GREATER LAKES

Reconnecting the
Great Lakes Water Cycle

Improving Water Conservation & Efficiency in Six Great Lakes Communities

Prepared for Greater Lakes by Bill Christiansen of the Alliance for Water Efficiency

April 2016

A project of the Great Lakes Commission
Funded by the Great Lakes Protection Fund

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Preface

Sustainable management of human activity in the Great Lakes and St. Lawrence River system is critical to protect and restore ecosystems, maintain the economic health and vitality of the region, and ensure the livelihood of the millions of people who live here. Challenges continue to threaten the quality and quantity of this freshwater treasure, including a broken water system characterized by aging water, wastewater and stormwater infrastructure, a legacy of poor land use planning, wasteful behaviors towards water use, and a siloed approach to the management of water.

Municipalities are on the frontlines when it comes to the Great Lakes and St. Lawrence River, and are uniquely positioned to have a positive effect on this ecosystem through a shift in their approach to water management.

The Greater Lakes: Reconnecting the Great Lakes Water Cycle project, a project of the Great Lakes Commission and supported by the Great Lakes Protection Fund, is exploring and testing environmental and financial rationales for municipalities to adopt water conservation/efficiency and green infrastructure measures. This binational project focuses on six communities: Commerce Township, Lyon Township, and Southwest Oakland Township, all located in Oakland County, Michigan; and the cities of Guelph and Waterloo, and the Region of Waterloo, all located in Ontario.

During this project, we have carried out two detailed technical analyses of all six municipalities. The Alliance for Water Efficiency, one of our project partners, prepared this report entitled ***Improving Water Conservation & Efficiency in Six Great Lakes Communities***. One of our other project partners, Environmental Consulting & Technology, Inc., prepared a companion document on the same municipalities entitled ***Environmental Impacts of Water Withdrawals and Discharges in Six Great Lakes Communities: A Role for Green Infrastructure***.

Our purpose in this detailed work in the six municipalities has been to learn lessons that will be of benefit not just to those selected municipalities but also to all municipalities around the Great Lakes and St. Lawrence River basin. On the *Greater Lakes* website, you will find materials that we are confident will help municipalities and concerned citizens evaluate how water is managed in their communities and to carry out actions that will help you achieve your local goals.

The main lessons that we have learned from these detailed analyses and our other work in this project is that we must develop a more integrated, holistic approach to water management in order to restore the water system to a more natural condition that will better serve both human needs and the needs of wildlife and other parts of the ecosystem.

-- John Jackson, Project Manager, Greater Lakes: Reconnecting the Great Lakes Water Cycle

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Introduction

The Alliance for Water Efficiency (AWE) modeled the costs and benefits of potential water efficiency programs for seven communities using the Alliance's Water Conservation Tracking Tool. Four of the communities are located in Ontario, Canada, and three are located in Oakland County, Michigan, United States. The four Ontario, Canada communities included in this analysis are the Region of Waterloo, the City of Waterloo, the City of Cambridge, and the City of Guelph. The City of Cambridge was added to the project as an AWE Tracking Tool run only and was not included in the environmental benefit analysis conducted by Environmental Consulting & Technology, Inc. (ECT) in the companion analysis ***Environmental Impacts of Water Withdrawals and Discharges: A Role for Green Infrastructure*** The three communities in Oakland County, Michigan are Commerce Township, Lyon Township, and Southwest Oakland Township.

AWE's principal tasks in preparing this report included:

- Coordinating data collection, processing, and management
- Entering data inputs for the communities' AWE Water Conservation Tracking Tool analysis
- Identifying, designing, and inputting water conservation/efficiency programs that were evaluated with the AWE Water Conservation Tracking Tool
- Generating model outputs based on estimated levels of activity for each of the seven communities
- Documenting the modeling process and results for each of the seven communities

AWE carried out this work in full collaboration with municipal staff in each of the seven municipalities. We thank the municipalities for the substantial support that they provided to us throughout this study.

This report provides an overview of water efficiency planning using the AWE Water Conservation Tracking Tool, and details the modeling process for each of the seven communities. Because the Region of Waterloo is the wholesaler to the City of Waterloo and the City of Cambridge, the results for these three communities are grouped together. The results for the City of Guelph are presented separately, and the three communities in Oakland County, Michigan are grouped together. The outputs generated by this analysis include estimated program water savings, a cost-benefit analysis, a cursory review of the impact to water utility sales revenue, and energy and greenhouse gas reductions resulting from the conservation/efficiency programs.

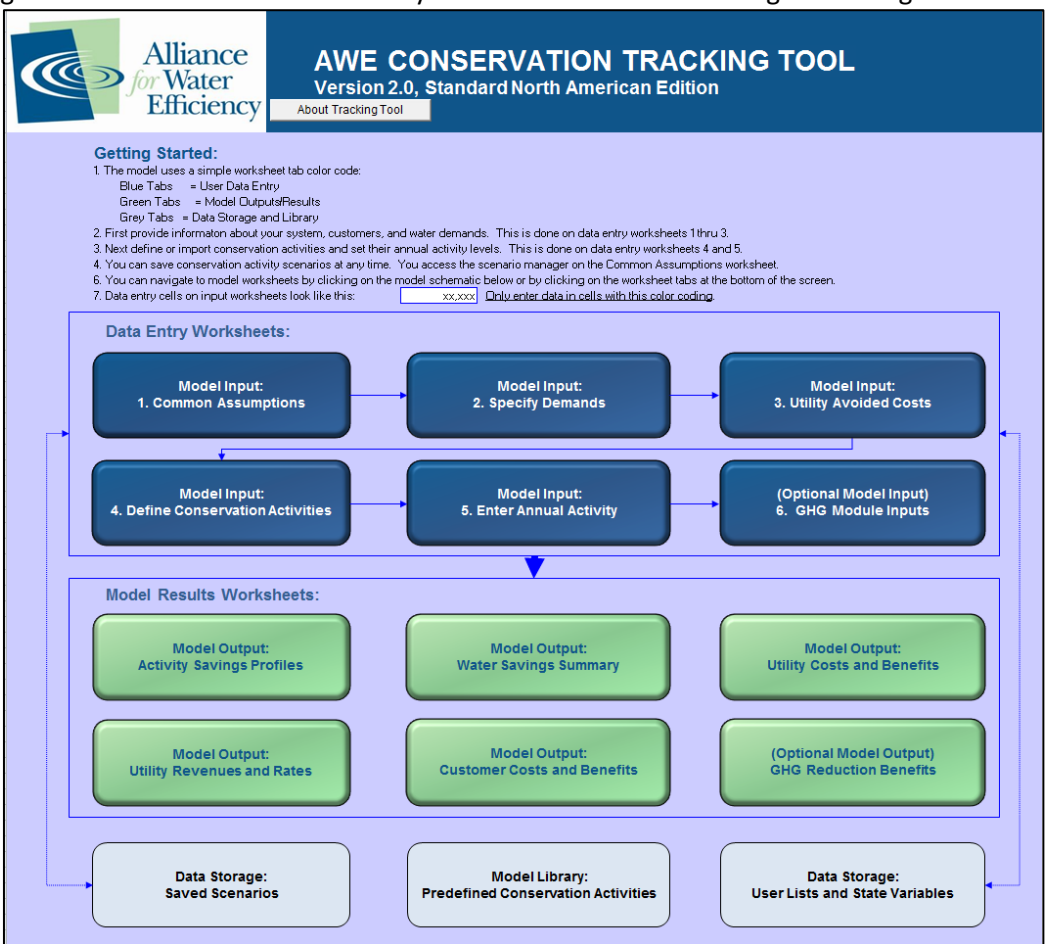
The paper concludes with a summary of findings and lessons learned from evaluating water conservation programs in seven communities in the Great Lakes Basin. These conclusions contain valuable lessons for municipalities throughout the Great Lakes basin.

The terms conservation and efficiency are used interchangeably throughout this paper and the word programs is sometimes referred to as activities and measures.

Overview of the Alliance for Water Efficiency Water Conservation Tracking Tool

The Alliance for Water Efficiency Water Conservation Tracking Tool is a Microsoft Excel based model that can be used to evaluate the water savings, costs, and benefits of conservation programs for a specific water utility service area. The Tracking Tool contains six data entry worksheets and six model results worksheets that are displayed graphically in Figure 1, which is a screen capture of the navigation screen. The blue boxes represent data entry sheets and the green boxes represent model output sheets.

Figure 1: Alliance for Water Efficiency Water Conservation Tracking Tool Navigation Screen



Data Entry Worksheets

The six data entry worksheets include: (1) Common Assumptions, (2) Specify Demands, (3) Utility Avoided Costs, (4) Define Conservation Measures, (5) Enter Annual Activity, and (6) GHG Module Inputs.

Common Assumptions Worksheet

The Common Assumptions worksheet requires demographic data such as a population projection extending approximately 40 years beyond the analysis start year. In addition to this, for the analyses of

municipalities in the U.S., the model requests data for the service area population in 1990, persons per household for single-family and multifamily housing, average bathrooms per household, and housing units built before 1994. This is required because changes to the plumbing code in the U.S. that became effective in 1994 means that fixtures in the home are more efficient after that date.

Financial information is also entered, such as the current interest rate the water utility pays to borrow money for long-term capital improvement projects, the assumed inflation rate, and the year in which to denominate costs and benefits.

The Tracking Tool requires entry of the peak water use season start and end dates, as well as average annual precipitation and evapotranspiration data.

Lastly, the various water utility customer classes are entered in the Common Assumptions worksheet (e.g., residential, commercial, industrial) as is the corresponding volumetric rates for water, sewer, gas, and electric service.

Specify Demands Worksheet

The Specify Demands worksheet allows the user to enter a pre-existing water demand forecast, or if one is not available the Tracking Tool has a simple built-in forecast generator that grows demands with population. Demands are expressed in terms of average daily consumption for the peak and off-peak seasons, and as total annual delivery volumes. The Tracking Tool can also adjust the baseline demand forecast to account for savings resulting from plumbing codes, such as the United States Energy Policy Act of 1992. This option is selected in the Specify Demands worksheet. Selecting the option to have the Tracking Tool estimate savings resulting from the plumbing code effectively counts savings that are realized passively through the natural replacement of fixtures such as toilets and showerheads. For example, the Energy Policy Act of 1992 created standards for toilets that made the maximum allowable flush volume 1.6 gallons (6 litres) for a residential toilet sold or otherwise installed in the United States after 1994. Many of the toilets installed before 1994 were 3.5 gallons per flush (13 litres), and some were 5 gallons per flush (19 litres) or greater. It is important for water providers to consider the impact of passive savings as plumbing codes passively impact water demands.

After the water demand forecast is entered, or generated in the Tracking Tool, the demand shares of each customer class are entered for the analysis start year. This includes data entry for non-revenue water. (Non-revenue water may include losses from leaks, theft, or meter inaccuracies.) Following this, the number of accounts is assigned to each customer class.

Utility Avoided Costs Worksheet

The Utility Avoided Costs worksheet collects information on the water system's operating and capital costs that would be avoided if customer demands were lowered. The user has the choice to enter avoided cost data manually if an avoided cost study has been conducted separately, or the user can utilize the built-in avoided cost calculator.

The Water Conservation Tracking Tool's avoided cost calculator consists of four data entry tables: (1) a table for entering variable operating and maintenance (O&M) costs for supplying water, (2) a table for entering variable O&M for treating wastewater, (3) a table for entering the year in which system capacity would need to be expanded, and by how much to accommodate future peak season demands, and (4) a table for entering the incremental cost of new system capacity.

Define Conservation Measures Worksheet

The Define Conservation Measures worksheet allows the user to enter details about water efficiency programs such as the expected costs and resulting savings. A user can design a program from scratch or import from the library of existing measures. There are 23 possible parameters for a conservation measure under five broad categories. Not all of the parameters have to be filled out as they are not applicable for all programs.

The water conservation program parameters are:

Unit Water Savings

1. Activity Name
2. Affected Customer Class
3. Unit Water Savings
4. Annual Rate of Savings Decay (%/Yr)
5. Peak Period Savings (% of Annual)
6. Useful Life (Years)
7. Participant Freeriders (% of Participants)

Utility Costs

1. Year in which Utility Costs are Denominated
2. Fixed Setup Costs
3. Cost Per Participant
4. Number of Years of Follow-on Utility Costs
5. Annual Follow-on Fixed Costs
6. Annual Follow-on Variable Costs

Participant Costs (Utility Customers)

1. Year in which Participant Costs are Denominated
2. Initial Cost Per Participant
3. Number of Years of Participant Follow-on Costs
4. Annual Follow-on Participant Costs

Participant Non Water Benefits

1. Sewer Water Savings
2. Natural Gas Savings
3. Electricity Savings

Plumbing Code

1. If there is a related plumbing code: Year in which Code Took (or will take) Effect
2. Code Unit Water Savings
3. Annual Rate of Code-Driven Replacement

The level of detail allowed by the Tracking Tool facilitates comprehensive accounting of the various factors that will impact the costs and benefits of a conservation measure. For example, freeriders are participants in a program that would have taken the same action without intervention, or incentive, from the utility. Therefore the resources expended by a water utility on freeriders do not actually generate a benefit as the action would have occurred anyway. A clear example of this would be a water utility providing a rebate for a high-efficiency toilet that the customer planned on purchasing before learning about the rebate. Not all water conservation programs will have freeridership, but the user has the option to include such estimates.

Enter Annual Activity Worksheet

The only data the user enters on this worksheet is the amount of activity for each conservation measure. If a utility selects a high-efficiency toilet program, the number of toilet replacements expected to be implemented each year by the utility would be entered.

GHG Module Inputs Worksheet

The GHG Module worksheet provides the Tracking Tool with the information it needs to estimate the reduction in GHG emissions due to plumbing/energy codes and conservation program activity. Three types of information are entered:

1. Emission factors for generated electricity in your region,
2. The average cost of electricity for your utility, and
3. The energy intensity of your service area's water supply and wastewater treatment.

Model Results Worksheets

The Tracking Tool's six model results worksheets include: (1) Activity Savings Profiles, (2) Water Savings Summary, (3) Utility Costs and Benefits, (4) Utility Revenue and Rates, (5) Customer Costs and Benefits, and (6) GHG Reduction Benefits.

Activity Savings Profiles Worksheet

The Activity Savings Profiles worksheet contains water saving summaries for each conservation program entered into the Tracking Tool. A chart is displayed for each program that illustrates the temporal pattern of water savings throughout the planning period. Annual water savings are divided between active program savings and passive savings when applicable. Active water savings are the water savings from activity implementation attributable solely to the program action. They equal gross water savings minus water savings that would have been realized anyway because of code requirements or program freeriders. These latter savings, i.e., those not directly attributable to the water provider's conservation program, are referred to as passive water savings. Not all conservation programs will have a passive savings component.

Water Savings Summary Worksheet

The Water Savings Summary worksheet summarizes water savings resulting from the scripted conservation programs and savings resulting from plumbing codes related to the natural replacement of toilets, showerheads, clothes washers, and dishwashers. It also shows the tool's calculation of the benefits from deferred and avoided capacity if applicable.

Four summary tables are included in the worksheet:

1. Service Area Demands Table – This table shows baseline demands; baseline demands adjusted for plumbing code; and baseline demands adjusted for plumbing code and program water savings.
2. Per Capita Demands Table – This table converts the demands from the Service Area Demands table to per capita demands using the population forecast from the Common Assumptions worksheet.
3. Service Area Water Savings Table – This table shows water savings from code requirements, water savings from program activity, and total water savings.
4. Customer Class Water Savings Table – This table shows how total water savings are divided among customer classes.

In addition to the summary tables, there is an assortment of charts that summarize water savings results.

Utility Costs and Benefits Worksheet

The Utility Costs and Benefits worksheet summarizes the costs and benefits of the conservation programs from the utility perspective. The outputs are organized in four tables:

1. Conservation Program Annual Budget – This table shows the annual cost to the utility of each defined conservation measure.
2. Conservation Program Cost Analysis Table – This table shows the unit cost ($/Unit Volume of Savings), present value cost, and annualized costs of conservation activities. The unit cost is the measure of the cost of the water savings for the activity. The present value cost is what the utility would need to spend or set aside today in order to fully fund the conservation program. The annualized cost is what the utility would need to expend annually if it were to finance the conservation program over some fixed number of years.
3. Conservation Program Benefits Analysis Table – This table shows the unit benefit ($/Unit Volume of Savings), the present value benefits, and the present value benefit broken down between avoided capacity, avoided supply, and avoided wastewater costs. The present value benefit is the economic value of future cost savings today.
4. Utility Conservation Program NPV and B/C Ratio Table – This table shows the net present value (NPV) and benefit-cost ratio (B/C ratio) for each of the conservation activities. NPV is simply the present value benefits less present value costs. The B/C ratio is the present value benefits divided by the present value costs. Both are measures of the conservation activity's economic worth from the perspective of the utility and its ratepayers. A positive NPV and a B/C ratio greater than one indicate the conservation activity would make the utility and its ratepayers better off financially – that is, the present value of future utility costs would be lower with the conservation than without it. Conversely, a negative NPV and a B/C ratio less than one indicate the conservation activity would make the utility and its ratepayers financially worse off. However, there may be instances in which utility staff choose to implement a program with a B/C ratio less than one. Examples of this may be an education program that builds awareness and trust with customers, or piloting new technology. Additionally, the B/C ratio of a collection

of conservation programs may have a high enough total NPV and corresponding B/C ratio to accommodate a program that is not cost-effective.

Utility Revenue and Rates Worksheet

The Utility Revenues and Rates worksheet summarizes impacts of the conservation program on utility revenue requirements, average customer bill, and the average rate for water. Annual impacts are shown graphically in charts. The charts show the impacts to revenue requirements, the average water rate, and the average customer bill assuming two alternative program financing methods. The first method assumes pay-as-you-go financing, where program costs are paid out of current revenues. The second method assumes debt financing, where program costs are paid by issuing 20-year debt.

Customer Costs and Benefits Worksheet

Conservation activity costs and benefits from the participating customer perspective are summarized on the Customer Costs and Benefits worksheet. The worksheet contains four tables:

1. Customer Conservation Program Costs Table – This table shows the unit cost ($/Unit Volume of Savings) and present value cost of conservation activities from the perspective of the participating customer.
2. Customer Conservation Program Benefits Table – This table shows the unit benefit ($/Unit Volume of Savings), the present value benefits, and the present value benefit broken down between water, gas, electricity, and sewer benefits from the perspective of the participating customer.
3. Lifetime Energy Savings Table – This table shows the lifetime electricity and gas savings on the customers' side of the meter for each conservation measure
4. Customer Conservation Program NPV and B/C Ratio Table – This table shows the net present value (NPV) and benefit-cost ratio (B/C ratio) for conservation activities from the perspective of the participating customer.

GHG Reduction Benefits Worksheet

Energy savings and GHG emission reductions due to plumbing/energy codes and conservation program activity are summarized in tables and charts on this worksheet. The outputs include total and cumulative electricity and gas savings, value of electricity and gas savings, and cumulative emission reductions. The results are split between the utility-side and customer-side of the meter as well as whether they are a result of plumbing/energy codes or conservation program activity. Gas savings are limited to the customer side as the model assumes the utility uses electricity in its operations. The data are expressed in either five year increments or annually.

Results of the Analysis for Each Community

The following section describes the modeling process for each of the seven communities and presents the findings. Each community has a unique set of circumstances that led to different methodologies and different conservation programs being analyzed. The Region of Waterloo in Ontario supplies water to the City of Waterloo and the City of Cambridge. Therefore, these three utilities are grouped together. Commerce Township, Lyon Township, and Southwest Oakland Township are also grouped together as they are all located in Oakland County, Michigan and their systems are operated by the Oakland County Water Resources Commissioner's Office.

The results presented in this section include costs associated with implementing water efficiency programs and the associated benefits. A primary output of each evaluation is the benefit-cost ratio (B/C ratio), which is the present value benefits of a particular water efficiency program divided by its present value costs. A ratio less than one indicates that the costs outweigh the benefits, a ratio of exactly one means the benefits and costs are equal, and a ratio greater than one suggests the benefits exceed the costs. As was indicated earlier, there may be programs with benefit-cost ratios less than one that a water provider will want to include if the entire portfolio of programs is cost-effective. This may include programs with hard to quantify benefits such as education and outreach efforts, or providing incentives to promote the use and awareness of cutting edge technology. In addition, this paper should be read in combination with ***Environmental Impacts of Water Withdrawals and Discharges: A Role for Green Infrastructure*** written for this project by Environmental Consulting & Technology in order to obtain an understanding of the non-financial benefits of actions related to the water cycle.

Region of Waterloo, City of Waterloo, and City of Cambridge, Ontario

Overview

The Regional Municipality of Waterloo is located in southern Ontario, Canada and supplies water to the cities of Cambridge, Kitchener, and Waterloo and the townships of North Dumfries, Wellesley, Wilmot, and Woolwich. The Region of Waterloo obtains its water from groundwater sources and the Grand River, and has been pursuing water conservation programs since at least 1985. As of 2011 the population of Waterloo Region was estimated to be 553,000. During the course of this project the Alliance for Water Efficiency collaborated with the team developing the Region of Waterloo's 2015-2025 Water Efficiency Master Plan. The two teams were able to add value to both the Region of Waterloo Water Efficiency Master Plan and the work being conducted under the *Greater Lakes project* funded by the Great Lakes Protection Fund. In addition to increasing the rigor of the analysis, the collaboration allowed the team to add the City of Cambridge to the Improving *Water Management in the Great Lakes Basin* water conservation evaluation.

Service Area Data Assumptions

2015 was selected as the base year for the Region of Waterloo Tracking Tool analysis, and for the analyses of the City of Waterloo and the City of Cambridge. The Region's population is expected to increase from 582,808 in 2015 to 909,545 in 2050. The service area population in 1990 was 391,360.

Table 1 illustrates the expected population forecast over time for the Region and the cities of Waterloo and Cambridge.

Table 1: Region of Waterloo, City of Waterloo, and City of Cambridge Population Forecasts

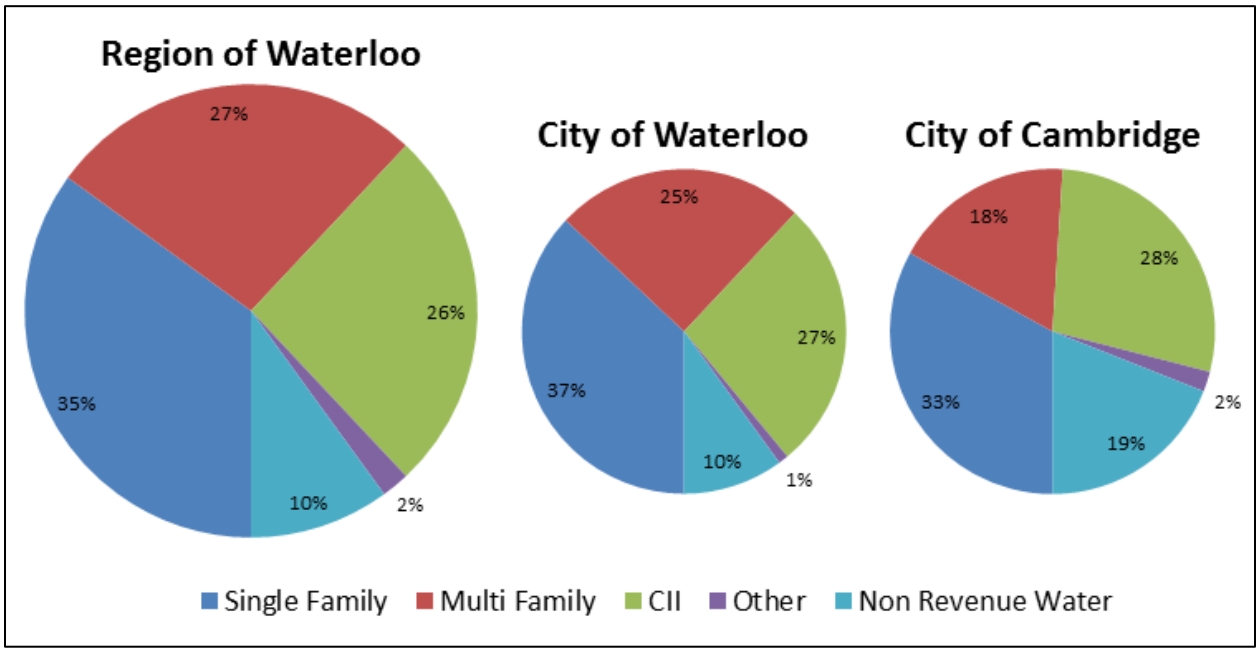
	2015	2020	2030	2040	2050
Region of Waterloo	582,808	627,231	726,494	823,400	909,545
City of Waterloo	134,990	144,707	166,291	188,472	202,892
City of Cambridge	131,894	138,621	153,123	169,143	182,084

It was assumed that the interest rate for the three service areas is 5 percent and the inflation rate is 2 percent. A peak water use season was entered as May 1 through September 30. Average reference evapotranspiration was entered as 59.94 centimeters per year accompanied by 93.98 centimeters of precipitation per year on average. The water customer classes entered were single-family, multifamily, CII (Commercial, Institutional, and Industrial), and other. The customer class water rates entered for the Region of Waterloo represented the wholesale price to its customers. The water rates for retail customers of the City of Waterloo and Cambridge were entered as $\$1.55/M^3$ and $\$1.68/M^3$ respectively for all customer classes. Sewer rates were entered as $\$1.76/M^3$ for the City of Waterloo and $\$1.91/M^3$ for the City of Cambridge.

The water demand forecast for the Region of Waterloo and the cities of Waterloo and Cambridge were projected using the Tracking Tool's built-in calculator that relies on population growth rates to estimate future water use. Peak and off-peak average day demands were entered for the base year (2015) for each service area. The total number of accounts for each customer class and the associated demand share were entered as well. As is illustrated in Figure 2, the Region of Waterloo's water consumption is dominated by residential use with a little over 25% of consumption represented by the commercial, institutional and industrial (CII) sector. Non-revenue water is almost twice as much in the City of Cambridge (19 percent) compared to the Region of Waterloo and City of Waterloo. The City of Cambridge is working to reduce its non-revenue water.[1]

[1] Shah, Yogesh. (May 2014). City of Cambridge Watermain Rehabilitation and Replacement Strategy– "Lessons Learned." Presentation at Trenchless Technology Road Show. http://www.cattevents.ca/pdf/TRS_ses4_Shah.pdf

Figure 2: Region of Waterloo, City of Waterloo, and City of Cambridge Customer Class Demand Shares



Avoided cost data were entered for each service area before the water efficiency programs were entered into the Tracking Tool. The short-run avoided costs for the Region of Waterloo were related to energy for transmission, treatment, and distribution, chemicals, and other operating maintenance costs. Additionally, costs related to potential expansion projects were entered. For the cities of Waterloo and Cambridge the short-run avoided costs entered represent the Region's wholesale water purchase price.

Water Efficiency Program Descriptions

Seventeen water efficiency programs were evaluated for the Region of Waterloo, City of Waterloo, and City of Cambridge. The programs were first modelled at the regional scale and then activity levels (e.g., number of toilet rebates) were assigned at the city level for the City of Waterloo and the City of Cambridge based on population proportions. Each program is described in the following section. Along with a general description, detail is provided about the model input assumptions and the resulting model outputs at the regional level. The analysis results presented in the remainder of this section are for the whole Region of Waterloo. Tables, figures and results for the cities of Waterloo and Cambridge can be found in Appendix A.

Water efficiency programs evaluated for the Region of Waterloo:

1. CII Tank-Type High Efficiency (HE) Toilet
2. CII Valve-Type HE Toilet
3. CII Laundromat
4. CII Pre-Rinse Spray Valve
5. Community Education
6. School Curriculum

7. Developer Incentive: Hot Water Recirculation System
8. Developer Incentive: Rainwater Harvesting System Plumbed
9. Developer Incentive: Greywater Recycling System
10. Targeted User Program: Education
11. Targeted User Program: Audit
12. Targeted User Program: Rebate
13. CII Cooling Tower
14. Restaurant Certification Program
15. CII Audit/Recommendations
16. Residential Rainwater Harvesting Rebate Outdoor Only
17. Toilet Flapper Replacement

Of the 17 water efficiency programs evaluated, six were ones that Waterloo Region has not been involved in in the past:

1. CII Cooling Tower Program
2. Developer Incentives
3. Restaurant Certification Program
4. Residential Rainwater Harvesting Rebate (Outdoor)
5. Residential Targeted User Program
6. Toilet Flapper Replacement

There were also new efforts related to community education, research, and advocacy.

CII Tank-Type HE Toilet

The CII Tank-Type HE Toilet program targets the commercial, industrial, and institutional sectors and offers incentives to replace tank-type 13-litre or greater per flush toilets with models that have a flush volume of 4.8 litres or less. The estimated annual savings per fixture was 44,000 litres per year, and each toilet was expected to cost the Region of Waterloo $20.

Approximately 50 toilet replacements were planned per year through 2025 for the entire Region of Waterloo service area. The CII Tank-Type Toilet replacements are estimated to save an average of 10.52 megalitres per year and have a benefit-cost ratio of 14.18.

CII Valve-Type HE Toilet

The CII Valve-Type HE Toilet program targets the commercial, industrial, and institutional sectors and offers incentives to replace valve-type (flushometer) 13-litre per flush or more toilets with models that have a flush volume of 4.8 litres or less. The estimated annual savings per fixture was 44,000 litres per year, and each toilet incentive was expected to cost the Region of Waterloo $150.

Thirty-five toilet replacements were planned per year through 2025 for the entire Region of Waterloo service area. The CII Valve-Type Toilet replacements are estimated to save an average of 8 megalitres per year and have a benefit-cost ratio of 1.89.

CII Laundromat

The CII Laundromat program analysis modelled potential costs and savings associated with replacing inefficient clothes washers at laundromats with high-efficiency machines. The estimated annual savings per machine was 118,994 litres per year, and each clothes washer replacement was expected to cost the Region of Waterloo $150.

Approximately 10 laundromat washing machine replacements were planned per year through 2025 for the entire Region of Waterloo service area. The CII Laundromat clothes washer replacements are estimated to save an average of 5.58 megalitres per year and have a benefit-cost ratio of 2.11.

CII Pre-Rinse Spray Valve

Pre-rinse spray valves are used in commercial and institutional settings to rinse food waste from pots, pans, utensils, and dishware before they enter a dishwasher. Water conserving valves consume less water and have an equal or better rinsing effectiveness because of improved spray pattern design. This program assumed a valve replacement would result in a savings of 107,070 liters per year at a cost of $80 per valve. Thirty pre-rinse spray valve replacements were planned per year through 2025 for the entire Region of Waterloo service area. The pre-rinse spray valve replacements are estimated to save an average of 31.31 megalitres per year and have a benefit-cost ratio of 15.11.

Community Education

Measuring the impact of education programs is far from an exact science, and is often left out of analyses that seek to estimate costs and benefits of conservation activities. That said, education is a foundational piece of any water efficiency effort. The project team included a Community Education program in the Tracking Tool analysis for the Region of Waterloo to gain perspective on costs and benefits. It was estimated that a $135,000 investment in community education would yield a savings of 33.37 megalitres per year and that the useful life of the education would be 5 years. It was assumed this investment would be made every year through 2025. The benefit-cost ratio was estimated to be 0.29. The Community Education program scripted in the Tracking Tool analysis included education, research, and advocacy programs and is comprised of the following components:

- Landscape Topsoil Depth Education and Advocacy
- Residential Hot Water Recirculation System Research
- Plumber Training Program
- Commercial Sub-Metering Education and Advocacy
- Website and CII E-Newsletter

School Curriculum

A school curriculum program was also evaluated to assess the possible benefits of providing school aged children education about water efficiency. It was estimated that a $15,000 investment in a water

efficiency school curriculum would generate a savings of 3.71 megalitres per year. It was assumed this investment would be made every year through 2025. The benefit-cost ratio was estimated to be 0.23.

Developer Incentives: Hot Water Recirculation Systems, Rainwater Harvesting Systems, and Greywater Systems

The Tracking Tool analysis for the Region of Waterloo included three incentive programs for developers: (1) hot water recirculation systems, (2) plumbed rainwater harvesting systems, and (3) greywater systems.

Hot water recirculation systems literally recirculate hot water in pipes and reduce, or eliminate, wait time for hot water. The program was designed with a cost of $150 per incentive and an estimated savings of 25,000 litres per year per system.

Forty hot water recirculation system incentives were planned per year through 2025 for the entire Region of Waterloo service area. The Hot Water Recirculation System incentive program is estimated to save an average of 7.86 megalitres per year and have a benefit-cost ratio of 1.08.

Plumbed rainwater harvesting systems use captured rainwater for in-house non-potable uses such as flushing toilets. The project team modeled the potential impact of a program that would incentivize developers to install these systems during construction of new housing. The incentive level was entered at $2,500 per system with an expected savings of 65,000 liters per system per year.

Approximately 15 plumbed rainwater harvesting system incentives were planned per year through 2025 for the entire Region of Waterloo service area. The estimates suggest an overall savings of 6.01 megalitres per year and a benefit-cost ratio of 0.11.

Greywater systems collect greywater from such uses as showers and baths, filter the water, and treat it with chlorine. Once it is filtered and chlorinated it can be used to flush toilets. The program was designed with a cost of $1,000 per incentive and an estimated savings of 20,000 litres per year per system.

Approximately 10 greywater system incentives were planned per year through 2025 for the entire Region of Waterloo service area. The estimates suggest an overall savings of 0.53 megalitres per year and a benefit-cost ratio of 0.05.

Targeted User Program: Education, Audit, and Rebate

The project team evaluated three programs that would target residential customers that have high water consumption patterns and would provide one or a combination of (1) education, (2) audits, or (3) rebates. It was estimated that the education program would reach 3,000 customers per year through 2025; there would be 255 audits performed per year through 2025, and 700 rebates for water efficient fixtures given per year through 2025 for the entire Region of Waterloo service area. The cost to reach each customer with education was estimated to be $40 with a 10,000 litre per year water savings, $150 for each audit with an estimated savings of 18,000 litres per year, and $60 per rebate per year with an

estimated 35,000 litres per year savings. The educational outreach program as a whole is estimated to save an average of 103.36 megalitres per year and have a benefit-cost ratio of 1.21, the audit program is expected to generate 46.28 megalitres per year with a B/C ratio of 1.36, and the targeted rebates are expected to yield 247.04 megalitres of savings per year with a B/C ratio of 6.59. Combined, the B/C ratio of all three programs is 2.37.

CII Cooling Tower

Cooling towers are often used to cool buildings, provide refrigeration, or cool industrial equipment. The savings in this program are generated with the use of conductivity controllers and efficient management practices. Each cooling tower rebate was estimated to cost $2,000 and save 794,482 liters per year. Approximately 15 cooling tower rebates were planned each year through 2025 for the entire Region of Waterloo service area. The cooling tower retrofits are estimated to save an average of 40.78 megalitres per year and have a benefit-cost ratio of 0.63.

Restaurant Certification Program

The Restaurant Certification program provides recognition to restaurants for using water efficiently. Rebates are offered to water customers that are food service establishments that can be used to lower water use through replacement of inefficient toilets, urinals, pre-rinse spray valves, and ice machines. Each certification was estimated to cost the Region of Waterloo $750 and save 341,444 litres per year.

Approximately 15 certifications were planned per year through 2025 for the entire Region of Waterloo service area. As a whole, the Restaurant Certification program is estimated to save an average of 58.53 megalitres per year and have a benefit-cost ratio of 5.22.

CII Audit/Recommendations

The project team modeled the costs and savings associated with a program for the CII sector that provides commercial, industrial and institutional customers with strategies and financial incentives to reduce water use. The annual budget for the CII Audit/Recommendations program was set to ~$150,000 through 2025 for the Region of Waterloo service area, and it was estimated to save 38,688 cubic meters per year. The program analysis predicted a benefit-cost ratio of 2.38.

Residential Rainwater Harvesting Rebate Outdoor Only

The water conservation analysis also included a program that rebates the purchase of rainwater harvesting barrels and tanks. The harvested rainwater is ultimately used to water plants and other outdoor non-potable applications, not for indoor purposes. Each rainwater harvesting rebate was estimated to cost the Region of Waterloo $375 and save 6,000 litres per year.

Approximately 45 rainwater harvesting rebates were planned per year through 2025 for the entire Region of Waterloo service area. The rainwater harvesting rebates are estimated to save an average of 2.18 megalitres per year and have a benefit-cost ratio of 0.13.

Toilet Flapper Replacement

Toilet flappers wear out with age and are often the cause for a leaking toilet. The project team modeled potential savings and costs associated with a toilet flapper program giveaway program.

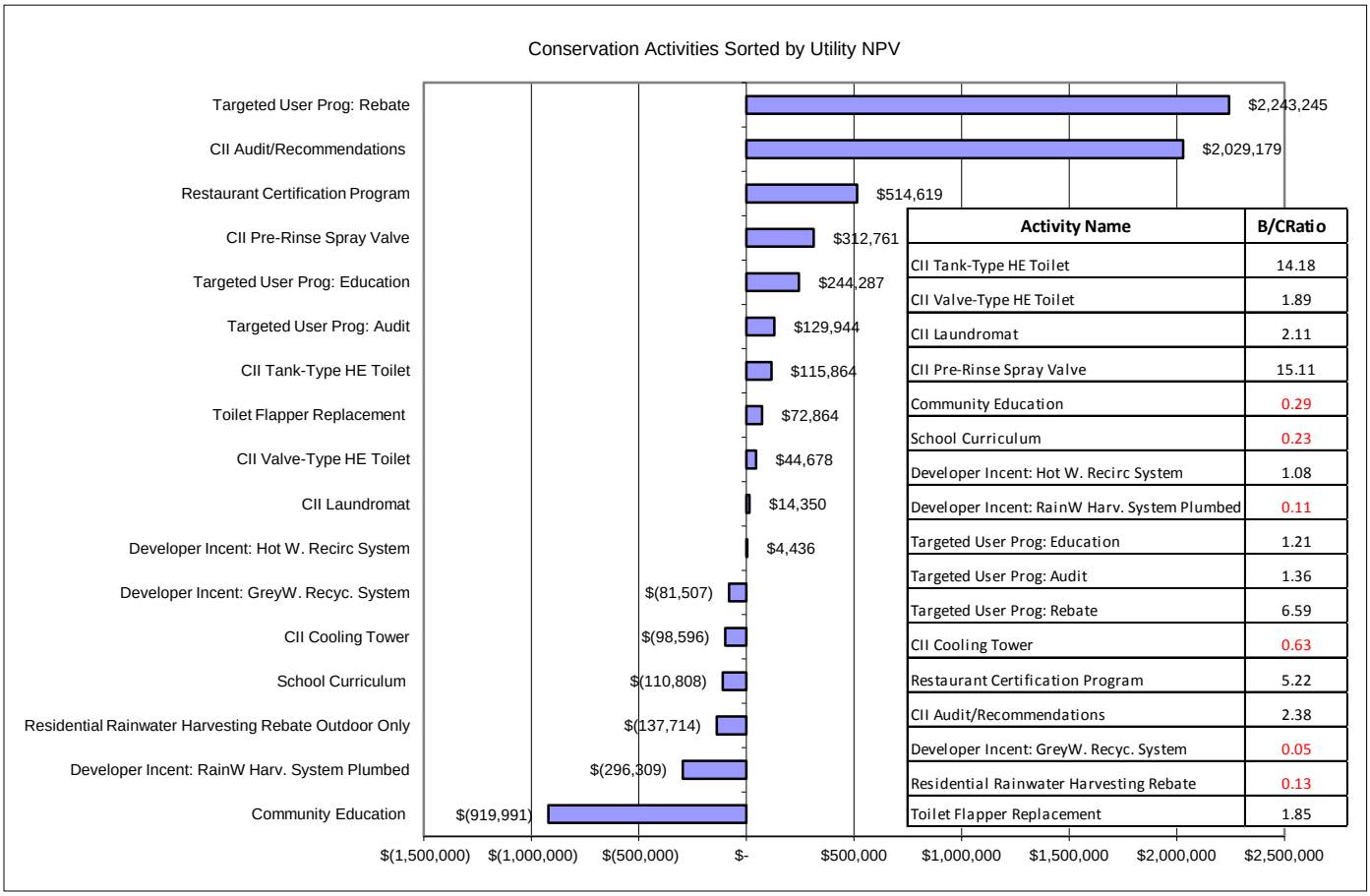
Three hundred toilet flapper replacements were planned per year through 2025 for the entire Region of Waterloo service area. Collectively, the toilet flapper replacements are estimated to save an average of 14.84 megalitres per year and have a benefit-cost ratio of 1.85.

Results

The results of the individual water conservation program evaluations for the Region of Waterloo demonstrate a wide range of savings and a variety of benefit-cost ratios. This section presents model outputs related to benefits and costs, service area water demands, impact to the utility sales revenue requirement, and energy savings and greenhouse gas emissions. To prevent the outputs from being cluttered, the output tables and figures for the City of Waterloo and the City of Cambridge are presented in Appendix A at the end of the report.

All of the programs analyzed for the Region of Waterloo can be found in Figure 3 sorted by net present value (NPV). A table inserted in the chart includes the B/C ratio.

Figure 3: Region of Waterloo Conservation Activities NPV and B/C Ratio



Benefits and Costs

As shown in Figure 3, of the 17 programs analyzed, six produced B/C ratios less than one. The portfolio as a whole generated a NPV of $4,081,302 and B/C ratio of 1.68.

Table 2 shows a snapshot of savings for each program from 2015 through 2025, and Table 3 shows the present value cost, present value benefit, net present value, and benefit-cost ratio for each program and for the entire portfolio of measures. The benefits are generated through avoided costs associated with supply and wastewater.

Table 2 contains water savings for each of the programs from 2015 through 2020 and includes a summation of all programs. The CII/Audit Recommendations program is projected to have the largest impact on water demands and is predicted to be cost-effective with a B/C ratio of 2.38. The Targeted User Education program is also expected to be cost-effective and produce a large reduction in water use. The savings resulting from any education program will have a large amount of uncertainty, and the savings that are realized may decay quickly unless the program operates on a continuous basis.

Table 2: Region of Waterloo Conservation Program Savings Snapshot 2015-2020

Activity Name	Conservation Program Savings Megalitres					
	2015	2016	2017	2018	2019	2020
CII Tank-Type HE Toilet	2.02	4.03	6.05	8.07	10.09	12.10
CII Valve-Type HE Toilet	1.53	3.07	4.60	6.14	7.67	9.21
CII Laundromat	1.07	2.14	3.21	4.28	5.35	6.43
CII Pre-Rinse Spray Valve	3.11	6.21	9.32	12.42	15.53	18.63
Community Education	33.37	63.40	90.44	114.76	136.66	136.66
School Curriculum	3.71	6.67	9.05	10.95	12.46	12.46
Developer Incent: Hot W. Recirc System	1.00	2.00	3.00	4.00	5.00	6.00
Developer Incent: RainW Harv. System Plumbed	0.91	1.82	2.73	3.64	4.55	5.46
Targeted User Prog: Education	30.00	58.50	85.58	111.30	135.73	158.94
Targeted User Prog: Audit	4.59	9.18	13.77	18.36	22.95	27.54
Targeted User Prog: Rebate	24.50	49.00	73.50	98.00	122.50	147.00
CII Cooling Tower	11.12	22.25	33.37	44.49	55.61	55.61
Restaurant Certification Program	5.80	11.61	17.41	23.22	29.02	34.83
CII Audit/Recommendations	38.69	77.38	116.06	154.75	193.44	232.13
Developer Incent: GreyW. Recyc. System	0.18	0.34	0.49	0.62	0.74	0.84
Residential Rainwater Harvesting Rebate Outdoor Only	0.26	0.53	0.79	1.06	1.32	1.58
Toilet Flapper Replacement	1.64	3.27	4.91	6.54	8.18	9.81
Total	**163.50**	**321.41**	**474.27**	**622.59**	**766.80**	**875.24**

Table 3 shows the present value cost, present value benefit, and net present value of each conservation program, and includes a total for all measures. The present value cost represents the cost of implementing the water conservation programs. The present value benefit represents the benefits provided by reduction in water demand. A large benefit indicates high water savings. A reduced demand results in lower variable costs on the water production side and the wastewater side. The net present value is the benefits minus the costs, and the benefit-cost ratio represents the benefits divided by the costs. A high benefit-cost ratio does not necessarily denote a high level of water savings; it only refers to the cost of a conservation program versus the benefits it produces.

Table 3: Region of Waterloo Costs and Benefits of Water Conservation Programs

Activity Name	PV Cost ($)	PV ($) Benefit	NPV($)	B/C Ratio
CII Tank-Type HE Toilet	$ 8,791	$ 124,655	$ 115,864	14.18
CII Valve-Type HE Toilet	$ 50,168	$ 94,846	$ 44,678	1.89
CII Laundromat	$ 12,900	$ 27,250	$ 14,350	2.11
CII Pre-Rinse Spray Valve	$ 22,170	$ 334,930	$ 312,761	15.11
Community Education	$ 1,290,042	$ 370,051	$ (919,991)	0.29
School Curriculum	$ 143,338	$ 32,530	$ (110,808)	0.23
Developer Incent: Hot W. Recirc System	$ 57,335	$ 61,771	$ 4,436	1.08
Developer Incent: RainW Harv. System Plumbed	$ 334,455	$ 38,147	$ (296,309)	0.11
Targeted User Prog: Education	$ 1,146,704	$ 1,390,991	$ 244,287	1.21
Targeted User Prog: Audit	$ 365,512	$ 495,456	$ 129,944	1.36
Targeted User Prog: Rebate	$ 401,346	$ 2,644,591	$ 2,243,245	6.59
CII Cooling Tower	$ 267,564	$ 168,968	$ (98,596)	0.63
Restaurant Certification Program	$ 121,837	$ 636,457	$ 514,619	5.22
CII Audit/Recommendations	$ 1,469,215	$ 3,498,394	$ 2,029,179	2.38
Developer Incent: GreyW. Recyc. System	$ 86,003	$ 4,496	$ (81,507)	0.05
Residential Rainwater Harvesting Rebate Outdoor Only	$ 157,672	$ 19,958	$ (137,714)	0.13
Toilet Flapper Replacement	$ 86,003	$ 158,866	$ 72,864	1.85
Total	**$ 6,021,057**	**$10,102,358**	**$ 4,081,302**	**1.68**

Service Area Water Demands

Figure 4 illustrates demand trends under three scenarios. The blue line depicts Region of Waterloo baseline demands projected out to 2035. Under this scenario no changes are made to present day per capita demand and population increases drive up demand accordingly. The red line subtracts savings resulting from natural replacement of fixtures and appliances such as toilets, showerheads, clothes washers, and dishwashers.

Canada does not have national plumbing codes similar to those in the United States' Energy Policy Act of 1992 that required, among other things, a maximum flush volume of 1.6 gallons (6 litres) for toilets. The Ontario Building Code (OBC) required toilets to have a flush volume of 6 litres per flush (lpf) or less in new construction beginning in 1996, but Ontario does not have a code relating to other installations or point of sale. After January 1, 2014 the amended Ontario Building Code required 4.8 lpf toilets in new residential buildings and 6.0 lpf toilets in all other newly constructed buildings. In 1996 residential showerheads were assigned a maximum flow rate of 9.5 litres per minute (lpm) for new residential construction via the OBC; that changed to 7.6 lpm in new construction after January 1, 2014.[2]

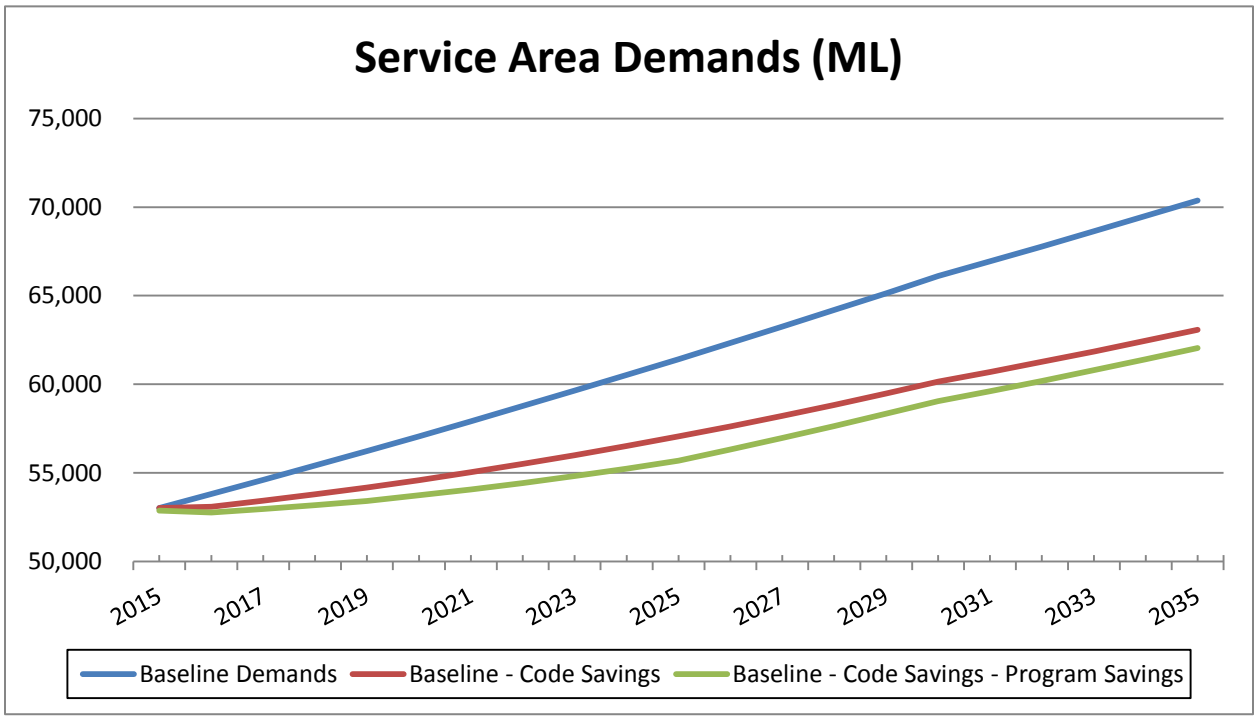
The Tracking Tool has a built-in calculator to estimate the passive savings resulting from the natural replacement of toilets, showerheads, clothes washers, and dishwashers. The project team made slight modifications to the Tracking Tool to customize the assumptions pertaining to natural fixture and

[2] Ontario Regulation 332/12 made under the Building Code Act, 1992. (November 2, 2012). http://www.e-laws.gov.on.ca/html/source/regs/english/2012/elaws_src_regs_r12332_e.htm

appliance replacement in the Region of Waterloo. For residential toilets, the number of currently installed inefficient toilets was estimated based on results from the 2013 Residential End Uses of Water Study (REUWS) Update Site Report for Region of Waterloo.[3] Typically, this figure is estimated by the Tracking Tool based on demographic data inputs. Additionally, the annual natural replacement rate was changed from the default of 4% per year to 3%. No change was made to the Tracking Tool methodology for estimating the number of installed CII toilets other than changing the natural replacement rate from the default value of 4% to 3%. The current stock of inefficient showerheads was also estimated using the REUWS Site Report for Waterloo and the natural replacement rate was changed from 12% per year to 6%. For clothes washers there were two modifications: (1) a change in the natural replacement rate assumption from 8.3% per year to 6% per year, and (2) a change in the assumption that 70% of the current clothes washer market share is efficient to 50%. For dishwashers the only change was an adjustment to the default natural replacement rate of 7.7% per year to 6%.

The green line in Figure 4 plots future water demands with both passive savings occurring from natural replacement and active savings resulting from water efficiency programs. There are large differences between the three lines and natural replacement; demand reductions from conservation programs are forecasted to lower future demands.

Figure 4: Region of Waterloo Service Area Demands 2015-2035



[3] Aquacraft. (March 22, 2013). Residential End Uses of Water Study Update - Site Report: Region of Waterloo. http://www.aquacraft.com/sites/default/files/doc/Waterloo%20Site%20Report%20Final%20Draft.pdf

Energy Savings and Greenhouse Gas Emissions

Water conservation programs reduce the need to pump, treat, and deliver water to customers, and decrease the amount of water flowing to wastewater treatment plants. This in turn reduces the energy consumption associated with these processes. Figure 5 illustrates the annual and cumulative electricity savings experienced by both the customer and the utility. These electricity savings are a result of projected water savings from natural fixture and appliance replacement (labeled as codes in Figure 5) and from water conservation programs.

Figure 5: Annual and Cumulative Electricity Savings

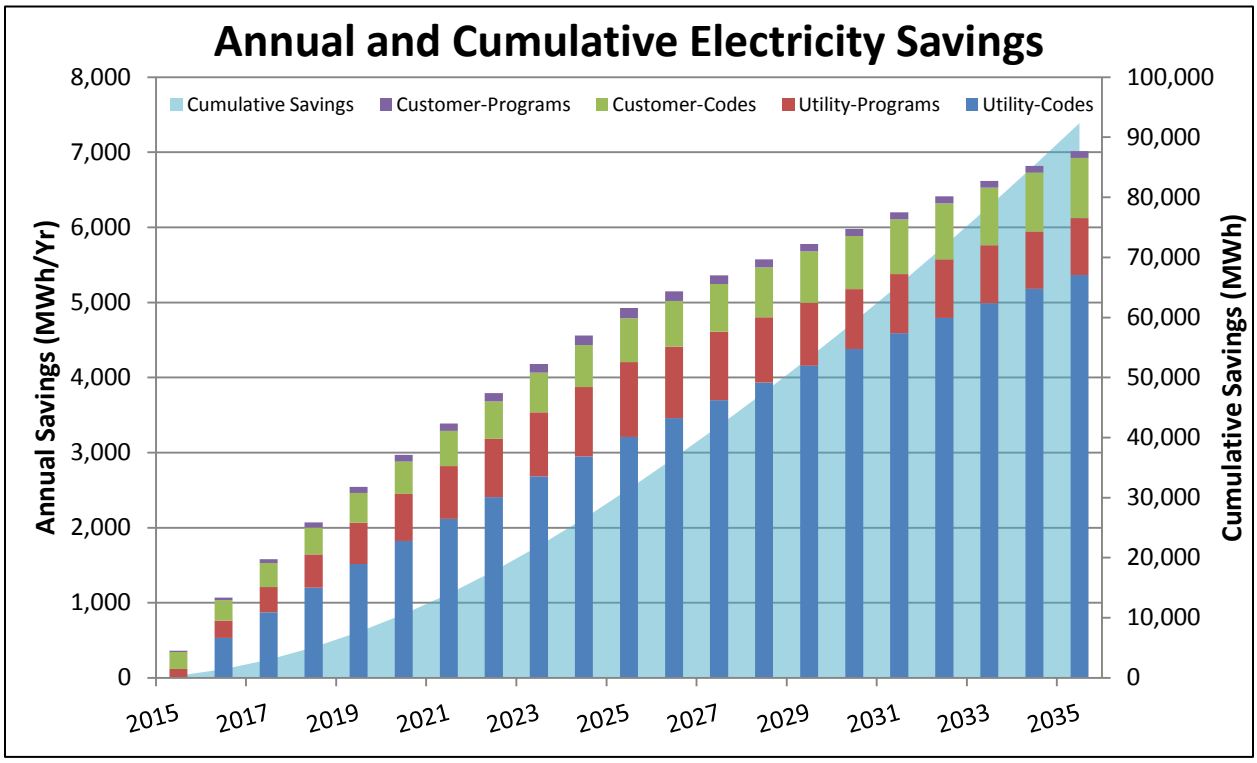
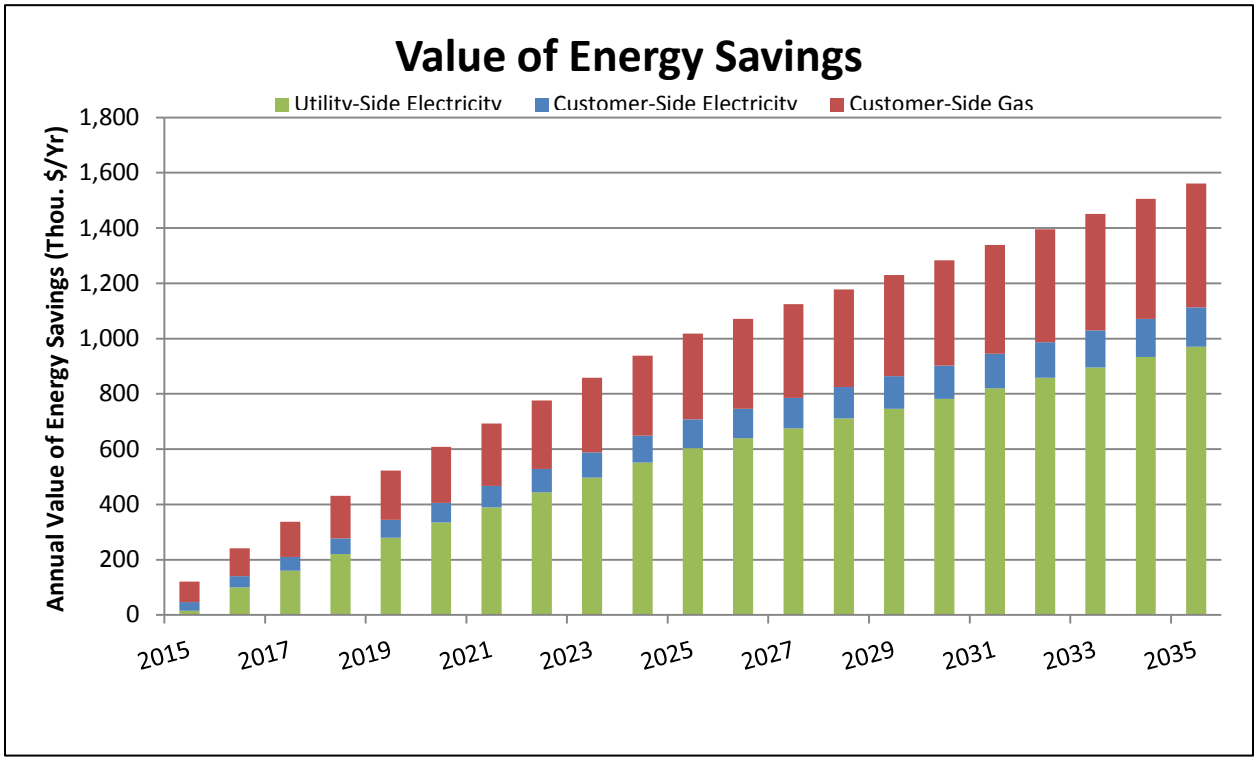


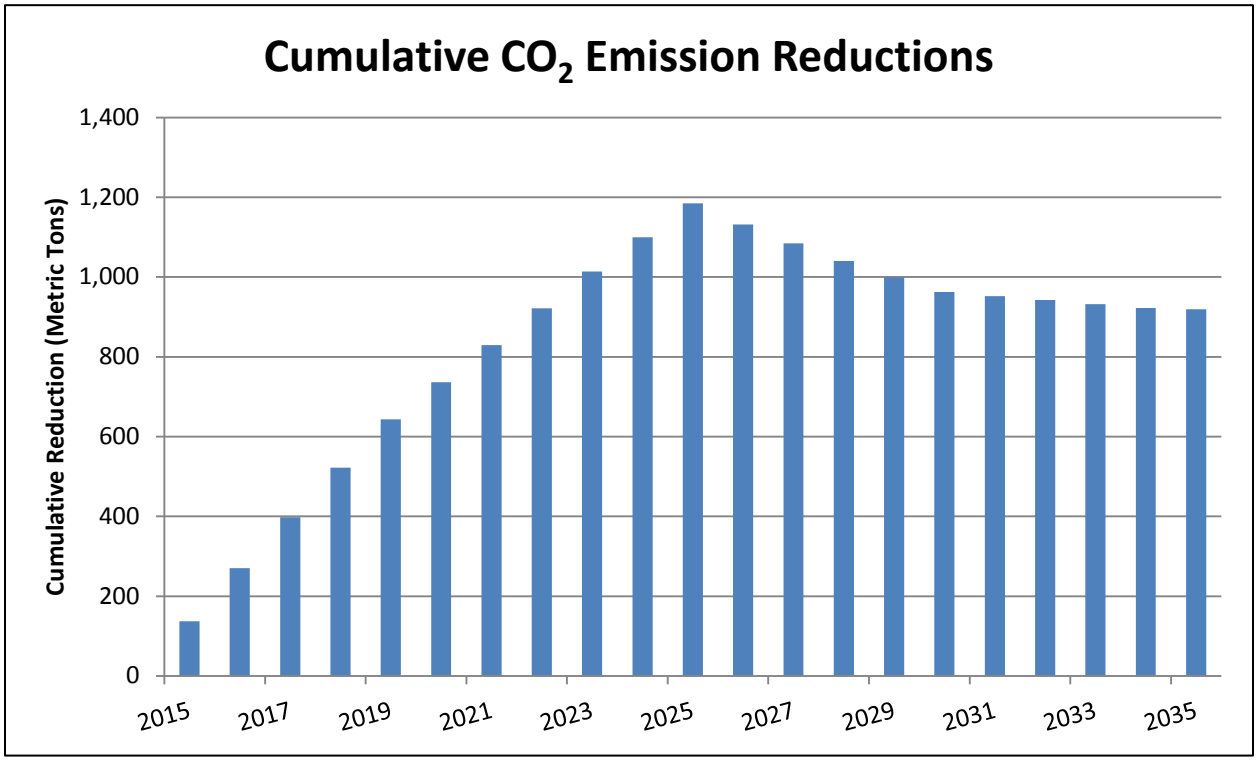
Figure 6 illustrates the value of energy savings resulting from reduced water demands. They are displayed in three categories: (1) utility electricity savings, (2) customer electricity savings, and (3) customer gas savings. The Tracking Tool assumes utilities use electricity, and not gas, to pump and treat water.

Figure 6: Value of Energy Savings for Utility Electricity and Customer Electricity and Gas



The energy savings resulting from water demand reductions also result in greenhouse gas emission reductions. Those reductions are displayed in Figure 7 and show reductions in metric tons for carbon dioxide (CO_2).

Figure 7: Cumulative CO_2 Emission Reductions



Lessons Learned

Seventeen water efficiency programs were analyzed for the Region of Waterloo. Many of the water conservation programs were cost-effective and many were new activities that have yet to be implemented. Even though the Region of Waterloo has been actively pursuing conservation since at least 1985, it is still finding ways to reduce water consumption. The Region appears to be phasing out its toilet rebate program, which represents a more traditional approach. This is not surprising as it has already had great success with this effort.

Some of the cutting edge aspects of this analysis include quantifying the costs and benefits of education programs, analyzing new technology such as greywater systems and rainwater harvesting systems that are plumbed for indoor non-potable uses, and evaluating programs that target high water users and developers. The Region of Waterloo is increasing its efforts in regard to education, pursuing new technology like template assisted crystallization (an alternative to water softeners), and still relying on the fundamentals through efforts like its toilet flapper replacement program. Other communities can learn that water efficiency works in this region and is cost-effective even for a wholesale water provider that has lower operating costs than its customers.

City of Guelph, Ontario

Overview

The City of Guelph is located in Ontario, Canada; in 2011 it had an estimated population of 121,688 over a land area of 87 square kilometers. Guelph obtains its water supply almost exclusively from groundwater sources. The City of Guelph has been pursuing water efficiency programs to manage demand since 1998. The Alliance for Water Efficiency worked closely with the City of Guelph to model current and future water efficiency programs. The City of Guelph provided model input data and chose the efficiency programs to be evaluated.

Service Area Data Assumptions

2011 was selected as the base year for the City of Guelph Tracking Tool analysis. The City of Guelph's population is expected to increase from 121,688 in 2011 to 227,000 in 2050, based on the best available population forecast at the time of the analysis (which does not reflect the specific planning projections of the City of Guelph). The service area population in 1990 was 86,460. Table 6 illustrates the expected population forecast over time in decadal increments.

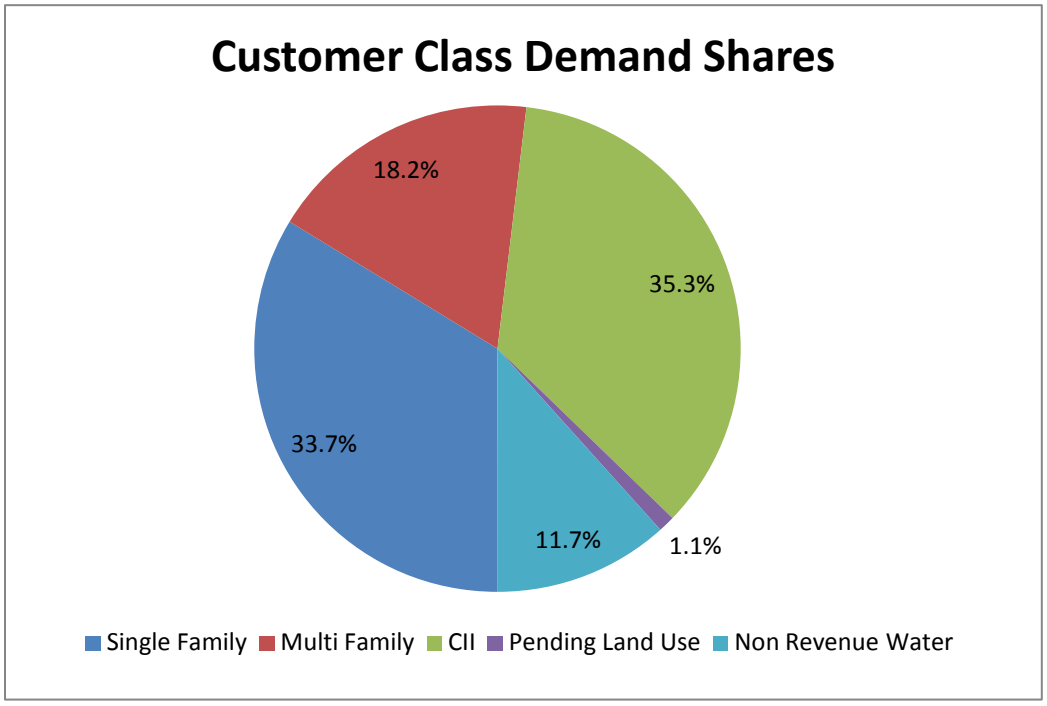
Table 6: City of Guelph Population Forecast

2011	2020	2030	2040	2050
121,688	143,217	169,749	196,000	227,000

Other notable data inputs include an interest rate of 3.01 percent and an inflation rate of 3.0 percent. Overall costs and benefits are expressed in 2013 dollars. May 1st was selected as the peak water use season start date and September 30th was selected for the peak season end date. Average reference evapotranspiration was entered as 59.94 centimeters per year with 90.79 centimeters of precipitation per year on average. The water customer classes entered were single-family, multifamily, ICI (industrial, commercial, and institutional), and pending land use. All sectors were assigned a water rate of $1.38 per cubic meter and a sewer rate of $1.52 per cubic meter.

The water demand forecast was projected using the Tracking Tool's built-in calculator that relies on population growth rates to estimate future water use. This required the user to enter a peak (48,308 cubic meters per day) and off-peak (43,608 cubic meters per day) average demand for the base year (2011). This generated an annual average of 45,565 cubic meters per day. The total number of accounts for each customer class and the associated demand share were entered on the same worksheet. The residential sector accounts for just over half of total demand at 33.7 percent for single-family, 18.2 percent for multifamily, with ICI making up 35.3 percent. Non-revenue water represented 11.7 percent of total system demand and pending land use accounted for 1.1 percent. Figure 8 illustrates the customer class demand shares.

Figure 8: City of Guelph Customer Class Demand Shares



Avoided costs are critical inputs for the AWE Tracking Tool; without them it would be impossible to quantify benefits of efficiency programs. The short run avoided costs entered for the City of Guelph for water supply were related to energy for transmission, treatment, and distribution, chemicals, and other operating maintenance costs. On the wastewater side, costs were entered for energy for transmission, treatment, and discharge, chemicals, and other operating maintenance costs. The Tracking Tool estimated that the City of Guelph would exceed its current capacity by 2040 if no conservation programs are implemented and no passive savings takes place and that 8,500 M^3/D of capacity would need to be added at a cost $512 per M^3/D. Unless a user value is entered, the Tracking Tool predicts the amount of capacity that will be added by taking the difference between current system peak capacity and the peak capacity needed to meet demands 20 years from the year in which system capacity equals peak period demand.

Water Efficiency Program Descriptions

Eleven water efficiency programs were evaluated for the City of Guelph, which are described in this section. Along with a general description, detail is provided about the model input assumptions and the resulting model outputs.

1. Royal Flush Toilet Rebate, Single Family
2. Royal Flush Toilet Rebate, Multi Family
3. Royal Flush Toilet Rebate, ICI
4. Smart Wash Washing Machine Rebate
5. Blue Built Home - Bronze

6. Blue Built Home - Silver
7. Greywater Reuse Systems
8. ICI Audit and Capacity Buyback Program
9. Rainwater Harvesting System
10. Healthy Landscape Visit
11. Efficient Home Visit Surveys (GEL/NetZero City)

Royal Flush Toilet Rebate SF, MF, and ICI

The Royal Flush toilet rebate program targets the single-family, multifamily, and ICI sectors and offers incentives to replace 13-litre or more per flush toilets with new WaterSense certified models with a flush volume of 4.8 litres or less. The estimated annual savings per fixture was 48,500 litres per year for single-family toilet replacements, 32,324 litres per year for multifamily replacements, and 49,200 litres per year for ICI toilet replacements. All rebates were estimated to cost $100 regardless of the customer class. This $100 per rebate cost includes $75 for the actual rebate and $25 in administrative costs.

The toilet rebate program has been in place since 2003, although it has evolved over the years. Going forward it was assumed that 1,000 single-family toilets would be rebated per year until 2025, 300 multifamily toilets would be rebated per year until 2025, and 25 ICI toilets would be rebated until 2025. Collectively, the single-family toilet replacements are estimated to save an average of 633 megalitres per year, multifamily 133 megalitres per year, and ICI 23 megalitres per year. Each of the toilet replacement programs are predicted to be cost-effective with benefit-cost ratios of 7.20, 4.82, 7.91.

Smart Wash Washing Machine Rebate

The Smart Wash Washing Machine Rebate offers a $100 incentive to customers who replace an old top loading washing machine with a new high-efficiency clothes washer with a water factor of 6.0 or less. The water factor of a washing machine is expressed in imperial units of measure and indicates how much water is required to wash one cubic foot of laundry. The smaller the water factor, the more efficient the machine.

It was assumed each clothes washer rebate will generate 28,100 litres per year of savings and cost $125 ($100 rebate, and $25 in administrative costs to process the rebate). A total of 700 clothes washer rebates were projected for every year from 2014 through 2025. Average annual program savings are predicted to be 252 megalitres. The analysis generated a benefit-cost ratio of 3.61 suggesting that it is a cost-effective investment.

Blue Built Home Program

The City of Guelph's Blue Built Home program certifies new homes based on the inclusion of high-efficiency fixtures and appliances. There are three levels of certification for Blue Built Homes: bronze, silver and gold. The requirements are related to toilets, clothes washers, hot water delivery systems, graywater systems, and rainwater harvesting systems. The bronze and silver levels of certification were evaluated in this analysis.

The bronze level of certification was modeled with a cost of $560 to the City of Guelph ($460 in incentives and $100 in administrative costs). Each bronze certified home is anticipated to save 56,660 litres per year compared to a new home that is not certified. There were ten certifications planned per year from 2014 through 2025. The average annual savings of the bronze certification program through the planning horizon are expected to be 29 megalitres and the program's estimated benefit-cost ratio is 1.66.

The cost of a silver certification was estimated to be $1,060 for administrative costs and incentives and save 85,040 litres per year. One silver certification was planned per year from 2014 through 2025. The average annual savings of the silver certification program through the planning horizon are expected to be 1.13 megalitres and the program's estimated benefit-cost ratio is 1.35.

(Since the time of analysis, the Ontario Building Code has been updated to include more efficient plumbing requirements for new home construction. As such, the Blue Built Home program standards have been updated and will have an impact on the amount of savings projected.)

Greywater Reuse Systems

The City of Guelph offers a rebate program for home residential greywater systems that collect greywater from such uses as showers and baths. The greywater is then filtered and treated with chlorine and used to flush toilets. The cost of each graywater system incentive was estimated to be $1,500 ($1,000 for rebate and $500 administrative cost) and the estimated annual savings of each were projected to be 28,380 litres. One greywater rebate was scripted per year from 2014 through 2025. The expected average annual savings resulting from this program are 0.25 megalitres. With the costs considered, the benefit-cost ratio was calculated to be 0.15, indicating this program will not be cost-effective long-term.

ICI Audit and Capacity Buyback Program

From the City of Guelph website, "The City of Guelph's Industrial, Commercial and Institutional (ICI) Capacity Buyback Program provides ICI water consumers financial assistance for water use facility audits and potential one time financial incentives for the implementation of capital retrofits to permanently reduce water use at their respective place of business."[4] This program ultimately pays ICI customers to reduce water consumption at a specified rate. This provides the City of Guelph a certain level of control over the program's cost-effectiveness.

In this analysis it was assumed the City will spend nearly $65,000 per year and generate a savings of 51,341,870 litres for each year's investment. The collective average annual savings over the planning horizon are expected to be 646 megalitres, with a benefit-cost ratio of 12.74.

[4] City of Guelph, Ontario Website. Industrial, Commercial and Institutional Capacity (ICI) Buyback Program. Accessed June 2014. http://guelph.ca/living/environment/rebates/ici-capacity-buyback-program/

Rainwater Harvesting System

The City of Guelph offers incentives to its customers for two types of rainwater harvesting systems: seasonal outdoor systems and all-season indoor/outdoor systems. This evaluation focused on the all-season systems that collect and store precipitation from downspouts that can then be used for purposes that do not require potable water such as laundry, flushing toilets, and landscaping.

It was assumed each rebate would cost the City of Guelph $2,500 ($2,000 for the rebate and $500 in administrative costs) and that rainwater harvesting systems would individually save 59,000 litres of water per year. Five rebates were scripted for 2014 and 2015 and then one per year through 2025. All totaled, the rainwater system rebates are expected to save an average of 0.82 megalitres on an annual basis and have a benefit cost ratio of 0.15.

Healthy Landscape Visit

The City of Guelph offers its water customers free consultations to help improve gardens and landscapes. A component of this is improved water use efficiency. It was estimated that the City would provide 350 healthy landscape visits per year from 2014 through 2025 and that each will save 11,300 litres per year. Each visit is projected to cost the City $70, and they are expected to collectively save an average of 10.54 megalitres per year throughout the planning period with a B/C ratio of 0.10.

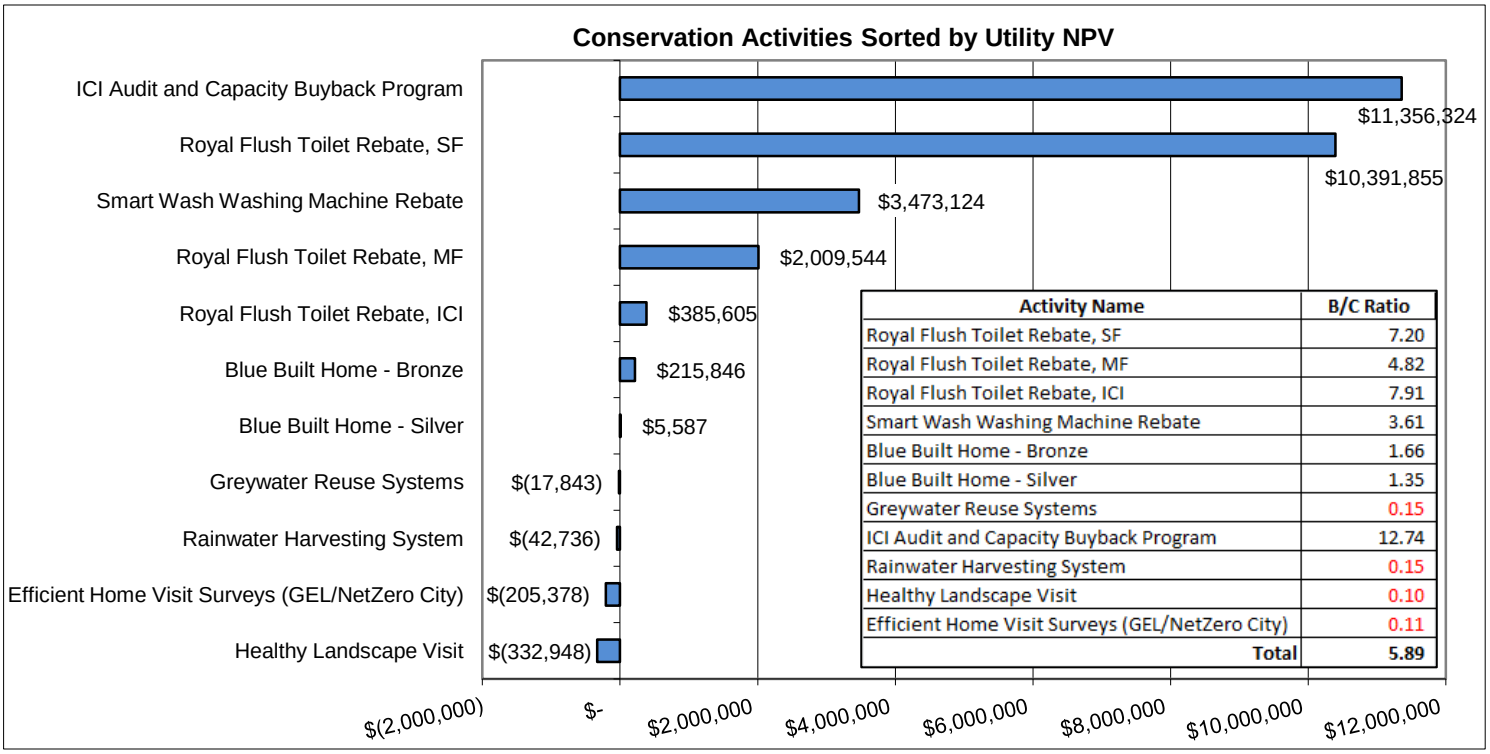
Each site visit was assigned a useful life of five years, meaning all savings associated with the survey stop after five years. This is a common assumption for efficiency programs that achieve savings predominately through behavioral changes because of the need for measures to effectively reinforce and maintain the changed behavior.

Efficient Home Visit Surveys (GEL/Net Zero City)

The City of Guelph collaborates with eMERGE Guelph and other organizations/agencies to provide efficient home visits. Part of the home visit includes a focus on water efficiency. It was estimated that 300 site visits will take place in 2014, 2015, and 2016. Each survey is projected to save 16,400 litres per year and cost ~$165. Total annual savings over the planning period were estimated to be 7.59 megalitres with a B/C ratio of 0.11.

All of the programs analyzed for the City of Guelph are in Figure 9 sorted by net present value (NPV). A table accompanies the chart that includes the benefit-cost ratio (B/C) ratio.

Figure 9: City of Guelph Conservation Activities NPV and B/C Ratio



Activity Name	B/C Ratio
Royal Flush Toilet Rebate, SF	7.20
Royal Flush Toilet Rebate, MF	4.82
Royal Flush Toilet Rebate, ICI	7.91
Smart Wash Washing Machine Rebate	3.61
Blue Built Home - Bronze	1.66
Blue Built Home - Silver	1.35
Greywater Reuse Systems	0.15
ICI Audit and Capacity Buyback Program	12.74
Rainwater Harvesting System	0.15
Healthy Landscape Visit	0.10
Efficient Home Visit Surveys (GEL/NetZero City)	0.11
Total	**5.89**

Results

The results of the individual water conservation program evaluations for the City of Guelph show a wide range of savings and a variety of benefit-cost ratios. This section presents model outputs related to benefits and costs, service area water demands, impact to the utility sales revenue requirement, and energy savings and greenhouse gas emissions.

Benefits and Costs

Of the 11 programs analyzed, only four produced B/C ratios less than one. The portfolio as a whole generated a NPV of $27,238,980 and B/C ratio of 5.89. Table 7 shows a snapshot of savings for each program from 2015 through 2020, and includes a total.

The single-family toilet rebate program, the ICI buyback program, and the clothes washer program have the biggest impact on demand. All three of these measures are cost-effective.

Table 7: City of Guelph Conservation Program Savings Snapshot 2015-2020

Activity Name	Conservation Program Savings Megalitres					
	2015	2016	2017	2018	2019	2020
Royal Flush Toilet Rebate, SF	310.05	354.36	398.48	442.40	486.14	529.71
Royal Flush Toilet Rebate, MF	68.86	77.69	86.47	95.22	103.93	112.60
Royal Flush Toilet Rebate, ICI	15.07	16.22	17.36	18.49	19.63	20.76
Smart Wash Washing Machine Rebate	97.86	116.55	135.24	153.92	172.61	191.30
Blue Built Home - Bronze	4.99	7.82	10.65	13.49	16.32	19.15
Blue Built Home - Silver	0.43	0.51	0.60	0.68	0.77	0.85
Greywater Reuse Systems	0.11	0.14	0.17	0.20	0.23	0.26
ICI Audit and Capacity Buyback Program	243.87	292.65	341.42	390.20	438.97	487.75
Rainwater Harvesting System	0.59	0.65	0.71	0.77	0.83	0.89
Healthy Landscape Visit	13.36	13.32	13.14	13.30	13.30	13.30
Efficient Home Visit Surveys (GEL/NetZero City)	13.34	15.11	11.62	7.68	4.53	2.02
Total	**768.54**	**895.02**	**1,015.85**	**1,136.34**	**1,257.25**	**1,378.56**

Table 8 shows the present value cost, present value benefit, net present value of each conservation program, and it includes a total for all measures. The benefits are generated through avoided costs associated with supply and wastewater. The benefit-cost ratio is also included on Table 8. A high benefit-cost ratio does not necessarily indicate a high level of water savings; it only refers to the cost versus the benefit.

Table 8: City of Guelph Costs and Benefits of Water Conservation Programs

Activity Name	PV Cost ($)	PV ($) Benefit	NPV($)	B/C Ratio
Royal Flush Toilet Rebate, SF	$ 1,676,300	$ 12,068,155	$ 10,391,855	7.20
Royal Flush Toilet Rebate, MF	$ 525,400	$ 2,534,944	$ 2,009,544	4.82
Royal Flush Toilet Rebate, ICI	$ 55,800	$ 441,405	$ 385,605	7.91
Smart Wash Washing Machine Rebate	$ 1,333,250	$ 4,806,374	$ 3,473,124	3.61
Blue Built Home - Bronze	$ 329,280	$ 545,126	$ 215,846	1.66
Blue Built Home - Silver	$ 15,900	$ 21,487	$ 5,587	1.35
Greywater Reuse Systems	$ 21,000	$ 3,157	$ (17,843)	0.15
ICI Audit and Capacity Buyback Program	$ 967,395	$ 12,323,719	$ 11,356,324	12.74
Rainwater Harvesting System	$ 50,000	$ 7,264	$ (42,736)	0.15
Healthy Landscape Visit	$ 368,970	$ 36,022	$ (332,948)	0.10
Efficient Home Visit Surveys (GEL/NetZero City)	$ 229,505	$ 24,127	$ (205,378)	0.11
Total	**$ 5,572,800**	**$ 32,811,780**	**$ 27,238,980**	**5.89**

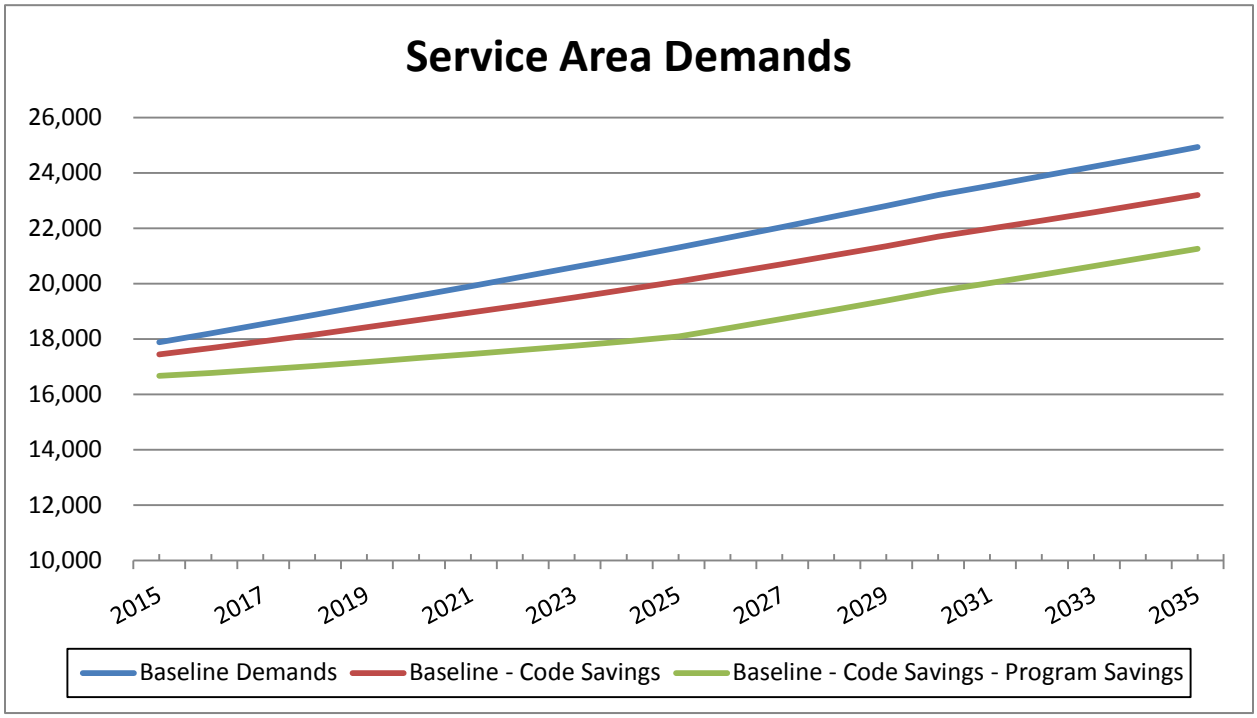
Service Area Water Demands

Figure 10 illustrates demand trends under three scenarios. The blue line depicts baseline demands projected out to 2035. Under this scenario no changes are made to present day per capita demand and population increases drive up demand accordingly. The red line subtracts savings resulting from natural replacement of fixtures and appliances such as toilets, showerheads, clothes washers, and dishwashers.

To date, Canada's national plumbing code has not been updated to include more efficient plumbing fixtures like that of the United States' Energy Policy Act of 1992 that required, among other things, a maximum flush volume of 1.6 gallons (6 litres) for toilets. However, the Ontario Building Code (OBC) required toilets to have a flush volume of 6 lpf or less in new construction beginning in 1996, but this does not apply to other installations or point of sale. After January 1, 2014 the amended Ontario Building Code required 4.8 lpf toilets in new residential buildings and 6.0 lpf toilets in all other newly constructed buildings. In 1996 residential showerheads were assigned a maximum flow rate of 9.5 lpm for new residential construction via the OBC; that changed to 7.6 lpm in new construction after January 1, 2014.[2] Despite Canada not having a national plumbing code with efficiency requirements like the U.S. Energy Policy Act of 1992, and the OBC only pertaining to new construction, it was assumed that natural replacement would occur at the same rate as in the United States. A review of the Canadian marketplace suggests it is nearly identical to the U.S. market and the offerings are predominately efficient products.

The green line in Figure 10 plots future water demands with both passive savings occurring from natural replacement and active savings resulting from water efficiency programs. There are large differences between the three lines and the conservation programs are forecasted to significantly lower the demand.

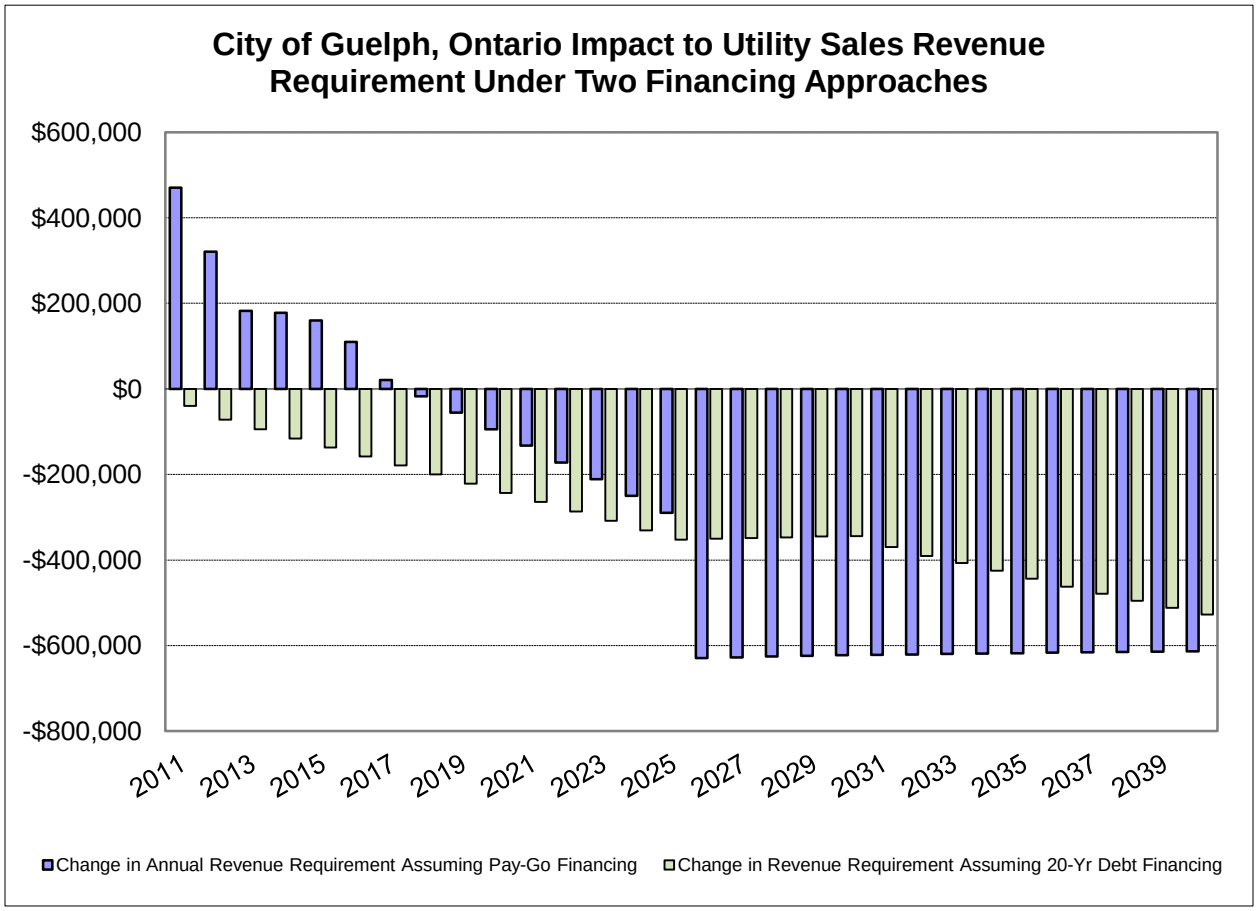
Figure 10: City of Guelph Service Area Demands 2015-2035



Impact to Utility Sales Revenue Requirement

Expenditures to finance water conservation programs and the resulting demand reductions will both have an impact on a utility's revenue requirement. Figure 11 shows the impact of reduced demands achieved through conservation programs to annual sales revenue requirement under two different financing approaches: (1) paying for the conservation programs up front (blue bars) or (2) paying for conservation with 20-year debt financing (green bars). Negative amounts indicate a decrease in utility revenue requirement, meaning that the avoided costs of water production exceed the conservation program costs. Positive amounts indicate an increase in utility revenue requirement, meaning that the conservation program costs exceed the avoided costs of water production. In this particular scenario, Guelph will have an increased annual sales revenue requirement in the first seven years if paid for up front out of current revenues. These costs are incurred to initiate the conservation programs. Some utilities may have a dedicated fund for such expenditures, which may reduce or eliminate a need to increase revenue to cover the costs of efficiency programs. If Guelph were able to debt finance the conservation programs, the annual sales revenue requirement would actually decrease from the outset of conservation program implementation.

Figure 11: Impact to City of Guelph Utility Sales Revenue Requirement



Energy Savings and Greenhouse Gas Emissions

Water conservation programs reduce the need to pump, treat, and deliver water to customers and decrease the amount of water flowing to wastewater treatment plants. This in turn reduces the energy consumption associated with these processes. Figure 12 illustrates the annual and cumulative electricity savings experienced by both the customer and the utility.

Figure 12: City of Guelph Annual and Cumulative Electricity Savings

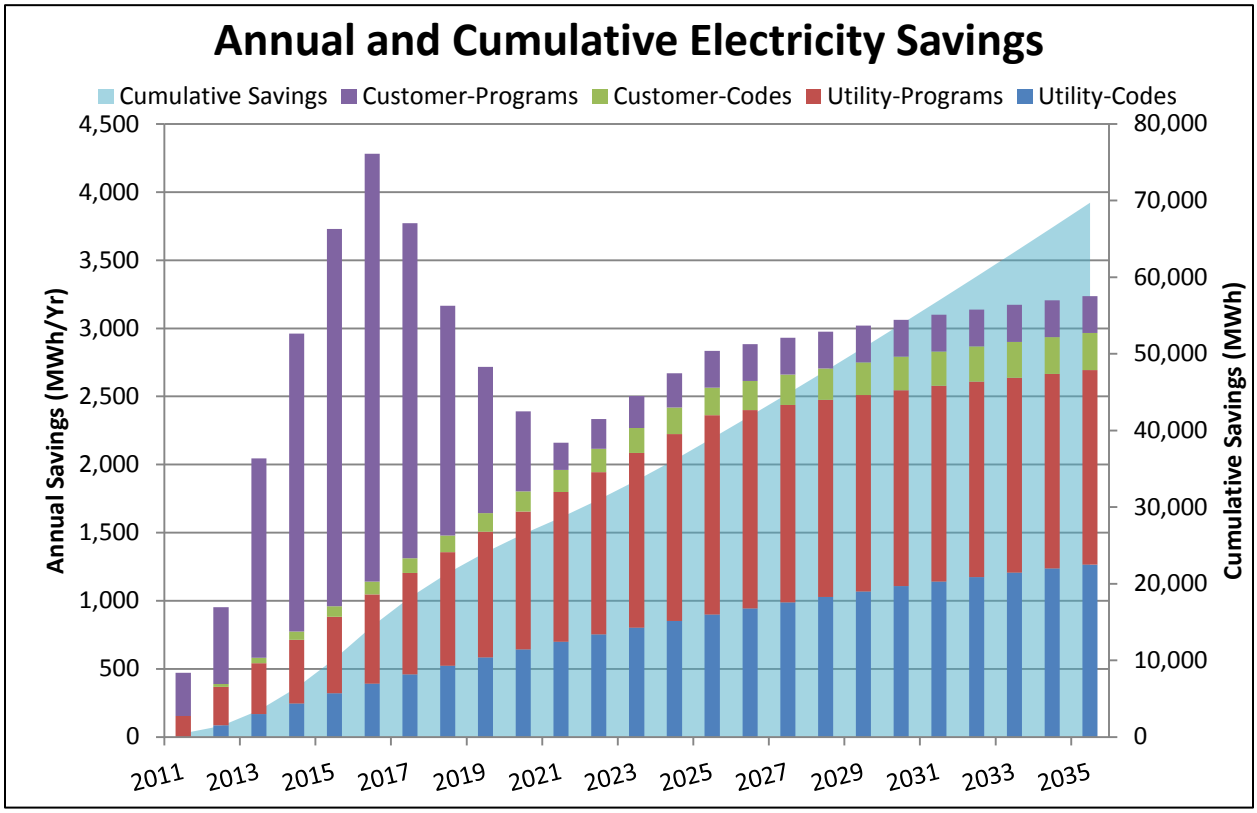
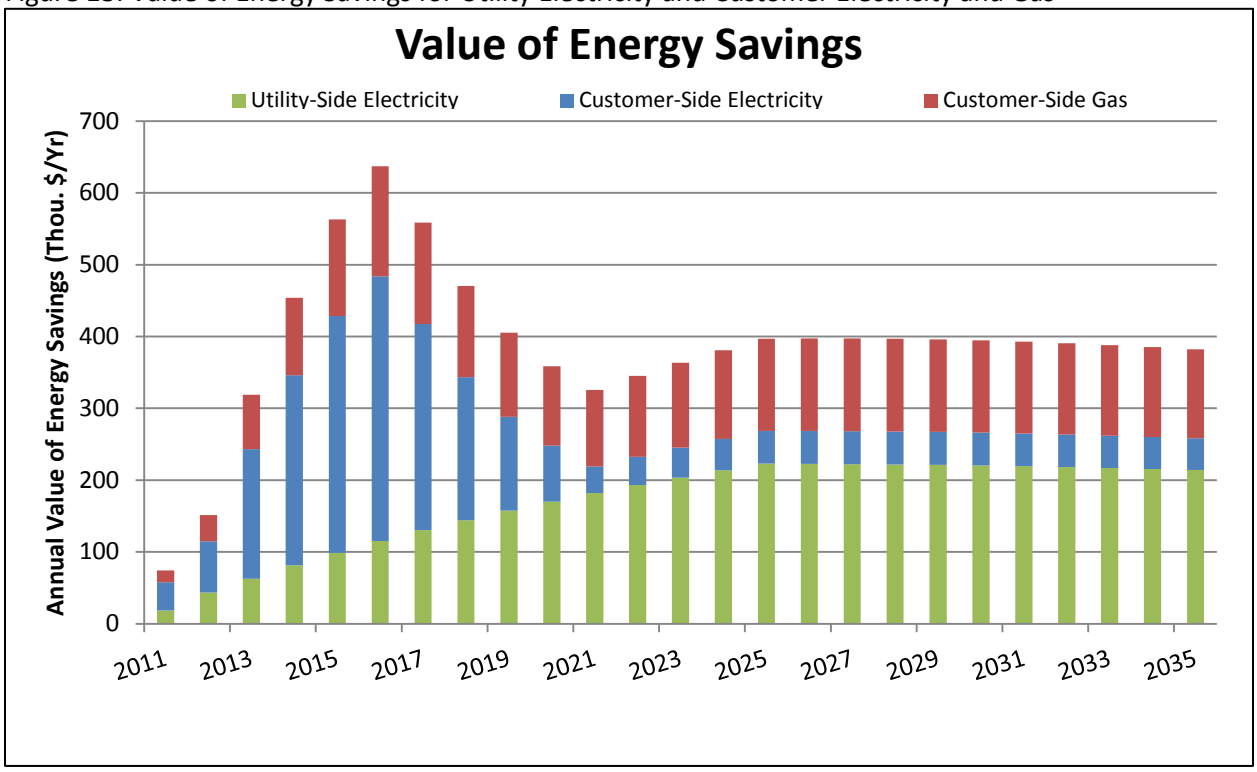


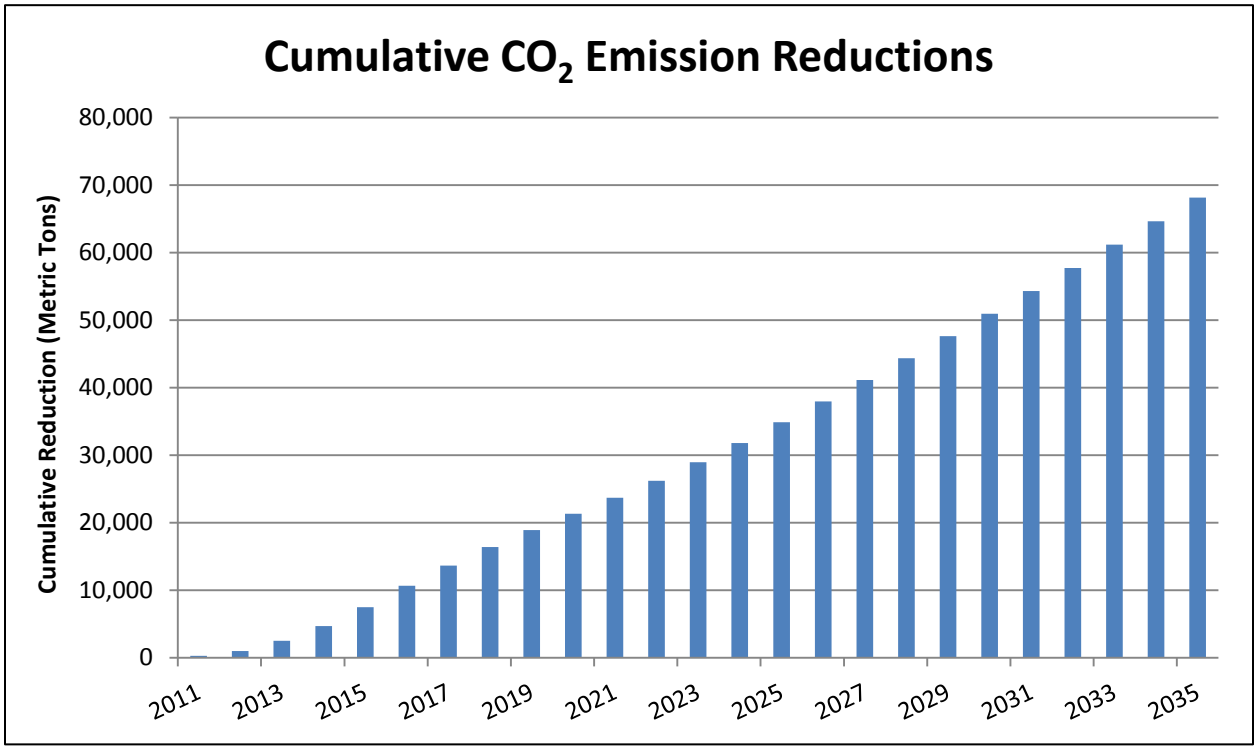
Figure 13 illustrates the value of energy savings resulting from reduced water demands. They are displayed in three categories: (1) utility electricity savings, (2) customer electricity savings, and (3) customer gas savings. The Tracking Tool assumes utilities use electricity, and not gas, to pump and treat water.

Figure 13: Value of Energy Savings for Utility Electricity and Customer Electricity and Gas



The energy savings resulting from water demand reductions also result in greenhouse gas emission reductions. Those reductions are displayed in Figure 14 and show reductions in metric tons for carbon dioxide (CO_2).

Figure 14: Cumulative CO_2 Emission Reductions



Lessons Learned

Despite a rich history of water conservation program implementation, the City of Guelph continues to find opportunities to increase efficiency and lower water demands. Traditional measures such as toilet replacements are still proving to be viable options, and cutting edge programs such as rainwater harvesting and greywater systems are being piloted. The four programs that produced a B/C ratio less than one were the greywater reuse system rebate, the rainwater harvesting system rebate, the healthy landscape visit, and the efficient home visits. Because the entire portfolio of measures is expected to be cost-effective, it could be argued that it is worth including these programs. The greywater system and rainwater harvesting system rebates represent relatively new approaches to saving water and may be worth piloting. The healthy landscape survey and efficient home visit program provide education and build a relationship with customers, which are excellent benefits that are difficult to quantify.

The benefits of water conservation programs and the savings resulting from natural replacement of inefficient fixtures and appliances also saves energy, which in turn saves money and lowers greenhouse gas emissions.

Oakland County, Michigan

Overview

Potential water conservation programs were evaluated for three communities in Oakland County Michigan: Commerce Township, Lyon Township, and Southwest Oakland Township. Southern Oakland County borders Wayne County, Michigan, where Detroit is located. The water systems of Commerce Township, Lyon Township, and Southwest Oakland Township are operated and maintained by the Oakland County Water Resources Commissioner's office. Commerce Township's water supply is treated surface water purchased from the Detroit Water and Sewerage Department (DWSD). The water source is Lake Huron. Lyon and Southwest Oakland Townships rely on local groundwater for drinking water supplies. The same water conservation programs were analyzed for each of the three communities; thus they are presented collectively in this section.

Service Area Data Assumptions

The project team had access to customer billing data for each community from 2010, 2011, and 2012 to analyze consumption patterns and determine the model's base year demands. Ultimately 2010 was selected as the base year because its weather patterns were the most similar to long-term averages. Population estimates for Lyon Township, Commerce Township, and Southwest Oakland Township service areas were generated using the number of residential accounts derived from the base year billing data and persons per household data rather than the population of the communities. Using the population data at the township level was not appropriate because many residents of the Lyon, Commerce, and Southwest Oakland Townships are on private wells or, in some cases, may be on another water system. Population projections were based on trends from data obtained from the Southeast Michigan Council of Governments (SEMCOG) 2040 regional forecast.[5]

Table 9: Oakland County Service Area Population Forecasts

	2010	2020	2030	2040	2050
Commerce TWP	13,818	15,319	15,788	16,034	16,294
Lyon TWP	3,768	4,637	4,979	5,083	5,165
SW Oakland TWP	5,136	5,640	6,007	6,244	6,345

It was assumed the interest rate for the three townships was 4.5 percent and the inflation rate was 3.0 percent. The interest rate was selected based on the yield of a bond issued for the Oxford Township water supply system in Oakland County.[6] The Oakland County Water Resources Commissioner's office bills customers on a quarterly basis. Billing data suggested a peak water use season of May 1st through November 1. Average reference evapotranspiration was entered as 37.32 inches per year with 31.33 inches of precipitation per year on average.[7,8] The water customer classes entered were residential,

[5] The 2040 Southeast Michigan Council of Governments Regional Forecast. (Accessed June 2013). http://www.semcog.org/RegionalForecast.aspx

[6] Oakland County Michigan Oxford Township Water Supply System Bond - Committee on Uniform Securities Identification Procedures (CUSIP) #672411XX8

[7] International Water Management Institute. (Accessed September 2013). World Water & Climate Atlas.

commercial, and irrigation. Commerce Township water rates were entered as $7.81 per thousand gallons for all customer classes, and Lyon and Southwest Oakland Townships were assigned $1.77/thousand gallons and $1.84/thousand gallons respectively. Sewer rates were entered as $4.01/thousand gallons for Commerce and $4.24/thousand gallons for Southwest Oakland. Lyon Township customers pay a flat rate for sewer service and no variable rate was entered.

The water demand forecast for each Township was projected using the Tracking Tool's built-in calculator that relies on population growth rates to estimate future water use. Peak and off-peak average day demands were entered for the base year (2010). The results of this are in Table 10.

Table 10: Peak and Off-Peak Average Day Demands and Peaking Factors

	Peak Season (MGD)	**Off-Peak Season** (MGD)	**Peaking Factor** (Peak/Off-Peak)
Commerce TWP	2.80	1.45	1.93
Lyon TWP	1.08	0.48	2.26
SW Oakland TWP	1.58	0.54	2.93

As shown in figure 15, the high peak season water use is notable and points to an opportunity for savings. Customers in Southwest Oakland Township used almost three times more water during the 2010 peak season compared to the off-peak season. Peak season consumption is higher primarily due to irrigation water use. As can be seen in Figure 16, residential water use makes up over 70 percent of the demand shares in all three townships. Commerce and Lyon Townships have 24 percent and 20 percent of their demands accounted for from commercial water use, and Southwest Oakland only 3 percent. Comparisons of water production and water billing data did not generate meaningful figures for non-revenue water. All systems are relatively new; therefore, non-revenue water resulting from leakage is assumed to be low.

http://www.iwmi.cgiar.org/resources/world-water-and-climate-atlas/

[8] National Climatic Data Center National Oceanic & Atmospheric Administration. (Accessed September 2013). Summary of Monthly Normals 1981-2010 for Detroit, MI. http://www.ncdc.noaa.gov

Figure 15: 2010 Consumption by Quarter in Million Gallons: Lyon, Southwest Oakland, and Commerce Townships, Oakland County, Michigan

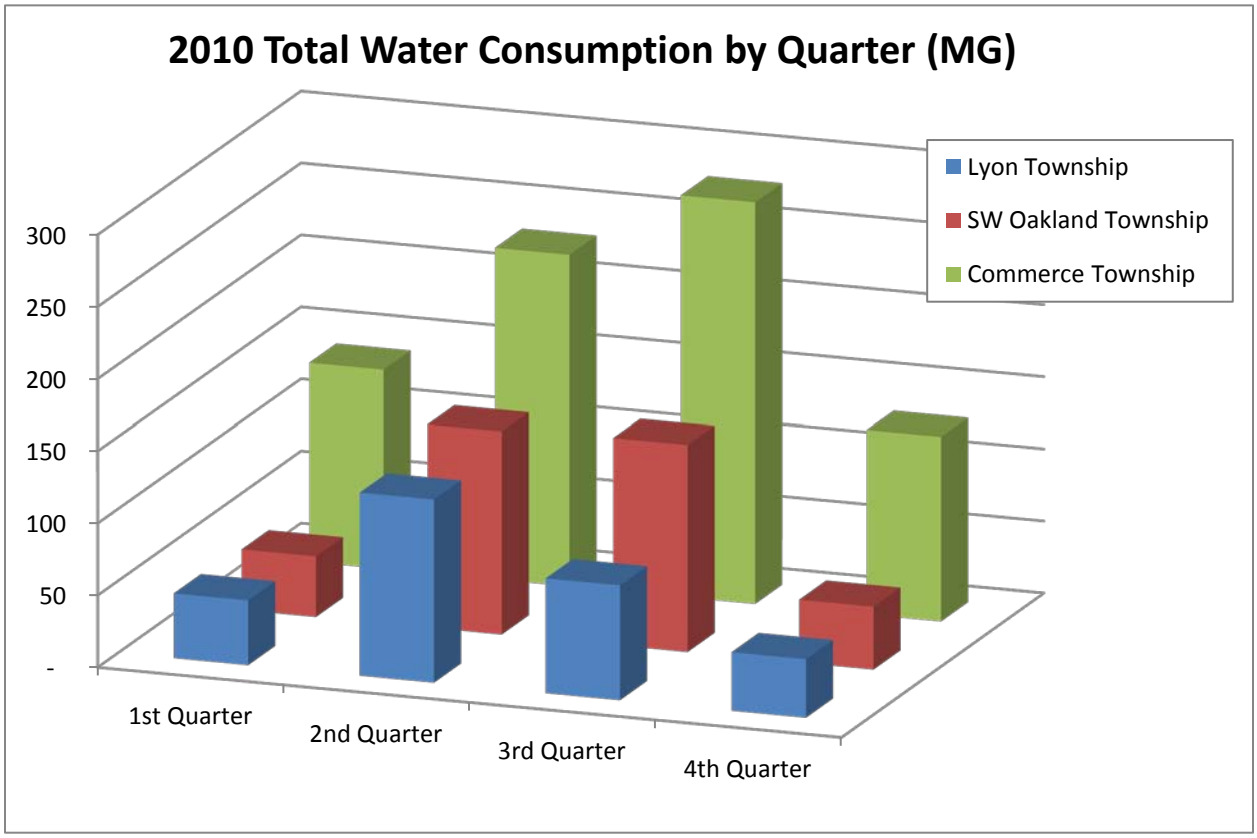
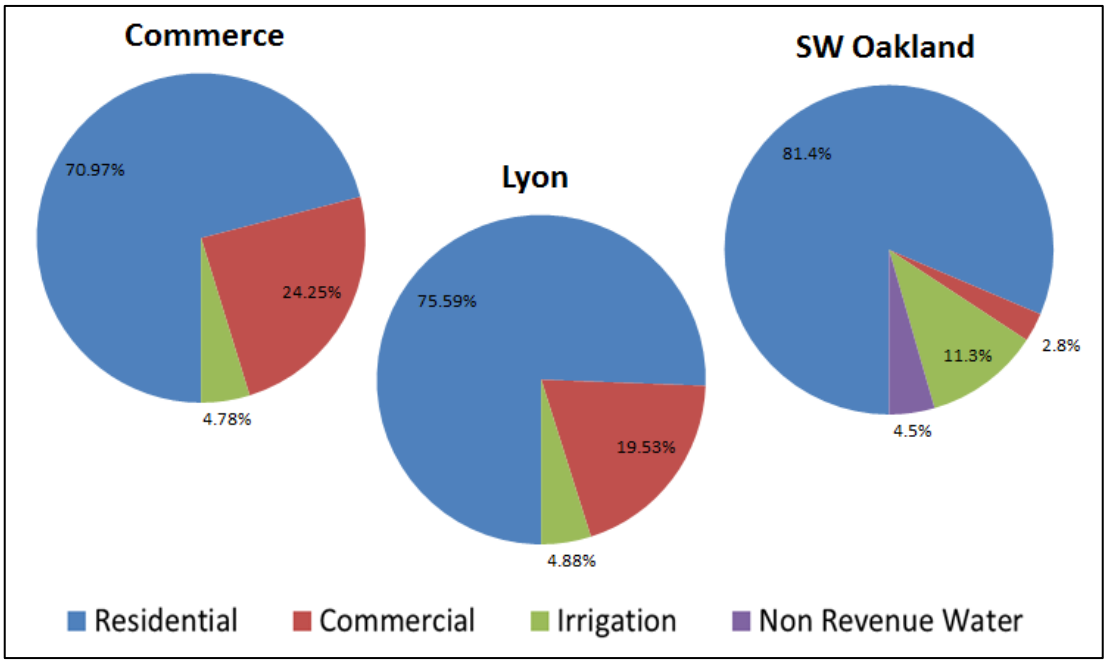


Figure 16: Customer Class Demand Shares



The homes in all three communities have large lots with landscapes predominately comprised of turf

grass. Using 2008 land use data from SEMCOG that lists the number of single-family homes and the total single-family acreage for each township, the average single-family lot size was determined to be 34,874 square feet in Commerce Township, 148,697 square feet in Lyon Township, and 145,384 square feet in Oakland Township. According to the U.S. Census *Highlights of Annual 2013 Characteristics of New Housing*, "The average new single-family home sold was built on a lot of 15,456 square feet."[9] The data suggest single-family lots in Oakland County are much larger than average, which helps anecdotally explain the high peaking factors.

Avoided costs for Commerce Township were limited to the price paid per million gallons of water since it purchases water from DWSD. Energy costs were entered for wastewater treatment as well based on energy bill records. Avoided costs inputs for Lyon and Southwest Oakland Townships were based on data in the 2007 Oakland County Water and Wastewater Master Plan.[10] The variable operating costs entered in the Tracking Tool are nearly five times greater for Commerce Township compared to Lyon and Southwest Oakland Townships. There could be many reasons Commerce Township's operating costs are higher. One factor is that Commerce purchases water from DWSD, while Lyon and Southwest Oakland Townships are supplied by less expensive local groundwater.

Water Efficiency Program Descriptions

Commerce, Lyon, and Southwest Oakland Townships do not currently have any water conservation programs. Commerce Township does have a landscape water use ordinance.[11] Seven water conservation programs were evaluated for the three Oakland County, Michigan communities. Five of the measures target residential water users and two target large landscape accounts such as home owners associations with a large irrigation account.

1. Residential High-Efficiency Toilet Rebates
2. Residential High-Efficiency Clothes Washer Rebates
3. Residential Efficient Irrigation Nozzle Replacements
4. Residential Irrigation ET Controller Rebates
5. Residential Soil Moisture Sensor Rebates - Targets High Water Users
6. Large Landscape Surveys
7. Large Landscape Irrigation Controller Rebates

Residential High-Efficiency Toilet Rebates

A residential high-efficiency toilet rebate program was scripted for each service area. The municipal cost of each rebate was entered as $150, which included $100 for the rebate, and $50 in administrative costs. Additionally, it is assumed the program will cost $2,000 to initiate. Rebates would only be

[9] U.S. Census. (2014). Highlights of Annual 2013 Characteristics of New Housing. https://www.census.gov/construction/chars/highlights.html

[10] Oakland County Water Resources Commissioner's Office. (2007). Oakland County Water and Wastewater Master Plan. http://www.oakgov.com/water/Pages/publications/water_wastewater_master_plan.aspx

[11] Commerce Charter Township, (Oakland County), Michigan, Code of Ordinances >> - CODE OF ORDINANCES >> Chapter 40 - UTILITIES >> ARTICLE III. - WATER AND SEWAGE >> DIVISION 4. - WATER SYSTEM >> Sec. 40-169. - Outdoor water use restrictions.

provided under this program for WaterSense labeled high-efficiency toilets replacing toilets of 3.5 gallons per flush or greater. It could be further required that participating customers replace all 3.5 gallon per flush or greater toilets on the property. Each toilet replacement was estimated to save 9,861 gallons per year.

The number of toilet rebates implemented in each community were based on the estimated installed base of inefficient toilets. It was assumed 300 toilets would be replaced per year from 2015 through 2019 in Commerce Township, and 100 per year from 2015 through 2019 for Lyon and Southwest Oakland Townships. The results indicate the high-efficiency toilet rebate is cost-effective for all three communities as is shown in Table 11's B/C Ratio column. The B/C ratio for Commerce Township is much higher than the other two communities due to its higher operating costs. Despite it being cost-effective, the high-efficiency toilet rebate program is a limited option due to the low stock of inefficient toilets currently installed in the service area. However, the rebates are expected to save 7.5 million gallons per year on average in Commerce over the course of the planning period, and 2.5 million gallons per year in Lyon and Southwest Oakland.

Table 11: High-Efficiency Toilet Rebate Average Annual Savings and B/C Ratio

	Average Annual Program Savings (MG)	**B/C Ratio**
Commerce Township	7.50	13.57
Lyon Township	2.50	1.38
Southwest Oakland Township	2.50	2.29

Residential High-Efficiency Clothes Washer Rebates

The residential high-efficiency rebate program was assumed to provide a $100 rebate toward the purchase of a high-efficiency clothes washer. An additional $50 administrative cost per rebate was factored in as well. Each clothes washer rebate was estimated to save 7,043 gallons per year. It was assumed 100 clothes washers would be replaced per year from 2015 through 2019 in Commerce Township, and 25 per year from 2015 through 2019 for Lyon and Southwest Oakland Townships. The clothes washers rebated were assigned a useful life of 11 years, meaning the savings are no longer counted 11 years after the rebate occurs.

As is shown in Table 12, the clothes washer rebate is only cost-effective for Commerce Township, where it is forecasted to save 2.58 million gallons per year on average. In Lyon and Southwest Oakland, where it is not cost-effective, it is expected to save 0.65 million gallons per year on average. The lower savings value for Lyon and Southwest Oakland is due to the size of the customer base, and thus a lower number of rebates. The difference in cost-effectiveness is due to difference in the operating costs for each service area.

Table 12: High-Efficiency Clothes Washer Rebate Program Average Annual Savings and B/C Ratio

	Average Annual Program Savings (MG)	B/C Ratio
Commerce Township	2.58	2.84
Lyon Township	0.65	0.43
Southwest Oakland Township	0.65	0.71

Residential Efficient Irrigation Nozzle Replacements

The residential efficient irrigation nozzle replacement program provides professional installation of high-efficiency nozzles in irrigation systems. The cost estimates are as follows: $3.50/nozzle for purchase, $5.00/nozzle for installation, and $1.50/nozzle for program marketing and administration. The total cost of each nozzle is $10.00. It is assumed each nozzle will save 187 gallons per year. The irrigation nozzles were assigned a useful life of five years. This program was not cost-effective for any of the three service areas. Its low cost may make it worth including with other conservation programs as it will increase awareness of landscape water use efficiency and build relationships with customers. Table 13 contains the average annual savings and B/C ratios.

Table 13: Residential Efficient Irrigation Nozzle Replacement Program Average Annual Savings and B/C Ratio

	Average Annual Program Savings (MG)	B/C Ratio
Commerce Township	0.05	0.51
Lyon Township	0.05	0.09
Southwest Oakland Township	0.05	0.09

Residential Irrigation ET Controller Rebates

This program provides rebates for technology that adjusts irrigation schedules according to real time measures of evapotranspiration (ET). Irrigation systems are often set to automatically water the landscape on a predetermined schedule regardless of weather, or need. Irrigation controllers bypass scheduled irrigation events when watering is not required. It was estimated that each ET controller rebate would be for $250 and result in a cost of $50 for staff and other administrative costs. Each ET controller is expected to save 6,781 gallons per year and have a useful life of 10 years. Each community was programmed to rebate 25 ET controllers per year from 2015 through 2019. As is presented in Table 14 the savings for each community is the same at 0.61 million gallons per year on average but the program is only cost-effective in Commerce Township. WaterSense labels ET controllers, which would be very helpful for a water provider offering rebates for such devices.[12]

[12] EPA WaterSense. (November 2011). Final Specification for Weather-Based Irrigation Controllers. http://www.epa.gov/watersense/docs/final_controller_specification_102611_final508.pdf

Table 14: Residential ET Controller Rebate Program Average Annual Savings and B/C Ratio

	Average Annual Program Savings (MG)	B/C Ratio
Commerce Township	0.61	1.22
Lyon Township	0.61	0.19
Southwest Oakland Township	0.61	0.21

Residential Soil Moisture Sensor Rebates - Targets High Water Users

Like ET based irrigation controllers, soil moisture sensors prevent irrigation systems from operating when watering is not needed. Instead of evapotranspiration data, soil moisture sensors rely on readings of soil moisture to determine if plants and turf grass require irrigation. This conservation program was designed to target the high water users, which in this case where defined as customers using 30,000 gallons more per month on average during the peak season than during off-peak season in Lyon and Southwest Oakland Townships. In Commerce Township the threshold was set to 20,000 gallons more per month on average during the peak season compared to off-peak season usage.

It was assumed a soil moisture sensor would reduce a customer's outdoor water use by 15 percent. This was considered a conservative estimate after the project team reviewed a variety of soil moisture sensor studies including those referenced in the *WaterSense Notice of Intent (NOI) to Develop a Draft Specification for Soil Moisture-Based Control Technologies*.[13] Savings resulting from the use of soil moisture sensors vary wildly and are very difficult to predict. Because the customer billing data was different for each community, and savings were estimated based on a 15 percent reduction of the targeted customers' outdoor water use, the average savings expected for each soil moisture sensor were also different. Each soil moisture sensor rebate was assumed to save 26,730 gallons per year in Commerce, 36,364 gallons per year in Lyon, and 39,636 gallons per year in Southwest Oakland.

Twenty-five soil moisture sensor rebates were planned per year in each of the three service areas from 2015 through 2019, and each soil moisture sensor was estimated to have a useful life of five years. As is shown in Table 15, the program is only expected to be cost-effective in Commerce Township. It is difficult to predict the water savings resulting from water conservation programs that target outdoor water use. Therefore it is likely worth piloting this program on a small scale considering the high peak season water use in Oakland County. EPA WaterSense is currently developing a specification for soil moisture sensors which will help utilities identify models that meet standards for efficiency and performance.

[13] EPA WaterSense. (2013). WaterSense Notice of Intent (NOI) to Develop a Draft Specification for Soil Moisture-Based Control Technologies. http://www.epa.gov/watersense/docs/sms-notice-of-intent-final.pdf

Table 15: Residential Soil Moisture Sensor Rebate Program Average Annual Savings and B/C Ratio

	Average Annual Program Savings (MG)	B/C Ratio
Commerce Township	2.48	3.08
Lyon Township	3.19	0.67
Southwest Oakland Township	3.67	0.83

Large Landscape Surveys

The large landscape survey conservation program is designed to provide site visits, training, device adjustment, equipment upgrade recommendations, or strategies such as water budgets. Although hardware improvements may result in a cost for the customer, this program does not specifically provide utility side rebates, distribution, or direct installation. The landscapes included in this program are assumed to have one acre of irrigable area on average. The savings estimates are generated in the Alliance for Water Efficiency's Water Conservation Tracking Tool based on a landscape watering requirement value derived from local evapotranspiration and rainfall data and multiplied by a factor representing an increase in efficiency. In this case each survey is expected to cost the water provider $600 and save 97,898 gallons per year. It was estimated that each water provider would conduct 15 surveys per year from 2015 through 2019. The program was scripted with a useful life of five years. The average annual savings and B/C ratios are in Table 16.

Table 16: Large Landscape Surveys Average Annual Savings and B/C Ratio

	Average Annual Program Savings (MG)	B/C Ratio
Commerce Township	4.08	4.27
Lyon Township	4.08	0.74
Southwest Oakland Township	4.08	0.77

Large Landscape Irrigation Controller Rebates

This program is designed to provide a survey and rebate for ET irrigation controllers for large landscapes. The landscapes included in this program are assumed to have one acre of irrigable area on average. The cost of each rebate was set to $2,100 of which $600 is incurred for the site visit and $1,500 is allocated to the rebate for the irrigation controller. Each rebate is expected to save 147,692 gallons per year. The savings estimates were generated in the Alliance for Water Efficiency's Water Conservation Tracking Tool based on a landscape watering requirement value derived from local evapotranspiration and rainfall data and a factor representing an increase in efficiency. For modeling purposes, each of the three communities was estimated to provide 15 large landscape irrigation controller rebates from 2015 through 2019. The rebated irrigation controllers were assigned a useful life of ten years. Table 17 shows the average annual savings and B/C ratios related to the large landscape irrigation controller rebates.

Table 17: Large Landscape Irrigation Controller Rebates Average Annual Savings and B/C Ratio

	Average Annual Program Savings (MG)	B/C Ratio
Commerce Township	7.91	3.94
Lyon Township	7.91	0.64
Southwest Oakland Township	7.91	0.66

Results

Seven water conservation programs were modeled for Commerce, Lyon, and Southwest Oakland Townships with varying results. All three communities have high peak season water demands that can be lowered with outdoor efficiency programs. This section presents model outputs related to benefits and costs, service area water demands, impact to the revenue requirement, and energy savings and greenhouse gas emissions.

Benefits and Costs

The following six tables show the expected savings for each conservation program from 2015 to 2020 and the associated costs and benefits for the three townships. The program with the highest water savings is the high-efficiency toilet rebate program; it is also the most cost-effective. Due to a limited number of inefficient toilets in the service areas of all three communities, this high water saving program with a positive B/C ratio is not a long-term option. However, it provides a great opportunity to lower demands until each service area is fully saturated with high-efficiency toilets.

Table 18: Commerce Township Conservation Program Savings Snapshot 2015-2020

Activity Name	Conservation Program Savings Million Gallons					
	2015	2016	2017	2018	2019	2020
Residential High-Efficiency Toilet Rebates	2.96	5.92	8.87	11.83	14.79	14.79
Residential High-Efficiency Clothes Washer Rebates	0.70	1.41	2.11	2.82	3.52	3.52
Residential Efficient Irrigation Nozzle Replacements	0.02	0.04	0.06	0.07	0.09	0.07
Residential Irrigation ET Controller Rebates	0.17	0.34	0.51	0.68	0.85	0.85
Residential Soil Moisture Sensor – Targets High Water Users	0.89	1.78	2.67	3.56	4.46	3.56
Large Landscape Surveys	1.47	2.94	4.41	5.87	7.34	5.87
Large Landscape Irrigation Controller Rebates	2.22	4.43	6.65	8.86	11.08	11.08
Total	**8.43**	**16.85**	**25.28**	**33.70**	**42.13**	**39.75**

Table 19: Commerce Township Costs and Benefits of Water Conservation Programs

Activity Name	PV Cost ($)	PV Benefit ($)	NPV($)	B/C Ratio
Residential High-Efficiency Toilet Rebates	$ 205,246	$ 2,785,880	$ 2,580,634	13.57
Residential High-Efficiency Clothes Washer Rebates	$ 71,745	$ 203,815	$ 132,070	2.84
Residential Efficient Irrigation Nozzle Replacements	$ 4,520	$ 2,314	$ (2,205)	0.51
Residential Irrigation ET Controller Rebates	$ 35,758	$ 43,539	$ 7,781	1.22
Residential Soil Moisture Sensor – Targets High Water Users	$ 35,758	$ 110,099	$ 74,341	3.08
Large Landscape Surveys	$ 42,538	$ 181,457	$ 138,919	4.27
Large Landscape Irrigation Controller Rebates	$ 144,230	$ 568,972	$ 424,741	3.94
Total	**$ 539,795**	**$ 3,896,077**	**$ 3,356,282**	**7.22**

Table 20: Lyon Township Conservation Program Savings Snapshot 2015-2020

Activity Name	Conservation Program Savings Million Gallons					
	2015	2016	2017	2018	2019	2020
Residential High-Efficiency Toilet Rebates	0.99	1.97	2.96	3.94	4.93	4.93
Residential High-Efficiency Clothes Washer Rebates	0.18	0.35	0.53	0.70	0.88	0.88
Residential Efficient Irrigation Nozzle Replacements	0.02	0.04	0.06	0.07	0.09	0.07
Residential Irrigation ET Controller Rebates	0.17	0.34	0.51	0.68	0.85	0.85
Residential Soil Moisture Sensor – Targets High Water Users	1.15	2.30	3.45	4.60	5.75	4.60
Large Landscape Surveys	1.47	2.94	4.41	5.87	7.34	5.87
Large Landscape Irrigation Controller Rebates	2.22	4.43	6.65	8.86	11.08	11.08
Total	**6.18**	**12.37**	**18.55**	**24.74**	**30.92**	**28.28**

Table 21: Lyon Township Costs and Benefits of Water Conservation Programs

Activity Name	PV Cost ($)	PV Benefit ($)	NPV($)	B/C Ratio
Residential High-Efficiency Toilet Rebates	$ 67,627	$ 95,931	$ 28,304	1.42
Residential High-Efficiency Clothes Washer Rebates	$ 18,809	$ 8,409	$ (10,400)	0.45
Residential Efficient Irrigation Nozzle Replacements	$ 4,388	$ 392	$ (3,996)	0.09
Residential Irrigation ET Controller Rebates	$ 34,717	$ 6,854	$ (27,862)	0.20
Residential Soil Moisture Sensor – Targets High Water Users	$ 34,717	$ 24,092	$ (10,624)	0.69
Large Landscape Surveys	$ 41,299	$ 30,759	$ (10,539)	0.74
Large Landscape Irrigation Controller Rebates	$ 140,029	$ 89,572	$ (50,457)	0.64
Total	**$ 341,585**	**$ 256,011**	**$ (85,575)**	**0.75**

Table 22: Southwest Oakland Township Conservation Program Savings Snapshot 2015-2020

Activity Name	Conservation Program Savings Million Gallons					
	2015	2016	2017	2018	2019	2020
Residential High-Efficiency Toilet Rebates	0.41	0.83	1.24	1.66	2.07	2.07
Residential High-Efficiency Clothes Washer Rebates	0.07	0.15	0.22	0.30	0.37	0.37
Residential Efficient Irrigation Nozzle Replacements	0.01	0.03	0.04	0.06	0.07	0.06
Residential Irrigation ET Controller Rebates	0.14	0.27	0.41	0.54	0.68	0.68
Residential Soil Moisture Sensor – Targets High Water Users	1.06	2.11	3.17	4.23	5.28	4.23
Large Landscape Surveys	1.17	2.35	3.52	4.70	5.87	4.70
Large Landscape Irrigation Controller Rebates	1.77	3.54	5.32	7.09	8.86	8.86
Total	**4.64**	**9.29**	**13.93**	**18.57**	**23.21**	**20.97**

Table 23: Southwest Oakland Township Costs and Benefits of Water Conservation Programs

Activity Name	PV Cost ($)	PV Benefit ($)	NPV($)	B/C Ratio
Residential High-Efficiency Toilet Rebates	$ 69,656	$ 159,772	$ 90,117	2.29
Residential High-Efficiency Clothes Washer Rebates	$ 19,374	$ 13,731	$ (5,642)	0.71
Residential Efficient Irrigation Nozzle Replacements	$ 4,520	$ 420	$ (4,100)	0.09
Residential Irrigation ET Controller Rebates	$ 35,758	$ 7,339	$ (28,419)	0.21
Residential Soil Moisture Sensor – Targets High Water Users	$ 35,758	$ 29,633	$ (6,126)	0.83
Large Landscape Surveys	$ 42,538	$ 32,936	$ (9,602)	0.77
Large Landscape Irrigation Controller Rebates	$ 144,230	$ 95,911	$ (48,320)	0.66
Total	**$ 351,833**	**$ 339,742**	**$ (12,091)**	**0.97**

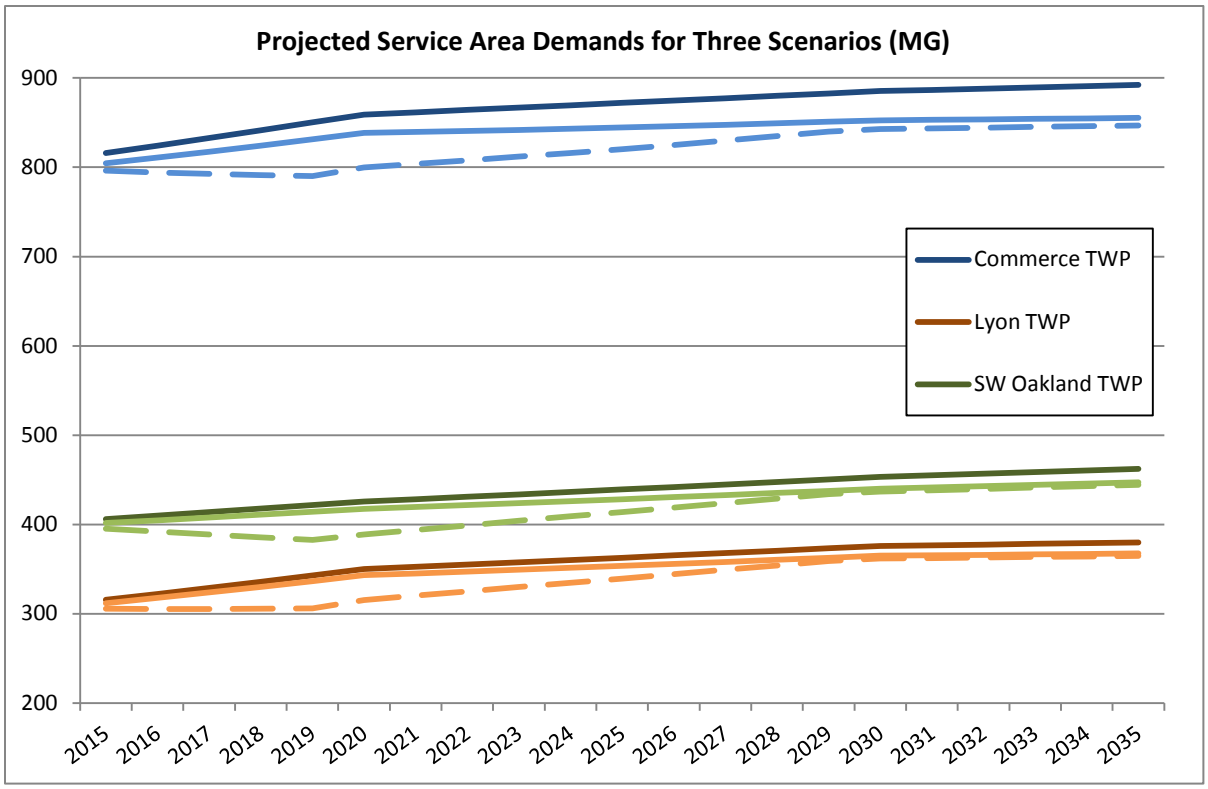
All of the water conservation programs, except for the irrigation nozzle replacements, are cost-effective for Commerce Township. Only one conservation program, the high-efficiency toilet rebate is cost-effective for Lyon and Southwest Oakland Townships. This is due to Commerce Township having higher avoided costs than Lyon and Southwest Oakland (which for purposes of this analysis is assumed to be largely a result of Commerce purchasing water from DWSD and Lyon and Southwest Oakland pumping local groundwater). If Lyon or Southwest Oakland Townships ever need to purchase water from DWSD in the future, or experience any other increase in avoidable costs, the B/C ratios of these conservation programs would increase.

The B/C ratio of the entire portfolio of measures is 0.75 for Lyon and 0.97 for Southwest Oakland. The costs in Southwest Oakland exceed the benefits by $12,091. Most of the programs are related to outdoor water and carry more uncertainty when estimating savings. Because of this, the communities could pilot the programs at a small scale and generate field results. It may be found that the programs are in fact cost-effective when field tested. Additionally, this analysis did not include any potential avoided costs due to large capital projects such as water system expansion. The project team was unable to locate any such estimates. Were this included, the added benefits of the water conservation programs may turn all of the B/C ratios positive. This is an important consideration if and when these communities area faced with storage and/or treatment expansion projects that can potentially be avoided with an increase in water use efficiency.

Service Area Water Demands

Figure 17 shows expected service area demands for Commerce, Lyon, and Southwest Oakland Townships under three scenarios: (1) Baseline demands generated using the AWE Water Conservation Tracking Tool which are based on population growth, indicated by the dark solid line, (2) Baseline demands less expected demand reductions resulting from the plumbing code, indicated by the lighter solid line, and (3) Baseline demands less expected plumbing code savings and minus the savings resulting from water conservation programs, indicated by the dashed line.

Figure 17: Commerce Township, Lyon Township, and Southwest Oakland Township Water Demands



The darkest solid line for each township represents a baseline demand forecast based simply on the base year per capita water use and the population forecast. The lighter colored solid line that is in the middle of each township's demand forecast represents the baseline demand less any savings occurring naturally through the plumbing code. The dotted line further subtracts savings from the conservation programs. Commerce's code savings are proportionally greater than Lyon and Southwest Oakland because of an older housing stock. This means there are more inefficient fixtures that will be replaced naturally with efficient counterparts when people do things like remodel their homes. The reader may notice that the dashed lines eventually catch up to the lighter colored solid line in the middle. This is due to the conservation activity only being planned through 2019, or five years after the start date. The useful life of program savings is eventually reached and the programs would need to be renewed, or new programs will need to be implemented in order to maintain or increase water savings.

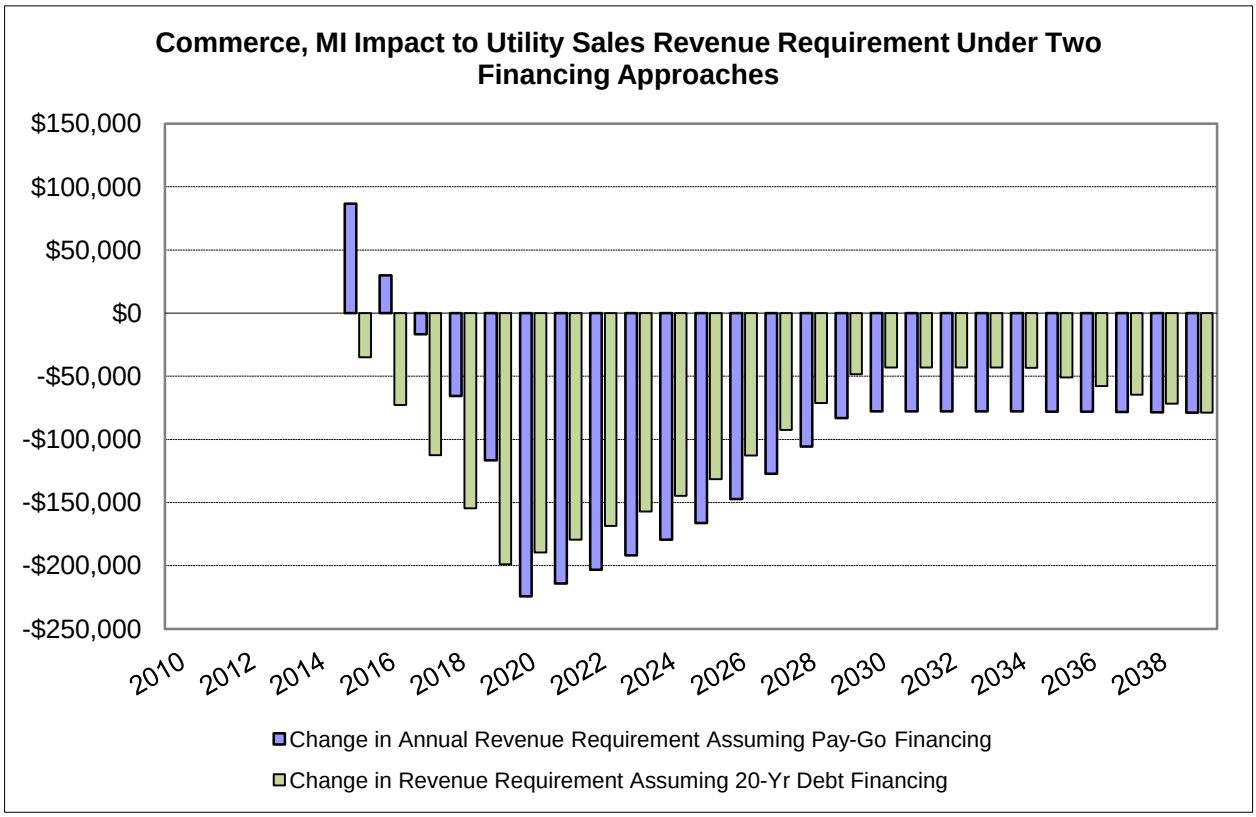
If these programs are implemented, Commerce Township is expected to reduce it projected baseline demand by 60 million gallons per year, or 7 percent, in 2019. The year 2019 represents the height of the savings resulting from the conservation programs for all three townships. Lyon Township's demand is expected to fall from 336 million gallons per year to 306 in 2019, a reduction of 30 million gallons or 11 percent. In Southwest Oakland the 2019 baseline demand is projected to be 422 million gallons per year and with code and programs savings it is expected to be 383, a reduction of 39 million gallons per year of 9 percent.

Impact to the Utility Sales Revenue Requirement

Spending money to fund water conservation programs and reducing demands can have an impact on a utility's revenue requirement. Figure 18 shows the impact to the revenue requirement for Commerce Township under two different financing approaches: (1) paying for the conservation programs up front (blue bars) or (2) paying for conservation with 20-year debt financing (green bars). Negative amounts indicate a decrease in the utility revenue requirement, meaning that the avoided costs of water production exceed the conservation program costs. Positive amounts indicate an increase in utility revenue requirement, meaning that the conservation program costs exceed the avoided costs of water production.

Figure 19 shows the impact to Lyon Township's revenue requirement. Because the charts for Lyon and Southwest Oakland Townships are very similar, Southwest Oakland's is not shown.

Figure 18: Impact to Commerce Township Revenue Requirement



Commerce Township's revenue requirement increases in 2015 by $86,500 (the first year of program implementation) if the conservation programs are paid for up front. That amount then tapers off and in 2017 the revenue requirement is less than it was in the base year because the benefits of the conservation programs outweigh the costs. If the programs are debt financed over 20 years the impact to the revenue requirement is negative from the outset because the payments are spread out.

Figure 19: Impact to Lyon Township Revenue Requirement

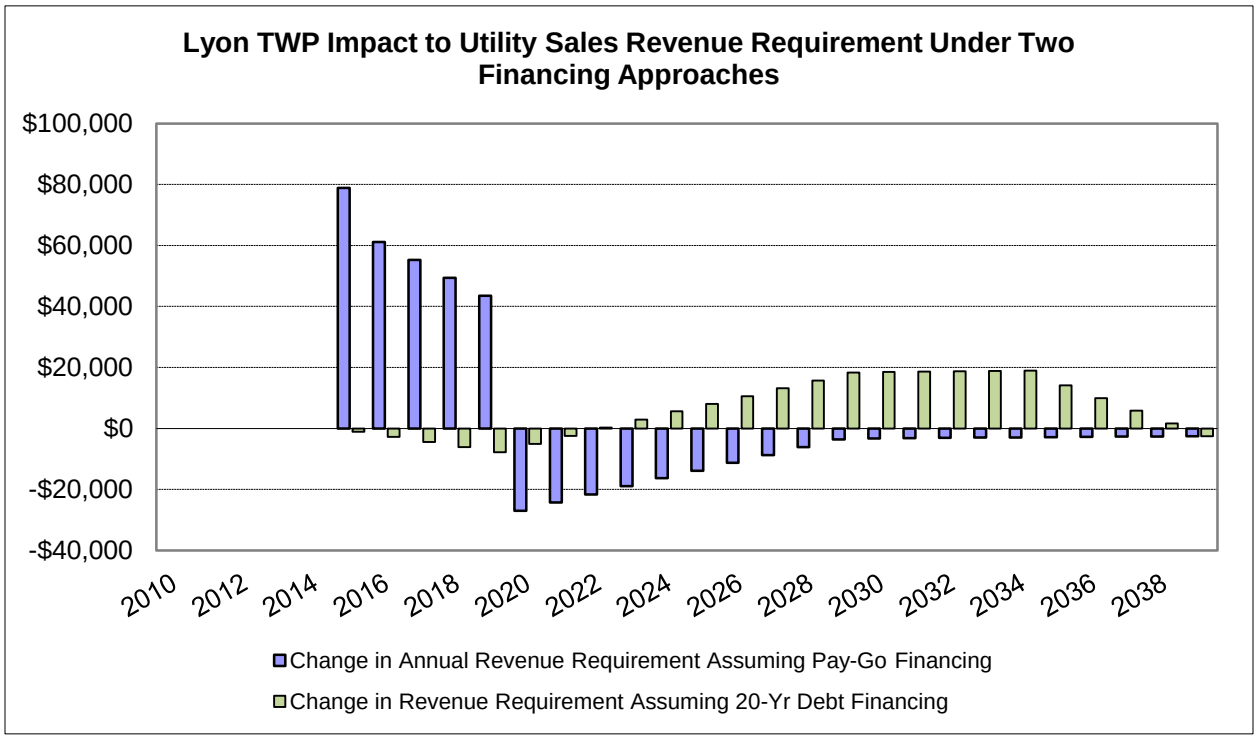


Figure 18 shows the revenue impact resulting from conservation programs in Lyon Township that differs from the scenario in Commerce Township. In Lyon Township the revenue requirement is increased substantially during the five years conservation programs are being implemented and then drops below zero in 2020. The revenue requirement goes negative because demands are still being lowered from the conservation programs that have been paid for by the end of 2019. Because the conservation programs are not cost-effective in Lyon Township the lowered revenue requirement from 2020 onward will not make up for the upfront costs incurred in years 2015 through 2019. If the programs were financed over 20 years the revenue requirement would be lower through 2021 but would then begin to increase in 2022 as the conservation program water savings begin to decay while the debt payments persist.

Energy Savings and Greenhouse Gas Emissions

This section presents Tracking Tool outputs related to energy and greenhouse gas emission reductions resulting from the water conservation programs. This is a result of a reduced need to pump, treat, and deliver water to customers, and a decrease in the amount of water flowing to wastewater treatment plants. The results are displayed as a total for the three Oakland County townships. Figure 20 illustrates the annual and cumulative electricity savings experienced by both the customer and the utility.

Figure 20: Commerce, Lyon, and Southwest Oakland TWPs Annual and Cumulative Electricity Savings

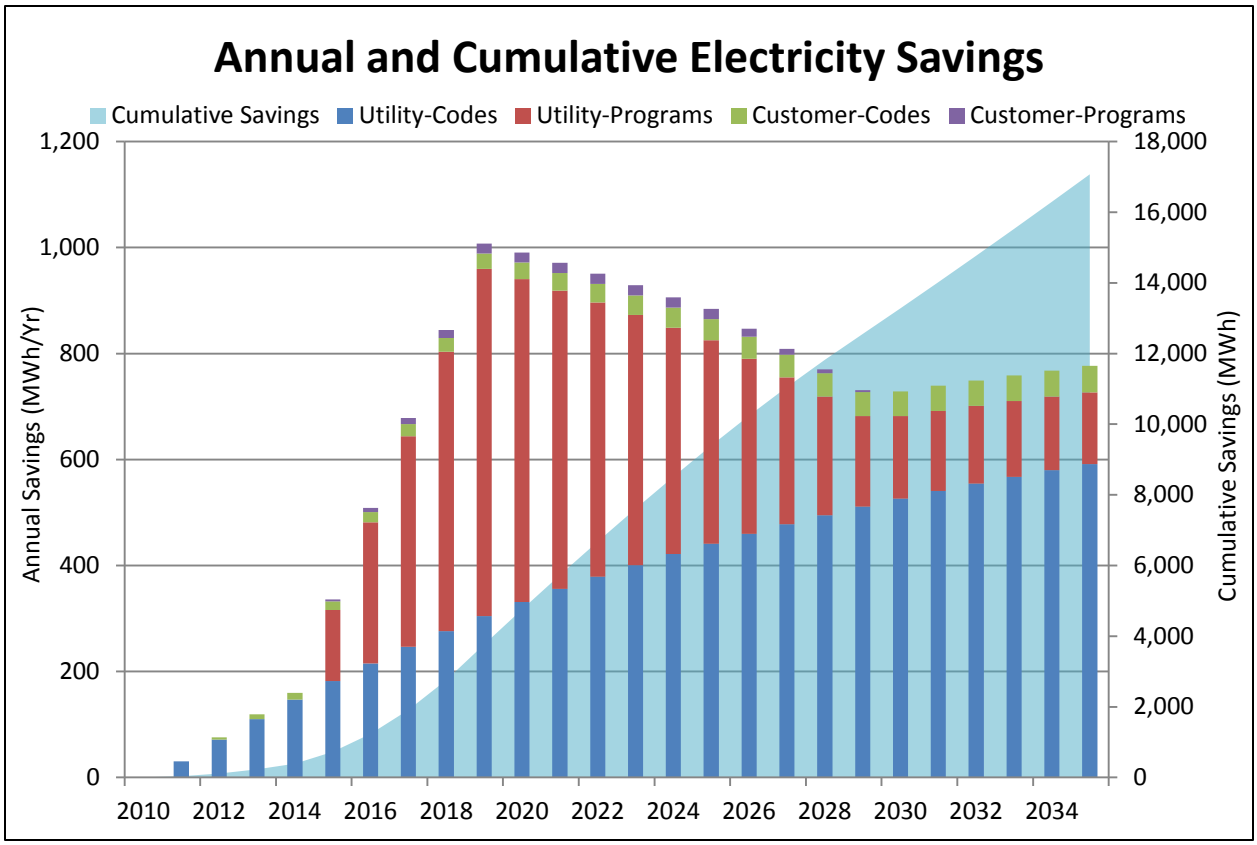
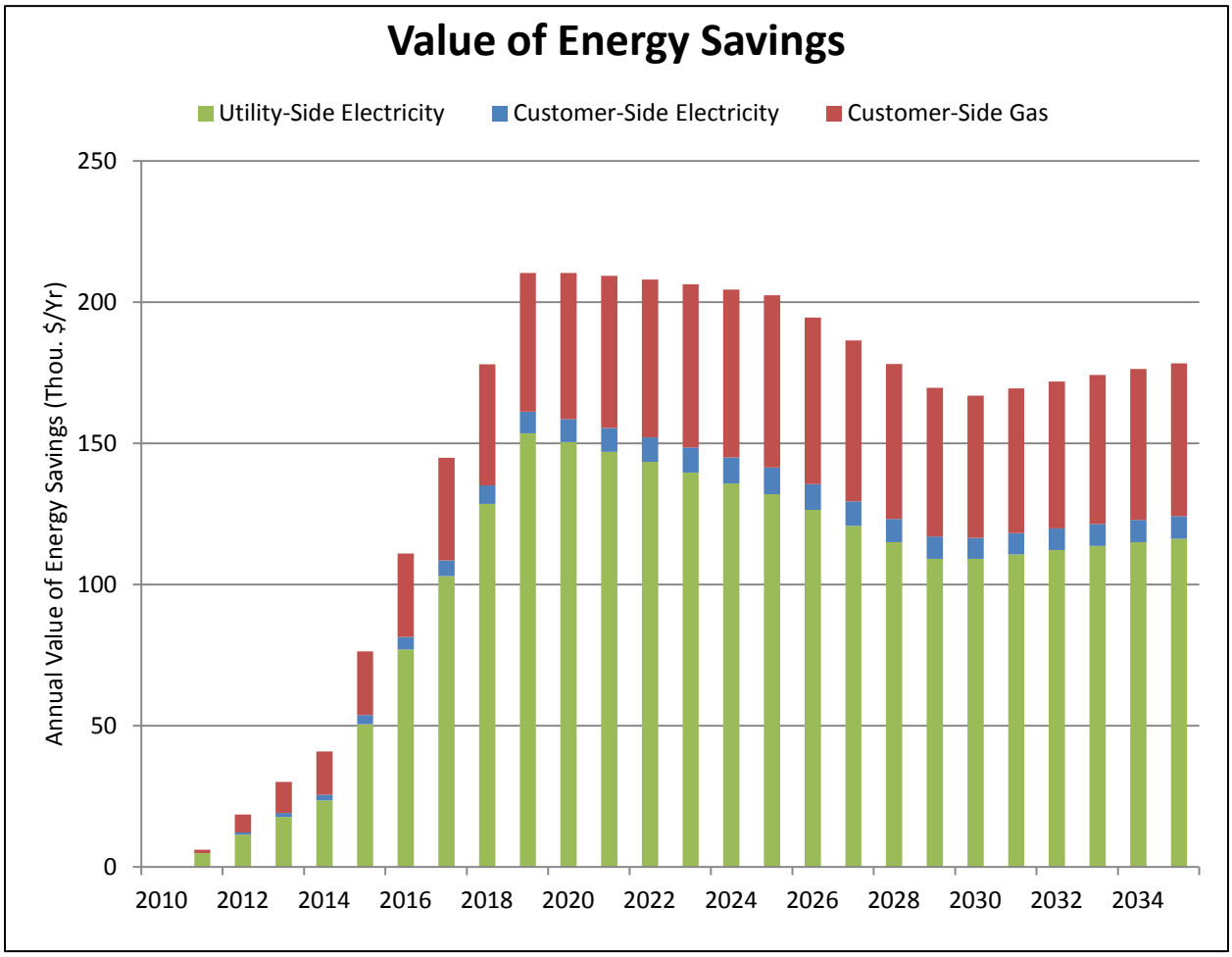


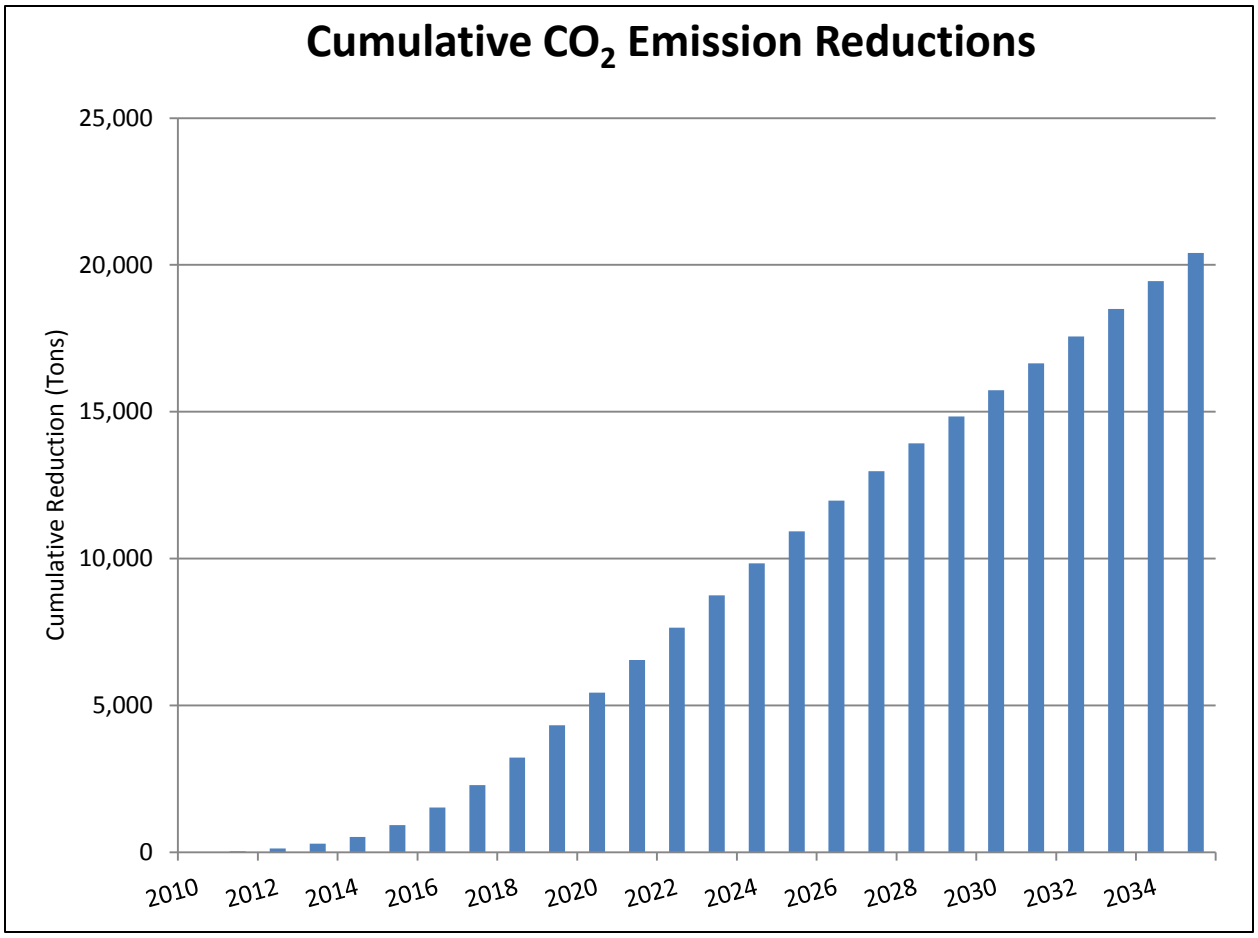
Figure 21 illustrates the value of the energy savings resulting from reduced water demands. They are displayed in three categories: (1) utility electricity savings, (2) customer electricity savings, and (3) customer gas savings. The Tracking Tool assumes utilities use electricity, and not gas, to pump and treat water.

Figure 21: Value of Energy Savings for Utility Electricity and Customer Electricity and Gas



The energy savings resulting from water demand reductions also result in greenhouse gas emission reductions. Those reductions are displayed in Figure 22 and show reductions in metric tons for carbon dioxide (CO_2). .

Figure 22: Cumulative CO_2 Emission Reductions



Lessons Learned

The analysis of Commerce, Lyon and Southwest Oakland townships provided several valuable lessons that can be learned from.

1. Millions of gallons can be saved in the three townships in Oakland County through the implementation of the water conservation programs modeled in this example.
2. The three service areas in Oakland County, MI have very high peak season water use compared to the off-peak season. This represents a large opportunity for demand reductions that may not be obvious without evaluating consumption patterns.
3. Low avoided costs, such as in Lyon and Southwest Oakland Townships, makes planning cost-effective water efficiency programs challenging.
4. Communities with a predominance of new housing (i.e., built after 1994) have less opportunity for residential indoor water efficiency programs.
5. Each service area is unique. What works in one community may not work elsewhere, despite how similar they appear.

6. Due to the uncertainty surrounding outdoor water use efficiency, it would be useful to pilot a variety of outdoor water efficiency programs at a small scale.
7. Achieving demand reductions may require additional strategies if conservation programs are not cost-effective. This may include ordinances pertaining to new construction, outdoor water use restrictions, educational programs, landscape professional training, or water rate design.

Summary

The evaluation of water conservation programs in the four communities in Ontario, Canada and the three communities in Oakland County, Michigan offer insight that can be learned from in regard to planning cost-effective water efficiency measures. The four communities in Ontario, Canada all have a deep history of water conservation program implementation, yet they are still having continued success and are finding new strategies to save water. The three communities in Oakland County do not have any history of water conservation program implementation and there is great potential for water use reductions. Each of the Oakland County communities has relatively new housing stock which limits the potential for residential indoor water conservation programs, but there is great opportunity to reduce the high peak season outdoor water use. The communities in Oakland County, Michigan are all similar from a demographic perspective, but have very different variable operating costs. The following represent lessons learned from the *Greater Lakes: Reconnecting the Great Lakes Water Cycle* water conservation program evaluation:

- The Regional of Waterloo and City of Guelph are experiencing continued success with water conservation and are finding new opportunities.
- The City of Cambridge has a high level of non-revenue water which is being addressed.
- There is potential to save millions of gallons of water in the three townships in Oakland County, Michigan.
- Water conservation programs will become increasingly cost-effective if a community can reduce demands to avoid expensive infrastructure expansion, or other rising operational costs.
- Water conservation programs will become increasingly cost-effective in Lyon Township and Southwest Oakland Township if those communities are faced with purchasing water from DWSD, or other rising operational costs.
- There is high outdoor water use in Oakland County despite being located in a humid continental climate.
- Piloting small scale programs will help deal with uncertainty associated with planning outdoor efficiency programs.
- Outdoor programs should be designed for success:
    - Target high irrigation users
    - Educate landscape professionals and customers
    - Follow-up to assess water savings
    - Follow-up to ensure equipment is programmed and functioning properly
    - Maintain turf quality
- Water conservation programs provide energy savings and greenhouse gas emission reductions.
- Variable operating costs have a large impact on the cost-effectiveness of conservation programs.
- Communities with new housing stock have a more limited opportunity for indoor residential conservation programs.
- Interest rates matter.
- Strategies beyond water conservation incentive programs may be good options in some communities.

    - Education
    - Ordinances and codes
    - Watering restrictions
    - Professional certification
    - Rate design
- Each service area is unique. What works in one community may not work elsewhere.

Ultimately the outcomes of this report suggest there is great potential for water demand reductions in the Great Lakes region and point to the need for careful planning before water conservation programs are implemented. There are many planning tools, resources, and case studies available to water providers in the Great Lakes that can be used to construct cost-effective water efficiency programs.

Appendix A – Tracking Tool Outputs for City of Waterloo and City of Cambridge

This appendix contains Tracking tool outputs for the City of Waterloo and the City of Cambridge. The same water conservation programs were modeled for the Region of Waterloo, the City of Waterloo, and the City of Cambridge. The level of program activity (e.g., number of rebates) for the City of Waterloo and City of Cambridge was determined based on the proportion of each city's population compared to the regional population. Because the populations of each city are similar, and the wholesale water rates paid by the two communities to the Region of Waterloo are identical, the outputs are also quite similar. For details about a particular table or figure, please reference the section that presents the Region of Waterloo outputs starting on page 16. For explanations of terms used in these tables, see "Overview of the Alliance for Water Efficiency Water Conservation Tracking Tool" at the beginning of this report.

The following figures and tables are included for each of the City of Waterloo and the City of Cambridge.

1. Figure: Conservation Activities NPV and B/C Ratio
2. Table: Conservation Program Savings Snapshot 2015-2020
3. Table: Costs and Benefits of Water Conservation Program
4. Figure: Service Area Demands 2015-2035
5. Figure: Annual and Cumulative Electricity Savings
6. Figure: Value of Energy Savings for Utility Electricity and Customer Electricity and Gas
7. Figure: Cumulative Greenhouse Gas Emission Reductions

City of Waterloo

Figure A1: City of Waterloo Conservation Activities NPV and B/C Ratio

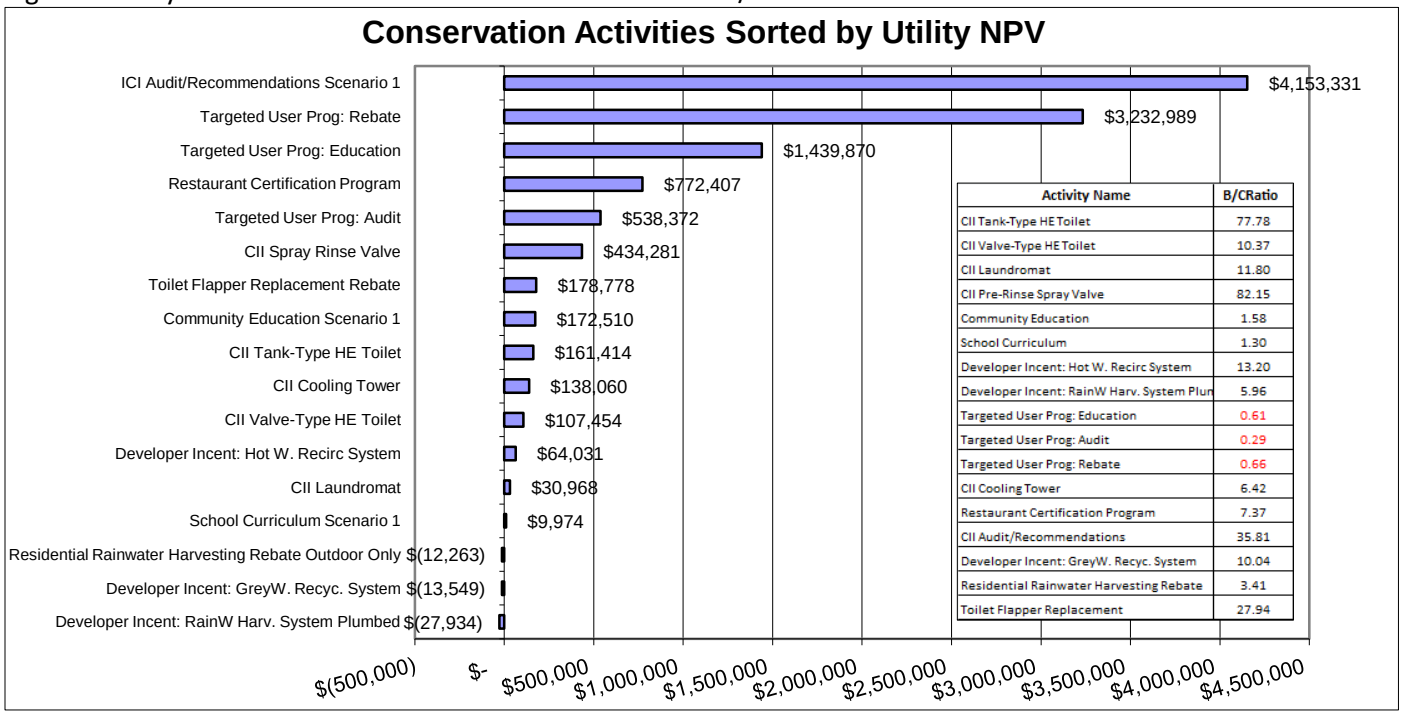


Table A2: City of Waterloo Conservation Program Savings Snapshot 2015-2020

Activity Name	Conservation Program Savings Megalitres					
	2015	2016	2017	2018	2019	2020
CII Tank-Type HE Toilet	0.48	0.96	1.45	1.93	2.41	2.89
CII Valve-Type HE Toilet	0.35	0.70	1.05	1.40	1.75	2.10
CII Laundromat	0.24	0.48	0.71	0.95	1.19	1.43
CII Pre-Rinse Spray Valve	0.75	1.50	2.25	3.00	3.75	4.50
Community Education	7.73	14.69	20.95	26.58	31.65	31.65
School Curriculum	0.86	1.55	2.10	2.54	2.89	2.89
Developer Incent: Hot W. Recirc System	8.96	17.92	26.88	35.84	44.80	53.77
Developer Incent: RainW Harv. System Plumbed	0.23	0.45	0.68	0.90	1.13	1.35
Targeted User Prog: Education	0.20	0.39	0.59	0.78	0.98	1.17
Targeted User Prog: Audit	0.04	0.08	0.11	0.14	0.16	0.19
Targeted User Prog: Rebate	0.06	0.12	0.18	0.24	0.30	0.36
CII Cooling Tower	6.95	13.55	19.82	25.78	31.44	36.82
Restaurant Certification Program	1.06	2.12	3.19	4.25	5.31	6.37
CII Audit/Recommendations	5.67	11.34	17.01	22.68	28.35	34.02
Developer Incent: GreyW. Recyc. System	0.38	0.75	1.13	1.50	1.88	2.26
Residential Rainwater Harvesting Rebate Outdoor Only	2.38	4.77	7.15	9.53	11.92	11.92
Toilet Flapper Replacement	1.37	2.73	4.10	5.46	6.83	8.19
Total	**37.70**	**74.10**	**109.33**	**143.51**	**176.74**	**201.88**

Table A3: City of Waterloo Costs and Benefits of Water Conservation Program

Activity Name	PV Cost ($)	PV ($) Benefit	NPV($)	B/C Ratio
CII Tank-Type HE Toilet	$ 2,102	$ 163,516	$ 161,414	77.78
CII Valve-Type HE Toilet	$ 11,467	$ 118,921	$ 107,454	10.37
CII Laundromat	$ 2,867	$ 33,835	$ 30,968	11.80
CII Pre-Rinse Spray Valve	$ 5,351	$ 439,632	$ 434,281	82.15
Community Education	$ 298,800	$ 471,310	$ 172,510	1.58
School Curriculum	$ 33,200	$ 43,174	$ 9,974	1.30
Developer Incent: Hot W. Recirc System	$ 340,300	$ 4,493,631	$ 4,153,331	13.20
Developer Incent: RainW Harv. System Plumbed	$ 12,900	$ 76,932	$ 64,031	5.96
Targeted User Prog: Education	$ 71,669	$ 43,735	$ (27,934)	0.61
Targeted User Prog: Audit	$ 19,112	$ 5,563	$ (13,549)	0.29
Targeted User Prog: Rebate	$ 35,835	$ 23,571	$ (12,263)	0.66
CII Cooling Tower	$ 265,653	$ 1,705,523	$ 1,439,870	6.42
Restaurant Certification Program	$ 84,569	$ 622,941	$ 538,372	7.37
CII Audit/Recommendations	$ 92,883	$ 3,325,872	$ 3,232,989	35.81
Developer Incent: GreyW. Recyc. System	$ 19,781	$ 198,559	$ 178,778	10.04
Residential Rainwater Harvesting Rebate Outdoor Only	$ 57,335	$ 195,395	$ 138,060	3.41
Toilet Flapper Replacement	$ 28,668	$ 801,074	$ 772,407	27.94
Total	**$ 1,382,491**	**$12,763,183**	**$ 11,380,692**	**9.23**

Figure A4: City of Waterloo Service Area Demands 2015-2035

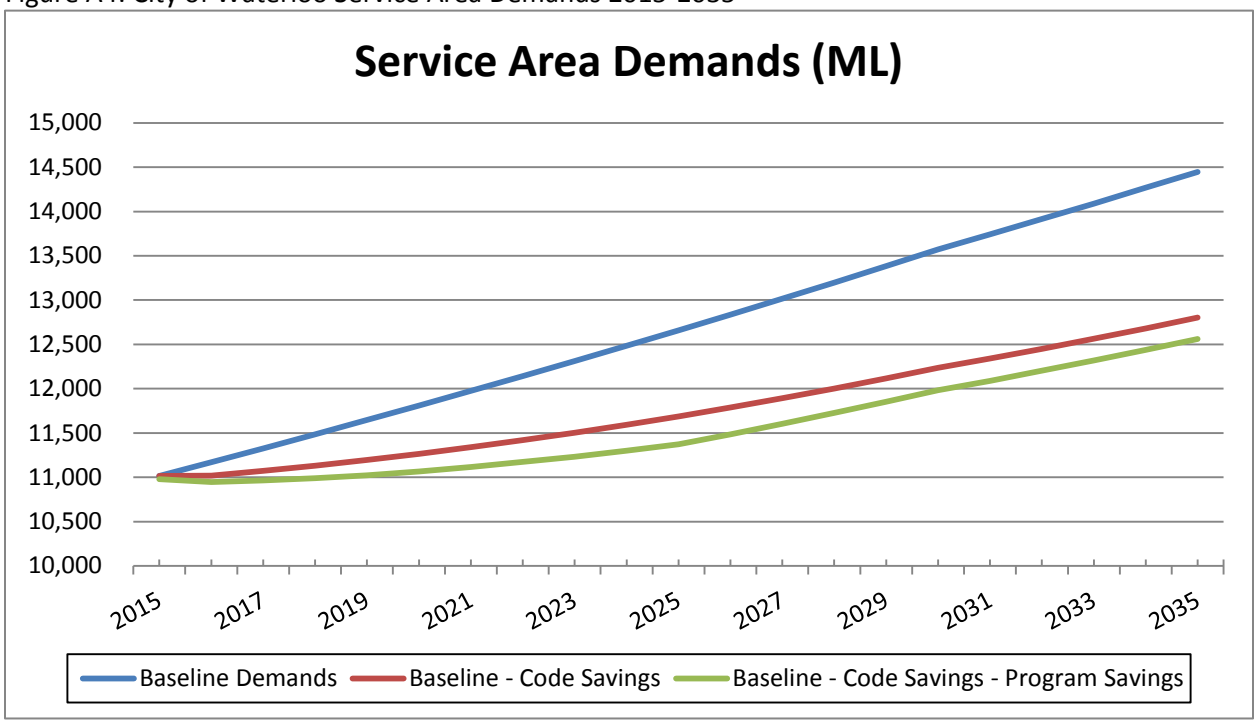


Figure A5: City of Waterloo Annual and Cumulative Electricity Savings

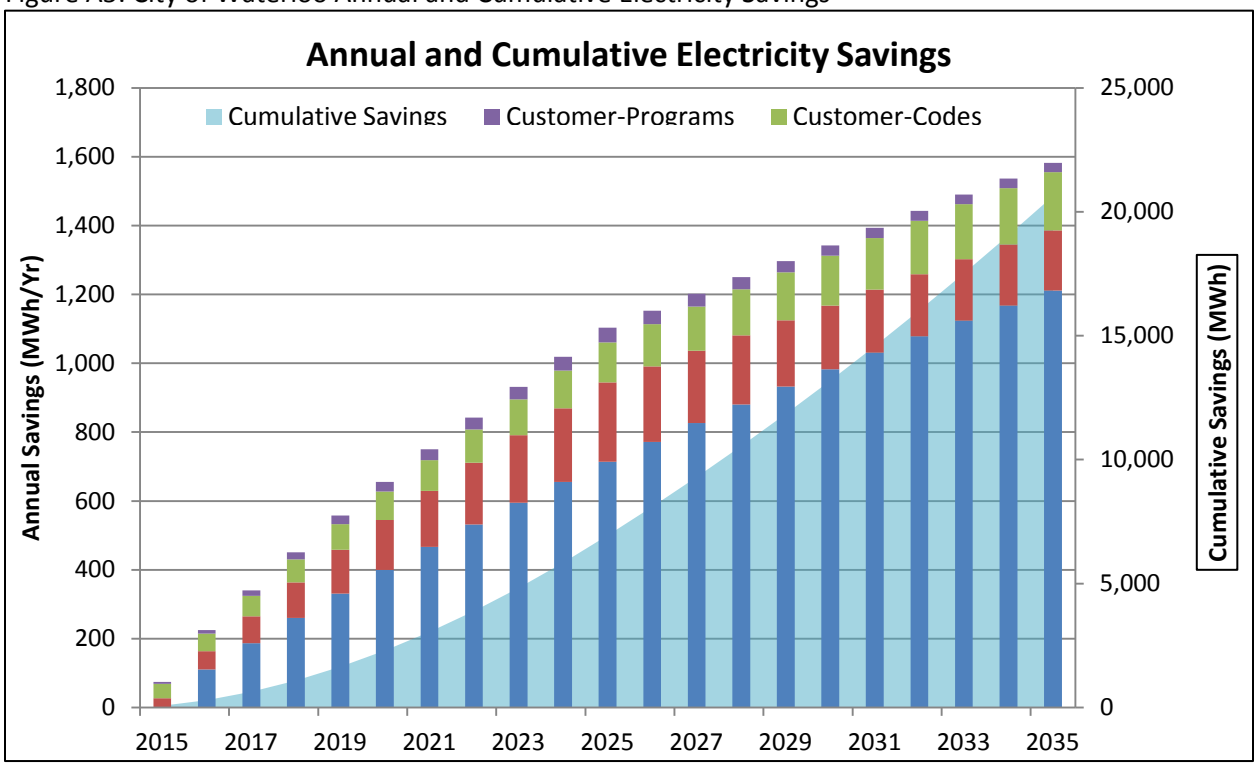


Figure A6: City of Waterloo Value of Energy Savings for Utility Electricity and Customer Electricity and Gas

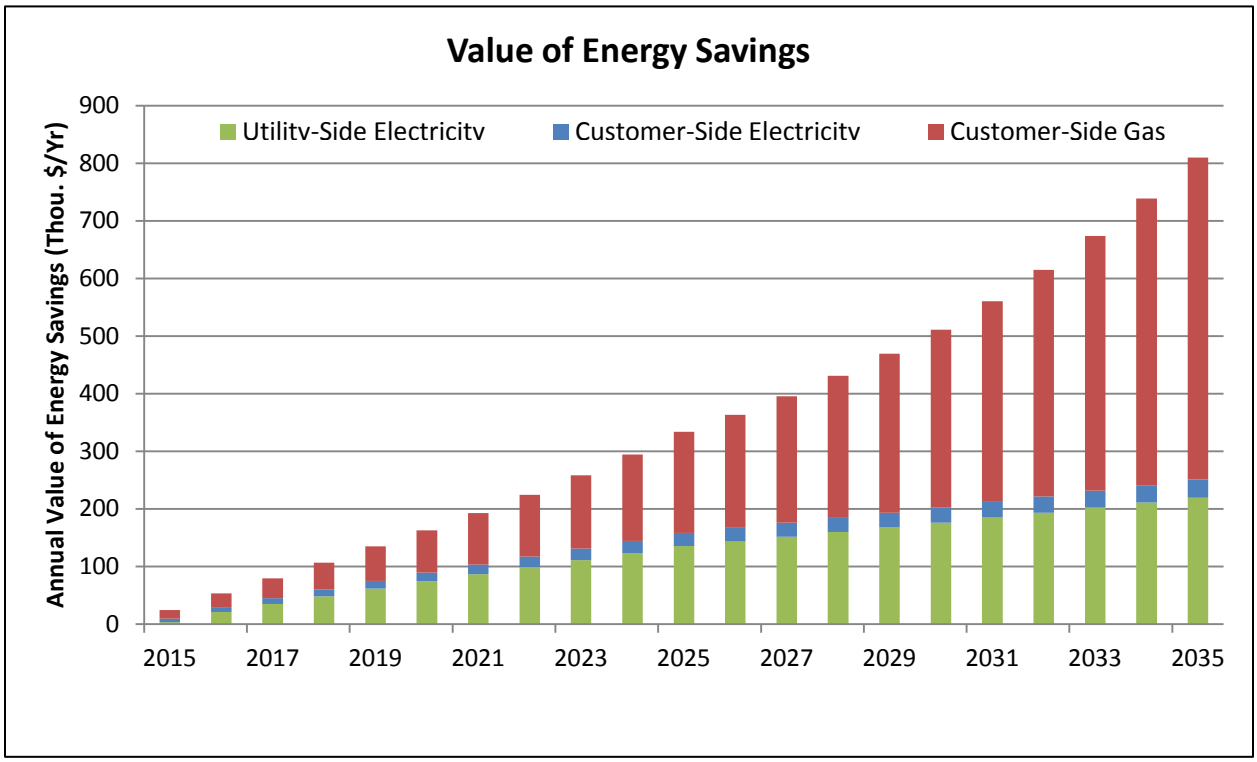
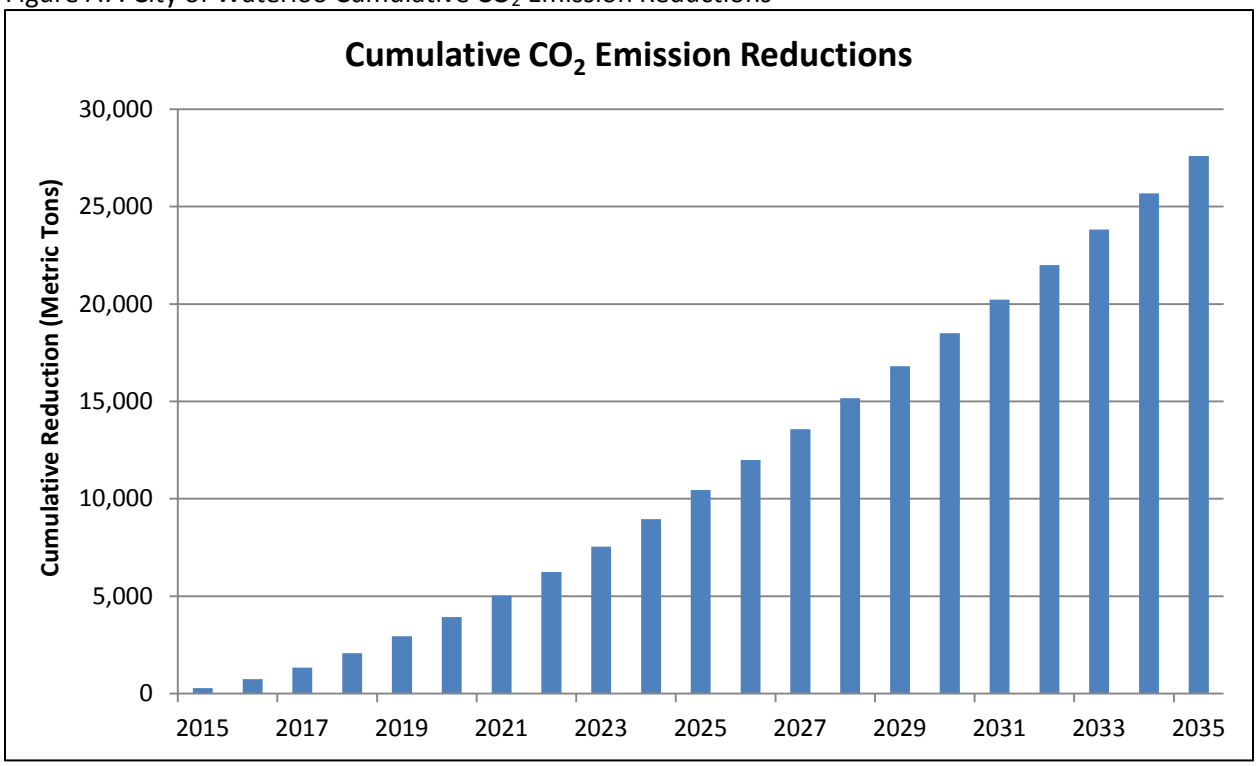


Figure A7: City of Waterloo Cumulative CO_2 Emission Reductions



City of Cambridge

Figure B1: City of Cambridge Conservation Activities NPV and B/C Ratio

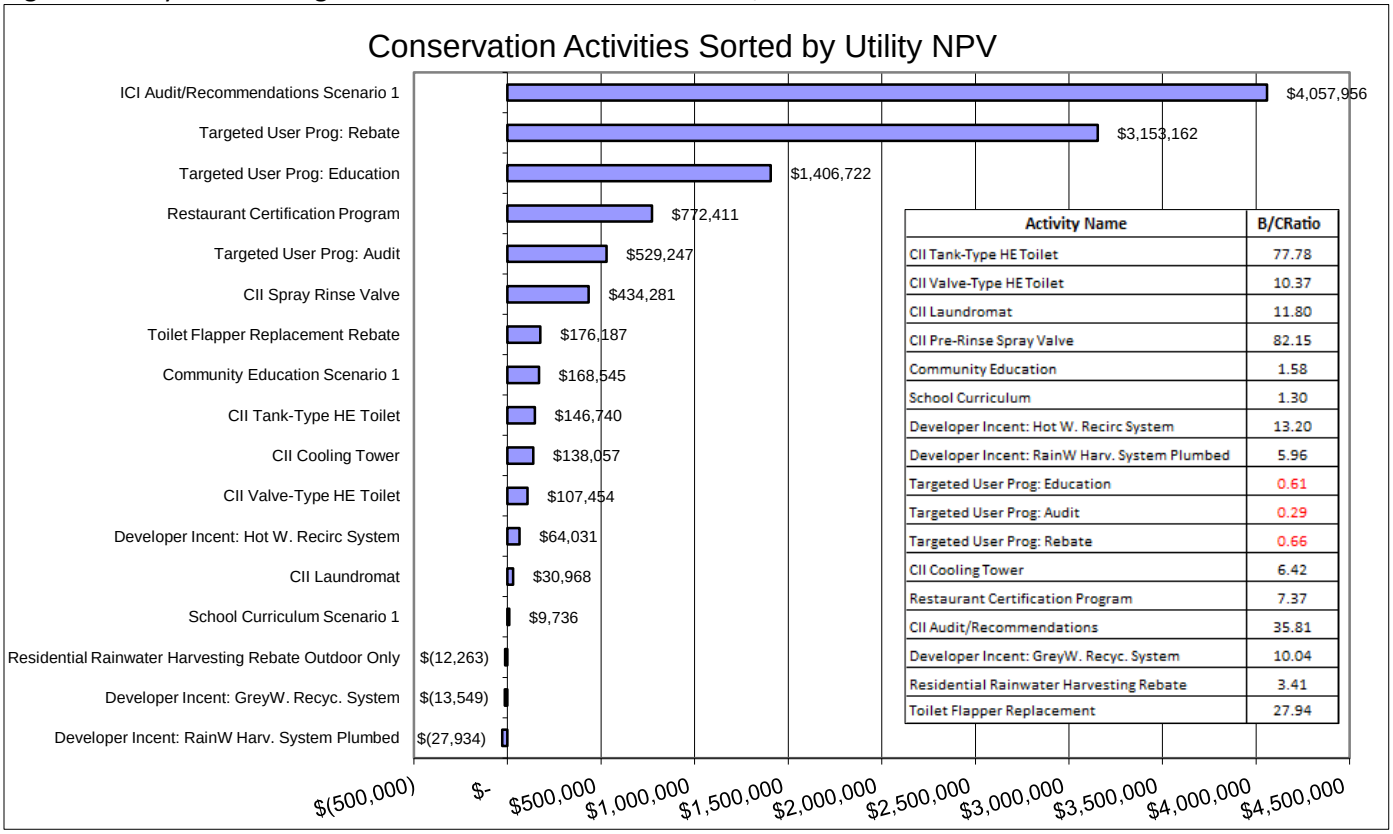


Table B2: City of Cambridge Conservation Program Savings Snapshot 2015-2020

Activity Name	Conservation Program Savings Megalitres					
	2015	2016	2017	2018	2019	2020
CII Tank-Type HE Toilet	0.44	0.88	1.32	1.75	2.19	2.63
CII Valve-Type HE Toilet	0.35	0.70	1.05	1.40	1.75	2.10
CII Laundromat	0.24	0.48	0.71	0.95	1.19	1.43
CII Pre-Rinse Spray Valve	0.75	1.50	2.25	3.00	3.75	4.50
Community Education	7.55	14.35	20.47	25.97	30.93	30.93
School Curriculum	0.84	1.51	2.05	2.48	2.82	2.82
Developer Incent: Hot W. Recirc System	8.76	17.51	26.27	35.02	43.78	52.53
Developer Incent: RainW Harv. System Plumbed	0.23	0.45	0.68	0.90	1.13	1.35
Targeted User Prog: Education	0.20	0.39	0.59	0.78	0.98	1.17
Targeted User Prog: Audit	0.04	0.08	0.11	0.14	0.16	0.19
Targeted User Prog: Rebate	0.06	0.12	0.18	0.24	0.30	0.36
CII Cooling Tower	6.79	13.24	19.37	25.19	30.72	35.97
Restaurant Certification Program	1.04	2.09	3.13	4.18	5.22	6.26
CII Audit/Recommendations	5.53	11.06	16.59	22.12	27.65	33.18
Developer Incent: GreyW. Recyc. System	0.37	0.74	1.11	1.48	1.85	2.22
Residential Rainwater Harvesting Rebate Outdoor Only	2.38	4.77	7.15	9.53	11.92	11.92
Toilet Flapper Replacement	1.37	2.73	4.10	5.46	6.83	8.19
Total	**36.93**	**72.59**	**107.11**	**140.60**	**173.16**	**197.76**

Table B3: City of Cambridge Costs and Benefits of Water Conservation Program

Activity Name	PV Cost ($)	PV ($) Benefit	NPV($)	B/C Ratio
CII Tank-Type HE Toilet	$ 1,911	$ 148,651	$ 146,740	77.78
CII Valve-Type HE Toilet	$ 11,467	$ 118,921	$ 107,454	10.37
CII Laundromat	$ 2,867	$ 33,835	$ 30,968	11.80
CII Pre-Rinse Spray Valve	$ 5,351	$ 439,632	$ 434,281	82.15
Community Education	$ 291,951	$ 460,495	$ 168,545	1.58
School Curriculum	$ 32,442	$ 42,178	$ 9,736	1.30
Developer Incent: Hot W. Recirc System	$ 332,496	$ 4,390,453	$ 4,057,956	13.20
Developer Incent: RainW Harv. System Plumbed	$ 12,900	$ 76,932	$ 64,031	5.96
Targeted User Prog: Education	$ 71,669	$ 43,735	$ (27,934)	0.61
Targeted User Prog: Audit	$ 19,112	$ 5,563	$ (13,549)	0.29
Targeted User Prog: Rebate	$ 35,835	$ 23,571	$ (12,263)	0.66
CII Cooling Tower	$ 259,537	$ 1,666,259	$ 1,406,722	6.42
Restaurant Certification Program	$ 83,136	$ 612,383	$ 529,247	7.37
CII Audit/Recommendations	$ 90,590	$ 3,243,751	$ 3,153,162	35.81
Developer Incent: GreyW. Recyc. System	$ 19,494	$ 195,681	$ 176,187	10.04
Residential Rainwater Harvesting Rebate Outdoor Only	$ 57,335	$ 195,393	$ 138,057	3.41
Toilet Flapper Replacement	$ 28,668	$ 801,079	$ 772,411	27.94
Total	**$ 1,356,761**	**$12,498,512**	**$ 4,081,302**	**9.21**

Figure B4: City of Cambridge Service Area Demands 2015-2035

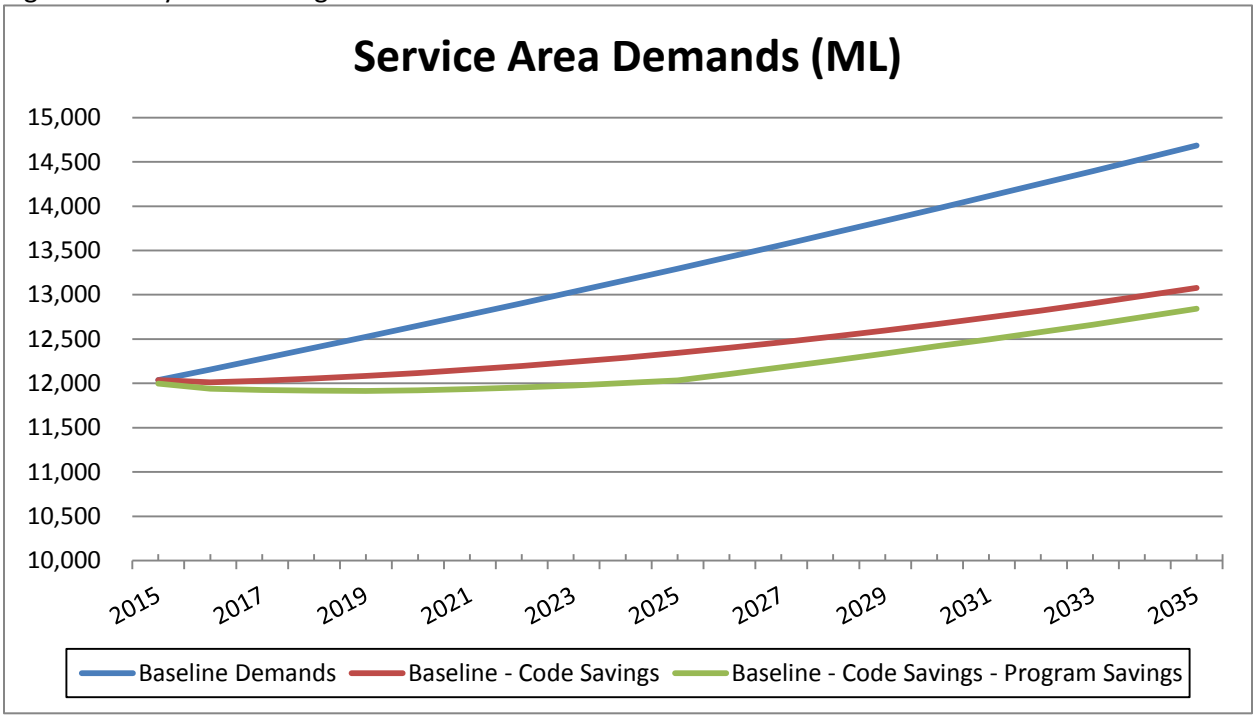


Figure B5: City of Cambridge Annual and Cumulative Electricity Savings

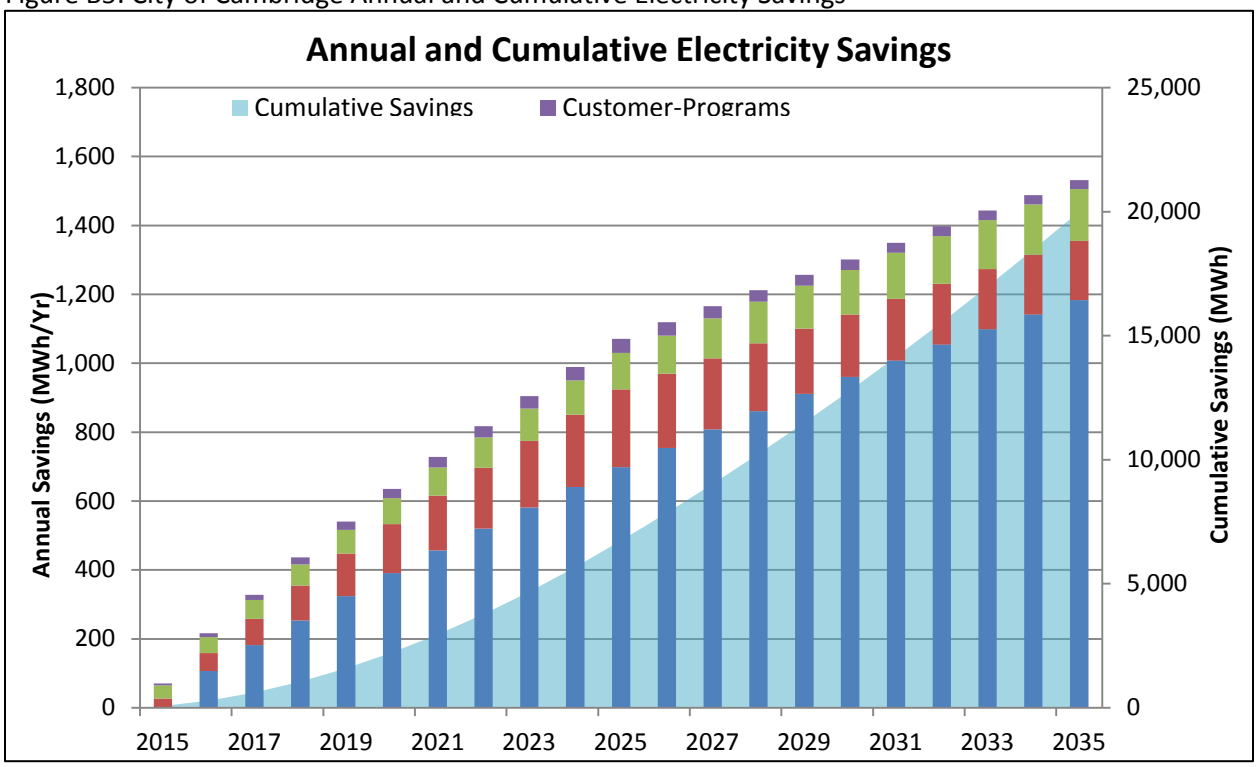


Figure B6: City of Cambridge Value of Energy Savings for Utility Electricity and Customer Electricity and Gas

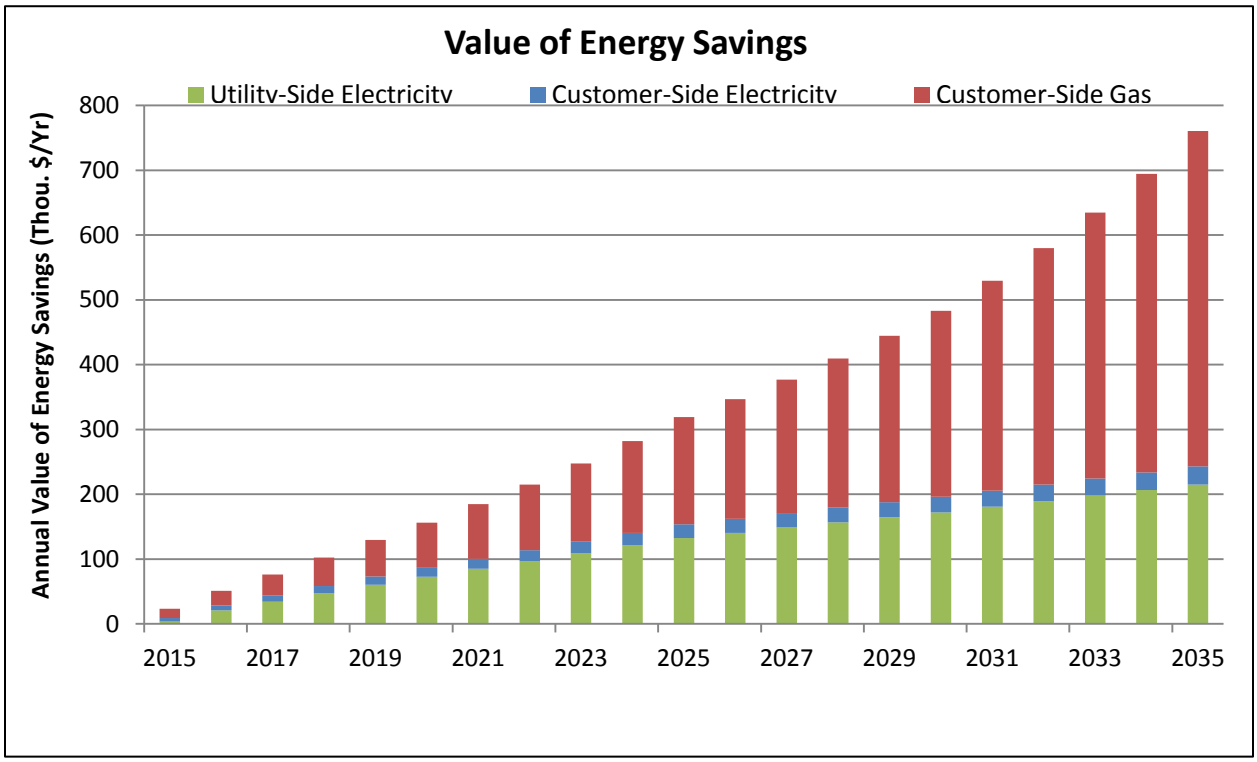


Figure B7: City of Cambridge Cumulative CO_2 Emission Reductions