Section 6

Collection, Treatment and Effluent Recharge System Technologies

6.1 Introduction and Background

This section describes the evaluation of sewer collection, wastewater treatment and effluent recharge system technologies performed to assess suitability for a future Town of Littleton wastewater management program. Advantages, disadvantages and engineering feasibility of the different technologies are included. Estimated planning level Opinion of Probable Project Cost (OPPC) are also provided, which include escalation to the estimated mid-point of construction, Year 2023.

The Town currently owns and operates a small sewer system serving a few municipal buildings including the Fire Station, Town Offices, Town Library, Alumni Field, Littleton High School, Littleton Middle School, and Russell Street Elementary School. The system includes 10,350 feet of pressure sewer, 3,900 feet of gravity sewer, three pumping stations, and a water reclamation facility located at Littleton High School, with groundwater discharge of approximately 17,600 gpd to the MassDEP-permitted effluent recharge site also located at Littleton High School.

6.2 Collection System Technologies

As the first step in developing planning level sewer collection system options, an assessment of the available collection system technologies was conducted. The three technologies for consideration in Littleton include:

- Conventional gravity sewers,
- Low pressure sewers, and
- Hybrid systems.

All three technologies include some form of sewer pipeline to collect the wastewater discharge from individual buildings and convey the flows to a common location. One of the key differences between the technologies are the manner in which the wastewater flows through the pipelines; for example, by gravity or under pressure. For all systems the sewer pipe materials and sizes are designed based on the specific project location, sewer area design criteria and the local utility's building requirements. More details about each system are included in the discussions below.

In addition to the technologies discussed in this section, CDM Smith also reviewed vacuum sewers, septic tank effluent pumping (STEP) systems, and septic tank effluent gravity (STEG) systems, but these technologies are not recommended for implementation in the Town of Littleton. Vacuum sewers are less flexible for future system expansion, are limited to relatively flat topographic areas, and require specialized operator training in order to provide adequate system monitoring response times when problems develop. STEP/STEG systems require on-site septic tanks to be in good condition, property owners to regularly pump the solids (septage) from the septic tanks, and the water reclamation facility in this system is very challenging to operate due to the dilute waste stream without organics needed for biological nutrient removal.

When evaluating the most cost-effective long-term collection system technology, important variables to consider are: building density of the area being sewered, topography of the area, climatic conditions, whether high groundwater exists, amount of the wastewater flows to be collected, as well as operations and maintenance requirements. The intent of this section is to present these technologies , discuss the advantages and disadvantages of each type, and present the planning level OPPCs of each type.

The data sources utilized in this project to develop planning level costs for collection system technologies were bid tabulations from recent CDM Smith projects in the region, and our firm's construction cost estimating database. A 25-percent construction contingency was applied to the construction cost which was then escalated to the estimated mid-point of construction, Year 2023 assuming a 3-percent inflation cost per year. This represents the Opinion of Probable Construction Cost (OPCC). A 20-percent project contingency and 25-percent for engineering and implementation was applied to the OPCC to develop the total OPPC.

6.2.1 Conventional Gravity Sewers

Conventional gravity sewers are the most common and simplest form of wastewater collection. The technology relies on installing sewer pipes at downhill slopes that allow wastewater to flow by gravity. Pipe diameter sizes and slopes are designed to maintain adequate velocities that keep solids suspended within the conveyed wastewater. Conventional gravity sewers typically start with a minimum pipe diameter of 8 inches to allow for equipment access during maintenance. Downstream pipe sizes increase proportionately as flow is collected. Gravity connections can be used from each house to the main sewer pipe in the road or right-of-way and are typically 6 inches in diameter. **Figure 6-1** depicts a typical gravity sewer service connection for a building, including abandoning an existing septic system.

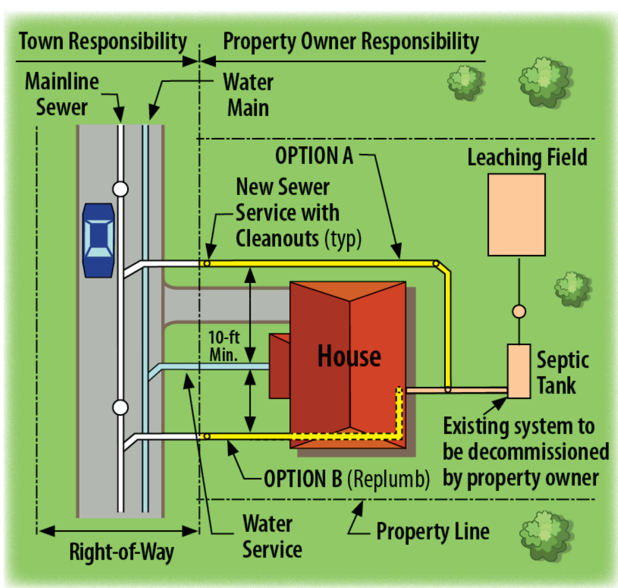


Figure 6-1 Gravity Sewer Service Connection

Homes abutting a gravity sewer that cannot connect by gravity due to elevation differences can pump up to the gravity pipe using a 1- to 1-1/2-inch diameter force main from a grinder pump as an alternate connection means. Most main line sewer pipes are buried approximately 8 to 12 feet deep within the roadway to allow for gravity house connections and to avoid other utilities in the road; however, this depth changes with the topography of the particular street. Manholes are located at all changes in direction or slope in the main sewer pipelines, or at a maximum of every 400 feet to allow for maintenance access. Wastewater collected at low points may require a pumping station to be installed to convey the wastewater via a force main to another gravity sewer or to a water reclamation facility. Areas where topography changes drastically can require multiple pumping stations that can significantly impact the cost and maintenance requirements for a conventional gravity sewer system.

Advantages:

- Typically, gravity systems require the least amount of energy to operate and work during power outages (with the exception of associated pumping stations and grinder pumps for individual connections, if needed).
- Gravity systems have the least amount of system maintenance of the three technologies.
- A well-designed system can handle greater flow fluctuations (seasonal and infilling).
- Gravity systems can accept pressurized flows discharged to it.
- It is a simple system to expand to service additional areas or receive future flows from adjacent areas.
- Most municipalities have staff familiar with this type of collection system.

Disadvantages:

- Project areas with undulating topography may require several pumping stations to support the gravity system.
- Depending on topography, slope and minimum cover pipe requirements can lead to deep sewer pipes in some areas, often where there is a substantial dip in the road.
- In high groundwater areas, and over time as pipe joints age, rain or groundwater can infiltrate into the pipes resulting in unnecessary conveyance and treatment of non-wastewater, which can increase overall sewer operation costs and limit capacity to accept new sewer flows/expansion. While it is possible to have infiltration in most types of collection systems, gravity sewers are by far the most susceptible. However, it can be mitigated with annually conducted Infiltration/Inflow (I/I) mitigation programs as required by MassDEP.
- In low flow periods, wastewater solids can build up in manholes and/or pumping station wet wells and there is a potential for odors if not properly mitigated.

The OPPC inclusive of materials and installation, for gravity sewers are estimated on a per linear foot basis and vary based on pipe diameter. The OPPC assumes an average depth of 8 to 12 feet below ground surface. **Table 6-1** presents the estimated OPCC and OPPC for common sizes of gravity sewer mains, **Table 6-2** presents the estimated OPCC and OPPC for pumping stations, and **Table 6-3** presents the estimated OPCC and OPPC for force main that would convey wastewater from each pumping station to another gravity sewer or to a water reclamation facility. These OPPC include the pipe, manholes, wye connections for each parcel, 6-inch service connections extending an average of 20 feet for each lot (from the street to the property line), paving, police details, and some allowances for drainage and mobilization. Paving costs assume a 6-foot wide trench for all pressure main. Private lateral connections from the home to the property line are not included in the OPPC below. Typically, individual homeowners are responsible for costs associated with these private lateral connections

Table 6-1
Conventional Gravity Sewer Estimated Capital OPPC

Pipe Diameter	Estimates per Linear Foot of Pipe at Mid-Point of Construction (2023)	
	OPCC	OPPC
8”	$ 270	$ 410
10”	$ 320	$ 470
12”	$ 320	$ 480
15”	$ 360	$ 530
18”	$ 360	$ 540
24”	$ 470	$ 710
30”	$ 480	$ 720
36”	$ 640	$ 960

Table 6-2
Pumping Stations Estimated Capital OPPC

Pumping Station Type	Pumping Station Capacity (gpd)	Estimates per each Pumping Station at Mid-Point of Construction (2023)	
		OPCC	OPPC
Submersible w/ Generator (No building)	25,000 – 100,000	$ 640,000	$ 960,000
	100,000 – 500,000	$ 1,300,000	$1,900,000
	500,000 – 1,000,000	$ 2,100,000	$3,200,000
	1,000,000 +	$ 2,400,000	$3,500,000
Submersible w/ Generator (With building)	25,000 – 100,000	$ 1,400,000	$2,000,000
	100,000 – 500,000	$ 3,200,000	$4,800,000
	500,000 – 1,000,000	$ 4,100,000	$6,200,000
	1,000,000 +	$ 5,900,000	$ 8,800,000

Table 6-3
Force Main Estimated Capital OPPC

Pipe Diameter	Estimates per Linear Foot of Pipe at Mid-Point of Construction (2023)	
	OPCC	OPPC
4- to 6-inch	$ 240	$ 360
8- to 10-inch	$ 290	$ 430
12- to 16-inch	$ 420	$ 640

6.2.2 Low Pressure Sewers

Low pressure sewers require each home or a small cluster of homes to have a grinder pump which grinds up solids and then pumps wastewater into a low-pressure force main located in the road or right-of-way. Wastewater from the home flows by gravity into the grinder pump chamber where the pump starts once the flow volume reaches a specific level. The wastewater is then conveyed out into a smaller diameter (1.25- to 4-inch) pipeline network installed at a 5- to 6-foot depth. **Figure 6-2** depicts a typical low pressure sewer service connection for a building abandoning an existing septic system.

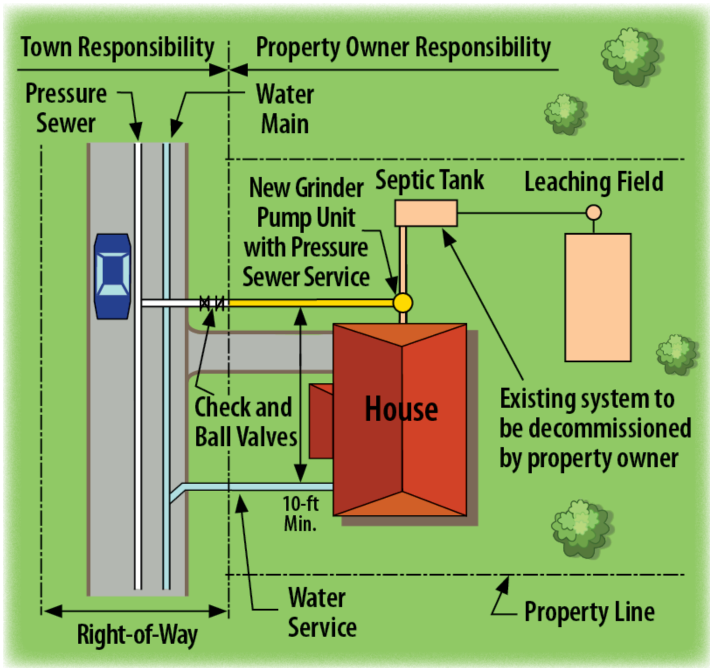


Figure 6-2 Low Pressure Sewer Service Connection

Rather than manholes, flushing connections are provided to allow for maintenance of the system. Additionally, air release and flow isolation valves are installed within the mainline piping network when necessary. Typically, individual homeowners are responsible for the installation and long-term maintenance of the grinder pump, which is installed on the building owner's property. The OPPC for a pressure grinder pumping station that a homeowner would need to incur is $17,000. In addition to the pump installation, this cost accounts for landscaping, lateral piping within the property lines and the potential addition of a back-up power source. Monthly power usage, which is also the responsibility of the property owner, is typically the same as that required to operate a small kitchen appliance.

Advantages:

- The pipeline is smaller in diameter and installed at shallower depths than conventional sewers (typically approximately 5 feet below ground surface), which results in a lower installation cost per foot.
- It is a watertight system and potential installation above groundwater level makes it less susceptible to infiltration/inflow (I/I) occurring.

- Pressure systems can more readily provide sewer service to neighborhoods/areas with changing topography or with minimal slopes as the installation depth is shallower than for gravity systems.
- Pressure system installation causes less disruption to areas during construction and for a shorter duration as compared to gravity systems due to the shallower installation depth in roadways.

Disadvantages:

- Pressure systems require a mechanical component (pump) at each connection to discharge to and operate the sewer system.
- Typically, pressure systems overall have higher energy use.
- Pressure systems are less flexible for future system expansion.
- Pressure systems require specialized operator training for the system and regular maintenance of the grinder pump units. It will need to be determined by the town whether maintenance is the town or building owner's responsibility.
- Pressure systems are more sensitive to wastewater flow fluctuations (daily and seasonal).
- In power outages the grinder pump can't run. There is some limited storage in the grinder pump system, however, prolonged power outages can lead to sanitary backups into the building if a generator or other power is not provided. Some municipalities mitigate this by keeping one or more trailer-mounted generators on hand and driving them to each grinder pump to pump them out temporarily during a prolonged power outage. This task takes labor and depending on the number of grinders, and can take a significant amount time to perform, especially since power outages often occur during poor weather conditions.

Table 6-4 presents estimated planning level OPPC for low pressure sewers on a per linear foot basis. OPPC assume that the pipe size does not affect the unit cost as there is not much variation. OPPC include the cost for valves, lateral piping, street paving, police details, and some allowances for drainage and mobilization. Paving costs assume a 6-foot wide trench for all pressure main. As the project progresses and if low pressure sewer technology is implemented into the recommended plan, a quote would be obtained from a vendor for the specific collection areas.

Table 6-4
Low Pressure Sewer Estimated Capital OPPC

Pipe Diameter	Estimates per Linear Foot of Pipe at Mid-Point of Construction (2023)	
	OPCC	OPPC
1.25- to 4-inch	$230	$340

6.2.3 Hybrid Systems

Communities with a combination of significant wastewater flow fluctuations, both hilly and flat topography, high and low groundwater conditions and perhaps planning several different phases of sewer construction, are often best suited to utilize a combination of sewer collection system technologies. This combination of sewer systems, or a hybrid system, utilizes the best fit technology solution for each particular phase or geographic area.

Conventional gravity sewer systems often prove to be the most reliable and cost effective, backbone of a hybrid system due to their ability to accept wider flow fluctuations and to be expanded in the future. Low pressure sewer systems can supplement the gravity systems to create a Hybrid system that avoids deep sewer construction and/or minimizes the total number of pumping stations.

6.2.4 Operations and Maintenance (O&M) for Collection Systems

The planning level estimates to operate and maintain a collection system vary based on the type of technology implemented as shown in **Table 6-5**. The planning level O&M estimates were developed from the *208 Plan Comparison of Costs for Wastewater Management Systems Applicable to Cape Cod* prepared by the Cape Cod Commission and issued in 2014[1] (208 Plan Cost Document) and were projected from the publication year of 2014 to 2018 with an estimated *Engineering News Record* (ENR) Construction Cost Index of 11,068. The ENR Construction Cost Index is an industry standard index for tracking costs over time. The planning level estimates were then escalated to the estimated mid-point of construction, Year 2023, assuming a 3-percent inflation rate per year. As shown in **Table 6-5**, at this stage in the planning process operations and maintenance estimates are not dependent on pipe and pumping station size.

Table 6-5
Collection System Operations & Maintenance Planning Level Estimates

Item	Estimated Annual O&M (2023)
Gravity Sewer ($/LF)	$ 3
Low Pressure Sewer ($/LF)	$ 4
Pumping Stations ($/each)	$ 40,000 – $ 83,000
Force Main ($/LF)	$ 1

6.3 Water Reclamation Facility Technologies

The prior section discussed options for wastewater collection and conveyance. This section describes the review of water reclamation facility technologies for the treatment of wastewater to be implemented in Littleton's recommended plan. Five treatment technologies were evaluated, including:

- Sequencing batch reactors (SBR),

[1] https://sp.barnstablecounty.org/ccc/public/Documents/208%20Final/Appendices/Chapter%204%20Appendices/Appendix%204C/Appendix%204C.pdf

- Oxidation ditches (OD),
- Membrane bioreactors (MBR),
- Trickling filters (TF), and a
- Community Water and Energy Resource Center (CWERC) system.

All of these technologies involve a biological process component and all but CWERC systems are considered conventional treatment technologies. To meet discharge permitting requirements, it is anticipated that the Town of Littleton's wastewater will need to be treated to 30 mg/L, 10 mg/L and 10 mg/L for Biological Oxygen Demand (BOD), Total Suspended Solids (TSS) and Total Nitrogen (TN), respectively. The intent of this section is to discuss these five types of treatment along with a schematic, discuss the ability of each technology to meet anticipated permitting requirements and to present planning level OPPC associated with the technologies.

6.3.1 Sequencing Batch Reactors (SBR)

Sequencing batch reactors (SBR) function as a combined aeration tank and clarifier, where all the biological reactions and settling/separation occur in a single tank, operating as a batch process. It is an activated sludge process and all the kinetics relationships apply that pertain to any other mode of activated sludge. The SBR operates between a constant low water level and a varying high water level, depending on the influent flow rate. Typically, more than one reactor is required to allow for constant fill of one of the reactors and for maintenance purposes. The SBR is operated under a predetermined cycle and typically follows the following six steps: Mixed Fill, Aerated Fill, React, Settle, Decant, and Idle, as shown in **Figure 6-3** and discussed below:

- **Mixed Fill –** Wastewater enters a partially filled reactor containing biomass. Bacteria biologically degrade the organics and use residual oxygen or alternative electron acceptors, such as nitrate. It is during this period that anoxic conditions are utilized for the selection of biomass with better settling characteristics.
- **Aerated Fill –** The influent flow continues under mixed and aerated conditions.
- **React –** Influent flow is terminated and directed to other batch reactor(s). Mixing and aeration continues in the absence of raw waste.
- **Settle –** The aeration and mixing are discontinued after the biological reactions are complete and the biomass settles under quiescent conditions. Excess biomass can be wasted at any time during the cycle. The settling time is adjustable during operations to match prevailing needs.
- **Decant –** After solid/liquid separation is complete during the settling period, the treated effluent is removed through a decanter. The reactor is then ready to receive the next batch of raw influent.
- **Idle –** The length of this step varies depending on the influent flow rate and the operating strategy.

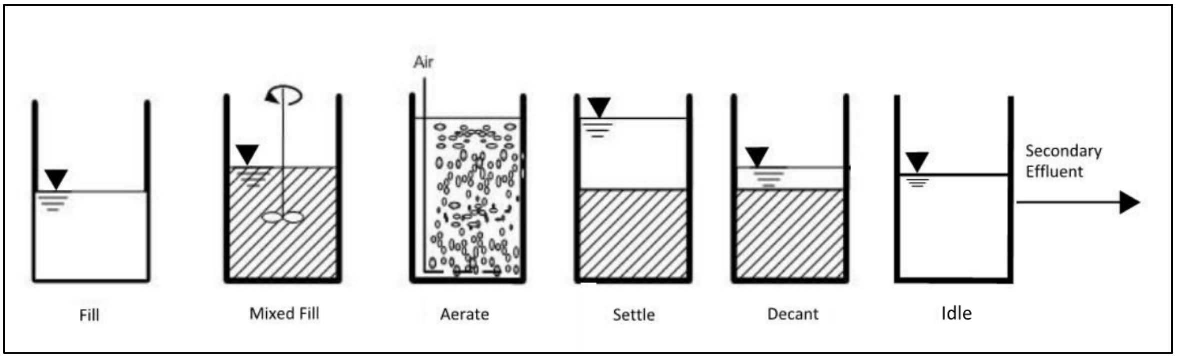


Figure 6-3. Schematic Diagram of the SBR Process

Since clarification and aeration occur within the same tank there is no internal recycle or return activated sludge common to conventional activated sludge treatment processes. Waste sludge is typically removed during the decant phase. A crucial feature of the SBR system is the control unit, including the automatic switches and valves that sequence and time the different operations. Since the heart of the SBR system is the controls, automatic valves, and automatic switches, these systems require more sophisticated maintenance than a conventional activated sludge system.

An important consideration for the SBR system is that the effluent discharges only intermittently resulting in a decant rate that is substantially higher than the plant inflow. This necessitates a post-SBR equalization tank to dampen peak SBR-effluent flows mitigating the need for oversized downstream process equipment. SBR systems have demonstrated the ability to meet the anticipated groundwater discharge treatment levels of 30 mg/L BOD, 10 mg/L TSS and 10 mg/L TN.

An SBR water reclamation facility is capable of handling flow variations by fluctuating water levels, as well as changing cycle times as needed for nitrification and denitrification. Additionally, an SBR water reclamation facility capacity can be increased in phases, with the typically square or rectangular shaped tanks lending themselves to common wall construction. Major components required for an SBR water reclamation facility are listed below:

- Headworks Building –Screening and Grit/Grease Removal
- SBR Tanks
- Effluent Equalization Tank
- Effluent Filters
- Disinfection
- Odor Control
- Septage Receiving Facilities
- Administration/Process Building
- Residuals Processing and Storage

- Effluent Recharge System

6.3.2 Oxidation Ditches (OD)

An oxidation ditch (OD) employs the activated sludge process in a ring- or oval-shaped channel equipped with means of aerating flow. Wastewater is aerated as it circulates around the perimeter of the ditch. For denitrification, anoxic zones can be created within the ditch, but external anoxic tanks are recommended for low total nitrogen limits. These systems are typically designed without primary clarifiers and require secondary clarifiers to separate the activated sludge from the flow stream.

Typically, mechanical mixing and aeration devices are provided, and in some cases a diffused air system is installed. Several varieties of mechanical equipment are commonly used, including horizontal brush rotors, rotating discs, or mechanical aerators, all of which should provide comparable performance. Flow is continuously moving in a circular motion around these tanks as influent is fed and effluent diverted off. OD systems have demonstrated the ability to meet the anticipated groundwater discharge treatment levels of 30 mg/L BOD, 10 mg/L TSS and 10 mg/L TN.

An oxidation ditch, operating as extended aeration, will generate less overall sludge and provide good buffering for peak flows and variations in loading. Because of the long sludge age, a larger tank is required compared to conventional activated sludge systems. Oxidation ditches have very simple operational requirements, and thus can be more favorable for smaller communities. However, because the process utilizes larger aeration tanks and requires longer solids retention time than the conventional process, the capital cost of the treatment structure is increased. In addition, depending on treatment requirements, oxidation ditch facilities may require supplemental aeration to the mechanical aerators to avoid low dissolved oxygen levels in the treatment unit. Major components required for an oxidation ditch water reclamation facility are listed below.

- Headworks Building –Screening and Grit/Grease Removal
- Anoxic Tanks
- Oxidation Ditch
- Secondary Clarifier
- Effluent Filters
- Disinfection
- Odor Control
- Septage Receiving Facilities
- Administration/Process Building
- Residuals Processing and Storage
- Effluent Recharge System

Figure 6-4 presents a schematic diagram of the oxidation ditch process.

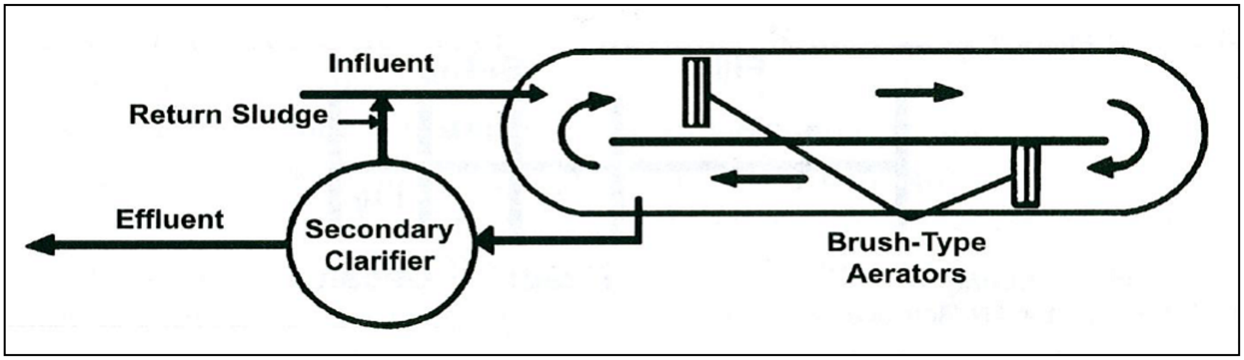


Figure 6-4. Schematic Diagram of and Oxidation Ditch Process

6.3.3 Membrane Bioreactor (MBR)

A membrane bioreactor (MBR) used for nitrogen removal is an activated sludge reactor with membrane filtration downstream of anoxic and aerobic bioreactors. Influent enters the headworks and flows into the pre-anoxic zone, then to the aerobic zone, then the post-anoxic zone. Then the mixed liquor suspended solids (MLSS) flow into the membrane tanks, where mixed liquor is re-aerated and solids are separated from the process effluent. Membrane tanks are aerated to provide final BOD removal and nitrification and to provide scour for prevention of membrane fouling. MBR systems have demonstrated the ability to meet the anticipated groundwater discharge treatment levels of 30 mg/L BOD, 10 mg/L TSS and 10 mg/L TN. Membranes require fine screening down to less than 2 millimeters (mm) in addition to the coarse screening and grit removal. One hundred percent redundancy must be provided for screening and membrane tanks.

The membranes must be capable of physically passing the peak hour flow through the membrane modules, and therefore an influent equalization tank is recommended to dampen peak hour flow. Flow is recycled from the membrane tanks to the aerobic zone, and then back to the pre-anoxic zone in order to avoid recycling high quantities of dissolved oxygen to the anoxic zones. The treatment process requirements are similar to that of an oxidation ditch water reclamation facility. Below is a list of major process components associated with an MBR water reclamation facility.

- Headworks Building (Coarse Screening)
- Grit/Grease Removal
- Fine Screening
- Pre-Anoxic Tanks
- Aerobic Tanks
- Post-Anoxic Tanks
- Membrane Tanks with Influent Equalization

- Disinfection
- Odor Control
- Septage Receiving Facilities
- Administration/Process Building
- Residuals Processing and Storage
- Effluent Recharge System

Figure 6-5 presents a schematic diagram of the MBR process.

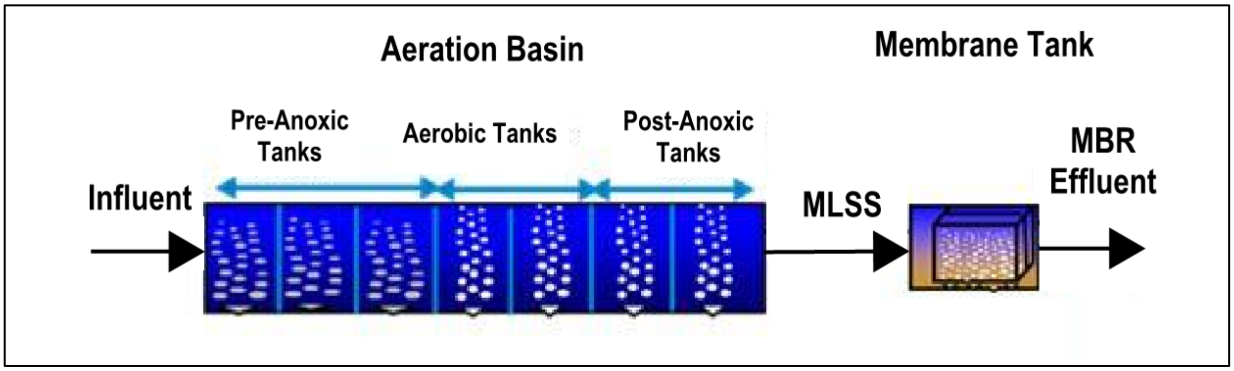


Figure 6-5. Schematic Diagram of the MBR Process

6.3.4 Trickling Filters (TF)

The tricking filter (TF) is a non-submerged fixed-film biological reactor using rock or plastic media over which wastewater is distributed continuously. Treatment occurs as the liquid flows over the attached biofilm (or slime layer), where microorganisms already in the water gradually attach themselves to the rock or plastic surface and form a film. The nitrogen (and other organic material) is then degraded by the aerobic microorganisms in the outer part of the slime layer.

Virtually all new trickling filter installations are constructed using plastic media. Other components of the TF include a wastewater dosing system, an underdrain system, and a structure to contain the packing. The underdrain system is a porous structure through which air can circulate and is used to collect TF effluent liquid. The collected liquid is passed to a sedimentation tank where the solids are separated from the treated wastewater. As the biological film continues to grow, the microorganisms near the surface lose their ability to cling to the medium, and a portion of the slime layer falls off the filter. This phenomenon of losing the slime layer is called *sloughing* and is primarily a function of the organic and hydraulic loading onto the TF. The sloughed solids are picked up by the underdrain and transported to a clarifier for removal.

A portion of the liquid collected in the underdrain system (or the settled effluent) is recycled to the tricking filter feed flow, in order to dilute the strength of incoming wastewater and to maintain enough wetting to keep the biological slime layer moist. Major components required for a TF water reclamation facility are listed below.

- Headworks Building (Coarse Screening)
- Grit/Grease Removal
- Primary Sedimentation Basin
- Trickling Filter
- Secondary Sedimentation
- Disinfection
- Odor Control
- Septage Receiving Facilities
- Administration/Process Building
- Residuals Processing and Storage
- Effluent Recharge System

Figure 6-6 presents a schematic diagram of the tricking filter process.

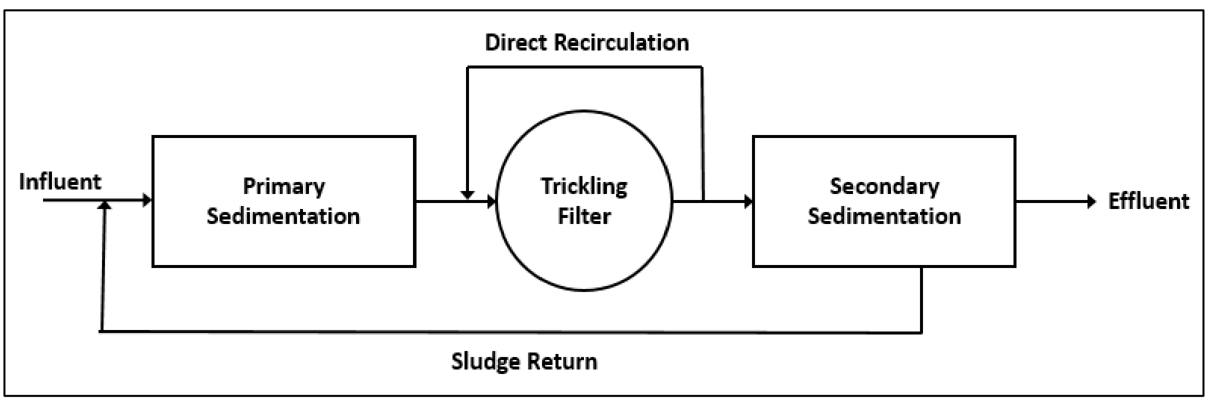


Figure 6-6. Schematic Diagram of a Single Stage TF Process

In terms of the quality of treatment and the ability to achieve permit compliance, trickling filter treatment technology is inferior to the other three conventional treatment technologies. TF systems have not demonstrated the ability to meet the anticipated groundwater discharge treatment levels of 30 mg/L BOD, 10 mg/L TSS and 10 mg/L TN. Therefore, this technology is not recommended for implementation in the Town of Littleton.

6.3.5 Treatment Disinfection and Sludge Removal

All four of the conventional treatment technologies discussed above include disinfection and residuals handling components. There are two typical disinfection methods for wastewater as listed below.

- UV (Ultraviolet Irradiation) and
- Chlorination/Dechlorination

The chlorination/dechlorination process requires chemicals and tankage that come at a significant cost. The UV disinfection process also comes at a high capital cost and requires significant electricity usage which results in high O&M costs. Therefore, the most appropriate option for disinfection varies amongst water reclamation facilities and should be assessed on a case by case basis.

Most water reclamation facilities today with flows under 5 mgd haul sludge created during the treatment process to an offsite facility after thickening. Common means of thickening include gravity thickeners, rotary drum thickeners (RDTs), and gravity belt thickeners (GBTs). Gravity thickeners are circular tanks where sludge settles and is collected at the bottom of the tank while supernatant discharges over a weir and into a launder where it is sent back to the headworks. The tankage negates the need for separate storage. Gravity thickeners are most effective for thickening primary sludges. RDTs consist of a hopper where sludge is fed followed by a rotating screen that holds solids while allowing filtrate to pass. Filtrate is collected and sent back to headworks while thickened sludge is discharged from the drum. GBTs include a rolling horizontal screen on which sludge is placed, with plows distributing the sludge across the screen. Solids are retained on the screen and discharged into a hopper while filtrate is collected in a pan below the screen and sent back to headworks. RDTs and GBTs typically require the use of polymer to facilitate thickening and tanks both upstream and downstream to store unthickened and thickened sludge, respectively. They also require water to clean the screens. With the treatment capacity of a facility in Littleton likely being less than 5 mgd, it is recommended that if one of the conventional treatment technologies is implemented then a hauling/disposal contract for the removal of thickened sludge be made with a licensed hauler and an approved off-site processing facility as necessary. The disposal methods for additional residuals including screenings and grit are to be determined during preliminary design.

6.3.6 Community Water and Energy Resource Center (CWERC)

A Community Water and Energy Resource Center (CWERC) is a small-scale water and energy recover facility, previously reviewed by the Town of Littleton under prior wastewater planning efforts. A CWERC accepts wastewater from sewer pipes and food waste from nearby users, transforming it into renewable energy (both thermal and electric), reclaimed water, nutrients, and compost. Since a CWERC is designed to do more than just treat wastewater, other technologies are involved to make up the energy recovery component.

Wastewater is treated using an MBR. This treatment process is described in detail in Section 6.3.3 and a schematic of the treatment process is shown in **Figure 6-5**.

The process continues as heat is captured by a heat pump. The thermal energy collected can be used to provide heating and cooling both internally at the facilities and externally for other nearby buildings in town. Since treatment for the CWERC is a biological process, the wastewater solids and organic food wastes are digested to create biogas, primarily methane, that can be used to generate electricity and thermal energy in a combined heat and power system.

The components included in a CWERC can vary depending on the wants and needs of the community it serves. Below is a list of some common components included in a system.

- Food Receiving and Processing Station
- Membrane Bioreactor (MBR)
- Anaerobic Digestor (for municipal sludge)
- Food Waste Digestor
- Dewatering of Food and Biosolids
- Storage Tanks
- Combined Heat and Power (CHP)
- Sludge Digestor

A CWERC facility can be disadvantageous in many communities due to the necessary reliance on outside factors for the system to operate. For example, to run a CWERC consistently, the facility must have a steady, reliable organic waste stream to feed the digester. The organic waste must also be pre-processed to ensure all inorganic waste is removed prior to feeding the digestor. It may be difficult to develop a consistent customer base as there are many alternatives for disposing organic waste at no charge. Additionally, the Town must produce enough wastewater flow for the digester to operate properly. If the owner is not in need of power, then a CWERC facility is a costly process for treating wastewater.

The cost to construct as well as operate and maintain a CWERC varies greatly for each facility since each community’s needs and resources differ. Therefore, no generic unit OPPC can be developed. However, as part of Section 8, a preliminary OPPC will be developed for the wastewater management scenario of a centralized CWERC as the water reclamation facility. In assessing this scenario, a specific site as well as the community’s needs and resources will be identified, thus providing design criteria needed to generate an estimate.

A schematic diagram of the CWERC process as shown in **Figure 6-7** was developed based on information from the Charles River Watershed Association presentation at the NEWEA 2016 Annual Conference.

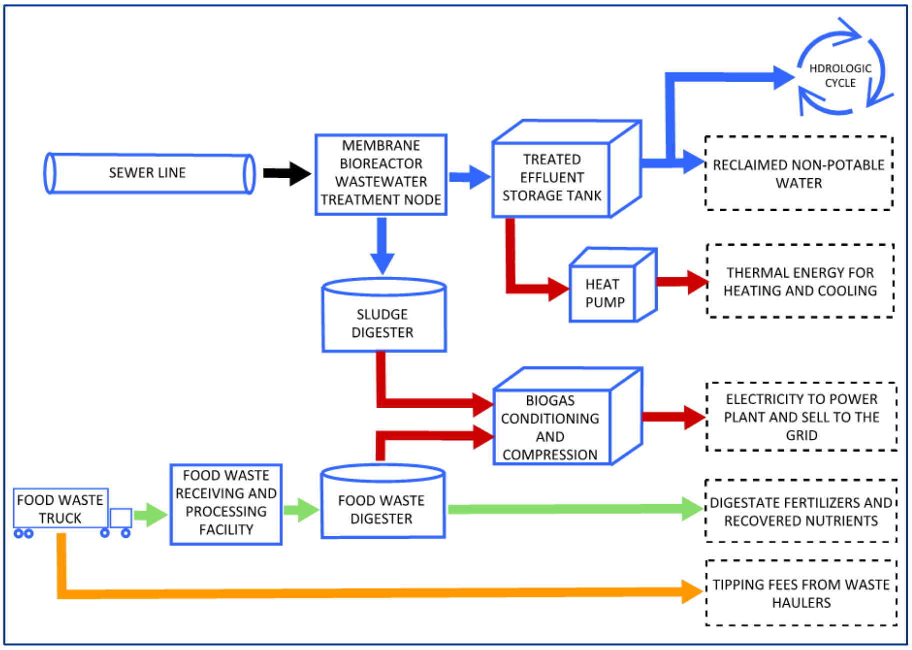


Figure 6-7. Schematic Diagram of a Typical CWERC Process

6.3.7 Treatment System OPPC

At this stage of the planning process, the OPPC for each of the four conventional treatment technologies (SBR, OD, MBR, and TF) are relatively similar and are assumed to follow the same cost scale based on capacity ranges of the reclamation facility. As part of Section 8, preliminary OPPCs will be developed for the wastewater management scenarios for conventional water reclamation facilities and the CWERC. Given the small capacity of each facility, the CWERC is likely to be more costly than conventional water reclamation facilities but both will be further evaluated in assessing scenarios as part of Section 8. Through scenario assessment a specific site as well as the community's needs and resources will be identified, thus providing design criteria needed to generate estimates.

6.4 Existing Package Plants and Potential Upgrades

As discussed in Section 2 of this report, there are currently seven on-site wastewater treatment plants in Littleton, commonly referred to as package plants, ranging in size from 17,600 gpd to 550,000 gpd. Six of those package plants are privately owned and operated while one is owned and operated by the Town of Littleton. A list of the plants, the address and the design flow for each is below.

- Littleton High School, 56 King Street – 17,600 gpd
- Littleton Nursing Home, 191 Foster Street – 18,000 gpd
- Pondside Apartments, 147 King Street – 23,000 gpd
- The Point, Route 119 and Route 495 Interchange – 38,500 gpd

- IBM, 550 King Street – 40,000 gpd
- Village Green, 15 Great Road – 55,000 gpd
- Patriot Beverage, 20 Harvard Road – 550,000 gpd

The Littleton Water Department owns and operates the facility at Littleton High School which uses a Fixed Activated Sludge Treatment (FAST) process. It is permitted to treat 17,600 gpd and has an average daily flow of 4,500. The following municipal buildings are served by the town facility:

- Town Fire Station
- Three Schools (Littleton High School, Littleton Middle School and Russell Street Elementary School)
- Alumni Field
- Town Offices on Shattuck Street
- Reuben Hoar Public Library

6.5 Effluent Recharge

After wastewater is treated, there are two next steps in the process: concentrated sludge solids are removed (as described in Section 6.3.5) and the plant effluent (or treated water) must then be discharged. For Littleton, three land-based disposal technologies for treated effluent are discussed here.

- Infiltration Basins
- Subsurface Leaching Systems
- Spray Irrigation

These technologies are presented below along with the advantages and disadvantages of each and the associated planning level OPPC. The capital OPCC were developed based on bid tabulations from recent CDM Smith projects in the region, and our firm's construction cost estimating database. The capital OPCC include a 25-percent construction contingency and are escalated to the estimated mid-point of construction, Year 2023, assuming a 3-percent inflation rate per year. A 20-percent project contingency and 25-percent for engineering and implementation were applied to the capital OPCC to develop the capital OPPC.

6.5.1 Infiltration Basins

Infiltration basins are open basins in which treated effluent percolates through the sand (or native material), the unsaturated zone of the soil, and then to groundwater. Infiltration basins are unlined and excavated at the ground surface. Infiltration basins have the smallest footprint, but the site cannot be used for other purposes. MassDEP generally allows hydraulic loading rates up to 5 gallons per day per square foot of basin area unless higher rates can be demonstrated for a specific site. Maintenance requirements are minimal. Typically, disinfection is required.

Advantages:

- Lower construction costs than subsurface leaching systems
- Easy access to soils underlying discharge
- Smallest land area requirement

Disadvantages:

- Requires periodic maintenance of the basins
- Requires dedicated area of open land
- If basins are not located at the water reclamation facility, will require construction of a pumping station and force main to transport the treated effluent

Table 6-6 presents the estimated capital OPPC on a per gallons per day basis.

Table 6-6
Infiltration Basin OPPC

Recharge Capacity (gpd)	Estimates per gpd of Design Flow at Mid-Point of Construction (2023)	
	OPCC	OPPC
100,000	$ 4.00	$ 5.00
500,000	$ 3.00	$ 4.00
1,000,000 +	$ 2.00	$ 3.50

6.5.2 Subsurface Leaching Systems

Subsurface leaching systems or soil absorption systems (SAS) are the most common disposal method presently employed in Littleton, as they are used for on-site septic systems. Although larger water reclamation facilities require large disposal areas, SAS can be installed beneath recreational and paved land areas. Large-scale SAS typically have pumps and pipes to pressure dose the infiltration areas. Maintenance is more difficult because the infiltration area is below the surface of the ground and solids cannot be easily removed. MassDEP generally allows hydraulic loading rates of 1 to 3 gallons per day per square foot of bed area. Typically, disinfection is not required unless the SAS is in a Zone II.

Advantages:

- Virtually no above ground utilities
- Can be installed in public areas (fields, under golf course fairways, parks, etc.)

Disadvantages:

- Requires the most land area of discharge options
- Generally, most expensive (land and construction costs) of the land discharge options

Table 6-7 presents the estimated capital OPPC on a per gallons per day basis.

Table 6-7
Subsurface Leaching System OPPC

Recharge Capacity (gpd)	Estimates per gpd of Design Flow at Mid-Point of Construction (2023)	
	OPCC	OPPC
100,000	$10	$15
500,000	$ 8	$ 12
1,000,000 +	$ 7	$ 11

6.5.3 Effluent Reuse - Spray Irrigation

Spray irrigation facilities are typically comprised of pumps, distribution piping and a spraying system consisting of risers and spray nozzles. Treated wastewater is pumped through various distribution lines and discharged via spray nozzles to the surrounding area. Spray irrigation systems discharge treated effluent to large areas such as fields, woods, and golf courses. Spray irrigation allows for a secondary use of land, provides inexpensive irrigation, promotes evapo-transpiration, and, in the case of golf courses, can reduce the need for commercial fertilizers. The potential for freezing temperatures in New England will require a secondary method of effluent disposal during winter months or large storage facilities. Therefore, typically spray irrigation systems are used in conjunction with subsurface leaching systems. MassDEP has stringent requirements for the use of reclaimed water, including a requirement for disinfection.

Advantages:

- Allows for secondary use on land (i.e., golf courses) as regulated by MassDEP
- Provides inexpensive means of irrigation, reducing clean water demands
- Provides nitrogen uptake by plant life and also reduced nitrogen application at golf courses

Disadvantages:

- Difficult to find locations suitable or willing to use spray irrigation
- Limited cold weather use due to potential freezing problems (redundancy required)
- Spray nozzles may be subject to clogging
- Requires secondary means of treated wastewater effluent recharge or storage during winter months (redundancy required)
- Must meet more stringent MassDEP requirements for reclaimed water use
- Applied at an agronomic rate; not disposal.

The cost to implement spray irrigation as an effluent reuse technology varies widely based on site conditions. An OPPC for spray irrigation would need to be determined during a preliminary design effort. Should the technology be included in the Town's recommended plan, a site specific OPPC will be developed.

Littleton has identified a site behind the High School, as shown in **Figure 6-8,** as a potential recharge site for the Town's treated effluent. Hydrogeologic studies have been conducted to determine the feasibility of the site in recharging treated effluent. The studies assume a soil absorption system would be implemented consisting of two subsurface leaching fields. The effluent recharge site has Massachusetts Department of Environmental Protection (MassDEP) approval for 175,000 gpd of treated effluent.

6.5.4 Operations & Maintenance (O&M) for Effluent Recharge Systems

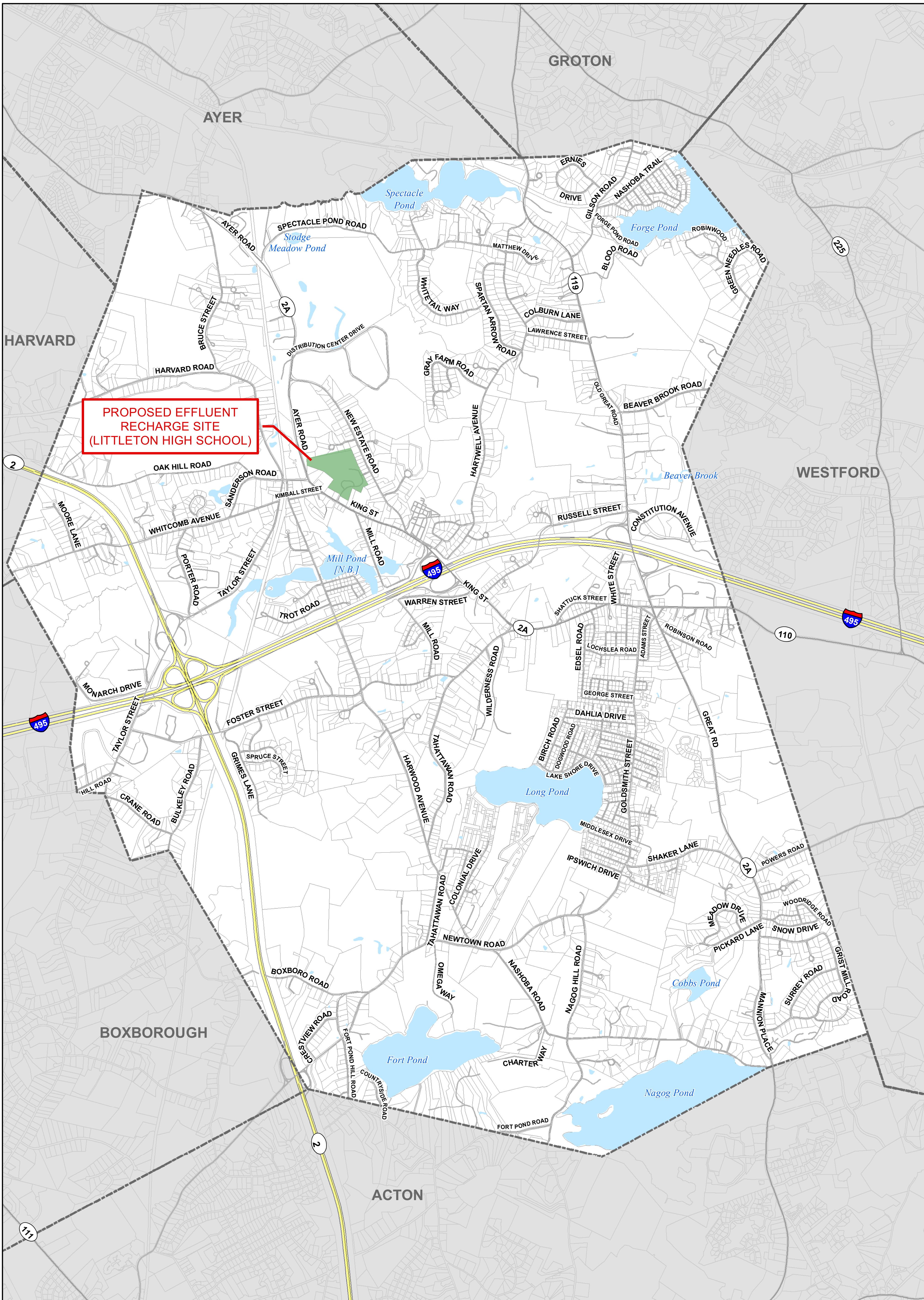
The annual operations and maintenance planning level estimates for effluent recharge vary based on the type of technology selected as shown in **Table 6-8**. Planning level estimates were developed from the 208 Plan Cost Document and were projected from the publication year of 2014 to 2018 with an estimated ENR of 11,068. The planning level estimates were then escalated to the estimated mid-point of construction, Year 2023, assuming an inflation rate of 3-percent per year.

Table 6-8
Estimated Effluent Operations & Maintenance Planning Level Costs

Item	Estimated Annual O&M OPPC (2023)
Infiltration Basin ($/Square Foot)	$ 4 – $ 7
Subsurface Leaching System ($/Square Foot)	$ 0.75 – $ 4

6.6 Regional Opportunities

In developing the most cost-effective and feasible recommended wastewater management plan for Littleton, opportunities to regionalize with neighboring towns are to be assessed. One potential opportunity is to coordinate shared treatment and effluent recharge with the Town of Ayer through an Intermunicipal Agreement (IMA). Ayer has an operating wastewater management program comprised of a collection system, a water reclamation facility and an effluent recharge system. Depending on the areas that the Town of Littleton decides to sewer and how much wastewater flow it amounts to, Ayer may have the extra capacity to accept a portion or all of Littleton's wastewater flow for treatment. To convey Littleton's wastewater flow to the Ayer water reclamation facility, Littleton would tie directly into Ayer's existing collection system near the Littleton-Ayer town line. The Town of Ayer has an agreement with the Massachusetts Development Finance Agency (Devens) to send a portion of wastewater flow to the Devens water reclamation facility for treatment daily. This flow is split at the Main Pumping Station in Ayer; therefore, Littleton's flow would be treated at one of the two facilities. Upon treatment at either water reclamation facility, the effluent would be discharged via the facility's NPDES permitted effluent discharge system. Further assessment of this scenario is to be conducted and discussed in Section 8. There are numerous advantages and disadvantages to regionalizing Littleton's wastewater treatment with the Town of Ayer as listed below.



Legend

Effluent Recharge Site

Littleton, MA

Wastewater Needs Assessment

September 2020

Proposed Effluent Recharge Site

Figure 6-8

1 in = 2,500 ft

0 0.5 1

Miles

MCCAFFREYZC P:\Littleton_MA\DATA\GDB\MassGIS\LittletonMaps\MXD\Littleton_Proposed_Effluent_Recharge_Site_Fig_7-X.mxd 6/3/2020

Advantages:

- Significantly reduces capital costs by utilizing existing treatment facilities
- Eliminates need for hiring and training additional Town staff for operations and maintenance of separate treatment facilities
- Removes Littleton from wastewater treatment “business”
- Regionalization typically benefits all parties involved due to economies of scale cost savings

Disadvantages:

- Littleton loses some “control” over wastewater treatment; will be governed by Intermunicipal Agreement with Ayer
- Littleton would be responsible for capital costs at Ayer WWTP associated with estimated flows, regardless of whether flow estimates are realized
- Scenario involves inter-basin transfer, which can be a permitting challenge
- Potential reluctance of general public to accept regionalization