Memorandum

To: *Charles Dam, PE, Public Works Director, Manchester-by-the-Sea*

From: *John Brito, PE*
Michael Guidice, PE

Date: *April 9, 2021*
Revised June 30, 2021

Subject: *Manchester-by-the-Sea Wastewater Treatment Facility Decommissioning Study*

Executive Summary

ES.1 Introduction and Background

The Town of Manchester-by-the-Sea (MBTS) used a Housing Choice Initiative grant received from the Commonwealth of Massachusetts Small Town Capital Grant Program to fund an engineering evaluation of options for decommissioning the Town's existing wastewater treatment facility (WWTF) with the goal of potentially redeveloping the site in the future. Decommissioning of the WWTF would require construction of a new wastewater pumping station and force main to convey the Town's wastewater to another location for treatment, followed by demolition of the existing WWTF to allow for redevelopment of the site.

MBTS contracted with CDM Smith Inc. (CDM Smith) to evaluate potential alternatives and issues associated with decommissioning the WWTF and to develop planning level cost estimates. The purpose of this memorandum is to summarize the results of this evaluation. In accordance with the approved scope, the study presents information on the existing wastewater facilities; evaluates alternatives for conveyance and discharge of the Town's wastewater; provides a conceptual layout and selection criteria for a new pumping station along with alternative force main layouts; identifies permitting requirements for all aspects of the project; provides cost estimates for proposed alternates; and discusses other considerations and next steps.

The original scope of work for this project identified two potential alternatives to be evaluated: connection to the City of Beverly's collection system for eventual conveyance to the South Essex Sewerage District (SESD) Wastewater Treatment Plant (WWTP) in Salem for treatment; and direct connection to the SESD WWTP via a force main through Beverly. However, during the course of this study, two additional alternatives (connection to the City of Gloucester's WWTP and an in-Town solution) were also identified and considered, as discussed below.

ES.2 Existing Infrastructure

The study gathered and presents information regarding the following existing infrastructure relevant to this evaluation:

MBTS WWTF

The Town facility went into operation in 1998 and treats an average daily flow of approximately 0.5 million gallons per day (MGD).

MBTS Collection System

Approximately 15.2 miles of gravity sewers ranging in diameter from 6-inches to 24-inches in addition to four pumping stations with two miles of associated force mains.

SESD WWTP

Regional facility located in Salem, MA that treats up to 29.7 MGD of wastewater from Beverly, Marblehead, Salem, Peabody, Danvers, and portions of Middleton and Wenham.

Discharge of MBTS flow to the SESD WWTP was the original intended solution for decommissioning the MBTS WWTF at the start of this study. However, as part of this evaluation, CDM Smith and MBTS staff held several discussions with a SESD representative to determine the viability of connecting to their system and WWTP (either directly or through connection to Beverly's system) in the future. The feedback from SESD is that the existing WWTP does not have available capacity to accept wastewater from MBTS, particularly under peak flow conditions. The position of SESD is that they do not view a MBTS connection to be a viable option due to the lack of capacity and a lack of interest in accepting new communities into the SESD system. However, they recognize that this evaluation is a planning level exercise to identify potential issues and planning level costs for options that may not be implemented for 15 to 20 years. Based on this position and understanding, further detailed discussions were not held with SESD to identify and collect information regarding issues that would be needed in order to perform a more thorough evaluation of these alternatives, such as specific potential connection points at the WWTP; capital costs needed for upgrades to accommodate MBTS flow; connection fees; and wastewater rates that would be assessed that would be needed for a more detailed evaluation of the SESD alternatives discussed below. In light of this information, it was decided that this study would focus on issues and planning level costs that could be identified and defined for the SESD alternatives, namely for the new pumping station and force main required for these alternatives. If at some point in the future capacity at the SESD becomes available at least these other issues and costs would have been identified. At that point, information related to the issues that were not addressed as part of this study would need to be collected and evaluated. Additionally, this information led to other alternatives being considered in this study at a high level, namely the Gloucester option and a potential in-Town solution.

Gloucester WWTP

Put into service in 1984, the Gloucester WWTP treats an average daily flow of approximately 7.24 MGD from Gloucester, Essex and Rockport. The facility is a primary wastewater treatment plant.

ES.3 Alternatives Evaluated

A total of five alternatives were evaluated as part of this study. For each of the alternatives, MBTS would need to construct a new wastewater pumping station and force main to discharge to the location associated with each alternative. A brief description of each of the alternatives follows.

Alternative 1 – Connection to Beverly

Under this alternative, the MBTS force main would be approximately 27,000 feet long (5 miles) and would connect to the Beverly collection system for eventual conveyance to the SESD WWTP for treatment. In this scenario, MBTS would become a customer of Beverly, much like Gordon College, rather than an SESD member community. As a Beverly customer, MBTS would have to pay 140 percent of the sewer rates that Beverly charges its commercial customers for its flow. Beverly's current (2021) commercial sewer rate is $6.18/100 cubic feet. At MBTS's current average daily flow of approximately 0.5 MGD, the sewer charge to be paid to Beverly would be approximately $5,800 per day, or $2.1M per year. The overall route for Alternative 1 is shown in **Figure 1**.

Alternative 2A – Connection to SESD (Bridge Route)

This alternative would bypass connecting into the Beverly collection system and connect directly to the SESD WWTP approximately 9 miles away from MBTS. At approximately 48,000 lf, the force main length under this alternative would be almost double the length of Alternative 1, but would not require the use of the Beverly gravity sewer system and pumping station to convey MBTS flow. As indicated, this alternative routing includes crossing the Veterans Memorial Bridge, which is a fixed span bridge connecting Beverly to Salem along the route to the SESD WWTP. The overall route for Alternative 2A is shown in **Figure 2**.

Alternative 2B – Connection to SESD (HDD Route)

The first approximately 36,000 lf of this route are identical to Alternative 2A. However, under this alternative route, the force main would cross under Beverly Harbor using horizontal directional drilling (HDD) as the installation method for approximately 2,200 lf. Once on the Salem side of the harbor, the force main would continue down Fort Avenue to the SESD WWTP. By running beneath the harbor, this route would be approximately 5,700 lf shorter than Alternative 2A that utilizes Veterans Memorial Bridge. The overall route for Alternative 2B is shown in **Figure 3**. The potential alignment of the HDD under the harbor is shown in **Figure 4**.

Alternative 3 – Connection to Gloucester

As discussed above, through outreach meetings with SESD, it was determined that SESD did not consider MBTS connection to their system to be a viable alternative. As such, MBTS contacted a representative of the City of Gloucester to discuss the goals of this evaluation and the potential for MBTS to convey wastewater to the Gloucester WWTP for treatment in the future. Gloucester staff were open to the idea from a long-range planning perspective, so this additional alternative was added to this evaluation.

The Gloucester WWTP is currently a primary treatment plant and will likely be required to upgrade to a secondary treatment plant in the future. This will require extensive planning, design and capital investment and could provide an opportunity for MBTS and Gloucester to collaborate on a regional solution that would benefit both communities. The proposed route from MBTS to the Gloucester WWTP would be a total distance of approximately 38,600 lf (7.3 miles), and is shown in **Figure 5**.

Potential Future Evaluated Alternative – In-Town Solution

The Town's consideration of an in-Town solution surfaced as a potential option during the late stages of the performance of this study. As such, evaluation of this option was beyond the contract-authorized project scope and remaining budget, and therefore a full vetting of such an option was not possible under this project. However, due to project execution efficiencies, some labor hours were available to have a high-level discussion with Town officials as to what steps would be best taken moving forward to more fully review such an option in the future. In the absence of specific site information regarding soil permeability, a conservative planning level estimate of recharge rate indicates that an approximately 5-acre site would be needed for effluent recharge based on existing Town flows if it were not cost-effective to use the existing WWTF outfall based on the location of the site. Additionally, approximately 1.5 acres would be needed for a new WWTF, for a total of approximately 6.5 acres to support a potential in-Town solution. It is recommended that for future consideration of an in-Town WWTF option at a new site, that the following engineering evaluations be performed: site location search and review; a detailed evaluation of hydraulics; permitting requirements; and a review of potential treatment and conveyance costs.

ES.4 Proposed Pumping Station and Force Main

CDM Smith performed a detailed hydraulic analysis and evaluated design considerations for the wastewater pumping station and force main that would need to be constructed to convey wastewater collected from MBTS to either SESD (either via the Beverly collection system or directly to the SESD WWTP) or Gloucester. This pumping station would be built at the existing wastewater treatment plant site, which is presently the low point of the MBTS collection system. Part of the original work scope was to identify any equipment at the current WWTF that could be retained in the headworks building and repurposed into the new pumping station design. After reviewing the building's remaining useful life and discussions with MBTS staff, it was decided that the best option would be to demolish the existing headworks building and build a completely new pumping station on the site. Construction of a new pumping station with no repurposing of existing buildings or equipment eliminates the costs and difficulties associated with maintaining the operation of the facility while trying to replace equipment and making modifications to the existing facilities. Additionally, the timeframe for implementation of this potential project is approximately 15 to 20 years in the future. At that time, the existing facilities will be approximately 40 to 45 years old and well beyond their useful life. Demolishing the headworks building, which is located at the center of the WWTF site, would also allow for better utilization of the site for future development.

A submersible pumping station is the least costly option for handling wastewater and is recommended for this project. The proposed submersible pumping station for MBTS would include pumps installed in an underground rectangular precast concrete wet well (approximately 10-feet x 16-feet internal dimension) and discharging individually to an adjacent rectangular precast concrete underground valve vault of the same dimensions. There would be 3 pumps, two duty plus one standby.

The proposed pumping station would be located in the southwest corner of the site adjacent to the railroad tracks and the American Legion Hall parking lot to maximize the space available for future development. **Figure 6** presents a conceptual layout of the proposed pumping station wet well, valve vault and control building on the existing WWTF site.

Based on the hydraulic analysis, a 14-inch high-density polyethylene (HDPE) force main is recommended for any of the alternative discharge locations.

ES.5 Permitting

This evaluation identified potential environmental permitting constraints and the environmental permits that would be needed for the different project components and each of the alternatives. Several federal, state, and local permits would be required to implement the proposed project. Since the project area is within a coastal zone and adjacent to or above/below watercourses and wetlands, permits and approvals would be required to work in or adjacent to these resources.

Table 5 summarizes the anticipated federal, state and local environmental permits and approvals required for each project component and alternative force main route.

ES.6 Planning Level Construction Cost Estimates

Planning level cost estimates were prepared for each of the various components of this project to be used for comparative purposes to assist the Town in making decisions moving forward.

The planning level Opinion of Probable Construction Cost (OPCC) estimates presented below include costs for labor, materials, equipment, contractor general conditions, insurance, bonds, overhead and profit, and construction contingency (30 percent for planning level). Costs are presented in 2021 dollars and have not been escalated to the mid-point of construction since the implementation timeframe is not clear at this time and is likely 15 to 20 years in the future.

For comparative purposes, **Table 7** presents the combined cost of each alternative, including the estimated cost for demolition of the WWTF, pumping station construction and force main. Also presented below are estimated engineering and implementation costs (assumed to be 25 percent of OPCC) and project contingency (assumed at 20 percent of total cost at this stage of project development). The combined total of the OPCC, engineering, and project contingency is the Opinion of Probable Project Cost (OPPC) for each alternative as presented below.

Table 7 Combined Alternative OPPCs in 2021 Dollars (in $M)

Project Alternatives	OPCC	Engineering	Project Contingency	OPPC
Beverly Connection	$19M	$4.8M	$4.8M	$29M
SESD Connection (Bridge Route)	$28M	$7.0M	$7.0M	$42M
SESD Connection (HDD Route)	$27M	$6.8M	$6.8M	$41M
Gloucester Connection	$20M	$5.0M	$5.0M	$30M

Note: Costs for improvements to the Beverly PS or the SESD and Gloucester WWTPs have not been included.

Introduction and Background

The Town of Manchester-by-the-Sea (MBTS) received a Housing Choice Initiative grant under the Commonwealth of Massachusetts Small Town Capital Grant Program in 2020. The Town applied for the grant to provide funding for an engineering evaluation into options for decommissioning the Town's existing wastewater treatment facility (WWTF) located at 12 Church Street on the waterfront in downtown MBTS with the goal of potentially redeveloping the site as a mixed-used transit-oriented development (TOD) at some point in the future. Decommissioning of the WWTF would require construction of a new wastewater pumping station on or near the site and a force main to convey the Town's wastewater to another location for treatment. The remaining land at the site could then be redeveloped into a TOD that would include a component of affordable housing.

The Town's 2015 Comprehensive Wastewater Management Plan (CWMP) identified capital needs that will be required at the WWTF over a 20-year planning horizon. These improvements will be necessary for the WWTF to continue to operate effectively and in conformance with its National Pollution Discharge Elimination System (NPDES) permit through that time period. The Town's 2019 Master Plan mentioned the possibility of evaluating new options for treatment of the Town's wastewater as the existing WWTF nears the end of its useful life in order to provide the opportunity for redevelopment of the downtown waterfront site.

Using funding from the Housing Choice Initiative grant, along with matching Town funds, MBTS contracted with CDM Smith to evaluate potential alternatives and issues associated with decommissioning the WWTF and to develop planning level cost estimates. The purpose of this memorandum is to summarize the results of this evaluation. In accordance with the approved scope, the study presents information on the existing wastewater facilities; evaluates alternatives for conveyance and discharge of the Town's wastewater; provides a conceptual layout and selection criteria for a new pumping station along with alternative force main layouts; identifies permitting requirements for all aspects of the project; provides a cost estimate for proposed alternates; and discusses other considerations and next steps. The original scope of work for this project identified two potential alternatives to be evaluated: connection to the City of Beverly's collection system for eventual conveyance to the South Essex Sewerage District (SESD) Wastewater Treatment Plant

(WWTP) for treatment; and direct connection to the SESD WWTP via a force main through Beverly. However, during the course of this study, two additional alternatives (connection to the City of Gloucester's WWTP and an in-Town solution) were also identified and considered as discussed below.

Existing Infrastructure

This section briefly summarizes the existing wastewater infrastructure in MBTS and the SESD and Gloucester WWTPs.

MBTS Wastewater Treatment Plant

The existing upgraded MBTS WWTF went into operation in 1998 and has not undergone any significant upgrades since that time. There have been some individual components and equipment that have been replaced; however, much of the current equipment used to handle and treat the wastewater is part of the original construction and has exceeded its expected life. The Town has had some recent condition assessments performed on the plant, including one completed in March 2018 by Tata & Howard titled *Manchester-By-The Sea Wastewater Treatment Plant Evaluation*. CDM Smith also performed an assessment in 2019, which focused on the process/mechanical systems. CDM Smith evaluated the WWTF with the understanding that it would likely be decommissioned in the future. CDM Smith recommended some priority project improvements to the plant, including heating system improvements in all buildings, plant water system replacement, replacement of the grit washer/classifier, return sludge pump replacements, and influent pump replacements.

While the plant does need improvements, it is still functioning well within its permit limits and can handle average and peak wastewater flows from the collection system. The WWTF has benefited from a reduction in peak flows due to recent infiltration/inflow (I/I) rehabilitation performed in the Town's sewer collection system.

MBTS Collection System

MBTS owns and operates approximately 15.2 miles of gravity sewers ranging in diameter from 6-inches to 24-inches in addition to four pumping stations with two miles of associated force mains. Like most collection systems, I/I can reduce the sewer system's capacity and cause permitting issues at the WWTF during peak events. In 2013, Woodard & Curran developed an I/I plan for the Town as part of an Administrative Consent Order requirement from the Massachusetts Department of Environmental Protection (MassDEP) due to the annual average flow at the WWTF exceeding 80 percent of the permitted annual flow. Since this I/I plan was initiated, the Town has spent close to $3 million on inspection and rehabilitation of the sewer system. MBTS has performed closed-circuit television (CCTV) inspections on approximately 25,000 linear feet (lf) of sewers and inspected all the manholes in the collection system. These inspections resulted in the rehabilitation of 18,800 lf of sewers lined using cured-in-place-pipe (CIPP), 550 lf of sewer replacements, and repair of 129 manholes. These repairs removed three tidal inflow sources, which may have accounted for an estimated 87,000 gallons per day (gpd) of inflow, and the reduction of peak infiltration by approximately 30 percent. These rehabilitation efforts have reduced the 12-month rolling monthly average daily flow at the WWTF to 0.40 – 0.50 million gallons per day (MGD) from the average of 0.55 MGD before the rehabilitation was performed. MBTS continues to successfully address I/I, which is an important factor that neighboring communities will consider when evaluating whether to accept flow from MBTS.

South Essex Sewerage District WWTP

South Essex Sewerage District (SESD) is a regional sewer district established in 1925 that owns and operates approximately 29 miles of conveyance pipelines, several pumping stations and a wastewater treatment plant (WWTP) located at 50 Fort Avenue in Salem. SESD currently conveys and treats wastewater from Beverly, Marblehead, Salem, Peabody, Danvers, and portions of Middleton and Wenham. The SESD WWTP is a secondary treatment plant designed to treat up to 29.7 MGD. With MBTS being roughly 9 miles from the SESD WWTP, it was identified as a potential option for future treatment of MBTS flows if the WWTF is decommissioned.

As part of this evaluation, CDM Smith and MBTS staff held several discussions with a SESD representative to determine the viability of connecting to their system and WWTP (either directly or through connection to Beverly's system) in the future. The feedback from SESD is that the existing WWTP does not have available capacity to accept wastewater from MBTS, particularly under peak flow conditions. The position of SESD is that they do not view a MBTS connection to be a viable option due to the lack of capacity and a lack of interest in accepting new communities into the SESD system. However, they recognize that this evaluation is a planning level exercise to identify potential issues and planning level costs for options that may not be implemented for 15 to 20 years. Based on this position and understanding, further detailed discussions were not held with SESD to identify and collect information regarding issues that would be needed in order to perform a more thorough evaluation of these alternatives, such as specific potential connection points at the WWTP; capital costs needed for upgrades to accommodate MBTS flow; connection fees; and wastewater rates that would be assessed that would be needed for a more detailed evaluation of the SESD alternatives discussed below. In light of this information, it was decided that this study would focus on issues and planning level costs that could be identified and defined for the SESD alternatives, namely for the new pumping station and force main required for these alternatives. If at some point in the future capacity at the SESD becomes available at least these other issues and costs would have been identified. At that point, information related to the issues that were not addressed as part of this study would need to be collected and evaluated. Additionally, this information led to other alternatives being considered in this study at a high level, namely the Gloucester option and a potential in-Town solution.

Gloucester WWTP

The Gloucester WWTP receives flow from Gloucester, Essex, and Rockport for a total served population of roughly 27,000. The facility is located at 50 Essex Street and was put in service in 1984 and was designed for an average daily flow rate of 7.24 MGD and a peak flow rate of 15 MGD. The permitted flow limit for the plant is 5.15 MGD as a 12-month rolling average. It is important to note that the Gloucester WWTP is currently a primary treatment plant and will likely be required to upgrade to a secondary treatment plant in the future, which will require extensive planning, design and capital investment. The permitted flows will likely increase after the plant is upgraded from a primary plant to a secondary plant. The Gloucester WWTP is approximately 7 miles away from the MBTS WWTF.

Alternatives Evaluated

CDM Smith evaluated a total of four main alternatives, with two variations of one of the alternatives, for a total of five options, as discussed below. These include: Connection to Beverly; Connection to SESD (Bridge Route); Connection to SESD (HDD Route); Connection to Gloucester; and an in-Town solution. For each alternative a new pumping station would need to be constructed at the existing WWTF site in order to pump wastewater flows from the MBTS collection system to the eventual discharge location.

The original scope of work identified the SESD WWTP, located approximately 9 miles away from the existing MBTS WWTF, as the most promising option for future discharge of wastewater for MBTS. The most direct route for a force main to the SESD WWTP is primarily along Route 127. The route would stay entirely in the public right-of-way (ROW) in two of the three SESD options, while one option has the proposed route leaving the public ROW for roughly 2,000 lf. CDM Smith did not explore placing the force main along the active railroad tracks or an ocean route due to the lack of data for these options and the low probability that these options would be feasible or cost-effective.

CDM Smith utilized existing geographic information systems (GIS) data to lay out the alternative force main routes and evaluate the potential discharge locations. Most of the GIS data used to create the force main profile and routing figures is publicly available, with the exception of the Beverly sewer infrastructure information, for which CDM Smith obtained permission to use in this evaluation. Publicly available GIS Digital Elevation Model (DEM) data was used to develop a conceptual profile of the force main for each of the alternative routes (with the exception of the in-Town alternative) in order to perform hydraulic evaluations. DEM data is an acceptable tool to use for this planning level exercise, but if these alternatives are further evaluated in the future, topographic survey and geotechnical borings should be completed along the routes.

A brief description of each of the alternatives evaluated is presented below. The hydraulic evaluation of the alternatives along with force main and pumping station design and sizing, permitting considerations, as well as estimates of construction costs, are discussed in subsequent sections of this memorandum.

Alternative 1 – Connection to Beverly

The City of Beverly, Massachusetts, is adjacent to MBTS, making them the closest SESD member community. Under this alternative, the MBTS force main would connect to the Beverly collection system for eventual conveyance to the SESD WWTP for treatment. In this scenario, MBTS would become a customer of Beverly, much like Gordon College, rather than an SESD member community. As a Beverly customer, MBTS would have to pay 140 percent of the sewer rates that Beverly charges its commercial customers for its flow. Beverly's current (2021) commercial sewer rate is $6.18/100 cubic feet. At MBTS's current average daily flow of approximately 0.5 MGD, the sewer charge to be paid to Beverly would be approximately $5,800 per day, or $2.1M per year.

The closest potential connection point to the Beverly collection system in the northwest section of the City flows into a series of pumping stations that connect to a common force main along Route 127, ranging in diameter from 10-inch to 14-inch. The force main discharges to a 30-inch reinforced concrete gravity sewer at the intersection of Route 127 and Boyles Street. During initial data-gathering activities, CDM Smith identified two gravity sewer locations along Route 127 that the MBTS force main could potentially discharge to, that would ultimately flow to a pumping station and be conveyed by the common force main. A third potential connection point at Route 127 and Boyles Street, which would bypass the Beverly pumping stations and common force main in Route 127 and connect directly into the 30-in gravity sewer, was also identified.

After the initial potential connection points were identified, CDM Smith and MBTS staff met with Mike Collins, the Commissioner of Public Services and Engineering in Beverly, to discuss the general overall concept of MBTS connecting into the Beverly collection system, as well as the specific potential connection points. Mr. Collins mentioned that the common force main was installed in the 1980s and had recently been repaired. Based on the discussion and further evaluation, it became clear that bypassing the existing pumping station and common force main would be the best option due to the force main's age and the potential capacity issues from additional MBTS flows. It is likely that the pumping station and common force main would have to be upgraded in order to accommodate flow from MBTS. The conceptual force main route with the proposed discharge point at the existing manhole on Beverly's 30-in gravity sewer at the intersection of Route 127 and Boyles Street is the preferred route for Alternative 1 and consists of approximately 26,500 lf (5 miles) of force main. The proposed route includes three Massachusetts Bay Transportation Authority (MBTA) grade crossings along Route 127. The overall route for Alternative 1 is shown in **Figure 1**.

CDM Smith was unable to obtain flow data for the existing 30-inch gravity sewer downstream of the preferred connection point to the Beverly collection system. Therefore, we were unable to evaluate whether the sewer and the downstream facilities, including SESD's Beverly pumping station, have sufficient capacity to handle additional flows from MBTS. Assuming that there is not sufficient capacity in the existing downstream sewer, a conservative estimate of the construction cost of upsizing the 30-inch sewer to a 36-inch sewer would be approximately $4M. This does not include an estimate for any improvements/upgrades required at the existing pumping station. If this alternative is pursued in the future, flow data would need to be obtained and analyzed to determine if upsizing of the 30-in sewer and Beverly pumping station would be required in order to provide sufficient capacity for MBTS to connect.

This Beverly connection alternative would be roughly four miles shorter than the force main alternatives with direct connection to the SESD WWTP presented below. This would obviously reduce force main construction costs when compared to the direct to SESD alternatives; however,

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Beverly Discharge Location

Proposed Force Main

PS MBTS Proposed Pumping Station

Figure 1
Alternative 1 - Connection to Beverly

1 inch = 1,500 feet

0 700 1,500 3,000 Feet

this alternative would make MBTS dependent on Beverly's infrastructure and responsible for the cost of any required downstream upgrades as mentioned above.

Alternative 2A – Connection to SESD (Bridge Route)

This alternative would bypass connecting into the Beverly collection system and connect directly to the SESD WWTP approximately 9 miles away from MBTS. At approximately 48,000 lf, the force main length under this alternative would be almost double the length of Alternative 1, but would not require the use of the Beverly gravity sewer system and pumping station to convey MBTS flow. This route would remain in the public ROW and follows the same path along Route 127 as Alternative 1, but continues on Route 127 through Beverly onto Lothrop Street, Stone Street and Cabot Street before entering Salem via Route 1A and the Veterans Memorial Bridge. As with Alternative 1, the proposed route includes three MBTA grade crossings along Route 127. Once in Salem, the force main would follow Bridge Street, Webb Street and Fort Avenue into the SESD WWTP site.

As indicated, this alternative routing includes crossing the Veterans Memorial Bridge, which is a fixed span bridge connecting Beverly to Salem. The bridge was opened in 1997 to replace a previous steel bridge that was demolished. The force main would have to be attached to the bridge for approximately 2,000 lf. Mounting a pipe on an existing bridge is much more economical than building a new independent pipe crossing. Due to the bridge's age, it may likely have prefabricated holes in bridge abutments or have locations for pipe support hangers, which would allow the force main to be supported across the span and hidden out of sight. Approval to connect to the bridge would have to be obtained from the Massachusetts Department of Transportation Highway Division (MassDOT), but at this time, there is no reason to believe that this connection would be denied due to the relatively new age of the bridge and the fact that the proposed force main would only be 14 inches in diameter. Connecting utilities to existing bridges is common practice but requires the designer to coordinate with the bridge owner to ensure that the pipe would not interfere with the bridge's integrity. MassDOT may have specific requirements such as pipe material and mounting location. CDM Smith has knowledge of a drinking water main connected to this bridge that has had issues with leaks and freezing during winter months, and pipe supports becoming loose due to the bridge's movement. These are all issues that would need to be clearly evaluated if this route were selected. The overall route for Alternative 2A is shown in **Figure 2**.

Alternative 2B – Connection to SESD (HDD Route)

The first approximately 36,000 lf of this route up to Stone Street are identical to Alternative 2A, including the three MBTA grade crossings along Route 127. However, under this alternative route, the force main would continue down Route 127 and then turn east on Water Street toward SESD's Beverly Pumping Station. From somewhere in the vicinity of the pumping station, the force main would cross under Beverly Harbor using horizontal directional drilling (HDD) as the installation method for approximately 2,200 lf. Once on the Salem side of the harbor, the force main would continue down Fort Avenue to the SESD WWTP. By running beneath the harbor, this route would be approximately 5,700 lf shorter than Alternative 2A that utilizes Veterans Memorial Bridge.

TP SESD WWTP

★ SESD Discharge Location

PS MBTS Proposed Pumping Station

Proposed Force Main

Figure 2

Alternative 2A - Connection to SESD (Bridge Route)

1 inch = 2,100 feet

0 1,050 2,100 4,200 Feet

CDM Smith

Horizontal direction drilling started primarily as an oil and gas industry pipeline installation technology that began to be widely used outside of the oil and gas industry in the 1990's. Construction of the crossing of Beverly Harbor using HDD for the MBTS force main, in general, would involve the following three steps: installing a pilot hole; reaming the pilot hole; and pulling back the new pipeline. The pilot hole would be drilled from the entry point at a prescribed entry angle from the horizontal and arc under the harbor. The pilot hole would be drilled until it exits on the other side of the river crossing at a prescribed exit angle at a pre-determined exit point. After the pilot hole is completed, the pilot hole would be enlarged by means of reaming to increase the diameter so that it is larger in diameter than the pipe to be installed. Reaming would be performed multiple times to increase the hole diameter incrementally. During the reaming process, slurry would be pumped into the hole to maintain the stability of the borehole and facilitate the removal of cuttings. After reaming operations are complete, the force main pipe would be pulled back into the conditioned borehole. The reamer would precede the pipeline to ensure that there are no obstructions. After the HDD pipe string is installed, the underground crossing pipe would need to be connected to the rest of the force main by open trenching on either side of the drilling operation.

For this memorandum, CDM Smith looked at the feasibility of using HDD for this alternative alignment at a planning level only. Horizontal directional drilling is a complicated construction method and requires detailed upfront planning by the designer and an experienced contractor with the correct equipment to successfully complete a drilling operation of this size. Extensive geotechnical information would need to be collected during future design activities to evaluate the feasibility of using this technology. Additionally, layout of sufficiently-sized staging areas on each side of the harbor would require careful evaluation and planning. It is noted that the existing force main from SESD's Beverly pumping station follows a similar route under the harbor. It is not known whether HDD was used to install that force main.

The overall route for Alternative 2B is shown in **Figure 3.** The potential alignment of the HDD under the harbor is shown in **Figure 4**. The HDD option would require more environmental permitting due to the harbor crossing, as discussed in more detail in a subsequent section of this memorandum.

Alternative 3 - Connection to Gloucester

Through outreach meetings with SESD, it was determined that SESD did not consider MBTS connection to their system to be a viable alternative. As such, MBTS contacted a representative of the City of Gloucester to discuss the goals of this evaluation and the potential for MBTS to convey wastewater to the Gloucester WWTP for treatment in the future. Gloucester staff were open to the idea from a long-range planning perspective, so this additional alternative was added to this evaluation.

The proposed route from MBTS to the Gloucester WWTP would follow Route 127 to Raymond Street, continuing as Hesperus Avenue in Gloucester, then rejoining Western Avenue (Route 127) to

Figure 3
Alternative 2B - Connection to SESD (HDD Route)

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HDD Bore Holes

Proposed Force Main

Figure 4
Horizontal Directional Drill Location

1 inch = 2,100 feet

0 1,050 2,100 4,200 Feet

CDM Smith

the intersection of Essex Avenue, and continuing to the Gloucester WWTP, for a total distance of approximately 38,600 lf (7.3 miles), as shown in **Figure 5**.

Potential Future Evaluated Alternative – In-Town Solution

The Town's consideration of an in-Town solution surfaced as a potential option during the late stages of the performance of this study. As such, evaluation of this option was beyond the contract-authorized project scope and remaining budget, and therefore a full vetting of such an option was not possible under this project. However, due to project execution efficiencies, some labor hours were available to have a high-level discussion with Town officials as to what steps would be best taken moving forward to more fully review such an option in the future. In the absence of specific site information regarding soil permeability, a conservative planning level estimate of recharge rate indicates that an approximately 5-acre site would be needed for effluent recharge based on existing Town flows if it were not cost-effective to use the existing WWTF outfall based on the location of the site. Additionally, approximately 1.5 acres would be needed for a new WWTF, for a total of approximately 6.5 acres to support a potential in-Town solution. It is recommended that for future consideration of an in-town WWTF option at a new site, that the following engineering evaluations be performed: site location search and review; a detailed evaluation of hydraulics; permitting requirements; and a review of potential treatment and conveyance costs. We have also included a section near the end of this memorandum that presents some general information about the concept of a new in-Town treatment option and some parameters that would need to be reviewed to determine the feasibility of the option in the future.

Proposed Pumping Station and Force Main

This section presents the hydraulic analysis and design considerations for the wastewater pumping station and force main that would need to be constructed to convey wastewater collected from MBTS to either SESD (either via the Beverly collection system or directly to the SESD WWTP) or Gloucester. This pumping station would be built at the existing wastewater treatment plant site, which is presently the low point of the MBTS collection system. Part of the original work scope was to identify any equipment at the current WWTF that could be retained in the headworks building and repurposed into the new pumping station design. After reviewing the building's remaining useful life and discussions with MBTS staff, it was decided that the best option would be to demolish the existing headworks building and build a completely new pumping station on the site. Construction of a new pumping station with no repurposing of existing buildings or equipment eliminates the costs and difficulties associated with maintaining the operation of the facility while trying to replace equipment and making modifications to the existing facilities. Additionally, the timeframe for implementation of this potential project is approximately 15 to 20 years in the future. At that time, the existing facilities will be approximately 40 to 45 years old and well beyond their useful life. Demolishing the headworks building, which is located at the center of the WWTF site, would also allow for better utilization of the site for future development.

The following sections present the hydraulic evaluation and the conceptual plan for the pumping station and force main.

Figure 5

Alternative 3 - Connection to Gloucester

CDM Smith

Design Flows

Estimated design flows for pumping from MBTS are shown in **Table 1**, based upon plant flow records provided for the past two years.

Table 1 MBTS Design Flows

Flow	Million Gallons Per Day (MGD)	Gallons per Minute (gpm)
Minimum Day Flow	0.2	139
Average Day Flow	0.47	326
Max. Day Flow	1.75	1,213
Peak Hour Flow	2.0	1,386

The design pumping rate should be based upon peak hour flow to assure that system overflow will not occur. Analysis of the WWTF flow records for the past two years indicates several occurrences of a peak hour flow rate on the order to 2.0 MGD, and one occurrence of a short duration peak of up to 2.4 MGD. Further evaluation beyond the scope of this study would need to be performed to determine if system storage is available or can be provided to mitigate the 2.4 MGD outlier peak rate to the point that design pumping capacity for the typical peak rate of 2.0 MGD will be adequate. The large disparity between minimum, average day, maximum day, and peak hour flows is a common characteristic of small capacity collection systems. These large differences present design challenges to select the appropriate pumping system and force main size.

Pumping Station Options

This section presents different pumping station options that the industry has historically used that were considered for the MBTS pumping station.

Submersible Pumping Station

Submersible pumps are installed in an underground vault that serves as the wet well, with an at-grade electrical cabinet or control building. Submersible pumping stations consist of two or more pumps designed to operate submerged in the wastewater, mounted on guides to allow the pumps to be lowered into and removed from the below-grade wet well by personnel working from grade elevation. The guide allows each pump to engage to the discharge piping when lowered in place at the bottom of the wet well. The pump chamber serves as the wet well. An adjacent below-grade structure (valve vault) is often used to house pump discharge piping and potentially a flow meter.

Dry Pit Pumping Station

Dry pit pumps are installed in an underground vault housing the discharge piping, drawing from a separate, below grade wet well, with an at-grade electrical cabinet or control building. This arrangement has been used extensively in the past. However, the added cost of a second deep underground structure and confined space entry issues to perform maintenance on the pumps make this type of station less desirable.

Suction Lift Pumping Station

Suction lift pumps are installed with an electrical cabinet in an enclosure at grade, mounted on top of an underground wet well. Suction lift-type pumps provide a reasonable solution for some applications. The pumps are easily accessible for maintenance as they are located in an above grade enclosure. This station is limited because of pump efficiency for self-priming type suction lift pumps and vacuum primed pumps' reliability. The suction lift capability is limited to 25 to 28 feet, making this type of pumping system effective only in relatively shallower (from grade to sewer invert) applications.

Wet Pit/Dry Pit Pumping Station

A wet pit/dry pit configuration consists of an underground pumping station with an underground wet well and adjacent pump room and an at-grade building to house station support and electrical equipment. The pumps are accessed by entering the dry pit substructure for inspection and maintenance. The facility's superstructure houses electrical and control equipment, potentially a standby generator, ventilation equipment, and personnel support facilities. These stations offer ease of access to the pumping equipment for monitoring and maintenance and have minimal limitations upon the selection of pumping equipment to meet flow and head conditions.

Pumping Station Design Selection

A submersible pumping station is the least cost option for handling wastewater and is recommended for this project. Submersible pump systems are remarkably adaptable to the range and variability of flows that are anticipated in this application. Submersible type pumping stations provide reasonable flexibility to select design pump capacity and head and are not limited to allowable station depth. Submersible stations are a good compromise between the cost of construction, accessibility, and maintenance.

Submersible pumps should be selected that incorporate up-to-date features to minimize the potential for pump impellers' clogging caused by fibrous materials flushed into the collection system. Due to the cost advantages of submersible type pumping stations, submersible pumps have received more development effort in recent years to provide reliable performance in wastewater collection systems.

Submersible pumps engage a special receiver mounted on the bottom of the wet well to provide a pipe connection for the pump. The pump engages and disengages the receiver by raising/lowering the pump on a guide rail. This arrangement allows the pump to be removed from the wet well for inspection and servicing without personnel entering the wet well. An adjacent shallow underground structure (valve vault) houses pump discharge piping, valves, and a flow meter. Consideration should be given to the installation of a screenings grinder at the inlet to the pumping station to further reduce the potential for large fibrous solids clogging the pumps.

The proposed submersible pumping station for MBTS would include pumps installed in an underground rectangular precast concrete wet well (approximately 10-feet x 16-feet internal dimension) and discharging individually to an adjacent rectangular precast concrete underground valve vault of the same dimensions. There would be 3 pumps, two duty plus one standby.

The range of flow rates from minimum day to peak hour flow is up to a 10:1 ratio, suggesting that multiple pumps are a potential solution to address the range of flows. However, because of hydraulic considerations when using multiple pumps discharging into a long common force main where most of the required pumping head is to overcome friction losses, previous experience concludes that a two duty pump system (with a third pump as standby) is the best selection. One pump will cover most flow conditions, with the second pump available to handle occasionally elevated flow rates.

Pumps will be variable speed, powered by variable frequency drives, to provide variable output flow in order to provide some degree of matching of the pumping rate to the influent flow rate. Provisions will be made in the pump controls to address low flows by limiting the pump low speed setting to require the operating pump to cycle on and off running at its lowest speed setting. The low speed setting provides sufficient energy to keep solids moving through the pump to minimize clogging.

Electrical equipment for a submersible pumping station is typically installed in an above-grade cabinet adjacent to the wet well and valve vault. However, the equipment can also be housed in a building to provide a more pleasing architectural appearance and protection from the elements for maintenance staff. The station will usually be equipped with a standby generator fueled by natural gas or diesel to provide standby power to the pumping station in case of utility power failure. The generator can be housed in an outdoor enclosure or in the same building as the electrical equipment. Odor control equipment such as filters for air vented from the wet well and/or chemical injection may be required and may also be housed in the building.

The proposed pumping station would be located in the southwest corner of the site adjacent to the railroad tracks and the American Legion Hall parking lot to maximize the space available for future development. **Figure 6** presents a conceptual layout of the proposed pumping station wet well, valve vault and control building on the existing WWTF site.

Collection and Conveyance System Design

Flow enters the existing wastewater treatment plant site via two 18-inch pipes that combine into a 24-inch pipe that conveys flow to the headworks building. The invert elevation of the 24-inch pipe at the headworks is approximately EL -6.8. If the new pumping station is located at the southwest corner of the WWTF site, the 24-in influent sewer can be extended from the headworks building and the bottom of the wet well would be set at approximately EL -17, with normal operating elevation in the wet well of approximately EL -12 to -7. Grade at the site is approximately EL +10, resulting in a station depth of approximately 27 feet. Depending upon storm surge elevation the top of the station may need to be elevated further above the existing grade, to place the top of the wet well, and all electrical/generator equipment at least 3 feet above storm surge flood elevation.

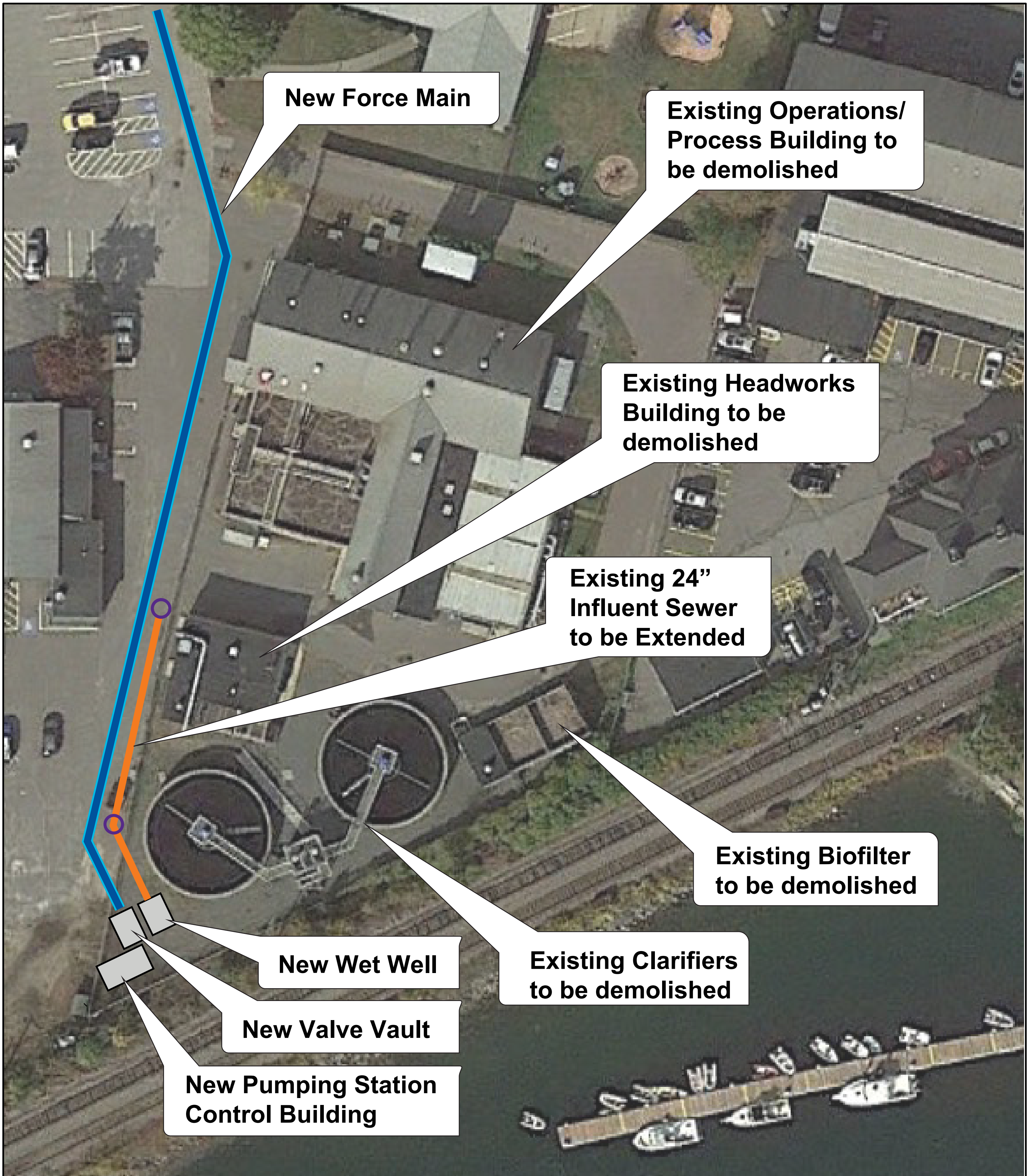

Figure 6
Proposed Pumping Station Location

CDM Smith

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The pump total design head is the sum of the static lift from the pumping station wet well to the discharge point plus friction head loss in the force main, plus an allowance for head losses within the pumping station piping. This calculation assumes there are no intervening high points in the force main that may affect the head calculation. As discussed below, because of the force main's undulating profile for all of the alternatives, there are high points along the various potential force main routes that impact the analysis of the pump discharge head.

Force Main Design

Pipe Material

Cement-lined ductile iron pipe is typically selected for force main material since it can be direct backfilled with select excavated material. High density polyethylene (HDPE) is an alternative material for force mains, which may be more expensive to install because the pipe requires special bedding material to assure the pipe will not be crushed or deflected because of soil pressure. However, HDPE pipe is recommended for the force main material on this project for the following reasons:

- HDPE has lower friction losses in the pipe compared to other pipe materials. This is particularly important to minimize head losses in the lengthy force main for this project.

- HDPE material is less prone to solids sticking to the interior pipe wall, reducing the potential for solids accumulation.

- HDPE is corrosion-resistant, both inside and outside the pipe. Cement-lined ductile iron pipe may require external protection due to the proximity to saltwater or other corrosive soil conditions, which increases the relative cost of installation of ductile iron pipe. The interior cement lining of ductile iron pipe may also experience internal corrosion caused by hydrogen sulfide.

Force Main Routes

For this study, the route of the force main follows streets to avoid the need for easements. The street layout from MBTS to both SESD and Gloucester offers minimal choices to select the shortest length and the least variation in grade elevation. The topography rises and falls, creating numerous high points and low points along the alignments. It is assumed that these high points and undulations in the elevation of the force main cannot be substantially mitigated by deep excavation or tunneling because of the potential for encountering rock excavation. The routes described below have not been vetted to identify major obstructions – either physical or institutional. For this study, it is assumed the pipeline can be installed as described and shown in the figures. Although an alignment following the railroad offers a potentially shorter route with much less variation in elevation, experience indicates that easements for a pipeline are extremely difficult to obtain along an active railroad right-of-way. Therefore, the railroad option did not receive further consideration in this evaluation. The different alternatives and their impact on the pumping station and force main design are presented below.

The Alternative 1 (Connection to Beverly) route has a total pipeline length of approximately 26,500 feet (5 miles). The route follows Summer Street to West Street and Hale Street (all Route 127) to a high point located approximately 25,000 feet from the pumping station at Endicott Drive in Beverly, at an elevation of approximately 52 feet. At this location, the force main will terminate to a gravity structure, and flow will continue as a gravity pressure sewer to the point of connection to the Beverly gravity collection system at Route 127 and Boyle Street. The static head of the system and the hydraulic design will be determined by the pipeline elevation at the gravity structure.

The Alternative 2A (Connection to SESD – Bridge) route utilizing Veterans Memorial Bridge has an overall length of approximately 48,000 feet (9.1 miles) and terminates at the SESD WWTP. The bridge crossing introduces another major high point of the alignment, which will be the governing discharge point of pumping. Except for peak flows, flow downstream of the bridge crossing high point will be a gravity pressure sewer, extending the remaining distance for direct discharge into the SESD WWTP. Depending upon specific elevations of high points, and/or specific effort to minimize the number of high points, the bridge may be the controlling high point elevation of the alignment. It may also be the only location that requires high volume odor control.

The Alternative 2B (Connection to SESD – HHD) route has an overall length of approximately 42,300 feet (8 miles) and is similar to Alternative 2A. However, instead of the bridge crossing, the route incorporates a subaqueous crossing of Beverly Harbor. Cutting across the harbor eliminates approximately 5,700 feet of pipeline. At maximum design flow rate, the flow will be pumped the entire distance from the MBTS pumping station to the SESD WWTP. At lower flow rates, the high points of the force main down-stream of the high point at Endicott Drive will act as intermediate breakpoints of the flow. The flow will be pumped to each high point, and from there, short sections of gravity flow within the force main will drop to the next lower high point. There will be four pipe segments that will partially empty of wastewater when pumping is stopped or flow only partially full during typical average day conditions. These lengths of pipe will vent gasses as the wastewater volume inside the pipe changes with changing flow rates. These high point vent locations will require high volume odor control.

The Alternative 3 (Connection to Gloucester) route has an overall length of approximately 38,600 feet (7.3 miles). Starting from the proposed pumping station, the highest point of the pipeline occurs on Hesperus Avenue near Castle Hill Road and the Hammond Castle Museum at an elevation of approximately 99 feet. Due to the high point elevation and subsequent high points near Steep Hill Drive and Old Salem Road, these high points will govern the hydraulic design of pumping. Flow from Old Salem Road to the Gloucester WWTP will be by gravity pressure sewer.

Force Main Sizing

Wastewater force main sizing is based upon trade-offs between cost of materials and installation, friction losses caused by flow velocity, maintenance of sufficient velocity to minimize sedimentation and accumulation of solids in the pipeline, and control of long transit times. Velocities between 2 and 6 feet per second (fps) are most desirable. A scouring velocity above approximately 3.5 fps should be met occasionally. Due to the length of the proposed MBTS pipeline, these criteria cannot be achieved simultaneously. The pipe must be sized large enough to achieve acceptable head losses at maximum flow, which results in excessively low velocities at minimum day and average flows.

Force main sizes of 12-inches and 14-inches were considered in this evaluation. Calculated velocities for these pipe sizes under the various flow conditions are presented in **Table 2**. The stated head loss is friction loss only in the force main, assuming a Hazen Williams "C" value of 150, corresponding to the HDPE pipe's low friction losses characteristic. The pump total head will be based on the sum of the force main friction losses, station friction losses, and static lift. **Table 2** shows that flow velocity under average conditions is below the recommended minimum of 2 fps for these pipe sizes and only approaches scouring velocity of 3.5 fps at maximum flow rates.

Table 2 Velocity and Headloss by Flow

	Minimum Day Flow (0.2 MGD)		Average Day Flow (0.47 MGD)		Max. Day Flow (1.75 MGD)		Peak Hour Flow (2.0 MGD)	
Pipe Diameter	Velocity (fps)	Headloss (ft/ 1000 ft)	Velocity (fps)	Headloss (ft/ 1000 ft)	Velocity (fps)	Headloss (ft/ 1000 ft)	Velocity (fps)	Headloss (ft/ 1000 ft)
12-inch Pipe	0.44	0.07	1.03	0.32	3.84	3.63	4.38	4.65
14-inch Pipe	0.37	0.04	0.88	0.22	3.27	2.46	3.73	3.14

It should be noted that sizes of pipe are nominal sizes – particularly for the distinction between 12-inch and 14-inch HDPE pipe. At 12-inch size, sizing changes from a measure of inside diameter (ID) to a measure of outside diameter (OD); therefore, 12-inch size is ID and 14-inch size is OD. This results in an actual inside diameter for hydraulic calculations of 11.3 inches for 12-inch pipe and 12.3 inches for the 14-inch pipe.

Detention time is the total time of transmission of flow from the pumping station to the point of discharge. Estimated detention times for 12-inch and 14-inch force mains for the different flow conditions and alternative routes are presented in **Table 3**.

Table 3 Flow Detention Times (Minutes)

	Minimum Day Flow (0.2 MGD)		Average Day Flow (0.47 MGD)		Max. Day Flow (1.75 MGD)		Peak Hour Flow (2.0 MGD)	
Pipe Diameter	12-inch	14-inch	12-inch	14-inch	12-inch	14-inch	12-inch	14-inch
Beverly Route	1,027	1,205	437	513	117	138	102	121
SESD (Bridge Route)	1,825	2,143	777	912	209	245	181	214
SESD (HDD Route)	1,597	1,875	680	798	183	214	158	188
Gloucester Route	1,455	1,727	619	733	166	197	145	172

The use of a 12-inch force main instead of 14-inch would result in a greater head loss at high flow rates but would shorten detention time in the pipeline. A 12-inch force main would require a design for greater pumping power to overcome the increased head losses. High head losses occur only during high flow rates. However, a pump selected to provide the power required to deliver peak hour flow through a 12-inch force main would result in reduced pump efficiency at low flow/reduced head conditions.

Whether the pipe size is 12-inch or 14-inch, the detention time under typical low flow operating conditions is excessive, with the likelihood that the wastewater will become septic and a source of odors and corrosion. All of the force main routes involve locations where venting of gasses within the pipeline must occur, and the gasses must be treated to remove/control odors. Thus, regardless of pipeline size and detention time, proactive odor control will be required for all of the alternatives.

Analysis of pump performance concludes that a single pump operating by itself at full speed would deliver a flow rate equal to approximately the maximum day flow – not much less than the peak hour design flow rate. This is because the pump's design for good solids handling results in a very "flat" performance curve and the length of the force main results in a very "steep" system curve. Operation of the second pump would be required only during peak hour flow conditions. This may be an advantage for control of solids accumulation in the force main, to allow a single pump to start and accelerate to high speed for a short duration to scour out accumulated solids.

Pumps would be operated at variable speed utilizing variable frequency drives. Based upon the manufacturer's information, the selected pumps can operate down to a flow rate of approximately 400 gpm – about 0.6 mgd. Lower speed (and flow rate) leads to highly inefficient operation and the potential for the pump's clogging. Thus, at typical average day flow rates, one pump must cycle on and off to match the net pumping rate with typical influent flow rates. Analysis indicates a substantial reduction of the operating head by selecting a 14-inch size force main by comparison of the pump design point, as shown in **Table 4**.

Table 4 Pump Head and Hp Requirements

	12-inch		14-inch	
Pumping Destination	**Pump Head (ft.)**	**Pump Hp**	**Pump Head (ft.)**	**Pump Hp**
Beverly Route	206	85	160	85
SESD (Bridge Route)	268	130	203	130
SESD (HDD Route)	268	130	190	85
Gloucester Route	263	130	202	130

Based on all of the above considerations, a 14-inch (nominal) size force main is recommended. As noted, neither size meets the preferred design criteria. During typical low flows, detention time is excessively long, and velocities are too low to prevent sedimentation. Means will be required regardless of size selection to address odor control and solids accumulation. The 14-inch size results in reduced pump design head and horsepower, which helps move the pump selection away from the highest head solids handling pump available.

Selection of Pump Design Point

The proposed new pumping station will have three equal-sized pumps selected such that two pumps running together will deliver the design peak hour flow rate of 2.0 mgd (1,386 gpm). Each pump will have a design point flow rate of 693 gpm. The pumps' required discharge head will vary based upon the force main size, destination, and route. Design point pump head is calculated as the sum of the force main friction loss based upon a C value of 140 for HDPE pipe, static lift, and head losses within the pumping station based upon a C value of 100 for cement-lined ductile iron pipe. Note that C value for HDPE pipe is assumed to vary between 140 and 150 and for cement-lined ductile iron pipe between 100 and 130, depending upon age and accumulation of debris on the pipe wall. The more conservative values (lower) are used as the basis for pump selection.

This application's potential pump selections are a Flygt Model NP 3301 (85 hp) and Model NP3315 (130 hp) submersible solids handling pumps driven by an 1800 rpm motor, depending of the alternative route/discharge location selected. Selection of specific impeller size within these pump selections provides coverage for all of the pumping scenarios presented. These selections were used for cost estimating purposes.

Other Design Considerations

Odor Control

The force main alignment's topography for all the alternatives is undulating, resulting in numerous intermediate high and low points in the pipeline. Gasses dissolved in the wastewater are most likely to come out of solution at high points because of the pipeline's reduced pressure. This will result in the accumulation of pockets of gas at every high point. Gasses must be vented because accumulated gas will restrict the flow of wastewater in the pipeline. Each high point in the pipeline profile must be equipped with an air release valve to release gasses. Some of the high points must also have a vacuum relief valve to prevent vacuum formation and hydraulic surge within the pipeline upon rapid reduction of flow potentially caused by pump shut-down. Air and vacuum release valves require monitoring and maintenance to assure their continued functionality.

Pipeline detention times are long, which will enhance the development of hydrogen sulfide in the wastewater, resulting in hydrogen sulfide gas coming out of solution at the high points of the pipeline and at points of discharge. Hydrogen sulfide is odorous and corrosive and must be treated if it is vented to the atmosphere. Hydrogen sulfide gas trapped in a gas pocket inside cement-lined ductile iron pipe results in corrosive attack to the cement lining and destruction of the pipe. The potential for accumulation of hydrogen sulfide at high points of the force main alignment eliminates ductile iron pipe as a potential pipe material selection. Hydrogen sulfide released into a concrete structure can cause corrosive damage to the concrete.

The potential for development of hydrogen sulfide emphasizes the need for thorough hydrogen sulfide control and odor control design throughout the pumping system with particular control at all points of release of the flow and high volume venting of gases. Odor control may be in the form of carbon cannisters at vents or chemical addition to the flow to react with hydrogen sulfide and other odor-producing chemicals. Chemical treatment may occur at the pumping station but may also be required along the length of the force main and/or at the termination of the pipeline.

Solids Deposition

Accumulation of solids in the force main will be a concern for this project because of the long length and required over-sizing to reduce pumping head at high flow rates. The over-sizing results in low flow velocities. Typical force main design selects pipe size and pump capacity to achieve velocities of 2 to 6 feet per second, and at least occasional flow rate to achieve scouring velocities of at least 3.5 feet per second. For this project, the force main velocity of 3.5 fps only occurs at flows above maximum day design flow with a 14-in pipeline. Solids are likely to settle and accumulate at low points in the force main. Blow-off valves installed in manholes should be installed at each low point. Additionally, the pumping station should be equipped to allow launching of a cleaning "pig" into the force main to periodically clean accumulated solids. A "pig" is a cylindrically-shaped device of slightly smaller diameter than the pipe being cleaned, usually constructed of polyurethane foam, that is placed into the force main and pumped through the pipeline along with the wastewater in order to clean the pipe. The termination of the force main should be also equipped with an appropriate piping arrangement to recover the cleaning pig.

Bypass Pumping

The pumping station should be equipped with a connection to the force main at the discharge from the valve vault to provide for bypass pumping of the station if major maintenance requires access into the wet well. Portable pumps can be used to draw wastewater from an upstream manhole (with the outlet plugged) and discharge it into the bypass connection to handle flow while maintenance is performed in the wet well. The bypass connection can also serve as the means to launch the pipeline cleaning pig.

Equalization Basin

One option for dealing with peak flows at pumping stations is installing an equalization basin that acts as a storage tank during high flow events. During these events some of the flow that would typically enter the pumping station would enter the equalization basin for temporary storage instead of backing up into the collection system. Wastewater stored in the equalization basin would flow to the station and be pumped after the high flow event has subsided. This "shaving" of the peak flows would allow the pumping station to deal with these events more efficiently and help mitigate peak flow issues at the receiving WWTP. Further evaluation of potential flow equalization requirements and strategies would be needed once a final destination for discharge of MBTS flow is determined. Tankage for equalization structures would further reduce available area for future development at the WWTF site.

Permitting

This section of the memorandum identifies potential environmental permitting constraints and the environmental permits that would be needed for the different project components and each of the alternatives.

Potential Environmental Permitting Constraints

To perform this desktop permitting review, the following assumptions were made:

- Alternative 1 (Beverly Connection) - The proposed force main would be entirely located within existing paved roadways and parking lots; however, jurisdictional wetland resource areas such as land subject to coastal storm flowage (LSCSF), bordering land subject to flooding (BLSF), and 200-ft Riverfront Area may extend onto the roadways and parking lots.

- Alternative 2A (SESD Connection - Bridge Route) – In addition to the assumptions for Alternative 1, a portion of the new force main would be attached to the existing Veterans Memorial Bridge between Beverly and Salem.

- Alternative 2B (SESD Connection - HDD Route)- In addition to the assumptions for Alternative 1, a portion of the force main would be located beneath the Beverly Harbor (i.e., within flowed tidelands) and installed using HDD from a location near the Beverly pumping station located at 135 Water Street to an area in the Salem Willows Park off Fort Avenue in Salem. This would require installing the force main within maintained lawns within Salem Willows Park, a City of Salem owned and maintained park.

- Alternative 3 (Gloucester Connection) – The proposed force main would be entirely located within existing paved roadways and parking lots; however, jurisdictional wetland resource areas such as land subject to coastal storm flowage (LSCSF), bordering land subject to flooding (BLSF), and 200-ft Riverfront Area may extend onto the roadways and parking lots.

- Construction of the overall project, regardless of the alternative force main route selected, will likely be funded using Massachusetts Department of Environmental Protection (MassDEP) State Revolving Fund (SRF) loans, which requires additional permitting efforts.

For preliminary planning purposes, Massachusetts Geographic Information System (MassGIS) OLIVER (Mass OLIVER) and local Mass GIS online viewers were used to analyze the project components and each alternative for conveying wastewater flow from the MBTS WWTF to the SESD

WWTP in Salem and the Gloucester WWTP. The following natural resources were examined for potential permitting constraints:

- Wetlands;
- Floodplain;
- Estimated Habitat of Rare Wildlife and Priority Habitat of Rare Species;
- Historical and Archaeological Resources;
- Coastal Zone including areas subject to Chapter 91 jurisdiction such as filled tidelands; and
- Adaption and Resiliency.

Wetlands

The force main routes for all the alternatives would be located within existing paved roadways within MBTS and the Cities of Beverly, Salem, and Gloucester. Although the force main would be installed within existing paved roadways, there are jurisdictional wetland resource areas directly adjacent to portions of the proposed routes. These jurisdictional wetland resources include perennial rivers and streams (e.g., Causeway Brook, Sawmill Brook, Chubb Creek, Danvers River, and several other tributaries) with associated 200-ft Riverfront Areas, Bordering Vegetated Wetlands (BVW), Salt Marshes, Coastal Beaches, and Coastal Banks.

Both Alternatives 2A and 2B would not directly alter wetland resource areas but would involve work within the 100-foot Buffer Zone of Coastal Bank for the Danvers River.

Floodplain

The existing MBTS WWTF parcel is entirely located within Zone AE with a base flood elevation (BFE) of 10 feet NAVD 88 per FEMA Flood Hazard mapping. The new pumping station at the MBTS WWTF site would be located within the 100-year floodplain (regulated as Land Subject to Coastal Storm Flowage) by the MBTS Conservation Commission. A portion of each of the proposed force main alternatives would also be located within the 100-yr floodplain. There are no performance standards for work in LSCSF in the state Wetlands Protection Act and Regulations nor in the local bylaws/ordinances of MBTS, Beverly, Salem, and Gloucester.

Estimated Habitat of Rare Wildlife and Priority Habitat of Rare Species

The Massachusetts Endangered Species Act (MESA) prohibits the "take" of any rare plant or animal species listed as Endangered, Threatened, or of Special Concern by the Massachusetts Division of Fisheries & Wildlife (MDFW). "Take" is defined in the Act as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding, or migratory activity of an animal or to collect, pick, kill, transplant, cut or process a plant.

The proposed pumping station, including all the force main alternatives, would not be located within the estimated habitat or priority habitat of any state listed rare or endangered species.

Historical and Archaeological Resources

The project components and alternatives would be located within previously developed areas such as existing paved roadways and parking lots and maintained Salem Willows Park lawns. It is not anticipated that there would be any adverse impacts on significant historical or archaeological resources. However, the project would need to be reviewed for historical and archaeological impacts by the Massachusetts Historical Commission (MHC) during the future permitting phase to meet SRF requirements.

Coastal Zone

The entirety of the project area is within the Massachusetts Office of Coastal Zone Management (CZM) jurisdiction. CZM would review and comment on the project during the Massachusetts Environmental Policy Act (MEPA) review further discussed below under State Permit Approvals.

The western portion of the existing MBTS WWTF site is located within filled tidelands, including the area where the new pumping station is proposed to be located. Therefore, the new pumping station's construction would require a Chapter 91 License from the MassDEP Waterways Program. A portion of the force main route for all alternatives would also be located within filled tidelands and require licensing.

Alternative 2B with the HDD crossing of Beverly Harbor is located within flowed tidelands (tidal waters seaward of the present mean high water), an area also regulated by the Waterways licensing program.

Adaption and Resiliency

Projects proposed in the Coastal Zone need to be designed to be resilient to the long-term threat posed by climate change, sea-level rise, and increased storm activity and intensity. The project's primary threat is coastal flooding in the areas near Days Creek in MBTS and along the Danvers River in Beverly and Salem.

In 2012, the U.S. National Oceanic and Atmospheric Administration (NOAA) conducted a review of the research on global sea-level rise projections. They concluded that the global mean sea level would likely rise at least eight inches above 1992 levels by 2100. With high greenhouse gas emissions rates, sea-level rise could be much higher, but it is unlikely to exceed 6.6 feet higher than 1992.

Both the low-end and "worst-case" possibilities were revised upward in 2017 following a U.S. Interagency Sea Level Rise Taskforce review. Based on their new scenarios, the global sea level is likely to rise at least 12 inches (0.3 meters) above 2000 levels by 2100. With higher greenhouse gas emissions, sea-level rise could be as high as 8.2 feet (2.5 meters) above 2000 levels by 2100. **Figure 7** below presents possible future sea-level rises predicted by NOAA.

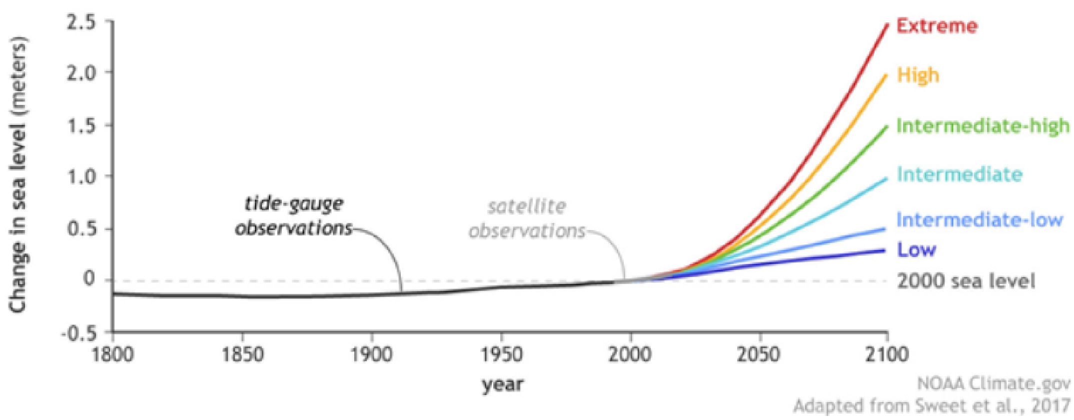

Figure 7 NOAA projected sea-level rise (source: https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level**)**

To assess the project's potential risk due to sea-level rise, we selected the Intermediate-high as a conservative (i.e., more severe) scenario. Under the Intermediate-high scenario, projected sea-level rise would be approximately 0.75 meters (2.47 feet) in 2075 (approximately 40 years after the start of construction). Based on projected sea-level rise scenarios on CZM's website, the proposed pumping station site on the MBTS WWTF property would be affected if there were a 3-ft sea-level rise. Based on this simple analysis, the new pumping station would need to be designed to withstand a minimum of 3 feet of sea-level rise to be resilient to future climate change and sea-level rise.

Description of Applicable Permits

Several federal, state, and local permits would be required to implement the proposed project. Since the project area is within a coastal zone and adjacent to or above/below watercourses and wetlands, permits and approvals would be required to work in or adjacent to these resources.

Table 5 summarizes the anticipated environmental permits and approvals required for each project component and alternative force main route.

Table 5 Permit Summary Table

Project Components	Federal Approvals			State Approvals					Local Approvals		
	ACOE PCN	NPDES CGP	U.S Coast Guard	MEPA	CH. 91 License	Article 97	MHC	MassDOT	Order of Cond.	MBTS Building Permit	Local DPW Permits
Decommission of MBTS WWTF				X			X		X		
New Pumping Station at WWTF Site				X	X		X		X	X	
Beverly Connection		X		X	X		X	X	X		X
SESD Connection (Bridge Route)	X	X	X	X			X	X	X		X
SESD Connection (HDD Route)	X	X	X	X	X	X	X	X	X		X
Gloucester Connection		X		X	X		X	X	X		X

The following describes the federal, state, and local permits/approvals required to work in or adjacent to regulated natural resources and their applicability to the project components and alternatives.

Federal Permits/Approvals

U.S. Army Corps of Engineers (USACE) Section 404 of the Clean Water Act and Rivers and Harbors Act, Section 10

Section 404 of the Clean Water Act (CWA) regulates the discharge of dredged or fill materials into the Waters of the U.S., including adjacent wetlands. Any discharge of dredged or fill material into Waters of the U.S. and/or adjacent wetland would require approval from the U.S. Army Corps of Engineers (USACE) per Section 404 of the CWA. The jurisdictional limit extends to the high tide line in tidal waters and up to the ordinary high-water line or wetland line in non-tidal waters. Section 10 of the Rivers and Harbors Act of 1899 (Section 10) requires approval from the USACE to fill or construct structures in Navigable Waters, including above or below navigable waters. The jurisdictional limit extends up to the high tide line.

In Massachusetts, the USACE has issued General Permits (GPs) [Effective Date: April 16, 2018; Expiration Date: April 5, 2023], allowing certain minor activities to proceed without or with limited USACE review. The Massachusetts GP was issued under Section 404 of the CWA and Section 10 of the Rivers and Harbors Act of 1899. Therefore, review for work subject to Section 10 is the same as described above for Section 404 of the CWA.

Both Alternatives 2A and 2B for the Danvers River/Beverly Harbor crossing would require authorization under GP 9 for Utility Line Activities as a PreConstruction Notification (PCN) since the activity occurs under, within, or above navigable waters of the U.S. and would be subject to Section 10 of the Rivers and Harbors Act. The PCN review and authorization is typically expected to take 6 to 9 months.

U.S. Fish and Wildlife Service (USFWS), Federal Endangered Species Act of 1973

Section 10 of the Endangered Species Act (ESA) is designed to regulate a wide range of activities affecting plants and animals designated as Endangered or Threatened and the habitats upon which they depend. With some exceptions, the ESA prohibits activities affecting these protected species and their habitats unless authorized by a permit from the U.S. Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service (NMFS). Permitted activities are designed to be consistent with the conservation of the protected species.

Section 7 of the ESA requires Federal agencies to consult with the USFWS to ensure that actions they fund, authorize, permit, or otherwise carry out will not jeopardize the continued existence of any listed species or adversely modify designated critical habitats. The following federally protected threatened or endangered species are listed as having the potential to occur in the project area, according to USFWS. However, no critical habitats are listed: piping plover (*Charadrius melodus*), small whorled pogonia (*Isotria medeoloides*), and northern long-eared bat (*Myotis septentrionalis*).

The USACE consults with the USFWS during the Section 404/Section 10 review process described above to confirm that the project will have "no effect" or is "not likely to effect" a federally listed threatened or endangered species.

National Marine Fisheries Service (NMFS)

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) (16 U.S.C. § 1855), as amended, requires Federal agencies that fund, permit, or carry out activities that may adversely impact Essential Fish Habitats (EFH) to consult with the NMFS regarding potential adverse effects of actions on EFH.

The USACE consults with the USFWS during the Section 404/Section 10 review process to confirm that the project will have "no effect" or is "not likely to effect" EFH.

United States Environmental Protection Agency (EPA), NPDES Construction General Permit (CGP)

The U.S. Environmental Protection Agency (EPA) regulates point source discharges of pollutants to waters of the United States through the National Pollutant Discharge Elimination System (NPDES) process. The project alternatives would require a NPDES Construction General Permit (CGP) for total land disturbance of equal to or greater than one acre and/or for dewatering of groundwater intrusion or stormwater discharges to Waters of the Commonwealth. Dewatering of groundwater intrusion and stormwater accumulation can alternatively be authorized under the NPDES Dewatering General Permit (DGP).

Under the requirements of the CGP, the project proponent, or designee, is required to prepare a Storm Water Pollution Prevention Pollution Plan (SWPPP) to document stormwater control measures during the construction period for the project. After completing the SWPPP, the proponent or designee is required to complete and submit to the EPA a Notice of Intent (NOI) to discharge stormwater. The selected construction contractor will be responsible for obtaining the NPDES CGP and preparing the SWPPP after the award of the contract. There is no review time for an NPDES CGP permit. The electronic NOI (eNOI) must be submitted at least 14 days before the start of construction.

A NPDES CGP would be required for each of the force main alternatives. Any dewatering during the construction of the new pumping station can be authorized under the NPDES DGP.

U.S. Coast Guard, Bridge Permit

The U.S. Coast Guard (USCG) has exclusive control to prevent any interference with navigability by bridges or other obstructions placed in navigable waters of the United States under Section 9 of the Rivers and Harbors Act of 1899 and the General Bridge Act of 1946. The purpose of these Acts is to preserve the public right of navigation and to prevent interference with interstate and foreign commerce. The General Bridge Act of 1946, as amended, the Rivers and Harbors Act of 1899, as amended, and the Act of March 23, 1906, as amended, all require the location and plans of bridges and causeways across the navigable waters of the United States be submitted to and approved by the Secretary of Homeland Security before construction. The General Bridge Act of 1946 is cited as the legislative authority for bridge construction in most cases.

The Bridge Permit application process ensures compliance with the National Environmental Policy Act (NEPA). The application process is initiated by submitting a written Project Initiation Request, followed by NEPA compliance documentation and a navigational impact report, and a public comment period.

Alternative 2A would require a USCG Bridge Permit. The USCG coordinates the review of a Bridge Permit application with the USACE. Navigational issues, including if the new sewer pipe would constitute the lowest horizontal component of the existing bridge, would concern the USCG. The Danvers River at this location is part of a Federal Navigation Project (i.e., the Beverly Harbor).

The U.S. Coast Guard Bridge permit process is expected to take 6 to 9 months to complete.

State Permits / Approvals

Massachusetts State Legislature Approval

Connecting to the SESD system, either through the City of Beverly or directly at the SESD WWTP would require approval of the State legislature in the form of an amendment to the SESD enabling legislation in order to allow a new community to become part of the District.

Certificate from the Executive Office of Energy and Environmental Affairs (MEPA Approval)

The Massachusetts Environmental Policy Act (MEPA) requires reviewing and evaluating certain large-scale projects to describe their environmental impact. It requires that permit granting agencies identify feasible measures to mitigate potential environmental damage. MEPA review is triggered if one or more of the review thresholds in 301 CMR 11.03 is met or exceeded and if state action is needed (i.e., either a state permit or state funding). The MEPA Regulations (301 CMR 11.00) establish thresholds, a procedure, and a timeline for a two-tiered review process, which generally proceeds as follows: the project proponent submits an Environmental Notification Form (ENF) to the Secretary of Energy and Environmental Affairs (Secretary). A 20-day public comment period follows, during which time the Secretary receives comments from the public and agencies and holds a site visit and consultation session. Up to 10 days following the close of the comment period, the Secretary issues a Certificate stating whether an Environmental Impact Report (EIR) is needed and what the EIR scope should include if required. If no EIR is needed, the state permitting agencies can issue the required permits, and the project can go forward. If an EIR is required, it is prepared by the project proponent and submitted to the Secretary. The EIR is reviewed and commented on at both Draft and Final stages by the public, state agencies, the Secretary, and the MEPA Unit. After completion of the review the Secretary issues a Certificate approving the project. MEPA does not allow for project segmentation, and therefore, the project components and selected alternative would be reviewed in one single ENF.

The project is subject to MEPA review since the force main alternatives exceed the review threshold for *construction of one or more new sewer mains five or more miles in length* [301 CMR 11.03

(5)(b)3.b] and the project requires both state permits (Chapter 91 License and MassDOT approval) and is expected to seek State Revolving Funding (SRF). It is not expected that an EIR will be required. The MEPA process takes approximately 45 days.

Massachusetts Office of Coastal Zone Management (CZM) - Coastal Zone Federal Consistency Review

The Massachusetts Office of Coastal Zone Management was established under the Federal Coastal Zone Management Act of 1972, as amended. The purpose of the Massachusetts CZM is to provide technical assistance to municipalities and state agencies with jurisdiction over coastal resources, ensure that responsibilities of the Executive Office of Energy and Environmental Affairs agencies are administered in a coordinated and consistent manner, and review projects proposed within the Coastal Zone for compliance with the CZM Policies established in 301 CMR 20.00.

CZM Consistency Review is required for any project requiring a federal permit for activities in the Coastal Zone and/or when a project located in the Coastal Zone is subject to MEPA review. A federal permit that requires a Consistency Statement from CZM is not valid until the Statement is issued. A CZM Consistency Review is often prepared as part of MEPA documentation or can be prepared as a stand-alone document.

MassDEP, 401 Water Quality Certification Program (314 CMR 9.00)

Section 401 of the Clean Water Act requires that states certify that federal actions will not prevent the attainment of state water quality criteria. There is no work associated with the project alternatives that require a permit from the USACE per Section 404 of the Clean Water Act. Consequently, a Water Quality Certification would not be required from the MassDEP per 314 CMR 9.00.

For minor impact projects [projects that alter no salt marsh and/or less than 5,000 square feet of federal and state jurisdictional wetlands and/or involve dredging less than 100 cubic yards of material and receive an Order of Conditions (wetlands permit) per the Massachusetts Wetlands Protection Act] no individual Water Quality Certification is needed. For projects that exceed those thresholds, an Individual Water Quality Certification is needed from the MassDEP. It is not anticipated that a 401 WQC would be required for any of the alternatives.

MassDEP, Interbasin Transfer Act

The Interbasin Transfer Act (ITA) gives the Water Resources Commission (WRC) the authority to approve or deny all transfers of water or wastewater (including municipal transfers) outside of the river basin of origin. The ITA became effective in March 1984. The Department of Conservation and Recreation (DCR) Office of Water Resources provides the technical and administrative work on the Act by the WRC. The ITA requires protection of the donor basin and sound water supply management practices before transferring water resources between river basins.

MBTS and the Cities of Beverly, Salem, and Gloucester are all located within the North Coastal river basin so although there would be a transfer of wastewater between municipalities, the transfer remains within the North Coastal river basin, and therefore, ITA review is not triggered. If MBTS choses to send flows to a basin outside of the North Coastal river basin, then ITA regulations should be re-examined.

MassDEP, Waterways Licensing Program (M.G.L. Chapter 91; 310 CMR 9.00)

The Waterways Licensing Program was formally established in 1866 with the passage of M.G.L. Chapter 91. Chapter 91 jurisdiction extends to the mean high-water mark of tidal water bodies and the ordinary high-water mark of non-tidal water bodies and includes "filled tidelands."

The existing MBTS WWTF site is located within Chapter 91 jurisdiction; therefore, a new Chapter 91 Waterways License would be required to construct the new pumping station within filled tidelands. Installation of the force main for all of the alternatives would also require Waterways licensing for the portion near the WWTF site within filled tidelands. Both force main Alternatives 2A and 2B would require new Chapter 91 Waterways Licensing for the Danvers River/Beverly Harbor crossing since the Danvers River is a navigable waterway. However, Alternative 2A may be approved as a Minor Modification to the existing Chapter 91 License for the Veterans Memorial Bridge (assuming the bridge has a valid Chapter 91 License).

The Waterways licensing process takes 6 to 9 months to complete and requires a 30-day public notice period. A Minor Modification to an existing Chapter 91 License takes 1 to 2 months to approve.

Article 97 Disposition

Article 97 of Amendments to the Massachusetts Constitution protects in perpetuity park and conservation land acquired for natural resources purposes from being developed. Disposition or change in the use of Article 97 land requires a two-thirds roll call vote of each house of the state legislature and is subject to the Article 97 Land Disposition Policy (February 19, 1998) administered by the EEA. The goal of this policy is to ensure no net loss of Article 97 lands. Disposition of Article 97 land requires replacement of real estate of equal or greater fair market value is granted to the disposing agency or its designee.

Willow Park in Salem is listed as Article 97 protected land in the City of Salem Open Space and Recreation Plan (Update 2007-2012). Alternative 2B may require an Article 97 land disposition depending on the alignment of the HDD and new force main in Salem. The disposition of municipal Article 97 land requires a unanimous vote of the local Conservation Commission and the Park and Recreation Commission, a two-thirds vote of the City Council, and two-thirds vote of the state Legislature in support of the conversion.

Massachusetts Historical Commission

Section 106 of the National Historic Preservation Act (NHPA) requires that project areas be evaluated to determine the presence of cultural resources. Any new construction projects or renovations to existing buildings or structures that require state funds, licenses, or permits are subject to the review requirements of the MGL Chapter 9, Sections 26-27c, as amended by Chapter

254 of the Acts of 1988 (950 CMR 71.00). As a part of the SRF process, a Project Notification Form (PNF) would be submitted to the Massachusetts Historical Commission to determine if the project will affect any significant cultural or archaeological resources. MHC has 30 days to review a PNF and issue a determination.

Tribal Historic Preservation Officers (THPO)

As a part of USACE permitting, the THPO's for the Wampanoag Tribe of Gay Head (Aquinnah), and Mashpee Wampanoag Tribe would be contacted to determine if the project would adversely affect any significant tribal cultural or archaeological resources. This coordination takes approximately one month.

Massachusetts Department of Transportation (MassDOT), Access Permit

Massachusetts Department of Transportation (MassDOT) regulates work within State-owned roadways. Route 127 (Bridge Street) from Ashland Avenue in Beverly and Route 1A at the Danvers River crossing fall under MassDOT jurisdiction. Therefore, work within these roads would require a MassDOT Access permit to complete the proposed work. This coordination can take approximately one month to prepare and one to three months to obtain the permit.

Local Permits/Approvals

Local review and approvals of the project would also need to be obtained from the local building, public works, zoning, and conservation commissions in MBTS, Beverly, Salem, and/or Gloucester as described below.

Conservation Commissions (Order of Conditions)

The Massachusetts Wetlands Protection Act (WPA) regulates the alteration of state-defined wetland resource areas. The Massachusetts Wetlands Protection Regulations (310 CMR 10.00) identify wetland resource areas subject to protection. The Rivers Protection Act protects perennial rivers, streams, and brooks in the Commonwealth and is enacted through Section 10.58 of the WPA. It establishes a 200-foot wide Riverfront Area that extends horizontally on both sides of perennial waterways. Under these regulations, alterations of wetland resource areas require the issuance of an Order of Conditions (OOC) by the local Conservation Commission. If performance standards cannot be met, a Variance from the Wetlands Protection Act must be obtained from the Commissioner of MassDEP unless the project qualifies as a Limited Project. The proposed project qualifies as a Limited Project under 310 CMR 10.53 since it is for a public utility.

The proposed project is subject to review and approval by the MBTS, Beverly, Salem and/or the Gloucester Conservation Commissions based on the alternative selected. All of the communities have local Wetland Bylaws and/or Wetlands Ordinances that are more stringent than the WPA. The Conservation Commissions also review the Massachusetts Stormwater Standards under the WPA and Regulations.

Manchester-by-the-Sea Conservation Commission

The MBTS Conservation Commission regulates all proposed work within and adjacent to wetland resource areas within MBTS subject to jurisdiction under the Massachusetts Wetlands Protection Act (WPA) and the MBTS General Wetlands By-Law Article XVII and Wetlands By-Law Regulations. The proposed sewer force main would be installed within the following regulated wetland resources areas: Land Subject to Coastal Storm Flowage (LSCSF), Bordering Land Subject to Flooding (BLSF), Riverfront Area, and 100-ft Buffer Zone. Decommissioning the existing MBTS WWTF and constructing the new pumping station would require work within LSCSF. Filing a Notice of Intent (NOI) with the MBTS Conservation Commission would be required. This permitting process takes two to three months.

Beverly Conservation Commission

The Beverly Conservation Commission regulates all proposed work within and adjacent to wetland resource areas in Beverly subject to jurisdiction under the WPA and the City of Beverly Wetlands Protection Ordinance (Chapter 287) and implementing regulations. The proposed new force main (Alternatives 1, 2A and 2B) would be installed within LSCSF, BLSF, Riverfront Area, and 100-foot Buffer Zone. Alternatives 2A and 2B would require work within the 100-ft Buffer Zone to Coastal Bank and LSCSF. Filing of a NOI with the Beverly Conservation Commission would be required for the project. This permitting process takes two to three months.

Salem Conservation Commission

The Salem Conservation Commission regulates all proposed work within and adjacent to Salem's wetland resource areas subject to jurisdiction under the WPA and the City of Salem Wetlands Protection and Conservation (Chapter 50). The proposed new force main (Alternatives 2A and 2B) would be installed within LSCSF and 100-foot Buffer Zone. The filing of a NOI with the Salem Conservation Commission would be required for Alternatives 2A and 2B. This permitting process takes two to three months.

Gloucester Conservation Commission

The Gloucester Conservation Commission regulates all proposed work within and adjacent to Gloucester's wetland resource areas subject to jurisdiction under the WPA and the City of Gloucester Wetlands Ordinance (Chapter 12). The proposed new force main (Alternative 3) would be installed within LSCSF and 100-foot Buffer Zone. The filing of a NOI with the Gloucester Conservation Commission would be required for this alternative. This permitting process takes two to three months.

MBTS Building Permit

The selected contractor would need to secure the required building, electrical, and plumbing permits for construction of the new pumping station from the MBTS Building Department. Obtaining a local building permit takes approximately one week.

MBTS Zoning Board of Appeals (ZBA)

The existing MBTS WWTF is located within the local Flood Plain District (i.e., FEMA mapped Zone AE). A special permit from the ZBA is not expected to be required if the bottom floor elevation of the new pumping station structure is a minimum of 1 foot above the base flood elevation (BFE) of 10 feet NAVD 88 and an Order of Conditions is secured from the MBTS Conservation Commission.

The applicable MBTS Zoning By-Law section is §4.8.4.3: "*any development in the Flood Plain District, including structural and non-structural activities, weather permitting by right or by special permit, shall be in compliance with Chapter 131, Section 40 of the M.G.L (i.e. the WPA) and with the following:*

(a) Section of the MA State Building Code (780 CMR) which address floodplain and coastal high hazard areas;

(b) Wetlands Protection Regulation (310 CMR 10.00); and

(c) Inland Wetlands Restriction (310 CMR 13.00)"

Department of Public Works

The selected contractor would need to secure all required street opening and trench permits from the MBTS, Beverly, Salem, and/or Gloucester Departments of Public Works (or applicable issuing authority). Obtaining street opening and trench permits take no longer than one week.

Intermunicipal Agreement Considerations

An intermunicipal agreement (IMA) would need to be negotiated and executed by MBTS and any of the other communities involved in the selected alternative. Intermunicipal agreements are governed by Chapter 40, Section 4A of the Massachusetts General Laws, or the "IMA law." According to Chapter 40, Section 4A, the chief executive officer of a city or town "may, on behalf of the unit, enter into an agreement with another governmental unit to perform jointly or for that unit's services, activities or undertakings which any of the contracting units is authorized by law to perform." The agreement would need to be approved by the city council and mayor in a city (Beverly, Salem, and Gloucester), and by the Board of Selectmen in MBTS. The IMA would need to address a number of issues, including the following:

- Collection system and/or WWTP upgrade cost sharing;
- WWTP operations and maintenance cost sharing;
- NPDES co-permittee issues;
- Sewer billing/metering;
- Sewer use regulations; and
- Infiltration/inflow.

Planning Level Cost Estimates

Planning level cost estimates were prepared for each of the various components of this project as described below to be used for comparative purposes to assist the Town in making decisions moving forward. Data sources used to develop planning level construction costs include bid tabulations from recent CDM Smith projects in the region and our firm's construction cost estimating database. The planning level Opinion of Probable Construction Cost (OPCC) estimates presented below include costs for labor, materials, equipment, contractor general conditions, insurance, bonds, overhead and profit, and construction contingency (30 percent for planning level). Costs are presented in 2021 dollars and have not been escalated to the mid-point of construction since the implementation timeframe is not clear at this time and is likely 15 to 20 years in the future.

OPCCs are presented in **Table 6** for the following components of the project: decommissioning the WWTF; construction of a new pumping station; and construction of each of the alternative force main routes.

WWTF Demolition

The estimate for decommissioning the existing MBTS WWTF includes demolition and removal of all buildings, tanks and equipment on the site; removal of all below grade foundations in their entirety; and backfill and compaction of the excavations to facilitate future planned development at the site.

New Pumping Station

The OPCC for the new pumping station includes excavation, including sheeting, bracing and dewatering; the precast wet well and valve vault (each 10-ft by 16-ft); a precast control building (14-ft by 28-ft) on an elevated concrete foundation; three submersible pumps, piping and valves; in-line grinder unit; emergency generator; electrical and instrumentation allowances; and an odor control system.

New Force Main

The OPCCs for all of the force main alternative alignments include excavation, including rock excavation for 50 percent of the trench; installation of the 14-inch HDPE pipe at a depth of 6 feet (5 feet of cover); backfilling; paving, including initial trench paving and full-width mill and overlay; air release/vacuum relief valves, including precast structures; and an allowance for traffic control (not policing). For the Connection to Beverly alternative, upsizing of the downstream gravity pipe has been included; however, costs for potential improvements for the Beverly pumping station have not been included since they were not able to be defined as part of this study. For the Connection to SESD – Bridge Route alternative, a carrier pipe and pipe supports have been included for the bridge crossing. For the Connection to SESD – HDD Route alternative, drilling costs have been included. For all of the force main alternatives, no costs have been included for any improvements at either the SESD or Gloucester WWTPs that would be required in order to allow them to accept MBTS flows.

Table 6 Planning Level OPCCs in 2021 Dollars (in $M)

Project Component	OPCC
WWTF Demolition	$2.5M
New Pumping Station	$3.1M
Force Main Alternatives:	
Beverly Connection	$13M
SESD Connection (Bridge Route)	$22M
SESD Connection (HDD Route)	$21M
Gloucester Connection	$14M

For comparative purposes, **Table 7** presents the combined cost of each alternative, including the estimated cost for demolition of the WWTF, pumping station construction and force main. Also presented below are estimated engineering and implementation costs (assumed to be 25 percent of OPCC) and project contingency (assumed at 20 percent of total cost at this stage of project development). The combined total of the OPCC, engineering, and project contingency is the Opinion of Probable Project Cost (OPPC) as presented below.

Table 7 Combined Alternative OPPCs in 2021 Dollars (in $M)

Project Alternatives	OPCC	Engineering	Project Contingency	OPPC
Beverly Connection	$19M	$4.8M	$4.8M	$29M
SESD Connection (Bridge Route)	$28M	$7.0M	$7.0M	$42M
SESD Connection (HDD Route)	$27M	$6.8M	$6.8M	$41M
Gloucester Connection	$20M	$5.0M	$5.0M	$30M

Note: Costs for improvements to the Beverly PS or the SESD and Gloucester WWTPs have not been included.

Potential Future Evaluation of a New In-Town Solution

As noted earlier in this memorandum, in the late stages of this evaluation the Town inquired about the possibility of handling wastewater in Town by relocating the WWTF to another site in MBTS instead of pumping to another municipality for treatment. As with the out of Town alternatives, any new in-Town treatment solution would still require demolition of the existing WWTF and construction of a new pumping station at the site to pump flow to an alternate location. Additionally, a new WWTF would need to be constructed at another site to provide treatment. Lastly, flow would need to be pumped from the new site back to the existing outfall pipe at the WWTF for ultimate discharge. Alternatively, a site would need to be found for groundwater recharge of the treated effluent from the new plant if it were not cost-effective to use the existing outfall.

The Town indicated that they are in the process of evaluating whether the development of a Limited Commercial District (LCD) that would include a 40R smart growth overlay district was a viable alternative for the Town. There is currently a proposed LCD project in the early stages of development that could potentially offer an opportunity for the Town to partner with the developer since wastewater treatment is needed at the site. Under this scenario, the developer would dedicate a portion of the property for construction of a new WWTF for the Town and the new development. Based on the footprint of the existing WWTF (approximately 1 acre), a minimum of 1.5 acres would be preferred to allow for potential expansion of the plant in the future.

Since the proposed LCD development site is not in close proximity to the existing WWTF, an evaluation of the cost-effectiveness of pumping treated effluent back to the existing ocean outfall would need to be performed. If it is determined that it is not cost-effective to do so, a new location for groundwater recharge of the treated effluent from the new plant would also be required.

CDM Smith is currently working on the design of two groundwater recharge projects for clients in Massachusetts. One of the most critical aspects of these projects is locating a site that has soils and water table conditions that allow for recharge of treated wastewater. Ideal locations will have highly permeable soils, a deep water table, and adequate soil depth. When sizing a groundwater recharge site, the permeability of the soils is critical. Groundwater recharge rates are established by performing permeability tests at proposed recharge sites and are subject to approval by MassDEP. The two projects CDM Smith is working on have recharge sites approved for 136,000 gpd/acre (highly permeable soils and a deep water table) and 110,000 gpd/acre (permeable soils and a deep water table). Without any information on soil permeability or water table level at any potential recharge sites in MBTS, a conservative recharge rate of 100,000 gpd/acre can be used for planning purposes to estimate the required size of a recharge field.

Based on an average daily flow of approximately 500,000 gpd at the existing WWTF, a 5-acre site would be needed to recharge the effluent. This area would be in addition to the 1.5 acres that would be needed for a new treatment plant mentioned previously. In total, MBTS would need to locate approximately 6.5 acres for the development of a recharge site and a new WWTF if it is not cost-effective to use the existing outfall. Recharge sites can be built under recreation fields and park sites so development of a site could allow for the creation of new green spaces if these locations are available.

Further investigation and engineering evaluation beyond the scope of this project would be needed to determine if an in-Town solution for wastewater treatment could potentially be viable. These evaluations would include, but not be limited to: site location search and review; a detailed evaluation of site hydraulics; permitting assessment; and development of wastewater treatment and conveyance costs.

Closing

As discussed above, SESD has indicated that discharging wastewater flow from MBTS to their system, whether by connecting to the Beverly collection system or directly to the SESD system is not a viable option at this time. The SESD conveyance system and treatment facility are at full capacity, especially during wet weather conditions. Member communities periodically face capacity restrictions during storm events. Similarly, the Gloucester WWTP would not be able to accept flow from MBTS under current conditions.

However, since the implementation of the potential alternatives evaluated during this study and presented in this memorandum is not likely to occur for 15 to 20 years, the situation at either the SESD or Gloucester wastewater treatment plants, or both, could change in the intervening years. That is, large-scale upgrades at these facilities might be required within that timeframe. In particular, as indicated, the Gloucester WWTP is currently a primary treatment plant, and in all likelihood will need to be upgraded to a secondary plant in the near future. These situations where upgrades are required may present the opportunity for MBTS to revisit the alternatives presented in this memorandum and begin discussions with either entity about the possibility of conveying flow to the upgraded facility. MBTS would want to be involved in discussions during the early stages of planning for the upgrade at either plant in order to be in a position to more fully evaluate the issues and cost-sharing associated with conveying flow to one of these facilities.

cc: Susan Brown, Town Planner, MBTS
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