Appendix G

TM6 - Identification and Screening of Alternative Liquid Treatment Options

The Regional Municipality of Waterloo

Wastewater Treatment Master Plan Update

Technical Memorandum No. 6: Identification and Screening of Alternative Liquid Treatment Options

Final

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1. Introduction

1.1 Background

The Regional Municipality of Waterloo (the Region) is an upper tier municipal government, providing municipal services to seven area municipalities with a total population of approximately 550,000 people. The Region owns thirteen (13) wastewater treatment plants (WWTPs), one (1) wastewater residuals processing facility, six (6) wastewater pumping stations (with a seventh station under construction), and two wastewater collection systems (Ayr in the Township of North Dumfries and Wellesley in the Township of Wellesley), treating an approximate average of 66 million cubic meters of wastewater annually. Wastewater facilities are operated and maintained by the Ontario Clean Water Agency (OCWA) under contract to the Region. Most of the collection systems and pumping station infrastructure that conveys wastewater to the Region's treatment facilities are owned, managed and operated by the area municipalities (City of Cambridge, City of Kitchener, City of Waterloo, Township of Wilmot, and Township of Woolwich).

The Region has experienced steady residential and industrial/commercial/ institutional (ICI) growth for many years, and anticipates this will continue as a result of factors such as a strong local economy, the Province of Ontario's Places to Grow (P2G) Act and major Regional and Provincial transportation initiatives that are underway. The Region completed a Wastewater Treatment Master Plan (WWTMP) in 2007 (Earth Tech, 2007) to plan for future growth and provision of treatment capacity throughout the Region. Due to changing population growth patterns, wastewater flows, and environmental regulations, the Region is now updating the WWTMP.

CIMA Canada Inc. (CIMA) has been retained by the Region to update the 2007 Master Plan and to develop a current, comprehensive, cost-effective and feasible strategy. These changes will address the anticipated wastewater treatment and disposal needs of the Region over the next 35-year planning period in a manner consistent with the Region's Strategic Plan.

This Technical Memorandum (TM6) has been prepared to document alternative options for liquid treatment, consistent with the Region's wastewater treatment objectives and existing facilities. Options to address process and capacity constraints, as well as for effluent quality enhancements, energy savings and greenhouse gas reductions through the liquid treatment process are considered and screened on a Region-wide and plant specific basis.

1.2 Objectives of TM6

The objectives of this Technical Memorandum are to:

- Identify alternative liquids treatment options
- Screen options based on overall Region-wide goals and specific service area needs for each wastewater treatment plant

2. Objectives of the WWTMP Update

The key objectives of the WWTMP Update include the following:

- Provide capacity to service growth
- Maximize and optimize the use of existing infrastructure
- Reduce energy requirements and greenhouse gas emissions

Each of these objectives are discussed in more detail in the sections below.

2.1 Provide Capacity to Service Growth

Providing capacity to service growth is an integral objective to the development of any Master Plan. As presented in TM1A: Wastewater Treatment Plant Population and Flow Projections and TM1B: Sewage Pumping Station Population and Flow Projections, the 2007 WWTMP Update was based on the aggressive Places To Grow (P2G) population projections. Due to the more moderate growth observed in the Region (as compared to the P2G projections), the growth based capacity needs are not as great as previously expected.

2.2 Maximize and Optimize the Use of Existing Infrastructure

The Region has invested significant funds in wastewater infrastructure and any plan must ensure that this infrastructure is fully utilized and optimized to make use of this investment. All options consider the infrastructure currently in place within a treatment plant and consider the compatibility of any new processes or technologies with this existing infrastructure.

Asset replacement items have also been documented with respect to each WWTP to identify opportunities to optimize current performance and operation. These items will be factored into each of the alternatives and related timing needs as the short-list of alternatives are further developed.

2.3 Reduce Energy Requirements and Greenhouse Gas Emissions

As part of the Master Plan development, the Region is committed to investigating options for the reduction of energy and greenhouse gas (GHG) emissions through innovative processes and technologies. Additionally, as part of this objective, other related initiatives are being considered, including recovery of energy and nutrients, minimizing waste, water reuse and any other processes to provide more environmentally sustainable and innovative wastewater treatment. These objectives will be discussed further in later sections as specific technologies are described.

3. Growth Considerations for Wastewater Service Areas

Based on the moderate growth scenario (base case) developed as part of this WWTMP Update, flow forecasts have been developed for each treatment plant.

Figure 1 and Figure 2 provide the existing rated capacities, as well as the expected capacity needs in 2051 for each of the Region's larger and smaller treatment plants, respectively.

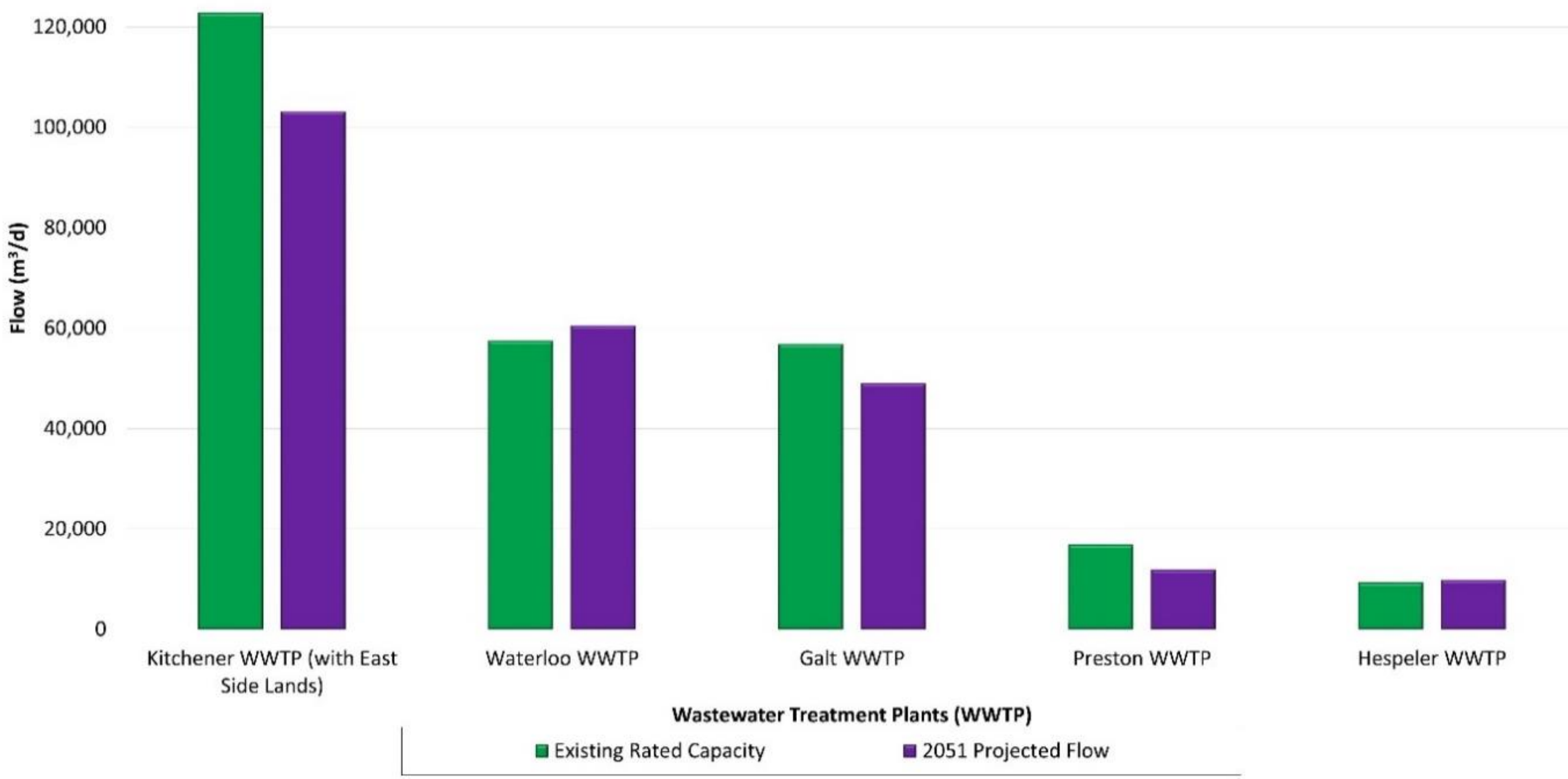

Figure 1 Future Wastewater Flow Capacities – Larger Plants

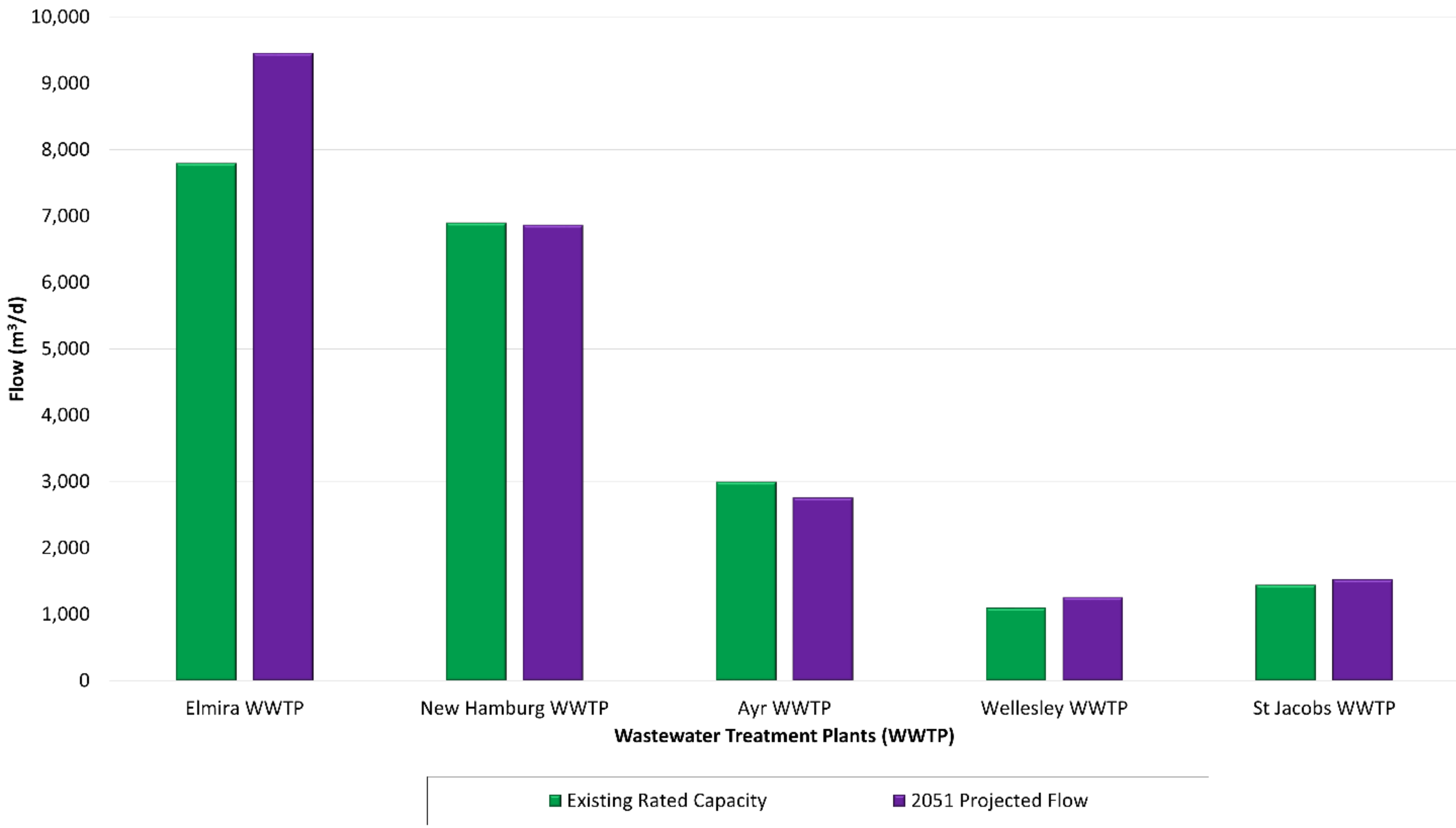

Figure 2 Future Wastewater Flow Capacities – Smaller Plants

Based on the population growth and flow forecasts, several plants will reach or exceed their rated capacity within the 2051 planning period. Table 1 shows which treatment plants are expected to require expansion within the short, medium and long term. The Ontario Ministry of Environment and Climate Change (MOECC) recommends that planning be initiated for treatment plants when 85% of capacity has been reached, so this timing is also included for planning purposes.

It is important to note that some plant have limitations that may impact their ability to reliably treat the rated capacity due to peak flows and/or loadings which are higher than the original design. As a result, some early works may be recommended to allow plants to reliably treat their rated capacity. The implementation timelines for the preferred options will consider these limitations, where applicable.

In addition to the 10 treatment plants shown in Figure 1 and Figure 2, there are three (3) small development-based wastewater treatment plants within the Region (Alt-Heidelberg WWTP, Conestogo WWTP and Foxboro Green WWTP). These treatment plants have not been discussed with respect to options for growth or effluent quality, as there are no plans to provide additional capacity at these facilities. There may be some opportunities for operational enhancement and reduced energy use, which could be considered on a business case basis when reviewing the results of pilots at larger plants or with asset renewal projects.

Table 1 Timing for Expected Plant Capacity Increases

WWTP Service Area	Timing	Year Reaching 85% of Rated Capacity	Year Exceeding Rated Capacity
Waterloo	Short-term	2020	2041
St Jacobs	Short-term	2025	2042
Elmira	Medium-term	2030	2039
Wellesley	Medium-term	2032	2041
Hespeler	Long-term	2036	2047
Kitchener with East Side Lands	Long-term	2041	Beyond 2051
Galt	Long-term	2047	Beyond 2051
Ayr	Long-term	2043	Beyond 2051
New Hamburg	Long-term	2041	Beyond 2051
Preston without East Side Lands	Long-term	Beyond 2051	Beyond 2051

It can be noted that the Region owns seven (7) sewage pumping stations (SPSs), including the Ayr SPS that is currently under construction. This memo has not considered a long-list of options for the SPSs since there is limited need for additional capacity in the planning period, with the exception of Morningside and Baden SPS. Options for providing capacity at these stations will be developed and evaluated in TM10 - Development and Evaluation of Short-Listed Options.

4. Effluent Quality Considerations

One of the key objectives for the WWTMP Update is to meet changing regulations with respect to wastewater treatment and effluent quality. Phosphorus and ammonia removal for non-toxic effluent are expected to be key drivers for existing and expanding plants. These key parameters will be discussed further in the following sections.

4.1 Nitrogen

An important consideration for existing and expanding plants is the ammonia loading to receiving waters. The Region has taken significant steps to implement upgrades, including year-round nitrification at its wastewater treatment facilities. The upgrades put in place have achieved significant reductions in ammonia loadings to the receiving waters. The only facility currently (or after on-going upgrades) not providing year-round nitrification is the Hespeler WWTP

Since the completion of the 2007 WWTMP, the Region has also completed several assimilative capacity or receiving water quality impact studies for specific segments of the receiving waters to support plans for plant upgrades and expansions. These studies have been carried out for the Grand and Speed Rivers for the Waterloo and Hespeler WWTPs (Stantec, 2014), the Middle-Grand River for the Kitchener WWTP (Stantec, 2010) and the Nith River for the New Hamburg WWTP (XCG, 2014). The proposed effluent limits and specific constraints related to effluent quality will be further discussed in Section 7 for plant specific options.

There has also been increased interest in nitrate loadings, especially for larger plants in sensitive watersheds. This is primarily being driven by the Conservation Authorities, as a concern regarding aquatic (especially fish) habitat. There is still some uncertainty related to potential requirements for denitrification as the MOECC does not currently have a Provincial Water Quality Objective (PWQO) for nitrate. Nitrate limits and denitrification were not considered as part of this WWTMP Update because they are currently not regulated, but moving forward there should be awareness that regulations may be subject to change as the impacts of nitrates become better understood.

4.2 Phosphorus

All of the Region's WWTPs that discharge to a surface water body, either discharge directly to the Grand River or to a tributary of the Grand River (i.e. Speed, Nith, Conestogo, and Canagagigue). The Grand River is Policy 2 for total phosphorus (TP) in the Central Basin of the Grand River watershed, in that concentrations consistently exceed the Provincial Water Quality Objective (PWQO; MOE 1994a) of 0.03 mg/L (GRCA 2011). This means that no further degradation of water quality will be allowed for that contaminant and all reasonable and practical measures to improve water quality shall be undertaken (MOE, 1994b).

TP is the key water quality parameter for the Grand River watershed and the focus of Lake Erie remedial efforts (i.e., the Canada-Ontario Action Plan for Lake Erie 2017, [Section 1.1]; IJC 2014).

To assist in reducing toxic and nuisance algal blooms in Lake Erie, the Great Lakes Water Quality Agreement (GLWQA, adopted in 2014) proposed a binational (i.e., Canada and the United States) load reduction target of 40% (from 2008 loads) of TP entering the Western and Central Basin of Lake Erie by 2025, with an "aspirational" interim goal of 20% by 2020 (Canada-Ontario Agreement Partners 2017). Domestic action plans that will outline strategies to meet the targets will be developed by 2018. To this end, the Canada-Ontario Draft Action Plan (Action Plan) for Lake Erie was posted for comment in February 2017 and outlines proposed binational and domestic commitments for Ontario that are related to phosphorus reductions.

The Action Plan applies to tributaries, point and non-point sources entering the Western and Central Basins of Lake Erie. A phosphorus reduction target for the Eastern Basin of Lake Erie (into which the Grand River discharges) has not been established and requires further scientific assessment to be revisited in 2020. The phosphorus loading to the Eastern Basin is notably lower than to the Western and Central Basin – 12% of the loading is to the Eastern Basin, while the remaining 88% discharges to the Western and Central Basin (Canada-Ontario Agreement Partners 2017). However, the phosphorus load from the Grand River is potentially a factor in nuisance *Cladophora* blooms in the nearshore zone of the Eastern Basin. Canadian sources and specifically, the Grand River watershed, are the largest phosphorus contributor to the Eastern Basin – the mean load of TP from the Grand River between 2003 and 2013 was 340 tonnes/year. Canadian sources contribute 54% of the TP load to the Eastern Basin (Canada-Ontario Agreement Partners 2017). The finalization of the Action Plan will be based on comments on the draft Action Plan and engagement of key stakeholders including First Nations and Metis communities and the public.

Although the Action Plan and GLWQA targets do not apply to the Grand River watershed at this time, targets for the Eastern Basin are likely to follow. Similarly, many of the proposed actions in the Action Plan (for the Western and Central Basins) will likely carry over as proposed actions for the Eastern Basin.

One key action highlighted in the draft Action Plan focuses on point sources (which contribute 10% to 15% of total load to Lake Erie) and the establishment of a legal effluent discharge limit of 0.5 mg/L TP for all municipal WWTPs that have an average daily flow of 3.78 MLD or more; including the upgrade of all plants with >3.78 MLD flows to an equivalent tertiary level of treatment.

4.2.1 Phosphorus Trading and Offsetting

As previously described, the Grand River is Policy 2 for TP in the Central Basin of the Grand River watershed.

In 1998, the MOECC Eastern Region agreed that a broader interpretation of “all reasonable and practical measures to improve water quality shall be undertaken” would include phosphorus offsetting or credit trading instead of the previous interpretation which only considered enhanced treatment. Through the broader interpretation of this policy, municipal and industrial dischargers were provided a potentially less costly alternative for phosphorus control (Conservation Ontario 2003).

Since the costs for controlling non-point source phosphorus loads may be seven to ten times less expensive than those for controlling point source pollution such as wastewater treatment plant (WWTP) effluent quality (Conservation Ontario 2003), there are opportunities to control phosphorus loadings to the watershed through investments in non-point source controls, or by trading phosphorus loadings amongst treatment plants.

Phosphorus offsetting is a flexible watershed based program that ultimately improves and protects water quality. It allows for a limited increase in pollutant discharge to be “offset” by greater reductions elsewhere in the same watershed. The reduction is achieved through an offsetting ratio that is applied to the discharge. Phosphorus offsetting is often more economical than point-source control because more cost effective controls can be constructed to achieve the required phosphorus reductions (LSRCA 2014).

Phosphorus offsetting can either occur as “one-offs” or as a formal program. The program is based on site-specific conditions for municipal and/or industrial WWTPs, and is determined on a case-by-case basis. Water quality offsets can be explored as part of sewage treatment plant design or as part of the Class EA planning process (Tovilla, 2015).

Since the passing of the Lake Simcoe Protection Act in 2008, Section 75 of the Ontario Water Resources Act (OWRA) was amended to allow for Water Quality Trading (WQT) regulations to be made in Ontario (Water Resources Act, Section 75). This includes prescribing areas, parameters, and persons to which the regulation applies, the requirements for monitoring and reporting, designating an administrative body and determining the creation, trading and retirement of credits or offsets. This amendment came into effect July 1, 2017.

The most common phosphorus offsetting programs currently in place involve implementing best management practices (BMPs) related to agricultural practices. Calculating the amount of phosphorus diverted from watercourses from BMPs is complicated due to high variability among individual practices and the influence of a wide variety of factors. In recognition of this complexity and uncertainty, the MOECC has typically required an offsetting ratio of 4:1 or greater (i.e., for every 1 kg increase of phosphorus produced by a WWTP above the existing load, 4 kg must be removed from the watershed).

In order to implement a program where phosphorus loadings are offset or traded between treatment plants, (i.e., one plant achieves a greater reduction in phosphorus loadings, trading an increase in loading from another plant), it will be important to consider the local areas influenced by controls (i.e., upstream or near trading WWTP) to minimize negative local receiver impacts. Any potential phosphorus offsetting or trading program would require significant consultation with the GRCA and the MOECC to determine the parameters and regulatory requirements surrounding implementation. Further detail on a potential phosphorus off-setting program is provided in TM9A - Phosphorus Off-Setting Opportunities.

A summary of the implications of the effluent quality considerations on the Region’s treatment plants is provided in Table 2. Based on those treatment plants identified in

Table 2 as requiring phosphorus reductions, Table 3 provides a summary of the opportunities available using phosphorus offsetting and trading.

Table 2 Summary of Effluent Quality Considerations for WWTPs

Plant	Receiver	Nitrification	Phosphorus Removal	Notes
Kitchener WWTP	Grand	Existing	Existing Tertiary	No changes expected.
Waterloo WWTP	Grand	Existing	✓	Tertiary equivalent expected. ECA update required to meet Lake Erie effluent targets.
Galt WWTP	Grand	Existing	Existing Tertiary	ECA update required to meet Lake Erie effluent targets.
Preston WWTP	Grand	Existing	✓	TP reduction and ECA update required to meet Lake Erie effluent targets for Lake Erie Loading Limits.
Hespeler WWTP	Speed	✓	✓	TP reduction and ECA update required to meet Lake Erie effluent targets. ACS indicates a TP objective of 0.4 mg/L and year-round nitrification at expansion.
Elmira WWTP	Canagagigue	Existing	Existing Tertiary	TP reduction with expansion due to sensitivity of Canagagigue Creek.
St Jacobs WWTP	Conestogo	Existing	Existing Tertiary	TP reduction with expansion due to sensitivity of Conestogo River.
New Hamburg WWTP	Nith	Existing	Existing Tertiary	No changes expected.
Wellesley WWTP	Nith	Existing	Existing Tertiary	TP reduction with expansion due to sensitivity of Nith River.
Ayr WWTP	Nith	Existing	Existing Tertiary	No changes expected.

Table 3 Summary of Effluent Quality Opportunities for WWTPs

Plant	Receiver	Phosphorus Removal	P Off-set (Non-Point Source)	P Trading with Another WWTP
Waterloo WWTP (with expansion and Lake Erie targets)	Grand	✓	**X** -4:1 very difficult for large plant	✓ Kitchener WWTP
Preston WWTP (Lake Erie targets)	Grand	✓	✓	**X** Downstream of Kitchener and Waterloo WWTPs
Hespeler WWTP (with expansion and Lake Erie targets)	Speed	✓	✓	**X** None in Region control
Elmira WWTP (with expansion)	Canagagigue	✓	✓	**X** None in Region control
Wellesley WWTP (with expansion)	Nith	✓	✓	**X** None in Region control
St Jacobs WWTP (with expansion)	Conestogo	✓	✓	**X** None in Region control

5. Technology Considerations

The WWTMP Update is developed on the basis that treatment scenarios will need to incorporate increasingly stringent effluent quality based on current regulatory experience across Canada. Any treatment plant upgrades or expansions undertaken will need to undergo further study and design, during which, technologies should be reviewed in more detail based on local constraints and opportunities to best meet the objectives of the process upgrade, increased flows and loadings, desired effluent criteria, and reduced energy consumption.

Depending on the timing of the project from the completion of the WWTMP Update, any time an upgrade is being considered, the state of the industry should be reviewed to determine if a new or innovative technology would provide a benefit to the Region that may have been developed in the period between the assessment and the implementation of the upgrade.

A broad overview of treatment technologies including available and emerging technologies is provided in Table 4, as well as a preliminary review of the suitability and benefit of the technology for the Region over existing conventional technologies. These technologies include advanced wastewater treatment technologies which focus on the removal of nutrients through biological processes, physical/chemical processes, as well as those with potential for energy reduction and conservation. The list in Table 4 is adapted from the US EPA document “Emerging Technologies for Wastewater Treatment and In-Plant Wet Weather Management” (US EPA, 2013).

Table 4 New/Innovative Technologies to Consider

Technology	High-Level Description	Benefit/Suitability to the Region
Nitrogen and Phosphorus Removal		
Biological-Chemical Phosphorus and Nitrogen Removal (BCFS) Process	The BCFS process has been developed to achieve low-nutrient effluent concentrations at relatively low BOD/N and BOD/P ratios in the influent. The return sludge is introduced at the start of the anoxic zone to prevent the presence of nitrate in the anaerobic zone. Mixed liquor is recirculated from the end of the anoxic zone to the anaerobic zone. At the end of the anoxic zone, most of the nitrate is removed. In the aerobic zone, the phosphorus is taken up by phosphate-accumulating bacteria in the activated sludge. This results in a lower energy and BOD demand as well as lower sludge production. Chemical precipitation of phosphorus is used to ensure compliance with effluent standards regarding phosphorus.	Some Region facilities have anoxic zones and there is potential to implement these at additional facilities. There is currently no internal recycle capability and anaerobic zones within the Region's facilities, but this could be considered in future.
Biological Nutrient Removal (BNR) (Modified University of Cape Town (MUCT) Process or Westbank Process)	Two examples of a BNR process include the MUCT and Westbank processes. The MUCT process provides efficient nitrogen removal by sending the RAS to the anoxic zone. The anaerobic reactor, is located upstream of two anoxic reactors. RAS is subjected to the first anoxic reactor stage. There is an internal recycle from the first anoxic reactor to the anaerobic reactor, and another internal recycle from the oxic reactor to the second anoxic reactor. The westbank process is a version of the Three-Stage Bardenpho® but includes RAS denitrification to provide efficient phosphate and nitrogen removal. First, RAS is subjected to an anoxic stage to remove nitrates. While a fraction of the influent wastewater is sent to the anoxic	Limited potential for implementation within the Region's facilities without significant process and tankage modifications.

Technology	High-Level Description	Benefit/Suitability to the Region
	reactor, the remaining portion is fed to the anaerobic reactor directly. There is also an internal recycle from the oxic reactor to the second-stage anoxic reactor.	
Integrated Fixed-film Activated Sludge (IFAS) with Biological Phosphorus Removal	The IFAS hybrid processes include any activated sludge system that has some type of fixed/film media in a suspended growth reactor to increase the amount of biomass available for treatment. The IFAS media can be retrofitted into existing activated sludge systems and lagoons. An important feature of the IFAS process is that it provides the capability to decouple the solids retention time (SRT) of the suspended biomass from the SRT of the biomass attached to the IFAS media. This feature is especially useful with processes that must nitrify and perform enhanced biological phosphorus removal (EBPR) because the optimal SRT for EBPR is short (<5 days) while the optimal SRT for nitrification is generally longer (> 8 days).	There is potential to implement the IFAS process within the existing facilities. Provides potential benefit to the Region as this can be implemented with limited change to existing process configuration.
Aerobic Granular Sludge Process (AGSP)	AGSP is an aerobic biological treatment process that generates dense sludge pellets, thereby providing highly efficient sold-liquid separation with simultaneous nitrification and denitrification within the granules, providing energy savings for treatment. Some technologies apply a carrier media in continuous flow applications (i.e., S-Select with Mimics®)	The traditional granular sludge process (Nereda®) has limited application due to the need for batch processes compared to the continuous flow configuration of Region plants. Technologies that use similar operating conditions as granular sludge together with a ballast (i.e., S-Select with Mimics®) have significant potential for Region facilities as this can be implemented within the existing process configuration.

Technology	High-Level Description	Benefit/Suitability to the Region
Advanced Biological Nutrient Recovery (e.g. ClearAs)	Wastewater is mixed with carbon dioxide and algae to initiate nutrient recovery in a photobioreactor environment. Ultrafiltration separates the clean water from a recycle stream of return activated algae, which is sent back to mix with new wastewater entering the process.	Limited full-scale experience with this technology. Continue to monitor for potential implementation in the future.
Phosphorus Removal		
Modified Anaerobic/Oxic (A/O) Process	The modified A/O process provides phosphate and nitrogen removal. If nitrification is not required and the temperatures are not high, the simple two-stage, high-rate A/O process may be sufficient. However, with higher temperatures some nitrate formation cannot be avoided. Therefore, RAS should be subjected to an anoxic stage to remove nitrates before mixing it with the influent wastewater.	Low potential within the Region, as all plants will be required to achieve a high level of nitrification and would require significant re-configuration of existing tankage with limited benefits.
Reactive Media Filtration	Reactive media filtration combines co-precipitation and adsorption to a reactive filter media in an upflow sand filter. Reactive hydrous ferric oxide-coated sand media is created by using an iron coagulant on the filter media and accomplishes phosphorus removal by adsorption and filtration.	Little experience and best suited for very low TP levels (<0.1 mg/L). Limited benefit over other filtration technologies at TP limits > 0.1 mg/L
Phosphorus Recovery (Struvite or Calcium Phosphate Precipitation)	In phosphorus recovery, sludge liquor is returned to an upflow fluidized bed reactor along with a chemical added to generate a precipitate. A common additive is magnesium to generate a magnesium ammonium phosphate precipitate ($MgNH_4PO_4$), otherwise known as MAP or struvite.	Low potential within the Region due to current process configurations and chemical phosphorus removal practices.
Real-Time Phosphorus Control	Real-time phosphorus control allows a more efficient or lower chemical use for phosphorus removal by controlling the dosage of chemical required based on on-line monitoring and controls.	Significant potential for implementation within the Region’s facilities as this can be implemented within the existing process configuration.

Technology	High-Level Description	Benefit/Suitability to the Region
Nitrogen Removal		
Deammonification (Sidestream)	Deammonification (sidestream) involves removing ammonia in a two-step process that requires initial partial nitritation to convert approximately 50 percent of the ammonia to nitrite. Anaerobic ammonia oxidation (Anammox) bacteria convert the nitrite and the remaining ammonia to nitrogen gas under anoxic conditions. The process requires only partial nitritation, which theoretically reduces the energy demand up to 63 percent compared to conventional nitrification and denitrification. The deammonification process is a completely autotrophic process and does not require any supplemental carbon.	Potential for implementation within the Region's facilities for sidestream treatment of high-strength recycle streams.
Nitritation and Denitritation (Sidestream)	Nitritation and denitritation (sidestream) involves the oxidation of ammonia to nitrite (nitritation) in an aerobic environment; however, unlike nitrification, the nitritation process stops the oxidation at nitrite and does not proceed from nitrite to nitrate (nitrification). To accomplish nitritation without nitrification, reactor environmental conditions are controlled to promote the growth of ammonia-oxidizing bacteria (AOB) while inhibiting the growth of nitrite-oxidizing bacteria (NOB). Nitritation is desirable because it consumes approximately 25 percent less oxygen than complete nitrification. To provide complete nitrogen removal, nitritation is often coupled with denitritation. Similar to the more common denitrification process for reducing nitrate, the process of denitritation involves reducing nitrite to nitrogen gas by heterotrophic bacteria using carbon as an electron donor in an anoxic environment. The reactor is likely carbon limited requiring a supplemental carbon source. The	Potential for sidestream treatment due to opportunity for energy savings and reduced sludge production, however there is limited full scale North American applications. There is some experience in Europe. It is recommended this technology be monitored and reviewed when expansions are required.

Technology	High-Level Description	Benefit/Suitability to the Region
	denitritation process requires 40 percent less carbon than the denitrification process.	
Ammonia Recovery	Ammonia recovery from high-concentration sludge liquors, such as centrate streams, can be accomplished by vacuum distillation or by stripping with air or steam coupled with ammonia adsorption into sulfuric acid to produce ammonium sulfate.	Low potential within the Region due to current process configurations and limited experience with this technology.
Solids Removal		
Compressible Media Filtration (CMF)	CMF uses a synthetic fiber media bed that is passively compressed from the sides by the head of the incoming water. The lateral compression forms a cone-shaped porosity gradient that allows the stratification and removal of large and small particles from the top to the bottom of the media bed.	Limited experience and provides minimal benefits over filtration technologies currently in use.
Ballasted Sedimentation	Ballasted sedimentation uses conventional chemical coagulation and flocculation along with the addition of dense ballasting agent. The dense ballast significantly increases the weight and settleability of chemical flocs, resulting in high-rate sedimentation. It is considered an established process for the treatment of wet weather flows, but is also being applied to primary and tertiary effluents.	Potential for implementation within the Region.
Multi-stage Filtration	Implementing filtration in series with a first stage filter or first-stage clarifier and chemical addition between stages allows the finer colloidal particles that escape the first solids separation stage to be targeted.	Some potential for implementation within the Region, however limited additional benefit over existing filtration technologies for TP limits >0.1 mg/L.
Nanofiltration (NF) and Reverse Osmosis (RO)	RO operates by high-pressure diffusion of solutes through the membrane; NF uses both diffusion and sieving action. NF removes many of the same organic compounds that would be targeted with RO but allows more of the inorganic material to remain. Both processes are used for	Little potential for implementation at Region’s facilities due to high energy usage and limited additional benefit over existing filtration technologies.

Technology	High-Level Description	Benefit/Suitability to the Region
	removing priority organic pollutants, recalcitrant organics, bacteria and viruses, as well as achieving low levels of total nitrogen.	
Solids Minimization		
Cyclic Metabolic Environment	The cyclic metabolic environment process seeks to reduce solids production from biological wastewater treatment by adding an unaerated interchange tank to the process and cycling the biomass between the metabolic environments established in the interchange tank and the main bioreactor. A portion of sludge from the main treatment process is pumped to a sidestream interchange bioreactor where the mixed liquor is converted from an aerobic environment to a facultative environment. Some bacteria decay in the interchange reactor, while other bacteria break down and use the remains of the decaying organisms, their by-products and anaerobically digestible organics.	Low potential within the Region due to current process configurations and limited experience with this technology.
OpenCel Focused Pulse	OpenCel uses electrical pulses to disrupt WAS cell structure causing the cells to lyse. OpenCel focused pulse (FP) technology uses high-frequency micro-pulses of between 20 and 60 kV for no more than 0.1 seconds to cause the cell membrane to swell and rupture. Once ruptured, the WAS is more readily degradable by the active microorganisms.	Low potential within the Region due to current process configurations and limited experience with this technology.
Multi-Stage Activated Biological Process (MSABP™)	MSABP™ is a method of domestic and industrial wastewater treatment based upon spatial succession of microorganisms by trophic level. The spatial segregation provides conditions at which bacteria are used as a food source sequentially by first primary and then higher level microorganisms in the food chain. The spatial	Low potential within the Region due to current process configurations and limited experience with this technology.

Technology	High-Level Description	Benefit/Suitability to the Region
	microorganism succession provides treatment by aerobic and anaerobic microorganisms maintained at different stages of the biological reactor. Removal of organics and nitrification take place in the first four compartments. Fifth and sixth compartments are anoxic and denitrification occurs in these compartments. Usually 80 percent of the BOD is reduced in these compartments leaving about 20 percent available for denitrification processes. The seventh and eighth compartments operate in endogenous phase and digest remaining volatile solids.	
Solids Settleability		
Ballasted Activated Sludge	The ballasted activated sludge process adds a dense ballast to the mixed liquor to enhance settling characteristics. The ballast is inert, which increases the density of activated sludge flocs to increase settling rates by as much as 30 times conventional settling rates. The enhanced settling characteristics allow the activated sludge system to be operated at up to three times the mixed liquor concentration of conventional systems.	Very applicable to Region facilities. There is also opportunity to consider technologies that use a ballast together with modified operating conditions to reduce energy use (i.e., S-Select with Mimics®)
Aerobic Granular Sludge Process (AGSP)	AGSP is an aerobic biological treatment process that generates dense sludge pellets, thereby providing highly efficient solid-liquid separation. As noted under technologies for ‘Nitrogen and Phosphorus Removal’, AGSP also allows simultaneous nitrification and denitrification within the granules.	The traditional granular sludge process (Nereda®) has limited application due to the need for batch processes compared to the continuous flow configuration of Region plants. Technologies that use similar operating conditions as granular sludge together with a ballast (i.e., S-Select with Mimics®) have significant potential for Region facilities as

Technology	High-Level Description	Benefit/Suitability to the Region
		this can be implemented within the existing process configuration.
Membrane Processes		
Membrane Aerated Biofilm Reactor (MABR)	The MABR process reactor uses a bundle of hollow-fiber, composite membranes sealed on one end and submerged in the water to be treated. Air is introduced inside the fibers and diffuses through to a biofilm that develops on the outside surface of the membrane. Because the air permeates the membrane in the opposite direction than the water-based compounds, counter-gradients are established for the concentration of each, thus improving the efficiency of the gas use.	Very suitable for Region's facilities as provides the benefit of improved energy efficiency with a small footprint and improved treatment performance.
Membrane Bioreactor (MBR)	The membrane bioreactor (MBR) is the combination of two basic processes – biological degradation and membrane separation to remove solids from the influent wastewater. It is possible to operate MBR processes at higher mixed liquor suspended solids (MLSS) concentrations compared to conventional settlement separation systems, thus reducing the reactor volume to achieve the same loading rate.	Suitable for Region's facilities as provides the benefit of a small footprint and improved treatment performance, however can have increased energy use.
Vacuum Rotation Membrane (VRM®) System	The VRM® system employs flat-sheet, ultrafiltration-membrane segments configured into disks rotating on a horizontal shaft. The hydrophilic membrane has a pore size of approximately 38 nm. Sequential cleaning of the rotating membranes is achieved with scouring air introduced next to the shaft at about half the water depth, providing high-intensity scouring of 1/6 to 1/8 of the disk near the 12 o'clock position. The membranes rotate through the scouring section several times per minute, and	Limited full-scale experience and little potential for implementation within the Region's facilities due to incompatibility with existing process configuration.

Technology	High-Level Description	Benefit/Suitability to the Region
	have shown that neither back-pulsing nor regular cleaning is required.	
Bioaugmentation		
Bioaugmentation	Bioaugmentation increases treatment capacity by adding bacteria to the bioreactor or upstream of the treatment reactor. Most frequently used to enhance nitrification, thereby allowing more reactor volume to be used for denitrification or phosphorus removal. Can also be used to decrease influent loadings.	Limited potential within the Region's facilities as nitrification is already provided. Opportunities to enhance performance in conjunction with other technologies (i.e., MABR).
Energy Conservation – Aeration		
Automated SRT/DO Control	Optimization and automatic control of dissolved oxygen (DO) and sludge age (SRT) in aeration systems to optimize DO and SRT set points and reduce energy consumption while maintaining process performance.	Potential for implementation within the Region for operational enahancement.
Dual Impeller Aerator (mechanical mixing)	Dual impeller aerator provides additional mixing energy near the floor of an aeration basin, permitting greater power turndown when a variable frequency drive (VFD) is used and an associated energy savings.	Limited potential for implementation due to existing equipment and configuration. Potential to review as part of asset management replacement of equipment.
Integrated Air Flow Control	Integrated air flow control uses modern control capabilities to integrate basin and blower air control into a coherent strategy that eliminates the pressure control loop common in many automatic DO control systems. Air valves at individual tanks are used to distribute total air flow from the blowers proportionally to total demand. Blowers are controlled to provide the total system air flow required to meet total process demand.	Potential for implementation within the Region for operational enhancement.
Single-stage Centrifugal Blowers with Inlet	Single-stage centrifugal blowers equipped with inlet guide vanes pre-rotate the intake air before it enters the high speed blower impellers. This reduces flow more efficiently	Limited potential for implementation at this time due to existing equipment and configuration. Potential to review as part of

Technology	High-Level Description	Benefit/Suitability to the Region
Guide Vanes and Variable Diffuser Vanes	than throttling. Blowers that are also equipped with variable outlet vane diffusers have improved control of the output air volume. Utilizing inlet guide vane and discharge diffusers on a single-stage centrifugal blower makes it possible to operate the blower at its highest efficiency point.	asset management replacement of equipment.
Critical Oxygen Point Control	Critical oxygen point control is a control method based on respirometric measurements. Bacteria respire by diffusion of oxygen across their cell wall. Oxygen diffuses from a high concentration external to the bacterial cell wall to the low concentration internal to the bacterial cell. Diffusion will only take place once the oxygen concentration differential across the cell wall is sufficient to drive the oxygen through it. The minimum concentration at which this occurs is called the critical oxygen point. Below the critical oxygen point, the biodegradation rate will rapidly decrease. At the critical oxygen point, the biodegradation rate will be at a maximum for the available food source. Accurately knowing the critical oxygen point for the active biomass allows the optimal DO set-point to be determined.	Limited experience with this technology. Potential to monitor in future for implementation for operational enhancement.
Ammonia Based Aeration Control	Use of on-line ammonia analyzers to trim DO set-points. Allows for operation at the lowest possible DO concentration, while achieving effluent ammonia objectives. This can provide approximately 10-25% energy savings due to reduced aeration demands when compared operation at a fixed DO set-point.	Potential for implementation within the Region for operational enhancement at plants which incorporate a DO control system.
Ultra-fine Bubble Diffusers	Recent advances in membrane materials have led to ultra-fine bubble diffusers, which generate bubbles with an average diameter between 0.2 and 1.0 mm. The primary appeal of ultra-fine bubble diffusion is improved oxygen	Potential to review as part of asset management replacement of equipment.

Technology	High-Level Description	Benefit/Suitability to the Region
	transfer efficiency (OTE). Additionally, some composite materials used in the manufacture of ultra-fine bubble diffusers are claimed to be more resistant to fouling, which serves to maintain the OTE and reduce the frequency of cleaning.	
Energy Conservation – Mixing		
Intermittent Mixing	An optimization algorithm is used to convert mixing in the anoxic/anaerobic zones of BNR reactors and mixed liquor channels from continuous to intermittent (On/Off). This patent pending method of maintaining solids in suspension allows reduced energy usage without compromising effluent quality and process reliability.	Potential for implementation within the Region for operational enhancement.
Pulsed Large Bubble Mixing	Pulse large bubble mixing reduces the energy required for anoxic or anaerobic zone mixing by firing short bursts of compressed air into the zone instead of mechanically mixing it. Uniquely designed nozzles produce a mass of large air bubbles, ranging from marble to softball size, which mix the water as they rise to the surface. The large air bubbles, much larger than those made by coarse bubble diffusers, are designed to minimize oxygen transfer and maintain anoxic or anaerobic conditions.	Opportunity to consider for existing anoxic zones during asset renewal or anoxic zones that may be implemented in the future.
Effluent Disinfection		
Peracetic Acid (PAA)	PAA is a stronger oxidant than hypochlorite or chlorine dioxide but not as strong as ozone. PAA concentration in the discharge needs to be managed but expected consumption of quenching chemical is lower than in case of chlorine.	Potential for implementation within the Region.

5.1 Compatible Technologies

Based on the review of new and innovative technologies for implementation within the Region's treatment plants, four (4) technologies related to expansion of capacity were considered highly compatible with the Region's existing infrastructure. In order to ensure that the objective of maximizing and optimizing the use of existing infrastructure is met, these technologies were considered further as part of any proposed expansion or upgrade recommended through this WWTMP Update. Other technologies noted in Table 4 can also be considered in the future as they mature or as opportunities are available based on asset renewal.

5.1.1 Integrated Fixed Film Activated Sludge (IFAS)

Integrated fixed film activated sludge (IFAS) is a modification of the conventional activated sludge process, which consists of both suspended and attached biomass growth achieved by incorporating biofilm media (free floating or fixed to a grid) to aeration tanks of an activated sludge plant. This allows a higher inventory of biomass to be maintained per unit tank volume than conventional activated sludge (CAS) and provides for longer SRTs to achieve nitrification. The IFAS provides treatment equivalent to a CAS process, but at a smaller footprint.

The IFAS process is gaining wider interest for nitrification expansion. IFAS has been shown to significantly increase the rate of nitrifying bacteria growth, which is the rate limiting step in the conventional activated sludge process. Thereby, the key advantage of the IFAS process is the increase in plant capacity without the need for additional aeration tanks. Table 5 provides a summary of the advantages and disadvantages of the IFAS technology.

Table 5 Summary of Advantages and Disadvantages of IFAS Technology

Advantages	Disadvantages
• Proven technology – used at facilities in Ontario and North America to improve nitrification • Smaller footprint • Similar capital cost to conventional activated sludge (CAS) • Simplified MOECC approvals	• Slightly higher or similar energy requirements as CAS • Long-term maintenance access (media movement) • Hydraulic considerations for free-moving media installations - Headloss across media retention screens

There are several installations within Ontario of the IFAS technology, including the Peterborough WWTP.

5.1.2 Membrane Bioreactor (MBR)

Membrane bioreactors (MBR), as an advanced activated sludge wastewater treatment process, typically consist of a suspended growth biological reactor coupled with a submerged ultrafiltration membrane system. Mixed liquor from the biological reactor is fed to the membrane tanks and clean effluent is drawn through membrane filters by permeate pumps. The membrane essentially provides the functions of secondary clarification and tertiary filtration in a CAS process, thus eliminating the need for secondary clarifiers and tertiary filters. Oxygen requirements are provided by a combination of diffused air and an air scouring system. Excess biological sludge is pumped directly from the process tank. A typical MBR process is capable of reliably achieving very low effluent TP concentrations (<0.1 mg/L).

The MBR process is not limited by the sludge settling characteristics, as with other suspended growth technologies. As such, an MBR can be operated at considerably higher mixed MLSS concentrations (i.e. typically in the range of 6,000 to 10,000 mg/L) than the CAS or extended aeration processes. By operating at a high MLSS and eliminating the need for secondary clarifiers and tertiary filters, the system footprint is significantly reduced compared to a conventional system. They can be easily retrofitted into existing activated sludge systems.

The MBR system also allows the biological process to be operated at extended SRT values, ensuring complete nitrification even under extreme cold weather conditions. Many MBR systems are commonly operated with SRT values exceeding 20 days. Under these conditions, the sludge yields at extended SRTs are lower than for the CAS processes due to endogenous decay of biomass in the reactor.

With increasingly stringent effluent requirements, MBR has become more widely used across Canada and North America. The main factors limiting the use of MBR technology has been the high capital operating costs and it is energy intensive.

The MBR technology is a proven technology with a number of units in operation in Ontario including the Port McNicoll, Creemore, and Oxford (London, Ontario) facilities. Table 6 provides a summary of the advantages and disadvantages of the MBR technology.

Table 6 Summary of Advantages and Disadvantages of MBR Technology

Advantages	Disadvantages
• Proven technology – used at facilities in Ontario and North America • Smaller footprint • Ability to achieve very low TP (0.05 mg/L) • Simplified MOECC approvals	• Higher capital and energy requirements as compared to CAS - Continues to improve as technology matures • Upstream fine screening (potential headloss concerns in existing hydraulic gradeline)

5.1.3 Mebrane Aerated Biofilm Reactor (MABR)

The Membrane Aerated Biofilm Reactor (MABR) process employs a gas transfer membrane to deliver oxygen to a biofilm that grows on the surface of a membrane. The technology is being evaluated for its potential to increase existing treatment capacity by providing nitrification in a smaller tank volume than that required for conventional treatment. This effectively expands the capacity of the existing treatment plant, without the need to construct additional infrastructure. The MABR process has the added benefit of improving performance for TSS and nitrogen removal during stressed conditions (specifically cold temperature peak flow periods).

A significant benefit of the MABR technology is the potential to reduce the energy consumption required for aeration by up to 40% compared to the current conventional treatment process. The significant energy savings for MABRs result from the delivery of oxygen at an efficiency up to four times greater than fine bubble aeration. Reducing the electricity usage also provides the added benefit of a reduction in greenhouse gases generated in the production of that electricity.

Nutrient removal is also enhanced for the MABR technology as the biomass inventory is increased by supplementing a suspended growth system with attached growth enabling simultaneous nitrification and denitrification in the existing tank footprint. By implementing biological phosphorus removal, coagulant supply and solids handling required for a chemical treatment technology are reduced.

Table 7 provides a summary of the advantages and disadvantages of the MABR technology.

Table 7 Summary of Advantages and Disadvantages of MABR Technology

Advantages	Disadvantages
• Smaller footprint • Reduced energy (very efficient, lower pressure oxygen transfer across membrane) • Simultaneous nitrification/denitrification (reduced effluent nitrate)	• Developing technology – limited full-scale applications • Capital and long-term operating and maintenance (O&M) costs not well understood • MOECC approvals may require pilot testing

The MABR technology is considered an emerging technology and does not have any full-scale applications at this time. Pilot studies were conducted at the O'Brien Water Reclamation Plant in Chicago, the Guelph Wastewater Treatment Plant and the Oxford Wastewater Treatment Plant in London, Ontario. A pilot study has also recently been completed within the Region of Waterloo at the Hespeler WWTP

5.1.4 Granular Sludge / Ballasted Flocculation

The granular sludge process is an aerobic biological treatment process that generates dense sludge pellets. It has been demonstrated that granular sludge has improved settling characteristics, facilitating highly efficient solid-liquid separation. Compact structured and biologically efficient aerobic sludge granules with wide diverse microbial species have been developed and shown to exhibit excellent settleability, high biomass retention, and tolerance to toxicity. With high biomass retention and biological activity, a granular sludge reactor can be operated at higher biomass concentrations, allowing higher loading rates while maintaining the longer SRT necessary for stable nitrification and providing anoxic and anaerobic micro-environments in the sludge granules if desired for nutrient removal. To achieve granulation under aerobic process conditions, short settling times are used to introduce a strong selective advantage for well-settling sludge granules. Poor-settling biomass is washed out under these conditions.

Granular sludge process research and application has primarily used a sequencing batch reactor (SBR) configuration (US EPA, 2013). A similar process has recently been developed for a continuous flow configuration (Caprariu, 2017) that requires the addition of an inert ballast. As a result, the content of biomass in the aeration tanks and solids loading rate (SLR) to the clarifiers can be increased significantly.

Table 8 provides a summary of the advantages and disadvantages of the granular activated sludge technology

Table 8 Summary of Advantages and Disadvantages of Granular Sludge Technology

Advantages	Disadvantages
• Smaller footprint • Simultaneous nitrification/denitrification and lower energy due to operating regime (reduced effluent nitrate)	• Developing technology – limited full-scale application in North America; but a number of plants using batch technology worldwide • Capital and long-term O&M costs not well understood • MOECC approvals may require pilot testing

There are no full-scale installations of granular sludge technology in Canada, but there are over 30 full-scale installations in either construction or operation in other parts of the world. The Region is considering piloting this technology at the Elmira WWTP.

6. Regional Wastewater Options

A general long-list of liquid treatment options is provided in this section. Plant-specific liquid treatment options relevant for individual WWTPs are discussed in Section 7. Options are generally grouped into two overall categories, being opportunities to accommodate growth (diversion of flows, I/I reduction, industrial pre-treatment and expansion), and opportunities to enhance operations and reduce energy usage (such as sidestream treatment, anoxic selectors, chemically enhanced primary treatment, etc.). Other Regional wastewater options that are not stand-alone solutions, but are considered as part of the implementation of the Regional approach for wastewater treatment, include watershed management, resource recovery, asset management and renewal, and water re-use. These options are also discussed in this section.

6.1 Accommodate Growth

In order to meet one of the key objectives of the WWTMP Update, growth within the Region must be accommodated. Within the following sections, a number of options will be discussed that can accommodate the projected growth. Some options are stand-alone and others must be considered in combination to achieve the growth needs within the plant service areas.

6.1.1 Diversion of Flows

This option maximizes the use of existing infrastructure by changing sewershed boundaries to transfer flow from a WWTP with a constraint to a WWTP with capacity available. Several considerations must be taken into account to determine if this option is feasible for each treatment plant. These considerations include:

- Capacity constraints at transfer WWTP
- Collection system modifications (pumping and/or conveyance) required to achieve the diversion
- Distance (high costs and odour/corrosion risk) within the collection system for the diversion
- If collection system costs are not extreme, diversion could be considered as an interim measure to maximize use of existing infrastructure

6.1.2 Inflow & Infiltration Reduction

Inflow and infiltration (I/I) can be a significant issue within wastewater collection systems and leads to high flows being conveyed to the treatment plant, which has many unit processes limited by peak flows (including headworks, clarifiers, filtration, disinfection). Therefore, I/I control is an important factor to allow the treatment plant to operate properly, to alleviate concerns with potential plant bypasses due to high I/I flows, as well as to enable the accurate planning of any necessary upgrades or expansions to the treatment plants.

There can be challenges with the implementation of I/I reduction programs for two-tiered systems, whereby local municipalities are responsible for collection systems and the Region is responsible for treatment. In the past, Regional Council approved a policy to enter into a cost-sharing arrangement with the Township of Woolwich to address the high I/I at the St Jacobs and Elmira WWTPs. The agreement was in place for 10 years (1998 to 2008); however based on flow monitoring data, high I/I continues to be a concern. It is recognized that finding and addressing the causes of I/I can be difficult, particularly if the issue relates to private residences. A key component moving forward for I/I reduction should include a public awareness campaign to increase the level of understanding of the impacts for items such as foundation drain and downspout connections to the collection system. Additionally, there is potential to to review/discuss opportunities with local municipalities to focus on repairs and rehabilitation of areas identified through monitoring programs to have high I/I.

A review of flows identified high I/I within the following WWTP service areas:

- St Jacobs
- Elmira
- Wellesley

For the above listed service areas, I/I reduction will form an integral part of any approach for that treatment plant; however it will not serve as a stand-alone solution. On-going flow monitoring is being undertaken in Wellesley (where the collection system is owned and operated by the Region) to identify areas of higher I/I and potential measures to reduce these extraneous flows.

For remaining service areas, reductions in I/I will continue to be encouraged as lower peak flows improve operation and increase the remaining capacity for the plants.

6.1.3 Industrial Pre-Treatment

Many industries discharge their wastewater to the collection system for treatment at the Region's WWTPs. A discharger in contravention of the Sewer-Use By-Law limits may attain compliance by either installing pre-treatment, implementing process control measures, hauling the non-compliant material for off site treatment or, if the option is available, entering into a Surcharge Agreement with the Region. Under a Surcharge Agreement, the Region treats this wastewater up to a predetermined limit for an additional fee.

Surcharge Agreements are only available for four substances because these are treated by the Region's wastewater treatment plants without causing operational problems if present above the Sewer-Use By-Law limits. These are: total suspended solids (TSS), biochemical oxygen demand (BOD), Kjeldahl nitrogen (TKN), and TP. Surcharge Agreements are only considered if there is sufficient treatment capacity at the receiving wastewater treatment plant.

While local industries are an important part of the economy, a single Surcharge Agreement can use upwards of 15% of a wastewater treatment plant's capacity. Pre-treatment at the source can significantly reduce flow and/or loading. A balance is therefore necessary to ensure future approaches are sustainable and continue to retain/attract local industries.

Several Ontario municipalities have successfully implemented industrial pre-treatment programs balancing regulation, enforcement practice, education and incentives. For example, some programs waived the surcharge fee while the pre-treatment system was being installed, to provide a financial incentive to businesses to implement the system.

6.1.4 Expansion

Expansion to accommodate growth involves increasing a plant's capacity to accommodate growth in flow and/or loading. There are several opportunities to accomplish this, including:

- Re-rating through optimization, process control and/or minor strategic upgrade works
- Conventional plant expansion using similar technology as existing

- Expansion using an alternative technology (such as those discussed in Section 5, and other emerging technologies that may be developed in the future).

Each of these opportunities will be discussed in more detail in the following sections.

Re-Rating

Re-rating involves addressing bottlenecks in key unit processes to improve throughput capacity. This could include one or multiple process optimizations, process control and/or strategic upgrade approaches.

Table 9 provides a summary of the advantages and disadvantages of re-rating.

Table 9 Summary of Advantages and Disadvantages of Re-Rating

Advantages	Disadvantages
• Generally, lower in capital cost compared to conventional expansion • Low cost alternative for plants with only moderate expansion needs (10% expansion)	• Need to complete site specific testing to demonstrate performance for MOECC approval - Unit processes that exceed MOECC design guideline values • May not provide overall plant expansion needs

Conventional Plant Expansion

A conventional plant expansion involves providing additional capacity to accommodate growth using the same or similar technology as existing within the treatment plant. Table 10 provides a summary of the advantages and disadvantages of a conventional plant expansion.

Table 10 Summary of Advantages and Disadvantages of Conventional Plant Expansion

Advantages	Disadvantages
• Proven technology • Well understood capital and long-term O&M requirements • Simplified MOECC approvals	• Generally a larger footprint than more advanced and/or newer technologies • Limited energy savings opportunities over existing - Some opportunities available through equipment selection, controls, anoxic selectors, etc.

Expansion Using Alternative Technologies

An expansion using an alternative technology may be implemented to provide potential footprint savings, energy savings or improved effluent quality. Four of the more compatible technologies with existing Regional infrastructure were previously described in Section 5, with a discussion of the advantages and disadvantages provided in that section as well. At the time of expansion, a state of industry review should be completed to identify if other new and emerging technologies would provide value to the upgrade.

6.2 Enhance Operations and Reduce Energy Usage

Improving the operation and performance of individual unit processes could be implemented with the goals to address an existing bottleneck, reduce energy needs or improve performance. One of the key objectives of the Region's WWTMP update is to consider energy reduction and efficiency, as well as innovation within wastewater treatment. In order to optimize and reduce energy use, options should be considered as a component of any upgrade, and can also be considered without expansion based on a business case to provide a rationale for implementation as a stand-alone project. The following sections provide details of some key energy reduction methods.

It should be noted that the energy reduction methods described here are a selection of the more relevant technologies and strategies available at this time and compatible with existing infrastructure. When projects are being implemented, a review of available technologies should be conducted to determine if there have been any advancements or new technologies developed that may offer additional advantages to the Region.

6.2.1 Sidestream Treatment

Sidestream treatment is commonly considered for high strength side streams such as sludge dewatering centrate, and digester supernatant. These streams can contribute significant nitrogen loading to the liquid treatment train. For example, in a typical WWTP, the recycle sidestream nitrogen may be up to 3 – 5% of the total influent flow and 15 – 35% of the nitrogen load. The large amount of ammonia from the sidestream can bleed through secondary treatment to the effluent if there is insufficient air or SRT available for nitrification, or both.

By implementing a sidestream treatment system and removing ammonia and/or phosphorus from the sludge dewatering or digester supernatant stream, the nutrient burden on the mainstream treatment trains would be reduced. Ultimately, this would help the WWTP increase its capacity and defer upgrades. Separately treating the high strength stream can also offer other potential benefits, including lower aeration energy cost, less risk of ammonia bleed through to effluent, and a smaller aeration reactor volume requirement.

6.2.2 DO Control and Anoxic Selectors

DO control provides optimization and automatic control of DO and SRT in aeration systems to optimize DO and SRT set points and reduce energy consumption while maintaining process performance.

The concept of a selector is the use of a specific bioreactor design that favors the growth of floc forming bacteria instead of filamentous bacteria to provide an activated sludge with better settling and thickening properties. Of specific interest is the addition of an anoxic selector zone to the treatment process, which also reduces the required aeration energy, in addition to improved settleability. In the recent upgrades at both Waterloo and Kitchener WWTPs, the Region has integrated anoxic selectors to denitrify the return activated sludge (RAS).

While there are several benefits associated with anoxic selectors, the ability to implement this within an existing aeration tank depends on the available aeration capacity for winter nitrification and may require the implementation of a swing zone if the aeration capacity is required at certain times of the year.

6.2.3 Chemically Enhanced Primary Treatment

Chemically enhanced primary treatment (CEPT) is a wastewater treatment process in which chemicals, generally metal salts (e.g. ferric chloride or alum) and/or polymers, are added upstream of primary clarifiers to enhance settling characteristics of solids and improve performance.

CEPT facilities improve the removal efficiencies for suspended solids and BOD. As a result, a CEPT facility can also provide additional secondary treatment capacity through reduced chemical sludge mass in aeration tanks and lower energy consumption through reduced BOD loadings. Therefore, the implementation of CEPT can potentially defer large capital expenditures beyond the design year, while preserving site space and allowing for flexibility to add infrastructure as required by future growth.

The primary disadvantages of the CEPT process is higher raw sludge generation, which may require larger sludge digestion facilities. However, this provides an opportunity to increase digester gas production for beneficial use (i.e., through a combined heat and power (CHP) facility).

CEPT is a well-established and proven treatment option to optimize primary treatment at WWTPs, with published performance data for some large facilities in North America. Careful dosing control is required to ensure adequate nutrients are available in primary effluent to support the secondary treatment biological processes.

6.2.4 Automation Upgrades

In consideration of the high level of ammonia and phosphorus removal required at most Region facilities, two potential automation upgrades include:

- Ammonia analyzers
- Phosphate analyzers

Ammonia-based aeration control of the activated sludge process can lead to significant aeration energy savings, and potential performance improvements for nitrogen and biological phosphorus removal plants. Several studies report that ammonia control can provide energy savings in the range of 10 to 25%, while also improving total nitrogen removal. Some considerations for the implementation of ammonia control include (Rieger, 2014):

- For typical municipal nitrifying plants, ammonia control reduces aeration, although should have no impact on BOD removal. The carbonaceous oxygen requirements will be satisfied if complete (or near complete) nitrification is achieved.
- Plant performance becomes more stable. In plug flow nitrifying plants, there is often a sudden drop in oxygen demand at the point in the bioreactor where ammonia removal by nitrification is complete. The position of this point moves over the day, depending on the influent loading rate and temperature variations, making aeration control more difficult. Despite multiple DO control loops, it is difficult to account for this step change in oxygen demand. Depending on the location of the DO probes, this may lead to over-aeration of the downstream sections of the

aerated bioreactors, even if diffuser tapering partly accounts for the oxygen demand profile. When using ammonia control, nitrification is never complete, and therefore, this problem is avoided.

Increased denitrification occurs through simultaneous nitrification and denitrification at lower DO concentrations; conventional denitrification occurs if aeration is switched off completely.

Similar to ammonia analyzers, phosphate analyzers can be used to stabilize effluent TP concentrations and potentially reduce chemical usage through automation of dosages. There is limited full-scale experience documenting the savings potential. However, it is reasonable to expect chemical savings in the range of 10%.

6.2.5 Emerging Innovative Technologies

Several potential technologies show potential for enhancing operations and/or reducing energy use within the Region's WWTPs (as indicated in Table 4). Many of these technologies are in the development stages and therefore unable to be evaluated fully for their suitability at this stage, but should be considered when asset management renewal or plant expansions are taking place.

6.2.6 Wastewater Optimization Program

As part of the approach for enhancing operations and reducing energy, optimizing the operation of the existing wastewater treatment infrastructure is an important consideration. The Region has partnered with the GRCA and the MOECC to improve the operation of wastewater treatment plants through participation in the Wastewater Optimization Program (referred to as Optimization) and Performance Based Training. The goal of the Optimization program is to improve the quality of treated effluent that leaves a wastewater treatment plant.

Optimizing a plant is a collaborative process and has two main steps:

- Identify factors that have the potential to limit the performance of a wastewater treatment facility, which may include administrative, operational and/or maintenance factors. A system called the Composite Correction Program, developed by the US Environmental Protection Agency is used in the Optimization program to identify potential limiting factors.

- Systematically address those limiting factors, starting with the highest priority issues. This includes training plant operators and managers on strategies to address the plant's performance shortfalls and to apply best practices for wastewater treatment.

Many benefits have been noted through optimizing plant performance, including:

- deferred capital investments for municipalities
- fewer bypasses
- improved effluent quality
- potential reductions in operating costs

Information and resources related to the Optimization program, including case studies, are provided on the GRCA website.

The Optimization process has been completed for several of the wastewater treatment plants in Waterloo Region. Currently, the Region is proceeding together with the MOECC and GRCA with the next step, which is Performace Based Training.

6.3 Watershed Management

The Grand River watershed drains an area of 6800 square kilometers and there are 39 municipalities (regional, local and single tier), as well as two First Nations, that form part of the watershed. It has long been recognized that management of the watershed must be a collaborative effort by all stakeholders.

In 2009, the GRCA, watershed municipalities, provincial governments, federal departments, and First Nations came together to review and update the Grand River Water Management Plan (WMP) to ensure a healthy river system and linkage to Lake Erie, secure water supplies, manage flood risks and deal with climate change (GRCA, 2014).

This collaborative effort is needed to ensure that clean water is available to all within the watershed. The Region was a key stakeholder in the development of the 2014 WMP and continues to work with stakeholders to improve the management of the watershed. Other key initiatives that the Region has undertaken since the completion of the 2007 WWTMP include the Surface Water Quality Monitoring Program (SWQMP) and collaboration with the University of Waterloo. The SWQMP focuses on the impacts of ten of the Region's WWTPs on their respective receiving waters. This program provides evidence needed to obtain approvals, provides sufficient understanding to effectively evaluate alternatives during Master Plan updates and gives adequate evidence to demonstrate the degree of receiver improvement resulting from implementation of WWTP upgrades and other projects intended to improve receiver quality. Collaboration with the University of Waterloo (UW) has led to findings that upgrades to the Region's WWTPs are making a significant difference to the health of the fish in the Grand (Servos, 2017).

Before the upgrades, endocrine disrupting compounds (such as estrogen from birth control pills and chemicals that mimic natural hormones) were making their way into the river, causing male rainbow darter fish to develop female traits. Concentrations were so high that in some areas, every male fish sampled in the UW research showed some female traits. Immediately after the Kitchener plant was upgraded, this dropped to 29 per cent. Within three years, it dropped below 10 per cent (Servos, 2017).

6.4 Asset Management and Renewal

The Region has significant investments in wastewater infrastructure across the Region. In order to provide continued reliable service into the future, equipment requires both on-going maintenance and replacement over the life-cycle. In recognition of the value of existing infrastructure, the Region has implemented a comprehensive asset management program for all of its facilities to best manage on-going maintenance and plan for asset renewal.

Historically, when an asset has reached the end of its useful life, many municipalities simply do a replacement with similar equipment. In consideration of the Region's objectives to reduce energy consumption, greenhouse gas emissions and operating costs, there is a unique opportunity at the end of an asset's life cycle to consider implementing newer technologies based on a life cycle assessment. Some key opportunities include:

- **Pumps**: Selection of pumps with high operating efficiencies and/or reduced maintenance costs
- **Blowers**: Operation of blowers represents a significant component of the overall plant operating costs. Any replacement should consider blowers with higher

operating efficiencies, improved turndown capacity and reduced maintenance costs.

- **Aeration diffusers**: Select diffusers and layout density to maximize operating efficiency and reduce life cycle costs. During diffuser replacement, there is also a unique opportunity to consider incorporation of an anoxic selector, at the facilities where this is not already present, to reduce energy consumption (see Section 6.2 for additional details).
- **Disinfection equipment**: Disinfection at most of the Region's facilities is provided using ultraviolet disinfection. During asset replacement, there is opportunity to consider alternative UV equipment with improved efficiency and turndown capacity and/or alternative disinfection technologies (i.e., paracetic acid or similar).

6.5 Water Re-use

There is the potential to investigate re-use of treated wastewater where possible, feasible and practical. Wastewater re-use opportunities present a number of challenges such as current regulation requirements and Codes (i.e. Ontario Building Code, Plumbing Code) regarding water use and plumbing restrictions, and the Region's northern climate (resulting in seasonal applications and need for storage). However, there are also potential advantages such as the reduction in treatment requirements and the decrease in potable water use for industrial or agricultural purposes.

There are opportunities to investigate water re-use within Waterloo Region, particularly in the context of the development of the East Side Lands (ESLs). The ESLs have been identified primarily for employment development and water re-use may be particularly beneficial for new potential industries. The ESLs also provide a good opportunity for water re-use as there are far fewer challenges to implementing a water re-use scheme within newly developed areas as compared to retrofitting existing infrastructure.

Further investigation into this option, as well as coordination with area municipalities related to water and wastewater billing and implementation requirements would be required. There would also need to be support from potential end-users in order to make water re-use a feasible alternative. There is funding available through the

Federation of Canadian Municipalities (FCM) related to plans and studies that may be available for further investigation of this option.

It is important to note that this is not a stand-alone option for any wastewater treatment plant, but could form part of a Regional wastewater approach.

7. Plant Specific Options

Several key areas of consideration are discussed in the sections below for each treatment plant, as well as the options that are feasible for that treatment plant based on the constraints and considerations identified.

7.1 Kitchener WWTP

The Kitchener WWTP is a conventional activated sludge plant with a rated average day flow capacity of 122,745 m^3/d. The average day flow was 70,970 m^3/d between 2012 and 2014, or approximately 60% of the rated capacity. The treated effluent is discharged to the Grand River.

The Kitchener WWTP is currently in the process of Phase 3 upgrades to provide reliable effluent quality with year-round nitrification. The Phase 3 upgrades include new headworks, new secondary treatment plants (Plants 3 and 4 to replace Plant 1), tertiary filtration and anaerobic digestion upgrades. The Region is also installing a biogas CHP unit for energy recovery and greenhouse gas emission reduction at the Kitchener WWTP. The rated capacity of the plant will remain at 122,745 m^3/d.

7.1.1 Capacity Needs

As described in Section 3, the Kitchener WWTP has sufficient capacity for the planning period to 2051, including the flow from the East Side Lands (ESL).

7.1.2 Effluent Quality Considerations

The Kitchener WWTP is nearing completion of significant upgrades to the facility to improve effluent quality by providing full year-round nitrification and tertiary phosphorus removal. No changes to current effluent quality limits are expected, particularly since no expansion will be required during the planning period.

7.1.3 Plant Specific Opportunities

Table 11 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation. It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve all Region objectives.

Table 11 Summary of Options for Kitchener WWTP

Potential Option		Feasibility for Kitchener WWTP	Rationale
Diversion		X	• No capacity restriction in planning period.
I/I Reduction		X	• Flows and loadings are consistent with normal mixed residential commercial/ industrial uses. Continue to encourage on-going I/I reduction.
Industrial Pre-treatment		X	• Flows and loadings are consistent with normal mixed residential/commercial/ industrial uses. Continue to encourage and promote awareness of industrial pre-treatment.
Expansion	Re-Rating	X	• No expansion beyond rated capacity in planning period.
	Conventional	X	• No expansion beyond rated capacity in planning period.
	New Technology	X	• No expansion beyond rated capacity in planning period.
Effluent Quality Improvements		X	• No changes to current limits expected.
Operational Enhancement and Energy Reduction	DO Control and Anoxic Selector	X	• Current upgrades incorporate DO control and anoxic selector.
	CEPT	✓	• Increase digester gas for on-going implementation of co-generation.
	Sidestream Treatment	✓	• Feasible with on-site dewatering operations (at adjacent Manitou Drive facility).
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.1.4 Asset Management and Renewal

General asset management and renewal opportunities have been noted that should be considered at all plants when other upgrades or projects are undertaken at a facility (refer to Section 6.4).

Specific to the Kitchener WWTP, there are significant on-going upgrades and there are no near-term asset management and renewal opportunities that have been identified.

7.2 Waterloo WWTP

The Waterloo WWTP is a conventional activated sludge plant. The plant has an existing ECA approved hydraulic capacity of 72,730 m^3/d and a rated average day flow capacity of 57,500 m^3/d. The average day flow was 46,640 m^3/d between 2012 and 2014, or approximately 80% of the rated capacity. The treated effluent is discharged to the Grand River.

The Waterloo WWTP is currently undergoing upgrades that will provide the plant with a capacity of 57,500 m^3/d with year-round nitrification, which mainly includes primary treatment upgrades, modification of existing aeration tanks to provide a high level of year-round nitrification, installation of new blowers and retrofit of the secondary digesters to operate as either primary or secondary digesters. The Region is also installing a biogas CHP unit for energy recovery and greenhouse gas emission reduction at the Waterloo WWTP.

7.2.1 Capacity Needs

As described in Section 3, the Waterloo WWTP will require an expansion by the year 2041 based on the moderate growth scenario.

7.2.2 Effluent Quality Considerations

The Waterloo WWTP is expected to have changes to effluent quality limits, particularly since an expansion to the rated capacity will be required during the planning period. As discussed in Section 4, an assimilative capacity study (ACS) was completed for the Grand and Speed Rivers for the Waterloo and Hespeler WWTPs. Table 12 provides existing ECA effluent objectives and limits while Table 13 provides the future effluent limits recommended by the ACS for the Waterloo WWTP up to the year 2051 when assuming an expansion to 73,200 m^3/d (Stantec, April 2014).

Table 12 Waterloo WWTP Existing ECA Effluent Objectives and Limits

Parameter	**Effluent Objectives**	**Non-Compliance Limits (>54,600 m^3/d) (1)**	**Non-Compliance Limits (≤ 54,600 m^3/d)**
	Concentration (mg/L) (2)	**Concentration (mg/L) (2)**	**Concentration (mg/L) (2)**
$CBOD_5$	10.0	15.0	15.0
TSS	10.0	15.0	15.0
TP	0.4	0.6	0.8
TAN	1.5	1.8	-
E. coli (counts/100 mL) (3)	100	200	-

Notes:
1. Upon the completion of the current Contract No. 4 upgrades at the plant.
2. Based on monthly average concentration values.
3. Based on monthly geometric mean.

Table 13 Waterloo WWTP Proposed Effluent Objectives and Limits

Parameter	**Effluent Objectives**	**Non-Compliance Limits**	
	Concentration (mg/L) (1)	**Concentration (mg/L) (1)**	**Loading (kg/d) (2)**
$CBOD_5$	10.0	15.0	860
TSS	10.0	15.0	860
TP	0.2 (0.4) (3)	0.4 (0.6) (3)	23
TAN	1.5	1.8	103
E. coli (counts/100 mL) (4)	100	200	-

Notes:
1. Based on monthly average concentration values.
2. Based on the annual average loading during any calendar year.
3. The 0.2 mg/L TP effluent objective and the 0.4 mg/L TP effluent non-compliance limit are pending the reconsideration of the ACS to coincide with the ECA amendment for the WWTP upgrading. Numbers in parentheses apply between 2013 and 2024/25 for the interim objectives and non-compliance limits.
4. Based on monthly geometric mean.

The proposed objectives and non-compliance limits represent a reduction in TP concentrations and loadings to the receiving water, in line with the level of treatment provided by tertiary systems.

7.2.3 Plant Specific Opportunities

Table 14 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation. It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve all Region objectives.

Table 14 Summary of Options for Waterloo WWTP

Potential Option		Feasibility for Waterloo WWTP	Rationale
Diversion		✓	• Divert excess flows to the Kitchener WWTP for treatment on a permanent basis using existing Regionally owned pumping stations.
I/I Reduction		X	• Flows and loadings are consistent with normal mixed residential commercial/ industrial uses. Continue to encourage on-going I/I reduction.
Industrial Pre-treatment		X	• Flows and loadings are consistent with normal mixed residential/commercial/ industrial uses. Continue to encourage and promote awareness of industrial pre-treatment.
Expansion	Re-Rating	✓	• Re-rating may provide for 2051 flows.
	Conventional	✓	• Expansion required to accommodate 2051 flows.

Potential Option		Feasibility for Waterloo WWTP	Rationale
	New Technology	✓	• Expansion required to accommodate 2051 flows.
Effluent Quality Improvements		✓	• Phosphorus reduction and ECA update is expected to be required based on ACS and to meet Lake Erie targets. • As discussed in Section 4, options to achieve targets include phosphorus trading or conventional tertiary treatment.
Operational Enhancement and Energy Reduction	DO Control and Anoxic Selector	X	• Current upgrades incorporate DO control and anoxic selector.
	CEPT	✓	• Increase digester gas for optimization of on-going implementation of co-generation.
	Sidestream Treatment	✓	• Feasible with on-site dewatering operations.
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.2.4 Asset Management and Renewal

General asset management and renewal opportunities have been noted that should be considered at all plants when other upgrades or projects are undertaken at a facility (refer to Section 6.4).

Specific to the Waterloo WWTP, there are significant on-going upgrades and there are minimal near-term asset management and renewal opportunities that have been identified.

7.3 Galt WWTP

The Galt WWTP is a conventional activated sludge plant with an existing Stage 1 rated average day flow capacity of 56,800 m^3/d and a future Stage 2 rated capacity of 76,000 m^3/d. The average day flow was 35,000 m^3/d between 2012 and 2014, or approximately 60% of the Stage 1 rated capacity. The treated effluent is discharged to the Grand River.

In 2016, the Region completed a Facility Plan for the upgrades at the Galt WWTP to address key issues/deficiencies that were identified at the facility. The upgrades program is focused on achieving Stage 1 rated capacity, with provisions for future upgrades to Stage 2 rated capacity. A phased approach has been developed for the short and medium term upgrades at the plant. The Region is currently moving forward with the first phase of upgrades to headworks, tertiary treatment and UV disinfection. Additionally, the Region is installing a biogas CHP unit for energy recovery and greenhouse gas emission reduction at the Galt WWTP.

7.3.1 Capacity Needs

As described in Section 3, the Galt WWTP has sufficient capacity for the planning period to 2051.

7.3.2 Effluent Quality Considerations

The Galt WWTP is currently in the planning stage for upgrades to improve effluent quality by improving existing treatment processes. Although the upgrades are expected to provide improved effluent quality by alleviating plant bottlenecks, no changes to current effluent quality limits are expected, particularly since the facility already incorporates tertiary treatment and no expansion will be required during the planning period. The existing ECA phosphorus limits are higher than the Lake Erie limits. However, since the plant already incorporates tertiary treatment these limits can be easily achieved with existing infrastructure and only minor operational adjustments.

7.3.3 Plant Specific Opportunities

Table 15 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation. It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve all Region objectives.

Table 15 Summary of Options for Galt WWTP

Potential Option		Feasibility for Galt WWTP	Rationale
Diversion		X	• No capacity restriction in planning period.
I/I Reduction		X	• Flows and loadings are consistent with normal mixed residential commercial/ industrial uses. Continue to encourage on-going I/I reduction.
Industrial Pre-treatment		X	• Flows and loadings are consistent with normal mixed residential/commercial/ industrial uses. Continue to encourage and promote awareness of industrial pre-treatment.
Expansion	Re-Rating	X	• No expansion beyond rated capacity in planning period.
	Conventional	X	• No expansion beyond rated capacity in planning period.
	New Technology	X	• No expansion beyond rated capacity in planning period.
Effluent Quality Improvements		X	• ECA update expected to meet Lake Erie effluent targets, however plant is already achieving effluent quality required for Lake Erie Draft Action Plan.
Operational Enhancement and Energy Reduction	DO Control and Anoxic Selector	✓	• Current upgrades incorporate DO control but potential to incorporate anoxic selector.
	CEPT	X	• Limited by available digester capacity.
	Sidestream Treatment	✓	• Feasible with on-site dewatering operations.
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.3.4 Asset Management and Renewal

General asset management and renewal opportunities have been noted that should be considered at all plants when other upgrades or projects are undertaken at a facility (refer to Section 6.4).

Specific to the Galt WWTP, there are several asset management and renewal items that have been noted based on the recently completed Facility Plan (CIMA, 2016). The Region is currently undertaking upgrades at the Galt WWTP to address these items.

7.4 Preston WWTP

The Preston WWTP is a conventional activated sludge plant with a rated average day flow capacity of 16,860 m^3/d. The average day flow was 9,000 m^3/d between 2012 and 2014, or approximately 55% of the rated capacity. Treated effluent is discharged to the Grand River.

The Preston WWTP is currently implementing upgrades to headworks, blowers and electrical systems to improve the reliabilit

7.4.1 Capacity Needs

As described in Section 3, without the ESLs, the Preston WWTP has sufficient capacity for the planning period to 2051. With ESLs, the plant has sufficient capacity to accommodate planned growth and ESLs flows in the short-term until approximately 2041. A diversion to the Kitchener WWTP will be constructed and commissioned ahead of this timeline to ensure that the Preston WWTP continues to operate within the approved rated capacity. After this long-term servicing solution of conveying flows to the Kitchener WWTP has been constructed, the available capacity at the Preston WWTP will be restored and sufficient for the projected 2051 flows.

7.4.2 Effluent Quality Considerations

The Preston WWTP provides full nitrification and a high level of phosphorus removal through chemical addition. Reductions for effluent phosphorus concentrations are anticipated during the planning period to meet the Lake Erie effluent targets.

7.4.3 Plant Specific Opportunities

Table 16 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation. It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve all Region objectives.

Table 16 Summary of Options for Preston WWTP

Potential Option		Feasibility for Preston WWTP	Rationale
Diversion		X	• No capacity restriction in planning period.
I/I Reduction		X	• Flows and loadings are consistent with normal mixed residential commercial/ industrial uses. Continue to encourage on-going I/I reduction.
Industrial Pre-treatment		X	• Flows and loadings are consistent with normal mixed residential/commercial/ industrial uses. Continue to encourage and promote awareness of industrial pre-treatment.
Expansion	Re-Rating	X	• No expansion beyond rated capacity in planning period.
	Conventional	X	• No expansion beyond rated capacity in planning period.
	New Technology	X	• No expansion beyond rated capacity in planning period.
Effluent Quality Improvements		✓	• Phosphorus reduction and ECA update expected to be required to meet Lake Erie effluent targets. • As discussed in Section 4, options to achieve targets include phosphorus offsetting, orprocess

Potential Option		Feasibility for Preston WWTP	Rationale
			optimization for phosphorus removal.
Operational Enhancement and Energy Reduction	DO Control and Anoxic Selector	X	• Upgrades on-going to improve DO control and efficiency and already equipped with anoxic selector.
	CEPT	X	• Minimal benefit without cogeneration on-site to utilize additional digester gas
	Sidestream Treatment	X	• Not applicable without on-site dewatering operations and minimal digester supernating.
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.4.4 Asset Management and Renewal

General asset management and renewal opportunities have been identified that should be considered at all plants when other upgrades or projects are undertaken at a facility (refer to Section 6.4).

Specific to the Preston WWTP, the following asset management and renewal items should be considered:

- Replacement of UV medium pressure reactors – consideration for new technology (such as peracetic acid) or more efficient UV system
- Short-term opportunity to improve controls of the UV system based on water quality.

7.5 Hespeler WWTP

The Hespeler WWTP is an extended aeration plant with a rated average day flow capacity of 9,320 m^3/d. The current average day flow is 6,940 m^3/d (average between 2012 and 2014), or approximately 75% of the rated capacity. Treated effluent is discharged to the Speed River.

A Facility Assessment has recently been completed for the plant to identify facilities that require improvements before the next planned expansion (Stantec, 2015). The recommended upgrades include the construction of a new fine screening and grit removal facility, new air blowers, addition of a third secondary clarifier and a new WAS thickening facility.

7.5.1 Capacity Needs

As described in Section 3, the Hespeler WWTP will require an expansion by the year 2047 based on the moderate growth scenario.

7.5.2 Effluent Quality Considerations

The Hespeler WWTP is expected to have changes to current effluent quality limits, particularly since an expansion to the rated capacity will be required during the planning period. As discussed in Section 4, an ACS was completed for the Grand and Speed Rivers for the Waterloo and Hespeler WWTPs.

Table 17 provides the future effluent limits recommended by the ACS for the Hespeler WWTP up to the year 2051 when assuming an expansion to 13,200 m^3/d (Stantec, April 2014).

The proposed objectives and non-compliance limits represent the implementation of year-round nitrification, as well as a reduction in TP concentrations and loadings to the receiving water, consistent with tertiary level equivalent effluent.

Table 17 Hespeler WWTP Current ECA and Proposed Effluent Objectives and Limits

Parameter	Effluent Objectives	Non-Compliance Limits	
	Concentration (mg/L) (1)	Concentration (mg/L) (1)	Loading (kg/d) (2)
Current			
$CBOD_5$	15.0	25.0	233
TSS	15.0	25.0	233
TP	0.75	1.0	9.3
E. coli (counts/100 mL) (3)	150	200	-
Future (up to 2051) (4)			
$CBOD_5$	10	15	200
TSS	10	15	200
TP	0.4	0.6	8
TAN May 1 to November 30 December 1 to April 30	 2 5	 4 7	 53 94
E. coli (counts/100 mL) (3)	150	200	-

Notes:
1. Based on monthly average concentration values.
2. Based on the annual average loading during any calendar year.
3. Based on monthly geometric mean.
4. Based on ACS for the Hespeler and Waterloo WWTPs (Stantec, April 2014).

7.5.3 Plant Specific Opportunities

Table 18 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation. It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve all Region objectives.

Table 18 Summary of Options for Hespeler WWTP

Potential Option		Feasibility for Hespeler WWTP	Rationale
Diversion		X	• Capacity shortfall within planning period is small. Not cost effective for very small flow quantity.
I/I Reduction		X	• Flows and loadings are consistent with normal mixed residential commercial/ industrial uses. Continue to encourage on-going I/I reduction.
Industrial Pre-treatment		X	• Flows and loadings are consistent with normal mixed residential/commercial/ industrial uses. Continue to encourage and promote awareness of industrial pre-treatment.
Expansion	Re-Rating	✓	• Re-rating may provide for 2051 flows.
	Conventional	✓	• Expansion required to accommodate 2051 flows.
	New Technology	✓	• Opportunity to evaluate/test developing technologies as capacity increase is not required until 2047. • On-site pilot testing of MABR process and peracetic acid disinfection are on-going.
Effluent Quality Improvements		✓	• Year-round nitrification required. • Phosphorus reduction and ECA update expected to be required based on ACS and to meet Lake Erie targets. • As discussed in Section 4, options to achieve targets include phosphorus offsetting,

Potential Option		Feasibility for Hespeler WWTP	Rationale
			or process optimization for phosphorus removal.
Operational Enhancement and Energy Reduction	DO Control and Anoxic Selector	✓	• Potential to implement anoxic selector for energy efficiency.
	CEPT	X	• Not applicable as there are no primary clarifiers.
	Sidestream Treatment	X	• Not applicable without on-site dewatering operations.
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.5.4 Asset Management and Renewal

General asset management and renewal opportunities have been noted that should be considered at all plants when other upgrades or projects are undertaken at a facility (refer to Section 6.4).

Specific to the Hespeler WWTP, the following asset management and renewal items should be considered:

- Diffuser replacement in the next 10 years
- Replacement of chlorination/dechlorination with newer technology (peracetic acid or UV).

Although several other items were identified through a condition assessment completed for the plant, the Region is currently completing upgrades to address the majority of the items noted.

7.6 Wellesley WWTP

The Wellesley WWTP is an extended aeration package plant with a rated capacity of 1,100 m^3/d. The average day flow was 870 m^3/d between 2012 and 2014, or approximately 80% of the rated capacity. The treated effluent is discharged to the Nith River.

The Wellesley WWTP is currently completing upgrades to the tertiary filtration process to improve reliability and operability of tertiary treatment (CH2M Hill, 2015).

7.6.1 Capacity Needs

As described in Section 3, the Wellesley WWTP will require an expansion by the year 2041 based on the moderate growth scenario.

7.6.2 Effluent Quality Considerations

The Wellesley WWTP is currently completing upgrades to improve effluent quality by upgrading the tertiary filtration process. It is expected that a reduction in TP concentrations to the receiving water will be required as part of a future expansion.

7.6.3 Plant Specific Opportunities

Table 19 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation. It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve Region objectives.

Table 19 Summary of Options for Wellesley WWTP

Potential Option	Feasibility for Wellesley WWTP	Rationale
Diversion	X	• Capacity shortfall within planning period is small. Not cost effective for very small flow quantity.
I/I Reduction	✓	• I/I reduction is a potential opportunity as wet weather flows are higher than normal mixed

Potential Option		Feasibility for Wellesley WWTP	Rationale
			residential/commercial/ industrial uses.
Industrial Pre-treatment		X	• Flows and loadings are consistent with normal mixed residential/commercial/ industrial uses. Continue to encourage and promote awareness of industrial pre-treatment.
Expansion	Re-Rating	✓	• Re-rating may provide for 2051 flows.
	Conventional	✓	• Expansion required to accommodate 2051 flows.
	New Technology	✓	• Expansion required to accommodate 2051 flows.
Effluent Quality Improvements		✓	• Enhanced nutrient removal expected to be required with the next expansion due to sensitivity of Nith River. • As discussed in Section 4, options to achieve TP reduction include phosphorus offsetting, or expansion of conventional tertiary treatment.
Operational Enhancement and Energy Reduction	DO Control and Anoxic Selector	✓	• Potential to improve DO control and implement anoxic selector as part of next upgrade/expansion.
	CEPT	X	• Not applicable as there are no primary clarifiers.
	Sidestream Treatment	X	• Not applicable without on-site dewatering operations.
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.6.4 Asset Management and Renewal

General asset management and renewal opportunities have been noted that should be considered at all plants when other upgrades or projects are undertaken at a facility (refer to Section 6.4).

Specific to the Wellesley WWTP, the following asset management and renewal items should be considered:

- Ozone replacement – consider newer technology such as peracetic acid
- Headworks screening and flow diversion improvements
- Raw sewage pumping station refurbishment
- WAS and sludge storage refurbishment

The Wellesley WWTP also requires upgrades to the tertiary treatment process, which is currently under design and construction.

7.7 Ayr WWTP

The Ayr WWTP is an extended aeration package plant with a rated average day flow capacity of 3,000 m^3/d. The average day flow was 1,300 m^3/d between 2012 and 2014, or approximately 45% of the rated capacity. The treated effluent is discharged to the Nith River.

7.7.1 Capacity Needs

As described in Section 3, the Ayr WWTP has sufficient capacity for the planning period to 2051.

It should be noted that a new raw wastewater pumping station in Ayr (referred to as the Ayr WWPS) is in construction, which will convey wastewater from new development in the southern area of Ayr to the Ayr WWTP. As such, the Ayr WWTP will have two WWPSs that convey all flows directly to the plant. Therefore, the future capacity requirements of the plant need to consider not only the population projections but also the WWPS operation and capacity with respect to the plant peak flow capacity. Based on pumping capacity of Phase 1 of the Ayr WWPS, it is expected that operating strategies can be used at the two pumping stations to maintain the combined flow received at the Ayr WWTP below the plant peak design flow.

7.7.2 Effluent Quality Considerations

No changes to current effluent quality limits for the Ayr WWTP are expected. The plant currently incorporates full nitrification and tertiary phosphorus removal and no expansion is required during the planning period.

7.7.3 Plant Specific Opportunities

Table 20 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation. It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve all Region objectives.

7.7.4 Asset Management and Renewal

General asset management and renewal opportunities have been noted that should be considered at all plants when other upgrades or projects are undertaken at a facility (refer to Section 6.4).

Specific to the Ayr WWTP, there were no asset management and renewal opportunities identified.

Table 20 Summary of Options for Ayr WWTP

Potential Option		Feasibility for Ayr WWTP	Rationale
Diversion		X	• No capacity restriction in planning period.
I/I Reduction		X	• Flows and loadings are consistent with normal mixed residential commercial/ industrial uses. Continue to encourage on-going I/I reduction.
Industrial Pre-treatment		X	• Flows and loadings are consistent with normal mixed residential/commercial/ industrial uses. Continue to encourage and promote awareness of industrial pre-treatment.
Expansion	Re-Rating	X	• No expansion beyond rated capacity in planning period.
	Conventional	X	• No expansion beyond rated capacity in planning period.
	New Technology	X	• No expansion beyond rated capacity in planning period.
Effluent Quality Improvements		X	• No changes to current limits expected.
Operational Enhancement and Energy Reduction	DO Control and Anoxic Selector	✓	• Potential to improve DO control and efficiency and already equipped with anoxic selector.
	CEPT	X	• Not applicable as there are no primary clarifiers.
	Sidestream Treatment	X	• Not applicable without on-site dewatering operations.
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.8 New Hamburg WWTP

The New Hamburg WWTP is a sequencing batch reactor (SBR) plant with an existing ECA rated capacity of 5,200 m^3/d. The plant is currently in the detailed design phase for the Phase 2 expansion to increase the rated capacity to 6,900 m^3/d to accommodate future community growth (HMM, 2015).

The average day flow was 3,700 m^3/d between 2012 and 2014, or approximately 55% of the Phase 2 rated capacity of 6,900 m^3/d. The treated effluent is discharged to an oxbow wetland upstream of the Nith River.

7.8.1 Capacity Needs

As described in Section 3, upon completion of the current expansion, the New Hamburg WWTP has sufficient capacity for the planning period to 2051.

7.8.2 Effluent Quality Considerations

The plant is currently in the process of detailed design for the Phase 2 expansion, with agreed effluent quality limits for the expanded facility. Beyond the current expansion, no changes to current effluent quality limits are expected, particularly since no additional expansion will be required during the planning period.

7.8.3 Plant Specific Opportunities

Table 21 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation. It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve all Region objectives.

7.8.4 Asset Management and Renewal

General asset management and renewal opportunities have been noted that should be considered at all plants when other upgrades or projects are undertaken at the facility (refer to Section 6.4).

Specific to the New Hamburg WWTP, several asset management and renewal opportunities have been identified, however the Region is currently undertaking an expansion and upgrade at the New Hamburg WWTP to address these items.

Table 21 Summary of Options for New Hamburg WWTP

Potential Option		Feasibility for New Hamburg WWTP	Rationale
Diversion		X	• No capacity restriction in planning period.
I/I Reduction		X	• Flows and loadings are consistent with normal mixed residential/ commercial/industrial uses. Continue to encourage on-going I/I reduction.
Industrial Pre-treatment		X	• Flows and loadings are consistent with normal mixed residential/ commercial/industrial uses. Continue to encourage and promote awareness of industrial pre-treatment.
Expansion	Re-Rating	X	• No expansion beyond Phase 2 rated capacity in planning period.
	Conventional	X	• No expansion beyond Phase 2 rated capacity in planning period.
	New Technology	X	• No expansion beyond Phase 2 rated capacity in planning period.
Effluent Quality Improvements		X	• No changes to current Phase 2 limits expected.
Operational Enhancement and Energy Reduction	DO Control and Anoxic Selector	X	• Current expansion incorporates DO control and anoxic cycles are integral to SBR process.
	CEPT	X	• Not applicable as there are no primary clarifiers.
	Sidestream Treatment	X	• Not applicable without on-site dewatering operations.
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.9 St Jacobs WWTP

The St Jacobs WWTP is an oxidation ditch extended aeration plant, with a rated capacity of 1,450 m^3/d. The average day flow was 920 m^3/d between 2012 and 2014, or approximately 65% of the rated capacity. The treated effluent is discharged to the Conestogo River.

7.9.1 Capacity Needs

As described in Section 3, the St Jacobs WWTP will require an expansion by the year 2042 based on the moderate growth scenario. However, due to the significant I/I issue expereiced at the plant, the existing plant capacity is limited by UV and tertiary filters to treat the rated flow capacity. This will be considered as part of the overall implementation timing recommendations for the preferred option.

7.9.2 Effluent Quality Considerations

The existing plant provides a high level of nitrification and tertiary phosphorus removal, however, it is expected that a reduction in TP concentrations to the receiving water will be required as part of a future expansion.

7.9.3 Plant Specific Opportunities

Table 22 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation. It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve all Region objectives.

Table 22 Summary of Options for St Jacobs WWTP

Potential Option	Feasibility for St Jacobs WWTP	Rationale
Diversion	✓	• Divert flow from St Jacobs to Waterloo WWTP. • Existing asset condition and projected life should be considered.
I/I Reduction	✓	• I/I reduction is a potential opportunity as wet weather flows

Potential Option		Feasibility for St Jacobs WWTP	Rationale
			are higher than normal mixed residential/commercial/ industrial uses.
Industrial Pre-treatment		X	• Flows and loadings are consistent with normal mixed residential/commercial/ industrial uses. Continue to encourage and promote awareness of industrial pre-treatment.
Expansion	Re-Rating	✓	• Re-rating may provide for 2051 flows.
	Conventional	✓	• Expansion required to accommodate 2051 flows.
	New Technology	✓	• Expansion required to accommodate 2051 flows.
Effluent Quality Improvements		✓	• Phosphorus reduction is expected to be required with the next expansion. • As discussed in Section 4, options to achieve TP reduction include phosphorus offsetting, or expansion of conventional tertiary treatment.
Operational Enhancement and Energy Reduction	DO Control and Anoxic Selector	✓	• Potential to implement anoxic selector as part of next upgrade/expansion.
	CEPT	X	• Not applicable as there are no primary clarifiers.
	Sidestream Treatment	X	• Not applicable without on-site dewatering operations.
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.9.4 Asset Management and Renewal

General asset management and renewal opportunities have been noted that should be considered at all plants when other upgrades or projects are undertaken at a facility (refer to Section 6.4).

Specific to the St Jacobs WWTP, the following asset management and renewal items should be considered:

- Oxidation ditch brush aerator motor gear drives. Opportunity to consider a more energy efficient aeration technology to replace aging brush aerators
- Secondary clarifier enclosure needs repairs
- Sludge handling equipment needs replacement.

7.10 Elmira WWTP

The Elmira WWTP is a biological nutrient removal (BNR) plant with a rated average day flow capacity of 7,800 m^3/d. The current average day flow was 4,400 m^3/d between 2012 and 2014, or approximately 55% of the rated capacity. The treated effluent is discharged to the Canagagigue Creek.

7.10.1 Capacity Needs

As described in Section 3, the Elmira WWTP will require an expansion by the year 2039 based on the moderate growth scenario. However, influent concentrations at the Elmira WWTP are higher than the original design and will limit the ability of the existing plant to treat the rated flow capacity. This will be considered as part of the overall implementation timing recommendations for the preferred option.

7.10.2 Effluent Quality Considerations

The existing facility provides a high level of nitrification and tertiary phosphorus removal. It is expected that a reduction in TP concentrations to the receiving water will be required as part of a future expansion for the Elmira WWTP.

7.10.3 Plant Specific Opportunities

Table 23 provides a summary of the options discussed in Section 6 related to accommodating growth, as well as operational enhancement and energy reduction, and identifies those that are recommended for further development and evaluation.

It is important to note that some of these options will be incorporated in conjunction with one another and do not provide stand-alone options to achieve all Region objectives.

Table 23 Summary of Options for Elmira WWTP

Potential Option		Feasibility for Elmira WWTP	Rationale
Diversion		X	• Not considered due to significant distance for pumping to Waterloo WWTP, as well as significant capital impact on Waterloo WWTP.
I/I Reduction		✓	• I/I reduction is a potential opportunity as wet weather flows are higher than normal mixed residential/commercial/industrial uses.
Industrial Pre-treatment		✓	• Potential opportunity due to high loadings from industrial uses.
Expansion	Re-Rating	✓	• Re-rating may provide for 2051 flows.
	Conventional	✓	• Expansion required to accommodate 2051 flows.
	New Technology	✓	• Expansion required to accommodate 2051 flows. • Opportunity to evaluate/test developing technologies; granular sludge pilot is being planned.
Effluent Quality Improvements		✓	• Phosphorus reduction expected to be required with the next expansion. • As discussed in Section 4, options to achieve TP reduction include phosphorus offsetting, or expansion of conventional tertiary treatment.
Operational Enhancement	DO Control and Anoxic Selector	X	• Anoxic selector already incorporated in BNR process.

Potential Option		Feasibility for Elmira WWTP	Rationale
and Energy Reduction	CEPT	X	• Minimal benefit with no anaerobic digestion process.
	Sidestream Treatment	X	• Minimal benefit with no anaerobic digestion process.
	Automation Upgrades	✓	• Decreased energy requirements through more efficient aeration. • Potential for online ammonia and phosphate analyzers

7.10.4 Asset Management and Renewal

General asset management and renewal opportunities have been noted that should be considered at all plants when other upgrades or projects are undertaken at the facility (refer to Section 6.4).

Specific to the Elmira WWTP, the following asset management and renewal items should be considered:

- Primary and secondary clarifier mechanisms need replacement or repair

8. Short-List of Options

8.1 Regional Wastewater Options for Further Development

As previously discussed, options are generally grouped into two overall categories, being opportunities to accommodate growth (diversion of flows, I/I reduction, industrial pre-treatment and expansion), and opportunities to enhance operations and reduce energy usage (such as sidestream treatment, DO control and anoxic selectors, chemically enhanced primary treatment, automation upgrades, etc.). Other Regional wastewater options that are not stand-alone solutions, but are considered as part of the implementation of the Regional approach for wastewater treatment, include watershed management, resource recovery, asset management and renewal, and water re-use. These options are also discussed in this section.

The following Regional wastewater options will be carried forward for further development related to the evaluation criteria (documented in TM5 - Evaluation Methodology):

- Accommodate growth
- Enhance operation and reduce energy usage
- Asset management and renewal
- Watershed management
- Water re-use

All of the options discussed as Regional wastewater options will be carried forward for evaluation in TM10 - Development and Evaluation of Short-Listed Options. Implementation of components of the Regional wastewater options at the plant specific level is discussed in Section 8.2.

8.2 Plant Specific Options for Further Development

Plant specific options are listed in the following sections that are being short-listed for further development relative to the evaluation criteria. Options are listed under two separate categories, including:

- Capacity options to accommodate growth and address effluent quality considerations, for evaluation using evaluation criteria documented in TM5 - Evaluation Methodology

- Opportunities for operational enhancement, and energy reduction, for evaluation using a business case

8.2.1 Plant Specific Options to Accommodate Growth and Address Effluent Quality

The following sections provide a list of the short-listed options for each treatment plant related to growth and effluent quality to be further developed and evaluated in TM10 - Development and Evaluation of Short-Listed Options.

Capacity and Phosphorus Reduction for Waterloo WWTP

1. Diversion to Kitchener WWTP with tertiary equivalent at Waterloo WWTP
2. Expansion with phosphorus trading
   - Re-rating with phosphorus trading with Kitchener WWTP
   - Conventional with phosphorus trading with Kitchener WWTP
   - New technology with phosphorus trading with Kitchener WWTP
3. Expansion with phosophorus removal
   - Re-rating with tertiary treatment
   - Conventional with tertiary treatment
   - New technology with tertiary treatment

Capacity and Phosphorus Reduction for Hespeler WWTP

1. Expansion with phosphorus off-setting
   - Conventional with phosphorus off-setting
   - New technology with phosphorus off-setting
2. Expansion with phosphorus removal
   - Conventional with phosphorus removal (optimization of secondary treatment)
   - New technology with phosphorus removal (optimization of secondary treatment)

Phosphorus Reduction for Preston WWTP

1. Process optimization to achieve phosphorus reduction
2. Non-point phosphorus off-set with no change to existing Preston WWTP limits

Capacity for St Jacobs WWTP Service Area

1. Diversion to Waterloo WWTP with I/I reduction
2. Expand St Jacobs WWTP with I/I reduction
    - Conventional
    - New technology
    - Consider P off-setting if required to simplify technology train for quality beyond tertiary equivalent

Capacity for Elmira WWTP Service Area

1. Expand Elmira WWTP with industrial pre-treatment and I/I reduction
    - Conventional
    - New technology
    - Consider P off-setting if required to simplify technology train for quality beyond tertiary equivalent

Capacity for Wellesley WWTP Service Area

1. Expand Wellesley WWTP with I/I reduction
    - Conventional
    - New technology
    - Consider P off-setting if required to simplify technology train for quality beyond tertiary equivalent

Table 24 summarizes the plant specific options to accommodate growth and address effluent quality.

Table 24 Plant Specific Options for Growth and Effluent Quality

Plant	I/I Reduction	Industrial Pre-Treatment	Diversion	Expansion	Phosphorus Removal[1]	Phosphorus Off-Setting	Phosphorus Trading
Kitchener WWTP							
Waterloo WWTP			✓ **(to Kitchener WWTP)**	✓	✓ **(Expansion and Lake Erie targets)**		✓ **(Expansion and Lake Erie targets)**
Galt WWTP							
Preston WWTP					✓ **(Lake Erie targets)**	✓ **(Lake Erie targets)**	
Hespeler WWTP				✓	✓ **(Expansion and Lake Erie targets)**	✓ **(Expansion and Lake Erie targets)**	
Wellesley WWTP	✓			✓	✓ **(Expansion)**	✓ **(Expansion)**	
Ayr WWTP							
New Hamburg WWTP							
St Jacobs WWTP	✓		✓ **(to Waterloo WWTP)**	✓	✓ **(Expansion)**	✓ **(Expansion)**	
Elmira WWTP	✓	✓		✓	✓ **(Expansion)**	✓ **(Expansion)**	

Notes:

1. Phosphorus removal includes teriarty filtration treatment that provides a tertiary equivalent effluent quality, and process optimization to reduce phosphorus effluent concentrations

8.2.2 Plant Specific Options for Operational Enhancement and Energy Reduction

The following sections provide a list of the short-listed options for each treatment plant related to operational enhancement and energy reduction to be further developed and evaluated in TM10 - Development and Evaluation of Short-Listed Options.

Kitchener WWTP

1. CEPT
2. Sidestream treatment
3. Automation upgrades

Waterloo WWTP

1. CEPT
2. Sidestream treatment
3. Automation upgrades

Galt WWTP

1. Sidestream treatment
2. Anoxic selector
3. Automation upgrades

Hespeler WWTP

1. Anoxic selector
2. Automation upgrades

Wellesley WWTP

1. Anoxic selector
2. Automation upgrades

St Jacobs WWTP

1. Anoxic selector
2. Automation upgrades

All other treatment plants have the option for automation upgrades. Table 25 summarizes the plant specific options for operational enhancement and energy reduction.

Table 25 Plant Specific Options for Operational Enhancement and Energy Reduction

Plant	CEPT	Sidestream Treatment	Automation Upgrades	DO Control and Anoxic Selector
Kitchener WWTP	✓	✓	✓	
Waterloo WWTP	✓	✓	✓	
Galt WWTP		✓	✓	✓
Preston WWTP			✓	
Hespeler WWTP			✓	✓
Wellesley WWTP			✓	✓
Ayr WWTP			✓	
New Hamburg WWTP			✓	
St Jacobs WWTP			✓	✓
Elmira WWTP			✓	

9. Next Steps

The next steps in the WWTMP process include the development of information to enable the evaluation of options, including:

- Develop information on the short list of growth/effluent quality alternatives
  - Comparison and score each against evaluation criteria
  - Identify preferred alternatives
- Develop information on the opportunities for energy savings
  - High level business case with approximate capital and operating costs for each
  - Work with Region to identify appropriate timing for each opportunity
  - Budget constraints, shortest payback, with planned infrastructure asset renewals, etc.

This information will be summarized in TM10 - Development and Evaluation of Short-Listed Options, and evaluated using the evaluation criteria documented in TM5 - Evaluation Methodology.