To:	**Emily Stahl**	Company:	**City of Guelph**
From:	**Sam Ziemann**	Our File:	**75-41-151088**
Cc:	**Wayne Galliher**	Date:	**4 December 2015**

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*.

<table>
<tr><td rowspan="9">Volume from Own Sources (corrected for known errors)</td><td rowspan="11">System Input Volume</td><td>Water Exported (corrected for known errors)</td><td colspan="3">Billed Water Exported</td><td>Revenue Water</td></tr>
<tr><td rowspan="10">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled metered Consumption</td><td rowspan="8">Non-revenue Water</td></tr>
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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

7.0 REFERENCES

Abbotsford Mission Water & Sewer Services. (2012). *Water Efficiency Plan, Stage 2: Review of Existing Initiatives.* Abbotsford.

Alliance for Water Efficiency. (2010). *Public and Consumer Education Programs*. Retrieved from Alliance for Water Efficiency: http://www.allianceforwaterefficiency.org/public_education.aspx

Alliance for Water Efficiency. (2013, March 4). *Residential Clothes Washer Introduction*. Retrieved from Alliance for Water Efficiency: http://www.allianceforwaterefficiency.org/1Column.aspx?id=1344&LangType=1033&terms=washing+machines

Alliance for Water Efficiency. (2015, March 16). *Residential Dishwasher Introduction*. Retrieved from Alliance for Water Efficiency: http://www.allianceforwaterefficiency.org/1Column.aspx?id=1398&terms=dishwashers

Alliance for Water Efficiency. (2015, March 19). *The Water Audit Process*. Retrieved from Alliance for Water Efficiency: http://www.allianceforwaterefficiency.org/1Column.aspx?id=2082&terms=water+loss+audit

Alliance for Water Efficiency. (2015). *Water Loss Control - What Can Be Done?* Retrieved from Alliance for Water Efficiency: http://www.allianceforwaterefficiency.org/Water_Loss_Control_-_What_Can_Be_Done.aspx

Association of Municipalities Ontario. (2012, October 31). *Local Improvement Charges Regulation Amended*. Retrieved from Association of Municipalities Ontario Web site: https://www.amo.on.ca

Boyd, R. (2013, October 21). Clean Energy Financing: Briefing Note. Edmonton, Alberta.

Burt, C., & Howes, D. (2011). *Low Pressure Drip/Micro System Design - Analysis of Potential Rebate.* Retrieved from Irrigation Training & Research Center Web site: http://www.itrc.org/reports/pdf/design.pdf

C. Lenzi, C. B. (2014). Infrastructure Leakage Index assessment in large water systems. *12th International Conference on Computing and Control for the Water Industry, CCWI2013*, (pp. 1017-1026).

California Department of General Services. (2015). New water efficiency rules approved for California K-12 and community college construction. *DGS NewsWire*.

California Department of Water Resources. (2015, 09 11). *Turf Replacement Initiatives*. Retrieved from Clifornia Department of Water Resources: http://www.water.ca.gov/turf/

City of Boulder. (2009). *Rule Establishing the Methodology to Be Utilized in Determining the Monthly Water Budget.* Retrieved from City of Boulder Web site: https://www-static.bouldercolorado.gov/docs/water-budget-rules-1-201304191236.pdf

City of Clermont. (2015). *Reuse Information*. Retrieved from City of Clermont: http://www.clermontfl.gov/departments/environmental-services/reuse-information.stml

City of Kamloops. (2015). *Water Meter Rates*. Retrieved from City of Kamloops: http://www.kamloops.ca/finance/watermeterrates.shtml

City of Vancouver. (2014, April 9). *Metered utility rates for water, sewer, and energy.* Retrieved from City of Vancouver: http://vancouver.ca/home-property-development/metered-rates.aspx

Colorado Water Conservation Board. (2010). *Guidebook of Best Practices.* Denver: Colorado WaterWise.

Denver Water. (2015). *Commercial and Multifamily Services*. Retrieved from Denver Water: www.denverwater.org/Conservation/commercial-multifamily-services/

Denver Water. (2015). *Cooling Tower Performance Rebate Program*. Retrieved from Denver Water: http://www.denverwater.org/Conservation/commercial-multifamily-services/incentive-programs/cooling-tower/

Dickinson, M. A. (2005). Redesigning Water Loss Standards in California Using the New IWA Methodology. *CUWCC.* Sacramento.

Energy Star. (2015, March). *Clothes Washers; Products*. Retrieved from Energy Star: https://www.energystar.gov/products/certified-products/detail/clothes-washers

Environment Canada. (2004). *2004 Municipal Water Use.* Ottawa: Ministry of the Environment.

Environment Canada. (2011). *2011 Municipal Water Pricing Report.*

Environmental Protection Agency. (2012, August). *WaterSense Labeled Multi-Family New Homes*. Retrieved from Environmental Protection Agency: www.winnipeg.ca/waterandwaste/water/conservation/tipsMultiFamily.stm

J. Kinkead Consulting. (2006). *An Analysis of Canadian and Other Water Conservation Practices and Initiatives.* Mississauga: Canadian Council of Ministers of the Environment.

Koeller & Company. (2007). *Potential Best Management Practices; Year 3 Report.* California.

Long Beach Water Department. (2015). *Multi-Family Conservation*. Retrieved from Long Beach Water Department: The Standard in Water Conservation and Environmental Stewardship: www.savingwater.org/rebates/

Mcmenamin, H. (2013, April 18). Government assistance available to boost efficiency of irrigation systems. *Alberta Farmer Express*.

Mills, K. (2011, April 4). *Seasonal water rate approval by Abbotsford council*. Retrieved from The News: http://www.abbynews.com/news/119233759.html

Multi-housing Laundry Association. (2006). *How to Figure Rates for Laundry Utilities Cost Worksheet*. Retrieved from Multi-housing Laundry Association: http://www.mla-online.com/workback.htm

National Research Center Inc. (2002). *A National Study of Water & Energy Consumption in Multifamily Housing.* Boulder, Colorado: Multi-housing Laundry Association.

New Hampshire Department of Environmental Services. (2013). *Water Efficiency: Industrial Water Users.* Concord: New Hampshire Department of Environmental Services.

New York Department of Environmental Protection Public Affairs. (2012, December 5). *Department of Environmental Protection Announces Leak Notification Program Has Saved New Yorkers $26 Million Since 2011*. Retrieved from New York City Environmental Protection: http://www.nyc.gov/html/dep/html/press_releases/12-95pr.shtml#.Va1AJE1RGpp

OWWA Water Efficiency Committee. (2005). *Water Efficiency Best Management Practices.* Markham: Ontario Water Works Association.

Pembina Institute. (2004, May). *Using Local Improvement Charges to Finance Building Energy Efficiency Improvements: A Concept Report.* Retrieved from https://www.pembina.org/reports/LICProgramFinal-ReportMay27042.pdf

Persram, S. (2013, July 25). *Using Local Improvement Charges to Finance Residential Energy Upgrades.* Retrieved from Quality Urban Energy Systems of Tomorrow (QUEST) Web site : http://www.questcanada.org/sites/default/files/publications/Primer.pdf

Reese, P., Kasler, D., & Sabalow, R. (2015, July 15). California adopts strict lawn-reduction rules for drought savings. *The Sacramento Bee*.

Region of Waterloo. (2015). *Conservation*. Retrieved from Region of Waterloo: http://www.regionofwaterloo.ca/en/aboutTheEnvironment/Conservation2.asp

Shedletzky, A. (2013, July 30). Toronto Approves Innovative Energy Efficiency Pilot Program Utilizing "Local Improvement Charges". *Canadian Energy Perspectives: Developments in Energy and Power Law*.

Texas Water Development Board. (2004). *Industrial Alternative Sources and Reuse of Process Water.* Retrieved from https://www.twdb.texas.gov/conservation/BMPs/Ind/doc/4.2.pdf

Town of Okotoks. (2014). *Water Conservation, Efficiency and Productivity Plan.* Okotoks.

United States Department of Energy. (2015). *Federal Energy Management Program.* Retrieved from Office of Energy Efficiency & Renewable Energy Web site: http://energy.gov/eere/femp/best-management-practice-8-steam-boiler-systems

United States Environmental Protection Agency. (2011). *Water Management Plan.* Houston: US EPA.

United States Environmental Protection Agency. (2015, April 23). *Best Practices*. Retrieved from United States Environmental Protection Agency Web site: http://www.epa.gov/greeningepa/water/best_practices.htm

United States Environmental Protection Agency. (2015, May 8). *Fix A Leak Week*. Retrieved from US EPA Web site: http://www.epa.gov/WaterSense/pubs/fixleak.html

University of Nebraska-Lincoln. (2015). *Soil & Water Management: Water Conservation*. Retrieved from University of Nebraska-Lincoln Web site: https://cropwatch.unl.edu/tillage/water

Wagman, D. (2013, December 5). *Reclaimed water one innovative method used to ease pressure on stae's scarce water resources*. Retrieved from InnovatioNEWS: http://www.innovationews.com/water/reclaimed-water-is-one-innovative-method-being-used-to-ease-pressure-on-scarce-water-resources/

Water Conservation Advisory Council. (2004, November). *Low Pressure Center Pivot Sprinkler Irrigation Systems.* Retrieved from Save Texas Water Web site: http://www.savetexaswater.org/bmp/doc/Agriculture/Low_Pressure.pdf

Water World. (2006, January 5). *Eraring Power Station saves money with water reclamation*. Retrieved from Water World: http://www.waterworld.com/articles/2006/01/eraring-power-station-saves-money-with-water-reclamation.html

Watersmartpeel. (2009, August). *Indoor Water Efficiency Audit.* Retrieved from Peel Region Web site: https://www.peelregion.ca/watersmartpeel/businesses/pdfs/parmalat-case-study.pdf

WaterTap. (2013). *Financial Incentives and Prices for Water*. Retrieved from WaterTap Ontario: http://www.watertapontario.com/asset-map/utilities/financial-incentives

Wilson, C., & Bauer, M. (2014, August 11). *Drip Irrigation for Home Gardens*. Retrieved from Colorado State University Extension: http://www.ext.colostate.edu/pubs/garden/04702.html