering was in place for 18.4% (n=35) of the respondents. Further to the Green Energy Act, the Province of Ontario enacted the Water Conservation Act 2010 which requires public institutions to develop water conservation plans for their campus and implement that plan. Submetering will likely be required to assist with validating those plans (Bill 72).

Water Conservation Measures

Survey respondents identified water conservation measures that they have already incorporated into a LEED® (or other standard) "green" building. In order of highest response count first, the results are shown in Table 3.

In recent years, manufacturers have introduced more water-efficient washroom components. In the opinion of the lead author, this has made the selection of these items easier for institutional facility professionals and respective LEED® Accredited Professionals who recommend solutions for their clients. The results in Table 3 represent a list of water conservation measures that would be applicable to an institutional building used for academic purposes. The list does not include more extensive measures that may be used in an institutional central utility plant such as modifications to boiler feeds, cooling towers and research intensive water feeds.

Low-flow toilets, showerheads and faucets represent the three most common measures and Table 4 illustrates recommended water-efficient fixture specifications noting the fixture

TABLE 3. Identified Water Conservation Measures.

Measure	Response (Percent)	Response Count (n =)
Low-flow toilets	80.5	153
Low-flow showerheads	71.1	135
Low-flow faucets	70.5	134
Water efficient appliances	56.8	108
Waterless Urinals	32.6	62
Dual-flush toilets	22.6	43
Rainwater Harvesting for irrigation	21.6	41
Reclaim gray water (sinks, showers, etc.	7.4	14
Reclaiming wastewater and treatment water	5.8	11
Not applicable for our institution	5.3	10
Rainwater Harvesting for Potable use	2.6	5
Composting Toilets	1.6	3
Rainwater Harvesting for Potable use including drinking water.	0.5	1

TABLE 4. Recommended Water Efficient Fixture Specifications.

Fixture Type	Baseline Commercial Requirements	Recommended for LEED® Facility
Water Closet	6.0 L/flush	*Dual –Flush*
		3.0/6.0 L/flush
		Pressure Assist Low-Flow
		4.8L/flush
Urinals	3.8L/flush	0.5L/flush
Lavatory Faucets	1.9L/min.	1.9L/min
Private Faucets (hotel-motel, guest rooms, hospital patient rooms)	8.3L/min.	1.9L/min.
Shower Heads	9.5L/min.	3.8 to 5.7 L/min.

Note: Specifications and flow rates are provided for an operating pressure of 414 Kilopascals (60 psi).

type, baseline requirements for commercial and residential scenarios and recommended volumes and rates for LEED® facilities such as the ETB (CaGBC 2011a).

LEED® Canada (version LEED® 2009) tracks the credit distribution for new construction buildings. Water-related credits appear to be targeted often. The credit distribution indicates a significant uptake on Water Efficiency credits in general and for Credits 3.1 – Water Use Reduction , 20% reduction (97% uptake) and 3.2 Water Use Reduction – 30% reduction (92% uptake) specifically. The percentage achieved represents how common a LEED® credit these have been of the LEED® Canada projects reaching certification (CaGBC 2011b). The Engineering Technology Building (ETB) at McMaster received for Water Efficiency the maximum number of credits available, 5 (i.e. a 100% uptake).

Waterless Urinals

Waterless urinals have been in the general institutional market place for over 25 years and use a trap insert filled with a proprietary sealant liquid instead of water. The sealant, a mixture of aliphatic alcohol and surfactants, has a lower specific gravity than urine thus allowing the urine to flow down through the urinal trap cartridge to the drain while the sealant acts as a vapour barrier to reduce odors.

Follow-up interviews revealed that waterless urinals were generally disliked from an operational perspective due to factors that included functionality, odors and cleaning. Only 4 of the 24 interviewees acknowledged that they would recommend waterless urinals and two of those four confirmed that their custodial and maintenance staff would not recommend them. Two interviewees confirmed that they did not use waterless urinals at all on their campus and both stated that it was concerns from fellow colleagues that discouraged the use of them. Several interview candidates stressed the need for adequate training and maintenance for waterless urinal use and were discouraged by the cost of replacement cartridges and the proprietary fluid used as the sealant. Many commented about the urinals and the odor as follows: "the reality is that they are not meeting manufacturer's claims", "we don't want them… problems with maintenance" and "smelled like a nightmare." As indicated and reinforced in Table 3, less than one-third of the respondents (n=62) use waterless urinals. Identified barriers to use/implementation of these devices by the interviewees were operational problems inclusive of cleaning, cartridge replacement and drain slope (n=17). Several interviewees (n=5) who are not in favor of waterless urinals would consider a low-flow (0.5 L) urinal option for their operation.

Several interviewees stated that they were or had been using early models of waterless urinals and that new and improved models incorporated into newly constructed buildings were a slight improvement with regards to odor. The lead author experienced that same issue as an early adaptor of waterless urinal technology and that new models or brands achieved slight improvements for odor only. Operational and maintenance issues still remain and are discussed in more detail later in this paper.

DISCUSSION: WATERLESS URINALS AND RAINWATER HARVESTING AT MCMASTER UNIVERSITY

Waterless Urinals

A brief overview of the operational experiences with waterless urinals at McMaster University by the lead author is provided to supplement the findings and outcomes resulting from the survey and follow up interviews.

McMaster University currently has 24 waterless urinals in service, located in two recently constructed buildings. The David Braley Athletic Centre (DBAC) (LEED® Silver, 11 urinals) and the Engineering Technology Building (LEED® Gold, 13 urinals) contain waterless urinals as part of the LEED® approach for new facilities in accordance with the university's sustainable Building policy. LEED® credits for water efficiency W.E. Credit 3.1 and 3.2 were achieved.

Operational cleaning and maintenance of waterless urinals at McMaster is formalized in departmental procedures and fundamentally each waterless urinal takes 30 seconds to spray and wipe down the exterior of the bowl. This procedure occurs 2 times per day, 7 days a week. The interior is sprayed only and not wiped. Random maintenance is required on an as-needed basis for blockage of the unit and the plumbing drain. This has occurred in two installations on campus: the David Braley Athletic Centre men's change room - main washroom (4 waterless urinals removed in 2008) and the Campus Services Building men's main floor washroom (5 waterless urinals removed in 2009). In each circumstance, the removal was a result of numerous complaints due to functionality and odor. Functional challenges occurred due to blockage of drain lines as a result of precipitation from urine and low slope in the drain lines. Research on urine-collecting systems has acknowledged that mineral precipitation can cause blockages leading to major maintenance problems (Udert et al 2003). An analysis performed by McMaster's Environmental Health Laboratory on the composition of solids found in a blocked drain line in DBAC, concluded that the precipitate consisted mainly of Ca, Mg and Na. A study on selected urinal systems concluded that the composition of precipitates is affected by dilution with tap water (Udert et al 2003). Drain lines for waterless urinals are recommended to have at least a 2% fall to avoid precipitation build-up and blockage. In each building above, the replacement urinal utilizes a flush volume of 0.47 L and uses a "urine–sensing" automatic flush which is engaged immediately after use.

The DBAC building and its operation is an ancillary function of the university and is charged for all utilities and services. McMaster's Facility Services section has an accurate record of all urinal-related charges to this facility and annual charges are shown in Table 5. For the purposes of this exercise, one week of the year was discounted to allow for statutory holidays. This summary provides a guide to actual costs experienced with these fixtures. Water savings are difficult to project unless accurate counts are made on the frequency of use. The DBAC facility is a heavily-used facility under the jurisdiction of the Athletics and Recreation department and is home to many team sport training programs, a fitness center with over 5000 members (including the lead author at the time of research), a physiotherapy clinic, sports camps, and major functions including dinners with seating exceeding 500.

Accurate data on the use per day is difficult to obtain unless counts are made on the use and frequency. The author, in the capacity of a fitness club member and a staff member responsible for operations, through casual observation and experience projected a modest frequency of 25 uses/day/urinal. As such, the water savings is estimated on the basis of a commercial/institutional flush urinal water use. With reference to Table 4 and considering a urinal flush volume of 3.8 l/flush, total usage amounts to 98,450 uses/year for all 11 urinals equaling 374 m3 of municipal water consumption and valued at $820. The supplier's marketing literature notes that the yearly operating cost of the urinal as $380 or 24% less than experienced in the DBAC facility. This is based on their 15,000 use/urinal profile (Water Matrix 2011). Given the usage demographics the marketing information is certainly in the correct magnitude and would be considered reasonable by the researcher.

While there are ongoing challenges with the operation of these types of urinals and interview participants were generally not in favor of them, a case could be made that a good urinal manufacturer and model have merit from a cost-saving perspective. A well-managed operations team, with suitable training, equipment and materials would help deflect criticism from their continued installation and use.

TABLE 5. 2010 Waterless Urinal Operational Unit Costs – McMaster University DBAC Building

Number of Waterless Urinals	Sealant (Metrix Eco-Layer^{TM}) 2010 Annual Supply Costs	Cleaning Product (Matrix Enviro Clean^{TM}) 2010 Annual Supply Costs	Urinal Traps 2010 Annual Supply Costs	Custodial Labour Costs per Unit. 2010 Annual (est. avg.)	Average Annual Operating Unit Cost per Urinal
11	$1650/year	$2,840/year	$730/year	$290/year	$500/year

Rainwater Harvesting

Further to the rainwater harvesting information gathered through the survey and follow-up interviews, a unique rainwater harvesting to potable treatment system is in place at McMaster University and an overview of the system and early-stage operation and performance is provided. Water consumption data is detailed and early indicators on the cost and performance of the system are provided. Operational challenges are also summarized.

McMaster University, in Hamilton, Ontario has embraced rainwater harvesting in the design and construction of the five-storey, 11,625 m2 Engineering Technology Building (ETB). Opened in the fall of 2009, the ETB is home to more than 850 students, faculty, researchers and staff. The ETB incorporates an innovative approach to water conservation with a comprehensive rainwater harvesting system whereby the building is designed to collect rainwater from the roof and reuse it for both non-potable and potable applications for all building occupants, thus reducing the reliance on municipal water supplies. This treatment system, with a design flow of 166 liters/minute, is a licensed drinking water treatment system serving a designated facility under provincial regulation (Drinking Water Systems, O. Reg. 170/03) and is classified as a “large non-municipal non-residential” system. Photos of the rainwater treatment system are shown in Appendix A.

Functionally, the system is comprised of a non-potable and potable supply to the building. Potable water is supplied to all sinks, fountains and a ground floor café. Defined research laboratories (constructed and anticipated through future fit-out) and associated spaces were serviced with municipal water only. This planning strategy removed uncertainty with volume demand and consumption attributed to these areas. The cisterns were sized to accommodate an estimated two-week volume for potable, non-research requirements. No permanent irrigation systems were installed and all landscaping was native and adaptive species.

The system was designed to allow for the educational use of engineering students for research and was configured to provide additional treatment trains and monitoring. This design methodology allowed for maximum flexibility to collect information and to use the treatment system, as well as the entire building, as a teaching tool. This vision is consistent with the research on green campuses by Sharp (2002), who concluded that the ultimate vision of the environmentally sustainable campus is a vision of a learning organization and a living laboratory for the practice and development of environmental sustainability. The ETB embraces sustainable water management principles not unlike those outlined in the soft path for water which views water as the means to accomplish specific tasks and outcomes. Core principles include matching the quality of water delivered to that needed by the end use. Examples range from recycling bath water to planting drought-resistant landscaping (Brandes and Brooks, 2006).

All capital construction for the water treatment system was incorporated into the construction of the main building and the system became functional in May 2010 after several months of commissioning, trial runs and Ministry of the Environment (MOE) registration as a drinking water system. For the purposes of this paper, summary information is provided from the startup in May 2010 until March 2011. This specific time period has allowed the lead author to capture the operation of the system at the following stages:

1. The end of term 2 (winter term) in the 2009 - 2010 curriculum year;
2. Through the majority of the summer months in 2010;
3. The commencement and completion of Term 1 (Fall Term) in the 2010-2011 curriculum year;
4. Christmas break period 2010;
5. The commencement and the majority of Term 2 in the 2010 – 2011 curriculum year.

The ETB is metered for municipal water by an Onicon Model F-1210 meter (design flow rate – 90 gpm) and is interconnected to the McMaster University central utility plant energy management system. Consumption was measured and time stamped in 15 minute intervals. The cistern level is measured by a hydrostatic level transmitter installed inside of the building on the inlet header. The functionality of this feature was not completely engaged at the time of the startup and data were not available for review at the time of this research. No first-flush device is in place for this system as it was presumed that rainwater captured on a sixth story roof would have limited dirt and debris that required diversion. Other than atmospheric fallout and nominal roof ponding, this anticipated outcome had held true (Cupido et al 2010b). All water consumption data was accessed with permission for use in this research document. Consumption data for the stages noted above are found in Table 6 and Figure 2.

The system was engaged and fully functional on August 12, 2010 and functioned until October 14, 2010. The Ministry of the Environment required improved treatment methodologies and requested the addition of a sodium chloride contact chamber to ensure adequate contact time for virus removal. The non-potable portion of the system remained engaged until the installation of the chamber began in early January 2011.

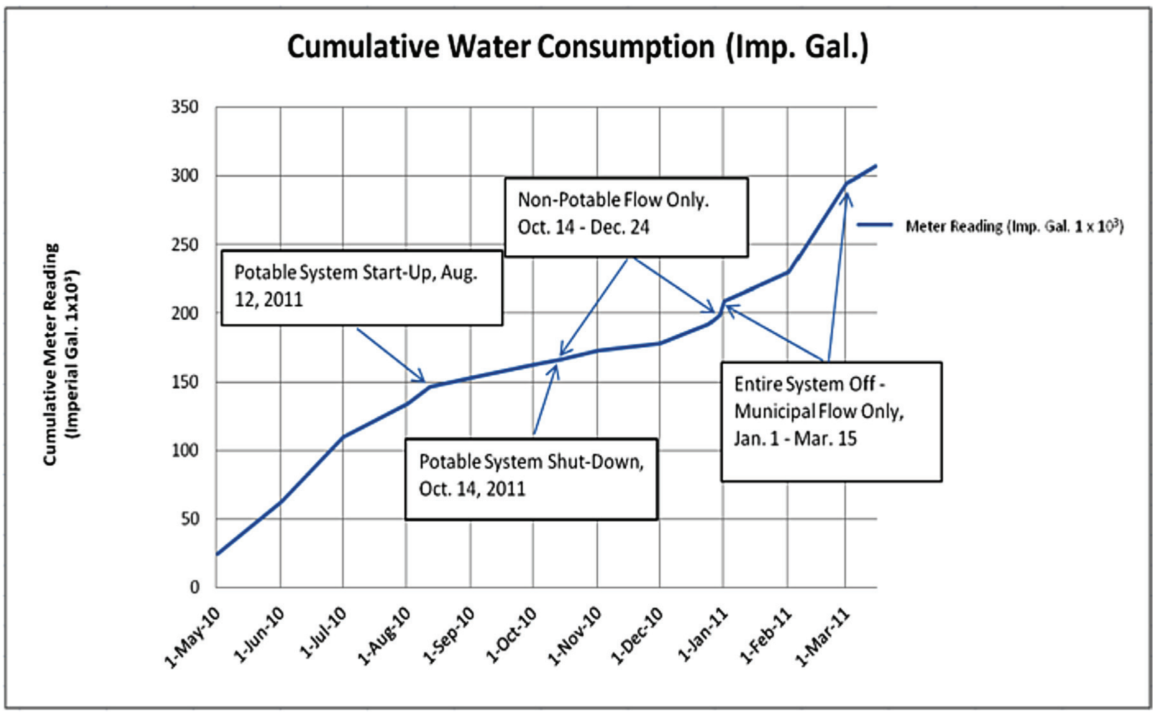
Consumption results clearly indicate that a fully functioning system is providing considerable savings, specifically from municipally supplied/used water. Average daily consumption figures for municipally supplied water are reduced by approximately 74% and when MOE upgrades were requested, the potable supply was turned off but the non-potable supply remained and the performance indicated a considerable savings as well amounting to 69%. During the installation of the sodium chloride contact chamber in an adjacent room, the system was off and municipal water consumption showed a four-fold increase from the system's fully functional state.

McMaster is home to approximately 25,000 individuals and the campus annual water consumption in 2009-2010 was 862,000 m3 or approximately 35 m^3 per individual/year (96 L/day). With reference to Table VI, users of the ETB use less than a liter of municipal water per day when the treatment system is fully functioning. This result is encouraging and provides an incentive for continued operation and further research on this system.

TABLE 6. ETB Water Consumption Trends from start-up to end of school term (Spring 2011).

Date	Meter Reading (Imp. Gal.)	Consumption Trends	Total Volume Consumption (Imp. gal.)	Average Daily Consumption (Imp. gal.)	Remarks
1-May-10	24440				
1-Jun-10	62650				
1-Jul-10	109670				
1-Aug-10	134050				
12-Aug-10	146130	May 1 - August 12	121690	1181	System not functioning (off)
1-Sep-10	153060				
1-Oct-10	162280				
14-Oct-10	166050	August 12 – October 14	19920	311	System fully functional with Non-Potable and Potable Flow.
1-Nov-10	172760				
1-Dec-10	177920				
24-Dec-10	192130	October 14 – December 24	26080	367	System partially functional with Non – Potable flow only.
30-Dec-10	198500				
1-Jan-11	208580				
1-Feb-11	229880				
1-Mar-11	294960				
15-Mar-11	307150	January 1 – March 15	98570	1332	System not functional (off) while installing contact chamber.

FIGURE 2. Water Consumption pattern for the ETB treatment system (May 2010 – March 2011.)



The ETB water treatment system was installed at a tendered capital cost of approximately \$181,600. This cost includes the installation cost of the cisterns. The operating costs for the period May to March 2012 do not include hydro costs for the equipment operation. A summary of the capital cost of the system and the early operating and maintenance costs are provided in Table 7. There is recognition that this installation is the first of its kind in an institutional, urban setting in Canada. Comparative studies on an institutional level have not been found, however there are several studies in Canada and abroad that articulate some limited information for residential installation of rainwater harvesting equipment utilized for non-potable purposes. These studies have shown that conventional supplies are less costly than RWH, however an opportunity exists for cost savings on a municipal level when delayed infrastructure improvements and reduced operating costs are factored into consideration (Canada Mortgage and Housing Corporation 2008).

The capital costs associated with this treatment system can be placed in perspective to other common building construction metrics. The ETB was constructed for \$48M or \$384/ft^2. The system was installed at a building unit cost of \$1.45/ft^2 and as a convenient reference, this value is comparable to the cost of the painting contract for the building. From another perspective, the system was installed at a unit cost of approximately \$3632 per cubic meter of stored rainwater or 0.38% of the capital cost of the ETB. By comparison, research and modeling for residential units indicated a unit cost of approximately \$1000/m^3 of stored rainwater (Canada Mortgage and Housing Corporation 2008). When cost factors in the ETB system are considered, such as redundancy of filtration and disinfection equipment for risk and educational purposes (estimated value - \$18,085), the capital costs of installation are further reduced and may appear more favorable on a unit cost basis.

TABLE 7. ETB Rainwater Harvesting System Installation and Early Operating Costs.

Rainwater Harvesting Component	Capital Cost	Operating Costs	Remarks
Treatment System	\$112,300		Includes all filtration and disinfection equipment supply and install.
Mechanical Connections	\$51,200		Includes cisterns and connections for system to building.
Electrical Connections	\$10,600		Includes energizing of all equipment and all electrical tie-ins to building.
Engineering Design	\$7,500		For design and submission drawings to MOE.
Total	**\$181,600**		
Operational Costs (to March 7, 2011)		\$7400	Includes costs for sodium chloride, equipment modifications and calibrations, spot water testing, troubleshooting and alarm response.

(Note: Operating costs from Facility Services financial reports for ETB)

CONCLUSIONS

It is clear that higher education institutions are engaging in water conservation practices across Canada and the United States. Over two-thirds of facility management professionals in higher education rank water conservation as equally important or more important than the conservation of electricity and natural gas. Further, in a study to determine if an institutional policy or state legislation guided them for their sustainable practices (Cupido et al 2010), it was found that nine out of ten (90%) of those that did have an institutional policy or state legislation acknowledged that water conservation was equally or more important. This appears to reinforce the value of having an institutional policy or state legislation as a tool for undertaking sustainable practices.

Barriers have been identified for rainwater harvesting with the most prevalent perceived barrier being state or provincial legislation which limits the process of rainwater harvesting particularly in western regions of APPA. Facility representatives surveyed and interviewed agreed that policy enhancements at local, state and/or provincial levels will likely advance this initiative

While the recognition of the importance of water conservation is better understood in higher education, operational challenges are evident, particularly as they relate to waterless urinals. The simplicity of the function of these fixtures is disadvantaged by their operational problems, including cleaning and maintaining them. Barriers to implementing these devices include operational problems and related odors. Early adopters of this technology are now migrating to functionally improved fixtures or new low–flow fixtures that utilize a small volume to accomplish the intended task and reduce the disadvantages experienced. Diffusion of innovation theory predicts that as these installations prove successful and facility managers become aware of the reliability of the improved systems, waterless urinals will be installed more widely in higher education settings.

A unique water conservation approach at McMaster University is showing significant promise for future site–based solutions. Less reliance on municipal and ground source systems may become more common place as capital costs are reduced, municipally supplied water costs increase and ground sources become restrictive, contaminated or depleted. A system such as this does not appear to be a candidate for a return-on-investment approach at this time due to the high capital installation costs and relatively high operating costs versus the supply of municipal water at low rates. MOE legislation and licensing have limited flexibility to operate the treatment equipment and improve efficiencies both in equipment and costs.

Opportunities for Future Research

There remains limited research on water conservation in Higher Education and an assessment of the operating costs associated with this endeavor. The installation of a rainwater–to-potable water treatment system in the ETB at McMaster University provides a significant opportunity to initiate or enhance research on system capital costs, ROI, long term operating costs (chlorine, equipment replacement or major repair, etc.) and water quality.

Facility management professionals in Higher Education have a wealth of experience and are prepared to share information on campus operations as well as assist with peer-reviewed research initiatives. In order to encourage the adoption of water conservation measures, it is recommended that they continue to publicize the success of the water conservation innovations they have installed and, in particular, ensure that their colleagues at other institutions are informed of them. One factor that has been found to be particularly effective in encouraging the adoption of technology by decision-makers is to provide a means for personal observation of the successful operation of the innovation. This is particularly important in the case of waterless urinals, where the first versions of this technology proved extremely difficult to maintain and this caused initial rejection of the technology. Thus, it would be helpful to provide opportunities for decision-making facility managers (or others who could act as champions for the new technology) to tour successful water conservation installations and talk with operators, managers, and users to obtain first-hand evidence of the reliability and effectiveness of waterless urinals.

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APPENDIX A:

Photos of the water treatment system in the ETB at McMaster University

FIGURE 3. View of the filtration components (Multimedia and Activated Carbon).

FIGURE 4. View of the disinfection components (Chlorination and Ultraviolet Light).