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Subject:	**Final Literature Review on Best Practices of Water Conservation & Efficiency**		

CITY OF GUELPH

LITERATURE REVIEW ON BEST PRACTICES OF WATER CONSERVATION & EFFICIENCY

C3 WATER INC.

4 December 2015

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	October 14, 2015	Draft Literature Review on Best Practices of Water Conservation & Efficiency	Patricia Wiebe	Bill Gauley
2	November 23, 2015	Final Literature Review on Best Practices of Water Conservation & Efficiency	Bill Gauley Andrea Williams	Sam Ziemann

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1.0 INTRODUCTION

A "best practice" is a method, approach, or technique that has been shown to consistently produce superior results when striving to meet a specific goal, such as a reduction in water demands. The list of applicable best practices included in this report have been summarized from the various sources listed in Section 7. These best practices inform opportunities to improve water conservation and efficiency in either a general context or in a specific residential and/or industrial context.

2.0 GENERAL BEST PRACTICES

2.1 *Water Management Planning*

According to the United States Environmental Protection Agency, the first best management practice for an individual facility to consider is the development of a water management plan (United States Environmental Protection Agency, 2015) that would set both long-term and short-term goals towards increased water conservation. A water management plan typically identifies specific water use goals, strategies to achieve those goals, and applicable methodologies to verify program effectiveness. In order to facilitate the water management plan, sufficient staff capacity/expertise are required to develop the strategy, organize and direct implementation, and track and evaluate the impacts.

The Ontario Water Opportunities and Conservation Act promotes and requires effective planning in order to achieve greater water conservation and efficiency in the Province. The Act has provided the framework for the Ministry of the Environment and Climate Change to encourage water conservation programming (e.g. Showcasing Water Innovation).

2.2 *Information and Education Programs*

Social marketing campaigns, school education programs, and general public outreach are all examples of programs that help promote a greater awareness of water efficiency and conservation practices in society. All these programs are based on the assumption that if consumers are more aware of the benefits associated with using water more efficiently, they are far more likely to participate in and support water efficiency activities within their community. Awareness programming should explain how water efficiency can impact water quality, how using less water results in cost savings to both the consumer and the utility, that lower demands can help defer, downsize, or eliminate the need for infrastructure expansion projects, and that lower demands will reduce energy requirements and greenhouse gas emissions (OWWA Water Efficiency Committee, 2005). To be truly effective, an information and education program must resonate with and achieve buy-in from the public. For example, while it has been shown that an aggressive public education program during a severe drought can help reduce demands by more than 20 percent, demands are likely to return to pre-campaign levels shortly after the drought has ended, even with continued publicity (Alliance for Water Efficiency, 2010).

2.3 *Smart Metering / Advanced Metering Infrastructure*

Metering and billing customers based on 'real time' demands (requiring the adoption of smart meters) helps to motivate customers to reduce consumption by providing more immediate and direct feedback on water use activities and conservation efforts, and by helping customers detect premise leaks more immediately. Abbotsford, British Columbia installed an automated meter reading system that has saved an estimated 49 cubic metres of water per year or an average household savings of 134 litres per day (Abbotsford Mission Water & Sewer Services, 2012). An automated water metering pilot study was one of the recommendations in Guelph's 2009 Water Conservation and Efficiency Strategy.

Toronto is in the process of replacing their old water meters with new meters connected to an automatic meter reading system. The new "smart" meters will deliver information four times a day to the city. Once the new system is in place it will be possible for the city to track residential customer water demands and notify customers when demand patterns are indicative of potential leakage (note that non-residential customers often have highly variable water demands and, as such, it is not normally possible to flag potential leakage based on changes in demand patterns).

2.4 *Water Loss Control*

Water loss control involves system audits, loss tracking, infrastructure maintenance, leak detection, and leak repair. According to the United States Environmental Protection Agency, "some older facilities may lose 10 or more percent of their total water production and purchases to system leaks or poor metering practices" (United States Environmental Protection Agency, 2015).

2.4.1 Auditing

Completing water audits helps municipalities be more accountable for their operations. During the late 1990s and early 2000s the American Water Works Association and International Water Association jointly developed the *International Water Association/American Water Works Association Water Audit Method* – considered the industry best practice for municipalities completing a water balance (Alliance for Water Efficiency, 2015). Figure 1 presents the format of the *International Water Association/American Water Works Association water balance*.

Volume from Own Sources (corrected for known errors)	System Input Volume	Water Exported (corrected for known errors)	Billed Water Exported			Revenue Water
		Water Supplied	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water
					Billed Unmetered Consumption	
				Unbilled Authorized Consumption	Unbilled metered Consumption	Non-revenue Water
					Unbilled unmetered Consumption	
			Water Losses	Apparent Losses	Systematic Data Handling Errors	
					Customer Metering Inaccuracies	
					Unauthorized Consumption	
				Real Losses	Leakage on Transmission and Distribution Mains	
					Leakage and Overflows at Utility's Storage Tanks	
Water Imported (corrected for known errors)					Leakage on Service Connections up to the point of Customer Metering	

Figure 1: Schematic of the water audit methodology developed by the American Water Works Association and International Water Association.

2.4.2 Infrastructure Leakage Index

The infrastructure leakage index is a ratio between the current annual real losses and unavoidable annual real losses in a system. The unavoidable annual real losses represents the lowest technically achievable annual real losses for a well-maintained and well-managed system. The infrastructure leakage index for a system is indicative of the speed and quality of water main leak repairs, the level of active leakage control, and the quality of assets managed in that system. The lower the infrastructure leakage index value, the closer the system is to its unavoidable annual real losses value, i.e., there is less water loss in the system.

Table 1: Categories of action corresponding to Infrastructure Leakage Index Values (Dickinson, 2005)

Infrastructure Leakage Index	Technical Performance Category	
1 – 2	A	Further loss reduction may be uneconomic unless there are shortages; careful analysis needed to identify cost effective improvement
2 – 4	B	Potential for marked improvements; consider pressure management; better active leakage control practices, and better network maintenance
4 – 8	C	Poor leakage record; tolerable only if water is plentiful and cheap; even then, analyze level and nature of leakage and intensify leakage reduction efforts
> 8	D	Horrendously inefficient use of resources; leakage reduction programs imperative and high priority

2.4.3 Pressure Management

There is a direct relationship between leakage and pressure – higher pressures within the water mains results in a higher rate of leakage. Or, put another way, reducing the pressure within the distribution system will reduce the rate of leakage (note that minimum pressure requirements must be maintained for service). Pressure within city zones or district metered areas can be controlled by pressure-reducing valves that can reduce area pressures during periods of low demand, such as during the night (Alliance for Water Efficiency, 2015). Pressure management will not only reduce leakage but it will also increase the life of infrastructure elements (e.g., water mains) because of less pressure fluctuation in the distribution system.

2.4.4 Active Leak Detection

Active leakage detection uses sonic detection (sensitive acoustic listening equipment) to locate leaks in the water distribution system based on sound propagation. The use of district metered areas is considered to be a North American Best Management Practice for water loss reduction. Where possible, district metered areas are supplied through one or two flowmeters to monitor supplies to the area. Water demands for the entire area are monitored and recorded 24-hours per day. The total demand of the area as well as the minimum night flow rate into the area are used to estimate water losses. Where leaks are suspected, the district metered areas can be further sub-divided to better pinpoint the leak location or sonic detection crews can be sent in to comb the area in greater detail. (Alliance for Water Efficiency, 2015).

2.5 *Financial Incentive Programs*

2.5.1 Rebate Programs

By providing financial incentives to customers, a transition to high-efficiency fixtures and appliances can be achieved or expedited, resulting in reduced water demands. Examples of common rebate programs include: toilet rebate programs, solar hot water incentive programs, greywater reuse programs, showerhead rebate programs, and washing machine rebate programs. As stated in Colorado's WaterWise guidelines, a full retrofit of toilets, clothes washers, showerheads, and faucets in single family residences has shown to reduce indoor demand by approximately 30 percent (Colorado Water Conservation Board, 2010).

2.5.2 Retrofit Programs

As programs become increasingly targeted to high water users in each sector, multi-residential retrofit programs have continued to be used as a tool for water efficiency programming. For example, because of the growing impact of the historic drought in the area, Long Beach, California is currently offering a $200 rebate to multi-residential apartments and condos that install very efficient 3.0-litre toilets and 5.7-litre per minute showerheads – far more than the $50 rebate they have historically offered. Buildings must have a minimum of five living units and existing toilets must flush with 6 litres or more. The city's website also notifies customers that, starting in 2017, all multi-family housing in California must be fitted with water-efficient 4.8-litre toilets (Long Beach Water Department, 2015).

The City of Denver, Colorado provides free water audits to their multi-family residential customers. A city inspector visits each apartment suite for about 3 to 5 minutes to complete the water audit (check for leaks and water savings potential). They note that some property managers conduct standard annual inspections at the same time (smoke detector checks, energy-efficient lighting improvements, vandalism, etc.) to decrease the disturbance to the residents. The city inspectors can typically complete 100 units per day. Each apartment suite is provided with a free water-efficient showerhead, lavatory faucet aerator, and kitchen aerator. The property manager is also provided with historical water consumption information for the site and information on available rebates (note that the City only offers toilet rebates to single-family customers and individual units in condos or townhomes, not for multi-residential apartment buildings) (Denver Water, 2015).

2.5.3 Local Improvement Charges

A local improvement is a project undertaken by municipality that provides a benefit to properties in a specific geographic location within the municipality, such as sidewalks, sewers, traffic calming features, and water and wastewater infrastructure (Persram, 2013). Local improvement charges are fees imposed by the municipality on those property owners in the specific vicinity that benefit from the local improvement. These charges allow the municipality to recover all or part of the cost of the project. This incentive model can be used in single-family residential, multi-family residential, commercial, and industrial sectors (Boyd, 2013). Enough local participation is needed to create a sufficient "critical mass" to warrant proceeding with such projects, however, once backed by residents, municipalities can use the local improvement process to undertake work on both public and private property.

Local improvement charges are legislated under the Ontario Municipal Act, 2001. On October 25, 2012, the Minister of Municipal Affairs and Housing filed an amendment allowing Ontario municipalities to use local improvement charges to finance private sector conservation projects with repayment of loans on the property tax billing system (Association of Municipalities Ontario, 2012). Local improvement charges are currently used by several Canadian municipalities, including the City of Vancouver, Peel Region, the City of Edmonton, the City of Oshawa, and the City of Toronto. Payment periods vary depending on the project and the city in question, but generally range between 5 and 15 years (Pembina Institute, 2004). Many municipalities allow property owners the option of paying the charge as a lump sum or through annual instalments on their property tax bill. Peel Region further allows owner-initiated local improvements to use the local improvement charges system (Pembina Institute, 2004). Local improvement charges are largely eligible only to existing built forms and not for Greenfield developments.

In July 2013, Toronto City Council unanimously approved its first pilot local improvement energy and water efficiency program called the Home Energy Loan Program. This is a three-year, $20 million pilot program involving 1000 single-family homes and 10 multi-residential buildings located in specific areas of the city (Shedletzky, 2013). Property owners will repay this investment to the city via a special charge on their property tax bills. The program is intended to be easy to implement and self-funded with no transfer payments required from the City. The customer charge, which is based on the area and age of the home, is intended to be equivalent to, or less than, the energy or water savings accruing to the property owner (Shedletzky, 2013).

2.5.4 Capacity Buyback Programs

Capacity buyback programs are another tool that allows the utility to pay customers a rebate tied directly to the average volume of water they save on a daily basis when they implement approved permanent process or equipment changes. Typically this is a one-time cash rebate based on a predetermined rate (i.e., a specified dollar value per litre per day) for verified water savings. This type of program is usually most applicable to the Industrial, Commercial, and Institutional customer sectors where water uses are quite diverse both in nature and in volume and, therefore, it is difficult to estimate the potential for savings associated with implementing a change without first completing a site inspection.

Many municipalities across Canada and the United States operate capacity buyback programs, including Guelph, Toronto, Peel Region, and York Region. All of these programs operate in essentially the same manner – an approved auditor arranges to conduct a site visit at the participating facility. Generally, one or more suitable site staff accompany the auditor during the site visit to act as a guide and to provide an explanation of how water is used by the facility. Where the auditor feels there may be an opportunity to reduce demands in the facility they often install monitoring equipment (e.g., sub-meter and data logger). When the audit is completed (including any monitoring) the auditor prepares a "Pre" report that includes a brief description of the facility, how water is used within the facility, and a number of recommendations on how the facility can reduce water use. For each recommendation the auditor identifies the potential volume of water savings, the potential cost savings, the associated rebate amount (which is based on the volume of water saved on a daily basis), an estimate of the implementation costs, and the estimated return on investment. A copy of the “Pre” report is provided to both the facility and the city. After a facility implements one or more of the recommended measures, the auditor will verify the water savings and prepare a "Post" report outlining what measures were implemented and what savings were achieved.

2.5.5 Tax Incentives

Tax incentives are a tool to provide incentives to existing and new construction opportunities. For example, in cases where the upfront cost of a water-efficient fixture, appliance, or process is far greater than the cost of an inefficient model, a tax incentive may help 'tip the scales' towards selecting the efficient model. One common example of a tax incentive is accelerated depreciation, which allows the consumer to depreciate the value of the water efficiency product more quickly than normal in order to offset, partially or fully, the initial investment capital in an accelerated manner (WaterTap, 2013). The use of tax incentives for water efficiency initiatives is rare in Canada/Ontario due to regulations limiting the use of user rate and tax expenditures for related service.

2.5.6 Development Incentive Programs

A Density Bonus Program has been used for various conservation efforts (energy, green building and water conservation) to incentivize new development to align with environmental goals. The Town of Okotoks, Alberta implemented a Density Bonus Program from 2005 to 2011 for new development where "indoor and outdoor water conservation measures were registered to each parcel through a restrictive covenant". From 2007 to 2010, the Density Bonus Program resulted in an additional water savings of 17 percent compared to the average reduction of 9 percent observed from general conservation programming (Town of Okotoks, 2014).

2.6 *Regulatory Enforcement*

Regulations are one way to encourage a city or municipality to improve water efficiency. A water waste ordinance, for instance, is a municipal regulation prohibiting the waste of water from sources that can include excess irrigation runoff, excessive pavement washing, failure to repair leaks, utilizing single-pass water cooling, and improper maintenance of cooling towers at an unnecessarily low conductivity level (Colorado Water Conservation Board, 2010). Landscaping design, installation, and maintenance regulations could be a cost-efficient method to affect change. Likewise, regulations on training requirements for landscape irrigation professionals in water efficiency would place motivation on increased awareness.

2.6.1 Outdoor Water Use Restrictions

Many jurisdictions throughout North America employ an outdoor water use restriction by-law in an effort to reduce average summer day and peak day water demands. The Town of Okotoks, Alberta has assigned allowable times (6 a.m. - 9 a.m. and 7 p.m. – 11 p.m.) and days (2 days per week) in an effort to reduce its outdoor water demands (Town of Okotoks, 2014).

2.6.2 Indoor Water Use Restriction

New development and renovation projects can be required to use indoor water conservation measures and this requirement can be enforced through the issuance of a plumbing or building permit (Town of Okotoks, 2014). It is unlikely, however, that the City of Guelph would be able to enforce any by-law that required developers to build "beyond the Ontario Building Code" regarding the use of water efficient measures.

2.6.3 Water Taking Permits

In Ontario, the Ontario Water Resources Act requires those customers requesting more than 50,000 litres per day to apply for a Permit to Take Water. The Act requires applicants to submit a plan as part of the application process describing how they intend to use water efficiently. Some communities are considering requiring new large water consumers to prepare and submit a Water Conservation Plan or to implement a Water Consumption Budget (Town of Okotoks, 2014).

2.7 *Billing System Considerations*

A conservation-based rate structure is designed to reduce the volume of discretionary water use and to encourage the implementation of water efficiency measures. There are several types of conservation-based water billing systems, including: seasonal rates, water budget-based rates, increasing block rates, and tap fees.

2.7.1 Seasonal Rates

Seasonal rates are higher unit water rates that are implemented each year for a specific time period, usually during the summer months when the water supply is most stressed due to increased demand associated with lawn watering and outside activities. Seasonal rates are established specifically to encourage conservation during peak use periods. Seasonal water rates are being implemented in Vancouver, British Columbia, where rates increase by 25 percent increase during the dry summer months (City of Vancouver, 2014).

2.7.2 Water Budget-Based Rates

A rate structure where households are assigned a "water budget" based on the anticipated needs of that household either by the number of people living in the house and/or property size. Users are charged a certain rate for water use within their budget and a higher rate for water use that exceeds their budget. The City of Castle Rock and the City of Boulder have both implemented water budget-based rates. In Boulder, they have established different block rates for each customer sector - single-family, multi-family, and Industrial/Commercial/Institutional, with further subdivisions within each sector and separately metered irrigation (City of Boulder, 2009). The City of Kamloops charges $0.38 per cubic metre for the first 135 cubic metres and $0.61 per cubic metre for demands in excess of 135 cubic metres. (City of Kamloops, 2015).

2.7.3 Increasing Block Rate

A rate structure in which the unit price of each succeeding block of usage is charged at a higher unit rate than the previous block(s). Separate rate price tiers can be established for each customer sector. Cities that have increasing block rate structures include Denver, City of Glenwood Springs, and City of Grand Junction.

2.7.4 Fees

A fee based on the size of the water meter at the facility, i.e., on the anticipated demand at the site. As such, a tap fee can provide an incentive for developers to implement water efficient practices. Many municipalities include a separate fee on the customer water bill based on the meter size. For example, Halton Region adds a “monthly service charge” to customer water bills based on meter size ranging from $25.84 for meter sizes of 20 millimetre or less up to $2990.19 for 250 millimetre meters.

2.8 *Water Audits/Surveys*

Water audits or surveys involve evaluations of indoor and outdoor use on a customer-by-customer basis. The survey can include evaluating overall water use, leak detection, provision or recommendation of retrofit devices, customer education, and/or evaluation of outdoor water use and recommendations on modifying systems or practices for increased water efficiency.

In Peel Region, for instance, Parmalat (dairy) was the first facility included in the Region's Indoor Water Audit Program (Watersmartpeel, 2009). Between 2005 and 2007 the facility used approximately 1,300 cubic metres of water per day (Watersmartpeel, 2009). The water savings recommendations resulting from the audit were the installation of steam traps (instead of adding water) to prevent fogging and the reuse of condensed steam to replace some of the case washing water (Watersmartpeel, 2009). The recommendations resulted in a water use reduction of 192 cubic metres per day, or $87,500 annually (Watersmartpeel, 2009).

The Region of Waterloo has adopted the Alliance for Water Efficiency's *homewaterworks Water Calculator* and re-branded it as "the WET challenge" for use in the Region. The calculator is an online self-auditing tool where single- family residents input certain data (e.g., how often they shower or wash clothes, if they have a dishwasher, what is the flush volume or age of their toilets, etc.) and the program provides them with an estimated of how much water they use. If the resident "scores" over 240 litres per person today they qualify for a free in-home consultation with a goal of reaching 165 litres of water consumption per day per person (Region of Waterloo, 2015).

3.0 RESIDENTIAL BEST PRACTICES

3.1 *Water Efficient Fixtures*

Fixture replacement programs can provide incentives for customers to conserve water by installing more water efficient products, e.g., toilets, urinals, faucet aerators, and showerheads (Colorado Water Conservation Board, 2010).

For instance, replacing a 9.5 litres per minute showerhead with a 7.6 litres per minute WaterSense® certified showerhead in an apartment suite will save approximately 22.8 litres per day or 8.3 cubic metres per year. In Guelph this water savings equates to a reduction of $26 in annual water costs. It is also estimated that the new showerhead would save approximately 5.8 cubic metres of hot water per year and $8 per year in natural gas fees. Total savings in this example, therefore, is about $34 per year. Since the cost of a new WaterSense® certified showerhead can range from a low of about $10 to over $100, the return on investment could range from only 3 or 4 months to more than 3 years[1].

3.2 *Water Efficient Appliances*

Appliance rebate programs are used to increase the uptake of water efficient appliances. Washing machines can consume 15 to 40 percent of the indoor household water use (Alliance for Water Efficiency, 2013). The United States Environmental Protection Agency's Energy Star program estimates that inefficient washers use about 87 litres per load and efficient models use only 49 litres per load; representing a savings of about 38 litres per load (Energy Star, 2015).

[1] Values based on 2 occupants taking 0.75 showers per day at 8 minutes per shower with 70 percent of the water being heated with natural gas.

Water-efficient dishwashers can use as little as 20 percent of the water used by hand washing dishes (Alliance for Water Efficiency, 2015). However, a Californian study has concluded that dishwasher replacement programs should not generally be considered a best management practice due to the fact that dishwashing accounts for only about 1.4 percent of typical residential indoor water use and that other measures (i.e. other appliance and fixture replacement) would yield higher savings (Koeller & Company, 2007).

3.3 *Rules for New Construction*

New construction provides a good opportunity to build in conservation and efficiency practices. It is often easier and less costly to implement a measure or install a product in a new house than to retrofit an existing home. Mandatory implementation of efficiency measures is recommended in Colorado's guidelines, as encouragement alone is unlikely to produce a significant increase in participation levels (Colorado Water Conservation Board, 2010). The Ontario Building Code enforces a minimum level of water conservation by requiring all new construction to be fitted with maximum 7.6 litre per minute showerheads and 4.8-litre toilets (dual-flush toilets are also allowed).

One example of implementing this best practice can be found in California, where the California Building Standards Commission approved water efficiency requirements for any new public school construction, specifically improving water efficiency in landscaping as well as encouraging the use of non-potable water for non-drinking uses (California Department of General Services, 2015).

3.4 *Residential Water Loss Control*

Perhaps the greatest waste of water in a municipal system is water lost through leakage, both in the distribution system and after it has been delivered to the customer. Even a relatively small leak can lead to significant water loss if the water is lost 24 hours per day. While a customer can easily identify a dripping faucet or showerhead, some leaks are more difficult to identify. For example, a leaking toilet can waste 700 litres of water per day yet go unnoticed for months. Some leaks can be underground, like irrigation system leakage, or hidden, as with a water softener stuck on bypass. While the presence of a large leak can make itself known to the customer via an unexpected "spike" in the water demand and an associated increase in the water bill, smaller leaks may cause only a moderate increase in water demand and, therefore, go unnoticed by the customer. The United States Environmental Protection Agency estimates that the average household loses about 100 litres per day in leakage with the top 10 percent of homes losing more than 340 litres per day in leakage (United States Environmental Protection Agency, 2015).

New York City's Leak Notification Program includes residential and multi-residential buildings. The program is monitored by the Department of Environmental Protection and alerts customers via email if water usage triples for five consecutive days. This allows the program to proactively alert customers to potential water leaks on their property. Since 2011, the City has sent out nearly 32,000 leak notifications resulting in an estimated savings of $26 million in reduced leakage (New York Department of Environmental Protection Public Affairs, 2012). It's a voluntary program, where customers are provided the opportunity to receive email notifications. The program requires wireless meter readers that record water demand data four times per day (i.e., advanced metering infrastructure). While Guelph provides information on its website outlining how customers can identify and fix leaks, and they are moving to monthly water billing, they do not currently have an automated metering infrastructure system and are not able to proactively notify customers based on high daily water demands.

4.0 IRRIGATION BEST PRACTICES

4.1 *Water Efficient Landscaping*

According to the United States Environmental Protection Agency, converting to a water-efficient landscape can reduce customer demands by more than 50 percent (2015). Native vegetation, suited to the area's climate, will usually need much less water than imported vegetation. Furthermore, proper topography can decrease the amount of water required to reach the vegetation's rooting zones.

In California, the water scarcity caused by the ongoing drought has led to new regulations by the California Water Commission on water-efficient landscaping (Reese, Kasler, & Sabalow, 2015). Now, turf grass and other plants intolerant of drought cannot cover more than 25 percent of lawns for new homes and businesses vs. the previous regulation that allowed turf grass to cover 33 percent of the lawn (Reese, Kasler, & Sabalow, 2015). Under these regulations, new residential lawns will use about 20 percent less water and commercial landscaping about 35 percent less water than under previous requirements (Reese, Kasler, & Sabalow, 2015). Landscape water budgets will compare consumption against the needs of the area, providing solid information to the customer on efficient irrigation practices.

California's Department of Water Resources has also funded a turf replacement program where turf is replaced with water efficiency landscaping at a cost of $2 per square foot, up to $2,000 per site (California Department of Water Resources, 2015). The Department specifies program requirements, such as the number of trees, type and amount of mulch, allowable installed structures (e.g., patio stones with permeable grout), types and amounts of plants, and allowable irrigation.

4.2 *Water Efficient Irrigation*

Once the amount of water required for irrigation has been determined, various technologies exist to irrigate only when the area needs water and not when there has recently been precipitation. Devices include rain and moisture sensors, and weather-based controllers that adjust irrigation schedules based on local weather data. Efficient irrigation practices have been shown to reduce landscape watering by up to 35 percent (Colorado Water Conservation Board, 2010).

One example of water efficient irrigation best practices being put to use is the partnership between Landscape Ontario, Peel Region and York Region to develop a Water Smart Irrigation Professional program. This program is designed to shift the water-efficiency focus from the customer to the contractor. The Water Smart Irrigation Professional program trains contractors how to calculate the optimum level of irrigation for each zone based on plant type, micro-climate, soil type and slope, etc., using a custom-designed computer program. Qualifying contractors (i.e., contractors that have passed the Water Smart Irrigation Professional training program) are paid a set fee by Peel or York Region (depending on the location of the customer) to audit and optimize their customers' irrigation systems. The average water savings during the pilot study for the Water Smart Irrigation Professional program saved 10,000 litres per day per acre of landscape (a reduction in depth of water applied of about 17 millimetres per week) while maintaining the health and beauty of the landscape.

4.3 *Water Reuse*

Reuse of water for irrigation purposes decreases the demand for potable water. There are barriers to implementing this best practice, however, including cost and health & safety concerns. One example of water reuse for irrigation is in the City of Clermont, Florida, which collects domestic wastewater through 55 miles (88 kilometres) of pipe, then treats and redistributes the water for irrigation (City of Clermont, 2015). The reclamation facility can produce an average of 2.2 million gallons (8.3 mega litres of water for reuse each day (City of Clermont, 2015).

4.4 *Drip/Micro-Irrigation System*

Small diameter tubing with regular openings, either immediately above or below ground level, minimizes the distance water will travel to the vegetation's rooting zone and, therefore, improves water efficiency and reduces energy costs. Drip irrigation has a water efficiency of over 90 percent in comparison to a standard sprinkler system's 50 to 70 percent efficiency (Wilson & Bauer, 2014). With appropriate sizing, drip irrigation can also reduce the required pressure by 90 to 118 kilopascals and save $30 to $40 per acre per year in energy costs (Burt & Howes, 2011).

4.5 *Low Pressure Center Pivot Sprinkler Irrigation Systems*

In large areas, mechanized sprinklers can be overhead or close to the ground with drop tubes or fixed nozzles. The systems would be applicable in a variety of climates, topographies, crop types, and soil types. Low pressure center pivot sprinkler irrigation systems have an application efficiency of 70 to 95 percent, in comparison to 40 to 80 percent efficiency in standard systems (Water Conservation Advisory Council, 2004).

The Province of Alberta has agreed with this best practice and implemented a five year Irrigation Efficiency Program that helps farms invest in new or upgraded low pressure center pivot systems by covering 40 percent of the costs (Mcmenamin, 2013).

5.0 INDUSTRIAL BEST PRACTICES

5.1 *Boiler and Steam Systems*

Boiler and steam systems lose water through evaporation, blowdown, and process consumption. Efficient practices can minimize loss, conserve water, reduce demands, and lower energy costs. These practices can include: leak detection, pre-treating boiler water, automating blowdown, insulating pipes to reduce heat losses, installing meters on inlet and outlet lines, installing a hot water recovery system on water tanks, and using efficient heat exchanger designs (New Hampshire Department of Environmental Services, 2013).

One example of implementing this best practice is the boiler upgrades and decentralized steam system at Naval Air Station Oceana in Virginia Beach, Virginia (United States Department of Energy, 2015). In this project the air station replaced inefficient aging boilers and steam pipes with more efficient boilers and ground sourced heat pumps, saving approximately 74 mega litres of water per year.

5.2 *Industrial Alternative Sources and Reuse of Process Water*

Reusing non-potable water where possible improves water efficiency. Sources of non-potable water can include: treated effluent, rainwater, condensate, greywater, storm water, sump pump discharge, and saline sources (Texas Water Development Board, 2004). The sources of non-potable water and possible uses are as innumerable as the types of industry, and each facility would need to consider the opportunities on a case-by-case basis. For example, Denver, Colorado has a Water Recycling Plant that provides cooling water to the Cherokee Power Plant. Water quality requires less than 0.6 milligrams per litre of phosphorus to prevent calcium phosphate scaling and also non-detectable amounts of ammonia to avoid stress corrosion cracking of admiralty metals (Wagman, 2013). The plant buys $840,000 worth of reclaimed water per year at an equivalent cost of $0.26 per cubic metre (Wagman, 2013).

5.3 *Rinsing/Cleaning*

In rinsing and cleaning processes, various strategies can be used to achieve the required goals with less water. Not every strategy will work for a particular process. Efficiency strategies include (New Hampshire Department of Environmental Services, 2013):

- Dry methods wherever possible (compressed air/brushes)
- Installation of flow restrictors
- Maintenance of nozzles
- Sensor installation to shut off flow when not in use
- Reclaim waste water
- Switch to intermittent flow rather than continuous
- Reuse water

5.4 *Increasing Cooling Systems' Efficiency*

In a once-through cooling system, water is disposed down the drain after a single use. Popular examples of once-through cooling equipment include: degreasers, condensers, air compressors, welding machines, ice machines, x-ray equipment, and air conditioners (United States Environmental Protection Agency, 2015).

Cooling towers and evaporative condensers are effective for cooling because they take advantage of water's high enthalpy of evaporation, which refers to the large amount of heat required to change water from liquid phase to gaseous phase. However, the evaporation process increases the concentration of dissolved solids (minerals) in the remaining cooling water. If the concentration becomes too high it can foul or damage the cooling system (scale formation, corrosion, biological growth, etc.) and reduce the efficiency and lifecycle of the system. To help prevent the concentration of suspended and dissolved solids from becoming too high, a portion of the recirculated cooling water (which is high in dissolved solids) is purposely discharged as blowdown and replaced with fresh water. Optimizing the balance between water quality and minimizing blowdown can greatly improve water efficiency (United States Environmental Protection Agency, 2015).

Other water efficiency practices can include: replacement of water-cooled equipment with air-cooled, installing temperature control valves, minimizing water flow, installing timers for when cooling is not needed, proper operation and maintenance, and installing meters to measure conductivity and flow volumes (New Hampshire Department of Environmental Services, 2013).

Denver Water, Colorado, is one provider who is implementing this best practice, and offers to pay customers $18.50 for every 1,000 gallons (3.78 cubic metres) of water saved below their average consumption over the previous 3 years. Customers can receive 50 percent of project costs up to $40,000. Projects must save a minimum of 50,000 gallons (190 cubic metres) per year to qualify. Sub-meters must be installed on makeup water and blowdown water (Denver Water, 2015).

6.0 KEY CONSIDERATIONS

For the City of Guelph, several of these best practices have already been implemented, including: water management planning, information and education programs, water loss control, rebate incentive programs, conservation coordinator, and water efficient technology. While the industrial and residential best practices are not under the City's direct influence, there is the possibility of relevant promotion and incentives. Table 2 highlights the water efficiency best practices discussed in this review with the corresponding program in the City of Guelph.

Table 2: Summary of best practices and the City's current actions.

Category	Best Practice	Guelph's current action
General Best Practices	Water Management Planning	1. Water Conservation Department 2. Water Conservation and Efficiency Public Advisory Committee 3. Municipal Facility Upgrades: - installation of a rainwater harvesting system - irrigation system upgrades
	Information and Education Programs	1. Resources for Youth: - The Yellow Fish Road Program - Grade 2 and 8 In-school Education Programs - The Waterloo Wellington Children's Groundwater Festival - H2Awesome 2. Healthy Landscapes – a one-hour consultation on how to have a water efficient landscape. 3. eMerge Home Visits – a one hour consultation to inform residents on how to increase water conservation in the home.
	Smart Metering	Preliminary research on implementation – no smart meters have been installed.

Category	Best Practice	Guelph's current action
General Best Practices	Water Loss Control	Water Loss Management – through annual leak detection: - Sonic condition assessment - Installation of district metered areas
	Financial Incentive Programs	1. Water Conservation Rebate Programs: - Royal Flush Toilet Rebate Program - Greywater Reuse Rebate Program - Smart Wash Washing Machine Rebate Program - Rainwater Harvesting System Rebate Program 2. Blue Built Home Water Efficiency Standards and Rebate Program – Bonze, Silver or Gold certification. 3. Water Smart Business – the Industrial, commercial and institutional sectors can apply for capacity buyback rebates for implementing water saving measures.
	Regulatory Enforcement	Outside Water Use Program – enforced by City of Guelph Water Services and Bylaw Enforcement Officers.
	Billing System Considerations	Guelph water rates are currently under review.
	Water Audits/Surveys	Water Smart Business – the Industrial, commercial and institutional sectors can have audits completed to review where water saving measures could be implemented.
Residential Best Practices	Water Efficient Fixtures	Royal Flush Toilet Rebate Program
	Water Efficient Appliances	Smart Wash Rebate Program
Residential Best Practices	Rules for New Construction	N/A
	Residential Water Loss	N/A
	Water Efficient Landscaping	Healthy Landscapes – free home visits to residents of the City of Guelph.

Category	Best Practice	Guelph's current action
Irrigation Best Practices	Water Efficient Irrigation	Water Smart Irrigation Professional program – Guelph is a Level 1 Partner.
	Water Reuse	N/A
	Drip/Micro-Irrigation Systems	N/A
	Low Pressure Center Pivot Sprinkler Irrigation Systems	N/A
Industrial Best Practices	Boiler and Steam Systems	Can be applicable to the Industrial/Commercial/Institutional Buyback Program
	Industrial Alternative Sources and Reuse of Process Water	Can be applicable to the Industrial/Commercial/Institutional Buyback Program
	Rinsing/Cleaning	Can be applicable to the Industrial/Commercial/Institutional Buyback Program
	Increasing Cooling Systems' Efficiency	Can be applicable to the Industrial/Commercial/Institutional Buyback Program

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To:	**Emily Stahl**	Company:	**City of Guelph**
From:	**Sam Ziemann**	Our File:	**75-41-151088**
Cc:	**Wayne Galliher,**	Date:	**25 September 2015**
Subject:	**Residential Water Softening and Salinity Water Use Reduction**		

CITY OF GUELPH

RESIDENTIAL WATER SOFTENING AND SALINITY WATER USE REDUCTION

C3 WATER INC.

25 September 2015

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	September 14, 2015	Draft Residential Water Softening and Salinity Water Use Reduction	Bill Gauley	Sam Ziemann
2	September 25, 2015	Final Residential Water Softening and Salinity Water Use Reduction	Bill Gauley	Sam Ziemann

Table of Contents

1.0 INTRODUCTION

The 2015 Water Efficiency Strategy Update will identify a set of preferred program alternatives, associated water savings, program implementation forecasts, and supporting program resources required to achieve the water demand reduction targets outlined in the 2014 Water Supply Master Plan.

Guelph's water supply depends mainly on groundwater with high calcium and magnesium concentrations. These high concentrations of dissolved minerals (mainly calcium) from the bedrock affect the hardness of the water. Water hardness is generally defined in terms of grains per gallon or milligrams per liter where a grain is defined as 64.8 milligrams of calcium carbonate. Water with less than 1 grain per gallon (17.1 milligrams per liter) is considered soft water (e.g., lake water). Water with 3.5 – 7.0 grains per gallon (60 – 20 milligrams per liter) is considered moderately hard. Hard water contains between 7.0 – 10.5 grains per gallon (120 - 180 milligrams per liter), and very hard water contains greater than 10.5 grains per gallon (180 milligrams per liter). In Guelph, water hardness ranges from 21 to 33 grains per gallon (360 – 566 milligrams per liter) depending on where in the City you are located (see: http://watersoftenerfacts.ca/my-water-hardness for more information).

Dissolved calcium and magnesium can precipitate out of hard water as scale, which can build up on the insides of pipes, water heaters, coffee makers, and industrial machinery. Scale can reduce the rate of flow through pipes and is also a poor conductor of heat. In a study for the United States Department of Energy, even a thin film of scale (less than a millimeter) on a heat exchange surface can increase energy demands by 10 percent (Pacific Northwest National Laboratory, 1998). Hard water will reduce soap's ability to lather and can react with soap to form a sticky scum.

The objective of this report is to review the technology and potential water (and salt) savings associated with City customers using a nucleation assisted crystallization water conditioner instead of the very popular ion exchange water softener. Reducing the amount of salt water discharge from water softeners will also improve our water quality. Note that while nucleation assisted crystallization-type systems are commonly referred to as Template Assisted Crystallization systems, the name Template Assisted Crystallization is trademarked by Next Filtration Technologies Inc. of Lake Worth, Florida. As such, this Technical Memo will refer to the process as nucleation assisted crystallization.

2.0 ION EXCHANGE – WATER SOFTENING

2.1 Definitions

Water softening is the removal of calcium, magnesium and other metal ions found in hard water. Most residential water softeners use "ion exchange" technology where hardness ions are exchanged for sodium (by dissolving salt) or potassium ions in the resin tank of the softener. When the resin beads become coated with calcium and magnesium ions, the resin must be regenerated with a saline solution. Unlike calcium and magnesium, sodium and potassium ions do not form scale.

2.2 Current Municipal Practice

From 2011 to 2012 the Ontario Drinking Water Stewardship Program, in an effort to protect municipal drinking water sources from sodium and chloride loading, provided grants of up to 80 percent (up to $2,000) the total costs (parts and labour) to homes, farms, institutions, or businesses that used a septic system and replaced their inefficient water softener with an efficient unit that met the California Efficiency Rating of at least 4000 grains of hardness removed per pound of salt used (Ontario Drinking Water Stewardship Program, 2011).

The Inland Empire Utilities Agency, located in southern California and serving approximately 830,000 people in western San Bernardino County, has a regional ordinance that prohibits homeowners from installing a self-regenerating water softener. Homeowners are not required to remove self-regenerating water softeners that they currently have, but when existing technology fails, they must replace it with a tank-exchange water softener. These softeners work in a similar manner to self-regenerating water softeners, but feature a removable tank that can be replaced with a fresh one when the resin is depleted. The depleted tanks are removed by a professional service and discharge into the local brine line that sends the salt to a treatment plant that handles salty wastes. By using the brine line to properly dispose of this salt, recycled water and groundwater within Inland Empire Utilities Agency's service area and the Santa Ana watershed are protected. A rebate of up to $2,000 is offered to homeowners installing an exchange tank softener (Inland Empire Utilities Agency, 2015).

Beginning in 2003, the Santa Clara Valley Sanitation District of Los Angeles County (Sanitation District) banned the installation of time initiated regeneration water softeners. They currently offer a $150 rebate to customers removing ion-exchange water softeners. Their website states "automatic water softeners release a salty waste into the sewer system. Though the wastewater is thoroughly treated before discharge into the Santa Clara River, the treatment process does not remove salt. The salty waste may be harmful to downstream aquatic life and/or agriculture." The rebate program was initiated in response to their customers' concerns about losing the capital investment they had in their softener. The $150 value is intended to equate to about 75 percent of the reasonable value of a used ion-exchange water softener. The Sanitation District does allow homes to have exchange tank softeners where the resin tank is exchanged periodically by a service provider for a new softening tank (Los Angeles County Sanitation District, 2015).

From June 2014 Scottsdale, Arizona began a two-year pilot program offering residents a rebate for removing or upgrading their inefficient water softeners. The city offered a $50 rebate to the first 300 customers each year that replaced their existing softener with a high-efficiency softener; they offered a $100 rebate to the first 100 customers each year who removed a self-generating salt-using water softener and replaced it with a tank-exchange system; and they offered a $250 rebate to the first 200 customers that removed and did not replace their water softener. The city's website states "conventional water softeners…increase the amount of salt discharged into the city's sewer system. The increased salt, or salinity, has negative impacts on the environment and adds significant costs to wastewater treatment to remove it." The high levels of salinity in the wastewater reduces the quality of the reclaimed water used for irrigation and recharge. The City's Mayor, W.J. "Jim" Lane made the following statement "This program is a positive first step to educate our residents about the environmental impact of salinity in our reusable wastewater and to help motivate them to change or eliminate water softeners that add salt to our most precious resource" (City of Scottsdale, 2015).

2.3 Benefits and Barriers

There are benefits and barriers to using ion exchange technologies in water softening, as presented in Table 2-1.

Table 2-1: Summary of benefits and barriers associated with using ion exchange.

Benefits	Barriers
• A reliable and effective technology. • Widely available. • Easy to bypass drinking fountains or outdoor hose bibbs. • Removes dissolved inorganics effectively. • Relatively low initial capital costs.	• Adds sodium (salt) into the environment and to water sources (groundwater and surface water). • Additional water use from backwashing and regeneration. • Does not effectively remove particles or bacteria. • High long-term operating costs. • Water softener technologies are not governed by the Ontario Building Code and therefore defining performance parameters is a challenge.

2.4 Local Feasibility

According to a 2015 Homeowner Research Report, approximately 80 percent of Guelph residents address the water hardness with residential ion exchange water softeners (Freeman Associates, 2015). Therefore, prorating findings from a Region of Waterloo Report to match Guelph's population, residential water softeners in Guelph are expected to use approximately 0.5 billion litres of water per year as backwash as well as dispelling 10,000 tonnes of salt into the environment per year (Region of Waterloo, 2014).

Because of the hardness of the City's water, it is unlikely that homeowners will be willing to operate without any type of water softener. However, the City may consider offering a rebate to homeowners that remove their existing self-regenerating salt-based ion exchange water softener and replace it with a tank-exchange system where the resin tank is exchanged periodically by a service provider for a new softening tank. This would eliminate the need for regeneration in participating homes and prevent salt from being discharged to drain.

3.0 NUCLEATION-ASSISTED CRYSTALLIZATION

3.1 Definition

Nucleation-assisted crystallization converts calcium and magnesium (hardness) into microscopic crystals that stay suspended in water without forming scale on pipes and appliances. Nucleation-assisted crystallization media consist of polymer or resin beads whose surfaces have been chemically treated in such a way that the resulting cavities (due their carefully-controlled size) provide sites in which accumulation of hard water minerals is energetically more favourable than nucleation that might take place within the water itself.

3.2 Current Municipal Practice

Research failed to identify any municipal nucleation-assisted crystallization programs either in North America or abroad as this technology is relatively new and there are still some questions surrounding its suitability as a replacement for ion exchange water softeners, especially in the residential market.

The results of a study commissioned by the Water Reuse Research Foundation in the United States indicated that the Template Assisted Crystallization unit that was tested (which was certified by the German Technical Association for Gas and Water) reduced scale by approximately 90 percent, a factor comparable to ion exchange water softening. Unlike ion exchange softeners, however, nucleation-assisted crystallization units require no water for backwash and no salt.

The Region of Waterloo and City of Guelph, both of which have hard water, are completing a joint study to determine the potential of nucleation-assisted crystallization technology to significantly reduce water and salt use associated with residential ion exchange softening in their respective communities. The study is expected to:

- Determine the availability of suitable nucleation-assisted crystallization units in the local and international marketplace,
- Gather user satisfaction feedback from local nucleation-assisted crystallization users,
- Evaluate the performance of selected nucleation-assisted crystallization units, including assessing how long the media will last.

Please visit http://watersoftenerfacts.ca for further information on past works and for future published information of the study.

3.3 Benefits and Barriers

There are benefits and barriers to using nucleation-assisted crystallization technologies in water softening, as presented in Table 3-1.

Table 3-1: Summary of benefits and barriers associated with using template-assisted crystallization.

Benefits	Barriers
• Reduces scale by 90 percent, comparable to ion exchange water softening. • No water use required for backwashing. • No electricity/power eliminates energy costs. • No salt released into the environment or required to purchase. • No pumps, meters, or valves equates to less maintenance.	• Less effective with water containing higher levels of minerals. • May be damaged by chemical impurities such as chlorine. • Units may need to be plumbed downstream of sediment/carbon filters. • Does not effectively remove particles or bacteria.

Benefits	Barriers
	• Does not remove minerals, but simply prevent scaling (Adventus Research+Consulting Inc., 2014). • Does not actually soften water. As such, may not be suitable for homeowners that prefer the 'feel' of soft water, including using less soaps and detergents. • There are currently no American National Standards Institute or NSF (originally established as the National Sanitation Foundation, the letters NSF no longer represent any specific words) Standards for testing the effectiveness of nucleation-assisted crystallization units. • Media must be replaced approximately every three years (depending on quality of water and through-put). Cost of media replacement is not widely advertised but expected to be approximately $143 per year (Pure Water Produts, LLC, 2015).

3.4 Local Feasibility

The local feasibility of widespread adoption of nucleation-assisted crystallization water conditioners replacing ion exchange water softeners is currently unclear. Product availability, unit purchase costs, media replacement costs, and maintenance factors are all aspects that will affect local feasibility. But, perhaps the most important aspect is whether or not nucleation-assisted crystallization water conditioners will meet the needs and expectations of local homeowners regarding both scale formation and the "feel" of the treated water.

4.0 ELECTRICALLY INDUCED PRECIPITATION, CAPACITIVE DEIONIZATION, ELECTROMAGNETIC WATER TREATMENT

4.1 Definitions

- *Electrically Induced Precipitation*: An electric field makes a soft precipitate from dissolved scale forming particles on an electrode. Subsequent backwash cleans the electrode (Michaud, 2011).
- *Capacitive Deionization*: A technology to deionize water by applying an electrical potential difference over two porous carbon electrodes. Anions (ions with a negative charge) are removed from the water and are stored in the positively polarized electrode. Cations (ions with a positive charge) are stored in the cathode. Both the electrode and cathode are porous and have high surface areas. The system is

regenerated by a reversal of current. This process is commonly used for the desalination of brackish water.

- *Electromagnetic Deionization*: Magnetic water treatment is accomplished by passing water through a strong magnet installed on or in a feed line. Then, when the water is later heated it has less tendency to scale and the scale that does form is of a looser texture that is easily removed. Studies showed a 22 to 48 percent reduction in scale using magnetic water treatment.

4.2 Current Municipal Practice

Research failed to identify any municipal programs either in North America or abroad that rebate or promote electrically induced precipitation, capacitive deionization, or electromagnetic water treatment for residential customers. Almost all *independent* articles on these physical water treatment methodologies refer to them as “controversial” technologies that have not been clearly proven to work.

4.3 Benefits and Barriers

Using electrically induced precipitation, capacitive deionization, or electromagnetic water treatment in water softening can have the following benefits and barriers.

Table 4-1: Summary of benefits and barriers associated with using electrically induced precipitation, capacitive deionization, or electromagnetic water treatment.

Benefits	Barriers
• No need for salt or regeneration.	• Unproven technologies – may not actually function as advertised.

4.4 Local Feasibility

Not considered locally feasible due to the considerable lack of third-party verification that these physical water treatment systems work. A 2011 study by Arizona State University evaluated the following four non-salt alternatives to ion exchange softener - electrically induced precipitation, capacitive deionization, electromagnetic water treatment, and Template Assisted Crystallization to “*identify credible alternatives to ion exchange water softeners that would provide consumers with the ability to reduce the impacts of hard water without creating the negative salinity impacts*” (Mara Wiest, 2011).

All four devices were tested for 21 days using three different water qualities by running water around a heating element (much like a water heater). While all of the devices were somewhat effective at removing scale, the Template Assisted Crystallization method was proven to be dramatically superior to the other treatment methods, removing over 90 percent of hard water scale. The other devices achieved scale removal levels of less than 50 percent (Mara Wiest, 2011).

5.0 KEY CONSIDERATIONS

At this time it appears that there are only two alternatives for the City of Guelph to consider as viable alternatives to the popular self-generating ion exchange water softener homeowners:

1. Promotion of and/or offering rebates to customers that convert from using self-generating ion exchange water softeners to tank-exchange systems where the softener's resin tank is exchanged periodically by a service provider for a new softening tank. This would eliminate home regeneration and prevent salt from being discharged to drain but still allow customers to maintain the benefits associated with using soft water. Proven technology, however, the popularity of tank-exchange softeners is much lower now than it was 30 years ago. Further research is needed regarding program costs and availability for Guelph customers.
2. Promotion of and/or offering rebates to customers that convert from using self-generating ion exchange water softeners to Nucleation-assisted crystallization systems requiring no salt or regeneration. It should be noted that this technology is relatively new and has not yet been proven to meet the soft water needs of residential customers.

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To:	**Emily Stahl**	Company:	**City of Guelph**
From:	**Sam Ziemann**	Our File:	**75-41-151088**
Cc:	**Wayne Galliher,**	Date:	**September 25, 2015**
Subject:	**Water Reuse and Demand Substitution Technologies**		

CITY OF GUELPH

WATER REUSE AND DEMAND SUBSTITUTION TECHNOLOGIES

C3 WATER INC.

25 September 2015

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	September 14, 2015	Draft Water Reuse and Demand Substitution Technologies	Andrea Williams	Bill Gauley
2	September 25, 2015	Final Water Reuse and Demand Substitution Technologies	Bill Gauley	Sam Ziemann

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1.0 INTRODUCTION

The 2015 Water Efficiency Strategy Update will identify a set of preferred program alternatives, associated water savings, program implementation forecasts, and supporting program resources required to achieve the water demand reduction targets of the 2014 Water Supply Master Plan. As part of the strategy scope, a series of technical memos are being prepared on technology and policy areas of opportunity, as identified through ongoing program operation, industry best practice research, and common areas of customer/stakeholder inquiry.

The objective of this report is to summarize water reuse and demand substitution technologies available and feasible in the City of Guelph.

2.0 DIRECT POTABLE REUSE

2.1 Definition

Direct potable reuse is described as "the incorporation of reclaimed water directly into a potable water supply system" (Metcalf & Eddy, 2003). This level of reuse is not currently found in Canada nor is it common worldwide. However, it is gaining traction as population increases, treatment technology advances, and fresh water sources become limited or less dependable.

2.2 Current Municipal Practice

Windhoek, Namibia has been practicing direct potable reuse since its original Goreangab Water Reclamation Plant was commissioned in 1968. Today, the New Goreangab Water Reclamation Plant, built in 2002, receives influent from both the wastewater treatment plant and a surface water reservoir. The water treatment process used by this plant is shown in Figure 1. Winhoek has been credited worldwide as the first municipality to supplement their drinking water with reclaimed wastewater and can provide up to 50 percent of the community's water demand during severe drought conditions.

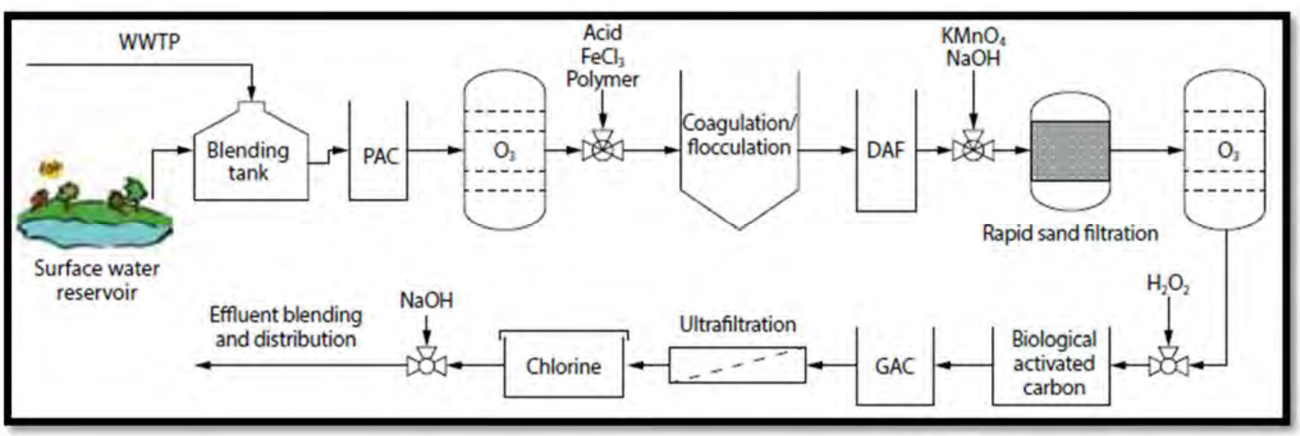

Figure 1 Process flow diagram for the New Goreangab Water Reclamation Plant (Australian Academy of Technological Sciences and Engineering, 2013).

Beaufort West Municipality, South Africa, began operating a direct potable reuse plant in January 2011 to provide a reliable source of drinking water. The plant regularly supplies 20 percent of the town's water but, at full capacity, can supply 25 percent of the water demand (Australian Academy of Technological Sciences and Engineering, 2013).

In 2013, Big Spring, Texas, implemented the first example of direct potable reuse in North America. Direct potable reuse now provides 15 percent of the city's water (Australian Academy of Technological Sciences and Engineering, 2013). The plant consists of microfiltration, reverse osmosis, and ultraviolet disinfection. Some factors that persuaded the City to pursue direct potable reuse were:

- Low number of potential customers for non-potable reuse initiatives.
- Low density development in the area meant that a purple pipe option for distribution of non-potable reuse would be too expensive.
- Raw drinking water sources were generally distant and a lower elevation resulting in expensive delivery costs, whereas wastewater was already available locally.

2.3 Benefits and Barriers

The following are benefits and barriers to implementing direct potable reuse:

Table 2-1: Summary of benefits and barriers associated with direct potable reuse.

Benefits	Barriers
• While treatment cost savings can be realized in areas where source water quality is lower than wastewater effluent, e.g., if a coastal city has saltwater intrusion in their groundwater, this is not currently the situation in Guelph. • While the system carbon footprint can be reduced in situations when source water must be transported over significant distances, this is not currently the situation in Guelph. • Water security and reliability as direct potable reuse serves as an additional 'source' of water for the City. This is especially important in areas with insufficient available water supplies, however, this is not currently the situation in Guelph.	• Additional treatment aspects (and associated cost) required to treat wastewater to potable standards. • Health concerns about pathogen transmission and emergent pollutants that are not currently monitored. • Aesthetic and public acceptance; the 'ick' factor and perception of 'toilet to tap' water. • Direct potable reuse legislation and regulations are not currently in place in Canada.

2.4 Local Feasibility

Public acceptance would be the determining factor in moving towards a direct potable reuse solution for the City of Guelph. No level of Canadian government currently has legislation regulating the direct potable reuse of wastewater. Completing the necessary testing and developing suitable legislation may take considerable time and, as such, this measure is not currently feasible for implementation by the City. However, examples of current projects in the United States could be used to establish a framework for implementation in the City.

3.0 INDIRECT POTABLE REUSE

3.1 Definition

Indirect potable reuse can be defined as the integration of reclaimed water into a drinking water supply reservoir (Metcalf & Eddy, 2003). An example of this would be recharging an aquifer with suitably treated wastewater effluent for later use.

3.2 Current Municipal Practice

Orange County, California has implemented a groundwater replenishment system that uses treated wastewater to recharge the aquifers of north and central Orange County (Groundwater Replenishment System). The facility can produce 265,000 cubic metres of reclaimed wastewater per day (equal to about 37 Olympic-sized swimming pools). Furthermore, the system saves the County energy costs by producing water at half the energy it would take to pump fresh water from distant sources and a third the energy required to desalinate the same volume of seawater (Groundwater Replenishment System).

Singapore has NEWater plants that supply industrial customers with high-grade recycled wastewater. During drought periods, Singapore also practices indirect potable reuse by supplementing their raw water reservoirs with NEWater (Public Utility Board, 2014). Singapore currently imports most of its drinking water from Malaysia but plans to have 55 percent of its drinking water supply provided by NEWater plants by 2060 (Public Utility Board, 2014).

In 2004 the small town of Cloudcroft, New Mexico (population of 1,000), incorporated an indirect potable reuse system to supplement their drinking water supply with 50 percent treated wastewater as an alternative to trucking 75 cubic metres of water per day into the town which is located 9,000 feet above sea level. The wastewater is treated by a membrane bioreactor and reverse osmosis and is then blended with well and spring water for at least a 2 week detention time in an artificial reservoir to allow for natural treatment by diffusion and sunlight (Australian Academy of Technological Sciences and Engineering, 2013).

3.3 Benefits and Barriers

The following are benefits and barriers to implementing indirect potable reuse:

Table 3-1: Summary of benefits and barriers associated with indirect potable reuse.

Benefits	Barriers
• The quality of the reclaimed water improves as it passes through the natural environment – as such, less intensive treatment is required at the water treatment plant. • Well established method. • Generally positive public perception when educational programs are provided.	• More expensive than direct potable reuse. • Possible contamination of the groundwater aquifer. • Potentially high levels of organic chemicals in treated wastewater and their toxicological effects. • Potentially high levels of total dissolved solids, nitrates, and pathogens in treated wastewater. • Still not 100 percent backed by the public due to public health concerns.

3.4 Local Feasibility

The City of Guelph currently uses water from the Eramosa River to recharge the shallow aquifer at the Carter Wells. A portion of the effluent produced from Guelph's Wastewater Treatment Facility could be further treated and used to replace or augment the current removals from Eramosa River. A report provided by AquaTeam Solutions to the City of Guelph outlined aquifer recharge as a possible reuse alternative for the City to consider implementing (CH2M Hill, 2009). The two methods suggested for aquifer recharge in Guelph were surface infiltration and direct injection. Application of the alternatives discussed would be dependent on a variety of factors including the level of pre-treatment, the hydrogeological conditions for infiltration, and residence times for direct injections.

4.0 NON-POTABLE REUSE

4.1 Definition

Non-potable reuse is defined as "all applications that do not involve either indirect or direct potable use" (Metcalf & Eddy, 2003). Greywater reuse systems are small-scale examples of non-potable reuse. Large-scale systems involve purple pipe-type infrastructures that deliver reclaimed wastewater to end-users for non-potable purposes, e.g., golf course irrigation.

A residential greywater reuse system will typically collect water from showers and baths, filter, treat with chlorine, and store for later use where potable water is not required, e.g., toilet flushing. The 2012 Ontario Building Code specifies that "greywater that is free of solids" can be used for toilet or urinal flushing, priming of floor drain traps, or sub-surface irrigation. For any other use in Canada, the greywater must be treated sufficiently for bacteria, protozoa, and viruses to remove any risk to public health (Health Canada, 2010).

4.2 Current Municipal Practice

4.2.1 Greywater Reuse

The City of Tucson, Arizona, has a Single Family Residential Gray Water Rebate Program. This program will provide a rebate for half of the start-up costs (up to $1000) to customers installing a greywater irrigation system (City of Tucson, 2014). Any citizen who wishes to apply for the rebate is required to attend a workshop on greywater management practices, operation, and maintenance (City of Tucson, 2014).

Santa Clara Valley Water District, California, has a “Graywater Laundry to Landscape” rebate program providing $200 to single-family households that connect their clothes washer discharge to a greywater irrigation system (Santa Clara Valley Water District, 2014).

Santa Rosa, California, has a Graywater System Rebate Program that entails two rebates - the first is a Per Fixture Rebate of $75 for each fixture that routes greywater to reuse and the second is a Sustained Reduction Rebate of $200 for every 1,000 gallons (3.8 cubic metres) of sustained monthly reduction up to the full cost of the system (City of Santa Rosa Water Conservation).

4.2.2 Reuse for Irrigation

Be’er Sheva, Israel is home to an effluent reuse system that treats wastewater from a nearby water treatment plant. About 90 percent of the reclaimed water is used for farmland irrigation and the remaining 10 percent is used for irrigation of municipal parks (Waterworld, 2012). In general, wastewater reuse for irrigation in Israel has increased from 17 percent in 2000 to over 50 percent in 2012. It is estimated that Israel’s wastewater reuse has increased to approximately 55 million cubic metres daily (Waterworld, 2012).

The City of Clermont in Florida collects domestic wastewater through 55 miles of pipe, then treats and redistributes the water for irrigation (City of Clermont). The reclamation facility can produce an average of 2.2 million gallons (8,328 cubic meters) of water for reuse each day (City of Clermont).

In the City of Vernon British Columbia, wastewater effluent is pumped to a reservoir 7 kilometers from the treatment plant. For over 30 years the water has been used to irrigate 970 hectares of agricultural and recreational lands (Vespa, 2010).

4.2.3 Industrial Reuse

Denver, Colorado has a Water Recycling Plant that provides cooling water to the Cherokee Power Plant. Water quality requires less than 0.6 milligrams per litre of phosphorus to prevent calcium phosphate scaling and also non-detectable amounts of ammonia to avoid stress corrosion cracking of admiralty metals (Wagman, 2013). The plant buys $840,000 worth of reclaimed water per year at an equivalent cost of $0.26 per cubic metre (Wagman, 2013).

Eraring Power Station near Newcastle, Australia, uses microfiltration and reverse osmosis to treat wastewater effluent to a level that meets the high water quality requirements for boiler feed-water. The Station previously needed to demineralize potable water, but with a chemical cost of less than

$0.01 for each cubic metre of reclaimed water produced, the Station saved an estimated $52,000 American per year starting in 2006 (Water World, 2006).

4.3 Benefits and Barriers

The following are benefits and barriers to implementing Non-Potable Reuse systems:

Table 4-1: Summary of benefits and barriers associated with Non-potable Reuse systems.

Benefits	Barriers
• Greywater systems are expected to reduce single-family household water use by between 15 and 30 percent. • Wastewater reuse for irrigation lessens the strain on water supplies. • Nutrients in wastewater are sometimes beneficial for plant growth. • Economically viable for industrial reuse of wastewater when treatment was already required.	• Health Concerns related to pathogens. • More efficient fixtures produce less greywater and need less greywater – thus reducing the associated benefit and increasing payback periods. • Reluctance of homeowners to assume required maintenance activities. • Potential requirement for installation and annual testing of backflow prevention device on participating homes. • Lack of municipal management framework regarding risk and liability. • Lack of public awareness and acceptance, e.g., marketability of crops. • Effect of water quality, e.g., industrial reuse requires specific water quality to prevent increased maintenance. • Water quality issues when used in cooling towers, e.g., scaling, metallic corrosion, biological growth and fouling.

4.4 Local Feasibility

The City of Guelph has already established a greywater reuse system rebate program. Under direction of the Ontario Building Code and other industry standards the program focused on systems that collect water from baths and showers to provide water for toilet flushing in the home. Any household that installs a greywater reuse system is eligible to receive a $1,000 incentive upon completion and inspection (City of Guelph, 2015). More information on the program can be found at *guelph.ca/greywater*.

In May 2009 Guelph initiated the Greywater Field Test, a study of 25 household greywater reuse systems in new and existing households. These systems were successful in decreasing the household demand by an average of about 23 litres per capita per day (an average of 16.6 litres per capita per day was saved in homes specifically equipped with efficient toilets). Aesthetic water quality parameters, such as odour and colour, were the primary concerns expressed by the field test participants. The payback period was also estimated to be 20 years or more and, combined with the higher than anticipated maintenance requirements, it is currently unfeasible to argue for greywater systems in single family households. There may be better opportunities for large scale systems, and further automated technology would be more practical (City of Guelph, 2012).

There are also large-scale systems that may be feasible for the City to consider including a purple pipe infrastructure, irrigation reuse and industrial reuse. AquaTeam Solutions recommended that several short- and long-term wastewater reuse applications should be investigated with short-term uses conservatively accounting for about 0.07 percent (54 cubic metres per day) of the current wastewater discharge and long-term uses potentially accounting for 6 percent (3,850 cubic metres per day). Potential short-term end uses for treated greywater include construction site dust control, municipal works uses, on-site wastewater treatment plant irrigation and downtown flowerbed irrigation. Industrial cooling and processing, park and golf course irrigation, a municipal dual-water system (purple pipe), dewatering polymer make-up at the wastewater treatment plant, and groundwater recharge were recommended for long-term implementation alternatives for wastewater reuse, however, the study advised that additional greywater treatment/polishing would be required and that further consultation with Health officials would be necessary regarding how and where the treated greywater could be used (especially in areas frequented by the public).

5.0 RAINWATER HARVESTING

5.1 Definition

A rainwater harvesting system involves the collection and storage of rainwater from roofs and buildings (Regional District of Nanaimo, 2015). There are two types of rainwater harvesting: passive and active. Passive harvesting systems are small volume systems that capture rooftop runoff, such as a rain barrel (United States Environmental Protection Agency, 2013). Active harvesting systems are larger water systems that include water quality treatment and supply pumps (United States Environmental Protection Agency, 2013).

5.2 Current Municipal Practice

5.2.1 Rainwater Harvesting

The Regional District of Nanaimo has a Rainwater Harvesting Incentive Program. The program offers rebates of $450 for 1,000 gallons (3.8 cubic metres) cisterns that treat the water up to potable standards (Regional District of Nanaimo, 2015). The District also offers rebates of $300 for eligible system expenses, including transport piping, debris traps, filters, and installations (Regional District of Nanaimo, 2015).

5.2.2 Stormwater Reuse

Toronto, Ontario has an innovative waterpark called Sherbourne Commons that treats stormwater with ultraviolet disinfection. The treatment facility was a solution for a stressed combined sewer system which resulted in sewer backups during heavy rains.

5.3 Benefits and Barriers

The following are benefits and barriers to implementing a rainwater harvesting system:

Table 5-1: Summary of benefits and barriers associated with rainwater harvesting.

Benefits	Barriers
• Easy to maintain. • Reduces water bills. • Reduces demand on groundwater. • Slows or captures stormwater flows, thus reducing the threat of floods and soil erosion. • Rainwater is not chlorinated and is naturally soft, therefore better for vegetation.	• Unpredictable supply. • High capital costs. • Regular maintenance. • Rainwater collected from roofs may contain sediments or animal droppings. • Limits to storage capability. • Any system must comply with building codes and regulations. • Maintaining stored water quality and quantity against evaporation and fouling. • While developing communal rainwater harvesting systems may improve the rate of return on investment, there may be extensive liability concerns related to customers supplying rainwater to each other (subject to legal review).

5.4 Local Feasibility

The City of Guelph currently has a rainwater harvesting system rebate program offering two rebates. The first rebate is for seasonal outdoor systems, and offers $0.10 per litre for an approved seasonal rainwater barrel up to $400 (minimum tank size of 500 litres required). The second rebate is $2,000 for an approved all-season system. Although the City has been offering a rainwater harvesting system rebate since 2012, in a study conducted by Lura Consulting only 1.5 percent of those surveyed had a system in place. Awareness and technology availability remain issues. For example, there are no “off the shelf” packaged rainwater harvesting systems available through local plumbing/hardware stores. It should also be noted that all-season rainwater harvesting systems used to replace indoor potable water demands (vs. a system used only during the summer months for irrigation) are complex systems and may not be feasible as a retrofit for all properties due to limited access to plumbing, lack of area available to construct underground storage tanks, etc..

The Guelph Transit facility uses a rainwater harvesting system for washing its buses, capturing up to 13,500 litres of stormwater per rain event, reducing surges and related impacts to local infrastructure (City of Guelph).

The Canada Mortgage and Housing Corporation publishes *Collecting and Using Rainwater at Home – A Guide for Homeowners* (Canada Mortgage and Housing Corporation, 2015). The Guide states that the *2010 National Plumbing Guide of Canada* permits the use of rainwater for toilet and urinal flushing as well as subsurface irrigation. The Guide also estimates that about 80 percent of the rain that falls on our roofs can be recovered if the storage tank is large enough.

As an example, if a home's roof area were 100 square metres, the storage tank would need to have a capacity of about 2.5 cubic metres to capture all of the water that would fall on the roof during a 1-inch (25 millimetres) rain event. Guelph receives about 931 mm of precipitation (rain and snow) each year (Current Results; Weather and Science Facts, 2010). If 80 percent of this precipitation could be captured and, again, assuming a 100 square meters of roof area, the volume captured each year could equal about 74.5 cubic metres for an average of about 204 litres per day. As such, a typical single-family home with a sufficiently sized rainwater harvesting system could potentially reduce their potable water demands by about 50 percent. The homeowner could save about $113 per year in water costs at the 2015 rate (it is assumed that the homeowner would still need to pay the portion of the water rate associated with wastewater treatment). Of course there would be costs associated with the operations and maintenance of the rainwater harvesting system, in addition to the original purchase and installation costs.

Although the actual purchase and installation costs will vary depending on the size and design of the system, the Canada Mortgage and Housing Corporation Guide suggests the costs associated with purchasing and installing a rainwater harvesting system for a 3-person home in Guelph to be about $8,000. The return on investment for a single-family sized rainwater harvesting systems, therefore, is quite long.

6.0 KEY CONSIDERATIONS

All the water Guelph supplies to its customers is potable, i.e., water that is safe to consume, even though less than 10 percent of this water supply is actually consumed by customers. The rest is used to flush toilets, to wash clothes and dishes, for bathing, for cooling, for irrigation and further uses. The situation is similar for manufacturing and industrial processes where the majority of the water supplied is not consumed.

Since potable water is not required for the majority of end uses, it is possible, and in some cases may even be practical, to substitute alternative water supplies in place of the potable water provided by the City. Reusing water can significantly reduce the demand for potable municipal water, however, the initial costs associated with building water reuse systems and the ongoing costs associated with adequately treating the wastewater, rainwater, or greywater often result in extremely long return on investment periods.

In Guelph’s 2014 Water Supply Master Plan re-use alternatives were investigated and found that significant reductions from reclaim and re-use options will only be achieved through centralized facilities – either treatment to non-potable standards for landscaping irrigation and other non-potable uses through a dual plumbing system or treatment to potable standards for use in the existing distribution system.

If the availability of local freshwater becomes much more scarce or the costs associated with building and operating reuse systems declines significantly, these systems are expected to become much more popular. Based on current conditions, however, it is recommended that the City efforts are directed to larger-scale rainwater harvesting or greywater reuse projects where the volume of water savings is higher and the cost per litre of water savings is lower.

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From:	**Sam Ziemann**	Our File:	**75-41-151088**
Cc:	**Wayne Galliher, Julie Anne Lamberts**	Date:	**1 September 2015**
Subject:	**Industrial Consumptive Cooling Process and Water Conditioning Technology Efficiencies**		

CITY OF GUELPH

INDUSTRIAL CONSUMPTIVE COOLING PROCESS AND WATER CONDITIONING TECHNOLOGY EFFICIENCIES

C3 WATER INC.

1 September 2015

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	July 17, 2015	Draft Industrial Consumptive Cooling Process and Water Conditioning Technology Efficiencies	Patricia Wiebe	Bill Gauley
2	September 1, 2015	Final Industrial Consumptive Cooling Process and Water Conditioning Technology Efficiencies	Bill Gauley	Sam Ziemann

Table of Contents

1.0 INTRODUCTION

The 2015 Water Efficiency Strategy Update will identify a set of preferred program alternatives, associated water savings, program implementation forecasts, and supporting program resources required to achieve the water demand reduction of the 2014 Water Supply Master Plan. As part of the strategy scope, a series of technical memos are being prepared on technology and policy areas of opportunity, as identified through ongoing program operation, industry best practice research, and common areas of customer/stakeholder inquiry The objective of this report is to outline potential efficiency options related to industrial cooling processes.

2.0 INDUSTRIAL CONSUMPTIVE COOLING EFFICIENCIES

2.1 Definition

An industrial cooling system removes heat from a process or piece of equipment by transferring it to another medium, often water and sometimes air. For water-based cooling systems, the heated water can simply be discharged down the drain as a once-through cooling system, or it can be cooled and reused as a recirculating cooling system. There are two types of recirculating systems, open and closed. The types of water-based cooling systems are described below:

- Once-through cooling system, Figure 1: This is the most water-intensive industrial cooling method wherein the cooling water contacts and lowers the temperature of a heat source and then is discharged to drain. Once-through cooling is prohibited by Guelph's municipal sewer use bylaws 13791 (1991) and 15202 (1996).

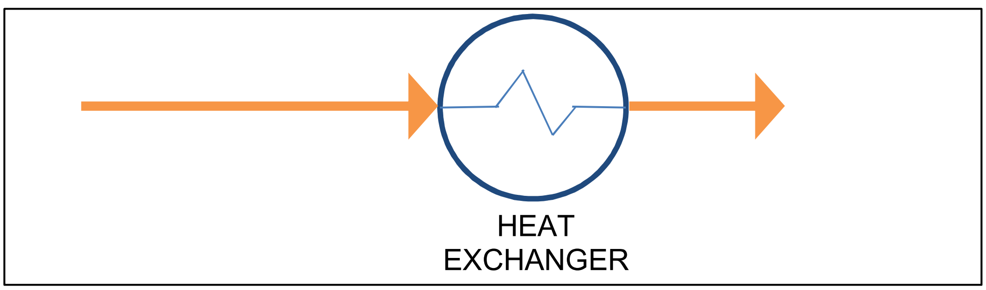

Figure 1: Once-through cooling system – cooling water absorbs heat and is then discharged to waste

- Open recirculating system, Figure 2: Cooling is achieved via use of a cooling tower. After the cooling water picks up heat from the process or equipment, it is sprayed over fill (structured panels with a large surface area) inside the cooling tower where heat is transferred from the cooling water via both a direct energy (sensible heat) exchange between the water and the air and through the evaporation (latent heat) of a portion of the cooling water.

- Closed recirculating system, Figure 3: Cooling is achieved via use of an evaporative condenser. After the cooling liquid picks up heat from the process or equipment it passes through a heat exchanger which itself is cooled by water or air. As with open systems, water lost through evaporation must be replaced.

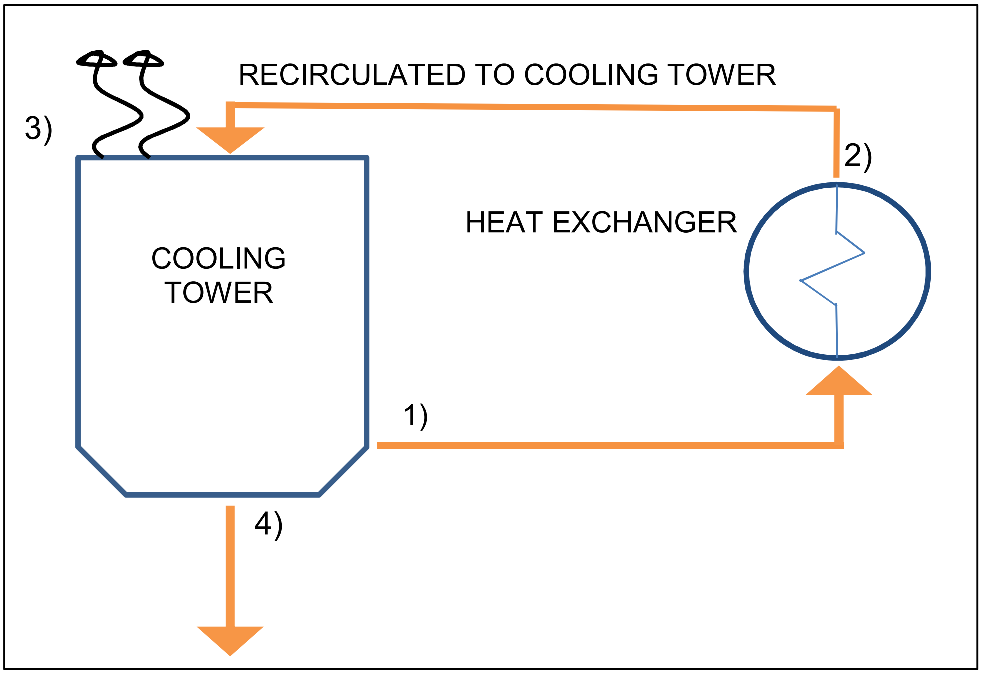

Figure 3: Open recirculating system where 1) water travels from the cooling tower to the heat exchanger 2) is recirculated back to the cooling tower that 3) promotes evaporation with air to cool the water and 4) uses blowdown to remove some of the water's impurities

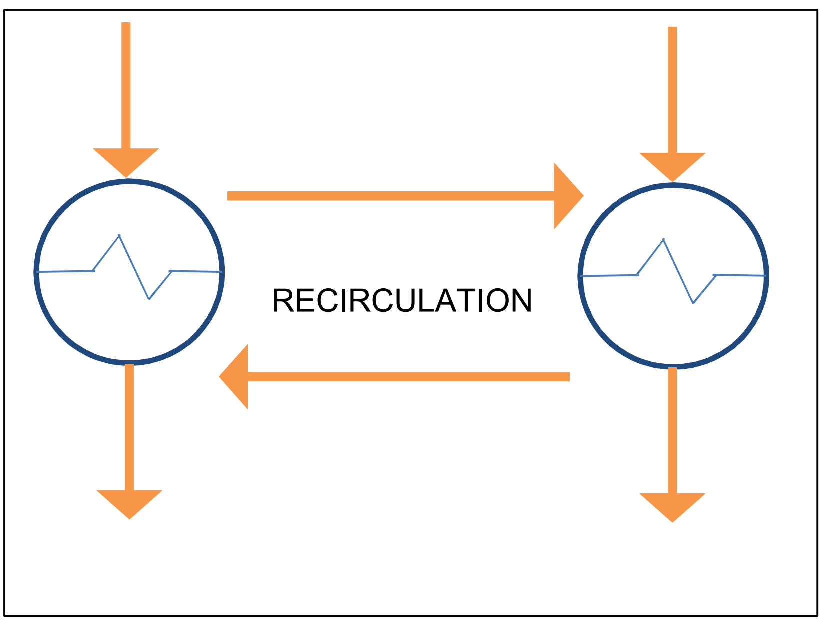

Figure 2: Using the water to cool, and then using a subsequent heat exchanger to cool the water.

2.2 Description

Cooling towers and evaporative condensers function by evaporating water. They are effective for cooling because they take advantage of water's high enthalpy of evaporation, which refers to the large amount of heat required to change water from liquid phase to gaseous phase. The amount of water evaporated is related to how much heat is being removed from the system. A rule of thumb for evaporation loss is 6.8 litres per hour of evaporation per ton of cooling (Conservation Mechanical Systems Inc.). Evaporation accounts for the greatest water loss during the operation of a cooling tower or evaporative condenser.

Water can also be lost from the cooling system through splash-out and drift. Drift is the term used for water that is physically removed from the system by the force of air moving through the tower. A rule of thumb for splash/drift loss in a new system is "0.008 percent of recirculating water" (Conservation Mechanical Systems Inc.). Splash-out and drift losses account for the second greatest water loss during the operation of a cooling tower or evaporative condenser.

As stated above, cooling towers and evaporative condensers function by evaporating water. However, the evaporation process increases the concentration of dissolved solids (minerals) in the remaining cooling water. If the concentration becomes too high it can foul or damage the cooling system (scale formation, corrosion, biological growth, etc.) and reduce the efficiency and lifecycle of the system. To help prevent the concentration of suspended and dissolved solids from becoming too high, a portion of the recirculated cooling water (which is high in dissolved solids) is purposely discharged as blowdown and replaced with fresh water. In some cases the blowdown contains not only a high level of dissolved solids but also a high level of toxic materials such as biocides and corrosion inhibitors.

Blowdown is qualified by the term "cycles of concentration". The cycles of concentration for a system can be calculated as the ratio of the concentration of dissolved solids in the recirculated water to the concentration in the incoming makeup water. For example, if the mineral content in the recirculated water is four times as great as the mineral content in the makeup water, the cycles of concentration for that system would be 4.0. Blowdown accounts for the third greatest water loss during the operation of a cooling tower or evaporative condenser.

The volume of water evaporated by a cooling tower or evaporative condenser is directly related to the amount of heat being removed by the system. The volume of water lost through splash-out and drift is directly related to the system design and maintenance. The volume of water lost through blowdown, however, can be reduced by increasing the cycles of concentration through proper water treatment, or conditioning, of the water.

Operating at higher cycles of concentration requires a lower volume of makeup water. However, the volume of water savings decreases as the level of cycles of concentration increase. For example, increasing cycles of concentration from 5 to 8 will decrease the volume of makeup demand by only about 15 percent as much as increasing the cycles of concentration from 2 to 5 (Figure 4).

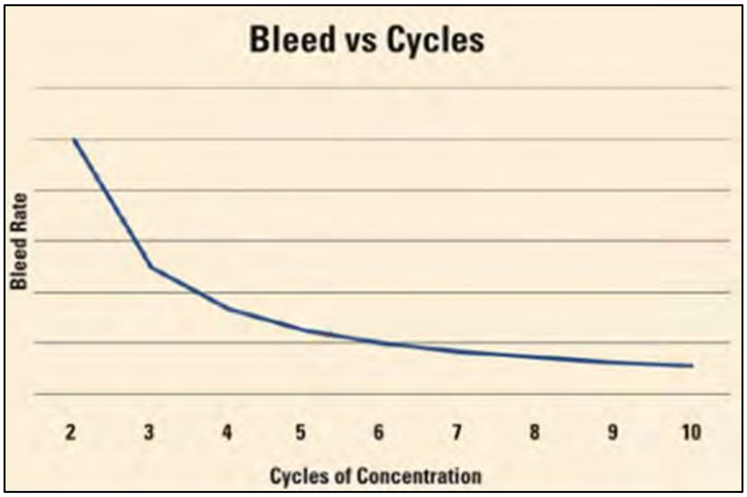

Figure 4: Operating a cooling tower with high cycles reduces the water use from bleed rate **(Harfst 2008)**.

2.3 Water Efficiency Options

There are several methods for minimizing the volume of makeup water required, such as:

- Use of Soft Water Makeup: Calcium and magnesium are typically the two primary scale formers in a cooling system. Softening the makeup water will remove these ions and enable the cooling tower to run at higher cycles of concentration, thus reducing the volume of blowdown and makeup water required. Soft water, however, is not only corrosive but the cost of producing the soft water (salt, energy, and regeneration water costs) may make using 100 percent soft water makeup uneconomical for a cooling tower. As such, it may be beneficial to use a blend of hard water and soft water as makeup. The most economical balance for the blend would need to be calculated on a case-by-case basis.
- Acid Feed: Adding acid to the recirculated water will increase the solubility of calcium and magnesium and allow for higher cycles of concentration to be achieved. Many facilities, however, have acid-handling safety concerns that make them hesitant to use this alternative.
- Use of Reverse Osmosis Concentrate: Reverse osmosis concentrate (or reject water) may be blended with potable water for cooling tower makeup. If the water is softened prior to the reverse osmosis process, the concentrate will also be soft water. Reverse osmosis concentrate is often high in alkalinity and care should be taken to avoid mixing it with hard well water as high alkalinity in addition to hardness can result in the formation of scale on heat exchange surfaces.
- Use of Recycled Wastewater: Some wastewaters are suitable to use as cooling tower makeup without any extra treatment such as non-contact once-through cooling water. However, since there are often impurities in alternate sources of makeup water that can cause scale build-up, corrosion, and/or microbiological growth in the cooling system, it is important to use the correct form(s) of water treatment. If the quality of the recycled wastewater is variable, it is important to routinely monitor water quality and adjust treatment accordingly. An engineering and

economic analysis should be completed to determine both the feasibility and potential cost savings associated with using recycled wastewater.

- Use of Rainwater – Although unpredictable as a source of water, rainwater can be a viable source of makeup water. Approximately 25 litres of rainwater can be recovered per inch (25 mm) of precipitation per square metre of collection surface. Rainwater from the facility's roof is directed to a storage tank and then pumped to the cooling tower when needed as makeup water. While rainwater is relatively pure, it may require some treatment (e.g., addition of biocide to reduce microbial growth) or filtering to remove oil and other contaminants prior to use as makeup water.
- Use of Condensate – The operation of air conditioning equipment often produces large quantities of cold, nearly distilled condensate from the air handler cooling coils. Because this condensate does not contain the dissolved mineral impurities present in potable water, it will enable the cooling system to operate at higher cycles of concentration.
- Use of Conductivity Meter: If the conductivity of the recirculated water is below design parameters, the system will use more water than necessary; if the conductivity is above design parameters, there is an increased risk of scale and corrosion. Having a properly functioning conductivity meter will help keep the system running at the proper conductivity, thereby minimizing blowdown and the volume of makeup water required.
- Fixing Leaks: Leaks are uncontrolled water losses that could be considered another form of blowdown. If the system has a properly functioning conductivity meter installed, the volume of water lost through a small leak would be offset by an equal reduction in the volume of blowdown. Leaks start to become a real problem, however, when the rate of leakage exceeds the required blowdown rate and the cycles of concentration or conductivity cannot be maintained. If a cooling system's blowdown is lower than expected but the system cannot maintain the set conductivity, then there may be excessive leakage in the system.
- Conversion to Air for Cooling Purposes: In some cases, it is possible to switch from water cooling to air cooling and remove wasting of water from cooling applications altogether. Factors to consider in switching from water to air include energy efficiency and performance (Alliances for Water Efficiency). Equipment that falls into the air cooling category include air compressors, vacuum pumps, ice machines, refrigeration condensers, hydraulic equipment, and x-ray processing equipment (Alliances for Water Efficiency).

2.4 Current Municipal Practice

Some municipalities offer financial rebates to customers that reduce the volume of makeup water used by their cooling towers or evaporative condensers. Because the volume of water savings will vary from system to system and from day to day, it is not possible to accurately predict the level of savings that can be achieved by a system. As such, some communities (including Guelph) offer these types of rebates through their Capacity Buy-Back programs. Other communities that currently offer (or have previously offered) Capacity Buy-Back program include: Region of Peel, City of Toronto, and York Region.

The Region of Waterloo has considered targeting facilities with cooling towers (identified through the use of aerial photos) to offer them cooling system water audits at low or no cost (Region of Waterloo 2013).

The water rates of most municipalities, including Guelph, include both water and wastewater fees. In 2015 Guelph customers paid a water rate of $1.52 and a wastewater rate of $1.66 for every cubic meter of water they received from the City (plus additional fixed fees). This type of billing structure is based on the idea that a significant portion of the water received by a customer is subsequently returned to the City as wastewater that must be treated and discharged back into the environment. In some cases a portion of the water received by a customer is not returned to the City as wastewater, e.g., water used for irrigation or water that is evaporated, and thus there are no related wastewater collection or treatment costs. Some municipalities, e.g., Toronto, offer a sewer surcharge exemption (i.e., a reduction of some or all of the wastewater portion of the water bill) to customers that can prove they do not discharge all of the water they receive into the sanitary sewer. Guelph does not currently offer customers a sewer surcharge exemption, so a customer that reduces their cooling water demand will also reduce their water bill by $3.18 per cubic meter (e.g., $1.52 per cubic meter water and $1.66 per cubic meter for wastewater). Should the City adopt a sewer surcharge exemption in the future, the financial benefit to customers reducing their cooling water demand would be reduced from $3.18 to only $1.52 per cubic meter of savings.

2.5 Benefits and Barriers Associated with Improved Industrial Cooling Efficiency

There are benefits and barriers to implementing water efficient industrial cooling, as presented in Table 2-1.

Table 2-1: Summary of benefits and barriers associated industrial cooling efficiency.

Benefits	Barriers
• Water savings and lower water costs for industrial customers. • Lower municipal peak water demands, which result in increased water capacity as well as lower operational costs related to energy and chemical demands. • Potential to lower capital costs related to avoided, downsized, or deferred infrastructure. • Potential sharing of efficiency improvement costs if City rebates are provided.	• Inertia of industrial customers to evaluate the efficiency of their cooling systems. • Complexity of treatment processes – lack of trained on-site personnel. • Potentially high costs associated with using alternative water sources for makeup water and pre-conditioning. Potentially high energy costs in air cooling. • Overall cost of cooling system versus potential cost savings from reduced makeup water may sway customers to 'err on the side of caution' regarding the volume of makeup water used (e.g. decide to use more water to avoid scaling and biological fouling).

3.0 CASE STUDIES

Capital Regional District (British Columbia): between 2007 and 2014, the CRD offered rebates of up to $5,000 as incentives for businesses to replace their once-through water-cooled equipment with non-water-cooled equipment. A total of 200 units were replaced as part of this program with an estimated total annual savings of 745,000 cubic meters of water. The program was cancelled at the end of 2014.

San Antonio Water System (San Antonio, Texas): Audit-based program evaluates commercial, industrial and institutional cooling tower and cooling water systems at no cost. Costs savings related to reduced water usage and sewer charges, reduced corrosion, reduced fouling, and reduced chemical costs are identified. Improvements may be eligible for up to 100 percent of the cost of implementation under the San Antonio Water System Commercial Custom Rebate program (San Antonio Water System).

Denver Water (Colorado): Cooling Tower Performance Rebate Program pays customers $18.50 for every 1,000 gallons (3.78 cubic metres) of water saved below their average consumption over the previous 3 years. Customers can receive 50 percent of project costs up to $40,000. Projects must save a minimum of 50,000 gallons (190 cubic metres) per year to qualify. Sub-meters must be installed on makeup water and blowdown water (Denver Water).

Los Angeles Department of Water and Power (California): Program offers rebates for cooling tower conductivity controllers ($625 per unit), pH/conductivity controllers ($3,000 per unit), and air-cooled ice machines ($1,000 per unit) (Los Angeles Department of Water and Power).

United States Department of Energy: Program offers online guidance on cooling tower management (Best Management Practice #10: Cooling Tower Management) as part of its federal energy management program (United States Department of Energy).

Leadership in Energy and Environmental Design is a worldwide third party certification program. To qualify for Water Efficiency certification (5 points), cooling towers and evaporative condensers for air conditioning systems, such as chilled water systems, must:

- achieve a minimum of 5 cycles of concentration under normal conditions or 4 cycles of concentration if the makeup water hardness exceeds 200 milligrams per litre (11.7 grains per gallon)
- be equipped with makeup and blowdown meters, conductivity controllers and overflow alarms as well as efficient drift eliminators that reduce drift loss to less than, or equal to, 0.001 percent of recirculating water in a counter-flow tower or 0.005 percent in a cross-flow tower use no more than 2.3 gallons (8.7 litres) per ton hour or 2.5 litres per kilowatt hour of potable water for cooling tower or evaporative condenser make-up.

El Dorado Hills, California: offered a $900 rebate to customers installing a conductivity meter, a $450 rebate to customers agreeing to supply and install a water meter on their cooling tower, and a $300 rebate to customers agreeing to read the new meter each month for a 24-month period and send the meter readings to the City (California Urban Water Conservation Council).

Contra Costa Water District: offers rebate of 50 percent of cost of conductivity meter up to $500 (Contra Costa Water District).

4.0 KEY CONSIDERATIONS

There are a number of ways to reduce the volume of makeup water required for cooling towers and evaporative condensers, including properly treating the recirculation water to maximize the cycles of concentration. For example, to qualify for Leadership in Energy and Environmental Design points a cooling tower must operate at a minimum of 5 cycles of concentration (or a minimum of 4 cycles of concentration if the hardness of the makeup water supply is greater than 11.7 grains).

Operating at higher cycles of concentration can reduce the volume of makeup water required (though the savings above a cycles of concentration value of 5 is minimal), it can also increase the potential for scaling and/or fouling which will reduce the effectiveness and efficiency of the system. The installation of a conductivity meter can help maintain the proper cycles of concentration for the cooling system to maximize water savings and minimize the potential for scaling or fouling (Aherne).

The volume of makeup water can also be reduced by lowering the concentration of dissolved minerals in the makeup water supply to the cooling system by blending soft water or air-handling condensate in with the raw potable water supply.

It is also sometimes possible to augment or replace the potable water supply of the cooling system with an alternative supply, such as rainwater, recycled wastewater, or reverse osmosis concentrate. When using or adding alternative water supplies it is important to monitor and treat the chemistry of the recirculation water to minimize the potential for scaling or fouling. A cost-effectiveness evaluation should be done on a case-by-case basis.

Some municipal programs offer rebates to industrial customers that reduce their potable water demands. The rebate level can be based on the volume of water saved (e.g., Capacity Buyback Program) or the cost of implementation to achieve the savings or simply a pre-set value. Some programs require a minimum volume of savings to qualify for a rebate. Some programs offer rebates up to 100 percent towards the installation of a conductivity meter on the cooling system.

Guelph currently provides financial incentives to non-residential customers reducing water demands through the City's Industrial/Commercial/Institutional Capacity Buyback program. Capacity Buyback programs are considered equitable to customers because the size of the financial incentive is directly related to the magnitude of water savings achieved and maintained by the customer. Providing an incentive based on water savings versus the use of a particular process or piece of equipment helps reduce any liability that might fall to the City if the process or equipment does not meet the customer's expectations. Capacity Buyback programs also allow the greatest level of freedom to the customer to tailor their water savings efforts to meet their specific needs and expectations.

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To:	**Emily Stahl**	Company:	**City of Guelph**
From:	**Sam Ziemann**	Our File:	**75-41-151088**
Cc:	**Wayne Galliher, Julie Anne Lamberts**	Date:	**August 31, 2015**
Subject:	**Mass Fixture Retrofit Programs for Multi-Residential Settings**		

CITY OF GUELPH

MASS FIXTURE RETROFIT PROGRAMS FOR MULTI-RESIDENTIAL SETTINGS

C3 WATER INC.

31 August 2015

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	July 20, 2015	Draft Mass Fixture Retrofits for Multi-Residential Settings TM	Andrea Williams	Bill Gauley
2	August 31, 2015	Final Mass Fixture Retrofits For Multi-Residential Settings TM	Bill Gauley	Sam Ziemann

Table of Contents

1.0 INTRODUCTION

The 2015 Water Efficiency Strategy Update will identify a set of preferred program alternatives, associated water savings, program implementation forecasts, and supporting program resources required to achieve the water demand reduction of the 2014 Water Supply Master Plan. As part of the strategy scope, a series of technical memos are being prepared on technology and policy areas of opportunity, as identified through ongoing program operation, industry best practice research, and common areas of customer/stakeholder inquiry. The objective of this report is to summarize mass fixture retrofit programs that could be implemented in Guelph's multi-residential buildings.

2.0 MASS FIXTURE RETROFITS

2.1 Definition

Mass fixture retrofits consist of replacing or retrofitting all or part of the existing plumbing fixtures in a multi-residential apartment building, e.g. toilets, faucets, showerheads, and clothes washers, with water-efficient models. Replacing existing fixtures with water-efficient products can typically reduce a multi-residential apartment building's water demand by 30 to 40 percent (Water Matrix, 2014). Multi-residential buildings contain numerous plumbing fixtures and present a significant opportunity to implement meaningful water savings for multi-residential building owners and/or condo corporations. Evidently, multi-residential buildings are less likely than single family homes to have water efficient fixtures installed. According to Statistics Canada, only 42 percent of apartments and 58 percent of multi-unit housing had water efficient fixtures by 2006, compared to 63 percent of single family housing (Gibbons, 2009).

Programs can be implemented to incentivize property owners to capture potential water savings through education, water auditing, and fixture replacement.

2.2 Program Details

2.2.1 Education

Information can educate owners on which fixtures provide the greatest water savings, return on investment, and installation (United States Environmental Protection Agency, 2010). Technology continues to evolve to produce better products and educational programming can be a valuable tool to inform owners of the latest trends. For example, owners who had previously participated in water saving retrofits would see increased savings with the new 3-litre flush toilets compared to 6-litre flush toilets that were once the benchmark for water efficiency technology (Water Matrix, 2014).

2.2.2 Audits

Audits are used to investigate and evaluate existing water usage. They are instrumental in determining water saving potential. Typically, historical water data is reviewed to determine if further on-site investigation is warranted. One item to consider for an audit is the age of the building. As of January 1, 1996, the Ontario Building Code has mandated 6-litre or less toilets, and the newer 2012 Building Code requires new residential construction or renovation to implement high efficiency 4.8 litre toilets. Other items to consider include number of units and seasonal or other influences on water demand (i.e. times of higher occupancy – such as in local student housing). An on-site audit will measure flows for each fixture, check for leaks and calculate potential water savings if replacements and retrofits are implemented.

2.2.3 Toilets

Inefficient toilets flush with more than 13.25 litres of water (volume is a conversion from the United States standard of 3.5 gallons). The United States Energy Policy Act of 1992 mandated that by January 1, 1994, all toilets sold in the United States could flush with no more than 1.6 gallons (6 litres). Due to the size of the United States marketplace compared to the Canadian marketplace, toilet manufacturers began to focus on developing new 6-litre toilet models, though many continued to produce 13.25-litre models for sale in Canada. On January 1, 1996 the Ontario Building Code required that all toilets installed in new construction projects flush with no more than 6 litres of water. This requirement prompted a complete shift in the Ontario toilet marketplace towards 6-litre toilet fixtures, and was finalized by the ban on 13-litre toilets in the province in 2010. As of January 1, 2014, the 2012 Building Code requires new residential construction or renovation to implement 4.8 litre toilets, and this will likely prompt a further shift towards the higher efficiency toilets.

In 2006 the United States Environmental Protection Agency initiated their WaterSense® product labeling program for water efficient products. To qualify for WaterSense® certification, toilet models flushed with no more than 4.8 litres of water and clear at least 350g of simulated waste in a single flush[1]. Almost immediately, toilet manufacturers began to focus on developing 4.8-litre toilets. Therefore, virtually all new toilet models being developed for the Canada/United States market flush with 4.8 litres or less. The most water-efficient WaterSense® certified toilet model (developed by the Canadian company Hennessey & Hinchcliffe Inc.) flushes with only 3.0 litres of water and yet has a flush performance rating (i.e., a Maximum Performance score) of almost twice the minimum requirement for WaterSense®. Over the last five years more than 120,000 of these 3.0-litre toilets have been installed in Ontario – most of these in multi-family residential apartment buildings (Water Matrix, 2014).

Several field-studies have identified that the average person flushes a toilet in their home about 5 times per day (American Water Works Association, 1999). As such, switching from a 13.25-litre toilet model to a 4.8-litre or 3.0-litre model will save an estimated 42.25 litres per capita per day or 51.25 litres per capita per day respectively. It is estimated that in the Greater Toronto area approximately 80 percent of the toilet fixtures being replaced in multi-family buildings are older 6-litre models, yet the overall water savings in these buildings is still generally between 20 and 35 percent, largely because many of the early-model 6-litre models provided poor flushing performance (sometimes requiring more than a single flush to remove waste), flushed with more than six litres of water, or had trim components that were susceptible to leakage (Water Matrix, 2014).

2.2.4 Showerheads

Showering constitutes one of the largest residential indoor water uses. A comprehensive 2013 single-family water demand monitoring program (Residential End Uses of Water 2013 Update) completed by the Water Research Foundation (United States) included two greater Toronto area municipalities,

[1] WaterSense® toilet models must also conform to the applicable requirements in ASME A112.19.2/CSA B45.1 and, if dual-flush, to A112.19.14.

Waterloo Region and Peel Region. The original 1999 Residential End Uses of Water Study by the American Water Works Association studied the residential water uses of 1000 residences in each of 14 study cities, with a final study group of 100 in each, throughout North America. Some of the results of these studies is summarized below in Table 2-1.

Table 2-1: Average Results from National Research Center Inc. and American Water Works Association studies on residential water use.

	Waterloo Region (2013)	**Peel Region** (2013)	**North America** (1999)
Showers Per Capita Per Day	0.55	0.68	0.75
Shower Duration	7.1 minutes	7.6 minutes	8.2 minutes
Shower Flow Rate	7.4 litres per minute	7.5 litres per minute	8.3 litres per minute
Volume Per Shower	53.4 litres	57.2 litres	65 litres

Based on these results, there is an indication that the volume of water used for showering was approximately 15 percent lower in 2013 than in 1999. It is likely that a significant portion of these savings is related to the development of a WaterSense® certification for showerheads in 2010 and changes in the Building Code[2].

The national standard for showerhead flow rate in both the United States and province of Ontario at this time (2015) is 9.5 litres per minute (2.5 gallons per minute). This is compared to the maximum flow rate allowed for a WaterSense® certified showerhead which is 20 percent lower at 7.6 litres per minute (2.0 gallons per minute).

In addition to water savings, using a more efficient showerhead will save energy by reducing hot water usage. It is estimated that an average family can save about $30 per year in reduced energy costs (Environmental Protection Agency, 2015). If both energy and water savings are considered, a typical home could save as much as $75 per year by installing a WaterSense® certified showerhead. This is based on multiplying the following factors together: a 20 percent savings on 65 litres per capita per day; 3 persons per home; 365 days per year; and $3.18 per cubic metre equals $45.27 per year. The expected savings in multi-residential buildings may be slightly lower because water and wastewater costs are typically incorporated in rental fees and so there is less motivation for tenants to reduce demands.

2.2.5 Faucet Aerators

There are two main types of faucet use in the multi-residential customer sector: lavatory (i.e., bathroom) faucet use and kitchen faucet use. The water use patterns for lavatory and kitchen faucet use is quite different. Kitchen faucets are commonly used to supply certain volumes of water by filling vessels such as sinks, pots, jugs, etc. As such, reducing the flow rate from a kitchen faucet has very little effect on water demands. Reducing flow rates will, however, increase the time required to fill the vessel and could potentially inconvenience the homeowner. This could perhaps cause the homeowner to revert

[2] Note that Codes and Standards identify the maximum flow rates allowed for showerheads and, as such, flow rates measured in the field tend to be less than the maximum allowed.

back to a higher flow rate fixture. This is the primary reason that WaterSense® has no plans to certify low flow rate kitchen faucets. Conversely, people often use lavatory faucets to wash their hands or face, or to rinse their toothbrush or razor. As such, reducing the flow rate of a lavatory faucet can reduce water demands; but since water demands associated with lavatory faucet use in the home is thought to be much less than demands associated with kitchen faucet use, the total volume of savings is not expected to be significant (69 percent of residential faucet use occurs in the kitchen versus the remaining 31 percent in the bathroom) (American Water Works Association, 1999).

2.2.6 Clothes Washers

A 2002 study by the National Research Center Incorporated (United States) found that clothes washer water use was 3.3 times greater in multi-residential buildings with in-suite laundry facilities than for buildings with shared or common laundry areas (123 versus 37 litres per suite per day) (National Research Center Inc., 2002). This study also identified that the number of loads per week was much higher for buildings with in-suite laundry[3]. However, a report by the Multi-housing Laundry Association identifies an average duty factor of 2.2 loads per day per washer for buildings with common laundry areas (Multi-housing Laundry Association, 2006). As such, the potential water savings is 2.2 times greater in multi-residential buildings with common laundry areas than in buildings with in-suite laundry. Energy Star estimates that inefficient washers use about 87 litres per load and efficient models use only 49 litres per load; representing a savings of about 38 litres per load (Energy Star, 2015). Based on these values, a clothes washer replacement program would be expected to save about 38 litres per day per machine in buildings with in-suite washers and about 84 litres per day per machine in buildings with common laundry areas.

2.2.7 Leakage

While reducing leakage is not specifically a “retrofit” action, in many cases changing out toilets, showerheads, and faucet aerators results in a significant reduction in leakage. In some cases, the volume of water saved through reduced leakage can equal or even exceed the water savings directly related to the fixture change-out. For example, a toilet leaking at 0.06 litres per minute will lose 86 litres per day. Replacing a 13.25-litre toilet with a 4.8-litre model will save 85 litres per day in an apartment with 2 occupants[4]. Companies specializing in multi-family fixture retrofit programs (e.g., Water Matrix) will record and repair any plumbing leaks they find as they move from suite to suite (the client is billed a set fee for each leak repair). As such, actual water savings are generally higher for multi-residential buildings than what would be predicted based on the fixture change-out alone.

2.2.8 Return on Investment: Customer

Mass fixture retrofit programs involve a capital investment by the customer to upgrade existing fixtures. The return on investment is a result of the savings from reducing water and energy demands. Financial incentives offered by municipalities will lessen the capital investment requirement of the property owner and, therefore, improve the return on investment for the property owner. The return on investment for

[3] 1 load per day per suite for in-suite laundry versus 0.4 loads per week per suite for common laundry facilities
[4] Values based on difference of 13.25 litres to 4.8 litres per flush, 5 flushes per capita per day, with 2 occupants.

any building is dependent on the financial value of the water and energy (if any) savings, the cost of the retrofit (materials and labour), and the size of financial incentive, if any.

Examples

Toilet Change-out: there are essentially three levels of water-efficient toilet types: WaterSense® certified 4.8-litre models, Maximum Performance PREMIUM 4.0-litre models, and Ultra-High-Efficiency 3.0-litre models (not yet adapted as an industry standard). Note that Maximum Performance PREMIUM and Ultra-High-Efficiency fixtures are also WaterSense® certified. As such, the following three levels of savings, summarized in Table 2-2, are possible.

Table 2-2: Return on Investment: Customer Levels

Level	Water Savings	Annual Cost Savings[5]	Return on investment[6]	Return on investment with $75 Royal Flush incentive
1	Replacing a 13.25-litre toilet with a 4.8-litre model will save 84.5 litres per day[7] or 30.8 cubic metres per year	$98	2.6 years	1.8 years
2	Replacing a 13.25-litre toilet with a 4.0-litre model will save 92.5 litres per day or 33.8 cubic metres per year	$107	2.3 years	1.6 years
3	Replacing a 13.25-litre toilet with a 3.0-litre model will save 102.5 litres per day or 37.4 cubic metres per year.	$119	2.1 years	1.5 years

Shower Change-out: replacing a 9.5 litres per minute showerhead with a 7.6 litres per minute WaterSense® certified showerhead in an apartment suite will save approximately 22.8 litres per day[8]. In Guelph this water savings equates to a reduction of $26 in annual water costs. Assuming that 70 percent of the water used in the shower is hot water[9], the new showerhead would save approximately 5.8 cubic metres of hot water per year. If this water were heated by natural gas, the cost savings would be about $8 per year[10]. Total savings in this example, therefore, is about $34 per year. Since the cost of a new WaterSense® certified showerhead can range from a low of about $10 to over $100, the return on investment could range from only 3 or 4 months to more than 3 years.

[5] At a volumetric cost of $3.18 per cubic metre.
[6] Based on an average cost for a new water-efficient toilet (supply and install) of $250, the return on investment would be about 2.5 years with no City incentive. Both 4.8-litre and 3.0-litre toilets have a fairly wide variation in price.
[7] Based on 2 occupants at 5 flushes per capita per day, 13.25 to 4.8 litres per flush.
[8] Based on 2 occupants taking 0.75 showers per day for 8 minutes, or 8.3 cubic metres per year.
[9] Based on cold water temperature of 50 degrees and hot water temperature of 120 degrees (Celsius).
[10] Based on a savings in natural gas of about 41.5 cubic metres per year.

Clothes Washer Change-out: replacing an inefficient top-loading clothes washer with a high-efficiency model is expected to save about 38 litres per day per machine in buildings with in-suite washers and 84 litres per day per machine in buildings with common laundry areas, or 13.9 and 30.7 cubic metres per year respectively. In Guelph this water savings equates to a reduction in annual costs of $44 per machine for buildings with in-suite laundry and $97 per machine for buildings with common laundry areas. Assuming that 22 percent of the laundry water is hot, the new washer would also save about $20 of hot water per year for in-suite laundry buildings and $44 per year for common laundry area buildings (National Research Center Inc., 2002). Total savings to the customer is about $64 per machine per year for in-suite laundry buildings and $141 per machine per year for common laundry room buildings.

2.2.9 Return on Investment: Municipality

The City of Guelph currently uses a value of $4.68 per litre per day when estimating the cost of adding additional water supply and wastewater treatment to their system[11] (AECOM and Golder Associates, 2014) (CH2M Hill, 2009). As such, water efficiency measures that affect both water and wastewater (e.g., toilet or shower replacement) need to cost the City less than $4.68 litres per day of savings to be considered cost-effective.

Examples

Toilet Change-out: as stated above, there are three levels of water-efficient toilets readily available in the marketplace: 4.8-litre models, 4.0-litre models, and 3.0-litre models. Since toilets with lower flush volumes would save more water, the City would be able to provide a higher rebate to those models. For example[12]:

- Replacing a 13.25-litre toilet with a 4.8-litre model will save approximately 84.5 litres per day. To be considered cost-effective, any rebate offered for this measure would need to cost the City less than $396 (i.e., 84.5 litres per day times $4.68 per litres per day = $396).
- Replacing a 13.25-litre toilet with a 4.0-litre model will save approximately 92.5 litres per day. To be considered cost-effective, any rebate offered for this measure would need to cost the City less than $433.
- Replacing a 13.25-litre toilet with a 3.0-litre model will save approximately 102.5 litres per day. To be considered cost-effective, any rebate offered for this measure would need to cost the City less than $480.
- Replacing an older 6.0-litre toilet with a 4.0-litre model will save approximately 20 litres per day. To be considered cost-effective, any rebate offered for this measure would need to cost the City less than $94.
- Replacing an older 6.0-litre toilet with a 3.0-litre model will save approximately 30 litres per day. To be considered cost-effective, any rebate offered for this measure would need to cost the City less than $140.

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[11] Based on $1.46 per litres per day for water supply infrastructure and $3.22 per litres per day for wastewater infrastructure.

[12] Based on 2 occupants and a single toilet per suite

Shower Change-out: replacing a 9.5 litres per minute showerhead with a 7.6 litres per minute WaterSense® certified showerhead in an apartment suite will save approximately 22.8 litres per day[13]. This savings would be worth $107 to the City, i.e. any rebate less than $107 that is offered by the city to achieve this level of water and wastewater savings per day would be considered cost-effective[14].

Clothes Washer Change-out (in-suite buildings): based on an equivalent cost of supply in Guelph of $4.68 per litres per day and a projected savings of 38 litres per day, the 'value' to the City is about $178 per efficient washer installed, e.g., any rebate less than $178 that is offered by the city to achieve this level of water and wastewater savings per day would be considered cost-effective.

Clothes Washer Change-out (common laundry room buildings): based on an equivalent cost of supply in Guelph of $4.68 per litres per day and a projected savings of 84 litres per day, the 'value' to the City is about $393 per efficient washer installed, e.g., any rebate less than $393 that is offered by the city to achieve this level of water and wastewater savings per day would be considered cost-effective.

These examples of return on investment are summarized in Table 2-3.

Table 2-3: Summary of Return on Investment Examples for Municipality

	Maximum Possible Rebate (City should offer less than for cost effectiveness)	**Water Savings** (litres)
Toilet Change-out		
13.25-litre to 4.8-litre	$396	84.5
13.25-litre to 4.0-litre	$433	92.5
13.25-litre to 3.0-litre	$480	102.5
6.0-litre to 4.0-litre	$94	20
6.0-litre to 3.0-litre	$140	30
Shower Change-out		
9.5 litres to 7.6 litres	$107	22.8
Clothes Washer Change-out		
In-suite Buildings	$178	38
Common Laundry Room Buildings	$393	84

2.3 Current Municipal Practice

Calgary, Alberta, currently offers rebates of $50 per toilet to multi-unit buildings with three or more living units that replace 13-litre or more toilets with WaterSense® certified fixtures (The City Of Calgary, 2015).

Richmond, British Columbia, offers a $100 utility tax rebate to both single-family and multi-family customers replacing older toilets flushing with 6-litre or more with 4.8-litre models (new toilets do not

13 Based on 2 occupants each taking 0.75 showers per day for 8 minutes.
14 Based on the equivalent cost of supply of $4.68 per litres per day.

have to be WaterSense® certified). There is a limit of 2 toilets per dwelling (City of Richmond British Columbia, 2015).

Red Deer, Alberta, provides rebates to customers that replace 13-litre toilets - $50 rebates if the new toilet flushes with 4.8-litre or less and $25 if the new toilet flushes with 6-litre (The City of Red Deer, 2015).

Seattle, Washington offers toilet rebates to multi-family buildings based on the flush volume of the toilet being installed; $75 per fixture for 4.8-litre models and $150 per fixture for 4.0-litre or less Maximum Performance Premium fixtures. All toilets must be WaterSense® certified. Buildings must have at least four living units and all toilets in the building must be replaced. Existing toilets must be pre-2004 models (Long Beach Water Department, n.d.).

Long Beach, California is currently offering an increased rebate to multi-residential apartments and condos to install very efficient 3.0-litre toilets and 5.7-litre per minute showerheads because of the impact of the historic drought in the area. The rebate has historically been $50 but has been increased to $200 per toilet-showerhead combination to increase participation. Buildings must have a minimum of five living units and existing toilets must flush with 6-litre or more. The website also notifies customers that, starting in 2017 in California, all multi-family housing must be fitted with water-efficient plumbing fixtures (e.g., 4.8-litre toilets) (Long Beach Water Department, n.d.).

British Columbia Hydro offers a $50 rebate to customers installing front-loading clothes washers with an Integrated Modified Energy Factor between 2.76 and 2.94 or top-loading washers with an Integrated Modified Energy Factor of 2.30 or higher. They also offer $100 rebates if the new washer has an Integrated Modified Energy Factor greater than 2.94 (British Columbia Hydro, 2015).

Pacific Gas and Energy Company has teamed up with approximately 30 water agencies in California to offer up to $150 rebates to customers purchasing and installing a qualifying Energy Star certified clothes washer. The new washer must be purchased and installed in 2015. Commercial models do not qualify for a rebate (Pacific Gas and Electric Company, 2015).

The City of Denver Colorado provides free water audits to their multifamily residential customers. A city inspector visits each apartment suite for about 3 to 5 minutes to complete the water audit (check for leaks and water savings potential). They note that some property managers conduct standard annual inspections at the same time (smoke detector checks, energy-efficient lighting improvements, vandalism, etc.) to decrease the disturbance to the residents. The city inspectors can typically complete 100 units per day. Each apartment suite is provided with a free water-efficient showerhead, lavatory faucet aerator, and kitchen aerator. The property manager is also provided with historical water consumption information for the site and information on available rebates (note that the City only offers toilet rebates to single-family customers and individual units in condos or townhomes, not for multi-residential apartment buildings) (Denver Water, 2015).

City of Winnipeg posts water savings tips for multi-family residential buildings on its website (City of Winnipeg, 2014). A number of indoor water savings tips are identified, including: reading the building water meter weekly, posting signs within each building promoting water efficiency, installing suggestion boxes in prominent areas within the building, replacing inefficient toilets, showerheads, and faucet aerators with efficient models, and using automatic dishwashers only for full loads.

WaterSense® labeled multi-family apartment buildings are fitted with WaterSense-labeled toilets, faucets, and showerheads as well as ENERGY STAR® qualified dishwashers and clothes washers (where applicable). Outdoors, WaterSense-labeled homes have water-smart landscapes that include regionally appropriate plant choices and, if irrigation systems or pools are installed, efficient technologies that help keep water use low (Environmental Protection Agency, 2012).

The Arizona Water Company (public utility) operates a multi-family residential indoor water audit program that offers free water audits to identify water savings opportunities in space cooling, sanitation, and other indoor water uses upon request from the customer. The auditor will present the customer with water savings recommendations along with a number of conservation pamphlets (Arizona Water Company, 2012).

Note: It appears that fewer municipalities are offering plumbing fixture rebates currently than, say, ten years ago. For example, Toronto, Peel Region, and York Region have recently phased out their toilet fixture rebate program. The reasons for cancelling their rebate programs may include a perception of no longer requiring the associated water savings or preferring to let the declining availability of inefficient fixtures in the marketplace lead to the installation of efficient fixtures over time. It should be pointed out that all three of these municipalities take all (or the majority) of their water supply from the Great Lakes.

2.4 Benefits and Barriers of Mass Retrofit Programs for Multi-Residential Settings

The following benefits and barriers (Table 2-4) are presented with respect to the mass retrofit programs for multi-residential settings.

Table 2-4: Summary of benefits and barriers associated with mass retrofit programs for multi-residential settings.

Benefits	Barriers
• Reduce installation costs for customers (property owners/managers for bulk-metered buildings and individual tenants for individually-metered buildings), potentially leading to more retrofits. • Most multi-residential apartment buildings and many condos are bulk-metered at the point where the water supply enters the building. As such, any reduction in water demand would reduce the overall water bill (cost of operations)	• Very few multi-residential apartment buildings have sub-meters on the water supply to each suite so the building's overall cost of water and wastewater is included in the monthly rental costs and divided equally among the suites. As such, there is no *direct* financial benefit to tenants to reduce water demands (though water savings may *indirectly* reduce the magnitude of future rent increases).

for the building vs. for individual tenants. For apartment buildings, this could either increase the profit for the building owner or reduce future rent increases for the tenants. For condos, a reduction in the cost of operations could be passed on to the tenants via reduced monthly maintenance fees. • Lower municipal water demands, which results in lower operational costs related to energy and chemical demands, as well as, potentially lower capital costs related to avoiding, downsizing, or deferring infrastructure. • One multi-residential owner can decide to retrofit numerous units (lower administrative cost per fixture change-out than for single-family customers). • Increase exposure for City water efficiency / conservation programs.	• Multi-residential buildings are typically bulk-metered at the point where the water supply enters the building and it is not generally possible to differentiate between any water saved by installing new toilets (for example) and water saved by installing new showers, faucet aerators, or clothes washers, or water savings achieved as the result of a tenant awareness program. As such, if more than one measure is implemented it is difficult to assess the return on investment for individual measures. • Perception of reduced flushing performance of low volume toilets and reduced "force" from low flowrate showerheads and aerators. • Tenants can easily and inexpensively remove/replace low-flow showerheads and aerators with higher flow rate models if they are not satisfied with the performance (it is unlikely that a tenant would replace a toilet or clothes washer). • City may be subsidizing a measure that may eventually be completed even with no rebate due to declining availability of inefficient fixtures in the marketplace.

2.5 Local Feasibility

As part of their Royal Flush program, the City of Guelph currently offers $75 rebates to multi-residential customers replacing toilets flushing with 13-litre or more with WaterSense® certified models. Offering a free multi-residential water audit could instigate a mass fixture retrofit where property owners have otherwise shown no initiative and be a well-received compliment to the Royal Flush Rebate Program. The City may also wish to consider offering rebates to customers that replace 6-L toilet models with WaterSense® certified fixtures that flush with no more than 4.8 litres or with MaP Premium fixtures that flush with no more than 4.0 litres (note that MaP Premium fixtures are also WaterSense® certified). Note that the City may wish to offer a lower rebate level if the rebate is based on water savings.

The City may also wish to develop a marketing program – possibly directly marketing applicable property management companies or City-wide broadcast marketing - outlining the water and cost savings, as well as the high level of customer satisfaction associated with multi-residential fixture change-out programs.

3.0 KEY CONSIDERATIONS

In bulk-metered apartment buildings tenants don't pay for the water they use and, therefore, they are less likely to be concerned with the efficiency of their plumbing fixtures or if their fixtures are leaking (unless the leak is noisy or otherwise disturbing). Property owners and managers are generally more inclined to replace old and inefficient plumbing fixtures if doing so is financially beneficial to them and the return on investment is relatively short. In bulk-metered buildings any City rebate would be sent directly to the property owner/manager.

In individually-metered apartment buildings tenants do pay for the water they use and the City's rebate program would be similar to their single-family program, i.e., the rebate would be sent directly to the tenant replacing their toilet.

Condo buildings may or may not be individually metered. Some condos may allow tenants to make certain physical changes inside their unit without condo board approval and others may not. As such, programs developed for the condo market will need to be flexible to allow for various different scenarios.

Any rebate provided by the City to a multi-residential customer for the replacement of inefficient plumbing fixtures with high-efficiency models will reduce the upfront retrofit purchase and installation costs; the resulting water savings (from reduced flow rates, flush volumes, and leakage) will reduce the customers' ongoing utility costs. Payback periods of less than two years are easily achievable for toilets and showerheads, payback periods for clothes washers are typically greater than 7 years. The installation of new fixtures may also increase tenant satisfaction and the value of the property.

Helping customers reduce their water demands is also a benefit to the City. Lower demands means lower energy and chemical costs for treatment and pumping, and potentially lower capital costs related to avoiding, downsizing, or deferring infrastructure expansion projects. Based on an equivalent cost of supply/treatment construction (water and wastewater) of $4.68 per litres per day of capacity, the value of the water savings achieved by mass fixture change-outs in multi-residential buildings can be significant, e.g., over $400 per toilet when 13-litre fixtures are replaced and approximately $100 per toilet when 6-litre fixtures are replaced. Note that these savings values do not include any reductions in demands because of reduced leakage. As such, the City may wish to consider offering rebates (albeit lower value rebates) for the replacement of older 6-litre toilet fixtures.

The replacement of inefficient (and potentially leaking) plumbing fixtures and appliances in multi-residential apartment buildings with new WaterSense® and/or Energy Star certified high-efficiency products has the potential to benefit the customer, the tenant, and the City.

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To:	**Emily Stahl**	Company:	**City of Guelph**
From:	**Sam Ziemann**	Our File:	**75-41-151088**
Cc:	**Wayne Galliher, Julie Anne Lamberts**	Date:	**8 September 2015**
Subject:	**On-Bill Efficiency Repayment Systems, Local Improvement Charges Financing & Other Alternate Incentive Models for Water Efficiency Programming**		

CITY OF GUELPH

ON-BILL EFFICIENCY REPAYMENT SYSTEMS, LOCAL IMPROVEMENT CHARGES FINANCING & OTHER ALTERNATE INCENTIVE MODELS FOR WATER EFFICIENCY PROGRAMMING

C3 WATER INC.

8 September 2015

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	June 25, 2015	Draft On-Bill Efficiency Repayment Systems TM	Andrea Williams	Bill Gauley
2	September 3, 2015	Final On-Bill Efficiency Repayment Systems TM	Bill Gauley	Sam Ziemann

Table of Contents

1.0 INTRODUCTION

The 2015 Water Efficiency Strategy Update will identify a set of preferred program alternatives, associated water savings, program implementation forecasts, and supporting program resources required to achieve the water demand reduction targets outlined in the 2014 Water Supply Master Plan. The objective of this report is to summarize incentive models that could be used to promote Guelph's water efficiency programming moving forwards. These incentive models include: on-bill efficiency repayment systems, local improvement charges, capacity buyback programs, and tax incentives.

2.0 ON-BILL EFFICIENCY REPAYMENT SYSTEMS

2.1 Definition

An on-bill efficiency repayment system is an innovative method for communities to invest in water efficiency improvements. These types of programs, which have been implemented in Britain and the United States since the 1990s (National Grid, Britain and New London Resource Project, Wisconsin), have experienced a recent surge in popularity. On-bill financing allows customers to make immediate improvements and achieve immediate water savings – for example, to purchase an efficient fixture or appliance, or to install a more efficient process – while spreading the associated payment costs over time. Program participation can "reduce utility bills, improve the value of the property, create new jobs, and deliver efficiency to the utility, which works to lower energy bills for everyone and reduce pollution" (Natural Resources Defense Council, 2013).

As stated by American Council for an Energy-Efficient Economy, "No two on-bill programs are exactly alike" (Bell C. , 2011). Each program can be customized to suit community and customer needs. Either structured as a loan, tariff, or lease, the customer repays for the fixture, appliance, or service via an additional fee on their utility bill until repayment is complete – often over several years.

In *Loan-Based Systems*, the financial obligation is assigned to the participating customer. Loans can either be supplied by the utility itself or by another lender - such as a financial institution. With default rates typically lower than 2 percent, on-bill financing provides a safe opportunity for financial institutions to leverage the utility's relationship with the customer (American Council for an Energy Efficient Economy, 2012). Some of the most successful loan-based systems in the United States are financed through a *public benefits fund* (supported through very small surcharges added to customers' utility bill) and administered by utilities. This system works well where repayment periods don't exceed the expected time when a customer resides at the property. A *service-level agreement* between the landlord and the tenant regarding payment by the tenant can be used in the multi-family customer sector where landlords typically pay the utility bills. This would be treated along the same lines as the rest of utility bill procedures between landlords and tenants.

In *Tariff-Based Systems* the financial obligation is tied to the customer's water meter so it transfers to a new owner if the property is sold. This system tends to work well for single-family residential and small industrial customers. While utilities can implement these incentive systems without too much effort, there will be an increase in administration costs. In *Lease-Based Systems*, the utility or City would lease the equipment to the customer for a set fee that would be continually present on the bill, a similar process to a water heater rental.

2.2 Current Municipal Practice

The use of on-bill financing to support efficiency improvement programs is becoming more popular across North America. Currently, utilities in at least 23 states in the United States have implemented or are about to implement on-bill financing programs, many of which already have legislation in place that supports adoption including: Illinois, Hawaii, Oregon, California, Kentucky, Georgia, South Carolina, Michigan, and New York.

In Canada, the City of Toronto's Home Energy Loan Program offers low interest loans to homeowners interested in improving the energy and water efficiency of their home. The City provides the funding to complete the improvements and the homeowner repays the City over time through installments on their property tax bill. The financing in this case is attached to the property and not the homeowner.

In March 2015, the Ontario Ministry of Energy posted amendments to Ontario Regulation 161/99 under the Ontario Energy Board Act (1998) and Ontario Regulation 160/99 under the Electricity Act (1998) (Government of Ontario, 2015). These amendments clarified that utility led on-bill financing for electricity conservation and demand management measures are activities that electricity utilities can undertake. While this proposed amendment is specific to electricity utilities, the government is also encouraging other utilities (e.g., natural gas) to offer on-bill financing (Service Ontario, 2015).

Other examples of current programs include:

- National Grid - An investor-owned electricity and gas company servicing the United States and Great Britain, National Grid has offered on-bill financing for small business customers since the 1990s (Natural Resources Defense Council, 2013). Between 2011 and 2008 the program provided over 16,000 loans (Bell, Nadel, & Hayes, 2011). By 2011, the program began to implement financing for residential customers as well (Bell, Nadel, & Hayes, 2011).
- United Illuminating (Connecticut) - Offers interest-free on-bill loans to small commercial customers that upgrade or replace existing electrical equipment with high-efficiency equipment (Natural Resources Defense Council, 2013). The project size ranges from $8,000 to $12,000 and is financed over 24 to 36 months (Local Clean Energy Alliance). The program is operating at capacity and the company has shifted some marketing funds into additional rebates and loans. One key finding in this program was that extending payback periods for loans more than doubled the participants (Bell, Nadel, & Hayes, 2011).
- San Diego Gas & Electric - Offers eligible customers zero-percent financing for qualifying energy-efficient business improvements (San Diego Gas & Electric, 2014).
- Southern California Gas Company - Offers qualified non-residential customers zero-percent, unsecured loans up to $100,000, or up to $20,000 for homeowners, to finance the purchase and installation of eligible measures (Southern California Gas Company, 2015). Monthly payments are added to the customer's utility bill. Repayment terms are from one to ten years and there is no penalty for early repayment (Southern California Gas Company, 2015).

Between 2006 and 2011, the program had extended 856 loans to a total of 20.8 million dollars (Bell, Nadel, & Hayes, 2011).

- Pacific Gas and Electric - Produced an on-bill financing customer and contractor handbook outlining customer eligibility, projects/measures eligibility, fees and interest, etc. (Pacific Gas and Electric Company, 2014).
- Clean Energy Works Oregon – This loan-based on-bill financing program targets single family and multi-family residential sectors. The loan is transferrable at property sale to new owners for a fee. The median loan size was $12,633 in the pilot phase, with a 20 year repayment term. On average, the improvements in energy efficiency save 4,249 kilowatt hours and 380 therms annually (American Council for an Energy Efficient Economy, 2012). In mid-2011, there had been 599 participants in the program.
- South Carolina has on-bill financing programs to apply retrofit measures that promote energy efficiency. The programs, as of 2011, were expected to reach 185,000 to 195,000 houses and were estimated to save an overall 2,668,800 megawatt hours and 2.4 million tonnes of carbon dioxide emissions annually (Bell, Nadel, & Hayes, 2011). Estimates from Coastal Carolina University claims that the on-bill financing program will provide and support 7,113 jobs by 2030 (Bell, Nadel, & Hayes, 2011).

2.3 Benefits and Barriers

There are benefits to implementing on-bill financing as well as barriers in implementing a successful program, as presented in Table 2-1. Overall, on-bill financing is a financial collection mechanism that is, in many ways, uniquely positioned to reduce first-cost barriers.

Table 2-1: Summary of benefits and barriers associated with on-bill financing.

Benefits	Barriers
• Drastically reduces or eliminates 'first costs' for customers. • Can align timing of costs with benefits. • Leverages existing billing relationship. • Can operate concurrently with a rebate program to reduce the total amount financed. • Financing can be tied to a property so that debt transfers across owners/tenants. • Customer bill payment history can be used instead of or to complement a full credit report. • On-bill financing is a versatile financing tool	• Utility may not have the technical and administrative capacity or expertise to support an on-bill financing program. • Utility may not wish to become lending institution. • Customer may take efficient fixture or appliance with them if they move, thereby eliminating the savings. • On-bill financing may require a redesign of utilities' billing systems. • Equity considerations if program is funded by all customers (tax payers) but only a limited number of customers benefit from

that can be combine with a variety of different sources of capital and implementation strategies.	the program. • Need for marketing and education – availability of financing doesn't guarantee participation and many customers may not be familiar with how financing options operate.

2.4 Local Feasibility

About 75 percent of a single-family residential customer's annual water bill in Guelph is directly related to the volume of water they use. Therefore, a customer that significantly reduces their water demands will see a significant reduction in their water bill. Due to this fact, the City's billing structure lends itself to the implementation of a successful on-bill financing program. Consider the following example:

Example – Single-Family Home Installing Water Efficient Toilets

- Based on a current (2015) water/wastewater volumetric rate of $3.18 per cubic metre and basic fee of $0.58 per day, a family of three using 157 litres per person per day would have an annual water bill of $908.
- If the family replaces three existing 13.25 litre toilets with water-efficient 4.8 litre models they would save 46 cubic metres each year and reduce their annual water bill by $147.
- If the total cost to replace three toilets was $600, the payback period, without including interest, would be 4.1 years.
- The homeowner would see no reduction in their water bill for the first 4.1 years (until the loan was fully paid) but then they would see an annual reduction of $147 on their water bill and a total net benefit of $2,337 over the expected twenty year lifespan of the new toilets. Note that these values do not include inflation.
- If an annual interest rate of 2.4 percent was used, the cost to the City to provide the 4.1-year loan to purchase four efficient toilets would only be about $30, or about 10 percent of the cost of providing four toilet rebates at $75 each.

In the example above, the efficiency loan can be fully paid by the customer in a relatively short period of time with high net benefits to both the City and the customer. Of course there are other examples where the loan payment term will be much longer or the benefits to the customer or the City are far lower. Therefore, the City should consider establishing eligibility parameters regarding the program, such as: limitations on the duration of expected payment terms, on-bill financing's applicability to each customer sector (single-family residential, multi-family residential, industrial, commercial, and institutional customers), limits on the value of the loan, etc.

3.0 LOCAL IMPROVEMENT CHARGES

3.1 Definition

A local improvement is a project undertaken by municipality that provides a benefit to properties in a specific vicinity within the municipality, such as sidewalks, sewers, traffic calming features, and water and wastewater infrastructure (Persram, 2013). Local improvement charges are fees imposed by the municipality on those property owners in the specific vicinity that benefit from the local improvement. These charges allow the municipality to recover all or part of the cost of the project. This incentive model can be used in single family residential, multi-family residential, commercial, and industrial sectors (Boyd, 2013). Municipalities can use the local improvement process to undertake work on both public and private property.

3.2 Current Municipal Practice

Local improvement charges are legislated under the Ontario Municipal Act, 2001. On October 25, 2012, the Minister of Municipal Affairs and Housing filed an amendment allowing Ontario municipalities to use local improvement charges to finance private sector conservation projects with repayment of loans on the property tax billing system (Association of Municipalities Ontario, 2012). Local improvement charges are currently used by several Canadian municipalities, including the City of Vancouver, Peel Region, the City of Edmonton, the City of Oshawa, and the City of Toronto. Payment periods vary depending on the project and the city in question, but generally range between 5 and 15 years (Pembina Institute, 2004). Many municipalities allow property owners the option of paying the charge as a lump sum or through annual installments on their property tax bill. Peel Region further allows owner-initiated local improvements to use the local improvement charges system (Pembina Institute, 2004). Local improvement charges are largely eligible only to existing built forms and not for Greenfield developments.

In July 2013, the Toronto City Council unanimously approved its first pilot local improvement energy and water efficiency program called the Home Energy Loan Program. This is a three-year, $20 million pilot program involving 1000 single-family homes and 10 multi-residential buildings located in specific areas of the city (Shedletzky, 2013). Property owners will repay this investment to the city via a special charge on their property tax bills. The program is intended to be easy to implement and self-funded with no transfer payments required from the City. The customer charge, which is based on the area and age of the home, is intended to be equivalent to, or less than, the energy or water savings accruing to the property owner (Shedletzky, 2013).

3.3 Benefits and Barriers

There are benefits to implementing local improvement charges as well as barriers in implementing a successful program, as presented in Table 3-1.

Table 3-1: Summary of benefits and barriers associated with local improvement charges.

Benefits	Barriers
• Customers receiving benefit pay associated costs. • Charges are intended to operate at zero net cost to the city. • Municipality is able to spread the cost of local improvement over several	• Since local improvement charges are tied to the property, there may be a disincentive for homeowners to participate in the program if they expect to have a short or uncertain stay in the home. • When the local improvement involves

years to minimize the annual payment required from affected property owners. • Mechanism for collecting improvement charges by a municipality currently exists – the property tax system. • Since the local improvement charges are included on the owner's property tax bill, they are tied to the property. Unpaid property taxes or improvement charges would be subject to a "tax lien" which would have priority over other debts on the property, including mortgages. • Any increase in property value arising from a local improvement would be beneficial to the property owner.	measures such as new sidewalks or roadways, the charges can often be calculated in advance based on the length of the property abutting the improvement. It may be more difficult to develop a fair charge schedule for improvements to local water and/or wastewater systems since it can be more difficult to identify each customers' benefit resulting from the local improvement charge. • Potential legal risks from unsatisfied clients should the program or anticipated savings not meet expectations.

3.4 Local Feasibility

The City of Guelph is developing a program called Guelph Energy Efficiency Retrofit Strategy that takes advantage of the local improvement financing from the City with repayment on the property tax bill (Chapman, 2015). As such, there may be a potential to collaborate and market both programs (water and energy) as a single package. The local improvement charge mechanism allows for individual properties to voluntarily join the program. The financed efficiency measures would have to be possible to implement in an individual basis, with each property gaining the benefits.

4.0 CAPACITY BUYBACK PROGRAMS

4.1 Definition

Capacity buyback programs allow the utility to pay customers a rebate tied directly to the average volume of water they save on a daily basis when they implement approved permanent process or equipment changes. This is a one-time cash rebate typically based on a predetermined rate (i.e., a specified dollar value per litre per day) for verified water savings. This type of program is usually most applicable to the Industrial, Commercial and Institutional sectors where it is difficult to estimate in advance the expected average volume of water savings that would achieved by implementing a measure.

4.2 Current Municipal Practice

Many municipalities across Canada and the United States operate capacity buyback programs, including Guelph, Toronto, Peel Region, and York Region. All of these programs operate in essentially the same manner – an approved auditor arranges to conduct a site visit at the participating facility. Generally, one or more suitable site staff accompanies the auditor during the site visit to act as a guide and to provide an explanation of how water is used by the facility. Where the auditor feels there may be an opportunity to reduce demands in the facility they often install monitoring equipment (e.g., sub-meter and data logger). When the audit is completed (including any monitoring) the auditor prepares a "Pre" report that includes a brief description of the facility, how water is used within the facility, and a number of recommendations on how the facility can reduce water use. For each recommendation the auditor identifies the potential volume of water savings, the potential cost savings, the associated rebate amount (which is based on the volume of water saved on a daily basis), an estimate of the implementation costs, and the estimated return on investment. A copy of the “Pre” report is provided to both the facility and the city. After a facility implements one or more of the recommended measures, the auditor will verify the water savings and prepare a "Post" report outlining what measures were implemented and what savings were achieved.

4.3 Benefits and Barriers

There are benefits to implementing capacity buyback programs as well as barriers in implementing a successful program, as presented in Table 4-1.

Table 4-1: Summary of benefits and barriers associated with capacity buyback programs.

Benefits	Barriers
• Allows for ‘out of the box’ innovations to be included because the rebate is based on actual water savings. • Easy to change incentive rate. • Incentive based on verified savings, therefore fair to customers and to City. • Incentive is usually lower on a litre per day savings basis than other rebates (i.e. toilet rebates).	• Obtaining sufficient participation in the program. • Sometimes difficult or costly to verify savings. • Savings can vary from day to day or season to season. • It may take months or years for companies to secure necessary budget for large projects.

4.4 Local Feasibility

This form of incentive program is currently used in Guelph (and many other municipalities such as Peel Region, York Region, and City of Toronto) for the industrial, commercial and institutional customer. The simple method of determining water savings (i.e. basic rate calculations) could allow for innovations that do not fit Guelph’s current water efficiency programming.

5.0 TAX INCENTIVES

5.1 Definition

Tax incentives are a tool to provide incentives to existing and new construction opportunities. For example, in cases where the upfront cost of the water-efficient fixture, appliance, or process is far greater than the cost of the inefficient model, a tax incentive may help ‘tip the scales’ towards selecting the efficient model. One common example of a tax incentive is accelerated depreciation, which allows the consumer to depreciate the value of the water efficiency product more quickly than normal in order to offset, partially or fully, the initial investment capital in an accelerated manner.

5.2 Current Municipal Practice

In 2002, New Jersey passed bills to provide business tax credits and sales tax refunds for water reuse in industrial processes. The program provided business tax credits of up to half of the purchase cost of the equipment and a full sales tax credit to the customer. To receive these tax incentives, the business must first obtain a determination of environmental benefit from the government and submit it to the Department of Taxation.

Arizona taxpayers who install a "water conservation system" (defined as a system to harvest residential greywater and/or rainwater) can take a one-time tax credit of 25 percent of the cost of the system (up to a maximum of $1,000). Builders are eligible for an income tax credit of up to $200 per living unit constructed with a water conservation system installed.

In Mexico, renewable energy infrastructure projects are able to depreciate up to 100 percent in the first year, in comparison to only 2 percent for real estate investing. Water treatment plants can qualify if they convert their waste to energy or if they practice water recycling.

The State of Texas offers tax incentives for purchasing ozone treatment or water reuse equipment. In fact, ozone laundry systems and laundry water reuse systems are exempt from sales tax and, in many cases, from property tax.

The National Urban Water and Desalination Plan in Australia, implemented in 2008, will fund 10 percent of a project's capital cost up to $100 million in Australian currency with the specific funding structure to be worked out on a project-by-project case either through grants or tax offsets. Payments are generally made after agreed upon milestones have been completed. Eligible projects must provide water to an urban population of at least 50,000 and have eligible capital costs of at least $30 million. The projects must have all of their energy needs met by renewable energy or they must buy carbon offsets.

5.3 Benefits and Barriers

There are benefits to implementing tax incentives as well as barriers in implementing a successful program, as presented in Table 5-1.

Table 5-1: Summary of benefits and barriers associated with tax incentive programs.

Benefits	Barriers
• Reduces upfront costs for customer. • Relative easy to calculate incentive amounts.	• May require government involvement beyond the municipal level. • May involve providing funding for unsuccessful or inefficient projects.

5.4 Local Feasibility

Implementing both rebate programs and tax incentive programs may be redundant in Guelph. A tax incentive program would require further provincial government involvement and detailed planning before implementation would be possible at the municipal level.

6.0 KEY CONSIDERATIONS

Of the four potential measures outlined in this Technical Memo, the simplest and easiest to implement is the capacity buyback program. Capacity buyback programs are fair and equitable to both the City and the customer since the rebate amount is directly proportional to the level of water savings achieved by the measure. They also offer a level of security to the City since the rebate is not paid to the customer until the water savings has been achieved. Capacity buyback programs can be cost-effective for the City to implement because the rebate rate for litres per day savings is usually much lower than the rebate rate offered for the replacement of residential fixtures and appliances. What's more, Guelph currently has a capacity buyback program in place. As stated earlier, one of the biggest barriers to implementing a successful capacity buyback program is obtaining sufficient participation from industrial, commercial, and institutional customers.

On-bill financing is generally tied to the cost of the measure versus the anticipated water savings. Offering on-bill financing can be effective if one of the primary impediments to customer participation is the cost. Many of the common indoor residential water efficiency measures have relatively low costs (e.g., toilets, showerheads, faucet aerators, clothes washers) so offering on-bill financing for these measures may have minimal impact on participation rates. Outdoor residential measures (e.g., landscaping, irrigation systems) typically have much higher costs but it is also much more difficult to estimate the associated potential for water savings if the City is not involved in the design and construction of the project. As such, on-bill financing may not be ideally suited for the residential customer sector.

While on-bill financing may be better suited to the industrial, commercial, and institutional customer, unlike a capacity buyback program, it is difficult to link the City's cost of financing to the volume of water saved on an individual customer basis. However, the City should investigate including an on-bill financing option with their current capacity buyback program to help link program costs with program water savings. Combining financial rebates with on-bill financing might also help increase the number of industrial, commercial, and institutional sites participating in the capacity buyback program.

The barriers associated with implementing a local improvement charge or tax incentive program directly related to improving water efficiency appear to be more challenging than those associated with implementing a capacity buyback or on-bill financing program. Since offering too many program options may be confusing to the customer it is recommended that the City concentrate on their capacity buyback program and investigate including an on-bill financing element in that program.

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To:	**Emily Stahl**	Company:	**City of Guelph**
From:	**Sam Ziemann**	Our File:	**75-41-151088**
Cc:	**Wayne Galliher, Julie Anne Lamberts**	Date:	**August 31, 2015**
Subject:	**Private Customer Leak Detection Notification Technologies**		

CITY OF GUELPH

PRIVATE CUSTOMER LEAK DETECTION NOTIFICATION TECHNOLOGIES

C3 WATER INC.

31 August 2015

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	July 7, 2015	Draft Private Customer Leak Detection Notification Technologies	Bill Gauley	Sam Ziemann
2	August 31, 2015	Final Private Customer Leak Detection Notification Technologies	Bill Gauley	Sam Ziemann

Table of Contents

1.0 INTRODUCTION

The 2015 Water Efficiency Strategy Update will identify a set of preferred program alternatives, associated water savings, program implementation forecasts, and supporting program resources required to achieve the water demand reduction of the 2014 Water Supply Master Plan. As part of the strategy scope, a series of technical memos are being prepared on technology and policy areas of opportunity, as identified through ongoing program operation, industry best practice research and common areas of customer/stakeholder inquiry. The objective of this report is to outline private customer leak notification technologies.

2.0 PRIVATE CUSTOMER LEAK NOTIFICATION TECHNOLOGIES

2.1 Definition

Perhaps the greatest waste of water in a municipal system is water lost through leakage, both in the distribution system and after it has been delivered to the customer. Even a relatively small leak can lead to significant water loss if the water is lost 24 hours per day. While a customer can easily identify a dripping faucet or showerhead, some leaks are more difficult to identify. For example, a leaking toilet can waste 700 litres of water per day yet go unnoticed for months. Some leaks can be underground, like an irrigation system leakage, or hidden, as with a water softener stuck on bypass. While the presence of a large leak can make itself known to the customer via an unexpected "spike" in the water demand and an associated increase in the water bill, smaller leaks may cause only a moderate increase in water demand and, therefore, go unnoticed by the customer. The United States Environmental Protection Agency estimates that the average household loses about 100 litres per day in leakage with the top 10 percent of homes losing more than 340 litres per day in leakage (United States Environmental Protection Agency, 2015).

2.2 Types of Programs

2.2.1 Passive Informational Programs

Information to help customers find and repair leaks can be found on many municipal websites, including the City of Guelph's Fix a Leak Web page, and included with customer water bills (see Figure 1). Other municipalities have advertised on radio, TV, magazines, etc. Messages can include:

- Identifying average per capita or per household water demands within the community.
- Noting the customer's current demand is higher than their average demand for the same time of year to prompt the customer to check for leakage within the home,
- Noting the customer's demand is higher than the average demand in their neighbourhood to prompt the customer to check for leakage within the home,
- Noting that an unusually high water bill may be the result of a leak.

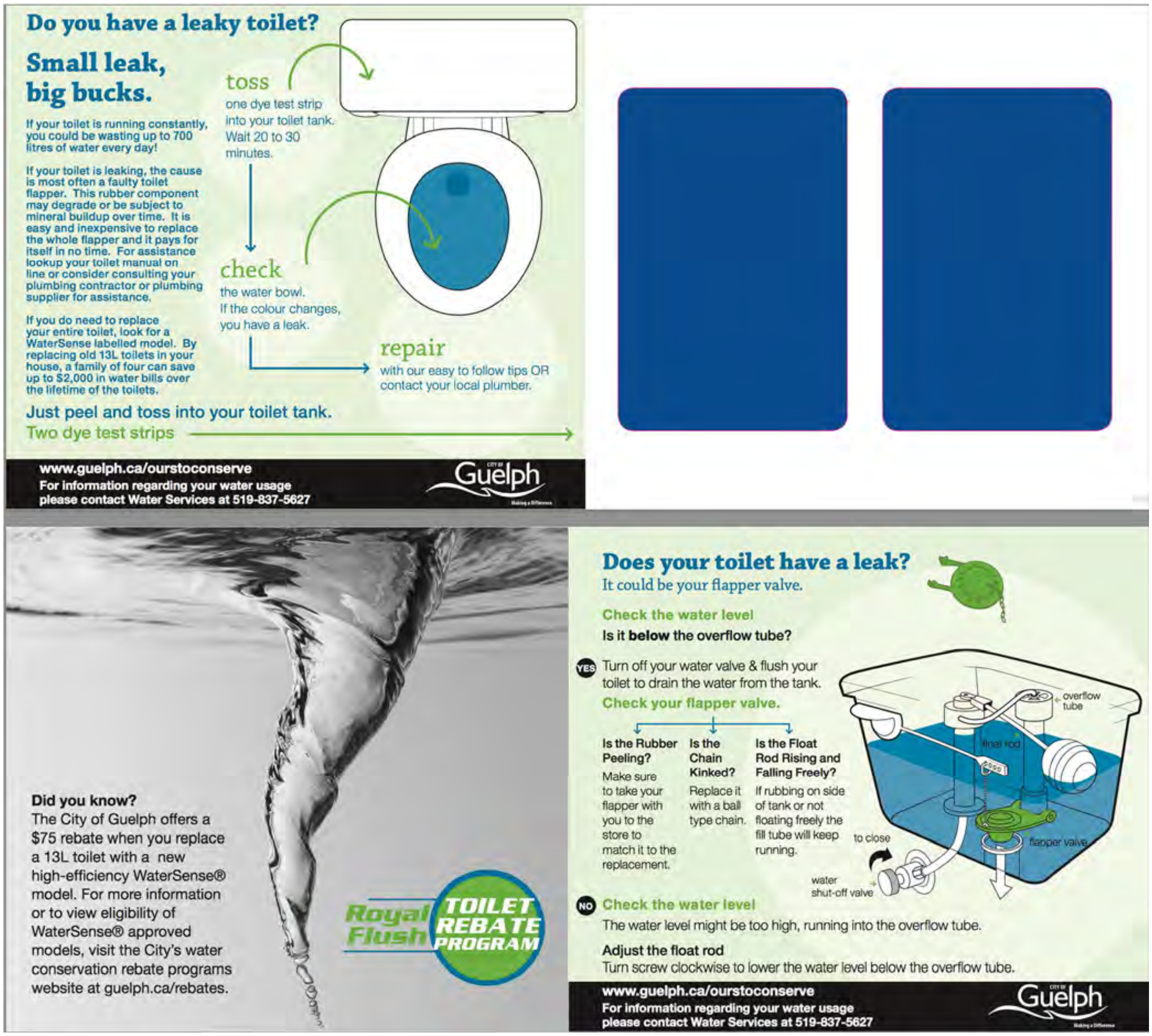

Figure 1 – Example of Bill Stuffer

Other messages explain how the customer can use their water meter to check for leaks. For example, the customer can read their water meter right before they go to bed and then again first thing in the morning, or after any extended period when no water is being used. If the meter reading is higher on the second reading there may be some leakage in the home. Or, if their water meter has a low flow indicator, they can inspect this during a period when no water is being used in the home – a rotating low flow indicator might indicate the presence of leakage (Figure 2).

Figure 2 – Examples of Low Flow Indicators

If the homeowner suspects leakage they should inspect all faucets and valves for drips and leaks indoors and outdoors, including: water heaters, water softeners, floor drain primers, clothes washers, dish washers, hose bibbs and irrigation systems. If no leak can be found the homeowner should inspect their toilets as the most common source of leakage in the home. First they should look and listen for obvious signs of leakage, such as the toilet is re-filling even though it wasn't flushed, or the water in the bowl has ripples. Next they should add food colouring, a toilet dye strip, or a leak detection tablet to the water in the tank and, without flushing, wait a few minutes – if the coloured water in the tank has seeped into the bowl then there is a leak.

It is important to engage customers to periodically check for leaks since it is very difficult for the municipality to determine if there are leaks unless they are significant. Unfortunately, small leaks may also be ignored or unnoticed by the customer. However, even the water lost through apparently small leaks can add up. For example, a faucet leak of one drop per second wastes 25 litres per day and a small toilet leak of 0.1 litres per minute would equate to a water loss of 144 litres per day, an extra $167 per year on the water bill. Note that the City of Guelph, like many other municipalities, does not have cost forgiveness policies for water lost through leakage, so it is in homeowners' interest to monitor and manage leakage to avoid potentially significant costs.

2.2.2 Active Notification Programs

Communities using automatic meter reading technology for water customers can access near real-time demand data for each customer. As such, it is possible to determine if a customer's water use pattern is indicative of leaking in the home. For example, a continuous demand over several days or unusually high demands may indicate a leak. Some communities with automatic meter reading systems use programs to evaluate their customers' water demands on a continual basis and send notifications to customers with demand patterns that may indicate leakage. Automatic meter reading systems using wireless radio frequency-based technology work best for this application as they do not require a meter reader to 'walk by' or 'drive by' each customer.

2.2.3 In-home Measures

There are two basic types of home leak detection devices: flow-based and sensor-based. Flow-based systems use a flow sensor and automatic shut off valve; any flow through the meter that could indicate a potential leak will trigger an alarm and shut off the water supply to the home or, in some cases, to the appropriate appliance. Sensor-based systems rely on placing sensors in high-risk locations within the home, such as near a water heater or clothes washer. When the sensor detects water it can sound an alarm and/or send a signal to shut off the water supply to the home.

An example of a flow-based device is the FloLogic (FloLogic, 2015). This device has a flow sensor that can detect both major leaks (e.g., a burst pipe) and slow leaks (e.g., a leaking toilet flapper). When a potential leak is identified, the device can automatically sends a text alert to a smart phone and/or automatically shuts off the water supply to the home. The cost of the FloLogic system is approximately $2,000. Other examples of similar devices include:

- Leak Defence System, approximately $2,700 (Water Security Solutions, 2015)
- Water Hero (Water Hero Inc., 2014) - note: this product does not appear to be commercially available at this time
- LeakSmart (leakSMART, 2014) - note: this product does not appear to be commercially available at this time

An example of a sensor-based device is the FloodMaster (Flood Master, 2015). The device has a sensor puck that is placed in an area within the home that might be prone to leakage, such as near the water heater or clothes washer. If the sensor puck comes in contact with water the device can sound an alarm and/or shut off the water supply to specific appliances such as a clothes washer or water heater, or to the entire home with the shutoff motor. The cost of the FloodMaster is approximately $300. The sensor-based systems tend to be less expensive than the flow-based system because they only monitor for the presence of water and not the pattern of water demands in the home.
Other examples of similar devices include:

- WaterCop, approximately $500 (DynaQuip, 2015)
- PipeBurst Pro, approximately $850 (PipeBurst Pro, 2015)
- Floodstop, approximately $250 (OnSite PRO Inc., 2015)
- leakSMART (leakSMART, 2014) note: this product does not appear to be commercially available at this time
- Leak Gopher, approximately $450 (Leak Gopher, 2015)

There are also less expensive sensor-based leak detection devices that can send a notification to smart phone if they come in contact with water but are not able to shut off the water supply to the home. These devices are designed to help reduce property damage caused by broken pipes or a leaking basement rather than to identify a leaking toilet, faucet, or showerhead where the leaking water just flows down the drain and not onto the floor. Two examples of this type of leak detection device are:

- INSTEON Leak Sensor approximately $40 (The Home Depot, 2015)
- Zircon Leak Alert, approximately $20 (Zircon, 2014)

2.2.4 Customer Portals

Some agencies, like Park City, Utah, enable customers to review their current and historical water demands online via a customer portal. Customers can log on to their account and view a detailed analysis of the home water use and receive personalized water savings recommendations. Park City's system, which employs an advanced meter infrastructure system, will also email customers if their water demand pattern indicates a potential leak. As of May 2014, Park City (population 8,000) had delivered over 150 potential leak alerts to customers, 70 percent of which were addressed within 10 days of receiving the notification (WaterSmart Software, 2015).

Another customer portal system - the AquaHawk system – is used by the Dublin San Ramon Services District in California (Dublin San Ramon Services District, 2015). This system allows the customer to set their own water demand targets in volume or cost and to receive texts or email notifications if they exceed their target or if their demand pattern is indicative of leakage. Note that homes must be connected to a wireless automatic meter reading system. The portal provides homeowners with a great deal of information - a screenshot of the portal is provided below (Figure 3).

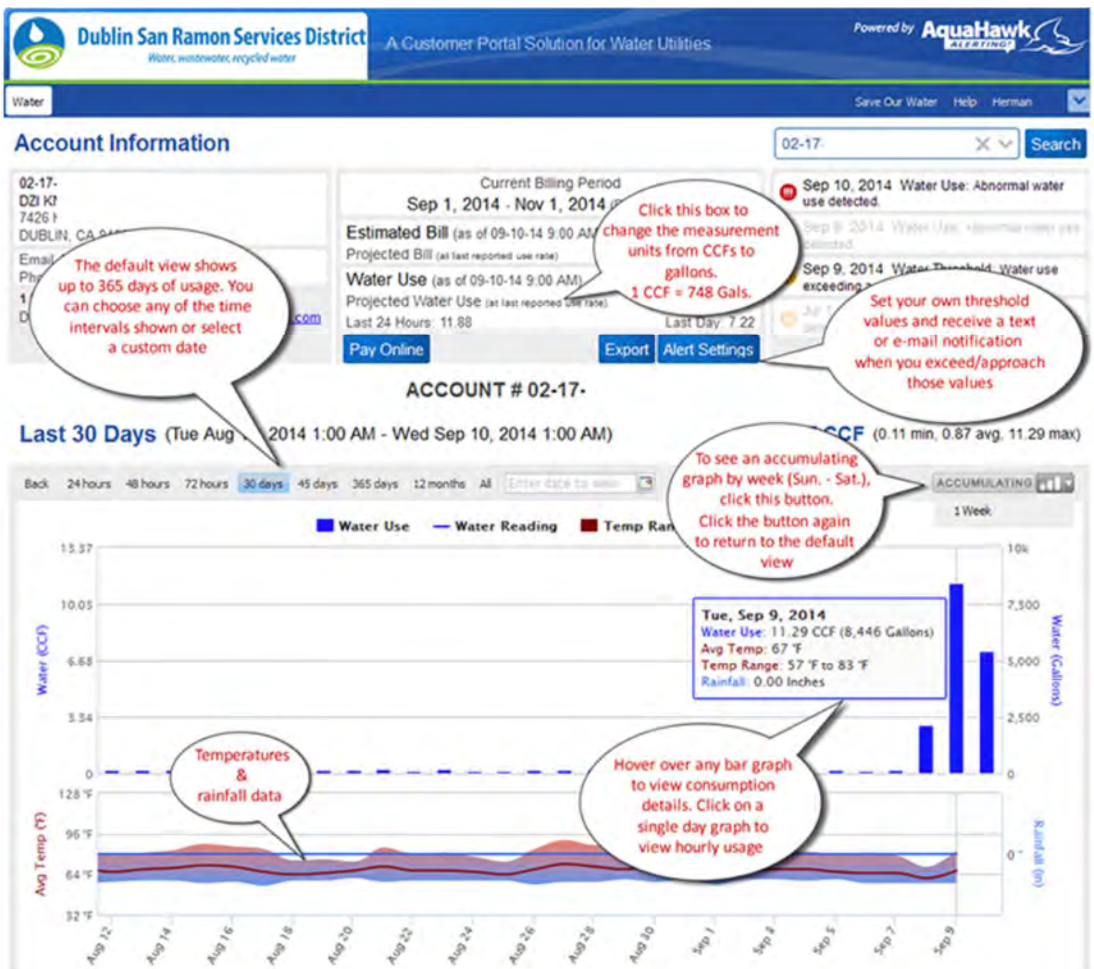

Figure 3 – Example of a Customer Portal

2.3 Current Municipal Practice

2.3.1 Passive Informational Program

Passive information programs include having dedicated webpages, dedicated programming weeks, and notices about how to determine if leaks are presented. A few examples are presented below.

- Guelph currently has a “Fix a leak” web page dedicated to reducing customer leakage (City of Guelph, 2013).
- Peel Region has similar information on their website including a video showing customers how to use their water meter to look for leakage (Region of Peel, 2013).
- Halton Region which provides information on how much water can be wasted via a dripping faucet or leaking toilet, how to check if your toilet is leaking, how to apply for a toilet rebate, and to select WaterSense® fixtures when replacing older fixtures (Halton Region, 2011)
- Region of Waterloo which provides information on how much water can be wasted via a leaking toilet and how to check if your toilet is leaking (Region of Waterloo, 2010)
- Durham Region provides comprehensive information on how to use your water meter and low flow indicator to check for leaks in the home, the financial cost of leakage on water bill, how to check if your toilet is leaking, and how water is used within the home (Durham Region, 2015), and many others.

Non-municipal agencies are also active in promoting “fix a leak” type programs. For example, the United States Environmental Protection Agency’s WaterSense® program has operated a program called “Fix a Leak Week” since 2009. The dedicated website contains information on how to fix leaks, facts and figures, educational resources, and videos – as well as highlights from previous years (United States Environmental Protection Agency, 2015). Recently, the third week of March was selected as the “Fix a Leak Week” and activities such as family fun runs, leak detection contests, and WaterSense® demonstrations were organized in many United States cities as part of the program.

The Arizona Municipal Water Users Association has produced a “Smart Home Water Guide – Find & Fix Leaks” guide available online that includes step-by-step instructions and the following six sections: How to Read You Water Meter, Outdoor Visual Leak Inspection, Indoor Visual Leak Inspection, Isolation Method for Continuous Leaks, Water Efficiency Around the Home, and Glossary and Resources (Arizona Municipal Water Users Association, 2015).

Another method recommended by some agencies such as Ramona, California asks the homeowner, or technician, to attach a pressure gauge to one of the home’s hose bibbs or laundry sink and then turn on the valve to pressurize the gauge. Next, ensure all of the water-using equipment in the home is turned off. Next, the main water shut-off valve to the home is closed. If the reading on the pressure gauge remains steady for 10 to 15 minutes there is no leak in the home; if the reading drops slowly there is a small leak in the home; if the reading drops quickly there is a large leak or some water-using device was not properly closed (Ramonas Plumber, 2010).

2.3.2 Active Notification Programs

Active notification programs include use of mandatory programs. Examples are provided below.

The City of Guelph is moving to monthly billing in the fall of 2015. They are also developing an application that will use the monthly billing data to evaluate customer water demands on a neighbourhood-by-neighbourhood basis. The City will send a notice to customers if they are using significantly more water than their “neighbours” suggesting that they check for leaks or consider installing efficient fixtures and appliances when it is time to replace their existing models.

Toronto is in the process of replacing their old water meters with new meters connected to an automatic meter reading system. The new "smart" meters will deliver information four times a day to the city. Once the new system is in place it will be possible for the city to track residential customer water demands and notify customers when demand patterns are indicative of potential leakage (note that non-residential customers often have highly variable water demands and, as such, it is not normally possible to flag potential leakage based on changes in demand patterns).

New York City, New York, has expanded its Leak Notification Program to include multi-residential buildings (homes with as few as four units). This program, monitored by the Department of Environmental Protection, alerts customers via email, if their water usage triples for five consecutive days. This allows the Department of Environmental Protection to proactively alert customers to potential water leaks on their property. Since the program began in 2011, the City has sent out nearly 32,000 leak notifications resulting in an estimated savings of $26 million in reduced leakage (New York Department of Environmental Protection Public Affairs, 2012). For the program to work, customers are provided the opportunity to sign up online to receive email notifications. Therefore, enabling homeowners to quickly respond to potential leaks and fix them before they become a serious billing problem. This program requires wireless meter readers that record water demand data four times per day.

League City, Texas, has a leak detection notification program where customers are notified via email if their meter records continuous flow for 24 hours (League City, 2015). Customers must register for the program. The website links to the Environmental Protection Agency's WaterSense® Fix A Leak Week website to provide information to customers on how to find and repair leaks in their home.

San Francisco Public Utilities Commission has launched a pilot program to notify single-family customers if they have a potential leak. This program is made possible via the use of wireless water meters that record water demand data hourly. Homes are notified via a postcard stating "You may have a LEAK" if the meter records continuous flow of at least 28 litres per hour for three days. The postcard directs the homeowner to a city website that states that about one in five San Francisco homes have an ongoing plumbing leak and identifies ways to check for leaks in the home as well as how much money a leak can cost you (San Francisco Public Utilities Commision, 2015). Customers can also call the Public Utilities Commission to schedule a free in-home water-wise evaluation (San Francisco Public Utilities Commission, 2015).

The city of Abbotsford, British Columbia, has a detailed webpage regarding water leaks (City of Abbotsford, 2015). The site provides information on what the customer should do if they believe their water bill is inaccurate, as well as information on how to find and repair water leaks within the home. The City's advanced meter infrastructure technology also allows them to monitor customer water demands for continuous flows that may indicate leakage. If potential leaks are identified, a letter is mailed to the customer advising them of the continuous consumption. The City may mail a second or third letter if the continuous consumption continues. The city does not monitor non-residential customer meters for leaks because of the varied nature of water consumption within these facilities. The City will also arrange for someone from their Engineering Department to check for leaks on a customer's property if the customer suspects they may have a leak and contacts the City. One time leak adjustments are available to owner-occupied residential properties after prompt repairs have been done. In order to qualify for a bill adjustment, repairs must have been done within two weeks of the possible leak notification letter or the billing date, whichever is earlier. Billing adjustments are based on the average daily consumption prior to the leak. The cost of repairs are the responsibility of the property owner.

2.4 Benefits and Barriers

The expected benefits and barriers in implementing leak detection notification technologies are listed below in Table 2-1.

Table 2-1: Summary of benefits and barriers associated with leak detection.

Benefits	Barriers
• Lower customer water bills. • Reduced potential for water-related property damage. • Lower municipal water demands, which results in lower operational costs related to energy, chemical demands, and potentially lower capital costs related to avoided, downsized, or deferred infrastructure. • Better customer service and response time to leaks noted. • Increase in the level of information received by customers helps avoid billing disputes for unknown leakage, etc. • Higher level of information available to customers (e.g., customer portal, re-designed water bills).	• Customers may lack motivation to check for visible and hidden leaks. • Customer's capacity to complete expensive or difficult leak repairs. • Customers may lack sufficient motivation to repair leaks. • Small leaks may not register on the water meter, thus more difficult for an automatic meter reading system to identify. • Relatively high cost of installing a flow-based in-home leak detection and water shut-off system. • Inability of sensor-based in-home leak detection system to identify fixture and appliance leaks that do not result in flooding. • Cost of installing and operating wireless automatic meter reading equipment. • Lack of understanding that even a relatively small leak can amount to a large volume of water wastage and a significant water bill. Customers may lack sufficient motivation to repair the leak.

2.5 Local Feasibility

Guelph, like many other area and North American municipalities, provides detailed information on a City website that customers can use to help them check for leaks. While these types of sites offer a great deal of information, they are *passive* by design and rely on customers to access the site to look for information. Notification programs, on the other hand, are *active* by design insofar as they do not require any action from the customer other than a one-time signing up to participate in the notification program. Guelph does not currently have advanced meter infrastructure in place for automatic reading of customer water meters and, therefore, cannot immediately implement a leak detection notification program that can notify customers of leakage at the time of the event. As stated earlier, the City does currently mail notifications to both residential and non-residential customers if their demands are 150 percent or more compared to the same billing period in the previous year.

Implementing a meter replacement program to upgrade or replace existing single-family customer meters to an automatic meter reading system suitable for identifying customer leakage on a timely basis may be costly – especially if the conversion is done over a short period of time. Preliminary analysis by the City estimated a cost of $4.33 million ($96.22 per user) for 45,000 meters installed without accounting for operation and maintenance costs. The City could begin requiring automatic meter reading capable meters to be installed in new development or when older meters require replacing. This strategy would spread the program costs over many years by extending the time required for full conversion.

There are other benefits associated with using automatic meter reading, or advanced metering infrastructure besides customer leak detection, such as:

- providing better demand data for hydraulic modeling or demand forecasting
- lowering meter reading costs, vehicle fuel and maintenance costs, and associated greenhouse gas emissions
- better customer service, for instance because the City would be better able to address customer complaints with immediate access to their water demand data
- better enabling use of seasonal water demand rates, excessive daily demand rates, or even time-of-day rates

3.0 KEY CONSIDERATIONS

Active customer leak notifications are expected to be much more effective at reducing leakage than the more passive method of posting information on “how to find and fix leaks” on municipal websites. While Guelph is moving to a monthly billing cycle in the fall of 2015 and they are developing a screening program where they will identify and notify customers with unexpectedly high monthly demands to check for leaks, the most effective leak notification programs take advantage of the more granular water demand data that can be generated via automatic meter reading systems where customer water meters are read one or more times per day per day such that unusual water demand patterns or extended periods of continuous use can be identified almost immediately. Should the City of Guelph decide to convert to an automatic meter reading/advanced meter infrastructure system, it would be able to implement an active customer leak notification program and/or to develop a customer water use portal that would enable customers to retrieve more detailed and almost real-time data regarding their water use and potential water efficiency measures.

Of the two types of home-based leak detection systems, flow-based and sensor-based, it appears that flow-based systems would be the most effective at flagging the most common type of leakage within the home. For instance, in cases where fixture/appliance leaks tend to discharge to drain rather than cause flooding. Unfortunately, the relatively high cost of these systems of around $3000 may make the widespread use of these systems unlikely. While sensor-based systems are significantly less expensive, ranging from about $30 for an alarm-only system to about $300 for a system that can shut of the water supply to the home, they are only effective if they come in contact with water. These are leaks that would be readily obvious to the homeowner, ergo sensor-based systems are more suited to prevent flood damage than to reduce water demands and water bills.

Another challenge faced by Guelph and other municipalities is a general lack of understanding by customers of the information contained on the water bill. Customers pay water and wastewater costs based on how many cubic metres of water they use during the billing cycle but it is likely that most customers are more familiar with litres or even gallons than cubic metres. Based on the results of interviews with customers in other jurisdictions and a survey completed by the University of Indiana, it appears that very few customers are fully aware of how much water they use on a daily basis, whether they would be considered efficient or inefficient, or how this demand compares with other homes in their neighbourhood (Yoshida, 2014).

Guelph may want to consider taking advantage of delivering monthly water bills to residential customers, beginning in the fall of 2015 to re-design their water bill to provide more comparative information in an easy to understand manner.

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From:	**Sam Ziemann**	Our File:	**75-41-151088**
Cc:	**Wayne Galliher, Julie Anne Lamberts**	Date:	**31 August 2015**
Subject:	**New Construction Based Irrigation System Design and Construction Standards**		

CITY OF GUELPH

NEW CONSTRUCTION BASED IRRIGATION SYSTEM DESIGN AND CONSTRUCTION STANDARDS

C3 WATER INC.

31 August 2015

VERSION	DATE	DESCRIPTION OF REVISIONS	REVISED BY	REVIEWED BY
1	July 14, 2015	Draft New Construction Based Irrigation System Design and Construction Standards	Patricia Wiebe	Bill Gauley
2	August 31, 2015	Final New Construction Based Irrigation System Design and Construction Standards	Bill Gauley	Sam Ziemann

Table of Contents

1.0 INTRODUCTION

The 2015 Water Efficiency Strategy Update will identify a set of preferred program alternatives, associated water savings, program implementation forecasts, and supporting program resources required to achieve the water demand reduction outlined in the 2014 Water Supply Master Plan. As part of the strategy scope, a series of technical memos are being prepared on technology and policy areas of opportunity, as identified through ongoing program operation, industry best practice research and common areas of customer/stakeholder inquiry. The objective of this report is to outline the potential water savings (financial and consumption) associated with developing irrigation system design and construction standards for new construction.

It has been estimated that as much as 50 percent of the water applied in landscape irrigation is wasted due to over-watering caused by inefficiencies in irrigation methods and systems (United States Environmental Protection Agency, 2015). Ideally, landscapes should be designed such that they require little or no supplemental irrigation, e.g., the use of drought tolerant plants or non-plant material. When irrigation systems are required, they should be designed and constructed to function as efficiently as possible. This requires coordination between the irrigation contractor and the landscape contractor during the initial stages of the program - once a system is installed it is far more difficult to make improvements. An effective irrigation system design and construction standard can significantly reduce overwatering by applying water only where and when it is required.

2.0 NEW CONSTRUCTION IRRIGATION SYSTEM DESIGN AND CONSTRUCTION STANDARDS

2.1 Definition

It is important to note that a standard differs from a code or a bylaw in that a standard is intended to help ensure that certain common (“standard”) practices are followed. A standard is a voluntary benchmark ensuring the end product is safe, reliable, and meets the expectations of the marketplace. A code or bylaw is a prescriptive and mandatory requirement, generally intended to ensure a certain minimum level of health and safety is maintained or that regulations are followed. Design and construction requirements for outdoor irrigation systems are not covered by the Ontario Building Code. The City of Guelph does have a backflow prevention bylaw which requires a device and associated testing to protect the City’s water supply from potential threats.

Irrigation System Design and Construction Standards can be relatively simple guidelines or they can include very extensive and detailed specifications. Standards intended to foster efficient landscape irrigation should identify minimum expectations for various elements, including:

- Use of a master valve to prevent potential continuous leakage with an easy to get at shut off feature,
- Use of a system sub-meter to monitor water demands,
- Use of a weather-based controller that uses evapotranspiration rates to avoid over-watering or watering when not required,
- Use of rain sensor to prevent system operation during or immediately after a rain event,

- Sprinkler spacing and selection,
- Local evapotranspiration rates,
- Pressure control options including pressure regulated rotary spray nozzles and check valves, and
- Backflow Prevention.

2.2 Descriptions of Standard Components

2.2.1 Master Valve

A master valve is an electric valve installed on the water supply connection to the irrigation system. When closed, there is no water supply to the irrigation system. As such, a master valve will greatly reduce water lost due to a leaky zone because water will only be provided to the system when the master valve is open versus the valve being open 24 hours per day. A master electric valve is typically connected to the "master" or "pump" connection in the system controller.

2.2.2 Sub-Meter

It is not uncommon for irrigation contractors and homeowners alike to have little perspective of the volume of water that is applied each time the irrigation system operates. There are, however, several advantages to installing a sub-meter on the water supply to an automatic irrigation system, including the following:

- Allow the irrigation contractor to verify that the depth of water being applied to each zone on a weekly basis matches the irrigation needs of the landscape.
- Make it easier for the owner to identify leaks, as unusually high water demand in any zone could indicate a leak.
- Provide information to the homeowner regarding the volume and cost of water used on an annual basis, as knowing the cost may prompt the homeowner to operate their system more efficiently.
- Make it easier to identify savings related to making improvements to the irrigation system (e.g., spray heads, pressure regulators, etc.), to the irrigation control system (e.g., installing a weather-based controller or rain sensor), or to the landscape itself (e.g., converting to native plant material or xeriscaping).

2.2.3 Weather-based Controllers

The use of a weather-based “smart” controller rather than the simple timer used in ‘standard’ controllers can result in significant water savings. Weather-based controllers use local evapotranspiration values, on-site soil moisture values, or information provided by a local weather station to tailor the system’s watering schedule to suit current site conditions. The water savings generated by “smart” controllers can vary greatly from site to site based on climate and vegetation, as well as, how efficiently water is being applied by the system. Conservative estimates indicate a savings of between 10 and 25 percent of current demand (Southern California Area Office, Temecula, California; Water Resources Planning and Operations Support Group, Denver, Colorado, 2008).

2.2.4 Sensors

Rain sensors prevent irrigation systems from operating during or immediately after a rain event. The resulting savings will vary from year to year depending on the frequency of rain events. For example, there would be little or no savings during a drought year but there could be almost 100 percent savings during a year with frequent rain events. Rain sensors are relatively inexpensive – often costing less than $40. Not only can rain sensors pay for themselves very quickly with the water savings they achieve, they help eliminate the negative impression associated with operating an irrigation system is operating during a rainstorm.

Similar to rain sensors, soil moisture sensors suspends a watering cycle when the soil moisture is above a set threshold. The soil sensor also monitors temperature and electrical conductivity. Knowing the electrical conductivity of the irrigated soil is especially valuable when reclaimed water is used for irrigation. Reclaimed water can be high in dissolved ions which can accumulate overtime and cause a negative impact of plant health (Rain Bird, 2015). Depending on the application, water savings can be up to 40 percent and the device could pay for itself within a year (Rain Bird, 2015).

2.2.5 Sprinkler Spacing and Selection

For proper coverage, sprinkler heads should be installed such that the spray from each head just reaches all the heads adjacent to it (head-to-head coverage). Head-to-head coverage helps ensure a more uniform water application, which saves water and promotes a healthy landscape. The following is recommended for sprinkler placement.

- Sprinklers with the greatest radius should be used in the larger areas. Sprinklers should be placed in such a way to minimize or avoid spraying hardscapes such as sidewalks and driveways, or other non-plant materials.
- Half-circle sprinklers should be placed on edges and borders, quarter-circle sprinklers in corners, and full-circle sprinklers in the middle of open spaces.
- Bubblers or drip irrigation should be used where possible to irrigate small areas, flowerbeds, or individual plants.

Dividing the landscape into areas with similar water needs will create zones which should only contain a single “type” of sprinkler (e.g., rotors, sprays, drip) to avoid ‘mixed precipitation’ issues. Another aspect to consider is micro-climates in the yard, i.e.shady areas will not need as much water as sunny areas.

2.2.6 Local Evapotranspiration Rates

Evapotranspiration is the combination of water evaporating from the soil and water transpiring from the vegetation as shown in Figure 1. Water lost through evapotranspiration must be replaced or the plant will not have enough water. Sometimes it is possible to deficit irrigate (i.e., replace less than the total volume of water lost through evapotranspiration) for short periods of time with only a minimum negative effect on the plant health.

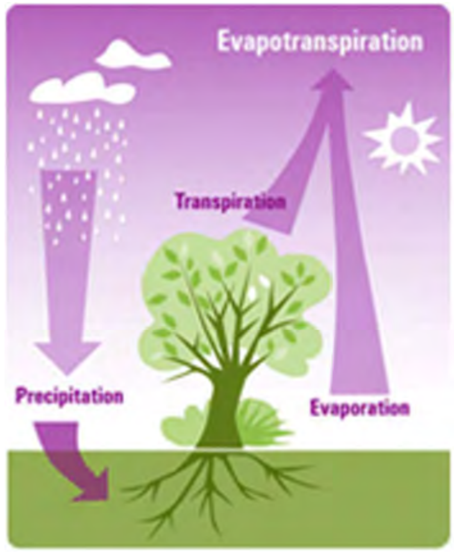

Figure 1 Diagram of Evapotranspiration (Regional Water Providers Consortium, 2015)

Local evapotranspiration rates are used to determine how much water the plant material in an irrigation zone should receive on a weekly basis based on the zone's micro-climate, primary plant material, soil type, and soil slope. For example, Landscape Ontario's *Water Smart Irrigation Professional* program states that a turf landscape exposed to full sun needs about 1-inch of water replacement per week during the peak summer month (including both precipitation and supplemental irrigation). Water replacement values are used to properly adjust the irrigation schedule (controller) to ensure that the landscape receives sufficient water without over-watering. Evapotranspiration values can also be used by some controllers to automatically reduce zone runtimes during the spring and fall months when the plants' water requirements are lower (i.e., some controllers have an automatic seasonal adjustment feature).

2.2.7 Pressure Control Options

Uneven water pressure in an irrigation system can cause uneven water application rates, thus reducing the efficiency of the system. For example, a 5 pounds per square inch reduction in pressure can reduce the application rate by approximately 7 percent (Rain Bird Sprinkler Manufacturing Corporation, 2000). Uneven pressure in an irrigation system can be caused by uneven terrain, long pipe lengths, headloss at fittings, etc.

Another issue for irrigation systems is high water pressure. Most spray head nozzles are designed to operate at 30 pounds per square inch yet municipalities commonly provide water to their customers at pressures of 50 pounds per square inch or higher. Excessive pressures can cause sprinklers to over-spray and to 'mist' or 'fog' rather than providing concentrated streams of water, thus wasting more water than what is needed for base irrigation purposes. Solutions include controlling the pressure to the entire irrigation system (suitable for smaller systems) or using pressure-regulating heads to ensure that all heads are operating at the proper pressure.

2.2.8 Backflow Prevention

Most irrigation systems are supplied via municipal potable water – the same water system that supplies drinking water to the customer. Irrigation systems are constructed under gardens and lawns where they may be exposed to weed killers, pesticides, fertilizers, pet waste, etc. A pipe break or a low water pressure problem may cause potentially dangerous water to be drawn into the irrigation system (i.e., to backflow). Backflow can introduce contaminated water inside the home and to the municipal drinking water system. All irrigation systems should be fitted with a suitable backflow prevention device in accordance with the City's Backflow Prevention By-Law.

2.3 Current Municipal Practice

Since new irrigation system installation projects are often awarded based on price, designers and installers sometimes don't include important features or aspects that would help improve system efficiency. In fact, not all installers and almost no customers are fully aware of the difference between a properly designed and operated irrigation system and an inefficient system. As long as the customer's turf and plants appear healthy there is no *perceived* problem with the current system by either the contractor or the customer. Landscape maintenance is the primary driver (i.e., keep the grass green) with very little thought given to the water efficiency of the system. Because of this, there is a huge potential for water savings related to optimizing automatic irrigation systems with no negative impact on landscape health and appearance.

Many municipalities and irrigation companies have developed irrigation design and construction manuals. As such, should Guelph decide to develop their own irrigation design and construction standard, it may be beneficial for the City to review some of the following to identify suitable criteria:

- Saskatchewan Irrigation Design and Construction Standards Manual (Government of Saskatchewan, 2015)
- City of Kelowna, British Columbia – Landscape & Irrigation Guide to Water Efficiency (City of Kelowna, 2010)
- Irrigation Industry Association of British Columbia – Standards for Landscape Irrigation System (Irrigation Industry Association of British Columbia, 2008)
- RainBird Landscape Irrigation Design Manual (Rain Bird Sprinkler Manufacturing Corporation, 2000)
- Hunter Residential Sprinkler System Design Handbook (Hunter Industries Incorporated, 2015)
- TORO Do-It-Yourself Sprinkler Planning & Installation Guide (The Toro Company, 2008)

The City of Kelowna in British Columbia has a semi-arid climate and typically high outdoor water use that combine to strain the water supply infrastructure. As such, the city has adopted a water regulation bylaw that requires a permit application for any residential or commercial irrigation installation. The permit requires that every system be installed with an irrigation master shut-off valve, include a backflow protection device, and every system be equipped with a "smart" controller.

Landscape Ontario, Peel Region and York Region have partnered to develop a Water Smart Irrigation Professional program designed to shift the water-efficiency focus from the customer to the contractor.

Traditionally, the main goal for both customers with automatic irrigation systems and their maintenance contractors was maintaining a lush and green landscape. Neither the customer nor the contractor is typically aware of how much water is being applied on a weekly basis or how much water could be saved. While there are visible cues that indicate if a plant is being under-watered, there are no visible cues to indicate over-watering unless the over-watering is extremely severe. The Water Smart Irrigation Professional program trains contractors how to calculate the optimum level of irrigation for each zone based on plant type, micro-climate, soil type and slope, etc., using a custom-designed computer program. The qualifying contractors are paid a set fee by Peel or York Region, depending on the location of the customer, to audit and optimize their customers' irrigation systems. Customers receive a report showing how much water and cost savings they will achieve each year with an optimized system. While many customers may not be motivated to make changes to their irrigation systems for a relatively small cost savings each year, the Water Smart Irrigation Professional program is financially beneficial to the irrigation contractors (a small financial incentive for each optimized system multiplied by many system optimizations each year) and the contractors are able to provide a higher level of customer service at no additional cost. The average water savings during the pilot study for the Water Smart Irrigation Professional program saved 10,000 litres per day per acre of landscape (a reduction in depth of water applied of about 17mm per week) without compromising the health and beauty of the landscape. Should Guelph decide to develop an Irrigation System Design and Construction Standard, they may wish to consider including aspects of the Water Smart Irrigation Professional program.

2.4 Benefits and Barriers

The use of irrigation system design and construction standards provides benefits, yet there are also barriers to a successful implementation of standards.

Table 2-1: Summary of benefits and barriers associated with implementing irrigation system design and construction standards.

Benefits	Barriers
• Leads to a higher minimum level of efficiency for new irrigation systems. • Clear description of expected minimum criteria for installation. • Assist in reducing summer and peak demands. • Provides customers additional criteria to evaluate contractors (e.g., contractors that meet or exceed requirements outlined in standard may be viewed more positively by customers).	• Enforcement/auditing and program maintenance (especially if providing incentive) may be costly, time consuming and not sustainable over the long term. • Developing a Standard (voluntary) is not the same as developing a mandatory bylaw and, as such, the industry may be free to ignore recommendations. • Open to criticism – possibly seen as design restrictive. • Effectiveness may be reduced if not developed in concert with landscape

• Potentially provides city with some control over new installations, especially if city offers rebates or incentives to contractors meeting or exceeding the minimum requirements outlined in the standard.	design professionals. • Many irrigation professionals do not exclusively work in the City of Guelph. Therefore, often have limited knowledge of the City's programs and requirements. • Communication of the program to irrigation professionals would be a challenge as they are often not located in the City of Guelph.

3.0 LOCAL FEASIBILITY

Currently, customers are not aware of how much water their irrigation systems use, how much systems should use, or how much additional money they are spending each season because of their inefficient practices[1]. Clients do not insist on system optimization because they are unaware that their system is not optimized and contractors do not see any financial benefits associated with reducing water demands of their clients. In fact, most contractors tend to adjust the system to over-irrigate somewhat to err on the side of caution. Developing an irrigation system design and construction standard defining the minimum requirements for efficient landscape design and operation and potentially offering rebates to contractors that follow the Standard and can provide verification of applying the optimum level of irrigation (e.g., perhaps through Landscape Ontario's Water Smart Irrigation Professional program) supports the concept of market transformation in Guelph and, therefore, fits in with the City's goals of the Water Efficiency Strategy.

In May 2013, Lura Consulting consulted the public for the Outside Water Use By-law Review on behalf of the City. One of the questions posed to the public was whether additional requirements should be included for those choosing to install an automated sprinkler system. 79 percent of survey respondents agreed to additional requirements. Further comments included that the City should provide incentives for residents to install water efficient systems, and the City should educate residents regarding the use of efficient irrigation systems. There was some concern expressed that additional requirements in installing automated sprinkler systems would be too intrusive and too costly. Other ideas to promote efficient irrigation systems included: monitoring the performance of irrigation systems with annual checks, as well as promoting the use of efficient designs, nozzles, and controller (Lura Consulting, 2013).

4.0 KEY CONSIDERATIONS

The goal of developing an *Irrigation System Design and Construction Standard for New Construction* is to help transform the marketplace in the City such that new irrigation systems incorporate the efficiency aspects that are currently so often left out because of cost, such as: weather-based control

[1] Based on feedback obtained as part of Landscape Ontario Water Smart Irrigation Professional program development and training.

systems, master valves, pressure-regulated heads, and rain sensor shut-offs. The information contained in the Standard will help educate key market players and generate customer demand for efficient systems. It is anticipated that this program will improve the efficiency of new systems (including design, operations, and maintenance) and potentially the efficiencies of existing systems (related to maintenance and operation) as contractors become more familiar with the requirements set out in the Standard. Also, based on Lura Consulting's 2013 survey, the Guelph residents are interested in further incentives and education on water efficient irrigation systems. As stated earlier, Peel and York regions have participated in Landscape Ontario's Water Smart Irrigation Professional program – a program that provides training and other tools to qualifying irrigation contractors to help them optimize their customers' irrigation practices. Both Peel and York offer incentives to contactors conducting Water Smart Irrigation Professional program irrigation assessments for their local customers. Perhaps Guelph could consider offering incentives to contractors that follow the recommendations outlined in the Standard (carrot approach). Issuing fines to contractors that fail to follow the recommendations outlined in the Standard is another approach (stick approach), but it may be much more difficult to enforce.

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