Development and Application of Policy-Based Tools for Institutional Green Buildings

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Abstract

An opportunity exists to enhance policy development and application in higher education as it relates to the promotion of sustainable building practices and the application of Leadership in Energy and Environmental Design (LEED®) principles. No previous research has been conducted to determine if policy instruments are essential for sustainable building practices, together with the use of LEED®, for the implementation of institutional green buildings in North America.

The primary research goal is to determine if policy is essential for sustainable building practices and the implementation of LEED® for new construction and major renovations in higher education buildings in Canada and the United States. A specific focus on water conservation and water quality is undertaken related to green buildings. A comprehensive quantitative web-based survey was developed and administered to poll members of APPA (formerly the Association of Physical Plant Administrators) on their use of policies or other instruments for sustainable development and the specific use of LEED® applications for new construction and major renovations on their campuses. Qualitative telephone interviews were conducted with a subset of the survey respondents to explore and supplement components of the survey and to gain greater insight as to the strategic application of sustainable facility initiatives at their respective institutions. A sustainable building policy template is developed for application to the higher education sector.

Using a mixed-methods approach has provided clear evidence that these institutions are contributing to the growth in sustainable practices in higher education and that the facility professionals are contributing to much needed leadership in this field. Institutions that have implemented sustainable/green building policies for their new buildings or major renovations are exhibiting policy compliance and meeting their LEED® targets, while some institutions that utilize non-policy practices are not complying.

This research provides a framework for an institutional sustainable building policy that is suitable for use as a template for senior facility professionals and their specific policy development. This work contributes to a foundation for future research related to sustainable/green building policy development and its application to the higher education sector.

A review of survey participants' water conservation approaches was undertaken with a specific application to a rainwater harvesting-to-potable water system in the Engineering Technology Building (ETB) at McMaster University. Field research was undertaken on the evaluation of three white roof membranes: modified bitumen finish ply, polyvinylchloride (PVC), and thermoplastic polyolefin (TPO); and their effects on the runoff water quality were studied. An analysis of the quality of rainwater runoff was performed from each of these three membranes and compared to Ontario provincial drinking water standards. Analyses were performed to determine if there is a preferred membrane for this function.

Results of the water quality testing and analysis indicate that the selected white roof membranes will provide a suitable catchment surface for a green building and/or use in a rainwater collection system. When compared to Ontario's MOE water quality requirements, no particular roof membrane of the three researched (modified bitumen, PVC and TPO) provided superior water quality results to suggest that either was preferred or recommended as a rainwater harvesting (RWH) catchment surface.

This research has revealed that higher education institutions are engaging in water conservation practices across Canada and the United States. Operational challenges are evident, particularly as they relate to waterless urinals. The ETB system that harvests rainwater and provides treatment to potable standards is showing significant promise for future site–based solutions.

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Publication List

This thesis consists of the following papers:

Paper I
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Paper II
Cupido, A.F., Baetz, B.W., and Chidiac, S.E. 'Water Conservation: Opportunities in Higher Education'. To be submitted February 2012.

Paper III
Cupido, A.F., Baetz, B.W., Guo, Y., and Robertson, A. 'An Evaluation of Rainwater Runoff Quality from Selected White Roof Membranes'. Accepted in the Water Quality Research Journal of Canada, January 2012.

Co-Authorship

This thesis has been prepared in accordance with the regulations for a 'Sandwich' thesis format or as a compilation of papers stipulated by the Faculty of Graduate Studies at McMaster University and has been co-authored.

Chapter 2: Evaluating Institutional Green Building Policies: A Mixed-Methods Approach
by: A.F. Cupido, B.W. Baetz, A. Pujari, and S. Chidiac

The survey was developed, completed and analyzed by A.F. Cupido in consultation with Dr. B.W. Baetz. Chapter 2 was written by A.F. Cupido and edited by Dr. B.W. Baetz, Dr. S. Chidiac and Dr. A. Pujari.

Chapter 3: Water Conservation: Opportunities in Higher Education
by: A.F. Cupido, B.W. Baetz and S. Chidiac

The survey was developed, completed and analyzed by A.F. Cupido in consultation with Dr. B.W. Baetz. Chapter 3 was written by A.F. Cupido and edited by Dr. B.W. Baetz and Dr. S. Chidiac.

Chapter 4: An Evaluation of Rainwater Runoff Quality from Selected White Roof Membranes
by: A.F. Cupido, B.W. Baetz, Y. Guo, and A. Robertson

The rainwater testing protocol and analysis was developed by A.F. Cupido and A. Robertson in consultation with Dr. B.W. Baetz. Roof membrane materials on the Engineering Technology Building were selected by A.F. Cupido. Chapter 4 was written by A.F. Cupido and edited by B.W. Baetz, Dr. Y. Guo, and A. Robertson.

Contents

Abstract iii
Acknowledgements v
Publication List vi
Co-Authorship vii

Chapter 1 Thesis Summary 1
1.0 Introduction 1
1.1 Impetus and Scope of Research 1
1.2 Background 3
1.2.1 Policy Development 3
1.2.2 Green Buildings and LEED® 5
1.2.3 Water Efficiency, Conservation and Quality 8
1.3 Summary of Papers 11
1.4 Conclusions 13
1.5 Suggestions for Future Work 15
1.6 References 16

Chapter 2 Evaluating Institutional Green Building Policies: A Mixed-Methods Approach 22

Chapter 3 Water Conservation: Opportunities in Higher Education 45

Chapter 4 An Evaluation of Rainwater Runoff Quality from Selected White Roof Membranes 72

Appendix A: A Quantitative Web-Based Survey on the use of Policies or Non-Policies for Sustainable Development and the use of LEED® Applications. 110

Appendix B: Interview Questions 126

Chapter 1 Thesis Summary

1.0 Introduction

This chapter summarizes the research presented in this thesis, starting with the thesis motivation and research objectives. This thesis is framed around the combined themes of public policy, sustainability, water quality and water conservation. Qualitative and quantitative approaches were undertaken with professional peers to understand their use of a green building rating system and to develop a policy tool for use in higher education applications. Water conservation approaches were explored and an innovative approach to harvesting rainwater to produce potable water was analyzed and summarized. An overview of rainwater quality from selected white roof membranes is discussed. The research period occurred from February 2007 to September 2011 and an increased interest in green buildings and policy in higher education was observed during this period.

Contributions made in this thesis take the form of technical journal papers. A brief summary of each paper and corresponding key conclusions are presented. Potential future research is then discussed.

1.1 Impetus and Scope of Research

Many international higher education institutions have responded to the major challenge of sustainable development by making sustainability central to the critical dimensions of university life and this movement is growing (Clugston and Calder 2003). In an examination of institutional policies related to environmental sustainability, it was concluded that university sustainability policies are important because they appear to determine the degree to which a university will attempt environmental change and engage in sustainable initiatives (Wright 2002). There are, however, very few examples of universities that have institutionalized a systematic commitment to environmentally sustainable campus operations to realize the opportunities and enormous efficiencies that can be achieved (Sharp 2002).

There is clear evidence that an opportunity exists to enhance policy development and application in higher education as it relates to the promotion of sustainable building practices and the application of LEED®. To date, no overview has been conducted within higher education applications amongst senior facility professionals in the context of green building policies and their development and application along with the corresponding use of LEED®. These individuals play a crucial role and hold the responsibility of ensuring that their green buildings are operated, maintained and perform as intended (Bosch and Pearce 2003).

Thesis Scope and Objectives

The research in this thesis pertains to higher education and that sector's use of green building policies and LEED®. Water conservation approaches in this sector and specifically the utilization of rainwater harvesting from the Engineering Technology Building (ETB) at McMaster University are detailed.

The primary research goal is to determine if policy tools are essential for sustainable building practices and the implementation of LEED® for new construction and major renovations in higher education buildings in Canada and the United States. A specific focus on water conservation and water quality was undertaken related to green buildings. The following tasks were completed to achieve the main research objective:

- A comprehensive quantitative web-based survey was developed and administered to poll members of APPA (formerly the Association of Physical Plant Administrators) on their use of policies or non-policies for sustainable development and the specific use of LEED® applications for new construction and major renovations on their campuses. This survey received approval from the ethics research board of McMaster University;
- Qualitative telephone interviews were conducted with a subset of the survey respondents to explore and supplement components of the survey and to gain greater insight as to the strategic application of sustainable facility initiatives at their respective institutions;

- A sustainable building policy template was developed for application to the higher education sector;
- A review of survey participants' water conservation approaches was undertaken with a specific application to a rainwater harvesting-to-potable water system in the Engineering Technology Building (ETB) and waterless urinals at McMaster University;
- Water quality testing and analysis was performed on three white reflective roof membranes installed on the ETB roof assembly to determine if there is a preferred membrane for this function.

1.2 Background

1.2.1 Policy Development

Public policy has many definitions and interpretations, however, for the purposes of this document, the Government of Canada through the Voluntary Sector Initiative defines public policy as follows: "a set of interrelated decisions, taken by public authorities, concerning the selection of goals and the means of achieving them (Voluntary Sector Initiative (Canada) 2003). In addition, public policy development is seen as the complex and comprehensive process by which policy issues are identified, the policy agenda is shaped, issues are researched, analyzed and assessed, policies are drafted and approved and their impact is assessed upon implementation (Voluntary Sector Initiative (Canada) 2003).

On April 24, 2002, a Green Building Roundtable of the U.S. Senate Committee on Environment and Public Works was held in conjunction with the U.S. Green Building Council (USGBC). In this roundtable, diverse interests were brought together to educate members of Congress on green building trends and generated discussion about the economic and health benefits of green building, the barriers facing its progress and the opportunities available to federal agencies to further promote sustainable practices. A number of recommendations were generated out of that Roundtable including the need to strengthen existing Federal policies relating to green building and to promote LEED® as the U.S. national green building standard for U.S. Federal buildings (United States Green Building Council 2003).

A significant attempt to define the sustainable university was made in the Talloires Declaration of 1990 when twenty-two university leaders convened in Talloires, France to voice their concerns about the state of the world and to create a document that articulated key actions universities must take to create a sustainable future. The Declaration recognized a university's responsibility to increase the awareness, knowledge, technologies and tools to create an environmentally sustainable future and provide the leadership necessary to respond to the challenge. A key action of the Declaration was to encourage all universities to engage in education, research, policy formation, and information exchange to move toward a sustainable future (Clugston and Calder 1999).

Many international higher education institutions have responded to the major challenge of sustainable development by making sustainability central to the critical dimensions of university life and this movement is growing (Clugston and Calder 2003). The former President of Carleton University, Richard Van Loon, acknowledged that basic university research can provide an important contribution to a better quality of life by increasing our understanding of public policy issues (Sharpe 2005).

The Association of University Leaders for a Sustainable Future (ULSF) is an international membership organization of academic leaders and institutions committed to the advancement of sustainability and global environmental literacy. An on-going Sustainability Indicators Project by the ULSF reveals a set of orientations and activities found in colleges and universities that are fully committed to sustainability. One such approach is that the institution follows sustainable policies and practices in its production and consumption. These would include: sustainable building construction and renovation, energy conservation practices and CO_2 reduction practices, amongst many others. As well, these operational practices would be integrated into the educational activities of the school (Clugston and Calder 1999). Staff and faculty in higher education must practice their sustainable policies, avoid rigid bureaucracy and integrate sustainable development into all university activities (Gudz 2004). Persistent leadership and proactive involvement from the very senior levels of presidents and chancellors will ensure that sustainable initiatives remain as high priorities (Dyer 2011).

1.2.2 Green Buildings and LEED®

McMaster University, as a member of the Canada Green Building Council (CaGBC), has approved a *Sustainable Building Policy* (McMaster University 2008) for all future buildings on campus. At the time the policy was approved for implementation in 2005, it was the only sustainable building policy at an Ontario university. At the end of the research period, three additional institutions have formalized policies in place for their sustainable building development.

A fundamental component of McMaster's Sustainable Building Policy is Leadership in Energy and Environmental Design (LEED®). Developed in the United States and now entrenched in Canada, it is a bi-nationally accepted benchmark for the design, construction and operation of high performance green buildings. LEED® promotes a whole-building approach to sustainability and was created to transform the built environment to sustainability by providing the building industry with consistent, credible standards for what constitutes a green building. LEED® for new construction and major renovation projects is designated as LEED-NC (United States Green Building Council 2007). Several assessment rating systems are used throughout the building industry to evaluate designs and these systems have similar qualities to LEED (Retzlaff 2009). In the North American market, LEED® is the dominant system and is being adapted to worldwide markets (Fowler and Rauch 2006). LEED® is not without some shortcomings and in some instances can result in unintended consequences. It is recognized that many consider cost and lack of flexibility as flaws to this rating system (Retzlaff 2009). Building professionals must recognize that any rating system should not be blindly followed (Bray and McCurry 2006).

LEED® Canada for new construction and major renovations version 1.0 is an adaptation of the U.S. Green Building Council's (USGBC) LEED® rating system and is tailored specifically for Canadian climates, construction practices and regulations. Launched in December 2005, and known as LEED Canada-NC 1.0 Rating System, it recognizes leading edge buildings that incorporate design, construction and operational practices that combine healthy, high-quality and high-performance advantages with reduced environmental impacts. Through a designation process, LEED® Canada provides for a voluntary, consensus-based, market-responsive set of criteria that evaluate project performance from a whole-building, whole-life perspective, providing a common understanding for what constitutes a green building in a Canadian context. This is achieved by awarding points earned by meeting specific performance criteria that outperform typical standard practice. The points are defined as prerequisites and credits (Canadian Green Building Council 2007a). The prerequisites and credits in the LEED Canada structure are organized in the five principal LEED categories:

- Sustainable Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality

An additional category, Innovation and Design Process, addresses sustainable building expertise as well as design measures not covered under these five environmental categories. Following a registration process and the construction of the building, project ratings are certified by the CaGBC based on the total point score. The certification is preceded by an independent review and audit of the project's construction documents by experienced design professionals that follow a well-defined and transparent methodology. Improved building performance is certified with ratings – Certified, Silver, Gold or Platinum – based on the total number of points earned by a project. McMaster University's *Sustainable Building Policy* requires new facilities to meet or exceed the Silver Level Rating of LEED Canada (McMaster University 2008). To obtain a certification in Canada, an organization must be a member of the CaGBC and similarly must be a member of the USGBC for certification in the United States (Canadian Green Building Council 2007a).

Since the development of the first version of LEED in 1998, the USGBC has maintained an extensive website that contains current statistics, green building facts and LEED program summaries. At the commencement of the research period in February 2007, there were 5,300 registered green building projects in the U.S. of which 715 were LEED certified. These green building numbers represented a staggering increase from 2003 and showed a five-fold increase in registrations and an almost ten-fold increase in certified projects. Institutional projects represented approximately five percent of the registered projects (United States Green Building Council 2007). Near the end of the research period, over 43,000 projects were registered, with 8860 certified (U.S. Green Building Council 2011). The Council's website now has a separate link to policy and government resources which reinforces their commitment to all levels of government and the pursuit and development of green building programs and initiatives.

Information available from the CaGBC as of February 2007 indicated that there are 402 registered LEED projects across Canada and 57 projects had been certified. As of November 2011, over 3400 were registered and 498 certified (Canadian Green Building Council 2011). McMaster University has five certified building projects as of the Summer of 2011: The David Braley Athletic Centre, Les Prince Hall, Burke Science Building, Engineering Technology Building (ETB) and most recently, the Ron Joyce Center.

At the commencement of the research period, approximately 20% of Canadian colleges and universities were members of the CaGBC which was an indicator of the institutional level of interest in green buildings and LEED®. As such, Canadian university buildings represented less than 5% of the total LEED® registered Canadian buildings (18 in total) and McMaster had approximately one quarter of those (Canadian Green Building Council 2007b). There is a significant opportunity for increased membership and the promotion of institutional green buildings in Canada.

In 2000, The City of Seattle became the first U.S. city to adopt a sustainable building policy. During the first four years, the city found that incremental costs decreased as LEED® was introduced earlier in the project budgeting and design process. They also found that projects that have the right combination of program, design team and project manager saw no additional cost (Barker 2004). A recent comprehensive case study concluded that significant economic savings may result from green construction by improving employee productivity, providing health and safety benefits as well as savings in energy, maintenance and operating costs (Ries and Bilec

2006). In an effort to reduce their environmental footprint, the Government of Canada is requiring all new government office buildings to meet the LEED Gold level (Government of Canada 2010).

Globally, buildings represent a significant economic and ecological investment and it is estimated that they consume approximately 40% of the total energy used worldwide. Emissions resulting from the burning of fossil fuels contribute to global warming, smog and acid rain. Buildings and their ongoing operation are responsible for approximately one-third of global greenhouse emissions (Cole 2005). Green buildings have many features that make them far superior to conventional buildings and over their lifecycle, will use approximately 40% less energy. They are more cost-effective to operate and are more adaptive to alternate uses, thus providing longer economic lives. Characteristics include: optimal site selection, thermal efficient roofs, walls and windows, significantly smaller heating, ventilating and air conditioning systems, efficient electrical lighting fixtures, adaptive access to natural daylighting and efficient water supply and wastewater fixtures, including rainwater and wastewater recycling systems (Cole 2005). From an institutional perspective, green buildings may be an opportunity to showcase innovation and attract incoming students and faculty (Richardson and Lynes 2007). The water efficiency and water conservation component of green buildings and the related policy tools will be a major focus of this thesis. The research will relate specifically to the LEED Canada-NC 1.0 categories of Water Efficiency and Innovation and Design.

1.2.3 Water Efficiency, Conservation and Quality

The critical importance of water as a precious natural resource cannot be overstated. On a national level, Canada has substantial water resources and a range of water resource management challenges, including improved protection and conservation of water and aquatic ecosystems. Canada has 7% of the world's renewable supply of fresh water and 20% of the world's total freshwater resources (including glaciers and polar ice cap waters) (Canada 2003). Canadian provinces and territories have primary jurisdiction over most areas of water management and protection. Most of these governments delegate certain authorities to municipalities, especially in the areas of drinking water treatment, distribution and wastewater treatment operations for urban areas. Most major uses of water in Canada are permitted or licensed under provincial water management authorities. Governments have developed a substantial range of policies, regulations, strategies and frameworks to enhance the safety of drinking water supplies and to protect and conserve water quality, quantity and aquatic ecosystems (Canada 2003). Critical legislation, such as *The Great Lakes Charter* and the *Charter Annex* implementing agreements, provide for enhanced commitments through stronger conservation and science with the mechanisms to ensure implementation (Council of the Great Lakes Governors 2001).

Despite Canada's strong environmental values, a 2001 report from the 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). The David Suzuki Foundation has published a report, entitled *Sustainability within a Generation*, in response to the environmental performance gap. The report outlines a plan and the types of policies needed to make Canada a world leader in sustainability (Boyd 2004). As an evaluation of Canada's progress in sustainability, the Sustainability Planning Group at Simon Fraser University completed a major academic study using the most recent OECD verified and published data. The study examines 29 indicators within the framework of the nine goals of the *Sustainability within a Generation* to compare Canada's environmental performance to those of the other OECD nations. One of the specific goals is to protect and conserve water. It recommends that Canada implement comprehensive water policies that protect freshwater systems from the threats of climate change as well as industrial, agricultural and municipal pollution (Gunton 2005). In relation to that goal, Canada's water consumption was 1,420 m^3 of water per capita; more than double the average OECD per capita consumption of 613 m^3 and more than 10 times that of the most efficient OECD country of Denmark. Canada ranks 29th, second last to the United States (Gunton 2005).

All levels of 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 our water laws and policies must evolve to reflect this reality (Boyd 2003).

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). As ongoing pressure from economic growth continues, concerns will be introduced regarding reduced reliability of 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). The approach to harvesting rainwater for potable water use in the Engineering Technology Building at McMaster University will provide institutional leadership relating to demand reduction, innovation and use of advanced technology.

A recent report entitled *Balancing Act: Water Conservation and Economic Growth* from the Canada West Foundation's Building the New West Project, identified current public policy as one of four main barriers to increased water conservation in Alberta. Gaps between science and policy, the lack of innovation and lack of partnerships among governments, academia, industry and nonprofit organizations are seen as examples gathered during consultations of the public policy barriers (Wilkie 2005).

In their review of green building activity, future versions of LEED® and similar building assessment systems, Kibert and Grosskopf (2005) suggest several major strategies that should be included in the next generation of green buildings. One of the features in their ideal green building is an optimized building hydrologic cycle. This concept would incorporate rainwater harvesting systems and graywater systems to further reduce potable water use as well as use natural systems to process wastewater. They believe this approach has significant potential for reducing energy and infrastructure costs as well as developing a synergistic relationship with natural systems. This approach, in combination with rainwater harvesting, further enhances the opportunity to reduce the dependence on the municipal water system. As water resources continue to be stretched, the use of recycled water for site specific, non-potable urban uses is growing (Lazarova et al 2003). Successful water recycling projects have been implemented in many countries. An integrated approach to urban water, sewerage and stormwater planning has resulted in more sustainable solutions and substantial cost savings for local communities (Anderson 2003).

The Canadian Water and Wastewater Association (CWWA), on behalf of the Canada Mortgage and Housing Corporation (CMHC), undertook to review practices for water reuse in residential and other buildings. The review included looking at regulations and standards governing non-potable water. While rainwater harvesting and graywater practices are commonly used in several European countries, research indicated that rainwater harvesting and graywater reuse are rarely practiced and almost never encouraged or permitted in Canada and the United States. Notable exceptions are Florida and California which are areas where there is a critical water shortage. In jurisdictions that do permit this practice (some countries in Europe, the Caribbean and Australia), many require specific water quality parameters or treatment levels. It was concluded that applications of these practices are supported by commercially available technologies (Soroczan 2003).

The University of Victoria was the recipient of the 2005 APPA Effective and Innovative Practices Award for their *Water Reuse Initiative*. Their Medical Sciences building 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). As it relates to higher education, many universities are becoming 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).

1.3 Summary of Papers

The following section provides a condensed summary description of the papers comprising this sandwich dissertation:

Paper I: Evaluating Institutional Green Building Policies: A Mixed-Methods Approach

(Published in the Journal of Green Building, Vol.5, No. 1, pp. 115-131, May 2010).

A quantitative survey and qualitative follow-up interviews with institutional facility professionals has provided an excellent opportunity to evaluate sustainable building policies and non-policies (guidelines, standards, laws or goals) in higher education across the United States and Canada. The findings in this paper indicate that policy development and application are important components of sustainability in higher education. Challenges will still remain with institutions on reaching their LEED® target level and several institutions are working their way through their first LEED® building. A policy template was developed that will provide institutions with the incentive and framework to move forward with the creation of their own sustainable building policy and the use of the LEED® building assessment rating system.

Paper II: Water Conservation: Opportunities in Higher Education

(To be submitted to the International Journal of Sustainability in Higher Education)

A Mixed-Methods study consisting of a quantitative survey and qualitative interviews with senior facility professionals at higher education institutions in North America was conducted to evaluate the institutions' use of policy related to sustainable building practices with a specific focus on approaches to water conservation. This paper highlights a new and innovative approach to water conservation in higher education whereby a LEED® Gold facility at McMaster University in Hamilton, Canada harvests rainwater and provides treatment to potable standards. This approach is showing significant promise for future site-based solutions. The findings in this paper indicate that higher education institutions are engaging in water conservations practices. While the importance of water conservation is better understood, operational challenges are evident, particularly as they relate to waterless urinals.

Paper III: An Evaluation of Stormwater Runoff Quality from Selected White Roof Membranes

(Submitted to the Water Quality Research Journal of Canada, February, 2011)

The quality of rainwater harvested from selected white membrane roof systems and subsequently treated for potable use in an urban, institutional setting is studied. A new Leadership in Energy and Environmental Design (LEED®) Canada Gold facility on the campus of McMaster

University in Hamilton, Canada offered an excellent opportunity to analyze the quality of rainwater from different roof assemblies. Field research was undertaken on the evaluation of three white roof membranes: modified bitumen finish ply, polyvinylchloride (PVC), and thermoplastic polyolefin (TPO); and their effects on the runoff water quality were studied. An analysis of the quality of rainwater runoff was performed from each of these three membranes and compared to Ontario provincial drinking water standards. This paper provides the results of rainwater quality testing on these membranes and their suitability for future institutional green building applications. The related policy implications for rainwater harvesting (RWH) in Ontario are explored.

1.4 Conclusions

As presented in Paper I, the comprehensive quantitative web-based survey and qualitative interviews with members of APPA on their use of policies or non-policies for sustainable development revealed the following conclusions:

1. Institutions that have implemented sustainable/green building policies for their new buildings or major renovations are exhibiting policy compliance and meeting their LEED® targets, while some institutions that utilize non-policy practices are not complying.
2. Provincial and State legislation appears to support higher education sustainable initiatives and is the catalyst to compliance for some, as exhibited in the western regions of APPA.
3. The findings also confirm that the motivator for many institutions, with a policy in place, is assured lower building operational costs.
4. Using a mixed-methods approach has provided clear evidence that these institutions are contributing to the growth in sustainable practices in higher education and that the facility professionals are contributing to much needed leadership in this field.

The findings in Paper II revealed the following:

5. It is clear that Higher Education institutions are engaging in water conservation practices across Canada and the United States.

6. Over two-thirds of the Facility professionals in Higher Education rank water conservation as equally important or more important than the conservation of electricity and natural gas.
7. In those institutions that did have an institutional policy or state legislation, nine of ten (90%) acknowledged that water conservation was equally or more important. This appears to reinforce the value of having a policy or state legislation as a tool for undertaking sustainable practices.
8. There were observed correlations regarding interviewees and how they rated water conservation importance with their institutions signing of the ACUPCC. Four of five that felt that water conservation was *more important* and seven of ten that felt it was *equally important* had signed the ACUPCC. As the acceptance and signatory participation in the ACUPCC grows, this may suggest a growing acceptance for water conservation.
9. 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.
10. A unique water conservation approach at McMaster University is showing significant promise for future site–based solutions.

Research at McMaster University's Engineering Technology Building (LEED® Gold) and other RWH research have demonstrated that the outcome of treated rainwater commences with the design of the roof system and the associated collection of the rainwater. The findings in Paper III include:

11. There is no evidence that the researched roof membranes produce undesirable residuals, particularly vinyl chloride and the selected metals.
12. The research roof membranes will provide a suitable catchment surface for a green building and/or use in a rainwater collection system.
13. When compared to Ontario's MOE water quality requirements, no particular roof membrane of the three researched (modified bitumen, PVC and TPO) provided

superior water quality results to suggest that either was preferred or recommended as a RWH catchment surface.

14. Rainwater harvested from the selected white roof membranes provides water that was not suitable for potable use without appropriate treatment prior to distribution within the building.
15. Care must be taken to minimize residual ponding on the roof surface, regardless of the size or volume of the ponded water, to minimize the risk of microbiological contamination.
16. Water quality testing results suggest that atmospheric particulate was a primary pollutant in this RWH collection system.

1.5 Suggestions for Future Work

- Additional research and understanding is needed on the correlation between Provincial and State Legislature, the ACUPCC (as well as Canadian derivatives) and institutional policy and non-policy compliance.
- While there has been excellent research on the cost of green buildings in relation to non-green buildings, additional research needs to be made available to higher education stakeholders responsible for planning, designing and operating green buildings regarding the environmental benefits and educational aspects of these facilities.
- Institutional urban settings may offer unique influences that could impact a RWH initiative. More work is required to understand these influences and how a new institutional building design, and more specifically the associated roof design, would need to be modified or customized.
- Although there is industry and manufacturer’s literature available on the general maintenance of white roof membranes, it will be necessary to develop specific guidelines for the use and maintenance of roof surfaces that capture rainwater for potable and non-potable purposes within the building. These guidelines may help to minimize the risk of contamination.

- An opportunity exists to enhance public policy development requiring some degree of rainwater harvesting for all public agency buildings. As well, public education regarding water issues, conservation and RWH may begin to remove policy barriers (Farahbakhsh et al. 2008). Compliance with recognized green building rating systems such as LEED® will help motivate facility professionals to take advantage of design strategies and enhance their potential building rating.
- There remains limited research on water conservation in Higher Education and operating costs associated with this endeavor. The installed 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.

1.6 References

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EVALUATING INSTITUTIONAL GREEN BUILDING POLICIES: A MIXED-METHODS APPROACH

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ABSTRACT

Sustainable or green building practices have been adopted recently by many higher education institutions for their new campus buildings and major renovations. To date, no formal study has been conducted to determine if policy is essential for sustainable building practices and the implementation of LEED® for these institutional green buildings in North America. A mixed-methods approach consisting of a quantitative survey and qualitative interviews was undertaken with senior facility professionals at higher education institutions in North America. The survey evaluated the institution's use of a policy, guideline, standard, law or goal related to sustainable building practices and the interview identified specific practices as well as issues such as leadership, policy compliance and barriers to adopting sustainable building policies. This paper provides a framework for an institutional sustainable building policy that is suitable to use as a template for senior facility professionals and their specific policy development. This work contributes to a foundation for future research related to sustainable/green building policy development and its application to the higher education sector.

KEYWORDS

Sustainable buildings, green buildings, higher education institutions, facility services, leadership, LEED®, policy.

INTRODUCTION

The sustainability movement in higher education has been emerging from its early stages over the past five years or more. Most of the tangible indicators have occurred in campus operations, particularly in energy conservation and renewable energy, purchasing, transportation, waste management, water conservation and sustainable building designs (Elder 2008).

New green buildings, often referred to as sustainable buildings, are a growing trend on higher education campuses across Canada and the United States. These facilities are being constructed as universities and colleges

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strive to incorporate into their campuses a built environment that reflects the movement to sustainability and "green" facilities.

A significant attempt to define the sustainable university was made in the Talloires Declaration of 1990 that recognized a university's responsibility to increase the awareness, knowledge, technologies and tools to create an environmentally sustainable future and to provide the leadership necessary to respond to the challenge. A key action of the Declaration was to encourage all universities to engage in education, research, policy formation, and information exchange to move toward a sustainable future (Clugston 1999). Many international higher education institutions have now responded to the major challenge of sustainable development by making sustainability central to the critical dimensions of university life and this movement is growing (Clugston 2003).

Senior facility professionals, by the very nature of their position and its 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 perhaps 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.

The development of this paper was undertaken by the lead author who is a senior facility professional at a Canadian university (McMaster University in Hamilton, Ontario) and a member of APPA (formerly the Association of Physical Plant Administrators), the association of choice serving higher education facilities professionals. (For information on APPA, please see website www.appa.org.) Also, the lead author is a registered Professional Engineer in the Province of Ontario.

Leadership in Energy and Environmental Design (LEED®)

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. 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 common 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. (For information on the CaGBC, please see website www.cagbc.org and the USGBC see website www.usgbc.org.)

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). Developed in the United States and now in place 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. There are subtle differences that exist between the CaGBC's LEED® document and the USGBC's LEED® document. LEED® Canada for new construction (LEED®

Canada–NC) and major renovations (LEED® Canada-EB) is an adaptation of the USGBC's LEED® rating system and is tailored specifically for Canadian climates, construction practices and regulations. Another clear difference of importance between the two systems is that LEED® Canada has one additional point when compared to the USGBC's LEED®. This credit is identified as MRc8 – Durable Building. This additional credit was developed as a result of the many building envelope failures experienced in the British Columbia condominium market from units that were constructed in the 1980's and 1990's. This credit incorporates building envelope commissioning principles and formalizes the material selection process for the building envelope by utilizing updated federal standards.

Both the CaGBC and the USGBC recognize institutional environments and the challenges presented by a campus setting and they have supplemented their general guidelines with an application guide for campuses. The fundamental intent of the application guide is to clearly define how campus projects can address the challenges of completing LEED® documentation for projects implemented on large sites with a shared campus infrastructure. This shared infrastructure includes such items as CFC reduction in HVAC equipment, stormwater management and innovative wastewater technologies (CaGBC 2008). It must be understood that LEED® is not without some shortcomings and in some instances can result in unintended consequences. Building professionals must recognize that any rating system should not be blindly followed (Bray 2006).

A Need for Policy

The United States has over 4,100 higher education institutions and according to the United States Green Building Council (USGBC) website on LEED® initiatives in governments and schools, as of November 2008, only forty-one have practices or formal policies listed that promote sustainable buildings (USGBC 2008). Canada has over 140 higher education institutions and 33 are registered members with the CaGBC (CaGBC 2007). It is not clear how many of these institutions have policies or practices that promote sustainable facilities with a requirement to achieve LEED® certification, as the CaGBC does not track this information. However, it does provide an indication of the level of interest from institutions for green buildings and LEED® certification in Canada. As of November 2008, higher education projects represented 13 of the 124 LEED® certified projects in Canada (2008 e-mail to lead author; unreferenced) and McMaster University has been awarded two LEED® certified projects of the 13 identified in Canada. As well, McMaster University is a member of The Association for the Advancement of Sustainability in Higher Education (AASHE) (see www.aashe.org/). This leading organization maintains a list of campus building guidelines and green building policies, with thirty-three policies identified and listed on file as of January 2009 (AASHE 2009). As well, AASHE maintains the American College and University Presidents' Climate Commitment (ACUPCC) Reporting System (for information on ACUPCC please see http://www.presidentsclimatecommitment.org/ and the ACUPCC Reporting System see: http://acupcc.aashe.org/statistics-search.php?r=1) which contains a list of 368 institutions that have indicated they have established or are in the process of establishing a green building policy for all new construction and major renovations. It was outside the scope of this research paper to evaluate this relatively new and changing resource, however the information is significant and highly relative and will be an important resource for future related research. While the number of available policies provides a general level of institutional commitment to sustainable buildings, this study identified that the relative percentage of institutions with a policy is extremely low and is estimated to be less than ten percent.

In an examination of institutional policies related to environmental sustainability, it was concluded that university sustainability policies are important because they seem to determine the degree to which a university will attempt environmental change and engage in sustainable initiatives (Wright 2002). While there has been excellent research on policy options in the broader public sector in the United States (Pearce et al., 2007), to date no overview has been conducted within higher education applications amongst senior facility professionals in the context of green building policies and their development and application along with the corresponding use of LEED®.

It has become evident through literature reviews, web searches and referencing appropriate organizations that track policy documents related to green or sustainable buildings for higher education institutions in Canada and the United States, that an opportunity exists to enhance policy development and its application in higher education as it relates to the promotion of sustainable building practices and the application of LEED®.

The primary purpose of this paper is to determine if policy is essential for sustainable building practices and the implementation of LEED® for new construction and major renovations of higher education institutional green buildings in Canada and the United States. This paper illustrates the importance of policy versus the use of guidelines, standards, laws or goals amongst the higher education sector. Survey and interview outcomes will be identified, with a specific focus on leadership, policy compliance and barriers to adopting a sustainability policy. In addition, this paper provides a synthesis of opinions and existing practices related to institutional green buildings of member institutions of APPA. Information and data obtained from participants in the voluntary web-based survey and follow-up interviews, as well as the assembly, comparison and review of over 40 higher education policies from Canada and the United States has provided the foundation for a policy template that is suitable for institutions to utilize in their respective green building applications. The paper concludes with opportunities for future research within the higher education sector regarding sustainability policies and institutional green buildings.

APPROACH AND METHODOLOGY

A comprehensive quantitative web-based survey was developed by the lead author to poll members of APPA, including all member Canadian universities, on their use of policies or non-policies for sustainable development and the specific use of LEED® applications for new construction and major renovations on their campuses. The intent was to determine if institutional policies are an important criterion for their sustainable building practices and their use of LEED®. The 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 used a non-policy (i.e., a guideline, standard, law or goal). Each participant was asked if they wished to be contacted for a follow-up qualitative telephone interview. For the purposes of this paper, the general brief definitions and applications of the words policy, guideline, standard, law or goal are as follows:

- A Policy is "a course or principle of action adopted or proposed by an organization or individual" (AskOxford: Compact Oxford English Dictionary 2009). This would typically be a policy adopted by a higher education institution and approved by their governing board.
- A Guideline is "a general rule, principle or piece of advice" (ibid.). Most Facility Services departments have general building and operation guidelines to provide to their staff or professional consultants.
- A Standard is "a required or agreed level of quality or attainment" (ibid.). Most Facility Services departments typically have written standards for their construction and maintenance of specified equipment and are used by both staff and professional consultants.
- A Law or more specifically a Statute Law is "the body of principles and rules of law laid down in statutes" (ibid.). Generally referring to legislation in the form of executive orders from a state or statutes from a province that require the institution to follow a certain course of action for sustainable practices.
- A Goal is "an aim or desired result" (ibid.). Many Facility Services departments or their institution may have a goal to achieve sustainability in the absence of anything more specific.

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 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). (For information on CFaR, see www.appa.org/Research/CFaR/index.cfm.) 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 components of the web-based survey and to gain greater insight as to the strategic application of sustainable facility 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.

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

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Interview questions are shown in Table 1 and a similar policy question/non-policy question stream was utilized. The 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.

TABLE 1. Interview questions regarding policy and non-policy.

Q1. Please elaborate on your choices for the development of your institution's tool or instrument for green buildings. Tell me about your highest rating(s)? Why did you rate them so?
Q2. Policy Question. Please tell me more about applying your institution's green building policy with your design team? What barriers to using the policy have you experienced with the design team?
Q3. Policy Question. If your institution has a green building policy, are you adhering to it? If yes, what had facilitated this? Have you had challenges adhering to this policy and what are they? If you haven't been able to adhere to it, can you please tell me more about that?
Q4. Policy Question. Have you ever registered for LEED® with a goal of obtaining a specific level, and not achieved it? What were the reasons for missing the goal? If applicable, have you taken steps to minimize this outcome to ensure you obtain the desired level?
Q5. Non Policy Question. In the survey, you were asked your opinion about barriers to adopting a policy; please elaborate on your highest rated barriers? What are your suggestions for overcoming these barriers?
Q6. Non Policy Question. In the survey, you were asked if you have ever been in a scenario where you wished you had a policy to ensure a particular level of LEED®, have you ever experienced a scenario where members of the design team suggested a lower level of LEED®? Why do you think they were suggesting this? What was the outcome of that situation?
Q7. Non Policy Question. If you do not have a green building policy but a guideline, standard, law or goal, are you adhering to it? If not, please tell me more?
Q8. Non Policy Question. Have you ever considered initiating a project with a specified LEED® target, but never actually following through with the LEED® registration, documentation, etc. as a cost saving measure or for any other reason?
Q9. Non Policy Question. If you received a template for a sustainable policy, would that be something your institution would readily accept and put in place? Would you be the driver for that or someone else?
Q10. Do you retain a professional consultant to assist you in the LEED® registration and subsequent documentation and follow-through to certification with your Green Building Council? Do you find the professional fees and application fees too high? Have you ever considered undertaking this process yourself?

The analysis of the survey responses included identifying trends or patterns amongst the institutions with specific reference to matters regarding policy and non-policy such as: leadership and policy development, policy compliance, barriers to the use of policy and policy relationships to LEED®.

The information gathered in the follow-up interviews was synthesized to determine if any common regional preferences, patterns or idiosyncrasies were evident from each APPA geographic region. This paper also provides an evaluation of existing higher education green building policies and non-policies that were available from the participants of the follow-up interviews. Compliance of the policy or non-policy was of particular interest in this research.

A green building policy template, suitable for a higher education institution, was developed following the assembly and review of over 40 green building policies. An institutional governance policy framework was used and developed in the context of a public policy and the formal policy process of the Privy Council Office of the Government of Canada (Canada. Privy Council Office 2009).

SURVEY AND INTERVIEW: FINDINGS AND OUTCOMES

For the purposes of this paper, only the principal findings and outcomes are identified and discussed. A total of 218 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 the establishment of green building policies.

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 is well-balanced and generally is 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 researcher's university has 60 buildings with over 5 million square feet on one main campus.

Policy and Non-Policy Development

The survey indicated that over 85 percent of the respondents acknowledged they have either adopted or are in the process of adopting a "green" building policy, guideline, standard, law or goal. This high percentage is likely reflective of the ongoing movement towards sustainability on campuses. The researcher was specifically interested in *who* was most responsible for the development of the document (i.e., the policy, guideline, etc.) and *why* was it developed from the respondent's perspective.

The participants acknowledged that primarily, a team of staff members in various departments was responsible for the development of the document (n=69) followed by themselves individually (n=36) nearly 25 percent of the time. Two survey responses recognized their institution's President was most responsible. Follow-up interviews revealed that the institution's President had an important contribution in some cases, but there did not appear to be any correlation between an institution having a policy and the President having signed the ACUPCC. Similarly, in a study on the state of sustainability in higher education in Atlantic Canada, it was found that signing or bypassing the Talloires Declaration seemed to have no effect on an institution's sustainability performance (Beringer et al., 2008).

Further to the survey and the follow-up interviews, it was recognized that several states and two provinces were providing leadership with recent legislation regarding sustainability and the construction of new buildings in their jurisdictions. Many states have now approved similar legislation in the form of executive orders and this has been well-documented and analyzed (DuBose and Bosch 2007).

The *why* response was more revealing with the following key findings:

- Firstly, the participants rated the response that their institution wanted to engage in sustainability initiatives and attempt environmental change almost equally with the response that the policy or non-policy provides an opportunity to reduce a building's operating cost.
- Secondly, they acknowledged that the development of the policy or non-policy was the vision from either themselves or another senior official. Follow-up interviews reinforced this finding that senior facility professionals are playing a key role in policy and non-policy development at their respective institutions.

Facility professionals are becoming more informed about the benefits related to sustainable initiatives and building operating costs. The reduction of building operating costs is well-documented (Kats and Alevantis 2003).

Respondents have also recognized the important role that students are playing by influencing administration to move toward more sustainable initiatives. Students are being buoyed by increasing environmental curriculum in higher education across North America. An example of this is both the undergraduate and graduate curricula in sustainability at Arizona State University. In their new Tempe-based School of Sustainability, the first of its kind in the world, doctorate programs are being offered (Blanchet 2008).

Institutions with a Policy: Outcomes

The survey diverged into two specific streams in an effort to more accurately understand the issue of institutions with a policy and those using a non-policy approach to achieving green buildings.

Approximately one-quarter of the respondents (n=49) indicated that their institution has adopted a sustainability/green building or similar policy as the specific tool or instrument that requires or guides their campus to have a "green" building.

The following outcomes were observed:

- The building assessment rating system of choice was LEED® (n=34). Other responses included Green Globes (n=1), B.R.E.E.A.M. (n=1) and LEED® equivalencies (n=4).
- The most common level identified in their policies was Silver (n=21), followed by the Certified level (n=14).
- The majority of these policies (n=34) were less than two years old.
- Less than 40 percent (n=18) reviewed their policies on an annual basis.

- Over half of respondents (n=27) acknowledged that as a member of their "green building" design team, that they had to use their institution's policy to insist on obtaining a particular LEED® level (or other rating system) with their stakeholders, users or other team members.

These findings were supported by the dialogue in the follow-up interviews. Several interviewees commented that their institution's policy avoided challenges with their design team when some members were more concerned about space and program. Several institutions perceived themselves as early adopters and already had a LEED® building on campus. Most notably, all interviewees with a policy felt that it assured them of reduced building operating costs.

Institutions without a Policy: Outcomes

The following outcomes and principal results, from institutions that did not have a policy, were as noted:

- The building assessment rating system of choice was LEED® (n=82). Other responses included Green Globes (n=1) and LEED® equivalencies (n=2).
- The most common level identified in their guidelines, standards, laws or goals was Silver (n=45), followed by the Certified level (n=27). Over 20 percent of the respondents (n=21) did not reference any system.
- Over 60 percent (n=59) indicated that their guidelines, standards, laws or goals are not mandatory and are only a target to meet or exceed that requirement.
- Fifty-one participants would welcome a policy that would require all new buildings or major renovations to be "green" and the requirement identified would be LEED® Certified.
- Almost 60 percent of respondents (n=56) acknowledged that in their capacity as a member of their "green building" design team, it would be desirable to have a green building policy to ensure that the team could obtain a particular "green" building standard such as LEED® and/or a particular level of LEED® that others may be arguing against for various reasons.
- Almost 90 percent of the respondents (n=84) without a policy acknowledged that a green building/sustainable building policy template would be considered a valuable tool for implementing a policy at their institution.

In order to test the statistical significance of the two groups (policy versus no policy) on the two questions of interest, a Pearson Chi Square test was performed. The two questions of interest were: If you have a green building policy, what assessment rating system do you use or if you don't have a policy, what assessment rating system do you use for measuring a green building? Secondly, what is the minimum level of LEED® you wish to achieve, whether you have a policy or not? The answer to the first question revealed that the differences between the groups (policy versus no policy) was not statistically significant (p=0.202), but what was noteworthy was that both groups overwhelmingly chose LEED® as a green building policy (69.4% and 79.4% respectively). With respect to the level, the differences between the groups (policy versus no policy) was not statistically significant (p=0.176), but what was notable was that both groups identified Silver as the most common minimum recommended level of policy (42.9% and 45% respectively).

HIGHER EDUCATION AND FACILITY LEADERSHIP

Many senior administrative officials in higher education would understand that moving toward a more sustainable future will require the active support of all stakeholders at their respective institution. Higher education needs its governing bodies and senior administration to recognize its primary role of student learning and that failing to reach sustainability is not an option to be considered (Wojciechowske 2003). Achieving sustainability will be a challenge and it will require leaders in each institution to step forward and contribute.

In a 2000 study at seventy-nine Canadian universities on environmental management, it was concluded that the support and oversight of a senior administrative body is more important than a set of guiding environmental principles in driving improved environmental performance (Herremans and Allwright 2000).

An outcome of the qualitative follow-up interviews was the acknowledgement by the participants that when asked about the development of their institution's tool or instruments for green buildings, 19 of the 24 participants indicated that they were either the driving force or major influence behind the document. Most importantly, this was in evidence in each case where the institution has a policy. This fact speaks to the leadership provided by these senior facilities officers. As well, many indicated that they were active members and participants in administrative committees for sustainability, environmental and/or a green building team. In the opinion of the interview participants, the institution's President has provided important senior support in some cases. Over half of these Presidents (n=13) have signed the ACUPCC, with one interview participant noting that their President had former facility experience.

APPA held a *2008 Thought Leaders Symposium* to assess the future of higher education and the implication of that future on educational facilities. Facilities leaders were joined by various institutional experts in academic affairs, human resources, student services, administration and finance. Representatives were comprised of community colleges, private institutions and state universities. One of the top facility issues and challenges was to make sustainability central to facility operations and to take on the leadership role for this strategic issue. Higher education institutions in general, and facilities departments in particular, need to demonstrate that they are making responsible, green decisions across all aspects of their operations. It was concluded that it was critically important for senior campus facility professionals to understand major trends affecting higher education and to ensure alignment of the facility department's mission with that of the institution (Lunday 2008). Senior facility professionals, who participated in the survey and follow-up interviews, appear to be taking on this challenge and demonstrating success within their respective institutions.

In a recent case study on green buildings at an Ontario university, it was concluded that strong university leadership is necessary to champion green buildings and this leadership needs to come from those on campus who have decision-making authority for new building construction. As well, this leadership is tied to the successful implementation of green building policies and it was acknowledged that if the administration at this particular campus looked at green buildings as an opportunity to showcase its innovation to incoming students, this may attract and retain additional students and faculty to the campus (Richardson 2007).

In a study of state-wide green building policies, interview findings suggested that successfully passing or implementing a formal green building policy, without a strong champion in a position of power or authority, is unlikely (DuBose and Bosch 2007). This is reflected in the findings of this current study as well.

POLICY AND NON-POLICY COMPLIANCE

A specific focus of the follow-up interviews was to ask participants whether or not their institution was complying with their sustainable policy or their guideline, standard, law or goal. Nine of the participants work with institutions that are guided by State or Provincial legislation, while 15 are not.

Table 2, which has been sorted by APPA Region, represents an attempt to correlate interview responses from each participant and to determine if policy or non-policy compliance is evident. The following observations are made:

- Eight of the 24 institutions have been identified with an institutional policy that requires them to obtain a LEED® certification for new buildings and major renovations.
- Two of the 16 institutions without a policy adhere to their state's legislation to guide them for their sustainable building practices.
- In each case, an institution that is guided by policy or legislation has complied with the policy or legislation (and reached their LEED® target) for their new buildings or have acknowledged that they are utilizing the policy or legislation for the first time on their first building and intend to comply.
- LEED® Silver (n=13) is the most common level to be achieved amongst institutions with policy.
- Three institutions with a non-policy did not comply with their guideline, standard, goal or state legislation although one interviewee acknowledged that their institution intended to meet a specific level of LEED® in accordance with their guidelines but did not receive their anticipated level (a lower level was approved) from their Green Building Council.
- Not reaching the anticipated LEED® target was experienced by three institutions that registered for certification.
- The fact that ten institutions are seeking their first LEED® certification is testimony to the newness of the process for many.
- There appears to be no correlation between the signing of the ACUPCC and whether or not an institution has a policy.
- From a regional perspective, both ERAPPA and MAPPA appear to have no state or provincial legislation for these institutions along with no policy as well. Yet there is some recognition for the effort to obtain LEED® certification in the majority of cases.

TABLE 2. Policy/non-policy and LEED® comparisons with interview participants.

Interview No.	APPA Region	Policy (Yes/No)	Government (Prov./State) Legislation	ACUPCC (Signed/Not Signed)	LEED® Reference	Compliance with Policy/Non-Policy	LEED® Target Reached	LEED® Consultant Used
5	CAPPA	No	Yes	Signed	Certified	No	No	No
4	CAPPA	No	No	Signed	Silver	Yes	Yes	Yes
6	**CAPPA**	**Yes**	**No**	**Not signed**	**Silver**	**Yes**	**Yes**	**No**
7	**CAPPA**	**Yes**	**Yes**	**Not signed**	**Silver**	**Yes**	**Yes**	**Yes**
1	ERAPPA	No	No	Not signed	Silver	No	No	Yes
2	ERAPPA	No	No	Signed	Certified	Yes	No	Yes
3	ERAPPA	No	No	Signed	Certified	Yes	Yes	Yes
14	ERAPPA	No	No	Signed	Gold	First building	N/A	Yes
8	MAPPA	No	No	Not signed	Silver	First building	N/A	Yes
9	MAPPA	No	No	Not signed	Certified	Yes	Yes	Yes
23	MAPPA	No	No	Not signed	Silver	First building	N/A	Yes
15	MAPPA	No	No	Not signed	Silver	First building	N/A	Yes
16	**PCAPPA**	**No**[1]	**Yes**	**Signed**	**Silver**	**First building**	**N/A**	**Yes**
22	**PCAPPA**	**Yes**	**Yes**	**Signed**	**Certified**	**First building**	**N/A**	**N/A**
24	**PCAPPA**	**Yes**	**Yes**	**Not signed**	**Silver**	**Yes**	**Yes**	**Yes**
18	**PCAPPA**	**Yes**[2]	**Yes**	**Signed**[2]	**Silver**	**Yes**	**Yes**	**Yes**
11	RMAPPA	No	No	Not signed	None	N/A	N/A	N/A
12	RMAPPA	No	Yes	Signed	Silver	First building	N/A	No
13	**RMAPPA**	**No**[1]	**Yes**	**Signed**	**Highest**	**First building**	**N/A**	**Yes**
25	**RMAPPA**	**Yes**	**Yes**	**Signed**	**Silver**	**First building**	**N/A**	**No**
19	SRAPPA	No	No	Not signed	None	No	No	N/A
21	SRAPPA	No	No	Signed	None	Yes	N/A	No
17	**SRAPPA**	**Yes**	**No**	**Signed**	**Silver**	**First building**	**N/A**	**Yes**
20	**SRAPPA**	**Yes**	**No**	**Not signed**	**Highest**	**Yes**	**Yes**	**Yes**

Notes:

1. Interviewees 13 and 16 are with institutions that do not have a formal policy but treat their state legislation as if it were a policy for their institution and department.
2. Interviewee 18 is with an institution that utilizes their sustainable development policy as their sustainable "building" policy and the institution has signed a Provincial equivalent to the ACUPCC.

BARRIERS TO ADOPTING A POLICY

A key research initiative for this paper was to identify barriers to adopting a sustainable building policy. While most of the respondents (n=154) are taking some initiative to promote sustainable buildings and practices, they are doing so with non-policy tools or instruments that are generally not mandatory at their institution. When asked in their opinion what the barriers to adopting a policy were and to what extent did they agree or disagree with a list of possible barriers, the following principal responses were received in the rank order:

- Consulting and other costs to apply for LEED® registration and designation.
- Green buildings are more expensive than traditional buildings.
- A guideline or standard is sufficient to meet the intent.
- A policy would limit their flexibility on a given project.
- No one has taken the time or made the effort to draft a policy.
- State or Provincial law supersedes a need for a policy.

Follow-up interviews reinforced these results amongst those institutions that did not have a policy. An attempt was made to determine why interviewees perceived these to be barriers and various responses were noted. Several interviewees acknowledged senior management apathy, lack of institutional leadership and insufficient institutional inertia. One interviewee felt that LEED® criteria were arbitrary and that there was no business case for a LEED® building, while another indicated that there was no single impediment to having a policy but there was some angst from senior officials for having a policy regarding green buildings.

Several interviewees, from institutions that had a policy, acknowledged that they were able to overcome these barriers with a unified front of student engagement, senior management leadership, curriculum advancements and professional consultants active in sustainability. One interviewee specifically recognized their institution's Board of Governors for their leadership, while another confirmed that their institution has a long established culture of sustainable initiatives and their current level of sustainability is a vision of a number of champions, including past facility directors, campus planners and the institution's President.

The following analysis and discussion will address the two most frequently identified barriers to a sustainable building policy: firstly, consulting and other costs and secondly, green building costs.

Consulting and other Costs

In an attempt to place the consulting cost into perspective, this researcher will summarize the costs associated with a current project on the McMaster University campus. The university is currently constructing a new Faculty of Engineering research building with a total project value of $48 million and approximately 125,000 square feet in size. The anticipated opening is summer 2009. The total project value is broken down into soft costs (i.e. architect's fees, related consulting fees, permit costs, project management fees, etc.) of $5 million and hard costs (primarily general construction and related fit-out) of $43 million. A LEED® consultant has been retained and the associated fees for the specific scope of activities are shown in Table 3. (Permission granted by the Vice-President, Administration of McMaster University.) It is shown that the LEED® consultant represents only 2.78 percent of the total soft costs and 0.29 percent of the total construction value.

TABLE 3. LEED® consulting costs versus other soft costs.

LEED® Consultant Scope and other Soft Costs in the New Building Project	Associated Fees	Percentage of Soft Costs ($5M)	Percentage of Hard Costs ($43M)	Percentage of Total Costs ($48M)
Energy Efficiency Design, Energy Review and Final Model, LEED® Design, Verification and Site Review	$55,700	1.11%	0.13%	0.12%
LEED® Certification	$14,000	0.28%	0.03%	0.03%
CaGBC LEED® Fees (est.)	$9,300	0.19%	0.02%	0.02%
Measurement and Verification	$30,000	0.60%	0.07%	0.06%
Green Education	$30,000	0.60%	0.07%	0.06%
Total LEED® Consultant	***$139,000***	***2.78%***	***0.32%***	***0.29%***
Architects and Sub-consultants	$3,800,000	76.00%	8.84%	7.92%
Other Consultants (geotechnical, storm water management, landscaping, etc.)	$300,000	6.00%	0.70%	0.63%
Building Permit	$197,000	3.62%	0.42%	0.38%
Other Costs (internal, project management, etc.)	$580,000	11.60%	1.35%	1.21%

These values, when put into perspective of the entire building cost and when referenced to other related soft costs, are small and less than other project soft costs that appear to add less value to the greening of the project. The timeline and duration of the activity required for LEED® certification is often neglected when assessing the fees. A sizeable capital project as noted here typically requires the LEED® consultant to be part of the project team for several years (early planning to post construction) and the costs and related value need to put into that perspective. The only way to validate the LEED® effort is to retain a third-party or utilize existing staff to follow through with the registration, documentation, correspondence and submission to the respective Green Building Council to obtain the approved certification. Interview participants generally acknowledged that their respective departments did not have the available skilled resources to perform this effort themselves. Some institutions, who anticipate a large capital development plan, have retained staff or trained existing staff to manage the LEED® registration and certification process themselves and felt that it was better value to do so. Several institutions now retain the Architect, in their role as the prime consultant, to perform the LEED® certification process and it appears that this overall approach is growing based on the interviews with each APPA region.

Opposition to LEED® certification in the U.S. has been demonstrated for state-level green buildings in the form of industry lobbies and state agencies (DuBose and Bosch 2007).

Green Building Costs

The cost of incorporating sustainable design features in building projects has been a subject of discussion and argument amongst institutional facility professionals on both sides of the U.S.-Canadian border for many years. Several survey respondents, who participated in the follow-up interviews and have been in their roles as facility professionals for more than a decade, acknowledged that the cost of providing sustainable design features into their new buildings has been offset by improved operating costs since the late 1980's. These costs not only included energy costs but maintenance costs as well.

Several industry reports have attempted to address the question of the costs of incorporating sustainable design features into projects. In a report for the CaGBC in 2005, it was concluded that green buildings cost more than conventional buildings to design and construct, largely due to the design time and the implementation of non-standard materials and systems. The increase in capital costs are, however, overshadowed by operational benefits and occupancy benefits (Lucuik 2005).

In one of the most definitive cost benefit analysis of green buildings ever conducted, a sustainable buildings task force (Kats and Alevantis 2003) demonstrated conclusively that sustainable building is a cost-effective investment. The average reported construction cost premium for LEED® certified green buildings is less than two percent and would, on average, result in a life cycle savings of 20 percent of the total construction costs or more than ten times the initial investment in green building features.

A recent comprehensive case study concluded that significant economic savings may result from green construction by improving employee productivity, providing health and safety benefits as well as savings in energy, maintenance and operating costs (Ries and Bilec 2006).

In an updated look at the cost of building green which included the use of the USGBC's LEED® rating system as a parameter for determining the level of sustainable design, it was found that there is no significant difference in average costs for green buildings as compared to non-green buildings. As it relates to this research, it was recognized that the cost of documentation remains a concern for some project teams and contractors but as teams become more experienced, this concern is somewhat abating (Matthiessen and Morris 2007).

POLICY TEMPLATE

A research objective for this paper was to develop a sustainable building policy template for other institutions to utilize for their policy development process. A review was performed of eight sustainable policies gathered from interview participants who indicated that their institution had such a policy. As well, a review was completed of 33 known sustainable/green building policies, guidelines and/or standards of institutions that have these documents identified through the listings of the USGBC and AASHE. As noted earlier in this paper, almost 90 percent of the survey respondents acknowledged that a green building/sustainable building policy template would be considered a valuable tool for implementing a policy at their institution. Interview participants without a policy also acknowledged their desire for such a template.

Common themes emerging from the review of the assembled documents are as follows:

- All institutions (with the exception of two) referenced LEED® and the most common level/requirement was Silver. Several institutions use a minimum level of LEED® Silver and hence accept higher levels if they can be obtained. This level/requirement is referred as LEED® Silver (minimum). Two institutions did not reference any building assessment rating system.
- Twenty-four institutions had formal policies approved by the governing Board of their institution.
- The typical document size of a policy is one to two pages.
- Ten institutions reference or are impacted by State or Provincial legislation. With the exception of one State, all legislation originates from western States or Provinces.
- The typical policy document was structured with a policy framework that included: a Purpose, Policy statement/Guiding principle, Definitions and Authority/Responsible individual.

Interview participants welcomed a policy template and many indicated that they would desire the template to be straightforward and not to exceed two pages. The general acknowledgement from the interview discussions regarding policy was that many of the facility professionals are required to adhere to a variety of policies within an institutional environment and that many of these policies can be cumbersome to administer. Previous policy research at Pennsylvania State University has found that expressing policy suggestions in single-page, succinct documents increase the probability of implementation. It was acknowledged that long, complex documents are less likely to be read than a single page and limiting the concept to a single page will also guarantee improved focus for easier implementation (Pearce and Uhl 2003).

Public policy has many definitions and interpretations including, “a course of action or inaction chosen by public authorities to address a given problem or an interrelated set of problems” (Pal 1997). However, for the purposes of this document, the Government of Canada through the Voluntary Sector Initiative defines public policy as follows: “A set of interrelated decisions, taken by public authorities, concerning the selection of goals and the means of achieving them.” (Voluntary Sector Initiative 2003). In addition, public policy development is seen as the complex and comprehensive process by which policy issues are identified, the policy agenda is shaped, the issues are researched, analyzed and assessed, policies are drafted and approved, and their impact is assessed upon implementation (Voluntary Sector Initiative 2003).

A senior facility professional, working with his/her administrative team, may reference the following formal policy process used by the Privy Council of Canada. This process consists of five stages and is recognized as follows: Setting the Policy Agenda, Policy Development, Policy Review, Policy Approval and Implementation Approvals (Canada. Privy Council Office 2009). These stages are integrated with typical institutional processes and are shown in Table 4.

TABLE 4. Policy process stages and corresponding institutional actions.

Policy Process Stage	***Institutional Actions***
Setting the Policy Agenda	This planning stage is the opportunity to establish that this policy be ultimately approved at the highest level of governance, (i.e. Board of governors, regents, trustees etc.). The Facility Professional may address this as a written report or policy development plan to the senior administrative council.
Policy Development	For the purposes of this paper, a Policy Template is provided for this stage of the process. The Template forms the foundation for a final policy document. An Annual review shall form part of policy detail.
Policy Review	The Template is provided to senior levels of governance: The Planning, Building and Environmental Committees (i.e. standing committees of the Board) with formal reports for information, comment and review. Provide sufficient related documentation and detail regarding CaGBC/USGBC/LEED® to allow an informed decision to be made. All appropriate institutional stakeholders (senior staff, faculty, students, community, etc.) need to be consulted. Edits to template are made if necessary. Senior administrative team to support approval to standing committees of the Board.
Policy Approval	Final Report to senior levels of governance for approval with recommendation to the Governing Board for approval.
Implementation Approvals	Implementation approvals will include: integration of policy content into departmental standards and guidelines, information to Green Building Teams, procurement strategies for Professional consultants, contractors, LEED® Consultants. Staff training initiatives to be implemented. Advise appropriate Green Building Council and AASHE of the policy.

A template policy document was developed in the context of the following:

- Senior facility professionals, who participated in the survey and follow-up interviews, requested a one or two page policy document.
- Many observed policies contained document headers that provided for a Policy Title, Policy Number, Approval Authority, Approval Date and the Responsible Authority.
- Many observed policies contained a LEED® Silver rating as the level to be achieved.
- A stated purpose and defined principles was necessary for clarity and structure. (University of Alberta 2009).
- Definitions, LEED® and other related information would form part of an appendix or other support documents.

A template document that is suitable for other institutions to use for their policy development is provided in Appendix A.

OPPORTUNITIES FOR FUTURE RESEARCH

As evidenced by the number of institutions that are engaging in their first venture into green building certification, the lead author intends to follow-up with these institutions to help complete the documentation cycle identified in Table 2. As noted earlier and experienced by the lead author, the cycle may take several years and the first building is a learning experience for the entire building team.

Additional research and understanding is needed on the correlation between Provincial and State Legislature, the ACUPCC (as well as Canadian derivatives) and institutional policy and non-policy compliance. Often these can be out of step. No higher education institution should rely solely on other legislation to meet their sustainable building objectives. It is noted that the ACUPCC initiatives are still in the early stages and early signatories are just now coming to the stage where their climate action plans are due. Correlations with institutions that have a green building policy may appear in the very near future.

While there has been excellent research on the cost of green buildings in relation to non-green buildings, more needs to be done to educate higher education stakeholders responsible for planning, designing and operating green buildings. As the number of green buildings grows in the higher education sector in Canada and the United States, facility professionals in these institutions can contribute to the research needed to improve on the cost and performance of these green facilities.

A specific focus was undertaken in both the survey and the interviews regarding water conservation practices incorporated into new institutional green building construction or major renovations. The findings will inform future researchers to describe best practices for water conservation across APPA member institutions.

Limitations

There is an acknowledgement for potential limitations in this study. It is recognized that the study participants may also be green building stakeholders in their respective institutions and there is always a possibility that they will not be impartial. Did those institutions without a policy in place feel intimidated by a survey asking expressly about green building policies? The authors are satisfied that there was representation from institutions without green building policies. Conversely, were institutions with a policy in place more attracted to completing a survey about green building policies? Again, the authors are satisfied that there was not over-representation from those institutions. As well, the participation in a survey by the designated representatives of APPA may not guarantee broad-based participation, however, the authors are satisfied that they had complete data from a variety of institutions representing small, medium and large institutions across various regions of North America. Regardless of study limitations, there are important recommendations for practice.

CONCLUSIONS

A quantitative survey and qualitative follow-up interviews with institutional facility professionals has provided an excellent opportunity to evaluate sustainable building policies in higher education across the United States and Canada. Using a mixed-methods approach has provided clear evidence that these institutions are contributing to the growth in sustainable practices in higher education and that the facility professionals are contributing to the much needed leadership in this field. Campus sustainability should not be an isolated initiative divorced from such areas as facility operations, maintenance and capital renewal. The integration and balancing of these areas are often overlooked pieces to sustainability. Facility professionals should be major contributors to developing any large scale sustainability program on campus.

Previous research, along with the findings in this paper, indicates that policy development and application is an important component of sustainability in higher education. Institutions that have implemented sustainable/green building policies for their new buildings or major renovations are exhibiting policy compliance and meeting their LEED® targets, while some institutions that utilize non-policy practices are not complying. Challenges will still remain with institutions on reaching their target level and some institutions may experience this outcome as they work their way through their first LEED® building. Provincial and State legislation appears to support higher education sustainable initiatives and is the catalyst to compliance for some as exhibited in the western regions of APPA. The findings also confirm that the motivator for many institutions with a policy is assured lower building operating costs. It is hoped that the developed policy template will provide some institutions with the incentive and framework to move forward with the creation of their own sustainable building policy and the use of the LEED® building assessment rating system. The high percentage of participants requesting a policy template is testimony to the need for such a template.

Facility professionals will be required to help navigate through the barriers to adopting a sustainable policy and related practices. Additional research and education will assist in that endeavor. As their green building portfolio grows, these individuals are in a privileged position to enhance the profile of green buildings through their knowledge of planning, design and operation of these facilities. These efforts will ultimately enhance and positively impact the global environment of the future.

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Appendix A: Policy template for institutional green buildings.

INSTITUTION LOGO

Complete Policy Title:
Sustainable Building Policy

Policy Number (if applicable):
No. 1

Approved by:
Board of Governors, Regents, Trustees

Date of Most Recent Approval:

Date of Original Approval(s):
Date Here

Supersedes/Amends Policy Dated:

Responsible Executive:
Senior Facility Official

Enquiries:
University Secretariat

DISCLAIMER: If there is a discrepancy between this electronic policy and the written copy held by the policy owner, the written copy prevails.

Purpose

(Institution name) will provide leadership in the conservation, protection, improvement and sustainability of the environment.

Policy Statement

It is the policy of ***(Institution name)*** to:

- Develop new and undertake major renovations of occupied facilities to meet or exceed the Silver Level Rating of the LEED® (Leadership in Energy and Environmental Design) Rating System.
- Implement sustainable building principles in all new and existing buildings to achieve measurable life cycle cost savings.
- Support and promote sustainable building principles and operational initiatives, including energy reduction, water conservation and improved air quality.
- To support, promote and adhere to Federal, State or Provincial legislation (***insert appropriate legislation title and number here).***

Water Conservation:

Opportunities in Higher Education

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Abstract

Purpose The 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 (formerly the Association of Physical Plant Administrators), the association serving higher education facility professionals. A specific focus regarding waterless urinals and their operational concerns was attempted.

Design/methodology/approach A mixed-methods study was conducted consisting of a quantitative survey and qualitative interviews with senior facility professionals. The survey evaluated the institution's use of policy related to sustainable building practices with a specific focus on approaches to water conservation.

Findings It is clear that higher education institutions are engaging in water conservation practices across Canada and the United States. 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. A new facility on the campus of McMaster University in Hamilton, Canada that harvests rainwater and provides treatment to potable standards is showing significant promise for future site–based solutions.

Practical Implications Less reliance on municipal and ground source systems may become more common place based on the early operational effectiveness of this treatment system.

Originality/value This work contributes to a foundation for future research and analysis related to best-management practices for water conservation in the higher education sector. The paper illustrates an innovative rainwater harvesting system that produces potable water for the building occupants.

Keywords Water conservation, higher education, LEED®, rainwater harvesting, waterless urinals, policy

Paper Type Research Paper

Introduction

All levels of 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 our water laws and policies must evolve to reflect this reality (Boyd, 2003). Despite Canada's strong environmental values, a 2001 report from the 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). As ongoing pressure from economic growth continues, concerns will be introduced regarding reduced reliability of 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).

The sustainability movement in higher education has been emerging from its early stages and has seen significant progress over the past five 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). New green buildings, often referred to as sustainable buildings, are a growing 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 professionals, by the very nature of their position and its 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).

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 (formerly the Association of Physical Plant Administrators), the association serving higher education facility professionals. The relationship between water conservation importance and institutional policy is discussed. A specific focus regarding waterless urinals and their operational concerns is attempted. The paper illustrates an innovative rainwater harvesting system that produces potable water for the building occupants. The operational outcomes and challenges are identified. The 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.

Developed in the United States and now in place 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). McMaster University successfully implemented a *Sustainable Building Policy* in 2005 and has five LEED® certified buildings (McMaster University 2008). It must be understood that LEED® is not without some shortcomings and in some instances can result in unintended consequences. Building professionals must recognize that any rating system should not be blindly followed (Bray 2006).

As well, McMaster University is a member of The Association for the Advancement of Sustainability in Higher Education (AASHE) (see www.aashe.org/). This leading organization maintains the American College and University Presidents' Climate Commitment (ACUPCC) Reporting System. The Reporting System contains a list of several hundred institutions that have indicated they have established or are in the process of establishing a green building policy for all new construction and major renovations.

Approach And 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. 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 used a non-policy. 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 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 I. 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.

Figure 1. APPA's six geographical regions ([Geographical Regions Map] 2007).

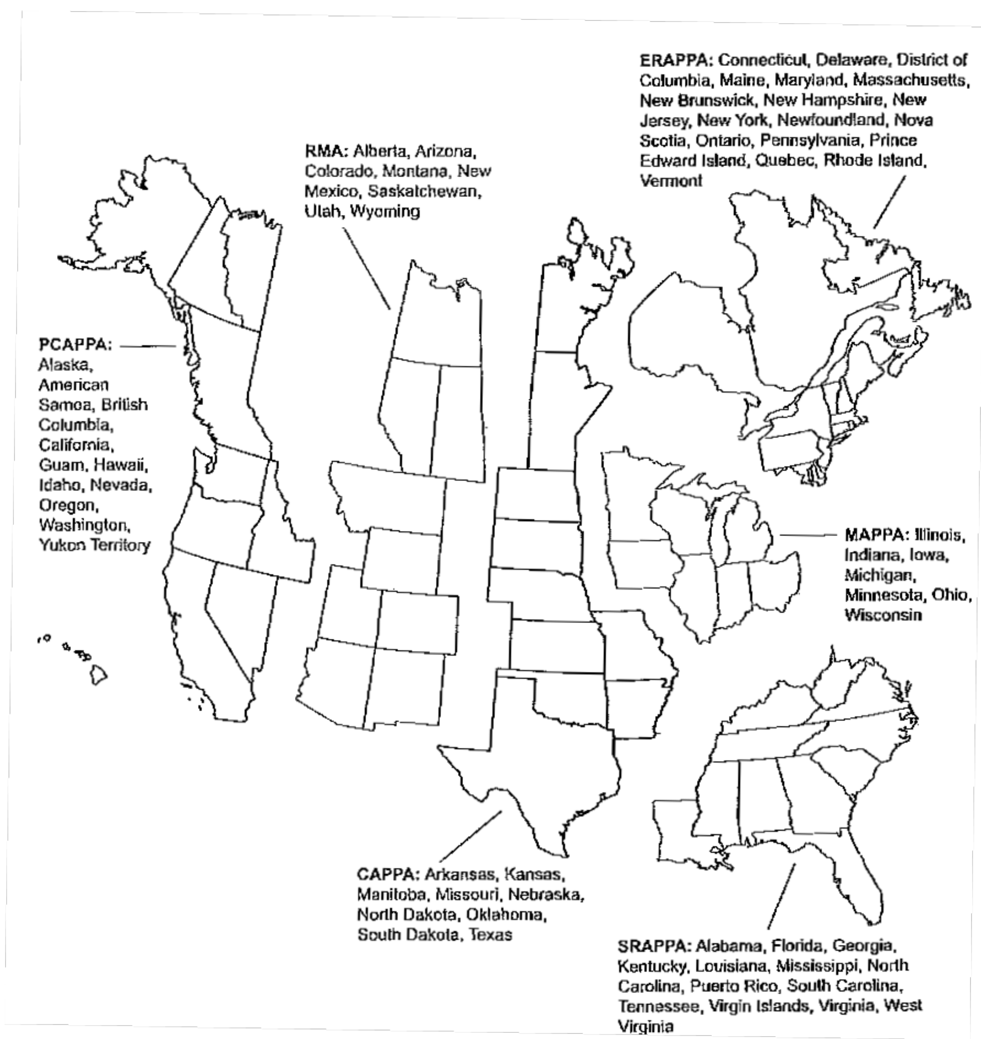


Table I. Interview questions regarding institutional water practices.

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.

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

Survey And Interview: Findings And Outcomes

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 is well-balanced and generally is 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 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 II, there appeared to be no specific regional indicator of those interviewed who felt that water conservation was more important or equally important. 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." Recent 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 2010), nine acknowledged that water conservation was equally or more important with only one indicating it was less important.

Table II. Ratings of Water Importance in APPA Regions

Interview No.	**APPA Region**	**Policy (Yes/No)**	**Government (Prov./State) Legislation (Yes/No)**	**ACUPCC (Signed or Not Signed)**	**Water Conservation Rating More, Equally, Less (Important)**
5	CAPPA	No	Yes	Signed	Equally
4	CAPPA	No	No	Signed	Less
6	CAPPA	Yes	No	Not-Signed	Equally
7	CAPPA	Yes	Yes	Not-Signed	Equally
1	ERAPPA	No	No	Not-Signed	More
2	ERAPPA	No	No	Signed	Equally
3	ERAPPA	No	No	Signed	More
14	ERAPPA	No	No	Signed	Less
8	MAPPA	No	No	Not-Signed	Less
9	MAPPA	No	No	Not-Signed	Less
23	MAPPA	No	No	Not-Signed	Equally
15	MAPPA	No	No	Not-Signed	Less
16	PCAPPA	Yes	Yes	Signed	Less
22	PCAPPA	Yes	Yes	Signed	More
24	PCAPPA	Yes	Yes	Not-Signed	Less
18	PCAPPA	Yes	Yes	Signed	Equally
11	RMAPPA	No	No	Not-Signed	Less
12	RMAPPA	No	Yes	Signed	More
13	RMAPPA	No	Yes	Signed	More
25	RMAPPA	Yes	Yes	Signed	Equally
19	SRAPPA	No	No	Not-Signed	Equally
21	SRAPPA	No	No	Signed	Less
17	SRAPPA	Yes	No	Signed	Equally
20	SRAPPA	Yes	No	Not-Signed	Equally

Rainwater Harvesting

When asked what method is used to harvest rainwater as a component of their green building, approximately two-thirds of the 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. 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), 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 individuals 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; capital costs to install the system, operating costs, state restrictions on the operations, public concerns for risk and staff training challenges. These barriers are consistent with barriers indentified 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 is in place for 18.4% (n=35) of the respondents. Further to the Green Energy Act, the province of Ontario has recently enacted the Water Conservation Act 2010 which will require 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

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 III**.**

Table III. 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

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 III 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 IV illustrates recommended water-efficient fixture specifications noting the fixture type, baseline requirements for commercial and residential scenarios and recommended volumes and rates for LEED® facilities such as the ETB (CaGBC 2011a).

Table IV. 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).

LEED® Canada 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 ETB at McMaster received 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 20 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 liked waterless urinals and two of those four confirmed that their custodial and maintenance staff did not like 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: “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 III, less than one-third of the respondents (n=62) use waterless urinals.

Several 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 remained 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 (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 V. 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 author), 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 IV 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 m^3 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 V. 2010 Waterless Urinal Operational Unit Costs – McMaster University: DBAC Building

Number of Waterless Urinals	**Sealant (Metrix Eco-Layer™) 2010 Annual Supply Costs**	**Cleaning Product (Matrix Enviro Clean™) 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 m^2 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 of 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 was 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 2010). 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 VI 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.

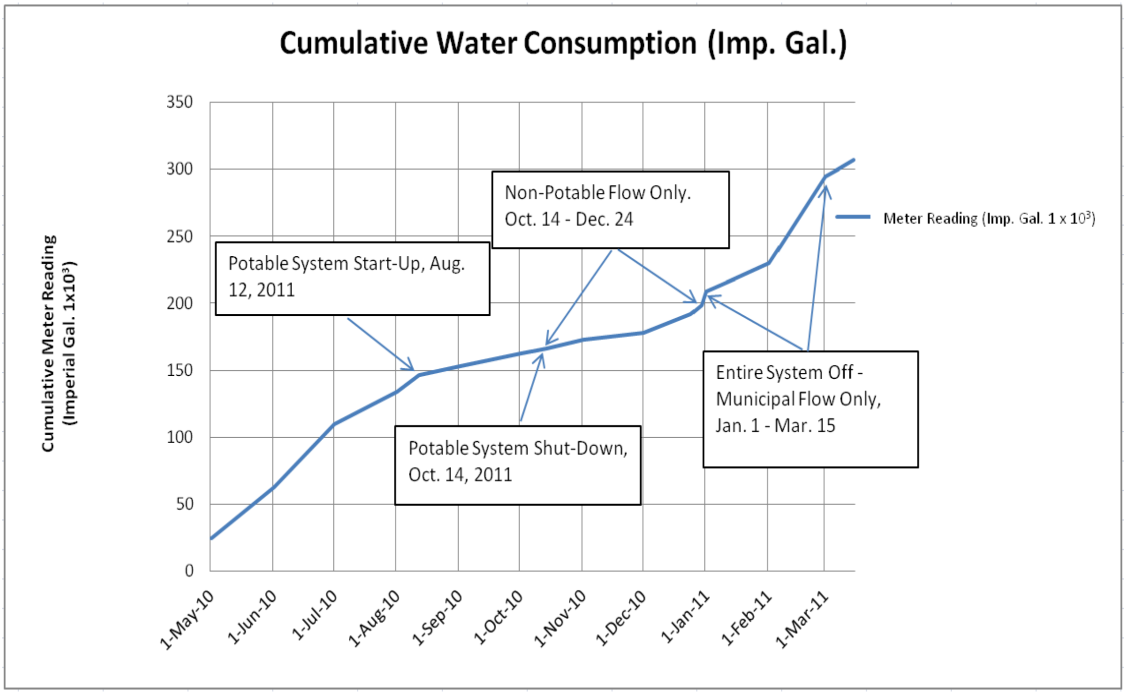
Consumption results clearly indicate that a fully functioning system is providing considerable savings, specifically from municipally supplied/used water. Average daily consumption figures for municipally supplied water are reduced by approximately 74% and when MOE upgrades were requested, the potable supply was turned off but the non-potable supply remained and performance indicates 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.

Table VI. 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.

McMaster is home to approximately 25,000 individuals and the campus annual water consumption in 2009-2010 was 862,000 m^3 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.

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



Considering system performance during the time-frame of the study period (May 2010 – March 2011), precipitation data was gathered to measure against operation. Meteorological data for the duration of the system operation was provided by the McMaster weather station located on a nearby building approximately 400 m from the ETB and is used for research purposes at the university. The average annual precipitation for the City of Hamilton is 987 mm consisting of 833 mm of rainfall from April to November and the balance in snowfall between December and March. (Environment Canada 2011). Average rainfall for the three-month period of August to October during the past five years was 271 mm. Although the 2010 study period had a lower precipitation total of 237 mm, it was within the annual standard deviation of rainfall of ± 66 mm.

McMaster's weather station recorded four precipitation occurrences ≥ 10 mm and thirty - four ≤ 10 mm. Two significant rainfall events were recorded on August 22 (19 mm) and October 9 (29.9 mm); both contributing to the cistern capacity and supply for the treatment system. The ETB contains a 2052 m^2 roof and if a rainfall with nominal intensity of 5 mm/hr is considered, even a small precipitation event would generate adequate cistern volumes for the treatment system to accommodate daily needs within the building. With consideration for the stormwater overflow outlet, the net or working capacity for each cistern is 22.73 m^3 for a total cistern capacity of approximately 44.5 m^3. For the amount of rainfall during the three-month period of August to October 2010 and the number of rainfall events during this period, the total cistern capacity appears to be suitable for efficient operation of the system.

The ETB water treatment system was installed at a tendered capital cost of $181,575. 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 VII. 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 VII. 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 the Facility professionals in higher education rank water conservation as equally important or more important than the conservation of electricity and natural gas. Further to a study to determine if an institutional policy or state legislation guided them for their sustainable practices (Cupido et al 2010), those that did have an institutional policy or state legislation nine of ten (90%) 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.

There were observed correlations between how interviewees rated water conservation importance with their institutions signing of the ACUPCC at the time of the interview. Nine of thirteen that felt that water conservation was *equally important* or *more important* had signed the

ACUPCC. As the acceptance and signatory participation in the ACUPCC grows, this may suggest a growing acceptance for water conservation.

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. Early adopters to 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.

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 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 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.

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Appendix A: Photos of the water treatment system in the ETB at McMaster University

Photo 1: View of the filtration components (Multimedia and Activated Carbon).

Photo 2: View of the disinfection components (Chlorination and Ultraviolet Light).

An Evaluation of Rainwater Runoff Quality from Selected White Roof Membranes

Anthony Cupido, Brian Baetz, Yiping Guo and Anna Robertson

Abstract

While there has been research on rainwater quality and quantity from green roofs and some conventional roof systems, there does not appear to be any significant study regarding the quality of rainwater harvested from selected white membrane roof systems and subsequently treated for potable use in an urban, institutional setting. A new Leadership in Energy and Environmental Design (LEED®) Canada Gold facility on the campus of McMaster University in Hamilton, Canada offered an excellent opportunity to analyze the quality of rainwater from different roof assemblies. Field research was undertaken on the evaluation of three white roof membranes: modified bitumen finish ply, polyvinylchloride (PVC), and thermoplastic polyolefin (TPO); and their effects on the runoff water quality were studied. An analysis of the quality of runoff was performed from each of these three membranes and compared to Ontario provincial drinking water standards. This paper provides the results of runoff quality testing on these membranes and their suitability for future institutional green building applications.

Key Words

Rainwater harvesting; white roof membranes; LEED®; water quality; green buildings.

Introduction

In a recent review of the concepts around peak water limits to freshwater withdrawal use, Gleick and Palaniappan (2010) acknowledged that the use and management of water will be shaped by paradigm shifts. Recognizing and understanding peak water limits will provide the stimulus for innovation and behaviors that reduce water use and shift water policy toward a more sustainable water future. As it relates to higher education, many universities are becoming 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).

Developed in the United States and now well-established in Canada, Leadership in Energy and Environmental Design (LEED®) is a nationally accepted benchmark for the design, construction and operation of high performance green buildings. LEED® was created to provide 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). These new green buildings, often referred to as sustainable buildings, are a growing trend on higher education campuses across Canada and the United States (Cupido et al. 2010). 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. Increasingly, these institutions are demanding roofing systems that are more compatible with the environment and meet LEED®

requirements (Liu 2005). A major practice in LEED® buildings is water conservation and institutions are focusing on sustainable roofing systems that may assist with water conservation needs. With the advent of this environmental movement for institutional buildings, rainwater harvesting (RWH) has again become a viable initiative to conserve water.

Three viable roofing systems could be considered for sustainable roofing and compliance with LEED®: garden roof systems, reflective roofs and photovoltaic (PV) integrated roofs (Lui 2005). In the context of rainwater harvesting, PV integrated roofs are not typically installed for this direct purpose and are not explored in this study. Garden roofs are specialized systems that support vegetation growth on rooftops and recent research has demonstrated that these roof styles will function to retain over 60% of the rainwater measured and reduce peak runoff flows by 75% (Hathaway et al. 2008; Lui 2005; Baskaran et al. 2007). Through field studies, green roofs and their vegetative media have also demonstrated high concentrations of nutrient outflow; namely nitrogen and phosphorus (Hathaway et al 2008); (Toronto and Region Conservation Authority 2006). Garden roofs do not appear to be good candidates for buildings that are designed to harvest rainwater for domestic use, particularly if the rainwater is disinfected with chlorine (Mendez et al. 2010). On the other hand, reflective roofs are typically single-ply, white membranes that address LEED® requirements and may help facilitate rainwater harvesting.

A defined LEED® credit is found in the *Sustainable Sites* category and is designated as *SSc.7.1 Heat Island Effect, Roof.* This credit can be achieved by the utilization of roofing material having a high Solar Reflectance Index (SRI) equal to or greater than 78 for a low-sloped roof (≤ 2:12 slope). The SRI is calculated using solar reflectance (the fraction of solar energy that is reflected by the roof) and thermal emittance (the relative ability of the roof surface to radiate absorbed heat). Both of these properties are measured as a fraction or percentage. The material's SRI is determined using ASTM E1980, "Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces." Materials with the highest SRI are the coolest and the most appropriate choice for mitigating the heat island effect (van Tijen and Cohen 2008). Major roofing membrane manufacturers will provide a technical data sheet for each membrane and the SRI parameter is typically listed and would have been measured by a nationally recognized laboratory.

Roofing membranes that meet the SRI criteria are commonly white, reflective membranes and when installed are often referred to as cool roofs for their highly reflective and emissive properties. Cool roofs can be an important element in a green building and have been shown to save energy, reduce urban heat island effect, decrease roof maintenance and related costs, and assist with green building program compliance (Akbari et al. 2005; van Tijen and Cohen 2008).

Several studies completed on rainwater runoff quality emanating from domestic roofs have identified the potential for water quality risk (Thomas 1998; Spinks et al. 2003; Evans et al. 2006). In an extensive study of the variability of roof runoff, which included measurements with an experimental roof system on the flat roof of a building on the campus of the University of Bayreuth in Germany (Förster 1999), it was concluded that the pollution of roof runoff was influenced by local sources. Specifically, heavy metals such as cadmium, lead and chromium have been detected in rooftop-harvested rainwater from an experimental study with small roof areas (< 33 m^2) and various, older roof types (tar felt, pantiles, asbestos cement, zinc sheet and gravel) at this same institution (Quek and Förster 1993; Lye 2009). Two separate modes of contamination of the roof catchment from a microbiological perspective are likely: the direct activities of insects, birds and small mammals, or the atmospheric deposition of environmental organisms. In recent research, major emphasis has been placed on the possible introduction of pathogenic organisms through fecal contamination of the catchment surface (Evans et al. 2006).

While there has been research on water quality and quantity originating from green roofs and some conventional roof systems, there does not appear to be any significant study regarding the quality of rainwater harvested from different white membrane roof systems in an urban, institutional setting.

The primary purpose of this research paper was to determine the runoff quality draining from three different reflective roof membranes following a rainfall event, to compare the results with the Province of Ontario’s drinking water quality standards (Ontario Drinking Water Quality Standards, O. Reg. 169/03), and to recommend the suitability of these roof membranes for future institutional green building applications.

In a larger context, rainwater collection and reuse is playing an important role in a broader movement towards more sustainable urban drainage practices and land development (Farahbakhsh et al. 2009). Rainwater utilization has been acknowledged as one of the best available methods for recovering natural hydrological cycles and assisting in sustainable urban development (Kim et al. 2005a). More recently in Germany, rainwater usage is becoming more commonplace in many commercial applications, including schools. The benefits include reduced demand on combined sewer systems and cost-effectiveness of private rainwater usage (Herrmann and Schmida 1999).

Background

McMaster University, in Hamilton, Ontario has embraced rainwater harvesting in the design and construction of the five-storey, 11,625 m^2 Engineering Technology Building (ETB). Opened in the fall of 2009, the ETB is home to more than 1,000 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. After draining from the roof, the rainwater is stored in two 25,000 liter precast concrete cisterns located below ground surface at the south end of the building. The cisterns have an overflow to the municipal storm sewer system for rain events in excess of the storage capacity. The stored rainwater is drawn from the cisterns into the building to be treated by filtration and disinfection. The treatment system is primarily composed of:

- multimedia filters to remove particulate from the runoff (20 micron diameter and above),
- activated carbon filters to remove organics and heavy metals that may be present in the runoff due to atmospheric fallout,
- micro-filters (5 micron to 1 micron nominal pore size),
- ultraviolet disinfection system sized for potable water quality,
- sodium hypochlorite addition to provide residual disinfection in the distribution system.

Instrumentation includes a turbidity meter, chlorine residual analyzer, flow meters, pressure transmitters and level sensors, with all being integrated into the building automation controls. 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 and is classified as a "large non-municipal non-residential" system.

The system layout allows for easy access by engineering students for research activities 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 has achieved a LEED® Canada – NC Certification (Gold) from the Canada Green Building Council. The rainwater harvesting design feature is a primary LEED® component of the ETB building and to facilitate the LEED® compliance, three reflective, white, single-ply membranes were selected: modified bitumen, polyvinyl chloride (PVC), and thermoplastic polyolefin (TPO).

Modified bitumen membranes are made from bitumen and modifying polymers together with fillers and special property additives, which for Canadian climates provide membrane flexibility at low temperatures (Delgado et al. 2005). Both PVC and TPO roof membranes are polymer-based thermoplastic membranes that share some characteristics, including durability and seams that can be heat welded. In particular, PVC membranes are versatile and are produced by adding stabilizers, plasticizers and other components to the PVC resin to provide for the desired performance of the membrane. PVC membranes have been on the roofing market for over 30 years and are the only commercial roofing product being recycled back into new material at the end of their service in North America (Paroli et al. 1996; Capocci and Hubbard 2005; Graveline 2010). TPO membranes, unlike PVC membranes, do not contain plasticizers and have been on the market for over 20 years (Paroli et al. 2000). The specific membranes and manufacturers used on the ETB roof are detailed in the next section. The ETB's roof and associated rainwater harvesting system provided an excellent opportunity for this research.

Approach and Methodology

Roofing Layout

The ETB contains a 2,052 m^2 roof assembly, as shown in Fig. 1 and consists of two white membrane roof levels: a main roof or plaza level (area 1.1, 2.1 and 3.1), located 22.4 meters above ground level, and a mechanical penthouse level (area 4.1, 4.2 and 4.3) located an additional 5.5 meters above the main roof level. Both roof levels are defined as having low-slope roofs (slope ≤ 2:12).

The plaza level contains essential strobic fan exhaust systems, plumbing vents, window cleaning davit arm anchors, and lightning capture cables. This level is considered to be the maintenance service level and would be accessed on a regularly scheduled basis (several times per year) by University staff or service contractors. This roof level surface consists of a finish ply modified bitumen membrane cap sheet (Siplast: Paradiene 30 CR FR TG) that is surfaced with a reflective, white synthetic chip.

The mechanical penthouse roof level provided the primary research area and consists of three structural bays, each having a different white roof membrane. Area 4.1 contains the same roof membrane surface as the main roof level. Area 4.2 contains a single-ply polyvinylchloride membrane (Sarnafil G410 EnergySmart Roof® PVC), and Area 4.3 contains a single-ply thermoplastic polyolefin roofing membrane (Firestone UltraPly™ TPO). This roof level is essentially unoccupied at all times and typically does not require any service access other than an annual roof inspection.

A descriptive summary of the roof areas and surface membranes is provided in Table 1. These selected membranes all comply with LEED® requirements for the solar reflectivity index (SRI).

Water Quality Testing

The scope of water quality testing pertained only to the roof areas as noted and did not include testing of the treated water side of the water treatment system in the ETB. Water quality testing occurred on two roof levels of the building and at five defined test sampling ports, labeled SP 1-5:

- Three sample ports in the mechanical penthouse room under each structural bay ensured that water quality samples were obtained from the rainwater runoff draining from each of the three penthouse roof membranes. Specifically, SP 1 for the Siplast: Paradiene 30 CR FR TG, SP 2 for the Sarnafil G410 EnergySmart Roof® PVC, and SP 3 for the Firestone UltraPly™ TPO. (Shown in Table 1)
- Two sample ports at either end on the fifth floor to capture the rainwater runoff coming from the plaza level. One of the two test ports best captured the rainwater roof runoff nearest the main exterior mechanical equipment on the roof, specifically

SP 4 (capturing approximately 25% of the total plaza roof area). The other test port, SP 5 (capturing approximately 75% of this roof area) best collected the rainwater runoff from a large open area on the plaza level and provided the location for the raw rainwater control. All the plaza level roofing is the Siplast: Paradiene 30 CR FR TG membrane. (Shown in Table 1)

To facilitate the ability to collect a roof drainage sample, a 40 mm sample drain line intercepted the roof drain piping immediately before the storm riser in each section of testing. The design provided a trap with a higher water column on the inlet so that new rainwater would flush out the previous rainwater collected, ensuring that the test sample came from the last rainfall. A hose bibb connection with a ball valve and spout allowed for a controlled filling of sample containers. A schematic is provided in Fig. 2.

Meteorological data for each rain event was provided by the McMaster Weather station, located on a nearby building, approximately 411 meters from the ETB. This station is used for research purposes at the University.

All water sampling was conducted in accordance with the Province of Ontario's Ministry of the Environment (MOE) drinking water guidelines as outlined in *The Safe Drinking Water Act, 2002* (Safe Drinking Water Act, SO 2002, c.32), *Ontario Regulation 169/03* (Ontario Drinking Water Quality Standards, O. Reg. 169/03) *and 170/03* (Drinking Water Systems, O. Reg. 170/03). Samples were typically evaluated for the following: nitrite (as nitrogen), nitrate (as nitrogen), selected metals (arsenic, cadmium, chromium, mercury and lead), vinyl chloride, total coliforms, E. coli and heterotrophic plate counts. All samples were taken within 24 hours of a rain event(s) and submitted to a licensed laboratory for analysis. Six sample containers, supplied by the testing lab for the parameters noted, were used at each port for a total of 30 per event. No samples were tested for radiological standards. A one-time, complete sampling event, for the penthouse level roof membranes only, was completed for O. Reg. 170/03 Schedule 23 which comprises nine inorganic parameters and Schedule 24 which comprises 56 organic parameters. The Schedule 23 analytes are comprised of nine selected metals and Schedule 24 analyte classes include PCB's, phenols, pesticides, herbicides and PAH's. The sampling under these schedules is typically performed on an annual basis in accordance with the regulations for licensed water systems ranging from small to large, municipal or non-municipal and residential or non-residential (Drinking Water Systems, O. Reg. 170/03).

Three glass pyrex dishes (average size 30 cm by 20 cm by 4 cm deep), located on the plaza level at the south end of the ETB, were used to collect raw rainwater samples as a reference control point. The cistern water quality was randomly tested as part of the testing requirements for the water treatment system. The cistern water test results are provided as a reference to the sample port results and to possibly ascertain if the cumulative collection of all roof drainage resulted in significantly different readings. Rainwater sampling and testing occurred from March 2010 to November 2010.

Results and Discussion

Nitrite/Nitrate

Nitrite is oxidized to nitrate fairly rapidly and is seldom present in surface waters in significant concentrations (Ontario MOE 2006). Nitrates are typically present in water as a result of decay of plant or animal material, the use of agricultural fertilizers, domestic sewage or treated wastewater contamination or soluble nitrogen compounds found in geological formations (Ontario MOE 2006). Only the decay of plant or animal material is relevant at this elevation.

The results of 14 nitrite/nitrate tests are shown in Table 2. Test results clearly indicate that there is a presence of nitrites and nitrates; however, their presence is not significant and well within maximum allowable water quality concentrations. The TPO roof provided the maximum recorded nitrite value (0.668 mg/L) and nitrate value (2.0 mg/L) from the second test in late March. These values may be attributed to winter atmospheric accumulation not washed out from earlier late winter rainfall events (only three recorded rainfall events >1mm, maximum precipitation event 10mm) from January 1, 2010 to March 26, 2010. During the research period, the average number of antecedent dry days and the average rainfall intensity were 5.3 days and 14.3 mm respectively. With reference to Table 2, these nitrite/nitrate values (mean and maximum) are consistent with the cool roof portion of a five pilot-scale (~3m^2) roof study by Mendez et al (2010) on the effect of roof material on water quality for rainwater harvesting systems.

In humans, excessive nitrate intake may accelerate the rate of formation of methemoglobinemia. Infants under 6 months of age are most susceptible to methemoglobinemia caused by nitrates ingested in drinking water (Ontario MOE 2006).

Metals

As shown in Table 3, the investigation of the selected five metals and vinyl chloride in the roof runoff revealed only three maximum readings that exceeded the reporting detection limit for the MOE water quality standards in Ontario, with the exception of lead. The abnormally high levels of lead from a non-metal roof system warranted an investigation into the possible sources within the ETB roof system and associated plumbing. It was concluded that the source of the lead contamination resulted from the roof drainage sample ports described earlier. The preliminary design of the piping required 40 mm copper drain lines from the main cast iron storm lines to the hose bibb connections, approximately 1.5 m above floor level. The length of the copper lines varied depending on the location, but ranged from approximately 4 to 6 meters. After discussions with the mechanical sub-contractor, it was confirmed that lead-based solder was used for these lines. It was the firm's erroneous understanding that these lines were to drain to a non-potable water system. The copper lines in test ports 1, 2 and 3 were replaced with a PVC piping system with a larger 80 mm gooseneck assembly to provide more adequate water testing volume (3.5 L). Results on the system, after the upgrade, demonstrated significant improvement and lead levels below MAC levels. Prior to the piping improvements, the average lead result (3 tests) from these three sample ports was 19 µg/L and following the change to PVC piping the average lead result dropped to 6.5 µg/L. The origin of the lead contamination appears to have resulted from a design/construction practice and was essentially resolved.

One O. Reg. 170/03, Schedule 23 and Schedule 24 test was undertaken on the penthouse level in early October. The Schedule 23 results of these water quality tests revealed only two parameters that exceeded the MAC: barium - 2440 µg/L (MAC = 1000 µg/L) and lead - 10.2 µg/L (MAC=10 µg/L). Both of these results emanated from the modified bitumen membrane (Area 4.1). No other inorganic parameters exceeded the MAC in tests for the PVC or TPO roof membranes. A subsequent follow-up test for barium on the next rain event (29 days later), indicated a runoff concentration of 952 µg/L from SP 1. The other membranes (SP 2 and SP 3) had barium values of 134 µg/L and 32 µg/L respectively, which are less than 14% of MAC.

The high levels of barium suggest a localized source. Barium compounds have a variety of industrial applications and are generally present in air in particulate form. Its presence is mainly attributed to industrial emissions including diesel oil where it is used to reduce black smoke emissions from diesel engines (Federal-Provincial Subcommittee…1990)). The close proximity of the ETB to a large hospital complex with numerous diesel-fueled emergency generators that are tested on a regular weekly basis may be the source, although this possibility was not conclusively verified. As it relates to other possible sources of contamination, the ETB is located at the front of the McMaster campus and abuts a major arterial roadway that services western Hamilton, Dundas and the campus. As well, this facility is within 400 m of the campus central utility plant building and several science buildings. These adjacencies may contribute to some of the atmospheric particulate found on the roof membranes. The Schedule 24 results yielded no test result values > MDL for all listed organic compounds.

The mean test results for As, Cd, Cr and Pb, identified in Table 3, are consistent with first flush results from the pilot-scale (~3m^2) cool roof study by Mendez et al 2010. The results provided in Mendez et al for As, Cd and Cr had mean values well below MAC and below RDL identified in Table 3 and were within the range of mean values and maximum recorded readings identified in the results of this research. Lead (Pb) mean values identified by Mendez et al exceeded RDL and the maximum value, in their range of results, exceeded MAC in Table 3. This comparison must be kept in context with recognized differences in the research approach of Mendez et al, including the small pilot surface area, study located at ground level and the higher roof slope which may influence results when compared to the lead author's research.

Vinyl Chloride

Vinyl chloride is a synthetic chemical with no known natural sources and is classified as a human carcinogen (Federal-Provincial Subcommittee…1992). It is used in the manufacture of commercial PVC roof membranes in such a manner that no trace of vinyl chloride is present in them (Paroli et al. 1996). PVC is produced by polymerization of vinyl chloride monomer and produces a chemical bond that is highly inert and almost indestructible. (Paroli et al. 1996). Testing outcomes, identified in Table 3, were anticipated with all results less than the maximum detectable limits (Ontario MOE 2006).

As noted earlier, no organic parameters exceeded the MAC, including vinyl chloride, in any of the three penthouse roof membranes for tests taken in accordance with the O. Reg. 170, Schedule 24 samples.

Microbiological Parameters

As identified in Table 4, the rainwater samples collected in the study showed the presence of microbiological contaminants. Available cistern readings are referenced in the context that this location is the end destination for the raw rainwater and may be influenced by individual results from each roof level.

Positive Total Coliform (TC) counts were evidenced from all roof sections with the exception of the TPO roof on the penthouse level. The raw rainwater (control) sampling revealed two positive TC observations. The cistern water was tested from a water sampling point inside the basement mechanical room and resulted in frequent positive results with lower unit values. The lower unit values may be a result of contact with chlorinated municipal make-up water in the cistern during low volume periods (minimal or no rainfall) or resulting from higher demand in the facility.

E. coli tests were positive on one occurrence for all roof sections with the exception again of the TPO roof and the control. Positive test results occurred on days when the daily maximum temperature was ≥ 19.7°C. The highest E. Coli results occurred on September 16 (13 CFU/100mL @ SP2 and 41 CFU/100mL @ SP5) following an antecedent dry period of 12 days. These results suggest contamination from airborne deposition or birds and continue to raise the issue of risk for untreated rainwater harvested for potable or non-potable use.

The heterotrophic plate count (HPC) yielded a range from <10 to >2000 CFU/ml spread plate and further yields awareness of risk for any pre-treatment locations of harvested rainwater. In Health Canada's *Guidelines for Canadian Drinking Water Quality*, it is acknowledged that HPC tests can be used as one of several methods available for monitoring overall water quality. However, they do not indicate water safety and therefore do not indicate the possible presence of human pathogens. No guideline value has been established for HPC levels in drinking water, but effective treatment should include disinfection, resulting in HPC concentrations as low as 10 CFU/ml. The Guidelines conclude that while numerical limits for the microbiological quality of raw water supplies are not proposed, the microbiological quality of raw water should be considered when selecting sites for new treatment plants (Federal-Provincial-Territorial Committee…2008).

During the study period, the lead author recorded 31 visits to the plaza roof and the penthouse roof and no birds were observed during these visits. Regardless, on two occasions only, bird droppings were seen at the base of the access ladder to the penthouse roof. The positive observations of E. coli indicate not only recent fecal contamination of the rainwater roof runoff but also the possible presence of intestinal disease-causing bacteria, viruses and protozoa. There may be two contributing factors to this contamination: the mechanical penthouse roof water ponding and atmospheric particulate. Particulates were identified in the pyrex dish used for the rainwater control measurements and observed on the penthouse roof.

During the test period, the pyrex dish used to collect raw rainwater control samples collected a gritty particulate material that covered portions of the inside of the base of the dish. The material was tested in the University's Optical Spectroscopy Facility and determined to be composed of inorganic nitrates, aliphatic secondary amides, aliphatic hydrocarbons and primary aliphatic alcohols. Also present were possible silicon oxides (quartz). The test report concludes that the nitrates are likely the nitrogen source required for growing plants in soil, while the remaining organic materials are decomposed organic matter (likely humus) (2010 personal communication from S.A. Kornic; unreferenced, see Acknowledgement).

The design detail of the mechanical penthouse roof requires an insulation sump (1.2 m by 1.2 m square) around each of the six roof drains. The depth of the sump is approximately 10 mm and is intended to ensure that all insulation is tapered properly toward the drain. In the PVC and TPO roof sections, three of the four drains have sumps that were not ideally installed and hence have some ponding in addition to what would be found in the designed sump. It is estimated that the irregular area of ponding is double the 2.25 m^2 design area, with an average depth of 20 mm. It is estimated that approximately 5 liters of rainwater ponded in each of these locations when there were not extended dry weather periods. This may have been an attraction to birds although this possibility was not formally studied.

In addition, both of the PVC and TPO membranes have experienced a film that appears to be atmospheric fallout as described above (in the pyrex dish) and the albedo effect of these roofs has noticeably changed. The effects of soiling on light-colored roof membranes have been well researched (Levinson et al. 2005; Carlson et al. 2009) and in particular, the deposition of soot, dust and/or biomass can lower the initial solar reflectance by over 20%.

Grab sample results of the PVC and the TPO roof water ponding are provided in Table 5 and were taken in an effort to determine the likely source of contamination identified in Table 4.

Results in Table 5 seem to suggest that rainwater ponding may be a contributing factor to the accumulation of coliforms and E. coli. A black algae was seen in the PVC and TPO ponds and atmospheric deposits in the rainwater control in the October samples. The ponded water enters the sample ports and ultimately the cistern during a rainfall event of sufficient intensity.

Lye (2009) summarized parameters that are particularly important for optimum performance of rainwater collection systems. These include the type of roof material used and more importantly the material deposited on roof catchments as a source of contamination. In a related earlier study, Lye (2002) summarized that consumption of untreated rainwater is a definite risk to the health of consumers.

Opportunities for Future Research

Institutional urban settings may offer unique influences that could impact a RWH initiative. More work is required to understand these influences and how a new institutional building design, and more specifically the associated roof design, would need to be modified or customized.

Although there is industry and manufacturer's literature available on the general maintenance of white roof membranes, it will be necessary to develop specific guidelines for the use and maintenance of roof surfaces that capture rainwater for potable and non-potable purposes within the building. These guidelines may help minimize the risk of contamination.

Concern for the real and perceived health risks associated with the quality of harvested rainwater is a major barrier that has limited the adoption of large-scale rainwater harvesting in Canada. There has been significant resistance on the part of regulatory authorities in the development of policies or legislations that promotes the implementation of rainwater harvesting (Farahbakhsh et al. 2009). An opportunity exists to enhance public policy development requiring some degree of rainwater harvesting for all public agency buildings. As well, public education regarding water issues, conservation and RWH may begin to remove policy barriers (Farahbakhsh et al. 2008). Compliance with recognized green building rating systems such as LEED® will help motivate facility professionals to take advantage of design strategies and enhance their potential rating.

Conclusions

Research at McMaster University's Engineering Technology Building (LEED® Gold) and other RWH research have demonstrated that the quality of collected rainwater commences with the design of the roof system. The roof design includes the specified roofing product(s) and must take into account the proximity to anticipated contaminant sources as well as the likelihood of microbial contamination.

The following conclusions were derived from this research:

- There is no evidence that the researched roof membranes produce undesirable residuals, particularly vinyl chloride and the selected metals (As, Cd, Cr, Hg and Pb).
- The research roof membranes will provide a suitable catchment surface for a green building and/or use in a rainwater collection system.
- When compared to Ontario's MOE water quality requirements, no particular roof membrane of the three researched (modified bitumen, PVC and TPO) provided superior water quality results to suggest that any one was preferred or recommended as a RWH catchment surface.
- Rainwater harvested from the selected white roof membranes provides water that was not suitable for potable use without appropriate treatment prior to distribution within the building.
- Care must be taken to minimize residual ponding on the roof surface, regardless of the size or volume of the ponded water, to reduce the risk of microbiological contamination.
- Water quality testing results suggest that atmospheric particulate was a primary pollutant in this RWH collection system.

As a result of the findings of this research, it is recommended that a white roof membrane system used for rainwater harvesting be maintained to minimize any residual ponding, thus reducing the risk of microbial contamination entering the storage cistern used to collect the rainwater. It is also recommended that a white roof membrane system be cleaned bi-annually, at a minimum, to prevent the build-up of atmospheric particulate from the local air pollution experienced in this urban setting. All cleaning washoff should be collected locally and not allowed to enter the roof drains to ensure that it is diverted from the RWH system. This practice would be consistent with the recommendations of Jordan et al. (2008) who advocate regular maintenance and cleaning of roof-based rainwater catchment surfaces. More practically, a drainage design that incorporates a first flush diverter may improve the quality of roof runoff by allowing initial roof drainage to bypass the cistern. Further testing may help determine the optimal bypass volume for the first flush system.

New roof membranes incorporating TiO_2 (such as the Siplast Eco-Activ® membrane) or situations whereby it is applied as a coating to existing surfaces, may provide substantial opportunities. In these applications, an improved wash-off of pollutants is attributed to increased hydrophilicity thus resulting in easier particle and micropollutant detachment on the roof surface. (Kim et al. 2005b). These membranes may be more suitable for RWH applications by helping to improve the water quality of the roof runoff.

The Province of Ontario has commenced the implementation of progressive legislation (Bill 72) to ensure that public agencies provide water conservation plans that will include sustainable water management strategies. It appears that legislation may advance the movement toward innovation and the implementation of rainwater harvesting systems in the public sector. Higher educational institutions must demonstrate leadership for this important approach to water management. Rainwater harvesting initiatives, such as the one demonstrated at McMaster University, are viable approaches to ensure compliance with these new public sector requirements.

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List of Figures

Fig. 1. Roof assembly

Fig. 2. Schematic of a rainwater testing port

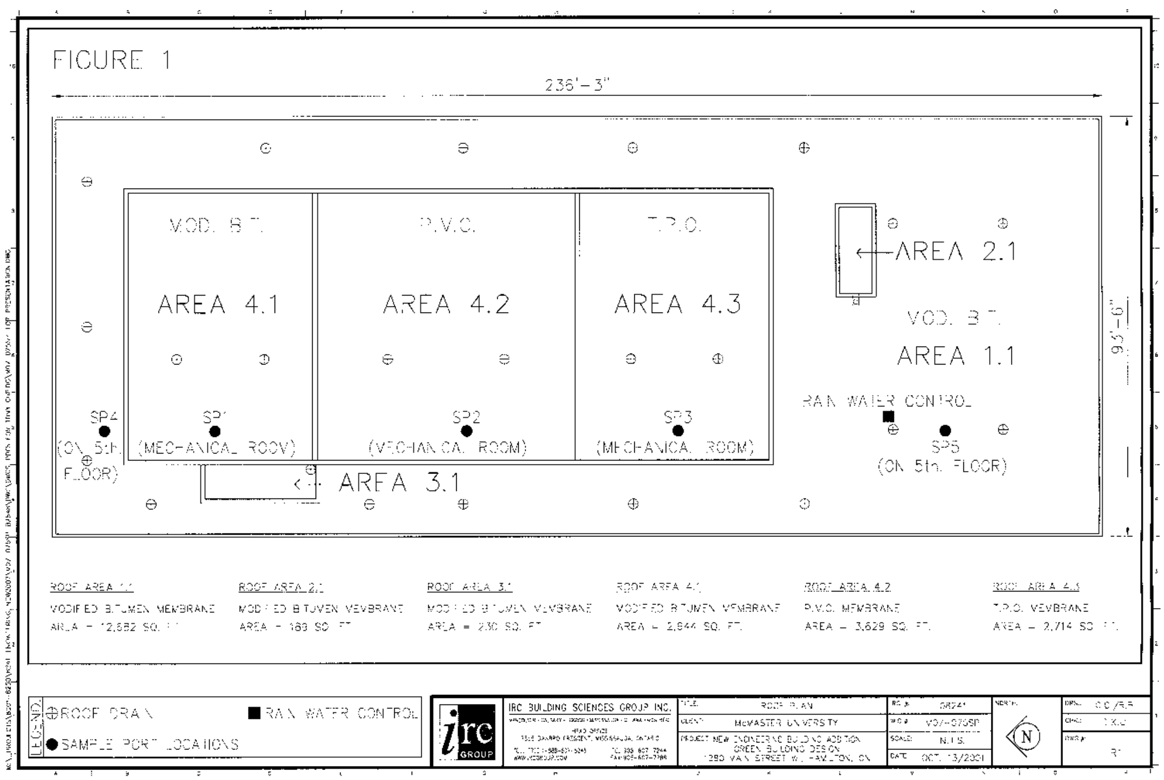

Fig. 1. **Roof assembly.**

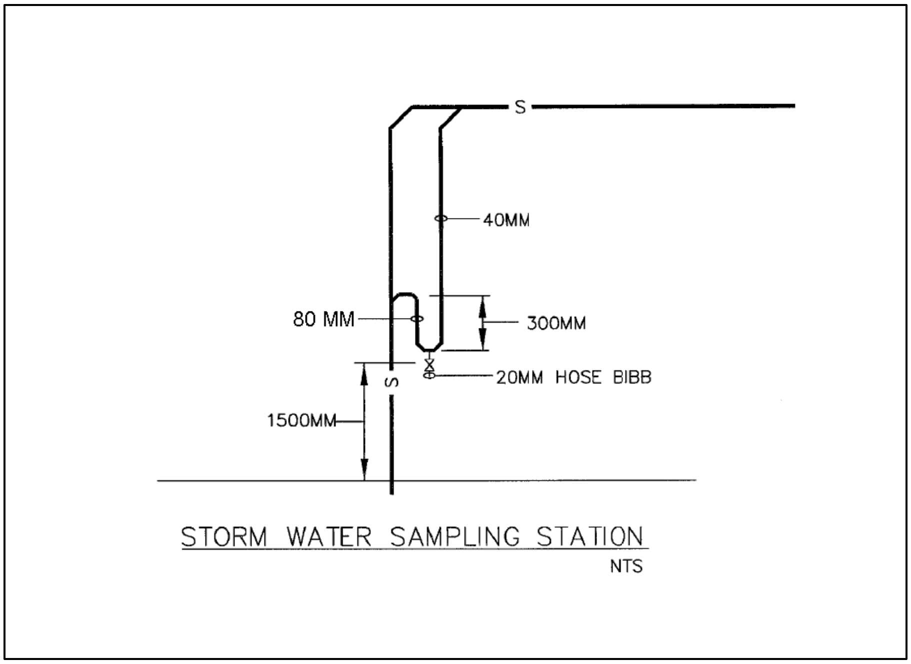

Fig. 2. Schematic of a rainwater testing port.

List of Tables

TABLE 1. Roof area summary

TABLE 2. Water quality test results – nitrite/nitrate

TABLE 3. Water quality test results – selected metals and vinyl chloride

TABLE 4. Water quality test results - microorganisms (number of investigated samples is given in parenthesis)

TABLE 5. Grab sample results from ponding areas on penthouse mechanical roof (area 2 and 3 only)

TABLE 1. Roof area summary

Roof Section	*Area Size (m^2)*	*Roof Product*	*Product Description*	*LEED® Compliance*	*Solar Reflective Index (SRI)*	*Sampling Port (SP)*
1.1	1178	Siplast: Paradiene 30 CR FR TG CR - Cool Roof FR - Fire Retardant TG - Torch Grade	Consists of a lightweight random fibrous glass mat impregnated and coated with high quality styrene-butadiene-styrene (SBS) modified bitumen and surfaced with reflective, white synthetic chips.	Yes	87	SP 5
2.1	17.5	Siplast: Paradiene 30 CR FR TG	(as above)	Yes	87	SP 5
3.1	21.4	Siplast: Paradiene 30 CR FR TG	(as above)	Yes	87	SP 4
4.1	246	Siplast: Paradiene 30 CR FR TG	(as above)	Yes	87	SP 1
4.2	337	Sarnifil G410 EnergySmart Roof® Membrane	A single-ply polyvinylchloride (PVC) membrane that is a heat-weldable product containing ultraviolet light stabilizers, flame retardant and integral fiberglass mat reinforcement.	Yes	104	SP 2
4.3	252	Firestone UltraPly™ TPO	A flexible thermoplastic polyolefin (TPO) roofing membrane that is produced with polyester weft inserted reinforcement.	Yes	97	SP 3

TABLE 2. Water quality test results – nitrite/nitrate (14 samples)

	MAC	RDL	MDL	SP 1	SP 2	SP 3	SP 4	SP 5	CONTROL Plaza Level	Cistern SP 101
Nitrite (as nitrogen) (mg/L)	1	0.1	0.005							
Max. Recorded Readings (mg/L)				0.092	0.037	0.668	0.024	0.014	0.013	0.149
Mean (mg/L)				0.034	0.018	0.146	0.014	0.010	0.011	0.040
Standard Deviation (mg/L)				0.025	0.014	0.193	0.007	0.003	0.003	0.043
Nitrate (as nitrogen) (mg/L)	10	1.0	0.013							
Max. Recorded Readings (mg/L)				1.300	1.180	2.000	0.324	0.252	0.371	0.682
Mean (mg/L)				0.695	0.446	0.764	0.181	0.146	0.325	0.382
Standard Deviation (mg/L)				0.421	0.349	0.648	0.104	0.080	0.032	0.216
Nitrate + Nitrite (as nitrogen) (mg/L)	10	1.0	0.013							
Max. Recorded Readings (mg/L)				1.390	1.220	2.150	0.347	0.259	0.384	0.795
Mean (mg/L)				0.730	0.464	0.919	0.194	0.270	0.336	0.466
Standard Deviation ±(mg/L)				0.439	0.360	0.701	0.109	0.268	0.034	0.218

MAC – Maximum Acceptable Concentration
RDL – MOE Required Reporting Detection Limit
MDL – Method Detection Limit

TABLE 3. Water quality test results – selected metals and vinyl chloride (number of samples in parenthesis)

	MAC	RDL	MDL	SP 1 (12)	SP 2 (12)	SP 3 (12)	SP 4 (7)	SP 5 (8)	CONTROL Plaza Level (4)	Cistern SP 101 (5)
Arsenic µg/l	25.0	2.5	0.2							
Max. Recorded Readings (µg/L)				0.8	0.6	0.6	0.3	0.5	0.2< MDL	0.5
Mean (µg/L)				0.3	0.3	0.3	0.2	0.3	N/A	0.3
Standard Deviation ±(µg/L)				0.2	0.1	0.1	0.0	0.1	N/A	0.1
Cadmium µg/l	5.0	1.0	0.003							
Max. Recorded Readings (µg/L)				0.154	0.255	0.280	1.090	0.588	0.059	0..068
Mean (µg/L)				0.072	0.095	0.099	0.854	0.338	0.047	0.028
Standard Deviation ±(µg/L)				0.033	0.070	0.080	0.141	0.115	0.009	0.017
Chromium µg/L	50.0	5.0	0.5							
Max. Recorded Readings (µg/L)				2.6	5.9	7.9	4.0	4.3	1.9	1.3
Mean (µg/L)				1.0	2.1	1.8	1.1	1.8	1.0	0.7
Standard Deviation ±(µg/L)				0.7	1.9	2.4	1.2	1.6	0.7	0.3
Mercury µg/L	1.0	0.1	0.02							
Max. Recorded Readings (µg/L)				0.03	0.04	0.02< MDL	0.02< MDL	0.02< MDL	0.02< MDL	0.02< MDL
Mean (µg/L)				<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
Standard Deviation ±(µg/L)				<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
Lead µg/L	10.0	2.0	0.02							
Max. Recorded Readings (µg/L)				22.00	40.80	48.40	173.00	63.40	5.11	1.34
Mean (µg/L)				7.68	10.91	11.74	35.29	17.63	1.89	0.62
Standard Deviation ±(µg/L)				5.31	11.68	14.66	56.68	18.46	2.82	0.44
Vinyl Chloride µg/L	2	0.2	0.17							
Max. Recorded Readings (µg/L)				0.17< MDL	0.17< MDL	0.17< MDL	0.17< MDL	0.17< MDL	0.17< MDL	0.17< MDL
Mean (µg/L)				<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

Standard Deviation ±(µg/L)				<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

MAC – Maximum Acceptable Concentration
RDL – MOE Required Reporting Detection Limit
MDL – Method Detection Limit

TABLE 4. Water quality test results - microorganisms (number of samples in parenthesis)

	MAC	Sample Port (SP) 1	SP 2	SP 3	SP 4	SP 5	CONTROL Plaza Level	Cistern SP 101
Total Coliforms CFU/100ml	0							
Min.-Max. Value		0-24	0-26	0-0	0-0	0-47	0-55	0-11
Positive Observations		2(11)	3(11)	0(11)	1(11)	2(11)	2(10)	7(10)
E. Coli CFU/100ml	0							
Min.-Max. Value		0-1	0-1	0-0	0-1	0-41	0-0	0-2
Positive Observations		1(8)	1(8)	0(6)	1(8)	1(8)	0(10)	1(10)
Heterotrophic Plate Count (HPC) CFU/1 ml Spread Plate	0							
Min.-Max. Value		1620->2000	220->2000	170->2000	1180->2000	730->2000	10->2000	<10 >2000
MAC – Maximum Acceptable Concentration								

TABLE 5. Grab sample results from ponding areas on penthouse mechanical roof (area 2 and 3 only)

Sample ID	Sample Date	Total Coliform (CFU/100 ml)	E. Coli (CFU/100ml)	HPC CFU/1ml Spread Plate	Turbidity NTU	Total Dissolved Solids (µs/cm)
PVC Roof Section	23 August 2010	63	54	>2000	N/A	N/A
	12 October 2010	12	0	>2000	5.92	250
	17 November 2010	0	0	>2000		80.5
TPO Roof Section	12 October 2010	3	0	>2000	7.12	865
	17 November 2010	0	0	>2000		186
Rainwater Control	23 August 2010	0	0	>2000		
	12 October 2010	0	0	1360		450
	17 November 2010	4	0	90		10.52

1. Consent Form

* 1. Consent for Web-Based Survey

Development and Application of Policy-Based Tools for Institutional Green Buildings

The purpose of this research project is to determine if institutional policies are an important criterion for sustainable building practices and the use of Leadership in Energy and Environmental Design (LEED®). This research will focus on the importance of water as an essential natural resource that needs to be better utilized in an institutional environment.

You are being invited to complete a short (10-15 min.) web-based survey. This voluntary survey will provide the researcher with information related to your institutions use of policies, guidelines, standards, laws or goals related to sustainable practices and the use of LEED®.

Results of the research will be available for your information and it is anticipated that it will form part of APPA's research program through the Center of Facilities Research (CFaR)

The information obtained will be kept confidential and your privacy will be respected.

This research project has been reviewed and approved by the McMaster Research Ethics Board. If you have concerns or questions about your rights as a participant or about the way the research is conducted, you may contact: McMaster Research Ethics Board Secretariat, (905)525-9140 ext.23142, c/o Office of Research Services. E-mail: ethicsoffice@mcmaster.ca

CONSENT
I have read the information presented above regarding a research project being conducted by Anthony Cupido of McMaster University (cupidot@mcmaster.ca). I understand that I may change my mind and withdraw from the study at any time up to the point when I submit my answers. I may do so by exiting the survey or closing my browser.

I agree to participate in this study.

Please choose a button below to proceed.

- ◯ Yes, I Agree to Participate
- ◯ No, I don't want to participate

2. Demographic Information

2. What is your current role at your Institution?

- ◯ Facilities AVP
- ◯ Facilities Director/Manager
- ◯ Senior Administrator
- ◯ Facilities Planner
- ◯ Capital Projects Manager
- ◯ Sustainability Officer
- ◯ Other (please specify)

3. What is the total size (sq. footage) of your Institution?

- ◯ 0 – 500,000 sq.ft.
- ◯ 500,000 – 1 million
- ◯ 1 million – 2 million
- ◯ 2 million – 3.5
- ◯ 3.5 – 5.0
- ◯ 5.0 – 1.0
- ◯ > 10 million

4. How many buildings are on your campus(es)?

- ◯ 0 – 10
- ◯ 10 – 20
- ◯ 20 – 30
- ◯ 30 – 40
- ◯ 40 – 50
- ◯ 50 – 75
- ◯ 75 – 100
- ◯ > 100

5. Which of the following apply at your institution? (Check all that apply)

- [ ] Public
- [ ] Private
- [ ] Urban
- [ ] Suburban
- [ ] Rural
- [ ] Four-Year
- [ ] Two-Year
- [ ] One main campus
- [ ] One main campus and other locations

3. General Questions

6. In recognition of the significant environmental and health impacts associated with institutional buildings, has your institution adopted a "green" building policy, guideline, standard, law or goal?

- ◯ Yes
- ◯ No
- ◯ In the process of doing so

7. If you have adopted a policy, guideline, standard, law or goal for "green" buildings, who was most responsible for the development of it?

- ◯ myself, the surveyee
- ◯ another staff member in my department
- ◯ another staff member in a different department
- ◯ a team comprised of staff members in various departments
- ◯ the State or Province
- ◯ Other (please specify)

8. In an effort to determine why the policy, guideline, standard or goal was developed...?
(To what extent do you agree or disagree with each of the following?)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
It was the vision of myself or another senior official	◯	◯	◯	◯	◯
Other institutions were doing it so we chose to develop as well	◯	◯	◯	◯	◯
It was a follow up with a Federal, State, Provincial or Municipal initiative	◯	◯	◯	◯	◯
Participation in the Talloires Declaration	◯	◯	◯	◯	◯
Our institution wanted to engage in sustainable initiatives and attempt environmental change	◯	◯	◯	◯	◯
Students played an important role by influencing administration	◯	◯	◯	◯	◯
Our institution has an environmental curriculum	◯	◯	◯	◯	◯
Local Citizen groups, in the community where the institution is located, played a role.	◯	◯	◯	◯	◯
It provides an opportunity to reduce a building's operating costs.	◯	◯	◯	◯	◯

Other (please specify and provide the extent as above)

9. Does your institution have Federal / State / Provincial incentive programs to assist with green building costs?

- ◯ Yes
- ◯ No

* 10. If your institution has adopted a "green" building policy, guideline, standard, law or goal, what is the specific tool or instrument that <u>requires or guides</u> your campus to have “green” buildings? (Please choose only one answer.)

- ◯ A sustainability/green building policy or similar policy
- ◯ A design/construction guideline
- ◯ A design/construction standard
- ◯ A state or provincial law
- ◯ An Environmental/Sustainable Goal
- ◯ Not Applicable
- ◯ Other (please specify)

4. Policy Related Questions

11. A green building policy would likely commit or require your institution's administration to adhere to a recognized assessment rating system for a green building. The system used on your campus is:

- ◯ LEED®
- ◯ Green Globes
- ◯ GB Tool
- ◯ B.R.E.E.A.M.
- ◯ Not applicable, we do not reference any system.
- ◯ Other (please specify)

12. If LEED® is used, the minimum level to be achieved is:

- ◯ Certified
- ◯ Silver
- ◯ Gold
- ◯ Platinum
- ◯ Not Applicable – Do not use LEED®

13. Approximately how long have you had a sustainable/green building policy at your institution?

Other (please specify)

14. Does your institution annually review and/or update your policy?

- ◯ Yes
- ◯ No
- ◯ Other (please specify)

* 15. In your capacity/role as a member of a new "green building" design team, have you ever had to use your institution's green building policy to insist on obtaining a particular LEED® level (or other rating system) with stakeholders, users or other team members?

- ◯ Never (0%)
- ◯ Sometimes (e.g. less than 50%)
- ◯ Often (e.g. more than 50%)
- ◯ Always (100%)

5. Non-Policy Related Questions

16. If you do not have a policy, but utilize a guideline, standard, law or goal, which specific assessment rating system does your institution reference for measuring a green building?

- ◯ LEED®
- ◯ Green Globes
- ◯ GB Tool
- ◯ B.R.E.E.A.M.
- ◯ Not applicable, we do not reference any system.
- ◯ Other (please specify)

17. If LEED® is used, the minimum level to be achieved is:

- ◯ Certified
- ◯ Silver
- ◯ Gold
- ◯ Platinum
- ◯ Not applicable, do not use LEED®

18. Is your guideline, standard, goal, or law…?

- ◯ Mandatory, thus committing and requiring the institution to meet or exceed that requirement
- ◯ Not Mandatory and is only a target to meet or exceed that requirement
- ◯ Other (please specify)

19. If your campus does not have a policy for the construction / renovation of green buildings, what in your opinion are the barriers to adopting a policy? (To what extent do you agree or disagree with the following possible barriers.)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Green sustainable buildings are more expensive than traditional buildings	○	○	○	○	○
A policy would limit flexibility on a given project	○	○	○	○	○
There is not a sufficient business case to justify a policy for green buildings	○	○	○	○	○
Consulting and other costs to apply for LEED® registration and designation	○	○	○	○	○
A guideline or standard is sufficient to meet the intent	○	○	○	○	○
Our State or Provincial law supersedes a need for a policy	○	○	○	○	○
No one has taken the time or made the effort to draft a policy	○	○	○	○	○

Other (please specify and provide a rating number as above)

20. If it is not mandatory at your institution to obtain a specific green building requirement, (such as LEED®) would you welcome a policy that would require all new buildings or major renovations to be "green"

- ○ Yes
- ○ No

21. If yes, the green building requirement would be:

- ○ LEED® Certified
- ○ Silver
- ○ Gold
- ○ Platinum
- ○ Other (please specify)

22. In your capacity/role on a new “green building” design team, have you ever been in a scenario where you wished you had a green building policy to ensure that you obtain a particular “green” building standard such as LEED® and/or a particular level of LEED® that others may be arguing against for various reasons.

- Never (0%)
- Sometimes (less than 50%)
- Often (more than 50%)
- Always (100%)

23. If a green building/sustainable building policy template was available to you, would you consider that as a valuable tool for implementing a policy at your institution?

- Yes
- No
- Comments (please elaborate)

It would be very appreciated if you provided responses to the remaining questions!

6. Water Conservation Questions

24. What water conservation measure(s) have you already incorporated into a LEED® (or other standard) "green" building?
(check all that apply)

- ☐ waterless urinals
- ☐ low-flow showerheads
- ☐ low-flow toilets
- ☐ dual-flush toilets
- ☐ composting toilets
- ☐ low flow faucets
- ☐ rainwater harvesting for irrigation
- ☐ rainwater harvesting for potable use
- ☐ rainwater harvesting for potable use including drinking water
- ☐ reclaim gray water (sinks, showers etc.)
- ☐ reclaiming wastewater and treatment water
- ☐ water efficient appliances
- ☐ not applicable for our institution

25. How do you rank the importance of water conservation with conservation of electricity and natural gas?

- ○ less important
- ○ equally important
- ○ more important

26. How does your campus receive its water supply?

- ○ municipal supply
- ○ private water supply
- ○ well(s)
- ○ Other (please specify)

27. Do you meter and/or submeter your campus buildings to measure water consumption?

- ○ Yes
- ○ No
- ○ Some, but not all

28. If your institution harvests rain water as a component of your "green" building (s), what method is used? (check all that apply)

- [ ] not applicable – we do not harvest rainwater
- [ ] roof water collection and storage into a cistern, tank, pond, etc.
- [ ] holding pond retention
- [ ] swales or bioswales
- [ ] parking lot collection
- [ ] reservoir
- [ ] Other (please specify)

29. If your institution harvests rainwater, what treatment method is used prior to its application in/at your “green" building(s). (check all that apply)

- [ ] not applicable, we do not harvest rainwater
- [ ] no treatment at all
- [ ] filtration
- [ ] some treatment for disinfection
- [ ] full treatment for disinfection
- [ ] treatment for disinfection to meet applicable drinking water standards
- [ ] Other (please specify)

7. Reminder

Once you submit your responses, it will not be possible to withdraw them from the survey.

8. Request for Follow-up Interview

* 30. Would you be willing to be contacted to take part in a brief follow-up interview (35-45 minutes) by phone or in person?

- ◯ Yes
- ◯ No

9. Contact Information for Follow-up

* 31. Please enter your contact information. (This information will be placed in a separate file.)

Name:

Institution:

Email Address:

10. Thank You Page

Thank you for taking the time to complete the survey involving research on the development and application of policy-based tools for institutional green buildings. Your input is appreciated!

The researcher will be available to answer questions you may have concerning this study, now or in the future. For more information concerning the research, you may contact Anthony Cupido, the researcher at (Tel) 905-525-9140 x23054 or e-mail at cupidot@mcmaster.ca.

This research project has been reviewed and approved by the McMaster Research Ethics Board. If you have concerns or questions about your rights as a participant or about the way the research is conducted, you may contact:

McMaster Research Ethics Board Secretariat
Telephone: (905) 525-9140 ext. 23142
c/o Office of Research Services
E-mail: ethicsoffice@mcmaster.ca

Appendix B

Interview Questions

Development and Application of Policy-Based Tools for Institutional Green Buildings

Anthony Cupido (Ph.D. Candidate)
Faculty of Engineering – McMaster University

Information about these interview questions: Interviews will be one-to-one and will be open-ended (not just “yes or no” answers). As a result, the exact wording may change. Sometimes the questions may differ slightly if you are at an institution with a policy or a guideline, standard, law or goal. Institutions with a policy will not be answering, for example, questions 5-9 inclusive. Institutions without a policy will not be answering questions 2-4 inclusive.
A copy of the survey questions will be made available to the participant for reference.

1. With reference to Question 8 in the survey, please elaborate on your choices for the development of your institution’s tool or instrument for green buildings. Tell me about your highest rating(s)? Why did you rate them so?

2. **Policy Question.** With reference to Question 15 in the survey, please tell me more about applying your institution’s green building policy with your design team? What barriers to using the policy have you experienced with the design team?

3. **Policy Question.** If your institution has a green building policy, are you adhering to it? If yes, what had facilitated this? Have you had challenges adhering to this policy and what are they? If you haven’t been able to adhere to it, can you please tell me more about that?

4. **Policy Question.** Have you ever registered for LEED® with a goal of obtaining a specific level, and not achieved it? What were the reasons for missing the goal? If applicable, have you taken steps to minimize this outcome to ensure you obtain the desired level?

5. **Non Policy Question.** With reference to Question 19 in the survey which asked your opinion about barriers to adopting a policy; please elaborate on you highest rated barriers? What are you suggestions for overcoming these barriers?

6. **Non Policy Question.** With reference to Question 22 in the survey which asked if you have ever been in a scenario where you wished you had a policy to ensure a particular level of LEED®, have you ever experienced a scenario were members of the design team suggested a lower level of LEED®? Why do you think they were suggesting this? What was the outcome of that situation?

7. **Non Policy Question.** If you do not have a green building policy but a guideline, standard, law or goal, are you adhering to it? If not, please tell me more?

8. **Non Policy Question.** Have you ever considered initiating a project with a specific LEED® target, but never actually following through with the LEED® registration, documentation etc. as a cost saving measure or for any other reason?

9. **Non Policy Question.** If you received a template for a sustainable policy, would that be something your institution would readily accept and put in place? Would you be the driver for that or someone else?

10. Do you retain a professional consultant to assist you in the LEED® registration and subsequent documentation and follow-through to certification with your Green Building Council? Do you find the professional fees and application fees too high? Have you ever considered undertaking this process yourself?

11. Tell me more about how you rated the importance of water conservation with the conservation of electricity and natural gas?

12. 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?

13. 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.