4. Great Pond Traditional Wastewater Management Alternatives

4.1. Introduction

This Section outlines the traditional wastewater management strategies included in the Great Pond TMDL Compliance Preferred Alternative, which includes:

– Existing sewering in the Great Pond watershed (the Little Pond Sewer Area)
– Sewer extensions in the Great Pond watershed (the Teaticket Acapesket Study Area)
– An Existing Sewer Area Redevelopment Allocation (ESRA)
– Upgrades at the Falmouth WWTF to treat collected wastewater from TASA and ESRA (Planning Flow 1)
– Identification of a preferred treated effluent discharge approach for Planning Flow 1

4.2. Collection System

4.2.1. Anticipated Nitrogen Load Removal Through Sewering

4.2.1.1. Little Pond Sewer Service Area

A portion of the Great Pond watershed was sewered in 2017 as part of the Little Pond Sewer Area (LPSA) project. LPSA includes 253 parcels in the Great Pond watershed. As of January 2022, according to the Town of Falmouth Wastewater Division, 99.5% of the parcels in LPSA have been connected to the sewer system. The nitrogen load removal from Great Pond through sewering these parcels is estimated to be 1,000 kg/yr.

4.2.1.2. Teaticket Acapesket Sewer Service Area

As part of the Great Pond TMDL Compliance Preferred Alternative, the Teaticket Acapesket Sewer Area (TASA) will be sewered to significantly reduce septic nitrogen load to the Great Pond watershed. The proposed collection system will collect wastewater from approximately 1,800 parcels in the Great and Green Pond watersheds through a combination of gravity and low-pressure sewers and then will convey the flow to the Town of Falmouth WWTF.

Approximately 1,300 of the identified TASA parcels are in the Great Pond watershed. The existing nitrogen load removal projected for Great Pond through sewering of TASA is estimated to be 6,188 kg/yr. The conceptual collection system and wastewater flow estimates include an allocation for future growth, which will increase the overall nitrogen load removal of the system in the future and will be taken into account in sizing of treated effluent discharge.

Sewering will be augmented by the other nitrogen-reduction strategies discussed in Section 3 of this report as part of the Great Pond TMDL Compliance Preferred Alternative.

The conceptual TASA Phase 1 collection system is illustrated in Figure 4-1 (see Attachments) The conceptual collection system, which was developed to optimize the extent of gravity sewer in the system, involves two new lift stations (one on the Town owned Augusta parcel on Route 28, and one within Falmouthport) and two existing lift stations (Alphonse Street Lift Station and Spring Bars Road Lift Station). This layout relies on the Town obtaining a set of four sewer easements on private properties. If the Town is not able to acquire the proposed sewer easements, more of the collection area will be served by low pressure (and grinder pumps), as shown on Figure 4-2 (see Attachments). As the project progresses to design, the Town will further refine the layout of the proposed sewers.

Flow from TASA is proposed to be conveyed from a single booster lift station (on the Augusta parcel on Route 28) via force main to the Town of Falmouth WWTF. The proposed force main is anticipated to follow Brick Kiln Road to Blacksmith Shop Road and connect to the Town of Falmouth WWTF, as shown on Figure 4-3 (see Attachments).

4.2.2. Project Phasing

The proposed TASA collection system is divided into two phases. Phase 1 consists of infrastructure on the Maravista and Teaticket Peninsulas (primarily within the Great Pond Watershed) and connections to approximately 811 dwelling units on 602 properties. Phase 2 includes infrastructure on the Acapesket Peninsula (within both Great Pond and Green Pond Watersheds) and connections to approximately 1,189 properties. Lift Station locations and easements (if any) on the Acapesket peninsula Phase 2 area have yet to be determined.

4.3. Wastewater Treatment

4.3.1. Treatment of Flows from Great Pond Watershed and Existing Service Redevelopment Allocation (ESRA)

An evaluation of the existing Town of Falmouth WWTF's ability to treat the proposed flow from TASA and ESRA, on a capacity and treatment level basis, was conducted and is summarized in the 'Falmouth WWTF Fiscal Sustainability Plan Including a Plant Evaluation and Condition Assessment – Final Report' prepared by GHD and dated December 2020 (attached Appendix 4.1). That report recommended a set of WWTF upgrades to provide capacity to treat anticipated flows from TASA and ESRA (Planning Flow 1) while continuing to meet the WWTFs groundwater discharge permit. In April 2022, Town Meeting approved a $24,000,000 appropriation to implement the recommended WWTF improvements. A ballot vote passed in May 2022 to complete borrowing authorization for this project, referred to as the 'Falmouth WWTF TASA Improvements Project'. The project is currently being designed and is expected to go out for bid in the spring of 2023. Additional future upgrades will be required to treat Planning Flows 2 and 3 at the Town of Falmouth WWTF.

Projected flows and loads for the upgraded facility to treat Planning Flow 1 are summarized in Tables 4.1 and 4.2.

Table 4.1. Falmouth WWTF TASA Improvements Project – Design Flows

Parameter	WWTF Pre-LPSA (mgd)	LPSA (mgd)	TASA (mgd)[1]	ESRA (mgd)	Total Future Flow (mgd)
Average Day	0.45	0.26	0.36	0.14	1.21
Maximum Month	0.81	0.47	0.65	0.25	2.18
Maximum Day	0.86	0.49	0.68	0.27	2.30
Peak Hour	1.53	0.88	1.22	0.48	4.11

Notes:

1. Estimated wastewater flows for TASA were developed using water use data from 2014-2016 and a 20% wastewater allocation to account for undesignated redevelopment and potential development of currently un-developable parcels.

Table 4.2. Falmouth WWTF TASA Improvements Project – Design Loads[1]

Influent Characteristic	WWTF Pre-LPSA (lb/d)	LPSA (lb/d)	TASA (lb/d)[2]	ESRA (lb/d)	Total (lb/d)
BOD	670	630	680	210	2,190
TSS	700	740	800	220	2,460
TN	110	150	160	30	450
TP	20	20	20	10	70

Notes:
1. Reference: 'Falmouth WWTF Fiscal Sustainability Plan Including a Plant Evaluation and Condition Assessment – Final Report' prepared by GHD and dated December 2020. Totals are shown rounded to two significant figures.
2. Estimated wastewater flows for TASA were developed using water use data from 2014-2016 and a 20% wastewater allocation to account for undesignated redevelopment and potential development of currently un-developable parcels.

Table 4.3 summarizes the wastewater treatment process improvements recommended in this evaluation to serve TASA and ESRA flows (Planning Flow 1) and continue to meet the groundwater discharge permit.

Table 4.3. Falmouth WWTF TASA Improvements Project - Recommended Process Improvements [1]

Item	Recommendation {for Planning Flow 1}
Secondary Treatment	– Add one SBR tank, including all equipment.
Sludge Processing	– Add one new blended sludge tank. – Add two new thickened sludge tanks. – Add two new gravity belt thickeners. – Modify the existing Sludge Processing Building to accommodate recommended new sludge processing equipment (gravity belt thickeners and ancillary equipment). – Add a new pipe and pump gallery for sludge processing and storage.
Equalization Volume	– Add new equalization tanks (the size of two additional influent wet wells).
Ultraviolet (UV) Disinfection	– Replace the existing UV system.

Notes:
1. Improvements associated with treating flows from TASA and ESRA. Reference: 'Falmouth WWTF Fiscal Sustainability Plan Including a Plant Evaluation and Condition Assessment – Final Report' prepared by GHD and dated December 2020.

4.3.2. Treatment of Future Flows (Conceptual Level)

A conceptual layout for future expansions at the WWTF (beyond the capacity to treat TASA and ESRA flow) is outlined in the 'Falmouth WWTF Fiscal Sustainability Plan Including a Plant Evaluation and Condition Assessment – Final Report' prepared by GHD and dated December 2020 (attached Appendix 4.1).

The conceptual layout shows proposed locations for additional preliminary and secondary treatment processes and sludge handling processes. The conceptual layout represents one way the facility could expand in the future to further increase capacity and is based on maximizing available space at the site. A treatment facility evaluation will be required to identify required improvements at the Falmouth WWTF to treat anticipated flows from Planning Flows 2 and 3.

4.3.3. Potential Future Regulatory Requirements

4.3.3.1. Contaminants of Emerging Concern (CECs)

The term Contaminants of Emerging Concern (CECs) is used to represent chemicals in three sub-categories:

- Endocrine disruptors
- Pharmaceuticals
- Personal care products

CECs are being detected in water and wastewater in extremely small concentrations due to improvements in analytical methods for these chemicals and to the prevalence of pharmaceutical and personal care product use. CECs are considered “emerging” because neither the extent of the human nor the environmental health risk of these constituents has been determined, and there are few regulatory limits on them (in Massachusetts CECs are only regulated in effluent groundwater discharges to Zone I or II groundwater areas).

If required in the future, wastewater treatment processes could be added to reduce CECs, for example:

- Coagulation and flocculation
- Membrane filtration
- Advanced oxidation
- Granular activated carbon (GAC) adsorption

In addition to the many contaminants that fall into the category of CECs, per- and polyfluoroalkyl substances (PFAS) is a group of chemicals that has received attention recently. PFAS are manmade chemicals used in many products including household cleaning products and sprays, food packaging, and firefighting foam. PFAS contaminants are linked to negative health effects including cancer and thyroid hormone distribution. PFAS has been detected in groundwater and drinking water supplies throughout the United States and the world.

When a treated effluent discharge is within a Zone I or II groundwater area, Massachusetts has implemented effluent concentration limits for Total Organic Carbon (Total Organic Carbon is used as a surrogate for CECs). The existing treated effluent discharge areas at the Town of Falmouth WWTF and the future treated effluent discharge locations evaluated for this project are all outside Zone I and Zone II groundwater areas and are not subject to effluent Total Organic Carbon concentration limits.

4.3.3.2. Phosphorus Removal

The Town of Falmouth WWTF currently does not have an effluent phosphorus limit. Soil attenuation evaluations (outlined in Section 4.4), conducted for the two proposed effluent recharge sites upgradient of freshwater bodies (Open Sand Beds 14 & 15 and the Allen Parcel) indicated that the soils between the proposed effluent recharge sites and the nearest freshwater bodies have a significant phosphorous attenuation capacity. Because of these soil attenuation evaluation findings, phosphorus treatment is not anticipated to be required at the Town of Falmouth WWTF.

The ’Town of Falmouth, Massachusetts Final Blacksmith Shop Road Wastewater Treatment Facility Phosphorus Removal Evaluation’, prepared by GHD and dated March 2014 (Appendix 4.2) outlines options for phosphorus removal processes that could be added to the treatment process in the future, if phosphorus removal is required at the plant to reduce effluent phosphorus concentrations to less than 1 mg/L.

If required in the future, wastewater treatment processes could be added to the treatment process for phosphorus removal and include:

- Metal salt precipitation
- Cloth filtration

4.4. Effluent Discharge

4.4.1. Technology Evaluation (Summary of Past Effort)

Effluent discharge technology options for future flows were initially evaluated as part of the ‘Little Pond, Great Pond, Green Pond, Bournes Pond, Eel Pond, and Waquoit Bay Watersheds Alternatives Screening Analysis Report’, prepared by GHD and dated November 2007. An updated technology evaluation was conducted in 2019 and is summarized in ‘TASA TM-3 – Technical Memorandum No, 3,’ prepared by GHD and dated April 2019 (Appendix 4.3). This evaluation recommended the following effluent discharge technologies be evaluated further as part of subsequent planning efforts:

1. Open sand beds are recommended for conceptual layout development due to their relatively high hydraulic loading capacity, which allows for a smaller footprint than other land-based discharge options. The Town of Falmouth currently uses this technology at the Falmouth WWTF and is familiar with the technology.
2. Subsurface leaching facilities are recommended for further evaluation in areas with a potential secondary use (for example under fairways in a golf course or under public parks/ballfields) due to their minimal visual impact. The Town of Falmouth currently uses this technology at the New Silver Beach WWTF and is familiar with the technology.
3. Ocean outfalls are recommended for conceptual layout development due to the relatively small land area required for this technology, relatively high disposal capacity, and the ability to discharge outside a nutrient impacted watershed thereby reducing nitrogen loading impacts to coastal embayments through effluent discharge. The Town of Falmouth had an ocean outfall in Woods Hole that was abandoned in the 1980s.

4.4.2. Potential Effluent Discharge Site Evaluations

25 potential sites for treated effluent recharge were identified and screened in 2007. An updated discharge technology evaluation was conducted in 2019 for 6 land-based sites and 2 ocean outfall options. Based on the findings of these previous evaluations, 3 potential land-based effluent discharge site options and 2 potential ocean outfall locations were selected for further consideration as future effluent discharge sites. Each site was evaluated for each of the three Planning Horizons outlined in Section 2.1, to assess the suitability of each site for both near-term and longer-term wastewater planning needs.

A description of each site is provided in this Section. Field investigations and nutrient sensitive receptors analyses for each land-based site are summarized in this Section and outlined in further detail in ‘Great Pond Targeted Watershed Management Plan Final Technical Memorandum 3 - Additional Site Characterizations of Allen Parcel, Beds 14 & 15 and Augusta Parcel (GP TM-3)’ prepared by GHD and dated June 2022 (Appendix 4.4).

4.4.2.1. Existing/Expanded WWTF Open Sand Beds 14 & 15

The Town of Falmouth WWTF has 15 effluent disposal open sand beds. The 2021 groundwater discharge permit for the WWTF allocates effluent flow limits to these beds by watershed. Open Sand Beds 1-13 are located within the West Falmouth Harbor watershed and are subject to an annual effluent nitrogen load limit of 4,109 pounds per year (equivalent to an average annual flow of 0.45 mgd at an average annual effluent total nitrogen concentration of 3 mg/L). Open Sand Beds 14-15 are located outside of the West Falmouth Harbor watershed. The average annual flow limit for Open Sand Beds 14-15 is 0.26 mgd. The permitted capacity of the existing Open Sand Beds 1-15 is allocated to current and future flows from existing sewer service areas.

This project evaluated options to increase the capacity of Open Sand Beds 14 & 15 through an increase in the design hydraulic loading rate to the existing beds and a potential bed area expansion in the undeveloped area to the west and/or north of the existing beds.

4.4.2.1.1. Treated Effluent Hydraulic Load Testing to Assess Appropriate Hydraulic Loading Rate for Site

The permitted hydraulic loading rate for Open Sand Beds 14 & 15 is based on a hydraulic loading rate of 7 gallons per day / square foot (gpd/sf). In the Summer of 2020, an in-situ treated effluent hydraulic load test was performed at Open Sand Beds 14 & 15 to evaluate the potential to increase the permitted hydraulic loading rate of the two existing open sand beds. This evaluation was performed in accordance with the MassDEP approved ‘Final Hydraulic Load Testing – Work Plan for Existing Open Sand Beds 14 & 15’, prepared by GHD and dated July 7, 2020. Testing occurred during a two-month period (August and September 2020) using treated effluent from the Town of Falmouth WWTF. The capacity of beds 14 & 15 was observed to be greater than the WWTF effluent flow available during the test period, so the maximum infiltration rate for the beds could not be determined during the test. However, the test did demonstrate that together, the beds could accommodate at least 11 gpd/sf. Testing results were reviewed with MassDEP on June 15, 2021, and it was agreed that a weighted loading rate of 11 gpd/sf was hydraulically appropriate for the site.

The treated effluent hydraulic load testing findings are provided in the ‘Final Open Sand Beds 14 & 15 Hydraulic Load Test Summary’, prepared by GHD and dated May 24, 2021 (Appendix 4.5).

4.4.2.1.2. Field Investigations

United States Department of Agriculture (USDA) maps indicate that the soils in the area are primarily Plymouth-Barnstable Complex (484). Plymouth-Barnstable Complexes are generally defined as hilly or rolling and bouldery. Soil borings completed at the site in 2014 indicate consistent, sandy material at depth across the existing open sand bed footprint site. The 2020 field investigations, which consisted of 2 shallow geo-probe borings and 3 test pits, indicated subsurface material that is generally considered appropriate for infiltration purposes. The results of this 2020 field investigation are described in greater detail in the ‘Great Pond Targeted Watershed Management Plan – Technical Memorandum 3 Additional Site Characterizations of Allen Parcel, Beds 14&15 and Augusta Parcel (GP TM 3)’, prepared by GHD and dated 2022.

4.4.2.1.3. MassWildlife Rare Species Listing

A State-Listed Rare Species request was submitted in 2020 for the parcel upon which Open Sand Beds 14 & 15 are located. A response letter was received from the Massachusetts Division of Fisheries and Wildlife (DFW) on February 7, 2020 (NHESP Tracking No. 02-23886) which stated that the Natural Heritage database indicates that the site is not currently mapped as a Priority or Estimated Habitat.

4.4.2.1.4. Potential Phosphorus Migration Evaluation

Groundwater modeling and particle tracking of treated water recharge at the Open Sand Beds 14 & 15 site conducted in 2011[2] indicated that flow discharged to open sand beds 14 & 15 is anticipated to migrate with groundwater to Buzzards Bay. The groundwater model also indicated that approximately 42% of the treated effluent would pass through Crocker Pond, a small freshwater kettle pond to the west of Recharge Beds 14 & 15. Because Crocker Pond is a freshwater pond, it is phosphorus limited. An evaluation conducted by EcoLogic in 2013[3] indicated that the aquifer soils downstream of Recharge Beds 14 & 15 have a large capacity to sequester phosphorus and significantly retard migration of phosphorus downstream. The 2013 evaluation considered an annual average effluent flow of 0.26 mgd to Open Sand Beds 14 & 15 under three effluent treatment scenarios:

- Effluent total phosphorus concentration of 2.5 mg/L (actual average effluent WWTF total phosphorus concentration based on December 2010 – June 2014 WWTF data).
- Effluent total phosphorus concentration of 1.0 mg/L (representing an upgrade to enhanced secondary treatment for phosphorous with chemical addition).

[2] ‘Technical Memorandum No. 9 – Groundwater Modeling for Sites 7 and 10’, prepared by GHD, dated October 4, 2011.
[3] ‘Crocker Pond, Falmouth: Potential Soil Attenuation of Phosphorus Migration from infiltrating Treated Wastewater at Site 7’, prepared by EcoLogic LLC, dated August 8, 2013 and September 20, 2013.

– Effluent total phosphorus concentration of 0.2 mg/L (representing an upgrade to tertiary treatment for phosphorus).

The absorptive capacity of the soil (in years) was estimated to be 100 years for the existing level of treatment at the WWTF and up to 1,400 years if the WWTF were upgraded to tertiary treatment for phosphorus.

In 2021[4], EcoLogic ran an additional simulation within the existing Open Sand Beds 14 & 15 footprint, which increased the average annual flow discharged at the site to 0.55 mgd. The analysis was conducted using the 10-year average effluent Total Phosphorus concentration (2010 – 2020) from the Falmouth WWTF of 2.68 mg/L. A simulation was also conducted for the average annual flow of 0.26 mgd using the 10-year effluent phosphorus average. Both simulations are summarized in Table 4.4.

Table 4.4. Estimated Soil Attenuation Capacity Between Open Sand Beds 14 & 15 and Downgradient Freshwater Bodies at Two Treated Effluent Discharge Rates

Downgradient Freshwater Bodies	**Zone**	**Soil Attenuation Capacity Time Period (years) Between Open Sand Beds 14&15 and Downgradient Freshwater Bodies**	
		Average Annual Treated Effluent Flow = 0.26 mgd	**Average Annual Treated Effluent Flow = 0.55 mgd**
Crocker Pond	Unsaturated	3.9	4.5
	Saturated	99.6	162.4
	Total	**103.5**	**166.9**

Notes:
1. Effluent TP Concentration = 2.68 mg/L (2010 through 2020 Falmouth WWTF data).

Counter-intuitively, the conclusion was that the soil attenuation capacity time period (years) was actually longer at a higher discharge rate, because at a higher discharge rate, the discharge would spread out over a larger soil prism increasing the soil surface area available for phosphorus attenuation.

In 2021, EcoLogic also reviewed groundwater monitoring well data downgradient of Open Sand Beds 14 & 15. The analysis indicated that phosphorus migration is consistent with the 2013 evaluation. Over the monitoring period (2016 – 2020) groundwater phosphorus concentrations in the monitoring wells remained consistent (i.e., did not increase), with the exception of Monitoring Well 21A, as anticipated. MW-21A and 21B are located twelve feet downgradient from the end of Open Sand Bed 14. MW-21A is screened at the top of the water table. MW-21B is screened 28 feet below MW-21A. As expected, phosphorus concentrations in MW-21A have increased over time, due to the well's immediate proximity to the discharge beds and minimal contact time with the soil, whereas phosphorus concentrations in MW-21B have a lower phosphorus concentration due to the increased opportunity for phosphorus attenuation within the soil profile at a lower depth. EcoLogic concluded that the monitoring data collected to date does not indicate issues of potential concern related to downgradient phosphorus migration.

[4] 'Appendix 4.7: Crocker Pond, Falmouth Potential Soil Attenuation of Phosphorus Migration from Infiltrating Treated Wastewater at Falmouth WWTF Open Sand Beds 14 &15', prepared by EcoLogic, LLC and dated June 2021.

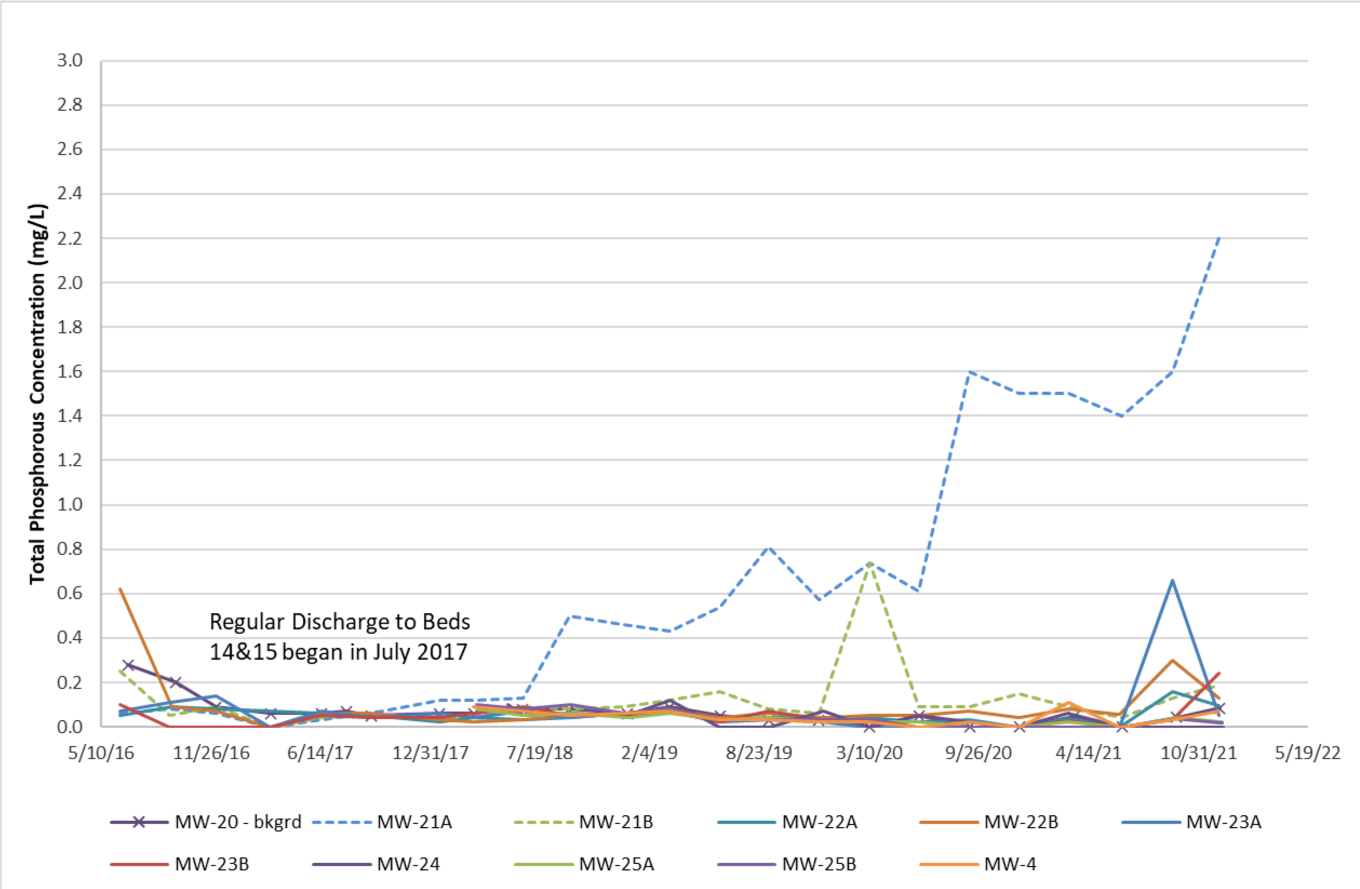

Figure 4.4 ***Total Phosphorus Concentrations in Open Sand Bed 14 & 15 Groundwater Monitoring Well Network***

4.4.2.1.5. Assessment of Nitrogen Migration Through Groundwater to Surface Waters and Groundwater Mounding

GHD developed a local-scale groundwater model for Open Sand Beds 14 & 15, based on the USGS regional flow model developed for the Sagamore Lens of the Cape Cod aquifer system (Walter, et. al., 2019). The local-scale model provides greater resolution in the vicinity of the site.

A particle tracking simulation was conducted under this groundwater flow field to estimate potential effluent migration (advective migration only) from the proposed effluent discharge area to downgradient waterbodies. The results of the modeling scenarios were analyzed to determine the percentage of total effluent recharge that reaches specific receptors under each scenario.

Initial simulations were used to estimate the maximum average annual flow that can be recharged at Open Sand Beds 14 & 15, without any treated effluent discharge migration in groundwater from Open Sand Beds 14 & 15 to West Falmouth Harbor. Initial simulations indicate up to 0.76 mgd (average annual flow) can be recharged at Open Sand Beds 14 & 15 without discharge migration via groundwater to West Falmouth Harbor. Table 4.5 outlines two simulations modeling a recharge of 0.76 mgd from Open Sand Beds 14 & 15. The total percent of discharge migrating to West Falmouth Harbor does not increase above current permit conditions with the increased flow to Open Sand Beds 14 & 15. Additional simulations should be conducted once a conceptual layout has been established for a potential open sand bed expansion at this site to refine this value.

Groundwater mounding analyses, conducted for the initial simulations, indicate that the modeled groundwater mound is anticipated to extend through Crocker Pond. Further investigations should be conducted to assess potential impacts of the groundwater mound on Crocker Pond.

Table 4.5. Treated Effluent Discharge Migration in Groundwater to Surface Water as a Percentage of Discharge from Open Sand Beds 9 - 15 (as a Percentage of Total Discharge at the Site)

Scenario	Model Input		Model Output				
	Average Annual Flow to Open Sand Beds 9-13 (mgd)	Average Annual Flow to Open Sand Beds 14 -15 (mgd)	Herring Brook	Buzzards Bay	West Falmouth Harbor		
					Mashapaquit Creek	Snug Harbor	Outer Harbor
2021 Permit Conditions	0.45	0.26	0%	54%	34%	0%	12%
2020-Existing Open Sand Beds 14 & 15-0.76 mgd[1]	0.45	0.76	11%	56%	22%	1%	9%
2020-Expanded Open Sand Beds 14 & 15-0.76mgd[2]	0.45	0.76	16%	75%	3%	0%	6%

Notes:

1. Scenario 2020-Existing Open Sand Beds 14 & 15-0.76 mgd represents anticipated average annual treated effluent flow to the existing Open Sand Beds 14 & 15 under Planning Flow 1.
2. Scenario 2020-Expanded Open Sand Beds 14 & 15-0.76mgd represents anticipated average annual treated effluent flow to an expanded Open Sand Beds 14 & 15 under Planning Flow 1. This scenario assumes that the existing open sand beds are expanded to the north.
3. All percentages rounded to nearest whole number

4.4.2.1.6. Summary of Evaluations at Open Sand Beds 14 & 15

Findings of the evaluations conducted for Open Sand Beds 14 & 15 are summarized below:

- Field investigations indicate subsurface material that is generally considered appropriate for infiltration purposes.
- Treated effluent hydraulic load testing at the site indicates that the site can hydraulically accommodate an increase in hydraulic loading rate (findings indicate that a hydraulic loading rate of at least 11 gpd/sf is currently appropriate for the site from a hydraulic perspective).
- MassWildlife has indicated that the site is not currently mapped as a Priority or Estimated Habitat.
- A phosphorus migration analysis indicated that the anticipated soil absorption capacity between the site and downgradient freshwater bodies is greater than 100 years, based on the Falmouth WWTFs current treated effluent phosphorus concentrations.
- Particle tracking simulations indicate that additional flow (up to 0.76 mgd total average annual flow) can be discharged at the site without any treated effluent discharge migration in groundwater to surface water in the West Falmouth watershed. These simulations will be further refined once a conceptual layout has been established for a potential open sand bed expansion.

4.4.2.2. Augusta Parcel

The Augusta Parcel is approximately 20 acres and is town-owned. It is surrounded by residential and commercial properties and is located in the Great Pond watershed. The site is currently undeveloped, but portions of the site have previously been cleared and developed for uses including a drive-in movie theater site. The site was previously identified as a potential site for wastewater facilities to serve the Teaticket area of Falmouth. The site has been selected as the location for a proposed booster station, as part of the TASA collection system conceptual layout. This booster station would collect raw wastewater from the TASA area (and possibly other future services areas) and pump it to the Town of Falmouth WWTF.

The site has also been identified as a potential site for treated effluent discharge. The deed for the Augusta Parcel currently limits potential wastewater treatment and disposal on the property to flow from an area including the Maravista peninsula and most of the Acapesket peninsula, as well as an area north of Route 28 which is not currently under consideration for sewering. In 2020, Falmouth Town Counsel confirmed that this deed restriction will expire in August 2033.

The Town of Falmouth has expressed an interest in developing playing fields or other recreational uses on the site as a secondary use. To accommodate this, conceptual layouts developed for the site incorporate both open sand beds and subsurface leaching trenches (to allow the potential accommodation of playing fields on a portion of the site).

4.4.2.2.1. Field Investigations

USDA maps indicate that the soils on the site are primarily Carver Sands (252C & 259B) and Merrimac Fine Sandy Loam (254A). During hydraulic load testing, conducted in Fall of 2018 a hydraulic loading rate of 138 gpd/sf was observed on this parcel. MassDEP has previously indicated that, if hydraulic load testing indicates a high infiltration rate, the agency would consider a maximum design loading rate of 7 gpd/sf for open sand beds until performance testing with actual treated effluent from a WWTF proved that a higher rate was warranted. Based on this MassDEP limitation, a proposed design hydraulic loading rate of 7 gpd/sf was used for the site for planning. If the site is developed, it is recommended that performance testing be conducted with actual treated effluent from a WWTF to evaluate the ability to request an increase in the rated capacity of the open sand beds. Additional field investigations (borings and test pits) conducted in 2020 confirmed a high anticipated permeability at the site and very favorable soils for treated effluent discharge.

4.4.2.2.2. MassWildlife Rare Species Listing

A State-Listed Rare Species request for the Augusta Parcel was submitted in 2020. A response letter was received from the Massachusetts Division of Fisheries and Wildlife (DFW) on December 23, 2020 (NHESP Tracking No. 20-39770). The response letter stated that the Natural Heritage database indicates that the site is not currently mapped as a Priority or Estimated Habitat.

4.4.2.2.3. Potential Phosphorus Attenuation Evaluation

No freshwater bodies have been identified downgradient of the Augusta Parcel. Therefore, a phosphorus migration evaluation was not completed for this site.

4.4.2.2.4. Assessment of Nitrogen Migration Through Groundwater to Surface Waters and Groundwater Mounding

GHD developed a local-scale groundwater model for the Augusta Parcel, based on the USGS regional flow model developed for the Sagamore Lens of the Cape Cod aquifer system (Walter, et. al., 2019). The local-scale model provides greater resolution in the vicinity of the Augusta Parcel. A particle tracking simulation was conducted under this groundwater flow field to estimate potential effluent migration (advective migration only) from the proposed effluent discharge area to downgradient waterbodies. The results of the modeling scenarios were analyzed to determine the percentage of total effluent recharge that reaches specific receptors under each scenario.

Modeling simulations were conducted for Planning Flows 1 and 3. These two flow rates were chosen to simulate the range of flows under consideration for this site. The simulations indicate that at Planning Flow 1, 100 percent of treated effluent discharged at the Augusta parcel is anticipated to surface in Great Pond. The modeling also indicates that at Planning Flow 3, a small percentage of treated effluent migration in groundwater is anticipated to surface in Perch Pond (which flows into Great Pond) and the majority flows directly to Great Pond. Model scenario findings are summarized in Table 4.6.

Groundwater mounding analyses, conducted for the initial simulations, indicate that the anticipated groundwater mound does not intersect any surface water bodies.

Table 4.6. Treated Effluent Discharge Migration in Groundwater to Surface Water as a Percentage of Discharge from the Augusta Parcel (as a Percentage of Total Discharge at the site)

Scenario	Model Input		Model Output	
	Average Annual Flow to Open Sand Beds (mgd)	Average Annual Flow to Subsurface Leaching Trenches (mgd)	Great Pond	Perch Pond
2021-Augusta-0.5 mgd	0.5	0	100%	0%
2021-Augusta-1.03 mgd	0.95	0.08	95%	5%

Notes:

4. Scenario 2021-Augusta-0.5 mgd represents anticipated average annual treated effluent flow to the Augusta Parcel under Planning Flow 1.
5. Scenario 2021-Augusta-1.03 mgd represents anticipated average annual treated effluent flow to the Augusta Parcel under Planning Flow 3.
6. All percentages rounded to nearest whole number

4.4.2.2.5. Summary of Evaluations at the Augusta Parcel

Findings of the evaluations conducted at the Augusta Parcel are summarized below:

– Field investigations indicate subsurface material with a high infiltration capacity that is very favorable for treated effluent discharge.

– MassWildlife has stated that the site is not currently mapped as a Priority or Estimated Habitat.

– No freshwater bodies (phosphorus sensitive receptors) were identified downgradient of the site.

– Particle tracking simulations indicate that at Planning Flow 1 all treated effluent discharge is anticipated to migrate through groundwater to Great Pond. As flow increases to the site (Planning Flow 3), a small portion of the treated effluent discharge is anticipated to surface in Perch Pond (which flows into Great Pond), and the majority surfaces directly in Great Pond.

4.4.2.3. Allen Parcel (Site 4)

The Allen Parcel is approximately 70 acres and is Town-owned. The parcel is forested and undeveloped. Fourteen acres in the southwest corner of the parcel—labeled as ‘Lot 3’ on the ‘2005 Allen Parcel Plan of Land’—has been identified for general municipal use. The property has a 100-foot-wide utility easement along the western boundary of the property. The “municipal use” portion of the property abuts residential neighborhoods to the south and west.

4.4.2.3.1. Field Investigations

USDA maps indicate that the soil at the site is predominately Enfield Silt Loam (265A) with a pocket of Merrimac Fine Sandy Loam (254B) in the southwest corner of the property. Initial subsurface investigations at the site in 2010 indicate primarily outwash plain with sandy soils. A 3-day hydraulic load test conducted in 2018 indicated generally high permeability at the test site (measured recharge rates of 130 gpd/sf) and generally favorable soils for treated effluent recharge. During the 2018 field investigations, a layer of lower-permeability soil was discovered approximately 10-inches thick at approximately 28-inches to 38-inches below grade. This layer (if found within the boundary of the proposed effluent recharge facilities) would need to be excavated and removed if the site were developed for treated effluent disposal. Further investigation of this layer was conducted in 2020 through soil borings and test pits. The test pits generally indicated:

– silt loam in the upper 3-feet of soil in all the test pits,

– loamy sand from approximately 3 feet to up to 11 feet below ground elevation, and

– medium to coarse sand below the loamy sand.

Medium to coarse sand is typically highly favorable for treated effluent infiltration. Silt loam and loamy sand are anticipated to have a lower infiltration rate than medium to coarse sand. It is anticipated that the less permeable materials (silt loam) would need to be removed if the site were developed for infiltration of treated wastewater. However, once the less permeable material is removed, the deeper soils have a high permeability rate and are generally favorable for treated effluent discharge.

4.4.2.3.2. MassWildlife Rare Species Listing

A State-Listed Rare Species request was submitted for the Allen Parcel in January 2020. A response letter was received from the Massachusetts DFW on February 7, 2020 (NHESP Tracking No. 20-39170). The response letter noted that a portion of the project site is located within Priority Habitat 223 (PH 223) for five state-listed rare species.

A pre-filing consultation request was submitted for the site in Spring 2021. Upon review of the submitted conceptual plans for the site, DFW indicated that the portion of the site under consideration for treated effluent disposal is not anticipated to have any state-listed species concerns due to the following reasons:

1. The four butterfly and moth species in the rare-species listing response (Herodias underwing moth, buck moth, frosted elfin, and pink sallow) are associated with the pine-dominated habitat in the northeastern and eastern portions of the property and not in the southwestern portion of the property, which is the proposed project area.
2. Eastern Whip-poor-will habitat is only mapped on lands that fall under an existing protection and the proposed project area does not fall under this category.

4.4.2.3.3. Potential Phosphorus Attenuation Evaluation

Fresh-water bodies are typically phosphorus limited. Four fresh-water bodies were identified down-gradient of the proposed Allen Parcel site:

– Coonamessett River
– Flax Pond
– Mill Pond
– Backus Brook

In 2021 an evaluation was conducted by EcoLogic to assess the potential soil attenuation capacity of the soil between the Allen Parcel and each down-gradient fresh-water body.

Three (3) composite soil samples (representing separate soil horizons) were collected from a soil boring and submitted to the Cornell University Nutrient Analysis Laboratory to quantify soil characteristics related to the soil's capacity to absorb phosphorus. The analysis indicated that the soils are composed predominately of sand-sized particles, low in organic matter, oxic (oxygen is present) in the unsaturated zone, and slightly acidic. These soil characteristics are considered highly favorable for phosphorus adsorption.

EcoLogic used an empirical model to estimate the phosphorus retention capacity of the soils within the anticipated flow path of the treated effluent (soil prism), using the estimated quantities of reactive aluminum present in the analyzed samples and parameters established through literature reviews. Estimated saturated and unsaturated soil prism volumes were estimated using the groundwater model developed by GHD for the site. The estimated soil attenuation capacity was calculated for Planning Flow 1 and Planning Flow 3. These two flow rates were chosen to simulate the range of flows under consideration for this site. The analysis was conducted using the 10-year average effluent Total Phosphorus concentration (2010 – 2020) from the Falmouth WWTF of 2.68 mg/L.

The analysis indicated a 50-to-60-year soil attenuation capacity between the Allen Parcel and the Coonamessett River, and over 100 years of soil attenuation capacity between the Allen Parcel and Flax Pond, Mill Pond, and Backus Brook in both flow scenarios (Table 4.7).

Table 4.7. Allen Parcel Estimated Soil Attenuation Capacity to Downgradient Freshwater Bodies

Downgradient Freshwater Body	Zone	Soil Attenuation Capacity Time Period (years) Between the Allen Parcel and Downgradient Freshwater Bodies	
		Average Annual Treated Effluent Flow = 0.5 mgd	Average Annual Treated Effluent Flow = 1.03 mgd
Coonamessett River	Unsaturated	0.2	0.5
	Saturated	49.3	60.1
	Total	**49.5**	**60.6**
Flax Pond	Unsaturated	2.2	2.7
	Saturated	139.6	113.0
	Total	**141.8**	**115.7**
Mill Pond	Unsaturated	1.0	1.0
	Saturated	309.8	208.1
	Total	**310.8**	**209.1**
Backus Brook	Unsaturated	2.2	1.8
	Saturated	478.5	174.6
	Total	**480.7**	**176.4**

Notes:
1. Effluent TP concentration = 2.68 mg/L (2010 through 2020 Falmouth WWTF data).

4.4.2.3.4. Assessment of Nitrogen Migration Through Groundwater to Surface Waters and Groundwater Mounding

GHD developed a local-scale groundwater model for the Allen Parcel, based on the USGS regional flow model developed for the Sagamore Lens of the Cape Cod aquifer system (Walter, et. al., 2019). The local-scale model provides greater resolution in the vicinity of the Allen Parcel. A particle tracking simulation was conducted under this groundwater flow field to estimate potential effluent migration (advective migration only) from the proposed effluent discharge area to down-gradient waterbodies. The results of modeling scenarios were analyzed to determine the percentage of total effluent recharge that reaches specific receptors under each scenario.

Modeling simulations were conducted for Planning Flow 1 and Planning Flow 3. These two flow rates were chosen to simulate the range of flows under consideration for this site. The results of the two simulations are summarized in Table 4.8. In both scenarios, particles flow to Great Pond via Flax Pond and/or the Coonamessett River, and particles flow to Green Pond via Flax Pond, Backus Brook, and/or Mill Pond. Under both scenarios, approximately 65% of the discharge at the Allen parcel ultimately flows to Great Pond, and 35% ultimately flows to Green Pond. However, the “route” that the particles take to the coastal ponds is different in the two scenarios. For example, the model indicates in the higher effluent discharge scenario, a larger percentage of flow surfaces directly in the Coonamessett River and Backus Brook.

Groundwater mounding analyses, conducted for the initial simulations, indicate that the anticipated groundwater mound does not intersect any surface water bodies.

Table 4.8. Treated Effluent Discharge Migration in Groundwater to Surface Water from the Allen Parcel (as a Percentage of Total Discharge at the site)

Model Inputs		Model Outputs										
Scenario	Average Annual Flow (mgd)	Great Pond Watershed				Green Pond Watershed					Great Pond Total	Green Pond Total
		Coonamessett River		Great Pond		Backus Brook	Green Pond		Mill Pond			
		Through Flax Pond to River	Directly to River	Through Flax Pond to Great	Directly to Great Pond	Directly to Backus Brook	Through Flax Pond to Mill Pond	Directly to Mill Pond	Through Flax Pond to Green Pond	Directly to Green Pond		
2021-Allen-0.5 mgd	0.5	47%	10%	9%	0%	8%	10%	14%	2%	0%	66%	34%
2021-Allen-1.03 mgd	1.03	29%	30%	5%	1%	18%	7%	10%	1%	1%	64%	36%

Notes:

1. Scenario 2021-Allen-0.5 mgd represents anticipated average annual treated effluent flow to the Augusta Parcel under Planning Flow 1.
2. Scenario 2021-Allen-1.03 mgd represents anticipated average annual treated effluent flow to the Augusta Parcel under Planning Flow 3.
3. All percentages rounded to nearest whole number.

4.4.2.3.5. Summary of Evaluations at the Allen Parcel

Findings of the evaluations conducted for the Allen Parcel are summarized below:

- Field investigations indicate material that is generally considered appropriate for infiltration purposes. A layer of less permeable material has been detected at the site, which would need to be removed if the site were developed for treated effluent discharge.
- MassWildlife has indicated that although the site is mapped as a Priority Habitat, the portion of the site under consideration for treated effluent disposal is not anticipated to have any state-listed species concerns.
- A phosphorus migration analysis has indicated that the anticipated soil absorption capacity between the site and downgradient freshwater bodies is greater than 50 years for the Coonamessett River and over 100 years for Flax Pond, Mill Pond, and Backus Brook, based on the Falmouth WWTFs current treated effluent phosphorus concentrations.
- Particle tracking simulations indicate that treated effluent discharge at the site is anticipated to migrate through groundwater to both the Great Pond watershed and the Green Pond watershed.

4.4.2.4. Ocean Outfall

The long-term option of treated effluent discharge through an ocean outfall is being evaluated for treated effluent disposal in the Town of Falmouth. Ocean outfalls are a proven technology that have the advantage of bypassing nutrient impacted watersheds, estuaries, and coastal ponds (as opposed to land-based discharge options). Ocean outfalls are currently being utilized by multiple Massachusetts communities, including Boston, Dartmouth, Fall River, and New Bedford.

The Town of Falmouth operated an ocean outfall for the village of Woods Hole from 1946 through 1985 that discharged chlorinated raw sewage into Great Harbor. In the mid-1980's the Town of Falmouth WWTF was constructed on Blacksmith Shop Road and discharge from the Woods Hole outfall was discontinued.

The Town, as part of its most recent effluent discharge evaluations, is considering possible sites in Vineyard Sound and Buzzards Bay.

Construction of an ocean outfall at Nobska Point in Woods Hole, extending approximately 2,000 feet into Vineyard Sound, was first evaluated as part of wastewater planning efforts in the 1970's. At the time, a treatment facility was proposed in Woods Hole, near Nobska Point. Town Meeting approved this approach, but it failed at a subsequent ballot vote. A potential ocean outfall at Nobska Point was re-examined as part of the CWMP process in 2011 and conceptual costs were developed for a force main from the Falmouth WWTF to Nobska Point with an ocean outfall off Nobska Point.

In 2018, GHD subcontracted with J. Churchill, G. Cowles, and J. Rheuban to develop a hydrodynamic ocean model to simulate the plume dispersion for a potential ocean outfall location on Buzzards Bay. The methodology used to develop the model and findings is outlined in the attached report 'Assessing the Effect of Ocean Effluent Discharge off of West Falmouth, MA' (see Appendix 4.6). As outlined in the report, the results of the year-long effluent tracking simulations indicate a negligible (less than one percent) effect on total nitrogen concentrations in Buzzards Bay and West Falmouth Harbor from a potential ocean outfall 4,380 linear feet from the shoreline with an effluent nitrogen concentration of 3 mg/L. The proposed length, established through modeling, was used in the development of a conceptual basis of design for an ocean outfall into Buzzards Bay off of West Falmouth Harbor.

In 2022, a follow-up hydrodynamic ocean modeling evaluation was initiated to evaluate potential ocean outfall options at Buzzards Bay and Vineyard Sound.

The Massachusetts Oceans Sanctuary Act (M.G.L. c132A) regulations establish state environmental policy to be enforced in the five Massachusetts Ocean Sanctuaries (consisting of the Cape Cod Ocean Sanctuary, the Cape and Islands Ocean Sanctuary, the North Shore Ocean Sanctuary, and the South Essex Ocean Sanctuary). The regulations outline prerequisites that must be met for new or modified discharges into ocean sanctuaries. The Falmouth WWTF effluent meets or exceed effluent requirements outlined in the Ocean Sanctuaries Act. An extensive permitting process is anticipated for the approval of a new municipal wastewater discharge into an ocean sanctuary, but since the Act was modified in 2014 no municipality has applied for a permit.

4.4.2.5. Discharge Site Capacity Summary

Conceptual layouts for Planning Flow 1-3 were developed for each potential treated effluent discharge site and used to estimate the hydraulic capacity of each site under the conceptual layout. The estimated hydraulic capacity of each site is summarized in Table 4.9, along with a conclusion regarding the planning flows each site would be able to accommodate.

Table 4.9. Estimated Hydraulic Capacity by Effluent Discharge Site and What Planning Flows Each Site Could Accommodate

Parameter	Open Sand Beds 14/15	Augusta Parcel	Allen Parcel	Ocean Outfall
Area Available for Effluent Discharge (acres)	3.1 acres	19.4 acres	12.6 acres	N/A
Maximum Estimated Average Annual Flow Hydraulic capacity (mgd)	0.5 mgd[3]	1.03 mgd	1.6 mgd	2+ mgd
Hydraulic Capacity for Planning Flow 1 - Great Pond Preferred Approach?	✓	✓	✓	✓
Hydraulic Capacity for Planning Flow 2 – South Coast Preferred Approach?	No	✓	✓	✓
Hydraulic Capacity for Planning Flow 3 – Great Pond Contingency Approach?	No	✓	✓	✓
Hydraulic Capacity for Additional Future Sewering?	No	No	Limited	✓

Notes:

1. Approximate area available for treated effluent discharge was estimated for each site based on identified constraints at the site.
2. Maximum estimated average annual flow hydraulic capacity (mgd) was estimated based on selected treated effluent discharge technology for the site and a design hydraulic loading rate of 7 gpd/sf for open sand beds and 3 gpd/sf for subsurface leaching facilities.
3. Estimated additional capacity available at the site.

4.4.3. Discharge Evaluation Matrix

A discharge evaluation alternatives matrix (Table 4.10) was developed to compare the treated effluent discharge sites. Each site was evaluated based on the following parameters:

1. **Site Description**
   - Location
   - Property Ownership
   - Distance to the Falmouth WWTF on Blacksmith Shop Road
2. **Regulatory Constraints**
   - Current Zoning
   - Property Legal Restrictions
   - Additional Studies Anticipated to develop the site for treated effluent discharge
   - Anticipated length of treated effluent discharge permitting process
3. **Environmental Impacts**
   - Downstream Phosphorus Receptors
   - Downstream Nitrogen Receptors
4. **Public Acceptance**
   - Estimated annual energy use for the treated effluent infrastructure (treated effluent lift station, force main system and treated effluent discharge)
   - Proposed treated effluent discharge method
   - Adjacent land uses
   - Anticipated odor or noise impacts
   - Potential Secondary Uses

– Existing Land Use

5. **Planning Level Capital Cost Estimates**

– Preliminary level Engineers Opinion of Probable Capital Costs for treated effluent infrastructure (treated effluent lift station, force main system and treated effluent discharge) sized for Planning Flow 1 (Great Pond Preferred Alternative). Cost estimate for each planning flow is inflated to the anticipated midpoint of construction for that project. Midpoint of construction for Planning Flow 1 is estimated as 2026 for cost estimating purposes.

– Preliminary level Engineers Opinion of Probable Capital Costs for treated effluent infrastructure (treated effluent lift station, force main system and treated effluent discharge) sized for Planning Flow 2 (South Coast Preferred Alternative). Cost estimates are cumulative with previous planning flows. Cost estimate for each planning flow is inflated to the anticipated midpoint of construction for that project. Midpoint of construction for Planning Flow 2 is estimated as 2037 for cost estimating purposes.

– Preliminary level Engineers Opinion of Probable Capital Costs for treated effluent infrastructure (treated effluent lift station, force main system and treated effluent discharge) sized for Planning Flow 3 (Great Pond Contingency Alternative). Cost estimates are cumulative with previous planning flows. Cost estimate for each planning flow is inflated to the anticipated midpoint of construction for that project. Midpoint of construction for Planning Flow 3 is estimated as 2047 for cost estimating purposes.

Table 4.10. Planning Flow 1-3 Discharge Evaluation Matrix

Category	Parameter	Open Sand Beds 14/15	Augusta Parcel	Allen Parcel	Ocean Outfall
Site Description	Location	Off Thomas Landers Road	Off Brick Kiln Road	Off Carriage Shop Road	Buzzards Bay or Vineyard Sound
	Ownership	Town Owned	Town Owned	Town Owned	State Owned
	Distance to Falmouth WWTF (miles) – approximate force main length	0 miles	4 miles	4 miles	6 miles (Vineyard Sound) 2 miles (Buzzards Bay)
Regulatory Constrains	Zoning	– Municipally Owned – Zoned Public Use	– Municipally Owned – Zoned Light Industrial A (Would Need to Be Rezoned for Public Use)	– Municipally Owned – Zoned Light Industrial A (Would Need to Be Rezoned for Public Use)	N/A
	Legal Restrictions	None	Deed restriction limits effluent discharge until 2033	None	Marine Sanctuaries Act, Clean Water Act
	Additional Studies Anticipated	Hydrogeological Evaluation (as part of the Groundwater Discharge Permit Application Process)	Hydrogeological Evaluation (as part of the Groundwater Discharge Permit Application Process)	Hydrogeological Evaluation (as part of the Groundwater Discharge Permit Application Process)	Field investigations, ambient monitoring, hydrodynamic modeling
	Anticipated Length of Permitting Process	Up to 8 months (Groundwater Discharge Permit)	Up to 8 months (Groundwater Discharge Permit)	Up to 8 months (Groundwater Discharge Permit)	Uncertain (multiple federal and state permits)

Category	Parameter	Open Sand Beds 14/15	Augusta Parcel	Allen Parcel	Ocean Outfall
Environmental Impacts	Downstream Phosphorus Receptors	Crocker Pond, Herring Brook	None	Flax Pond, Coonamessett River, Mill Pond, Backus Brook	None
	Downstream Nitrogen Receptors	Buzzards Bay, Herring Brook	Great Pond	Great Pond, Green Pond	Vineyard Sound or Buzzards Bay. Potential impacts to downstream nitrogen receptors can be mitigated through proposed outfall design. Modeling indicates that potential impacts are below the level of detection.
Modeling Public Acceptance	Estimated Annual Energy Use	Minimal (gravity flow)	Moderate (pumping from WWTF to remote site)	Moderate (pumping from WWTF to remote site)	Moderate (pumping from WWTF to remote site)
	Proposed Discharge Method	Open Sand Beds	Open Sand Beds and Subsurface Leaching Trenches	Open Sand Beds	Ocean Outfall
	Anticipated Odor or Noise Impacts – Post Construction	No	No	No	No
	Adjacent Land Use(s)	Municipal Wastewater Treatment Facility, One Residential Property	Lumberyard, Residential Properties	Town Conservation Land, Residential Properties	Potential impact would be undetectable along the shore based on outfall placement.
	Identified Potential Secondary Uses	None	Future Recreational Fields	None	None
	Existing Land Use	Existing Open Sand Beds; potential expansion area is undeveloped wooded.	Disturbed currently undeveloped parcel (former outdoor movie theater); partially wooded.	Undeveloped parcel, wooded.	No detectable impact.

Category	Parameter	Open Sand Beds 14/15	Augusta Parcel	Allen Parcel	Ocean Outfall
Planning Level Cumulative Capital Cost Estimates	Planning Flow 1: Great Pond Preferred TMDL Compliance Approach	$1.4 M	$23M - $27M	$30M	N/A
	Planning Flow 2: South Coast Preferred TMDL Compliance Approach	Cannot accommodate additional flow	$28M - $33M	$35M	$57M - $217M
	Planning Flow 3: Great Pond Contingency TMDL Compliance Approach	Cannot accommodate additional flow	$33M - $36M	$38M	$57M - $217M

Notes:

1. Cost estimate ranges are based on six alternatives that were developed through Great Pond TWMP Working Group Meetings and represent cost range of sending different effluent discharge site combinations.
2. Cost estimates are cumulative. Cost estimate for each planning flow is inflated to the anticipated mid-point of construction for that project. Midpoint of construction is estimated as 2026 for Planning Flow 1, 2037 for Planning Flow 2 and 2047 for Planning Flow 3.
3. Cost estimate for Open Sand Beds 14-15 for Planning Flow 1 assumes an increase in rated hydraulic load capacity of the existing beds as well as an expansion of the beds. Cost estimate range for Augusta Parcel represents differing assumptions in the portion of Planning Flow 1 discharged at Open Sand Beds 14-15.
4. Outfall cost range depends on many variables including outfall location, length, soil characteristics, and diameter and pipe material. Additional study is recommended to better define outfall cost.

4.4.4. Conclusions

The Discharge Alternatives Evaluation Matrix was presented to and discussed during Water Quality Management Committee Meetings on November 8, 2021 and November 22, 2021. At the November 22, 2021, the WQMC supported the recommendation of the Great Pond TWMP Working Group to:

1. Designate existing Open Sand Beds 14 & 15 as the preferred treated effluent discharge site for the projected ESRA/TASA flows in the short-term contingent on the MEP report results for Herring Brook (which the Town is anticipating receiving in 2023).
2. Consider ocean outfall options in Buzzards Bay and Vineyard Sound, along with land-based options at the Allen and Augusta parcels, for projected mid-term and long-term wastewater flows.

Both recommendations were reviewed and discussed with the Falmouth Select Board on December 6, 2021.

4.5. Coastal Resilience Design Conditions

The Town of Falmouth is a coastal community with over 68 miles of coastline. The proposed TASA is covered by two Federal Emergency Management Agency Flood Insurance Rate Maps (FEMA FIRMs).

– FEMA FIRM Number 25001C0737J, effective July 16, 2014
– FEMA FIRM Number 25001C0729K, effective July 16, 2014

FEMA defines the land area covered by the floodwaters of the Base Flood as a Special Flood Hazard Area (SFHA). The Base Flood is the 1-percent annual chance flooding event and is also commonly known as the 100-year flood event. The SFHA is broken down into three different coastal flood zones, which are designated by wave height, as follows:

- AE Zone – Area with shallow flooding only, where potential for breaking waves and erosion is low. Wave height is expected to be less than 1.5 feet.
- Coastal AE Zone – Area with potential for breaking waves and erosion during the Base Flood. Wave height is expected to be 1.5 to 3.0 feet.
- VE Zone – Wave height is expected to be greater than 3.0 feet.

The Base Flood Elevation (BFE) shown on a FEMA FIRM includes the anticipated wave height for a given area. Portions of the proposed TASA area are located within all three of the coastal flood zones. The most recent FEMA FIRM maps show anticipated Base Flood Elevations between 12 feet and 15 feet above mean sea level for areas within the SFHA.

Construction in the SFHA is regulated by the Massachusetts Building Code and would require provisions in the design to allow wastewater infrastructure located in the SFHA to withstand the Base Flood. As the design of wastewater infrastructure proceeds, FEMA FIRM maps and industry design guidelines and regulations will be assessed, and design accommodations will be incorporated to increase the coastal resilience of this infrastructure.