Appendix 4-23

Technical Memorandum S-0 on
Collection System Technology Comparison

TECHNICAL MEMORANDUM S-0

December 20, 2012

To	Town of Falmouth, MA		
Copy to	File; Project Team		
From	J. Jefferson Gregg, P.E., BCEE	Tel	774-470-1640
Subject	Wastewater and Nutrient Management Services Collection System Technology Comparison	Job No.	8615097

1. PURPOSE OF MEMO

The purpose of this Technical Memorandum is to summarize the comparison of Sewer Technologies based on information developed from existing Falmouth facilities planning reports, site visits to various system installations and information provided by system manufacturers and design guidelines.

2. BACKGROUND - GENERAL

An Alternatives Screening Analysis Report (ASAR) for the Town of Falmouth was completed in November 2007 and a Draft Comprehensive Wastewater Management Plan (CWMP) and Environmental Impact Report (EIR) document was developed in July 2012 and subsequently submitted for State review. As part of these documents (and previous facilities planning efforts in Town) the collection system technologies discussed herein were identified and screened as part of the ASAR, and the following document provides a summary of that evaluation and expands upon it.

When discussing collection system technologies, it is important to identify the Town's existing collection system. The existing centralized wastewater collection system in Falmouth is comprised of approximately 7 miles of gravity collection pipe; nine municipally operated pumping stations, and approximately 9 miles of force main to deliver the wastewater to the Falmouth WWTF. The collection system collects wastewater from the following areas: (1) Woods Hole; (2) Main Street; (3) Falmouth Beach; and (4) the Davis Straits/Inner Harbor area. The majority of the collection system was constructed in 1986, although most portions of Woods Hole were sewered in 1949. Two newer areas include the New Silver Beach area (served by its own WWTF) and the High School (which pumps to the Blacksmith Shop Road facility).

The nine pumping stations, located throughout the system are identified as follows Jones-Palmer, Shivericks Pond, Woods Hole, Gardiner Road, Inner Harbor, Falmouth Beach, and the newly constructed New Silver Beach station and the Falmouth High School dual pumping stations. A schematic of the system is illustrated in Figure 1.

The Town is now looking to expand this collection system in the Lower Little Pond service area, and is evaluating the use of several technologies including: vacuum, gravity (traditional and septic tank effluent—gravity (STEG)), low pressure (grinder and septic tank effluent—pump (STEP)).

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3. BACKGROUND - COLLECTION SYSTEM ALTERNATIVES

3.1 Introduction

The final layout and design of a collection system depends on several factors. The key factors include the type of collection system technology, the topography of the service area, utilities located in the road right-of-way (ROW), groundwater elevations, and the location of the treatment and treated water recharge site(s). Some of these factors will be identified as part of this evaluation, while many of the site-specific factors would be identified during final design.

The installation of a wastewater collection system in the road ROW is very disruptive to traffic activity. This will be particularly true in Falmouth, which has relatively narrow streets and increased automobile and pedestrian traffic during the summer season. To the Town's benefit, many of the most congested and heavily trafficked areas of Town are already sewered, helping to minimize these impacts. The use of trenchless technology to install a collection system must be considered during the planning and design processes to minimize disruptions. Trenchless technology is technology that allows installation of wastewater collection and transmission mains without digging a trench the entire length of the sewer in the road ROW, entrance and exit "pits" would be required, but disruption would be significantly reduced, but not eliminated.

As part of the CWMP planning, estimates were prepared for the system coverage and system costs based on a gravity/low pressure grinder pump system. The Town has contracted with GHD to update these costs and evaluate additional system technologies on both a capital and O&M cost. Each type of collection system technology offers some flexibility on how (or where) individual sewers are installed, but the overall system coverage for the various technologies will generally be the same.

Several types of sanitary sewer collection systems are in use throughout the United States, each with advantages and disadvantages. This additional analysis for the Lower Little Pond service area is being performed to determine the feasibility of a particular collection system and make a recommendation for 30% preliminary design that can ultimately be used for final design.

An overview of each of the technologies including advantages and disadvantages is summarized below.

3.2 Gravity Sewers and Pumping Stations

The most prevalent type of collection system in general use is a traditional gravity sewer. This type of system involves the installation of sewers at a constant downhill gradient. The slope is designed to maintain a sufficient velocity within the sewer line to ensure that all solids stay suspended within the waste stream. The minimum size of a typical sanitary sewer is 8 inches. The pipe size increases proportionally with the expected wastewater flow. The sewer is installed at a constant slope until its depth becomes so great that a sewage pumping station (or lift station) is needed to "lift" the flow to a wastewater treatment plant or to another gravity sewer. In flat terrain, several lift stations may be required before the flow is pumped to a treatment facility.

In most situations, homes along a gravity sewer connect into the system with gravity service connections from the building to the collector sewer. Houses that are below the street elevation use small pumps and a small diameter force main (1 to 2 inches) for discharging to the collector sewer.

The installation cost and ease of construction of a gravity sewer depend greatly upon the topography within a particular area and on the specific soil types. In areas where topography is consistently increasing or decreasing, the sewers can be installed close to minimum depth. In very hilly areas, deep sewers and/or pumping stations may be required. This can significantly increase construction costs when compared with other options.

Advantages of gravity sewers include the following:

- A properly designed and installed gravity sewer requires little maintenance.
- A gravity system can be easily expanded to serve additional areas. Additional capacity can be provided to accept present and future flow without affecting performance.
- The potential for odors in a properly designed gravity sewer is low.
- A gravity system is reliable, since it is not dependent upon electrical power for operation. When pumping stations are used on collector sewers, electrical generators are provided to supply power during a power outage.

Disadvantages of gravity sewers include:

- Gravity sewers are installed at a constant slope, and thus can require deep excavations as the topography changes. Construction with trenchless technologies is generally difficult as constant grades are required. Construction is generally disruptive to traffic patterns and surface infrastructure, as they are often located within the paved roadway to avoid conflicts with water and gas utilities on the Cape that are typically located closer to the shoulder(s) of the road.
- Pumping stations are required to transport the sewage out of low points in topography.
- Feasibility may be limited by availability of appropriate pumping station locations.
- Capital and operation and maintenance costs increase with each pumping station required.
- Pumping stations tend to increase the potential for odor emissions.
- Improper installation techniques could result in infiltration and exfiltration.

3.3 Pressure Sewers with Grinder Pumps

A pressure sewer system requires the installation of a grinder pump to serve each building or group of buildings. Wastewater flows by gravity into a pump chamber, where the sewage is shredded and pumped into a pressure sewer, eventually discharging to a gravity main or directly to a pumping station or treatment facility. This type of technology has become more widely used over the past 20 years, and is particularly suited to areas where there is a need to minimize excavation depths.

The typical pressure in this type of system is 5 to 40 pounds per square inch (psi). Pressure systems can be expanded to serve additional areas up to a design limit of 60 psi. Typically, systems can be expanded to serve additional homes; however there are design limitation and the overall expansion capability tends to be less than that of a gravity sewer.

When connecting the pressure sewer lines into a gravity line or directly to a pumping station, odor control for larger systems may be required at the discharge point to mitigate odors created in the pressure sewer pipe. Also, manholes at the discharge point should be protected from corrosion resulting from high hydrogen sulfide concentrations.

Advantages of a pressure sewer include the following:

- The collection main is installed at a relatively shallow depth and is independent of grade changes. This allows shallower excavation, lower piping construction costs, and less overall disruption to the area due to a shorter installation construction period.
- A pressure sewer can serve areas of hilly terrain or marginal slope.
- The pressure sewer piping (beyond the pumping chamber) is not susceptible to infiltration, unlike gravity sewers.
- The shredding action of the pump eliminates the need for a larger-size collection system. Pressure sewers tend to be much smaller diameter than a typical sanitary sewer, ranging from 1-1/4 inch to 6 inches, depending upon the expected design flow.
- The pressure sewer mains (at shallower depths than gravity) are easier to locate in road shoulders to minimize construction in roads where space is available.
- Some portions of pressure sewers could be installed with trenchless technologies, thus reducing general disruptions experienced during construction.
- Homes with generators can maintain operation of their pumps as long as their home electrical system is set up to accommodate the load (this is becoming more common with the larger number of power outages in recent years).

Disadvantages to this type of system include the following:

- Each building or group of buildings in the system would have to be equipped with a pump unit, which increases operation and maintenance requirements. Towns that operate their own systems typically have to maintain an inventory of pumps/ parts for these units to minimize disruption of service, otherwise this becomes the homeowner's responsibility to have their system maintained.
- Each pump unit is dependent upon electrical power for proper operation; since the pumps are located at individual homes, municipal backup electrical power is typically not provided. Storage capacity is typically built into each pump chamber (normally 60 gallons). However, in a prolonged power outage, it would be possible for the wastewater flow to exceed this capacity and back up into the pipelines within the structures. This can be remediated by providing electrical connections on each pump unit to allow a service crew to connect a portable generator and pump out each unit during times of prolonged power outage. Another option is to install a larger capacity unit or a dual tank system, thus providing more storage.
- This system is more sensitive to seasonal flow conditions than a gravity sewer. In areas with extreme seasonal fluctuations, minimum flow conditions must be carefully quantified to be sure the sewage flow can properly travel through the system. If inadequate flow exists, solids can harden within the sewer and cause blockages.
- There is a potential for exfiltration of sewage into the surrounding soil if leaks or breaks occur in the pipeline.
- Training would be required to familiarize operating staff with maintenance of the pumps and pressure sewers.
- Ownership considerations need to be clearly defined early in the selection and design process. Costs for systems will depend on who owns, operates, and maintains the grinder pump. Easements may also be required to address maintenance and emergency power issues.

- Odors can be released at the point of discharge into a gravity sewer or pumping station.

3.4 Septic Tank Effluent Sewers

Septic tank effluent sewers use either new or approved existing septic tanks and are designed to transport septic tank effluent to a treatment facility. The use of septic tanks reduces the amount of solids and grease entering the sewer. An effluent screen or baffle wall located upstream of the discharge point helps to keep solids out of the sewer.

Septic tank effluent sewer systems require septic tank maintenance, including routine pumping and treatment of septage. Each septic tank should be inspected during sewer construction to replace those tanks that provide inadequate service. Inadequate tanks include those that are prone to infiltration, are insufficient in size, have inappropriate inlets or outlets, or do not meet current Title 5 requirements.

When connecting septic tank effluent into existing gravity systems, odor control systems may be required at the discharge point and downstream pumping stations to mitigate odors caused by the hydrogen sulfide content in the effluent. Manholes at the discharge point should be protected from corrosion, which can occur as a result of the high hydrogen sulfide concentrations.

There are two types of septic tank effluent collection systems: (a) septic tank effluent pump systems; and (b) septic tank effluent gravity systems. A discussion of each system is presented in the following sections.

3.5 Septic Tank Effluent Sewers—Septic Tank Effluent Pump (STEP) System

The STEP system involves the installation of an effluent pump immediately downstream of the septic tank (or in the discharge end of the septic tank), which pumps the effluent to a pressure sewer. Thus, the system is very similar to a pressure system. This type of system is not very common in New England, the facility in Gloucester, MA is the facility most commonly referenced when discussing these systems.

The STEP system has the following advantages:

- The system can serve in areas of hilly or flat terrain.
- The pumps and piping can be installed at shallow depths, reducing construction costs and overall disruption associated with excavation.
- The pressure sewer (beyond the septic tank) is not susceptible to infiltration because the system is pressurized.
- Septic tank effluent pumps may be less expensive than grinder pumps because the need for a shredder is eliminated.
- Few solids are transported in the system, which reduces the potential for sewer blockages caused by solids deposition.
- Homes with generators can maintain operation of their pumps as long as their home electrical system is set up to accommodate the load (this is becoming more common with the larger number of power outages in recent years).

The STEP system has the following disadvantages:

- Not a common system in the region, so operational issues by a municipality are not as well documented. Operation by homeowners would be common to those with septic systems with pumping systems.
- The septage must be periodically pumped from the individual septic tanks. Town will need to consider how and where the septage is managed.
- The system relies on electrical power to operate the pumps and will not function during power outages (unless specifically on generators as discussed above). However, the pumps are frequently installed in tanks with relatively large storage capacity.
- Each building or group of buildings in the system would have to be equipped with a pump unit, which increases operation and maintenance requirements. Spare parts must be maintained for these units to minimize disruption of service similar to a grinder pump system.
- Hydrogen sulfide buildup is common within these pipelines, increasing the potential for odors and corrosion.
- There is a potential for exfiltration of wastewater into the surrounding soil if leaks or breaks occur in the pipeline.
- Training is required to familiarize operating staff with maintenance of the pumps and pressure sewers.
- A treatment plant that receives flow from this type of system must be carefully designed because it will not receive the higher organic loading that is typically needed for biological nitrogen removal treatment processes. Management of the septage at the treatment facility needs to be accounted for to manage peak loads.
- Ownership considerations need to be clearly defined early in the selection and design process. Costs for systems will depend on who owns, operates and maintains the pump in a STEP system. Easements may also be required to address maintenance and emergency power issues.
- Greater levels of site investigations are required to establish the adequacy of existing septic tanks.
- Location of septic system will dictate pump location and may increase length of lateral service. Other systems may allow relocation of sanitary piping at the house (unless a new STEP tank is installed).

3.6 Septic Tank Effluent Sewers—Septic Tank Effluent Gravity (STEG) System

The STEG system can be used to transport effluent from septic tanks to a pumping station or treatment facility. Layout of the system is very similar to a gravity system.

Advantages of STEG sewers include the following:

- A flatter slope can be maintained in comparison with gravity sewers, because most of the larger solids have been removed in the septic tank.
- The lack of solids allows smaller diameter pipes to be installed. Sizes typically range from 4 to 6 inches versus 8 inches or greater for a typical gravity sewer.
- Cleanouts can be installed instead of manholes, reducing installation costs.
- Very little maintenance is required on this type of system when compared to a pressure or vacuum system unless pumping stations are used.

STEG sewers have the following disadvantages:

- System has same topographical limitations as a traditional gravity sewer system; therefore properties below the elevation of the sewer main will need to pump into the system via a STEP system.
- The septage must be periodically pumped from the individual septic tanks.
- Hydrogen sulfide buildup is common within these pipelines, which increases the potential for odors and corrosion.
- They are not adaptable to hilly terrain.
- A treatment plant that receives flow from this type of system must be carefully designed because it will not receive the higher organic loading that is typically needed for biological nitrogen removal treatment processes.
- Greater levels of site investigations are required to establish the adequacy of existing septic tanks. Location of existing septic tank may also limit ability to connect to the sewer main by gravity.
- Pumping stations are required to transport the sewage out of low points in topography.
- Feasibility may be limited by availability of appropriate pumping station locations.
- Capital and operation and maintenance costs increase with each pumping station required.
- Pumping stations tend to increase the potential for odor emissions.
- Improper installation techniques could result in infiltration and exfiltration.
- Existing septic system location will dictate depth of sewers in road.

3.7 Vacuum Sewers

Vacuum sewers are considered a “new” technology in Massachusetts, and to date only three systems have been installed in the State: Barnstable, Provincetown, and Newburyport (Plum Island). Vacuum sewers are typically 4 to 12 inches in diameter, and therefore are typically smaller in diameter than traditional gravity sewers and rely upon a vacuum created within the pipeline to draw the sewage towards a pumping station. A vacuum pump located at the vacuum station draws air out of the sewer, creating a vacuum inside the sewer. Sewage from individual homes flows by gravity to a vacuum valve pit located on property like a grinder or STEP system or at the property line. Flows from larger facilities, such as hotels/motels, restaurants, apartments, condominium and large commercial facilities are handled by buffer tanks instead of valve pits; however the operational aspects are similar and rely on the same type of vacuum valve usually in configurations of 2 or more. As sewage fills a chamber in the bottom of the valve pit or buffer tank, a sensor activates an automatic vacuum valve. When the valve opens, sewage is drawn into the sewer because of the pressure difference between the sewer and atmospheric pressure outside the valve. Each subsequent opening of the valve draws the sewage (and air) further downstream until it reaches the vacuum station, where it is pumped from the receiving tank to a gravity sewer, another pumping station or treatment facility.

Advantages of vacuum sewers include:

- Vacuum sewers can be installed at shallower depths than gravity as allowed by their use of a saw tooth configuration, which can reduce installation costs and excavation time.
- Because the piping must be airtight to allow proper vacuum operation, the infiltration potential tends to be low. Infiltration can occur if a pipe leaks or breaks in areas where the line is completely

submerged in groundwater; however, leaks are readily apparent through the vacuum system operation records and loss in vacuum pressure.

- There are no power requirements at individual properties. Vacuum stations can be equipped with emergency generators at their main stations, which allow the system to remain in operation during power outages.
- The vacuum sewer mains can be located in road shoulders to minimize construction in roads where space is available.
- Vacuum sewer mains are typically smaller diameter that gravity sewers, and can be installed at flatter slopes than traditional gravity.
- Saw tooth configuration can allow installation to avoid some utility conflicts, however only as long as there is sufficient headloss and friction loss available in the system to allow additional bends beyond the original design.

A vacuum system has the following disadvantages:

- A vacuum must be constantly maintained in the pipeline for the system to work. Malfunctions (air leaks) in the line can affect the entire system and must be fixed quickly to keep the system operational. Leaks or malfunctions may also be difficult to locate.
- The potential for odor generation at the vacuum station is greater due to the vacuum pumps constantly pulling air from the system. This air flow must be treated to minimize odors.
- Operator training would be required to gain sufficient knowledge to operate and maintain the vacuum pipelines, vacuum pumping stations, and emergency response procedures. The “learning curve” for these systems is much greater than other collection systems.
- This type of system is not readily adaptable to hilly terrain.
- To design a properly operating system, the design flows must be estimated as accurately as possible, and a detailed route survey must be performed. Vacuum systems are sized for specific cases and cannot be easily expanded to serve additional homes.
- There is a potential for frozen valve controllers, depending on the valve pit depth.
- Systems are less common in Massachusetts; therefore contractors are less familiar with the system, which has very system specific design requirements that are very different from gravity and low pressure systems.
- Headloss and length of system limit the application of this technology.
- System is very sensitive to the types and flow variations which can impact system performance and capacity.
- Large commercial developments (hotels, motels) typically require the use of buffer tanks, which complicate the system.
- Large flows entering vacuum systems at one location are difficult to manage and should not be located at the ends of the collection system lines.
- Gravity and pumping stations should not be connected into vacuum systems, large flow rates from pumping stations and infiltration/inflow from gravity systems can overwhelm the vacuum valves.
- Buffer tank installations (if needed) add to operation and maintenance requirements (act as small pumping stations).

- Influent pipe to buffer tanks (if needed) are susceptible to clogging with rags and can create backups in the gravity lines feeding the system, and can impact flow splitting in these structures.
- Seasonal use can impact the system; system relies on even distribution of air into the system to move flow, and the addition of automatic air valves to assist this can add to energy costs at the vacuum station.

4. COMBINATION OF TECHNOLOGIES

In many cases, the combination of terrain, soil conditions, and congestion of an area prevents one single type of sewer system from being cost effective. In these situations, the combination of two or more methods may achieve an optimum solution. The combination most widely used is pressure sewers discharging to gravity sewers.

In some cases, it is not feasible to combine methods due to the inherent characteristics of the specific technology. Septic tank effluent systems are designed to transport only liquids using a small diameter pipe. Thus, any other type of system which carries solids should not be permitted to connect into this system. Also, septic tank effluent systems are designed to lessen the organic loading to a treatment plant, and this advantage would be minimized if a septic tank effluent system discharged into a sewer carrying all the solids.

When considering a combination of technologies during design, a careful review should be made of the local conditions, and cost estimates should be prepared which include construction as well as operating and maintenance costs.

5. SCREENING OF COLLECTION SYSTEM TECHNOLOGIES

5.1 General

As discussed previously, wastewater collection with gravity sewers and pumping stations is a widely used, simple, and reliable technology. Gravity sewers can easily be expanded to accommodate additional flows. The relative cost of gravity sewers depends on environmental conditions and increases with the number of stations required and depth of excavations. Gravity within the project area will be limited by both availability of pumping station sites and sewer depths, and therefore will need to be considered with some form of low pressure system.

Pressure sewers are less widely used than gravity sewers, but have relatively low construction costs and are adaptable to changes in topography. Public acceptance of pressure sewers may be low due to the need for a pump at each individual home or business. In addition, pressure sewers rely on electrical power, and flow has the potential to backup during power outages. System can be used with gravity or as a stand-alone system.

Septic tank effluent sewers are less widely used than grinder pump type systems, and also either requires installation of pumping equipment to fit into (or adjacent to) the septic tank or appropriate topography for STEG type systems to flow by gravity. The main advantage of these systems is the reduced amount of solids transported in the collection system and the reduced potential for sewer blockage caused by solids deposition. Unfortunately, the lack of organic solids in the sewage delivered to the treatment plant will make the nitrogen removal process more difficult, and the septage still needs to be periodically removed and treated. These systems also require periodic pumping of the individual septic systems, which adds a high operational cost and potential for odor generation. The STEG system will be limited in the same way that gravity is; however it can be used in combination with a STEP system. The STEP system like the grinder system could be a stand-alone system.

Vacuum sewers have maintenance requirements similar to low pressure systems and require significant staff training for implementation and operation. Vacuum sewers are not easily expandable and require accurate flow estimates prior to construction. The capital costs of vacuum sewers are typically slightly higher than low pressure systems. Vacuum systems have a greater reliability of continued operation during power outages than low pressure systems because electrical service is not required at the valve pit. Similar to gravity and STEG, the vacuum sewer system will be limited by topography and also by available pumping station locations; it is also limited in its ability to connect with other systems. Some systems may require dual collection sewers in the road service separate parts of the collection service area due to the system design constraints.

5.2 Screening Criteria

A standard set of evaluation criteria was established as part of the CWMP to compare all wastewater and nitrogen management methods (traditional and non-traditional) on a "level playing field." The following Table is copied from Chapter 7 of that report.

Table 5-1 Evaluation Criteria Summary from WQMC Workshop in April 2012

Evaluation Criteria Theme	Previous Criteria Used	Proposed Criteria for Adaptive Management Evaluations
Social	· Anticipated public acceptance. · Potential land requirements.	· Achieves multiple benefits including public health, jobs, tourism, economy, ecology. · Open to alternatives. · Public acceptability including perception of impacts to property value. · Voter acceptability. · Level if disruption to individual properties. · Institutionally viable (planning, engineering & finance).
Environmental	· Effluent quality to protect aquatic ecosystems. · Potential for air emissions (odor and noise).	· Protect ecological value: restoration of water quality and habitat in ponds and estuaries. · "Robustness" for meeting standards: attention to nitrogen, phosphorus, emerging constituents, carbon and other alterations and stressors. · Avoid externalization. · Work up from the estuary" biological metrics for a health aquatic environment.

Evaluation Criteria Theme	Previous Criteria Used	Proposed Criteria for Adaptive Management Evaluations
		· Energy efficiency—life cycle energy use.
Economic	· Capital cost. · Operating costs.	· Capital and operating costs. · Cost per pound of nitrogen removed. · Advance the low-hanging fruit. · Affordability within available tax limits. · Indirect costs and benefits (e.g. job creation). · Total property owner cost. · Capacity to pay taxes. · Amenability to types of financing (e.g. betterment). · Ease of distributing costs.
Ease of Implementation	· Ease of implementation. · Ease of operation and maintenance.	· Don't be constrained by current regulations.
Resource Use	· Energy use.	· Maximize resource recovery and minimize non-renewable resource use (water, nutrients, energy).
Ease of Regulatory Approvals	· Meeting regulatory requirements.	· Compliance with regulations and Total Maximum Daily Loads (TMDL) as a floor. · Measure compliance at the sentinel level not by percentage of properties sewered. · Necessary regulatory changes identified for each alternative.
Resilience/Adaptability	· Flexibility	· Resilience to climate change/aging population. · Able to manage uncertainty (modular, spaced). · Flexible to growth.

Based on these criteria, the above identified technologies are compared under each of these categories.

It should be understood that each is being compared as a stand-alone, however the system implemented in any area may be a combination of systems and therefore those comparisons are made on a planning area specific basis, as identified in the Lower Little Pond Service Area Evaluation Technical Memorandum S-1.

The following Tables outline each technology relative to these criteria. Commonalities between technologies are grouped in the Table, for example gravity systems (gravity and STEG) may be in a common box between the two columns, as might STEP and STEG systems, and lastly STEP and Grinder pumps may have similar components as well. Criteria common to all technologies will cross all columns.

Table 5-2 Social

<table>
<tr><th>Gravity System</th><th>STEG System</th><th>STEP System</th><th>Grinder Pump System</th><th>Vacuum System</th></tr>
<tr><td colspan="5">· The above listed systems are strictly a means of conveyance, and therefore aid in meeting the TMDLs through conveying untreated (limited treated) wastewater to a facility equipped to do so. Ultimately, TMDL compliance is a function of where the treated water is recharged and to what level of treatment (independent of the collection system).
· All systems are subject to infiltration and exfiltration in the portion between the home and the tank/pump chamber or gravity lateral connection at the ROW.
· Sewer systems typically increase the property value.
· Betterments and fees are always the perceived negatives of these systems.</td></tr>
<tr><td colspan="2">· Possible public opposition to pumping station locations.
· Deeper excavations and perceived additional road disruption.</td><td colspan="2">· Public opposition to having pump on property.</td><td>· System will not operate properly with any level of infiltration or exfiltration due to loss of vacuum at that point.
· Possible opposition to having valve pit on property.</td></tr>
<tr><td>· Public acceptance high for no need for electrical at property.</td><td colspan="2">· Installation of new septic tank (if necessary) increases onsite disruption.
· Disruption reduced if existing septic tank can be reused.
· Installation of new septic tank (if necessary) increases onsite disruption.
· Disruption reduced if existing septic tank can be reused, although electrical still required for STEP.</td><td>· Need to install grinder pump on property including electrical work.</td><td>· Need to locate valve pit either on property or at ROW.
· Public acceptance high for no need for electrical at property.</td></tr>
<tr><td></td><td colspan="4">· Routine access to private property may be required based on ownership and maintenance of these systems.</td></tr>
</table>

Table 5-3 Environmental

<table>
<tr><th>Gravity System</th><th>STEG System</th><th>STEP System</th><th>Grinder Pump System</th><th>Vacuum System</th></tr>
<tr><td colspan="5">· All systems require routine maintenance and inspection at some level, therefore requiring vehicle trips and energy consumption.
· As stated above none of the systems treat wastewater, they convey it to the treatment system which ultimately impacts the TMDL. However removal from the impacted watershed and recharge of treated effluent outside of any impaired water bodies works in favor of meeting the TMDLs.
· Installation of sewer systems eliminates Title 5 systems that are currently impacting the watersheds.</td></tr>
<tr><td colspan="2">· Gravity systems require energy only at the pumping station.</td><td colspan="2">· Pumping systems require small energy use, but at each individual home/property.</td><td>· More pumps (vacuum and sewage) needed than typical gravity station (sewage only) increasing energy demands.</td></tr>
</table>

Table 5-4 Economic

<table>
<tr><th>Gravity System</th><th>STEG System</th><th>STEP System</th><th>Grinder Pump System</th><th>Vacuum System</th></tr>
<tr><td colspan="5">· All systems costs will be impacted by the topography, soil conditions, groundwater conditions and properties being served and therefore each system has the opportunity to be the most economical.
· Cost structure and funding mechanism and ownership issues need to be resolved before each system can be compared on equal footing.</td></tr>
<tr><td>· Perceived greatest capital costs due to depth of sewer required, more likely to encounter groundwater.</td><td>· Perceived lower cost than gravity due to pipe size, however still dependent on gravity and therefore has same limitations and cost impacts.</td><td colspan="2">· Typically the lowest capital cost to install due to small trench size compared to other technologies.
· Additional jobs created through maintaining more pumps.</td><td>· Perceived lower cost than gravity due to pipe size, however still dependent on gravity (with vacuum assistance) and therefore can have similar limitations and cost impacts.</td></tr>
<tr><td></td><td colspan="2">· Septic haulers still needed for routine maintenance.</td><td></td><td></td></tr>
</table>

Table 5-6 Ease of Implementation

<table>
<tr><th>Gravity System</th><th>STEG System</th><th>STEP System</th><th>Grinder Pump System</th><th>Vacuum System</th></tr>
<tr><td colspan="2">· Gravity installations typically require deeper excavations.</td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="3">· STE and grinder systems will all require easements on private property if systems are installed or owned, operated or maintained by the Town.</td><td>· May or may not require easement on private property.</td></tr>
<tr><td></td><td></td><td colspan="2">· Require maintenance program for pumps if owned or maintained by the Town.</td><td>· Much greater learning curve for operators.</td></tr>
<tr><td colspan="2">· Pumping station(s) required, land acquisition or easement may be required.</td><td colspan="2">· Pumping station(s) may be required to serve these areas if not pumped directly to the WWTF or gravity collection system. Land acquisition or easement may be required.</td><td>· Pumping station(s) required, land acquisition or easement may be required.</td></tr>
<tr><td colspan="5">· Pumping station siting requirements and considerations regarding public acceptance and implementation.</td></tr>
</table>

Table 5-7 Resource Use

<table>
<tr><th>Gravity System</th><th>STEG System</th><th>STEP System</th><th>Grinder Pump System</th><th>Vacuum System</th></tr>
<tr><td></td><td colspan="2">· Potential to reuse existing septic tanks.</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">· Septic haulers still required, fuel resource.</td><td></td><td></td></tr>
<tr><td colspan="5">· Any pumping station needs may require superstructure and material resources for construction.</td></tr>
<tr><td colspan="2">· Energy requirements associated with supporting pumping station.</td><td colspan="2">· Energy requirements at individual properties.</td><td>· Slightly higher energy requirements than typical gravity pumping station.</td></tr>
<tr><td colspan="5">· Resource recovery would be at the WWTF, typically easier and more cost effective to recover resources at a larger facility.</td></tr>
</table>

Table 5-8 Ease of Regulatory Approvals

<table>
<tr><th>Gravity System</th><th>STEG System</th><th>STEP System</th><th>Grinder Pump System</th><th>Vacuum System</th></tr>
<tr><td colspan="5">· All collection systems provide no treatment and therefore only provide conveyance to a wastewater treatment facility which is where the ability to achieve TMDL through nitrogen reduction would be achieved.
· All systems are MassDEP approved and can be found in Massachusetts. Gravity and low pressure systems being the most common types.</td></tr>
<tr><td></td><td colspan="2">· Regulators may require additional documentation on septic tank integrity.</td><td></td><td></td></tr>
</table>

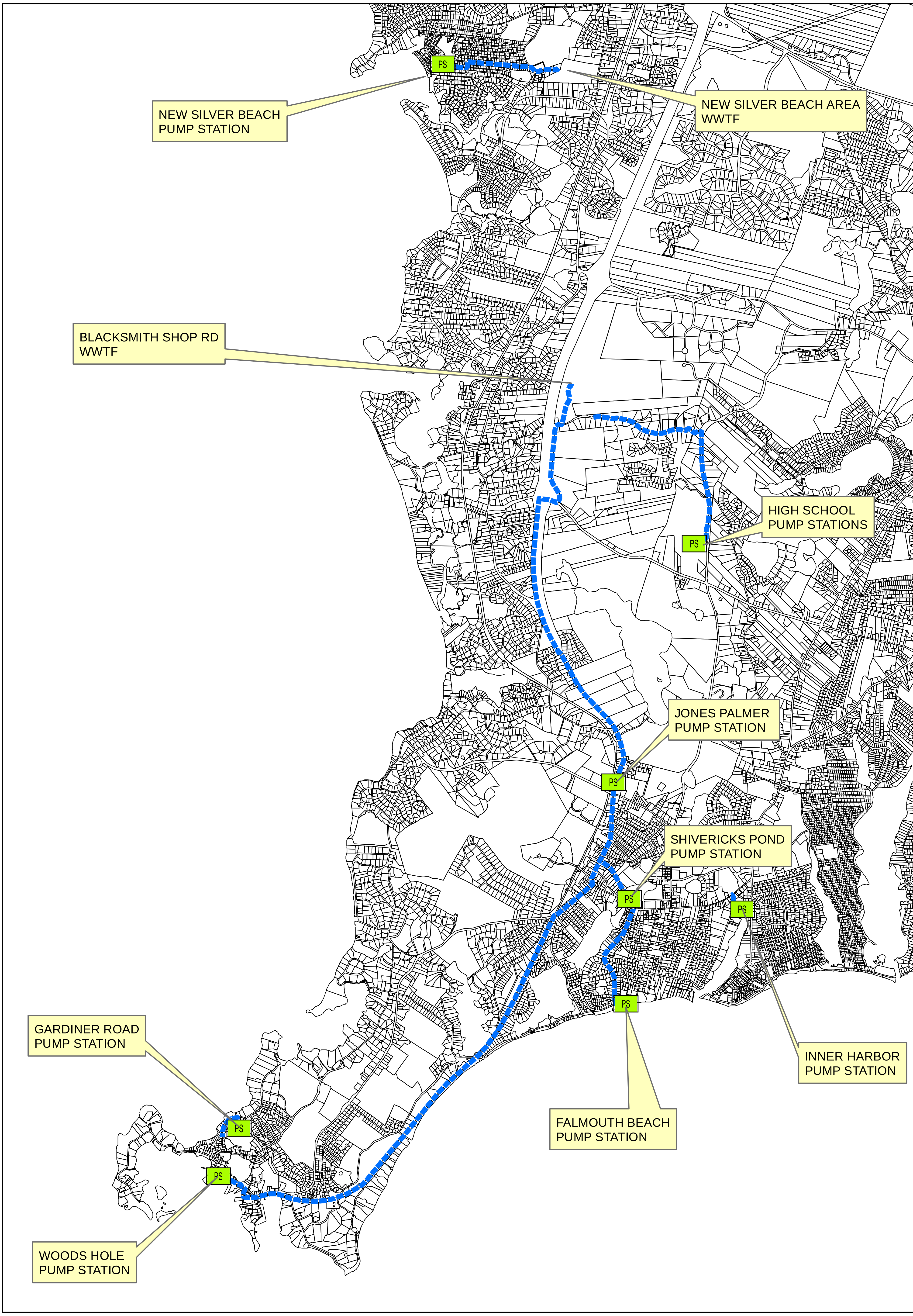
Table 5-9 Resilience/Adaptability

<table>
<tr><th>Gravity System</th><th>STEG System</th><th>Grinder Pump System</th><th>STEP System</th><th>Vacuum System</th></tr>
<tr><td colspan="2">· Gravity systems most difficult to isolate if damaged.</td><td colspan="3">· Can isolate extremities of the system that might be located at the coastline and most likely to be impacted by climate change.</td></tr>
<tr><td>· Typically the simplest to expand for future growth.</td><td>· Expansion restricted by its reduced size and need to maintain gravity (could only receive flow from STEP system if pumping were required).</td><td colspan="2">· Can be expanded if designed properly to take into consideration the pumping system type and force main size.</td><td>· Most difficult to expand in the future due to construction requirements (maintaining vacuum for other users) and friction and flow sensitive.</td></tr>
</table>

6. ALTERNATIVES

As identified in the project scope, the following collection system technologies will be further evaluated as part of the Lower Little Pond Service Area Evaluation Technical Memorandum S-1 based on their specific application within this service area. These Alternatives include:

1. Gravity/low pressure type systems:
   - 1A. Combination of Gravity/Low pressure system (grinder pump)
   - 1B. Combination of Gravity/STEP
   - 1C. STEP/STEG
2. All low pressure systems
   - 2A. Grinder pumps
   - 2B. STEP
3. Vacuum sewer



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PS Existing Pump Station

Existing Force Main

TOWN OF FALMOUTH, MASSACHUSETTS

Wastewater and Nutrient Management Services

WASTEWATER FACILITY LOCATIONS

Job Number	86-15097
Revision	A
Date	17 Dec 2012

Figure 1

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