Appendix F Carleton Place Wastewater Treatment Plant Expansion Options Evaluation Memo

Stantec

Memo

To:	Guy Bourgon, P.Eng. Town of Carleton Place	From:	Pierre Wilder, P.Eng. and Olav Natvik, P.Eng. Stantec Consulting, Ottawa, ON
Project/File:	163401646	Date:	November 21, 2022

Reference: Carleton Place Wastewater Treatment Plant Expansion Options Evaluation

1 Introduction

The Town of Carleton Place's water & wastewater infrastructure will require expansion to accommodate planned growth to 2041. Stantec Consulting Ltd. (Stantec) was retained by the Town of Carleton Place (Town) to prepare a Master Plan and undertake Schedule 'C' Municipal Class Environmental Assessments (MCEA) and to identify problems & opportunities, identify alternative solutions, and define implementation plans for the expansion of the Town's water treatment plant (WTP) and wastewater treatment plant (WWTP). The 30-day public review period for the Master Plan was completed July 5, 2022, and contained the following preferred alternatives:

- To expand the existing WTP on the existing site at John St.;
- To add water storage at the WTP site as part of the expansion; and,
- To expand the existing WWTP on the existing site off Patterson Cres. and partially into the neighbouring property (Town's household hazardous waste and compost depot).

The Master Plan was undertaken in accordance with the Master Plan process, which generally addresses Phases 1 and 2 of the Class EA process. The Town is proceeding with Phases 3 and 4 of the Class EA process to complete the planning and preliminary design for these recommended projects, which generally includes identifying and evaluating a range of alternative design concepts, identifying a preferred design, and documenting the decision-making process within an Environmental Study Report. The Schedule 'C' MCEA projects are now underway for the above noted preferred alternatives to complete the planning and preliminary design, including phasing and planning level costing, that were presented in the Master Plan.

2 Purpose

The purpose of this memorandum is to present and evaluate the feasible alternative design concepts to determine the preferred alternative to expand the WWTP on the existing and adjacent sites and develop a strategy for implementation. This memorandum satisfies steps 1 to 4 of Phase 3 of the Municipal Class Environmental Assessment Planning process and will form the basis for upcoming consultation with review agencies and the public prior to confirmation of the preferred design solution.

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3 Wastewater Treatment Plant Expansion Needs and Constraints

The Town's wastewater is conveyed to the WWTP via a separated gravity sewer network including eleven (11) pumping stations. The existing WWTP has a rated capacity of 7,900 m^3/d annual average flow and a peak design flow of 22,000 m^3/d. The plant is considered a conventional activated sludge plant with base flow treatment through complete works for flows up to 10,400 m^3/d and excess wet weather flows greater than this passing through physical/chemical clarifiers for enhanced primary treatment. The plant is operated by the Ontario Clean Water Agency (OCWA) under *Carleton Place Water Pollution Control Pant* CofA No. *5001-7FZT4A* (MOE, October 3, 2008).The preferred alternative solution to accommodate the future servicing needs for the WWTP up to 2041, based on the evaluation performed in the Master Plan, consists of expanding the WWTP within the existing site footprint and onto the neighbouring property to the north, currently serving as a household hazardous waste and compost yard site (also owned by the Town, see **Figure 1**). The high-level expansion footprint illustrated in **Figure 1** was assumed for the Master Plan evaluation and is further defined within the preliminary site plans of the expansion options, presented in Figure 2 and Figure 3. This option seeks to maintain use of the existing processes, where practical, while providing the necessary treatment capacity to accommodate future growth.

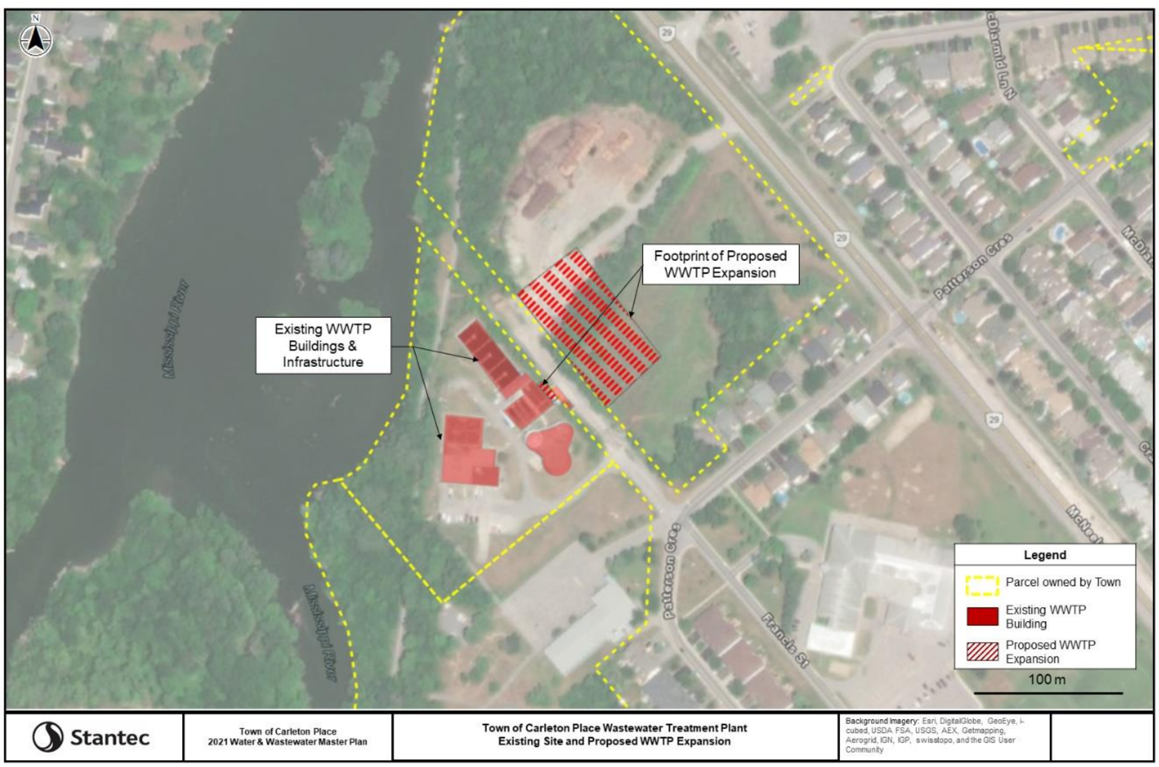


Figure 1: Potential Footprint for WWTP Expansion

The following is a summary of WWTP planning constraints and needs, some of which are discussed in the **Phase 1 and 2 Reports**:

- The WWTP requires an expansion by 2025 to increase its rated capacity to 10,625 m^3/d and peak design flow to 42,500 m^3/d to meet 20-year design average daily and peak hourly flows.
  - The influent design loads are anticipated to increase proportionally with service population and combined with the need for continuous nitrification, will require a significant increase in secondary treatment capacity.
  - The existing plant experiences high peak flows, upwards of 30,000 m^3/d, particularly during the Spring, and is believed to be significantly influenced by inflow and infiltration (I/I) and potentially illegal sump pump connections. To meet future growth, a peak hourly flow of 42,500 m^3/d should be designed for and will require significant capacity increases for raw sewage pumping, preliminary treatment (screening and grit removal), tertiary treatment, and disinfection.
- An updated assimilative capacity study (ACS) was completed as part of this MCEA to determine the appropriate effluent limits and objectives for the upgraded WWTP facility.
  - It is expected that tertiary treatment (or ultrafiltration) and continuously nitrifying secondary treatment will be required to meet the new non-compliance limits for Total Phosphorus (TP) and Total Ammonia Nitrogen (TAN).
- The existing WWTP site is very tight with limited space between processes for interior expansion.
  - The land directly north of the WWTP is a hazardous waste depot and compost yard owned and operated by the Town. This depot is intended to be moved to the planned municipal yard on Bates Dr, which may open up space for WWTP expansion.
- A geotechnical investigation was not completed at the existing site but based on background document review and the proximity to the River, it is expected that any deep excavations would encounter rock and groundwater.
- A Species At-Risk (SAR) review was completed at the existing site and the southern portion of the hazardous waste depot area and did not identify any SAR on the existing property but found several potentially suitable habitats for Blanding's Turtles and SAR Bats. These should be considered at the design stage. .
- A Stage 1 Archaeological Assessment (AA) was completed at the existing site and the southern portion of the hazardous waste depot area and concluded the existing site was free of archaeological potential. Any expansion into undisturbed forested areas to the north of the existing site will require archaeological consideration.

4 Long List of Expansion Options and Screening

4.1 Expansion Options Long List Development

A long list of wastewater treatment options potentially suited to expand the existing WWTP has been developed. **Table 1** provides a general process description for each treatment option as well as relative advantages/disadvantages.

Each of the long-listed treatment options have been selected for its ability to provide tertiary treatment, as was determined through the ACS will be required for the expanded Carleton Place WWTP. Several new technologies and treatment intensification options, such as Membrane Aerated Biofilm Reactor (MABR), Granular Sludge / Ballasted Flocculation, Integrated Fixed Film Activated Sludge (IFAS), and Chemically Enhanced Primary Treatment (CEPT) could be considered in conjunction with the options presented below. However, alone these technologies and processes do not meet the required level of treatment and plant capacity expansion.

Table 1: Long List of WWTP Expansion Options

Treatment	Process Description	Advantages	Disadvantages
Facultative lagoon + SAGR for ammonia removal + filters for total phosphorus (TP) removal	• Natural lagoon system having minimum 2 treatment/storage cells. Organic total suspended solids (TSS) and biochemical oxygen demand (BOD5) are naturally degraded within the lagoons. A coagulant such as alum or ferric chloride is added to chemically precipitate soluble phosphorus. • Submerged aerated growth reactor (SAGR) is a form of engineered wetland which is used to reduce lagoon effluent ammonia levels. Effluent flows through an aerated rock bed that allows nitrification to occur even in cold weather conditions. Nitrification may need to be encouraged by adding a caustic in low alkalinity wastewater. • SAGR effluent is passed through a tertiary filtration process to ensure consistent effluent TSS, cBOD5, and TP levels before discharge. Coagulant and polymer is added prior to the filters to reduce TP levels.	• With sites having large area, suitable construction soils, and sufficient receiver assimilative capacity, facultative lagoons generally represent lowest unit cost for construction and operation of all available treatment processes. • Very little operator attention normally required. • SAGR removes ammonia and generates non-toxic effluent. • Tertiary filters provide effluent polishing and TP removal to ensure consistent effluent quality.	• Requires large area for lagoons, SAGR, and filtration processes. • Potential for odour complaints. • Generally inefficient and inconsistent treatment.

Treatment	Process Description	Advantages	Disadvantages
Sequencing Batch Reactors (SBR) + filters for TP removal	• Biological treatment and solids/liquid separation are achieved in a single vessel by sequencing the “react”, “settle”, and “decant” operations. • Biological treatment and filtration are achieved in a 2-step process involving sequencing batch reactor for biological treatment and solids/liquid separation, followed by sand or cloth media filtration for particulates filtration. • TP removal is usually achieved by adding a coagulant such as alum or ferric solutions. Nitrification may need to be encouraged by adding a caustic in low alkalinity wastewater.	• Excellent tertiary effluent quality. • SBR/filter process can be expanded with flow/load increase.	• Requires greater operator skill, O&M. • Complicated programming required for plant automation resulting in long commissioning period and troubleshooting if issues arrive during operation. • As a mechanical plant process, higher construction and O&M costs versus lagoon option.
Conventional Activated Sludge (CAS) + filters for TP removal	• Biological treatment and solids/liquid separation are achieved in primary settling tank, an aerated tank, followed by a secondary clarifier. • Biological treatment and filtration are achieved in 2-step process involving aeration tank for biological treatment, secondary clarifier for solids/liquid separation, followed by sand or cloth media filtration for particulates filtration. • TP removal is usually achieved by adding a coagulant such as alum or ferric solutions. Nitrification may need to be encouraged by adding a caustic in low alkalinity wastewater.	• Standard technology that is easy to operate and matches existing plant treatment process • Excellent “tertiary” effluent quality. • CAS/filter process can be expanded with flow/load increase.	• As a mechanical plant process, higher construction and O&M costs versus lagoon option. • Greater space requirement than other options due to requirement for additional tankage.
Rotating Biological Contactors (RBC) + filters for TP removal	• Biological treatment and filtration are achieved in a 3-step process involving primary sedimentation for raw sewage particulates removal, RBC tank for biological treatment, secondary clarifier for solids/liquid separation, followed by sand or cloth media filtration for particulates filtration.	• Excellent “tertiary” effluent quality. • RBC/filter process can be expanded with flow/load increase.	• Occasionally variable treatment performance due to inability to pace aeration to changing wastewater strength. • Not particularly well suited for larger flow applications as the main process.

Treatment	Process Description	Advantages	Disadvantages
Membrane bioreactor (MBR)	• Biological treatment and filtration are achieved in a 1-step process involving aeration tanks for biological treatment and ultra-filtration membranes for solids/liquid separation and particulates filtration.	• Excellent tertiary effluent quality, representing best available technology. • MBR process is modular and is easily expanded with flow/load increase. • Package MBR processes can be purchased. • It is possible to operate MBR processes at higher mixed liquor suspended solids (MLSS) concentrations compared to conventional settlement separation systems, thus reducing the reactor volume to achieve the same loading rate.	• As an advanced mechanical plant process, typically higher operating and maintenance costs for chemicals, electricity, membrane replacement vs other mechanical plants

4.2 Long List Options Screening

A series of critical “YES / NO” type questions can be asked to screen the various expansion options described in **Table 2** to help identify a short-list of treatment process options for further evaluation. The questions selected for screening the options are as follows:

1. Is there sufficient space for a new process?
2. Will MECP approve the new process and issue a letter of conformance?
3. Are there other proven installations in Ontario?
4. Are there suitable sludge management options available?
5. Does the process maximize and optimize the use of existing infrastructure?
6. Will the process provide capacity to service growth and allow for expansion beyond the 20-year planning horizon?

Table 2 – Long List Options Screening

Process	Sufficient Space?	MECP Approval?	Proven Installs?	Sludge Plan?	Use Existing Infrastructure?	Future Expansion?	PASS / FAIL - Comments
Lagoon + SAGR + filters	NO	YES	YES	YES	NO	NO	FAIL – insufficient space for current and future expansions, poor use of existing mechanical treatment plant infrastructure.
SBR + filters	YES	YES	YES	YES	NO	YES	FAIL – requires significant operator oversight, poor use of existing mechanical treatment plant infrastructure.
CAS + filters	YES	YES	YES	YES	YES	YES	PASS – carried forward for further evaluation.
RBC + filters	YES	YES	YES	YES	NO	YES	FAIL – Can have variable treatment and effluent quality, poor use of existing mechanical treatment plant infrastructure.
MBR	YES	YES	YES	YES	YES	YES	PASS – carried forward for further evaluation.

The short-list of options identified based on the results of the screening assessment are:

- **Alternative 1** – WWTP Conventional Activated Sludge Treatment Upgrade; and
- **Alternative 2** – WWTP Membrane Bioreactor Treatment Upgrade.

These alternatives will be further explored and evaluated in the following sections.

5 Short Listed Options

5.1 Alternative 1 – WWTP Conventional Activated Sludge Treatment Upgrade

A conventional plant expansion involves providing additional capacity to accommodate growth using the same or similar technology as existing within the treatment plant. Alternative 1 includes expanding the WWTP by adding new aeration tanks and secondary clarifiers to increase the plant's secondary treatment capacity and adding tertiary treatment with filtration. As described in **Table 3,** and shown in the process flow diagram (**Figure 2**), this option seeks to maintain use of the existing processes, where practical, while providing new infrastructure where necessary to increase treatment capacity to accommodate future growth. Furthermore, the layout of the sanitary collection system can be maintained with this WWTP expansion option.

Table 3: Alternative 1 Upgrades by Unit Process

Unit Process	Description of Upgrades
Raw Sewage Pumping	• Replacing the raw sewage pumps in the existing control building to meet the 2041 peak hour flow (PHF) (42,500 m^3/d). • Installing new forcemain from raw sewage pumping to new headworks building.
Preliminary Treatment (Screening and Grit Removal)	• Installing a new headworks building to house new screening and grit removal equipment to meet the 2041 PHF (42,500 m^3/d). • Installing odour control facilities for the new headworks building. • Installing a new gravity-fed preliminary effluent pipe from the new headworks building to the existing primary clarifiers.
Primary Treatment	• Reuse of the existing primary clarifiers, converting the physical/chemical clarifiers to standard primary clarifiers, while keeping the chemical dosing system online if needed.
Secondary Treatment	• Re-use of the existing aeration tanks and secondary clarifiers with revisions to permit fine bubble aeration. • Installing two new aeration tanks and two new secondary clarifiers to meet nitrification requirements for the upgraded plant. • Installing new blower equipment and building to service the old & new plants.
Tertiary Treatment, Disinfection, and Effluent Pumping	• Construction of a new tertiary treatment, disinfection, and effluent pumping building to house filtration and disinfection equipment to achieve improved effluent quality and accommodate 2041 PHF (42,500 m^3/d). • Adding effluent pumping equipment to provide means of discharging effluent during 100-year river level event.
Solids Management	• Converting the existing secondary digester to a primary digester to increase plant’s anaerobic digester capacity. • Installing an additional liquid sludge storage tank to increase on-site storage capacity. • Reserving space on site for potential future WAS thickening and dewatering to suit year-round solids management strategies that maximize beneficial nutrient re-use and minimize cost.

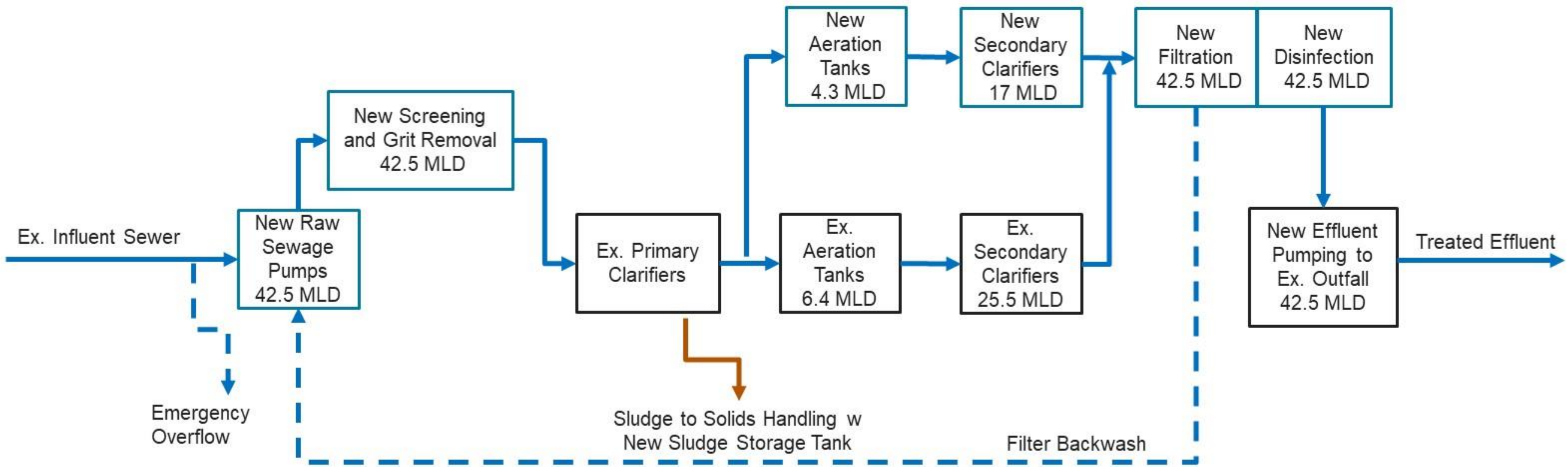


Figure 2: Alternative 1 Process Flow Diagram

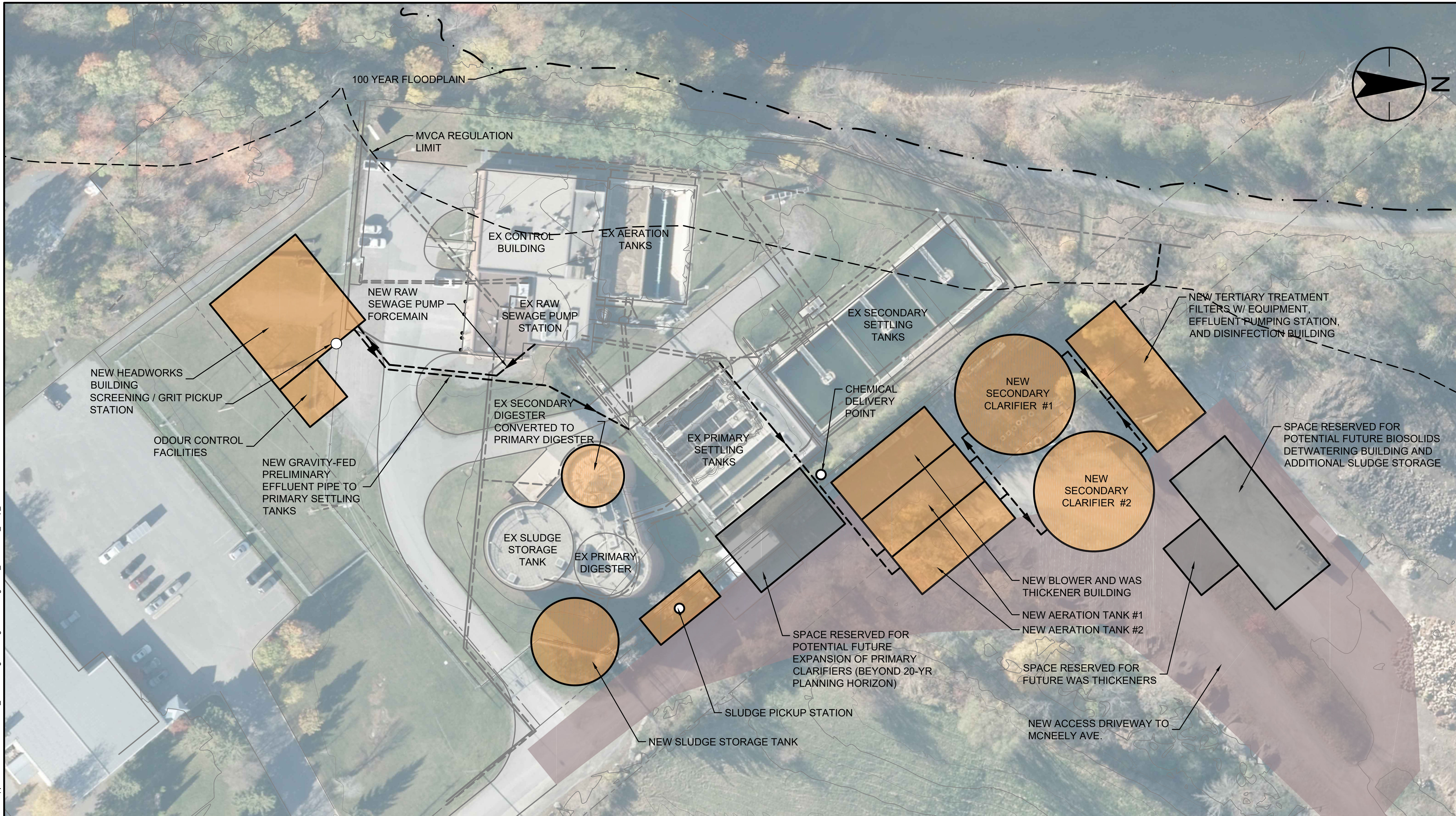
A significant portion of the land to the north of the existing site will be required to provide adequate space for new infrastructure, as shown in **Figure 3**, given the existing plant property is constrained by existing infrastructure and underground utilities. The Town owned-land to the north of the existing plant has been previously disturbed as it is used as a hazardous waste depot and compost site. The depot is intended to be moved to the planned municipal yard on Bates Dr.

Although this alternative could lead to a reduction in land, this does not impede on parkland or on the Mississippi Riverwalk Trail. However, Alternative 1 would involve encroaching on existing treed areas to provide sufficient space for new infrastructure. Should Alternative 1 be the preferred option, additional studies will be required to qualify the natural, archeological, and cultural impacts and mitigation measures.

Table 4 provides a summary of the advantages and disadvantages of a conventional plant expansion.

Table 4: Summary of Advantages and Disadvantages of Alternative 1 – WWTP Conventional Activated Sludge Treatment Upgrade

Advantages	Disadvantages
• Proven technology • Well understood capital and long-term O&M requirements • Ability to achieve low TP as low as 0.15 mg/L monthly non-compliance limit. • Simplified MECP approvals	• Larger footprint to accommodate expanded capacity • Limited energy savings opportunities over existing – Some opportunities available through equipment selection, controls, anoxic selectors, etc. • Added complexity of operating the new secondary treatment processes in conjunction with the existing plant. The existing aeration tanks are relatively shallow (~3.2m in depth) in comparison to the current industry standard (>4m in depth). • Numerous flow splits required making hydraulic control more challenging. • Likely will require effluent pumping to discharge effluent to river during 100-year flood event based on existing plant's hydraulic grade line in combination with headloss through new tertiary filters. • Requirement to treat filter backwash reduces overall capacity of plant, especially during peak flow events. • Highest initial capital expenditure and lifecycle cost.



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Client/Project
TOWN OF CARLETON PLACE

CLASS ENVIRONMENTAL ASSESSMENTS FOR WATER AND SEWAGE FACILITY EXPANSIONS

Project No.
1634-01646

Title
ALTERNATIVE 1 - WPCP CONVENTIONAL SLUDGE TREATMENT UPGRADE

Revision	Date
D	2022.10.26
Reference Sheet	**Figure No.**
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5.2 Alternative 2 – WWTP Membrane Bioreactor Treatment Upgrade

Membrane bioreactors (MBR), as an advanced activated sludge wastewater treatment process, typically consist of a suspended growth biological reactor coupled with a submerged ultrafiltration membrane system. Mixed liquor from the biological reactor is fed to the membrane tanks and clean effluent is drawn through membrane filters by permeate pumps. The membrane essentially provides the functions of secondary clarification and tertiary filtration in a CAS process, thus eliminating the need for secondary clarifiers and tertiary filters.

Alternative 2 includes expanding the WWTP by converting the existing secondary clarifier tanks to aeration tanks to increase the plant's secondary treatment capacity and adding MBRs to provide clarification and improve effluent quality to tertiary treatment level. Existing WWTP infrastructure will be reused in conjunction with new tanks and buildings required for Alternative 2, as described in **Table 5** and shown in the process flow diagram (**Figure 4**). Furthermore, the layout of the sanitary collection system can be maintained with this WWTP expansion option.

Table 5: Alternative 2 Upgrades by Unit Process

Unit Process	Description of Upgrades
Raw Sewage Pumping	• Replacing the raw sewage pumps in the existing control building to meet the 2041 PHF (42,500 m^3/d). • Installing new forcemain from raw sewage pumping to new headworks building.
Flow Equalization	• Existing aeration tanks can be converted to raw sewage equalization tanks to buffer peak flow events.
Preliminary Treatment (Screening and Grit Removal)	• Installing a new headworks building to house new screening and grit removal equipment to meet the 2041 PHF (42,500 m^3/d). • Installing odour control facilities for the new headworks building. • Installing a new gravity-fed preliminary effluent pipe from the new headworks building to the existing primary clarifiers.
Primary Treatment	• Reuse of the existing primary clarifiers, converting the physical/chemical clarifiers to standard primary clarifiers, while keeping the chemical dosing system online if needed.
Secondary and Tertiary Treatment, and Disinfection	• Converting the existing secondary clarifiers to aeration tanks to meet nitrification requirements for the upgraded plant. • Construction of new MBR tanks and disinfection building to house MBR and disinfection equipment to achieve improved effluent quality and accommodate 2041 PHF (42,500 m^3/d).
Solids Management	• Converting the existing secondary digester to a primary digester to increase plant's anaerobic digester capacity. • Installing an additional liquid sludge storage tank to increase on-site storage capacity. • Reserving space on site for potential future WAS thickening and dewatering to suit year-round solids management strategies that maximize beneficial nutrient re-use and minimize cost.

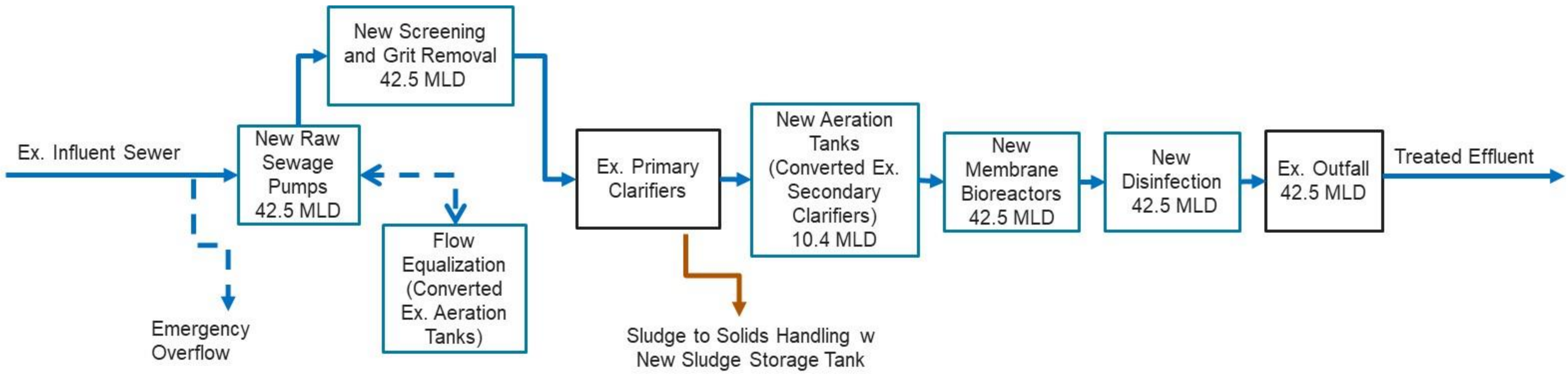


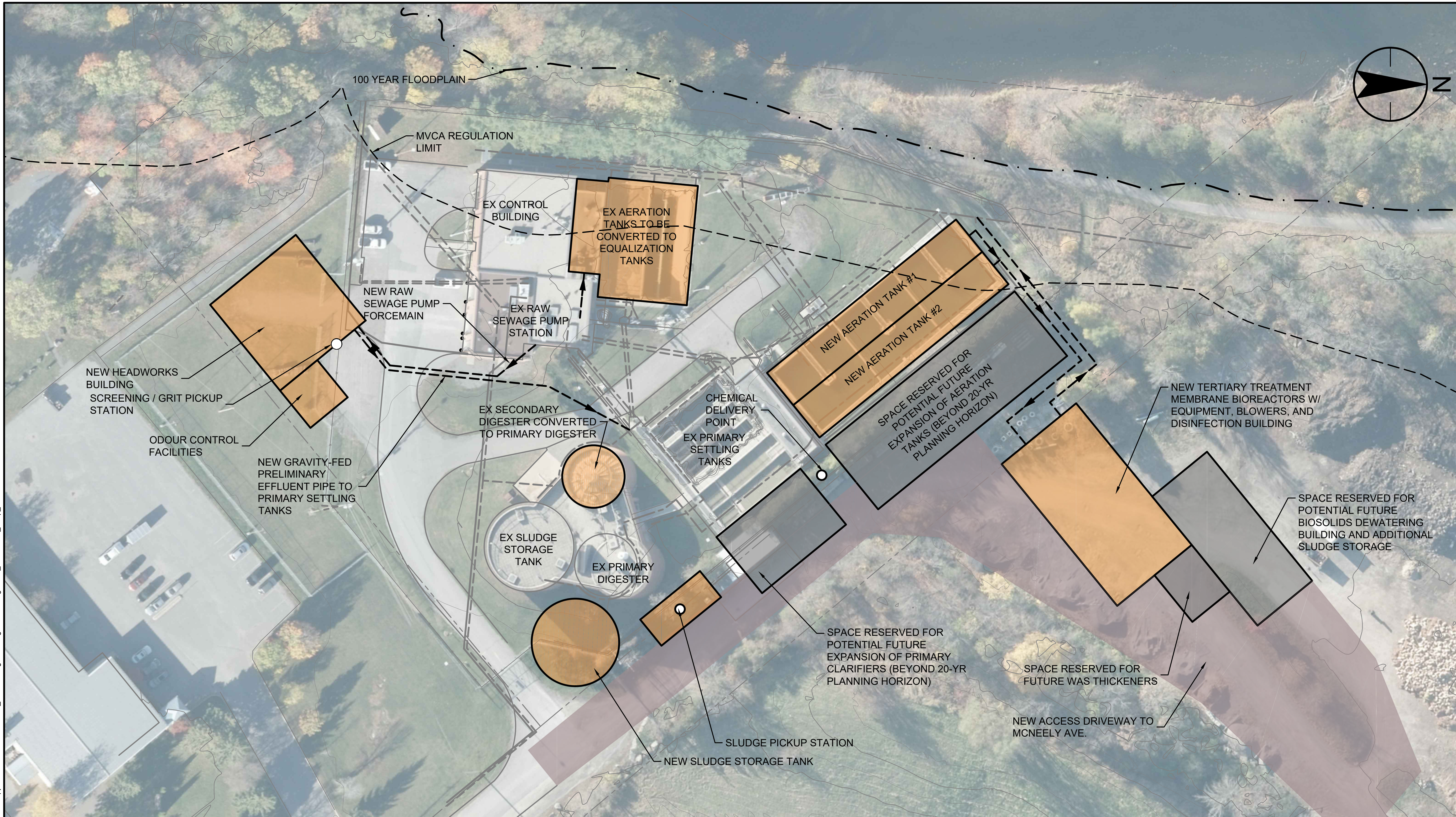
Figure 4: Alternative 2 Process Flow Diagram

Similar to Alternative 1, a portion of the land to the north of the existing site will be required to provide adequate space for new infrastructure, as shown in Figure 5. However, new infrastructure required for Alternative 2, including MBR, disinfection, and solids management buildings, has a smaller proposed footprint than Alternative 1 and is not constrained by the existing plant's hydraulic grade line. Adequate space for the Alternative 2 proposed buildings and tanks can be provided in the previously disturbed area of the Town's current hazardous waste depot, resulting in minimal impacts to treed areas.

Table 6 provides a summary of the advantages and disadvantages of an MBR plant expansion.

Table 6: Summary of Advantages and Disadvantages of Alternative 2 – WWTP Membrane Bioreactor Treatment Upgrade

Advantages	Disadvantages
• Proven technology – used at facilities in Ontario and North America. • Smaller footprint. • Ability to achieve very low TP (<0.1 mg/L as monthly non-compliance limit). • Ability to operate plant at higher mixed liquor suspended solids concentrations (6,000 to 10,000 mg/L) and solids retention time to further increase capacity of existing treatment processes and ensure complete nitrification, even in cold weather conditions. • Reduced flow splits and simplified hydraulics control. • Simplified MECP approvals. • Lower capital cost.	• Higher operating cost and energy requirements as compared to conventional plant. – Continues to improve as technology matures. • Upstream fine screening required for MBR. • Added complexity for design and construction for conversion of existing secondary clarifier to aeration tanks. • Requires additional operator training to become familiar with MBR treatment process.



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TOWN OF CARLETON PLACE

CLASS ENVIRONMENTAL ASSESSMENTS FOR WATER AND SEWAGE FACILITY EXPANSIONS

Project No.
1634-01646

Title
ALTERNATIVE 2 - WPCP MEMBRANE BIOREACTOR TREATMENT UPGRADE

Revision	Date
D	2022.10.26
Reference Sheet	**Figure No.**
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5.3 Life Cycle Cost Analysis

An opinion of probable construction cost (Class 4 estimate (-30% to +50%) in $CAD 2022) and preliminary 20-year life cycle cost analysis were developed for both alternatives. The result is shown in **Table 7**. Detailed calculations and assumptions for the life cycle cost analysis are provided in **Appendix A**. This table assumed expansion is completed in 2025.

Table 7: Life Cycle Cost Analysis

Process System	Opinion of Probable Cost (2022 $CAN)		Proposed Upgrades and Notes
	Alternative 1 – WWTP Conventional Activated Sludge Treatment Upgrade	Alternative 2 – WWTP Membrane Bioreactor Treatment Upgrade	
WWTP Expansion 2023 – 2025: Increase WWTP capacity to ADF = 10,625 m^3/d and PF = 42,500 m^3/d to support population growth up to 2041			
Raw Sewage Pumping Station	$1,000,000	$1,000,000	• Costing assumes larger firm pump capacity required based on projected PHF of 42.5 MLD, as well as forcemain modifications to connect to the new Headworks building.
Headworks	$6,500,000	$6,500,000	• Costing includes complete replacement and upsizing of the screening and grit removal equipment to meet PHF of 42.5 MLD. In addition, cost assumes that a new Headworks building will be constructed offline to house this equipment and mitigate to impacts to operations during construction.
Primary Clarifiers & Yard Piping	$2,000,000	$2,000,000	• Costs included re-routing existing piping to the physical/chemical clarifiers for use in the biological treatment process. This also includes general yard piping not accounted for elsewhere.
Aeration Tanks	$5,600,000	$2,500,000	• Alternative 1 costing assumes that a new aeration tank will be required to expand plant capacity by approximately 4.3 MLD based on the requirement for continuous nitrification. In addition, the costs include blower upgrades and a new blower building (to account for separate aeration zones) and installation of fine bubble diffusers in the existing aeration tanks to address existing operational issues. • Alternative 2 costing assumes conversion of the existing aeration tanks to equalization tanks.

Process System	Opinion of Probable Cost (2022 $CAN)		Proposed Upgrades and Notes
	Alternative 1 – WWTP Conventional Activated Sludge Treatment Upgrade	Alternative 2 – WWTP Membrane Bioreactor Treatment Upgrade	
Secondary Clarifiers	$4,000,000	$1,500,000	• Alternative 1 costing assumes that a new secondary clarifier will be required to expand plant capacity by approximately 4.3 MLD based on the requirement for continuous nitrification. • Alternative 2 costing assumes conversion of the existing secondary clarifiers to aeration tanks, including modification to existing blowers to service new pressure zone and installation of fine bubble diffusers.
Membrane Bioreactors	N/A	$7,500,000	• Costing assumes construction of new MBR tanks to house membranes and new building to house blowers and permeate pumps, including equipment cost.
Tertiary Treatment (Filtration)	$2,850,000	N/A	• Costing assumes that filter equipment must be sized to meet projected PHF of 42.5 MLD and more stringent effluent limits.
UV Disinfection	$950,000	$1,755,000	• Alternative 1 assumes UV equipment will be housed in the tertiary filter building, reducing building costs for disinfection line item. • Costing assumes that UV equipment must be sized to meet projected PHF of 42.5 MLD and more stringent effluent limits.
Anaerobic Digestion Upgrades	$1,500,000	$1,500,000	• Costing assumes the conversion of the secondary digester to a primary digester.
Onsite Sludge Storage	$2,000,000	$2,000,000	• Costing assumes installation of new sludge storage tank that matches the size of the existing tank.
Chemical Storage Building	$500,000	$500,000	• Requirement to upgrade the Chemical Storage Building with the implementation of either filtration for tertiary treatment or MBR.
Electrical Supply, Standby Generator	$1,500,000	$1,500,000	• Costs to size the new generator to meet the increased electrical demand from Headworks/Tertiary/Disinfection equipment required to meet projected PHF of 42.5 MLD.

Process System	Opinion of Probable Cost (2022 $CAN)		Proposed Upgrades and Notes
	Alternative 1 – WWTP Conventional Activated Sludge Treatment Upgrade	Alternative 2 – WWTP Membrane Bioreactor Treatment Upgrade	
Replacement, and Boiler Upgrades			
Effluent Pumping Station	$2,000,000	N/A	• Alternative 1 would likely require the addition of an effluent pumping station to discharge plant effluent when the Mississippi River level is high. • Alternative 2 includes provision to pump effluent within the MBR line item.
Outfall (Provisional)	$250,000	$250,000	• Potential need to upgrade the plant outfall to meet the future peak flow requirements to be assessed in future design stages. Condition assessment prior to expansion is recommended to confirm.
Sub-Total	**$30,650,000**	**$28,505,000**	
Contingency, Engineering, & Additional General Contract Costs	**$12,873,000**	**$11,972,000**	• Includes contingency (20%), engineering (10% - includes design and contract administration), additional general contract costs that are significant factors of construction contracts, including mobilization/demobilization/bonds/insurance (2%), and contract contingency/cash allowance (10%). Contractor's overhead and profit is assumed to be included in items above.
Total Construction Cost	**$43,500,000**	**$40,500,000**	• Class 4 estimate (-30% to +50%) in $CAD 2022.
Present Value 20-Year O&M Cost	**$33,100,000**	**$36,300,000**	• See **Appendix A** for model assumptions.
20-Year Life Cycle Cost	**$76,600,000**	**$76,800,000**	

6 Alternatives Evaluation Criteria & Rating System

The criteria for the evaluation of the alternatives fall into four main categories as presented in **Table 8**:

- Natural environment;
- Cultural environment;
- Socio-Economic environment; and
- Technical environment.
- **Table 9** presents the criteria and the related key considerations and impacts to assess. Each alternative is then qualitatively assessed against each criteria using a reasoned argument approach, resulting in a determination identifying each option as preferred or least preferred.

Reference: **Carleton Place Wastewater Treatment Plant Expansion Options Evaluation**

Table 8: Alternatives Evaluation Criteria

Category	Criteria
Natural Environment	**Aquatic Environment** • Potential to impact fish and fish habitat • Potential to impact surface water quality and quantity
	Terrestrial Environment • Potential to impact wildlife/habitat (i.e., Species-at-Risk, spawning areas, significant ecological areas, etc.) • Potential to affect vegetation (i.e., wooded areas, wetlands, conservation areas, etc.) • Potential to impact individual trees or landscaped features
Cultural Environment	**Archaeological Resources** • Potential to impact undisturbed lands
	Built Heritage Resources / Cultural Landscape • Potential to impact known built heritage resources or cultural landscapes/features
Socio-Economic Environment	**Noise/Vibration & Air Quality** • Potential to impact noise sensitive areas (i.e., residential dwellings, daycares, etc.) during construction • Potential to affect local air quality during construction • Potential to affect local air quality during operational phase
	Property Requirements • Requires acquisition of private property
	Aesthetics • Potential to impact visual aesthetics of study area
	Land Use • Potential to impact existing and future designated land use and/or community use

Reference: **Carleton Place Wastewater Treatment Plant Expansion Options Evaluation**

Category	Criteria
	Consistency with Municipal Planning Objectives and Existing/Proposed Development • Satisfies the goals and objectives of the Town's Official Plan • Consistency with municipal/regional policies • Potential to support existing and future development within the area
	Health & Safety • Potential to impact health and safety of residents • Potential to impact health and safety of employees • Potential impacts to groundwater quality (i.e., wells, effect Source Water Protection area, etc.) • Potential to encounter contaminated subsurface conditions
	Community Access • Disruption to existing traffic, private property and business access during construction • Disruption to existing traffic, private property and business access during operation
Technical Environment	**Functionality/Reliability of Wastewater Treatment** • Treated effluent quality • Reliability of the treatment process • Potential for risk of sewage backups and impacts to collection system
	Monitoring Requirements & Efficiencies • Impacts to operational monitoring requirements and efficiency
	Cost • Relative capital, operational and maintenance costs ($)
	Utilities • Potential to impact existing utilities

Reference: **Carleton Place Wastewater Treatment Plant Expansion Options Evaluation**

Category	Criteria
	Constructability & Feasibility • Potential to disrupt existing traffic, property access or functionality of existing facilities during construction • Location, depth of excavation, soil conditions, rock removal, groundwater control, in-water works, workable construction area, construction duration
	Expandability • Potential to be expanded or flexible to meet future population needs
	Climate Change • Ability to increase resilience to climate change (i.e., severe weather events) within the study area • Impacts to known climate change contributors (i.e., GHG emissions)

7 Alternatives Evaluation

Table 9 shows the evaluation of the alternatives for the WWTP expansion.

Table 9: Evaluation Summary for WWTP Expansion

Evaluation Criteria		Alternative Design Solutions	
Factors	**Measures**	**Alternative 1: WWTP conventional activated sludge treatment upgrade**	**Alternative 2: WWTP membrane bioreactor treatment upgrade**
Natural Environment			
Aquatic Environment	• Potential to impact fish and fish habitat. • Potential to impact water quality and quantity.	• Low potential to impact fish and fish habitat as expansion will not require new effluent outfall pipe into Mississippi River. However, minor impacts from increased effluent loadings. • Moderate potential to impact water quality and quantity due to site's proximity to the Mississippi River and potential runoff during construction of a larger number of structures than Alternative 2. However, impacts may be mitigated through design and construction management measures.	• Low potential to impact fish and fish habitat as expansion will not require new effluent outfall pipe into Mississippi River. However, minor impacts from increased effluent loadings. • Low potential to impact water quality and quantity due to site's proximity to the Mississippi River and potential runoff during construction. However, impacts may be mitigated through design and construction management measures and there are less structures than Alternative 1.
Terrestrial Environment	• Potential to impact wildlife/habitat (i.e., Species-at-Risk, spawning areas, significant ecological areas, etc.). • Potential to affect vegetation (i.e., wooded areas, wetlands, conservation areas, etc.). • Potential to impact individual trees or landscaped features.	• High potential to impact wildlife/habitat, including bird nesting and bat habitat, as the construction of new Primary Clarifier, Tertiary Treatment and Disinfection Building, Secondary Clarifiers, and Blower and WAS Thickener Building would extend past existing site into surrounding land and require a larger footprint than Alternative 2. • High potential to impact vegetation through expansion as expansion extends into previously undisturbed lands. • Higher potential to impact individual trees. More individual trees anticipated to require removal, when compared to Alternative 2.	• Moderate potential to impact wildlife/habitat, including bird nesting and bat habitat, as the construction of the new Primary Clarifier and MBR and Disinfection Building would extend past existing site into surrounding land. • Moderate vegetation removals required where expansion is required. • Moderate potential to impact individual trees that would require removal to accommodate expansion due to additional MBR and Disinfection Building and Primary Clarifier.
Natural Environment Summary		**Least preferred**	**Preferred**
Cultural Environment			
Archaeological Resources	• Potential to impact artifacts.	• Moderate potential to impact undisturbed lands (i.e., areas with archaeological potential) as expansion would take place within forest areas, requiring Stage 1 and Stage 2 Archaeological Assessments; however, deemed moderate as adjacent developed land lacked archaeological potential.	• Low potential to impact undisturbed lands as expansion would take place within existing developed site and southern portion of adjacent hazardous waste depot, which retains low to no archaeological potential.
Built Heritage Resources / Cultural Landscape	• Potential to impact known built heritage resources or cultural landscapes/features.	• No impact to built heritage or cultural landscapes/features.	
Cultural Environment Summary		**Least preferred**	**Preferred**

Reference: **Carleton Place Wastewater Treatment Plant Expansion Options Evaluation**

Evaluation Criteria		Alternative Design Solutions	
Factors	**Measures**	**Alternative 1: WWTP conventional activated sludge treatment upgrade**	**Alternative 2: WWTP membrane bioreactor treatment upgrade**
Socio-Economic Environment			
Noise/Vibration & Air Quality	• Potential to impact noise sensitive areas (i.e., residential dwellings, daycares, etc.) during construction. • Potential to affect local air quality during construction. • Potential to affect local air quality during operational phase.	• Moderate-high potential for temporary noise impacts caused by construction vehicles. • Moderate-high potential for temporary impacts to local air quality due to construction equipment exhaust/dust. • Moderate potential for impacts to local air quality during operation phase due to increase in bio-gas production and use of flare, as well as occasional odours. Odour issues will be mitigated by providing odour control facilities for the new Headworks Building.	• Moderate potential for temporary noise impacts caused by construction vehicles. • Moderate potential for temporary impacts to local air quality due to construction equipment exhaust/dust. • Moderate potential for impacts to local air quality during operation phase due to increase in bio-gas production and use of flare, as well as occasional odours. Odour issues will be mitigated by providing odour control facilities for the new Headworks Building.
Property Requirements	• Requires acquisition of private property.	• No impact to private property.	
Aesthetics	• Potential to impact visual aesthetics of study area	• Moderate potential to impact visual aesthetics of the Carleton Place Curling Club due to the construction of the new Headworks and Dewatering Building and Odour Control Facilities.	
Land Use	• Potential to impact existing and future designated land use and/or community use	• No impact to existing or designated land use. Community use will not be impacted since the public does not use the WWTP grounds. The land to the north of the existing plant is owned by the Town and currently used as a hazardous waste depot and compost site. The depot is intended to be moved to the planned municipal yard on Bates Dr.	
Consistency with Municipal Planning Objectives & Future Development within the Area	• Satisfies the goals and objectives of the Town's Official Plan • Consistency with municipal/regional policies	• Satisfies the goals of the Town's Water and Wastewater Master Plan to support future projected population growth in the 20-year planning horizon (to 2041). • Consistent with municipal/regional policies related to servicing existing and future population in an environmentally responsible manner and account for the health and safety of residents.	
Health & Safety	• Potential to impact health and safety of residents • Potential to impact health and safety of employees • Potential impacts to groundwater quality (i.e., wells, effect Source Water Protection area, etc.) • Potential to encounter contaminated subsurface conditions	• Low potential to impact the health and safety of Town residents. • Improves health and safety of employees through design of new buildings and processes with improved safety features. • Low potential to impact groundwater quality including private wells. • High potential to encounter contaminated subsurface conditions for portion of expansion extending onto existing hazardous waste depot site due to the construction of a larger number of structures than Alternative 2.	• Low potential to impact the health and safety of Town residents. • Improves health and safety of employees through design of new buildings and processes with improved safety features. • Low potential to impact groundwater quality including private wells. • Moderate-high potential to encounter contaminated subsurface conditions for portion of expansion extending onto existing hazardous waste depot site.
Community Access	• Disruption to existing traffic, private property and business access during construction. • Disruption to existing traffic, private property and business access during operation.	• Moderate potential to impact traffic during construction, which can be mitigated by providing access to the site via McNeely Avenue instead of directing construction traffic via residential streets. • Decreases impact of traffic during operation by providing access to the site via McNeely Avenue instead of directing traffic via residential streets. In addition, potential to improve sludge storage and dewatering which may decrease traffic by reducing frequency of visits by solids disposal trucks.	
Socio-Economic Environment Summary		**Least Preferred**	**Preferred**

Reference: **Carleton Place Wastewater Treatment Plant Expansion Options Evaluation**

Evaluation Criteria		Alternative Design Solutions	
Factors	**Measures**	**Alternative 1: WWTP conventional activated sludge treatment upgrade**	**Alternative 2: WWTP membrane bioreactor treatment upgrade**
Technical			
Functionality/Reliability of Wastewater Treatment	• Treated effluent quality. • Reliability of the treatment process. • Potential for risk of sewage backups and impacts to collection system.	• Improves and maintains treated effluent quality. • Improves reliability of treatment processes. • Low potential risk for sewage backups and impacts to collection system.	
Monitoring Requirements & Efficiencies	• Impacts to operational monitoring requirements and efficiency.	• Moderate impact to operational monitoring requirements as the addition of separate secondary treatment process will add sampling points that require compliance monitoring and reporting. • Moderate improvement in efficiency of treatment with separate blowers and aeration control required between new and existing aeration tanks and continued use of shallow existing aeration tanks.	• Low impact to operational monitoring requirements as the addition of MBR will add minimal sampling points that require compliance monitoring and reporting. • High improvement in efficiency of treatment with re-purposing of deeper existing secondary clarifiers as aeration tanks, ability to operate at higher mixed liquor suspended solids concentrations and automation of MBR cleaning.
Cost	• Relative capital, operational and maintenance costs ($)	• High 20-year lifecycle cost. Higher construction cost but lower O&M cost than Alternative 2.	• High 20-year lifecycle cost. Lower construction cost but higher O&M cost than Alternative 1.
Utilities	• Potential to impact existing utilities	• Positive impact to sewer system by reducing surcharge and flooding frequency. • Low impact to other existing utilities. Upgraded hydro connection may be required	
Constructability & Feasibility	• Potential to disrupt existing traffic, property access or functionality of existing facilities during construction • Location, depth of excavation, soil conditions, rock removal, groundwater control, in-water works, workable construction area, construction duration	• Low impact to existing traffic, property access or functionality of existing facilities during construction as majority of new infrastructure can be constructed offline on the site north of the existing plant and can be accessed from McNeely Avenue. Tie-ins of new infrastructure to existing plant may require short shutdowns or temporary treatment processes. • Geotechnical investigation of site will be required, likely rock removal and groundwater will be encountered during construction due to site proximity to the river. However, no in-river works needed as existing outfall pipe has capacity to serve future flow rates.	• Moderate impact to existing traffic, property access or functionality of existing facilities during construction as retrofit of the existing secondary clarifiers is proposed, which will require temporary diversion of aeration tank effluent and additional coordination during construction. However, majority of new infrastructure can be constructed offline on the site north of the existing plant and can be accessed from McNeely Avenue. Tie-ins of new infrastructure to existing plant may require short shutdowns or temporary treatment processes. • Geotechnical investigation of site will be required, likely rock removal and groundwater will be encountered during construction due to site proximity to the river. However, no in-river works needed as existing outfall pipe has capacity to serve future flow rates.
Expandability	• Potential to be expanded or flexible to meet future population needs	• High potential to expand beyond projected 20-year population horizon as adjacent lands are owned by Town.	
Climate Change	• Ability to increase resilience to climate change (i.e., severe weather events) within the study area • Impacts to known climate change contributors (i.e., GHG emissions)	• Moderate improvement in resiliency to climate change due to accommodation of 2041 projection peak flows. • High potential to increase known climate change contributors through construction of several concrete tanks and increased energy consumption, although there are opportunities to implement more energy efficient processes.	• Moderate-high improvement in resiliency to climate change due to accommodation of 2041 projection peak flows and conversion of existing aeration tanks into flow equalization tanks for use as emergency storage. • Moderate-high potential to increase known climate change contributors through increased energy consumption of MBR processes, although there are opportunities to implement more energy efficient processes.
Technical Summary		**Least preferred**	**Preferred**
OVERALL CONCLUSION		**Least preferred**	**Preferred**

LEGEND
Preferred
Least Preferred

8 Conclusions and Next Steps

The preferred alternative for WWTP expansion based on the detailed evaluation is: ***Alternative 2 - WWTP Membrane Bioreactor Treatment Upgrade*** with the following key advantages:

- Optimizing use of existing infrastructure, including conversion of the existing aeration tanks to equalization tanks to buffer peak flows and conversion of the existing secondary clarifiers to aeration tanks to improve oxygen transfer efficiency;
- Smaller footprint required for the plant expansion;
- Reduced flow splits and simplified hydraulic control;
- Lower initial capital cost; and
- Ability to accommodate increased influent loading by operating the plant at higher MLSS.

It is recommended that the Town inspect the existing infrastructure that is proposed to be reused, including the outfall and effluent diffusers, to confirm their condition is adequate for future use.

The preliminary preferred alternative will be presented in an upcoming online Public Information Centre to solicit comment and input from stakeholders, including review agencies, the public, and those who previously expressed interest in the Master Plan. Input from review agencies and the public is necessary and important at this stage to assist the Town by providing additional information, in reviewing the evaluation and in arriving at the preferred decision. The study will be fully documented in the ESR, to which this memo will be appended.

Regards,

Stantec Consulting Ltd.

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Attachment: APPENDIX A:Life Cycle Cost Analysis

Appendix A: Life Cycle Cost Analysis

Life Cycle Cost Analysis for Carleton Place Wastewater Treatment Plant Upgrading Options

General Assumptions

Period of the life cycle cost analysis	20	years
Expansion Completed in Year	2025	
Costs proportional to wastewater treated:	$ per m^3 treated	
Chemicals	$ 0.170	
Biosolids Hauling	$ 0.079	
Electricity	$ 0.112	
Services, supplies and equipment	$ 0.113	
Electricity costs increases		
Associated w/ new MBRs	30%	net increase assumed
Associated w/ new AT (incl. blowers), SC, filters	15%	net increase assumed
Costs increasing on an annual basis independent from water demand increase		
Management Fee	$ 112,000	for 2022
Annual increase rate	2%	to consider addtional regulatory requirements
Labour Costs associated to treatment technology		
Base Labour Costs	$ 329,000	for 2022
Associated w/ new aeration tanks	10%	net increase assumed
Associated w/ new secondary clarifiers	10%	net increase assumed
Associated w/ new MBRs	10%	net increase assumed
Associated w/ new tertiary filters	10%	net increase assumed
Associated w/ new UV	10%	net increase assumed
End of service life of SCADA & Instrumentation	**2034**	
Cost for replacing SCADA & instrumentation	$ 500,000	
Social Discount Rate:	3.0 %	https://muse.jhu.edu/article/396282/pdf

Alternative 1 - Conventional Activated Sludge Expansion

Electricity net increase **15%** **Labour net increase** **40%**

Year	Serviced Populatio (p)	Average Daily Flow (m3/d)	Chemicals ($/yr)	Biosolids Hauling ($/yr)	Electricity ($/yr)	Services, sup & repl ($/yr)	Labour ($/yr)	Manage-ment ($/yr)	Other Costs ($/yr)	Total ($/yr)	Present Value ($/yr)
2021	12500	5,723	$190,307	$109,888	$234,676	$199,960	$275,719	$111,285		$1,121,835	$1,121,835
2022	13400	6,211	$202,500	$180,000	$240,080	$256,026	$328,615	$111,285		$1,318,506	$1,318,506
2023	14300	6,698	$415,614	$194,123	$274,639	$276,115	$328,615	$113,510		$1,602,617	$1,555,939
2024	15200	7,185	$445,852	$208,247	$294,620	$296,204	$328,615	$115,780		$1,689,318	$1,592,344
2025	16100	7,673	$476,090	$222,370	$361,791	$316,292	$ 460,600	$118,096		$1,955,240	$1,789,322
2026	17000	8,160	$506,328	$236,493	$384,770	$336,381	$ 460,600	$120,458		$2,045,030	$1,816,983
2027	17700	8,414	$522,089	$243,855	$396,747	$346,852	$ 460,600	$122,867		$2,093,009	$1,805,448
2028	18400	8,668	$537,849	$251,216	$408,723	$357,322	$ 460,600	$125,324		$2,141,036	$1,793,084
2029	19100	8,922	$553,610	$258,578	$420,700	$367,793	$ 460,600	$127,831		$2,189,112	$1,779,949
2030	19800	9,176	$569,371	$265,939	$432,677	$378,264	$ 460,600	$130,388		$2,237,239	$1,766,097
2031	20500	9,430	$585,132	$273,301	$444,654	$388,735	$ 460,600	$132,995		$2,285,416	$1,751,581
2032	20950	9,550	$592,546	$276,764	$450,289	$393,661	$ 460,600	$135,655		$2,309,515	$1,718,496
2033	21400	9,669	$599,961	$280,227	$455,924	$398,587	$ 460,600	$138,368		$2,333,668	$1,685,891
2034	21850	9,789	$607,376	$283,691	$461,559	$403,513	$ 460,600	$141,136	$ 500,000	$2,857,874	$2,004,456
2035	22300	9,908	$614,791	$287,154	$467,193	$408,439	$ 460,600	$143,958		$2,382,136	$1,622,119
2036	22750	10,028	$622,206	$290,617	$472,828	$413,365	$ 460,600	$146,838		$2,406,455	$1,590,950
2037	23200	10,147	$629,621	$294,081	$478,463	$418,292	$ 460,600	$149,774		$2,430,831	$1,560,258
2038	23650	10,267	$637,036	$297,544	$484,098	$423,218	$ 460,600	$152,770		$2,455,266	$1,530,040
2039	24100	10,386	$644,451	$301,008	$489,733	$428,144	$ 460,600	$155,825		$2,479,760	$1,500,296
2040	24550	10,506	$651,866	$304,471	$495,367	$433,070	$ 460,600	$158,942		$2,504,316	$1,471,022
2041	25000	10,625	$659,281	$307,934	$501,002	$437,996	$ 460,600	$162,121		$2,528,934	$1,442,216
										Total PV=	**$33,094,996**
										Equiv. AV=	**$2,224,504**
	Construction Costs (see Table 7 in memo)										
2022	$CAD									$ 43,523,000.00	$43,523,000
										Total PV=	**$76,617,996**

Alternative 2 - Membrane Bioreactor Expansion

Electricity net increase **30%** **Labour net increase** **40%**

Year	Serviced Populatio (p)	Average Daily Flow (m3/d)	Chemicals ($/yr)	Biosolids Hauling ($/yr)	Electricity ($/yr)	Services, sup & repl ($/yr)	Labour ($/yr)	Manage-ment ($/yr)	Other Costs ($/yr)	Total ($/yr)	Present Value ($/yr)
2021	12500	5,723	$190,307	$109,888	$234,676	$199,960	$275,719	$111,285		$1,121,835	$1,121,835
2022	13400	6,211	$202,500	$180,000	$240,080	$256,026	$328,615	$111,285		$1,318,506	$1,318,506
2023	14300	6,698	$415,614	$194,123	$274,639	$276,115	$328,615	$113,510		$1,602,617	$1,555,939
2024	15200	7,185	$445,852	$208,247	$294,620	$296,204	$328,615	$115,780		$1,689,318	$1,592,344
2025	16100	7,673	$476,090	$222,370	$408,981	$316,292	$ 460,600	$118,096		$2,002,430	$1,832,507
2026	17000	8,160	$506,328	$236,493	$434,957	$336,381	$ 460,600	$120,458		$2,095,218	$1,861,574
2027	17700	8,414	$522,089	$243,855	$448,496	$346,852	$ 460,600	$122,867		$2,144,759	$1,850,088
2028	18400	8,668	$537,849	$251,216	$462,035	$357,322	$ 460,600	$125,324		$2,194,348	$1,837,732
2029	19100	8,922	$553,610	$258,578	$475,574	$367,793	$ 460,600	$127,831		$2,243,986	$1,824,566
2030	19800	9,176	$569,371	$265,939	$489,113	$378,264	$ 460,600	$130,388		$2,293,675	$1,810,648
2031	20500	9,430	$585,132	$273,301	$502,653	$388,735	$ 460,600	$132,995		$2,343,415	$1,796,032
2032	20950	9,550	$592,546	$276,764	$509,022	$393,661	$ 460,600	$135,655		$2,368,249	$1,762,199
2033	21400	9,669	$599,961	$280,227	$515,392	$398,587	$ 460,600	$138,368		$2,393,136	$1,728,852
2034	21850	9,789	$607,376	$283,691	$521,762	$403,513	$ 460,600	$141,136	$ 500,000	$2,918,078	$2,046,681
2035	22300	9,908	$614,791	$287,154	$528,132	$408,439	$ 460,600	$143,958		$2,443,075	$1,663,615
2036	22750	10,028	$622,206	$290,617	$534,501	$413,365	$ 460,600	$146,838		$2,468,128	$1,631,723
2037	23200	10,147	$629,621	$294,081	$540,871	$418,292	$ 460,600	$149,774		$2,493,239	$1,600,315
2038	23650	10,267	$637,036	$297,544	$547,241	$423,218	$ 460,600	$152,770	$ 4,000,000	$6,518,409	$4,062,057
2039	24100	10,386	$644,451	$301,008	$553,611	$428,144	$ 460,600	$155,825		$2,543,639	$1,538,943
2040	24550	10,506	$651,866	$304,471	$559,981	$433,070	$ 460,600	$158,942		$2,568,929	$1,508,975
2041	25000	10,625	$659,281	$307,934	$566,350	$437,996	$ 460,600	$162,121		$2,594,282	$1,479,483
										Total PV=	**$36,302,781**
										Equiv. AV=	**$2,440,117**
	Construction Costs (see Table 7 in memo)										
2022	$CAD									$ 40,477,100.00	$40,477,100
										Total PV=	**$76,779,881**

Notes:

1. Membrane replacement assumed in 2038 (15 years)
2. 2021 O&M costs based on actual expenditures
3. 2022 O&M costs based on budgeted values
4. Chemical costs beyond 2022 expected to increase substantially based on discussions with operators