Appendix G
Hydraulic Modeling Memo

Memorandum

Date:	5/10/2023
Project No.:	21005A
To:	Town of Montague, MA
From:	Lisa Muscanell-DePaola, Project Manager Steve Guerrette, Lead Project Engineer
Subject:	Turners Falls Wastewater Collection System Study Hydraulic Modeling Summary

This memorandum summarizes the results of the sewer analysis of the Turner's Falls sewer system in the Town of Montague, MA. The Turner's Falls sewer system is a combined sewer system containing three combined sewer overflow (CSO) structures located at 7th and L Streets, Avenue A, and Greenfield Road. The sewer system is inundated by high flows during rain events, causing the system to surcharge and overtop the diversion weirs in each of the CSO structures for both the 3-month and 1-year, 24-hour design storms. The completed modeling also predicts that for the design storms considered, the existing sewer system floods to grade in some locations, resulting in sanitary sewer overflows (SSOs). The results of the analysis are discussed in greater detail in the following sections of this memorandum.

The analysis was conducted to help the Town understand flow dynamics in select sections of the gravity sewer within the Turners Falls sewershed. In addition, this analysis and the associated model will help the Town evaluate the impact of several proposed improvements on the hydraulic grade line in the sewer, as well as their effectiveness of abating sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs) in the drainage area. The study begins at the intersection of 7th and L Streets, just upstream of the CSO diversion structures, and extends downstream to the Clean Water Facility (CWF).

Background

In December 2005, the Town of Montague developed a Long-Term Control Plan (LTCP) for Combined Sewer Overflows (CSO) and Water Pollution Control Facility Plan, which included recommendations for reducing CSOs and complying with regulatory objectives. Since 2005, some of the LTCP recommendations have been implemented while other recommendations were omitted or modified. The recommendations that have been implemented include:

- The construction of an off-line storage pipe on Avenue A, which consists of a weir and a 750-foot, 48-inch reinforced concrete pipe (RCP) buffer line[1].
- The raising of the weir level by 18 inches at the Greenfield Road CSO regulator[2], along with raising the weir level approximately 18 inches at the Avenue A CSO regulator and approximately 14 inches at the 7th Street CSO regulator.
- The increasing of downstream pipe diameters at the Avenue A CSO regulator from 12-inch RCP to 21-inch polyvinyl chloride (PVC) pipe and the increasing of downstream pipe diameters at the 7th Street CSO regulator to 21-inch PVC pipe.

- The construction of a Wet Weather Chlorine Contact Tank (WWCCT) at the CWF to allow for some primary effluent flow to be bypassed from secondary treatment to maximize the amount of influent that can be provided disinfection with adequate contact time before discharging.

[1] It is Wright-Pierce's understanding that the Town of Montague does not have a standard operating procedure (SOP) in place for the operation of the buffer line, however, as of the writing of this memorandum, the buffer line is currently in use. As discussed later in this report using the buffer line in its current configuration would only result in overall CSO volume decreases of 11% to 18% for 3-month and 1-year design storms respectively.

[2] Although the Town of Montague increased downstream pipe diameters on the Avenue A CSO regulator and the 7th Street CSO regulator, the downstream pipe diameter on the Greenfield CSO regulator has not increased since 2005. In addition, it appears following a survey done in 2009 by the Town of Montague that there is a significant dip in this influent interceptor pipe upstream of the CWF and that the pipe is likely surcharged or partially full under most flow conditions due to the water surface elevation upstream of the mechanical bar screen in the Headworks Room of the CWF.

The Town of Montague was issued an Administrative Order (CWF-AO-R01-FY20-31) from the U.S. Environmental Protection Agency (EPA) on June 11th, 2020, addressing compliance with its National Pollutant Discharge Elimination System (NPDES) permit to meet numeric effluent limitations and minimize CSOs. In December 2021, the Town of Montague developed an "interim" CSO LTCP Update meeting the requirements of the Administrative Order, specifically item IV.3.

The Town of Montague also received an 18-month extension to the deadline stated in the Administration order for the "final" CSO LTCP Update. The new deadline for the "final" CSO LTCP Update is June 30th, 2023. In between the "interim" and "final" CSO LTCP Updates, the Town of Montague and Wright-Pierce developed and implemented a field investigations and hydraulic modeling scope of work, funded by a Massachusetts Department of Environmental Protection (MA DEP) State Revolving Fund (SRF) Asset Management Program grant.

This memorandum summarizes the results of the sewer hydraulic modeling and analysis of the Turner's Falls sewer system in the Town of Montague. It will be utilized to prepare the "final" CSO LTCP Update due June 30th, 2023.

Flow Monitoring

As part of the Turners Falls Wastewater Collection System Study, the Town was able to complete Town-wide flow monitoring efforts. The flow metering program, which is discussed in greater detail in a separate memo, included the installation of five meters over the course of a 10-week monitoring period from March 30 through June 8, 2022. During this period, sewer data was documented at 15-minute intervals and reviewed. Flow meter locations were based on the Town's GIS database as developed by RCAP Solutions.

The flow monitoring program was supplemented with data from three meters installed and maintained by ADS Environmental Services at the CSO regulators. Wright-Pierce analyzed the data from these three meters over the course of the same 10-week monitoring period. The flow meter locations are shown in Figure 1 in Appendix A.

The flow meters captured collection system flows for several representative rain events during the metering period including at least two events totaling over 1.0-inches of rain in a 24-hour period. The model was calibrated using data from the best available storm events that occurred during the flow monitoring period. Further information on model calibration methods is provided in the sections below.

Model Development

EPASWMM5.1, was used by Wright-Pierce as the hydrologic/hydraulic modeling software. EPASWMM is a dynamic rainfall-runoff simulation model. It allows the user to create, edit, modify, run, map, analyze, and design sewer network models.

EPA SWMM5.1 is a computational engine and is capable of accounting for various hydrologic and hydraulic processes such as:

- Time-varying rainfall.
- Routing direct runoff, dry weather flows, and external inflows such as known flows from unmodeled pump stations, flows from groundwater infiltration, and any additional miscellaneous flows entering the collection system.
- Using a wide variety of standard closed and open conduit shapes, model flow dividers, pumps, weirs, and orifices.
- Applying flows from surface runoff, rainfall dependent inflow and infiltration (RDII), and dry weather sanitary flow.
- Modeling backwater, reverse flow, surcharging, surface ponding, and tidal effects on the system.

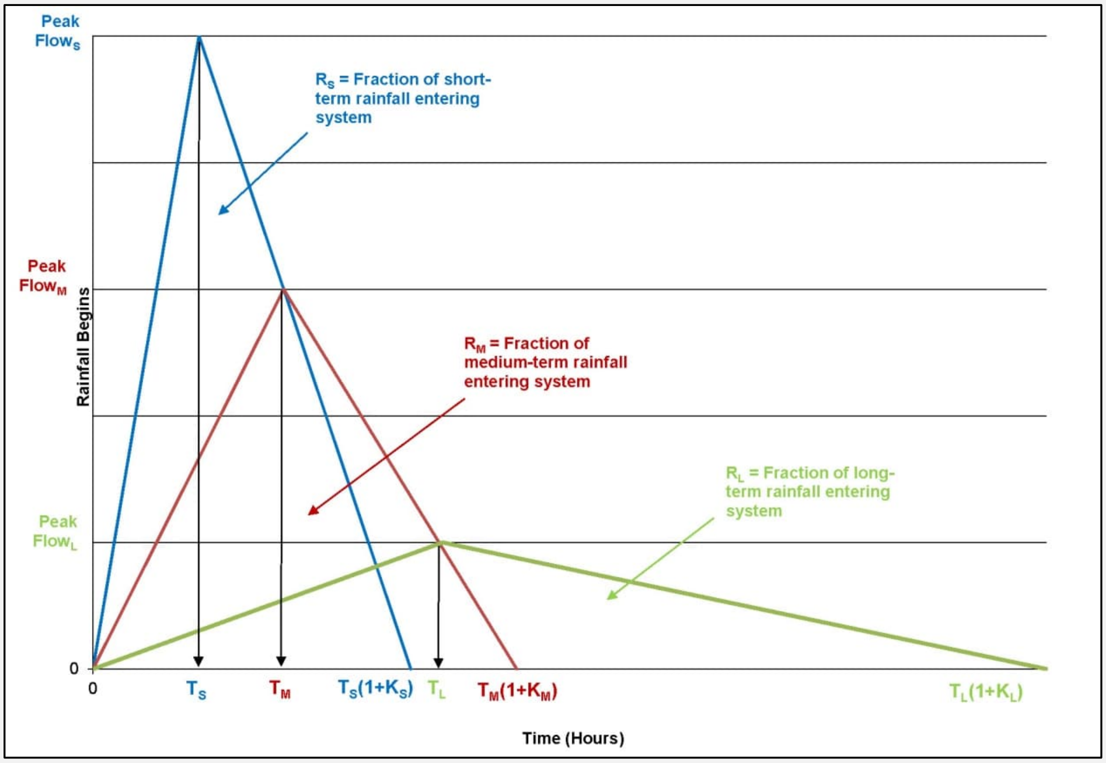
Hydrologic Data

Based on previous modeling and calibration experience, it was determined that the model should employ RDII using unit hydrographs to model the hydrology of the system instead of impervious area runoff and soil infiltration properties because we had the data from the detailed flow monitoring program. The model can represent RDII as a function of the rainfall time series. Individual RDII unit hydrographs can be developed in the model to represent the fraction of rainfall that enters the system as RDII. Each unit hydrograph is defined by three parameters including:

- "R" - the fraction of rainfall volume that enters the sewer system.
- "T" - the time from the onset of rainfall to the peak of the unit hydrograph, in hours.
- "K" - the ratio of time to recession of the unit hydrograph to the time to peak.

Up to three different sets of RTK parameters can be used to create each unit hydrograph. The purpose of these is to allow the user to simulate short-, medium-, and long-term responses from a rain event. Unit hydrographs can be used to replace the rainfall-runoff process in the model that uses subcatchment properties, provided that properly calibrated unit hydrographs are utilized. Figure 2 summarizes the components of RTK Unit Hydrographs.

Figure 2 RTK Unit Hydrograph Parameters



Hydraulic Data

The hydraulic model (manhole and pipe network) was developed using a combination of the Town's existing GIS database, record drawings and survey plans, and field collected data. The following data was obtained, reviewed, and used to build the model:

GIS Database

- Town GIS database obtained from RCAP Solutions; and
- Existing GIS layers from sewer mapping prepared by others.

Field Collected Data

- Field data to support the model, collected by Wright-Pierce between June 6 and June 10, 2022, included sewer manhole location and rim elevations obtained using survey grade GPS equipment. The field survey also included obtaining manhole rim to invert depths and confirmation of pipe sizes.
- Subsequent follow-up site visits to select manholes within the model extents were also conducted to verify collected data, collect missing information, and to physically enter manholes using confined space entry equipment to verify information difficult to obtain from the surface.

Record Drawings and Survey Plans

- Structure Elevations/Locations – Montague Wastewater Treatment Plant, by Roberge Associates Land Surveying, June 2009
- Avenue A and Seventh Street Sewer Pipeline Improvements, by CDM, March 2006

- Sewer Elevations Plan, by Northeast Survey Consultants, July 2021

Overall, the SWMM model contains 66 nodes (manholes, outfalls), and 61 links (pipes, weirs, orifices) for a total of approximately 12,530 linear feet of pipe.

Model Calibration

Model calibration is the process by which the model is adjusted to predict sewer system performance for a storm event at locations where sewer flow information is known. Model calibration is an important step in the development of a sewer model as it brings the model from a "best guess" state to an accurate predictive tool.

Using the flow meter and rain gauge data, the model was calibrated to predict the impact of rain events on the sewer system. This was achieved by iterative adjustment of parameters within the model while comparing the model output at each meter location to the flow meter data. The model was calibrated manually starting with meter data for the upper most sewersheds then progressively working downstream within the system until all locations were calibrated. The primary model parameters adjusted for calibration of the model included dry weather flow rates and RDII unit hydrographs.

The model assumes that pipes are clean and free of any maintenance issues that could impact flow capacity and conveyance.

Model Simulations

The main goal in the model simulations was to better understand what is happening in the collection system now and to quantify the downstream impacts of various improvement alternatives that utilize the existing buffer line, increase pipe sizes in surcharged and flooding sections, and / or reduce the amount of inflow and infiltration (I/I) entering the system.

The SWMM model was run for two design storms including the 3-month, 24-hour (1.87” of rain) and 1-year 24-hour (2.47” of rain) design storms. These design storms were run for existing conditions and two alternatives. The design storms were selected based on the information contained within previous LTCP studies, and on MassDEP’s typical guidelines that generally require that combined sewer overflows be limited to 4 occurrences per year. It is anticipated that a 3-month,24-hour design storm would statistically be exceeded, on average, four times per year. Additionally, mitigation of CSOs to a 1-year event level of control is a potential next step following the achievement of a 3-month level of control, therefore knowing how the system performs under a 1-year, 24-hour design storm is important to future planning efforts. Storms will and do often exceed the 1-year return interval; therefore, additional design storms should be considered in future hydraulic modeling and design phases.

The following model simulations were included in this study:

- Existing Conditions – The existing conditions model run was conducted to establish baseline system performance. For this model run, it was assumed that the buffer line was not in service. During the field survey, it was discovered that the buffer line was full of water and that the line was not drained in advance of a rain event, therefore this was used as the baseline conditions for analyzing existing system performance. The simulation quantifies the total CSO volumes from the three monitored CSOs at 7th & L Streets, Avenue A, and Greenfield Road as well as any noted surcharging or potential SSOs.

- Alternative 1 – Use of the existing buffer line during storm events – Determine the efficiency of the buffer line and effects of the associated reduction in volume from the main trunkline on CSO volumes, surcharged pipes, and manholes flooding to grade. The simulation would quantify total CSO volumes from the three monitored CSOs at 7th & L Streets, Avenue A, and Greenfield Road. Based on the results of this alternative, several additional modification alternatives, and iterations at or near the upstream end of the buffer line were proposed to allow the buffer line to perform as efficiently as possible.

- Alternative 2 – Upgraded system pipe sizes along trunkline near the CWF – Evaluate the necessary pipe size changes to the trunkline needed to reduce any surcharged pipes, and CSO volumes at the Greenfield regulator. The purpose of this alternative is to determine the pipe size required to eliminate CSOs at the Greenfield regulator, as well as to quantify the impact that pipe replacement of varying extents and scopes would have on the Greenfield regulator.

The results of the model simulations are summarized in Table 1 and are described in the following paragraphs.

Existing Conditions

The model was run for existing conditions using a 3-Month, 24-hour recurrence interval design storm and a 1-year, 24-hour design storm to establish baseline system performance. The results of the existing conditions model simulation are summarized in Table 1. The model predicts that approximately 134,000 gallons would overflow across all CSOs for the 3-month event, and approximately 267,000 gallons would overflow for the 1-year event. See Table 1 for overflow gallons at each CSO. Additionally, several portions of the existing interceptor line between Avenue A and the CWF were predicted to surcharge above crown of pipe and even flood to grade (SSO) for both design storms. Surcharged sewers and overflowing manholes are identified on Figure 3 in Appendix A.

Table 1 Montague, MA Existing Conditions Results

	Model-Predicted CSO Volumes (Gal)			
	7th & L Streets CSO	Avenue A CSO	Greenfield Road CSO	Total CSO Volume
Existing Conditions – 3-Month	20,000	65,000	49,000 (95,000)	134,000 (180,000)
Existing Conditions – 1-Year	48,000	98,000	121,000 (186,000)	267,000 (332,000)

[1] Values in parentheses show model results including CWF tailwater conditions.

Alternative 1 – Use of the Existing Buffer Line During Storm Events

Alternative 1 was run for the 3-month and 1-year, 24-hour design storms. Several iterations were modeled to include various additional projects that could help maximize the effectiveness of the buffer line while reducing CSO volumes and downstream SSOs. The options modeled as part of this alternative included:

1. Using the buffer line with no additional system changes by manually operating the downstream gate to drain the buffer line after rain events and closing the gate before an event.

2. Raising the Avenue A CSO weir to allow more flow to enter the buffer line before a CSO occurs. This would also include the operation of the downstream buffer line gate as described in 1A.
3. Increasing the pipe size between Avenue A diversion and the buffer line diversion structures to allow flow to enter the buffer line more efficiently. This would also include the operation of the downstream Buffer Line gate as described in 1A.
4. Raising the Avenue A weir and increasing the pipe size between the diversion structures. This would also include the operation of the downstream buffer line gate as described in 1A.
5. Increasing the pipe size between Avenue A diversion and the buffer line diversion structures and adding an orifice plate (steel plate with a 12 to 15-inch diameter hole) to the 30-inch outlet of the buffer line inlet structure to maximize flow entering the buffer line and help reduce downstream SSOs along the interceptor. This would also include the operation of the downstream buffer line gate as described in 1A.
6. A combination of raising the Avenue A weir and increasing the pipe size between the diversion structures, and upstream flow reductions through various sewer separation projects. The goal of this model run is to use the buffer line to its full potential, while determining to what extent flow reductions need to occur in the upstream sewershed to eliminate SSOs in downstream sewers. This would also include the operation of the downstream buffer line gate as described in 1A.

1A – Buffer Line Only

The results of the Buffer Line only run indicate that using the existing system configuration with the downstream slide gate operated to empty the buffer line after rain events and close to capture volume from a new rain event, the buffer line would capture and store flows preventing them from continuing downstream, resulting in an overall reduction in sewer system surcharge and flooding to grade. This alternative reduces CSO volumes by approximately 10% at the downstream Greenfield CSO. This is an overall positive impact, with little to no negative consequences.

However, this model run revealed that under the current configuration, CSOs at Avenue A would continue to occur before the buffer line can be filled. Additionally, the buffer line does not fill, even for a 1-year 24-hour design storm, only filling to approximately 30% of its full volume. The Avenue A weir is too low in elevation to allow flow to continue to pass through the structure and fill the buffer, and/or the capacity of the pipe connecting Avenue A to the downstream buffer line diversion structure is too small, which forces additional flow out of the Avenue A CSO regulator.

Based on the results of this model run, additional options were considered and run through the model to try to optimize the performance of the existing buffer line while not negatively impacting upstream or downstream conditions.

1B - Buffer Line On and Raise Avenue A Weir

This model run analyzed the impacts of raising the weir at Avenue A to force more flow through to and fill the buffer line prior to leaving the CSO. The results of the model run indicated that raising the weir approximately 1.0’ would allow the buffer line to fill to approximately 75% of its full volume for the 3-month event, and to approximately 90% of its full volume for the 1-year event.

This change also reduces downstream sewer surcharge and SSO volume and reduces system wide CSO volumes by approximately 40%. This alternative results in a 1’ increase in hydraulic grade line (HGL) upstream of Avenue A as the water surface needs to rise an additional 1' to exit the CSO. No new SSOs were noted for the design storms analyzed under this scenario. Based on the results of this model run, it was determined that the sewer leaving the Avenue A diversion structure did not have the capacity to send enough flow downstream to the buffer line structure, therefore additional alternatives involving increasing the pipe diameter for this segment of pipe were considered.

1C - Buffer Line On and Increase Pipe Size to Buffer Line Structure

This model run analyzed the impacts of increasing the pipe diameter between the Avenue A diversion structure (AV-12) and the next structure, which diverts flows to the buffer line (AV-13), from a 21" to a 30". The goal of this model run was to allow more flow to get to the buffer line prior to overflowing the CSO at Avenue A. The results of the model run indicated that increasing the pipe size from AV-12 and AV-13 would allow the buffer line to fill to approximately 75% of its full volume for the 3-month event and to approximately 90% of its full volume for the 1-year event.

The overall results to downstream sewer surcharge and SSOs were similar to alternative 1B and were reduced from existing conditions. This change also reduces system wide CSO volumes by approximately 40% compared to existing conditions, which is comparable to option 1B. This alternative, however, does not result in the same upstream HGL change that raising the weir height does. Based on the results of this alternative, it appears that a combination of 1B and 1C may be required to fully utilize the buffer line.

1D- Buffer Line On, Increase Pipe Size to Buffer Line Structure, and Raise Avenue A Weir

This model run analyzed the impacts of a combination of the upgrades looked at in 1B and 1C. The results of the model indicate that the buffer line would not completely fill for the 3-month design storm but would fill to 100% for the 1-year design storm. While the buffer line still does not fill for the 3-month event, overflows at Avenue A are eliminated. In addition, overall CSO volumes are reduced by approximately 50%. However, both upgrades together would result in sending additional flow to downstream areas that are already inundated during these events, which could make system surcharging worse.

1E- Buffer Line On, Increase Pipe Size to Buffer Line Structure, and Add Orifice Plate

This model run analyzed the impacts of constructing the improvements in 1C while adding an orifice plate to the line leaving the buffer line diversion structure. The goal of this alternative would be to restrict flow from continuing downstream along the interceptor and force it to fill the buffer line and overflow through Avenue A. The results of the model run indicate that this alternative, which assumes the installation of a 15" orifice plate, would result in filling the buffer line to 100% full for both the 3-month and 1-year events, while eliminating downstream SSOs for the 3-month and significantly reducing downstream SSOs for the 1-year event.

This alternative also results in an overall CSO reduction of approximately 50% for the 3-month design storm and 38% for the 1-year. Based on the results of this model run, it appears that the installation of an orifice plate in the buffer line structure should be considered for construction alongside any modifications to the Avenue A or buffer line structure. If the Town completes an extensive sewer separation project that eliminates downstream SSOs in the future, additional hydraulic modeling should be conducted to confirm if the orifice plate should be removed.

1F- Buffer Line On, Increase Pipe Size to Buffer Line Structure, and Raise Avenue A Weir, Reduce Flows Upstream

This model run was conducted to determine the overall level of upstream inflow and infiltration (I/I) reduction required to construct alternative 1D and eliminate SSOs downstream in the interceptor. The goal of this model run is to inform the Town of the extent of I/I reduction necessary to reduce flows such that SSOs are eliminated or reduced for the 3-month and 1-year design storms. The result of the model runs indicate that upstream I/I volume would need to be reduced by approximately 35% to eliminate downstream SSOs for the 3-month design storm and by approximately 76% for the 1-year event.

Additionally, when modeled alongside the upgrades from 1D, it was determined that a 35% reduction in I/I would nearly eliminate CSOs from 7th and L, eliminate Avenue A, and reduce Greenfield CSO by 85% for the 3-month design storm. For the 1-year event, assuming a 76% reduction in I/I volume alongside the improvements from 1D, it was determined that overflows from 7th and L and Avenue A would both be eliminated, and Greenfield would be reduced by approximately 90%. The I/I volume reductions modeled under this alternative are not necessarily tied to performing the Priority 1 and Priority 2 improvements discussed in the Turner's Falls collection system study technical memorandum prepared by Wright-Pierce in 2023. It is likely that additional catch basin separation and I/I mitigation work would be needed in addition to those improvements identified to meet the 35% I/I reduction modeled in this analysis.

Alternative 1 Results

The result of the model runs conducted under Alternative 1 indicate that manually operating the buffer line slide gate to allow the stored flows to drain and closing prior to a rain event could reduce CSOs by approximately 10% at the downstream Greenfield CSO, however, it would have little impact on Avenue A CSOs without additional system modifications. Wright-Pierce recommends that the Town of Montague take initial steps to manually operate the buffer line slide gate by closing the slide gate prior to any significant rain events and opening the gate after rain events to release any stored volume, once flows at the downstream CWF have subsided, to capture CSO volumes to the extent possible.

A combination of raising the weir at the Avenue A diversion structure, increasing the pipe size between Avenue A diversion structure and the buffer line diversion structure, and installing an orifice plate to the outlet of the buffer line diversion structure would produce a short-term solution by reducing CSO volumes, reducing surcharging in downstream sewers, and increasing the volume of flow directed to the buffer line. These changes are relatively inexpensive and easy to install, modify, or remove. Wright-Pierce recommends that the Town of Montague perform these upgrades within a timeframe that is cost feasible to the Town but within the next three to five years. Additional hydraulic modeling is also recommended to verify the pipe size, orifice size and weir height combination that results in the most effective control.

Ultimately, the long-term solution to mitigating CSOs for the 1-year storm and beyond will likely include upstream I/I reduction and sewer separation projects.

The results of the Alternative 1 model simulations are summarized in Table 2 (3-month storm event) and Table 3 (1-year storm event) below.

Table 2 Montague, MA Alternative 1 Results – 3 Month

Alternative	Model-Predicted CSO Volumes (Gal)				
	7th & L Streets CSO	Avenue A CSO	Greenfield Road CSO	Total CSO Volume	Total CSO % Reduction
Existing Conditions	20,000	65,000	49,000	134,000	-
1A - Buffer Line Only	20,000	65,000	34,000	119,000	11%
1B – Buffer Line/Raise Ave. A	20,000	12,000	48,000	80,000	40%
1C – Buffer Line/AV-12-AV-13 30	20,000	12,000	47,000	79,000	41%
1D – Buffer Line/AV-12-AV-13 30"/Raise Ave. A	20,000	0	48,000	68,000	49%
1E – Buffer Line/ AV-12-AV-13 30"/Orifice Plate	20,000	11,000	34,000	65,000	51%
1F – Buffer Line/Raise Ave. A/AV-12-AV-13 30"/I/I Reduction Projects	1,000	0	18,000	19,000	86%

Table 3 Montague, MA Alternative 1 Results – 1 Year

Alternative	Model-Predicted CSO Volumes (Gal)				
	7th & L Streets CSO	Avenue A CSO	Greenfield Road CSO	Total CSO Volume	Total CSO % Reduction
Existing Conditions	48,000	98,000	121,000	267,000	-
1A - Buffer Line Only	48,000	107,000	64,000	219,000	18%
1B – Buffer Line/Raise Ave. A	48,000	35,000	79,000	162,000	39%
1C – Buffer Line/AV-12-AV-13 30"	48,000	33,000	77,000	158,000	41%
1D – Buffer Line/AV-12-AV-13 30"/Raise Ave. A	48,000	3,000	84,000	135,000	49%
1E – Buffer Line/ AV-12-AV-13 30"/Orifice Plate	48,000	56,000	62,000	166,000	38%
1F – Buffer Line/Raise Ave. A/AV-12-AV-13 30"/I/I Reduction Projects	0	0	27,000	27,000	90%

Alternative 2 - Increase System Pipe Sizes Along Trunkline While Not Operating the Existing Buffer Line

Alternative 2 was run for the 3-month and 1-year, 24-hour design storms. Several iterations were modeled to include various project extents and their potential impacts on CSO volumes at the Greenfield CSO. The options modeled as part of this alternative include:

- Increasing the pipe diameter between PS-GE-4 and PS-GE-3 to be a full length 24-inch pipe.
- Increasing the last two pipe diameters before the CWF to be 30-inch pipes.
- Increasing all pipe diameters between the Greenfield CSO to the CWF to 24-inch.
- increasing all pipe diameters between the Greenfield CSO to the CWF to 30-inch.

Alternative 2 does not include any of the work proposed under Alternative 1.

2A – Increase Pipe Diameter from PS-GE-4 to PS-GE-3 to 24-inch

The results of this alternative simulation indicate that by increasing one segment of pipe to 24-inch between PS-GE-4 and PS-GE-3, CSO volumes can be reduced at the Greenfield CSO by up to 37% for a 3-month design storm and 25% for a 1-year design storm. This pipe was measured by Wright-Pierce field staff to be 24-inches in diameter at the upstream end and only 15-inches in diameter at the downstream end. The location and reason for this transition was unable to be determined in the field, therefore, the entire pipe segment was conservatively modeled as a 15-inch diameter pipe.

2B – Increase Pipe Diameter of Last Two Pipes before CWF to 30-inch

The results of this alternative simulation indicate that by replacing the last two pipe segments upstream of the CWF with 30-inch pipes, CSO volumes could be reduced at the Greenfield CSO by up to 51% and 34% for the 3-month and 1-year design storms, respectively.

2C – Increase Pipe Diameter from Greenfield CSO to CWF to 24-inch

The results of this alternative simulation indicate that by upgrading the entire length of sewer between the Greenfield CSO diversion structure and the CWF with 24-inch diameter pipes, CSO volumes could be reduced at the Greenfield CSO by up to 69% and 76% for the 3-month and 1-year design storms, respectively.

2D – Increase Pipe Diameter from Greenfield CSO to CWF to 30-inch

The results of this alternative simulation indicate that by upgrading the entire length of sewer between the Greenfield CSO diversion structure and the CWF with 30-inch diameter pipes, CSO volumes could be eliminated at the Greenfield CSO for both the 3-month and 1-year design storms.

Alternative 2 Results

The result of the model runs conducted under Alternative 2 indicate that elimination of Greenfield CSOs for rain events up to and including the 1-year, 24-hour design storm could be achieved by increasing the interceptor pipe diameters between the CSO and the CWF to 30-inch diameter.

Based on the need to bypass pump for any of the proposed upgrade projects and the ongoing maintenance issues caused by sediment and grit deposits near the CWF, it is recommended that if the Town pursues a project that increases pipe sizes in this area, that they also relay the pipe to maintain minimum recommended pipe slopes. This would maintain the full flow scouring velocities needed to keep pipes clean and would provide enough capacity to reduce CSO volumes in the future.

However, a pipe size increase would increase peak flows to the CWF, which would require the Town to use the Wet Weather Chlorine Contact Tank (WWCCT) more frequently to bypass excess flows away from their secondary treatment process. Additionally, the capacity of the CWF's WWCCT system is currently unknown and would require additional study to verify that the increase in flow rates could be accommodated. Based on current conditions, the CWF's primary treatment capacity is approximately 4 MGD; there will be a Greenfield CSO overflow if the flow to the CWF is above approximately 4 MGD assuming that the influent pipes downstream of the Greenfield CSO interceptor are clean and that the CWF Headworks grit channels and influent screening channel are not full of debris.

The hydraulic model used for this analysis only considers the collection system and assumes that the CWF can convey additional flows without impacting the upstream gravity system. After review of previous studies of the CWF, it was confirmed that this was not a conservative assumption. Therefore, to estimate the potential impact that the CWF's capacity has on CSOs, the hydraulic model was re-run assuming that it was pushing against a tailwater condition at the CWF. For these tailwater model runs, a technical memorandum developed by Wright-Pierce, dated 7/30/2021 was referenced, which estimated that the hydraulic capacity of the primary treatment processes of the CWF without overflowing the Greenfield Road CSO structure is 4.07 MGD. Using this flow rate, the hydraulic model predicted that the tailwater elevation from the CWF could be as high as 140.4 prior to causing an overflow at Greenfield CSO. Using this tailwater elevation, the Existing Conditions and Alternative 2(A-D) models were re-run, and the results were summarized in Table 4. The values in parentheses indicate those that were predicted during the tailwater conditions run.

The Town of Montague could consider replacing and relaying the last two segments of sewer entering the CWF with 24" or 30-inch pipe for an interim solution. This would allow for a reduction in CSO volumes leaving Greenfield Road CSO of up to 30% for a 3-month design storm. However, additional hydraulic modeling is required first to estimate the overall impact of constructing both short-term recommendations for Alternatives 1 and 2 and to determine if 24" or 30" pipe should be installed for Alternative 2's short-term recommendation.

The long-term solution to mitigating CSO volumes from Greenfield CSO is to increase the pipe diameter between Greenfield CSO and the CWF to a 30-inch diameter pipe. However, if the Town pursues additional sewer separation projects and/or the projects recommended in the Turner's Falls collection system study memo (priority 1 and priority 2 I/I rehabilitation projects), sewer system flow rates should be re-monitored downstream of the projects and the model revisited to determine the extent of additional projects needed. Alternatively, another long-term solution to mitigating CSO volumes from Greenfield CSO is to design and construct multiple, phased sewer separation projects.

The results of the Alternative 2 model simulations are summarized in Table 4 (3-month storm event) and Table 5 (1-year storm event) below.

Table 4 Montague, MA Alternative 2 Results – 3 months

Alternative	Model-Predicted CSO Volumes (Gal)[2]					
	7th & L Streets CSO	Avenue A CSO	Greenfield Road CSO	Total CSO Volume	Total CSO % Reduction[1]	Estimated Peak Flow to CWF (MGD)[1]
Existing Conditions	20,000	65,000	49,000 (95,000)	134,000 (180,000)	-	5.8 (4.9)
2A – Increase Pipe Diameter of Segment PS-GE-4-PS-GE-3 Pipe to 24”	20,000	65,000	31,000 (69,000)	116,000 (154,000)	13% (14%)	6.4 (5.5)
2B – Increase Pipe Diameter of Last 2 Pipe Segments before CWF to 30”	20,000	65,000	24,000 (65,000)	109,000 (150,000)	19% (17%)	6.6 (5.7)
2C – Increase Pipe Diameter from Greenfield CSO to CWF to 24”	20,000	65,000	15,000 (45,000)	100,000 (130,000)	25% (28%)	7.0 (6.2)
2D – Increase Pipe Diameter from Greenfield CSO to CWF to 30”	20,000	65,000	0 (0)	85,000 (85,000)	37% (53%)	8.4 (8.4)

[1] Alternative 2 does not include any of the work proposed under Alternative 1.
[2] Values in parentheses show model results including CWF tailwater conditions.

Table 5 Montague, MA EPASWMM Model Simulation Results – 1 year

Alternative	Model-Predicted CSO Volumes (Gal)[2]					
	7th & L Streets CSO	Avenue A CSO	Greenfield Road CSO	Total CSO Volume	Total CSO % Reduction[1]	Estimated Peak Flow to CWF (MGD)[1]
Existing Conditions	48,000	98,000	121,000 (186,000)	267,000 (332,000)	-	5.9 (5.1)
2A – Increase Pipe Diameter of Segment PS-GE-4-PS-GE-3 Pipe to 24”	48,000	98,000	91,000 (147,000)	237,000 (293,000)	11% (12%)	6.6 (5.7)
2B – Increase Pipe Diameter of Last 2 Pipe Segments before CWF to 30”	48,000	98,000	80,000 (138,000)	226,000 (284,000)	15% (14%)	6.8 (5.9)
2C – Increase Pipe Diameter from Greenfield CSO to CWF to 24”	48,000	98,000	29,000 (68,000)	175,000 (214,000)	34% (36%)	7.1 (6.3)

Alternative	Model-Predicted CSO Volumes (Gal)[2]					
	7th & L Streets CSO	Avenue A CSO	Greenfield Road CSO	Total CSO Volume	Total CSO % Reduction[1]	Estimated Peak Flow to CWF (MGD)[1]
2D – Increase Pipe Diameter from Greenfield CSO to CWF to 30"	48,000	98,000	0 (0)	146,000 (146,000)	45% (56%)	8.7 (8.7)

[1] Alternative 2 does not include any of the work proposed under Alternative 1.
[2] Values in parentheses show model results including CWF tailwater conditions.

Recommendations

The result of the model runs conducted in this study revealed the following immediate, short- and long-term recommendations for the Town of Montague. These recommendations may not be all inclusive of sewer collection system and CWF studies and construction projects that should be developed and implemented in the Town of Montague. These recommendations do not include improvements in the Millers Falls sewer collection system.

Immediate Recommendations

- Manually operate the buffer line slide gate by closing the slide gate prior to any significant rain events and opening the gate after rain events to release any stored volume, once flows at the downstream CWF have subsided, to capture CSO volumes to the extent possible.
- Develop a standard operating procedure (SOP) for buffer line operation and maintenance.

Short-Term Recommendations

- Design and construct an improvement project (Avenue A Buffer Line Improvement Project) to raise the weir at the Avenue A diversion structure, increase the pipe size between the Avenue A diversion structure and the buffer line diversion structure, and install an orifice plate to the outlet of the buffer line diversion structure to reduce CSO volumes, reduce surcharging in downstream sewers, and increase the volume of flow directed to the buffer line. Additional hydraulic modeling is required during the preliminary design to verify the pipe size, orifice size and weir height combination that results in the most effective control. Refer to the Avenue A Buffer Line Improvement Project (Alternative 1D and Alternative 1E) – Opinion of Probable Construction Cost (OPCC) subsection below.
- Evaluate and / or confirm the peak capacity of the CWF's primary treatment and WWCCT systems to verify ability to convey increased flow rates and verify the appropriate tailwater to include in the hydraulic modeling at flow rates exceeding 4.07 MGD.
- Consider / evaluate replacing and relaying the last two segments of sewer entering the CWF with 24-inch or 30-inch pipe.
- Perform additional hydraulic modeling to estimate the overall, comprehensive impact of constructing the short-term recommendations in the vicinity of Avenue A/buffer line (Alternative 1) and just upstream of the CWF (Alternative 2).
- Design and construct upstream I/I reduction projects (Priority 1 and Priority 2 Turners Falls I/I Sewer Rehabilitation projects).

- Perform additional flow monitoring and subsequent hydraulic modeling after each short-term recommendation is implemented.

Avenue A Buffer Line Improvement Project (Alternative 1D and Alternative 1E)- Opinion of Probable Construction Cost (OPCC)

Table 6 provides the planning level total estimated OPCC for the Avenue A Buffer Line Improvement Project. Refer to the first bullet point under Short-Term Recommendations above on page 14 of 17.

Unit costs provided in the following tables are based on average bid tabulations based on Wright-Pierce reviewed design projects and on Wright-Pierce estimates for services. These planning-level costs were developed using standard cost estimating procedures consistent with industry standards using unit cost information. Several assumptions were made (see footnotes below the table); during preliminary design, these assumptions will be clarified and a revised OPCC should be developed. The following OPCC is based on May 2023 (ENR Index 13288) construction costs and subject to inflation, rate of escalation etc.

Table 6 Avenue A Buffer Line Improvement Project (Alternative 1D and Alternative 1E) – Planning Level OPCC

Item	Quantity	Unit Price	Cost
Avenue A Buffer Line Improvement Project[1]			
Crew Labor & Equipment	5 days	$10,000 / day	$50,000
Sewer Bypass Rental & Operation	1 week	$10,000 / week	$10,000
Pipe Replacement (from 20" to 30")	7 LF	$500 / LF	$3,500
Pipe Boot Adjustment in MH (21" to 30")	2 each	$5,000 / each	$10,000
Officers and Signs for Traffic	5 days	$4,000 / day	$20,000
Install 12" to 15" Orifice plate in MH	1 each	$25,000/ each	$25,000
Diversion Weir Adjustments	1 each	$5,000 / each	$5,000
Paving	1 (lump sum)	$5,000	$5,000
Construction Subtotal	-	-	$126,000
Design Contingency (20%)			$25,200
Construction Contingency (35%)			$44,100
Engineering and Administrative Fees (30%)			$37,800
Technical Services Allowance (Hydraulic Modeling and Field Investigations)			$30,000
Avenue A Buffer Line Improvement Project Total (rounded)			$300,000

[1]Assumptions:

The Contractor will only be required to perform minimal dewatering during construction.

All excavation areas have been previously excavated with no ledge present.

All excavation areas have been previously excavation with clean fill that can be replaced in trench during backfilling.

Construction work can be performed with one lane closure.

The existing manholes can accept larger pipe and the orifice plate without replacement.

Pipe replacement length measured from manhole center to manhole center.

A local bypass can be performed, although the option for a longer bypass (and lane closure length) is available if a wider travel lane is needed.

Budgetary Planning Level Costs

Table 7 provides short-term recommendations' budgetary planning level costs using May 2023 dollars (ENR Index 13288). All budgetary planning level costs are to provide an order of magnitude; actual cost to the Town of Montague is subject to final scope. Wright-Pierce recommends that the Town of Montague implement some or all of the short-term recommendations within a timeframe that is cost feasible to the Town but within the next three to five years.

Table 7 Short-Term Recommendations – Budgetary Planning Level Costs

Short-Term Recommendations	Order of Magnitude Cost
Avenue A buffer line improvement project	$300,000
Evaluate and/or confirm peak capacity of CWF WWCCT and primary treatment	$30,000
Hydraulic modeling	$100,000
Design and construction of upstream I/I reduction projects (Priority 1 and Priority 2 projects in Turner's Falls)	$1,200,000
Total	$1,750,000 (rounded)

Long-Term Recommendations

- Perform a combined sewer separation study / 30% preliminary design to confirm where all combined sewers are currently located in Town, to develop a phased approach to sewer separation, to confirm reuse of existing sewer infrastructure and make recommendations for rehabilitation, to develop an opinion of probable construction cost (OPCC), and to evaluate potential funding sources.
- Perform additional field investigations and design and construct other upstream I/I reduction projects.
- Perform additional flow monitoring and subsequent hydraulic modeling downstream of the I/I reduction and sewer separation projects after each phase or project is completed.
- Consider increasing the pipe diameter between Greenfield CSO and the CWF to a 30-inch diameter pipe, assuming the updated hydraulic modeling confirms this is still necessary.
- Design and construct sewer separation projects. A phased approach may aid the Town in completing this work within a timeframe that is cost feasible. If the Town completes an extensive sewer separation project that

eliminates downstream CSOs in the future, additional hydraulic modeling should be conducted to confirm if the orifice plate (part of the Short-Term Recommendations at the Avenue A CSO) should be removed.

Budgetary Planning Level Costs

Table 8 provides some long-term recommendations' budgetary planning level costs using May 2023 dollars (ENR Index 13288). All budgetary planning level costs are to provide an order of magnitude; actual cost to the Town of Montague is subject to final scope. Wright-Pierce recommends that the Town of Montague implement some, or all, of these long-term recommendations within a timeframe that is cost feasible to the Town. These long-term recommendations and budgetary planning level costs should be revisited within the next five years.

Table 8 Long-Term Recommendations – Budgetary Planning Level Costs

Long-Term Recommendations	Order of Magnitude Cost
Sewer Separation Study / 30% Preliminary Design Report[1]	$1,750,000
Additional I/I and SSES, Field Investigations, Flow Metering	$300,000
Hydraulic modeling	$200,000
Design and construction of future upstream I/I reduction projects	$2,500,000
Sewer Separation Project (Multiple Phases)[2]	$20M-$25M
Total	$25M-$27M (rounded)

[1] Based on 16,000 LF of sewer separation in Turner's Falls. Includes topographic survey, field investigative work, geotechnical investigations, report development, OPCC development, and 30% drawings.

[2] Based on 16,000 LF of sewer separation in Turner's Falls. OPCC will be developed as part of the Sewer Separation Study / 30% Preliminary Design Report.