LINCOLN, MASSACHUSETTS

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Lincoln Woods Wastewater Treatment Plant Evaluation Report – Phase 2

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Engineering a Better Environment

Lincoln Woods Wastewater Treatment Plant Evaluation Report – Phase 2

Lincoln, MA

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List of Abbreviations

WWTP – Wastewater Treatment Plant

TCB – The Community Builders, owners of the WWTP at Lincoln Woods

WWEM – Wastewater Environmental Management Inc., contract operator of Lincoln Woods WWTP

MassDEP – Massachusetts Department of Environmental Protection, authority in charge of issuing groundwater discharge permit

GWDP – Groundwater Discharge Permit, issued to domestic and commercial wastewater, and certain industrial facilities determining allowable effluent flows and loads limits

UV – ultraviolet, beyond the violet end of the visible light spectrum, kills pathogens to provide disinfection in wastewater

BOD – Biochemical Oxygen Demand, indicator of how much oxygen is required to break down organic material in wastewater

TSS – Total Suspended Solids, particles above 2 microns in size suspended in water (sand, gravel, bacteria)

TN – Total Nitrogen, sum of nitrate-nitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), ammonia-nitrogen (NH_3-N) and organically bonded nitrogen (excess levels of TN may lead to low levels of dissolved oxygen)

FET – Flow Equalization Tank, used to prevent wide variations in influent flow, temperature, and contaminant concentrations

NON – Notice of Non-compliance, notice to a facility indicating a permit violation, issued by MassDEP

RTC – Return to Compliance, a facility's plan to return effluent discharge levels back to permitted standards (includes timeframe and steps facility will take)

DMR – Discharge Monitoring Report, periodic water pollution report prepared by the facility indicating amounts of effluent contaminants

mg/L – milligrams per liter, concentration of contaminant in the wastewater (X mg of contaminant per 1 L of wastewater)

lbs./day – pounds per day, measure of pollutant loading rate (X lbs. of contaminant per 1 day)

gpd – gallons per day, measure of flow rate of wastewater

HP – horsepower, measurement of engine power (the power needed to raise 550 pounds 1 foot)

kW – kilowatt, measure of 1,000 watts of electrical power

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Section 1 Introduction

1.1 Background

The Town of Lincoln contracted with Wright-Pierce in the Summer of 2021 to perform a two-part evaluation of the Lincoln Woods Wastewater Treatment Plant (WWTP), which services the Lincoln Woods Apartments and the commercial buildings at the Mall at Lincoln Station (The Mall). The WWTP is currently owned by the apartment managing company, The Community Builders (TCB). The Mall is owned by the Rural Land Foundation of Lincoln. The first phase of the evaluation was completed in October 2021 and evaluated the existing conditions of the WWTP, including:

- Compliance history with the plant's Massachusetts Department of Environmental Protection (MassDEP) Groundwater Discharge Permit (GWDP), number X274018/3-4
- The condition of the WWTP
- The flows and loads for the prior three years
- The existing flow and treatment capacity of the facility
- Expansion options for the Mall, both within the existing permitted flow limit (26,000 gpd) and should the plant be expanded beyond the permitted limit

Phase 2 evaluates alternative treatment options for the WWTP and potential flow expansion alternatives.

An aerial site plan of the project area is included at the end of this section as Figure 1-1.

1.1.1 Phase 1 Summary

The sewer system for Lincoln Woods consists of a gravity piping system, two pump stations and force mains, and the WWTP. The wastewater treatment plant is an activated sludge-type system and consists of a flow equalization tank (FET) with chopper pumps, a comminutor, a single combined biological treatment tank that includes the aeration, clarification, and solids handling processes, a denitrification filter, UV disinfection, and open sand bed effluent disposal. There is a solar field that provides power for the WWTP, a backup power generator, and a building that houses equipment. The treatment plant consists of a mixture of vintage 1970s and early 2000s equipment and structures. Overall, the older components of the facility are in fair to poor condition. The Phase 1 report summarizes several recommendations regarding how to address near-term improvements needs. The year 2025 was assumed for near-term WWTP improvements with an estimated project cost of $380,000, including a full demolition and replacement of the existing building.

The second part of the Phase 1 evaluation consisted of an analysis regarding the performance of the WWTP. The influent flows and loads (BOD, TSS, nitrogen) to the facility were evaluated from January 2018 to June 2021. This analysis provided a baseline for the incoming strength of the wastewater and the variations in flow to the plant. The effluent quality for the plant was also analyzed, compared to the requirements in the GWDP, and was used to evaluate the performance of the WWTP. In general, the incoming wastewater strength is typical for a residential community with minimal higher strength contributions from commercial properties such as restaurants. It was also determined that the COVID-19 pandemic had a significant impact on the incoming wastewater strength as residential contributions increased, and commercial contributions decreased during shutdown months, resulting in lower concentration of BOD/TSS in the influent. Overall, the WWTP was observed to generally be performing well and only had few permit exceedances, which were primarily explained by mechanical failure of equipment.

Flow capacity and potential sewer expansion were a focus of Phase 1. An analysis was completed to determine the current used flow capacity at the WWTP. The method for this analysis is provided by MassDEP and contains two parts; the current flow discharged to the WWTP and the flow that could be discharged to the WWTP based on existing connections that are currently not contributing flow (buildout). The two flows are added and compared to the permitted effluent flow to determine how much flow capacity is remaining for the existing WWTP. MassDEP allows for this analysis as they acknowledge the 110 gpd per bedroom design flow is a conservative estimate. If the historical data proves the design rate was conservative, additional expansion can be allowed. For the period of June 2019 to June 2021, the WWTP flow was determined to be 17,110 gpd and the buildout flow was estimated to be 960 gpd, totaling 18,070 gpd. Subtracting this value from the permitted flow of 26,000 gpd results in 7,930 gpd of available flow capacity for the existing WWTP. This value was used to consider expansion alternatives for The Mall. Historical Mall flows of 2,295 gpd were established from flow meter data provided by TCB. This value was used as a baseline for commercial flow and four expansion alternatives were developed based on increasing the baseline by increments of 10, 25, 50, and 100 percent. A resulting residential flow was determined based on the 7,930 gpd available and subtracting the increased commercial flow. The number of bedrooms was calculated from the residential flow by dividing the MassDEP-required 110 gpd per bedroom. The number of bedrooms that could be added under the scenarios considered ranged from 50 to 70.

The final part of Phase 1 evaluated the WWTP flow and treatment capacity to determine if the plant could be expanded and/or treat more flow and load based on the existing infrastructure and processes. It was noted that MassDEP guidelines require redundant treatment processes be provided in excess of 50,000 gpd. This Phase 1 analysis focused on the existing 26,000 gpd permitted flow limit and the upper expansion limit of 50,000 gpd due to the redundancy requirement as increasing flow over 50,000 gpd would result in significant cost increases. It was determined that the Flow Equalization Tank size would likely need to be increased to provide 50% more volume; the biological treatment tank is limited by BOD removal and the likely maximum is 40,000 gpd; the denitrification filter is only sized for 26,000 gpd; the UV disinfection equipment is sized for 40,000 gpd; and the effluent disposal beds have an unknown capacity and should be tested for a potential increase in capacity. Based on the effluent disposal beds' 10,500 square foot surface area, the capacity could range from 21,000 to 52,500 gpd. It was also noted that effluent disposal reserve capacity is not currently provided but could be required by MassDEP should the effluent flow be expanded over the current permitted limit.

Upon review of the downgradient monitoring well data, it is noted that there is history of elevated nitrate found in the groundwater. There were several occurrences of exceedances of 10 mg/L from 2017 to 2018 but none in 2019. These are likely due to the WWTP process upsets. The water levels in the wells are typically low, between 10 and 15 feet below the sand bed finished grade elevation. There was one measurement in August 2019 where the water table elevation was high in the monitoring well downgradient of the sand beds (4 feet below grade), which means the water table elevation was likely higher at the sand beds themselves due to mounding (DEP Small Treatment Plan guidelines require maximum groundwater elevation, including mounding to be no less than 4 feet below the bottom of the sand bed). After reviewing the effluent data, the month leading up to the monitoring well sampling (8/22), there was between 5,000 and 10,000 gpd discharged, which is much less than half of the permitted allowance. In addition, there was less than one inch of rain in the preceding 3 days. Therefore, this is likely an outlier measurement. Based on the review, it appears that WWTP operations needs to be more consistent for nitrate and total nitrogen removal, but groundwater levels are likely not a concern at the current effluent flows.

1.2 Report Purpose

The overall project for the Town of Lincoln consists of two phases with an option to include a third. Phase 2 provides a detailed assessment of treatment alternatives and two flow expansion scenarios for the Lincoln Woods WWTP. This report summarizes the evaluation performed for alternative treatment methods with cost-benefit analyses and provides conclusions and recommendations for the Town of Lincoln moving forward. The optional Phase 3 would investigate and evaluate a new treatment facility and effluent disposal area at a different location (if the Phase is selected by the Town to move forward).

The Phase 2 report is organized as follows:

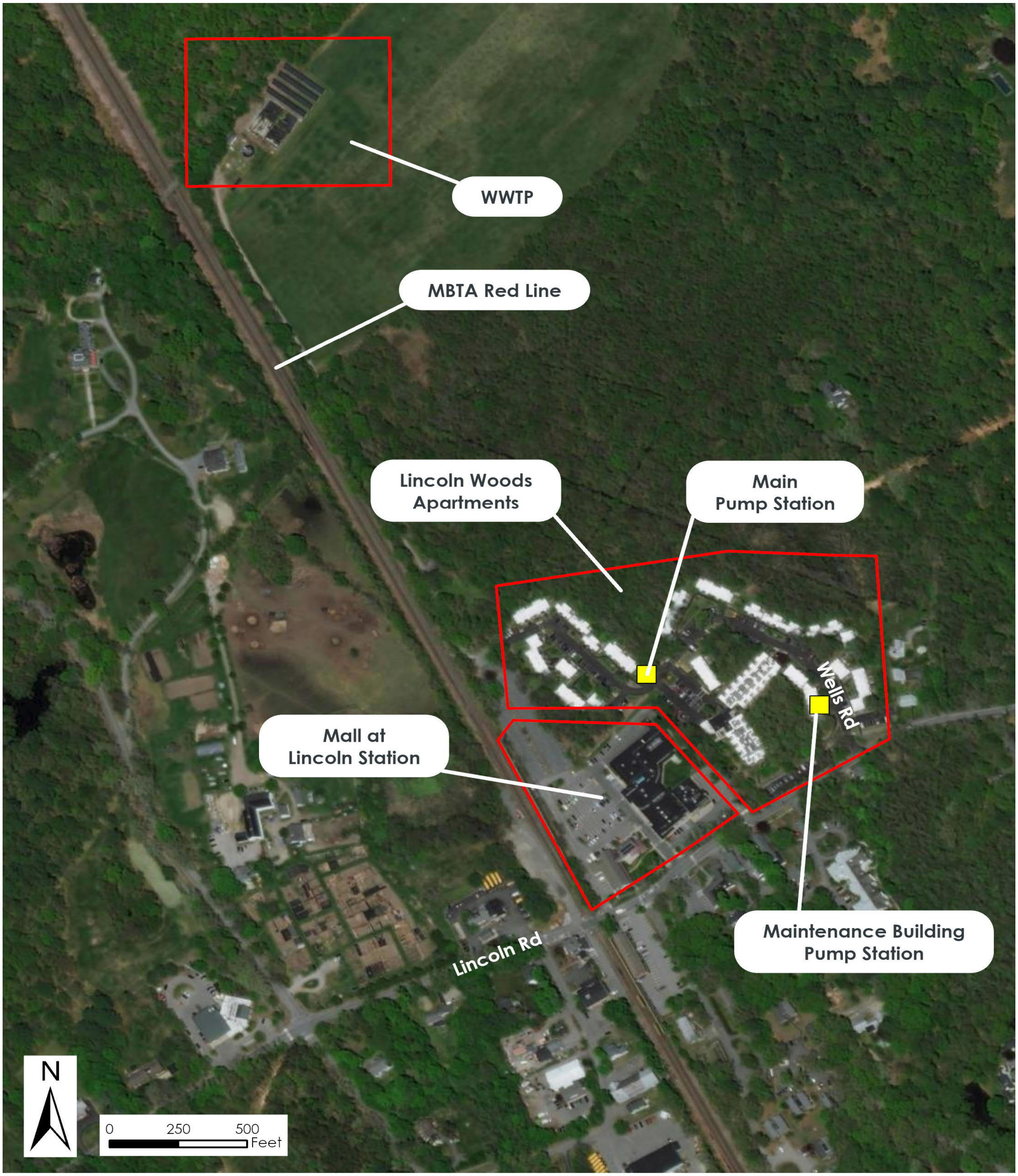
- Section 1 – Introduction
- Section 2 – Alternatives Analyses
- Section 3 – Conclusions & Recommendations

1.3 Project Scope of Services

The scope of Phase 2 of this project includes the study and evaluation of future capacity and treatment alternatives. The Phase 2 project scope of services includes the following tasks:

- Identify treatment options including alternative technologies. Consider effluent disposal needs.
- Evaluate and quantify the capital costs for alternative capacity expansion options of the existing system, as relevant.
- Provide the pros and cons for the alternative treatment methods and perform a cost-benefit analysis for each.
- Estimate capital costs for the recommended plan
- Complete report to summarize all findings and recommendations

Figure 1-1 Project Site Aerial View



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Section 2 WWTP Treatment Alternatives Analysis

This section of the report summarizes the steps and costs required to upsize the existing system to treat 40,000 gpd (limit of existing bioreactor) and evaluation of three treatment technology alternatives for the Lincoln Woods WWTP for a capacity of 50,000 gpd and 60,000 gpd. The treatment technology alternatives are based on the experience of Wright-Pierce with similar small WWTPs. The alternatives do not include a “replace in-kind” option as the existing treatment system is outdated and WP does not recommend its continuance long-term, especially if design and permitted flows should exceed 40,000 gpd. This section presents a description of the treatment alternatives evaluated, pros and cons of each alternative, conceptual comparative capital costs, estimated annual operation and maintenance (O&M) costs, present worth cost comparisons, conceptual site layouts, and ranking of the alternatives evaluated.

In order to develop comparative criteria, manufacturer input was solicited to complete conceptual designs for each treatment method.

2.1 Existing System Modifications

As summarized in Phase 1, there are several components of the existing WWTP that would need to be modified or replaced to increase flow capacity over the existing permitted limit of 26,000 gpd to a new limit of 40,000 gpd to maximize the potential of the existing system. The 40,000 gpd limit is based on the maximum capacity of the existing bioreactor at the current BOD loading. The following list of tanks/treatment processes would require a change to increase flow from 26,000 gpd to 40,000 gpd:

- Flow Equalization Tank (FET) – current working volume of 10,000 gallons, maximum of 16,600 gallons – should provide 50% of daily flow per MassDEP guidelines
- Denitrification Filter – sized for 26,000 gpd, capacity depends on depth of tank, depth of sand media, and nitrate load coming into the filter from the bioreactor
- Effluent Clearwell – sized for Denitrification Filter (26,000 gpd) backwash requirements – maximum volume of 13,000 gallons
- Effluent Disposal Sand Beds – unknown maximum capacity

The other components of the existing treatment system meet or exceed the 40,000 gpd capacity and would not require changes.

To add additional volume to the FET, the tank height could be increased. This would require the various piping systems coming into the tank (force main from main pump station, return flow from bioreactor, and return flow from denite filter) be modified as well so the volume in the tank would not backflow into the pipes. The tank would need to increase approximately 1.5 feet in height to increase capacity to approximately 20,000 gallons.

The denite filter would require an additional smaller filter to increase capacity to 40,000 gpd. The smaller filter would be 4-feet in diameter and require 4-feet of sand media depth.

The Effluent Clearwell is designed to provide 50% of the Denitrification Filter volume. To have a properly designed clearwell for a 40,000 gpd Denitrification Filter, the volume would need to be increased, which could be done by adding height to the tank. However, the pipe connecting the filter to the clearwell is gravity-fed. Increasing the elevation of this pipe, without the potential for backflow may not be feasible. It is likely that a new tank would be required, or a combination of the existing tank and a smaller connected overflow tank to provide the additional volume. The better and more cost-effective solution is the addition of a smaller overflow tank.

Table 2-1 summarizes the costs associated with the modification work to increase the existing WWTP to a 40,000 gpd flow capacity. It is important to note that this does not include effluent disposal, as the existing capacity of the sand beds is unknown. As noted in Phase 1, infiltration/hydraulic capacity testing of the sand beds is recommended. These costs are discussed in the next subsection. The costs in Table 2-1 include civil sitework, structural work, piping modifications, and treatment equipment (denite filter sand). It is important to note that the Phase 1 report also summarizes near-term improvements (equipment replacement and new WWTP building) that are recommended for the existing WWTP to continue operating. These costs are included in the table as the project year would likely be the same. Additionally, cost incurred during construction for the contractor and subcontractors, inflation to the midpoint of construction, engineering services, and a project contingency for unknown items are included to provide an overall project cost for the work. These factors were not included in the Phase 1 project costs.

Table 2-1 Planning-level Project Cost Estimate, 40,000 gpd Modifications to Existing WWTP

Item	Estimated Cost
Flow Equalization Tank	$75,000
Denitrification Filter	$100,000
Effluent Clearwell	$60,000
Phase 1 Near-Term Improvements	$380,000
Subtotal Bare Construction Costs	**$615,000**
Additional Contractor Costs	$115,000
Subtotal Construction Bid Cost	**$730,000**
Construction Contingency (25%)	$185,000
Inflation to Midpoint of Construction (11.3%)	$85,000
Total Estimated Construction Cost	$1,000,000
Engineering Services	$400,000
Legal and Administrative Allowance (5%)	$50,000
Total Project Cost	$1,450,000

This project cost estimate is compared to the overall project cost estimates provided in Section 3 for the 50,000 gpd and 60,000 gpd treatment alternatives.

2.1.1 Effluent Disposal

As mentioned in Phase 1 and discussed again in this report, effluent disposal capacity is an unknown at the Lincoln Woods WWTP. The original hydrogeologic study and disposal bed design from the mid-70s is not available for review and evaluation. Subsequent studies of the soils and groundwater or disposal bed capacity have not been conducted. The four existing beds are 52.5 feet by 50 feet, each, totaling 10,500 square feet of disposal area. At 26,000 gpd of permitted flow, that equates to 2.5 gpd per square foot of hydraulic loading to the beds. MassDEP guidelines allow loading rates of up to 5 gpd per square foot if the system can prove it can handle this loading rate. For the existing disposal area, that could result in up to 52,500 gpd of flow (5 gpd per square foot x 10,500 square feet). If, for example, a 40,000 gpd capacity is the goal, a loading rate of 3.8 gpd per square foot would be required to be proven and permitted (this is within the maximum loading rate in the DEP guidelines). Regardless of the ultimate disposal bed capacity, increasing the permitted effluent disposal flow over the existing 26,000 gpd would require approval by MassDEP and a permit modification.

The first step in the capacity increase process would be a hydrogeological study to determine the existing soils and capacity of the sand beds. The study could involve items such as soil borings, infiltration and/or percolation tests, test pits, and ledge probes. A hydraulic loading test (with potable water) would likely also be performed within the existing beds to determine actual loading rate capacity. Once the existing soils and existing sand bed disposal capacity are understood, the results would be summarized and presented to MassDEP. If the results are favorable to increase effluent disposal capacity, there would likely be minimal additional effort required to increase the permitted effluent disposal capacity (i.e., additional effluent disposal area would not need to be designed and constructed). The effort described above would likely cost from $50,000 up to $100,000 in today's dollars. If the results of this testing are not favorable, and it is shown that additional disposal area would be required to increase the permitted flow over 26,000 gpd, additional work would be required.

The work required to construct additional disposal area would involve a similar hydrogeological study in a new location, plus additional engineering design, MassDEP approval, bidding, and construction. This is a highly variable process and as such, has a large range of cost implications. If the hydrogeological evaluation in the new location is favorable, the design, DEP approval, bidding, and construction process could cost around $500,000 in addition to the original $50,000-$100,000 for the study. If the process is not favorable and/or the construction is difficult, the work could cost as much as $800,000. These costs are presented in today's dollars and are for planning purposes only.

2.2 Alternatives Design Criteria

The existing Lincoln Woods WWTP is permitted to treat and dispose of 26,000 gpd of wastewater. Historic flow contribution to the WWTP and remaining capacity at the WWTP based on the existing permitted flow was analyzed during Phase 1. Expansion scenarios were evaluated for commercial and residential development within the Mall based on the capacity analysis. For Phase 2, two flow expansion alternatives were developed to give the Town further knowledge on how the plant could be expanded and the resulting development potential. MassDEP Small WWTP Design Guidelines (July 2018) require redundant treatment processes once 50,000 gpd treatment and disposal is exceeded. Accordingly, 50,000 gpd is the first design scenario and the second scenario is based on flow greater than 50,000 gpd, hence the redundancy requirement would apply. A flow of 60,000 gpd was provided to the manufacturers based on feedback from the Town. The primary reason for the second flow scenario selected is to provide the Town with an idea regarding additional cost for a redundant treatment system. A secondary goal was to work with the treatment system manufacturers to understand the flexibility of their systems regarding flow expansion at the same loading criteria. The Town stated interest in knowing the maximum flow each alternative system could treat before “upsizing”, and what the resulting “upsized” system would cost.

For comparative purposes in this report, flow is presented as strictly residential, commercial is not considered, so number of bedrooms can be calculated and used as a measure for each flow scenario. The MassDEP Title V standard of 110 gpd per bedroom is used for this calculation. The existing available capacity from the Phase 1 report is 72 bedrooms. The difference between 50,000 gpd and the existing 26,000 gpd is an additional 218 bedrooms, totaling 290 bedrooms of additional expansion compared to the present. A 60,000 gpd WWTP would provide an additional 309 bedrooms, totaling 381 bedrooms.

In addition to flow, influent load (BOD, TSS, N) and effluent disposal permit limits must be considered when designing a WWTP. Based on analysis completed in Phase 1 and the existing GWDP, WP provided the loading criteria summarized in Table 2-2 to the manufacturers.

Table 2-2 Design Criteria

Parameter	Influent Concentration	Effluent Permit Limit
BOD (mg/l)	400	30
TSS (mg/L)	400	30
Nitrate (mg/L)	-	10
Total Nitrogen (mg/L)	-[1]	10

1. Influent nitrogen concentration is not sampled at the WWTP, typical medium strength wastewater values were used by the manufacturers to estimate influent Ammonia and organic nitrogen (TKN) values

It should be noted that an increase over the permitted flow limit would require approval by MassDEP. That approval would require that the permittee demonstrate the existing disposal field (sand beds) has adequate capacity or additional effluent disposal area would need to be permitted, designed, and constructed.

Three potential treatment alternatives were considered for the alternative's analysis. The alternatives include a Membrane Bioreactor (MBR), Amphidrome™, and a Sequencing Batch Reactor (SBR). These alternatives are standard treatment types for small WWTPs with GWDPs. The comparison between alternatives includes capital costs for the equipment and structures, annual operation and maintenance costs, compatibility with existing systems and site, expandability, and ease of operation.

Operations and maintenance (O&M) costs for a WWTP include costs to operate, maintain, and monitor the system and should include contingencies for equipment replacement. Operating costs include electrical power for equipment, chemicals required by the treatment systems, sludge removal required by the system, and operator hours required to run the system. Maintenance costs are defined as costs incurred to maintain the system. This includes replacement parts costs and labor hours required to maintain the system and equipment. The costs are expressed as a yearly average, which in some cases involves annualizing the cost, such as replacement parts that are only required every 10 years.

Capital cost estimates for this analysis are not total project costs. The capital costs are derived from manufacturer proposals for their equipment and tankage required, only. These costs are planning level and for comparison from one alternative to another. Appendix A includes the manufacturers' technology brochures. The recommended plan presented in Section 3 provides a planning level total project cost estimate, which does include additional items such as permitting, engineering services, and additional costs required to construct the WWTP.

Site layouts were developed based on structure sizing required by the manufacturers. The layouts were developed using the entire WWTP parcel, not just the current footprint of the existing WWTP. Figure 2-1 shows the existing layout of the WWTP.

Figure 2-1 Existing Site Plan

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2.3 Membrane Bioreactor (MBR)

MBR wastewater treatment systems utilize a combination of the conventional activated sludge treatment process and advanced filtration with membrane units. Historically used for larger facilities, MBRs are now being used with more frequency for small wastewater treatment facilities. When operated correctly, MBRs can produce a very high-quality effluent which can even be used for effluent reuse applications. Effluent re-use is outside the scope of the project but could be of interest in the future to provide benefits such as irrigation.

The treatment processes prior to the membranes are conceptually similar to the existing WWTP. A pre-treatment tank or screening system removes large debris to protect the sensitive membrane, a flow equalization tank is used to manage flows to the system, and the bioreactor has an aeration zone similar to the existing aerated zone of the bioreactor tank that removes BOD. The MBR bioreactor also has an anoxic zone before and after the aeration zone (within the same tank, separated by baffle walls) to assist in nitrogen removal. The anoxic zones are mixed, but no air is provided. This allows specific bacteria in these zones to use oxygen in the nitrate, NO_3-, to grow rather than oxygen supplied by a blower. As the oxygen is consumed from the nitrate, the nitrogen compound is reduced to nitrogen gas (denitrification), N_2, that can rise out of the wastewater and into the atmosphere. The nitrification-denitrification cycle is illustrated below in Figure 2-2. Finally, rather than a clarifier and a denitrification sand filter, the membranes are used to remove solids from the wastewater stream. The effluent is drawn through the membrane by a vacuum, filtering out the suspended solids. A typical MBR system schematic is shown in Figure 2-3. The membranes are essentially microfilters that are provided in two main designs, flat-plate, and hollow-fiber (more typical), which is shown in Figure 2-4.

Figure 2-2 Nitrification-Denitrification Cycle

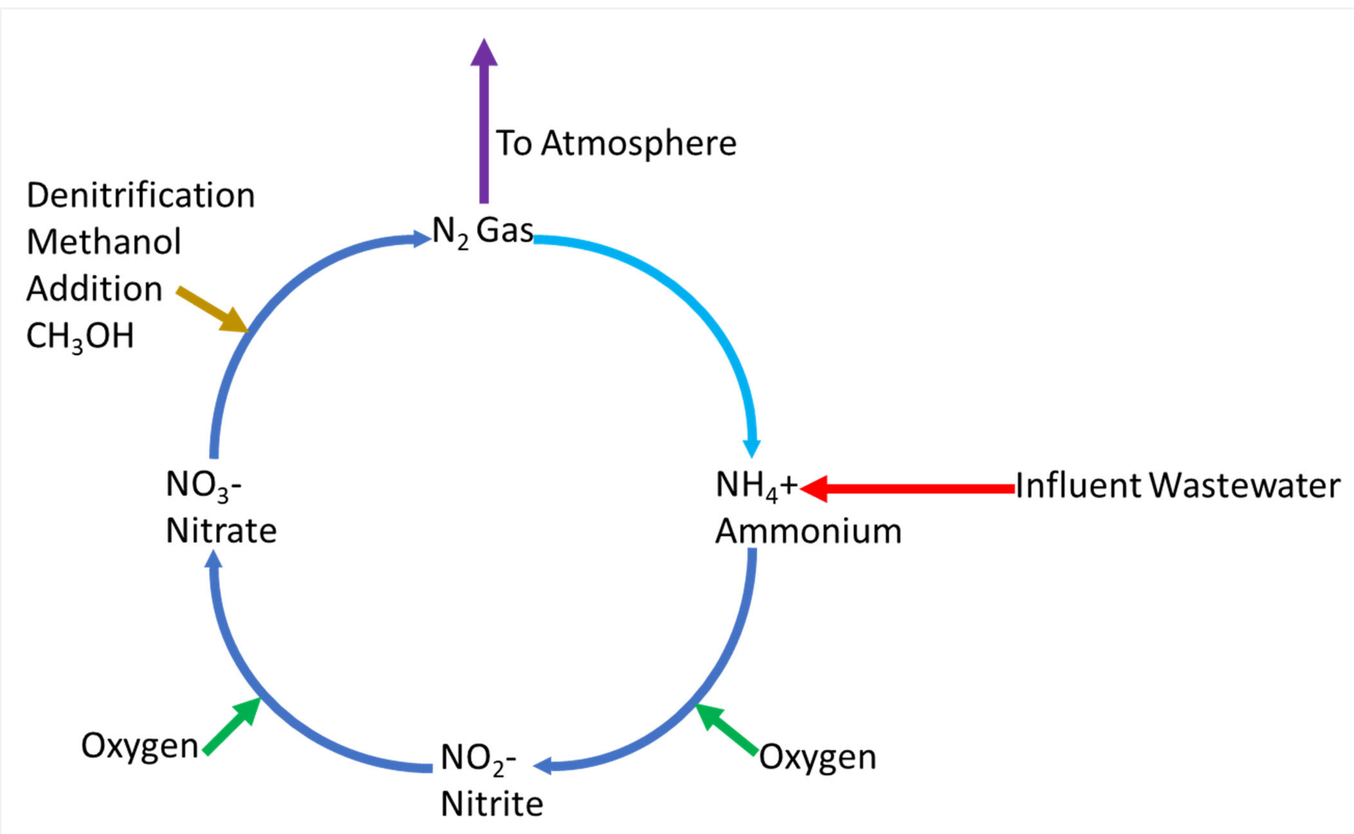


Figure 2-3 MBR System Schematic

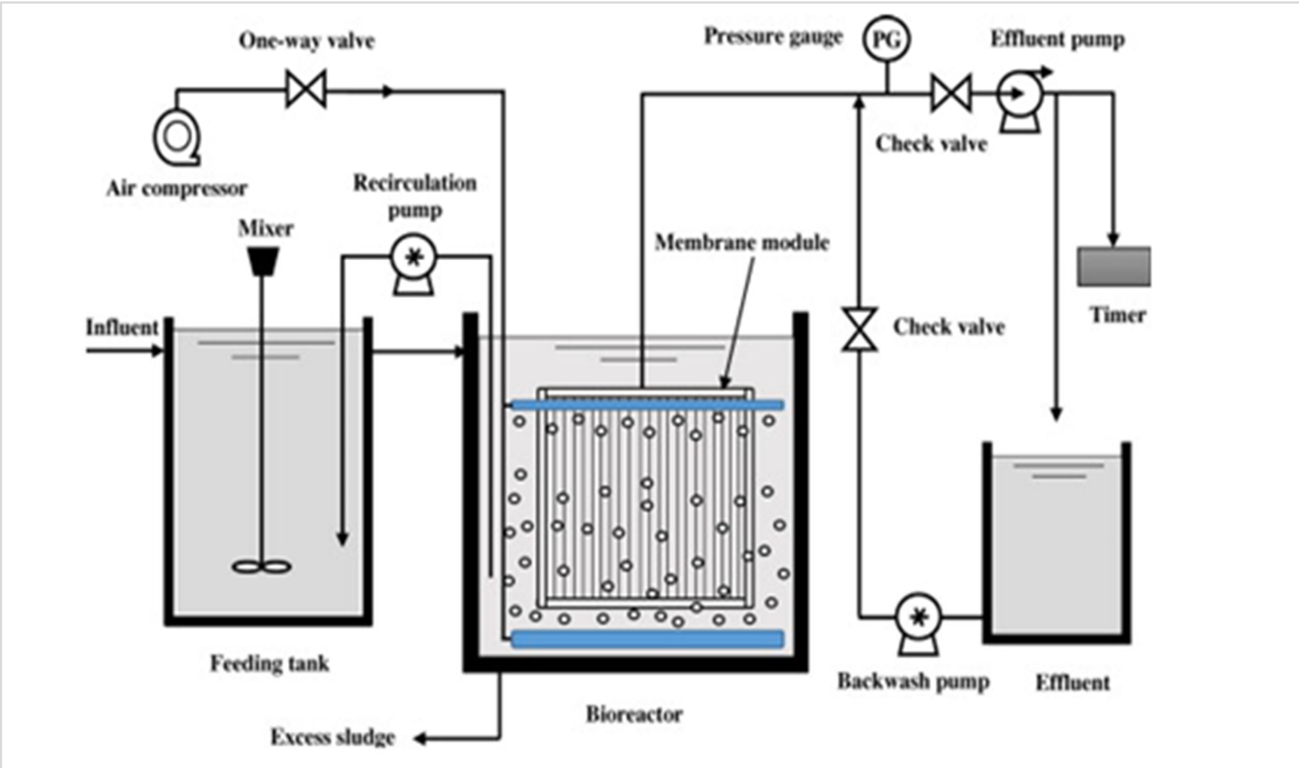


Figure 2-4 Hollow Fiber Membrane Units

The membrane microfiltration units can be immersed within the bioreactor or located in a separate unit (more typical). When they are located in a separate unit, the separated suspended solids are recirculated into the bioreactor. The separate unit is typically placed within a building to protect the equipment from the elements. The membrane units are continuously scoured with air bubbles to prevent membrane clogging and fouling. The bioreactor requires blowers for air supply, recirculation of nitrified wastewater within the bioreactor, supplemental carbon for nitrogen removal, and recycling of activated sludge. Regular sludge removal is required to maintain the system.

2.3.1 Advantages and Disadvantages

MBR systems have the advantage of producing a high-quality effluent without the need for several additional processes. This allows them to have a relatively small plant footprint that can be a combination of above- and below-grade components. The effluent quality is such that it can be used for wastewater reuse applications (irrigation, for example). MBRs can also be installed in a phased approach where additional membrane modules can be added to the process as flows and loads dictate. The sludge produced by MBRs contains less water than other processes, which means less trucking (and cost) required for removal and disposal. However, MBRs typically include higher capital costs due to more equipment and a larger building to house the membrane skid. Membranes are costly to replace and typically require replacement every 7 to 10 years. MBRs typically have more chemical usage for cleaning of the membranes and carbon required to meet low nitrogen limits, and similar equipment maintenance and parts replacement requirements compared to other systems.

This report summarizes Suez's conceptual design for their MBR system, which is a hollow-fiber style membrane system. The costs in the following subsections are based on the 50,000 gpd design.

2.3.2 Operating and Maintenance Costs

The overall system design includes flow equalization and pre-treatment, a biological treatment train that includes a pre-anoxic basin, aeration basin, and post-anoxic basin followed by a membrane tank.

The yearly power usage for the Suez MBR system is approximately 113,000 kW-hr. The existing WWTP is powered through the solar field at no cost, but for comparison between the alternatives, a cost of $0.16 per kW-hr was used to establish a cost for electrical usage. A review of the total capacity of the solar field versus what is required for the new system was not conducted but should be completed as part of the preliminary design phase of a WWTP upgrade. Similarly, a unit cost was assumed for a labor rate ($30/hr.), dollar per gallon for chemicals ($2/gal for sodium hypochlorite and $5/gal for methanol), and dollar per gallon for sludge disposal ($0.15/gal).

The annual operating costs are summarized in Table 2-3. These costs are based on the 50,000 gpd design scenario.

The replacement parts line item is only for equipment that needs to be replaced within the 20-year life cycle and is different than other systems. For example, pumps, mixers, and blowers have a typical life span of 20 years, so those are not considered. Membranes have a typical lifespan of 7-10 years, so the replacement cost is included and annualized. These costs are for comparative purposes from one system to another and should not be considered all-in costs to operate a WWTP on an annual basis. For example, MassDEP requires a Grade 4 facility (such as Lincoln Woods WWTP) be operated at a minimum for 3 hours per day during the week and 1 hour per day on the weekends and holidays. The labor cost in the table does not reflect that requirement.

Table 2-3 MBR Annual Operating and Maintenance Costs

Parameter	Suez
Electrical Consumption	$18,000
Chemical Usage	$4,000
Sludge Removal	$66,000
Labor	$16,000
Routine Maintenance	$6,000
Part Replacement	$2,000
Total	$112,000

2.3.3 Capital Costs

The estimated capital cost comparison for this analysis only includes equipment and structures, no engineering, effluent disposal costs, etc. In order to directly compare the manufacturer's proposals, it must be understood what each proposal included and didn't include so an equal comparison can be made. For the items not in the vendor proposal, an estimated cost was added so all options were compared equally. In order to maintain the existing treatment system during construction of a new treatment plant, re-using infrastructure was kept to a minimum and utilizing open space outside the existing fence line but within the parcel boundary was evaluated. The proposal from Suez includes all equipment, including the prepackaged membrane skid and control system, and the electrical motor starters/drives. The proposal did not include required tanks or building, as those are provided by a general contractor. These costs were estimated using dimensions provided by the manufacturers. Due to the membrane skid assumed to be installed indoors, the building is slightly larger than for the other two WWTP alternatives and this was reflected in the estimated cost. The proposal also did not include a UV system for disinfection, so a price was added for that equipment.

The estimated capital costs are summarized in Table 2-4.

Figure 2-5 shows the proposed site plan for the MBR system. An area is outlined in this figure for potential additional sand bed construction that could be used for additional flow capacity or if MassDEP were to require reserve area to be constructed.

Table 2-4 MBR Capital Costs

Parameter	Suez
Equipment Supplied by Manufacturer	$600,000
Estimate for Structures, Building, UV	$775,000
Total Capital Cost	$1,375,000

Figure 2-5 MBR Site Layout, 50,000 gpd

2.3.4 Complexity

A key criterion to review when completing an alternatives analysis for treatment methods is to look at complexity. Complexity can be defined as more equipment, additional processes, difficult to operate and/or difficult to control. For this analysis, the MBR treatment system is the most complex. The MBR system has the most equipment, requires careful process control with manual addition of supplemental carbon addition, chemical cleaning of the membranes, and more instrumentation to monitor than the other alternatives. This is reflected in the higher labor cost in the O&M table.

2.3.5 Expandability

For this analysis, expandability is defined as how easily a 50,000 gpd WWTP could be expanded to handle additional flow. The analysis assumes two scenarios. First, a 50,000 gpd WWTP has been designed and constructed, but expansion is desired and an additional 10,000 gpd (totaling 60,000 gpd) is required. This scenario increases the difficulty of expansion as the treatment processes and tanks would have been designed for a 50,000 gpd facility. Second, during design, future planning was included, so the tanks and equipment would be designed upfront to ensure 60,000 gpd could be treated in the future while able to treat 50,000 gpd in the near-term. This is important to consider as it affects the treatment alternatives differently due to the nature of their design.

For the MBR system, expanding beyond a 50,000 gpd design would be relatively simple. The tank structures for equalization, bioreactor, and clearwell would need to be increased in size to reflect the additional volume required. As flow from tank-to-tank is done by pumping, raising influent and effluent pipes with the tank wall height would be achievable. The existing pumps would likely not need to be changed. The blowers and mixers may need to be increased in size. The membranes are the more limiting factor. Typically, membranes are provided in modules that have a specific number of membranes that can treat up to a certain flow at the design loading. Per Suez, the maximum flow the membranes could handle as provided in their proposal at the design loading is around 60,000 gpd. Knowing that, the membranes would not need to be modified in this scenario. Additionally, once 50,000 gpd is exceeded, treatment redundancy would be required by MassDEP. For the MBR system, the membranes themselves already have a redundant design so one unit can be taken offline for cleaning or other maintenance without interrupting treatment. The only addition that would be required for the MBR system would be an additional bioreactor and associated equipment (2 mixers, 1 air diffuser grid, 1 blower, 1 pump).

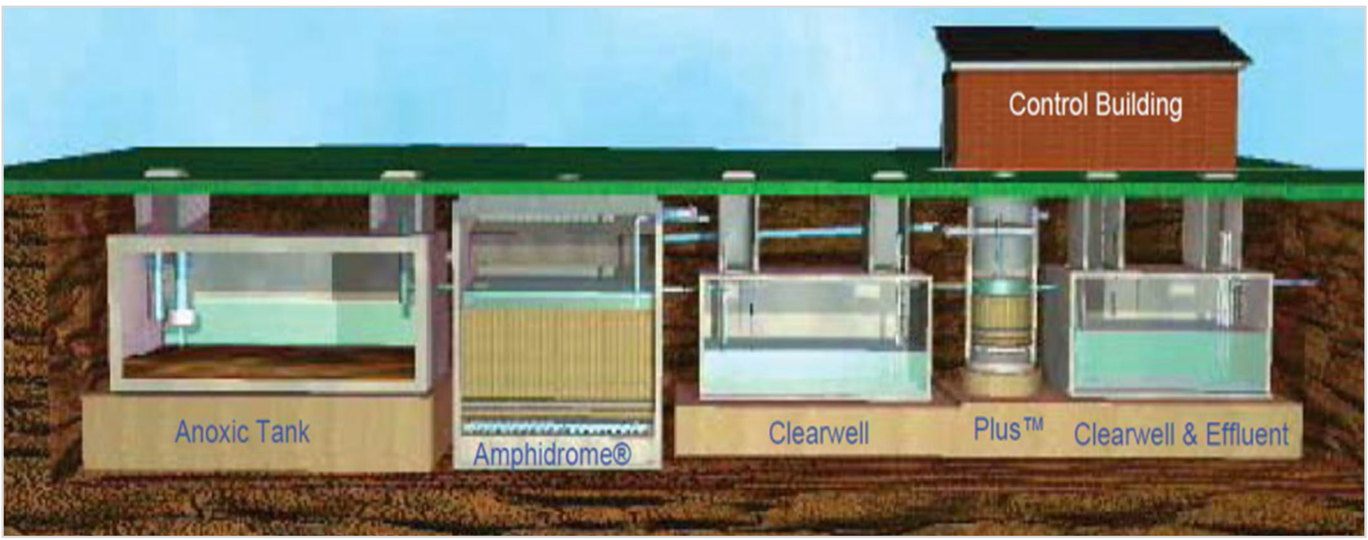
Alternatively, if the initial design process were to include future planning and the tanks and associated equipment were to be sized for a 60,000 gpd facility, but no redundancy was included, the overall cost compared to the 50,000 gpd design would not change significantly. The volume of the bioreactor, and each zone within it, would increase, but the 10,000-gallon addition could be accomplished by simply making the tank 1 foot longer and 2 feet wider, making the overall cost difference minimal. The equipment required would also be similar in cost, as it does not appear larger equipment would be required between the two scenarios. It would make more sense to design for 60,000 gpd for the MBR system, with provisions to meet the redundancy requirement in the future should 50,000 gpd be exceeded. The expandability of the MBR system is very flexible in comparison to the other two treatment alternatives evaluated, especially if forethought is included in the initial design of the system for future flows.

To understand the “next size up” capacity of the membranes, WP worked with Suez to understand the membrane design. To expand beyond 60,000 gpd, an additional membrane module would be required. The added module would increase the capacity to 75,000 gpd and cost approximately $9,000 (just the membrane). If the other structures and equipment were designed for the higher flow upfront, that would be the only change required to increase flow from 50,000 gpd or 60,000 gpd.

2.4 Amphidrome™

As shown in Figure 2-6, the Amphidrome™ system is a submerged, attached-growth treatment system. The treatment process consists of an anoxic equalization tank, the Amphidrome™ reactor and sand filter, clear well, AmphidromePlus™ polishing sand filter, and post effluent clearwell. Wastewater from the anoxic tank flows downward through the sand filter, providing contact with the bacterial population adhering to the sand particles that provides the BOD removal, and then flows into a clear well. Oxygen is provided in this stage. From the clearwell, the wastewater can be mixed with a supplemental carbon source as needed and pumped through a second sand filter (similar to the existing WWTP denite filter) for increased nitrogen removal. Liquid from the clearwell is pumped back through the Amphidrome™ reactor/sand filter to backwash the filter and return liquid to the anoxic tank. Figure 2-5 shows the proposed site plan for the Amphidrome™ system.

Figure 2-6 Amphidrome™ Schematic



2.4.1 Advantages and Disadvantages

Some advantages that are provided with the Amphidrome™ system include consistent treatment while being energy efficient and having low chemical costs. Similar to the MBR system, supplemental carbon is required for nitrogen removal, but the system does not require chemical cleaning like the MBR system. The Amphidrome™ system has the lowest sludge disposal cost out of the three alternatives. Some of the disadvantages of the Amphidrome™ system include the need for additional tankage and intermediate pumping steps. The system is typically less difficult to operate than the MBR system, but more difficult to operate than the SBR system.

2.4.2 Operating and Maintenance Costs

The Amphidrome™ system includes equalization/anoxic tankage, Amphidrome™ reactor tank, intermediate clear well, Amphidrome Plus™ tank, and final clear well. The chemicals that are needed for this system include alkalinity and a supplemental carbon source. Equipment needs for this process are similar to an MBR - pumps and mixers in the anoxic tank, blowers for aeration, intermediate and final pumping, and chemical feed systems. The electrical usage for this system is less than the MBR alternative due to less use and smaller motor sizing despite the similar equipment required. The estimated annual operating costs for the Amphidrome™ system are summarized in Table 2-5.

Table 2-5 Amphidrome™ Annual Operating and Maintenance Costs

Parameter	Amphidrome
Electrical Consumption	$13,000
Chemical Usage	$4,000
Sludge Removal	$55,000
Labor	$12,000
Routine Maintenance	$3,000
Part Replacement	$1,000
Total	$88,000

2.4.3 Capital Costs

The proposal for capital costs for the Amphidrome™ system include equipment and tank internals, controls, VFDs, and chemical feed systems, but does not include concrete tanks for the Amphidrome™ and AmphidromePlus™ tanks, FET, two clearwells, or the building. A cost is estimated for the structures based on dimensions required from the vendor. The estimated cost is summarized in Table 2-6. Figure 2-7 shows a conceptual site layout for the Amphidrome™ 50,000 gpd system.

Table 2-6 Amphidrome™ Capital Costs

	Amphidrome™
Equipment Supplied by Manufacturer	$502,000
Estimate for Structures and Building	$699,000
Total Capital Cost	$1,201,000

2.4.4 Complexity

The Amphidrome™ system is comparable to the MBR system in terms of complexity. The equipment and process are very similar, along with the controls, chemical needs, and level of difficulty to maintain and operate the system. The below ground, in-tank sand filter is more difficult to operate than the membrane filter due to the fact that operators cannot use “visuals” to assist in their operation of the system. Operators are typically less familiar with this treatment system as it is less common and typically only used in small WWTP applications, whereas the other treatment systems evaluated are typically used for larger WWTPs and/or clean water treatment applications (MBR).

2.4.5 Expandability

For this analysis, expandability is defined as how easily a 50,000 gpd WWTP could be expanded to treat 60,000 gpd. For the Amphidrome™ system, expanding beyond the 50,000 gpd design would be difficult. As each process tank is designed for a specific volume and related sand-media depth, each structure would need to be increased in height to handle the additional 10,000 gpd of volume. The tank modifications are similar to those required for the MBR system, but there are more tanks for the Amphidrome™ system. Similar to the MBR system, the tanks could be sized for the larger capacity upfront during design to meet a future capacity of 60,000 gpd at little additional cost compared to the 50,000 gpd design presented. However, when considering the redundancy requirement, the Amphidrome™ system would require an additional bioreactor and an additional denitrification filter, essentially doubling the cost over an MBR and SBR system to meet redundancy. This makes the Amphidrome™ system the least attractive alternative in terms of upsizing from 50,000 gpd to 60,000 gpd.

Figure 2-7 Amphidrome™ Site Layout, 50,000 gpd

2.5 Sequencing Batch Reactor (SBR)

The sequencing batch reactor (SBR) wastewater treatment system is a modified activated sludge treatment process that utilizes a batch treatment cycle to perform the necessary wastewater treatment. SBRs minimize the plant footprint by combining multiple treatment processes into one tank, thereby reducing the capital cost. The process incorporates the introduction of wastewater to a reactor, providing time for the necessary reactions to occur, and sequentially discharging a volume of treated effluent that is essentially equal to the original volume of influent. An SBR is a well-established treatment process that is capable of producing a high-quality effluent, while operating over a wide range of hydraulic and organic loadings.

The SBR process typically operates as a five step "fill and draw" system, which is carried out in sequential order within a specific time period as shown in Figure 2-8. The steps are as follows:

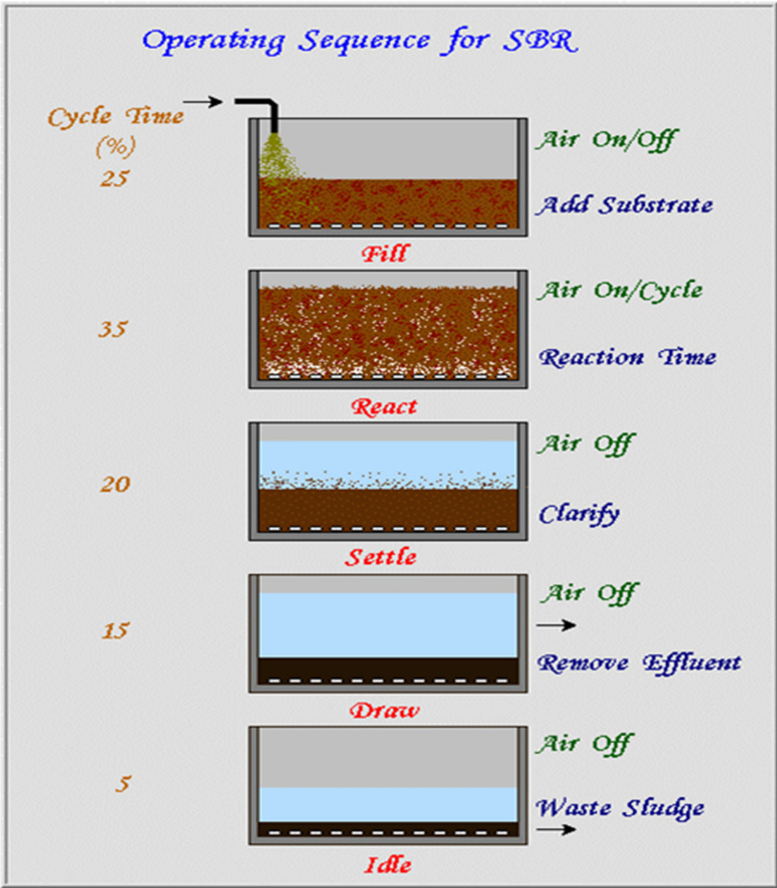
1. Mix/Fill - to add preliminary treated wastewater to the reactor (under mixing, no air)
2. React- to complete reactions initiated during Fill (under aeration)
3. Settle - to allow solids separation to occur (no aeration or mixing)
4. Decant - to remove treated and clarified wastewater from the top of reactor tank (no aeration or mixing)
5. Sludge Wasting/Idle - to remove excess sludge from the reactor tank bottom (no mixing or aeration)

The mix/fill step is similar to an anoxic zone, where denitrification occurs with no air being supplied to the tank. The react step is similar to the aerated zone, where air is introduced to remove BOD. In a two-tank system (which is standard practice for SBRs), the general principle is to have one reactor continue to receive the influent flow while the other reactor proceeds through the React, Settle, Decant, and Sludge Wasting stages. SBRs have become highly automated, with the prevalent use of reliable Programmable Logic Controllers (PLCs), making the systems much more practical for use in small systems.

2.5.1 Advantages and Disadvantages

There are several advantages that come with a sequencing batch reactor system. In new construction, these systems require less space and have less associated equipment and chemical requirements than other treatment systems. Due to the batch nature of the system, they are typically able to handle volatile swings in influent flows and loads better than other treatment systems. These systems are able to adapt well to different influent flows and work well with automated controls. Disadvantages of an SBR system include the necessity for deeper tanks compared to other treatment systems since all treatment occurs in one tank. This typically drives the tanks to be aboveground. In addition, due to the nature of batch treatment, redundant tankage is required at any flow rate, resulting in higher capital costs. SBRs typically require more sludge removal than the other treatment alternatives evaluated. Some manufacturers require larger equipment to keep the deep tanks mixed and aerated, which results in large electrical costs.

Figure 2-8 Typical SBR Sequence



2.5.2 Operating and Maintenance Costs

This evaluation includes one possible vendor for a sequencing batch reactor system, an AquaSBR® SBR provided by Aqua-Aerobic Systems, Inc. The Aqua-Aerobic system is used regularly in the SBR market and has a unique design in that their internal tank equipment is a combination mixer-aerator-decanter where other designs de-couple those systems into individual components. This results in less capital cost when compared to other SBR manufacturers for smaller treatment plants. When more mixing energy is needed for larger treatment systems (like the 60,000 gpd design), Aqua-Aerobics does use the more standard de-coupled equipment design.

The Aqua-Aerobic system consists of concrete tanks and combination aerator, mixer, decanter equipment (no blowers). The SBR system relies on sludge removal to keep the system operating properly, which would require a storage tank and pumps. There are typically no chemical needs for the SBR system.

When compared to the Amphidrome™ and MBR systems, the sludge for the SBR system is much thinner, which requires more frequent removal and trucking, resulting in a higher annual cost.

The operating costs for the 50,000 gpd design are summarized in Table 2-7.

Table 2-7 SBR Annual Operating and Maintenance Costs

Parameter	AquaSBR
Electrical Consumption	$36,000
Chemical Usage	$0
Sludge Removal	$90,000
Labor	$9,000
Routine Maintenance	$3,000
Part Replacement	$1,000
Total	$139,000

2.5.3 Capital Costs

The Aqua-Aerobic system includes the SBR mixer-aerator-decanting equipment and controls and influent pumps and does not include the VFDs/motor starters, two concrete SBR tanks, FET, effluent chamber, or sludge holding tank. An estimate has been included for the concrete tanks based on the manufacturer provided dimensions. The SBR system has the smallest building required due to chemical storage and feed equipment not being required.

The estimated capital costs for the SBR system are shown in Table 2-8. Figure 2-9 shows the conceptual site plan for the SBR system.

Table 2-8 SBR Capital Costs

	Aqua-Aerobic
Equipment Supplied by Manufacturer	$298,000
Estimate for Structures and Building	$836,000
Total Capital Cost	$1,134,000

2.5.4 Complexity

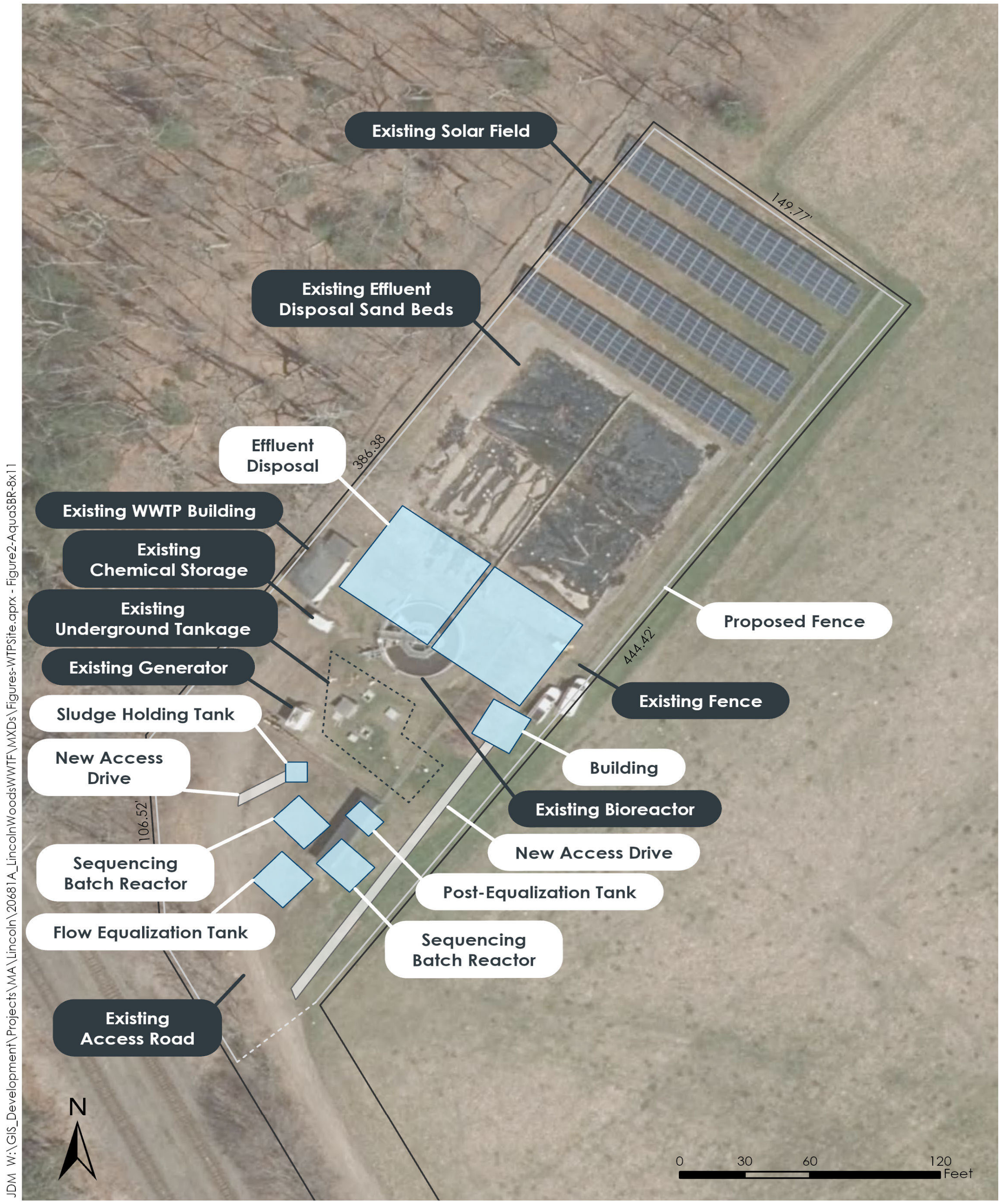
The SBR system is simple to operate, especially when compared to the other two treatment alternatives. The system includes less equipment, no requirement for chemical addition, and can be heavily automated through instrumentation and controls. The activated sludge system is widely used for all sizes of WWTPs, leading to operator familiarity and easier operation.

2.5.5 Expandability

For this analysis, expandability is defined as how easily the 50,000 gpd WWTP could be expanded to handle an additional 10,000 gpd (totaling 60,000 gpd) of flow. For the SBR system, expanding beyond the proposed 50,000 gpd design would be costly. Increasing the tank height would be relatively simple, similar to increasing the bioreactor volume for the MBR and Amphidrome™ systems. However, once 50,000 gpd is exceeded, the internal tank equipment (mixer-aerator-decanter) would need to be replaced with de-coupled mixers, aeration system, and decanters. The pre-equalization and post-equalization tanks would also need to be increased to reflect the additional volume required. It is likely that the blowers would also need to be replaced for a larger size.

One major benefit to the SBR design is that the 50,000 gpd system is already redundant, so to increase to 60,000 gpd would not require an additional tank to be constructed like the other 2 alternatives. Finally, if future planning was considered during the initial design, the SBR system becomes much easier to expand in the future. The equipment in the tanks would be initially designed as the de-coupled mixer, aerator, and decanter and would not need to be replaced to meet the 60,000 gpd design in the future. Also, the tanks could be oversized during the initial design to enable treatment of 60,000 gpd in the future. In this regard, the SBR system is the most favorable when considering the redundancy requirement over 50,000 gpd. The initial capital cost for the 60,000 gpd design compared to the 50,000 gpd design is approximately $50,000 more for the equipment. The structural costs for the tanks would be significant, approximately $200,000. However, the other two alternatives would cost more to add the redundant tanks required to meet the 60,00 gpd design.

Figure 2-9 SBR Site Layout, 50,000 gpd



2.6 Comparison of Treatment Alternatives

In order to compare the treatment alternatives on a cost basis, the capital and annual operation and maintenance (O&M) costs were considered. Table 2-9 includes the summary of estimated capital and O&M costs for each alternative as provided by the manufacturers, a present worth for the annual O&M costs, and the total present worth for each alternative. These costs are based on the 50,000 gpd design.

Each treatment alternative includes 20-year life cycles for equipment, so the replacement schedule is very similar between alternatives. The only difference is the membranes for the MBR alternative would be replaced at least twice in the 20-year cycle.

Table 2-9 Capital and O&M Cost Summary and Present Worth Analysis

Parameters	MBR	Amphidrome™	SBR
Capital Cost	$1,375,000	$1,201,000	$1,134,000
Annual O&M Cost	$112,000	$88,000	$139,000
Present Worth O&M[1]	$1,666,000	$1,309,000	$2,068,000
Total Present Worth	$3,041,000	$2,510,000	$3,202,000

1. 20-years, 3% interest rate

Based on the estimated costs evaluation presented above, the Amphidrome™ system has the lowest present worth cost and the SBR system has the highest present worth cost. The SBR has the lowest capital cost, but the alternatives do not differ significantly for capital cost. The Amphidrome™ system has the lowest annual O&M cost.

To compare the treatment alternatives on a non-cost basis, a weighted scale was used for various criteria. The lower the number, the more favorable the parameter/alternative. Based on the analysis, the SBR system is the least complex and the MBR system and Amphidrome™ are similar in their operational complexities, with Amphidrome™ being slightly more complex than the MBR. The MBR system provides the highest quality effluent out of the three options. Finally, the MBR system is the easiest to expand to gain additional flow capacity. The SBR system is slightly easier to expand than the Amphidrome™ system but both are difficult. The SBR system is the most favorable to meet the redundancy requirement if flows are increased from 50,000 gpd to 60,000 gpd as the initial design already contains a completely redundant treatment tank. The comparison between alternatives is summarized in Table 2-10.

Table 2-10 Ranking of Alternatives

Parameters	MBR - Suez	Amphidrome™	SBR – Aqua-Aerobics
Capital Cost	3	2	1
Annual O&M Cost	2	1	3
Complexity	2	3	1
Expandability	1	3	2
Effluent Quality	1	2	2
Total	9	11	9

1. Lower number is more favorable

Based on the cost and non-cost evaluation and comparison between alternatives, replacing the existing system with a new MBR treatment system or new SBR system appear to potentially be a "good fit" for the Lincoln Woods WWTP as a longer-term treatment solution. Despite having the lowest capital cost and easiest operation of the alternatives, the SBR system is the most expensive to operate annually and is difficult to expand on. The capital and O&M costs of the Amphidrome™ system are less than the other two alternatives, but the non-monetary factors decrease its favorability. The effluent quality and the expandability of the MBR system are favorable. Depending on which criteria are most important, any alternative could be a viable option, but based on the reliable, high quality effluent and expandability of the MBR system, this alternative treatment system is recommended for further analysis. This analysis will be used to establish a path forward and evaluate and document what is involved in getting the new system constructed, including a discussion on permitting, engineering, and additional construction costs that must be considered for an upgrade project. A comparison of costs between a 50,000 gpd and 60,000 gpd WWTP are also included in Section 3 for the recommended system.

3

Section 3 Conclusions and Recommendations

3.1 Recommended Plan

Phase 1 evaluated the existing WWTP, which established how much the existing system can treat on a flow and load basis. Based on the analysis, the ultimate bioreactor treatment capacity under the existing BOD concentration is 40,000 gpd. The Flow Equalization Tank, Denitrification Filter, and Effluent Clearwell would need to be modified to increase capacity to 40,000 gpd to match the bioreactor capacity. These modifications were analyzed in Section 2 of this report to provide a conceptual cost for the improvements. It was noted that in addition to these improvements, the near-term WWTP improvements identified in Phase 1 should also be completed at the same time, which include aging equipment and WWTP building replacement. The cost was $1,496,000. This cost does not include any additional effluent disposal that may be required with the increase in flow.

Based on input from the Town, two scenarios were evaluated in Phase 2 for flow expansion and three treatment alternatives were evaluated for the WWTP. The flow scenarios were 50,000 gpd and 60,000 gpd. The MassDEP-required treatment redundancy applies over 50,000 gpd.

The treatment alternatives evaluated include a Membrane Bioreactor, Amphidrome™, and Sequencing Batch Reactor. Based on the evaluation summarized in Section 2, the MBR treatment system is recommended to replace the existing treatment system at the Lincoln Woods WWTP. The main drivers for this recommendation are the superior effluent quality achieved by this system and its flow expandability. The MBR system can be constructed on the existing WWTP parcel but would require space outside of the existing fence line. The system requires a pre-treatment tank, flow equalization tank, bioreactor with a pre-anoxic zone, aerated zone, and post-anoxic zone, membrane feed tank, a building to house the membrane skid, blowers, UV, and chemical storage and feed equipment, and an effluent storage tank. If a design capacity is selected that exceeds 50,000 gpd, an additional bioreactor would be required to meet the MassDEP redundancy requirement.

If this project were to be undertaken, a permit modification would be required, as discussed further below. Also, additional effluent disposal capacity is a key component, and the current effluent disposal bed capacity is unknown. If additional effluent disposal area is needed, two additional sand beds could be constructed in the existing WWTP location as shown in the site layouts in Section 2. If additional space is needed, the Town-owned abutting parcel could be an option and the disposal area could be additional sand beds or a subsurface leach field. The two sand beds identified in the existing space could be used for reserve capacity should MassDEP require it. Costs associated with these efforts are discussed in Section 2. Evaluation of the existing beds could range from $50,000 to $100,000. Additional disposal area study, design, bidding, and construction could range from $500,000 to $800,000.

3.2 Construction Considerations

Constructability is a key criterion to review when considering an upgrade project and its cost relative to the site constraints. For Lincoln Woods, the existing WWTP parcel owned by TCB is larger than the existing WWTP site bounded inside the fence. This is important to note when planning for a potential treatment system replacement. If an upgrade must occur within the existing fence line, the project would be significantly more expensive. Primarily, this is due to no open space to construct new tanks while keeping the existing WWTP processes online. In addition to process tank construction, the electrical systems would not be able to be properly sequenced to keep the existing plant online while bringing new processes online. As a result, wastewater would need to be pumped and hauled during the entire construction period, which could take one to one and a half years. Daily trucking of wastewater is very expensive and requires significant coordination with the operator, trucker, and a local WWTP willing/able to accept the trucked wastewater.

Due to the parcel being larger than the existing fenced boundary of the plant, there is a significant amount of room available to construct new tanks outside of the fenced area but within the parcel bounds without impacting the existing WWTP processes. As shown in Figure 2-5, the MBR system can be constructed in the southwest portion of the parcel in its entirety, tested, and approved for use while the existing WWTP remains online. If redundant treatment tanks are required (bioreactor), they can also fit within the existing footprint. The biggest sequencing consideration for the upgrade project is how to provide power to the new processes while keeping existing systems online. The design engineer would need to determine if the existing solar array is large enough to accomplish this, and if not, provide a means for temporary power during startup of the systems before an official startup could be authorized for the new system.

During construction, a significant amount of sitework would be required to re-grade the parcel, demolish and construct fencing, add new access roads/driveways/walkways, add complete site drainage, and site work to accommodate the new tanks. In addition, new duct banks would be required to run electrical and instrumentation wiring throughout the site and to connect to the existing solar array system. Underground piping would be required between process tanks, the new building, and the existing effluent disposal beds. If additional effluent disposal area is required, a significant amount of hydrogeologic work would be required and site work and piping depending on the disposal method chosen.

3.2.1 Facility and Land Ownership

An important consideration when planning for expansion and how it relates to the existing WWTP is ownership. Currently TCB owns the WWTP and the land it is built on and accessed by. The RLF (the Mall owners) pays for O&M and replacement equipment based on the percentage of flow they use. In addition, the Town also owns a land conservation parcel that directly abuts the WWTP parcel that could be a potential location for additional effluent disposal (if needed). When considering expansion/upgrade to the WWTP, it will be important for the facility owner (TCB or a potential new entity) to understand the different stakeholders involved in the project and work with them during the planning, design, and construction phase of the project.

3.3 Permitting

Permitting (regulatory and environmental) is a key consideration when planning for and implementing a WWTP upgrade project. There are several entities that would be involved with permitting the project. MassDEP would be a key entity that would be responsible for issuing regulatory permits related to treatment plant design (review and approval) and groundwater discharge. The Town of Lincoln would be involved through the issuance of a building permit during construction and potentially for land use in the abutting parcel if the land was needed for effluent disposal. In terms of environmental permitting, it does not appear Wetlands Protection Act permitting with the Lincoln Conservation Commission would be necessary, as the project area is far enough away from the nearest wetland resource area. Also, it does not appear the project would trigger a Massachusetts Environmental Policy Act (MEPA) review (Environmental Notification Form or Environmental Impact Report) based on the size of alterations and the project being proposed on the existing parcel.

3.4 Schedule

A general project implementation schedule is outlined below in Table 3-1. The schedule is based on the experience of Wright-Pierce on similar projects. Many factors arise during the design phase that could extend the project schedule, such as hydrogeologic studies and MassDEP permitting, and approval related to effluent disposal. This schedule also does not include time for the planning and design for development of residential or commercial property.

Table 3-1 Typical Upgrade Project Schedule

Milestone	Timeframe
Preliminary Design & Permitting	9-12 months
Final Design	9-12 months
Bidding	3 months
Construction	14-18 months
Total Design, Bidding, and Construction	3-4 Years

3.5 Project Cost Estimate

A planning level cost estimate was developed for the 50,000 gpd MBR treatment alternative that includes estimates of total project costs, including construction, engineering, permitting, administration, and contingencies. This section is intended to present the overall magnitude of cost involved in replacing the existing WWTP with a new higher-capacity WWTP. In addition to this project cost estimate, it is important to note that the near-term upgrades presented in the Phase 1 report would likely also need to be completed, minus the building replacement since a new building is included in the new WWTP project. This is due to the duration of design, bidding, and construction being in the 3-to-4-year timeframe. The estimated cost of the Phase 1 near-term improvements without the building is $119,000. This project involves replacing pumps at both offsite pump stations, replacing the comminutor, clarifier mechanism, denitrification blower, backwash and effluent pump, UV system, and methanol feed pumps. The equipment has reached the end of its useful life and will likely need to be replaced within the next 5 years.

The estimated costs to construct a new WWTP were developed using standard cost estimating procedures, including conceptual design layouts, manufacturer proposals, and unit cost information from similar projects. In addition to the manufacturer’s equipment proposal cost and estimated cost for the concrete structure and new building, the cost estimate in this section includes associated ancillary costs such as process piping, civil sitework, HVAC and plumbing, instrumentation and controls, and electrical modifications to support the equipment. Where appropriate, information derived from recent construction cost data was incorporated. The cost estimate also includes mobilization/demobilization, contractor’s overhead markup, construction contingency, inflation to the midpoint of construction, and engineering services. The cost estimate does not include effluent disposal in the abutting parcel, which would be a significant cost to consider with hydrogeological studies, permitting, piping, and site work being necessary. It also does not include land acquisition should a developer wish to purchase the existing WWTP parcel from TCB. Refer to Section 2 for the potential costs associated with effluent disposal efforts.

Many factors arise during design (e.g., foundation conditions, owner-selected features and amenities, code issues, etc.) that cannot be definitively identified and estimated at this time. These factors are intended to be covered by a contingency; however, this estimated contingency may not be adequate for all circumstances. The cost estimate is for planning purposes only.

This cost estimate is based on an ENR Construction Cost Index of 12467 (November 2021). The construction cost estimate and total project cost estimate for the new WWTP are presented in Table 3-2 below.

Table 3-2 Planning-level Project Cost Estimate, 50,000 gpd Design

Item	Estimated Cost
Process	$810,000
Civil	$420,000
Architectural	$250,000
Structural (Tanks and Foundations)	$620,000
Mechanical (HVAC/P)	$20,000
Instrumentation	$25,000
Electrical	$400,000
Specials (Decommissioning/Bypass Pumping)	$200,000
Subtotal Bare Construction Costs	**$2,745,000**
Additional Contractor Costs	$500,000
Subtotal Construction Bid Cost	**$3,245,000**
Project Contingency (25%)	$812,000
Inflation to Midpoint of Construction (11.3%)	$366,000
Total Estimated Construction Cost	**$4,423,000**
Engineering Services[1] (25%)	$1,106,000
Legal and Administrative Allowance (5%)	$221,000
Total Project Cost	$5,750,000

1. Engineering services includes design, bidding, construction administration, and field inspection during construction

These costs are for a 50,000 gpd facility. Once 50,000 gpd is exceeded, redundancy for treatment is required by MassDEP. Three scenarios were reviewed to address this requirement.

1. A facility is designed with consideration for up to 60,000 gpd so the tanks and equipment are properly sized up front, but the redundant tank is not constructed until sometime in the future, when 50,000 gpd is exceeded.
2. A 50,000 gpd facility is designed and constructed but new development is desired, and the facility needs to increase to treat 60,000 gpd. This means existing tank volume needs to be increased and a second bioreactor with internal equipment is required to meet redundancy requirements.
3. A 60,000 gpd, fully redundant, facility is designed and constructed initially.

For scenario 1, the costs would be very similar to those presented in Table 3-2. The only difference between these scenarios is slightly larger tanks and provisions for piping and electrical to construct a future bioreactor seamlessly. The magnitude of cost for this scenario is approximately $6 million. If necessary, in the future, the additional bioreactor would cost approximately $500,000 to add on, plus inflation for the future project year.

For scenario 2, the tank volumes for flow equalization, existing bioreactor, and clearwell would need to be increased by 10,000 gallons. Also, a second bioreactor would need to be constructed with the internal equipment necessary. The equipment would be two mixers, two pumps, air diffuser grid, and instrumentation. Piping, electrical, and civil sitework would also be required. The magnitude of costs would be approximately $1 million, plus inflation to the project year.

Finally, WP worked with Suez (MBR manufacturer) to determine what would be required to design and construct a 60,000 gpd, redundant, facility. The layout of the facility would be very similar to that shown in Figure 2-5, with an additional Bioreactor installed next to the one shown on the figure. There would be no change to the building size. Table 3-3 summarizes the estimated project costs for the 60,000 gpd WWTP.

Table 3-3 Planning-level Project Cost Estimate, 60,000 gpd Design

Item	Estimated Cost
Process	$935,000
Civil	$470,000
Architectural	$250,000
Structural (Tanks and Foundations)	$905,000
Mechanical (HVAC/P)	$20,000
Instrumentation	$30,000
Electrical	$450,000
Specials (Decommissioning/Bypass Pumping)	$200,000
Subtotal Bare Construction Costs	**$3,260,000**
Additional Contractor Costs	$608,000
Subtotal Construction Bid Cost	**$3,868,000**
Project Contingency (25%)	$967,000
Inflation to Midpoint of Construction (11.3%)	$436,000
Total Estimated Construction Cost	**$5,271,000**
Engineering Services[1] (25%)	$1,318,000
Legal and Administrative Allowance (5%)	$264,000
Total Project Cost	$6,853,000

3.5.1 Annual Operation and Maintenance Costs

In addition to capital costs, O&M costs are important to consider. During Phase 1, TCB's invoices for the WWTP's contract operator (WWEM) were reviewed. It was found that the annual O&M costs were low in comparison to similarly sized facilities. This is due in part to the solar array, which results in no-cost for electrical usage. Based on WPs experience, this size facility can cost $2-$3 per gallon to operate, annually. At 50,000 gpd, that means $100,000-$150,000 of annual O&M cost. It is important to remember that in addition to the O&M costs presented in Section 2, additional costs are typically incurred for a WWTP. For example, the labor costs presented in Section 2 do not include the minimum required operational hours of 17 hours per week. Also, costs such as permit renewals, lab testing, engineering assistance, and a sinking fund for capital improvements should be considered. As such, the value presented in this section is higher than in Section 2.

3.6 Conclusions

The WWTP at Lincoln Woods was constructed in the 1970s and has a permitted flow capacity of 26,000 gpd. It uses conventional activated sludge technology, with disinfection and effluent disposal to open sand beds. A majority of the equipment is near the end of its useful life, the original structures and bioreactor are in need of repair and/or replacement, and the building is in need of complete replacement. The WWTP is owned and operated by TCB; it is situated on land owned by TCB, and TCB holds the groundwater discharge permit.

An evaluation of current wastewater flows indicates the following:

- 15,800 gpd used by TCB for residential purposes
- 2,300 gpd used by the Mall for commercial purposes
- Approximately 7,900 gpd unused under existing permit.

The unused capacity could support approximately 72 additional bedrooms of residential expansion.

Upgrading of the existing WWTP could generally retore its useful life. Our estimates of construction (not total project) costs are:

- Near-term including a new building, 2025 - $380,000
- Short term, 2035 - $121,000
- Long-term, 2050 - $2,126,000
- Additional Considerations, 2065 – $700,000

Upsizing the existing WWTP so the facility can treat 40,000 gpd with the existing process would cost $1.5 million. That includes the near-term improvements cost identified above.

An alternative to "piece-meal" upgrading would entail the construction of a new WWTP at the same location. If a new WWTP were to be built, we recommend the MBR technology and expect the cost to be approximately $5.8 million for a 50,000 gpd facility. A facility this size could cost between $100,000 and $150,000 to operate annually (includes sinking fund for equipment replacement). If the new WWTP were to be sized for 60,000 gpd, the total project cost would increase by approximately $1.1 million.

Effluent disposal capacity is a key unknown and potential limiting factor in any expansion scenario for the WWTP. Testing should be completed (could cost up to $100,000 in additional cost) on the existing beds to determine their capacity (loading rate). Two areas were identified on the existing site for construction of two beds if the existing tankage and building were demolished, which was included in the cost estimate above. A cost to construct a new effluent disposal system outside the existing site boundaries was not included at this time as there are too many unknowns (but could cost from $500,000 to $800,000 as noted previously in the report).

Table 3-4 summarizes the design flows, resulting residential development potential in bedrooms, the associated costs for the improvements, and cost per bedroom. The bedroom expansions are based on 110 gpd per bedroom and the difference between the design flow and the existing permitted effluent flow of 26,000 gpd, with 72 bedrooms of expansion included in each from the Phase 1 analysis.

Table 3-4 Expansion and Cost Summary

Flow	Total Expansion Potential	Cost of Improvements	Cost Per Bedroom
"Do Nothing" (26,000 gpd)	72 bedrooms	$0.75 million	$10,400/bedroom
40,000 gpd (existing WWTP upsize)	199 bedrooms	$1.5 million	$7,500/bedroom
50,000 gpd (new WWTP)	290 bedrooms	$5.8 million	$20,000/bedroom
60,000 gpd (new WWTP)	381 bedrooms	$6.9 million	$18,100/bedroom

The "do nothing" approach includes the near-term improvements from Phase 1, with additional costs for the total project (such as engineering). On a cost per bedroom basis, expanding the existing system up to 40,000 gpd appears to be the most cost-effective option. This option, and the 50,000 and 60,000 gpd options, do not include a cost to increase effluent disposal area and/or testing. All 4 scenarios would benefit from a hydrogeological study but is only required for the last 3 (increasing disposal capacity over 26,000 gpd). This would add an additional $50,000 to $100,000. If additional disposal area is required, the costs could range from $500,000 to $800,000 in addition to the costs presented in column 3 in Table 3-4. It is likely that upgrading the existing WWTP to 40,000 gpd will still be the most favorable scenario.

APPENDIX

Wright-Pierce
Engineering a Better Environment

Water Technologies & Solutions

ZeeWeed* membranes for municipal wastewater treatment

ready for the resource revolution

SUEZ

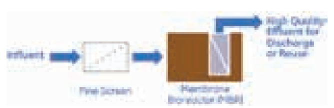
ZeeWeed membrane bioreactors (MBR) produce effluent for discharge or reuse that far exceeds the world's most stringent regulations

simple and reliable ZeeWeed MBR technology

MBR systems are increasingly being specified as the best available technology for virtually all wastewater treatment applications—from greenfield plants, to retrofits, to water reclamation projects. MBR systems offer economic and operational advantages over conventional wastewater treatment plants including extremely compact footprints, simplified operation and consistently higher quality effluent—all at comparable lifecycle costs.

conventional multi-step tertiary treatment process

ZeeWeed MBR treatment process



Hundreds of municipalities have discovered that with ZeeWeed MBR, you don't have to worry whether your system will meet current or future discharge and reuse regulations. The physical barrier of the UF membrane ensures a crystal clear effluent at all times that exceeds the world's most stringent regulations, including California's Title 22 reuse and the European Bathing Water Quality standards.

SUEZ brings over 25 years of experience to MBR systems—setting the industry standards for research and development, membrane manufacturing, system design and support. Our successful global track record with small, medium and large MBR projects ensures that you get the best value for your money with smart design features that provide trouble-free performance.

ZeeWeed MBR features & benefits

- Physical UF barrier produces high quality effluent suitable for direct non-potable reuse
- Unmatched fiber ruggedness ensures long membrane life
- "Self-healing" fibers eliminate catastrophic membrane failures
- Multiple effective cleaning techniques maintains long-term, peak system performance and provides a simple, rapid method of recovery in the event of an upset
- Hollow fibers provide a greater filtration surface area that reduces plant footprint
- Automated in-situ cleaning simplifies operation and maintenance
- Compact design minimizes land acquisition and construction costs
- Proven system performance in hundreds of municipal and industrial applications provides you with peace of mind

Forsyth County, GA -
1 MGD (3,800 m3/d)‡

Traverse City, MI -
7 MGD (26,500 m3/d)‡

Brescia, Italy -
11 MGD (41,640 m3/d)‡

* Average Daily Flow

reinforced membranes are the key to MBR

ZeeWeed membranes are built tough to ensure a long operating life. The reinforced, hollow fiber design is the key to reliable long-term membrane performance as it offers a large filtration surface area and can withstand the challenging high solids environment in an MBR. ZeeWeed is an ultrafiltration (UF) membrane and produces high quality effluent from the moment you start the system.

enhanced nutrient removal (ENR) and biological nutrient removal (BNR) of nitrogen and phosphorus

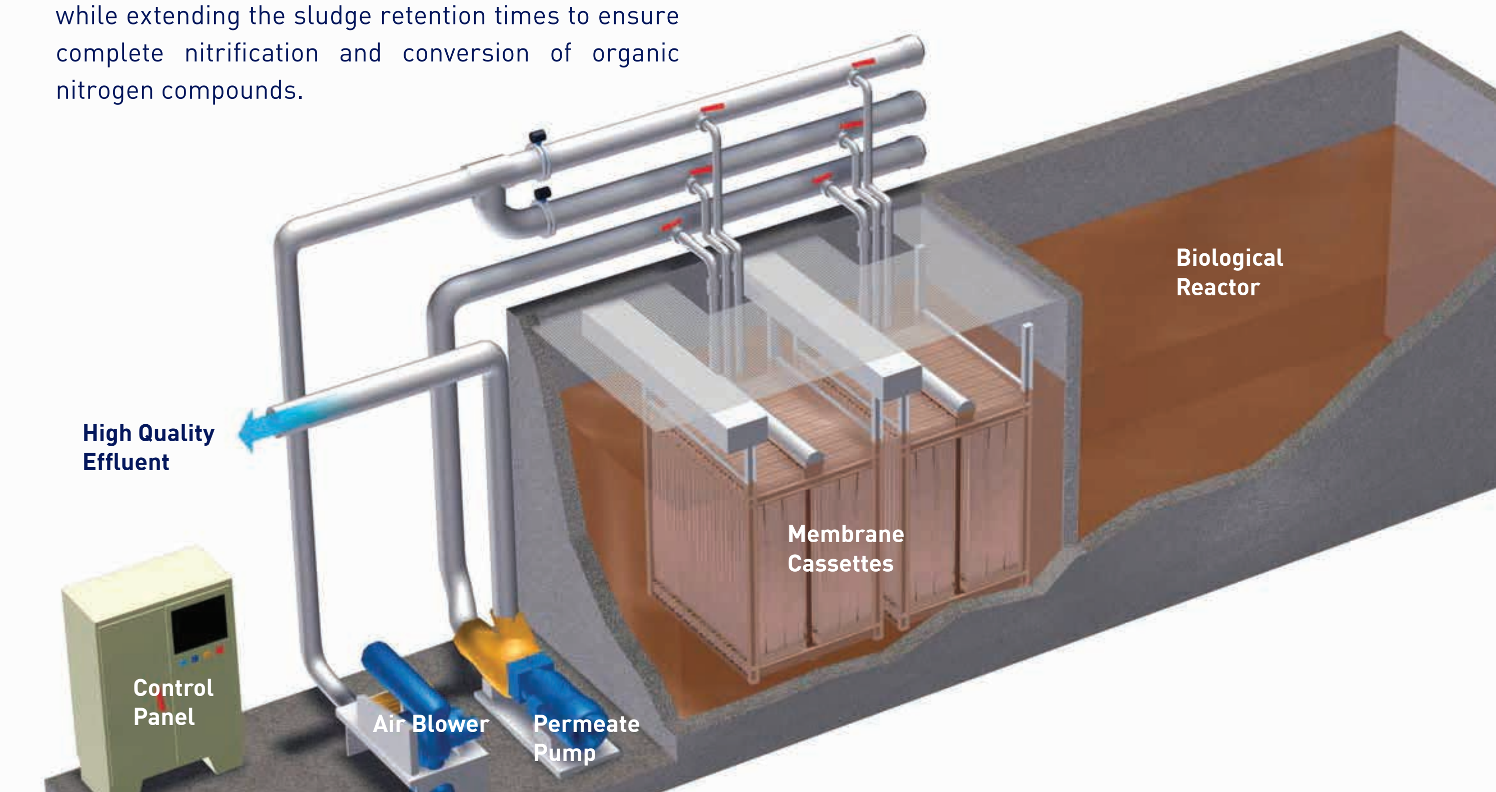
ENR and BNR effluent standards are among the most stringent in North America and demand the best available technology to ensure compliance at all times. ZeeWeed MBR systems are extremely flexible and process configurations can be tailored to meet specific wastewater characteristics, discharge requirements and plant retrofit applications. ZeeWeed UF membranes allow the biological reactor to operate at MLSS concentrations of up to 12,000 mg/L. This optimizes nitrification and denitrification, while extending the sludge retention times to ensure complete nitrification and conversion of organic nitrogen compounds.

Reusing the majority of their existing infrastructure, the city of Woodstock, GA converted a 0.5 MGD (1,893 m3/d) SBR into a 2.5 MGD (9,464 m3/d) ZeeWeed MBR designed to achieve nitrification, denitrification and biological phosphorous removal.

achievable ZeeWeed MBR treatment results

BOD5	< 2 mg/L
TSS	< 1 mg/L
NH3-N	< 0.5 mg/L
Total Nitrogen	< 3 mg/L§
Total Phosphorous	< 0.05 mg/L§
Turbidity	< 0.1 NTU
Fecal Coliform	< 2.2 CFU/100 mL†
SDI	< 2

§ with appropriate biological design and chemical addition
† after disinfection

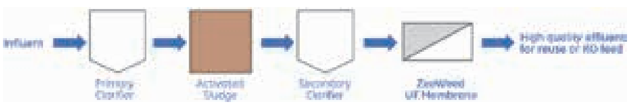


ZeeWeed MBR is a simple process. A basic production train consists of a biological reactor, membrane basin, permeate pump, air blower and automated control equipment. Trains are simply expanded and/or multiplied to meet capacity requirements.

ZeeWeed tertiary filtration for beneficial water reuse

ZeeWeed tertiary UF systems are designed to operate downstream of a conventional activated sludge process, where no further biological treatment is necessary, but where high quality water is required. The system features a small footprint that can be placed virtually anywhere or can even be used to retrofit existing granular filter media.

tertiary treatment process



- Physical ultrafiltration (UF) barrier - Produces high quality effluent suitable for direct non-potable reuse
- Produces ideal reverse osmosis (RO) feedwater - Allows the RO to operate at peak performance, reduces cleaning and fouling
- Eliminates plant upsets and turbidity spikes - Tolerates variable water quality and produces high quality effluent at all times
- Modular design allows for simple and efficient
- sand filter retrofits - Reduced capital costs through use of existing infrastructure
- Lowers chemical requirements - Pretreatment and cleaning chemical usage can be dramatically reduced
- Compact design - Small plant footprint reduces capital costs
- Greater level of automation - Reduces operating costs

Gwinnett County, GA
50 MGD (189,000 m3/d)‡

Bedok, Singapore
11 MGD (41,635 m3/d)‡

Find a contact near you by visiting www.suezwatertechnologies.com and clicking on "Contact Us."

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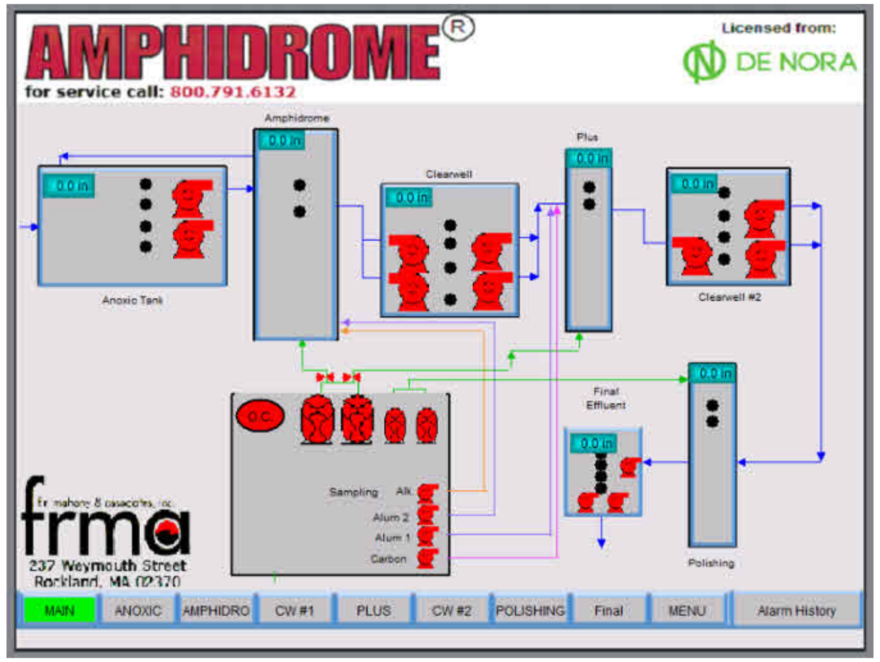
CUSTOMIZED TOUCH SCREEN CONTROLS



Typical Applications

Condominiums
Cluster System Developments
Health Care Facilities
Resorts
Shopping Malls
Schools
Office Parks

Single Family Home

f.r. mahony & associates inc.
frma
273 Weymouth Street • Rockland MA 02370

Water & Wastewater Technologies

tel. 800-791-6132
fax. 781-982-1056
www.amphidrome.com

Amphidrome®

Waste Water Treatment System

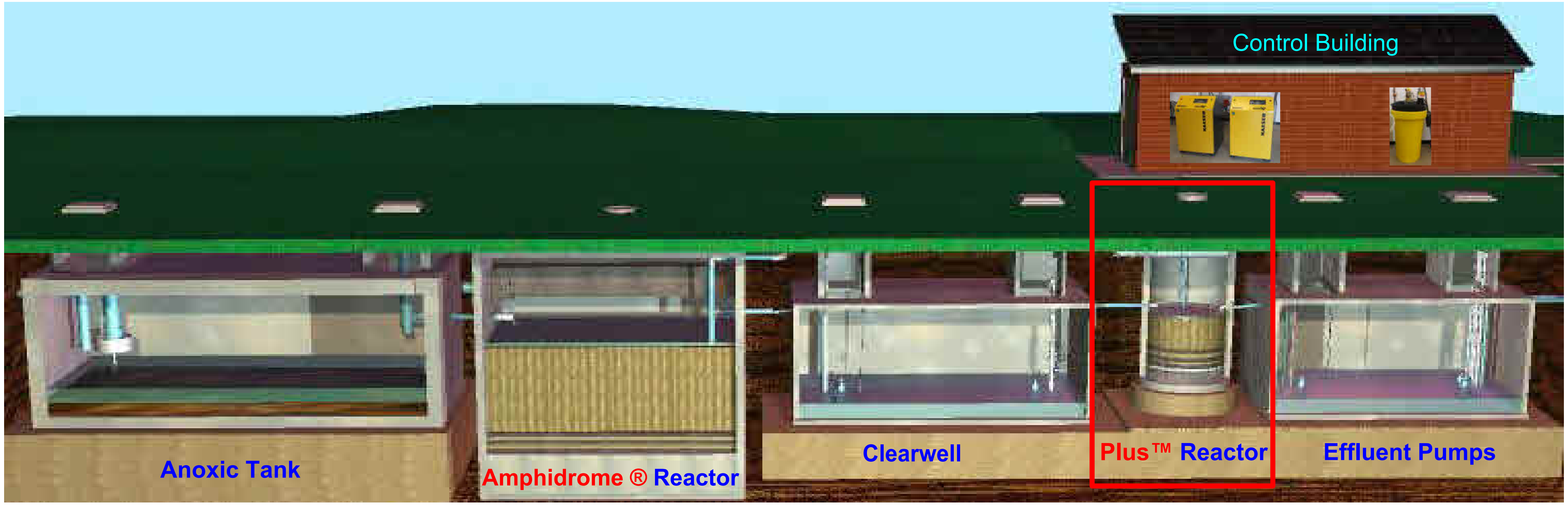
Advanced Nutrient Removal

Low Visual Site Impact

Your Economical Treatment Solution

frma

Amphidrome® System



The **Amphidrome® System** is a Submerged Attached Growth **B**iologically **A**ctive **F**ilter (BAF) providing BOD reduction, superior nitrification, denitrification, phosphorus reduction and filtration of suspended solids in a single reactor.

A spherical sand media provides maximum surface area for microorganisms to attach themselves. The microorganism environment is manipulated with intermittent aeration.

The result is an energy efficient superior treatment system with a very small footprint.

SYSTEM BENEFITS

Low Visual Site Impact	**System Below Grade**
Low Audible Site Impact	**Premium Sound Enclosed Blowers**
Simple to Operate	**Touch Screen, Remote Access for Monitoring and Control**
Energy Efficient	**Intermittent Aeration**
Consistent Treatment	**Fixed Film Reactor With High Biomass**
Filtered Effluent	**Effluent Is Filtered Through Our Deep Media Bed Filter**
Easily Upgradable	**Future Nitrogen or Phosphorus Limits**

With the addition of an **Amphidrome® Plus™** denitrification reactor, nitrogen is further reduced to the lowest level biologically attainable. An enhanced level of phosphorus reduction can also be achieved.

A small building houses a control panel, blowers, and any other ancillary equipment as may be required for a specific application such as alkalinity feed or ultraviolet (UV) disinfection.

ALL SYSTEMS ARE CUSTOM CONFIGURED TO MEET STRINGENT LIMITS

Advanced Nutrient Removal

Ammonia < 1 mg/l

Nitrogen to ≤ 3 mg/l TN

Phosphorus ≤ 0.15 mg/l TP

Contaminants of Emerging Concern

TOC Reduction

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

AquaSBR®

Sequencing Batch Reactor

AquaSBR®
Sequencing Batch Reactor

For over 35 years, Aqua-Aerobic Systems has led the industry in sequencing batch reactor technology with performance proven and cost effective treatment systems capable of effectively removing nutrients and reducing phosphorus with the flexibility of process control that adapts to changing demands.

The AquaSBR® sequencing batch reactor provides true batch technology with all phases of treatment accomplished in a single reactor. All components are easily accessible and the advanced decant system ensures optimum quality effluent withdrawal. Treatment can be optimized with the IntelliPro® process monitoring and control system to further reduce operation and maintenance,energy costs and improve performance.

System Features and Advantages

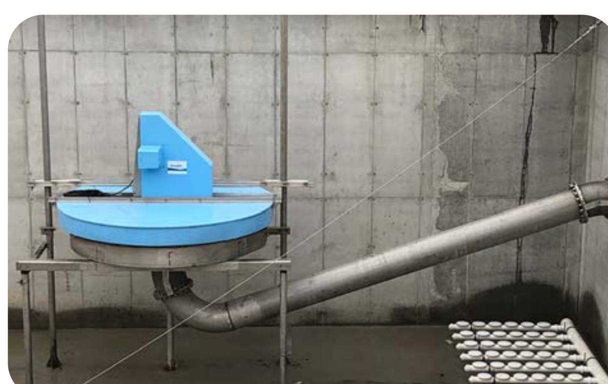
- Independent aeration and mixing with the Aqua MixAir® system provides process advantages and lower energy consumption
- A true-batch system utilizes Mix-Fill, React-Fill, React, Settle and Decant phases within a single reactor
- No secondary clarifiers and return activated sludge (RAS) lines
- All components of the AquaSBR system are retrievable and easily accessible
- Hydraulic fluctuations are easily managed through the flexibility of a time managed process operating strategy
- Enhanced biological nutrient removal:
  - Anaerobic period during Mix-Fill phase to achieve low biological phosphorus requirements
  - Minimize metal salt usage with automated addition after biological luxury uptake to achieve <0.5 mg/l TP
- Ideal for low total nitrogen requirements:
  - Flexibility to modify aeration cycling for TN removal under changing conditions
  - Achieves total nitrogen levels down to 3.0 mg/l
- Low cost of ownership

Aqua MixAir® System

The AquaSBR sequencing batch reactor utilizes the Aqua MixAir® system by providing separate mixing with the AquaDDM® direct-drive mixer and an aeration source such as the Aqua-Jet® surface aerator or Aqua-Aerobic diffused aeration. This system has the capability to cyclically operate the aeration and mixing to promote anoxic/aerobic and anaerobic environments with low energy consumption. In addition, the Aqua MixAir system can achieve and recover alkalinity through denitrification, prevent nitrogen gas disruption in the settle phase, promote biological phosphorus removal, and control certain forms of filamentous bacteria.

Advanced Decanter

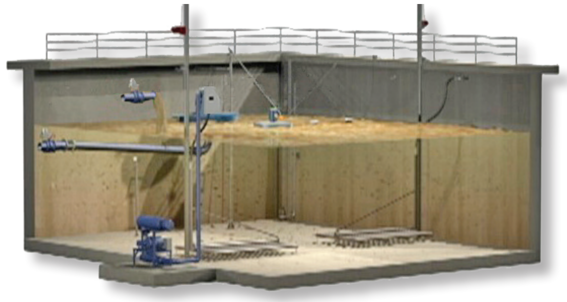
The Aqua-Aerobic floating decanter follows the liquid level, maximizing the distance between the effluent withdrawal and sludge blanket. It is an integral component to the AquaSBR system and provides reliable, dual barrier subsurface withdrawal with low entrance velocities to ensure surface materials will not be drawn into the treated effluent. The decanter is easily accessible from the side of the basin and requires minimal maintenance.



AquaSBR®
Phases of Operation

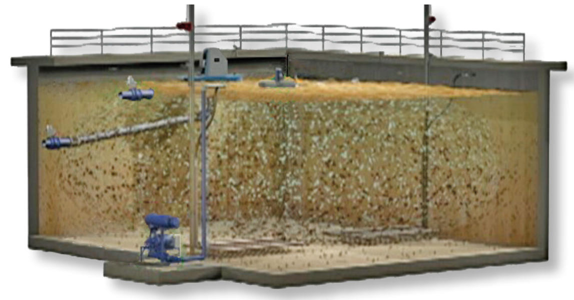
The AquaSBR sequencing batch reactor system features time-managed operation and control of aerobic, anoxic and anaerobic processes within each reactor including equalization and clarification. The AquaSBR system utilizes five basic phases of operation to meet advanced wastewater treatment objectives. The duration of any particular phase may be based upon specific waste characteristics and/or effluent objectives.

1 Mix-Fill



- Influent flow enters the reactor
- Mixing is initiated with the AquaDDM mixer to achieve complete mix of the reactor contents in the absence of aeration
- Anoxic conditions are created which facilitate removal of any residual nitrites/nitrates (NO_x) via the process of denitrification
- In systems requiring phosphorus removal, the Mix-Fill phase is extended to create anaerobic conditions where phosphorus accumulating organisms (PAO) release phosphorus then ready for subsequent luxury uptake during aeration times
- Anoxic conditions assist in the control of some types of filamentous organisms

2 React-Fill

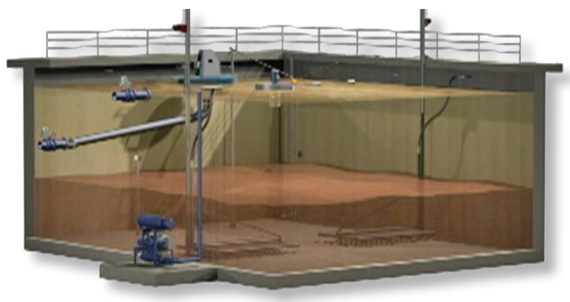


- Influent flow continues under mixed and aerated conditions
- Intermittent aeration may promote aerobic or anoxic conditions
- Biological/chemical oxygen demand (BOD/COD) and ammonia nitrogen (NH_3) are reduced under aerated conditions
- Luxury uptake of phosphorus is produced under aerated conditions
- NO_x is reduced under anoxic conditions
- Separation of aeration and mixing allows the aeration source to be turned down during low flow conditions to conserve energy while the system's flexibility allows nitrification/denitrification to be easily managed

3 React

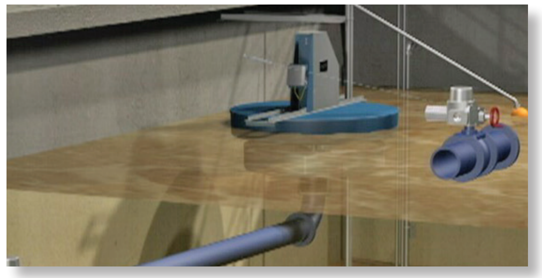
- Influent flow is terminated creating true batch conditions
- Mixing and aeration continue in the absence of influent flow
- Biological/chemical oxygen demand (BOD/COD) and ammonia nitrogen (NH_3) reduction continue under aerated conditions
- Oxygen can be delivered on a "as needed" basis via dissolved oxygen probes while maintaining completely mixed conditions
- Provides final treatment prior to settling to meet targeted effluent objectives

4 Settle



- Influent flow does not enter the reactor
- Mixing and aeration are terminated
- Ideal solids/liquid separation is achieved due to perfectly quiescent conditions
- Adjustable time values allow settling time to match prevailing process conditions

5 Decant/Sludge Waste



- Influent flow does not enter the reactor
- Mixing and aeration remain off
- Decantable volume is removed by subsurface withdrawal
- Floating decanter follows the liquid level, maximizing distance between the withdrawal point and the sludge blanket
- Small amount of sludge is wasted near the end of each cycle

IntelliPro®
Process Monitoring and Control System

The IntelliPro system is a personal computer (PC) based program that interfaces with the AquaSBR system's programmable logic controller (PLC) via a network connection to assist operators in optimizing the treatment process of the plant and further reducing operating costs.

System Advantages

- Real-time, online monitoring and control
- "Active Control Mode" which automatically receives, interprets and proactively adjusts in-basin instruments and process variables including biological nutrient removal, chemical addition and energy
- Reduces the operator's sampling time
- Real-time and historical graphical trending of process parameters
- BioAlert™ process notification provides corrective action to eliminate operational interruptions and upsets
- Assists in the optimization of enhanced nutrient removal
- Online operation and maintenance support
- Remote troubleshooting provides on-demand troubleshooting assistance

AquaSBR®
Typical Applications

Biological Nutrient Removal

- 1.65 MGD Avg. Daily Flow
- Replaced flow-through activated sludge system for enhanced biological nutrient removal (EBNR) to meet Chesapeake Bay Initiative.

Phosphorus Removal

- 2.7 MGD Avg. Daily Flow
- Dissolved oxygen control optimizes power consumption
- Process control achieves 98% removal of total influent phosphorus

Nitrification

- 0.8 MGD Avg. Daily Flow
- Dual basin system. Utilizes process control via IntelliPro® system.

Reuse

- 2.0 MGD Avg. Daily Flow
- 3-basin system followed by (2) AquaDisk® cloth media filters produces reuse quality water.

Industrial Pretreatment

- .075 MGD Avg. Daily Flow
- Treating high strength dairy waste since 1991.

Retrofit

- 0.88 MGD Avg. Daily Flow
- Dual basin retrofit uses existing oxidation ditch to provide treatment flexibility and power savings

Providing TOTAL Water Management Solutions

Visit our website at www.aqua-aerobic.com to learn more about the AquaSBR® Sequencing Batch Reactor and our complete line of products and services:

Aeration & Mixing

Biological Processes

Filtration

Oxidation & Disinfection

Membranes

Controls & Monitoring Systems

Aftermarket Products and Services

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

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solutions@aqua-aerobic.com

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Engineering a Better Environment

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