KEY MESSAGES & LESSONS LEARNED:

Advancing Energy Efficient Water Delivery Services – Pilot Study

DATE OF SUBMISSION: 30 / 01 / 2017

PREPARED FOR: INDEPENDENT ELECTRICITY SYSTEM OPERATOR
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1. INTRODUCTION

1.1 PURPOSE

The Canadian Urban Institute (CUI), with input from the University of Toronto, conducted a two-phase Water-Energy Pilot Study using a municipal water distribution system in Ontario. Phase 1 of this study, Visualizing Energy Use for Water Services (VEU) was conducted in 2012 and developed a mapping tool to calculate energy metrics for assessing water distribution performance and identified potential for improvement.

Phase 2 of the study used the tools we developed in Phase 1 and the same municipal water system to model energy use throughout the distribution system and evaluate potential energy efficiency strategies. The tools are meant to be useful to other Ontario municipalities interested in increasing energy efficiency of municipal water delivery services. This document presents a summary of the key messages and lessons learned.

1.2 BACKGROUND & RATIONALE

In 2012, CUI completed Phase 1 of the pilot study and developed energy metrics to describe energy performance of a water distribution system, as well as a mapping tool to calculate and visualize these metrics. Figure 1 shows the energy metrics that allow system efficiency to be evaluated through the identification and quantification of how energy is supplied, delivered, and dissipated throughout a water distribution system. Energy supplied equals the sum of energy dissipated, lost, potential, and delivered.

![Figure 1: Schematic representation of the different forms of energy in a water distribution system with a single reservoir, pump, pipe and tank.](image)

In Phase 2 of the study, the water-energy performance tools were expanded to include an Excel Summary tool used to summarize and chart these metrics. After applying the tools in the pilot study system to investigate energy use and evaluate proposed energy efficiency strategies, stakeholder feedback was collected from municipal staff as well as policy and research organizations.

Water management is commonly one of the largest energy costs for a municipality.

The municipal water system used in the pilot study is responsible for over 30% of that city’s annual electricity consumption. 25-30% of that is used for water distribution. Distribution consumes energy at pumps and tanks, through dissipation due to friction, losses from leaks, overcoming differences in elevation and in the pressurized water delivered to customers.

Traditionally many water utilities’ conservation efforts have focussed on customer demand management. These efforts to reduce water use include awareness and education, and promotions and incentives for water efficient
appliances (shower heads and low flush toilets). The energy conservation component of this approach calculates the reduction in upstream energy that results from measures to reduce overall consumer demand. In most cases, these efforts have been very effective - targets were met and markets are transformed.

Utilities may now want to explore additional opportunities for energy reduction and cost savings.

This study has demonstrated the potential savings of reducing electricity use in water distribution systems. It provides the water-energy performance tools that can be used to:

- determine energy embedded in various components of a municipal water delivery system;
- identify target areas for efficiency strategies; and
- evaluate the effectiveness of selected energy conservation strategies.

The greatest value of this project is likely the potential application of the water-energy tools in small/medium Ontario municipalities, specifically those with limited resources that have not had the opportunity to implement energy management strategies in their water distribution systems.

This report summarizes the key messages and final lessons learned from the pilot project.

2. KEY MESSAGES

In completing this study, CUI has identified seven key messages from both the study methodology and results.

1. Although water systems are typically analyzed through pressure and flow metrics, the energy embedded in these systems is becoming a more frequently discussed opportunity for energy conservation and cost reduction. Quantifying energy embedded in water distribution networks offers municipalities a new lens through which to analyse these systems and better align energy input and need. Energy metrics were developed in Phase 1 of study to assess the energy performance of a water distribution system and applied again in the present study to identify and evaluate opportunities for improving system efficiency.

2. In Phase 2 of the study, an Excel based summary tool was developed for summarizing and visualizing energy metrics by hour, metric (supplied, dissipated, delivered), or component type (junctions, pipes, valves, pumps, tanks, reservoirs), and calculating energy required by pressure district.

3. In large well-resourced municipal water delivery systems, the water-energy performance tools may be one of several ways to identify and evaluate energy efficiency strategies.

4. The real potential for energy and cost savings is likely in the application of the water-energy performance tools in small/medium Ontario municipalities; specifically those with limited resources that have not implemented energy efficiency strategies.

5. The water-energy performance tools are an effective, low cost alternative to energy optimization software for small-medium municipal water delivery systems that want to identify strategies to reduce energy costs but are not in a position to acquire or operate higher cost energy optimization software.

6. In theory, the water-energy performance tools should be universally applicable to any Ontario water distribution system that uses a network of pipes and pumps, and therefore, has potential for improved energy efficiency. However, there may be challenges for immediate implementation – key among them may be the lack of a hydraulic model.
3. LESSONS LEARNED

CUI summarizes 10 lessons learned from the pilot study regarding water delivery system operations, but more importantly, on how the water-energy performance tools can benefit small/medium Ontario municipalities with identified improvements.

1. Water delivery systems in Ontario municipalities use a significant amount of electricity and there are potential opportunities to reduce this consumption through efficiency improvements. Figure 2 illustrates the difference between energy currently supplied to a network and minimum energy requirements. The light blue area is the potential energy savings.

![Figure 2: Energy supplied and minimum energy required.](image)

2. The water-energy performance tools work to effectively identify components of the system that use high amounts of electricity. Figure 3 outlines the water-energy tools developed to calculate and visualize the energy metrics.

![Figure 3: Schematic diagram of the water-energy performance tools and their outputs.](image)
The EPANET files are inputted to Inptools which converts them to both shapefiles and CSV hydraulic result files. The shapefiles are used in an ArcMap Add-In to calculate energy metrics and map the distribution system. The CSV files are inputted to the Excel Summary Tool to summarize and graph these metrics. The resulting Excel tables of the energy metrics are joined to the shapefiles to map energy embedded throughout the system.

3. The resulting Excel Tool’s graphs provide snapshots of the overall system energy use and of the energy metrics for each component type. Examples from the Pilot Study system are shown in Figure 4.

![Figure 4: Example graphs from the Excel Summary Tool](image)

As shown, the majority of energy supplied to the Pilot Study system is used to overcome elevation differences (or potential) in the network.

4. The resulting maps (examples not provided to keep the Pilot Study system unidentified) are easily understood by anyone who can see the high energy using components of the water system. No training is needed to understand the results. This can help convey information to residents and elected officials.

5. Based on benchmarking global best practices, seven strategies to reduce energy use were identified as most applicable to water systems in Ontario municipalities. The water-energy performance tools are effective in evaluating the energy efficiency strategies and identifying which strategy would produce the most savings. Figure 5 displays the seven strategies for energy management that were investigated in the pilot study. As part of this original study, expected energy reductions and payback periods for each strategy were calculated but are not displayed below. However, the diagram shows the strategies in descending order of potential energy savings if applied in the pilot system (i.e. the tools showed VFDs to have the greatest potential for energy reductions).
Table 1 describes the potential application of each strategy to the example water system used in the pilot study.

Table 1: Proposed energy efficiency strategies and their potential applications

<table>
<thead>
<tr>
<th>No.</th>
<th>Proposed Strategy</th>
<th>Potential Applications &amp; Implications</th>
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</table>
| 1.  | Variable frequency drives (VFDs) | • Because modelled pump throttling causes 90% of energy dissipated at valves, VFDs applied to select water treatment plant valves could reduce energy supplied.  
• Large space requirements for VFDs may be restrictive. |
| 2.  | Pump refurbishment | • Because pumps are responsible for approximately 60% of total energy dissipated in example water network. Refurbishment could be used to improve efficiency of the top energy dissipating pumps. |
| 3.  | Pressure reducing valves (PRVs) | • Reduces leakage and bursts.  
• Existing PRVs in the example system were implemented to control supply, not to reduce pressure. PRVs are not favoured due to the overall increase in energy cost to operate them. |
4. Demand management
   - Demand management education programs and rebates can result in energy savings by promoting water conversation.
   - May be more economical alternative to improving infrastructure.
   - Demand reduction reduces revenue.

5. Energy recovery at valves
   - Hydrokinetic turbines can replace PRVs to harness dissipated energy from pumps at higher elevations than customers and convert it to electricity.
   - High capital cost.

6. Pump rescheduling
   - Energy costs can be reduced by scheduling pumps to operate off-peak and using gravity supply from tanks during peak electricity usage hours when prices are greater.

7. Water rate energy surcharge
   - The rate structure can be modified to reflect energy use to recover energy costs and potentially incent water conservation by customers at higher elevation.
   - Elevation surcharge may be concern for larger ICI consumers or low-income users.
   - User feedback should be sought.

6. Feedback collected from system operators that trailed the water-energy performance tools, as part of the consultation phase of the pilot project, indicated there could be improvements made. The below chart summarizes the feedback received.

<table>
<thead>
<tr>
<th>Recommended Improvements</th>
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<tbody>
<tr>
<td>• Automate tool operations where possible; consider using one main dashboard</td>
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<tr>
<td>• Explore how input files can vary; consider inputs more accurate than hourly averages</td>
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<tr>
<td>• Add more system components to analyse performance at a more granular scale</td>
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<tr>
<td>• Separate water distribution and water supply within the tools</td>
</tr>
<tr>
<td>• Incorporate cost metrics in the Excel Summary tool</td>
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<tr>
<td>• Develop an internal staff training program to build in-house capacity of the water-energy performance tools and the software they use</td>
</tr>
</tbody>
</table>

7. It is important to hold a training workshop for system operators on how to use the tools once they are automated. Holding an additional training session on how to apply the results to the evaluation of efficiency strategies would enable staff to gain a more practical perspective on how the tools can be used. A User Guide was developed to describe the methodologies and tools developed and/or applied in the study. It is an important resource for the training.

8. Where implemented, energy optimization software typically produces significant reductions in energy costs. However, successful adoption of optimization software has been minimal across utilities in Ontario, likely due to the initial high capital costs and complex technical requirements.
9. The water-energy performance tool is an effective, low-cost alternative to energy optimization software for small to medium municipal water delivery systems that want to identify strategies to reduce energy costs but are not in a position to adopt energy optimization software. Based on our engagement sessions, it would be valuable for CUI to explore the application of the water-energy tools in other Ontario municipal water networks. The opportunities and challenges are presented below.

<table>
<thead>
<tr>
<th>Tools for Small/Medium Municipalities</th>
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<tbody>
<tr>
<td><strong>Opportunities</strong></td>
<td><strong>Challenges</strong></td>
</tr>
<tr>
<td>• Building awareness of energy use within a water utility</td>
<td>• No existing hydraulic models or resources to develop one</td>
</tr>
<tr>
<td>• Small/medium networks will likely find the tools simpler to operate than more complicated systems</td>
<td>• Costs of energy efficiency initiatives typically need a payback shorter than on council term (4 years) to be considered</td>
</tr>
<tr>
<td>• Tools may provide smaller water suppliers planning and diagnostic abilities at a lower cost than optimization software</td>
<td>• Potential skills and knowledge training required for in-house staff</td>
</tr>
</tbody>
</table>

10. For many small/medium municipalities, there are no existing hydraulic files, which are needed as the inputs to the water-energy performance tools. In these cases, the following steps are required prior to implementing the tools.

i. Develop hydraulic models.

ii. Determine system data points required and compare with available data to determine if additional meters/sensors need to be implemented.

iii. Negotiate data sharing between the utility, municipality and Ontario Clean Water Agency (if relevant).

iv. Pilot the tools in a small municipality.

4. CONCLUSION

Based on the interview findings and engagement sessions, feedback suggests it would be worthwhile for CUI to explore the application of the water-energy performance tools in other Ontario municipal water systems. The following potential next steps were developed with the objectives to improve the usability of the tools and increase new-user awareness of energy efficiency potential:

a. Automate tools where possible: contract a computer developer to create a single water-energy dashboard to increase user accessibility.

b. Investigate the potential for an Ontario-wide hydraulic modelling program: explore the opportunity of implementing such a program by evaluating and presenting the additional benefits of hydraulic models.

c. Conduct a second pilot project: in a smaller municipality such as Sudbury, Ontario, to demonstrate the feasibility of the tools in small/medium Ontario municipalities.

d. Consider a simpler online version of the tools: developed as a free trial for municipalities with existing hydraulic models.
Improving Electricity Conservation in Small-Medium Municipal Water Distribution Systems Across Ontario

PARTICIPATION REQUEST – revised: July 27, 2018

The **Canadian Urban Institute** (CUI), working with the Ontario Clean Water Agency (OCWA) has been awarded a conservation fund from the Independent Electricity System Operator (IESO) to complete the project *Improving Electricity Conservation in Small-Medium Water Distribution Systems Across Ontario*. This project will refine and pilot the application of a low tech, low cost technology that can be used to identify and evaluate energy efficiency measures and reduce electricity costs in Ontario water distribution systems. As part of this, **CUI and OCWA are looking to engage the managers and operators of 3 municipal water distribution networks (that service 250,000 or less customers) to participate in the piloting of the newly refined technology with support from OCWA.**

**Background**

Water and wastewater operations use the largest amount of electricity in most Ontario municipal system portfolios. This often accounts for more than 30% of a municipality’s total expenditure on electricity. In a strategic research project completed in 2017 with the University of Toronto and Toronto Water, CUI developed water-energy performance tools that quantify and visualize embedded energy throughout municipal water distribution systems. Using Toronto Water as a demonstration system, the technology was shown to be effective as a good visualizing and planning tool.

Using hydraulic models as the input, the technology calculates energy use of different system components from pressure and flow, and then summarizes results in summary tables and maps. Energy-uses measured include:

- Energy supplied by pumps, tanks, and reservoirs;
- Energy dissipated by pumps, valves, and pipes;
- Energy delivered to junctions and tanks; and
- Energy required by pressure district.

For example:

*Figure 1: Map of energy dissipated in the Toronto Water distribution network during peak demand on the average demand day*
The technology also evaluates the effectiveness of energy efficiency strategies by estimating the resulting energy savings. The City of Toronto was able to virtually test seven different strategies to determine if improved energy efficiencies could be achieved and calculate the potential reduction in energy costs.

**Objective**
The main objective of this new project funded by IESO is to refine the water-energy performance tools developed in the strategic research project to make them easily usable and valuable for the majority of small-medium municipal water systems across Ontario. We would also like to demonstrate how the tools can identify opportunities for these systems to conserve energy through pressure and flow management. Ultimately this could result in long-term reductions in energy consumption costs and environmental impacts.

**Participation Request**
CUI is requesting your Municipality’s participation to pilot the water-energy performance tools. For all participating systems, CUI and other project team members will provide the following services at no cost to the Municipality:

1. Outfit the Municipality with the required computer hardware (funded by IESO) to run the performance tools independent from existing operations.
2. Project support and coordination from OCWA.
3. Develop or upgrade and calibrate water distribution system hydraulic models, as needed, for the system.
4. Produce hydraulic model summary reports for any model developed or upgraded.
5. Work with system managers and operators to conduct demonstration tests of the water-energy performance tools.
6. Share and replicate the tool outcomes in staff training workshops for each participating system and provide a training manual / user guide.

As part of this project, CUI and OCWA will require:
- Participation in two half-day training workshops:
  1. Background on the project and an introduction to the technology.
  2. Technical training on implementing and using the technology.
- Three informational meetings with system Managers;
- Supply of background information regarding the distribution system; and
- Operations assistance and SCADA data if fire flow tests are required for calibration.

**Project Team**

<table>
<thead>
<tr>
<th>Organization</th>
<th>Team Member</th>
<th>Role</th>
</tr>
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<tbody>
<tr>
<td>Canadian Urban Institute</td>
<td>Jeff Evenson</td>
<td>Project Lead</td>
</tr>
<tr>
<td></td>
<td>Geneva Starr</td>
<td>Project Coordinator &amp; Researcher</td>
</tr>
<tr>
<td>Ontario Clean Water Agency</td>
<td>Indra Maharjan</td>
<td>Municipal Water System Specialist &amp; Participant Coordinator</td>
</tr>
<tr>
<td>HydraTek</td>
<td>Ahmad Malekpour</td>
<td>Programming Expert for Tool Refinements</td>
</tr>
<tr>
<td>University of Toronto</td>
<td>Bryan Karney</td>
<td>Water-Energy Expert for Project Evaluation</td>
</tr>
<tr>
<td>R.V. Anderson Associates</td>
<td>Kim Sayers</td>
<td>Hydraulic Model Expert</td>
</tr>
<tr>
<td>Technical consultant</td>
<td>Rebecca Dziedic</td>
<td>Water-Energy Expert and Tool Developer</td>
</tr>
</tbody>
</table>
Required inputs of participating municipal water distribution systems:

- Existing water distribution hydraulic models or drawings
- Coordination with OCWA & CUI during demonstration tests
- Participation in two half-day workshops
- 3 meetings with system managers
- Operations assistance for fire flow testing for model calibration

Project outputs the distribution systems will receive:

- Computer hardware
- Calibrated hydraulic model of your water distribution system
- Hydraulic model summary report
- Water-energy performance tool
- Training workshops & manuals for adopting the water-energy tool
- Energy consumption analysis of your distribution system
- Evaluation of energy efficiency strategies for your system

**Contacts**

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a) **Generator Replacement Project**
Generator and Generator Switchgear pre-selection RFQ deadline is April 4, 2019. Work is ongoing. EXP has nearly completed the development and design for new Generators at LAWSS WTP and are progressing through the compliance documentation and tendering stage of the project. Project scope has been updated to include replacement of WTPs main 4160V switchgear and updated to include provision for use of the new generators for non-standby power.

b) **Radio/PLC Upgrade & Replacement**
Work has resumed. Experteers spent the week of February 5th completing steel work and running new cable at all LAWSS “satellite” locations. During the week of March 25, 2019 Experteers began building the foundation for the new radio tower to be installed at ELPS. On Thursday April 11, 2019, Experteers is hosting a new Factory Acceptance Test (FAT) for the system with the assistance of MegaCom and GE.

c) **Admin HVAC Rebuild**
Work underway. Shop drawings for the new condenser units have been reviewed and approved by Building Innovations early in 2019. During the week of March 25, 2019 work began to prepare the “penthouse” at the WTP for the new equipment. Compressor units are scheduled to arrive the second week of May.

This report was prepared by Clinton Harper, LAWSS General Manager

Attachment(s): none
To: LAWSS Joint Board of Management

From: Clinton Harper

Date: Thursday April 4, 2019

Subject: LAWSS 20-Year Growth Plan- Modelling Report (February 2019)

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**Recommendation:**

It is recommended that AECOM finalize LAWSS 20-Year Growth Plan-Modelling Report (February 2019) and proceed with Financial Planning Report focusing on Alternative 1A, 2A, 2B, 3B, 3C, 4C, 5A, 5B, 5C, 6A, 6B as described in the Plan

**Background:**

In September 2017 LAWSS hired AECOM to complete a conceptual engineering design and costing estimate related to planned growth for LAWSS over the next 20 years. The municipal members provided an estimate of their expected 20-year growth.

In April 2018, with the help of the LAWSS technical group, AECOM finalized Technical Memorandum #1 and established baseline data for the system modeling. The second part of the project involved applying estimated growth factors to the baseline data to identify areas of concern. The second part also includes the development of “alternatives” or “capital upgrades” needed to address the areas of concern.

DRAFT LAWSS 20-Year Growth Plan- Modelling Report was presented to the LAWSS technical group for review on October 9th 2019. In summary, the hydraulic modeling identified the four (4) following areas of concern:

1. Existing fill constraints at East Lambton Pumping Station (ELPS).
2. Future fill constraints at West Lambton Pumping Station (WLPS).
4. Future High Lift Station (HLS) at Water Treatment Plant (WTP) Capacity.

The Capital improvements and alternatives recommended by the Engineer at that time included:

**Existing fill constraints at ELPS.**

1A. Install new booster pumping station approx. 8km west of ELPS (between Brigden Side Road and Telfer Road).

**Future fill constraints at WLPS.**

2A. Implement the grid reinforcement twinning works.

2B. Hydraulically separate the LAWSS WTP zone from the West Lambton Zone.

**Existing Watford Standpipe network capacity.**

3B. x2 Transmission Mains + Floating Storage + Pump Upgrades.

**Future HLPS Capacity.**

4C. Reduction in demand.

In November 2018 the Board authorized AECOM to reopen TM#1 after an issue with how some the assumptions were made was identified by OCWA staff. Refinement was needed to allow the new LAWSS water model to best match with what is observed in operations.

Assumptions were re-evaluated and on February 14th a revised DRAFT LAWSS 20-Year Growth Plan- Modelling Report was provided by AECOM based on the refined model data.

**Comments:**

While all areas of concern identified in the original LAWSS 20-Year Growth Plan- Modelling Report remained generally unchanged, the refinement of the model revealed an approx. 20% overestimate in the original analysis. This overestimate was further compounded when growth estimates were applied. The results of this Project will now better reflect actual demands and actual future system requirements.

The additional analysis also revealed a previously unidentified issue.

**Future Forest Standpipe Network Capacity**

5B. Reduction in Demand
5C. Explore feasibility of increased PRV setting.

Attached is a report prepared by AECOM further explaining the results of the data refinement.

**Consultation:**

Consultation between AECOM’s engineering team and OCWA-LAWSS review team is ongoing. Revised LAWSS 20-Year Growth Plan- Modelling Report was provided to the LAWSS Technical Team on February 14th.

**Financial Implications:**

The development of Financial Planning Report based on alternatives developed in LAWSS 20-Year Growth Plan- Modelling Report is included in AECOM’s scope of work for this project. There are no financial implications.

This report was prepared by Clinton Harper, LAWSS General Manager

Attachment(s):

- Change Summary Letter – AECOM March 21, 2019
- DRAFT LAWSS 20- Year Growth Plan Modelling Report (February 2019)
Executive Summary

The Lambton Area Water Supply System (LAWSS) provides potable water to its six partner municipalities (City of Sarnia, Township of St. Clair, Village of Point Edward, Town of Plympton-Wyoming, Township of Warwick and Municipality of Lambton Shores) and one customer area (Alvinston). As each service area is growing, LAWSS is looking for an engineered solution to expand its system in order to supply water to its members and customers over the next 20 years, as well as to potential new customers in Lambton County.

Building on Technical Memorandum 1 (Model and Base Data Review), this report outlines the steps in updating model demands and looks at key scenarios including:

- 2016 Peak Hour Demand (PHD);
- 2016 Maximum Day Demand (MDD) plus fill operations;
- 2036 PHD; and
- 2036 MDD plus fill operations.

Based on model results, the following areas of improvement were identified:

**Issue 1: Existing ELPS Fill Constraints**
- 2016 model results depict the ELPS fill operation constraint at the inlet of the ELPS. Capacity to deliver flow to the ELPS Reservoir is limited by pressure upstream of the ELPS which are noted to drop below 275 kPa (40 psi) at a fill rate of 120 L/s. This issue has been identified by LAWSS.

**Issue 2: Future WLPS Fill Constraints**
- 2016 results show that the WLPS is approaching its fill rate limit under its current operating method. Under 2036 conditions, the fill rate cannot be supplied under its current operating method.
- Under 2036 conditions, the WLPS cannot be turned off while filling without causing low pressures within the West Lambton Zone.

**Issue 3: ELPS to Watford Standpipe Network Capacity**
- Estimated 2016 demands are approaching the ELPS Watford PS system capacity. Further, this station has the highest discharge pressure within LAWSS due to its high static lift and surpasses MOECC criteria.
- The existing network in the ELPS Watford PS system cannot satisfy 2036 projected flows at acceptable pressures, regardless of pump capacity.

**Issue 4: Future LAWSS WTP HLPS Capacity**
- 2036 MDD + Fill flow requirements surpass the LAWSS Water Treatment Plant (WTP) High Lift Pump Station (HLPS) system conveyance capacity, keeping the current maximum discharge pressure (450 kPa or 65 psi) constant.
- 2036 MDD flow requirements surpass the current actual WTP treatment capacity.
- It is likely that 2036 MDD + Fill flow calculations overestimate future requirements due to assumptions that must be made when using a steady-state model, as was noted in the 2016 MDD + Fill scenario. By reducing requirements by the same proportion as was noted in 2016 MDD + Fill, pumping capacity will be able to supply required flow, but treatment capacity will not.

**Issue 5: ELPS to Forest Standpipe Network Capacity**
- Future ELPS (Forest) zone demands are projected to surpass the combined capacity of the existing ELPS Forest PS (with the discharge PRV at its current setting) and distribution network.

**Issue 6: Other Low System Pressures**
- 2016 model results show pressure deficiencies at the east end of Warwick consistent with current LAWSS observations. This is made worse in the 2036 scenarios if no improvements are made.
Based on model results, there is the possibility of pressures dropping slightly below 275 kPa (40 psi) while filling the WLPS Reservoir under 2016 MDD conditions. However, LAWSS has received no low pressure complaints in St. Clair. These modelled low pressures were noted to be in rural areas and consequently may go unreported.

Based on the review of the modelled alternatives, AECOM makes the following preliminary recommendations:

- **Alternative 1A**: Install a booster PS upstream of the ELPS (2016). Further, build a twin 600 mm main along London Line from the discharge of the booster PS to the ELPS Reservoir inlet valve (2036 scenario). To address low pressures along Confederation Line and Mandaumin Road, install 2.7 km of 300 mm-diameter main from the booster PS discharge down to Confederation Line & Brigden Road. Install a check valve just west of Confederation Line & Brigden Road to maintain higher pressure within the pressure-boosted zone.

- **Alternative 2A**: Implement the grid reinforcement twinning works (2036 scenario).

- **Alternative 2B**: Hydraulically separate the LAWSS WTP Zone from the West Lambton Zone (2036 scenario). Revise WLPS operations and piping such that the WLPS Reservoir can receive flow from the LAWSS WTP Zone while pumping to the West Lambton Zone. Install new check valves or revise existing check valves to ensure pressure zone separation at St. Clair Parkway & LaSalle Line, Tashmoo Avenue & LaSalle Line and on Plank Road roughly 3 km northwest of Waubuno Road. Lastly, install a check valve at the grid reinforcement twinning works connection to the existing system at LaSalle Line & Tecumseth Road.

- **Alternative 3B**: Install two 600 mm watermains from the ELPS Watford PS discharge to the Watford Standpipe, one along Confederation Line and one along Michigan Line, and include five (5) interconnections as shown in Figure 6-29. Build an additional 2.76 ML of floating storage near Watford for equalization purposes. No pump upgrade would be required assuming the ELPS Watford PS has three identical pumps with the same curve as in the model, allowing two pumps to operate in parallel as firm capacity.

- **Alternative 3C**: Develop a strategy to split the East Lambton Watford Zone into two separate zones as the discharge pressure at the ELPS Watford PS is quite high, largely due to the high static lift. The strategy should coordinate and include Alternative 1A (Booster PS to fill ELPS), Alternative 3B (two 600 mm mains, ELPS Watford PS upgrades, additional storage), and Alternative 5A (Warwick Booster PS). Review the history of watermain breaks in this high-pressure area and compare repair costs against anticipated capital costs (i.e. new pump station, water storage facility and transmission mains).

- **Alternative 4C**: Reduction in demands. Reduce LAWSS demands through water conservation measures, revising or refining growth figures, and by reducing Non-Revenue Water (NRW) to defer major infrastructure works. Currently, 2036 MDD + fill requirements surpass the current LAWSS WTP HLPS system capacity by roughly 17%. This figure is reduced should 2036 MDD + Fill rates be overestimated as described in Section 4.5.1.

- **Alternative 5A**: Discuss with Lambton Shores the possibility of providing more supply to Lambton Shores Zone 1 from the Grand Bend PS. At this time, supply shortfall is estimated at roughly 10 L/s (0.9 ML/d) during the 2036 MDD scenario.

- **Alternative 5B**: Reduction in demands in the ELPS (Forest) Zone. Reduce demands through water conservation measures, revising or refining growth figures, and by reducing Non-Revenue Water (NRW) to defer major infrastructure works.

- **Alternative 5C**: Conduct a condition assessment on the watermain connecting the ELPS to the Forest Standpipe to assess the impact of increasing the ELPS Forest PS discharge PRV setting. If deemed feasible, increase the PRV setting by 48 kPa (7 psi) to 669 kPa (97 psi).

- **Alternative 6A**: Warwick Booster PS and network upgrades. Warwick is currently building a booster PS to address low pressure on its east end. To create a pressure-boosted zone, two check valves are assumed to be installed, one on Egremont Road and one on Confederation Line. In 2036, watermain upgrades as noted in Figure 6-31 will be required to maintain minimum pressures.
Alternative 6B: Carry out local upgrades and modification to address remaining low pressures. The following works and modifications have been identified in this study, but should be revised with field investigation prior to implementation:
  o Warwick network improvements as shown in Figure 6-31 (outside LAWSS jurisdiction);
  o Connection of the existing 300mm dead-end pipe along McGregor Sideroad to the proposed grid reinforcement piping, ensuring the zone separation check valve is located farther south than this connection (see Figure 6-32);
  o Relocation of the check valve Along Plank Road farther north such that the low pressure nodes (shown in Figure 6-32) are located in the West Lambton Zone. Alternatively, upgrade to larger pipes in this area.
  o Construct 2.7 km of new 300 mm-diameter watermain from the discharge of the proposed booster station discharge running south to connect to Confederation Line Along Confederation Line and Mandaumin Road as shown in Figure 6-32;
  o Increase WLPS VFD pressure setting to 442 kPa (64 psi) as needed to maintain adequate pressure in northeast St. Clair during times of highest demand; and
  o Upgrade 4,350 m of watermain to larger diameter in North Warwick as shown in Figure 6-35 (outside LAWSS jurisdiction).

AECOM makes the following recommendations with regards to model refinement and further analysis:

  • Convert the model to Extended Period Simulation (EPS) to further investigate current and future filling operations and required flows.
  • Conduct long-term pressure logging to confirm if low pressures are a concern in northeast St. Clair (as shown in Figure 4-3) during 2016 PHD and 2016 MDD filling operations.
  • Review and confirm that modeled pump curves match those in the field.
  • Review and confirm model updates identified in Section 3.
  • Review existing emergency backup power and emergency pumping capacity to assess future requirements for each station.
  • Conduct a detailed field investigation and modelling study to assess the impacts of isolating the LAWSS WTP Zone from the West Lambton Zone. Study should identify and design appropriate measures to control for potential issues such as water age and transient pressures, as well as evaluate the need for the Indian Road Elevated Tank (ET) from hydraulic (cycling/turnover and emergency conditions) and transient perspectives.
Dear Mr. Harper

Further to our recent discussion, we have summarized the updates included in the February 2019 submission of the modelling report and this letter documents the updates applied to the original submission dated September 2018.

- 2016 Maximum Day Demand for LAWSS Water System was updated based on available SCADA data and flow transfer meter data. This update results in the following:
  - Percent of LAWSS water supply distribution for each member / customer was altered
  - 2016 Maximum Day Demand for LAWSS was reduced by about 2.5%
    - The 2.5% reduction in demand also applied to the forecasted maximum day demand for the system

- Hydraulic analysis was updated based on the updated water demands. The following summarizes the changes in hydraulic analysis results due to demand reduction:
  - Alternative 3B:
    - Additional storage for Watford was reduced from 4.1ML to 2.76ML
  - Pump station upgrade was no longer required, assuming the ELPS Watford PS has three identical pumps with the same curve as in the model, allowing two pumps to operate in parallel as firm capacity.
    - Alternative 4C:
      - The supply deficit at LAWSS WTP HLPS was reduced from 17% to 10%; a supply deficit is still projected

- The revision of the hydraulic analysis identified additional alternatives; which were not listed in the September 2018 submission. These alternatives were spotted when having a closer look at the demands in the East Lambton (Forest) Zone:
  - Alternative 5A, 5B and 5C

- Alternative 6A in the February 2019 submission was listed as Alternative 5A in the September 2018 submission. Alternative 6B was introduced in the February 2019 submission for consideration in mitigating remaining low pressures in the system.

The above-noted provide an overview of the changes when comparing the September 2018 and February 2019 submission. We believe this is sufficient to meet your needs. Should you have any questions, please feel free to contact the undersigned.