# AGENDA

## Town of Lunenburg Council Meeting

Wednesday, August 4, 2021 at 12:00 p.m.

Lunenburg Town Hall, 120 Townsend Street

(N.B. – 18 x person maximum in person attendance; members of public asked to contact Town Office at 902 634 4410 to determine if there is available seating; live broadcast on Town's YouTube channel; agenda subject to change due to additions and/or amendments)

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1. Call to Order – Mayor Risser

2. Acknowledgement of Mi'kma'ki the ancestral and unceded territory of the Mi'kmaq People – Mayor Risser

3. Agenda – draft motion

Motion: moved and seconded approval of the agenda.

4. Council Meeting Minutes Approval (defer to August 10, 2021 Council meeting)

5. Public Hearings, Presentations and Questions (Nil)

6. Correspondence, Petitions and Proclamations Consideration (Nil)

7. Business Arising from the Minutes/Unfinished Business

   a. Wastewater Treatment Plant Process Assessment and Optimization Reports - presentation by Lindsay Anderson, M.A. Sc., EIT, Dalhousie University

      - Moving Bed Bioreactor (MBBR) Assessment Preliminary Report

      - Polymer Dose Optimization Study Preliminary Report

   b. Long Term Wastewater Treatment Plant Expansion Report - presentation by Sarah Ensslin, P.Eng., CBCL Engineering.

8. Committee Meeting Minutes, Recommendations, Reports and Notices of Motion (Nil)

9. New Business (Nil)

10. Adjournment – Mayor Risser

Agenda items awaiting staff reports, etc. for further consideration

| Agenda Item | Assigned to | Council Meeting Assigned | Status | Anticipated Return Date |
|---|---|---|---|---|
| Cultural Action Plan | Corporate Services | September 8, 2020 | Staff will prepare a report about what the expectations of Town are and suggested resources | Assistant Municipal Clerk anticipates an August 2021 Council report |
| Watershed boundary extension and land management plan with external resources | Public Works | October 13, 2020 | Staff will prepare a report for draft Budget 2021/22 consideration | Town Engineer preliminary report anticipated for September 2021 Council meeting |

DALHOUSIE UNIVERSITY

Centre for Water Resources Studies

# Lunenburg Wastewater Treatment Plant
## MBBR Assessment
## Preliminary Report

July 16th, 2021

waterstudies

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# 1.0 Introduction

It has been recommended by CBCL that the MBBRs at the Lunenburg WWTF be tested for the presence of filamentous bacteria. Filamentous organisms grow as long strands that can result in poor sludge quality. This can cause filamentous bulking which impacts downstream clarification processes such as dissolved air flotation (DAF).

The CWRS has experience measuring adenosine triphosphate (ATP), which is the primary energy molecule in living cells, as a direct indicator of biomass. ATP can be used as an alternative measure to quantify changes in sludge bulking, allowing for preventative actions to occur. There are specialty ATP test kits developed by LuminUltra that can be used to assess the health of biological reactors, including filamentous bacteria. The ATP testing protocols provided by LuminUltra provide several indicators to gain insight on the health of the biomass in reactors, including:

- Total (tATP), dissolved (dATP) and cellular ATP (cATP): provides a direct indication of the overall biomass and living population in bioreactors.
- Specific attached growth ATP (s-agATP): measures the ratio of suspended to attached microorganisms in attached growth processes; higher proportions of attached relative to suspended microorganisms are ideal.
- Active biomass ratio (ABR): represents the percentage of solids that are active microorganisms; the ABR should be maximized. *Note that the ABR parameter is most relevant for activated sludge processes.*
- Biomass stress index (BSI): represents the stress level of the microbiological population and provides early warning of stressful conditions (e.g. toxicity which can lead to filamentous bacteria and bulking).
- Specific floc bulking ATP (s-fbATP): represents the quantity of ATP from bulking relative to overall microorganisms; provides early warning of bulking conditions associated with filamentous bacteria in clarification processes.

In general, microorganisms in bioreactors are in their best condition when cATP is maintained, s-agATP is maximized, BSI is minimized, s-fbATP is minimized, and ABR is maximized.

The CWRS has collected samples from the MBBRs at the Lunenburg WWTF on a regular basis for ATP testing to conduct a biomass assessment to inform the potential presence of filamentous bacteria. ATP test kits are routinely used at other utilities by operators; therefore, it is anticipated that this type of test could be integrated into routine sampling if required.

## 2.0 Approach

Samples were collected for ATP analysis on a weekly basis (when possible) starting in October 2020 from the four MBBR cells on train "B" at the Lunenburg WWTF. On some occasions, reagent supplies were limited and therefore some samples were not analyzed for ATP. In March 2021, we also began sampling the MBBR on train "A", in addition to train "B". Sampling was paused from mid-April to mid-June due to the third COVID-19 wave in Atlantic Canada.

Aqueous sample collected from the MBBRs were analyzed for both total ATP (tATP) and dissolved ATP (dATP) as well as the associated indicator parameters for biomass health such as cellular ATP (cATP), and biomass stress index (BSI), which is a calculation based on tATP and dATP (Fig 1). For floc bulking ATP (s-fbATP), aqueous MBBR samples were filtered and s-fbATP was measured on solids retained. Attached growth ATP (s-agATP) was measured on biofilm collected from MBBR media. All tests were conducted using LuminUltra's Quench Gone 21 Wastewater Test Kit. Figure 1 below depicts a schematic showing the relationship between the various types of ATP within a wastewater sample. Due to inconsistencies in initial data from samples collected in Fall 2020, this report only includes data from March to June 2021.

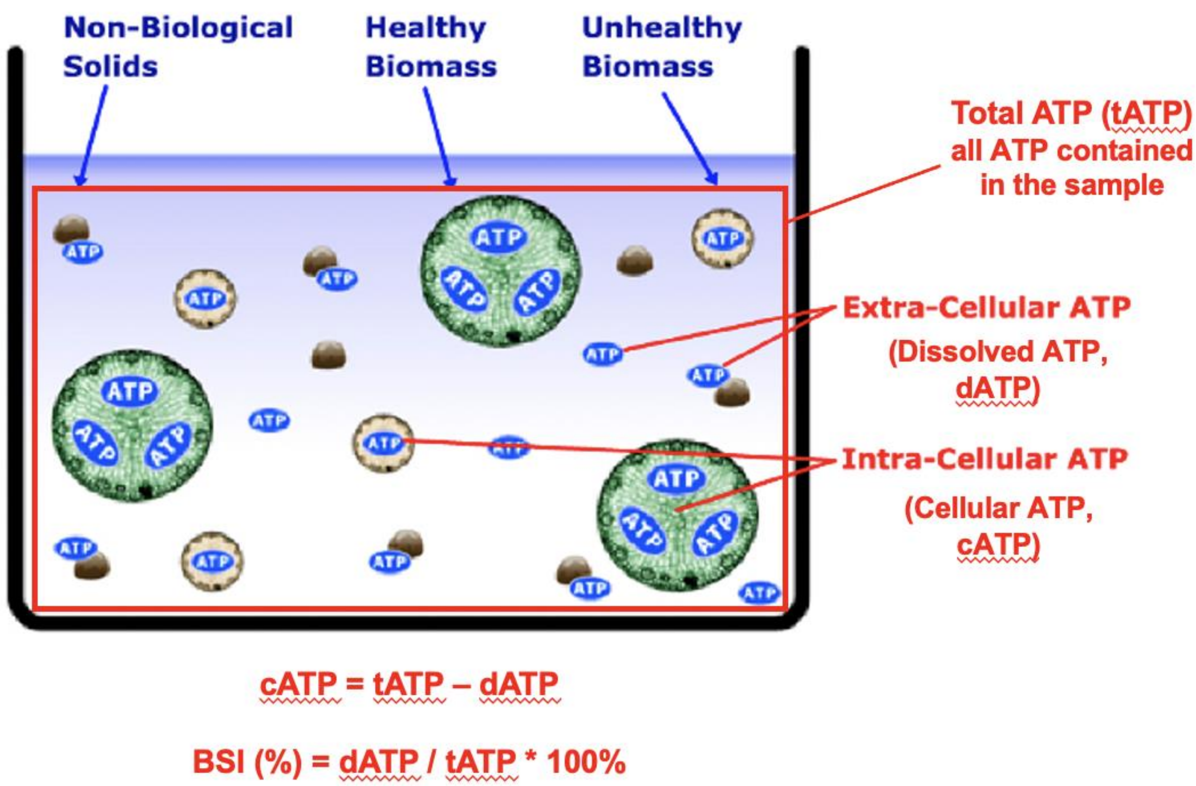


**Figure 1. Relationship between Total, Dissolved, Cellular ATP and BSI (Adapted from LuminUltra).**

# 3.0 Preliminary Findings

## 3.1 Total, Dissolved, and Cellular ATP

Total ATP (tATP) is a measurement of all the ATP contained in a sample and includes both intra and extra cellular ATP. Dissolved ATP (dATP) is a measure of extra cellular ATP, which is free floating ATP, and ATP that is bound to or complexed with solids in a sample. DATP provides information associated with the relative health of biomass; as biomass becomes unhealthy, it releases dATP. Therefore, a high dATP in relation to tATP may be associated with biomass mortality. Cellular ATP (cATP) is a measurement of intra cellular ATP (the difference between total and dissolved), which represents ATP from living microorganisms and is an indication of the living biomass.

Figure 2 depicts tATP for the MBBRs at the Lunenburg WWTF since March 2021. TATP concentrations ranged between ~25 to ~375 ng ATP/mL, however concentrations were generally upwards of 75 ng ATP/mL. This concentration is low compared to tATP concentrations observed in bioreactors at other wastewater treatment facilities that use similar ATP test kits. Typically, tATP concentrations range from 1,000-5,000 ng ATP/mL in wastewater bioreactors; suggesting that the biomass in Lunenburg are either being "washed out" or are not able to establish as a result of stressed environmental conditions. Consistent with general bioreactor activity, tATP concentrations generally increased with time from March to June, which was expected given warmer months increase water temperature and solids loading. Both factors will promote higher biomass activity.

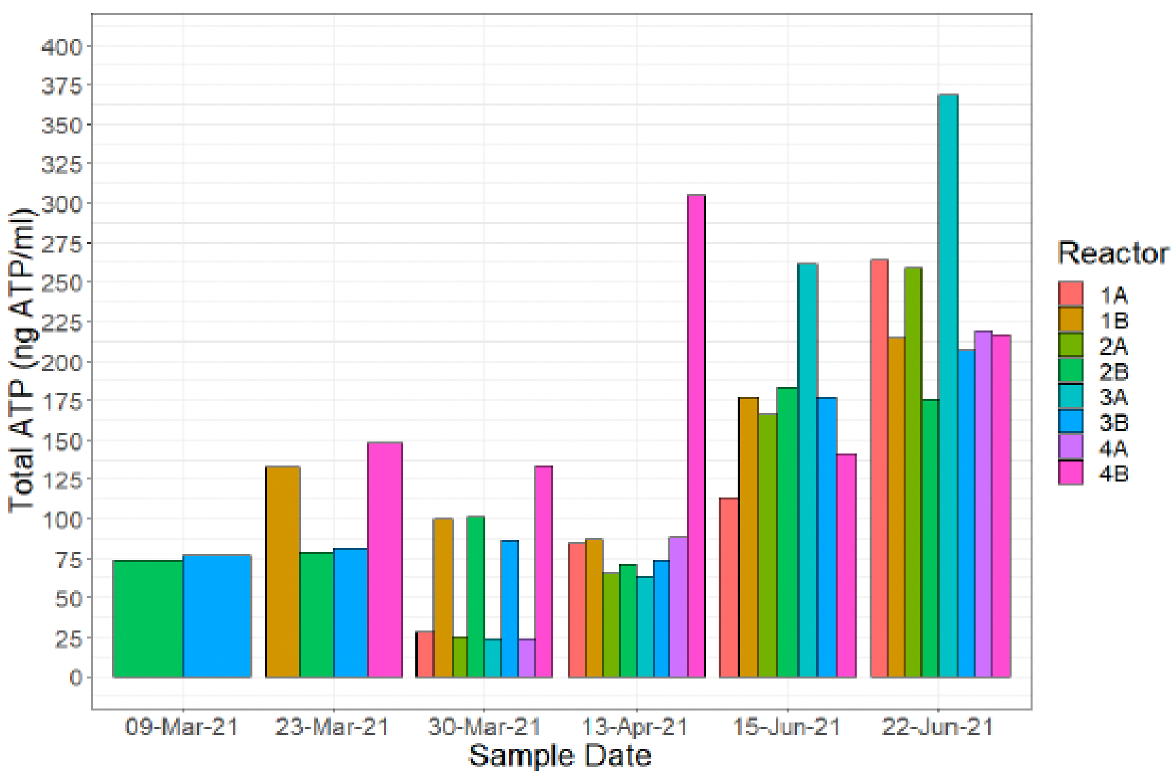

**Figure 2. Total ATP concentrations for samples collected from the Lunenburg MBBRs from March to June 2021.**

Figure 3 below shows cATP concentrations (the difference between tATP and dATP). Ideally, cATP should be maximized and maintained (i.e. the dATP should be much lower than the tATP), as unhealthy biomass releases dATP. As mentioned previously, a high dissolved ATP in relation to total ATP may be associated with biomass mortality.

The cATP in the MBBRs at the Lunenburg WWTF increased with time from March-June (Fig 3) and was highly variable across the trains A and B and within the cells of each train particularly during March and April. By the end of June 2021, the cATP appeared to be maintained in all of the MBBR cells on both trains A and B. This suggests that by June, the ATP was mostly intracellular in nature, and that the conditions in MBBRs were amenable to healthier biomass (i.e. were releasing less dissolved or extracellular ATP), most likely due to increasing solids content and warmer temperatures.

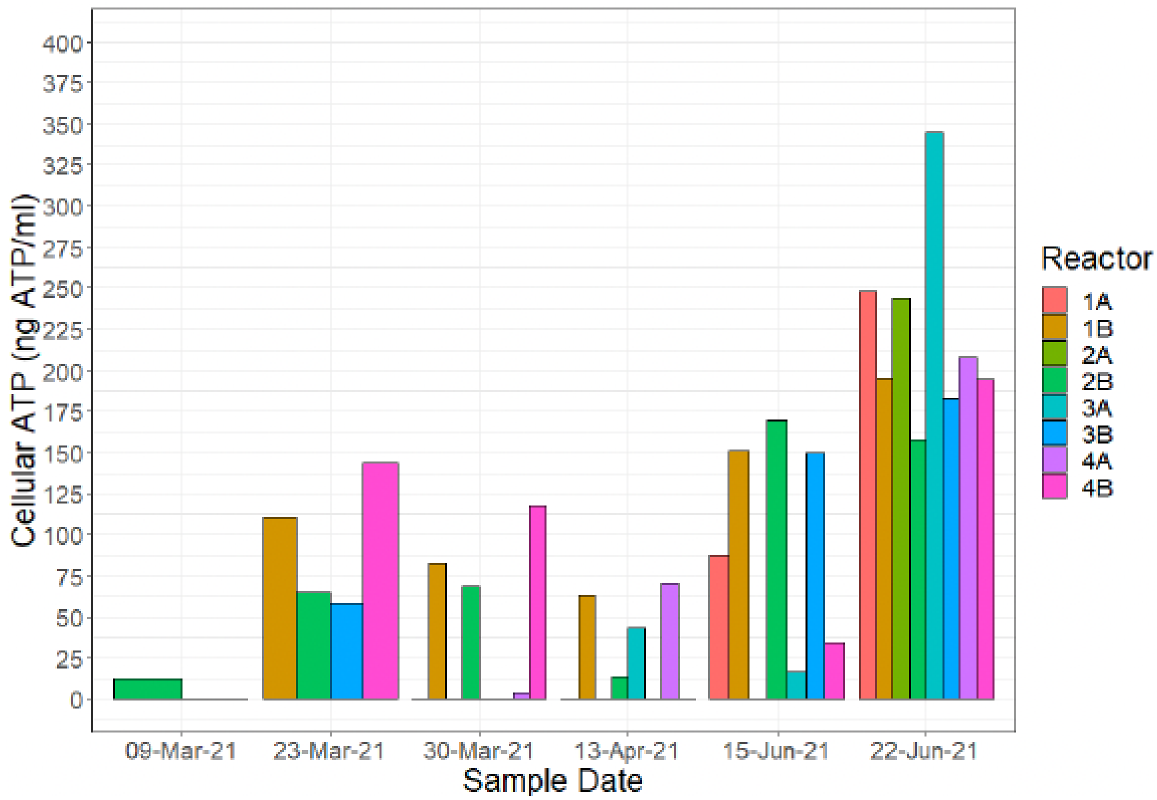


**Figure 3. Cellular ATP concentrations for samples collected from the Lunenburg MBBRs from March to June 2021.**

Data from other wastewater treatment facilities using cATP for process monitoring have reported typical cATP concentrations in bioreactors in the ~700 to ~3000 ng ATP/mL range, which suggests that values experienced in Lunenburg reactors may be low. This further supports that the biomass in reactors may have been washed out or were unable able to establish as a result of stressed environmental conditions. However, this may also be due to the nature of the wastewater at the time of sampling (e.g. low solids content), as the cATP concentrations begin to increase in the warmer months when solids increase.

Overall, based on tATP, dATP and cATP data, it appears that the concentration of biomass in the MBBRs is low, which indicates potential wash out or stressful conditions. However, the biomass concentration has been improving with time, as evidenced through increasing tATP and cATP concentrations from March to June 2021. TATP and cATP concentrations were sometimes inconsistent when comparing each train, particularly in March and April 2021, which may be attributed to operational factors or variations in water quality between batches. Both tATP and cATP concentrations improved in terms of concentration and consistency across the trains and cells during warmer months. Continued monitoring of ATP on a more frequent basis (e.g. several times per week) will provide additional insight on the quantities of biomass present in the Lunenburg MBBRs.

### 3.2 Specific Attached Growth ATP

Specific attached growth ATP (s-agATP) is a measurement of the ratio of suspended to attached microorganisms in attached-growth processes. In other words, it represents the amount of ATP attached to the media relative to the ATP suspended within the reactor. Higher fractions of suspended relative to attached microorganisms generally indicate sub-optimal process conditions. In attached growth reactors like MBBRs, a high specific attached growth ATP is ideal. Figure 4 depicts the s-agATP for the MBBRs at the Lunenburg WWTF from March to June 2021. It should be noted that data for s-agATP was only available for the “A” train in April 2021.

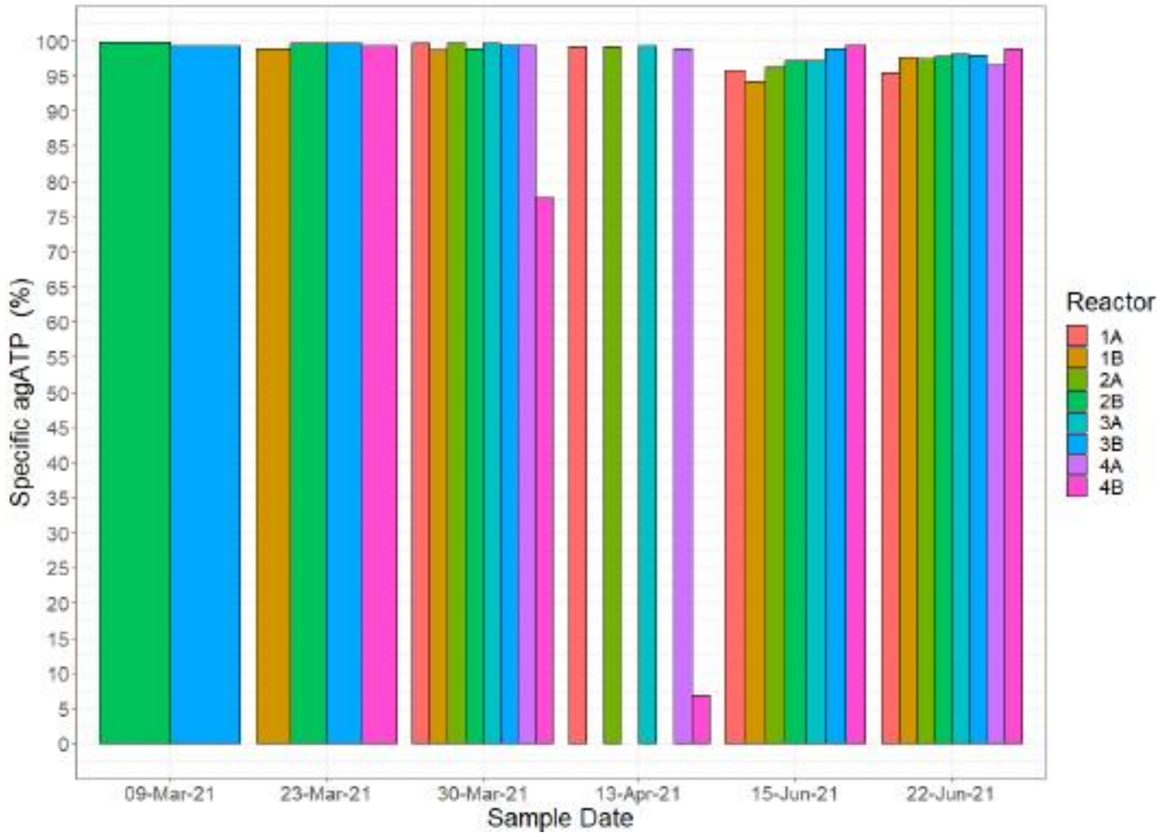


**Figure 4. Attached growth ATP (%) for samples collected from the Lunenburg MBBRs from March to June 2021.**

For good process control, it is recommended that the s-agATP remains above 90%. Preventative action is required between 75 to 90%, while corrective action would be required at below 75%. It should be noted that these interpretation guidelines are designed for generic risk management guidance only. Generally, the s-agATP was between ~95 and 99% for MBBR cells in both trains A and B from March to June 2021, which indicates that the majority of the active biomass is attached to the MBBR media as expected. There were only two occasions where the s-agATP was below 75%, which would have indicated corrective action.

Overall, it appears that the biomass attachment tendencies in the MBBRs are positive given the relatively high s-agATP values, which was expected given the attached-growth nature of MBBR systems. This suggests that were no major issues surrounding biomass detachment in the system. The routine use measurement of s-agATP can be used as an indicator to provide confirmation that the majority of active biomass is attached to MBBR media, as opposed to being suspended in the reactor.

### 3.3 Active Biomass Ratio

The active biomass ratio (ABR) represents the percentage of total suspended solids that are living microorganisms. This parameter is generally recommended for use in monitoring biomass in activated sludge plants. Further, the ABR is not accurate when the

TSS loadings are low (as they are in Lunenburg in the spring). In non-activated sludge bioreactors, the ABR is generally low.

We calculated the ABR for the Lunenburg system and it was typically very low, or negative. Therefore, the use of the ABR parameter was determined to be non-relevant to the Lunenburg system.

### 3.4 Biomass Stress Index

The BSI represents the stress level experienced by the microbiological population in bioreactors. This quantity provides an early warning of impending process problems and stressful conditions (i.e. toxicity in bioreactors). It is a measure of the ratio of tATP and dATP, and therefore the BSI approaches 100% when dATP is high. A high BSI may be associated with biomass mortality, stress and/or toxicity in bioreactors. For example, oxygen deprivation or nutrient deficiencies will often produce high BSI values.

Figure 5 below depicts the BSI for samples collected from trains A and B (cells 1-4) at the Lunenburg WWTF from March to June 2021.

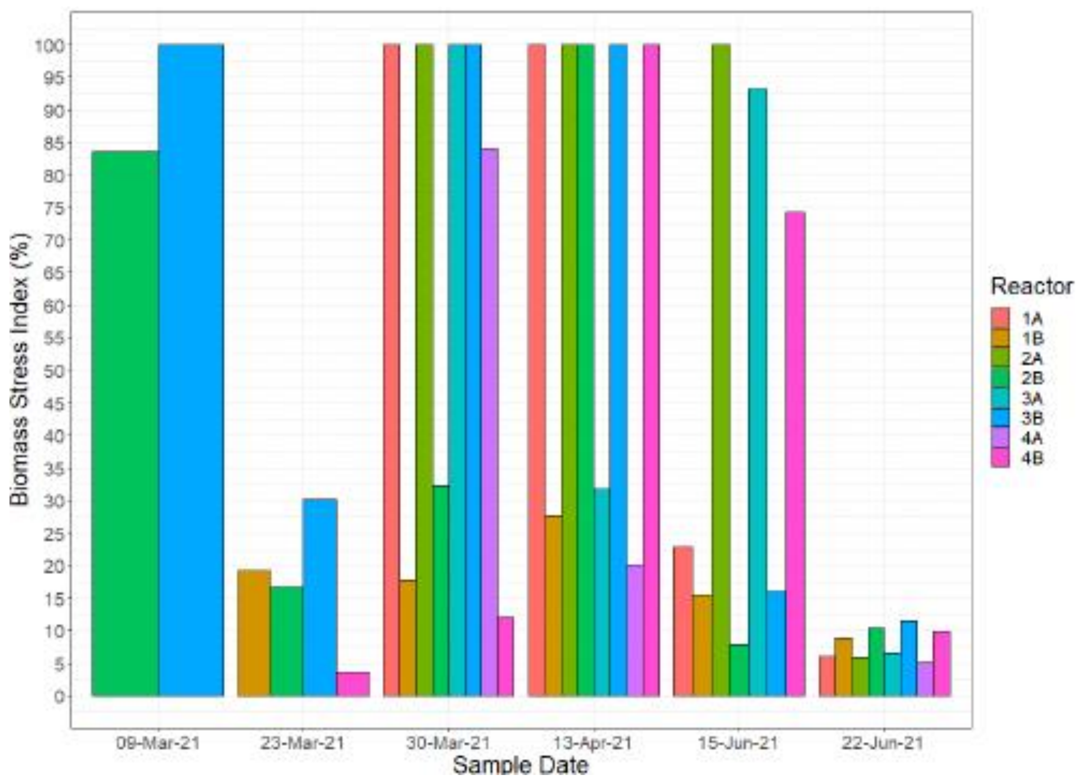


**Figure 5. Biomass stress index (%) for samples collected from the Lunenburg MBBRs from March to June 2021.**

In general, the BSI is an alarm of the wastewater process, where a change in BSI signals a change in biomass quality in reactors (e.g. high BSI indicates poor quality, low BSI indicates good quality). The BSI should be minimized – it is recommended that values remain below 30% for good process control. Preventative action is required between 30 and 50%, and corrective action is recommended at above 50%.

BSI values for the Lunenburg MBBR system were highly variable with time and within each train (Fig 5). The BSI exceeded 50% and reached 100% on several samples collected in March and April 2021. This could be indicative of poor biomass quality caused by reactor washout or other stressful conditions, potentially leading to filamentous organisms in the system.

On March 30th, we began sampling both A and B trains. Between March and April, the BSI fluctuated between 30 and 100%, and train "A" often had higher BSI than train "B". This suggests that the biomass in train A MBBRs may have been more stressed than those in train B. There were no notable trends for BSI across the individual cells within each reactor at this time.

When BSI values approach 100%, it does not necessarily mean that the microbiological population is dead or incapable of performing functions like BOD removal. It indicates that microorganisms *may* be compromised resulting in the release of dissolved ATP. Occurrences of high BSI should generally be taken as an indicator to investigate potential stressors in bioreactors (e.g. loss of nutrients or oxygen, severe toxicity). High BSI could also cause issues in downstream processes (e.g. filamentous bacteria and floc bulking, foaming, EPS production) which may impact DAF efficiency and polymer dosing. Therefore, evaluation of other parameters like s-fbATP (discussed below) in conjunction with BSI can provide more information on the potential for the presence of filamentous bacteria.

By June 2021 the BSI values improved substantially and were consistently below 15%, suggesting that the biomass quality was good. However, it is important to note that train "B" consistently had slightly higher BSI compared to "A" although they remained well within the range (<30%) for good control. Further, the BSI values were consistent across the four cells of each train.

Overall, BSI varied substantially during March to early June 2021 and values were above the 30-50% range, reaching 100% on many occasions. This could suggest that the biomass was of poor quality due to wash out or stressful conditions (e.g. lack of oxygen or nutrients, toxicity) and may have resulted in process upsets in the DAF units. Substantial improvements in BSI values, as well as consistency across the reactors was observed in June. Routine monitoring of BSI will alert operators to stress, or toxicity derived upsets well before any effects on effluent water quality is seen. Microbes under stress can release foam, and therefore operators may observe foaming downstream of the reactors when BSI values are high (e.g. >50%). BSI should also be monitored with s-fbATP (discussed below) to gain additional insight on differences in biomass quality caused by filamentous organisms.

### 3.5 Floc Bulking ATP

The specific floc bulking ATP (s-fbATP) represents the quantity of ATP from bulking microorganisms relative to total microorganisms. As the s-fbATP increases, the risk of microorganisms that cause bulking also increases. The measurement of s-fbATP in bioreactors can help with the indication of conditions that may promote filamentous bacteria which in turn would contribute to potential sludge bulking resulting in poor clarification in DAF units. By predicting the onset of bulking conditions, this technique can potentially assist operators to make corrective actions proactively.

Figure 6 depicts s-fbATP values for samples collected from the MBBRs at the Lunenburg WWTF from March to June 2021.

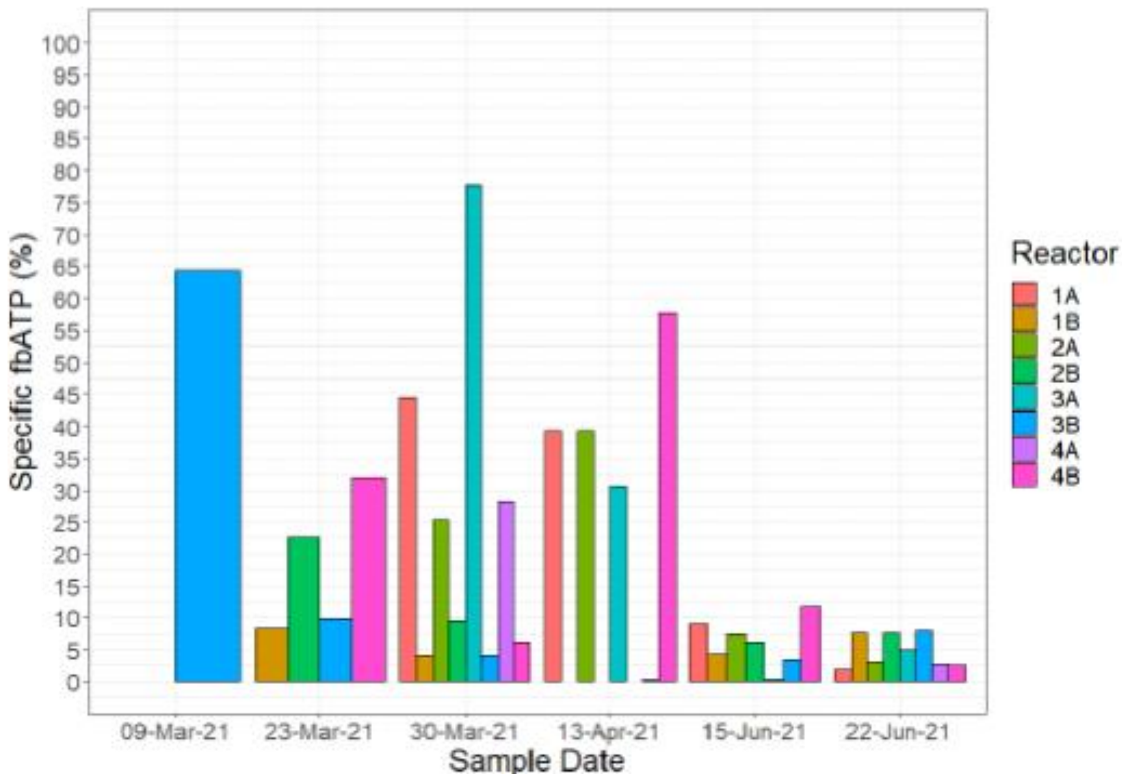


**Figure 6. Floc bulking ATP (%) for samples collected from the Lunenburg MBBRs from March to June 2021.**

As mentioned previously, the s-fbATP parameter can be used as an indicator or general alarm for bioreactor conditions that promote filamentous bacteria and bulking conditions. It is generally recommended that the s-fbATP remains below 30%. Preventative action is recommended when the s-fbATP is between 30 and 50%, while corrective action is required when it exceeds 50%.

Like the BSI and other ATP parameters, the s-fbATP values also had high variability during March and April 2021. This may be caused by differences in water quality between batches, or could indicate that the two trains may not have been operating in a comparable manner. Together, the s-fbATP and BSI provide good indication that there may have been an event on March 30th on train A causing biomass stress and possibly the presence of filamentous organisms.

By June, the s-fbATP data improved substantially; MBBR cells on trains A and B all had s-fbATP below 15%. Considering the lower BSI values for June, together these data suggest that floc bulking caused by filamentous bacteria was likely not a concern at this time.

When measured in conjunction with the BSI, the s-fbATP parameter can be used as an indicator for the potential presence of filamentous organisms. When both parameters exceed 30%, preventative or corrective action for the control of floc bulking conditions in the downstream DAF units should be considered. During the spring, the s-fbATP was highly variable across the two trains (as was the BSI), which may be caused by the variability in water quality between batches or by differences in operation. It is recommended that these parameters be measured routinely (e.g. daily) moving forward to gain more insight on possible filamentous activity in the system and to inform the potential impacts on downstream processes.

## 4.0 Summary and Recommendations

The goal of this work was to conduct a biomass assessment on the MBBRs at the Lunenburg WWTF to inform gain insight on the biomass quality and the presence of filamentous bacteria in the system. We conducted rapid ATP testing which provides several indices for overall biomass health including tATP, cATP, s-agATP, BSI and s-fbATP. The preliminary outcomes of the analysis are as follows:

- Total (tATP) and cellular ATP (cATP) provide a direct indication of the overall biomass content in bioreactors. In the Lunenburg WWTF MBBRs, tATP concentrations were low, ranging between ~25 to 375 ng ATP/mL although generally they were above 75 ng ATP/mL. CATP concentrations were also low, ranging between <50 and ~350 ng ATP/mL. Ideally the cATP should be maximized and maintained (bioreactors typically have ~700 to ~3000 ng ATP/mL). Low ATP content potentially indicates wash out or stressful conditions. ATP concentration increased with time from March to June 2021 which was not surprising as solids content in the influent typically increases during warmer months. Continued monitoring of tATP and cATP on a more frequent basis (e.g. daily or several times per week) will provide additional insight on the quantities of biomass present in the Lunenburg MBBRs.

- The specific attached growth ATP (s-agATP) measures the ratio of suspended to attached microorganisms; high s-agATP values are ideal in attached growth reactors. In the Lunenburg MBBRs, s-agATP values were generally between 95 and 99% which is above the recommended goal of >75% for good process control. Accordingly, there were no concerns of biomass detachment in the reactors. The routine use measurement of s-agATP can be used as an indicator to provide confirmation that the majority of active biomass is attached to MBBR media, as opposed to being suspended in the reactor.

- The biomass stress index (BSI) represents the stress level of the microbiological population and provides early warning of poor reactor conditions (e.g. toxicity which can lead to filamentous bacteria and bulking). The BSI values were highly variable during the monitoring period and exceeded the <30% guideline for good process control. In particular, during March and April sampling the BSI often exceeded 100% in some of the reactor cells suggesting poor biomass quality due to stressors (e.g. lack of oxygen or nutrients, toxicity, reactor wash out) which may have led to process upsets in the DAF units (e.g. filamentous organisms). This data agrees with tATP and cATP values, confirming that MBBR biomass was stressed during this time. BSI values improved to be consistently <<30% later in June. Regular BSI monitoring will provide indication of stressful conditions in MBBRs that can potentially lead to filamentous bacteria or foaming in downstream processes. It is highly beneficial to monitor BSI in conjunction with s-fbATP to gain additional insight on filaments.

- The Specific floc bulking ATP (s-fbATP) represents the quantity of ATP from bulking relative to overall microorganisms and can provide early warning of bulking conditions associated with filamentous bacteria. Preventative action is recommended when the s-fbATP is between 30 and 50%, while corrective action is required when it exceeds 50%. As with the previously mentioned indicators, the s-fbATP was variable in March and April, often exceeding the 30% to 50% range suggested for preventative control. When considered in conjunction with the BSI, it is possible that bioreactor conditions may have been amenable to filamentous organisms during this time. However, by June the s-fbATP values decreased substantially (<5% to ~10%) and remained stable in both reactors. This indicates improvements in bioreactor health and lowered risk for filamentous activity. Routine (i.e. several times per week or daily) measurement of s-fbATP as well as BSI moving forward will provide good indication of filamentous bacteria in the system and to inform the potential impacts on downstream processes.

Additional parameters such as the active biomass ratio (ABR), which represents the percentage of solids that are active microorganisms, are also available through the ATP testing kit. However, the ABR parameter is more relevant for activated sludge processes and was generally negative for samples collected from Lunenburg. Therefore, consistent monitoring of ABR was determined to be unnecessary for the Lunenburg reactors.

It is recommended that ATP monitoring, with a particular emphasis on BSI and s-fbATP continue on a regular basis (i.e. several times per week if possible) to continue monitoring biomass quality and possible risk for filamentous activity. These may also be useful to inform DAF operations such as polymer dose.

DALHOUSIE UNIVERSITY

Centre for Water Resources Studies

# Lunenburg Wastewater Treatment Plant
Polymer Dose Optimization Study
Preliminary Report

April 21, 2021

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# Lunenburg WWTP Polymer Dose Optimization Study
## *Executive Summary*

CBCL has identified excess polymer and solids carryover from the DAF unit in the effluent of the Lunenburg Wastewater Treatment Plant (WWTP). Performance improvements in the operation of the DAF process could minimize carryover and improve the performance of the UV disinfection system. Further, the Lunenburg WWTP is impacted by high salinity events due to potential inflow of seawater in the collection system; salinity is expected to impact polymer performance in the DAF. The primary objective of this work was to conduct jar testing experiments to optimize polymer dose under various water quality conditions with a goal of improving overall DAF performance. This work was completed from November 2020 and March 2021, and consisted of two phases: Phase 1 focused on optimizing the polymer dose under normal operating conditions (e.g. ambient salinity), while Phase 2 focused on challenge testing to understand the impacts of salinity on polymer dose and performance.

During Phase 1, we evaluated polymer doses ranging from 0.1 to 6 mg/L and compared to the current plant dose of 3 mg/L. The jar test data from Phase 1 suggested that under all influent conditions evaluated (e.g. TSS ranging between ~60 to >100 mg/L), a lower polymer dose could be considered. All jar tests indicated that a polymer dose well below the plant dose of 3 mg/L would be as effective in terms of UVT%, TSS and BOD5 removal, even under moderate to high influent TSS. Polymer dose requirement decreases with higher TSS influent concentration, which is logical as the DAF process will encourage particle aggregation in absence of chemical addition. Polymer dose ranges identified through jar tests were:

- Under the low TSS scenario (TSS < 60-70 mg/L) evaluated, the recommended polymer dose is 1 to 1.5 mg/L.
- Under the moderate TSS scenario (TSS 85-95 mg/L) evaluated, the recommended polymer dose is between 0.5 and 1 mg/L.
- Under the high TSS scenario (TSS > 100 mg/L), the recommended polymer dose is in the range of 0 to 0.5 mg/L.

For Phase 2, salt was added in known concentrations to wastewater sampled from the DAF influent (prior to polymer addition). Jar tests were conducted to determine the relative impact of conductivity on DAF performance. Jar testing in Phase 2 revealed that:

- When conductivity exceeded 20,000 uS/cm through salt addition, a noticeable impact on polymer performance was observed when held at a constant dose of 3 mg/L. Performance worsened as conductivity was increased incrementally through salt addition.
- A higher polymer dose (between 3-6 mg/L) may be required to remove TSS during high salinity conditions (e.g. 20,000-50,000 uS/cm or higher).

While the long-term solution is to minimize seawater infiltration, short-term solutions may address treatment processes that align with increased chloride concentrations. Jar testing work will continue in the spring and summer to capture the impact of seasonal changes in influent water quality on both baseline polymer dose, as well as for high conductivity conditions. While these experiments were conducted using controlled conditions, it is recommended that in addition to further jar testing, these dosages and conditions also be evaluated under a pilot or full-scale (on one train) scenario at the plant. Piloting will allow a further investigation of the conditions identified as optimal at bench-scale, under dynamic flow and water quality conditions and will help to identify polymer dose and type that perform more favorably under more realistic, dynamic conditions.

# 1.0 Introduction

CBCL has identified excess polymer and solids carryover from the DAF unit in the effluent of the Lunenburg Wastewater Treatment Plant (WWTP). Solids and polymer carryover from the DAF units can also impact the performance of the downstream UV disinfection system. Thus, performance improvements in the operation of the DAF process could minimize carryover and improve the performance of the disinfection system.

Further, the Lunenburg WWTP is impacted by high salinity events due to potential inflow of seawater in the collection system. Salinity is expected to impact polymer performance in the DAF units, and therefore salinity should be considered in DAF performance optimization.

Currently, polymer is fed at a constant dose (~3 mg/L) at the Lunenburg WWTP. Required polymer dose can be influenced by factors such as solids loading to the system and wastewater salinity. Thus, there is an opportunity to optimize polymer dose for various influent water quality conditions. Jar testing is a common laboratory-scale approach that can be used to evaluate chemical types and doses for water and wastewater treatment, which can inform full-scale operations.

The primary objective of this work was to conduct jar testing experiments to optimize polymer dose under various water quality conditions with a goal of improving overall DAF performance. This work was completed in two phases—Phase 1 focused on optimizing the polymer dose under normal operating conditions (e.g. ambient salinity), while Phase 2 focused on challenge testing to understand the impacts of salinity on polymer dose and performance.

This report provides an overview of data from jar tests conducted at the Lunenburg WWTP from November 2020 to March 2021.

# 2.0 Approach

## 2.1 Jar testing

Samples were collected on a weekly basis between November 2020 and February 2021 from the DAF influent pre-treatment (e.g. post-MBBR) for jar test trials. Flow rate at the time of sample collection was recorded, and the samples were characterized in terms of TSS, UVT%, BOD5, conductivity and pH.

For all jar test experiments described in Phases 1 and 2 below, the procedure involved an initial mixing period (8 min, 50 RPM) followed by polymer addition and rapid mix (1 min, 200 RPM), and a slow mix (8 min, 25 RPM) after which the saturated air/water mixture was injected resulting in a recycle rate of 13-15%. The jars were left to clarify prior to sampling for characterization in terms of TSS, UVT%, conductivity, pH and BOD5. For salinity trials (Phase 2), prior to jar testing, salt was added to the batch of water collected from the DAF influent pre-treatment and conductivity was also monitored.

### *2.1.1 Phase 1: Baseline polymer dose optimization*

Preliminary baseline jar testing was conducted to identify if general improvements in treatment could be achieved by adjusting polymer dose under normal operating conditions. This phase focused optimizing the polymer dose only (e.g. leaving recycle rate constant, pH and salinity/conductivity ambient). At the time of sampling, the plant was dosing at polymer at approximately 3 mg/L.

For this phase, polymer doses between approximately 0 and 6 mg/L were evaluated through various jar tests and were compared to a control jar at the current plant dose of (3 mg/L). Optimum polymer doses were based minimizing TSS and maximizing UVT%, however clarified BOD5 concentration was also considered as a response parameter. Jar testing was conducted on a regular basis during the period of November 2020 to March 2021 to provide optimal polymer dosing information for a range of water quality conditions in the Fall and Winter.

### *2.1.2 Phase 2: Impact of salinity on polymer performance*

Salinity is expected to impact polymer performance in the DAF units and therefore was considered as a factor for additional jar tests. For salinity trials, salt was added in known concentrations to wastewater sampled from the DAF influent (prior to polymer addition) and jar tested to determine the relative impact of salinity on DAF performance. First, jar tests were conducted where polymer dose was kept constant (plant dose of 3 mg/L) and salt (NaCl) was added at varying concentrations. Typically, the influent salinity ranges between 3-5 ppt but historical data suggests that salinity reach as high as 10 to 20 ppt (conductivity were maxima 10,000-15,000 uS/cm but upwards of 50,000 uS/cm has been observed). Accordingly, these jar test trials salt was added incrementally until conductivity was within the desired target range (e.g. high salt conditions), while the polymer dose was kept constant at 3 mg/L. This provides information on how the current DAF operations could be impacted if influent salinity were to increase (without adjusting polymer dose). We also conducted additional jar testing to identify optimum polymer dose ranges for high salinity conditions (e.g. conductivity between 20,000 and 50,000 uS/cm).

# 3.0 Results & Discussion

## 3.1 Phase 1: Baseline polymer dose optimization

Jar tests were conducted on a regular basis (e.g. weekly) to determine whether adjusting polymer dose only could improve treated water quality in terms of TSS, UVT and BOD5. All jar tests during this phase were conducted under ambient salinity and conductivity conditions (no salt was added). The jar test trials were conducted between November 2020 and March 2021, and results are categorized below based on TSS concentration measured on influent samples collected from full-scale.

### *3.1.1 Evaluation of polymer dose as a function of influent TSS*

The TSS ranges for fall/winter bench-scale experiments were categorized as: low (plant influent 60-70 mg/L; pre-DAF 50-55 mg/L), moderate (plant influent 85-95 mg/L; pre-DAF 70-80 mg/L), and high (plant influent ~130 mg/L; pre-DAF ~100 mg/L. Note that these were the ranges captured during experimental trials and it is possible that TSS concentrations were beyond these limits during the fall/winter experimental period.

#### *3.1.1.1 Low Influent TSS (60-70 mg/L)*

For the “low” TSS test condition, three jar testing events were considered (November 2020, January and February 2021), which had corresponding plant flows between 580,000 and 615,000 gal/day and influent TSS of between 60 and 70 mg/L (pre-DAF TSS 50-55 mg/L). There were no notable precipitation events on or leading up to these trials. The full-scale plant influent had BOD5 concentrations between 60 and 70 mg/L on both jar testing events (pre-DAF BOD5 were between approximately 30 and 40 mg/L), while ambient conductivity for the plant influent was approximately 1400 uS/cm. Figure 1 below depicts TSS and UVT data for the jar tests conducted on samples in low TSS condition.

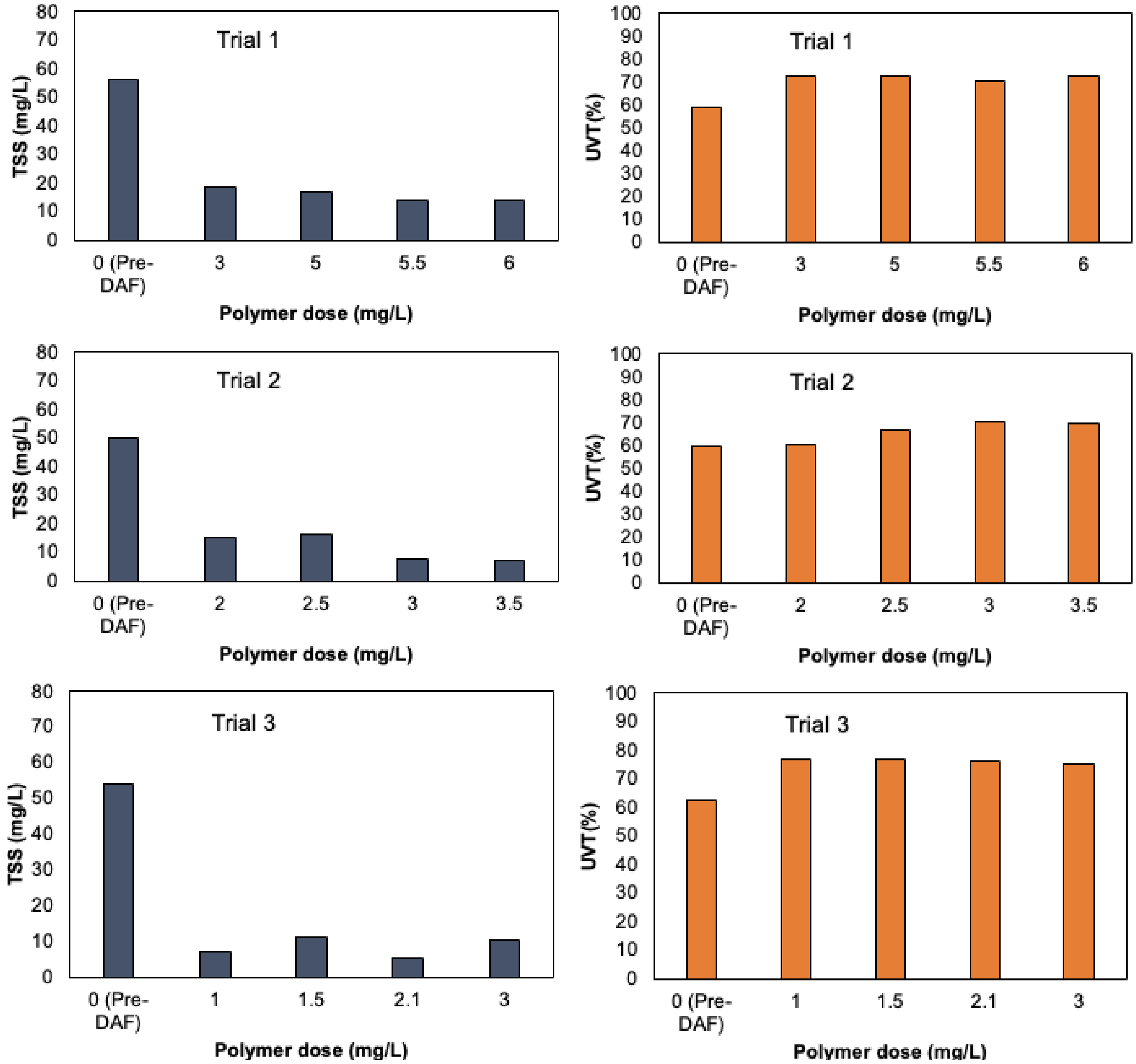



**Figure 1.** Results for polymer optimization at Lunenburg WWTP on the “low” influent TSS condition (60-70 mg/L). Pre-DAF represents an unclarified sample with no salt and no polymer addition. Samples were collected between November 2020 and February 2021. The plant operated at a dose of 3 mg/L during these trials.

For Trial 1 (Figure 1, top), a higher polymer dose range (3-6 mg/L) was considered in order to establish a point of diminishing returns. Results indicated that increasing the polymer dose above the plant dose of 3 mg/L did not provide any substantial improvements in TSS or UVT; all clarified jars for this trial had TSS between 14 and 18 mg/L, BOD5 between 20 and 25 mg/L, and UVT between 70 and 72%. This trial suggested that polymer dose could likely be lowered without hindering treated water quality.

For Trial 2 (Fig 1 middle), a dose range between 2 and 3.5 mg/L was considered. The 3 and 3.5 mg/L doses provided slightly better TSS reduction compared to the lower doses (e.g. 2 and 2.5 mg/L); the 3 and 3.5 mg/L polymer doses yielded TSS concentrations of approximately 8 mg/L (84-85% removal), while the 2 and 2.5 mg/L were approximately double (15-16 mg/L, 67-70% removal). Nevertheless, the treated TSS remained well below 20 mg/L regardless of the dose. The UVT improved slightly at higher polymer doses; the 2 mg/L dose yielded a UVT of approximately 60%, while the 2.5-3.5 mg/L doses yielded UVT of 67-70%. There were no considerable differences in BOD5 across the doses evaluated; all jars had clarified BOD5 of 15-17 mg/L, compared to influent and pre-DAF BOD5 concentrations of approximately 55 and 40 mg/L, respectively. As the lower polymer doses evaluated in this trial only had slightly lower TSS removal and comparable UVT% and BOD5 removal, this data also demonstrates the potential to reduce polymer dose below 3 mg/L at the full-scale.

For Trial 3, we considered doses below the current plant dose of 3 mg/L. A dose of 1 mg/L yielded a TSS of 7 mg/L (87 % removal compared to pre-DAF) and a UVT of 77%. Increasing the dose to 1.5 or 2.1 mg/L did not improve TSS removal (80-89% removal) or UVT substantially. The jar with the plant dose (3 mg/L) had a TSS of 10.5 mg/L (80% removal) and a UVT of 75%. There were no considerable differences in treated BOD5 across the doses evaluated; all jars had BOD5 of 14-16 mg/L (48-55% removal compared to pre-DAF sample). This trial also suggests that polymer dose could be lowered to without hindering treated water quality.

Based on these trials, under "low" influent TSS experienced in the fall/winter, **it is recommended that a lower polymer dose (i.e. 1 to 1.5 mg/L) be implemented** at full-scale to minimize polymer carryover in the treated effluent. Note that it is likely that a polymer dose below 1 mg/L may be possible, however this was not tested during these trials. The improvements in water quality (if any) observed at higher polymer doses in these trials would not outweigh the added chemical cost.

### *3.1.1.2 "Moderate" Influent TSS (85-95 mg/L)*

For the "moderate" TSS test condition, three jar testing events were considered (November 2020, January and February 2021). For two events, corresponding plant flows were between 500,000 and 530,000 gal/day and influent TSS of between 85 and 95 mg/L. However, one event had high flow (>2,400,000 gal/day), and influent TSS was approximately 40 mg/L. Approximately 60 mm of precipitation occurred on and during the days leading up to this event. However, the pre-DAF TSS and UVT for this event were comparable to the other events (e.g. 70-80 mg/L, ~60% UVT), and therefore they were considered in the moderate TSS category. The full-scale plant influent samples had BOD5 concentration between 50 and 60 mg/L on all testing events, while ambient conductivity for the plant influent was between approximately 1200-2000 uS/cm. Doses considered for the moderate TSS trials were between 0 and 5 mg/L. Figure 2 below depicts TSS and UVT data for the "moderate" TSS jar test trials.

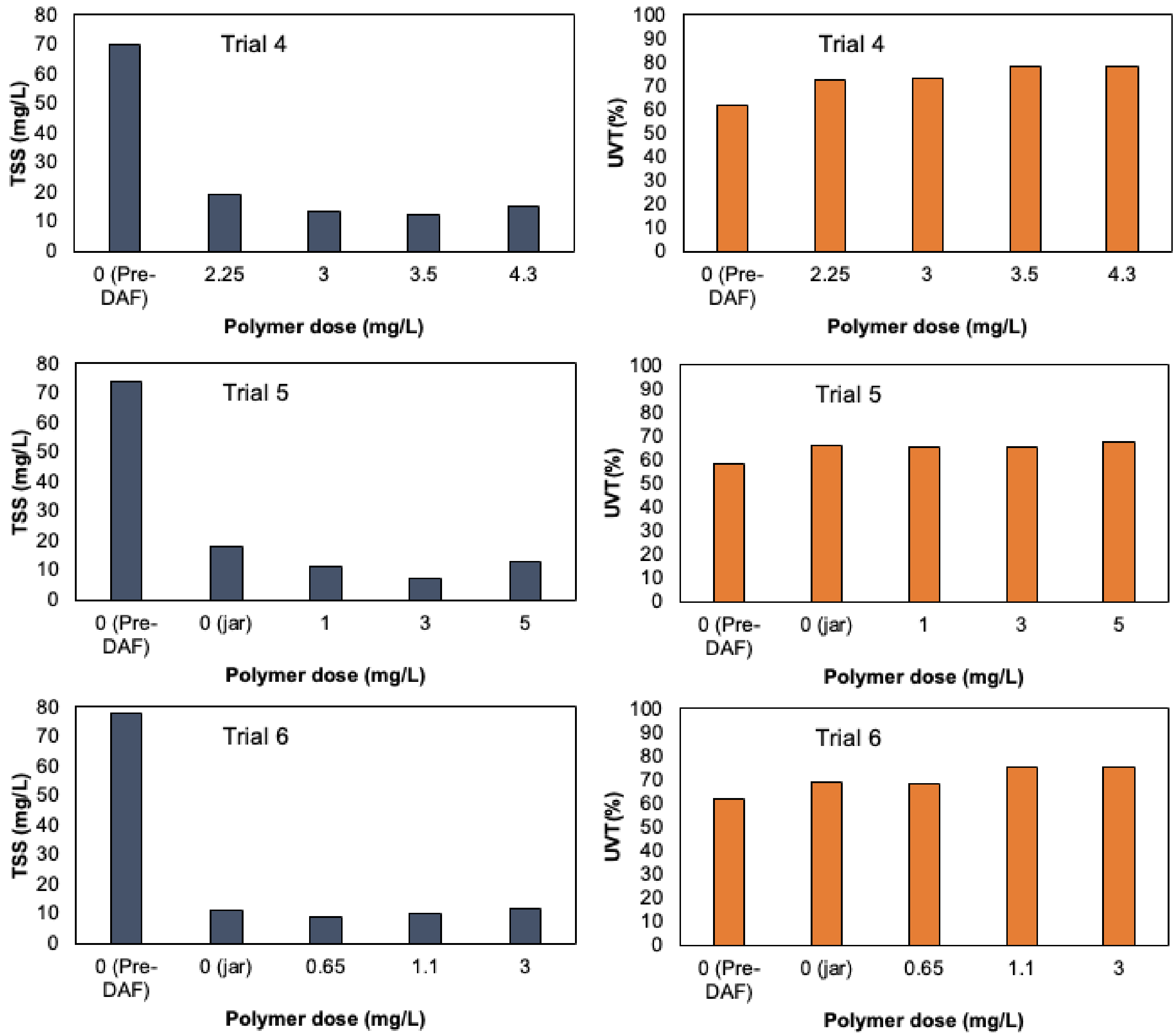



**Figure 2.** Results for polymer optimization at Lunenburg WWTP on the "moderate" influent TSS condition (85-95 mg/L). Pre-DAF represents an unclarified sample with no salt and no polymer addition. Samples were collected in November 2020, January and February 2021. The plant operated at a dose of 3 mg/L during these trials.

A dose range of 2.25 to 4.3 mg/L was considered for Trial 4 (Figure 2, top). Clarified TSS concentrations ranged between 13 and 19 mg/L (72 to 82% removal compared to pre-DAF). Polymer doses of 3 and 3.5 mg/L yielded the lowest TSS concentration of approximately 13 mg/L (80-82% removal), however the dose of 2.25 mg/L still achieved a 75% reduction in TSS. UVT improved slightly with increasing dose (range 72-78%). A dose of 2.25 mg/L provided comparable UVT (~72%) as the current plant dose of 3 mg/L (~73%), and dosing at 4.3 mg/L only increased UVT to 78%. BOD5 appeared to improve with increasing dose. For example, a dose of 2.25 mg/L yielded a clarified BOD5 of 30 mg/L while a dose of 3.5 mg/L yielded the lowest BOD5 of 13 mg/L. No substantial improvements in BOD5 were observed by increasing dose beyond 3.5 mg/L. Given that the 2.25 mg/L dose provided clarified water quality that was comparable to the plant dose of 3 mg/L, these results also demonstrate the potential to lower full-scale polymer dose.

For Trial 5 (Figure 2, middle), a broader range of polymer doses (1-5 mg/L) were considered due to the high flow on this occasion. All clarified samples yielded TSS concentration below 20 mg/L. The plant dose of 3 mg/L yielded maximum TSS removal (7 mg/L, 91% removal), however, the lowest dose of 1 mg/L achieved only a slightly higher TSS of 11 mg/L (85% removal). Increasing dose to 5 mg/L did not improve TSS removal. Further, clarified water without polymer addition (0 mg/L) achieved a TSS of 18 mg/L (75% removal). UVT was consistent at 66-67% across all jars (even with no polymer). BOD5 concentration was between 28 and 35 mg/L for all doses, with the lowest concentration achieved at a polymer dose of 5 mg/L. This trial suggested that there is potential to lower possibly as low as 1 mg/L.

For Trial 6 (Figure 2, bottom) we considered even lower polymer doses (0.65-1.1 mg/L). A jar with no polymer (0 mg/L) was also considered on this occasion, representing clarification without chemical addition. Overall, all jars provided comparable clarified TSS concentration in the range of 9-12 mg/L (85-89% removal from pre-DAF). The lowest polymer dose of 0.65 mg/L provided the lowest clarified TSS concentration (9 mg/L, 89% removal). The clarified water UVT improved slightly (from 68 to 75%) with increasing polymer dose, however the slight improvement in UVT may not be worth the increased chemical cost. Interestingly, the jar with no polymer showed no substantial differences compared to jars with polymer in terms of both of clarified UVT and TSS concentration. Further, BOD5 did not vary substantially across the doses evaluated. The lowest BOD5 concentration was achieved at a dose of 1.1 mg/L, and BOD5 removal for all jars was between 58-70%. Data from this trial suggested that there is potential to lower polymer dose below the plant dose of 3 mg/L (e.g. < 1 mg/L).

Based on these trials, **it appears that the plant can potentially lower polymer dose when influent TSS is within the moderate range (e.g. 85-95 mg/L), as doses between 0.5 and 1 mg/L** achieved comparable or better results in terms of TSS, UVT% and BOD5 than doses at or above 3 mg/L.

*3.1.1.3 “High” Influent TSS (>100 mg/L)*

On three occasions (in January 2020 and March 2021) the influent TSS was considered high, ranging between 130-150 mg/L (pre-DAF was ~75-110 mg/L) relative to the other trials conducted in the fall/winter. The ambient conductivity ranged between 1,200 and ~6,500 uS/cm for these trials, and the influent BOD5 was between 100 and 120 mg/L. Plant flows in the range of 450,000 and ~515,000 gal/day during these trials. No substantial precipitation occurred on the day of or leading up to these jar tests. Figure 3 depicts jar test data for the trials conducted under high influent TSS.

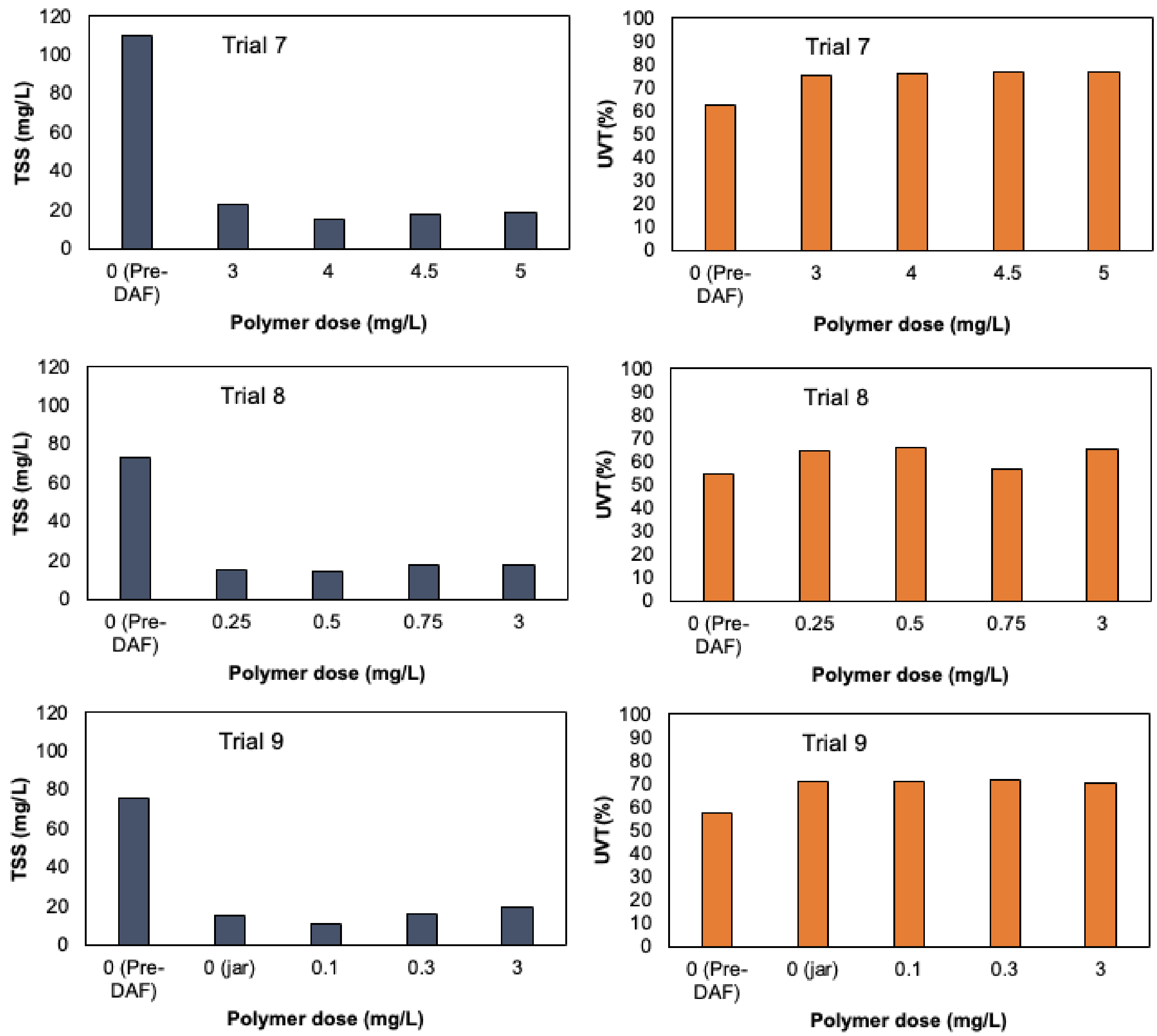



**Figure 3.** Results for polymer optimization at Lunenburg WWTP on the “high” influent TSS condition (>100 mg/L). Pre-DAF represents an unclarified sample with no salt and no polymer addition. Samples for Trial 7 through were collected in January, while Trials 8 and 9 were in March 2021. The plant operated at a dose of 3 mg/L during these trials.

For Trial 7 (Figure 3, top), a polymer dose range of 3-5 mg/L was evaluated. The clarified TSS was lowest at a dose of 4 mg/L (15 mg/L; 87% removal), however all other doses evaluated yielded TSS concentrations between 18-23 mg/L (80 to 83 % removal). Further, increasing dose did not improve UVT – values remained consistent at 75-77%. A polymer dose of 5 mg/L yielded the lowest BOD5 concentration (27 mg/L, 60% removal), however doses between 3 and 4.5 yielded BOD5 of 33-39 mg/L (40 to 50% removal). Accordingly, a dose of 3 mg/L was considered optimum, as increasing beyond this did not provide substantial improvement in TSS, UVT, or BOD5.  Based on this, we considered lower polymer doses for subsequent jar tests with high influent TSS conditions (Trials 8 and 9).

For Trial 8 (Figure 3, middle), we considered a polymer dose range between 0.25 and 0.75 mg/L, as well as the plant dose of 3 mg/L. Interestingly, all polymer doses considered had clarified TSS below 20 mg/L (75-80% removal); the 0.25 and 0.5 mg/L doses both had clarified TSS of approximately 15 mg/L, while 0.75 and 3 mg/L had slightly higher TSS at 18 mg/L. As for UVT, the addition of polymer only yielded slight improvements in UVT compared to the pre-DAF sample. For example, clarified UVT ranged between 56 and 65%, compared to 55% for pre-DAF. All polymer doses achieved clarified BOD5 below 50 mg/L, compared to a pre-DAF concentration of approximately 100 mg/L. The 0.5 mg/L dose yielded the lowest BOD5 concentration of 32 mg/L (69% removal), while the 0.25 mg/L dose was slightly higher at 42 mg/L (60% removal). Increasing the polymer dose beyond 0.5 mg/L did not improve BOD5 removal. This data also suggests that polymer dose at full-scale could be reduced to well below 3 mg/L during high influent TSS conditions; possibly in the range of 0.25 to 0.5 mg/L.

Finally, for Trial 9 (Figure 3, bottom) we evaluated even lower polymer doses, ranging between 0 and 0.3 mg/L. Similar to Trial 8, all doses yielded a clarified TSS below 20 mg/L (75-85% removal). A polymer dose of 0.1 mg/L achieved the lowest clarified TSS at 11 mg/L, however the jar with no polymer only had a slightly higher TSS of 15.5 mg/L. Increasing polymer dose did not improve TSS removal. All doses evaluated achieved UVT in the range of 70%. The plant dose of 3 mg/L yielded the highest BOD5 concentration (25 mg/L, compared to pre-DAF of 47 mg/L), the 0.1 mg/L dose had the lowest (19 mg/L). However, the jar with no polymer only had slightly higher BOD5 (22 mg/L). This data suggests that polymer dose could possibly be lowered to between 0 and 0.1 mg/L.

Based on these trials, even under "high" influent TSS experienced in the fall/winter (e.g. >100 mg/L), **a very low polymer dose (range of 0.0-0.5 mg/L) could be considered** at full-scale. Given the community concerns associated with the polymer the plant would be encouraged to consider these adaptive solutions in the upcoming months.

#### *3.1.2 Phase 1 Summary*

Based on the baseline jar tests conducted in Phase 1, it appears that even under high influent TSS conditions (e.g. >100 mg/L), it is possible that the polymer dose at the full-scale plant could be lowered substantially. **All jar tests indicated that a polymer dose well below the plant dose of 3 mg/L would be equally as effective, even under moderate to high influent TSS**.

- Polymer dose requirement decreases with higher TSS influent concentration, which is logical as the DAF process will encourage particle aggregation in absence of chemical addition. Polymer dose ranges identified in bench scale testing were:
    - Under the low TSS scenario (TSS < 60-70 mg/L) evaluated, the recommended polymer dose is 1 to 1.5 mg/L.
    - Under the moderate TSS scenario (TSS 85-95 mg/L) evaluated, the recommended polymer dose is between 0.5 and 1 mg/L.
    - Under the high TSS scenario (TSS > 100 mg/L), the recommended polymer dose is in the range of 0 to 0.5 mg/L.

While these experiments were conducted using controlled conditions, the town would be recommended to discuss these findings with the regulator to seek approval to evaluate these dosages under a pilot scenario at the plant. The pilot-scenario would be conducted at the Lunenburg wastewater plant and would occur along with additional jar testing. Piloting would allow a further investigation of the conditions identified as optimal at bench-scale, under dynamic flow and water quality conditions and will help to identify polymer dose and type that perform more favorably under more realistic conditions.

## 3.2 Phase 2: Impact of salinity on polymer performance

Salinity is expected to impact polymer performance in the DAF units and therefore salt was considered as a factor for additional jar tests. Historical data suggests that salinity can reach as high as 10-20 ppt (average ~3,700 uS/cm, high range 10-15,000 uS/cm, max ~56,000 uS/cm) and therefore salt (NaCl) was added to jars to simulate high salinity conditions. In this phase, we evaluated varying salinity concentration with constant polymer addition (plant dose of 3 mg/L), as well as varying polymer addition under high salinity conditions.

### *3.2.1 Evaluation of plant polymer dose varying salinity conditions*

Two conditions were considered for these trials; one condition where conductivity was between 15-25,000 uS/cm, which is considered high based on historical observations, and another condition where conductivity was much higher (e.g. upwards of 50-100,000 uS/cm). These ranges represent a scenario where the plant experiences seasonal conductivity highs, as well as a worst-case scenario where conductivity greatly exceeds seasonal levels. Salt was added incrementally to jars until desired conductivity values were obtained, while polymer dose was held constant at the current plant dose (3 mg/L). This was compared to a jar with no salt addition, and current plant polymer dose, as well as the pre-DAF sample (sampled prior to polymer addition at full-scale).

Plant flows were high (985,000 to 1,500,000 gal/day) for these trials; low precipitation levels (12mm cumulative) were observed in the days prior to testing. Figure 4 below depicts results for salinity jar test trials.

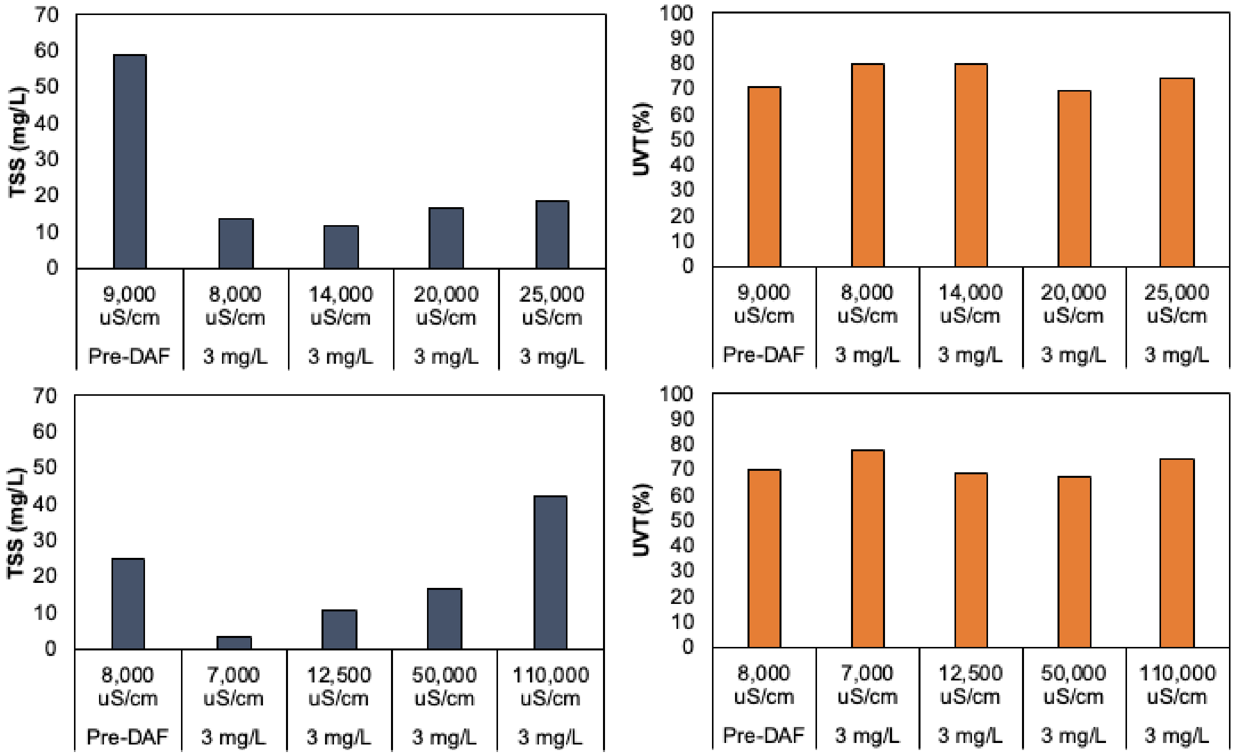



**Figure 4.** Results for salinity jar test trials at Lunenburg WWTP. Polymer dose was constant at 3 mg/L (plant dose) and salt was added to jars to mimic various conductivity conditions. Pre-DAF represents an unclarified sample with no salt and no polymer addition, Jar #1 represents a clarified sample at the current plant polymer dose with no salt addition (ambient conductivity). Jars 2-4 represent plant polymer dose with high conductivity (salt addition).

For both salinity conditions, the conductivity appeared to have an impact on solids removal—clarified water TSS concentration increased with the addition of salt. For the low salt condition (Figure 4, top), TSS concentrations were all below 20 mg/L, however the removal of TSS was reduced as conductivity increased. Further, UVT also appeared to be impacted by conductivity. The jars with lower conductivity (Jars 1 and 2) had 80% UVT, and UVT was reduced by 5-10% as conductivity increased (Jars 4 and 5). There were no noticeable trends between conductivity and BOD5 removal; the pre-DAF BOD5 was low (20 mg/L), and treated samples had BOD5 between 14-18 mg/L (9 to 30% removal compared to pre-DAF samples).

For the high salt condition (Figure 4 bottom), when no salt was added (e.g. ambient conductivity ~8,000-9,000 uS/cm), TSS removal was approximately 86% (3.5 mg/L) at the current plant polymer dose of 3 mg/L. As salt was added, TSS removal was lowered to 58% (10 mg/L), 34% (16.5 mg/L) and 0% (42 mg/L) for conductivities of 12,500, 50,000 and 110,000 uS/cm, respectively. Interestingly, the highest salt condition (Jar 4) had higher TSS concentrations than the pre-DAF sample. This could have been caused by high salinity impacting polymer efficacy, resulting in polymer contributing to the solids load. All jars had UVT in the range of ~70 to 80%. There were no trends between BOD5 removal and salt addition; all jars had 30-55% BOD5 removal (concentrations between 14-23 mg/L).

Overall, preliminary data suggests that current polymer performance may be impacted by high influent conductivity. A noticeable impact on polymer performance was observed when conductivity exceeded 20,000 uS/cm, performance worsened as conductivity was increased incrementally through salt addition.

### *3.2.2 Optimizing polymer dose under high salinity conditions*

We also conducted additional jar testing to determine an optimum polymer dose range under high salinity conditions. For these jar tests, we added salt to obtain conductivities of 20,000 as well as 50,000 uS/cm (typical "high" conductivity based on historical data) and evaluated a range of polymer doses to establish a point of diminishing returns. Figure 5 below depicts results for these trials.

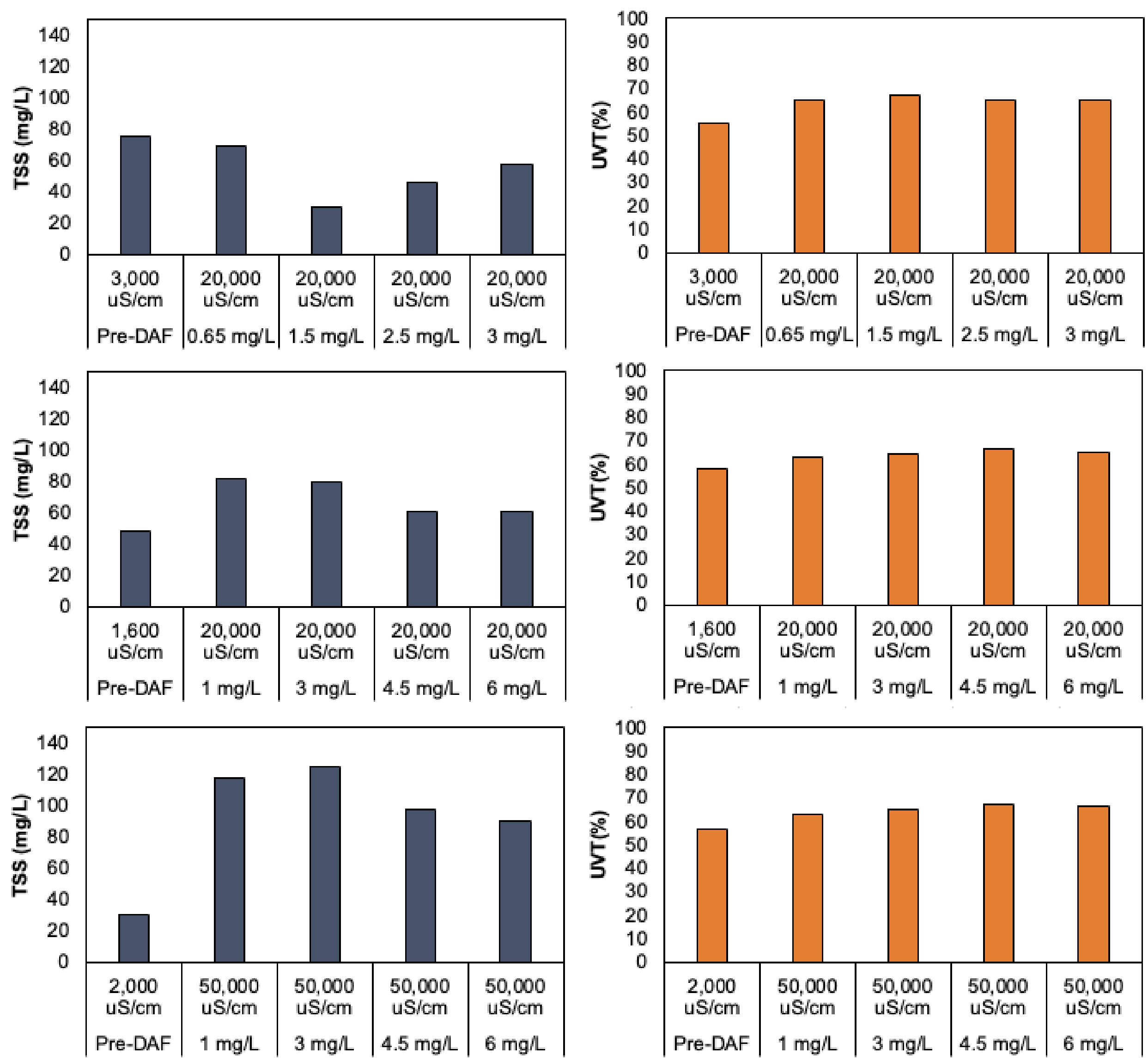



**Figure 5.** Results for preliminary salinity jar test trials at Lunenburg WWTP. Conductivity was held constant at either 20,000 or 50,000 uS/cm, through salt addition, while polymer dose was varied. Pre-DAF represents an unclarified sample with no salt and no polymer addition.

For the 20,000 uS/cm conductivity condition, we first evaluated a polymer dose range of 0.65 to 3 mg/L (Figure 5, top). This represented a scenario where the plant influent had high conductivity, and polymer dose was at or below the current value of 3 mg/L. A dose of 1.5 mg/L yielded the lowest clarified TSS concentration (30 mg/L, 81% removal). Beyond this dose, the clarified TSS began to increase. Similar to previous results, UVT% was not drastically impacted by polymer dose; all jars had a clarified UVT of 64-66%. The lowest BOD5 concentrations were achieved at the 0.65 and 1.5 mg/L polymer doses (15.2 and 20 mg/L BOD5, respectively), and the BOD5 concentration was highest (59 mg/L) in the jar dosed at 3 mg/L. Given this information, it appears that the optimum polymer dose was 1.5 mg/L. This is in contrast to previous salinity jar tests, which suggested that polymer performance was impacted under high salinity (e.g. higher polymer dose required).

Based on these results, we conducted a second set of jar tests on the 20,000 uS/cm conductivity condition where we considered a broader polymer dose range (1 to 6 mg/L) (Figure 5, middle). Here, all doses considered yielded a clarified TSS that were higher than the pre-DAF TSS of 48 mg/L. Increasing the polymer dose to 4.5 and 6 mg/L did reduce TSS to approximately 60 mg/L, but concentrations remained above the pre-DAF value of 48 mg/L. This reinforces previous data which suggested that salinity impacts polymer performance. UVT% did not improve substantially through polymer addition; for example, all doses yielded UVT between 63 and 66%, compared to 59% for the pre-DAF sample. All jars yielded a clarified BOD5 concentration between 25-30 mg/L. This data suggested that increasing polymer dose above 3 mg/L (possibly 6 mg/L or higher) may improve TSS removal. It should be noted that this is much higher than the 1.5 mg/L dose that was optimum in the jar test described above, and further jar testing should be done to confirm trends.

Finally, we conducted jar tests where the conductivity was increased to 50,000 uS/cm, and evaluated polymer doses between 1 and 6 mg/L (Figure 5, bottom). In this case, all polymer doses yielded a TSS above the pre-DAF concentration of 30 mg/, but it should be noted that this concentration is low (pre-DAF TSS typically between 50 and 100 mg/L). Regardless, clarified TSS decreased as polymer dose increased. A polymer dose of 6 mg/L yielded the lowest TSS concentration of 90 mg/L. Clarified UVT was between 63 and 66% for all polymer doses considered. Similarly, BOD5 concentration also improved with increasing polymer dose, however all jars had clarified BOD5 concentration between 20 and 30 mg/L. The 6 mg/L dose yielded the lowest BOD5 concentration. This results also suggest that a higher polymer dose may improve DAF performance under high salinity conditions.

This data further corroborates that polymer performance is impacted by salinity, and that a higher polymer dose may be required to improve DAF performance under high salinity conditions (e.g. 20,000-50,000 uS/cm). However due to inconsistencies in results it is suggested that additional jar tests are conducted to further narrow the polymer dose range.

### *3.2.3 Phase 2 Summary*

Jar test data suggests that current polymer performance may be impacted by high influent conductivity. A noticeable impact on polymer performance was observed when conductivity exceeded 20,000 uS/cm, and performance worsened as conductivity was increased incrementally through salt addition. Based on this, additional jar tests were conducted to optimize polymer dose under high conductivity scenarios. Although there were some inconsistencies in results, these jar tests revealed that a polymer dose between 3-6 mg/L may be required to remove TSS, as many jars had clarified TSS above the pre-DAF concentration.

As data in Phase 1 revealed that polymer dosing could be lowered significantly, or eliminated during typical conductivity conditions.  It is evident that the plant is highly vulnerable to high influent conductivity increases substantially (e.g. 20,000-50,000 uS/cm or higher).  While the long-term solution is to minimize seawater infiltration, short-term solutions may address treatment processes that align with increased chloride concentrations.  Summer research programs will specifically investigate this challenging treatment scenario.

## 4.0 Summary

A series of jar test experiments were conducted to identify optimal polymer dose under varying water quality conditions with a goal of improving overall DAF performance. This work consisted of two phases – Phase 1 focused on optimizing the polymer dose under a range of influent TSS concentrations observed during the fall and winter months, while Phase 2 focused on challenge testing to understand the impacts of high salinity on polymer dose and performance.

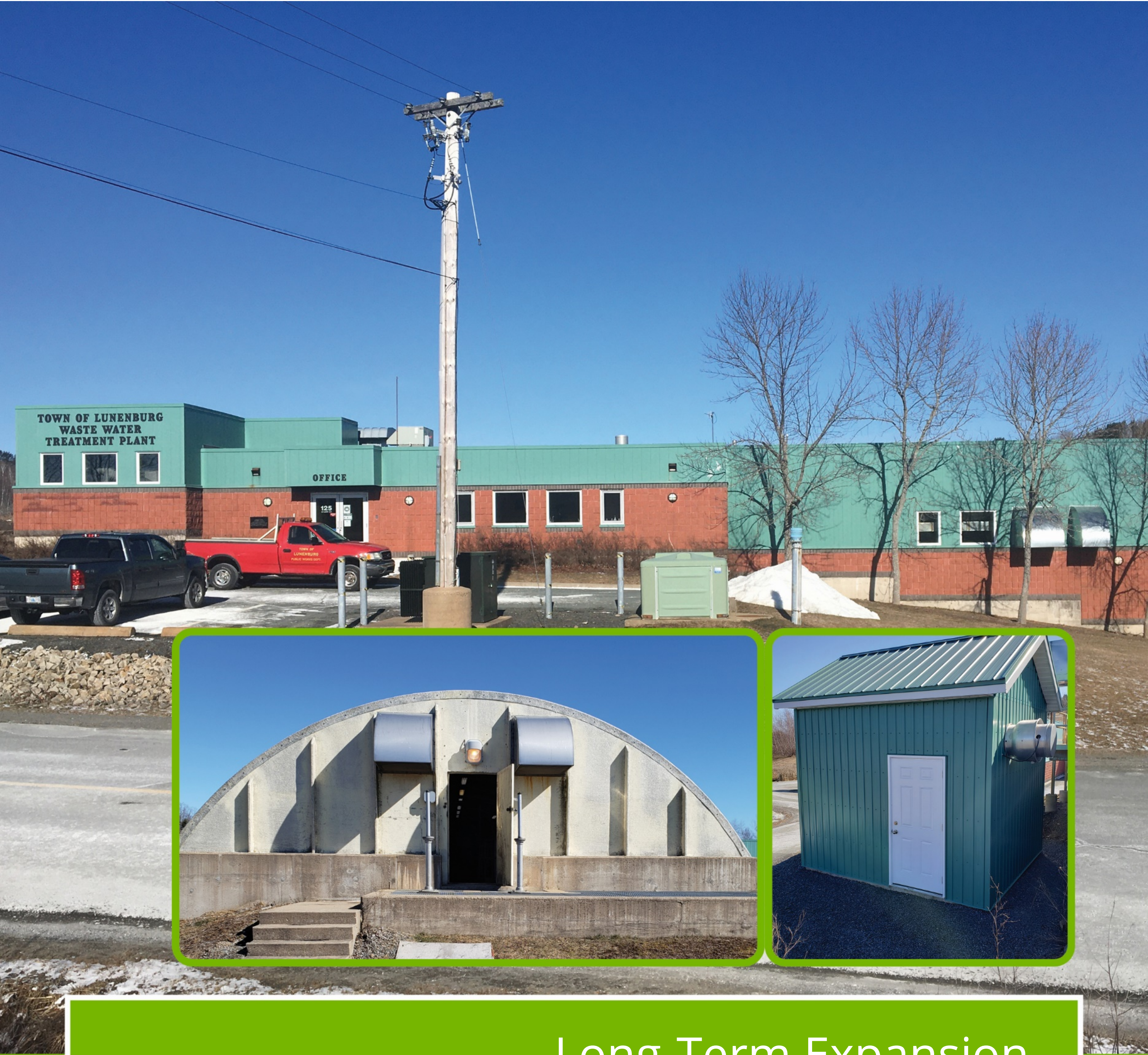
The jar test data reported in Phase 1 suggested that under all influent conditions evaluated (e.g. TSS ranging between ~60 to >100 mg/L during fall/winter months), a lower polymer dose could be considered. We evaluated polymer doses ranging from 0.1 to 6 mg/L and compared to the current plant dose of 3 mg/L. We also considered no polymer addition, and found that even the lowest polymer doses (e.g. 0.1 mg/L) performed as well as, or better than the plant dose in terms of UVT%, TSS and BOD5 removal. Polymer dose ranges identified at bench-scale were:

- 1 to 1.5 mg/L under low TSS conditions (60 to 70 mg/L)
- 0.5 to 1 mg/L under moderate TSS conditions (85 to 95 mg/L)
- 0 to 0.5 mg/L under high TSS conditions (>100 mg/L)

For Phase 2, jar test data suggested that when salt was added to simulate high influent conductivity, the effectiveness of polymer may be impacted, particularly with respect to TSS removal. A noticeable impact on polymer performance was observed when conductivity exceeded 20,000 uS/cm, and performance worsened as conductivity was increased incrementally through salt addition. Based on this, additional jar tests were conducted to optimize polymer dose under high conductivity scenarios, and results revealed that under high conductivity (e.g. 20,000-50,000 uS/cm), clarified TSS was often higher than the pre-DAF concentration, even at the highest polymer dose (6 mg/L). However, UVT% and BOD5 removal were not impacted substantially by salt addition. Accordingly, this phase revealed that the current polymer dose may be insufficient under high salinity conditions, that the dose should potentially be in the range of 3 to 6 mg/L when influent conductivity increases substantially.

Jar testing work will continue in the spring and summer to capture the impact of seasonal changes in influent water quality on both baseline polymer dose, as well as for high salinity conditions. Future jar test work will also consider operational factors such as alternative polymer type, recycle rate or pH adjustment to understand whether further improvements in water quality can be made.

While these experiments were conducted using controlled conditions, it is recommended that in addition to further jar testing, these dosages and conditions also be evaluated under a pilot-scale scenario at the plant. Piloting will allow a further investigation of the conditions identified as optimal at bench-scale, under dynamic flow and water quality conditions and will help to identify polymer dose and type that perform more favorably under more realistic, dynamic conditions.




# Long-Term Expansion

# Town of Lunenburg

# Wastewater Treatment Plant

## Draft Report

210803.01• July 2021

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| B | Reissued for Review | D.T. | July 30/ 21 | S.E. |
| A | Issued for Review | D.T. | July 7/21 | S.E. |
| **Issue or Revision** | | **Reviewed By:** | **Date** | **Issued By:** |



210803.01

July 30, 2021

Dennis MacPherson, P.Eng.
Town Engineer
Town of Lunenburg
177 Cumberland Street
Lunenburg, NS B0J 2C0

Dear Mr. MacPherson:

*RE: Town of Lunenburg - WWTP Long-Term Expansion Conceptual Design Report*

CBCL Limited (CBCL) was engaged by the Town of Lunenburg (the Town) to complete a conceptual design for the long-term expansion of the Lunenburg Wastewater Treatment Plant (WWTP). The long-term expansion will increase the capacity of the plant to accommodate a 50% increase in loading to the plant.

This report describes and evaluates five possible expansion options to accommodate the increase in loading. The evaluation is based on factors including expected effluent quality, the effects on operations, constructability and construction sequencing, and capital and operational costs.

Yours very truly,

CBCL Limited

**DRAFT**

| Prepared by: | | Reviewed by: |
|---|---|---|
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| Process Engineer | Process Engineer-in-Training | Process Engineer |
| E-Mail: sensslin@cbcl.ca | | |

Project No: 210803.01

# Contents

# Appendices



# Table of Acronyms

| Acronym | Definition |
|---|---|
| ACWGM | Atlantic Canada Wastewater Guidelines Manual for Collection, Treatment, and Disposal |
| ADF | Average Daily Flow |
| CBOD | Carbonaceous Biochemical Oxygen Demand |
| DAF | Dissolved Air Flotation |
| DO | Dissolved Oxygen |
| %DS | Percent Dry Solids |
| E. coli | Escherichia Coli |
| EQ | Equalization |
| $H_2S$ | Hydrogen Sulphide |
| HVAC | Heating, Ventilation and Air Conditioning |
| I&I | Inflow and Infiltration |
| MBBR | Moving Bed Bio-reactor |
| MBR | Membrane Bioreactor |
| MLSS | Mixed Liquor Suspended Solids |
| NSECC | Nova Scotia Environment and Climate Change |
| ODRC | Operator in Direct Responsible Charge |
| O&M | Operations and Maintenance |
| PDF | Peak Daily Flow |
| PLC | Programmable Logic Controller |
| RAS | Return Activated Sludge |
| SBR | Sequencing Batch Reactor |
| SCFM | Standard Cubic Feet per Minute |
| TBA | Temporary Bypass Authorization |
| TKN | Total Kjeldahl Nitrogen |
| TOL | Town of Lunenburg |
| TSS | Total Suspended Solids |
| UV | Ultraviolet |
| WAS | Waste Activated Sludge |
| WWTP | Wastewater Treatment Plant |
| WSER | Wastewater Systems Effluent Regulations |

# Chapter 1 Introduction

## 1.1 Background

The Lunenburg Wastewater Treatment Plant (WWTP) was constructed in 2002-2003 and is located on the South Shore of Nova Scotia, serving the Town of Lunenburg (the Town). In early 2021 the Town initiated a project for Wastewater Treatment and Outfall Pre-design. The project includes four main elements: pre-design of the treatment plant outfall, pre-design of the near-term capital upgrades at the WWTP, a building condition assessment report for the WWTP, and a conceptual design for the expansion of the WWTP. This report will focus on the conceptual design for the expansion of the WWTP with the goal of increasing the treatment capacity to meet the Town's future growth plan.

The WWTP receives and treats an Average Daily Flow (ADF) of 766,000 USgpd (2,900 $m^3$/d) and a Peak Daily Flow (PDF) of 3,000,000 USgpd (11,400 $m^3$/d). The treatment train includes influent screening, grit removal, biological treatment using a Moving Bed Bioreactor (MBBR), solids removal using Dissolved Air Flotation (DAF), and Ultraviolet (UV) disinfection.

The WWTP is sized appropriately to meet the current flows and loadings to the plant. The Town approved the Project Lunenburg Comprehensive Community Plan (Project Lunenburg) in May 2021. Project Lunenburg is a plan that encompasses the Town's vision for the next forty years and provides a framework for the anticipated growth in the community. Through several initiatives, the Town's population is predicted to increase by 50%, which would substantially increase loading the WWTP.

## 1.2 Purpose

The purpose of this report is to identify and develop an expansion plan for the WWTP to accommodate the anticipated growth (population increase) within the Town over the next forty years, as laid out by Project Lunenburg. The expansion plan must consider the following factors:

- Potential for improvements to the Town's collection system;
- Project Lunenburg planned population growth;
- Potential changes to regulatory requirements;
- Proven technologies for wastewater treatment;

- Possibility for operations and maintenance using current operations staff;
- Potential to maximize use of existing infrastructure; and
- Cost-effectiveness.

These factors have been discussed in the following sections.  Possible options have been identified, discussed, and evaluated, in order to lay out a feasible expansion plan the Town can use to accommodate planned growth.

# Chapter 2 Design Criteria

## 2.1 Existing Conditions

Historical records were reviewed to determine the flows and loads currently experienced by the plant and identify any trends or changes in recent years. The key parameters analyzed were ADF, PDF, as well as Carbonaceous Biochemical Oxygen Demand (CBOD) and Total Suspended Solids (TSS) loadings.

### 2.1.1 Flows

Current flows to the WWTP were determined from the analysis of flow entering the DAFs for the period of June 2020 to June 2021. The ADF during this period was determined to be 672,000 USgpd, while the PDF was 2,500,000 USgpd. The data is shown in Figure 1 below.

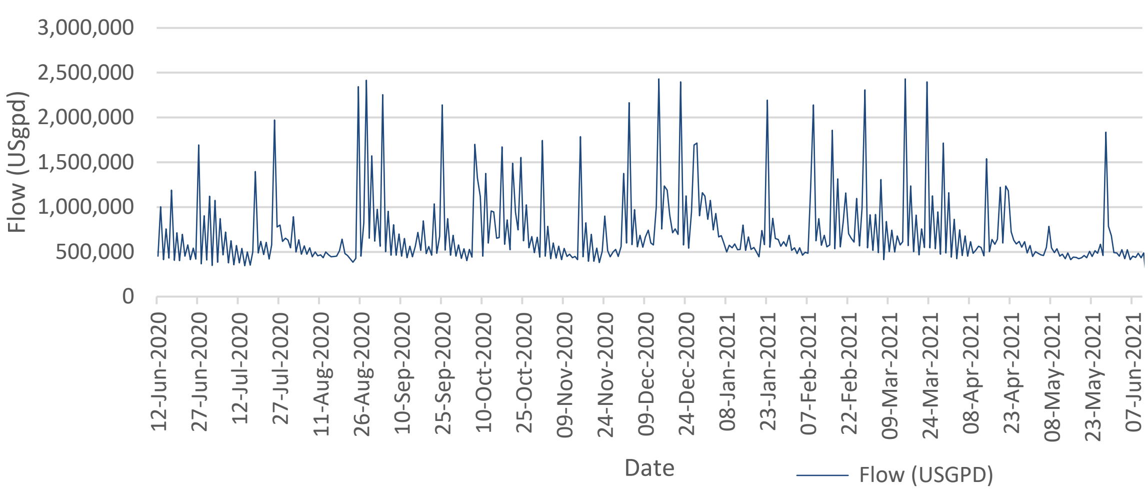



**Figure 1: Flow data from June 2020 to June 2021**

The WWTP services a population of approximately 2,263 people. At current ADF, this equates to an average daily per capita flow of approximately 300 USg/capita/day. For comparison, the Atlantic Canada Wastewater Guidelines Manual (ACWGM), (ACWWA, 2006) suggests a typical per capita flow of 90 USg/capita/day. The Town's per capita flow rate is very high, indicating a high level of inflow and infiltration (I&I) to the sewer system, which likely results from both combined sewers and seawater infiltration. The previous study (CBCL Limited, 2019) indicated a higher ADF of 760,000 USgpd and a PDF of 3,000,000 USgpd. Figure 2 shows the average daily flows on a monthly basis for the period from June 2018 to June 2021, to show the variation over this time period.

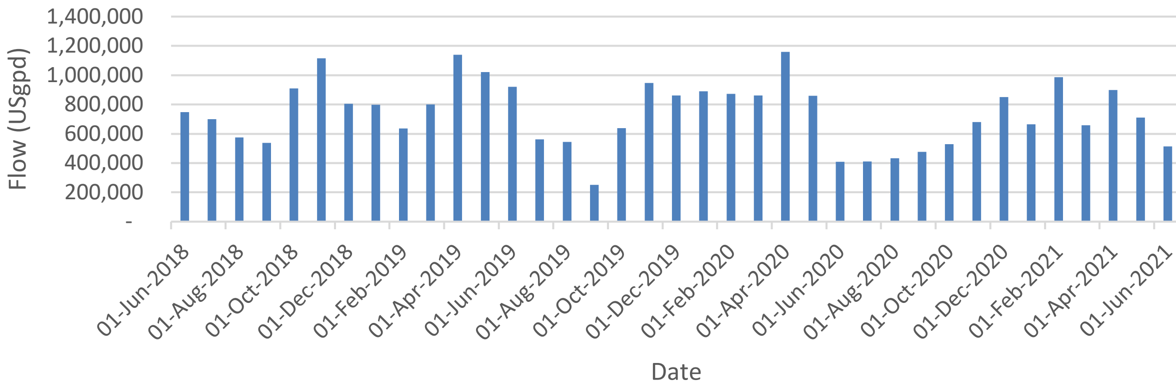



**Figure 2: Flow Data from June 2018 to June 2021**

Figure 2 indicates that the flow in 2020 was significantly lower than previous years. The flow appears to decrease substantially starting in Summer 2020. The decrease in overall plant flow may be as a result of the ongoing sewer separation work to reduce sea water infiltration, but may also indicate decreased tourist numbers during the past year due to the pandemic, or drier weather conditions. Due to the uncertainty of the cause of the flow reductions measured, the values identified in the previous study will be used for design purposes. This provides for a factor of safety on the design basis.

### 2.1.2 Loads

The wastewater loadings to the plant appear to be generally consistent with the ACWGM guidelines for per capita loadings. The ACWGM (ACWWA, 2006) recommends minimum wastewater per capita loadings of 0.08 kg CBOD/capita/day, 0.09 kg TSS/capita/day, and Wastewater Engineering (Metcalf & Eddy, Inc, 2003) recommends an allowance of 0.016 kg TKN/capita/day, where TKN is a measure of nitrogen in wastewater. The WWTP receives an average of 0.07 kg CBOD/capita/day, 0.13 kg TSS/capita/day, and 0.017 kg TKN/capita/day.

Additionally, the Town experiences significant increases in the peak loadings, likely as a result of the Town's strong summer tourism season. The population is reported to increase significantly during the summer months.

Representative flows and loads for the existing population are shown in Table 1.

**Table 1: Flows and Loads with Current Population**

| Parameters | Average | Peak |
|---|---|---|
| Population | 2,263 | |
| Flow (USgpd) | 766,000 | 3,000,000 |
| CBOD (kg/d) | 160 | 320 |
| TSS (kg/d) | 300 | 600 |
| TKN (kg/d) | 40 | 75 |

## 2.2 Future Conditions

Project Lunenburg was developed to provide guidance for most aspects of the community including land use, housing, transportation, and the environment over the next forty years, with the goal of strengthening the community and promoting growth. Project Lunenburg includes an increase in development in several areas within the Town. The planned new development areas can accommodate approximately 1,100 new residents which would result in a revised total population of approximately 3,360 people, increasing the service demand and wastewater loadings by about 50%.

Project Lunenburg documents identify that one of the challenges in accommodating this growth is the combined sewer system in some areas of the Town, which collects both sanitary wastewater and stormwater. Similar to other harbour communities, the Town historically used a combined sewer system that originally discharged directly into Lunenburg Front and Back Harbours. At the time of construction of the WWTP, the collection system was redirected to the WWTP. The combined sewers capture substantial amounts of rainfall which are then conveyed to the WWTP for treatment.

As part of Project Lunenburg, sewer separation work is recommended within the existing collection system and will be required in all areas of new development. If carried out strategically, the reduction in I&I paired with the expected growth in population is assumed to have a net-zero effect on the overall wastewater flows to the plant. However, the wastewater loads will increase by 50% overall. The resulting design wastewater flows and loads to the plant are summarized in Table 2.

**Table 2: Predicted Future Wastewater Flows and Loads**

| Parameters | Average | Peak |
|---|---|---|
| Population | 3,360 | |
| Flow (USgpd) | 766,000 | 3,000,000 |
| CBOD (kg/d) | 240 | 400 |
| TSS (kg/d) | 450 | 750 |
| TKN (kg/d) | 60 | 110 |

## 2.3 Effluent Limits

The effluent requirements are determined based on a combination of the Federal Wastewater Systems Effluent Regulations (WSER) and the Nova Scotia Environment and Climate Change (NSECC) Approval to Operate for the WWTP.

The receiving environment for the WWTP discharge is the Lunenburg Front Harbour. The outfall location is also being reviewed as part of this project. The outfall may be relocated to a position that promotes better mixing and dilution within this harbour. No changes are anticipated to the effluent requirements at this time, though over the course of the next forty years it is possible that effluent limits may become more stringent. The current effluent requirements are outlined in Table 3.

**Table 3: Effluent Limits**

| Parameter | Limit | Notes |
|---|---|---|
| CBOD (mg/L) | 20 | Quarterly Average |
| TSS (mg/L) | 20 | Quarterly Average |
| *E. coli* (count per 100 mL) | 1000/100mL | Quarterly geometric average |

# Chapter 3 Existing Treatment Plant Capacity

## 3.1 Description of Existing Facility

The existing treatment plant was constructed in 2002-2003 and consists of influent screening, grit removal, biological treatment using a Moving Bed Bioreactor (MBBR), solids removal via DAF, and UV disinfection. Solids from the DAF units are pumped to the sludge holding tank located in the aeration building. The sludge holding tank acts as a buffer tank to feed the rotary press for dewatering.

## 3.2 Capacity

The existing treatment plant is currently operating close to its rated capacity and would require significant upgrades to accommodate a 50% increase in organic loading while maintaining the hydraulic throughput as discussed above. The following sections review the key unit processes affected by the increase in loading, to identify any unit operations with available capacity to treat the additional load.

### 3.2.1 Inlet Screen

Wastewater flow from the catchment area is pumped to the headworks building to the influent bar screen. An emergency bypass channel is provided to direct influent to the MBBR in the event of a screen blockage. The influent is screened with a 0.1" (3 mm) continually-raked bar screen that collects the screenings and discharges to a compactor for disposal offsite. The existing screen has several operational issues and is recommended to be replaced as part of the near-term capital upgrades. The proposed replacement screen is a 0.2" (6 mm) perforated plate screen that is sized based on the current PDF. The performance of the inlet screen would not be significantly influenced by the increase in loading to the plant, but would require upgrades or replacement if peak flows were to increase. If a treatment system is selected where the downstream processes require a finer influent screen, then an alternative or additional screen would be required.

Screened wastewater flows to aerated grit tanks that aim to remove the heavier grit particles, while keeping the lighter organic particles in suspension. The grit tanks are sized adequately for the current flows and no increase in capacity is required, but like the screens, would need consideration if peak flows increased.

### 3.2.2 MBBR

The existing MBBR consists of two trains of four stages each, and has a total volume of 13,824 $ft^3$ (391 $m^3$, or 103,400 USgal). The MBBR cells are filled with an unconventional type of plastic media. The existing media were supplemented with new media in 2020 during the aeration upgrades. The capacity of the system is limited by the media's surface area to volume ratio. The existing media has a much lower surface area to volume ratio than would be expected for conventional media and has poor durability (visible reduction in size over the years as the plastic has worn down).

Both MBBR trains feed into the equalization tank that acts as a batch tank ahead of the DAFs. The equalization tank is equipped with aerators fed from the blowers to avoid settling of solids and septicity within the tank.

Air is supplied to the MBBR system by three (3) 50 hp blowers. Each blower has a rated capacity of 1050 SCFM at 7.5 psig. The blowers are recommended to be replaced as part of the near-term upgrades, due to age and spare part availability. Air from the blowers is also supplied to the equalization tank, sludge tank, and aerated grit tank. The current total air requirement of the MBBR system is 960 SCFM and can be supplied by one blower.

The design parameters of the existing MBBRs are summarized in Table 4 below.

### 3.2.3 DAFs

The wastewater flows from the equalization tank through the DAF influent channel where it is dosed with a polymer to enhance solids removal. Dissolved air flotation is a clarification process that uses air to float solid particles to the water surface for removal. Air is dissolved in the wastewater stream under pressure and then released at atmospheric pressure in a flotation tank or basin. This produces tiny air bubbles that adhere to the suspended solids in the water and float the solids to the surface of the water, where they are removed by a skimming device.

The existing DAF units were designed based on a flow rate of 1,040 USgpm, per unit, and a maximum solids loading rate of 200 mg/L. The DAF units are equipped with lamella plates to increase the rise rate in the DAF. This allows the DAF to operate at a higher capacity in a smaller footprint, but the lamella plates are difficult to clean. The design parameters of the existing DAF units are summarized in Table 4 below.

**Table 4: Existing MBBR and DAF Capacity**

| Parameter | Existing | Typical |
|---|---|---|
| No. of Blowers | 2 Duty+1 Standby | 2 Duty+1 Standby |
| Air flow per blower (SCFM) | 1050 | - |
| Air pressure (psig) | 7.5 | - |
| No. of MBBR Trains | 2 | 2 |
| No. of MBBR Stages | 4 | - |
| Total MBBR Bioreactor Volume (USgal) | 103,400 | - |
| MBBR Average/Peak Hydraulic Retention Time (hr) | 1.7/0.4 | - |
| MBBR Side Water Depth (ft) | 12.6 | - |
| MBBR Media Area to Volume Ratio ($ft^2/ft^3$) | 30 | 180-300 |
| MBBR Media Fill Fraction (%) | 37.5 | 50 |
| MBBR Media Area ($ft^2$) | 155,000 | - |
| MBBR Average/ Peak CBOD Loading ($g/ft^2d$) | 1.03/2.06 | 0.33-0.65 |
| No. of DAF units | 2 | 2 |
| Average Solids Concentration (mg/L) | 100 | - |
| DAF Volumetric Loading Rate (USgpd/unit) | 1,500,000 | - |
| DAF Flotation Area ($ft^2$/unit) | 150 | - |
| DAF Side Water Depth (ft) | 7.9 | - |
| Peak Hydraulic Loading Rate (USgal/$ft^2$/h) | 416 | - |

### 3.2.4 Ultraviolet Disinfection

The Ultraviolet (UV) disinfection system consists at a single bank containing a total of 32 bulbs. As part of the near-term upgrades an additional UV bank is recommended, to improve compliance with provincial effluent requirements. The measured UV transmittance (UVT) of the effluent entering the UV unit is lower than the design value. UVT is a measure of how easily UV light passes through the effluent. Low UVT can be caused by a number of factors, including colour, polymer carryover, foaming, and high concentrations of solids in the effluent. The low UVT of the effluent means that the installed equipment cannot emit enough UV light to successfully disinfect the effluent. The additional UV bank will double the capacity of the system, to provide the required UV dose, even at lower UVT values.

The UV capacity is based on the peak flow of the WWTP (i.e., 3,000,000 USgpm). As noted in Section 2, the overall flow to the plant is assumed not to increase. The UVT of the effluent wastewater is also not expected to deteriorate. The UV system, as recommended in the near-term upgrades, has sufficient capacity for disinfection requirements following WWTP expansion.

### 3.2.5 Rotary Press

Sludge dewatering is accomplished via a Fournier Rotary Sludge Press (Fournier Press). The Fournier Press includes two channels, each with the capacity to dewater sludge at a rate of 40 kg/h. The Fournier Press operates by feeding sludge at a low pressure into one of the two channels, which wrap around the Fournier Press. The sludge is rotated between two parallel revolving stainless steel filter elements. This slowly presses water out of the sludge through the filters. The process can produce a very dry sludge cake, depending on sludge characteristics.

The Fournier Press currently operates when the operator is present, in 8-hour shifts, about 5 days a week. The design capacity of the Fournier Press is summarized in Table 5 below.

**Table 5: Existing Fournier Press Capacity**

| Parameter | Existing |
|---|---|
| Solids Capacity per Channel (kg/h) | 40 |
| No. of Channels | 2 |
| Weekly capacity (kg/week) | 3,200 |
| Typical Cake Solids (%DS) | 20-30% |

# Chapter 4 Options for Expansion

Five different expansion options of the WWTP are discussed and evaluated below. The options were identified based on ability to provide reliable and effective wastewater treatment for a moderate sized facility. Four different technologies were explored including MBBR & DAF, Membrane Bio-Reactor (MBR), Sequencing Batch Reactor (SBR), and disk filtration polishing. The technologies for consideration were chosen based on their reliability and were evaluated for ease of retrofit, impacts on operations, and capital and lifecycle costs. All these expansion options are developed on the basis that the relevant Near-Term items have been completed prior to the WWTP expansion. These are listed in each Option description.

## 4.1 Option 1: Expanded MBBR and Existing DAF units

### 4.1.1 Technology Overview

The patented MBBR process was developed by the Norwegian company Kaldnes Miløteknologi. MBBRs are a system based on a biofilm reactor with no requirement for backwashing or return activated sludge. The MBBRs contain "carrier" (typically plastic) media with a high surface area for biofilm growth. The specific gravity of the carrier is slightly less than that of water so that aeration will keep the contents in suspension and completely mixed. The movement of the media is normally caused by coarse-bubble aeration. Aeration abrasion of the media carriers allows for biofilm to slough off, to maintain optimal biofilm thickness.

Similar to the existing arrangement, wastewater from preliminary treatment (screened and de-gritted) flows to the influent channel of the MBBR tanks. Following biological treatment in the MBBR, the wastewater flows to a secondary clarifier or DAF for solids removal, while the carrier material is kept in the reactor by a media retention sieve at the outlet of each MBBR tank. A typical MBBR and DAF process schematic and installation is shown in Figures 3 to 5.

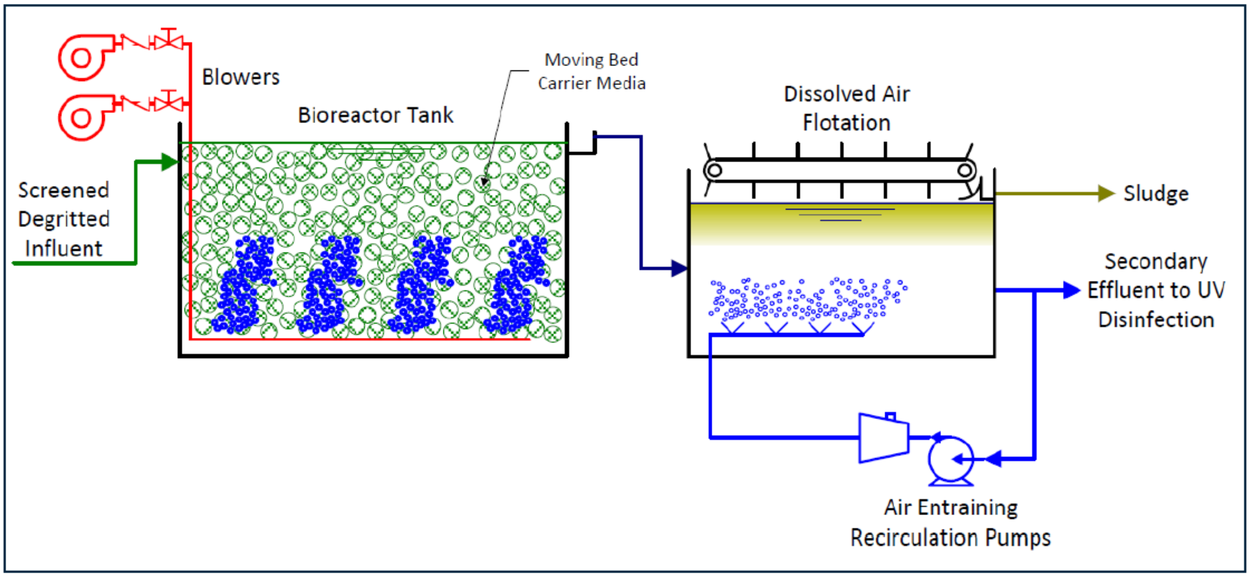



**Figure 3: Typical MBBR and DAF Schematic**

**Figure 4 & 5: MBBR media and DAF unit**

### 4.1.2 Description and Design Criteria

Option 1 would retain the same technology and maximize reuse of the existing infrastructure. The existing MBBR capacity would be expanded by replacing the existing media with new media with a better surface area to volume ratio. The increased surface area to volume ratio provides a greater area for biofilm growth. The existing DAFs can be retained as they appear to have sufficient capacity to handle the expected increase in load. The design criteria are summarized in Table 6 below.

**Table 6: MBBR and Existing DAF Design Criteria**

| Parameter | Proposed | Typical |
|---|---|---|
| No. of Blowers | 2 Duty+1 Standby | 2 Duty+1 Standby |
| Air flow per blower (SCFM) | 1,191 | - |
| Air pressure (psig) | 7.7 | - |
| No. of MBBR Trains | 2 | 2 |
| No. of MBBR Stages | 4 | - |
| Total MBBR Bioreactor Volume (USgal) | 103,400 | - |
| MBBR Ave./Peak Hydraulic Retention Time (hr) | 1.7/0.4 | - |
| MBBR Side Water Depth (ft) | 12.6 | - |
| MBBR Media Area to Volume Ratio ($ft^2/ft^3$) | 287 | 180-300 |
| MBBR Media Fill Fraction (%) | 46 | |
| MBBR Media Area ($ft^2$) | 1,825,000 | |
| MBBR Average/ Peak CBOD Loading ($g/ft^2d$) | 0.14/0.27 | 0.33-0.65 |
| No. of DAF units | 2 | 2 |
| Average Solids Concentration (mg/L) | 150 | - |
| DAF Volumetric Loading Rate (USgpd/unit) | 1,500,000 | - |
| DAF Flotation Area ($ft^2$/unit) | 150 | - |
| DAF Side Water Depth (ft) | 7.9 | - |
| Peak Hydraulic Loading Rate (USgal/$ft^2$/h) | 416 | - |

The media retention sieves between each stage of the MBBR must also be replaced with finer sieves to keep the smaller-diameter media in place. The existing aeration diffusers will be replaced with coarse-bubble diffusers that require less periodic maintenance. The DAF units can be retained with no additional upgrades beyond the recommended near-term upgrades to polymer dosing and weirs, although they will be operating closer to their design capacity than they are currently and there is a risk that peak solids loading may occasionally exceed the DAF design capacity.

Under this scenario, the existing sludge management system would require expansion to handle the additional solids load. This would be accomplished by adding a third channel to the Fournier Press, resulting in a 50% increase in capacity.

The proposed scope of work for this option includes the following:

- Removal/replacement of existing media with smaller diameter media (higher surface area to accommodate more biomass and increase biological treatment capacity);
- Removal/replacement of existing media retention sieves with finer sieves;
- Removal/replacement of existing fine-bubble aeration system with a corrosion-resistant coarse-bubble aeration system;
- Additional instrumentation including dissolved oxygen (DO) control within the bioreactor; and
- Addition of third channel to the Fournier Press.

This option assumes that the flood control berm, UV expansion, polymer pumps, aeration blowers, headworks screen and compactor, online instrumentation in the bioreactor, standby generator, mechanical upgrades, DAF manifolded manual weirs, polymer makedown equipment, and compressor pipework items have been completed already as per the Lunenburg WWTP Near-Term Upgrades Pre-Design Report (CBCL Limited, 2021). This Option 1 arrangement can be seen in PSK01 in Appendix A.

### 4.1.3 Operational Discussion

Operation of the upgraded MBBR and existing DAF would be very similar to the current operations. There are no additional components added that would require additional labour. The Fournier Press requires additional capacity to handle the increase in solids loading to the plant, but operation remains the same. The increase in solids loading to the plant will result in increased sludge hauling and disposal costs, but the sludge cake dryness should remain similar to existing.

The benefit of this option is that the operations are nearly identical and the operators are familiar with the equipment/process. Operators will be able to adapt to the upgrade with ease. The downside of this option is that any operational issues that are not resolved with proposed near-term upgrades to the existing system will also remain, such as the difficulty in cleaning the DAF lamella plates.

### 4.1.4 Construction Sequencing

The implementation and sequencing for this option is relatively straightforward, as most of the major equipment will be retained. The bioreactor trains can be taken out of operation, one at a time, to remove the old media and aeration equipment, and install the new media, aerators, and media retention screens. The first train can be commissioned and brought back online before taking the second train out of operation. No complete process bypasses would be required for this option, but depending on flows, some wastewater might bypass biological treatment if the flow exceeded the capacity of one train during wet weather.

A Temporary Bypass Authorization (TBA) will be required for any process bypasses, including taking one train out of service for construction. This must be obtained from Environment Canada under the terms of the WSER legislation. An Approval to Construct and Operate must be obtained from NSECC prior to construction. The overall construction and sequencing plan would be developed by the general contractor in close consultation with the Town’s Engineering and Operations team to minimize process disruptions.

## 4.2 Option 2: Expanded MBBR and New DAF Units

### 4.2.1 Technology Overview

The technology for this option is very similar to Option 1. Principles of operation remain the same with organics removal occurring in the MBBR and solids removal occurring in the DAF. The primary differences are that the proposed DAF units do not include lamella plates, which means that cleaning of the units is easier, and that they are taller than the existing units. The proposed DAF units are depicted below in Figure 6 below. Please note that this is shown as an example and is subject to change during detailed design.

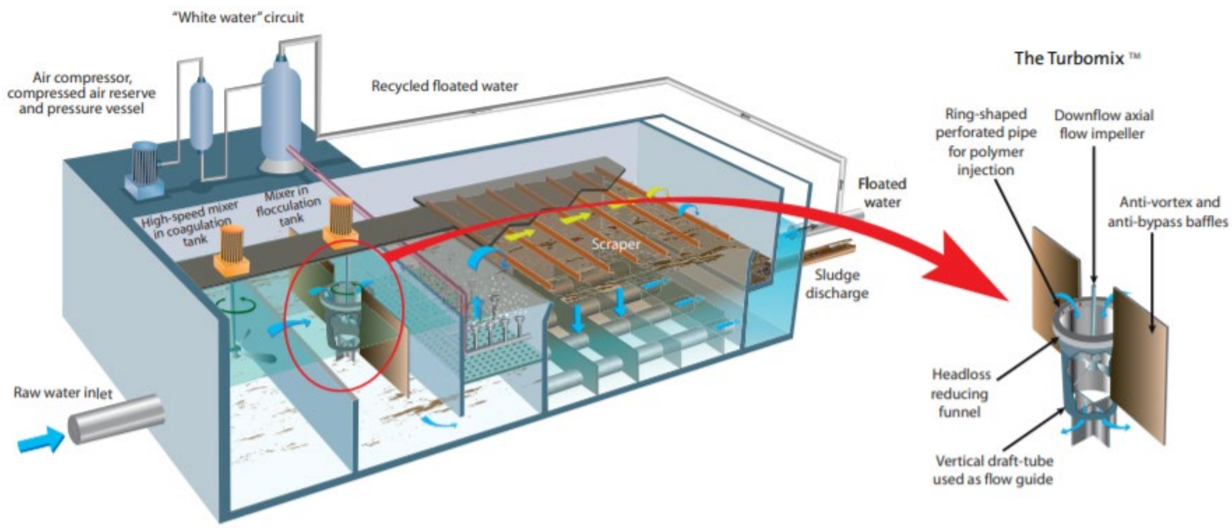



**Figure 6: Alternate DAF**

### 4.2.2 Option Description and Design Criteria

The MBBR upgrade will be similar to Option 1 with smaller, higher surface area media, media retention sieves, and coarse bubble aeration, but will be supplied by a different manufacturer. The manufacturer will also supply the DAF units, resulting in a single vendor supplying the core of the treatment process (integrated approach). The DAFs will be sized for the additional loading. The proposed DAFs are taller, which means they have a higher top water level than the existing DAFs so the MBBR effluent will no longer flow from the equalization (EQ) tank by gravity. It will be necessary to install pumps in the EQ tank to feed the DAF units and to pump all flows.

Additional instrumentation will be installed to provide better control of dosing and verification of effluent quality.

Under this scenario, the existing sludge management system would require expansion to handle the additional solids load. This would be accomplished by adding a third channel to the Fournier Press, resulting in a 50% increase in capacity.

The design criteria for the proposed system are shown below in Table 7.

**Table 7: Design Parameters MBBR and DAF**

| Parameter | Proposed | Typical |
|---|---|---|
| No. of Blowers | 2 Duty+1 Standby | 2 Duty+1 Standby |
| Air flow per blower (SCFM) | 710 | - |
| Air pressure (psig) | 6.5 | - |
| No. of MBBR Trains | 2 | 2 |
| No. of MBBR Stages | 4 | - |
| Total MBBR Bioreactor Volume (USgal) | 103,400 | - |
| MBBR Ave./Peak Hydraulic Retention Time (hr) | 1.7/0.4 | - |
| MBBR Side Water Depth (ft) | 12.6 | - |
| MBBR Media Area to Volume Ratio ($ft^2/ft^3$) | 240 | 180-300 |
| MBBR Media Fill Fraction (%) | 54 | |
| MBBR Media Area ($ft^2$) | 1,808,000 | |
| MBBR Average/ Peak CBOD Loading ($g/ft^2d$) | 0.27 | 0.33-0.65 |
| No. of DAF units | 2 | 2 |
| Average Solids Concentration (mg/L) | 150 | - |
| DAF Volumetric Loading Rate (USgpd/unit) | 1,500,000 | - |
| DAF Flotation Area ($ft^2$/unit) | 95 | - |
| DAF Side Water Depth (ft) | 11.3 | - |
| Hydraulic Loading Rate ($USgal/ft^2/hr$) peak | 660 | - |

The proposed scope of work for this option includes the following:

- Removal/replacement of existing media with smaller diameter media (higher surface area to accommodate more biomass and increase biological treatment capacity);
- Removal/replacement of existing media retention sieves with finer sieves;
- Removal/replacement of existing fine bubble aeration system with a corrosion-resistant coarse bubble aeration system;
- Additional instrumentation including DO control within the bioreactor;
- Installation of pumps in the EQ tank to feed the DAF units;
- Removal/Replacement of the existing DAF system with new DAF units, sludge skimmer, recirculation pumps and polymer make-down and dosing system (subsequent to the near term upgrades); and
- Addition of third channel to the Fournier Press

This option assumes that the flood control berm, UV expansion, polymer pumps, aeration blowers, headworks screen and compactor, online instrumentation in the bioreactor, standby generator, mechanical upgrades, and polymer makedown equipment, and compressor pipework items have been completed already as per the Lunenburg WWTP

Near-Term Upgrades Pre-Design Report (CBCL Limited, 2021). The Option 2 arrangement can be seen in PSK02 in Appendix A.

### 4.2.3 Operational Discussion

Similar to Option 1, operation would be very similar to the current arrangement at the WWTP. The biggest operational change will be the new DAFs. The principles of operation remain the same, though controls will vary from vendor to vendor. The new DAFs will not include the lamella plates that are currently an operational issue at the WWTP.

The benefit of this option is that the operations are nearly identical and the operators are familiar with the equipment/process, removing some of the current operational issues associated with the existing DAFs. An additional advantage is that the MBBR and DAF system will be supplied by one vendor. The MBBR and DAF are unit processes that are strongly linked and having a single vendor for both options could be beneficial in troubleshooting scenarios, not just on individual process units, but for the treatment system as a whole.

Similar to Option 1, the Fournier Press requires additional capacity to handle the increase in solids loading to the plant, but operation remains the same. The increase in solids loading to the plant will result in increased sludge hauling and disposal costs, but the sludge cake dryness should remain similar to existing. Additional pumping will be required from the equalization tank to the DAFs, which will incur additional electrical costs.

### 4.2.4 Construction Sequencing

The implementation and sequencing for this option is quite complex, due to the new DAF installation. The bioreactor trains can be taken out of operation one at a time to remove the old media and aeration equipment, and install the new media, aerators and media retention sieves. The first train can be commissioned and brought back online before taking the second train out of operation.

Removal of the existing DAFs and installation of new units will require the use of a crane. To facilitate this, the existing roof structure over a large section of the Process Room will need to be removed. The existing DAFs can be removed one at a time and the new ones put in place. While this is taking place, new pumps will be installed in the equalization tank. This will require a complete bypass of the bioreactor building for about two weeks. Altogether, three to six (3 – 6) weeks of process bypass will likely be needed to complete the work. This construction sequence has significant challenges.

The HVAC and existing roof in the process room will have to be significantly modified to accommodate the new, higher, DAFs. Significant controls modifications will also be required.

Similar to Option 1, a TBA will be required for any process bypasses and an Approval to Construct and Operate must be obtained from NSECC prior to construction. The overall construction and sequencing plan would be developed by the contractor in close consultation with the Town's Engineering and Operations team to minimize process disruptions.

## 4.3 Option 3: Sequencing Batch Reactor

### 4.3.1 Technology Overview

The Sequencing Batch Reactor (SBR) process is an aerobic suspended-growth (activated sludge) biological treatment process. The SBR process is a batch process whereby secondary biological treatment, including nitrification, and settlement/clarification is achieved in one reactor. This "fill and draw" type of treatment allows for aeration and clarification to occur in the same reactor. Settling is initiated after the aeration cycle, and clarified supernatant is withdrawn through a decanter mechanism.

A summary of the SBR process is provided below (note that there are some variations between different manufacturers):

1. Fill – Influent enters the anoxic pre-react zone in the SBR tank. The anoxic conditions favor the procreation of microorganisms with good settling characteristics. The wastewater then flows into the react zone of the SBR.
2. React – the microorganisms contact the substrate and a large amount of oxygen is provided to facilitate the substrate (CBOD) consumption. During this period aeration continues until complete biodegradation of CBOD is achieved. During this stage some microorganisms will die because the lack of food and will settle as sludge. The length of the aeration period determines the degree of CBOD consumption.
3. Settle – Aeration is discontinued at this stage and solids separation takes place leaving clear, treated effluent above the sludge blanket. During this clarifying period no liquids typically leave the tank to avoid turbulence in the supernatant.
4. Decant – This period is characterized by the withdrawal of treated effluent from the upper portion of the reactor by the floating solids excluding decanter. This maximizes the distance between the point of withdrawal and the settled sludge.
5. Idle – An idle period is provided as the reactor waits for the start of the next cycle. Sludge wasting typically occurs during this time.

The process is generally implemented using a minimum of two (2) reactors in parallel. It can be conducted as a true batch process where one reactor is filling while the other is settling, or as a continuous-feed SBR which receives influent during all phases of the treatment cycle and decants intermittently. A continuous-feed SBR is proposed for this option.

No Return Activated Sludge (RAS) circulation is required as the key microbes always remain in the reactor.  Waste Activated Sludge (WAS) is withdrawn as necessary, to maintain a healthy sludge age. The entire process is typically controlled using a Programmable Logic Controller (PLC). A typical process schematic and a photo of an SBR installation is shown in Figures 7 and Figure 8 respectively.

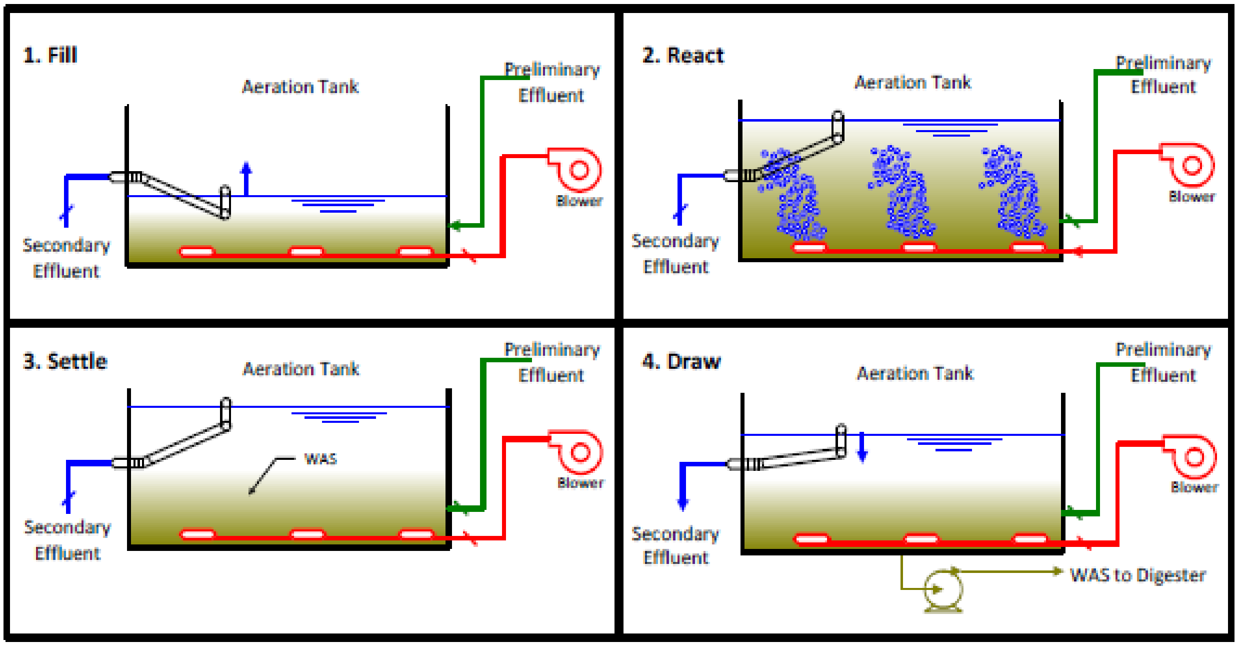



**Figure 7: Typical SBR Schematic**

**Figure 8: Installation of a three-train SBR system**

### 4.3.2 Option Description and Design Criteria

SBRs are operated at long solids and hydraulic retention times, resulting in large reactor volumes; however, the total number of tanks required is reduced, which can result in relatively compact site layouts. The flow equalization provided in SBR systems makes the process resistant to shock loadings. This process is often used for small to medium sized facilities similar to Lunenburg.  There are a number of SBRs in communities throughout Nova Scotia.

This design criteria for this system are summarized in Table 8. The tank footprint is currently shown as approximately 70ft. by 90 ft. The tank geometry (basin length, width, and depth) may change significantly to suit geotechnical conditions (assessed during detailed design phase). The geotechnical conditions on the site are poor, largely attributed to the previous land use as a municipal landfill. This constitutes a risk for this option.

**Table 8: SBR design parameters**

| Parameter | Proposed | Typical Design |
|---|---|---|
| No. of Blowers | 2 Duty +1 Standby | 2 Duty +1 Standby |
| Air flow per blower (SCFM) | 740 | - |
| Air pressure (psig) | 9.1 | - |
| No. of Basins | 2 | Minimum 2 |
| Basin Length (inside, ft) | 86.3 | 3 x width |
| Basin Width (inside, ft) | 28.9 | |
| Side Water Depth (ft) | 18.0 | 12-18 |
| Total Reactor Volume (USgal) | 670,500 | - |
| Design Hydraulic Retention Time (HRT, hr) | 21 | 15-40 |
| Cycles per Reactor per Day (average/peak) | 4-6 | 4-6 |
| React Time (min) (average/peak) | 120/90 | 60-120 |
| Settling Time (min) (average/peak) | 60/30 | 30-60 |
| Volumetric CBOD Loading (kg BOD/$ft^3$/d | 0.006 | 0.003-0.008 |
| Mixed Liquor Suspended Solids (MLSS, mg/L) | 3000 | 2000-5000 |

All existing bioreactor tanks (aeration basins, equalization tank, and sludge tank) will be repurposed as an aerobic sludge digester. Similar to previous options, the solids management system will also require expansion.

The existing blower capacity appears sufficient to provide air flow to both the SBR system and the sludge digester, but this should be looked into in more detail to ensure that it will work. The SBR decant rate at peak flow exceeds the design flow of the UV. Therefore, a new effluent equalization tank must be installed after the SBR in order to balance the flow to the UV and keep it within hydraulic limits. The design criteria for the additional upgrades are described below in Tables 9 and 10.

**Table 9: Equalization Tank Design Parameters**

| Parameter | Proposed |
|---|---|
| Peak Decant Flow Rate (USgpm) | 3,138 |
| Decant Time at PDF (hr) | 1 |
| UV Design Peak Flow Rate (USgpm) | 2,083 |
| EQ Tank Size (USgal) at 1.3-hour retention time | 82,000 |

**Table 10: Digester Design Parameters**

| Parameter | Proposed |
|---|---|
| Sludge to be Treated (kg/d) | 631 |
| Sludge Volume (USgpd) | 8500 |
| Digester Retention Time (days) | 21 |
| Digester Volume (USgal) | 178,000 |
| Aeration Requirement (SCFM) | 306 |

The proposed scope of work for this option includes the following:

- Construction of new tanks to provide a continuous-feed SBR complete with in-tank instrumentation and decanter;
- Construction of an effluent equalization tank complete with discharge pumps;
- Construction of yard pipework to connect existing air pipework to the new SBR tanks; as well as the screened, degritted influent to head of SBR tanks, and to pump SBR effluent to UV system;
- Removal of existing media from the MBBR bioreactor tanks.
- Modification of the bioreactor tankage to hydraulically connect all tanks to increase the sludge tank volume available;
- Removal of the existing DAF units including recirculation pumps and polymer make-down and dosing system; and
- Addition of third channel to the Fournier Press to increase capacity for sludge dewatering by 50%.

This option assumes that the flood control berm, UV expansion, polymer pumps, aeration blowers, headworks screen and compactor, online instrumentation in the bioreactor, standby generator, and mechanical upgrades have been completed already as per the Lunenburg WWTP Near-Term Upgrades Pre-Design Report (CBCL Limited, 2021). The Option 3 arrangement can be seen in PSK03 in Appendix A.

### 4.3.3 Operational Discussion

The operation of an SBR is relatively simple and does not require a high amount of operator intervention. The SBR eliminates the need for separate clarification mechanisms and reduces the amount of equipment requiring operating attention and maintenance. The SBR has highly automated controls that includes instrumentation, automatic valves, and decanters. The increased level of automation requires that the critical items (decanter, valves, etc.) are well maintained to reduce the risk of failure.

Each of the two SBR tanks have operational settings to allow them to process the entire PDF flow temporarily when necessary, to be able to isolate the other tank for maintenance.

The key operational costs associated with a SBR system include labour, maintenance, power, and sludge disposal. Maintenance costs would be somewhat reduced compared to the existing as there is less equipment to maintain. Chemical addition is not required for the use of the SBRs, though it is still required for sludge dewatering.

The Fournier Press requires additional capacity to handle the increase in solids loading to the plant, but operation remains the same. The increase in solids loading to the plant will result in increased sludge hauling and disposal costs, and these will be further increased by a reduction in the sludge cake dryness, since SBR sludge does not dewater as well as DAF sludge. This increases the volume and weight of the sludge for an equivalent solids content.

### 4.3.4 Construction Sequencing

The new SBR and equalization tanks are proposed to be located behind the existing bioreactor building. These can be constructed while the existing plant is in operation. Tie-ins would require a complete bypass for approximately one week. Once connected, the next phase of construction would require bypassing of the bioreactor to allow the modification of the existing bioreactor building as required. This could take 3−6 weeks to complete. Sludge accumulation during this time would be relatively low and removal could be accomplished by vacuum truck. The third rotary press channel could be added at this time. Removals could be undertaken once the SBR process was fully operational. This option includes significant changes to the overall controls system. It includes a change in treatment technology (lack of operator familiarity). There are moderate challenges in the construction sequencing of this option.

Similar to other options, a TBA will be required for any process bypasses and an Approval to Construct and Operate must be obtained from NSECC prior to construction. The overall construction and sequencing plan would be developed by the contractor in close consultation with the Town's Engineering and Operations team to minimize process disruptions.

## 4.4 Option 4: MBR

### 4.4.1 Technology Overview

The Membrane Bio-Reactor (MBR) process uses an aerobic suspended-growth (activated sludge) biological treatment process followed by a membrane filtration system. The key feature of the MBR system is the membrane filtration system that allows for elevated levels of biomass to remove organics from the wastewater, as well as very good solids removal. The effluent flows through the membrane, but the biomass and solids cannot pass through and are retained in the bioreactor system.  The suspended biomass is recycled to the head of the biological reactor and mixed with the influent wastewater stream to effectively remove organic matter.  The biomass in an MBR is suspended in the wastewater rather than being attached to plastic media as in an MBBR system. Similar to the SBR, sludge wasting is required periodically to reduce sludge build up and control the solids retention time within the MBR system. A typical schematic of the system is shown in Figure 9.

Benefits of an MBR system include a compact footprint and tertiary quality effluent without secondary clarification. However, they are often not cost-effective if regulatory effluent requirements do not specifically require their use. The membrane system can be damaged by large or stringy solids, therefore use of the MBR process requires a higher degree of fine screening (0.07", or 2 mm, drum screen) than the other options.

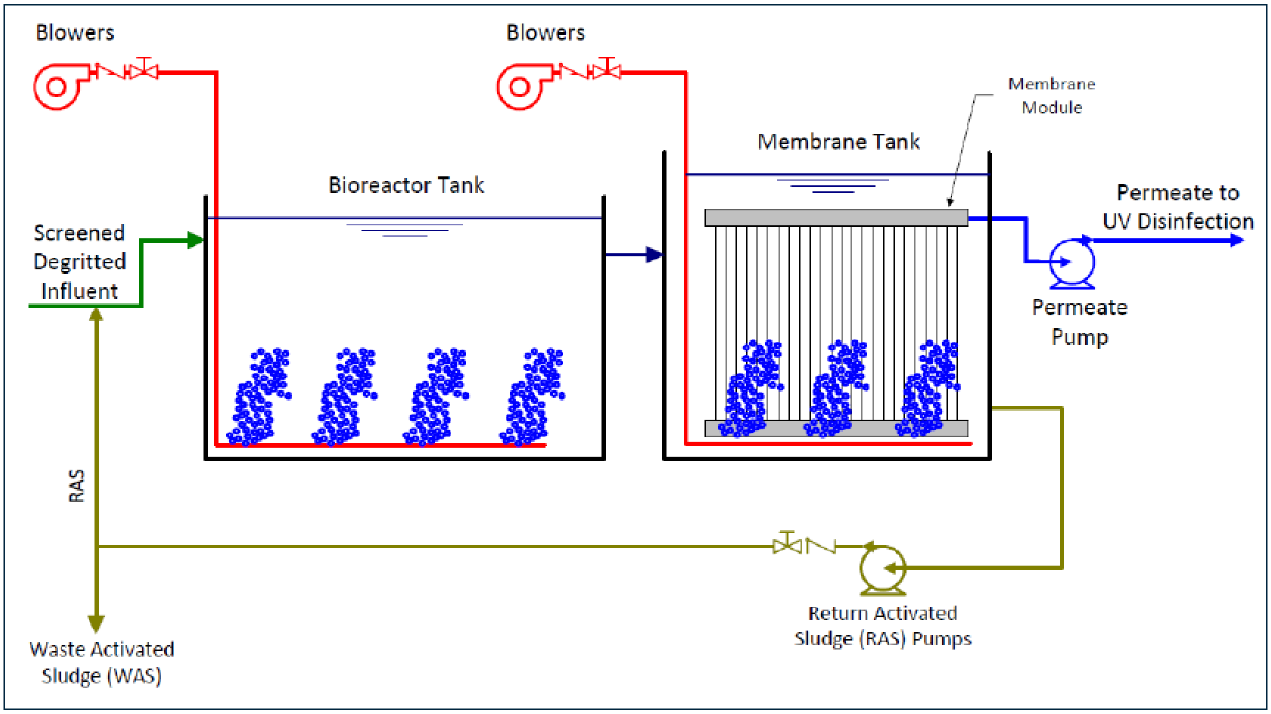



**Figure 9: Typical MBR Operation**

There are two basic configurations for membranes: hollow fiber bundles and plate membranes. The proposed installation includes hollow fibre tubular membranes bundled together. Bundles of membranes are grouped together and connected by manifolds into units that can be changed out for maintenance. Hollow fibre membrane systems are more common for wastewater applications than plate membranes.

**Figure 10: Membrane Module for Installation**

### 4.4.2 Option Description and Design Criteria

The MBR system would make use of the existing aeration tanks, equalization tank and sludge tank as a bioreactor tank. A new process building (approximately 70 ft. by 75 ft.) would be constructed to house the MBR equipment, including the membrane filtration trains, air compressor, blowers, back pulse water tank, sludge holding tank, and drum screening room. The building would include a general process area and electrical/control room.

The wastewater would first be screened and degritted in the existing headworks, and then would flow to the new screening room located in the new process building for additional 2 mm fine screening. The wastewater would enter the repurposed bioreactor from the east side of the bioreactor building as it does now, and be aerated with the existing aeration system, though with aerator changes to the equalization and sludge tanks. Flow from the bioreactor building would flow to the membrane filtration trains for solids removal. The permeate from the membrane will then flow to the existing process room for UV disinfection and effluent pumping. WAS will be directed to the sludge holding tank, while backwash water is directed to the head of the plant.

The design criteria for this option are summarized below in Table 11. Similar to the SBR, the tank and building geometry (length, width, and depth) may change significantly to suit geotechnical conditions. This constitutes a risk for this option.

**Table 11: MBR Design Parameters**

| Parameter | Proposed |
|---|---|
| No. of blowers | 2 Duty +1 Standby |
| Air flow per blower (SCFM) | 1050 |
| Air pressure (psig) | 7.5 |
| No. of Trains | 2 |
| No. of Cassettes per Train | 4 |
| No. of Modules | 320 |
| Total Reactor Volume (USgal) | 178,000 |
| Mixed Liquor Suspended Solids (MLSS, mg/L) | 8000 |

The proposed scope of work for this option includes the following:

- Removal of existing media from the MBBR bioreactor tanks;
- Modification of the bioreactor tankage to hydraulically connect all tanks to increase tankage
- Removal of existing coarse bubble aeration system from equalization and sludge tanks and replacement with a corrosion-resistant fine bubble aeration system for increased oxygen-transfer capacity;
- Installation of additional process instrumentation;
- Construction of new process building containing a 2 mm drum screen, a process area with blowers and compressors, a control room, a membrane filtration tank for the membrane cassettes, back-pulse water tank, and a sludge holding tank;
- Removal of the existing DAF units including recirculation pumps and polymer make-down and dosing system; and
- Addition of third channel to the Fournier Press

This option assumes that the flood control berm, UV expansion, polymer pumps, aeration blowers, headworks screen and compactor, online instrumentation in the bioreactor, standby generator, and mechanical upgrades have been completed already as per the Lunenburg WWTP Near-Term Upgrades Pre-Design Report (CBCL Limited, 2021). The Option 4 arrangement can be seen in PSK04 in Appendix A.

### 4.4.3 Operational Discussion

The operation of an MBR plant would be significantly different than the current MBBR and DAF process at the plant, though it is similar to the processes at the Town's Water Treatment Plant. It would likely require the Town to support the Operator in Direct Responsible Charge (ODRC) to upgrade to a Class III Wastewater Treatment certification, or to recruit a new Class III operator to take on the role of ODRC. Either way, an additional staff member would be required for maintenance of the added equipment and processes.

There would be very low risk of solids carryover in the effluent, and effluent quality would be enhanced to a target of 5 mg/L of both CBOD and TSS. There would be no requirement to use polymer in the wastewater treatment process, so risk of polymer carryover would be eliminated.

MBR systems require additional pumping to push the water though the membranes and to recirculate the solids through the bioreactor. The membrane filtration process also requires multiple cleaning systems to extend the membrane life and keep the system in operation. The primary cleaning system uses an air scour technique to reduce material build-up on the membranes, which uses air bubbles to move the membranes and dislodge solids. The secondary cleaning system uses a back-pulsing technique in which permeate is pumped backwards though the membranes to keep the pores clean. Finally, the membranes require periodic chemical clean-in-place operational procedures to remove scale and resistant organics. Clean in place chemicals and waste are recycled to the head of the plant.

The largest cost of the MBR system is the maintenance of the membrane units. Membrane units require periodic replacement. The period of replacement can be influenced by several factors, including effectiveness of upstream screening, operational throughput of the membranes, and proper cleaning. Effective upstream screening refers to the additional fine screening to prevent large solids from physically damaging the membranes. Operating the membranes at the appropriate throughput rate and operating within the system limits of design will reduce wear on the membranes.

The Fournier Press requires additional capacity to handle the increase in solids loading to the plant, but operation remains the same. The increase in solids loading to the plant will result in increased sludge hauling and disposal costs, and these will be further increased by a reduction in the sludge cake dryness, since MBR sludge does not dewater as well as DAF sludge. This increases the volume and weight of the sludge for an equivalent solids content.

Electricity and labour costs would increase significantly with an MBR system compared to the existing MBBR system. Electricity costs are typically higher with MBR systems due to the additional pumping and energy demand of the equipment. The labour costs increase as the MBR system would require an additional full-time Class III operator at the plant. Maintenance costs may also be high, to account for replacement membranes, maintaining additional equipment, clean-in-place chemicals, and the labour associated with these works.

### 4.4.4 Construction Sequencing

The new process building is proposed to be located behind the existing bioreactor building. It can be constructed while the existing plant is in operation. The new drum screen, sludge tank, and membrane equipment housed in the building can also be constructed without disruption to the existing plant. Once these are complete, the tie-ins and changeover would require complete bypass of the bioreactor and solids removal system to modify the existing bioreactor building as required. This could take 3–6 weeks of continuous bypass to complete. This option includes significant changes to the overall controls system. It includes a change in treatment technology and lack of operator familiarity. There are considerable challenges in the construction sequencing of this option.

## 4.5 Option 1A: Polishing with a Disk Filter

### 4.5.1 Technology Overview

A disk filter uses woven cloth filters mounted on multiple disks which provide a large filter area in a small footprint. The disk filter is used to remove TSS and excess polymer from the effluent prior to disinfection and discharge.

The proposed disk filter has an outside-in flow pattern and stationary disks. As the water passes from the tank through the cloth filter, it enters the core of each disk module. The water exits each disk through a discharge channel. By having a separate effluent port for each disk, each disk can be individually monitored and may be isolated for maintenance or replacement. Filtration can continue as normal with one or more disks isolated. Removal of a disk and replacement of the cloth media can be accomplished in about 1 hour, according to the manufacturer, minimizing downtime.

**Figure 11: Disk Filter**

### 4.5.2 Option Description and Design Criteria

The disk filter can be used as an addition to Option 1, or 2 if more stringent effluent criteria is expected at the plant in the future. The disk filter would provide effluent polishing for enhanced solids removal to produce effluent concentrations as low as 5 mg/L CBOD and TSS, depending on the upstream treatment and filter operations. This option would be most applicable to Options 1 and 2 as the expected effluent concentrations from either process is approximately 20 mg/L CBOD and TSS. The SBR could produce final effluent concentrations of 15 mg/L CBOD and TSS and would only require the disk filter option if the limits were below 15 mg/L, but would have a different arrangement, not detailed here.

The disk filter could also be used to reduce polymer discharge from the plant so that it cannot enter Lunenburg Front Harbour. This would not be an alternative to relocating the outfall, but could further reduce the effect of the effluent on the receiving water. Additional steps to better target polymer dosing and reduce polymer overdosing are recommended as well.

The disk filters would be implemented upstream of the UV to improve disinfection and reduce UV maintenance. This would require the disk filters, the UV system, and the effluent pumps to all be housed in a new building (approximately 44 ft. by 26 ft.) north of the existing bioreactor. In this option intermediate pumping of the clarified effluent from the DAF to the new disk filter building would be required.

The intermediate pumps could be installed in the existing effluent pump location. The existing UV units could possibly be relocated to the new disk filter building, though for construction sequencing purposes it might be preferable to replace some or all parts of the system.

The proposed design criteria for the disk filter is shown below in Table 12.

**Table 12: Disk Filter Design Parameters**

| Parameter | Proposed |
|---|---|
| Filter Headloss (psi) | 11 |
| Total number of Filters | 2 |
| Configuration | 2x 50% duty, no standby |
| Area per filter ($ft^2$) | 430 |
| Duty filtration area ($ft^2$) | 860 |
| Hydraulic Loading Rate ($gal/ft^2h$) | 860 |
| Surface solids loading rate ($kg/ft^2d$) | 0.13 |

The proposed scope of work for this option includes the following:

- Construction of new process building containing two disk filter units, a control room, the UV system, and the relocated final effluent pumps;

- Installation of intermediate pumps in the existing final effluent pump wet-well; and
- Modification of the yard piping to provide an intermediate forcemain to the new process building, as well as reconnection of the final effluent pumps to the effluent forcemain.

This option assumes that the flood control berm, UV expansion, polymer pumps, aeration blowers, headworks screen and compactor, online instrumentation in the bioreactor, standby generator, mechanical upgrades, DAF manifolded manual weirs, polymer makedown equipment, and compressor pipework items have been completed already as per the Lunenburg WWTP Near-Term Upgrades Pre-Design Report (CBCL Limited, 2021). The Option 1A arrangement can be seen in PSK05 in Appendix A.

### 4.5.3 Operational Discussion

The operation of the disk filter is automated and designed to require little operator intervention. In normal operation, solids accumulate on the outer surface of the cloth media, and a thin filter cake forms, raising headloss through the media. The tank level gradually rises to a set point level that triggers backwash operation. The backwash cleaning system initiates automatically without operation action required. Electronically controlled backwash valves direct suction from a sequence of disks, minimizing peak backwash flow and required power consumption. Influent to the disk filter can continue throughout the backwash cleaning cycle allowing for uninterrupted filtration. Sludge from backwashing would be pumped to the sludge tank for dewatering with the DAF sludge.

The addition of the disk filter requires daily inspection from the operator that will take approximately half an hour per day. It is assumed that this can be accommodated with the existing operations staff. The media elements require annual replacement.

### 4.5.4 Construction Sequencing

The new disk filter building could be constructed while the existing treatment plant is in full operation, but some shutdowns would be required for tie-ins and during relocation of the effluent pumps and UV. The plant would likely need to bypass disinfection and the final effluent pumps for two to three weeks.  This means that the secondary quality, but non-disinfected effluent would go through the emergency overflow to Lunenburg Back Harbour.  This construction sequence has moderate challenges.

A TBA will be required for any process bypasses, which must be obtained from Environment Canada under the terms of the WSER legislation. An Approval to Construct and Operate must be obtained from NSECC before beginning construction. The overall construction and sequencing plan would be developed by the contractor working together with the Town Engineering and Operations team with the goal of minimizing process disruptions.

# Chapter 5 Evaluation of Options

## 5.1 Capital Cost Comparison

The opinion of probable costs have been developed based on experience, qualifications and best judgement. The probable costs have been prepared in accordance with acceptable principles and practices. Market trends, non-competitive bidding situations, unforeseen site conditions, unforeseen labour, material adjustments, and the like are beyond the control of CBCL. As such, we cannot warrant or guarantee that actual costs will not vary from the opinion provided.

The costs associated with the recommended upgrades to the WWTP are shown below, in 2021 dollars, with no allowance for inflation. The opinions of cost include allowances for engineering and contingencies for unforeseen changes during design and construction. The Engineering allowance is indicative only. The summarized costs are in Table 13.

**Table 13: Opinion of Probable Costs**

| Summary Sheet | MBBR | MBBR + DAF | SBR | MBR | MBBR + DISK |
|---|---|---|---|---|---|
| | Option 1 | Option 2 | Option 3 | Option 4 | Option 1A |
| Mobilization | $76,000 | $157,000 | $220,000 | $230,000 | $222,000 |
| Building Modifications | - | $181,000 | $26,000 | $293,000 | $385,000 |
| Site Works/New Tanks | - | - | $1,822,000 | $1,679,000 | $469,000 |
| Metals | $52,000 | $127,000 | $41,000 | $75,000 | $52,000 |
| Process Equipment | $851,000 | $2,718,000 | $937,000 | $1,923,000 | $2,307,000 |
| Mechanical | $75,000 | $416,000 | $615,000 | $601,000 | $358,000 |
| Electrical | $86,000 | $454,000 | $600,000 | $557,000 | $586,000 |
| **Sub Total** | **$1,140,000** | **$4,053,000** | **$4,261,000** | **$5,358,000** | **$4,379,000** |
| Design Development Contingency (20%) | $228,000 | $810,600 | $852,200 | $1,071,600 | $875,800 |
| Construction Contingency (10%) | $114,000 | $405,300 | $426,100 | $535,800 | $437,900 |
| Engineering (10%) | $114,000 | $405,300 | $426,100 | $535,800 | $437,900 |
| **Total** | **$1,596,000** | **$5,674,200** | **$5,965,400** | **$7,501,200** | **$6,130,600** |

All of the options assume that a number of Near-Term upgrade items have been completed. For Options 1 and 1A, all the Near-Term items are assumed to be complete. For Option 2, all Near-Term items except the DAF manifolded manual weirs are assumed to be complete. For Option 3 and 4, all Near-Term items except for the DAF manifolded manual weirs, DAF polymer makedown, and compressor pipework are assumed to be complete, and the cost of the Polymer pumps are reduced to $40,000, to ensure they can operate until the expansion is complete.

The costs for each of these are laid out in Table 14, along with an Overall Total for the option. These totals are capital costs only and do not account for the potentially differing timing of the expenses.

**Table 14: Overall Opinion of Probable Capital Cost for Long-Term Expansion with Near-Term items included**

| Summary Sheet | MBBR | MBBR + DAF | SBR | MBR | MBBR + DISK |
|---|---|---|---|---|---|
| | Option 1 | Option 2 | Option 3 | Option 4 | Option 1A |
| Long Term Expansion | $1,596,000 | $5,674,200 | $5,965,400 | $7,501,200 | $6,130,600 |
| Near-Term Items | $3,593,000 | $3,433,000 | $2,934,000 | $2,934,000 | $3,593,000 |
| **Overall Total** | **$5,189,000** | **$9,107,200** | **$8,899,400** | **$10,435,200** | **$9,723,600** |

## 5.2 Operational Cost Comparison

Operations and Maintenance (O&M) costs were developed for the options based on experience and operation of similar facilities, coupled with historical costs for the existing facility and details from equipment suppliers. A comparison of the operational costs are shown in Table 15 below. Operational Costs are broken into five (5) categories: power; labour; sludge disposal; supplies, equipment, parts; and chemicals.

Power refers to the anticipated electrical costs. Labour refers to costs associated with operational staff, and should be taken as comparative, rather than absolute. Sludge disposal refers to the cost to haul and dispose of sludge and varies based on amount and the sludge dryness. Supplies, Equipment & Parts refers to anticipated spare parts/supplies for maintenance of each option, including membrane replacement. Chemical costs refers to the cost of polymer or other chemicals used for each option. All costs are represented on an annual basis.

**Table 15: Operational Cost Comparison (per year)**

| Category | Current | MBBR | MBBR+ DAF | SBR | MBR | MBBR+ DISK |
|---|---|---|---|---|---|---|
| | No Expansion | Option 1 | Option 2 | Option 3 | Option 4 | Option 1A |
| Power | $219,000 | $219,000 | $225,000 | $189,000 | $264,000 | $227,000 |
| Labour | $140,000 | $140,000 | $140,000 | $140,000 | $200,000 | $140,000 |
| Sludge Disposal | $61,000 | $91,000 | $91,000 | $125,000 | $125,000 | $100,000 |
| Supplies, Equipment & Parts | $19,000 | $28,000 | $28,000 | $25,000 | $56,000 | $32,000 |
| Chemicals | $39,000 | $30,000 | $25,000 | $15,000 | $18,000 | $44,000 |
| **Total O&M Costs** | **$478,000** | **$508,000** | **$509,000** | **$494,000** | **$663,000** | **$543,000** |

## 5.3 Technological Fit Comparison

There are a variety of different processes proposed, which also vary in their technological fit with the Town's wastewater treatment needs.

Either of the upgraded MBBR-DAF processes (Options 1 and 2) would be somewhat more complex than an SBR to operate, but would be similar to existing. Both would require consistent chemical dosing and good dosing control to meet wastewater quality objectives suited to a relocated outfall. This type of process is able to treat the wide range of flows and loads that the WWTP receives, because the microbes that make up the heart of the treatment process are attached to media so they are resistant to being flushed out during high flow conditions. Nonetheless, they require more equipment and they are unusual for this region, so maintenance requirements are higher and the operators cannot get advice on the process from local counterparts. The effluent quality from this process is comparable to that from an SBR process. In order to ensure that polymer is not entering the harbour, it is possible to add a polishing process such as a disk filter. This is also a future-proofing option if effluent standards rose in future to a level that this process could not reliably and continuously meet.

The most straightforward process of these is Option 3 (SBR), which uses only air and settling to produce good quality effluent that would be well suited to a relocated outfall. This process is largely automated and uses no chemicals. It reduces the amount of equipment to be maintained overall, resulting in simplified maintenance. This process is moderately resilient during quickly changing flows, but has programmed responses to allow it to adapt to the changing conditions. This is a very reliable process with low maintenance down-time required, because there are fewer pieces of equipment required.

The Option 4 (MBR) process is the most complex, even though it is also highly automated. By passing all flow through a membrane, it produces very good quality effluent, but this means that the membranes must be carefully protected from everything that could damage them, including from chemicals dumped inappropriately into the sewer. The membranes require additional headworks equipment to remove stringy material that can wrap around the membrane fibres, as well as any sharp objects. The membrane banks have a dedicated cleaning system to remove excess bacterial build up from the membrane surface. This process is also well suited to variable flows and loads because the key microbes cannot pass through the membrane and are retained in the plant. A program to periodically replace the membrane modules is required to ensure that they are kept in good repair. This membrane filtration process is familiar to Town staff because it is similar to the process in the water treatment plant, though with the addition of a biological treatment process as well. This process produces the highest quality effluent, which in fact is higher than would be typically required by regulators for marine receiving water. If the Town does not want to relocate the outfall, then this process would be the best suited, though the existing location still risks public exposure to undiluted effluent and is not recommended.

## 5.4 Regulatory Risk Comparison

Option 1 (MBBR with existing DAF) has a moderate regulatory risk, because the DAF units would be operating closer to their capacity limit, and there is a risk that peak solids loads could exceed the DAF design capacity.

Option 2 (MBBR with replacement DAF) has a low regulatory risk. It is sized for the expanded load, and this technology can reliably meet the current effluent criteria.

Option 3 (SBR) has a low regulatory risk. SBRs normally produce effluent that meets or exceeds the current effluent criteria.

Option 4 (MBR) has the lowest regulatory risk, because the effluent quality produced is significantly better than that currently required by the regulators, so it is unlikely to produce non-compliant effluent as long as it is well maintained.

Option 1A (MBBR with existing DAF with added disk filter) has a low regulatory risk This process would be able to produce very good, compliant effluent, and could be used to reduce regulatory risk of other options.

## 5.5 Operational Risk Comparison

Option 1 (MBBR with existing DAF) has a low-moderate operational risk. This process shows potential to use a lower polymer dose than the existing DAFs currently do, if ongoing experimental trials are successful, and combined with additional controls as presented in the parallel Near-Term Upgrades Pre-design Report (CBCL Limited, 2021). Lowering the dose could reduce the risk of solids and polymer carryover. The lamella plates in the existing DAFs will still need to be cleaned regularly, which is an ongoing maintenance issue.

No additional pumping would be required. The MBBR-DAF process is a reliable process, but has a fairly high number of pieces of equipment to maintain.

Option 2 (MBBR+DAF) has a low-moderate operational risk. The main process equipment would be supplied as a package in this case, which means that it is intended to work together as a unit, and gives one point of contact if there are process or maintenance issues. This process would use polymer less often than the existing DAFs currently do, and has a smaller risk of solids and polymer carryover. It would eliminate the current issue with cleaning the lamella plates in the DAFs. Pumping would be required from the MBBR to the DAFs, adding a new set of pumps to maintain. The MBBR-DAF process is a reliable process, but has a fairly high number of pieces of equipment to maintain. For Option 2 the Town could subscribe to a manufacturer program for online monitoring and process assistance in order to have additional notice of required maintenance, and ongoing technical support.

Option 3 (SBR) has low operational risk, and it is more resilient to the types of material coming into the plant that could damage an MBR. Since it requires no chemicals, then there are fewer supply chain risks than with a DAF process, and the risk of releasing polymer to the harbour is eliminated. However, SBRs are not as good as MBBRs at retaining the microbes in a high flow scenario because the microbes are suspended in the water rather than being attached to the media. Pumping would be required from the SBR to the UV, adding a new set of pumps to maintain. The SBR process is very reliable with low maintenance down-time required, partly because there are fewer pieces of equipment required, and also because they are very robust.

Option 4 (MBR) has a significant amount of operational risk, because the membranes can be damaged by chemicals, as well as stringy and sharp materials. Efforts to prevent chemicals entering the sewer or to remove stringy and sharp objects in the headworks are critical to managing the operational risk of membrane failure, which requires expensive replacement membranes, even though it does not usually result in rapid regulatory non-compliance. The WWTP has received material several times in the past that left sticky white residue all over equipment in the plant, as well as making the effluent cloudy, and visible in Lunenburg Front Harbour. It is likely (though not certain) that the membranes could remove this material, but also likely that they would be damaged by this or similar substances. Pumping would be required through the membranes, adding a new set of pumps to maintain, as well as additional blowers and chemical clean-in-place equipment. The MBR process is very reliable but has higher maintenance down-time required, and is vulnerable to failure of screening, as well as to non-standard influents such as that described above.

Option 1A (MBBR with existing DAF with added disk filter) has a low operational risk. This process would have low risk of polymer or solids carryover. The lamella plates in the existing DAFs will still need to be cleaned regularly, which is an ongoing maintenance issue, and there would be additional maintenance needed on the disk filter, as well as an additional set of pumps to maintain for intermediate pumping.  The disk filter adds reliability to the MBBR-DAF process by preventing solids or polymer carryover, but it also increases the amount of equipment to be maintained.

## 5.6 Construction Risk Comparison

Construction risks vary widely with these options, notwithstanding that some construction risks, by their nature, will not be identified until construction is underway.  The option with the lowest apparent construction risk is Option 1 (MBBR with existing DAF), which requires the least amount of alterations to existing structures and processes. Very low bypass duration would be anticipated with this option, and the risk of encountering poor geotechnical conditions on the site is minimized.

Option 2 (MBBR+DAF) has moderate construction risks, requiring significantly more alterations to existing buildings and equipment, as well as longer process bypasses, but with low risk of encountering poor geotechnical conditions.

Option 3 (SBR) has moderate construction risks.  Most of the work can be done without interference with existing processes, and the process bypass requirements are low. However, the risk of encountering poor geotechnical conditions on the site is high.  This would require a significant geotechnical investigation to determine appropriate design conditions, and may require substantial over-excavation and replacement with structural fill to provide a suitable base for the tanks.  Groundwater may also pose challenges on the site.

Option 4 (MBR) has the highest construction risk. Much of the work can be done without interference with existing processes, but process bypass requirements would be relatively high, comparable to Option 2. The risk of encountering poor geotechnical conditions on the site is high, comparable to Option 3, with a similar footprint.  This would require a significant geotechnical investigation to determine appropriate design conditions, and may require substantial over-excavation and replacement with structural fill to provide a suitable base for the tanks. Groundwater may also pose challenges on the site, though not to the same degree as with Option 3, because the tanks would be somewhat shallower.

Option 1A (MBBR with existing DAF with added disk filter) has moderate construction risks. Most of the work can be done without interference with existing processes, and the process bypass requirements are low, but the risk of encountering poor geotechnical conditions on the site is moderate compared to Options 3 and 4.  This would still require a significant geotechnical investigation to determine appropriate design conditions, and may require substantial over-excavation and replacement with structural fill to provide a suitable base for the building.  Groundwater may also pose challenges on the site, but to a lesser degree than Options 3 and 4.

## 5.7 Summary of Options

The following table summarizes the information in the sections above to give a simplified comparison of all the information.

**Table 16: Summary of Options**

| Category | MBBR | MBBR + DAF | SBR | MBR | MBBR + DISK |
|---|---|---|---|---|---|
| | Option 1 | Option 2 | Option 3 | Option 4 | Option 1A |
| Capital Cost | $1,596,000 | $5,674,200 | $5,965,400 | $7,501,200 | $6,130,600 |
| Operational Cost | $508,000 | $509,000 | $494,000 | $663,000 | $543,000 |
| Technological Fit | No change | No change | Good | Acceptable | Acceptable |
| Regulatory Risk | Moderate | Moderate | Low | Lowest | Low |
| Operational Risk | Moderate | Moderate | Lowest | Highest | Low |
| Construction Risk | Lowest | Moderate | Moderate | Highest | Moderate |

# Chapter 6 Recommended Upgrade

A Kepner Tregoe Decision Analysis Workshop was held with Town Staff on July 20 and 21, 2021, to fully discuss, evaluate, compare, and score each of the options. The resulting team decision was that Option 3 (SBR), with the highest score, was the preferred expansion option.

## 6.1 Description of Upgrade

Option 3 (conversion to SBR) is the recommended option for expansion. This includes replacing the current MBBR-DAF process with a Sequencing Batch Reactor process. This option assumes that the flood control berm, UV expansion, aeration blowers, headworks screen and compactor, online instrumentation in the bioreactor, standby generator, and mechanical upgrades have been completed prior to the capacity expansion.

Wastewater would enter the headworks for screening using the upgraded screen, and then pass through the grit removal tanks. Screened, degritted wastewater would flow by gravity to new SBR tanks to be constructed behind the existing bioreactor building. Here the wastewater would be aerated by the recently replaced blowers for biological treatment and then the air would be turned off to allow solids to settle out. The clear supernatant would be decanted from the top of the tank to a new equalization tank. From here it would be pumped to the expanded UV system for disinfection, and then it would flow to the effluent lift station to be pumped to the outfall.

Waste sludge would be pumped from the SBR tanks to the Aerobic Digester, which would be created by modifying the existing bioreactor building. The sludge would be aerated to break it down and stabilize it, and then dewatered using an expanded Fournier Press with a third channel prior to disposal off-site.

## 6.2 Key Reasons for Recommendation

The following factors contributed to the recommendation of Option 3 as the preferred option:

- Very reliable and consistent operations;
- Good resilience to changing influent conditions;
- No polymer required for process, so no risk of polymer carry-over;

- Low risk of odour generation;
- Acceptably short tie-in shutdowns during construction;
- Widely used by municipalities in the Maritimes; and
- Reduced maintenance and annual operational costs.

## 6.3 Risks to be Mitigated

A key construction risk with this option is the high likelihood of encountering poor geotechnical conditions on the selected site, which is a former landfill. To mitigate this risk, it is proposed to carry out a thorough and extensive geotechnical investigation prior to detailed design, to determine appropriate design conditions and a recommended technical approach to building these tanks. Construction of the SBR tanks may require substantial over-excavation and replacement with structural fill to provide a suitable base for the tanks, or it may be more cost-effective to use piles. A higher-than-typical design development contingency is recommended to be carried at this stage to ensure that funding is adequate to carry out the project. A strong construction contingency budget should also be considered, to adapt to unforeseen changes during construction.

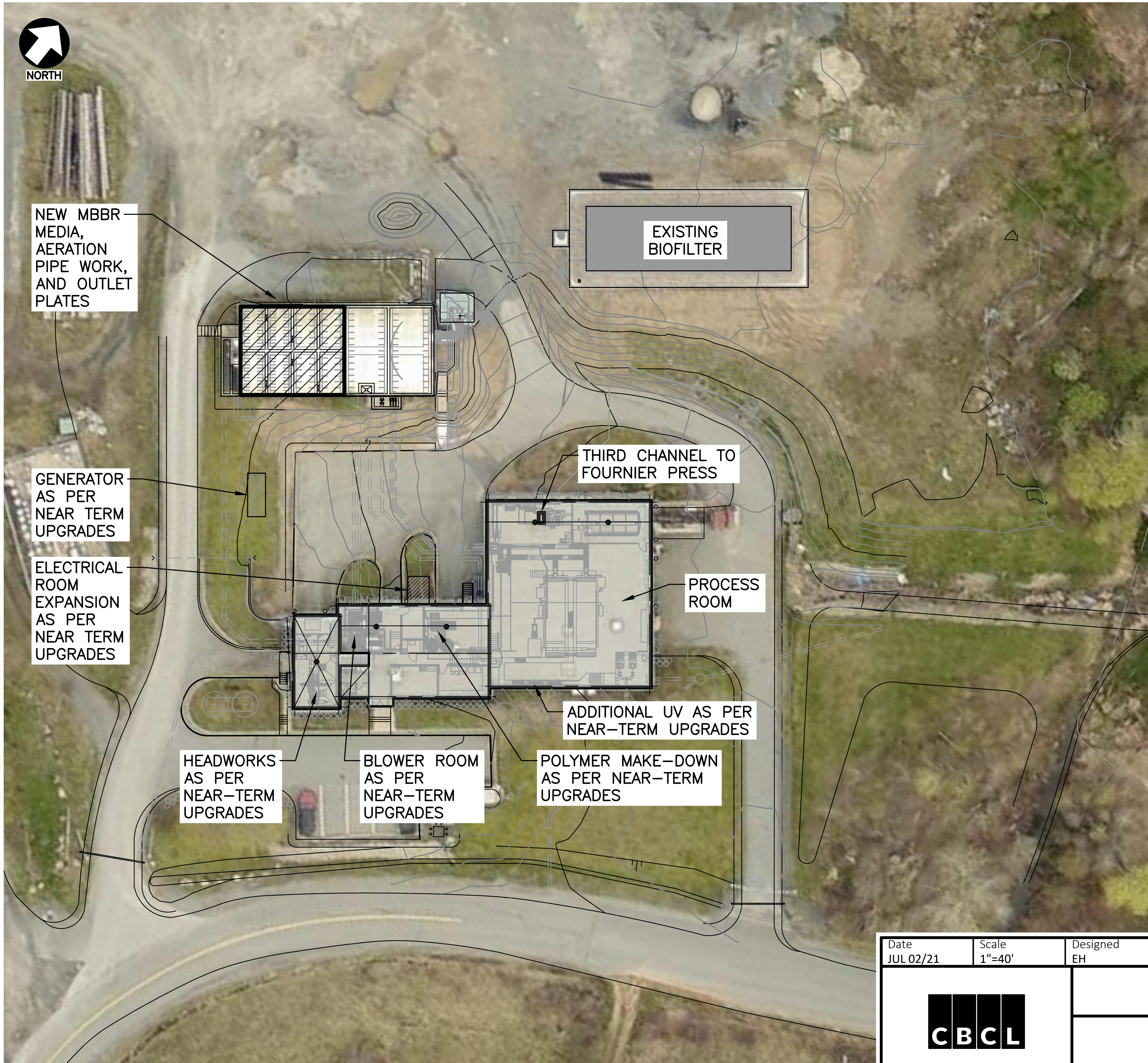
## 6.4 Next Steps

The next steps for proceeding to detailed design and construction of this option are as follows:

1. Submit report to NSECC for comment;
2. Continue to collect routine influent samples to provide data for future process sizing;
3. Continue steps to exclude seawater from the collection system;
4. Develop plan to construct required Near-Term items;
5. Develop plan for strategic sewer separation;
6. Apply for funding;
7. Procure and carry out predesign of SBR expansion, including geotechnical investigation;
8. Procure and carry out detailed design of SBR expansion, to produce tender package;
9. Submit Application for Approval to NSECC;
10. Tender construction of the expansion; and
11. Construct SBR expansion.

# APPENDIX A

## Sketches: Options for Expansion




## NOTES:

1. NEW MBBR MEDIA, AERATION EQUIPMENT, AND MEDIA RETENTION SIEVES.
2. EXISTING DAF UNITS RETAINED.
3. EQUALIZATION TANK AND SLUDGE TANK RETAINED. NEW AERATION PIPEWORK PROVIDED IN THESE TANKS.
4. BLOWERS, POLYMER MAKE-DOWN, POLYMER DOSING, UV, INLET SCREEN AND GENERATOR PROVIDED AS PER NEAR-TERM UPGRADE.

| Date | Scale | Designed | Drawn | Checked | Approved | CBCL No. | Contract |
|---|---|---|---|---|---|---|---|
| JUL 02/21 | 1"=40' | EH | NHM | - | - | 210803.01 | - |

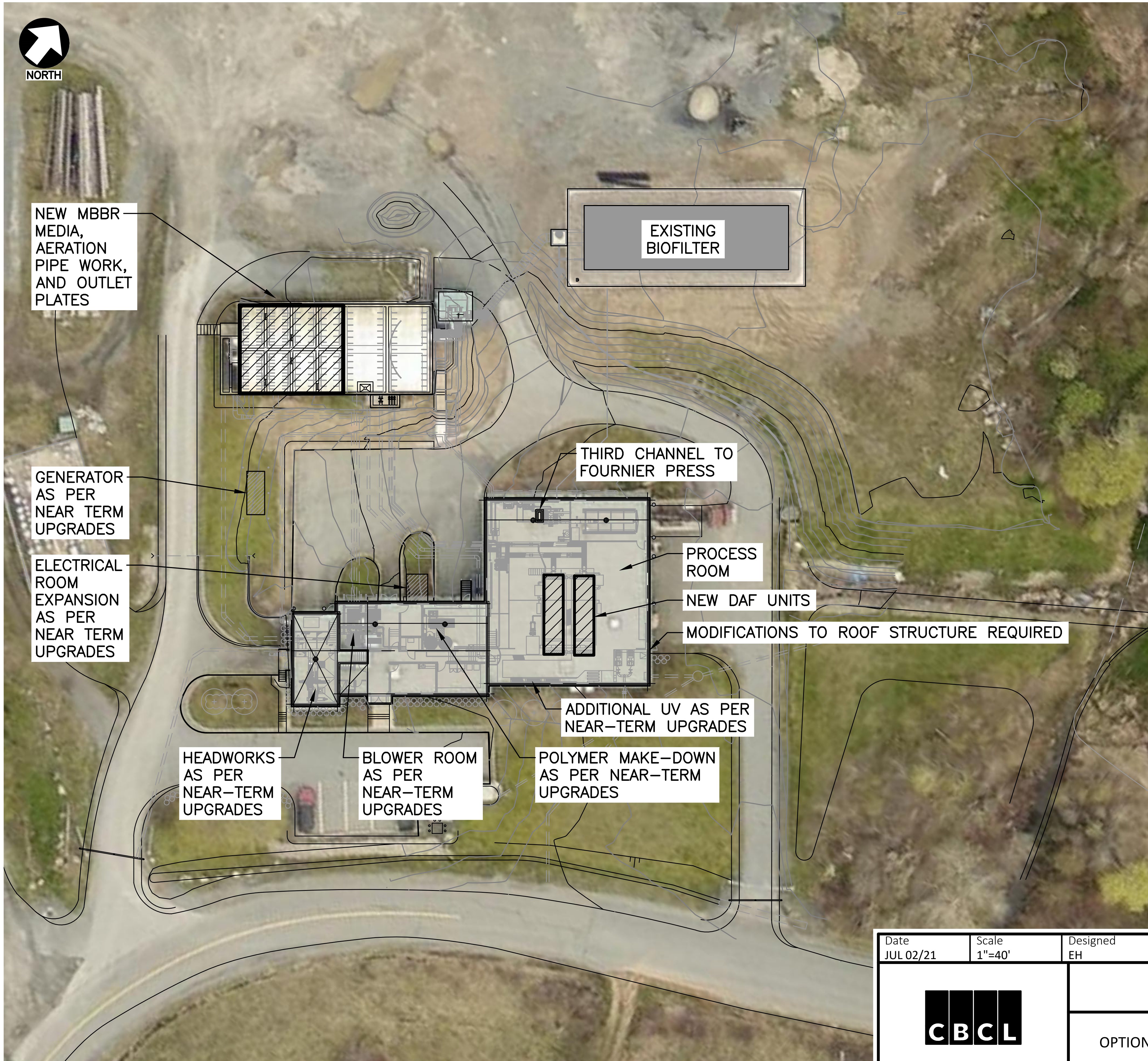
CBCL

TOL WWTP LONG TERM OPTIONS

OPTION 1 - MBBR UPGRADE

Drawing
**PSK01**

DRAWING NAME: Y:\HALIFAX\DATA\PROJECTS\210803.01 TOL WWTP & OUTFALL PREDESIGN AND BCA\44 CAD\06 PROCESS\210803.01_PSK01 LT OPTION 1.DWG LAYOUT NAME: PSK01 PLOT DATE:July 1, 2021 3:58:36 PM CAD OPERATOR: NOELM




## NOTES:

1. NEW MBBR MEDIA, AERATION EQUIPMENT, AND MEDIA RETENTION SIEVES.
2. NEW DAF UNITS INSTALLED.
3. EQUALIZATION TANK AND SLUDGE TANK RETAINED. NEW AERATION PIPEWORK PROVIDED IN THESE TANKS.
4. BLOWERS, POLYMER MAKE–DOWN, POLYMER DOSING, UV, INLET SCREEN AND GENERATOR PROVIDED AS PER NEAR–TERM UPGRADE.
5. MODIFICATIONS REQUIRED TO PROCESS ROOM ROOF STRUCTURE TO INSTALL NEW DAF UNITS.

| Date | Scale | Designed | Drawn | Checked | Approved | CBCL No. | Contract |
|---|---|---|---|---|---|---|---|
| JUL 02/21 | 1"=40' | EH | NHM | - | - | 210803.01 | - |

CBCL

TOL WWTP LONG TERM OPTIONS

OPTION 2 - MBBR UPGRADE AND DAF REPLACEMENT

Drawing

**PSK02**

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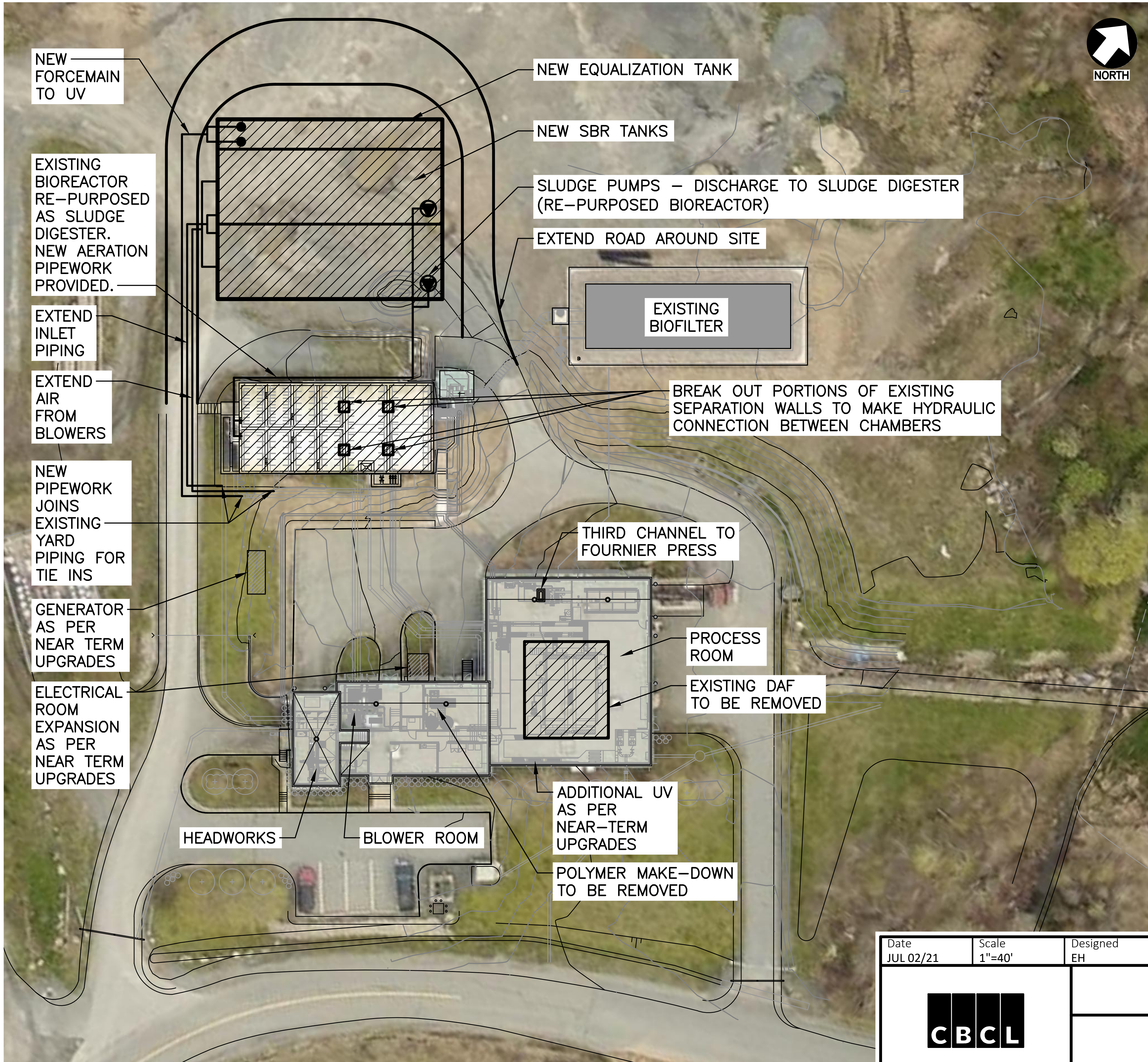



## NOTES:

1. TWO-TRAIN SBR SYSTEM WITH EFFLUENT EQUALIZATION TANK.
2. EXISTING BIOREACTOR RE-PURPOSED AS A SLUDGE DIGESTER TANK.
3. BLOWERS, UV, INLET SCREEN AND GENERATOR PROVIDED AS PER NEAR-TERM UPGRADE.
4. EXISTING BLOWERS TO FEED SBR AND SLUDGE DIGESTER.
5. EXISTING DAFs, POLYMER MAKE-DOWN, AND POLYMER DOSING TO BE REMOVED.

| Date | Scale | Designed | Drawn | Checked | Approved | CBCL No. | Contract |
|---|---|---|---|---|---|---|---|
| JUL 02/21 | 1"=40' | EH | NHM | - | - | 210803.01 | - |

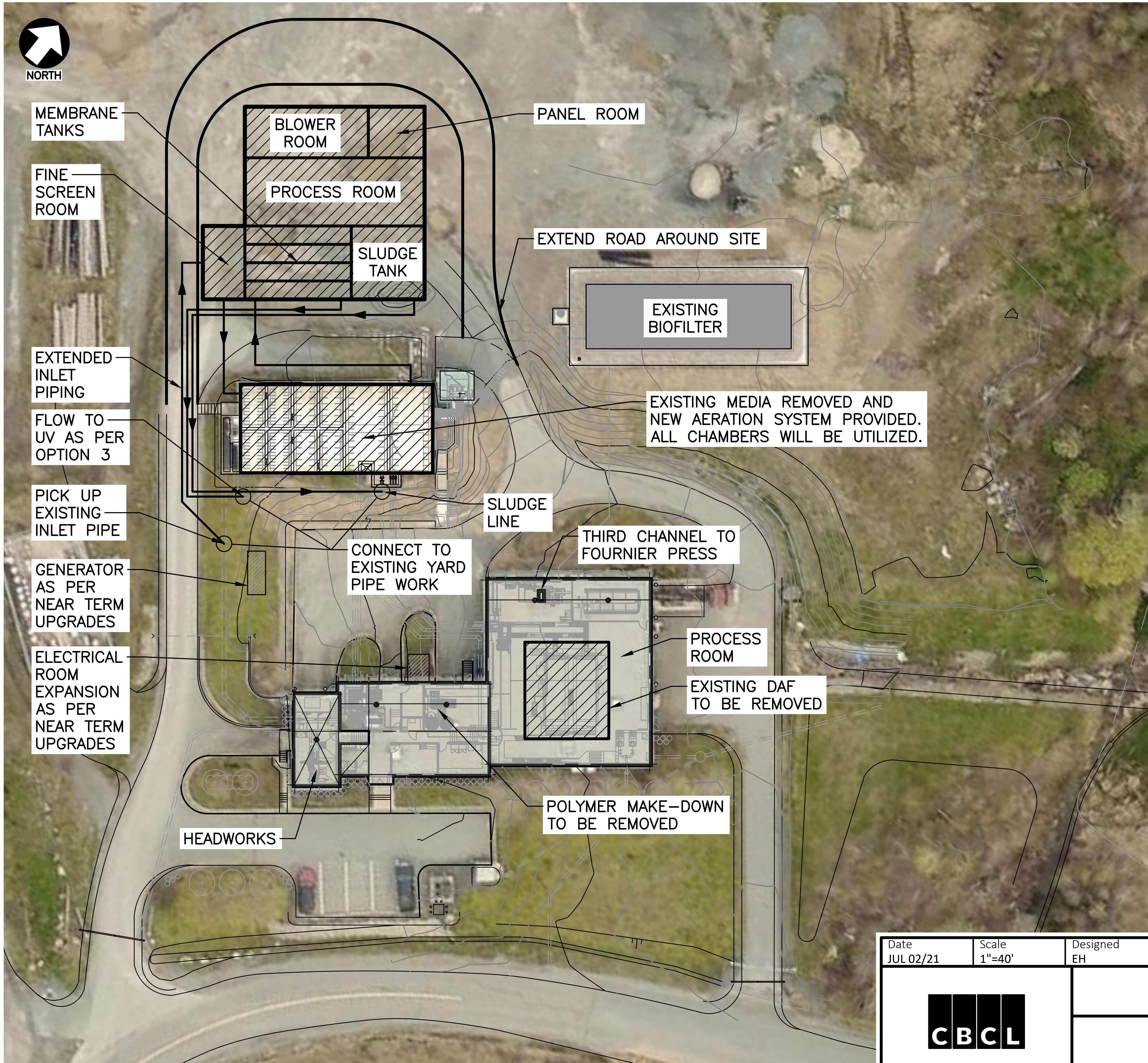
CBCL

TOL WWTP LONG TERM OPTIONS

OPTION 3 - SBR SYSTEM

Drawing
**PSK03**

DRAWING NAME: Y:\HALIFAX\DATA\PROJECTS\210803.01 TOL WWTP & OUTFALL PREDESIGN AND BCA\44 CAD\06 PROCESS\210803.01_PSK03 LT OPTION 3.DWG LAYOUT NAME: PSK03 PLOT DATE: July 1, 2021 3:59:36 PM CAD OPERATOR: NOELM




## NOTES:

1. NEW BUILDING PROVIDED TO HOUSE: MBR SYSTEM, ADDITIONAL BLOWERS, PROCESS PUMPS, SLUDGE TANK, AND A FINE SCREEN ROOM.
2. EXISTING BIOREACTOR WILL BE RE-USED FOR BIOLOGICAL TREATMENT. EXISTING MEDIA WILL BE REMOVED AND AERATION SYSTEM REPLACED.
3. BLOWERS ARE SUFFICIENT FOR BIOLOGICAL TREATMENT IN THE RE-PURPOSED BIOLOGICAL TANK. ADDITIONAL BLOWERS WILL BE REQUIRED FOR THE MBR SYSTEM ON A DEDICATED BASIS.
4. UV SYSTEM, GENERATORS, AND BLOWER PROVIDED DURING NEAR TERM UPGRADES.
5. EXISTING DAFs, POLYMER MAKE-DOWN, AND POLYMER DOSING SYSTEM TO BE REMOVED.

| Date | Scale | Designed | Drawn | Checked | Approved | CBCL No. | Contract |
|---|---|---|---|---|---|---|---|
| JUL 02/21 | 1"=40' | EH | NHM | - | - | 210803.01 | - |

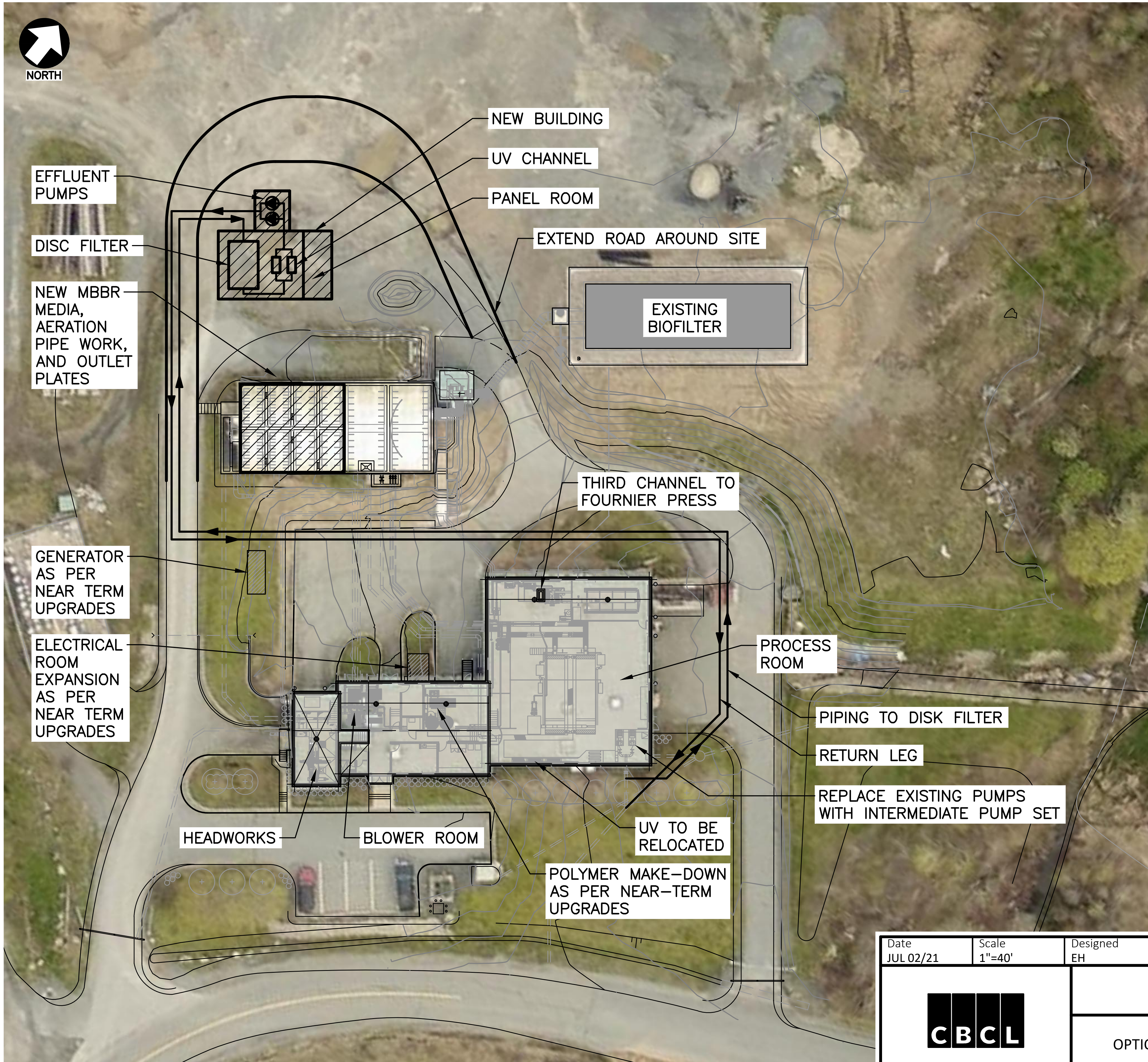
CBCL

TOL WWTP LONG TERM OPTIONS

OPTION 4 - MBR UPGRADE

Drawing
**PSK04**

DRAWING NAME: Y:\HALIFAX\DATA\PROJECTS\210803.01 TOL WWTP & OUTFALL PREDESIGN AND BCA\44 CAD\06 PROCESS\210803.01_PSK04 LT OPTION 4.DWG LAYOUT NAME: PSK04 PLOT DATE:July 1, 2021 4:00:14 PM CAD OPERATOR: NOELM




## NOTES:

1. DAF AND MBBR UPGRADES AS PER OPTION 1.
2. CONSTRUCTION OF NEW BUILDING TO HOUSE DISK FILTER AND UV SYSTEMS.
3. NEW PUMP STATION CONSTRUCTED BESIDE DISK FILTER BUILDING.
4. EXISTING EFFLUENT PUMPS RELOCATED TO NEW PUMP CHAMBER (SEE NOTE 3). INTERMEDIATE PUMPS TO BE FITTED IN PROCESS ROOM TO PUMP EFFLUENT TO DISC FILTER BUILDING.
5. UV UNITS REMOVED FROM PROCESS ROOM AND RELOCATED IN DISK FILTER ROOM.

| Date | Scale | Designed | Drawn | Checked | Approved | CBCL No. | Contract |
|---|---|---|---|---|---|---|---|
| JUL 02/21 | 1"=40' | EH | NHM | - | - | 210803.01 | - |

CBCL

TOL WWTP LONG TERM OPTIONS

OPTION 1A - MBBR, DAF AND DISK FILTER SYSTEM

Drawing
**PSK05**

DRAWING NAME: Y:\HALIFAX\DATA\PROJECTS\210803.01 TOL WWTP & OUTFALL PREDESIGN AND BCA\44 CAD\06 PROCESS\210803.01_PSK05 LT OPTION 5.DWG LAYOUT NAME: PSK05 PLOT DATE: July 29, 2021 9:56:50 AM CAD OPERATOR: NOELM

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