Section 12

Collection and Treatment System Evaluations

12.1 Purpose and Scope

This section evaluates the three wastewater scenarios recommended for further study as identified in Section 10. The evaluation includes an analysis of various types of sewer collection systems and of various treatment systems that are considered suitable for the flows and treatment levels required in these scenarios. The three scenarios include: 3A- single treatment plant; 4A- two treatment plants; and 5A- two treatment plants utilizing a regional option with Chatham. Capital and operation and maintenance costs are generated for each scenario followed by a brief discussion on noncost factors for each. A final recommended scenario is identified based on the cost and noncost factors.

The scenarios presented in this section have been updated from those presented in Section 10 to reflect the MEP results from the June 2012 Herring River Embayment System Report. Section 10 assumed a 25 percent nitrogen removal percentage for the Herring River watershed since the purpose of that section was to screen potential feasible scenarios. Now that the actual nitrogen removal values are better known, the required sewer service areas needed to remove 58 percent septic nitrogen in the Herring River watershed have been reflected in the three scenarios evaluated in this section.

12.2 Collection System Technologies

Harwich currently has no municipal sewers. So the type of sewer collection system needs to be evaluated as there are several variables that impact that decision. Now that the specific areas in Harwich needing collection have been defined it is appropriate to consider which sewer system technologies will provide the best cost-effective longterm service. Some important variables to consider include the density of the area being sewered, the topography of the area, climatic conditions, whether high groundwater exists, the variability of the wastewater flows to be collected both daily and seasonally, and the amount of labor and associated equipment required to maintain a sewer system.

The intent of this section is to present some of the more common types of sewers in use, discuss the advantages and disadvantages of each type and then develop a town-wide sewer collection system for cost planning purposes. This provides a guide for implementing the overall system but final decisions on the type of sewer and the exact layout would not be made until the actual design phase.

12.2.1 Types of Sewer Collection System Technologies

There are several types of sewer collection system technologies in use throughout the world, however the ones that appear most feasible for consideration in Harwich are considered below. The advantages and disadvantages of each are discussed with the intent of screening down to the type to be utilized in developing the Harwich sewer collection system master plan.

The five sewer collection system types evaluated for Harwich are as follows:

- Conventional gravity sewers
- Low-pressure sewers
- Vacuum sewers
- STEP or STEG Systems
- Hybrid systems

12.2.1.1 Conventional Gravity Sewers

Conventional gravity sewers are the most common and simple form of wastewater collection. The technology relies on installing sewer pipes at constant downhill slopes. 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 ease equipment access during maintenance. Downstream pipe sizes increase proportionately as flow is collected. Gravity connections can be used from the house to the main sewer pipe in the road or right-of-way (ROW) and are typically 6 inches. 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 2 inch forcemain as an alternate connection means. Most main sewer pipes are buried 8 feet deep to allow for mostly gravity house connections and to avoid other utilities in the road however this depth changes with topography. Manholes are periodically located in the main sewer pipelines to allow for maintenance access. Flows collected at low points require a pumping station to be installed to convey the wastewater to another gravity sewer or to an appropriate treatment facility. Areas where topography changes frequently can significantly impact the cost and maintenance requirements for conventional gravity sewers.

Advantages:

- Typically requires the least amount of energy to operate and works during power outages.
- Least amount of system maintenance required.
- Well designed system can handle greater flow fluctuations (seasonal and infilling).
- Can accept pressurized flows discharged to it.
- Simple system to expand to service additional areas or receive flows from adjacent areas.
- Most municipalities have staff familiar with this type of pipe construction and network.

Disadvantages:

- Requirement for constant slope pipes in changing topographic areas can lead to costly number of pumping stations.
- Constant slope pipes can lead to deep sewer pipes.

- In high groundwater areas infiltration into the pipes can lead to costly conveyance and treatment of clean water.

- In low flow periods the potential for odors may occur.

An alternate to conventional gravity sewers is a system that essentially operates in the same manner but utilizes smaller diameter pipes and shallower slopes relying on peak flows to flush the system. This unconventional gravity sewer system has been utilized with limited success and is not recommended for widespread use in Harwich.

12.2.1.2 Low Pressure Sewers

Low pressure sewers require each home or small cluster of homes to have a grinder pump which moves wastewater into a low-pressure forcemain located in the road or ROW. Wastewater from the home flows by gravity into the pump chamber where the pump starts once the flow volume reaches a specific capacity and the wastewater is conveyed out into a smaller diameter (1.25 to 4 inch) pipeline network installed at a 5 to 6 foot depth. Rather than manholes, air release and flow isolation valves are installed within the mainline piping network. Typically, individual homeowners are responsible for the long-term maintenance of the grinder pump. 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. With grinder pump systems, extended power outages have the potential to cause sewer backups unless provisions for connection to a portable generator are incorporated into the design of the system.

Advantages:

- Cheaper pipeline system to install due to smaller diameter pipes at shallower depth.

- Water tight system preventing infiltration/inflow (I/I) from occurring.

- Can more readily service areas with changing topography or with minimal slopes.

- Less disruption to areas during construction.

Disadvantages:

- Requires a mechanical component (pump) at each major connection to discharge to and operate the sewer system.

- Typically overall higher energy use.

- Less flexibility in future system expansion.

- Requires specialized operator training for the system and regular maintenance of the grinder pump units.

- More sensitive to wastewater flow fluctuations (daily and seasonal).

- Prolonged power outages can lead to sanitary issues if backup power is not provided.

12.2.1.3 Vacuum Sewers

Vacuum sewer collection system technology has been around for more than 100 years. In the late 1960s, vacuum technology was expanded to municipal wastewater collection systems and further development has continued more recently. More than 200 systems are in operation nationwide. On Cape Cod, the towns of Provincetown and Barnstable both use vacuum sewer system technology.

Vacuum sewer systems have three components: valve pits, vacuum pipelines, and vacuum/pumping stations. Wastewater flows from each property via gravity to a valve pit that usually serves one to four homes. When a sufficient volume of wastewater builds up in the valve pit, the valve opens and allows the wastewater to be drawn into the mainline. A vacuum pump located at a main vacuum/pumping station pumps air out of the pipeline network creating the vacuum inside the pipes. Vacuum mains typically range in size from 4 to 10 inches in diameter, depending on the number of homes served and the distance from the vacuum station. Similar to low-pressure sewers, vacuum mains can be installed at shallow depths and follow existing topography. Isolation valves are also installed periodically along main sewer lines for accessibility during maintenance of individual pipe segments.

The main component of a vacuum sewer conveyance system is a vacuum pumping station. This station must be centrally located within the system to minimize the length of vacuum mains. Equipment within the station includes vacuum pumps, a collection tank, and wastewater pumps. Vacuum pumps maintain suction in collection mains, delivering wastewater to the collection tank, while wastewater pumps convey sewage from the collection tank to another collection system segment or directly to the treatment facility. The only power demands for a vacuum system are at the vacuum/ pumping station. Typical service areas range from 500 to 1,200 homes. This number is limited by the capacity of the vacuum pumps, which can produce enough vacuum to overcome 15 to 20 feet of hydraulic head in the collection system.

Typical maintenance issues for vacuum sewers include valve pits where valves may become clogged and stuck in the open position. This triggers a low vacuum pressure alarm at the pumping station and can easily be rectified. Since valve pits are normally installed in the town’s right-of-way and are town-owned and maintained, this maintenance would be the responsibility of the Town. Property-owner responsibility is limited to the gravity connections on their individual lots, thereby being essentially equivalent to the responsibility with conventional gravity collection systems. The pressurized portion of vacuum systems is not susceptible to leaks from groundwater infiltration, because it is a closed system.

Advantages:

- Similar to low pressure sewers, typically less costly to install due to smaller pipes and shallower depths of pipe installation
- Fewer mechanical components than a low pressure sewer system.
- Less potential for infiltration of groundwater unless system breaks occur.
- The main vacuum/ pumping station can be equipped with backup power during power outages allowing the overall sewer system to continue operating.
- Less disruption to areas during construction.

Disadvantages:

- Less flexible and more sensitive to wastewater flow fluctuations;
- Requires constant vacuum to be maintained for whole system to work properly.
- Limited to relatively flat topographic areas.
- Requires specialized operator training in order to provide adequate system monitoring and response times when problems develop.
- Less flexible for future system expansion.

12.2.1.4 STEP or STEG Systems

Most homeowners and businesses in Harwich currently have a Title 5 septic system on their property for wastewater disposal. Title 5 system regulations were enacted in 1977 and required a two part system consisting of a septic tank at the front end for solids removal followed by an effluent recharge or liquid disposal field. Thus, some communities have tried to utilize this existing infrastructure by incorporating it into the sewer system. Two different types of uses have emerged as discussed below.

A Septic Tank Effluent Pumping (STEP) system involves the installation of an effluent pump in the back end of the septic tank or in a separate pumping chamber after the septic tank. The pump conveys the lower solids wastewater to a pressurized piping network similar to a low pressure sewer system. Periodically, about every 3 to 5 years, the septic tank is inspected and the solids removed for treatment at the wastewater treatment facility. Regular maintenance of the pump is required by the homeowner.

A Septic Tank Effluent Gravity (STEG) system operates similar to a Title 5 system except that the effluent is conveyed by gravity to a smaller diameter unconventional gravity sewer system. Periodically, about every 3 to 5 years, the septic tank is inspected and the solids removed for treatment at the wastewater treatment facility.

Advantages:

- Potential to re-utilize an existing new septic tank (must be water tight).
- Fewer solids are transported in the sewer system minimizing potential for blockages.
- STEP has similar advantages to a low pressure sewer system.
- STEG has similar advantages to an unconventional gravity sewer system.

Disadvantages:

- The solids (septage) must be pumped periodically from the septic tanks.
- Treatment plant design is more difficult due to dilute waste stream without organics needed for biological nutrient removal and need to increase size of septage receiving facilities.
- Difficult to assess water tightness of existing septic tanks.

- STEP has similar disadvantages to a low pressure sewer system.
- STEG has similar disadvantages to an unconventional gravity sewer system.

12.2.1.5 Hybrid Systems

In many communities, the combination of wastewater flow fluctuations, hilly and flat areas, high and low groundwater conditions and the sequencing of sewer construction over several phases can result in a combination of sewer system technologies being utilized. This combination of sewer systems is commonly referred to as a hybrid system. It utilizes the most cost-effective and efficient technology in a given area.

Conventional gravity sewer systems are often the 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 or vacuum systems often supplement the gravity systems to help offset deep sewer construction, additional pumping stations and extraneous flows (I/I). STEP systems could be utilized in localized areas but STEG systems would not be used as it would be mixing flows with and without solids negating the benefits of smaller pipes.

12.2.2 Recommended Collection System Technology – Hybrid System

Based on the knowledge of the areas requiring sewer service in Harwich and the discussion of advantages and disadvantages presented above, the recommended sewer system technology is a hybrid system. Conventional gravity sewers will be utilized as the main system technology due to their simple and reliable attributes. The gravity system will be supplemented with pumping stations and low pressure sewers in the areas where appropriate to help minimize costs. Typically, if an area with low pressure sewers exceeds more than 20 – 25 homes, a gravity system with a small pumping station will be utilized. In smaller neighborhoods, with less than 20 homes, or at the end of streets where topography drops down low pressure sewers will be utilized.

Vacuum sewers were considered in some areas throughout the five MEP watersheds in Harwich, but were eliminated as an option because of the change in topography in town. Flat terrain is most desirable for a vacuum system. Unfortunately, the topography in Harwich rises and falls more than 40 feet in several areas throughout the proposed collection system which is greater than the 12 to 15 feet of elevation that a vacuum system is able to accommodate. Also vacuum sewers would require another set of maintenance requirements versus the gravity or low pressure systems which does not seem justified for the few small areas where vacuum sewers might be considered applicable.

Similarly the STEP and STEG sewer systems were dropped from further consideration so as not to mix systems with solids and without solids in the wastewater and the need for organic matter in the waste in order to treat down to the low nitrogen levels required to meet the TMDLs.

12.3 Wastewater Flow Estimates

In Section 7, preliminary wastewater flow projections were developed for the entire town for the development of a recommended wastewater program. The wastewater flow estimates presented here are specific to the three wastewater options chosen for further evaluation. They are, in essence, a subset of the wastewater estimates presented in Section 7 since the wastewater service areas do not encompass the entire town and do not in most instances encompass the full extent of the MEP watersheds.

Existing and build-out wastewater flows were estimated for each area being proposed for sewers. As detailed in Section 7, the wastewater flows were estimated to be 93 percent of the water consumption for a given parcel. Wastewater flows are similar to water consumption, but a certain percentage (7 percent used here) is typically removed from the water consumption records to account for evaporation and other non-septic use such as irrigation systems or garden watering. The 93 percent annual adjustment coupled with the irrigation adjustment for July and August averages to the accepted industry standard of 90 percent. This adjustment is specific to the Town of Harwich and is considered a better estimate of average wastewater flow month to month, rather than using a 90 percent reduction across the entire year.

Build-out wastewater flows were calculated from the MEP model. The MEP, working with Harwich planning staff, developed a build-out estimate for the town as part of its nitrogen loading model. The build-out estimate took into account the town’s planning projections and current zoning and land use classifications. In areas such as Harwichport, the East Harwich Village Center area and areas along Route 28, the Town of Harwich is updating the buildout estimates because the MEP buildout is considered to be a rough estimate and the town is working to further develop these areas into high density mixed use developments. If these areas are to be developed as mixed use developments in the future, the additional development will result in increased wastewater flow. The MEP buildout estimates were utilized in the comparison of Options 3A, 4A and 5A, but appropriate revisions for buildout estimates will be incorporated into the recommended wastewater plan described in Section 13.

The subsections below present the wastewater flows estimated for each area proposed to be sewered, under both current and buildout conditions using best available data. The entire sewer service area is expected to have an initial daily average wastewater flow of between 0.76 to 0.79 MGD and a build-out daily average wastewater flow of 0.93 to 0.95 MGD. More detailed flow estimates are presented in Tables 12-1 to 12-3.

12.3.1 Infiltration and Inflow

Infiltration is only a concern in the gravity pipe sewer areas. Infiltration occurs due to groundwater entering the sewer through pipe joints over time, house service connections, defective pipes and manholes. Technical Review - 16, Guide for the Design of Wastewater Treatment Works, prepared by New England Interstate Water Pollution Control Commission, recommends an average estimate for gravity sewers at 250 gallons per day per inch-diameter-mile of new pipe (gpd/idm), and as the sewers age that estimate increases to 500 gallons per day per inch-mile of pipe. This is similar to the MassDEP CWMP guidelines, which suggest 200 and 500 gpd/idm for new and older sewers, respectively. The more conservative estimate has been used at this time due to high groundwater conditions in some areas to be sewered in Harwich. Actual infiltration flows will change as the groundwater table elevation fluctuates throughout the year.

Inflow can occur in older sewer systems due to illegal connections from roof leaders, sump pumps, cellar and foundation drains, and surface drains connected to the sewer. It can also occur due to cross-connections with storm drains and catch basins. Because the proposed sewer system will be a new sewer system, no inflow should occur. Efforts will be made to prevent these illegal connections during and after the start-up of the sewer system. Extensive public education regarding illegal inflow will accompany sewer connection information for residents and businesses to ensure the public understands the issue and the ramifications of making illegal connections. The town will require each parcel owner seeking a tie-in permit to sign a form acknowledging that they were informed about illegal connections and that they will not connect their sump pumps, downspouts, etc., to their sewer services. The form will also have them acknowledge that they were informed that it is against the State Plumbing Code, as well as local sewer use ordinances.

In addition to projected wastewater flows, Tables 12-1 to 12-4 below include the additional flow anticipated from infiltration for the entire sewer service area.

12.3.2 Summary of Flows

Tables 12-1 to 12-4 summarize the annual average daily flows associated with the three scenario collection systems.

Table 12-1
Scenario 3A Wastewater Flows

Watershed	Number of Parcels	Current Average Annual Wastewater Use (GPD)	Current Average Estimated I/I Flow (GPD)	Buildout Average Annual Wastewater Use (GPD)	Buildout Average Estimated I/I Flow (GPD)
Allen	234	52,100	2,250	57,000	4,500
Wychmere	123	26,300	1,450	29,000	2,900
Saquatucket	415	90,700	9,000	95,200	18,000
Pleasant Bay	1,031	171,500	31,000	201,800	62,000
Herring River	2,502	420,800	56,000	555,600	112,000
Total	***4,305***	***761,400***	***99,700***	***938,600***	***199,400***

Table 12-2
Scenario 4A Wastewater Flows

Watershed	Number of Parcels	Current Average Annual Wastewater Use (GPD)	Current Average Estimated I/I Flow (GPD)	Buildout Average Annual Wastewater Use (GPD)	Buildout Average Estimated I/I Flow (GPD)
Allen	234	52,100	2,250	57,000	4,500
Wychmere	123	26,300	1,450	29,000	2,900
Saquatucket	415	90,700	9,000	95,200	18,000
Pleasant Bay	1,295	224,300	38,000	258,000	76,000
Herring River	2,340	399,300	53,700	515,700	106,000
Total	***4,407***	***792,700***	***103,700***	***954,900***	***207,400***

Table 12-3
Scenario 5A Wastewater Flows

Watershed	Number of Parcels	Current Average Annual Wastewater Use (GPD)	Current Average Estimated I/I Flow (GPD)	Buildout Average Annual Wastewater Use (GPD)	Buildout Average Estimated I/I Flow (GPD)
Allen	234	52,100	2,250	57,000	4,500
Wychmere	123	26,300	1,450	29,000	2,900
Saquatucket	415	90,700	9,000	95,200	18,000
Pleasant Bay	1,205	205,900	34,900	235,900	69,800
Herring River	2,340	399,300	56,000	515,700	112,000
Total	***4,317***	***774,300***	***103,600***	***932,800***	***207,200***

Table 12-4
Summary of Wastewater Flows

Scenario	Number of Parcels	Current Average Annual Wastewater Use (GPD)	Current Average Estimated I/I Flow (GPD)	Buildout Average Annual Wastewater Use (GPD)	Buildout Average Estimated I/I Flow (GPD)	Total Buildout Flow (GPD)
3A	4,300	761,500	99,700	939,000	199,000	1,138,000
4A	4,400	793,000	103,700	955,000	207,000	1,162,000
5A	4,300	774,000	103,600	933,000	207,000	1,140,000

12.3.3 Peaking Factors

To develop flows for pipe and pumping station sizing, peaking factors were applied to the current and buildout wastewater flows for each area, using standard industry flow curves for determining the ratio between average daily and peak hour wastewater flows. In addition, the ratio of summer (June, July and August) to annual average daily flow was determined to be 1.91 from monthly municipal well pumping records. To evaluate low flows, the ratio of winter to annual average daily flow was determined to be 0.52. Peak hour infiltration was estimated at 1.75 times the average daily infiltration. Each of these factors will be used to refine collection system pipe sizing and pumping station selection and sizing.

12.4 Sewer System Layouts for Scenarios 3A, 4A, and 5A

Utilizing the recommended hybrid sewer system technology, preliminary layouts for wastewater program Scenarios 3A, 4A and 5A were developed. These layouts reflect the updated wastewater collection system areas as a result of the Herring River MEP Report and having treatment to 3mg/l total nitrogen in all three scenarios. As a result, the three layouts presented are different than the layouts presented in Section 10.

12.4. 1 Sewer Collection System for Scenario 3A

Scenario 3A is presented in Figure 12-1. In this scenario, effluent recharge utilizes only the HR-12 site. The total number of parcels sewered for this scenario is approximately 4,300 and the total buildout flow, based on average wastewater use, is about 940,000 gpd. The amount of infiltration/ inflow from the gravity pipes at buildout is estimated to be an additional 199,000 gallons per day.

Sewering for Scenario 3A would consist of collecting wastewater from each residential area through local pipe networks and conveying it through pumping stations to a final receiving facility in the Herring River watershed. A single treatment facility would process all collected wastewater for the Town and recharge at that site.

Collection System

The sewer system under this scenario utilizes conventional gravity pipes, pumping stations and low pressure sewers. The proposed gravity system utilizes 78 miles of gravity pipes and force mains ranging in size from 2-inches to 18-inches and utilizes 31 pumping stations. The low pressure sewer utilizes 23 miles of small diameter pressure pipe with no central pumping stations.

Treatment Facility and Effluent Recharge

This scenario will utilize one treatment facility, located at HR-12, the Harwich landfill site. This facility will receive flow from the entire town and will recharge the treated effluent onsite in infiltration basins located adjacent to the facility.

12.4.2 Sewer Collection System for Scenario 4A

Scenario 4A is presented in Figure 12-2. In this scenario, effluent recharge utilizes the HR-12 and PB-3 sites. The total number of parcels sewered for this scenario is approximately 4,400 and the total buildout flow, based on average wastewater use, is 955,000 gpd. The amount of infiltration/inflow estimated from the gravity pipes at buildout is estimated to be an additional 207,000 gallons per day.

Sewering for Scenario 4A would consist of collecting wastewater from each residential area in the Saquatucket, Wychmere, Allen, and Herring River watersheds through local pipe networks and conveying it with pumping stations and forcemains to a treatment facility at HR-12. A separate treatment facility located at PB-3 would be used for all wastewater collected within the Pleasant Bay watershed.

Collection System

The sewer collection system under this scenario utilizes a conventional gravity system, pumping stations and low pressure sewers. The proposed gravity system utilizes 78 miles of gravity pipes and force mains ranging in size from 2-inches to 16-inches and utilizes 32 pumping stations. The low pressure sewer utilizes 23 miles of small diameter pressure pipe with no central pumping stations.

Treatment Facility and Effluent Recharge

This scenario utilizes two treatment facilities; one located at HR-12, the Harwich landfill site and one at PB-3 in the Pleasant Bay. The PB-3 facility will receive flow from the Pleasant Bay Watershed area and the HR-12 facility will receive flow from the other four watersheds. Both facilities will recharge the treated effluent onsite in infiltration basins located adjacent to the treatment facility.

Scenario 3A
Updated Treatment and MEP Results
in Herring River

CDM Smith

Figure 12-1
Sewer Scenario 3A
Harwich, MA
August, 2012

Proposed Sewered Area
Treatment / Effluent Recharge
Village Centers
Allen Harbor
Herring River
Pleasant Bay
Saquatucket Harbor
Wychmere Harbor

Scenario 4A
Updated Treatment and MEP Results in Herring River

1 inch = 1,250 feet
0 1,250 2,500 3,750 5,000 Feet

CDM Smith

Figure 12-2
Sewer Scenario 4A
Harwich, MA
August, 2012

12.4.3 Sewer Collection System for Scenario 5A

Scenario 5A is presented in Figure 12-3. In this scenario, effluent recharge utilizes the HR-12 and PB-3 sites. This scenario is similar to 4A. For this option, the flow from the Pleasant Bay watershed is collected and transported to the existing Chatham treatment facility. Treated effluent is then conveyed back to PB-3 for recharge.

The total number of parcels sewered for this scenario is approximately 4,300 and the total buildout flow, based on average wastewater use, is 933,000 gpd. The amount of infiltration/inflow from the gravity pipes is estimated to be an additional 207,000 gallons per day.

Regional Option with Chatham

Under Scenario 5A, a regional option with Chatham was explored as a way to reduce cost for the Town of Harwich while utilizing capacity at the Chatham Water Pollution Control Facility (WPCF). At this time, the Chatham WPCF has additional capacity that is not being utilized because the planned collection system in Chatham will not be completed for several years. With an inter-municipal agreement, the Town of Harwich could utilize that additional capacity until it is needed by the Town of Chatham. For a long term solution, Harwich will need to pay for an expansion to the Chatham facility to accommodate the flow generated within the Pleasant Bay watershed under scenario 5A. The long term regional wastewater solution between Chatham and Harwich is a treatment only option. Similar to Harwich, several watersheds in the Town of Chatham are also limited by nitrogen and do have limited capacity for recharge. Thus, the regional option evaluated herein will require the Town of Harwich to recharge treated effluent back within the boundaries of Harwich so both towns can maintain the nitrogen balance as required by the current MEP information.

To determine if a regional option was feasible, the Towns of Harwich and Chatham developed costs for conveying wastewater generated within the Pleasant Bay Watershed in Harwich; treating the wastewater at the Chatham WPCF; and conveying the treated effluent back to Harwich for recharge. The agreement is for approximately 300,000 gpd of wastewater (this is an annual average flow) to be conveyed from the Pleasant Bay Watershed area in Harwich to the Chatham WPCF. Capital and O&M costs for conveyance from that location to the Chatham WPCF were also determined by Chatham and their engineer, GHD, using the planning level costs developed earlier in the Chatham CWMP. The results of this regional option were weighed against the other options presented in this section and are compared in table 12-13. A copy of the technical memorandum detailing the regional connection alternative to Chatham is included in Appendix E. Table 12-4, below details the costs for Harwich to connect to the Chatham system.

Table 12-4
Town of Harwich Share of the Collection Treatment and O&M System Costs to connect to the Chatham System

Type	Option 5A
Collection System	$2,400,000
Treatment System	$9,200,000
Annual O&M Costs	**$ 260,000**

Proposed Sewered Area
Treatment / Effluent Recharge
Village Centers
Allen Harbor
Herring River
Pleasant Bay
Saquatucket Harbor
Wychmere Harbor

Scenario 5A
Updated Treatment and MEP Results in Herring River

1 inch = 1,250 feet
0 1,250 2,500 3,750 5,000 Feet

CDM Smith

Figure 12-3
Sewer Scenario 5A
Harwich, MA
August, 2012

The collection system under this scenario utilizes a hybrid conventional gravity system with pumping stations and low pressure sewers. The proposed gravity system utilizes 82 miles of gravity pipes and force mains ranging in size from 2-inches to 16-inches and utilizes 32 pumping stations in Harwich and 2 pumping stations in Chatham. The low pressure sewer utilizes 23 miles of small diameter pressure pipe.

Treatment Facility and Effluent Recharge

This scenario will utilize two treatment facilities, located at HR-12, the Harwich landfill site and the Chatham WPCF. The Chatham WPCF will receive flow from the Pleasant Bay watershed and the HR-12 facility will receive flow from the rest of town (outside of the Pleasant Bay). HR-12 will recharge the treated effluent onsite at infiltration basins located adjacent to the facility. The effluent flow from the Chatham facility will be pumped back into Harwich for recharge at PB-3 in the Pleasant Bay watershed. For this scenario, PB-3 will only be utilized as an effluent recharge site.

12.5 Proposed Pumping Stations

The recommended collection system layouts include approximately 33 pumping stations which are fed by gravity sewers. Proposed pumping station locations shown on these layouts are only approximate and represent idealized locations, based on topography. As the town moves forward with the selected collection system then final pumping station sites will need to be reviewed and specific sites identified.

The final sites would be selected according to the following criteria:

1. Proximity to the low point in the collection system – gravity pumping stations should be located as close as possible to the low points.

2. Property ownership – ideally the selected parcels are already owned by the town.

3. Minimize permitting requirements -avoid work within wetland areas, the 100-foot buffer zone to wetlands, or the 200-foot riverfront area, where applicable.

4. The location of the 100-year floodplain – structures within the floodplain have to meet more stringent design and construction standards, to ensure that the stations continue to function properly during an anticipated flooding event, resulting in higher risks and more costly construction.

5. Location within EOEEA Article 97 Sites – these sites are preserved as open space and require an act of the Massachusetts state legislature for the construction of any structures. If possible, Article 97 sites should be avoided.

The approximate pumping station locations are shown on Figure 12-4. Since options 3A, 4A and 5A are similar, Figure 12-4 shows the approximate wastewater service area for the town and incorporates minor overlap for the three options. For planning purposes, this approach is appropriate since the locations will be better defined as each phase of the sewering plan is implemented. Table 12-6 lists the number of parcels immediately served by each station, along with the average daily flows each station will receive at full buildout. When each station is designed, these average daily flows will be used to calculate the peak design flows each station will need to accommodate.

Proposed Sewered Area
Treatment / Effluent Recharge
Village Centers
Allen Harbor
Herring River
Pleasant Bay
Saquatucket Harbor
Wychmere Harbor
Pump Stations

All Scenarios
Sewered Parcels

1 inch = 1,250 feet

0 1,250 2,500 3,750 5,000 Feet

CDM Smith

Figure 12-4
All Sewer Scenarios
Harwich, MA
August, 2012

Table 12-6
Pumping Stations and Estimated Flows For Options 3A, 4A and 5A

Pumping Station	Approximate Number of Parcels Immediately Served by PS			Current Average Wastewater Flow Into Pump Station (gpd)	Build-out Average Wastewater Flow Into Pump Station (gpd)	Build-out Estimated I/I Flow Into Pump Station (gpd)	Build-out Average Estimated I/I Flow Into Pump Station (gpd)
	3a	4a	5a				
PS-HR-01	143	143	143	25,800	2,100	31,200	4,200
PS-HR-02	254	254	254	45,800	3,700	55,400	7,400
PS-HR-03	411	409	409	145,400	11,800	176,000	23,500
PS-HR-04	468*	433	433	403,000	75,900	488,000	65,300
PS-HR-05	127	126	126	22,900	1,900	27,700	3,700
PS-HR-06	29	29	29	5,300	500	6,400	900
PS-HR-07	19	x	x	3,500	300	4,200	600
PS-HR-08 (Scenario 3A)	318	318	318	334,100	27,800	404,600	54,400
PS-HR-08 (Scenario 4A, 5A)	318	318	318	112,400	9,400	136,100	18,300
PS-HR-09	113	113	113	20,400	1,700	24,700	3,300
PS-HR-10	36	36	36	6,500	600	7,900	1,100
PS-HR-11	198	197	198	46,900	3,800	56,800	7,600
PS-HR-12	62	62	62	11,200	900	13,600	1,800
PS-HR-13	152	133	133	56,200	4,800	68,200	9,300
PS-HR-14	76	75	75	13,700	1,200	16,600	2,300
PS-HR-15	36*	11	11	17,300	1,500	21,000	2,900
PS-HR-16	60	x	x	10,800	900	13,100	1,800
PS-PB-01	413*	422	347	233,200	19,300	282,400	37,900
PS-PB-02	x	24	24	4,400	400	5,300	700
PS-PB-03	23	41	89*	36,600	3,100	44,300	5,900
PS-PB-04	x	36	26	16,100	1,400	19,500	2,600
PS-PB-05	x	83	33	10,500	900	12,700	1,700
PS-PB-06	28	28	28	5,100	500	6,200	900
PS-PB-07	130	131	130	57,600	4,800	69,700	9,400
PS-PB-08	83	84	84	15,200	1,300	18,400	2,500
PS-PB-09	104	104	104	18,800	1,600	22,700	3,100
PS-PB-10	61	55	55	10,300	900	12,500	1,700
PS-PB-11	117	114	114	31,000	2,600	37,600	5,100
PS-PB-12	115	158*	106	59,500	4,900	72,100	9,700
PS-A-01	251*	217	217	126,400	10,400	153,100	20,600
PS-S-01	228	209	209	61,500	5,100	74,500	10,100
PS-S-02	46	35	35	7,100	600	8,600	1,200
PS-S-03	20	20	20	10,700	900	13,000	1,800
PS-S-04	70	64	64	22,600	1,900	27,400	3,800
PS-W-01	117	104	104	81,200	6,700	98,300	13,300
Estimated Total to WWTP - Scenarios 3A - 5A				**761,500 - 774,000**	**61,000 - 64,000**	**933,000 - 955,000**	**121,000 - 128,000**

* The maximum number of parcels was used to calculate the capacity for that pump station

The pumping stations in the gravity system would mostly be submersible-type stations with on-site standby power. The stations would be predominately precast concrete underground stations, with the standby power and instrumentation and control panels above ground either in pedestal cabinets or housed in a prefabricated building. The larger stations, which will pump more than 2.5 mgd at peak flow to the wastewater treatment facility at build-out, will likely be a cast-in-place concrete wet pit/dry pit station with a building to house electrical equipment and controls.

12.6 Collection System Costs

12.6.1 Collection System Capital Costs

Cost estimates were developed for the three collection systems. These estimates, including both piping and pumping stations, are shown in Table 12-7.

Table 12-7
Estimated Collection System Costs

	3A	4A	5A
Number of Properties Served	4,305	4,407	4,317
Collection System Cost	$124,900,000	$137,500,000	$144,200,000
Collection System Cost for Harwich (Chatham System)			$2,400,000
Homeowner Hookup Cost	$19,000,000	$18,900,000	$18,500,000
Total	$143,900,000	$156,400,000	$165,100,000

The cost for gravity piping includes 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), excavation support, state highway construction considerations where applicable (flowable fill, etc.), paving, police details, and some allowances for drainage and mobilization. Paving is assumed to include a 2-inch trench patch and a 1.5-inch full width overlay on all currently paved roads.

The cost for individual homeowner hookups is also shown and includes an assumed cost for a service connection to the property line where the municipal collection system connects to the private service connection. For the homes or businesses with pressure sewers, an additional cost was included for the purchase and installation of a grinder pump.

All of these estimates include an allowance for planning level costs (25 percent), and for permitting, engineering and construction services (25 percent).

Similar to the cost analysis performed in section 10, the collection system costs for the three options are similar and only differ less than 15 percent. The 4A and 5A scenarios are slightly higher in costs due to added conveyance costs for two treatment facilities, particularly, with Scenario 5A since this scenario goes to Chatham and back.

It is important to note that these collection system costs include over 1,100 more parcels being sewered In the Herring River and are based on the conceptual sewer system master plan layout from pipe sizes and number of pumping stations versus Section 10 costs.

12.6.2 Collection System O&M Costs

Annual operation and maintenance costs for the three wastewater collection system alternatives under buildout conditions are shown below in Table 12-8. These costs have been divided into system wide costs and a summary of individual user costs that the property owner is required to pay. These costs are for operation of the collection system only and do not include operation and maintenance costs associated with the town's proposed wastewater treatment facilities.

Following the table is an explanation of the basis of the labor, equipment, power and other costs presented in the table.

Table 12-8
Operation and Maintenance Cost Summary for Buildout Conditions

Cost Category	Scenario 3A	Scenario 4A	Scenario 5A
Public Costs:			
Labor	$546,000	$561,000	$580,000
Power	$158,000	$162,000	$168,000
Miscellaneous Costs	$141,000	$145,000	$150,000
Total System Wide O&M	**$845,000**	**$868,000**	**$898,000**
Private User O&M Costs	$141,000	$123,000	$119,000
Total O&M	**$986,000**	**$991,000**	**$1,017,000**

[1]Does not include wastewater treatment charges.

12.6.2.1 Labor Costs

Typical Collection System O&M

The average cost for labor including salaries and fringe benefits is approximately $65,000 per employee per year. Scenarios 3A, 4A and 5A indicate that that Harwich's labor force will include a total of eight people for scenario 3A and nine people for scenarios 4A and 5A to maintain the collection system which includes thirty-one, thirty-two, and thirty-four pumping stations, respectively, at buildout.

Proposed Gravity System

To determine the number of personnel required for the gravity sewer system, the number of miles of sewer and the number of pumping stations was calculated. The proposed gravity system is expected to require a labor force of approximately six people for options 3A and 4A and seven people for option 5A. These staff will be needed to perform operation and maintenance of thirty-one (31) pumping stations and forty-five (45) miles of sewer for scenario 3A, thirty-two (32) pumping stations and forty seven (47) miles of sewer for scenario 4A, and (34) pumping stations forty-eight (48) miles of sewer for option 5A.

Proposed Pressure System

Similar to the gravity system, the pressure sewer alternative requires approximately two positions for all scenarios to maintain the pipelines. The majority of the pressure system maintenance cost is directly on the connection owner.

12.6.2.2 Power Costs

Power costs are based on connected horsepower and expected running times of pumps at the wastewater pumping stations. Annual costs are higher for pumping stations utilizing the gravity sewer option (main pumping station/three small collection system pumping stations). Pressure sewers have the lowest power costs as the town is only responsible for the main pumping stations and homeowners operate and maintain the grinder pumps.

12.6.2.3 Miscellaneous Costs

These costs include spare parts, vehicles, fuel and associated maintenance, training expenses and other miscellaneous costs. Since Harwich has no existing budget to review we estimated that miscellaneous costs are likely to represent 20 percent of the labor and power cost.

12.6.2.4 Private Costs

Pressure System

Every household has a grinder pump that is owned, operated and maintained by the homeowner The cost include $25/year for power and an allowance to purchase a service contract to maintain the system at $100/year for a total of $125/year per household. Scenarios 3A to 5A have between 950 and 1,130 lots on pressure sewers that require grinder pumps.

12.6.2.5 O&M Costs Summary

The O&M costs for the collection systems of the three options are similar and reflect the similarity of the three collection systems. The increased Public O&M cost for scenario 5A reflects the costs for the additional pumping station in Chatham, but overall the costs are considered to be equal.

12.7 Treatment Technology Evaluations

Three types of treatment facilities were evaluated to determine the most appropriate treatment technology for Harwich. The technologies were ranked based on several criteria, including capital and O&M costs, operational flexibility and expandability.

12.7.1 Key Evaluation Criteria

Three treatment system technologies were selected from experience and deemed feasible to meet the proposed treatment levels for the size flows to be treated. The treatment technologies are evaluated herein. Then the selected technology is incorporated into the three wastewater scenarios and used to compare the costs of the proposed wastewater collection and effluent recharge systems under scenarios 3A, 4A and 5A. Critical issues used to determine the technology selection of the wastewater treatment facility include:

Ease of expandability;

- Operational flexibility (ability to operate with seasonal variations in flows);
- Operability
- Capital Costs;
- O&M Costs;
- Space Requirements;
- Process Performance - The ability to meet Total Nitrogen limits (TN) in effluent as outlined in the 314 CMR 05 Groundwater Discharge Regulations (considered 3 mg/L TN for Harwich discharges)

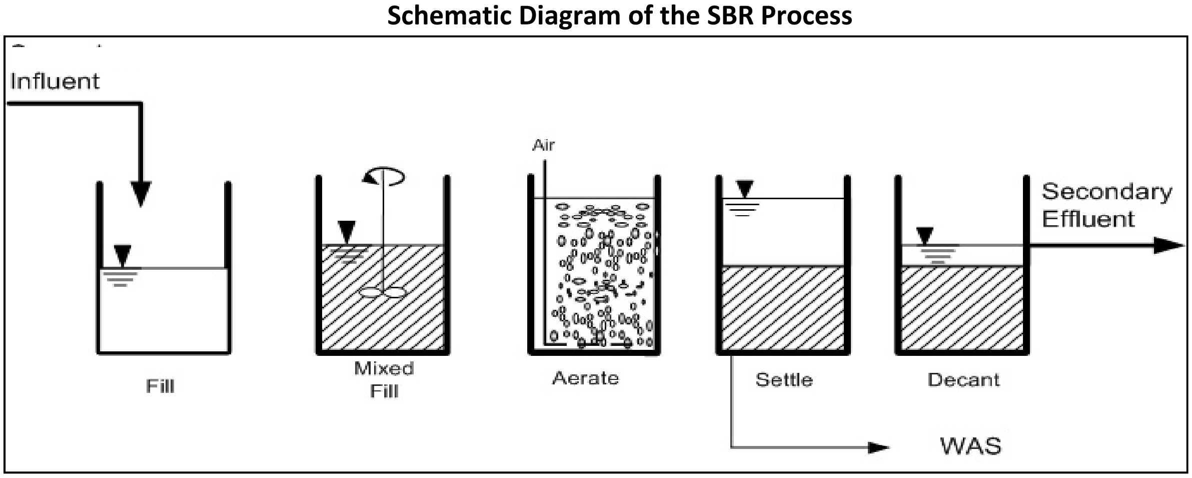
12.7.1.1 Description of Treatment Technologies

The three technologies selected for evaluation Sequencing Batch Reactors (SBRs), Oxidation Ditches (ODs) and Membrane Bioreactors (MBRs). Each is considered a biological process. These technologies were selected for their ability to remove total nitrogen down to low levels (3-5 mg/L annual average) and their ability to meet effluent criteria required for recharge to infiltration basins. Whereas the SBR, OD and MBR technologies can often achieve limits as low as 3 mg/L, it is assumed for this evaluation that an additional denitrification technology (along with supplemental carbon addition) will be necessary to achieve on a regular basis an annual average of 3 mg/L total nitrogen.

Sequencing Batch Reactors (SBRs)

Sequencing Batch Reactors function as a combined aeration tank and clarifier, where all the biological reactions and settling/separation occur in a single unit 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. 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 discussed below. Figure 12-5 presents a schematic diagram of the SBR process.

Figure 12-5
Schematic Diagram of the SBR Process



- ***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 the other batch reactor. Mixing and aeration continue in the absence of raw waste.
- ***Settle*** - The aeration and mixing is 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 settle time is adjustable during operations to match prevailing process needs.
- ***Decant*** – After solid/liquid separation is complete during the settle 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.

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. Sludge is typically removed and recycled 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 and therefore would greatly affect the size of the downstream process units. The decant rate is substantially higher than the plant inflow, hence requiring a post-equalization tank to dampen the peak flows so as not to require oversizing of downstream process equipment.

An SBR Waste Water Treatment Facility (WWTF) is capable of handling the seasonal flow variations by fluctuating water levels, as well as changing cycle times as needed for nitrification and denitrification. Whereas proper operation and the potential use of a supplemental carbon source could result in meeting the 3 mg/L total nitrogen limit, provisions should be made for effluent filters to ensure compliance. Additionally, an SBR WWTF capacity could be increased in phases, with the typically square or rectangular shaped tanks lending themselves to common wall construction. Major components required for an SBR WWTF are listed below.

- Headworks Building – Coarse 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
- Infiltration Basins for Recharge

The wastewater treatment facilities for the towns of Falmouth and Provincetown utilize SBR technology.

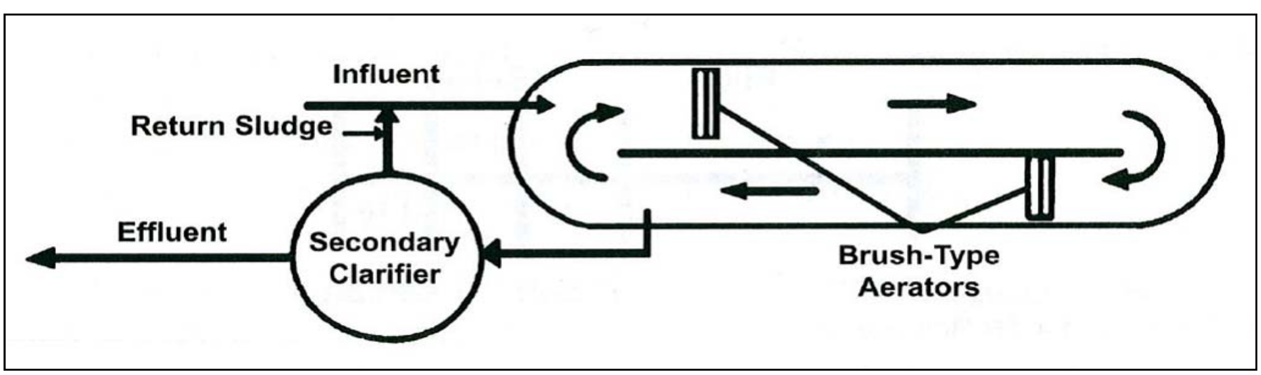
Oxidation Ditches (ODs)

The oxidation ditch is an activated sludge process in a ring- or oval-shaped channel that is equipped with mechanical aerators. 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.

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. 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. As with the SBR, provisions during the planning stage should be made for the use of effluent filters to ensure meeting the required 3 mg/L total nitrogen required for discharge. Major components required for an Oxidation Ditch WWTF are listed below. Figure 12-6 presents a schematic diagram of the oxidation ditch process.

Figure 12-6
Schematic Diagram of an Oxidation Ditch Process



- Headworks Building – Coarse 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
- Infiltration Basins for Recharge

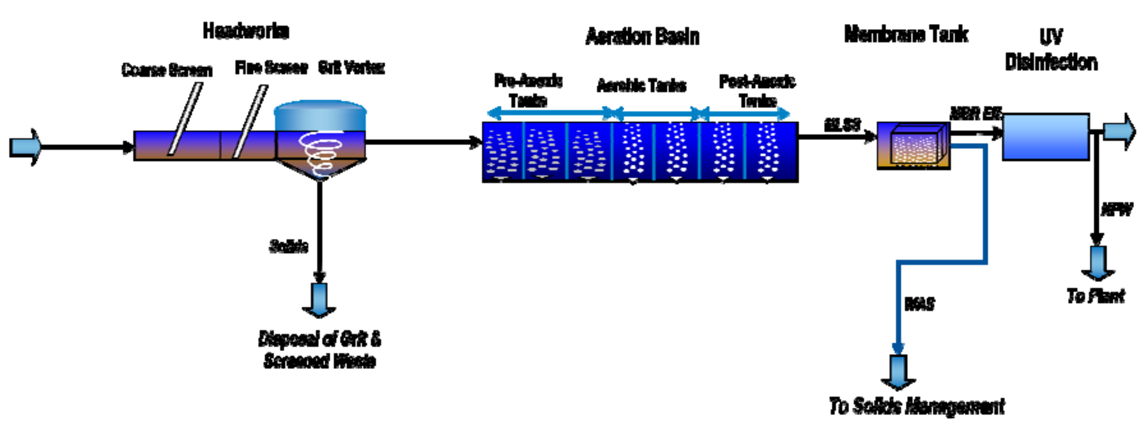
The wastewater treatment facilities for Chatham and the Massachusetts Military Reservation (MMR) In Bourne utilize Oxidation Ditch technology.

Membrane Bioreactor (MBR)

A membrane bioreactor 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 post-anoxic zone, and finally into the membrane tanks, where mixed liquor is re-aerated and solids separated from the process effluent. Effluent is then disinfected. Membrane tanks are aerated to provide final BOD removal and nitrification and to provide scour for prevention of membrane fouling. Membranes require fine screening down to less than 2 millimeters (mm) in addition to the coarse screening, and grit removal. 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 the Oxidation Ditch. Figure 12-7 presents a schematic diagram of the MBR process.

Figure 12-7
Schematic Diagram of the MBR Process



Below is a list of major process components associated with the MBR WWTF.

- 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
- Infiltration Basins for Discharge

The wastewater treatment facility for the Town of Cohasset utilizes MBR technology.

12.7.1.2 Disinfection

There are three typical disinfection methods for wastewater: ozone, UV (Ultraviolet irradiation) and chlorination. The ozonation process is very energy intensive for small facilities and there are significant costs associated with chemicals and tankage for chlorination/dechlorination required for groundwater recharge. For the purposes of this CWMP, it is recommended that UV Disinfection be utilized as the most feasible option for disinfection.

12.7.1.3 Residuals Handling

Most wastewater treatment facilities today with flows under 5 mgd haul offsite the thickened solids created during the treatment process. Thus, any proposed treatment facility for Harwich which are well below that size facility, will include solids thickening process equipment and storage tanks for unthickened and thickened residuals. It is recommended that thickened residuals be removed by establishment of a hauling/disposal contract with an approved off-site processing facility.

12.7.2 Biological Treatment Technology Comparison

All three technologies represent a feasible alternative for the new Harwich WWTF's. Each technology has its own advantages and disadvantages based on the listed evaluation criteria. Table 12-9, below presents those advantages and disadvantages.

Table 12-9
Comparisons of Three Treatment Technologies: Advantages and Disadvantages

Technology	Advantages	Disadvantages
Sequenced Batch Reactor (SBR)	▪ Able to meet strict effluent criteria for groundwater discharge standards ▪ Operationally flexible with respect to seasonal variations in flow. Cycle times may be adjusted as required to meet permit limits. ▪ Easily expanded with common wall construction for additional SBRs	▪ Expansion will be expensive as new large SBRs are constructed to handle the increase in flow. ▪ Requires effluent equalization ▪ May require filtration for discharge limits
Oxidation Ditch (OD)	▪ Simple process to operate ▪ Able to meet strict effluent criteria for groundwater discharge ▪ Resilient process to varied loadings and seasonal flexibility	▪ Process requires a lot of space ▪ Additional expansion requires more tankage than other processes (anoxic tanks plus OD plus clarifier) ▪ Mechanical aerators result in higher O&M costs for aeration process
Membrane Bioreactor (MBR)	▪ Able to meet strict effluent criteria for reclaimed water standards ▪ No additional filtration required ▪ Modular system is easily expandable. Cassettes can be easily dropped into membrane tanks as flow increases. ▪ Higher quality effluent	▪ Requires fine screening of less than 2mm ahead of the membranes ▪ Peak hour flow rates must pass through membranes, which will likely only occur during summer months due to seasonal flow (influent equalization) ▪ Membranes must be replaced every seven years and are expensive to replace

In addition to the summary of advantages and disadvantages, a ranking system was developed to assist with technology screening that is based on the key evaluation criteria. Those criteria are listed below with proposed rankings

The following factors provide a qualitative method for ranking the treatment technologies and a means for making a recommendation. The following are the assessment criteria and rationale used in performing the comparison of technologies:

- ***Ease of Expandability*** —Assessment of these criteria depends on the alternatives ability to allow for future expansion as potential phased expansion of collection system and needs areas arises. Alternatives are ranked by these criteria:

  5 - Difficult to expand

  3 - Flexibility and expandability are likely to be average

  1 - Easily expandable

- ***Operational Flexibility*** – This step assesses the ability of the process to meet seasonal flow fluctuations anticipated for Harwich. Alternatives are ranked by these criteria:

  5 - Difficult to meet flow variations (need additional tankage)

  3 - Average flexibility

  1 - Very flexible

- ***Operability*** – The difficulty of operating a process will be considered. Some processes are complex and require a lot of attention for proper operation. Some processes require special skills and extensive training for the operators. Alternatives are ranked by these criteria:

  5 - Processes difficult to operate or requiring special skills

  3 - Processes that require average attention and some additional staff and training

  1 - Less complex processes

- ***Capital Cost*** —Capital cost relates to the construction cost based on the facility needed for meeting build-out flows. Alternatives are ranked by these criteria:

  5 - High construction cost estimate

  3 - Medium cost when compared to other alternatives

  1 - Low construction estimate

- ***O&M Costs*** — O&M cost includes general maintenance, labor, supplies and power requirements. Mechanical equipment with high horsepower demands results in high O&M costs, and the need for replacement of components is evaluated here. Alternatives are ranked by these criteria:

  5 - High O&M estimate

  3 - Medium O&M estimate when compared to other alternatives

  1 - Low O&M estimate

- ***Space Requirements*** — This evaluates the footprint needed for the main components of the biological process.

  5 - A large quantity of space required for the suggested alternative

  3 - Space required is likely to be average

  1 - Minimal space is required of the alternative

- ***Process Performance*** — All of these alternatives would provide secondary effluent water quality that meet groundwater discharge standards. Some processes can more easily meet these performance standards than others. Alternatives are ranked by these criteria:

  5 - Processes that need additional process steps to meet the discharge standards (i.e. additional filtration)

  3 - Average process performance

  1 - High process performance

Table 12-10 summarizes all criteria into a matrix for ease in comparing the different alternatives. Each is graded for the potential response to the respective criteria. A ranking of 1, 3 and 5 is provided with

1 being the most desirable. The alternative with the lowest total score is the recommended plan for secondary wastewater treatment in Harwich.

Table 12-10
Matrix Assessment for Recommending Harwich WWTP Technology

Criteria	Sequencing Batch Reactor (SBR)	Oxidation Ditch (OD)	Membrane Bioreactor (MBR)
Ease of Expandability	1	5	1
Operational Flexibility	1	1	3
Operability	5	1	3
Capital Cost	1	3	3
O&M Cost	1	3	5
Space Requirements	3	5	1
Process Performance	1	1	1
Total Score	***13***	***19***	***17***

12.7.3 Recommended Technology

The recommended treatment technology for Harwich is an SBR process, with the construction to be phased in coordination with the collection system work. The key reasons for constructing the SBR process initially are to both minimize capital costs for the Town, to provide the best operational flexibility based on the anticipated plant flow variations, and to be easily expanded. Going forward, as the collection system grows and potential future permit regulations develop, the option to continue forward with SBR allows for maximum flexibility.

Supplemental Carbon Addition and Denitrification Filters

The town recently received the MEP report for the Herring River Watershed estuary system. Based on the results of this evaluation, the need for nitrogen removal within Harwich is greater than originally anticipated. Ultimately, the requirements for nitrogen removal will result in an annual average nitrogen discharge concentration of 3 mg/L on an average annual basis at ultimate buildout of the proposed collection system.

As the 3 mg/L concentration for discharge is based on the removal limits of technology, it is assumed for estimating purposes that any treatment facility for Harwich will need additional denitrification beyond what is described previously. For the purposes of this evaluation, it is recommended that supplemental carbon addition and denitrification filters be used to meet these very stringent effluent total nitrogen concentrations.

Supplemental Carbon Addition

Supplemental carbon alternatives are recommended for use as part of any wastewater alternative for Harwich. There are a variety of supplemental carbon sources that are used in nitrogen removal, with the most common being methanol and a proprietary product like the MicroC product line, manufactured by Environmental Operating Solutions (EOS). Other options do exist, but are typically contingent upon the availability of the product in close proximity to the wastewater treatment plant. Based on the flammability, safety, transportation, storage and permitting issues associated with methanol, it is not recommended for this application and a proprietary product should be considered during preliminary and final design.

It is assumed that the biological treatment process selected (i.e. SBRs, ODs and MBRs) would remove total nitrogen to 5 mg/L or less without the use of supplemental carbon addition. It should be noted that if the denitrification rates are less than typical values, it may be necessary to add supplemental carbon both during the biological treatment process and the final denitrification step. Controls will be provided that can modify dosage rates accordingly as results will vary based on seasonal temperature and flow variations associated with the annual population fluctuation in Harwich. In addition, since the effluent nitrogen concentration is based off of ultimate plant flows and nitrogen loadings, initial discharge concentrations as the sewer system is phased in may be greater than 3 mg/L. This could result in savings and minimize carbon dosing during initial phases of operation.

Denitrification Filters

As described above, the low total nitrogen effluent requirements of 3 mg/L on an average annual basis at buildout will require additional treatment to ensure compliance. It is recommended that denitrification filters be provided as an additional nitrogen removal process as they provide both the biological nitrogen removal and solids removal necessary to achieve low effluent total nitrogen concentrations. Denitrification filters are media filters that can operate in either a downflow or upflow mode depending on the manufacturer. The filters need to be backwashed periodically and the waste backwash water returned to an earlier process step for treatment. It is recommended during preliminary design to evaluate the need and point during the phased construction of the system of when to implement denitrification filters. This again will be based on the allowable loading at the selected recharge site.

12.8 Estimated Wastewater Treatment Flows and Loads

This section presents the flows and loads for Scenarios 3A, 4A and 5A.

Flows

Section 7 determined flow factors to account for seasonal variation in flows that result from the population changes that Harwich undergoes annually. Because of the seasonal fluctuations inherent to Cape Cod, wastewater treatment plant design conditions need to be evaluated to properly account for the change and flows. Using the annual flows calculated from the water use data, the average annual wastewater flows for Scenarios 3A, 4A and 5A are as follows:

- ***Scenario 3A – 1,138,000 gpd*** - This scenario will utilize one treatment facility, located at HR-12, the Harwich landfill site.
- ***Scenario 4A – 1,162,000 gpd*** - This scenario will utilize two treatment facilities, located at HR-12, the Harwich landfill site and PB-3 in the Pleasant Bay watershed. The PB-3 facility will receive flow from the Pleasant Bay and The HR-12 facility will receive flow from the rest of town outside of the Pleasant Bay area.
- ***Scenario 5A – 1,140,000 gpd*** - This scenario will utilize two treatment facilities, located at HR-12, the Harwich landfill site and the Chatham WPCF. The Chatham WPCF will receive flow from the Pleasant Bay area and the HR-12 facility will receive flow from the rest of town outside of the Pleasant Bay area. HR-12 will recharge the treated effluent onsite in infiltration basins

located adjacent to the facility. The effluent flow from the Chatham facility will be pumped back to Harwich for recharge at PB-3 in the Pleasant Bay Watershed. For this scenario, PB-3 will only be utilized as an effluent recharge site. Based on groundwater modeling and preliminary discussions with MassDEP, it is expected that Total Organic Carbon (TOC) will not be required at this site.

Based on the data analyzed and reviewed in Section 7, the seasonal peaking factors identified are 1.91 for summer flows, 0.78 for spring/fall flows and 0.52 for winter flows. Table 12-11 summarizes the seasonal flows in million gallons per day for Scenarios 3A, 4A, and 5A. Maximum day and peak hour flows are also included in this table.

Table 12-11
Buildout Seasonal Wastewater Flows and Peaking Factors

Scenario	Annual Average Flow (MGD)	Summer Average Flow (MGD)	Winter Average Flow (MGD)	Spring/Fall Average Flow (MGD)	Max. Day Flow (MGD)	Peak Hour Flow (MGD)
3A – HR12 Facility	1.14	1.99	0.69	0.93	3.97	6.30
4A – HR12 Facility	0.83	1.46	0.49	0.67	3.06	4.92
4A – PB3 Facility	0.34	0.57	0.21	0.28	1.31	2.20
5A – HR12 Facility	0.84	1.47	0.50	0.68	3.07	4.93
5A – Chatham, PB3 Effluent Recharge	0.31	0.52	0.19	0.25	1.20	2.01

Infiltration was added to average day flow to calculate the total average day flow.

Septage flows are considered to be minimal for each scenario evaluated. As described later in this section, the ability to receive limited hauled wastes will be incorporated into WWTF design but it is not anticipated to represent a significant volume of flow or constituent loading.

Loads

Design loads for wastewater flows are based on the constituent concentrations listed below. Depending on sewer construction phasing, initial loadings to the WWTF could represent a higher concentration of constituents depending on the make-up of the area being sewered. For comparison purposes, the build-out scenarios used for this evaluation focus on a more "typical" domestic wastewater strength as the majority of sewered areas represent residential connections. The residential loading concentrations were developed using values from the industry accepted Metcalf & Eddy, Wastewater Engineering. Going forward into preliminary stages, a more detailed evaluation of initial sewer phase waste strength should be estimated based on data collected from other seasonal Cape Cod communities. Table 12-12 lists the estimated concentrations for the Harwich wastewater.

Table 12-12
Estimated Average Wastewater Concentrations

Criteria	Buildout Loading
BOD (Biological Oxygen Demand)	245 mg/L
TSS (Total Suspended Solids)	260 mg/L
TKN (Total Kjehldahl Nitrogen)	45 mg/L

12.9 Treatment Facility Costs

The treatment facility costs presented here are for planning-level comparisons and are useful for giving a relative cost comparison for the three wastewater scenarios. Those costs were based on annual flows and account for the large seasonal flow swings characteristic of a seasonal community like Harwich. A cost for effluent recharge facilities was included and assumed that open infiltration basins will be utilized for effluent recharge at either HR-12 or PB-3. As stated in section 9, planning level estimates indicate that each infiltration basin can receive approximately 140,000 gpd of effluent recharge flow from the treatment facilities. Additional costs (approximately $250,000) were also carried for effluent recharge at PB-3 to include the land purchase costs.

All of the treatment facility estimates include an allowance for planning level costs (15 percent), and for permitting, engineering and construction services (25 percent).

Costs were developed for options 3A, 4A and 5A based on actual project costs that were completed for other communities in New England. The estimated project costs are summarized below in Table 12-13.

Table 12-13
Treatment Facility Construction Costs

Scenario	Total Average Flow with I/I	Cost
3A	**1,138,000 gpd**	**$65.4 million**
4A (Facility PB-3)	334,000 gpd	$28.4 million
4A (Facility HR-12)	828,000 gpd	$53.2 million
4A Total	**1,162,000 gpd**	**$81.6 million**
5A (Facility Chatham Expansion)	306,000 gpd	$ 9.2 million
5A (Facility HR-12)	834,000 gpd	$53.4 million
5A Total	**1,140,000 gpd**	**$62.6 million (1)**

(1) – Includes $2.0 million for infiltration basins to recharge effluent at PB-3

12.10 Estimated Costs for Scenarios 3A, 4A and 5A

This section presents the estimated costs for construction of the three wastewater alternatives under Scenarios 3A, 4A and 5A evaluated in this section. These estimated costs build on the scenarios that were presented in Section 10 and utilize updated information such as advanced levels of treatment (3 mg/l nitrogen is utilized in the Herring River and for all three options rather 5ppm that was considered in section 10). As stated earlier, these estimates include an allowance for planning level costs (15 percent), and for permitting, engineering and construction services (25 percent).

Table 12-14 presents the capital costs for options 3A, 4A and 5A that were evaluated in this section.

Table 12-14
Estimated Collection and Treatment System Capital Costs

Option	Scenario 3A	Scenario 4A	Scenario 5A
Collection System	$124,900,000	$137,500,000	$145,900,000
Treatment System	$65,400,000	$81,600,000	$62,600,000
Total (rounded)	***$190 Million***	***$219 Million***	***$209 Million***
Homeowner Hookup Cost	*$19.0 Million*	*$18.9 Million*	*$18.5 Million*

Table 12-15 presents the O&M costs for options 3A, 4A and 5A that were evaluated in this section.

Table 12-15
Estimated Collection and Treatment System O&M Annual Costs

Option	Scenario 3A	Scenario 4A	Scenario 5A
Collection System Public O&M	$845,000	$868,000	$898,000
Collection System Private O&M	$141,000	$123,000	$119,000
Collection System Total O&M	$986,000	$991,000	$1,017,000
Treatment System Total O&M	$2,100,000	$2,680,000	$1,950,000
Total (rounded)	**$3.1 Million**	**$3.7 Million**	**$3.0 Million**

In Table 12-16, the estimated total capital cost of each option is presented along with the estimated total O&M cost for each option. For comparison an Equivalent Annual Cost (EAC) is presented. The equivalent annual cost assumes that the capital cost is based on a 20 year loan with a 2% interest rate that assumes the State Revolving Fund (SRF) is the funding mechanism for the project.

Table 12-16
Estimated Collection and Treatment System and O&M Annual Costs

Option	Scenario 3A	Scenario 4A	Scenario 5A
Collection and Treatment Capital Costs	$190 Million	$219 Million	$209 Million
Equivalent Annual Capital Cost	*$11.7 Million*	*$13.4 Million*	*$12.7 Million*
Collection and Treatment O&M Cost	*$3.1 Million*	*$3.7 Million*	*$3.0 Million*
Total Equivalent Annual Cost	***$14.7 Million***	***$17.1 Million***	***$15.7 Million***

Scenario 4A is the most costly option because it requires the construction of two new treatment facilities and requires additional sewering in the Pleasant Bay (due to nitrogen treatment to 5mg/l). Scenario 4A is about 16 percent more than the cost of 3A which realizes a cost savings due to an economy of scale utilizing one treatment facility. Scenario 5A is about nine percent less costly than 4A because it utilizes the existing Chatham Water Pollution Control Facility. Options 3A and 5A can both be considered equivalent costs at this planning level since they are within seven percent of each other.

To select between Scenarios 3A and 5A, the town weighed the pros and cons of several non-cost options that are characteristic of these two scenarios. As a result, Scenario 5A appeared to have several benefits since it utilizes an existing facility and spreads out the effluent recharge into at least two watersheds. It also offers an opportunity for both Chatham and Harwich to implement a regional solution and share operations at the treatment works. Most importantly, Scenario 5A allows for easier phasing with delayed capital costs and reduces the overall size of the treatment facilities in Harwich.

Discussions to date between Chatham and Harwich representatives about implementing Scenario 5A have been positive and there are clearly additional benefits to both communities. The existing Chatham WPCF is constructed to treat a capacity of 1.3mgd and is permitted for 1.0mgd. The facility currently receives less than 0.2mgd. It will take several years of sewer construction for Chatham to reach the permitted flow. Thus, accepting Harwich flow now will help improve facility efficiencies and spread the costs across more users. The expansion costs to Harwich can be pushed off for a few years. Similarly, Harwich effluent can be recharged at the Chatham WPCF during these initial years which may assist Chatham in addressing future recharge capacity permit issues. Ultimately, Chatham is looking for 1.9mgd of treatment and recharge capacity. So, while Scenario 5A was evaluated with Harwich paying for the expansion and recharging the effluent back into Pleasant Bay Watershed, the initial capital costs associated with portions of these components can be delayed. Both communities should continue to pursue a formal inter-municipal agreement for this scenario.