Appendix L

TM-10 - Development and Evaluation of Short-Listed Options



Region of Waterloo

Wastewater Treatment Master Plan Update

Technical Memorandum No. 10
Development and Evaluation of Short-Listed Options

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1. Introduction

1.1 Background

The Regional Municipality of Waterloo (Region) is an upper tier municipal government, providing municipal services to seven local 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 pumping station under construction), and two (2) 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 convey 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 that this trend will continue due to a strong local economy, the Province of Ontario's Places to Grow 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. In light of changes to population projections, wastewater flows and environmental regulations, the Region has initiated an update to its WWTMP.

This Technical Memorandum No. 10 (TM10) has been prepared to evaluate the short-listed liquid and solids treatment options identified in Technical Memorandums No. 6 (TM6) and No. 7 (TM7).

1.2 Purpose of Technical Memorandum No. 10 (TM10)

The purpose of TM10 is to:

- Evaluate the short-listed WWTP growth/level of treatment alternatives
  - Develop information on each alternative

  - Compare and score each alternative against evaluation criteria
  - Identify preferred alternatives
- Evaluate the short-listed pumping station alternatives
  - Develop information on each alternative
  - Compare and score each alternative against evaluation criteria
  - Identify preferred alternatives
- Develop information on WWTP opportunities for energy savings and operational enhancements
  - Develop high level business case with approximate capital and operating costs for each opportunity

2. Short-Listed Alternatives

This section summarizes the recommended short-listed liquid and solids treatment options for further evaluation from TM6 and TM7.

2.1 Regional Wastewater Options

The following lists the options that do not form standalone solutions for any facility, but are short-listed and carried forward from a holistic Regional perspective as offering benefit from either environmental, social, technical or economic perspectives:

- Watershed management
- Resource recovery
- Asset management and renewal
- Water re-use
- Decrease inflow & infiltration (I/I)
- Industrial pre-treatment

These options are presented in Section 3.

2.2 Plant Specific Alternatives for Evaluation (Growth and Level of Treatment)

Table 1 presents the short-listed plant specific alternatives to accommodate growth and address level of treatment for evaluation for each WWTP. These alternatives are developed in Section 4. A detailed evaluation of each alternative against WWTMP evaluation criteria is provided in Section 5.

Table 1 Short-Listed Plant Specific Alternatives to Growth and Level of Treatment

Plant	Alternative No.	Description of Alternative
Waterloo WWTP	Wa1	Diversion to Kitchener WWTP
	Wa2	Expansion
	Wa3	Phosphorus Removal with Expansion to Meet ACS Targets and Lake Erie Basin Targets (1)
	Wa4	Phosphorus Trading (with Kitchener WWTP)
Preston WWTP	Pr1	Phosphorus Removal to Meet Lake Erie Basin Targets
	Pr2	Phosphorus Off-setting
Hespeler WWTP	He1	Expansion
	He2	Phosphorus Removal with Expansion to Meet ACS and Lake Erie Basin Targets (1)
	He3	Phosphorus Off-setting
Wellesley WWTP	We1	Expansion
	We2	Phosphorus Removal with Expansion to Meet ACS Targets
	We3	Phosphorus Off-setting
St Jacobs WWTP	SJ1	Diversion to Waterloo WWTP
	SJ2	Expansion
	SJ3	Phosphorus Removal with Expansion to Meet ACS Targets
	SJ4	Phosphorus Off-setting
Elmira WWTP	El1	Expansion
	El2	Phosphorus Removal with Expansion to Meet ACS Targets
	El3	Phosphorus Off-setting

Notes:

1. Phosphorus removal is expected to be required as part of the plant expansion to meet ACS targets, and/or to meet Lake Erie Basin targets. If expansion were deferred for any reason, then the Lake Erie targets will still need to be met.

It can be noted that Lake Erie Basin targets are expected to be lower for the Galt WWTP than current ECA requirements for phosphorus, however, the plant has tertiary filters installed and could meet this target with minor operational changes. Upgrades to the tertiary filtration system for Galt WWTP would not be required.

Solids stream upgrades are not discussed in this TM. Upgrades identified for the Galt, Wellesley, and Elmira WWTPs do not require detailed evaluation and upgrades will be included in the WWTMP Implementation Plan.

2.3 Plant Specific Options for Business Case Consideration (Enhance Operations and Reduce Energy Usage)

Table 2 presents the short-listed plant specific alternatives for business case consideration (enhance operations and reduce energy usage) for each WWTP. Details on business case opportunities are provided in Section 6.

Table 2 Short-Listed Plant Specific Alternatives for Enhanced Operation and Reduced Energy Usage

Option	Plants at which Option will be Considered	Purpose
Chemically Enhanced Primary Treatment (CEPT)	Kitchener WWTP	• Increase gas production compatible with CHP currently being installed
	Waterloo WWTP	
Sidestream Treatment	Kitchener WWTP	• Increase treatment plant capacity; • Lower aeration energy cost.
	Waterloo WWTP	
	Galt WWTP	
Anoxic Selector	Galt WWTP	• Reduce aeration energy
	Hespeler WWTP	
	Wellesley WWTP	
	St Jacobs WWTP	
Automation Upgrades	Kitchener WWTP	• Reduce aeration energy; • Improve nutrient removal performance
	Waterloo WWTP	
	Galt WWTP	
	Preston WWTP	
	Hespeler WWTP	
	Ayr WWTP	
	New Hamburg WWTP	
	Wellesley WWTP	

Option	Plants at which Option will be Considered	Purpose
	St Jacobs WWTP	
	Elmira WWTP	
Co-Digestion	Kitchener WWTP	• Increase gas production compatible with CHP currently being installed
	Waterloo WWTP	
Thermal Hydrolysis Pre-Treatment	Kitchener WWTP	• Increase gas production compatible with CHP currently being installed
	Waterloo WWTP	
	Galt WWTP	
TPAD	Kitchener WWTP	• Increase gas production compatible with CHP currently being installed
	Waterloo WWTP	
	Galt WWTP	
Post-Aerobic Digestion	Kitchener WWTP	• Increase treatment plant capacity; • Lower aeration energy cost.
	Waterloo WWTP	
	Galt WWTP	

In addition to the ten (10) larger plants, the Region owns three (3) smaller treatment plants: Foxboro, Conestogo and Heidelberg. These facilities are communal treatment plants servicing only a single residential development and do not have future growth needs, therefore no specific alternatives have been evaluated for these facilities. There may be opportunities for operational improvements, however these would be implemented on an asset renewal basis.

2.4 Pumping Station Options for Evaluation

Table 3 presents the short-listed pumping station options for evaluation. Section 7 provides details on pumping station alternatives.

Table 3 Short-Listed Pumping Station Options

Pumping Station	Alternative No.	Description of Alternative
Bridgeport SPS	B1	Do nothing (has capacity to meet 2051 flows)
Spring Valley SPS	SV1	Expansion to accommodate growth
Baden SPS	Baden1	Continue hauling excess wastewater to accommodate growth
	Baden2	Equalization tank expansion for peak flow
	Baden3	Expansion to accommodate growth
Morningside SPS	M1	Expansion to accommodate growth
Rose Street SPS	RS1	Do nothing (has capacity to meet 2051 flows)
Ayr SPS	A1	Do nothing (has capacity to meet 2051 flows)
Nith River Way SPS	NRW1	Do nothing (has capacity to meet 2051 flows)

3. Regional Wastewater Options

3.1 Watershed Management

The Grand River watershed drains an area of 6,800 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.

Since the completion of the 2007 WWTMP, the Grand River Conservation Authority (GRCA), watershed municipalities, provincial governments, federal departments, and First Nations came together in 2009 to review and update the Grand River Watershed 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 has been a key stakeholder in the development of the 2014 WMP. Another key initiative that the Region has undertaken since the completion of the 2007 WWTMP is the Surface Water Quality Monitoring Program (SWQMP). 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 River (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, the feminization of fish dropped to 29 per cent. Within three years, it dropped below 10 per cent (Servos, 2017).

3.2 Resource Recovery

Wastewater has a number of constituents that can be considered as a resource for recovery. Key items for consideration are nutrients (nitrogen and phosphorus) for fertilizer production and biopolymers, recovery of valuable trace metals or using digester gas to produce methanol or ammonia. There are also opportunities for converting biosolids to a resource (i.e., fuel source, additive for brick manufacturing, etc.), which are considered as part of the parallel Biosolids Master Plan.

The key factors for consideration include technologies available to recover resources from wastewater treatment, their operating costs and identifying markets for the resources. Wastewater resource recovery is still an emerging field and to date most of the developed technologies have focused around nutrient recovery. However, the majority of the WWTP infrastructure in the Region is based on the addition of metal salts to precipitate phosphorus and current nutrient recovery technologies (i.e., OSTARA® or similar) would need to be evaluated in more detail in terms of their economic viability.

Research on new technologies for resource recovery is on-going and should be reviewed at the time of any upgrades and as part of future Master Plan updates for future applicability to Region facilities. In consideration of the high level of treatment and cost of nutrient removal required at most Region plants, technologies that can provide phosphorus and/or nitrogen recovery could provide immediate benefit in reduced WWTP operating costs and nutrient loadings to the receiving water. As an example of developing technologies, high-rate algae production is being developed to recover phosphorus with the benefits of lower loadings to the receiving waterbody, reduced chemical costs and opportunities for biopolymer production. This technology has been implemented in WWTPs in the United States in Perrysburg, Ohio, Millbury, Massachusetts, and Missoula, Montana, with similar climates to Southern Ontario.

3.3 Asset Management and Renewal

The Region has significant investments in wastewater infrastructure across Waterloo 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 like 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 an opportunity to consider incorporation of an anoxic selector, at the facilities where this is not already present, to reduce energy consumption (see Section 6 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 turn-down capacity and/or alternative disinfection technologies (i.e., peracetic acid or similar).

As part of asset management and renewal, the Region should consider the energy use of each of the treatment processes. Although energy neutrality is not currently within the Master Plan's mandate, energy reduction strategies provide a foundation for potentially becoming energy neutral in the future. A separate study is recommended to develop the framework for becoming energy neutral to allow strategic investments in wastewater infrastructure at the time of asset renewal or upgrades that work towards this vision in a way that is financially sustainable.

Plant-specific opportunities related to asset renewal were identified in Technical Memorandum 6: Liquid Treatment Alternatives (TM6), however, they are not discussed in detail as part of TM10 as alternatives and preferred options should be

determined at the time of replacing any asset based on the latest available technology.

3.4 Water Re-use

Re-use of treated wastewater should be considered to reduce potable water consumption 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, the Region's northern climate (resulting in seasonal applications and need for storage for some re-use options), and the two-tiered system whereby the Region is responsible treatment and the area municipalities are responsible for collection systems (for the most part). However, there are also potential advantages such as the reduction in treatment requirements, reduced loading to the receiving water and the decrease in potable water use for industrial or agricultural purposes.

There are opportunities to investigate water re-use in the context of the development of the East Side Lands (ESLs) as there is significant employment development proposed within those lands where water re-use may be feasible and beneficial. There are also 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. It can be noted that 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.

The following sections provide a high-level review of treated municipal wastewater re-use in terms of options, water quality and level of treatment requirements, and economic, social and environmental factors for consideration for future implementation.

3.4.1 Options for Water Re-Use

Several options for water re-use are available, however, for the most part they have not been implemented within Ontario or Canada. The following are general options for water re-use:

- Non-Potable Water Re-use
  - Reuse for irrigation
  - Industrial re-use
  - Greywater re-use
- Potable Water Re-use
  - Direct potable water re-use
  - Indirect potable water re-use

3.4.2 Re-Use Water Quality Requirements/Standards

Currently there are no national guidelines or regulations for water re-use and reclamation in Canada, with the exception of the “Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing” (Health Canada, 2009), which were developed to promote on-site household reclaimed water use for the purpose of reducing potable water consumption.

At the provincial level, only the provinces of British Columbia and Alberta have developed regulatory guidance related to water re-use. In 2000, Alberta Environment published the “Guidelines for Municipal Wastewater Irrigation”, which supported the re-use of treated municipal wastewater for irrigation only when it is environmentally acceptable and agriculturally beneficial. In May 2001, British Columbia Ministry of Environment published a Code of Practice for the Use of Reclaimed Water (BCMELP, 2001), which serves as a guidance document for the use of reclaimed water in British Columbia and is designed to support the regulatory requirements prescribed in the Municipal Sewage Regulation.

In Ontario, there are currently no provincial policies or regulations governing water re-use and reclamation. The Ontario Ministry of the Environment and Climate Change (MOECC) decision to approve water re-use for any applications is made on a case-by-case basis, from the perspective of protecting the environment, as well as risk to human health.

In the United States, legislation for water reuse applications is the responsibility of the individual states and this varies considerably from state to state. Although there is no federal regulation, the U.S. EPA in 2012 published the revised “Guidelines for

Water Reuse" document to provide greater detail about the wide range of reuse applications and introduce new health considerations and sewage treatment technologies.

3.4.3 Level of Treatment Requirements and Other Factors

Table 4 presents a summary of the level of treatment and economic, social and environmental factors for various water re-use options (MOECC, 2011).

Generally, secondary treatment with disinfection, and in some cases supplemental disinfection, is a requirement for most water re-use options due to the potential for human exposure to effluent microbes.

Given the large water demands and relative lower water quality requirements associated with agricultural irrigation and landscape irrigation, opportunities exist for water re-use to reduce the reliance on freshwater sources. These are the areas that are most suitable for water re-use of reclaimed water. However, it should be noted that irrigation of food crops with reclaimed water is more complicated than irrigation of non-food crops, which usually requires secondary treatment, filtration and high-level disinfection of municipal wastewater to minimize risks of microbial contamination of the crops especially those grown for raw consumption (USEPA, 2012, and WHO, 2006).

Other areas, such as industrial (e.g, use for boiler feed or cooling water), commercial, and environmental and recreational uses require higher treatment than agricultural and irrigation application. For example, use of reclaimed water as boiler feed water usually requires extensive additional treatment. This is because the quality of boiler feed water is typically equivalent to or better than that of potable water. When used in a cooling water system, water quality issues such as corrosion, biological growth, and scaling, would also need to be considered. There are opportunities for applications in these areas depending on the specific water demand and water quality requirements. Another opportunity for water reuse is groundwater recharge, where reclaimed water is routed to the subsurface to ensure sustainable groundwater management.

Table 4 Level of Treatment Requirements and Factors for Water Re-use (1)

Re-use Option	Level of Treatment Required	Economic Factor: Capital Costs	Economic Factor: O&M Costs	Social Factor: Potential Health Risk	Social Factor: Public Acceptance	Environmental Factor: Energy Use	Environmental Factor: Potential for Adverse Impact
Agricultural	Low	Low	Low	Low	High	Low	Medium
Landscape irrigation	Low	Low	Low	Low	High	Low	Low
Environmental and recreational	Low – Medium	Low	Low	Medium	High	Low	Low
Domestic	Low – Medium	Low	Low – Medium	Medium	Medium	Medium	Low
Commercial	Low – Medium	Low	Low – Medium	Medium	Medium – High	Medium	Low
Industrial	Low – High	Low – High	Low – High	Low – Medium	High	Low – High	Low
Indirect potable use	High	High	High	Medium – High	Low – Medium	High	Low
Direct potable use	High	High	High	High	Low	High	Low
Other urban uses	Medium – High	Medium – High	Medium – High	Medium	Medium	Medium	Low

Notes:

1. Based on MOECC (2011), “Water and Energy Conservation Guidance Manual for Sewage Works”.

(Source: https://www.ontario.ca/document/water-and-energy-conservation-guidance-manual-sewage-works/water-reclamation-and-reuse)

The treatment requirements and cost associated with water re-use for potable water could be significantly higher than agricultural and industrial applications. In addition, public acceptance could be a barrier for this type of application, especially in Ontario where more fresh water resources are considered to be available.

3.4.4 Water Re-Use Case Studies

At present, water re-use and recycling in Canada is practiced on a relatively small scale and varies regionally depending on the availability of water supplies and regulatory flexibility. Typical applications include using treated municipal wastewater to irrigate agricultural non–food crops, urban parkland, landscaping and golf courses.

One successful example in Ontario is Ballantrae Golf & Country Club, in Ballantrae York Region, which is a privately owned and operated treatment facility treating 1,045 m^3/day of sewage from a 900-person residential development and a golf course. The treatment facility contains full biological and tertiary treatment. The treated effluent is disinfected with a UV disinfection system and used for irrigation of golf courses. Using the reclaimed water from the sewage treatment plant has allowed the facility to meet its irrigation needs, while operating in a location that is not serviced by a municipal water supply.

Another example is the Gold Bar Tertiary WWTP in Edmonton where the treated effluent is used for a Suncor Refinery (approximately 15,000 m^3/d) for hydrogen and steam production, and cooling applications.

3.4.5 Key Factors for Water Re-use Feasibility at Region of Waterloo

For future consideration of water re-use within the Region of Waterloo, a more detailed study would be required to verify the applicability and feasibility of water re-use options. Some key factors to consider through this assessment include:

- Identification of users and types of re-use demands
- Effluent quality and volume available for re-use
- Location of the potential end user(s) relative to the wastewater treatment facility
- Level of treatment required and technical feasibility
- Costs associated with treatment and distribution of re-use water

- Regulatory requirements
- Public acceptance: most areas in Ontario have abundant water resources and significant public consultation may be required to gain public support
- Health concerns: without the use of advanced treatment technologies, there are risks to human health associated with the microbiological and/or chemical constituents in treated wastewater
- Environmental concerns: ecosystems can be affected by constituents in treated wastewater associated with water reclamation and re-use.

3.5 Decrease Inflow & Infiltration (I/I)

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 essential to allow the treatment plant to operate properly, to alleviate any concerns with plant bypasses due to high I/I flows, as well as to enable the accurate planning of upgrades or expansions to the treatment plants.

There are challenges with the implementation of I/I reduction programs due to the two-tiered system whereby local municipalities are responsible for collection systems and the Region is responsible for treatment. However, a number of initiatives have been undertaken to identify and remedy I/I issues, including the following:

- Cost sharing agreement between the Region and the Township of Woolwich from October 1997 to December 2008, where the Township of Woolwich completed work to identify and reduce inflow and infiltration in Elmira and St Jacobs, including the following components:
  - Elmira I/I Study Overview (1998 to 2008) – Included infrastructure condition surveys, household surveys, groundwater and rainfall monitoring, sanitary sewer system monitoring.
  - Elmira I/I Reduction Capital Projects – Installation of new municipal services for sewer separation (i.e. third pipe solution of storm, sanitary and I/I sewer), including some new private side connections to the new sanitary sewers and manhole rehabilitation.

  - St Jacobs I/I Study Overview (1998 to 2008) – Included infrastructure condition surveys, household surveys, rainfall monitoring, sanitary sewer system monitoring, CCTV inspections, fog testing.
  - St Jacobs I/I Reduction Capital Projects – manhole rehabilitation and sewer repairs.

- Investigation completed by the Region within the Township of Wellesley, where the collection system has been owned by the Region since 2005, including the following components:
  - Sanitary Sewer Investigation Inflow and Infiltration Report (RVA, 2008) – investigation including two rounds of flow monitoring, smoke testing, CCTV inspection, and visual manhole inspections during wet weather events.
  - Sanitary Sewer Investigation Design Repair Report (RVA, 2008) – design report for repair of sanitary manholes near Firella Creek and sections of sewer along Nafziger Road
  - Sewage Flow Monitoring (RVA, 2010) – flow monitoring to confirm the reduction of I/I related to the sanitary manholes near Firella Creek and sections of sewer along Nafziger Road
  - Wellesley I/I Assessment and Mitigation Plan (GM BluePlan, 2017) – Flow monitoring and CCTV inspections have been completed
  - Capital Budget/Program has rehabilitation and repair work scheduled for 2018/2019 based on the findings of the 2017 CCTV inspection
- Investigation within the Township of North Dumfries, including the following components:
  - Sanitary Sewer Inflow and Infiltration Study – Community of Ayr (XCG, 2003) - study by the Township of North Dumfries including a flow monitoring program in 2000 and visual inspections of infrastructure that indicated extraneous flows were primarily infiltration.
  - 2007 Sanitary Sewer Flow Monitoring and Analysis in Swan St Area of Ayr (Thompson Flow Investigations, 2008) - conducted by a developer to confirm capacity in Swan St sewers in support of proposed development

progressing. Study indicated low I/I within the area of monitoring near Swan St and no follow up actions were recommended at that time.

- Ayr I/I Assessment and Mitigation Plan (GM BluePlan, 2017) – Flow monitoring and CCTV inspections have been completed
- Capital Budget/Program has rehabilitation and repair work scheduled for 2018/2019 based on the findings of the 2017 CCTV inspection

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 approach for I/I reduction should include a public awareness campaign to increase the level of understanding of the impacts of foundation drain and downspout connection to the collection system.

Elevated I/I has been identified as a problem within the following WWTP service areas:

+ St Jacobs
+ Elmira
+ Wellesley
+ Ayr

For the above listed service areas, I/I reduction should form an integral part of any approach for that treatment plant; however, it will not serve as a stand-alone solution.

3.6 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 pretreatment, 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: suspended solids, biochemical oxygen demand, Kjeldahl nitrogen, and phosphorus. 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 strategies 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.

3.6.1 Short-Term Actions

Based on the experience from many North American municipalities, efforts at the initial stage of the industrial pre-treatment programs are needed in identifying the impact of industrial discharge loadings and developing industrial discharge effluent limits through comprehensive survey and investigations. Updated Sewer-Use By-Laws and/or local regulation changes can then be used as the basis for implementing an industrial pre-treatment program.

In general, short-term actions in preparation of an industrial pre-treatment program include:

- Conduct industrial waste survey and WWTP raw wastewater sampling and analysis to identify the impact of loadings and any inhibitory substances from industries on the plant operations
- Perform technical evaluation to establish the industrial discharge limits
- Establish legal control mechanisms such as permit, contract, agreement, order, termination, etc. to be used to implement and enforce the pre-treatment regulations and Sewer-Use By-Laws
- Identify industrial dischargers that require pre-treatment (i.e. for those exceeding limits and instances where Surcharge Agreements are not possible). Notify the

industrial dischargers of all pre-treatment standards, bylaws, and the implementation deadline/schedule.

- Develop an effective compliance monitoring system.

3.6.2 Long-Term Actions

The long-term actions should focus on enhancing the monitoring program, optimizing the enforcement strategies, and continuously improving the program. Actions could include:

- Enhance inspection and monitoring program: optimizing the inspection frequency, standardizing the sampling and monitoring procedures
- Update the discharge limits and pre-treatment bylaws based on operation performance and regulation changes.
- Optimize the control mechanisms. Update the existing dischargers and identify new dischargers through permit application, periodical expiration, and renewal procedures.
- Optimize the compliance implementation system to easily schedule, track and evaluate sample analysis compliance, evaluate discharge concentration and loading.

3.6.3 Implementation within the Region of Waterloo

The Region of Waterloo is in the process of reviewing and updating the Sewer-Use By-Law. This includes an evaluation of the existing discharge limits and prohibitions, current industrial discharges and their impact on the Region's Wastewater Treatment Plants. The Region is also reviewing the Surcharge rate calculation method and plans to incorporate recommended changes in the Sewer-Use By-Law.

Surcharge Agreements are valid for one year. Limits are adjusted based on impact, available treatment capacity and actual discharge characteristics prior to renewal.

Based on the experience from other Ontario and North American municipalities, a combination of preventing discharge of any inhibitory substances and allowing a capped over-strength surcharge appears to be the most widely adopted approach to implementing industrial pre-treatment programs. The collected service fees and

surcharge fees can be used for improvement of wastewater treatment systems and optimization of the industrial pre-treatment program.

4. Plant-Specific Alternatives for Evaluation

The following section provides a summary of each plant-specific alternative in terms of the following:

- Description of the alternative and operating condition
- Key new tankage and/or equipment requirements
- Capital, operation and maintenance (O&M), and life-cycle costs.

Where not specifically discussed within each option, environmental, social, and legal/jurisdictional information is provided relative to the evaluation criteria for those categories in the detailed evaluation matrices in Section 5.

It should be noted that any treatment plant upgrades or expansions recommended 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 has been developed in the period between the assessment and the implementation of the upgrade.

4.1 Waterloo WWTP

The Waterloo WWTP is a conventional activated sludge plant, with an existing ECA approved hydraulic capacity of 72,730 m^3/d and a rated average day flow (ADF) capacity of 57,500 m^3/d. The current ADF is 46,600 m^3/d, or approximately 80% of the rated capacity. The treated effluent is discharged to the Grand River, a MOECC Policy 2 receiver with respect to total phosphorus (TP).

The following opportunities/constraints were identified for treatment of future flows and loadings for the Waterloo WWTP in TM6:

- Expansion is required by the year 2041 to a minimum design ADF of 63,600m^3/d (to accommodate projected 2051 flows of 60,500 m^3/d with a 5% safety factor). This is considered as part of the following alternatives:

  - Wa1 – Diversion to Kitchener WWTP
  - Wa2 – Expansion of Waterloo WWTP

- Phosphorus removal is expected to be required as part of the plant expansion to meet effluent phosphorus targets and Lake Erie Basin targets. This is considered as part of the following alternatives:
  - Wa3 – Phosphorus Removal (new tertiary filters) at Waterloo WWTP
  - Wa4 – Phosphorus Trading with Kitchener WWTP

The alternatives to address these opportunities/constraints to accommodate both growth and level of treatment are discussed in the following sections.

4.1.1 Wa1: Diversion to Kitchener WWTP

Description of Alternative

Option Wa1 is based on diverting flow in excess of the existing rated capacity (57,500 m^3/d) of the Waterloo WWTP to the Kitchener WWTP for treatment. The Bridgeport Sewage Pumping Station (SPS) would be upgraded to divert wastewater to the Kitchener WWTP, through the existing Spring Valley SPS, its associated forcemain and the downstream City of Kitchener trunk sewer. The intent of this diversion is to utilize excess capacity available at the Kitchener WWTP and defer a significant capital expansion of the Waterloo WWTP.

The Kitchener WWTP has a rated capacity of 122,745 m^3/d. The average plant flow was 70,290 m^3/d during 2011 to 2015 based on the 2016 Water and Wastewater Monitoring Report (WWWMR) (RMOW, 2017). The projected 2051 flow to the Kitchener WWTP with East Side Lands (ESL) is 111,500 m^3/d.

Diversion of a minimum of 3,000 m^3/d from the Waterloo WWTP will be required to maintain flow to the Waterloo WWTP below 57,500 m^3/d. With the diversion, the projected flow to the Kitchener WWTP would remain below the existing rated capacity of 122,700 m^3/d. As a result, this alternative would not require the expansion of either the Kitchener WWTP or the Waterloo WWTP within the 2051 planning period. Currently, average flows to the Bridgeport SPS are approximately 2,770 m^3/d (based on 2016 data), expected to increase to approximately 3,620 m^3/d in 2051. This capacity is sufficient to divert the required 3,000 m^3/d.

The following work would be required to facilitate the diversion from the Waterloo WWTP to the Kitchener WWTP:

- Upgrades to the Bridgeport Sewage Pumping Station (SPS) and construction of new forcemain and gravity sewer.
- Upgrades to the Spring Valley SPS and downstream forcemain. It is expected that the capacity of the existing Spring Valley SPS and forcemain would need to be increased from 245 L/s to 381 L/s for the diversion, according to the recently completed Bridgeport Sewage Pumping Station Flow Diversion Feasibility Study (R.V. Anderson, 2016). This study assumed the expanded capacity of the Spring Valley SPS was the total of the existing firm capacities for both stations (245 L/s for Spring Valley SPS and 135 L/s for the Bridgeport SPS). Based on flow projections completed as part of the WWTMP, it is anticipated that a slightly greater capacity would be needed for Spring Valley SPS (flow projection in 2051 is 252 L/s), however, the projections for Bridgeport remain below the existing firm capacity (flow projection of 114 L/s in 2051). Therefore, an estimated capacity of 381 L/s for the Spring Valley SPS was considered to be adequate should the Bridgeport SPS flows be diverted to the station.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 5 for Option Wa1. Operating costs include items to allow comparison between options, including energy, chemical consumption, equipment maintenance and labour. Additional cost estimate details are provided in Appendix B.

It should be noted that the cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report.

Table 5 Cost Estimate – Option Wa1: Diversion to Kitchener WWTP

Item	Cost
Capital Cost (1)	$5,200,000
Annual O&M Cost	$1,034,000
PV Life Cycle Cost (2)	$14,959,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to year 2051.

It can be noted that asset renewal opportunities have also been identified for the Spring Valley SPS as part of the Region's Asset Management Program. The estimated capital cost in Table 5 is for expansion only, however, there may be some alignment between initiatives, such as replacement of pumps, electrical upgrades, etc.

4.1.2 Wa2: Expansion

Description of Alternative

The following alternatives were considered for the Waterloo WWTP expansion, to accommodate an expanded capacity of 63,600 m^3/d, which includes a 5% safety factor on the 2051 future flow of 60,500 m^3/d:

- Wa2a - Conventional Plant Expansion
- Wa2b - Convert to New Technology
- Wa2c - Re-rating through Optimization and/or Minor Works

All options related to expansion may impact the outfall of the Waterloo WWTP. A detailed hydraulic assessment is recommended to confirm the existing outfall capacity; however, it was assumed for the purposes of the WWTMP that the impact would be the same between each of the expansion options and would not affect the evaluation of alternatives.

Wa2a - Conventional Plant Expansion

This option is based on expanding the existing plant with a conventional activated sludge (CAS) process. To achieve the required capacity of 63,600 m^3/d and to meet the future effluent quality requirements, the following work would be required for the expansion of the existing CAS process:

- Add one additional raw wastewater pump and one additional effluent water pump within the existing building footprint
- Construction of an additional secondary clarifier in the space previously occupied by the existing Stage 1 tankage, complete with RAS pumping provisions.

It can be noted that the existing aeration tankage was designed based on a 10-day solids retention time (SRT). This is considered conservative and ammonia objectives can be achieved at lower SRT without the need to provide additional aeration tankage.

Wa2b - Convert to New Technology

This option is based on converting the exiting CAS process to a granular sludge process; a newer biological treatment technology that generates dense sludge pellets, thereby providing highly efficient solids-liquid separation. While there are several new technologies that could be considered for a plant expansion, the Waterloo WWTP is limited hydraulically, so technologies that increase sludge density offer the greatest benefit for this facility. For this reason, the new technology assessment was based on this option. Further investigation of available new technologies should be conducted during the Class Environmental Assessment (Class EA) process for any expansion.

Two vendors are available for granular sludge technology: S:Select® and Nereda®, which both offer significant potential to enhance treatment in a smaller footprint, while reducing energy consumption.

S:Select® is a proprietary system offered by ESS DEMON (represented locally by ETA Inc.) that provides enhanced treatment by adding artificial granules (MIMICS®) to aeration tanks to act as a colonization surface for biomass. When integrated in a continuous flow activated sludge process, this technology modifies the operational regime with tight SRT and aeration control (usually controlled by pH and ORP). Floc formers are also selectively wasted via hydrocyclones to further promote a very dense floc that settles quickly. The key benefits of the S:Select® technology as compared to a CAS system include (Caprariu, 2017):

- Allows system to operate at MLSS concentration of 7,000-8,000 mg/L due to the improved sludge settling
- Up to 100% reduction in footprint as a result of higher biomass concentrations

- 15% energy usage reduction
- Allows secondary clarifiers to operate at increased solids loading rates (SLR) by a factor of 2.5-3.0, resulting in an increase in plant capacity by a factor of 2.0-3.0 without adding tankage.
- Associated capital and operational cost savings

To achieve the required capacity of 63,600 m^3/d, the following work would be required for the implementation of the S:Select® process:

- Add one additional raw influent pump and one additional effluent pump
- Installation of the packaged S:Select® system

No additional aeration tanks and secondary clarifiers would be required for the expanded Waterloo WWTP with the S:Select® process. As a new technology, MOECC may require pilot testing to demonstrate performance.

Nereda® is a proprietary system, marketed in North America by Aqua-Aerobics Inc. that provides advanced treatment using aerobic granular biomass. An aerobic granular biomass is comprised of compact granules, which are a layered microbial community that provides improved settling properties. Within a single tank with optimized batch cycle structures (i.e. fill/draw, react and settling), the system creates proper conditions to develop and maintain a stable granule, without a supplemental carrier. The granule layered with aerobic and anoxic/anaerobic zones allow for simultaneous processes to take place in the biomass, including enhanced biological phosphorus reduction, and simultaneous nitrification and denitrification. The key benefits of the Nereda® technology as compared to a CAS system include (Giesen, 2016):

- Allows system to operate at MLSS concentration of 8,000 mg/L or greater
- 25-75% reduction in footprint as a result of higher biomass concentrations
- 20-50% energy usage reduction, and
- Associated capital and operational cost savings.

Several Nereda® design configurations have been developed to suit various site applications. For the expansion of the Waterloo WWTP, a hybrid configuration was considered using Nereda® for a portion of the plant flow. The concept includes re-

tasking the existing RAS re-aeration tanks to Nereda® reactors. The excess granular sludge from the Nereda® reactors can then augment the existing conventional activated sludge system to improve settling in the existing secondary clarifiers.

To achieve the required capacity of 63,600 m^3/d or more, the following work would be required for the implementation of the Nereda® process:

- Add one additional raw influent pump and one additional effluent pump
- Retrofit of the existing RAS re-aeration tanks to Nereda® reactors
- Construction of a pre-equalization tank may be required to store flow when the Nereda® cycles are not in the fill/draw phase.

No additional aeration tanks and secondary clarifiers would be required for the expanded Waterloo WWTP with the Nereda® process. As a new technology, MOECC would likely require pilot testing to demonstrate performance.

Wa2c - Re-Rating

This option is based on increasing the treatment capacity through re-rating of the existing plant, which includes addressing bottlenecks in key unit processes to provide capacity.

The completion of the on-going upgrades to the Waterloo WWTP will provide a rated capacity of 57,500 m^3/d with full year-round nitrification. As part of the on-going upgrades, some unit processes were strategically oversized to allow operational flexibility and to accommodate future expansion (AECOM, 2011).

The capacity assessment completed as part of TM No. 2 indicated that all the unit processes have sufficient capacity to accommodate a moderate (10-15%) flow increase without expansion, with the exception of the raw influent and effluent pumping and secondary clarification processes. The capacity of the existing secondary clarifiers is limited by the surface overflow rate (SOR).

To achieve the required capacity of 63,600 m^3/d and to meet the future effluent quality requirements, the following work would be required to re-rate the plant:

- Conduct stress testing on the secondary clarifiers to demonstrate their actual peak flow capacity. The existing secondary clarifiers would operate at a peak SOR of 41 m^3/m^2/d to accommodate the future projected 2051 flows. This is only 10%

higher than MOECC Guidelines (37 $m^3/m^2.d$) and has been demonstrated at other plants that have good mixed liquor settling characteristics. Furthermore, since the aeration tanks have spare capacity (rated capacity for 57,500 m^3/day is based on a conservative SRT of 10 days), the solids loading rate to the clarifiers can be maintained at or below MOECC Guidelines (<170 $kg/m^2.d$). Internal clarifier baffling, currently planned for installation, will also improve performance and potentially increase capacity.

- The existing raw wastewater and effluent pumping stations have space to accommodate new pumps to increase capacity without building or wet well expansions.

It should be noted that Wa2c - Re-Rating is a non-infrastructure opportunity that will require additional studies and consultation with approval agencies to confirm feasibility. Refer to Section 5.2 for more details.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 6 for Option Wa2. Operating costs are not all inclusive and only include items to allow a comparison between options, including energy, chemical consumption, equipment maintenance and labour. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 6 Cost Estimates – Option Wa2: Expansion

Item	Wa2a - Conventional Expansion	Wa2b - Expansion with New Technology(1)	Wa2c - Rerating
Capital Cost (2)	$9,105,000	$8,800,000	$953,000
Annual O&M Cost	$1,000,000	$859,000	$970,000
PV Life Cycle Cost (3)	$18,078,000	$16,323,000	$11,686,000

Notes:
1. Cost estimates are based on S:Select technology, however, a preferred technology would be determined through a Class EA.
2. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
3. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to year 2051.

4.1.3 Wa3: Phosphorus Removal (New Tertiary Filters) at Waterloo WWTP

Description of Alternative

The Waterloo WWTP discharges treated water to the Grand River. An assimilative capacity study (ACS) was completed for the Grand River in 2014 which proposed an effluent total phosphorus TP objective of 0.2 mg/L with a calculated average daily loading of 14.6 kg/d at 72,730 m^3/d (Stantec, 2014).

For the purpose of this evaluation, a future effluent TP objective of 0.23 mg/L is expected for the Waterloo WWTP, based on maintaining the ACS 14.6 kg/d loading at the proposed design flow of 63,600 m^3/d. It is important to note that tertiary filters at the Waterloo WWTP would be capable of achieving lower TP concentration objectives of 0.20 mg/L with slightly higher chemical dosing.

Option Wa3 is based on constructing a new tertiary filtration facility to achieve the future TP effluent objective of 0.23 mg/L. For the purpose of this evaluation, disk filters were assumed based on the similarities to the Kitchener WWTP constraints (i.e., low headloss, small footprint, low O&M). To meet the future effluent quality requirements, the following work would be required for the implementation of the tertiary filtration system:

- Construction of a new tertiary filtration facility between the secondary clarifiers and UV disinfection. The existing UV disinfection system is designed to provide 1

m head between secondary clarifiers and UV. This allows for implementation of disk filters without an intermediate pumping station (AECOM, 2011).

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 7 for Option Wa3. It was assumed that tertiary treatment would be implemented within 5 years. Operating costs are for tertiary treatment only and include items for comparison, including energy, chemical consumption, equipment maintenance and labour. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 7 Cost Estimate – Option Wa3: Phosphorus Removal (New Tertiary Filters)

Item	Cost
Capital Cost (1)	$19,130,000
Annual O&M Cost	$78,000
PV Life Cycle Cost (2)	$18,411,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to year 2051.

4.1.4 Wa4: Phosphorus Trading (with Kitchener WWTP)

Description of Alternative

Option Wa4 is based on achieving water quality goals for phosphorus at the Waterloo WWTP through trading phosphorus loading with the Kitchener WWTP. The ultimate goal would be to eliminate tertiary filtration at the Waterloo WWTP by achieving lower effluent TP loadings at the Kitchener WWTP. Overall, loadings to the Grand River would remain the same as described for Alternative Wa3 and consistent with the loadings identified in the ACS for each plant.

Table 8 presents a summary of the phosphorus trading between the Waterloo and Kitchener WWTPs. Most recent MOECC approvals are drafted based on a monthly average objective and compliance concentration. Without tertiary filtration, it is

estimated that the Waterloo WWTP can reliably achieve a monthly average effluent TP concentration of 0.4 mg/L. Lower concentrations may be achievable with optimized secondary treatment, but bring increased risk when considering a monthly average compliance. Based on a target of 0.4 mg/L TP at the Waterloo WWTP, the Kitchener WWTP would need to achieve a monthly average concentration of 0.11 mg/L to maintain the same loadings to the Grand River. Single stage tertiary filtration can achieve monthly average concentrations ranging between 0.1 and 0.15 mg/L with optimized chemical dosing. As a result, the proposed trading concentration for Kitchener WWTP is approaching the limits of the installed technology and does introduce some compliance risk. Based on recent experience with a similar installation at the Orillia WWTC, the MOECC may require one (1) year full scale testing to demonstrate the Kitchener WWTP can achieve monthly average concentrations of 0.11 mg/L.

Table 8 Phosphorus Trading Between Waterloo and Kitchener WWTPs at 2051 Projected Flows

WWTP	Existing ECA Objective (1)	ACS Proposed Median Objective (2)	Calculated ACS Allowable Loading (3)	Revised Future Objectives		TP Trading Between Waterloo and Kitchener	
	Conc. (mg/L)	Conc. (mg/L)	Loading (kg/d)	Conc. (mg/L)	Loading (kg/d) (5)	Conc. (mg/L)	Loading (kg/d)
Waterloo	0.4	0.2	14.6	0.23 (4)	14.6	0.4 (6)	25.4
Kitchener	0.6	0.2	28.0	0.20 (1)	24.6	0.11 (7)	13.8
Total	-	-	42.6	-	39.2	-	39.2

Notes:
1. Based on ECA of each WWTP.
2. Based on ACS completed for the Waterloo WWTP (Stantec, 2014)
3. Calculated based on ACS proposed effluent objectives and ACS estimated projected 2051 flows (Stantec, 2014).
4. Based on calculated ACS loadings and updated projected 2051 flows developed in 2017 WWTMP.
5. Based on the revised concentrations and proposed future capacity.
6. Assumed achievable TP concentration for the Waterloo WWTP with dual-point addition for phosphorus removal.
7. The allowable TP concentration for the Kitchener WWTP after trading with the Waterloo WWTP.

It should be noted that Wa4 – Phosphorus Trading (with Kitchener WWTP) is a non-infrastructure opportunity that will require additional studies and consultation with approval agencies to confirm feasibility. Refer to Section 5.2 for more details.

Environmental Effects

A high-level review of the environmental effects of Option Wa4 was conducted using the Grand River Simulation Model (GRSM). The review of this scenario was conducted to determine whether any negative effects were observed in the Grand River related to the proposed trading scheme. In particular, since the Waterloo WWTP is upstream of the Kitchener WWTP, any effects on the portion of the Grand River between the two facilities were reviewed. GRSM modelling results show that there are significant concerns with this scenario since there would be statistically significant increases in the phosphorus levels in the Grand River between the Waterloo and Kitchener WWTPs. With the Policy 2 status of the Grand River with respect to phosphorus, it is unlikely that this alternative would be approved by the MOECC. Additionally, this portion of the Grand River also features the drinking water intake for the Mannheim Water Treatment Plant, which could pose additional risks to public health and safety.

Costs

A summary of the estimated capital and life cycle costs is provided in Table 9 for Option Wa4. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 9 Cost Estimate – Option Wa4: Phosphorus Trading (with Kitchener WWTP)

Item	Cost
Capital Cost (1)	-
Annual O&M Cost	$35,000
PV Life Cycle Cost (2)	$609,000

Notes:

1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to year 2051.

4.2 Preston WWTP

The Preston WWTP is a conventional activated sludge plant with a rated ADF capacity of 16,860 m^3/d. The current ADF is 9,000 m^3/d, or approximately 55% of the rated capacity. Treated effluent is discharged to the Grand River, a MOECC Policy 2 Receiver.

The following opportunities/constraints were identified for treatment of future flows and loadings for the Preston WWTP in TM6:

- No expansion beyond rated capacity is required within the planning period. The existing plant has sufficient capacity to accommodate the projected 2051 flow of 11,900 m^3/d. No expansion or diversion alternatives were considered.
- Phosphorus removal is expected to be required to meet Lake Erie effluent phosphorus target during the planning period. This is considered as part of the following alternatives:
  - Pr1 – Phosphorus Removal (Optimization of Secondary Treatment) at Preston WWTP
  - Pr2 – Phosphorus Off-Setting

The alternatives to address these opportunities/constraints to accommodate level of treatment are discussed in the following sections.

4.2.1 Pr1: Phosphorus Removal (Optimization of Secondary Treatment) at Preston WWTP

Description of Alternative

Option Pr1 is based on optimizing the secondary treatment process with chemical dosing to achieve the effluent TP objectives consistent with the expected Lake Erie targets.

For the purpose of this evaluation, an effluent TP objective of 0.4 mg/L was adopted for the Preston WWTP, based on achieving the Lake Erie Basin effluent targets at the existing rated capacity of 16,800 m^3/d.

The following work would be required for the implementation of the phosphorus removal process:

- Optimization of existing chemical dosing within secondary treatment process.

Costs

A summary of the estimated capital and life cycle costs is provided in Table 10 for Option Pr1. The Preston WWTP is currently achieving less than 0.4 mg/L TP, so there is no anticipated change to operating costs associated with this option.

Table 10 Cost Estimate – Option Pr1: Phosphorus Removal (Optimization of Secondary Treatment)

Item	Cost
Capital Cost (1)	$0
Annual O&M Cost	$0
PV Life Cycle Cost (2)	$0

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to year 2051.

4.2.2 Pr2: Phosphorus Off-Setting

Description of Alternative

Option Pr2 is based on implementing a phosphorus off-setting program to reduce phosphorus loading to the Grand River watershed.

Phosphorus off-setting is a flexible watershed based program that ultimately improves and protects water quality. It allows for a limited increase in pollutant discharge to be “off-set” by greater reductions elsewhere in the same watershed. The reduction is achieved through an off-setting ratio that is applied to the discharge. MOECC commonly requires an off-setting ratio of 4:1 or greater (i.e., for every 1 kg increase of phosphorus produced by a WWTP above the allowable load, 4 kg must be removed from the watershed). In some cases, phosphorus off-setting can be more economical than point-source control from both a capital and life cycle perspective (LSRCA 2014).

Phosphorus off-setting for the Preston WWTP would require close consultation with GRCA and MOECC to identify the most appropriate off-setting approach. For example, agricultural and rural non-farm Best Management Practice (BMPs) could be implemented to reduce phosphorus loads in spring runoff, including manure storage facilities, milkhouse wastewater treatment and livestock fencing around local creeks

(Hutchinson, 2017). As there is currently no program in place within the Region for phosphorus off-setting, a program would need to be developed, implemented and monitored.

The Preston WWTP is already achieving the future effluent limits associated with Lake Erie Basin loading limits. An off-setting program, could allow the Preston WWTP to reduce chemical dosages and operate at a higher effluent TP concentration. Based on achieving a monthly average effluent TP concentration of 0.6 mg/L at the Preston WWTP consistent with the current ECA objective, it is estimated that approximately 4,960 kg/year of phosphorus loading would need to be reduced through an off-setting program, inclusive of a 4:1 ratio. Table 11 summarizes the phosphorus loadings based on an off-setting program.

Table 11 Phosphorus Loading Estimate for Preston WWTP

Parameter	Value
Effluent TP Objective Achievable from Secondary Treatment Concentration Loading at Rated Capacity	 0.6 mg/L 10.1 kg/d
Proposed TP Loading Objective (1)	6.7 kg/d
Required TP Off-set Loading (2)	4,960 kg/year

Notes:
1. Based on effluent TP concentration of 0.4 mg/L consistent with proposed Lake Erie Basin Loading Limits
2. At a TP off-setting ratio of 4:1 as typically required by MOECC.

It should be noted that Pr2 – Phosphorus Off-Setting is a non-infrastructure opportunity that will require additional studies and consultation with approval agencies to confirm feasibility. Refer to Section 5.2 for more details.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 12 for Option Pr2. Capital costs are based on $350/kg for implementation of a phosphorus removal program (including construction of any controls) and O&M costs are based on $300/kg for on-going maintenance of the program (Hutchinson, 2017) and account for savings in chemical dosing from current operation. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the

preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 12 Cost Estimate – Option Pr2: Phosphorus Off-Setting

Item	Cost
Capital Cost (1)	$1,996,000
Annual O&M Cost	$1,479,000
PV Life Cycle Cost (2)	$31,249,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to year 2051.

4.3 Hespeler WWTP

The Hespeler WWTP is an extended aeration plant with a rated ADF capacity of 9,320 m^3/d. The current ADF is 6,940 m^3/d, or approximately 75% of the rated capacity. Treated effluent is discharged to the Speed River, a MOECC Policy 2 receiver with respect to TP.

A Facility Assessment was completed for the plant to identify processes that require improvements prior to 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 sludge thickening facility.

The following opportunities/constraints were identified for treatment of future flows and loadings for the Hespeler WWTP in TM6:

+ Expansion is required by the year 2047 to a minimum design ADF of 10,400 m^3/d (to accommodate the projected 2051 flow of 9,900 m^3/d with a 5% safety factor) and provide year-round nitrification. This is considered as part of the following alternative:
  - He1 – Expansion of Hespeler WWTP
+ Phosphorus removal is expected to be required to meet assimilative capacity study and Lake Erie effluent phosphorus targets. For Hespeler WWTP, both the Lake Erie and assimilative capacity phosphorus targets are expected to be the

same at 0.4 mg/L, however the primary driver for the phosphorus removal for Hespeler WWTP is the Lake Erie effluent target as that is expected to be required prior to the need for additional capacity. This is considered as part of the following alternatives:

- He2 – Phosphorus Removal (Optimization of Secondary Treatment) at Hespeler WWTP
- He3 – Phosphorus Off-Setting

The alternatives to address these opportunities/constraints to accommodate both growth and level of treatment are discussed in the following sections.

4.3.1 He1: Expansion

Description of Alternative

The following alternatives were considered for the Hespeler WWTP expansion to accommodate the proposed future rated capacity of 10,400 m^3/d (developed based on a 5% safety factor to the projected 2051 flow of 9,900 m^3/d):

+ He1a - Conventional Plant Expansion
+ He1b - Expansion with New Technology

He1a - Conventional Plant Expansion

To achieve the required capacity of 10,400 m^3/d and provide full nitrification, the following work is recommended for conventional plant expansion:

+ Expansion of existing aeration tanks
+ Upgrades to disinfection system

He1b - Expansion with New Technology - Membrane Aerated Biofilm Reactor (MABR)

This alternative is based on adding a Membrane Aerated Biofilm Reactor (MABR) process to the existing extended aeration process. While there are several new technologies that could be considered for a plant expansion, the Hespeler WWTP is limited on an organic loading basis, so technologies that address organic capacity limitations offer the greatest benefit for this facility. For this reason, the new technology assessment was based on MABR. Further investigation of available new technologies should be conducted during the Class EA process for any expansion.

MABR is an innovative technology that can provide energy savings, improvements to effluent quality and/or increased capacity in a smaller footprint. This technology diffuses oxygen across a low pressure membrane achieving exceptionally high oxygen transfer efficiencies (i.e. 4 times fine bubble aeration) and supports biological growth on the membrane fiber with similar treatment performance benefits as integrated fixed film activated sludge (IFAS).

There are currently two primary vendors of this technology, GE (rebranded to Suez in October 2017) Zeelung® and OxyMem®. For the purpose of this evaluation, GE Zeelung® was used as a conceptual design basis. The Region has also recently completed pilot testing of the GE Zeelung® MABR system at the Hespeler WWTP, with promising results, and is currently piloting the Oxymem technology at the Elmira WWTP.

The GE Zeelung® consists of a biological reactor with the membranes being installed directly into the bioreactor. For the upgrades of the Hespeler WWTP, the design concept includes a greenfield MABR tank installation upstream of the existing aeration tanks. This approach would minimize civil construction costs since existing aeration basins would not be modified and MABR system integration would be simplified by allowing the plant to continue operating during all phases of the upgrade project.

To achieve the required capacity of 10,400 m^3/d, the following work would be required for the implementation of the MABR process:

- Construction of new MABR tanks and splitter boxes.
- Upgrades to disinfection system.

A retrofit of the fine screens to 2 mm fine screens is underway, which will protect the MABR modules

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 13 for Option He1. Operating costs are not all inclusive and only include items to allow comparison between options, including energy, chemical consumption, equipment maintenance and labour. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred

alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 13 Cost Estimates – Option He1: Expansion

Item	He 1a - Conventional Plant Expansion	He1b - MABR
Capital Cost (1)	$19,636,000	$18,186,000
Annual O&M Cost	$429,000	$344,000
PV Life Cycle Cost (2)	$19,442,000	$18,181,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.3.2 He2: Phosphorus Removal (Optimization of Secondary Treatment) at Hespeler WWTP

Description of Alternative

The Hespeler WWTP discharges to the Speed River. The Hespeler WWTP effluent TP currently averages 0.5 mg/L using alum dosing prior to the secondary clarifiers.

An assimilative capacity study (ACS) was completed for the Grand and Speed Rivers for the Waterloo and Hespeler WWTPs in 2014. The ACS concluded that tertiary filtration at the Hespeler plant will have little influence on TP in the Speed River for 2051 conditions. A moderate TP reduction using optimized chemical dosing will ensure compliance with Policy 2 well into a 20 or 30-year planning period. It recommended that chemical precipitation be optimized to target a TP objective of 0.4 mg/L. As a result, the implementation of tertiary filtration could be deferred up to 2051 per the ACS (Stantec, 2014). The driver for improved effluent quality for this facility is the Lake Erie effluent target as this is expected to be required prior to the need for additional plant capacity.

To meet the proposed future effluent TP quality requirements, the following optimization of phosphorus removal could be considered:

- Improve chemical dosing and mixing. It is recommended that the plant relocate the dosing location of coagulant to the aeration tank effluent lauders (Stantec, 2015). This will provide more rapid mixing of chemical into the wastewater.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 14 for Option He2. It was assumed that upgrades to the chemical dosing systems would be implemented within 5 years. Operating costs are for optimization of secondary treatment only, including chemical consumption, equipment maintenance and labour. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 14 Cost Estimate – Option He2: Phosphorus Removal (Optimization of Secondary Treatment)

Item	Cost
Capital Cost (1)	$777,000
Annual O&M Cost	$26,000
PV Life Cycle Cost (2)	$1,144,000

Notes:
1. All costs are conceptual level opinions of probable costs and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051

4.3.3 He3: Phosphorus Off-Setting

Description of Alternative

Option He3 is based on implementing phosphorus off-setting program to reduce phosphorus loading to the Speed River and subsequently to Lake Erie (additional details about phosphorus off-setting are provided in Section 4.2.2).

Similar to the Preston WWTP, phosphorus off-setting would require consultation with MOECC and GRCA to determine the best approach for off-setting phosphorus loadings. One option could focus on implementing agricultural and rural non-farm BMPs to reduce phosphorus loads in spring runoff. As there is currently no program in place within the Region for phosphorus off-setting, a program would need to be developed, implemented and monitored.

Based on maintaining the existing ECA effluent objective of 0.75 mg/L, approximately 4,600 kg/year of phosphorus loading would need to be off-set based on a 4:1 ratio

relative to proposed future effluent TP objective of 0.40 mg/L. Table 15 summarizes the phosphorus off-set requirement.

Table 15 Phosphorus Loading Estimate for Hespeler WWTP

Parameter	Value
Existing ECA TP Effluent Objective	0.75 mg/L
ACS Proposed TP Effluent Objective (1)	0.40 mg/L
Proposed Future Plant Capacity	10,400 m^3/d
Off-Setting TP Loading (2)	4,600 kg/year

Notes:
1. Based on the ACS (Stantec, 2014).
2. At a TP off-setting ratio of 4:1 as required by MOECC.

It should be noted that He3 – Phosphorus Off-Setting is a non-infrastructure opportunity that will require additional studies and consultation with approval agencies to confirm feasibility. Refer to Section 5.2 for more details.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 16 for Option He3. Capital costs are based on $350/kg for implementation of a phosphorus removal program (including construction of any controls) and O&M costs are based on $300/kg for on-going maintenance of the program (Hutchinson, 2017). The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 16 Cost Estimate – Option He3: Phosphorus Off-Setting

Item	Cost
Capital Cost (1)	$1,852,000
Annual O&M Cost	$1,380,000
PV Life Cycle Cost (2)	$29,148,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.4 Wellesley WWTP

The Wellesley WWTP is an extended aeration package plant with a rated capacity of 1,100 m^3/d. The current ADF is 870 m^3/d, or approximately 80% of the rated capacity. The Region is currently reviewing opportunities to reduce inflow and infiltration to the Wellesley WWTP. These reductions could impact both average and peak flows to the plant and the overall timing of any future expansion. The treated effluent is discharged to the Nith River, a MOECC Policy 2 receiver.

The Wellesley WWTP is currently undergoing upgrades to the tertiary filtration process to improve reliability and operability of the existing filters. The upgraded filters will provide a peak flow capacity of 4,400 m^3/d (CH2M Hill, 2015).

The following opportunities/constraints were identified for treatment of future flows and loadings for the Wellesley WWTP in TM6:

- Expansion is required by the year 2041 to a minimum ADF of 1,320 m^3/d (to accommodate the projected 2051 flow of 1,260 m^3/d with a 5% safety factor). This is considered as part of the following alternative:
  - We1 – Expansion of Wellesley WWTP
- To maintain existing allowable TP loadings to the river, the effluent TP objective associated with a plant expansion will be reduced to 0.42 mg/L. The actual phosphorus concentration would be determined through an ACS in support of the expansion of the Wellesley WWTP. These noted opportunities and constraints are considered as part of the following alternatives:
  - We2 – Phosphorus Removal (Expansion of Existing Filters) at Wellesley WWTP
  - We3 – Phosphorus Off-Setting

The alternatives to address these opportunities/constraints to accommodate both growth and level of treatment are discussed in the following sections.

4.4.1 We1: Expansion

Description of Alternative

The following two alternatives were considered for the expansion of the Wellesley WWTP to accommodate the proposed future capacity of 1,320 m^3/d (developed based on a 5% safety factor to the projected 2051 flow of 1,260 m^3/d):

- We1a - Conventional Plant Expansion
- We1b - Expansion with New Technology

We1a - Conventional Plant Expansion

This option is based on expanding the existing plant with an extended aeration process. For this option, a third circular package plant, similar to the existing units could be added. This will provide slightly higher than the 2051 capacity requirements, but would simplify flow splitting and maintenance flexibility. Additional influent pumping and aeration capacity would also be required to treat the increased flow.

Per MOECC Policy 2 requirements, a reduction in TP concentrations to the receiving water is expected to be required with the next expansion. This is considered further as part of alternatives We2 and We3.

We1b - Expansion with New Technology - Granular Activated Sludge

This option is based on converting the existing extended aeration system to a granular activated sludge system. For the purpose of this evaluation, S:Select® with MIMICS® was used as the basis. While there are several new technologies that could be considered for a plant expansion, the Wellesley WWTP is limited hydraulically, so technologies that increase sludge density offer the greatest benefit for this facility. For this reason, the new technology assessment was based on this option. Further investigation of available new technologies should be conducted during the Class EA process for any expansion.

To achieve the required capacity of 1,320 m^3/d and to meet the future effluent quality requirements, the following work would be required for the implementation of the S:Select® granular sludge process:

- Add additional influent pumping capacity
- Installation of the packaged S:Select® system

+ Additional oxygenation capacity.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 17 for Option We1. Operating costs are not all inclusive and only include items to allow comparison between options, including energy, chemical consumption, equipment maintenance and labour. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 17 Cost Estimates – Option We1: Expansion

Item	WE1a - Conventional Plant Expansion	We1b - Granular Activated Sludge (S:Select®)
Capital Cost (1)	$6,586,000	$4,283,000
Annual O&M Cost	$63,000	$56,000
PV Life Cycle Cost (2)	$5,311,000	$3,689,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051

4.4.2 We2: Phosphorus Removal (Expansion of Existing Filters) at Wellesley WWTP

Description of Alternative

Option We2 is based on expanding the existing tertiary treatment facility to achieve the future effluent objectives.

Per Policy 2 requirements, a reduction in TP concentrations will be required as part of any future expansion. The actual future effluent TP objective will be confirmed through an ACS.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 18 for Option We2. Operating costs are for tertiary treatment only. The cost estimate does not include ancillary costs for items that are common among alternatives or

studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 18 Cost Estimate – Option We2: Phosphorus Removal (Expansion of Existing Filters)

Item	Cost
Capital Cost (1)	$867,000
Annual O&M Cost	$8,300
PV Life Cycle Cost (2)	$658,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.4.3 We3: Phosphorus Off-Setting

Description of Alternative

Option We3 is based on implementing a phosphorus off-setting program to reduce phosphorus loading to the Nith River (additional details about phosphorus off-setting are provided in Section 4.2.2).

Similar to the Preston and Hespeler WWTPs, phosphorus off-setting for the Wellesley WWTP could focus on implementing agricultural and rural non-farm BMP to reduce phosphorus loads in spring runoff. As there is currently no program in place within the Region for phosphorus off-setting, a program would need to be developed, implemented and monitored.

The existing filters can readily achieve an effluent TP objective of 0.2 mg/L for up to 1,100 m^3/d ADF, while secondary treatment alone should achieve TP concentrations of 0.4 mg/L. Considering a blending strategy of tertiary effluent and secondary effluent (1,100 m^3/d at 0.2 mg/L and 220 m^3/d at 0.4 mg/L), a phosphorus off-set of 166 kg/yr (inclusive of 4:1 off-set factor) would be required to achieve the equivalent loading of an upgraded plant achieving 0.15 mg/L effluent TP. Table 19 summarizes the phosphorus off-setting requirements for the Wellesley WWTP.

Table 19 Phosphorus Loading Estimate for Wellesley WWTP

Item	Value
Proposed WWTP TP Effluent Objective Tertiary Effluent Secondary Effluent Wellesley WWTP Effluent TP Loading	 1,100 m^3/d @ 0.2 mg/L 220 m^3/d @ 0.4 mg/L 0.31 kg/d
Anticipated TP Effluent Objective Based on Assimilative Capacity (1)	0.15 mg/L @ 1,320 m^3/d 0.20 kg/d
Off-Setting TP Loading (2)	166 kg/year

Notes:
1. Based on Phase 2 upgraded New Hamburg WWTP effluent objectives, as they both discharge to Nith River.
2. Includes a TP off-setting ratio of 4:1 as required by MOECC.

It should be noted that We3 – Phosphorus Trading (with Kitchener WWTP) is a non-infrastructure opportunity that will require additional studies and consultation with approval agencies to confirm feasibility. Refer to Section 5.2 for more details.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in

Table 20 for Option We3. Capital costs are based on $350/kg for implementation of a phosphorus removal program (including construction of any controls) and O&M costs are based on $300/kg for on-going maintenance of the program (Hutchinson, 2017). The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 20 Cost Estimate – Option We3: Phosphorus Off-Setting

Item	Cost
Capital Cost (1)	$67,000
Annual O&M Cost	$50,000
PV Life Cycle Cost (2)	$489,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.5 St Jacobs WWTP

The St Jacobs WWTP is an oxidation ditch extended aeration plant, with a rated ADF capacity of 1,450 m^3/d. The current ADF is 920 m^3/d, or approximately 65% of the rated capacity. The treated effluent is discharged to the Conestogo River, a MOECC Policy 2 receiver with respect to TP.

The following opportunities/constraints were identified for treatment of future flows and loadings for the St Jacobs WWTP in TM6:

- Expansion is required by the year 2042 to a minimum design ADF of 1,600m^3/d (to accommodate the projected 2051 flow of 1,530 m^3/d with a 5% safety factor). This is considered as part of the following alternatives:
  - SJ1 – Diversion to Waterloo WWTP
  - SJ2 – Expansion of St Jacobs WWTP
- A reduction in TP concentrations to the receiving water is expected to be required as part of a future expansion. This is considered as part of the following alternatives:
  - SJ3 – Phosphorus Removal (Expansion of Existing Filters) at St Jacobs WWTP
  - SJ4 – Phosphorus Off-setting

The alternatives to address these opportunities/constraints to accommodate both growth and level of treatment are discussed in the following sections.

4.5.1 SJ1: Diversion to Waterloo WWTP

Description of Alternative

Option SJ1 is based on converting the existing St Jacobs WWTP to a sewage pumping station (SPS) and diverting all wastewater flow generated in St Jacobs to the Waterloo WWTP for treatment.

The Waterloo WWTP has a rated capacity of 57,500 m^3/d. The existing flow was 45,870 m^3/d during 2011 to 2015 based on the 2016 WWWMR (RMOW, 2017). Based on the current population growth rate, the Waterloo WWTP is expected to exceed the current ECA rated capacity of 57,500 m^3/d in 2041. Therefore, depending

on the preferred approach for servicing Waterloo, an expansion of the Waterloo WWTP may be required by the year 2041.

The ECA rated capacity of the St Jacobs WWTP would not be exceeded until 2042, which is very similar timing to the Waterloo WWTP expansion. Therefore, this option would be to operate St Jacobs WWTP until the Waterloo WWTP is expanded in approximately 2041 and then decommission the St Jacobs facility, with all flows transferred to the expanded Waterloo WWTP for treatment.

The following work would be required to facilitate the diversion of wastewater flows from the St Jacobs WWTP to the Waterloo WWTP:

- Construction of a new pump station and forcemain to transfer flows from the St Jacobs WWTP to the Waterloo WWTP.
- Increased expansion of the Waterloo WWTP to provide 65,200 m^3/d capacity rather than 63,600 m^3/d. This slight increase in capacity can be provided by the expansion options (conventional or new technology) already considered for the Waterloo WWTP.
- Potential upgrades to the Waterloo WWTP collection system to accommodate increased flow from the St Jacobs service area.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 21 for Option SJ1. Operating costs are not all inclusive and only include items to allow comparison between options, including energy, chemical consumption, equipment maintenance and labour. Costs for the expansion of the Waterloo WWTP are not included, as this alternative would not be considered as a driver for the expansion at Waterloo, but rather an option should the Waterloo WWTP already have available capacity to receive flows from St Jacobs. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 21 Cost Estimate – Option SJ1: Diversion to Waterloo WWTP

Item	Cost
Capital Cost (1)	$9,830,000
Annual O&M Cost	$73,000
PV Life Cycle Cost (2)	$10,544,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.5.2 SJ2: Expansion

Description of Alternative

The following alternatives were considered for the St Jacobs WWTP expansion, to accommodate an expanded capacity of 1,600 m^3/d:

- SJ2a - Conventional Plant Expansion
- SJ2b - Re-rating through Optimization and/or Minor Works

SJ2a - Conventional Plant Expansion

This option is based on expanding the existing plant with a conventional activated sludge (CAS) process. To achieve the required capacity of 1,600 m^3/d and to meet the future effluent quality requirements, the following work would be required for the expansion of the existing CAS process:

- The minor shortfall in influent pumping capacity can be addressed through efforts to reduce I/I or alternatively replacing the existing pumps with slightly larger units
- Replace oxidation ditch with extended aeration tanks
- Alternative disinfection retrofit technologies such as more energy efficient UV systems can be considered to provide the moderate capacity increase required in a similar footprint as existing.

Tertiary treatment is considered as part of alternatives SJ3 and SJ4.

SJ2b - Re-Rating

The St Jacobs WWTP is an oxidation ditch extended aeration plant with an existing ECA rated capacity of 1,450 m^3/d, and requires an expansion to a capacity of 1,600

m^3/d. Given the small capacity increase for St Jacobs service area (i.e. 5%), there is good opportunity to realize the future capacity through re-rating of the plant.

Based on the capacity assessment completed in TM2, some unit processes require additional capacity to treat the future projected 2051 flows, including influent pumping, bioreactor, tertiary filtration and UV disinfection. These processes were designed based on the MOECC Design Guidelines (2008), which are considered conservative. The basis of the re-rating is summarized as follows:

- The minor shortfall in influent pumping capacity can be addressed through efforts to reduce I/I or alternatively replacing the existing pumps with slightly larger units
- The oxidation ditch is conservatively limited to an SRT of 15 days based on MOECC Guidelines. Treatment performance can potentially be maintained at a much lower SRT. Replacement of the existing brush aerators with jet aeration is recommended to reduce winter temperature drop and provide more efficient aeration control.
- Upgrades to distribution of flow to clarifiers to improve operations
- Alternative disinfection retrofit technologies such as more efficient UV systems can be considered to provide the moderate capacity increase required in a similar footprint as existing.

It should be noted that SJ2b – Re-Rating is a non-infrastructure opportunity that will require additional studies and consultation with approval agencies to confirm feasibility and approvals. See Refer to Section 5.2 for more details.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 22 for Option SJ2. Operating costs are not all inclusive and only include items to allow comparison between options, including energy, chemical consumption, equipment maintenance and labour. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 22 Cost Estimate – Option SJ2: Expansion

Item	SJ2a - Conventional	SJ2b - Re-Rating
Capital Cost (1)	$7,877,000	$2,342,000
Annual O&M Cost	$188,000	$208,000
PV Life Cycle Cost (2)	$8,854,000	$6,664,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.5.3 SJ3: Phosphorus Removal (Expansion of Existing Filters) at St Jacobs WWTP

Description of Alternative

Option SJ3 is based on expanding the existing tertiary treatment facility to achieve the future effluent objectives.

The St Jacobs WWTP discharges treated water to the Conestogo River. The existing plant provides a high level of tertiary phosphorus removal with a current ECA effluent TP objective of 0.2 mg/L. A Receiving Water Quality Impact Study (RWQIS) was completed for the Conestogo River in 2011, which proposed an effluent TP objective of 0.15 mg/L, resulting in a daily loading of 0.32 kg/d at an expanded plant capacity of 2,100 m^3/d (XCG, 2011).

For an expansion to 1,600 m^3/d (based on growth projections developed through this WWTMP), effluent TP concentration objectives are expected to range between 0.15 and 0.20 mg/L to maintain the daily loading identified in the RWQIS. This is consistent with the effluent quality achievable through single stage tertiary filtration systems, similar to the existing technology.

To achieve the required capacity of 1,600 m^3/d, the following work would be required:

- Replace the existing sand filtration system with a more compact technology (e.g. disk filters or similar). This will provide for the slightly higher capacity in the same footprint as the existing filters. Similar upgrades are currently being implemented for the Wellesley WWTP.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 23 for Option SJ3. Operating costs are for tertiary treatment only. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 23 Cost Estimate – Option SJ3: Phosphorus Removal (Expansion of Existing Filters)

Item	Cost
Capital Cost (1)	$1,459,000
Annual O&M Cost	$18,000
PV Life Cycle Cost (2)	$1,247,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.5.4 SJ4: Phosphorus Off-Setting

Description of Alternative

Option SJ4 is based on implementing a phosphorus off-setting program to reduce phosphorus loading to the Conestogo River (additional details about phosphorus off-setting are provided in Section 4.2.2).

As discussed previously, phosphorus off-setting for the St Jacobs WWTP could focus on implementing agricultural and rural non-farm BMPs to reduce phosphorus loads in spring runoff. As there is currently no program in place within the Region for phosphorus off-setting, a program would need to be developed, implemented and monitored.

The existing filters can achieve the current effluent TP objective of 0.2 mg/L for up to 1,100 m^3/d as per the capacity assessment in TM2. With optimized chemical dosing, secondary treatment alone should achieve monthly average TP objectives of 0.4 mg/L. Considering a blending strategy of tertiary effluent and secondary effluent (1,100 m^3/d at 0.2 mg/L and 500 m^3/d at 0.4 mg/L), a phosphorus off-set of 146 kg/yr

(inclusive of 4:1 off-set factor) would be required to achieve the equivalent loading of 0.32 kg/d identified through the RWQIS. Table 24 summarizes the phosphorus off-setting requirements for the St Jacobs WWTP.

Table 24 Phosphorus Loading Estimate for St Jacobs WWTP

Item	Value
Proposed WWTP TP Effluent Objective Tertiary Effluent Secondary Effluent St Jacobs WWTP Effluent TP Loading	 1,100 m^3/d @ 0.2 mg/L 500 m^3/d @ 0.4 mg/L 0.42 kg/d
Allowable Effluent TP Load Based on Assimilative Capacity (1)	0.32 kg/d
Required TP Off-set Loading (2)	146 kg/year

Notes:
1. Based on the allowable loading identified in the Receiving Water Quality Impact Study (XCG 2011).
2. Includes a TP off-setting ratio of 4:1 as required by MOECC.

It should be noted that SJ4 – Phosphorus Off-setting is a non-infrastructure opportunity that will require additional studies and consultation with approval agencies to confirm feasibility. See Refer to Section 5.2 for more details.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 25 for Option SJ4. Capital costs are based on $350/kg for implementation of a phosphorus removal program (including construction of any controls) and O&M costs are based on $300/kg for on-going maintenance of the program (Hutchinson, 2017). The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 25 Cost Estimate – Option SJ4: Phosphorus Off-Setting

Item	Cost
Capital Cost (1)	$59,000
Annual O&M Cost	$44,000
PV Life Cycle Cost (2)	$525,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.6 Elmira WWTP

The Elmira WWTP is a biological nutrient removal (BNR) plant with a rated ADF capacity of 7,800 m^3/d. The current ADF is 4,400 m^3/d, or approximately 55% of the rated capacity. The treated effluent is discharged to the Canagagigue Creek, a MOECC Policy 2 receiver with respect to TP.

The following opportunities/constraints were identified for the treatment of future flows and loadings for the Elmira WWTP in TM6:

- An expansion is required by the year 2039 to a minimum design ADF of 10,000m^3/d (to accommodate the projected 2051 flow of 9,500 m^3/d with a 5% safety factor). This is considered as part of the following alternatives:
  - El1 – Expansion of Elmira WWTP
- A reduction in TP concentrations to the receiving water is expected to be required as part of a future expansion. This is considered as part of the following alternatives:
  - El2 – Phosphorus Removal (Expansion of Existing Filters) at Elmira WWTP
  - El3 – Phosphorus Off-Setting

The alternatives to address these opportunities/constraints to accommodate both growth and level of treatment are discussed in the following sections.

4.6.1 El1: Expansion

Description of Alternative

The following two alternatives were considered for the expansion of the Elmira WWTP to accommodate the proposed future rated capacity of 10,000 m^3/d (includes a 5% safety factor to the projected 2051 flow of 9,500 m^3/d):

- El1a - Conventional Plant Expansion
- El1b - Expansion with New Technology

El1a - Conventional Plant Expansion

This option is based on expanding the existing plant with a biological nutrient removal (BNR) process. As per TM No. 2A, the existing site capacity layout creates challenges to provide a conventional plant expansion. To provide sufficient space for an expansion to 10,000 m^3/d, demolition of some existing tankage would be required to create space for newer tankage to better utilize the site capacity. Key work is summarized as follows:

- Demolish the two (2) existing circular primary clarifiers and the “old” unused aeration tanks built in 1967, leaving the footprint available for new rectangular primary clarifiers and new bioreactors.
- Construction of new rectangular primary clarifiers
- Add additional bioreactors and aeration capacity.
- Replacement of the UV disinfection capacity with a more compact and efficient technology.

Tertiary treatment is considered as part of alternatives El2 and El3.

El1b - Expansion with New Technology - Granular Sludge Process

This option is based on converting the existing BNR process to a granular sludge process. For the purpose of this evaluation, S:Select® with MIMICS® by ETA Intelligent Technologies was considered. While there are several new technologies that could be considered for a plant expansion, the Elmira WWTP is limited hydraulically, so technologies that increase sludge density offer the greatest benefit for this facility. For this reason, the new technology assessment was based on this

option. Further investigation of available new technologies should be conducted during the Class EA process for any expansion.

The Region has recently completed an optimization study for the Elmira WWTP (ETA, 2018, refer to Appendix C for the study report) and is currently considering pilot testing of the S:Select® system at the plant. Benefits of this system include:

- Provides 10,000 m^3/d capacity without additional tankage
- Eliminates the need to refurbish the two older secondary clarifiers

To achieve the required 2051 flow of 10,000 m^3/d and to meet the future effluent quality requirements, the following work would be required for the implementation of the S:Select® process at the Elmira WWTP:

- Construction of new primary clarifiers
- Installation of packaged S:Select® system
- Upgrades to the aeration system to accommodate the increased flow

Costs

A summary of the estimated capital, operating and life cycle costs is provided in

Table 26 for Option El1. Operating costs are not all inclusive and only include items to allow comparison between options, including energy, chemical consumption, equipment maintenance and labour. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 26 Cost Estimates – Option El1: Expansion

Item	El1a - Conventional Plant Expansion	El1b - Granular Activated Sludge (S:Select®)
Capital Cost (1)	$32,128,000	$14,170,000
Annual O&M Cost	$134,000	$116,000
PV Life Cycle Cost (2)	$25,074,000	$11,995,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.6.2 El2: Phosphorus Removal (Expansion of Existing Filters) at Elmira WWTP

Description of Alternative

Option El2 is based on upgrading the existing sand filter tertiary treatment facility to achieve future effluent objectives.

The Elmira WWTP discharges treated water to the Canagagigue Creek, a MOECC Policy 2 receiver. The existing plant provides a high level of tertiary phosphorus removal with a current ECA effluent TP discharge objective of 0.2 mg/L. A recent ACS is not available for Canagigue Creek. For the purpose of this Master Plan, it has been assumed that an effluent TP objective of 0.15 mg/L would be required for a plant expansion to 10,000 m^3/d. This would maintain the current ECA TP loading objectives of 1.56 kg/d (i.e., 0.2 mg/L at 7,800 m^3/d). A 0.15 mg/L TP objective is consistent with the effluent quality achievable with a single stage tertiary filtration system and optimized BNR performance with supplemental chemical addition. An ACS study is recommended to be completed as part of a Class EA study for expansion to confirm the level of treatment requirements.

The existing tertiary filter capacity is limited to the current plant rated capacity of 7,800 m^3/d. Additional filter capacity would be required to accommodate additional flows. Recent similar studies reviewing travelling bridge retrofits to disk filters (i.e. Banff WWTP and Galt WWTP) have shown that disk filters may provide up to double the capacity in the same footprint and hydraulic grade line. As a result, a retrofit of the existing travelling bridge filters to disk filters is estimated to be able to provide the expanded rated capacity of 10,000 m^3/d. This would require phased construction (one filter at a time) with reduced peak flow capacity during construction.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 27 for Option El2. Operating costs are for tertiary treatment only. The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 27 Cost Estimate – Option El2: Phosphorus Removal (Expansion of Existing Filters)

Item	Cost
Capital Cost (1)	$2,234,000
Annual O&M Cost	$14,000
PV Life Cycle Cost (2)	$1,744,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

4.6.3 El3: Phosphorus Off-Setting

Description of Alternative

Option El3 is based on implementing a phosphorus offsetting program to reduce phosphorus loading to the Canagagigue Creek (additional details about phosphorus off-setting are provided in Section 4.2.2).

As discussed previously, phosphorus off-setting for the Elmira WWTP could focus on implementing agricultural and rural non-farm BMPs to reduce phosphorus loads in spring runoff. As there is currently no program in place within the Region for phosphorus off-setting, a program would need to be developed, implemented and monitored.

The existing filters can achieve the current effluent TP objective of 0.2 mg/L up to current rated plant capacity of 7,800 m^3/d. With optimized chemical dosing, secondary treatment alone should achieve monthly average TP objectives of 0.4 mg/L. Considering a blending strategy of tertiary effluent and secondary effluent (7,800 m^3/d at 0.2 mg/L and 2,200 m^3/d at 0.4 mg/L), a phosphorus off-set of 1,372 kg/yr (inclusive of 4:1 off-set factor) would be required to achieve the equivalent

loading of 1.5 kg/d (0.15 mg/L at 10,000 m^3/d). Table 28 summarizes the phosphorus off-setting requirements for the Elmira WWTP.

Table 28 Phosphorus Loading Estimate for Elmira WWTP

Item	Value
Proposed WWTP TP Effluent Objective Tertiary Effluent Secondary Effluent Elmira WWTP Effluent TP Loading	 7,800 m^3/d @ 0.2 mg/L 2,200 m^3/d @ 0.4 mg/L 2.44 kg/d
Allowable Effluent TP Load Based on 0.15 mg/L Effluent TP Objective	1.5 kg/d (0.15 mg/L @ 10,000 m^3/d)
Required TP Off-set Loading (1)	1,372 kg/year

Notes:
1. Includes a TP off-setting ratio of 4:1 as typically required by MOECC.

It should be noted that El3 – Phosphorus Off-setting is a non-infrastructure opportunity that will require additional studies and consultation with approval agencies to confirm feasibility. See Refer to Section 5.2 for more details.

Costs

A summary of the estimated capital, operating and life cycle costs is provided in Table 29 for Option El3. Capital costs are based on $350/kg for implementation of a phosphorus removal program (including construction of any controls) and O&M costs are based on a $300/kg for on-going maintenance of the program (Hutchinson, 2017). The cost estimate does not include ancillary costs for items that are common among alternatives or studies. The costs for the preferred alternatives are to be further developed for the preferred alternative as part of the final Master Plan Report. Additional cost estimate details are provided in Appendix B.

Table 29 Cost Estimate – Option El3: Phosphorus Off-Setting

Item	Cost
Capital Cost (1)	$552,000
Annual O&M Cost	$412,000
PV Life Cycle Cost (2)	$4,935,000

Notes:
1. All costs are conceptual level opinions of probable costs in 2017 dollars and are accurate to +/-50%.
2. Based on a 2% growth rate, 2% inflation rate and 4% interest rate to 2051.

5. Evaluation of Growth/Level of Treatment Alternatives

5.1 Overview of Evaluation Process

5.1.1 Decision-Making Model

As described in more detail in TM5, the current WWTMP Update process is based on the same general evaluation methodology used in the 2007 WWTMP, a decision-making model centered on a multi-criteria analysis (MCA). The MCA provides a structured approach to determine overall benefits among alternative options, where the options accomplish several objectives. This evaluation methodology requires specification of desirable objectives and identification of corresponding indicators, which are then used to measure/assess the ability of each alternative option to meet a specific objective. The same decision-making model used in the 2007 WWTMP will be used for this WWTMP Update.

A variety of environmental and social indicators have been developed and are evaluated side by side with economic costs and benefits. Indicators provide a measurable tool to assess a wide range of qualitative categories and criteria, and compare and rank the alternative options against each specific objective.

The MCA approach includes the following major components:

+ **Evaluation Criteria:** A set of evaluation criteria is developed to reflect all aspects of factors of importance for a specific project. Alternative options are assessed and compared relative to the others against the evaluation criteria.

+ **Qualitative Rating:** Each alternative option is assigned a rating that reflects its ability to meet each evaluation criterion relative to the performance of the other alternative options.

5.1.2 Decision-Making Criteria and Rationale

The evaluation approach will follow a typical evaluation of impacts to a wide range of criteria that include natural, socio/cultural, financial and technical environments, as well as legal/jurisdictional and technical factors. The criteria used in the 2007 WWTMP were used as a basis for this WWTMP Update, with some modifications to enhance the criteria and address more recent factors such as climate change and greenhouse gas reductions. The modifications focused on adding criteria to make the evaluation more robust and consolidating criteria where there were potential

overlaps. The decision-making criteria and rationale is provided below and summarized in Table 30.

- Environmental Factors:
  - Surface water protection
  - Wells and aquifer protection
  - Protection of natural features
  - Climate change
- Social Factors:
  - Health and safety
  - Short and long-term growth
  - Land use
  - Community impacts (odour, noise, truck traffic)
  - Cultural and archaeological heritage
  - First Nations considerations
- Legal/Jurisdictional Factors:
  - Approvals
  - Land requirements
- Technical Factors:
  - Energy use and greenhouse gas generation
  - Constructability
  - Optimization of existing infrastructure
  - Innovation
  - Security, reliability and robustness

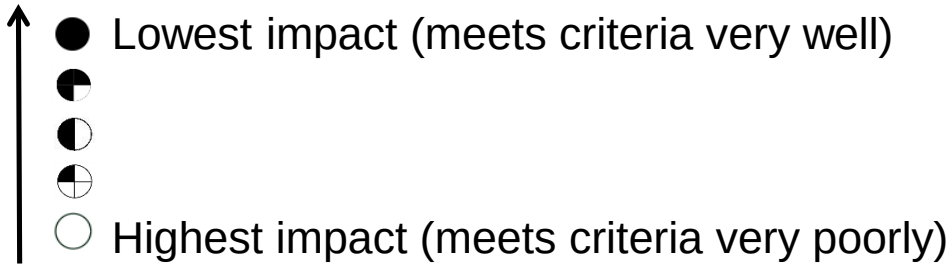
- Financial Factors:
  - Life-cycle cost
  - Cost to ratepayers
  - Financial sustainability.

Table 30 Decision-Making Criteria and Rationale

Category	Criteria	Rationale and Measures
Environmental Factors	**Surface Water Protection**	• Maximize reliability in achieving effluent quality limits • Protect fisheries and aquatic health • Use a watershed approach to protect surface waters
	Wells and Aquifer Protection	• Protect groundwater and respect Clean Water Act requirements
	Protection of Natural Features	• Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots • Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages
	Climate Change	• Resiliency to extreme conditions
Social Factors	**Health and Safety**	• Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)
	Short and Long-Term Growth	• Minimize potential negative effects on short term and long-term community growth and development • Meet Region's growth objectives outlined in ROP
	Land Use	• Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint
	Community Impacts (Odour, Noise, Truck Traffic)	• Minimize odours, noise and truck traffic affecting the community during construction and plant operation

Category	Criteria	Rationale and Measures
	Cultural and Archaeological Heritage	• Minimize potential impact to historical, cultural, archaeological and architecturally significant features
	First Nations Considerations	• Minimize the potential impact to First Nations communities
Legal/ Jurisdictional Factors	**Approvals**	• Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment
	Land Requirements	• Potential need to acquire land for additional treatment works and ownership requirements
Technical Factors	**Energy Use and Greenhouse Gas Generation**	• Minimize GHG emissions, net energy use, and sludge volumes • Maximize biogas generation for cogeneration and biofuel opportunities
	Constructability	• Flexibility of scheduling works is of key concern due to uncertainty in timing of growth • Minimize complex construction and maximize ability to maintain adequate treatment during construction
	Optimization of Existing Infrastructure	• Optimize existing infrastructure investment and treatment capacity
	Innovation	• Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency • Resource recovery
	Security, Reliability and Robustness	• Lesser likelihood of process upset or mechanical breakdown • Ability to meet performance objectives under a range of conditions
Financial Factors	**Life Cycle Cost**	• Minimize capital, operation and maintenance (life cycle) costs over the planning period
	Cost to Ratepayers	• Impact to existing ratepayers for user rates
	Financial Sustainability	• Balance infrastructure needs with ability to pay (user rates and development charges)

Based on the evaluation methodology described above, an evaluation matrix has been prepared describing the specific advantages and disadvantages that each alternative option offers for each criterion under consideration. For each alternative solution, information is provided to identify advantages and disadvantages of each alternative option with respect to the evaluation criteria. In this respect, comparisons and trade-offs can be made between alternatives. Trade-offs can involve forfeiting an advantage or accepting a disadvantage to address a higher priority consideration. Within the evaluation matrix, scores are assigned as follows:



5.2 Approach to Evaluations and Recommendations

In order to develop a robust plan for the Region's treatment plants, options have been grouped into infrastructure options and non-infrastructure opportunities. Infrastructure options are approaches that are more widely accepted by the industry and there is a high level of confidence that approvals could be obtained (such as expansions to existing processes or installing new technologies). Non-infrastructure options represent new approaches and will require additional studies and consultation to confirm feasibility and approvals. It can be noted that there may be some new infrastructure required for non-infrastructure options, however, this is normally minor work in comparison with an infrastructure option. Overall, non-infrastructure options are more focused on changes to operations or implementing new programs to achieve objectives.

To ensure that the Region has a fully-funded and feasible plan in place following the completion of this WWTMP study, for each plant, for both growth and level of treatment, an infrastructure option has been selected as the preferred alternative, and non-infrastructure opportunities are noted where available for future investigation. The following sections provide additional details on the options evaluated, the

detailed evaluation matrix and the preferred infrastructure options, as well as non-infrastructure opportunities for each treatment plant.

5.3 Waterloo WWTP

As described in Section 4.1, the alternatives evaluated for the Waterloo WWTP cover both growth and level of treatment alternatives, and include the following:

- Growth alternatives:
  - Infrastructure Options
    - Wa1 – Diversion to Kitchener WWTP
    - Wa2a – Conventional Expansion of Waterloo WWTP
    - Wa2b – Expansion of Waterloo WWTP Using New Technology (Granular Sludge)
  - Non-infrastructure Opportunity
    - Wa2c – Re-rating
- Level of treatment alternatives:
  - Infrastructure Option
    - Wa3 – Phosphorus Removal (New Tertiary Filters) at Waterloo WWTP
  - Non-infrastructure Opportunity
    - Wa4 – Phosphorus Trading with Kitchener WWTP

Based on the evaluations presented in Table 31 and Table 32 for growth and level of treatment alternatives, respectively, the following are the preferred infrastructure alternatives, with the key considerations, together with any non-infrastructure opportunities recommended for further investigation:

Growth

- Preferred Infrastructure Option: Expansion using New Technology (Granular Sludge)
  - Significant potential for energy savings

- Can be incorporated into existing infrastructure
- Preserves site space for future requirements
- Lowest annual operating cost
- Pilot testing may be required for approval

+ Non-Infrastructure Opportunity: Re-rating of the Waterloo WWTP (pending more detailed study to confirm feasibility)
  - Lowest cost alternative
  - Utilizes existing infrastructure
  - Could accommodate small capacity increase required within the planning period
  - Minimal environmental and social impacts due to reduced construction required for implementation.
  - Requires re-rating study and approval by MOECC prior to implementation

Level of Treatment

+ Preferred Infrastructure Option: Phosphorus Removal (New Tertiary Filters) at Waterloo WWTP
  - Minimal environmental impacts since tertiary filtration is a well understood process able to meet phosphorus removal targets to the Grand River
  - Reliable treatment technology
    - Minimal social impacts with construction restricted to existing treatment plant site, but does require site space

Table 31 Detailed Evaluation of Growth Options for Waterloo WWTP

Category	Criteria	Infrastructure Option Option Wa1 – Diversion to Kitchener WWTP		Infrastructure Option Option Wa2a – Expansion with Conventional Technology		Infrastructure Option Option Wa2b – Expansion with New Technology		Non-Infrastructure Opportunity Option Wa2c – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• This option is based on diverting a portion of the flow from the Waterloo WWTP service area to the Kitchener WWTP for treatment. Effluent quality limits would be met with treatment at the Kitchener WWTP, with improved effluent quality related to the recent upgrades to tertiary treatment. • Fisheries and aquatic health would be protected through adequate treatment capacity at the Kitchener WWTP for the additional flows from the Waterloo service area.	●	• This option is based on expanding the Waterloo WWTP using conventional activated sludge to provide the required capacity to meet the 2051 flow forecast. Expansion would be designed to meet future proposed effluent quality. Fisheries and aquatic health would be protected through adequate treatment capacity at the Waterloo WWTP.	●	• This option is based on expanding the Waterloo WWTP using new technology to provide the required capacity to meet the 2051 flow forecast. Expansion would be designed to meet future proposed effluent quality. Fisheries and aquatic health would be protected through adequate treatment capacity at the Waterloo WWTP.	●	• This option is based on re-rating the Waterloo WWTP to provide the required capacity to meet the 2051 flow forecast using optimization and minor works. A study would be conducted to ensure that the re-rating would be sufficient to meet future capacity and proposed effluent quality. Fisheries and aquatic health would be protected through the adequate treatment capacity at the Waterloo WWTP.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• All infrastructure necessary to convey flows from the Waterloo WWTP to the Kitchener WWTP would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to additional conveyance requirements from the Waterloo WWTP service area to the Kitchener WWTP.	●	• All new infrastructure necessary to provide additional capacity on the Waterloo WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to the moderate footprint of the additional treatment requirements at the existing Waterloo WWTP site.	●	• All new infrastructure necessary to provide additional capacity on the Waterloo WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to the small footprint of the additional treatment requirements at the existing Waterloo WWTP site.	●	• All new infrastructure necessary to provide additional capacity on the Waterloo WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to very limited construction requirements for a re-rating process.	●

Category	Criteria	Infrastructure Option Option Wa1 – Diversion to Kitchener WWTP		Infrastructure Option Option Wa2a – Expansion with Conventional Technology		Infrastructure Option Option Wa2b – Expansion with New Technology		Non-Infrastructure Opportunity Option Wa2c – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• Modifications to existing infrastructure are required to convey flows from Waterloo WWTP service area to the Kitchener WWTP, including upgrades to the Bridgeport SPS and Spring Valley SPS, and associated forcemains. There is some potential for impacts to natural features during this construction within the collection system.	◔	• Construction of additional infrastructure is required at the Waterloo WWTP site to provide the required additional capacity. There is minimal potential for impacts to natural features during this construction within the Waterloo WWTP site boundaries.	◔	• Construction of additional infrastructure is required at the Waterloo WWTP site to provide the required additional capacity. There is minimal potential for impacts to natural features during this construction within the Waterloo WWTP site boundaries.	◔	• There is no need for construction at the Waterloo WWTP site to provide the required additional capacity through a re-rating process, therefore there is negligible potential for impacts to natural features during this construction within the Waterloo WWTP site boundaries.	●
	Climate Change – Resiliency to extreme conditions	• The Kitchener WWTP has available capacity to treat increased flows, including those associated with extreme conditions as a result of climate change. The infrastructure upgrades required to the collection system (Bridgeport SPS, Spring Valley SPS and forcemains) to convey the additional flow to the Kitchener WWTP would require consideration to be sized for potential extreme conditions resulting from climate change.	◔	• Conventional activated sludge technology provides some flexibility to accommodate extreme conditions due to climate change as infrastructure is designed according to guidelines that provide some conservatism to handle fluctuations in conditions.	◔	• The new technology provides significant flexibility as there is the potential to operate at significantly higher MLSS concentrations and solids loading rates within the secondary treatment process using the existing infrastructure. This provides additional process flexibility within the existing infrastructure to potentially handle extreme conditions associated with climate change.	●	• Re-rating poses a slightly higher potential risk as a result of extreme conditions, since typically, the plant is run at higher than typical hydraulic or solids loading rates to achieve the additional capacity. This leads to higher potential for risk if extreme flow conditions are experienced as there is less flexibility to accommodate the higher flows within the existing infrastructure.	◑

Category	Criteria	Infrastructure Option Option Wa1 – Diversion to Kitchener WWTP		Infrastructure Option Option Wa2a – Expansion with Conventional Technology		Infrastructure Option Option Wa2b – Expansion with New Technology		Non-Infrastructure Opportunity Option Wa2c – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• The Kitchener WWTP provides a high level of wastewater treatment, so this option does not result in any increased risk to the public or downstream users of the Grand River.	●	• Conventional treatment technologies at the Waterloo WWTP provide a high level of wastewater treatment, so this option does not result in any increased risk to the public or downstream users of the Grand River	●	• The new technology proposed for the Waterloo WWTP provides a high level of treatment leading to no increased risk to public health and safety and downstream users.	●	• Re-rating poses a slightly higher potential risk to downstream users since typically, the plant is run at higher than typical hydraulic or solids loading rates to achieve the additional capacity. A detailed study is required under this option to ensure that the facility can operate safely and continue to meet effluent quality limits under re-rated conditions.	◔
	Short and Long-Term Growth – Minimize potential negative effects on short term and long-term community growth and development – Meet Region's growth objectives outlined in ROP	• The Kitchener WWTP has excess capacity for the planning period to 2051, so could accommodate additional flows from the Waterloo WWTP service area. Short-term and long-term growth could be accommodated under this option, however, there is less flexibility with this option as the amount of available flow for diversion is governed by the catchment area of the Bridgeport SPS.	◔	• Conventional technologies proposed would provide sufficient additional capacity to meet the needs of the Waterloo WWTP service area within the planning period to 2051. • Short-term and long-term growth could be accommodated under this option.	●	• The new technology proposed would provide sufficient additional capacity to meet the needs of the Waterloo WWTP service area within the planning period to 2051, and potentially additional capacity. • Short-term and long-term growth could be accommodated under this option.	◔	• Re-rating provides some additional capacity, depending on the results of a re-rating study. Without expansion, site capacity is reserved to accommodate future growth through expansion.	◑

Category	Criteria	Infrastructure Option Option Wa1 – Diversion to Kitchener WWTP		Infrastructure Option Option Wa2a – Expansion with Conventional Technology		Infrastructure Option Option Wa2b – Expansion with New Technology		Non-Infrastructure Opportunity Option Wa2c – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
Social	**Land Use** – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• No additional land would be required at the Waterloo WWTP site, preserving site area for potential future upgrades. Existing infrastructure at the Kitchener WWTP would be utilized. Additional land may be required at the Spring Valley SPS for expansion to accommodate redirected flows.	◔	• Conventional treatment technology would require new tankage at the Waterloo WWTP, requiring the use of some of the remaining site space, limiting the potential for additional future expansion. This represents the largest footprint option.	◐	• The new technology would use existing infrastructure at the Waterloo WWTP primarily, with minor additional infrastructure required. Some site space would be required, but it is minor compared to a conventional activated sludge expansion.	◔	• No additional land would be required for re-rating of the Waterloo WWTP, preserving site area for potential future upgrades.	●
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• Infrastructure upgrades are required to the collection system (Bridgeport SPS, Spring Valley SPS and forcemains) to convey the additional flow to the Kitchener WWTP, which may potentially impact residents in the areas of these stations. There would be no impacts to residents in the immediate vicinity of the Waterloo WWTP, and no additional impacts to residents during operation as existing capacity at the Kitchener WWTP is being utilized.	◐	• There will be some potential impacts during construction due to additional truck traffic and noise, which can be mitigated with proper construction practices and schedules. Impacts will be limited to Waterloo WWTP area during construction. Additional nuisance impacts are not expected during normal plant operations.	◔	• There will be some potential impacts during construction due to additional truck traffic and noise, which can be mitigated with proper construction practices and schedules. Impacts will be limited to Waterloo WWTP area during construction. Additional nuisance impacts are not expected during normal plant operations.	◔	• Community impacts will be minimal as there will be no significant construction associated with a re-rating option. Additionally, there will be no increased impact during operations as the process will remain the same.	●

Category	Criteria	Infrastructure Option Option Wa1 – Diversion to Kitchener WWTP		Infrastructure Option Option Wa2a – Expansion with Conventional Technology		Infrastructure Option Option Wa2b – Expansion with New Technology		Non-Infrastructure Opportunity Option Wa2c – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Infrastructure upgrades required to the collection system (Bridgeport SPS, Spring Valley SPS and forcemains) in order to convey the additional flow to the Kitchener WWTP have the potential to impact areas which are previously undisturbed and may potentially retain some archaeological potential. Detailed studies would be required at the time of design and construction.	◐	• Any additional infrastructure is limited to the existing Waterloo WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Any additional infrastructure is limited to the existing Waterloo WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Limited additional infrastructure is required and would be limited to the existing Waterloo WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed sites and road right-of-ways. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as construction is limited to existing disturbed sites. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as construction is limited to existing disturbed sites. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as construction is limited. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●

Category	Criteria	Infrastructure Option Option Wa1 – Diversion to Kitchener WWTP		Infrastructure Option Option Wa2a – Expansion with Conventional Technology		Infrastructure Option Option Wa2b – Expansion with New Technology		Non-Infrastructure Opportunity Option Wa2c – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
Legal/Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Performance of the Kitchener WWTP is well understood and there is little additional complexity or effort expected to obtain approval for treatment of additional flows from Waterloo WWTP service area at the Kitchener WWTP. Coordination would be required with the City of Kitchener to confirm approval for rerouting flows through the collection system.	◔	• Performance of the Waterloo WWTP is well understood and there is little additional complexity or effort expected to obtain approval for treatment of additional flows using conventional treatment technologies.	●	• Approvals are expected to require more effort due to limited full scale application of new technology within Ontario. Pilot testing may be required to obtain necessary approvals.	◐	• Detailed re-rating study is required to determine potential for re-rating given current and future hydraulic and solids loading rates. Additional consultation with MOECC is expected to be required to obtain approval for re-rating.	◔
	Land Requirements – Potential need to acquire land for additional treatment works and ownership requirements	• There is some potential need to obtain easements for new forcemains due to the required upgrades to the collection system between the Waterloo WWTP and the Kitchener WWTP. Expansion of Spring Valley SPS may also require additional land.	◔	• No additional land acquisition would be required for a conventional expansion of the Waterloo WWTP.	●	• No additional land acquisition would be required for construction of the new technology at the Waterloo WWTP.	●	• No additional land acquisition would be required for re-rating of the Waterloo WWTP.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Additional energy use and greenhouse gas generation associated with pumping flow twice from Waterloo WWTP service area to Kitchener WWTP for treatment. No impact to biogas generation as treatment process would remain the same regardless of treatment at Waterloo WWTP or Kitchener WWTP.	◐	• Energy use and greenhouse gas generation not expected to change from existing treatment process at Waterloo WWTP. Limited opportunities for additional biogas generation with existing process.	◔	• Depending on the particular vendor technology selected (to be determined during EA or design process), energy savings of greater than 15% are possible, therefore reducing greenhouse gas emissions related to energy use. Biogas generation isn't expected to change with the new technology.	●	• Energy use and greenhouse gas generation not expected to change from existing treatment process at Waterloo WWTP. Limited opportunities for additional biogas generation with existing process.	◔

Category	Criteria	Infrastructure Option Option Wa1 – Diversion to Kitchener WWTP		Infrastructure Option Option Wa2a – Expansion with Conventional Technology		Infrastructure Option Option Wa2b – Expansion with New Technology		Non-Infrastructure Opportunity Option Wa2c – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• The upgrades within the collection system required to convey the flow to the Kitchener WWTP would require careful planning and phasing in order to ensure that the additional capacity for the Waterloo WWTP service area is available when required.	◐	• Since the additional capacity required within the planning period to 2051 is small, the requirements to provide this capacity (new secondary clarifier and influent pumping) are constructed off-line with limited impact to existing plant operations or a need for construction phasing.	◔	• The construction requirements for the new technology to provide the additional capacity are expected to be minor as existing tankage will be fit with media to provide the enhanced treatment. Some phasing may be necessary to ensure no impact to existing plant operations during the start-up period of the new technology.	◔	• No construction required for re-rating allows complete flexibility in implementation schedule and no constructability impacts.	●
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• This option makes use of available treatment capacity at the Kitchener WWTP, but there is an investment required for the conveyance upgrades required to divert flows to the Kitchener WWTP.	◔	• Additional capacity is required so this option does not utilize existing available treatment capacity.	◐	• This option makes use of some existing infrastructure within the Waterloo WWTP site (RAS reaeration tanks) to provide the additional capacity using new technologies. Some new tankage is required for equalization purposes.	◔	• Re-rating is by definition an optimization of existing infrastructure, so this makes full use of infrastructure already in place within the Region.	●
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• There is little innovation under this option as it involves only collection system upgrades and conventional treatment at the Kitchener WWTP.	◐	• Very little innovation is involved in a conventional treatment expansion.	◓	• This option is based on a very innovative new process that provides benefits in terms of energy and footprint savings.	●	• Re-rating is moderately innovative as it involves studying the existing available capacity within the treatment plant and optimizing existing processes.	◔

Category	Criteria	Infrastructure Option Option Wa1 – Diversion to Kitchener WWTP		Infrastructure Option Option Wa2a – Expansion with Conventional Technology		Infrastructure Option Option Wa2b – Expansion with New Technology		Non-Infrastructure Opportunity Option Wa2c – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional activated sludge technology is well understood and is able to meet the performance objectives under a range of conditions.	●	• Conventional activated sludge technology is well understood and is able to meet the performance objectives under a range of conditions.	●	• There Is limited local full-scale data to understand the potential for upsets as a result of this new technology. Available data suggest the process is robust and not susceptible to process upset.	◔	• There is some minor risk of upset due to operation at higher hydraulic or solids loading rates necessary to obtain a re-rated capacity.	◑
	Cost to Ratepayers – Impact to existing ratepayers for user rates	• Moderate impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	◔	• Highest impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	◑	• Moderate impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	◔	• Lowest impact to existing ratepayers. Some funding would be available from development charges to accommodate re-rating.	●
Financial	**Financial Sustainability** – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●
	Life Cycle Cost – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $5,200,000 • Annual operating cost: $1,034,000 • PV life-cycle cost: $14,959,000	◔	• Capital cost: $9,105,000 • Annual operating cost: $1,000,000 • PV life-cycle cost: $18,078,000	◓	• Capital cost: $8,800,000 • Annual operating cost: $859,000 • PV life-cycle cost: $16,323,000	◑	• Capital cost: $953,000 • Annual operating cost: $970,000 • PV life-cycle cost: $11,686,000	●
Total Score			◑		◑		◔		●

Table 32 Detailed Evaluation of Level of Treatment Options for Waterloo WWTP

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option Wa3 – Phosphorus Removal (New Tertiary Filters) at Waterloo WWTP		**Option Wa4 – Phosphorus Trading with Kitchener WWTP**	
		Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• Tertiary treatment would be designed to meet the required effluent quality determined by the ACS (Stantec 2014), established to be protective of the surface water environment.	●	• It is estimated, based on the ACS (Stantec 2014) conducted, that the maximum allowable effluent TP concentration would be 0.11 mg/L for the Kitchener WWTP after trading with the Waterloo WWTP. The concentration is achievable with conventional tertiary filtration technology but with some risk to achieve this on a monthly average basis, as this is at the limit of technology for most current tertiary filtration technologies (e.g. ranging from 0.1 to 0.2 mg/L for disk filters). There would also be significant effects to the Grand River segment between the Waterloo and Kitchener WWTPs where the effluent would remain at an enhanced secondary treatment level.	○
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• There is limited potential impact to wells and aquifers due to construction of a new tertiary treatment process on the existing Waterloo WWTP site.	◔	• There is no impact on wells or aquifers as there is no construction required for this option.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• New tertiary treatment facility construction would be limited to a small area within the existing Waterloo WWTP site and is not anticipated to have any potential effects on terrestrial natural features.	●	• No construction and therefore no potential impacts to terrestrial features.	●
	Climate Change – Resiliency to extreme conditions	• A new tertiary treatment facility would have the flexibility to accommodate extreme conditions as a result of climate change.	●	• There is some potential risk associated with this option as the low monthly TP limit required at the Kitchener WWTP to meet the loading criteria for trading with Waterloo WWTP provides limited flexibility for process upset conditions or extreme conditions associated with climate change.	◐

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option Wa3 – Phosphorus Removal (New Tertiary Filters) at Waterloo WWTP		**Option Wa4 – Phosphorus Trading with Kitchener WWTP**	
		Rationale	Score	Rationale	Score
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• A new tertiary treatment facility would have the ability to produce high quality tertiary level effluent under a range of conditions and provide reliability for effluent quality for downstream users.	●	• There is some potential risk associated with this option as the low monthly TP limit required at the Kitchener WWTP to meet the loading criteria for trading with Waterloo WWTP provides limited flexibility for process upset conditions potentially leading to uncertainty of water quality for downstream users. Specifically, the intake for the Mannheim Water Treatment Plant is located between the Waterloo and Kitchener WWTPs, which could pose additional risks to health and safety.	◒
	Short and Long-Term Growth – Minimize potential negative effects on short term and long-term community growth and development – Meet Region's growth objectives outlined in ROP	• Meets growth needs through new tertiary facility.	●	• Trading can meet the short-term growth needs with some risk, but there is little flexibility to meet future long-term growth needs as the TP concentration required is at or near the limit of technology under the current planning period trading scenario.	◐
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• Land would be required for the new tertiary treatment facility.	◐	• No additional land would be required for phosphorus trading.	●
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• There will be some nuisance impacts during construction in the Waterloo WWTP area, but no anticipated additional impacts to residents during operation.	◔	• Community impacts will be minimal as there will be no construction associated with this option. There will be no increased impact during operations as the process will remain the same at Waterloo WWTP, however, there will be increased operational intensity at the Kitchener WWTP to maintain low effluent phosphorus levels.	◐
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Limited additional infrastructure is required and would be limited to the existing Waterloo WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• No new infrastructure required and therefore no potential impact.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed sites and road right-of-ways. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as no construction is required. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option Wa3 – Phosphorus Removal (New Tertiary Filters) at Waterloo WWTP		**Option Wa4 – Phosphorus Trading with Kitchener WWTP**	
		Rationale	Score	Rationale	Score
Legal/ Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Tertiary treatment processes are well understood, and minimal effort is expected in obtaining approval for this option.	●	• Increase in TP between Waterloo and Kitchener WWTP is not likely to be approved based on the Policy 2 status of the Grand River with respect to phosphorus. Furthermore, there may be challenges to demonstrate that the low concentrations required at Kitchener WWTP are achievable on an on-going monthly average basis.	○
	Land Requirements – Potential need to acquire land for additional treatment works and ownership requirements	• There is no need for any additional land to be acquired as all infrastructure would be on the existing Waterloo WWTP site.	●	• No additional land acquisition would be required for a phosphorus trading option.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Additional energy use and greenhouse gas generation associated with additional tertiary treatment process.	◐	• Minimal additional energy use or greenhouse gas generation associated with a phosphorus trading option.	●
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• Tertiary treatment process can be construction off-line with minimal impact on existing treatment processes.	●	• No construction required for trading, allows complete flexibility in implementation schedule and no constructability impacts.	●
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• Additional infrastructure is required at the Waterloo WWTP for this option, so it does not make use of existing infrastructure.	◐	• Tertiary treatment is already in place at the Kitchener WWTP, so this makes use of infrastructure already in place within the Region to achieve the desired phosphorus levels within the Grand River.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option Wa3 – Phosphorus Removal (New Tertiary Filters) at Waterloo WWTP		**Option Wa4 – Phosphorus Trading with Kitchener WWTP**	
		Rationale	Score	Rationale	Score
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• There is little innovation under this option as it involves construction of a conventional tertiary treatment process at the Waterloo WWTP.	◐	• Trading phosphorus is an innovative way to utilize existing infrastructure within the Region to provide the desired level of effluent quality without the need for costly new infrastructure.	●
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional tertiary treatment is well understood and is able to meet the performance objectives under a range of conditions.	●	• There is some risk of upset due to the low TP concentrations required to be achieved at the Kitchener WWTP on a monthly average basis in order to keep the TP loading at an acceptable level for trading with Waterloo WWTP.	◔
Financial	**Cost to Ratepayers** – Impact to existing ratepayers for user rates	• Highest impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	◔	• Lowest impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	●
	Financial Sustainability – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements.	●	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements.	●
	Life Cycle Cost – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $19,130,000 • Annual operating cost: $78,000 • PV life-cycle cost: $18,411,000	◐	• Capital cost: $- • Annual operating cost: $35,000 • PV life-cycle cost: $609,000	●
Total Score		●		◐	

5.4 Preston WWTP

As described in Section 4.2, the alternatives to be evaluated for the Preston WWTP are related to level of treatment only, and include the following:

- Level of treatment alternatives:
  - Infrastructure Option
    - Pr1 – Phosphorus Removal (Optimization of Secondary Treatment) at Preston WWTP
  - Non-infrastructure Opportunity
    - Pr2 – Phosphorus Off-setting

Based on the evaluation presented in Table 33, the following is the preferred infrastructure alternative, with the key considerations:

Level of Treatment

- Preferred Infrastructure Option: Phosphorus Removal (Optimization of Secondary Treatment) at Preston WWTP
  - Lowest cost alternative
  - Utilizes existing secondary treatment and chemical dosing infrastructure already available at the Preston WWTP
  - Preserves site space for future growth or treatment requirements
  - Minimal social impacts with no construction required.

Table 33 Detailed Evaluation of Level of Treatment Options for Preston WWTP

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option Pr1 – Phosphorus Removal (Optimization of Secondary Treatment) at Preston WWTP		Option Pr2 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• Phosphorus removal would be achieved using optimized secondary treatment to meet the effluent quality required for the Lake Erie effluent targets, established to be protective of the surface water environment.	●	• This option is based on implementing a phosphorus off-setting program to reduce phosphorus loading to the Grand River watershed. It is estimated that approximately 4,960 kg/y of phosphorus would be required to be removed from the environment through the off-setting practice, based on the expected off-setting 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). This is a good approach to reducing phosphorus on a watershed basis as it provides an overall benefit of further reduction of phosphorus from the 4:1 ratio.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• There is no potential impact to wells and aquifers as there is no construction to optimize secondary treatment on the existing Preston WWTP site.	◕	• There is no impact on wells or aquifers as there is no construction required for this option and there may be a potential benefit associated with improved farming practices concerning nutrient run-off.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• No construction required to optimize secondary treatment on the existing Preston WWTP site therefore no anticipated effects on terrestrial natural features.	●	• Phosphorus off-setting involves coordination with the local agricultural community in order to ensure that practices are implemented and monitored for success. Some potential changes may be required to existing agricultural land, but it is expected that these changes would improve the overall conditions of the area. No negative impacts are expected.	●
	Climate Change – Resiliency to extreme conditions	• Optimized secondary treatment facility would have the flexibility to accommodate extreme conditions as a result of climate change.	●	• Phosphorus off-setting is a flexible watershed based program that ultimately improves and protects water quality. It allows for a limited increase in pollutant discharge to be “off-set” by greater reductions elsewhere in the same watershed. Off-setting can be achieved under a range of flow conditions and is not susceptible to upsets due to extreme conditions.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option Pr1 – Phosphorus Removal (Optimization of Secondary Treatment) at Preston WWTP		Option Pr2 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• Optimized secondary treatment facility would have the ability to produce high quality effluent under a range of conditions and provide reliability for effluent quality for downstream users.	●	• 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 "off-set" by greater reductions elsewhere in the same watershed. This approach would protect downstream water users through overall improvement in nutrient loads.	●
	Short and Long-Term Growth – Minimize potential negative effects on short term and long-term community growth and development – Meet Region's growth objectives outlined in ROP	• Meets growth needs through optimization of the existing secondary treatment facility.	●	• Since the load of phosphorus entering the watershed from agricultural activities is much greater than that from municipal point sources, off-setting can meet the short and long-term growth needs with some risk due to timing of obtaining required approvals.	◕
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• No land is required as the existing secondary treatment and chemical dosing facilities are existing on the Preston WWTP site.	●	• No additional land would be required for phosphorus off-setting.	●
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• No nuisance impacts as there are no construction requirements at the Preston WWTP. No anticipated additional impacts to residents during operation.	●	• Community impacts will be minimal as there will be no construction associated with this option on the Preston WWTP site. Limited construction would be required on agricultural properties. There will be no increased impact during operations as the process will remain the same.	●
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• No additional infrastructure is required.	●	• Limited construction would be required on agricultural properties. Minimal potential for impact to heritage features on previously farmed lands.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as there is no construction required. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as no construction is required. Water quality within the watershed will be improved by the off-setting practice with a potential benefit to First Nations communities downstream.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option Pr1 – Phosphorus Removal (Optimization of Secondary Treatment) at Preston WWTP		Option Pr2 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Legal/ Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Optimized secondary treatment processes are well understood and minimal effort is expected in obtaining approval for this option.	●	• Approval for this option is expected to require significant effort to obtain given that there are few nutrient off-setting schemes in place within Ontario. Additional consultation with MOECC and GRCA is expected to be required to obtain approval for a phosphorus off-setting option, and a program must be developed for implementation and monitoring of the off-setting scheme.	◒
	Land Requirements – Potential need to acquire land for additional treatment works and ownership requirements	• There is no need for any additional land to be acquired as all infrastructure is existing on the Preston WWTP site.	●	• No additional land acquisition would be required for a phosphorus off-setting option.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Minimal additional energy use and greenhouse gas generation associated with optimized secondary treatment process.	◕	• No additional energy use or greenhouse gas generation associated with a phosphorus off-setting option.	●
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• No construction and therefore no impact on existing treatment processes.	●	• Limited construction would be required on agricultural properties for off-setting, allowing flexibility in implementation schedule and no constructability impacts on the existing treatment process.	●
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• No additional infrastructure is required at the Preston WWTP for this option, so it makes use of existing infrastructure.	●	• No new treatment plant infrastructure is required for this option. Some minor infrastructure would be required on agricultural properties to achieve the nutrient runoff reduction.	◔

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option Pr1 – Phosphorus Removal (Optimization of Secondary Treatment) at Preston WWTP		Option Pr2 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• There is little innovation under this option as it involves optimization of existing secondary treatment process at the Preston WWTP.	◐	• Phosphorus off-setting is an innovative way to reduce overall loadings within the watershed while improving agricultural practices without the need for costly new infrastructure at the WWTP.	●
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional secondary treatment is well understood and is able to meet the performance objectives under a range of conditions.	●	• The reduction is achieved through an offsetting ratio that is applied to the discharge, typically a 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). The operation and monitoring of the off-setting program must be established in order to ensure that performance objectives are achieved.	◔
Financial	**Cost to Ratepayers** – Impact to existing ratepayers for user rates	• Impact to rate payers is low for optimization of existing secondary treatment process.	●	• Impact to rate payers is very high due to on-going program costs for phosphorus off-setting. Existing ratepayers would be required to pay entire amount as there is no growth component.	○
	Financial Sustainability – Balance infrastructure needs with ability to pay (user rates and development charges)	• Minimal increased cost to optimize existing secondary treatment process.	●	• No development charges as upgrades are not growth related.	◔
	Life Cycle Cost – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $0 • Annual operating cost: $0 • PV life-cycle cost: $0	●	• Capital cost: $1,996,000 • Annual operating cost: $1,479,000 • PV life-cycle cost: $31,249,000	○
Total Score			●		◐

5.5 Hespeler WWTP

As described in Section 4.3, the alternatives to be evaluated for the Hespeler WWTP cover both growth and level of treatment alternatives, and include the following:

- Growth alternatives:
  - Infrastructure Options
    - He1a – Expansion of Hespeler WWTP with Conventional Treatment
    - He1b – Expansion of Hespeler WWTP Using New Technology (MABR)
- Level of treatment alternatives:
  - Infrastructure Option
    - He2 – Phosphorus Removal (Optimization of Secondary Treatment) at Hespeler WWTP
  - Non-infrastructure Opportunity
    - He3 – Phosphorus Off-setting

Based on the evaluations presented in Table 34 and Table 35 for growth and level of treatment alternatives, respectively, the following are the preferred infrastructure alternatives, with the key considerations, together with any non-infrastructure opportunities recommended for further investigation:

Growth

- Preferred Infrastructure Option: Expansion Using New Technology (MABR)
  - Lowest cost alternative
  - New, innovative technology
  - Small footprint preserving space for future expansion
  - Provides environmental benefits due to energy savings and greenhouse gas reductions

Level of Treatment

+ Preferred Infrastructure Option: Phosphorus Removal (Optimization of Secondary Treatment) at Hespeler WWTP
  - Lowest cost alternative through optimized chemical dosing
  - Site has space available for future requirements
  - High phosphorus load reduction challenging to achieve with phosphorus off-setting
  - Construction impacts limited to Hespeler WWTP site.

Table 34 Detailed Evaluation of Growth Options for Hespeler WWTP

Category	Criteria	Infrastructure Option Option He1a – Expansion with Conventional Technology		Infrastructure Option Option He1b – Expansion with New Technology (MABR)	
		Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• This option is based on expanding the Hespeler WWTP using conventional activated sludge to provide the required capacity to meet the 2051 flow forecast. Expansion would be designed to meet future proposed effluent quality, as determined by assimilative capacity study of the Speed River. Fisheries and aquatic health would be protected through adequate treatment capacity at the Hespeler WWTP.	●	• This option is based on expanding the Hespeler WWTP using new membrane aerated biofilm reactor (MABR) technology to provide the required capacity to meet the 2051 flow forecast. Expansion would be designed to meet future proposed effluent quality, as determined by assimilative capacity study of the Speed River. Fisheries and aquatic health would be protected through adequate treatment capacity at the Hespeler WWTP.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• All new infrastructure necessary to provide additional capacity on the Hespeler WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to the moderate footprint of the additional treatment requirements at the existing Hespeler WWTP site.	●	• All new infrastructure necessary to provide additional capacity on the Hespeler WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to the small footprint of the additional treatment requirements with an MABR at the existing Hespeler WWTP site.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• Construction of additional infrastructure is required at the Hespeler WWTP site to provide the required additional capacity. There is minimal potential for impacts to natural features during this construction within the Hespeler WWTP site boundaries.	●	• Construction of additional infrastructure is required at the Hespeler WWTP site to provide the required additional capacity. There is minimal potential for impacts to natural features during this construction within the Hespeler WWTP site boundaries.	●
	Climate Change – Resiliency to extreme conditions	• Conventional activated sludge technology provides some flexibility to accommodate extreme conditions due to climate change as infrastructure is designed according to guidelines that provide some conservatism to handle fluctuations in conditions.	●	• The new technology provides significant flexibility as it provides very high oxygen transfer efficiencies and therefore allows operation within a smaller footprint. • This provides additional process flexibility within the existing infrastructure to potentially handle extreme conditions associated with climate change.	●

Category	Criteria	Infrastructure Option Option He1a – Expansion with Conventional Technology		Infrastructure Option Option He1b – Expansion with New Technology (MABR)	
		Rationale	Score	Rationale	Score
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• Conventional treatment technologies at the Hespeler WWTP provide a high level of wastewater treatment, so this option does not result in any increased risk to the public or downstream users of the Speed River or Grand River watershed.	●	• The new technology proposed for the Hespeler WWTP provides a high level of treatment leading to no increased risk to public health and safety and downstream users.	●
	Short and Long-Term Growth – Minimize potential negative effects on short term and long-term community growth and development – Meet Region's growth objectives outlined in ROP	• Conventional technologies proposed would provide sufficient additional capacity to meet the needs of the Hespeler WWTP service area within the planning period to 2051. • Short-term and long-term growth could be accommodated under this option.	●	• The new technology proposed would provide sufficient additional capacity to meet the needs of the Hespeler WWTP service area within the planning period to 2051, and potentially additional capacity, depending on the specific implementation opportunities of the technology, that would be determined through additional study. • Short-term and long-term growth could be accommodated under this option.	●
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• Conventional treatment technology would require new tankage at the Hespeler WWTP, requiring the use of some of the remaining site space, limiting the potential for additional future expansion. This represents the largest footprint option.	◐	• The new technology would require some new infrastructure at the Hespeler WWTP, with a smaller footprint than conventional technologies. Some site space would be required, but it is minor compared to a conventional activated sludge expansion.	◔
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• There will be some potential impacts during construction due to additional truck traffic and noise, which can be mitigated with proper construction practices and schedules. Impacts will be limited to Hespeler WWTP area during construction. Additional nuisance impacts are not expected during normal plant operations.	◔	• There will be some potential impacts during construction due to additional truck traffic and noise, which can be mitigated with proper construction practices and schedules. Impacts will be limited to Hespeler WWTP area during construction. Additional nuisance impacts are not expected during normal plant operations.	◔
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Any additional infrastructure is limited to the existing Hespeler WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Any additional infrastructure is limited to the existing Hespeler WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed site. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as construction is limited to existing disturbed site. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●

Category	Criteria	Infrastructure Option Option He1a – Expansion with Conventional Technology		Infrastructure Option Option He1b – Expansion with New Technology (MABR)	
		Rationale	Score	Rationale	Score
Legal/ Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Performance of conventional activated sludge processes is well understood and there is little additional complexity or effort expected to obtain approval for treatment of additional flows using conventional treatment technologies.	●	• Approvals are expected to require more effort due to limited full scale application of MABR technology within Ontario. Pilot testing is being conducted for the Hespeler WWTP, which will help the approvals process.	◔
	Land Requirements – Potential need to acquire land for additional treatment works and ownership requirements	• No additional land acquisition would be required for a conventional expansion of the Hespeler WWTP.	●	• No additional land acquisition would be required for expansion with MABR at the Hespeler WWTP.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Energy use and greenhouse gas generation not expected to change from existing treatment process at Hespeler WWTP.	◐	• Depending on the particular vendor technology selected (to be determined during EA or design process), energy savings of approximately 25-50% are possible, therefore reducing greenhouse gas emissions related to energy use.	●
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• The majority of the additional tankage and processes can be constructed off-line and brought online without impacting the existing treatment process. Capacity could be phased to meet timing needs according to growth if necessary.	◔	• The new tanks and ancillary equipment for the MABR technology can be constructed offline to minimize any impacts to the existing treatment processes.	◔
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• Additional capacity is required so this option does not utilize existing available treatment capacity.	◐	• Some new tankage is required to house the MABR process equipment (membranes) within an anoxic zone, but much of existing infrastructure is utilized to provide the additional capacity.	◔
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• Very little innovation is involved in a conventional treatment expansion.	◓	• This option is based on a very innovative new process that provides benefits in terms of energy and footprint savings.	●

Category	Criteria	Infrastructure Option Option He1a – Expansion with Conventional Technology		Infrastructure Option Option He1b – Expansion with New Technology (MABR)	
		Rationale	Score	Rationale	Score
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional activated sludge technology is well understood and is able to meet the performance objectives under a range of conditions.	●	• There is limited local full-scale data to understand the potential for upsets as a result of this new technology. Available data suggest the process is robust and not susceptible to process upset, and able to meet all performance targets under a range of conditions.	◔
Financial	**Cost to Ratepayers** – Impact to existing ratepayers for user rates	• Moderate impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	◔	• Lowest impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	●
	Financial Sustainability – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●
	Life Cycle Cost – – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $19,636,000 • Annual operating cost: $429,000 • PV life-cycle cost: $19,442,000	◐	• Capital cost: $18,186,000 • Annual operating cost: $344,000 • PV life-cycle cost: $18,181,000	●
Total Score		◐		●	

Table 35 Detailed Evaluation of Level of Treatment Options for Hespeler WWTP

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option He2 – Phosphorus Removal (Optimization of Secondary Treatment) at Hespeler WWTP		Option He3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• Tertiary treatment would be designed to meet the required effluent quality determined by the ACS (Stantec, 2014), established to be protective of the surface water environment.	●	• This option is based on implementing a phosphorus offsetting program to reduce phosphorus loading to the Speed River and Grand River watershed. It is estimated that approximately 4,600 kg/y of phosphorus would be required to be removed from the environment through the off-setting practice, based on the expected 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). This is a good approach to reducing phosphorus on a watershed basis as it provides an overall benefit of further reduction of phosphorus from the 4:1 ratio.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• There is limited potential impact to wells and aquifers due to construction of mixing and chemical dosing upgrades on the existing Hespeler WWTP site.	◔	• There is no impact on wells or aquifers as there is no construction required for this option and there may be a potential benefit associated with improved farming practices concerning nutrient run-off.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• Construction would be limited to a small area within the existing Hespeler WWTP site and is not anticipated to have any potential effects on terrestrial natural features.	●	• Phosphorus off-setting involves coordination with the local agricultural community in order to ensure that practices are implemented and monitored for success. Some potential changes may be required to existing agricultural land, but it is expected that these changes would improve the overall conditions of the area. No negative impacts are expected.	●
	Climate Change – Resiliency to extreme conditions	• Phosphorus removal achieved through the upgraded chemical dosing facility would have some flexibility to accommodate extreme conditions as a result of climate change.	◔	• 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. Off-setting can be achieved under a range of flow conditions and is not susceptible to upsets due to extreme conditions.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option He2 – Phosphorus Removal (Optimization of Secondary Treatment) at Hespeler WWTP		Option He3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• The upgraded facility would have the ability to produce high quality effluent meeting ACS requirements under a range of conditions and provide reliability for effluent quality for downstream users.	●	• 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. This approach would protect downstream water users through overall improvement in nutrient loads.	●
	Short and Long-Term Growth – Minimize potential negative effects on short term and long-term community growth and development – Meet Region's growth objectives outlined in ROP	• Meets growth needs through phosphorus removal upgrades.	●	• Since the load of phosphorus entering the watershed from agricultural activities is much greater than that from municipal point sources, off-setting can meet the short and long-term growth needs with some risk due to timing of obtaining required approvals.	◕
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• Land within existing Hespeler WWTP site would be required for the mixing upgrades.	◔	• No additional land would be required for phosphorus off-setting.	●
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• There will be some nuisance impacts during minor construction in the Hespeler WWTP area, but no anticipated additional impacts to residents during operation.	◔	• Community impacts will be minimal as there will be no construction associated with this option on the Hespeler WWTP site. Limited construction would be required on agricultural properties. There will be no increased impact during operations as the process will remain the same as existing.	●
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Limited additional infrastructure is required and would be limited to the existing Hespeler WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Limited construction would be required on agricultural properties. Minimal potential for impact to heritage features on previously farmed lands.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed site. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as no construction is required. Water quality within the watershed will be improved by the practice with a potential benefit to First Nations communities downstream.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option He2 – Phosphorus Removal (Optimization of Secondary Treatment) at Hespeler WWTP		Option He3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Legal/ Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Optimized chemical dosing is well understood and minimal effort is expected in obtaining approval for this option.	●	• Approval for this option is expected to require significant effort to obtain given that there are few nutrient off-setting schemes in place within Ontario. Additional consultation with MOECC and GRCA is expected to be required to obtain approval for a phosphorus off-setting option, and a program must be developed for implementation and monitoring of the off-setting scheme.	◒
	Land Requirements – – Potential need to acquire land for additional treatment works and ownership requirements	• There is no need for any additional land to be acquired as all infrastructure would be on the existing Hespeler WWTP site.	●	• No additional land acquisition would be required for a phosphorus off-setting option.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Minimal additional energy use and greenhouse gas generation associated with phosphorus upgrades.	◔	• No additional energy use or greenhouse gas generation associated with a phosphorus off-setting option.	●
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• Upgrades can be constructed off-line with no impact on existing treatment processes.	●	• Limited construction would be required on agricultural properties for off-setting, allowing flexibility in implementation schedule and no constructability impacts on the existing treatment process.	●
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• Minor additional infrastructure is required at the Hespeler WWTP for this option.	◔	• No new treatment plant infrastructure is required for this option. Some minor infrastructure would be required on agricultural properties to achieve the nutrient runoff reduction.	◔

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option He2 – Phosphorus Removal (Optimization of Secondary Treatment) at Hespeler WWTP		**Option He3 – Phosphorus Off-Setting**	
		Rationale	Score	Rationale	Score
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• There is little innovation under this option as it involves construction of a conventional phosphorus removal process at the Hespeler WWTP.	◐	• Phosphorus off-setting is an innovative way to reduce overall loadings within the watershed while improving agricultural practices without the need for costly new infrastructure at the WWTP.	●
	Security, Reliability and Robustness – – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional chemical phosphorus removal is well understood and is able to meet the performance objectives under a range of conditions.	●	• The reduction is achieved through an offsetting ratio that is applied to the discharge, typically a 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). The operation and monitoring of the off-setting program must be established to ensure that performance objectives are achieved.	◔
Financial	**Cost to Ratepayers** – – Impact to existing ratepayers for user rates	• Impact to rate payers is moderate for minor upgrades. Some funding would be available from development charges to accommodate growth.	◐	• Impact to rate payers is very high due to on-going program costs for phosphorus off-setting.	○
	Financial Sustainability – – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements.	●	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements. May be challenges in allocation of development charges to a phosphorus off-setting program as impacts and benefits may be realized in different area municipalities.	◐
	Life Cycle Cost – – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $777,000 • Annual operating cost: $26,000 • PV life-cycle cost: $1,144,000	●	• Capital cost: $1,852,000 • Annual operating cost: $1,380,000 • PV life-cycle cost: $29,148,000	○
Total Score		●		◐	

5.6 Wellesley WWTP

As described in Section 4.4, the alternatives to be evaluated for the Wellesley WWTP cover both growth and level of treatment alternatives, and include the following:

- Growth alternatives:
  - Infrastructure Options
    - We1a – Expansion of Wellesley WWTP with Conventional Treatment
    - We1b – Expansion of Wellesley WWTP Using New Technology (Granular Sludge or similar)
- Level of treatment alternatives:
  - Infrastructure Option
    - We2 – Phosphorus Removal (Expansion of Existing Tertiary Filters) at Wellesley WWTP
  - Non-infrastructure Opportunity
    - We3 – Phosphorus Off-setting

Based on the evaluations presented in Table 36 and Table 37 for growth and level of treatment alternatives, respectively, the following are the preferred infrastructure alternatives, with the key considerations, together with any non-infrastructure opportunities recommended for further investigation:

Growth

- Preferred Infrastructure Option: Expansion Using New Technology (granular sludge or similar)
  - Lowest cost alternative
  - New, innovative technology
  - Small footprint preserving space for future expansion
  - Provides environmental benefits due to energy savings and greenhouse gas reductions

A key component of all alternatives for the Wellesley WWTP is inflow and infiltration reduction to reduce peak extraneous flows to the treatment plant. All alternatives include a solids upgrade component to provide sufficient solids treatment capacity to accommodate future flows.

Level of Treatment

+ Preferred Infrastructure Option: Phosphorus Removal (expansion of existing tertiary filters) at Wellesley WWTP
  - Low costs to expand existing tertiary filtration process
  - Minimal environmental impacts due to well understood tertiary filtration process
  - No additional site space required since tertiary filtration expansion can occur within existing building footprint.
+ Non-infrastructure Opportunity: Phosphorus Off-setting (pending more detailed study to confirm feasibility)
  - Lowest cost alternative
  - Utilizes existing tertiary treatment infrastructure already in place at the Wellesley WWTP
  - Preserves site space for future growth
  - Minimal social impacts due to no construction required
  - Minimal environmental impacts since overall phosphorus loading to Grand River is maintained.
  - As there is currently no program in place within the Region for phosphorus off-setting, a program would need to be developed, implemented and monitored for this alternative.

Table 36 Detailed Evaluation of Growth Options for Wellesley WWTP

Category	Criteria	Infrastructure Option Option We1a – Expansion with Conventional Technology		Infrastructure Option Option We1b – Expansion with New Technology (Granular Sludge)	
		Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• This option is based on expanding the Wellesley WWTP using conventional activated sludge to provide the required capacity to meet the 2051 flow forecast. Expansion would be designed to meet future proposed effluent quality, as determined by assimilative capacity study of the Nith River. Fisheries and aquatic health would be protected through adequate treatment capacity at the Wellesley WWTP.	●	• This option is based on expanding the Wellesley WWTP using new technology to provide the required capacity to meet the 2051 flow forecast. Expansion would be designed to meet future proposed effluent quality, as determined by assimilative capacity study of the Nith River. Fisheries and aquatic health would be protected through adequate treatment capacity at the Wellesley WWTP.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• All new infrastructure necessary to provide additional capacity on the Wellesley WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to the moderate footprint of the additional treatment requirements at the existing Wellesley WWTP site.	●	• All new infrastructure necessary to provide additional capacity on the Wellesley WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to the small footprint of the additional treatment requirements with a granular sludge system at the existing Wellesley WWTP site.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• Construction of additional infrastructure is required at the Wellesley WWTP site to provide the required additional capacity. There is minimal potential for impacts to natural features during this construction within the Wellesley WWTP site boundaries.	●	• Construction of additional infrastructure is required at the Wellesley WWTP site to provide the required additional capacity. There is minimal potential for impacts to natural features during this construction within the Wellesley WWTP site boundaries.	●
	Climate Change – Resiliency to extreme conditions	• Conventional activated sludge technology provides some flexibility to accommodate extreme conditions due to climate change as infrastructure is designed according to guidelines that provide some conservatism to handle fluctuations in conditions.	◔	• The new technology provides significant flexibility as it provides very high mixed liquor concentrations and energy savings and therefore allows operation within a smaller footprint. This provides additional process flexibility within the existing infrastructure to potentially handle extreme conditions associated with climate change.	◔

Category	Criteria	Infrastructure Option Option We1a – Expansion with Conventional Technology		Infrastructure Option Option We1b – Expansion with New Technology (Granular Sludge)	
		Rationale	Score	Rationale	Score
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• Conventional treatment technologies at the Wellesley WWTP provide a high level of wastewater treatment, so this option does not result in any increased risk to the public or downstream users of the Nith River or Grand River watershed.	●	• The new technology proposed for the Wellesley WWTP provides a high level of treatment leading to no increased risk to public health and safety and downstream users.	●
	Short and Long-Term Growth – Minimize potential negative effects on short term and long term community growth and development – Meet Region's growth objectives outlined in ROP	• Conventional technologies proposed would provide sufficient additional capacity to meet the needs of the Wellesley WWTP service area within the planning period to 2051. • Short-term and long-term growth could be accommodated under this option.	●	• The new technology proposed would provide sufficient additional capacity to meet the needs of the Wellesley WWTP service area within the planning period to 2051, and potentially additional capacity beyond the planning horizon, depending on the specific implementation opportunities of the technology that would be determined through additional study. • Short-term and long-term growth could be accommodated under this option.	●
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• Conventional treatment technology would require new tankage at the Wellesley WWTP, requiring the use of some of the remaining site space, limiting the potential for additional future expansion. This represents the largest footprint option.	◐	• The new technology would require some new infrastructure at the Wellesley WWTP, with a significantly smaller footprint than conventional technologies. Some site space would be required, but it is minor compared to a conventional activated sludge expansion.	◔
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• There will be some potential impacts during construction due to additional truck traffic and noise, which can be mitigated with proper construction practices and schedules. Impacts will be limited to Wellesley WWTP area during construction. Additional nuisance impacts are not expected during normal plant operations.	◔	• There will be some potential impacts during construction due to additional truck traffic and noise, which can be mitigated with proper construction practices and schedules. Impacts will be limited to Wellesley WWTP area during construction. Additional nuisance impacts are not expected during normal plant operations.	◔
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Any additional infrastructure is limited to the existing Wellesley WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Any additional infrastructure is limited to the existing Wellesley WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed site. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as construction is limited to existing disturbed site. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●

Category	Criteria	Infrastructure Option Option We1a – Expansion with Conventional Technology		Infrastructure Option Option We1b – Expansion with New Technology (Granular Sludge)	
		Rationale	Score	Rationale	Score
Legal/ Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Performance of conventional activated sludge processes is well understood and there is little additional complexity or effort expected to obtain approval for treatment of additional flows using conventional treatment technologies.	●	• Approvals are expected to require more effort due to limited full scale application of granular sludge processes within Ontario. There is a plan to conduct pilot testing of the process within the Region, which will facilitate the approvals process.	◐
	Land Requirements – Potential need to acquire land for additional treatment works and ownership requirements	• No additional land acquisition would be required for a conventional expansion of the Wellesley WWTP.	●	• No additional land acquisition would be required for expansion with granular sludge at the Wellesley WWTP.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Energy use and greenhouse gas generation not expected to change from existing treatment process at Wellesley WWTP. Limited opportunities for additional biogas generation with existing process.	◐	• Depending on the particular vendor technology selected (to be determined during EA or design process), energy savings of greater than 15% are possible, therefore reducing greenhouse gas emissions related to energy use. Biogas generation potential isn't expected to change with the new technology.	●
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• The majority of the additional tankage and processes can be constructed off-line and brought online without impacting the existing treatment process. Capacity could be phased to meet timing needs according to growth if necessary.	◔	• The new tanks and ancillary equipment for the granular sludge technology are primarily packaged and can therefore be installed offline to minimize any impacts to the existing treatment processes.	◔
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• Additional capacity is required so this option does not utilize existing available treatment capacity.	◐	• Some new tankage is required to house the MABR process equipment (membranes) within an anoxic zone, but much of the existing infrastructure is utilized to provide the additional capacity.	◔
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• Very little innovation is involved in a conventional treatment expansion.	◓	• This option is based on a very innovative new process that provides benefits in terms of energy and footprint savings.	●

Category	Criteria	Infrastructure Option Option We1a – Expansion with Conventional Technology Rationale	Score	Infrastructure Option Option We1b – Expansion with New Technology (Granular Sludge) Rationale	Score
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional activated sludge technology is well understood and is able to meet the performance objectives under a range of conditions.	●	• There is limited local full-scale data to understand the potential for upsets as a result of this new technology. Available data suggest the process is robust and not susceptible to process upset, and able to meet all performance targets under a range of conditions.	◔
Financial	**Cost to Ratepayers** – Impact to existing ratepayers for user rates	• Moderate impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	◔	• Lowest impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	●
	Financial Sustainability – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●
	Life Cycle Cost – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $6,586,000 • Annual operating cost: $63,000 • PV life-cycle cost: $5,311,000	◐	• Capital cost: $4,283,000 • Annual operating cost: $56,000 • PV life-cycle cost: $3,689,000	●
Total Score			◐		●

Table 37 Detailed Evaluation of Level of Treatment Options for Wellesley WWTP

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option We2 – Phosphorus Removal (Expansion of Existing Filters) at Wellesley WWTP		Option We3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• Tertiary treatment would be designed to meet the required effluent quality objectives as determined through an ACS to be protective of the surface water environment.	●	• This option is based on implementing a phosphorus offsetting program to reduce phosphorus loading to the Nith River and Grand River watershed. It is estimated that approximately 166 kg/y of phosphorus would be required to be removed from the environment through the off-setting practice, based on the expected 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). This is a good approach to reducing phosphorus on a watershed basis as it provides an overall benefit of further reduction of phosphorus from the 4:1 ratio.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• There is limited potential impact to wells and aquifers due to construction of a new tertiary treatment process on the existing Wellesley WWTP site.	◔	• There is no impact on wells or aquifers as there is no construction required for this option and there may be a potential benefit associated with improved farming practices concerning nutrient run-off.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• New tertiary treatment facility construction would be limited to a small area within the existing Wellesley WWTP site and is not anticipated to have any potential effects on terrestrial natural features.	●	• Phosphorus off-setting involves coordination with the local agricultural community in order to ensure that practices are implemented and monitored for success. Some potential changes may be required to existing agricultural land, but it is expected that these changes would improve the overall conditions of the area. No negative impacts are expected.	●
	Climate Change – Resiliency to extreme conditions	• A new tertiary treatment facility would have the flexibility to accommodate extreme conditions as a result of climate change.	●	• 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 “off-set” by greater reductions elsewhere in the same watershed. Off-setting can be achieved under a range of flow conditions and is not susceptible to upsets due to extreme conditions.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option We2 – Phosphorus Removal (Expansion of Existing Filters) at Wellesley WWTP		Option We3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• An expanded tertiary treatment facility would have the ability to produce high quality tertiary level effluent under a range of conditions and provide reliability for effluent quality for downstream users.	●	• 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. This approach would protect downstream water users through overall improvement in nutrient loads.	●
	Short and Long-Term Growth – Minimize potential negative effects on short term and long term community growth and development – Meet Region's growth objectives outlined in ROP	• Meets growth needs through new tertiary facility.	●	• Since the load of phosphorus entering the watershed from agricultural activities is much greater than that from municipal point sources, off-setting can meet the short and long-term growth needs with some risk due to timing of obtaining required approvals.	◔
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• Land would be required for the new tertiary treatment facility.	◐	• No additional land would be required for phosphorus off-setting.	●
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• There will be some nuisance impacts during construction in the Wellesley WWTP area, but no anticipated additional impacts to residents during operation.	◔	• Community impacts will be minimal as there will be no construction associated with this option on the Wellesley WWTP site. Limited construction would be required on agricultural properties. There will be no increased impact during operations as the process will remain the same.	●
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Limited additional infrastructure is required and would be limited to the existing Wellesley WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Limited construction would be required on agricultural properties. Minimal potential for impact to heritage features on previously farmed lands.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed site. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as no construction is required. Water quality within the watershed will be improved by the practice with a potential benefit to First Nations communities downstream.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option We2 – Phosphorus Removal (Expansion of Existing Filters) at Wellesley WWTP		Option We3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Legal/ Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Tertiary treatment processes are well understood and minimal effort is expected in obtaining approval for this option.	●	• Approval for this option is expected to require significant effort to obtain given that there are few nutrient off-setting schemes in place within Ontario. Additional consultation with MOECC and GRCA is expected to be required to obtain approval for a phosphorus off-setting option, and a program must be developed for implementation and monitoring of the off-setting scheme.	◔
	Land Requirements – Potential need to acquire land for additional treatment works and ownership requirements	• There is no need for any additional land to be acquired as all infrastructure would be on the existing Wellesley WWTP site.	●	• No additional land acquisition would be required for a phosphorus off-setting option.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Additional energy use and greenhouse gas generation associated with additional tertiary treatment process.	◐	• No additional energy use or greenhouse gas generation associated with a phosphorus off-setting option.	●
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• Tertiary treatment process expansion can be constructed off-line with minimal impact on existing treatment processes.	●	• Limited construction would be required on agricultural properties for off-setting, allowing flexibility in implementation schedule and no constructability impacts on the existing treatment process.	●
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• Additional infrastructure is required at the Wellesley WWTP for this option, so it does not make use of existing infrastructure.	◐	• No new treatment plant infrastructure is required for this option. Some minor infrastructure would be required on agricultural properties in order to achieve the nutrient runoff reduction.	◔
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• There is little innovation under this option as it involves construction of a conventional tertiary treatment process at the Wellesley WWTP.	◐	• Phosphorus off-setting is an innovative way to reduce overall loadings within the watershed while improving agricultural practices without the need for costly new infrastructure at the WWTP.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option We2 – Phosphorus Removal (Expansion of Existing Filters) at Wellesley WWTP		**Option We3 – Phosphorus Off-Setting**	
		Rationale	Score	Rationale	Score
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional tertiary treatment is well understood and is able to meet the performance objectives under a range of conditions.	●	• The reduction is achieved through an offsetting ratio that is applied to the discharge, typically a 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). The operation and monitoring of the off-setting program must be established in order to ensure that performance objectives are achieved.	◔
Financial	**Cost to Ratepayers** – Impact to existing ratepayers for user rates	• Impact to rate payers is moderate for new tertiary treatment process. Existing ratepayers would be required to pay entire amount as there is no growth component.	◐	• Impact to rate payers is moderate for capital on-going program costs for phosphorus off-setting.	◐
	Financial Sustainability – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements.	●	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements. May be challenges in allocation of development charges to a phosphorus off-setting program as impacts and benefits may be realized in different area municipalities.	◐
	Life Cycle Cost – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $867,000 • Annual operating cost: $8,300 • PV life-cycle cost: $658,000	◔	• Capital cost: $67,000 • Annual operating cost: $50,000 • PV life-cycle cost: $489,000	●
Total Score			◔		●

5.7 St Jacobs WWTP

As described in Section 4.5, the alternatives to be evaluated for the St Jacobs WWTP cover both growth and level of treatment alternatives, and include the following:

- Growth alternatives:
  - Infrastructure Options
    - SJ1 – Diversion to Waterloo WWTP
    - SJ2a – Conventional Expansion of St Jacobs WWTP
  - Non-infrastructure Opportunity
    - SJ2b – Re-rating
- Level of treatment alternatives:
  - Infrastructure Option
    - SJ3 – Phosphorus Removal (Expansion of Existing Filters) at St Jacobs WWTP
  - Non-infrastructure Opportunity
    - SJ4 – Phosphorus Off-setting

Based on the evaluations presented in Table 38 and Table 39 for growth and level of treatment alternatives, respectively, the following are the preferred infrastructure alternatives, with the key considerations, together with any non-infrastructure opportunities recommended for further investigation:

Growth

- Preferred Infrastructure Option: Expansion of St Jacobs WWTP Using Conventional Technologies
  - Minimal environmental impacts due to well understood conventional treatment process
  - Well understood process with no potential schedule or approval delays
  - Moderate capital and operational costs
- Non-infrastructure Opportunity: Expansion by Re-rating

  - Lowest cost alternative
  - Utilizes existing infrastructure
  - Accommodates small capacity increase required within the planning period
  - Minimal environmental and social impacts due to minimal construction required for implementation

Diversion to Waterloo WWTP may still be a beneficial option for St Jacobs WWTP, but would be dependent on a variety of factors. First, Waterloo WWTP would need to have adequate capacity. While an expansion at the Waterloo WWTP is only to be driven by needs within its catchment area, if an expansion were already being completed, consideration for St Jacobs could be made. In addition, re-rating of the St Jacobs WWTP would likely be preferable over diverting flows to the Waterloo WWTP, if re-rating is confirmed as a feasible option. As further studies and investigations are completed, the options should be reviewed to confirm the preferred approach based on the most recent information available.

It should also be noted that a key component of all alternatives for the St Jacobs WWTP is inflow and infiltration reduction to reduce peak extraneous flows to the treatment plant.

Level of Treatment

+ Preferred Infrastructure Option: Phosphorus Removal (Expansion of Existing Filters) at St Jacobs WWTP
  - Low costs to expand existing tertiary filtration process
  - No environmental impacts due to well understood tertiary filtration process
  - No additional site space required since tertiary filtration expansion can occur within existing building footprint.
+ Non-infrastructure Opportunity: Phosphorus Off-setting (pending more detailed study to confirm feasibility)
  - Lowest cost alternative

- Utilizes existing tertiary treatment infrastructure already in place and incorporates a blended effluent strategy to maximize existing tertiary treatment capacity and utilize off-setting for additional load due to growth
- Preserves site space for future growth
- Minimal social impacts due to no construction required
- Minimal environmental impacts since overall phosphorus loading to Grand River watershed is maintained.
- As there is currently no program in place within the Region for phosphorus off-setting, a program would need to be developed, implemented and monitored.

Table 38 Detailed Evaluation of Growth Options for St Jacobs WWTP

Category	Criteria	Infrastructure Option Option SJ1 – Diversion to Waterloo WWTP		Infrastructure Option Option SJ2a – Expansion with Conventional Technology		Non-Infrastructure Opportunity Option SJ2b – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• This option is based on replacing the St Jacobs WWTP with a pumping station and diverting all of the flow from the St Jacobs WWTP service area to the Waterloo WWTP for treatment. Effluent quality limits would be met with treatment at the Waterloo WWTP. • Fisheries and aquatic health would be protected through treatment at the Waterloo WWTP for the additional flows from the St Jacobs service area.	●	• This option is based on expanding the St Jacobs WWTP using conventional activated sludge to provide the required capacity to meet the 2051 flow forecast. Expansion would be designed to meet future proposed effluent quality. Fisheries and aquatic health would be protected through adequate treatment capacity at the St Jacobs WWTP.	●	• This option is based on re-rating the St Jacobs WWTP to provide the required capacity to meet the 2051 flow forecast using optimization and minor works. A study would be conducted to ensure that the re-rating would be sufficient to meet future proposed effluent quality, as determined by assimilative capacity study of the Conestogo River. Fisheries and aquatic health would be protected through the adequate treatment capacity at the St Jacobs WWTP.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• All infrastructure necessary to convey flows from the St Jacobs WWTP to the Waterloo WWTP would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to additional conveyance requirements from the St Jacobs WWTP service area to the Waterloo WWTP.	●	• All new infrastructure necessary to provide additional capacity on the St Jacobs WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to the moderate footprint of the additional treatment requirements at the existing St Jacobs WWTP site.	●	• Any new infrastructure necessary to provide additional capacity on the St Jacobs WWTP site would be minor and designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to very limited construction requirements for a re-rating process.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• Modifications to existing infrastructure are required to convey flows from St Jacobs WWTP service area to the Waterloo WWTP, including decommissioning the existing facility and pumping all flow through a new forcemain to the Waterloo WWTP collection system. There is some potential for impacts to natural features during this construction within the collection system.	◔	• Construction of additional infrastructure is required at the St Jacobs WWTP site to provide the required additional capacity. There is minimal potential for impacts to natural features during this construction within the St Jacobs WWTP site boundaries.	◔	• There is no need for construction at the St Jacobs WWTP site to provide the required additional capacity through a re-rating process, therefore there is negligible potential for impacts to natural features during this construction within the St Jacobs WWTP site boundaries.	●

Category	Criteria	Infrastructure Option Option SJ1 – Diversion to Waterloo WWTP		Infrastructure Option Option SJ2a – Expansion with Conventional Technology		Non-Infrastructure Opportunity Option SJ2b – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score
Social	**Climate Change** – Resiliency to extreme conditions	• The Waterloo WWTP has limited available capacity within the planning period to treat increased flows, including those associated with extreme conditions as a result of climate change. An upgrade to the Waterloo WWTP, triggered by flows within the Waterloo catchment area and designed to include St Jacobs flows under this option, would be sized to accommodate extreme conditions associated with climate change. There is limited capacity in portions of the Waterloo WWTP collection system, into which the new St Jacobs forcemain would discharge. All upgrades would require consideration to be sized for potential extreme conditions resulting from climate change.	◔	• Conventional activated sludge technology provides some flexibility to accommodate extreme conditions due to climate change as infrastructure is designed according to guidelines that provide some conservatism to handle fluctuations in conditions.	◔	• Re-rating poses a potential risk as a result of extreme conditions, since typically, the plant is run at higher than typical hydraulic or solids loading rates to achieve the additional capacity. This leads to higher potential for risk if extreme flow conditions are experienced as there is limited flexibility to accommodate the higher flows within the existing infrastructure. The increase in capacity required for the St Jacobs WWTP within the planning period is very small, so the risk due to extreme conditions is low.	◔
	Health and Safety – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• The Waterloo WWTP provides a high level of wastewater treatment, so this option does not result in any increased risk to the public or downstream users of the Conestogo or Grand River watershed.	●	• Conventional treatment technologies at the St Jacobs WWTP provide a high level of wastewater treatment, so this option does not result in any increased risk to the public or downstream users of the Grand River	●	• Re-rating poses a slightly higher potential risk to downstream users since typically, the plant is run at higher than typical hydraulic or solids loading rates to achieve the additional capacity. A detailed study would be required under this option in order to ensure that the facility can operate safely and reliably meet effluent quality limits under re-rated conditions.	◕
	Short and Long-Term Growth – Minimize potential negative effects on short term and long-term community growth and development – Meet Region's growth objectives outlined in ROP	• The Waterloo WWTP has limited capacity for the planning period to 2051, so would require an expansion to accommodate additional flows from the St Jacobs WWTP service area. Short-term growth could be accommodated within the St Jacobs WWTP and long-term growth, when the Waterloo WWTP is expanding, would be accommodated by diverting the flow there.	◔	• Conventional technologies proposed would provide sufficient additional capacity to meet the needs of the St Jacobs WWTP service area within the planning period to 2051. • Short-term and long-term growth could be accommodated under this option.	●	• Re-rating provides some additional capacity, depending on the results of a re-rating study. Since the required additional capacity within the planning period is small, it is expected that this option could accommodate short and long-term growth.	●

Category	Criteria	Infrastructure Option Option SJ1 – Diversion to Waterloo WWTP		Infrastructure Option Option SJ2a – Expansion with Conventional Technology		Non-Infrastructure Opportunity Option SJ2b – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• No additional land would be required at the St Jacobs WWTP site as the plant would be converted to a pumping station. As the available space at the Waterloo WWTP is limited, this option would require additional capacity for flows from the St Jacobs WWTP service area, potentially impacting future growth at the Waterloo WWTP.	●	• Conventional treatment technology would require new tankage at the St Jacobs WWTP, requiring the use of some of the remaining site space, limiting the potential for additional future expansion. This represents the largest footprint option.	◐	• No additional land would be required for re-rating of the St Jacobs WWTP, preserving site area for potential future upgrades.	●
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• Infrastructure upgrades are required to the collection system in order to convey the flow to the Waterloo WWTP, which may potentially impact residents in the areas of these required upgrades. There would be minor impacts to residents in the immediate vicinity of the St Jacobs WWTP due to the construction to convert the plant to a pumping station and decommission the WWTP, and no additional impacts to residents during operation as existing capacity at the Waterloo WWTP is being utilized.	◐	• There will be some potential impacts during construction due to additional truck traffic and noise, which can be mitigated with proper construction practices and schedules. Impacts will be limited to St Jacobs WWTP area during construction. Additional nuisance impacts are not expected during normal plant operations.	◔	• Community impacts will be minimal as there will be no significant construction associated with a re-rating option. Additionally, there will be no increased impact during operations as the process will remain the same.	●
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Infrastructure upgrades required to the collection system in order to convey the additional flow to the Waterloo WWTP have the potential to impact areas which are previously undisturbed and may potentially retain some archaeological potential. Detailed studies would be required at the time of design.	◐	• Any additional infrastructure is limited to the existing St Jacobs WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Limited additional infrastructure is required and would be limited to the existing St Jacobs WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed sites and road right-of-ways. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as construction is limited to existing disturbed sites. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as construction is limited. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●

Category	Criteria	Infrastructure Option Option SJ1 – Diversion to Waterloo WWTP		Infrastructure Option Option SJ2a – Expansion with Conventional Technology		Non-Infrastructure Opportunity Option SJ2b – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score
Legal/ Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Performance of the Waterloo WWTP is well understood and there is little additional complexity or effort expected to obtain approval for treatment of additional flows from St Jacobs WWTP service area at the Waterloo WWTP.	●	• Performance of the St Jacobs WWTP is well understood and there is little additional complexity or effort expected to obtain approval for treatment of additional flows using conventional treatment technologies.	●	• Detailed re-rating study is required to determine potential for re-rating given current and future hydraulic and solids loading rates. Additional consultation with MOECC is expected to be required to obtain approval for re-rating.	◔
	Land Requirements – Potential need to acquire land for additional treatment works and ownership requirements	• There is a potential need to obtain easements for a new forcemain due to the required upgrades to the collection system between the St Jacobs WWTP and the Waterloo WWTP.	◔	• No additional land acquisition would be required for a conventional expansion of the St Jacobs WWTP.	●	• No additional land acquisition would be required for re-rating of the St Jacobs WWTP.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Additional energy use and greenhouse gas generation associated with pumping flow from St Jacobs WWTP to Waterloo WWTP for treatment. Some potential to increase biogas generation at the Waterloo WWTP.	◔	• Energy use and greenhouse gas generation not expected to change from existing treatment process at St Jacobs WWTP. Limited opportunities for additional biogas generation with existing process.	◔	• Energy use and greenhouse gas generation not expected to change from existing treatment process at St Jacobs WWTP. Limited opportunities for additional biogas generation with existing process.	◔
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• The upgrades within the collection system required to convey the flow to the Waterloo WWTP would require careful planning and phasing in order to ensure that the additional capacity for the St Jacobs WWTP service area is available when required. •	◐	• Since the additional capacity required within the planning period to 2051 is small, the requirements to provide this capacity (new secondary clarifier and influent pumping) are constructed off-line with limited impact to existing plant operations or a need for construction phasing.	◔	• No construction required for re-rating allows complete flexibility in implementation schedule and no constructability impacts.	●
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• This option makes use of available treatment capacity at the Waterloo WWTP, but there is an investment required for the conveyance upgrades required to divert flows to the Waterloo WWTP.	◔	• Additional capacity is required so this option does not utilize existing available treatment capacity.	◐	• Re-rating is an optimization of existing infrastructure, so this makes use of infrastructure already in place within the Region.	●

Category	Criteria	Infrastructure Option Option SJ1 – Diversion to Waterloo WWTP		Infrastructure Option Option SJ2a – Expansion with Conventional Technology		Non-Infrastructure Opportunity Option SJ2b – Expansion by Re-Rating	
		Rationale	Score	Rationale	Score	Rationale	Score
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• There is little innovation under this option as it involves only collection system upgrades and conventional treatment at the Waterloo WWTP.	◐	• Very little innovation is involved in a conventional treatment expansion.	◔	• Re-rating is a little innovative as it involves studying the existing available capacity within the treatment plant and optimizing existing processes.	◔
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional activated sludge technology is well understood and is able to meet the performance objectives under a range of conditions.	●	• Conventional activated sludge technology is well understood and is able to meet the performance objectives under a range of conditions.	●	• There is some minor risk of upset due to operation at higher hydraulic or solids loading rates necessary to obtain a re-rated capacity.	◐
Financial	**Cost to Ratepayers** – Impact to existing ratepayers for user rates	• Moderate impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	◔	• Highest impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	◐	• Lowest impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	●
	Financial Sustainability – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●
	Life Cycle Cost – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $9,830,000 • Annual operating cost: $73,000 • PV life-cycle cost: $10,544,000	◐	• Capital cost: $7,877,000 • Annual operating cost: $188,000 • PV life-cycle cost: $8,854,000	●	• Capital cost: $2,342,000 • Annual operating cost: $208,000 • PV life-cycle cost: $6,664,000	◔
Total Score			◐		◔		●

Table 39 Detailed Evaluation of Level of Treatment Options for St Jacobs WWTP

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option SJ2 – Phosphorus Removal (Expansion of Existing Filters) at St Jacobs WWTP		Option SJ3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• Tertiary treatment would be expanded to meet the required effluent quality determined by the ACS (Stantec, 2014), established to be protective of the surface water environment.	●	• This option is based on implementing a phosphorus offsetting program to reduce phosphorus loading to the Conestogo River and Grand River watershed. This option is based on a blending strategy to maximize the capacity of the existing tertiary treatment process and off-set the additional loadings associated with the additional capacity due to growth. It is estimated that approximately 146 kg/y of phosphorus would be required to be removed from the environment through the off-setting practice, based on the expected 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). This is a good approach to reducing phosphorus on a watershed basis as it provides an overall benefit of further reduction of phosphorus from the 4:1 ratio.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• There is limited potential impact to wells and aquifers due to construction of an expanded tertiary treatment process on the existing St Jacobs WWTP site.	◔	• There is no impact on wells or aquifers as there is no construction required for this option and there may be a potential benefit associated with improved farming practices concerning nutrient run-off.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• Expanded tertiary treatment facility construction would be limited to a small area within the existing St Jacobs WWTP site and is not anticipated to have any potential effects on terrestrial natural features.	●	• Phosphorus off-setting involves coordination with the local agricultural community in order to ensure that practices are implemented and monitored for success. Some potential changes may be required to existing agricultural land, but it is expected that these changes would improve the overall conditions of the area. No negative impacts are expected.	●
	Climate Change – Resiliency to extreme conditions	• An expanded tertiary treatment facility would have the flexibility to accommodate extreme conditions as a result of climate change.	●	• 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. Off-setting can be achieved under a range of flow conditions and is not susceptible to upsets due to extreme conditions.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option SJ2 – Phosphorus Removal (Expansion of Existing Filters) at St Jacobs WWTP		**Option SJ3 – Phosphorus Off-Setting**	
		Rationale	Score	Rationale	Score
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• An expanded tertiary treatment facility would have the ability to produce high quality tertiary level effluent under a range of conditions and provide reliability for effluent quality for downstream users.	●	• 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. This approach would protect downstream water users through overall improvement in nutrient loads.	●
	Short and Long-Term Growth – Minimize potential negative effects on short term and long-term community growth and development – Meet Region's growth objectives outlined in ROP	• Meets growth needs through expanded tertiary facility.	●	• Since the load of phosphorus entering the watershed from agricultural activities is much greater than that from municipal point sources, off-setting can meet the short and long-term growth needs with some risk due to timing of obtaining required approvals.	◕
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• Minimal land would be required to expand the tertiary treatment facility. It is possible to retrofit the existing process to provide additional capacity with a different technology.	◔	• No additional land would be required for phosphorus off-setting.	●
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• There will be some nuisance impacts during construction in the St Jacobs WWTP area, but no anticipated additional impacts to residents during operation.	◔	• Community impacts will be minimal as there will be no construction associated with this option on the St Jacobs WWTP site. Limited construction would be required on agricultural properties. There will be no increased impact during operations as the process will remain the same.	●
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Limited additional infrastructure is required and would be limited to the existing St Jacobs WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Limited construction would be required on agricultural properties. Minimal potential for impact to heritage features on previously farmed lands.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed site. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as no construction is required. Water quality within the watershed will be improved by the practice with a potential benefit to First Nations communities downstream.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option SJ2 – Phosphorus Removal (Expansion of Existing Filters) at St Jacobs WWTP		**Option SJ3 – Phosphorus Off-Setting**	
		Rationale	Score	Rationale	Score
Legal/ Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Tertiary treatment processes are well understood and minimal effort is expected in obtaining approval for this option.	●	• Approval for this option is expected to require significant effort to obtain given that there are few nutrient off-setting schemes in place within Ontario. Additional consultation with MOECC and GRCA is expected to be required to obtain approval for a phosphorus off-setting option, and a program must be developed for implementation and monitoring of the off-setting scheme.	◔
	Land Requirements – Potential need to acquire land for additional treatment works and ownership requirements	• There is no need for any additional land to be acquired as all infrastructure would be on the existing St Jacobs WWTP site.	●	• No additional land acquisition would be required for a phosphorus off-setting option.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Additional energy use and greenhouse gas generation associated with additional tertiary treatment process.	◐	• No additional energy use or greenhouse gas generation associated with a phosphorus off-setting option.	●
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• Tertiary treatment expansion and retrofit would require a partial shutdown of the existing tertiary treatment process. Phasing would be required to bring the expanded process back on-line with no interruption to other plant processes.	◔	• Limited construction would be required on agricultural properties for off-setting, allowing flexibility in implementation schedule and no constructability impacts on the existing treatment process.	●
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• Additional infrastructure is required at the St Jacobs WWTP for this option, but it does have the potential to make use of existing infrastructure through retrofit of the existing tertiary facility.	◔	• No new treatment plant infrastructure is required for this option. Some minor infrastructure would be required on agricultural properties in order to achieve the nutrient runoff reduction.	◔
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• There is little innovation under this option as it involves expansion of a conventional tertiary treatment process at the St Jacobs WWTP.	◐	• Phosphorus off-setting is an innovative way to reduce overall loadings within the watershed while improving agricultural practices without the need for costly new infrastructure at the WWTP.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option SJ2 – Phosphorus Removal (Expansion of Existing Filters) at St Jacobs WWTP		**Option SJ3 – Phosphorus Off-Setting**	
		Rationale	Score	Rationale	Score
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional tertiary treatment is well understood and is able to meet the performance objectives under a range of conditions.	●	• The reduction is achieved through an offsetting ratio that is applied to the discharge, typically a 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). The operation and monitoring of the off-setting program must be established to ensure that performance objectives are achieved.	◔
Financial	**Cost to Ratepayers** – Impact to existing ratepayers for user rates	• Impact to rate payers is moderate for expanded tertiary treatment process. Existing ratepayers would be required to pay entire amount as there is no growth component.	◐	• Impact to rate payers is moderate for capital and on-going program costs for phosphorus off-setting.	◐
	Financial Sustainability – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements.	●	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements. May be challenges in allocation of development charges to a phosphorus off-setting program as impacts and benefits may be realized in different area municipalities.	◐
	Life Cycle Cost – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $1,459,000 • Annual operating cost: $18,000 • PV life-cycle cost: $1,247,000	◔	• Capital cost: $59,000 • Annual operating cost: $44,000 • PV life-cycle cost: $525,000	●
Total Score			◔		●

5.8 Elmira WWTP

As described in Section 4.6, the alternatives to be evaluated for the Elmira WWTP cover both growth and level of treatment alternatives, and include the following:

- Growth alternatives:
  - Infrastructure Options
    - El1a – Expansion of Elmira WWTP with Conventional Treatment
    - El1b – Expansion of Elmira WWTP Using New Technology (Granular Sludge or similar)
- Level of treatment alternatives:
  - Infrastructure Option
    - El2 – Phosphorus Removal (Expansion of Existing Filters) at Elmira WWTP
  - Non-infrastructure Opportunity
    - El3 – Phosphorus Off-setting

Based on the evaluations presented in Table 40 and Table 41 for growth and level of treatment alternatives, respectively, the following are the preferred infrastructure alternatives, with the key considerations, together with any non-infrastructure opportunities recommended for further investigation:

Growth

- Preferred Infrastructure Option: Expansion Using New Technology (granular sludge or similar)
  - Lowest cost alternative
  - New, innovative technology
  - Small footprint preserving space for future expansion, and allowing expanded capacity to be constructed within existing tankage, providing additional benefits on constrained site

- Provides environmental benefits due to energy savings and greenhouse gas reductions

A key component of all alternatives for the Elmira WWTP is inflow and infiltration reduction to reduce peak extraneous flows to the treatment plant. All alternatives include a solids upgrade component to provide sufficient solids treatment capacity to accommodate future flows.

Level of Treatment

+ Preferred Infrastructure Option: Phosphorus Removal (Expansion of Existing Filters) at Elmira WWTP
  - Lowest cost alternative
  - Utilizes existing tertiary treatment facility with retrofit to provide additional capacity for growth
  - High phosphorus load reduction challenging to achieve with phosphorus off-setting.

Table 40 Detailed Evaluation of Growth Options for Elmira WWTP

Category	Criteria	Infrastructure Option Option El1a – Expansion with Conventional Technology Rationale	Score	Infrastructure Option Option El1b – Expansion with New Technology (Granular Sludge) Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• This option is based on expanding the Elmira WWTP using conventional activated sludge to provide the required capacity to meet the 2051 flow forecast. Expansion would be designed to meet future proposed effluent quality, as determined by assimilative capacity study of the Canagigue Creek. Fisheries and aquatic health would be protected through adequate treatment capacity at the Elmira WWTP.	●	• This option is based on expanding the Elmira WWTP using new granular sludge technology to provide the required capacity to meet the 2051 flow forecast. Expansion would be designed to meet future proposed effluent quality, as determined by assimilative capacity study of the Canagigue Creek. Fisheries and aquatic health would be protected through adequate treatment capacity at the Elmira WWTP.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• All new infrastructure necessary to provide additional capacity on the Elmira WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to the moderate footprint of the additional treatment requirements at the existing Elmira WWTP site.	●	• All new infrastructure necessary to provide additional capacity on the Elmira WWTP site would be designed to be protective of all groundwater resources and meeting the Clean Water Act requirements. • There is minimal additional risk due to the small footprint of the additional treatment requirements with a granular sludge system at the existing Elmira WWTP site.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• Construction of additional infrastructure is required at the Elmira WWTP site to provide the required additional capacity. There is minimal potential for impacts to natural features during this construction within the Elmira WWTP site boundaries.	●	• Construction of additional infrastructure is required at the Elmira WWTP site to provide the required additional capacity. There is minimal potential for impacts to natural features during this construction within the Elmira WWTP site boundaries.	●
	Climate Change – Resiliency to extreme conditions	• Conventional activated sludge technology provides some flexibility to accommodate extreme conditions due to climate change as infrastructure is designed according to guidelines that provide some conservatism to handle fluctuations in conditions.	◐	• The new technology provides significant flexibility as it provides very high mixed liquor concentrations and energy savings and therefore allows operation within a smaller footprint. This provides additional process flexibility within the existing infrastructure to potentially handle extreme conditions associated with climate change.	◔
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• Conventional treatment technologies at the Elmira WWTP provide a high level of wastewater treatment, so this option does not result in any increased risk to the public or downstream users.	●	• The new technology proposed for the Elmira WWTP provides a high level of treatment leading to no increased risk to public health and safety and downstream users.	●

Category	Criteria	Infrastructure Option Option El1a – Expansion with Conventional Technology		Infrastructure Option Option El1b – Expansion with New Technology (Granular Sludge)	
		Rationale	Score	Rationale	Score
	Short and Long-Term Growth – Minimize potential negative effects on short term and long-term community growth and development – Meet Region's growth objectives outlined in ROP	• Conventional technologies proposed would provide sufficient additional capacity to meet the needs of the Elmira WWTP service area within the planning period to 2051. • Short-term and long-term growth could be accommodated under this option.	●	• The new technology proposed would provide sufficient additional capacity to meet the needs of the Elmira WWTP service area within the planning period to 2051, and potentially additional capacity beyond the planning horizon, depending on the specific implementation opportunities of the technology that would be determined through additional study. • Short-term and long-term growth could be accommodated under this option.	●
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• Conventional treatment technology would require new tankage at the Elmira WWTP, requiring the use of some of the remaining site space, limiting the potential for future expansion. Space is very limited at the Elmira WWTP, so this option presents a challenge for construction. • This represents the largest footprint option.	◔	• The new technology would require some new infrastructure at the Elmira WWTP, with a significantly smaller footprint than conventional technologies. Some site space would be required, but it is minor compared to a conventional activated sludge expansion.	◔
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• There will be some potential impacts during construction due to significant additional truck traffic and noise, which can be mitigated with proper construction practices and schedules. Impacts will be limited to Elmira WWTP area during construction. Additional nuisance impacts are not expected during normal plant operations.	◐	• There will be some potential impacts during construction due to additional truck traffic and noise, which can be mitigated with proper construction practices and schedules. Impacts will be limited due to limited construction. Additional nuisance impacts are not expected during normal plant operations.	◔
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Any additional infrastructure is limited to the existing Elmira WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Any additional infrastructure is limited to the existing Elmira WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed sites. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as construction is limited to existing disturbed sites. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●
Legal/ Jurisdicti	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Performance of conventional activated sludge processes is well understood and there is little additional complexity or effort expected to obtain approval for treatment of additional flows using conventional treatment technologies.	●	• Approvals are expected to require more effort due to limited full scale application of granular sludge processes within Ontario. There is a plan to conduct pilot testing of the process within the Region, which will facilitate the approvals process.	◐

Category	Criteria	Infrastructure Option Option El1a – Expansion with Conventional Technology		Infrastructure Option Option El1b – Expansion with New Technology (Granular Sludge)	
		Rationale	Score	Rationale	Score
Technical	**Land Requirements** – Potential need to acquire land for additional treatment works and ownership requirements	• No additional land acquisition would be required for a conventional expansion of the Elmira WWTP.	●	• No additional land acquisition would be required for expansion with granular sludge at the Elmira WWTP.	●
	Energy Use and Greenhouse Gas Generation – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Energy use and greenhouse gas generation not expected to change from existing treatment process at Elmira WWTP. Limited opportunities for additional biogas generation with existing process.	◐	• Depending on the particular vendor technology selected (to be determined during EA or design process), energy savings of approximately 15-25% are possible, therefore reducing greenhouse gas emissions related to energy use. Biogas generation potential isn't expected to change with the new technology.	●
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• The Elmira WWTP site is very constrained and there is little remaining space for expansion. This option is based on removing some existing tanks in order to utilize the space currently occupied by these processes. This will require careful planning and staging to ensure that there are no negative impacts to the remaining plant processes during construction.	◔	• The new tanks and ancillary equipment for the granular sludge technology are primarily packaged and can therefore be installed offline to minimize any impacts to the existing treatment processes.	◔
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• Additional capacity is required so this option does not utilize existing available treatment capacity.	◐	• All of the existing infrastructure is utilized to provide the additional capacity. Some additional equipment is required for new technology.	●
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• Very little innovation is involved in a conventional treatment expansion.	◔	• This option is based on a very innovative new process that provides benefits in terms of energy and footprint savings.	●

Category	Criteria	Infrastructure Option Option El1a – Expansion with Conventional Technology		Infrastructure Option Option El1b – Expansion with New Technology (Granular Sludge)	
		Rationale	Score	Rationale	Score
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional activated sludge technology is well understood and is able to meet the performance objectives under a range of conditions.	●	• There Is limited local full-scale data to understand the potential for upsets as a result of this new technology. Available data suggest the process is robust and not susceptible to process upset, and able to meet all performance targets under a range of conditions.	◔
Financial	**Cost to Ratepayers** – Impact to existing ratepayers for user rates	• High impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	◐	• Lowest impact to existing ratepayers. Some funding would be available from development charges to accommodate growth.	●
	Financial Sustainability – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●	• Balance of user rates and development charges as required upgrades related to growth and infrastructure renewal.	●
	Life Cycle Cost – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $32,128,000 • Annual operating cost: $134,000 • PV life-cycle cost: $25,074,000	◐	• Capital cost: $14,170,000 • Annual operating cost: $116,000 • PV life-cycle cost: $11,995,000	●
Total Score			◐		●

Table 41 Detailed Evaluation of Level of Treatment Options for Elmira WWTP

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option EI2 – Phosphorus Removal (Expansion of Existing Filters) at Elmira WWTP		Option EI3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Environmental	**Surface Water Protection** – Maximize reliability in achieving effluent quality limits – Protect fisheries and aquatic health – Use a watershed approach to protect surface waters	• Tertiary treatment would be expanded to meet the required effluent quality determined by an assimilative capacity study, established to be protective of the surface water environment.	●	• This option is based on implementing a phosphorus offsetting program to reduce phosphorus loading to the Canagigue Creek and Grand River watershed. This option is based on a blending strategy to maximize the capacity of the existing tertiary treatment process and off-set the additional loadings associated with the additional capacity due to growth. It is estimated that approximately 1,372 kg/y of phosphorus would be required to be removed from the environment through the off-setting practice, based on the expected 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). This is a good approach to reducing phosphorus on a watershed basis as it provides an overall benefit of further reduction of phosphorus from the 4:1 ratio.	●
	Wells and Aquifer Protection – Protect groundwater and respect Clean Water Act requirements	• There is limited potential impact to wells and aquifers due to construction of an expanded tertiary treatment process on the existing Elmira WWTP site.	◔	• There is no impact on wells or aquifers as there is no construction required for this option and there may be a potential benefit associated with improved farming practices concerning nutrient run-off.	●
	Protection of Natural Features – Minimize the potential impact from construction and operation to existing terrestrial habitats/features, vegetation, wetlands, and woodlots – Protect Greenlands Network, identified in Regional Official Plan (ROP) to include environmental features, ecological buffers, and linkages	• Expanded tertiary treatment facility construction would be limited to existing developed area within the existing Elmira WWTP site and is not anticipated to have any potential effects on terrestrial natural features.	●	• Phosphorus off-setting involves coordination with the local agricultural community in order to ensure that practices are implemented and monitored for success. Some potential changes may be required to existing agricultural land, but it is expected that these changes would improve the overall conditions of the area. No negative impacts are expected.	●
	Climate Change – Resiliency to extreme conditions	• An expanded tertiary treatment facility would have the flexibility to accommodate extreme conditions as a result of climate change.	●	• Phosphorus off-setting is a flexible watershed based program that ultimately improves and protects water quality. It allows for a limited increase in pollutant discharge to be “off-set” by greater reductions elsewhere in the same watershed. Off-setting can be achieved under a range of flow conditions and is not susceptible to upsets due to extreme conditions.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option EI2 – Phosphorus Removal (Expansion of Existing Filters) at Elmira WWTP		Option EI3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Social	**Health and Safety** – Minimize the potential risk to public health and safety, particularly on downstream users (including for recreation and tourism)	• An expanded tertiary treatment facility would have the ability to produce high quality tertiary level effluent under a range of conditions and provide reliability for effluent quality for downstream users.	●	• Phosphorus off-setting is a flexible watershed based program that ultimately improves and protects water quality. It allows for a limited increase in pollutant discharge to be "off-set" by greater reductions elsewhere in the same watershed. This approach would protect downstream water users through overall improvement in nutrient loads.	●
	Short and Long-Term Growth – Minimize potential negative effects on short term and long-term community growth and development – Meet Region's growth objectives outlined in ROP	• Meets growth needs through expanded tertiary facility.	●	• Since the load of phosphorus entering the watershed from agricultural activities is much greater than that from municipal point sources, off-setting can meet the short and long-term growth needs with some risk due to timing of obtaining required approvals.	◔
	Land Use – Maximize land use to preserve site area for any future requirements and minimize construction beyond the current footprint	• No additional land would be required to expand the tertiary treatment facility. It is possible to retrofit the existing process to provide additional capacity with a different technology in the same footprint.	●	• No additional land would be required for phosphorus off-setting.	◔
	Community Impacts (Odour, Noise, Truck Traffic) – Minimize odours, noise and truck traffic affecting the community during construction and plant operation	• There will be some nuisance impacts during construction in the Elmira WWTP area, but no anticipated additional impacts to residents during operation.	◔	• Community impacts will be minimal as there will be no construction associated with this option on the Elmira WWTP site. Limited construction would be required on agricultural properties. There will be no increased impact during operations as the process will remain the same.	●
	Cultural and Archaeological Heritage – Minimize potential impact to historical, cultural, archaeological and architecturally significant features	• Limited additional infrastructure is required and would be limited to the existing Elmira WWTP site, which is previously disturbed and has little to no remaining archaeological potential.	●	• Limited construction would be required on agricultural properties. Minimal potential for impact to heritage features on previously farmed lands.	●
	First Nations Considerations – Minimize the potential impact to First Nations communities	• No anticipated impact to First Nations communities as construction is limited to existing disturbed site. Effluent quality will meet all regulations and is not expected to impact First Nations communities downstream.	●	• No anticipated impact to First Nations communities as no construction is required. Water quality within the watershed will be improved by the practice with a potential benefit to First Nations communities downstream.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option EI2 – Phosphorus Removal (Expansion of Existing Filters) at Elmira WWTP		Option EI3 – Phosphorus Off-Setting	
		Rationale	Score	Rationale	Score
Legal/ Jurisdictional	**Approvals** – Minimize the complexity and time spent to obtain approvals considering current and future regulatory environment	• Tertiary treatment processes are well understood and minimal effort is expected in obtaining approval for this option.	●	• Approval for this option is expected to require significant effort to obtain given that there are few nutrient off-setting schemes in place within Ontario. Additional consultation with MOECC and GRCA is expected to be required to obtain approval for a phosphorus off-setting option, and a program must be developed for implementation and monitoring of the off-setting scheme.	◔
	Land Requirements – Potential need to acquire land for additional treatment works and ownership requirements	• There is no need for any additional land to be acquired as all infrastructure would be on the existing Elmira WWTP site.	●	• No additional land acquisition would be required for a phosphorus off-setting option.	●
Technical	**Energy Use and Greenhouse Gas Generation** – Minimize GHG emissions, net energy use, and sludge volumes – Maximize biogas generation for cogeneration and biofuel opportunities	• Slightly higher energy use and greenhouse gas generation associated with tertiary treatment process expansion.	◕	• No additional energy use or greenhouse gas generation associated with a phosphorus off-setting option.	●
	Constructability – Flexibility of scheduling works is of key concern due to uncertainty in timing of growth – Minimize complex construction and maximise ability to maintain adequate treatment during construction	• Tertiary treatment expansion and retrofit would require a partial shutdown of the existing tertiary treatment process. Phasing would be required to bring the expanded process back on-line with no interruption to other plant processes and ensure that tertiary treatment bypasses are minimized.	◐	• Limited construction would be required on agricultural properties for off-setting, allowing flexibility in implementation schedule and no constructability impacts on the existing treatment process.	●
	Optimization of Existing Infrastructure – Optimize existing infrastructure investment and treatment capacity	• Additional infrastructure is required at the Elmira WWTP for this option, but it does have the potential to make use of existing infrastructure through retrofit of the existing tertiary facility.	◕	• No new treatment plant infrastructure is required for this option. Some minor infrastructure would be required on agricultural properties in order to achieve the nutrient runoff reduction.	◕
	Innovation – Maximize use of innovative technologies and processes to enhance level of treatment or treatment efficiency – Resource recovery	• There is little innovation under this option as it involves expansion of a conventional tertiary treatment process at the Elmira WWTP.	◐	• Phosphorus off-setting is an innovative way to reduce overall loadings within the watershed while improving agricultural practices without the need for costly new infrastructure at the WWTP.	●

Category	Criteria	Infrastructure Option		Non-Infrastructure Opportunity	
		Option EI2 – Phosphorus Removal (Expansion of Existing Filters) at Elmira WWTP		**Option EI3 – Phosphorus Off-Setting**	
		Rationale	Score	Rationale	Score
	Security, Reliability and Robustness – Lesser likelihood of process upset or mechanical breakdown – Ability to meet performance objectives under a range of conditions	• Conventional tertiary treatment is well understood and is able to meet the performance objectives under a range of conditions.	●	• The reduction is achieved through an offsetting ratio that is applied to the discharge, typically a 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). The operation and monitoring of the off-setting program must be established in order to ensure that performance objectives are achieved.	◔
Financial	**Cost to Ratepayers** – Impact to existing ratepayers for user rates	• Impact to rate payers is low for expanded tertiary treatment process. Some funding would be available from development charges to accommodate growth.	◔	• Impact to rate payers is moderate for capital and on-going program costs for phosphorus off-setting. Some funding would be available from development charges to accommodate growth.	◑
	Financial Sustainability – Balance infrastructure needs with ability to pay (user rates and development charges)	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements.	●	• Balance of user rates and development charges as required upgrades related to growth and effluent quality improvements. May be challenges in allocation of development charges to a phosphorus off-setting program as impacts and benefits may be realized in different area municipalities.	◑
	Life Cycle Cost – Minimize capital, operation and maintenance (life cycle) costs over the planning period	• Capital cost: $2,234,000 • Annual operating cost: $14,000 • PV life-cycle cost: $1,744,000	●	• Capital cost: $552,000 • Annual operating cost: $412,000 • PV life-cycle cost: $4,935,000	◑
Total Score		●		◔	

6. Options for Business Case Consideration

A number of opportunities have been identified that offer one or more of the following benefits:

- Reduced energy consumption
- Increased biogas production
- Reduced biosolids production.

Options short-listed for consideration include:

- Chemically enhanced primary treatment (CEPT) of Kitchener and Waterloo WWTPs
- Sidestream treatment at Kitchener, Waterloo and Galt WWTPs
- Anoxic selector
- Automation upgrades
- Temperature phased anaerobic digestion for Kitchener, Waterloo and Galt WWTPs
- Thermal hydrolysis for Kitchener, Waterloo and Galt WWTPs.

Details on each alternative, together with estimated capital and operating costs are presented in this section to identify options with the best business case for implementation.

6.1 Chemically Enhanced Primary Treatment (CEPT)

6.1.1 Description of Alternative

This option is based on using chemically enhanced primary treatment (CEPT) to reduce the biochemical oxygen demand (BOD) and total suspended solids (TSS) loading to secondary treatment by improving BOD and TSS removal in primary treatment. This leads to increased secondary treatment capacity, lower energy consumption and increased biogas production. Improved BOD and TSS removal is accomplished by adding a chemical coagulant such as ferric chloride and/or polymer upstream of primary clarifiers.

The primary disadvantage of the CEPT process is increased primary sludge production (WEF, 2009), which may require larger sludge digestion and handling facilities. However, this also provides an opportunity to increase digester gas production for beneficial use (i.e., through a combined heat and power facility). CEPT can be considered for the Kitchener and Waterloo WWTPs to increase digester gas for the combined heat and power (CHP) systems at these facilities. The Galt WWTP digester capacity is limited to the existing rated plant capacity and thus limits the ability to practice CEPT without overloading the existing digesters.

The Kitchener and Waterloo WWTPs currently have provision to add ferric salts to primary clarifiers for enhanced primary treatment, and also have sufficient capacity in their existing anaerobic digesters to handle the increased primary sludge mass (refer to TM2). Therefore, there will be no additional work required for the implementation of CEPT at the two plants.

On review of historic data, the Kitchener WWTP already achieves greater than 70% TSS removal across the primary clarifiers with a portion of the chemical salt added upstream of the primary clarifiers. This compares to a typical removal efficiency of 50% without the addition of any chemicals. As a result, minimal additional benefits would be realized at the Kitchener WWTP by adding chemical and polymer to the primary clarifiers.

The Waterloo WWTP currently achieves typical primary clarifier removal efficiencies (i.e., approximately 50% TSS removal, 35% BOD removal). As a result, CEPT at this facility has the potential to increase removal efficiencies in the primary clarifiers to 50% for BOD and 70% for TSS with the following benefits:

+ Reduce aeration energy by approximately 8%
+ Improved operational flexibility and capacity in aeration tanks by allowing for a lower solids inventory
+ Increase in overall sludge production of approximately 5%
+ Increase digester gas production by approximately 12%.

6.1.2 Costs

A summary of the estimated capital and operating cost is provided in Table 42 for CEPT for the Waterloo WWTP. In general, the operation of CEPT results in break-

even operating costs with no significant overall benefit to the plant. It however, can be used to maximize the operating capacity of the CHP unit currently being installed to reduce plant energy costs and greenhouse gas footprint. Additional cost estimate details are provided in Appendix B.

Table 42 Cost Estimate – CEPT for Waterloo WWTP

Item	Waterloo WWTP
Capital Cost	-
Annual O&M Cost at Rated Capacity	+$1,000
Simple Payback	-

6.2 Sidestream Treatment

6.2.1 Description of Alternative

This option is based on implementing sidestream treatment of dewatering centrate to reduce nutrient loading to the liquids treatment train. This results in a more stable secondary treatment process and decreased energy usage. Sidestream treatment could be considered for the Kitchener, Waterloo and Galt WWTPs as these facilities have on-site digestion and dewatering operations.

For the purpose of this evaluation, the following two sidestream treatment technologies were used as the basis:

- Deammonification: targets dewatering centrate sidestream
- Post-Aerated Digestion: targets digested biosolids prior to dewatering providing both ammonia oxidation and additional biosolids destruction.

Both technologies are able to achieve a high level of ammonia reduction in the centrate returning to secondary treatment (typically >85%). This will improve the stability of secondary treatment and potential to allow operation at a slightly lower solids retention time.

Deammonification

Deammonification is a biological treatment process used to convert ammonia to nitrogen gas, in which a fraction of the ammonia is converted to nitrite by ammonia oxidizing bacteria (AOBs) followed by conversion of the nitrite and remaining ammonia directly to nitrogen by the anammox bacteria under anoxic conditions.

The major benefits of implementing the deammonification process are a reduction in aeration energy for nitrogen removal as compared to the conventional nitrification/denitrification process. Other benefits include reduced sludge and greenhouse gas production. Challenges to deammonification include the slow growth of the anammox bacteria.

There are deammonification systems in various modes, including attached growth (e.g. AnitaMox^{TM} by Veolia) and suspended growth (e.g. DEMON^{TM} marketed by ETA). For the purposes of this evaluation, the AnitaMox^{TM} technology was considered.

AnitaMox^{TM} is a single-stage deammonification process using moving bed biofilm reactors (MBBR), in which aerobic nitrification and anoxic ammonia oxidation (annamox) reactions occur simultaneously in different layers of a biofilm. This treatment system is specifically designed to treat high ammonia waste streams.

The following work would be required for the implementation of the AnitaMox^{TM} sidestream treatment at the above three WWTPs:

- Construction of new MBBR tanks. Each MBBR tank would be equipped with a medium bubble aeration system for nitrification and a mixer for proper suspension of the media and proper mixing distribution of the influent feed flow. Aeration would be provided to each reactor by multiple blowers.
- Installation of interconnecting piping between MBBR tanks and the existing treatment system

Table 43 provides a summary of AnitaMox^{TM} MBBR system design requirements for the Kitchener, Waterloo and Galt WWTPs.

Table 43 Summary of ANITA™ Mox MBBR Design Parameters (1)

Parameter	Kitchener WWTP	Waterloo WWTP	Galt WWTP
Design Centrate Flow (m^3/d) (2)	680	500	550
Centrate Influent Ammonia Composition (mg N/L)	1000	850	1000
Effluent Ammonia Objective	> 85% Removal	> 85% Removal	90% Removal
Number of Reactors	1	1	1
MBBR Reactor Dimension (L X W X SWD) (m)	10.5 x 10.5 x 6.0	8.3 x 8.0 x 6.0	8.3 x 8.0 x 6.0
Total Reactor Volume (m^3)	650	400	400
Number of Process Air Blowers	3 (30 kW) (2 duty, 1 standby)	3 (22 kW) (2 duty, 1 standby)	3 (22 kW) (2 duty, 1 standby)
Number of Mechanical Mixers	3	3	3

Notes:
1. Based on vendor quotes.
2. Estimated based on current rated capacity for each WWTP.

Post Aerobic Digestion (PAD)

Post-aerobic digestion (PAD) is a recently developed process, where anaerobically digested sludge are further stabilized aerobically with an aerobic digestion step prior to dewatering. A significant benefit of PAD is the nitrogen removal without the need for supplemental carbon and alkalinity (Johnson *et al*., 2013). Other benefits include reduced ammonia loading to secondary treatment, improved volatile solids (VS) destruction and reduced biosolids mass for dewatering and disposal. Ammonia loadings to secondary treatment can be reduced by approximately 85% or higher.

The following work would be required for the implementation of the PAD at these facilities:

- Construction of post-aerobic digesters, complete with blowers.
- Modification of digested sludge transfer and pumping systems to dewatering.

Table 44 provides a summary of the tankage requirements for the PAD systems at the three largest WWTPs in the Region.

Table 44 Summary of Post-Aerobic Digester Tankage Requirements

Parameter	Kitchener WWTP	Waterloo WWTP	Galt WWTP
Design Feed Biosolids (kg/d) (1)	22,700	10,300	11,500
Number of Aerobic Digesters	1	1	1
Total Digester Volume (m^3) (2)	3,600	1,400	1,600

Notes:
1. Based on anaerobic digested sludge production at the rated capacity of each WWTP.
2. Based on an SRT of 7 days in post aerobic digesters, which is within the typical SRT design value of 5-10 days for post aerobic digesters.

6.2.2 Costs

A summary of the estimated capital and operating costs are provided in Table 45 and Table 46 for sidestream deammonification and post-aerobic digestion, respectively. In general, post-aerobic digestion has similar capital costs to sidestream deammonification with significant additional operating cost savings due to a further reduction in biosolids production. If alternative funding were available, PAD would be more favourable from a payback perspective. Additional cost estimate details are provided in Appendix B.

Table 45 Cost Estimate – Sidestream Deammonification

Item	Kitchener WWTP	Waterloo WWTP	Galt WWTP
Capital Cost (1)	$5,050,000	$4,000,000	$4,000,000
Annual O&M Cost at Rated Capacity	-$10,000	+$3,000	+$4,000
Simple Payback	High	-	-

Notes:
1. All costs are conceptual level opinions of probable costs and are accurate to +/-50%

Table 46 Cost Estimate – Post Aerobic Digestion

Item	Kitchener WWTP	Waterloo WWTP	Galt WWTP
Capital Cost (1)	$5,800,000	$3,000,000	$3,000,000
Annual O&M Cost at Rated Capacity	-$135,000	-$51,000	-$50,000
Simple Payback	Medium	High	High

Notes:
1. All costs are conceptual level opinions of probable costs and are accurate to +/-50%

6.3 Anoxic Selector

6.3.1 Description of Alternative

This option is based on providing a pre-denitrification stage in a nitrifying plant, which can partially offset the energy costs associated with nitrification and reduce the total nitrogen concentration in the effluent. The application of an anoxic selector can reduce aeration energy costs by approximately 10-15%. In addition, selectors create a high food-to-microorganism (F/M) ratio in the front of the aeration tanks which has been shown to improve mixed liquor settling characteristics for improved process stability.

As mentioned in TM6, WWTPs in the Region currently not equipped with anoxic selectors, such as Galt, Hespeler, St Jacobs and Wellesley, could consider this option. It should be noted that the St Jacobs WWTP is an oxidation ditch and an anoxic selector is best implemented through the installation of jet aeration equipment; which can provide mixing independent of aeration.

Depending on the aeration tank configuration, the anoxic selector would range from 15% to 25% of the aeration tank volume. To provide improved operational flexibility, especially at lower sludge age facilities (i.e., Galt, Hespeler), it is recommended that the anoxic selector be configured with diffusers to allow aerobic operation, if required, during the coldest winter months for stable ammonia removal performance.

Anoxic/aerobic swing zones are relatively easy to incorporate into the existing aeration tanks. The following work would be required for the implementation of the anoxic/aerobic swing zones at the above plants:

- Convert the inlet portion of each aeration tank to an anoxic zone by adding baffle walls (non-structural wall) together with a low energy mixer.

In general, this retrofit should be considered during any planned diffuser maintenance replacement when it is easiest to modify the diffuser arrangement to accommodate the baffle wall. For Hespeler, the recommended MABR retrofit will incorporate the benefits of simultaneous nitrification/denitrification already.

6.3.2 Costs

A summary of the estimated capital and operating costs is provided in Table 47 for anoxic selector applications.

Table 47 Cost Estimates – Anoxic Selector

Item	Galt	Wellesley
Capital Cost(1)	$1,250,000	$218,000
Aeration Energy Savings	-$50,000	-$2,000
Simple Payback	Medium	High

Notes:
1. All costs are conceptual level opinions of probable costs and are accurate to +/-50%

6.4 Automation Upgrades

6.4.1 Description of Alternative

This option is based on installing on-line automation to provide real-time control for nutrient removal. Two potential automation upgrades include:

- Ammonia analyzers
- Phosphate analyzers

An ammonia-based real-time aeration control system in the activated sludge process provides more efficient aeration control for reduced energy savings and improved nutrient removal performance. Currently, most aeration systems that use real-time control are based on dissolved oxygen (DO) measurements. Most systems are operated at 2 mg/L DO based, which is the concentration reported in literature to maximize the growth rates for nitrifying organisms. However, in many cases effluent ammonia concentrations can be achieved at much lower DO concentrations. With on-

line ammonia analyzers, the DO set-point (an airflow to tanks) can be adjusted downward based on the real-time ammonia reading to maintain effluent objectives. Several studies report that ammonia-based aeration control can provide energy savings in the range of 15 to 25%, while also improving total nitrogen removal (Rieger *et al*., 2014).

Ammonia-based aeration could be considered for all the WWTPs in the Region. The following work would be required for the implementation of ammonia-based aeration control:

- Installation of ammonia probes/analyzers at the aeration effluent
- Upgrades to the existing blower control systems

Similar to ammonia analyzers, phosphate analyzers can be used to stabilize effluent TP concentrations and potentially reduce chemical usage through automation of dosages. Phosphate analyzers could be considered for all the WWTPs in the Region. There is limited full-scale experience documenting the savings potential. However, it is reasonable to expect chemical savings in the range of 10%. The works to implement a phosphate analyzer would include installation of the analyzer and implementation of feedback control for the chemical dosing pumps.

6.4.2 Costs

Table 48 summarizes the estimated payback for ammonia analyzers and automation for a range of plant sizes in the Region. In general, there is very good payback for the larger facilities (Kitchener, Waterloo and Galt), with diminishing returns for the much smaller plants. The three plants shown in the table provide a range of costs and returns based on the range of plant capacities within the Region.

Table 48 Cost Estimates – Ammonia Analyzer Automation

Item	Kitchener	Galt	Ayr
Capital Cost(1)	$300,000	$237,000	$173,000
Aeration Energy Savings	-$230,000	-$106,000	-$9,000
Simple Payback	Low	Low	Low

Notes:
1. All costs are conceptual level opinions of probable costs and are accurate to +/-50%

Similarly, phosphate analyzers are also very costly ranging from $25,000 to $50,000 plus installation, with on-going maintenance. As a result, payback will be significantly shorter at larger facilities. Currently, the Region is installing an on-line phosphate analyzer at the Kitchener WWTP which will provide good feedback on potential chemical savings relative to capital and operating requirements of the analyzer.

On-line ammonia analyzers should be considered initially at one of the larger plants with an existing DO control system (Kitchener or Waterloo). This will provide a good baseline of capital and maintenance costs relative to energy savings for refinement of the cost benefit analysis at other facilities.

6.5 Co-Digestion – FOG Import

6.5.1 Description of Alternative

Co-digestion is a process whereby additional substrates are imported into the digestion process to increase the biogas production. These substrates can typically include source separated organics (SSO), and energy-rich organic wastes (e.g. fats, oils and grease (FOG)). The Region conducted a study (CH2M Hill, 2014) reviewing the potential for co-digestion of the Region's SSO materials with wastewater sludge at the Region's existing wastewater treatment facilities. Due to the quantities of SSO collected and the scale of treatment facilities required, it was determined that utilizing existing wastewater infrastructure was not feasible for the co-digestion of SSO with wastewater sludge.

This option considers the potential to add energy-rich organic wastes (e.g. FOG or food scraps) to anaerobic digesters.

Typical co-substrate addition rates range between 5-20% by weight of sludge feed. Biogas yield could raise by 40-230% through the co-digestion process (Blischke *et al*., 2009). There may also be potential to recover a tipping fee for accepting the high energy waste material from industries; although there is increasing competition from other parties for this "feedstock".

Co-digestion could be considered for the Kitchener and Waterloo WWTPs, as the two plants have excess anaerobic digester capacity that could be used to treat FOG or other external wastes. In order to implement co-digestion for the Kitchener WWTP, the FOG would need to be received at the Manitou Drive site.

The implementation of a co-digestion system at a WWTP would require the following works:

- A FOG receiving/processing system including pre-treatment, tanks, pumping and odour treatment
- A beneficial gas utilization system (combined heat & power or processing to natural gas quality for injection to the grid or used to fuel Region vehicles).
- Potential modifications to the gas handling systems to handle the increase in methane output that is common with co-digestion.

6.5.2 Costs

A summary of the estimated capital costs and simple payback is provided in Table 49 for co-digestion for the Kitchener and Waterloo WWTPs. Overall, there appears to be a reasonable payback for this at the Kitchener and Waterloo WWTPs. A market assessment (to review available feedstock and potential revenues) and refinement of life cycle costs is recommended to determine the feasibility for the Kitchener and Waterloo WWTPs. Additional cost estimate details are provided in Appendix B.

Table 49 Cost Estimates – Co-Digestion

Item	Kitchener WWTP	Waterloo WWTP
Capital Cost	$4,310,000	$3,220,000
Annual O&M Cost at Rated Capacity	-$370,000	-$133,000
Simple Payback	Low	Medium

Notes:
1. All costs are conceptual level opinions of probable costs and are accurate to +/-50%

6.6 Thermal Hydrolysis Pre-Treatment

6.6.1 Description of Alternative

This option is based on adding thermal hydrolysis pre-treatment (THP) process to the anaerobic digestion process to produce more biogas for beneficial uses (CHP, dryer, vehicles, etc.).

THP process is a high-pressure, steam treatment process. Prior to digestion, WAS and/or primary sludge is dewatered up to 15%–20% solids and fed through a

hydrolysis vessel. The process involves the oxidation of sludge under elevated temperature (approximately 160 °C) and pressure (approximately 689 kPa). Under these conditions, pathogens are destroyed and cell structures in the sludge break down, releasing energy-rich compounds.

Following hydrolysis, sludge is fed to the anaerobic digester where it readily digests, resulting in high volatile solids destruction (approximately 65%) and approximately 20-30% more biogas production and 25 to 30% less dry solids production compared to conventional anaerobic digestion. Thermal hydrolysis can also enable the treatment of sludge in a reduced digester volume, allowing for increased capacity to treat more sludge and/or external wastes.

As recommended in TM7, THP was considered only for the largest treatment facilities such as the Kitchener, Waterloo and Galt WWTPs, due to operational complexity. The following work would be required for the implementation at these plants:

- Installation of pre-dewatering system, including dewatered cake feed pump and cake hopper.
- Installation of THP package system
- Installation of steam boiler and feed water system

There are two commercially available wastewater THP processes, with package systems available for medium to large hydrolysis plants. Reactor sizes range from 5 - 80 tons dry solids/day.

THP facilities run 24 hours a day, 7 days per week matched to the production of sludge at the facility and digester operation. In Ontario, steam boilers are required to be staffed whenever the process is on-line as per the Operator Engineers Act. This can increase labour costs, especially for Regional facilities which are currently only staffed during weekdays, with no evening or night shifts.

6.6.2 Costs

A summary of the estimated capital costs and simple payback is provided in Table 50 for THP for the Kitchener, Waterloo and Galt WWTPs. The capital costs for a THP facility is significant. Most of the significant benefits for THP in terms of energy recovery and reduced biosolids production are off-set by the staffing requirements due to the incorporation of a steam system. With alternative funding, THP could be

considered for the Kitchener WWTP (i.e., largest plant). Additional cost estimate details are provided in Appendix B.

Table 50 Cost Estimates – Thermal Hydrolysis Pre-Treatment

Item	Kitchener WWTP	Waterloo WWTP	Galt WWTP
Capital Cost(1)	$26,500,000	$20,250,000	$20,250,000
Annual O&M Cost at Rated Capacity	-$470,000	+$281,000	+$205,000
Simple Payback	High	-	-

Notes:
1. All costs are conceptual level opinions of probable costs and are accurate to +/-50%.

6.7 Temperature Phased Anaerobic Digestion (TPAD)

6.7.1 Description of Alternative

This option is based on the implementation of temperature phased anaerobic digestion (TPAD) to improve stabilization and produce more biogas for beneficial uses.

The TPAD system uses a smaller digester operating in the thermophilic temperature range followed by a larger digester operating in the mesophilic temperature range. The TPAD system allows the digestion process to be enhanced, with improved pathogen destruction, volatile solids removal, and gas production compared to conventional mesophilic digestion. This option is estimated to provide a 7% reduction in overall biosolids production.

The following work would be required for the implementation of TPAD at the Kitchener, Waterloo and Galt WWTPs:

- Construction of new thermophilic anaerobic digesters for the Kitchener and Waterloo WWTP.
- Retrofit of the existing digested sludge holding tank to a thermophilic anaerobic digester for the Galt WWTP.
- New heat exchangers, feed and transfer piping/pumping systems.
- Biogas treatment, storage, or CHP system (already in progress for all three plants)

Table 51 provides a summary of the TPAD design requirements for the plant rated capacity for the three WWTPs.

Table 51 Summary of TPAD Tankage Requirements

Parameter	Kitchener WWTP	Waterloo WWTP	Galt WWTP
Total Digester Feed Flow (m^3/d) (1)	1,020	570	530
Number of Thermophilic Digester	1 (new)	1 (new)	1 (existing)
Digester Dimension (Dia. X SWD) (m)	16.5 x 10.9	12.8 x 8.5	15.2 x 6.0
Total thermophilic Digester Volume (m^3)	2,400	1,100	1,100

Notes:
1. Average sludge production at rated capacity with 3.5% total solids.

6.7.2 Costs

A summary of the estimated capital costs and simple payback is summarized in Table 52 for the implementation of TPAD at the Kitchener, Waterloo and Galt WWTPs. Additional cost estimate details are provided in Appendix B. Overall, there is minimal business case to convert to TPAD at the Region facilities.

Table 52 Cost Estimates – TPAD

Item	Kitchener WWTP	Waterloo WWTP	Galt WWTP
Capital Cost(1)	$21,200,000	$14,800,000	$13,400,000
Annual O&M Cost at Rated Capacity	-$213,000	-$76,000	-$96,000
Simple Payback	High	High	High

Notes:
1. All costs are conceptual level opinions of probable costs and are accurate to +/-50%

6.8 Emerging Innovative Technologies

As discussed in Tech Memo No. 6 - Identification and Screening of Alternative Liquid Treatment Options, several emerging technologies show potential for enhancing operations and/or reducing energy use within the Region's WWTPs. 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.

6.9 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 (https://www.grandriver.ca/en/our-watershed/Wastewater-optimization.aspx, accessed January 2018).

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 Performance Based Training.

6.10 Summary of Options for Business Case Consideration

Table 53 provides a summary of the business case considerations and recommendation to reduce energy and chemical usage at the WWTPs.

Table 53 Summary of Business Case Options and Recommendations

Item	Benefit	General Findings	Summary of Recommendation
Chemically Enhanced Primary Treatment	• Increase digester gas production • Reduce aeration energy demands	• Chemical costs and increase sludge production off-set energy savings	• Consider for trial at Waterloo WWTP to document the cost-benefits. No capital investment required.
Sidestream Treatment (Deammonification and Post-Aerobic Digestion Considered)	• Reduce overall energy cost • Reduce biosolids production	• Post-aerobic Digestion (PAD) offers greatest savings opportunity to Region	• Consider PAD for sidestream treatment at Kitchener with highest overall payback, if alternative funding becomes available.
Anoxic Selector	• Reduce aeration energy cost	• Relatively low capital investment for on-going energy savings	• Integrate with any planned diffuser replacement project (i.e., asset management) or with planned expansion
Automation Upgrades	• Reduce chemical and energy usage	• Instrumentation cost limits payback for smaller facilities, greater benefit at larger facilities with higher potential for reductions in operating cost.	• Implement full-scale trial at larger plant (Waterloo or Kitchener) for detailed cost-benefit assessment • Assess results of ortho-phosphate analyzer at Kitchener WWTP for savings potential
Co-Digestion	• Use high energy waste from industry to produce digester gas	• Competing market for high energy wastes • Potential for good payback at Kitchener and Waterloo WWTP	• Complete market study and conceptual design to finalize business case for Kitchener and Waterloo WWTP

Item	Benefit	General Findings	Summary of Recommendation
Temperature Phased Anaerobic Digestion (TPAD)	• Reduce biosolids production and increase gas production	• High capital cost relative to moderate savings	• Not recommended
Thermal Hydrolysis Process (THP)	• Reduce biosolids production • Increase gas production • Improve dewaterability	• Requires operation of steam system • Significant labour cost in Ontario for plants currently only staffed during daytime	• Can be considered for Kitchener WWTP if alternative funding becomes available.

7. Pumping Station Alternatives

The Region owns seven (7) sewage pumping stations, including:

- Bridgeport SPS
- Spring Valley SPS
- Morningside SPS
- Baden SPS
- Rose St SPS
- Ayr SPS (currently under construction)
- Nith River Way SPS

Capacities of all Region SPSs was previously documented in TM2. This analysis noted that all Region pumping stations have adequate capacity to meet 2051 flow projections based on the current service areas with the exception of:

- Spring Valley SPS
- Morningside SPS
- Baden SPS

For the Spring Valley SPS, a study was conducted (RVA, 2015) to review the potential for a flow diversion from Waterloo WWTP to Kitchener WWTP, which would require a significant expansion to this SPS. Based on the evaluation of alternatives completed in this TM for the Waterloo WWTP, this alternative was not selected as the preferred alternative. Based on projected peak flows, there is still a very minor shortfall of firm capacity for 2051 flows (flows projected to be 252 L/s, approximately 7 L/s more than the existing firm capacity). This shortfall is less than 3% of the firm station capacity and can be addressed with future pump upgrades. Furthermore, asset management timelines will include a pump replacement well before 2046 when the station capacity is reached. This is an opportune time to provide a slight capacity increase for a firm capacity of approximately 265 L/s, which provides a 5% safety factor above the projections for 2051. Pump testing at the station is recommended closer to the pump replacement timeline to refine overall system curves (and C-Factor for forcemains) for the proper pump selection and operating head to meet the 265 L/s firm capacity.

In addition, potential changes to the forcemain alignment as related to the upcoming Ministry of Transportation of Ontario work should be considered.

For the Morningside SPS, a recent assessment (Stantec, 2017) concluded that pump replacement can provide a firm capacity of 290 L/s, which exceeds the projected 2051 flow of 272 L/s. In consideration of asset renewal timelines and code deficiencies (existing pumps are not the rated electrical classification to meet the most up-to-date codes), replacement of the existing pumps should be considered in the next 10 years. This is an opportune time to increase the firm capacity with minimal additional cost to the Region and well in advance of 2041 when capacity is reached. Although flow projections have considered overall growth for Baden and New Hamburg, the capacity needs at the Morningside SPS are impacted by the pump capacity at Baden SPS, as Baden SPS pumps into the Morningside SPS catchment. A final recommended capacity for Morningside SPS would be dependent on the recommendations for Baden SPS.

For the Baden SPS, there is a projected shortfall in capacity for 2051 flows. There are opportunities to reduce peak flows to the Baden SPS through I/I reduction. Even with successful reductions in I/I, increases to the equalization storage, pumping capacity, or both equalization storage and pumping capacity may be required to accommodate future flows. As noted, options for the Baden SPS and Morningside SPS are interrelated as the Baden SPS pumps directly to the Morningside SPS. Furthermore, the Morningside SPS then pumps directly to the New Hamburg WWTP. Based on the interrelation of these facilities, a more detailed study should be undertaken to determine the best overall approach for the pumping stations to address capacity and operational constraints.

8. Summary

The following sections provide a high-level overview of the alternatives selected to be included in the overall implementation plan for the Region's wastewater treatment and pumping facilities.

8.1 Regional Wastewater Recommendations

The following options do not form standalone solutions for any facility, but are recommended to be included in the holistic Regional implementation plan as they offer benefits for all WWTPs from either environmental, social, technical or economic perspectives:

- Watershed management
- Resource recovery
- Asset management and renewal
- Water re-use
- Decrease inflow & infiltration (I/I)
- Industrial pre-treatment

8.2 Plant Alternatives for Growth and Level of Treatment

Options for each facility have been recommended to address growth and level of treatment needs. Table 54 provides a summary of the recommendations.

It is noted that costs presented in this TM were developed for comparison of options and will be further refined in the implementation plan for the preferred options.

Table 54 Summary of Growth and Level of Treatment Recommendations

WWTP	Growth Recommendations		Level of Treatment Recommendations	
	Infrastructure Option	**Non-Infrastructure Opportunity**	**Infrastructure Option**	**Non-Infrastructure Opportunity**
Kitchener	• None required		• None required	
Waterloo	• Expansion with new technology (granular sludge)	• Expansion by re-rating	• Phosphorus removal (new tertiary treatment) at Waterloo WWTP	
Galt	• None required		• No upgrades required. Can achieve Lake Erie Basin limits with existing tertiary filters.	
Preston	• None required		• Phosphorus removal (optimization of secondary treatment) at Preston WWTP	
Hespeler	• Expansion using new technology (MABR)		• Phosphorus removal (optimization of secondary treatment) at Hespeler WWTP	
Ayr	• None required		• None required	
New Hamburg	• None required		• None required	
Wellesley	• Expansion using new technology (granular sludge)		• Phosphorus removal (expansion of existing filters) at Wellesley WWTP	• Phosphorus off-setting
St Jacobs	• Expansion using conventional technology	• Expansion by re-rating	• Phosphorus removal (expansion of existing filters) at St Jacobs WWTP	• Phosphorus off-setting

WWTP	Growth Recommendations		Level of Treatment Recommendations	
	Infrastructure Option	**Non-Infrastructure Opportunity**	**Infrastructure Option**	**Non-Infrastructure Opportunity**
Elmira	• Expansion using new technology (granular sludge)		• Phosphorus removal (expansion of existing filters) at Elmira WWTP	
Foxboro	• None required		• None required	
Conestoga	• None required		• None required	
Heidelberg	• None required		• None required	

8.3 Plant Alternatives for Energy and Chemical Savings

Options to reduce energy and chemical usage for each facility have been reviewed from a business case perspective and recommendations have been made and summarized in Table 55.

Table 55 Summary of Business Case Options and Recommendations

Item	Benefit	General Findings	Summary of Recommendation
Chemically Enhanced Primary Treatment	• Increase digester gas production • Reduce aeration energy demands	• Chemical costs and increase sludge production off-set energy savings	• Consider for trial at Waterloo WWTP to document the cost-benefits. No capital investment required.
Sidestream Treatment (Deammonification and Post-Aerobic Digestion Considered)	• Reduce overall energy cost • Reduce biosolids production	• Post-aerobic Digestion (PAD) offers greatest savings opportunity to Region	• Consider PAD for sidestream treatment at Kitchener with highest overall payback, if alternative funding becomes available.
Anoxic Selector	• Reduce aeration energy cost	• Relatively low capital investment for on-going energy savings	• Integrate with any planned diffuser replacement project (i.e., asset management) or with planned expansion
Automation Upgrades	• Reduce chemical and energy usage	• Instrumentation cost limits payback for smaller facilities, greater benefit at larger facilities with higher potential for reductions in operating cost.	• Implement full-scale trial at larger plant (Waterloo or Kitchener) for detailed cost-benefit assessment • Assess results of ortho-phosphate analyzer at Kitchener WWTP for savings potential

Item	Benefit	General Findings	Summary of Recommendation
Co-Digestion	• Use high energy waste from industry to produce digester gas	• Competing market for high energy wastes • Potential for good payback at Kitchener and Waterloo WWTP	• Complete market study and conceptual design to finalize business case for Kitchener and Waterloo WWTP
Temperature Phased Anaerobic Digestion (TPAD)	• Reduce biosolids production and increase gas production	• High capital cost relative to moderate savings	• Not recommended
Thermal Hydrolysis Process (THP)	• Reduce biosolids production • Increase gas production • Improve dewaterability	• Requires operation of steam system • Significant labour cost in Ontario for plants currently only staffed during daytime	• Can be considered for Kitchener WWTP if alternative becomes funding available.

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Appendix A

Vendor Information

Appendix B

Cost Estimates

Appendix C

Elmira WWTP Optimization Study Report