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December 28, 2022

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Todd J. Borci
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5 Post Office Square Suite 100 (OES 04-4)
Boston, MA 02109-3912

RE: Charles River and Alewife Brook/Upper Mystic River CSO Variances
CSO System Optimization for Alewife Brook and Lower Charles River Basins Project, Study and Preliminary Design

Dear Ms. King and Mr. Borci:

The Massachusetts Water Resources (MWRA) is pleased to submit the Alewife Brook and Lower Charles River System Optimization Evaluations Report. MWRA is submitting this report to the Massachusetts Department of Environmental Protection ("MassDEP") for review and approval in accordance with the MassDEP's *Final Determination to Adopt a Variance for Combined Sewer Overflow Discharges to Alewife Brook/Upper Mystic River Basin* (August 30, 2019) and *Final Determination to Adopt a Variance for Combined Sewer Overflow Discharges to Charles River Basin* (August 30, 2019) (collectively the "Variances"). This report is the third and final report on system optimization measures to be studied under the Variances, with the intent of evaluating whether implementation of these measures will improve combined sewer overflow (CSO) performance and water quality.

Using the MWRA's calibrated hydraulic model, MWRA has conducted system optimization evaluations at the remaining active regulators tributary to CSO outfalls that can discharge to the Alewife Brook and Charles River watersheds. Optimization measures evaluated included overflow weir modification or raising, dry weather connection relief and flow reallocation opportunities.

The details of these evaluations are include in the attached Alewife Brook and Lower Charles River System Optimization Evaluations report. Given the newly calibrated hydraulic model based on recent system information and extensive metering data collected during the CSO Post Construction Monitoring and Performance Assessment, MWRA in concurrence with MassDEP felt it worthwhile to looking for further opportunities to optimize CSO performance. Unfortunately, the study and subsequent report did not identify any optimization alternatives for the Alewife Brook CSOs and regulators, and only identified one alternative recommended for further action associated with the Charles River CSOs and regulators (CAM005). As you may recall, optimization measures were implemented in the mid-1990s, using an earlier version of the hydraulic model. At that time, approximately 100 system optimization measures were implemented reducing the system wide CSO volumes by over 20%. The limited opportunity for further optimization measures, without adverse hydraulic impacts suggests that these earlier efforts achieved the goal of maximizing the use of the CSO community's and MWRA's collection systems.

Optimization of the weir at CAM005 will continue to be evaluated. Due to the location of the regulator structure in the driveway of the Mt Auburn Hospital, access is limited and the proposed modifications of raising and lengthening the weir will need to be installed manually from inside the structure. MWRA is working with the City of Cambridge to collect additional information on the regulator structure by conducting an interior laser scan. In addition, further analysis of the optimal configuration for the raised and lengthened weir, including assessment of materials of construction and further analysis of the hydraulics through Computational Fluid Dynamics (CFD) modelling or detailed system monitoring, as well as a construction feasibility analysis is under consideration.

Please do not hesitate to contact me at dave.coppes@mwra.com, should you have questions or require any additional information regarding MWRA's progress to date in meeting CSO variance requirements.

Very truly yours,

Carolyn M. Fiore

for David W. Coppes, P.E.
Chief Operating Officer

cc: Fred Laskey, Executive Director
Carolyn Francisco-Murphy, General Counsel
Carolyn Fiore, Deputy Chief Operating Officer
Rebecca Weidman, Director, Environmental and Regulatory Affairs
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AECOM

Task 8.2 – 8.3: Alewife Brook and Charles River System Optimization Evaluations

CSO Post Construction Monitoring and Performance Assessment

MWRA Contract No. 7572

December 28, 2022

Project number: 60559027

Delivering a better world

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The 2019 Final Determination to Adopt a Variance for Combined Sewer Overflow (CSO) Discharges to Alewife Brook/Upper Mystic River Basin (the Alewife Brook/Upper Mystic River Variance), and the 2019 Final Determination to Adopt a Variance for Combined Sewer Overflow Discharges to Charles River Basin (the “Charles River Variance”) required that system optimization be conducted at each of the remaining active regulators tributary to CSO outfalls discharging to the Alewife Brook and Charles River watersheds. Six CSO outfalls (CAM001, CAM002, MWR003, SOM001A, CAM401A, and CAM401B) can discharge untreated CSO to the Alewife Brook. Eight CSO outfalls can discharge untreated CSO to the Charles River, and one outfall can discharge treated CSO. The untreated CSOs include CAM005, CAM007, CAM017, MWR010, MWR018, MWR019, MWR020, and MWR023, while the treated discharge is from the MWRA’s Cottage Farm facility at outfall MWR201.

Using the hydraulic model, overflow volumes by storm from the Typical Year were tabulated for each outfall, along with the predicted volumes from the 2-year and 5-year, 24-hour design storms. Profiles of the peak hydraulic grade line through the regulators were also developed. The model was then used to assess the impacts of incrementally raising the weirs and/or increasing the size of the dry weather flow connections at the regulators associated with these outfalls. For the Cottage Farm CSO facility, potential modifications to facility operations were evaluated.

For the Alewife Brook, no additional optimization measures were recommended for any of the existing CSO outfalls (CAM001, CAM002, CAM401A, CAM401B, MWR003, and SOM001A). For the Charles River, outfall CAM005 was the only outfall recommend for further optimization. The analysis of outfall CAM005 showed that raising the weir at regulator RE051 by 1 foot and lengthening the weir to 10 feet would reduce the CSO activation frequency and volume without creating adverse impacts on the hydraulic grade line in up to a 10-year 24-hour storm. No optimization measures were recommended at the remaining outfalls along the Charles River (outfalls CAM007, CAM017, MWR010, MWR018, MWR019, MWR020, MWR201 [Cottage Farm CSO facility], and the regulators upstream of outfall MWR023).

Optimization of the weir at CAM005 will continue to be evaluated. Given the likely non-standard configuration of the weir, CFD modelling may be needed to confirm the hydraulic performance. Due to the location of the regulator structure in the driveway of the Mt Auburn Hospital, access is limited and the proposed modifications would need to be installed manually from inside the structure. Additional information will be gathered on the regulator structure by conducting a laser scan. In addition, further analysis of the optimal configuration for the raised and lengthened weir, including assessment of materials of construction and further analysis of the hydraulics through CFD modelling or detailed system monitoring, as well as a construction feasibility analysis is under consideration.

1. Introduction

1.1 Report Purpose/Background

This report has been prepared in compliance with the conditions of the Alewife Brook/Upper Mystic River Variance and the Charles River Variance (collectively the “Variances”). Specifically, Attachment A to the Variances required the Massachusetts Water Resources Authority (MWRA) to:

> *… conduct system optimization evaluations at the remaining active regulators tributary to CSO outfalls discharging to the Alewife Brook and Charles River watersheds. The MWRA will implement recommended modifications to those regulators owned by MWRA and will provide technical support to member communities in their efforts to implement recommended modifications to community owned CSO regulators. The MWRA anticipates evaluating and implementing optimization measures such as regulator closing, overflow weir modification or raising, dry weather connection relief and flow reallocation opportunities.* (Variances, Exhibit A)

The optimization evaluations were part of a series of actions required by the Variances to:

> *…further MWRA's goals of improving water quality in the Lower Charles River, Upper Mystic River, and Alewife Brook. These measures are consistent with the requirements of 40 CFR 131.14, and allow for progress to be made towards attaining designated use(s) and water quality criteria. Collectively with the other elements of the CSO Variance requirements, these efforts comprise the Pollutant Minimization Program to be implemented during the course of the CSO Variance. Additional CSO system optimization efforts and on-going implementation of the "CSO Nine Minimum Controls" will be informed by MWRA's hydraulic model, which is in the process of being calibrated with extensive flow and overflow meter data being gathered, which commenced in 2018…These efforts will also be informed by MWRA's updated receiving water quality models, which will be produced and available in the early years of the variance period.* (Variances, Exhibit A)

System optimization measures were first implemented throughout the combined sewer communities of Cambridge, Somerville, Chelsea and Boston, as well as for MWRA owned and operated CSO outfalls, during the mid-1990's as part of the activities leading up to development of the 1997 *CSO Facilities Plan and Environmental Impact Report* (Metcalf & Eddy, 1997). Since that time, as MWRA and the CSO communities implemented the components of the 1997 plan, they have also actively looked for further opportunities to cost-effectively improve operations of their respective systems.

The calibration of MWRA's hydraulic model and the update of MWRA's receiving water quality models referenced in the Variances above were conducted as part of the MWRA's CSO Post Construction Compliance and Monitoring Program (PCCMP). The performance assessment was conducted to comply with the last two scheduled milestones in the 36-year-old Federal District Court Order in the Boston Harbor Case (U.S. v. M.D.C., et al, No. 85-0489 MA). From 1987 through 2015, MWRA addressed 182 CSO-related court schedule milestones, including completing the construction of the 35 wastewater system projects that comprised the MWRA's CSO Long Term Control Plan (LTCP) by December 2015. The last two court milestones required MWRA to:

- Commence by January 2018 a three-year[1] performance assessment including post-construction monitoring in compliance with EPA's CSO Policy (59 Fed. Reg. 18688) (April 19, 1994); and
- Submit by December 2021 the results of its performance assessment to the U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (DEP)

These requirements were pursuant to the March 15, 2006*, Second Stipulation of the United States and the Massachusetts Water Resources Authority on Responsibility and Legal Liability for Combined Sewer Overflow Control*, as amended on April 30, 2008 (the "Second Stipulation", see further discussion below). With submittal of the PCCMP report in December 2021, all of the court-imposed deadlines were met.

One of the goals of the PCCMP was to improve the level of confidence in the MWRA's collection system model for predicting system conditions and CSO discharges so that the model could reliably be used to establish system performance for the Typical Year. This effort included updating the model network to reflect changes in the MWRA system and the community systems to better represent CSO discharges. The update also included recalibration of the model using meter data collected from April 15, 2018 through June 30, 2020 at 64 regulator locations as well as data collected included existing MWRA and community flow meter data, and MWRA facility operational data. Overall, the metering program provided extensive data to assess CSO activations and for model calibration. The improved hydraulic model created the opportunity for MWRA to further evaluate the individual CSO regulators within the Alewife Brook and Charles River system for potential optimization measures that could further improve performance without causing adverse impacts such as upstream flooding. These evaluations were conducted regardless of whether the individual CSO outfalls were meeting the targets for average annual discharge volume or frequency specified in the Second Stipulation. The receiving water quality modelling conducted as part of the PCCMP also provides context for the potential water quality benefits of the potential optimization measures. The *Task 6: Final CSO Post Construction*

[1] On July 19, 2019, Federal District Court Judge Richard G. Stearns issued an order extending the milestone for submission of the final report by one year, from December 31, 2020 to December 31, 2021. MWRA had requested the extension to provide the time necessary to perform receiving water quality modelling to support water quality assessments for the Lower Charles River/Charles Basin and the Alewife Brook/Upper Mystic River.

Monitoring Program and Performance Assessment Report and *Semiannual Reports Nos. 2, 5, 6 and 7* provide additional information on model updates and recalibration.

1.2 Description of Baseline Model Used for Evaluations

The optimization evaluations presented herein were based on a "future conditions" baseline model. The starting point for development of the future conditions baseline model was the "Q1-2022" version of MWRA's model. The Q1-2022 model represents system conditions as of the first quarter of 2022 and includes updates for projects that were completed since the "Q4-2021" version of the model that was used as a basis of the performance presented in the December 2021 *Task 6: Final CSO Post Construction Monitoring Program and Performance Assessment Report* . Certain additional projects that are anticipated to be completed in the near future were then added to the Q1-2022 baseline conditions model to create the future conditions baseline used for the optimization evaluations. Projects that have been incorporated into the future conditions baseline model that were not in the Q4-2021 model include cleaning of the CAM005 outfall, Willard Street (Cambridge) sewer separation, the Somerville Marginal CSO Facility connection to the Somerville Medford Branch Sewer as described in the *Task 8.4 Somerville Marginal CSO Facility* report (AECOM 2021), the recommended improvements in the siphon chamber upstream of outfall BOS017, East Boston Phase II sewer separation, dry weather flow connection relief at CHE008, and Boston Gatehouse 1 operational updates based on the Boston Water and Sewer Commission (BWSC) standard operating procedures.

For this evaluation, the current MWRA Typical Year and design storms used for CSO evaluations under MWRA's CSO program were used. The 2-year and 5-year, 24-hour design storm characteristics are shown in Table 1-1.

Table 1-1: Design Storm Characteristics

Storm Event	Depth (in)	Max intensity (in/hr)
2-Year, 24-hour	3.15	1.18
5-Year, 24-hour	4.05	1.55

Table 1-2 presents the activation frequency and volume for the Typical Year and the 2-year and 5-year, 24-hour storms for the future conditions baseline. Optimization evaluations were not considered at locations that did not activate in the 5-year, 24-hour storm.

Table 1-2. Predicted Annual CSO Activation Frequency and Volume for the Future Conditions Baseline: Typical Year, and 2-year and 5-year, 24-hour Storms

Outfall	Regulator	Future Conditions Baseline					
		Typical Year		2-Year, 24-hour Storm		5-Year, 24-hour Storm	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Alewife Brook							
CAM001	RE-011	1	0.02	1	0.07	1	0.10
CAM002	RE-021	0	0.00	0	0.00	1	0.09
MWR003	RE-031	3	0.61	1	1.51	1	3.03
CAM401A	RE-401	5	0.66	1	1.36	1	2.16
CAM401B	RE-401B	4	0.50	1	0.71	1	0.99
SOM001A	RE-01A	8	4.47	1	2.78	1	4.16
SUM		8 (max)	6.26		6.43		10.53

Table 1-2. Predicted Annual CSO Activation Frequency and Volume for the Future Conditions Baseline: Typical Year, and 2-year and 5-year, 24-hour Storms

Outfall	Regulator	Future Conditions Baseline					
		Typical Year		2-Year, 24-hour Storm		5-Year, 24-hour Storm	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Upper Charles							
CAM005	RE-051	7	0.99	1	1.08	1	2.05
CAM007	RE-071	2	0.21	1	1.47	1	3.56
SUM		7 (max)	1.20		2.55		5.61
Lower Charles							
CAM017	CAM017	0	0.00	1	2.33	1	4.53
MWR010	RE036-9	0	0.00	0	0.00	0	0.00
	RE037	0	0.00	0	0.00	1	0.60
MWR018	Charles River	2	1.11	1	1.65	1	2.02
MWR019	Charles River	2	0.48	1	1.07	1	1.57
MWR020	Charles River	2	0.47	1	4.41	1	5.62
MWR201	Cottage Farm	2	8.90	1	19.82	1	28.19
MWR023	RE046-19	0	0.00	0	0.00	1	0.11
	RE046-30	0	0.00	0	0.00	0	0.00
	RE046-50	0	0.00	0	0.00	0	0.00
	RE046-54	0	0.00	0	0.00	0	0.00
	RE046-55 1	0	0.00	0	0.00	0	0.00
	RE046-62A	0	0.00	0	0.00	0	0.00
	RE046-90	0	0.00	0	0.00	1	0.13
	RE046-100	1	0.10	1	0.34	1	0.53
	RE046-105	0	0.00	1	0.02	1	0.08
	RE046-381	1	0.03	1	0.54	1	0.88
	RE046-192	0	0.00	0	0.00	0	0.00
MWR023 Upstream Regulator Total		1	0.13	1	0.23	1	0.43
SUM		2 (max)	11.25		30.18		44.26

1.3 Evaluation Approach

The approach for evaluating potential optimization measures for Alewife Brook and the Charles River included the following general steps:

1. Establish future baseline conditions for CSO activation frequency and volume under the Typical Year and 2-year and 5-year, 24-hour storms (see Table 1-2).

2. Develop plots of the peak hydraulic grade line (HGL) from the interceptor through each regulator and into the upstream system, for selected storms in the Typical Year, and for the 5-year, 24-hour storm. Selected storms in the Typical Year generally included the storm causing the largest CSO volume discharge, and one or more smaller storms that still caused CSO activations (if applicable).

3. Review the HGL plots to identify locations where raising the weir could potentially take advantage of available upstream storage or relieving a dry weather flow connection could potentially allow more flow into the interceptor system.

4. Where potential opportunities were identified, use the model to assess the impacts of incrementally raising the weir and/or increasing the size of the dry weather flow connection as appropriate. For CSO facilities (i.e., Cottage Farm), potential modification to facility operations were evaluated. CSO performance was assessed at the optimized regulator (or facility) and other hydraulically-related regulators, while HGL impacts were evaluated upstream of the regulator, in the interceptor, and upstream of hydraulically-related regulators.

5. At an initial screening level, adverse HGL impacts were considered to be where the baseline HGL in the 5-year, 24-hour storm was within seven feet of the ground surface and was predicted to increase by 0.25 feet or more as a result of the optimization measure.

6. Where an optimization measure was predicted to have an adverse impact on the HGL, mitigation measures such as lengthening the weir or providing a flap gate to minimize backflow from the interceptor were considered.

7. For optimization measures that showed a net benefit in CSO activation and/or volume reduction without adverse HGL impacts, concept-level sketches of the optimization measure were developed. The concepts were then reviewed with the MWRA and the appropriate CSO community. Implementation concerns were identified, as well as the need for further hydraulic evaluations to confirm the expected performance and/or sizing. If appropriate, planning-level estimates of construction costs were developed.

8. Based on the evaluations conducted, recommendations for implementation of optimization measures are presented. Note that Exhibit A of the Variances states that:

> *Implementation [of optimization measures] will proceed unless the feasibility evaluation clearly demonstrates that construction is technically infeasible, that the project will not provide water quality benefits through the reduction of CSO volume and frequency, or that the costs, alone or in conjunction with other activities specified in Exhibit A, would cause widespread social and economic impact.* (Variances, Exhibit A)

As part of the optimization evaluations presented below, some cases were identified where the predicted decrease in CSO discharge for the optimization measure was considered small, with minimal water quality benefit, and work needed to implement the optimization measure would require costs and/or construction impacts beyond what would normally be considered for “system optimization”. In these cases, the alternatives were not recommended for implementation as part of a system optimization program.

2. Alewife Brook Optimization Evaluations

2.1 System Overview and LTCP Goals

Six CSO outfalls (CAM001, CAM002, MWR003, SOM001A, CAM401A, and CAM401B) discharge to the Alewife Brook. The dry weather flow outlets from the regulators associated with these CSO outfalls directly discharge to either the Alewife Brook Branch Sewer (ABBS) or the Alewife Brook Conduit (ABC). Dry weather flow is carried by the ABBS and ABC to the Alewife Brook Pump Station. When the HGL exceeds the elevation of the overflow points in the regulators along the ABBS and ABC, excess flow discharges to the Alewife Brook. A schematic of the Alewife Brook System is shown in Figure 2-1.

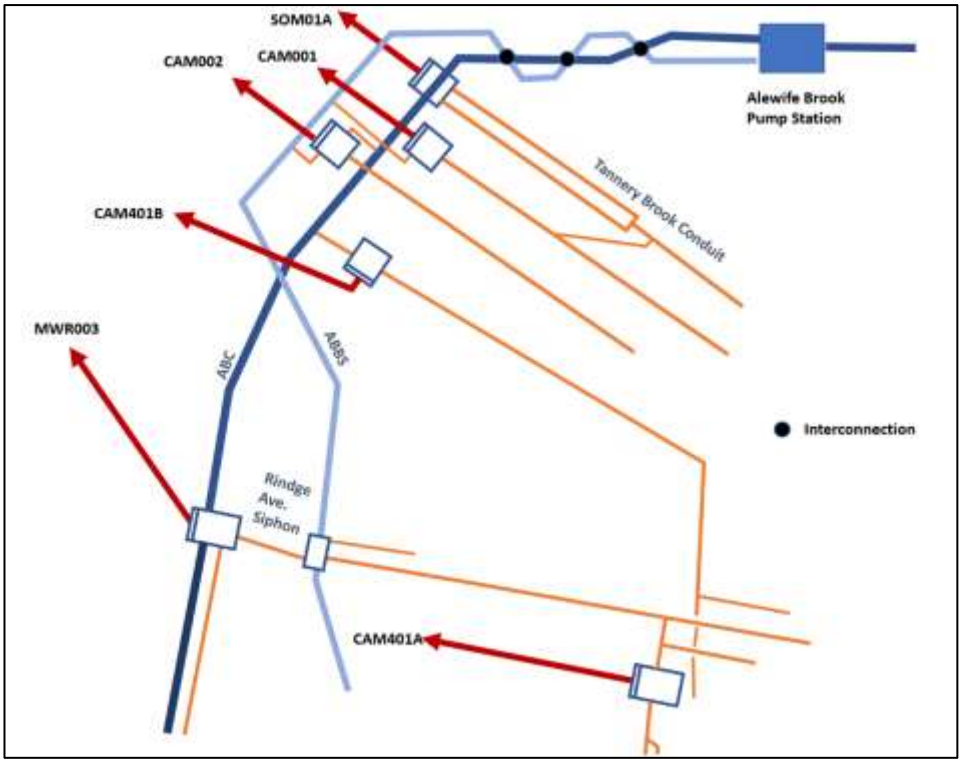

Figure 2-1: Schematic of Alewife Brook System

Table 2-1 below presents the Typical Year activation frequency and volume for the future conditions baseline and the Long Term Control Plan (LTCP) goals established for each outfall in the Alewife Brook system. As indicated in Table 2-1, as a whole, the total volume to Alewife Brook is under the LTCP goal, while the maximum activation frequency is exceeded by one activation. Each of the individual CSO outfalls meets its LTCP goals except for outfall SOM001A, which does not meet its LTCP goals for activation frequency and volume.

Table 2-1: Alewife Brook Typical Year Performance: Future Baseline Conditions and LTCP Goals

Outfall	Future Baseline Conditions(1)		Long Term Control Plan(2)	
	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Alewife Brook				
CAM001	1	0.02	5	0.19
CAM002	0	0.00	4	0.69
MWR003	3	0.61	5	0.98
CAM401A	5	0.66	5	1.61
CAM401B	4	0.50	7	2.15
SOM001A	8	4.47	3	1.67
Sum	8 (max)	6.26	7 (max)	7.29

1. Activation frequency and volume did not change for the Future Baseline Conditions compared to Q4-2021 conditions because there were no updates in Alewife Brook subsystem.
2. Activation frequency and volume values from the Second Stipulation. Refer to the *Task 6: Final CSO Post Construction Monitoring Program and Performance Assessment Report* for further background on the LTCP performance goals.

2.2 CSO Variance Related Optimization

System optimization evaluations were conducted for Alewife Brook outfalls CAM001, CAM002, CAM401A, CAM401B, MWR003 and SOM001A. The results of these evaluations are presented below.

2.2.1 CAM001

Regulator RE-011 discharges to outfall CAM001, and is located off the west side of Alewife Brook Parkway opposite Foch Street. The influent to regulator RE-011 is a single 1.33-foot diameter elliptical pipe. This pipe has an upstream interconnection to the Tannery Brook drain in Somerville. Dry weather flows are directed through a 1-foot diameter side orifice into a chamber, and then from the chamber to a 1-foot diameter circular pipe to the Alewife Brook Branch Sewer. During wet weather as the HGL rises, the water level has to exceed the overflow weir crest elevation of 109.94 ft (MDC datum) before discharging to the Alewife Brook. Table 2-2 presents the activations at outfall CAM001 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 2-2 presents a profile through the regulator structure with the peak HGL during the Typical Year.

Table 2-2: CAM001 Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
10/23/1992	0.02
2-Year, 24-Hour Storm Volume (MG)	
0.07	
5-Year, 24-Hour Storm Volume (MG)	
0.09	

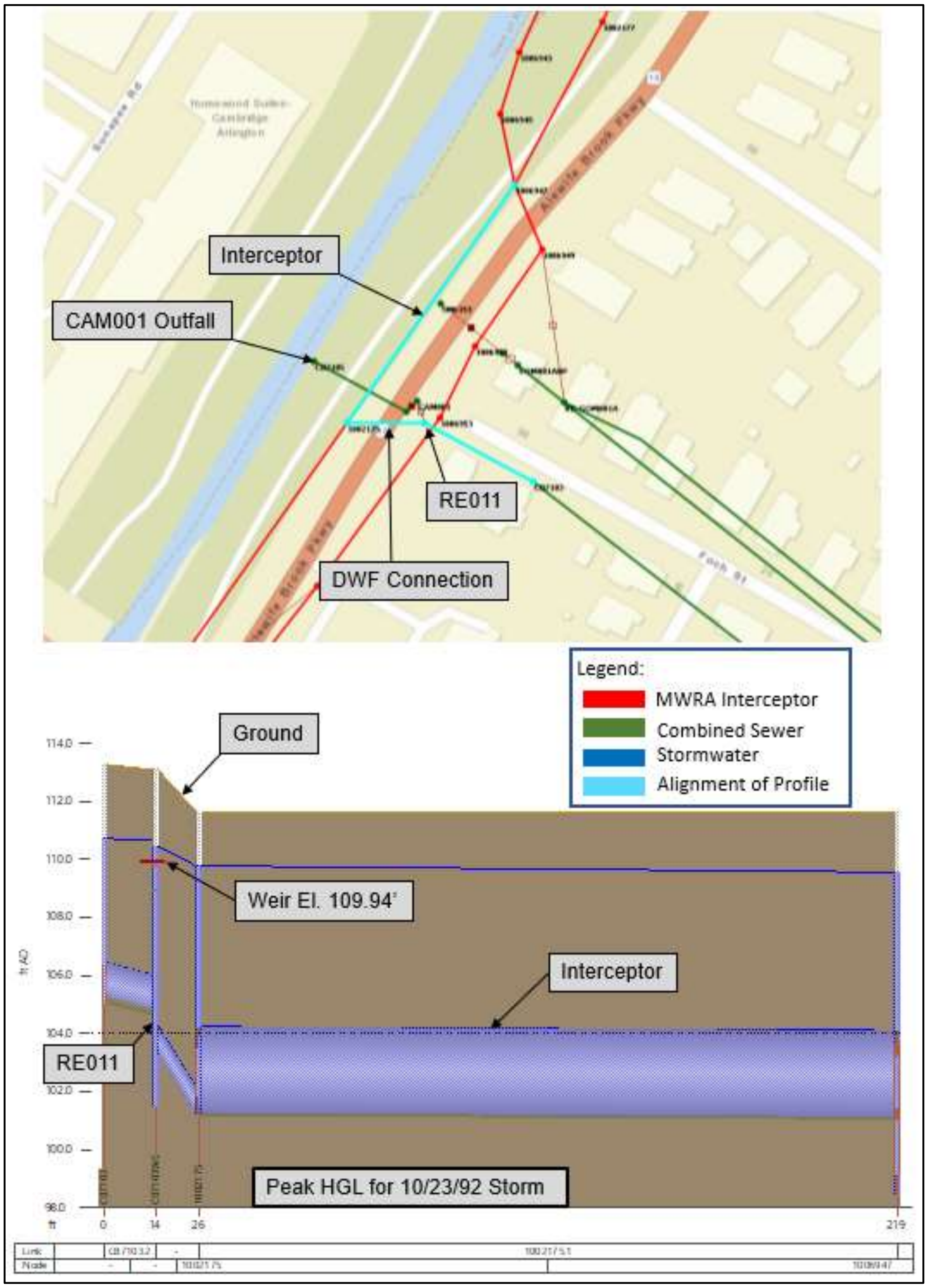

Figure 2-2: CAM001 Typical Year Regulator Profile

As indicated in Figure 2-2, the influent pipe upstream of regulator RE-011 was fully surcharged during the one storm in the Typical Year where a CSO activation was predicted. Nevertheless, a series of model runs were conducted to assess whether raising the weir could reduce the volume or eliminate the one activation. Raising the weir by at least 0.5 feet was found to be necessary to achieve zero activations in the Typical Year at outfall CAM001. However, with this alternative the HGL in the regulator rose by 2.4 feet during the 5-year, 24-hour storm, increasing the risk of flooding. Additionally, the net reduction of CSO volume to the Alewife Brook during the Typical Year was zero, as the overflow volume from outfall CAM001 was distributed to adjacent outfalls.

Additional model runs were conducted to assess raising the CAM001, CAM002, and MWR003 weirs in combination to mitigate the adverse impact to other outfalls caused by raising the CAM001 weir. Model runs were conducted in which the weirs at CAM001 and CAM002 were raised 0.25 feet, 0.5 feet, and 1 foot. These combined measures resulted in HGL increases greater than the screening-level guideline described in approach step No. 5 in Section 1.3

above (excessive HGL increases) and little to no net reduction of CSO discharge to the Alewife Brook. Model runs were also conducted in which the weirs at CAM001, CAM002 and MWR003 were raised 0.25 feet and 0.5 feet. These combined measures also resulted in excessive HGL increases and minimal net reduction of CSO discharge to the Alewife Brook. As a result, raising the CAM001 weir is not recommended.

The profile in Figure 2-2 shows that the HGL drops noticeably across the dry weather flow (DWF) connection indicating that if the DWF connection is enlarged, more flow could potentially be conveyed through the connection to the interceptor. The model was run with the DWF connection diameter increased from 1 foot to 1.25 feet and 1.5 feet. These alternatives included a flap valve to prevent reverse flow from the interceptor from adversely impacting CAM001 upstream system hydraulic performance during large storm events. The result of these model runs showed that increasing the DWF pipe size to 1.5 feet and providing a flap valve reduced the Typical Year activation frequency and volume to zero without adverse impacts to the HGL. However, the collection system model was developed with a simplified representation of the dry weather flow connection to the interceptor. The connection was modelled as a 1-foot diameter pipe, with an elevated roughness coefficient to represent the head losses between the regulator and the interceptor. The roughness coefficient was adjusted during model calibration as part of the PCCMP to match measured water levels in the regulator.

Therefore, an additional analysis was conducted by refining the configuration of the RE-011 regulator structure in the model to include the initial side-outlet orifice upstream of the DWF pipe. The roughness coefficient of the existing DWF connection was then adjusted to a more typical value (n=0.014), and the orifice coefficient was adjusted to match the previously predicted CSO volume for the Typical Year and 5-Year, 24-hour storm. This update was made to assess whether the orifice and its associated losses were the cause of the head loss through the DWF path, rather than the DWF pipe. With these updates to the model, a run was conducted with the orifice diameter increased from 1 foot to 1.5 feet without adjusting the loss coefficients.

Table 2-3 presents the Typical Year CSO activations and volumes for the Alewife Brook CSOs for the baseline with re-calibrated orifice at CAM001, and for the optimization alternative that involves increasing the orifice to 1.5 feet. As indicated in Table 2-3, increasing the DWF orifice diameter to 1.5 feet eliminated the predicted Typical Year activation at outfall CAM001. The net reduction in volume to Alewife Brook was 0.04 MG, due mostly to a 0.04 MG reduction at regulator RE01A (outfall SOM001A). This reduction likely was due to the upstream connection between the CAM001 and SOM001A systems. No adverse HGL impacts were noted for these alternatives for the 5-year, 24-hour storm.

Table 2-3. CAM001 Optimization Alternatives

Outfall	Regulator	Baseline*		Enlarged Orifice to 1.5 feet		Long Term Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Alewife Brook							
CAM001	RE-011	1	0.02	0	0.00	5	0.19
CAM002	RE-021	0	0.00	0	0.00	4	0.69
MWR003	RE-031	3	0.61	3	0.62	5	0.98
CAM401A	RE-40	5	0.66	5	0.66	5	1.61
CAM401B	RE-401B	4	0.50	4	0.51	7	2.15
SOM001A	RE-01A	8	4.48	8	4.44	3	1.67
SUM		**8 (max)**	**6.27**	**5**	**6.23**	**7 (max)**	**7.29**

* Results based on version of 2022 baseline condition model with update to RE-011 configuration to represent existing orifice.

Figure 2-3 presents a sketch of the configuration of regulator RE-011 (outfall CAM001). The regulator is located in a grassy area just west of Alewife Brook Parkway.

In terms of costs and construction impacts, enlarging the orifice connection would be preferable to replacing the existing DWF connection. However, in discussions with the City of Cambridge, it was noted that the existing regulator

RE-011 is a brick structure, and the structural feasibility of enlarging the size of the side orifice would need more detailed analysis. In addition, flow metering and/or 3-dimensional computational fluid dynamics (CFD) modelling would be required to more accurately assess the head losses through the regulator structure and to assess the sizing and potential benefits of the optimization measure under consideration. As indicated in Table 2-2 above, the baseline conditions Typical Year volume at outfall CAM001 is relatively low (0.02 MG), so the optimization measure would involve relatively subtle changes to performance.

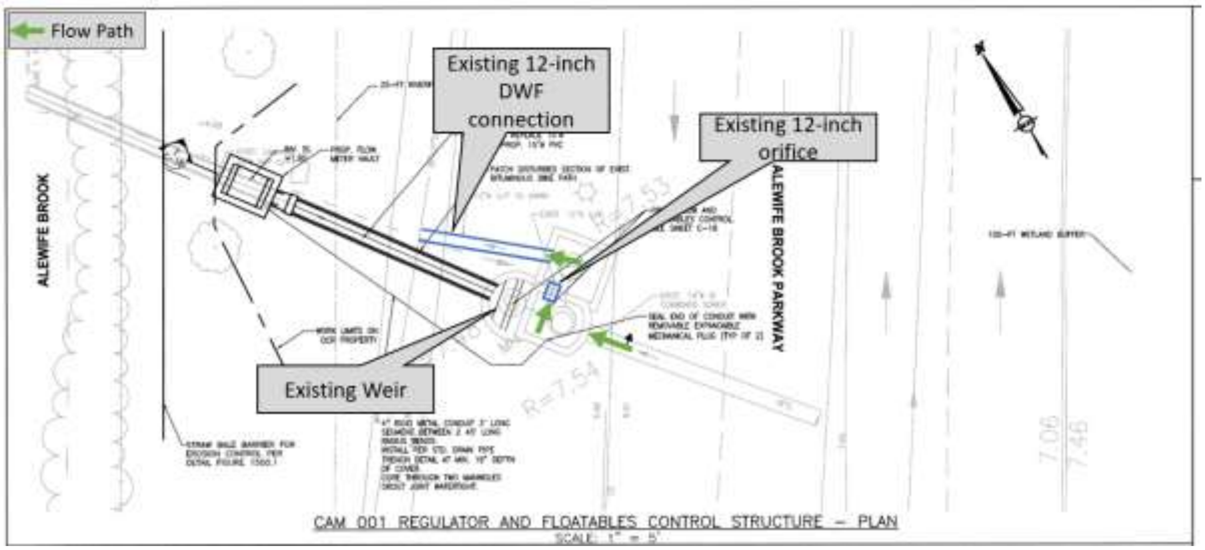

Figure 2-3. Outfall CAM001, Regulator RE-011 Layout

The water quality impacts of any further reduction in CSO volume at outfall CAM001 are anticipated to be minimal. The annual volume at outfall CAM001 represents less than 1 percent of the CSO volume to Alewife Brook. As indicated in Table 3-10 of the December 2021 PCCMP Report, Alewife Brook is predicted to be in attainment with the *E. coli* single sample maximum criterion of 235 #/100 mL 45 percent of the time when all sources of bacteria loads to Alewife Brook are considered. When CSO loads only are considered, Alewife Brook is predicted to be in compliance with the *E. coli* criterion 98.7 percent of the time.

Given the costs needed to conduct the additional hydraulic and structural evaluations of regulator RE-011 and the minimal expected benefit, no further optimization activities are recommended for outfall CAM001.

2.2.2 CAM002

Regulator RE-021 discharges to outfall CAM002, and is located in the intersection of Alewife Brook Parkway and Massachusetts Avenue. The influent to regulator RE-021 is a single 3.2 x 4-foot egg shaped pipe. Dry weather flows are directed to the Alewife Brook Branch Sewer through a 1.25 foot diameter circular pipe. During wet weather as the HGL rises, an internal weir discharges to the Alewife Brook Conduit as a secondary relief path before the HGL reaches the outfall overflow elevation of 111.08 ft. Once the hydraulic grade line exceeds elevation 111.08 ft, water flows over a weir and through the outfall discharging to the Alewife Brook. Table 2-4 presents the activations at outfall CAM002 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 2-4 presents a profile through the regulator structure with the peak HGL during the 5-Year, 24-hour storm.

Table 2-4: CAM002 Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
NA	NA
2-Year, 24-hour Storm Volume (MG)	
NA	
5-Year, 24-hour Storm Volume (MG)	
0.09	

As indicated in Table 2-4, outfall CAM002 does not activate during the Typical Year or the 2-year, 24-hour design storm, and discharges 0.09 MG of untreated CSO volume to the Alewife Brook during the 5-year, 24-your design storm. As indicated in Figure 2-4, during the 5-year, 24-hour storm, a limited amount of in-system storage appears to be available in the influent pipe to the regulator. As a result, a series of model runs were conducted to assess whether raising the weir could diminish or eliminate the activation in the 5-year, 24-hour storm. The CAM002 weir was raised 0.25 feet , 0.5 feet, and 1 foot, and assessed with the 5-year, 24-hour storm. Raising the weir 1 foot was necessary to eliminate the 5-year, 24-hour design storm activation. However, raising the weir caused the HGL in the regulator to rise by 0.5 feet to within 4.5 feet of the ground elevation. This HGL increase is greater than the screening-level guideline described in approach step No. 5 in Section 1.3 and would increase the risk of flooding. The net CSO volume reduction to the Alewife Brook was 0.01 MG as most of the volume from outfall CAM002 was distributed to adjacent outfalls. As a result, optimization by weir raising was not recommended at CAM002.

As indicated in the profile in Figure 2-4, the peak HGL in the downstream interceptor was above the weir elevation at Regulator RE-021. Although the profile showed a drop in the HGL across the DWF connection, increasing the diameter of the DWF connection would result in increased overflow volumes at outfall CAM002 due to the backwater effect caused by the higher HGL in the interceptor. Therefore, increasing the size of the DWF connection was not recommended for this location.

In conclusion, no optimization measures were recommended for outfall CAM002.

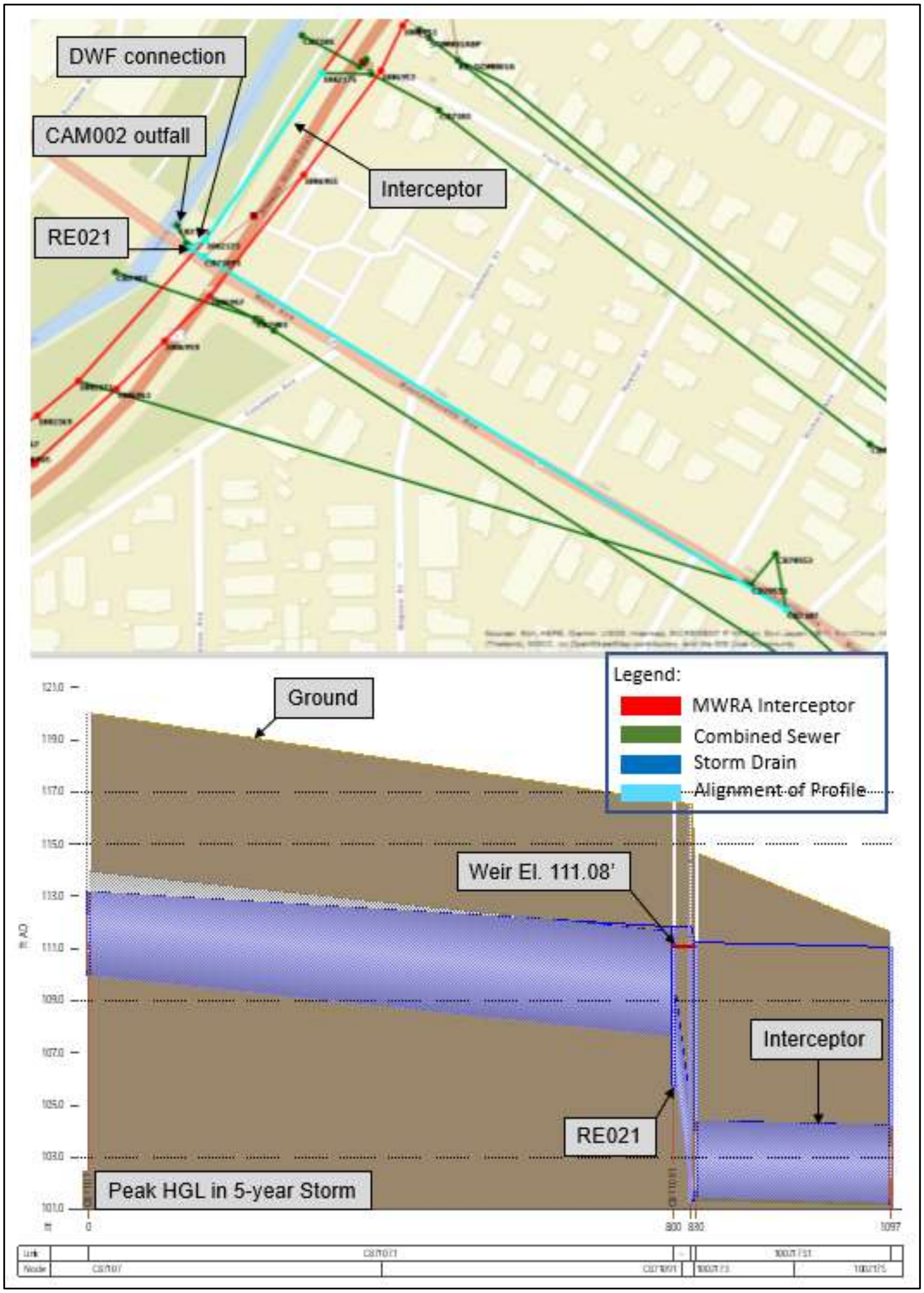

Figure 2-4: CAM002 Regulator Profile for 5-Year, 24-hour Storm

2.2.3 CAM401A

Regulator RE-401 discharges to outfall CAM401A, and is located at the intersection of Pemberton Street and Sherman Street. Regulator RE-401 functions as a side-outlet relief off of a 5.5 x 5-foot combined sewer on Sherman Street in Cambridge. During dry weather, flow continues down the combined sewer to a junction structure on the downstream Alewife Brook Branch Sewer. At that junction structure, flow can either continue down the Alewife Brook Branch Sewer or overflow into a siphon that ties into the Alewife Brook Conduit at regulator RE-031, associated with outfall MWR003. During wet weather, flow enters the regulator RE-401 structure through a 5 x 5.5-foot rectangular connection. When the HGL exceeds the weir elevation of 111.69 ft, the water begins to flow through a brush structure mounted on the overflow weir. The brush structure is intended to capture floatables and larger solids in the overflow. If the water level in the regulator continues to rise, flow can pass over the top of the brush structure. This flow path is represented in the model as a weir at elevation 114.49 ft. Flow then enters the 6-foot diameter circular outfall pipe through a flap gate.

Table 2-5 presents the activations at outfall CAM401A by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 2-5 presents a profile through the regulator structure with the peak HGL during the Typical Year.

Table 2-5: CAM401A Activation by Storm Event

Typical Year	
Date	**Volume (MG)**
5/2/1992	0.02
6/6/1992	0.02
8/18/1992	0.18
9/23/1992	0.20
10/23/1992	0.24
2-Year, 24-Hour Storm Volume (MG)	
1.36	
5-Year, 24-Hour Storm Volume (MG)	
2.16	

As indicated in Figure 2-5, limited storage was available in the upstream Sherman Street combined sewer for the largest storm in the Typical Year. During the 5-year, 24-hour storm, the baseline model predicts that the HGL upstream of outfall CAM401A is above the ground surface. Raising the weir was not considered for this location because of the currently predicted HGL impacts during the 5-year, 24-hour storm. Since this regulator functions as a side outlet weir, there is no DWF connection to optimize. In summary, no optimization alternatives were identified for outfall CAM401A.

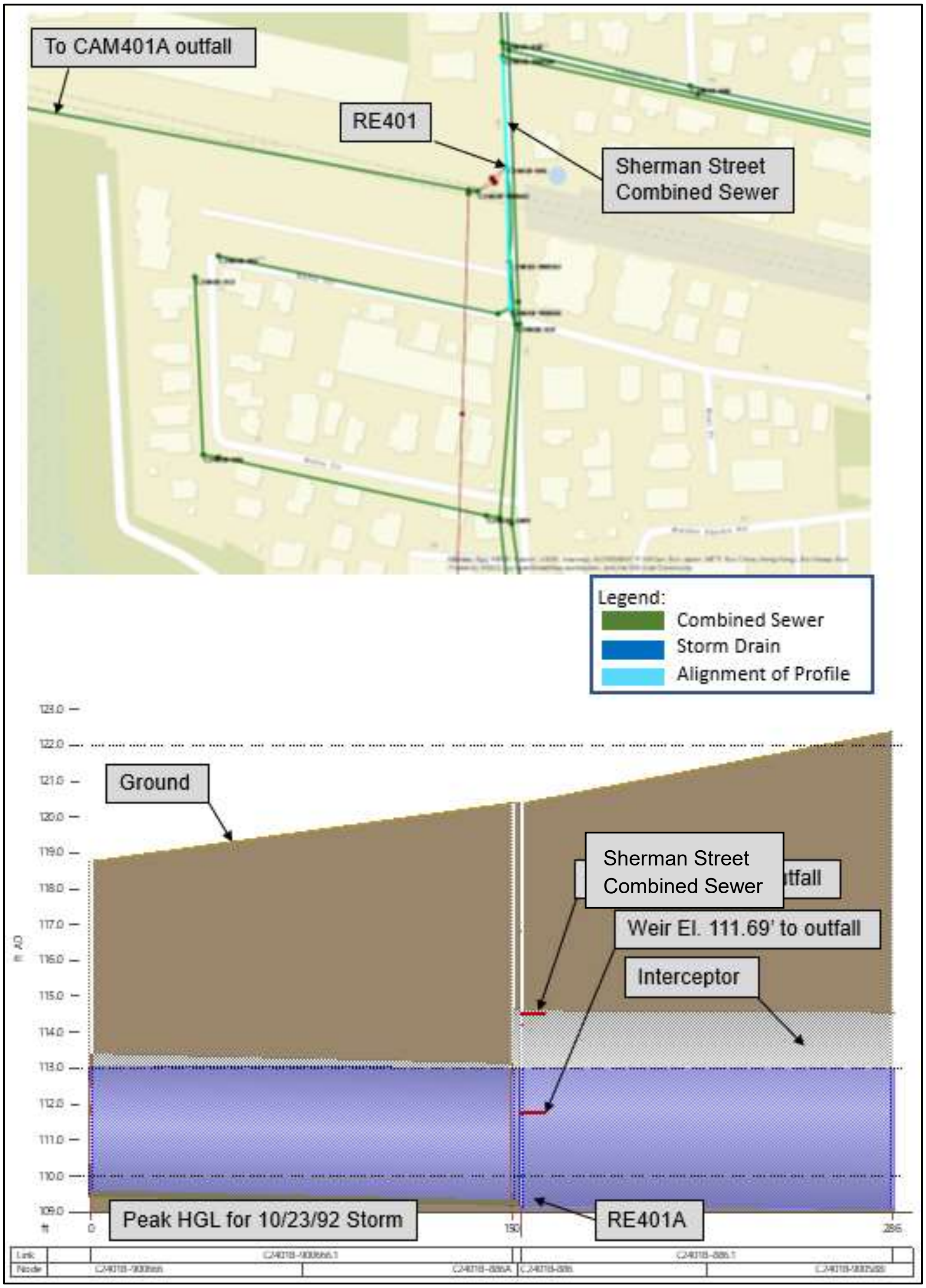

Figure 2-5: CAM401A Typical Year Regulator Profile

2.2.4 CAM401B

Regulator RE-401B discharges to outfall CAM401B, and is located at the intersection of Alewife Brook Parkway and Massachusetts Avenue. The influent to regulator RE-401B is a single 3.5-foot diameter circular pipe from the Cambridge system. Dry weather flows are directed to the Alewife Brook Conduit through an 18-inch diameter circular pipe. During wet weather, as the HGL rises to an elevation of 108.75 ft, flows enter a 2.5 foot diameter high-outlet pipe which discharges to the Alewife Brook. Table 2-6 presents the activations at outfall CAM401B by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 2-6 presents a profile through the regulator structure with the peak HGL during the Typical Year.

Table 2-6: CAM401B Activation by Storm Event

Typical Year	
Date	**Volume (MG)**
5/2/1992	0.01
8/18/1992	0.07
9/23/1992	0.26
10/23/1992	0.16
2-Year, 24-Hour Storm Volume (MG)	
0.71	
5-Year, 24-Hour Storm Volume (MG)	
0.99	

As indicated in Table 2-6, outfall CAM401B activates four times during the Typical Year, discharging 0.50 MG of untreated CSO to the Alewife Brook. As indicated in Figure 2-6, the influent pipe upstream of regulator RE-401B was fully surcharged during the largest storm in the Typical Year. Nevertheless, model runs were conducted to assess whether raising the elevation of the overflow could improve Typical Year CSO performance.

For modelling purposes, it was assumed that the overflow elevation could be raised by installing a steel plate in the high outlet pipe, creating an overflow weir. This approach effectively raised the elevation of the overflow while accounting for the head loss through the opening. Raising the weir 0.5 feet relative to the high outlet invert elevation was predicted to reduce the Typical Year overflow volume by 0.11 MG at outfall CAM401B, but the net discharge to the Alewife Brook was only reduced by 0.05 MG as water was distributed to other outfalls. With this configuration, the HGL in the regulator rose by 0.5 feet during the 5-year, 24-hour storm to within 5 feet of the ground surface. This HGL increase is greater than the screening-level guideline described in approach step No. 5 in Section 1.3 and would increase the risk of flooding. Since the weir could not be lengthened without major reconstruction of the regulator structure, raising the weir was not recommended for outfall CAM401B.

The profile in Figure 2-6 shows that the HGL drops across the DWF connection for the largest storm in the Typical Year indicating that if the DWF connection is enlarged, more flow could potentially be conveyed through the connection to the interceptor. Relief of the DWF connection was modelled by adding a second, parallel 1.5-foot diameter DWF connection from the regulator to the ABC. A flap valve was modelled on this second connection to minimize the potential for additional backflow from the interceptor during larger storms. The performance of this alternative in the Typical Year is presented in Table 2-7. As indicated in Table 2-7, this configuration was predicted to reduce the Typical Year activation frequency at outfall CAM401B from 4 to 3 and reduce the annual CSO volume at outfall CAM401B by 0.28 MG. However, the net volume reduction to Alewife Brook was only 0.11 MG, as some of the CAM401B volume was redistributed to other outfalls. In particular, the volume at outfall MWR003, located further upstream along Alewife Brook, increased by 0.09 MG, and the volume at outfall SOM001A, which is already higher than the LTCP volume goal, increased by 0.08 MG.

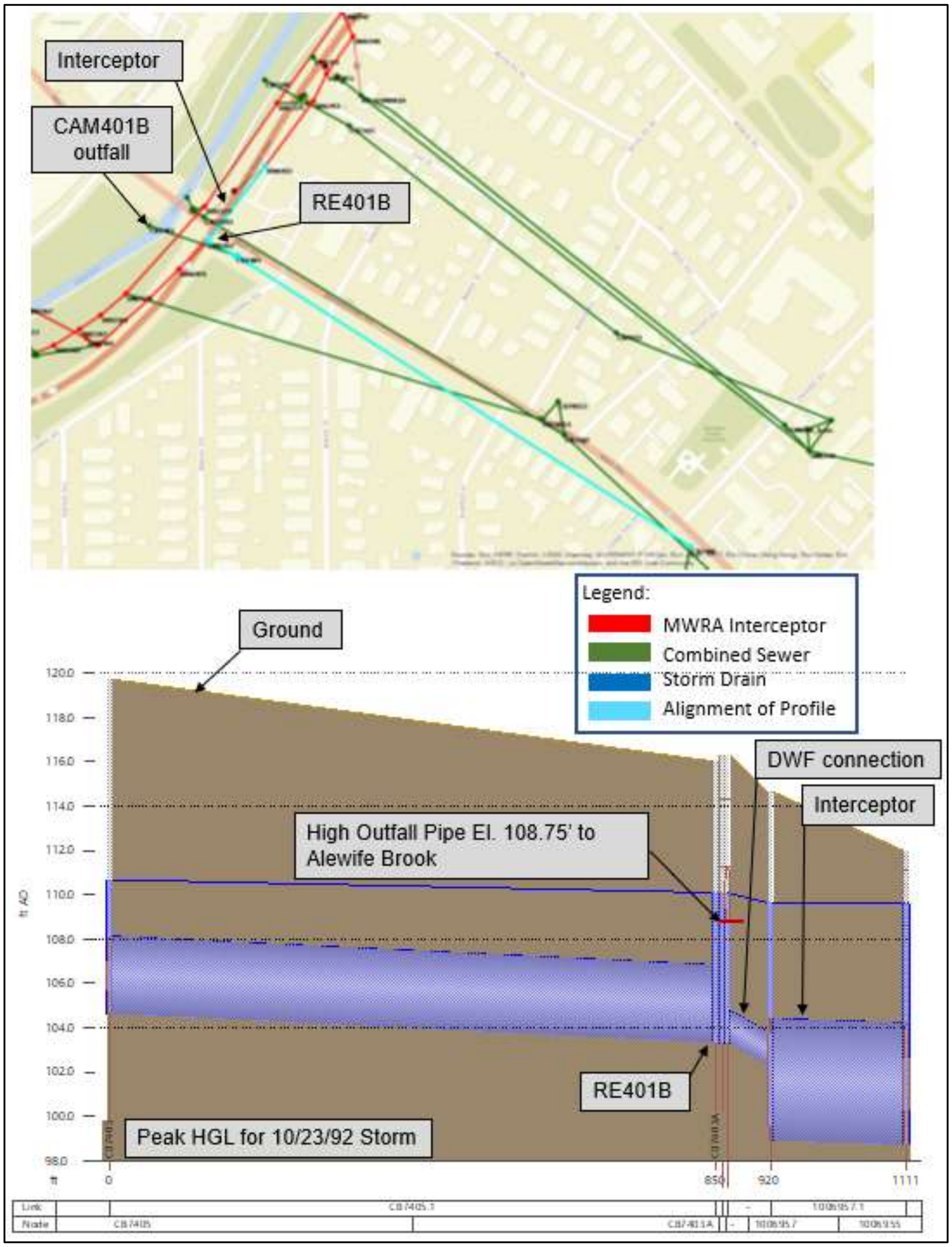

Figure 2-6: CAM401B Typical Year Regulator Profile

Table 2-7. CAM401B Optimization Alternative

Outfall	Regulator	Baseline		CAM401B Additional 18-in. DWF Pipe		Long Term Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Alewife Brook							
CAM001	RE-011	1	0.02	1	0.02	5	0.19
CAM002	RE-021	0	0.00	0	0.00	4	0.69
MWR003	RE-031	3	0.61	3	0.70	5	0.98
CAM401A	RE-40	5	0.66	5	0.67	5	1.61
CAM401B	RE-401B	4	0.50	3	0.22	7	2.15
SOM001A	RE-01A	8	4.47	8	4.55	3	1.67
SUM		**8 (max)**	**6.26**	**8 (max)**	**6.15**	**7 (max)**	**7.29**

Figure 2-7 presents a concept sketch of the alternative to provide a parallel 1.5-foot diameter DWF connection to the Alewife Brook Conduit. The work would require a large manhole to be constructed on the Alewife Brook Conduit to receive the new 1.5-foot diameter DWF connection. This construction work would take place at the intersection of Massachusetts Avenue and Alewife Brook Parkway, a location with very high traffic volume. Per the City of Cambridge, previous construction work at this location related to improvements at outfall CAM002 required night-time construction to mitigate traffic impacts, and the work unavoidably created substantial inconvenience to the local neighborhood.

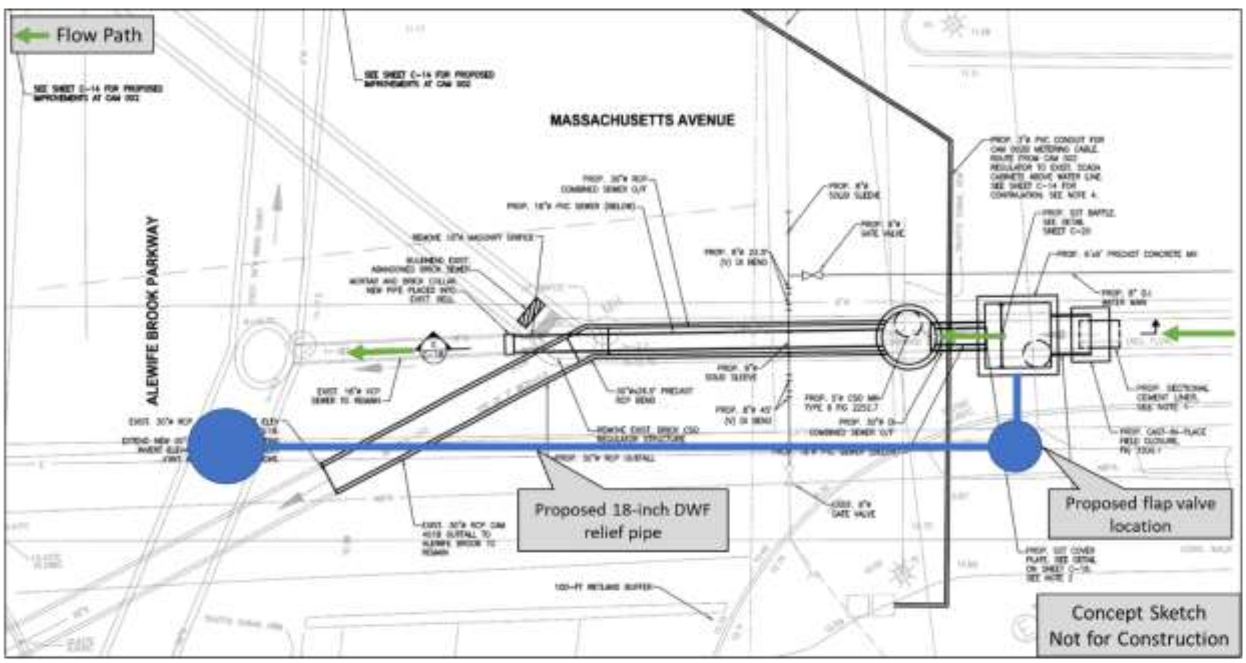

Figure 2-7. Concept Sketch of CAM401B Optimization Alternative

While no adverse HGL impacts were noted with this alternative during the 5-year storm, 24-hour storm, the layout would require the flow to take a right-angle bend out of the existing regulator structure, and another right-angle bend into the pipe connecting to the Alewife Brook Conduit. If this alternative were to be further considered, CFD modelling would be recommended to further assess the sizing, configuration, and performance of the alternative.

Due to the hydraulic connectivity of the regulators associated with outfalls CAM001 and CAM401B along the interconnected Alewife Brook Conduit and Alewife Brook Branch Sewer, model runs were conducted with the DWF connection capacities in both regulators increased. Optimizing both regulators as described above resulted in the elimination of the Typical Year activation at outfall CAM001, while the CAM401B activation frequency was reduced from 4 to 3 and the volume from 0.50 MG to 0.23 MG. The net reduction in volume to Alewife Brook was 0.15 MG.

In conclusion, for outfall CAM401B, while the alternative to provide a parallel 1.5 foot DWF connection would result in a nominal 0.11 MG net reduction in Typical Year volume to Alewife Brook, it would result in a 0.09 MG increase in volume further upstream along the brook at outfall MWR003. As described above for outfall CAM001, nominal reductions in CSO volume to Alewife Brook would not meaningfully change the level of attainment with the *E. coli* single sample maximum criterion. Whatever nominal benefit that would be achieved by the 0.11 MG net reduction would be offset by the 0.09 MG increase upstream along the Brook at outfall MWR003.

The nominal reduction in CSO volume for this alternative would not justify the cost and anticipated adverse construction impacts required to implement this alternative as an optimization measure. Accordingly, no further optimization activities are recommended for outfall CAM401B. Similarly, the combination alternatives evaluated for outfalls CAM001 and CAM401B are not recommended.

2.2.5 MWR003

The MWR003 regulator structure (RE031) receives influent flow directly from the Alewife Brook Conduit and via a siphon connection from the Alewife Brook Branch Sewer. Regulator RE-031 is located off Alewife Station Access Road and Steel Place. Dry weather flow continues down the Alewife Brook Conduit to the Alewife Brook Pump Station. During wet weather, the regulator functions as a side-outlet relief for the Alewife Brook Conduit. The overflow is controlled by a downward-opening sluice gate. If the HGL reaches elevation 109.66 flow will pass over the top of the gate, which functions as an overflow weir. If the HGL continues to rise during large storm events, the MWR003 gate drops down to elevation 106.99 ft based on two set points (el. 111.1 ft in the Alewife Brook Conduit, or el. 111.5 ft in the Alewife Brook Branch Sewer) to provide upstream flood relief. During the Typical Year, the model does not predict that the HGL reaches the trigger elevations that would cause the gate to drop. Table 2-8 presents the activations at outfall MWR003 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 2-8 presents a profile through the regulator structure with the peak HGL during the Typical Year.

Table 2-8: MWR003 Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
8/18/1992	0.05
9/23/1992	0.25
10/23/1992	0.31
2-Year, 24-Hour Storm Volume (MG)	
2.78	
5-Year, 24-Hour Storm Volume (MG)	
3.03	

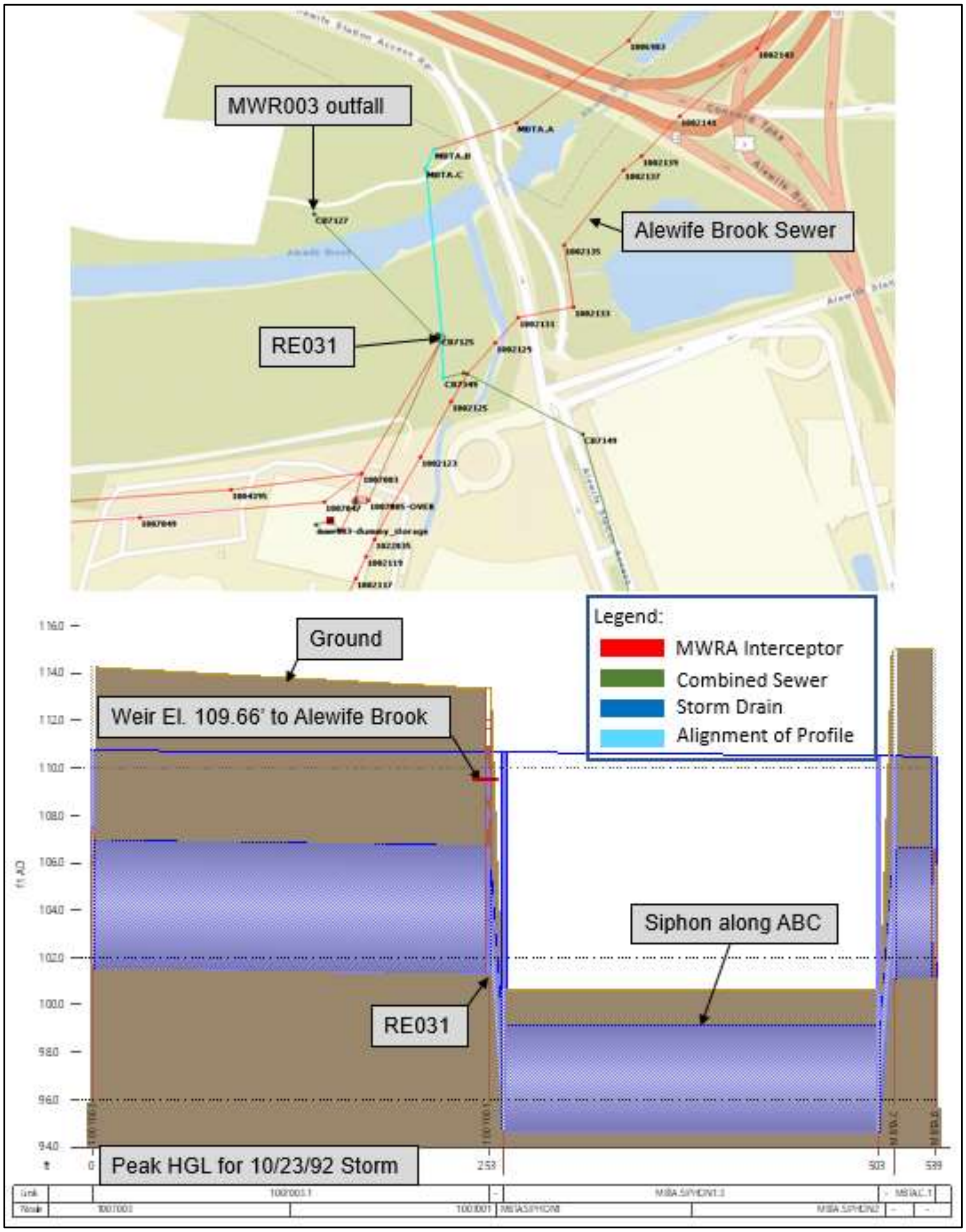

Figure 2-8: MWR003 Typical Year Regulator Profile

As indicated in Table 2-8, during the Typical Year outfall MWR003 activates three times, discharging 0.61 MG of untreated CSO to the Alewife Brook. As indicated in Figure 2-8, the influent pipe immediately upstream of regulator RE-031 was fully surcharged during the largest storm in the Typical Year. Nevertheless, model runs were conducted to assess whether raising the elevation of the overflow could improve the Typical Year performance. Raising the overflow elevation by up to 0.5 feet resulted in zero net CSO reduction to the Alewife Brook. During the 5-year storm, raising the weir by 0.5 feet resulted in an HGL increase greater than the screening-level guideline described in approach step No. 5 in Section 1.3. Due to the presence of the existing downward-opening sluice gate and its function to relieve the peak HGL during larger storms, lengthening the weir or providing a bending weir would not be feasible within the existing regulator structure. Since this regulator functions as a side outlet relief, there is no DWF connection to be optimized. As a result, no optimization is recommended at outfall MWR003.

2.2.6 SOM001A

Regulator RE-01A discharges to outfall SOM001A, and is located on Alewife Brook Parkway at Murray Hill Road. The influent to regulator RE-01A is a twin 4.5-foot diameter circular conduit (the Tannery Brook Drain). Dry weather flow passes through an orifice in the invert of the regulator structure into the Alewife Brook Conduit. The orifice has an equivalent diameter of 3 feet. During wet weather, when the depth of flow in the regulator exceeds the weir crest at elevation 110.12 ft, overflow occurs to the Alewife Brook.

Table 2-9 presents the activations at outfall SOM001A by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 2-9 presents a profile through the regulator structure with the peak HGL during the Typical Year.

Table 2-9: SOM001A Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
5/2/1992	0.37
6/6/1992	0.08
8/11/1992	0.61
8/18/1992	0.66
9/3/1992	0.07
9/9/1992	0.24
9/23/1992	0.91
10/23/1992	1.53
2-Year, 24-Hour Storm Volume (MG)	
2.78	
5-Year, 24-Hour Storm Volume (MG)	
4.16	

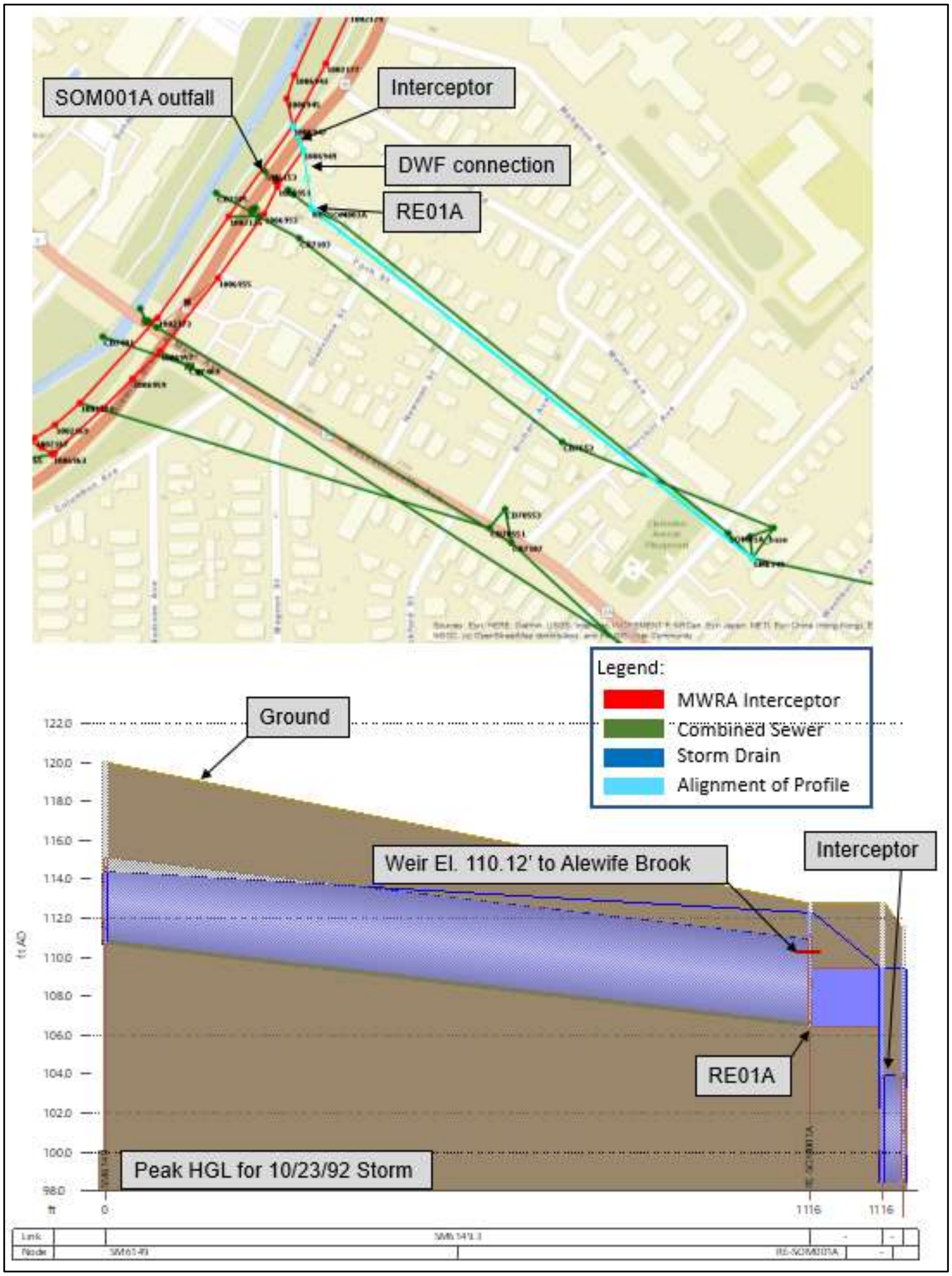

Figure 2-9: SOM001A Typical Year Regulator Profile

As indicated in Table 2-9, during the Typical Year outfall SOM001A activates eight times, discharging 4.47 MG of untreated CSO to the Alewife Brook. As indicated in Figure 2-9, limited in-system storage is available in the influent combined sewer for the largest storm in the Typical Year. Nevertheless, alternatives to raise the overflow weir were evaluated. Due to limited head space between the existing weir and the regulator structure roof slab, raising the weir by a maximum of 0.25 feet was assessed. However, this alternative produced no net reduction in CSO volume to Alewife Brook and resulted in an HGL increase greater than the screening-level guideline described in approach step No. 5 in Section 1.3.

Figure 2-9 shows a drop in the HGL across the DWF orifice for the largest storm in the Typical Year, indicating that the DWF orifice is restrictive. Increasing the size of the orifice from 2.67 x 2.67 feet to 4.67 x 2.67 feet in conjunction with raising the weir by 0.25 feet was predicted to reduce the CSO volume and activation frequency at outfall SOM001A but resulted in adverse HGL impacts (greater than the screening-level guideline described in approach step No. 5 in Section 1.3) during both the Typical Year and the 5-year, 24-hour storm.

Table 2-10 presents the results of this optimization alternative. As indicated in Table 2-10, this alternative reduced the activation frequency at outfall SOM001A by four, and the volume by 2.85 MG, bringing the outfall into compliance with the LTCP goal for volume, and missing the LTCP goal for activation frequency by one. The net reduction in volume to Alewife Brook was 1.68 MG. However, the volume at outfall MWR003 was predicted to increase by 0.66 MG, to a level that would be greater than the LTCP goal for volume at that outfall.

Table 2-10. Optimization Alternative for Outfall SOM001A

Outfall	Regulator	Baseline*		Enlarge Orifice & raise weir 0.25 feet*		Long Term Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Alewife Brook							
CAM001	RE-011	1	0.02	3	0.07	5	0.19
CAM002	RE-021	0	0.00	0	0.00	4	0.69
MWR003	RE-031	3	0.61	3	1.27	5	0.98
CAM401A	RE-40	5	0.66	5	0.75	5	1.61
CAM401B	RE-401B	4	0.50	5	0.86	7	2.15
SOM001A	RE-01A	8	4.47	4	1.62	3	1.67
SUM		**8 (max)**	**6.26**	**5 (max)**	**4.58**	**7 (max)**	**7.29**

* Results based on the Q1Q2-2021 baseline condition model. Refer to Task 6: Final CSO Post Construction Monitoring Program and Performance Assessment Report (AECOM 2021) and Semiannual CSO Discharge Report No. 7 (AECOM 2021) for details on the model versions.

The main concern with this alternative, however, was the predicted adverse HGL impacts. The peak HGL in the 5-year, 24-hour storm was predicted to increase by 0.75 feet and would exceed the ground elevation at a low point along the interceptor.

As a result, no optimization is recommended at outfall SOM001A.

2.3 Alewife/Upper Mystic River Summary and Conclusions

A summary of the Alewife Brook optimization runs is presented in Table 2-11 and Table 2-12 below. Table 2-11 summarizes the results of alternatives involving raising of weirs, and Table 2-12 summarizes the results of alternatives involving increasing the capacity of the DWF connections.

Legend for Tables 2-11 and 2-12:

Symbol	Decrease CSO at Outfall?	Net CSO Decrease to Alewife Brook?	Adverse HGL Impacts? (1)
✓	Yes	Yes	No
■	Yes	Yes	Yes
●	Yes	No	Yes
X	Yes, but less than 0.005 MG	No	Yes

1. Adverse hydraulic impacts are as defined by the screening-level guideline described in approach step No. 5 in Section 1.3 of this report.

Table 2-11: Alewife Brook Weir Optimization Summary

Outfall	Raise Weir 3"	Raise Weir 6"	Raise Weir 12"	Recommendation
CAM001	■	■	■	Raising weir not recommended
CAM002	■	■	■	
CAM001 & CAM002	●	●	●	
CAM001 & CAM002 & MWR003	●	●	●	
MWR003	●	●	-	
CAM401A*	-	-	-	
CAM401B	-	■	-	
SOM001A	X	-	-	

*Due to existing condition hydraulic grade line concerns, no evaluation of weir raising was conducted for outfall CAM401A.

Table 2-12: Alewife Brook DWF Connection Optimization Summary

Outfall	Alternatives Evaluated	Result	Summary of Evaluation	Recommendation
CAM001	• Increased DWF connection from 1 foot to: ○ 1.25 feet with flap valve ○ 1.5 feet with flap valve • Increased DWF orifice to: ○ 1.5 feet ○ 3 feet	✓	• Increasing the DWF connection to 1.5 feet was predicted to provide a 0.04 MG net reduction in CSO volume to Alewife Brook without adverse HGL impacts (1). • In terms of costs and construction impacts, enlarging the orifice connection would be preferable to replacing the existing DWF connection.	Increasing DWF connection capacity not recommended as optimization measure

Table 2-12: Alewife Brook DWF Connection Optimization Summary

Outfall	Alternatives Evaluated	Result	Summary of Evaluation	Recommendation
CAM001, continued			• The structural feasibility of enlarging the size of the side orifice would need more detailed analysis. • Flow metering and/or CFD modelling would be required to more accurately assess the head losses through the regulator structure and to assess the sizing and potential benefits of the optimization measures under consideration. • The water quality impacts of the reduction in CSO volume at outfall CAM001 are anticipated to be minimal.	
CAM002	N/A: Interceptor HGL is above weir. Increasing the diameter of the DWF connection would result in increased overflow at CAM002.	N/A	N/A	N/A
MWR003	N/A: Regulator functions as a side outlet weir so there is no dry weather flow connection to be optimized.	N/A	N/A	N/A
CAM401A	N/A: Regulator functions as a side outlet weir so there is no dry weather flow connection to be optimized.	N/A	N/A	N/A
CAM401B	Addition of a supplemental 1.5 foot DWF connection to the ABC with a flap valve.	✓	• Reduced the CAM401B Typical Year activation frequency from 4 to 3 and reduces the CSO volume by 0.28 MG with no adverse HGL impacts • Net reduction to Alewife Brook of 0.11 MG, but increase at MWR003 of 0.09 MG • The water quality impacts of the reduction in CSO volume are anticipated to be minimal • Construction impacts would be significant given high traffic location	Increasing DWF connection capacity not recommended as optimization measure
CAM001 & CAM401B	• Increased DWF connection from 1 foot to: ○ 1.25 feet with a flap valve ○ 1.5 feet with a flap valve • Addition of supplemental 1.5 foot DWF connection from upstream of CAM401B baffle to	✓	• Joint optimization eliminates two Typical Year activations in the Alewife and reduces the net discharge to the Alewife Brook by 0.15 MG, with no adverse HGL impacts [1] in the 5-year, 24-hour storm • See issues raised with CAM001 and CAM401B individual optimization alternatives.	Increasing DWF connection capacity not recommended as optimization measure

Table 2-12: Alewife Brook DWF Connection Optimization Summary

Outfall	Alternatives Evaluated	Result	Summary of Evaluation	Recommendation
CAM001 & CAM401B, continued	the ABC with flap valve.			
SOM001A	Increased size of DWF orifice from 2.67 feet x 2.67 feet to 4.67 feet x 2.67 feet in conjunction with raising the weir by 0.25 feet	■	• The net reduction in volume to Alewife Brook was 1.68 MG. • The volume at outfall MWR003 increased by 0.66 MG, to a level that would be greater than the LTCP goal for volume at that outfall. • Flooding was predicted for the 5-year, 24-hour storm	Increasing DWF connection capacity not recommended as optimization measure

1. Adverse hydraulic impacts are as defined by the screening-level guideline described in approach step No. 5 in Section 1.3 of this report.

As summarized in Table 2-11 and Table 2-12, no optimization measures were recommended for the Alewife Brook CSO outfalls.

MWRA is currently working with the City of Somerville to assess whether flood mitigation efforts that the city is currently investigating will reduce and/or attenuate the stormwater tributary to SOM001A. Reducing the stormwater tributary to SOM001A could mitigate potential adverse impacts caused by optimization measures. The City of Somerville is also working to assess if these potential flood mitigation efforts may have an overall benefit on CSO control. MWRA and the City of Somerville continue to work together to identify and investigate alternatives as well as the appropriate combination of flood mitigation and system modifications for CSO control that will meet the dual objectives, considering overall cost, constructability, and overall receiving water benefits.

3. Charles River Optimization Evaluations

3.1 System Overview and LTCP Goals

Eight CSO outfalls discharge untreated CSO to the Charles River, and one outfall discharges treated CSO. The untreated CSO outfalls include CAM005, CAM007, CAM017, MWR010, MWR018, MWR019, MWR020, and MWR023, while the treated discharge is from the MWRA's Cottage Farm facility at outfall MWR201. Outfalls CAM005 and CAM007 are located in Cambridge along the North Charles Metropolitan Sewer upstream of the Cottage Farm CSO Facility as shown in Figure 3-1. Outfall CAM017 is located along the Cambridge Marginal Conduit upstream of MWRA's Prison Point CSO Facility, as shown in Figure 3-2. Outfall MWR010 is located along the Charles River Valley Sewer (Figure 3-1). Outfalls MWR018, MWR019 and MWR020 are located along the Boston Marginal Conduit (BMC) upstream of the Prison Point CSO Facility (Figure 3-2). Outfall MWR023 is a large drainage conduit that receives overflow from multiple upstream CSO regulators in the City of Boston (Figure 3-2). The Cottage Farm CSO facility provides relief from the North Charles Relief Sewer and the South Charles Relief Sewer in Cambridge (Figure 3-1).

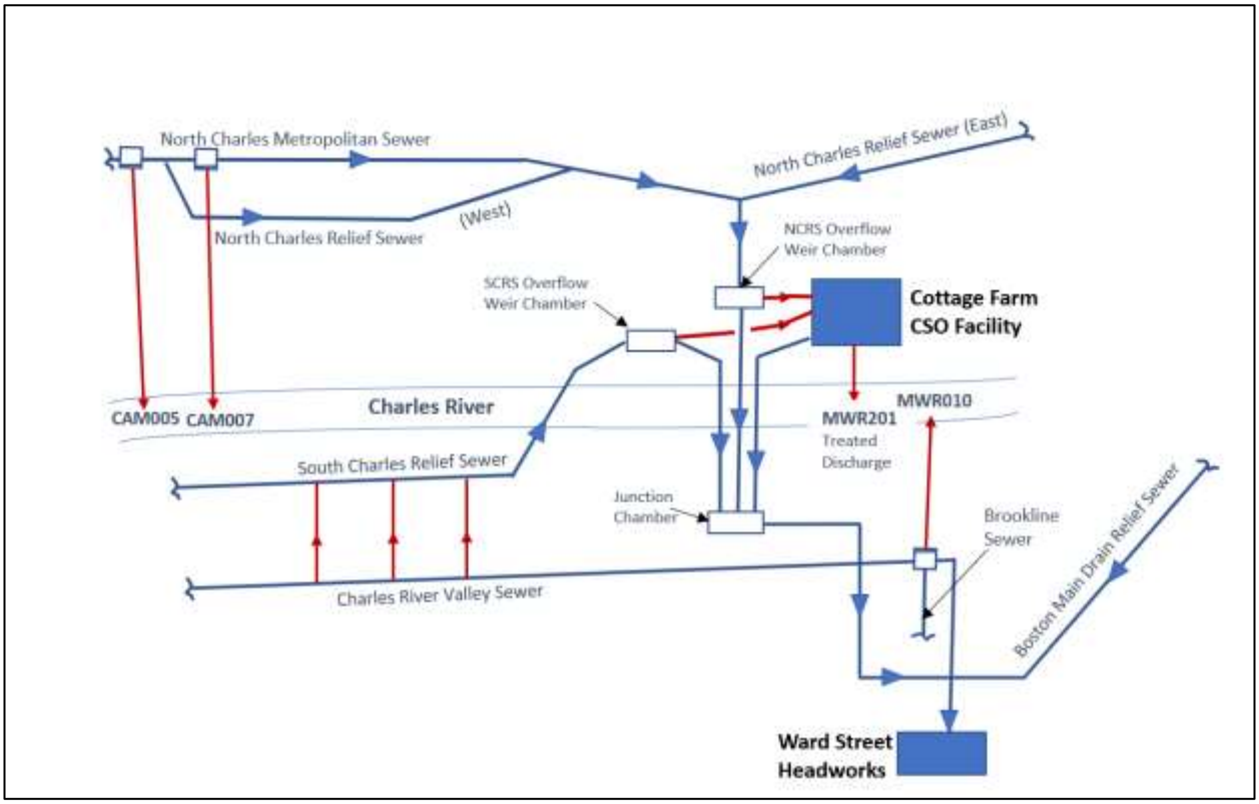

Figure 3-1. Schematic of the Charles River/Cottage Farm Sub-System

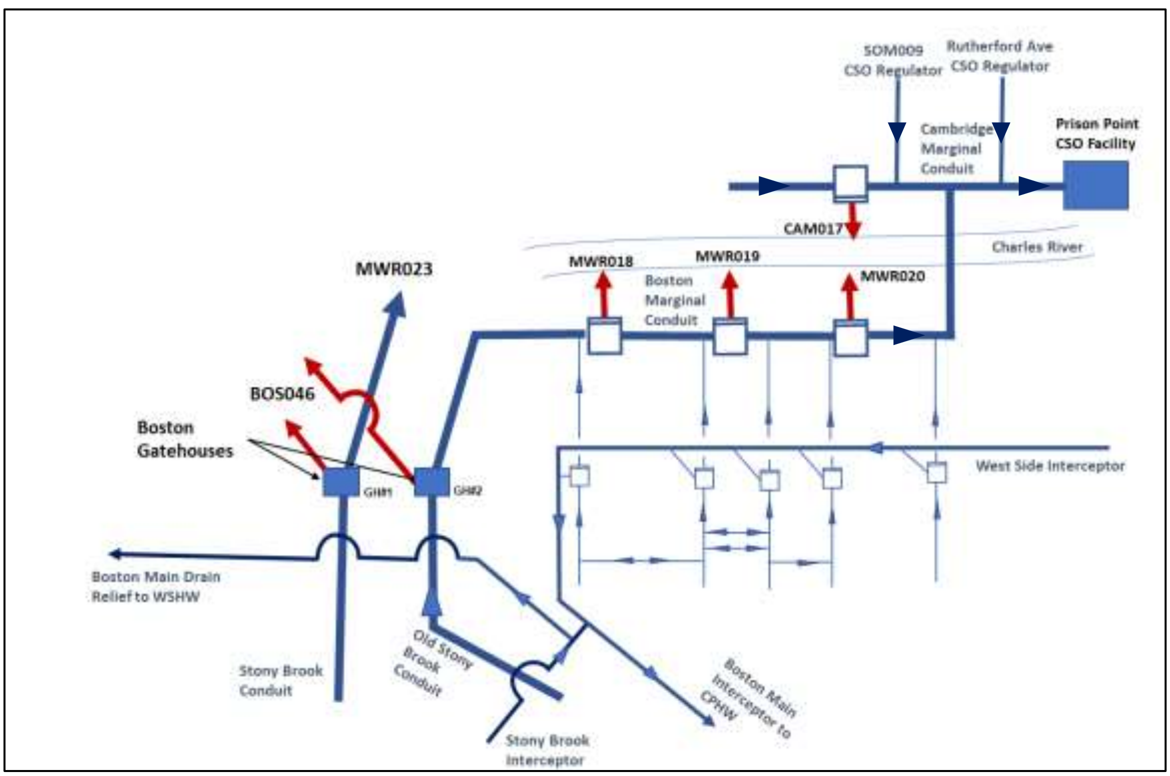

Figure 3-2: Schematic of Charles River/Prison Point Sub-System

Table 3-1 presents the Typical Year CSO activation frequency and discharge volume for the future conditions baseline for each CSO outfall discharging to the Charles River. The future conditions baseline model was based on the Q4-2021 model, and updated with the cleaning of the CAM005 outfall and the Willard Street sewer separation. Also included in Table 3-1 are the LTCP goals for activation frequency and volume.

Table 3-1: Charles River Typical Year Performance: Future Conditions Baseline and LTCP Goals

Outfall	Future Conditions Baseline		Long Term Control Plan(1)	
	Activation	Volume (MG)	Activation	Volume (MG)
Upper Charles				
CAM005	7	0.99	3	0.84
CAM007	2	0.21	1	0.03
Total	**7 (max)**	**1.20**	**3 (max)**	**0.87**
Lower Charles				
CAM017	0	0.00	1	0.45
MWR010	0	0.00	0	0.00
MWR018	2	1.11	0	0.00
MWR019	2	0.48	0	0.00
MWR020	2	0.47	0	0.00
MWR201 (Cottage Farm)	2	8.90	2	6.30
MWR023	1	0.03(2)	2	0.13
Total	**2 (max)**	**11.09**	**2 (max)**	**6.88**

Notes:

(1) Activation frequency and volume values from the Second Stipulation. Refer to the Task 6: Final CSO Post Construction Monitoring Program and Performance Assessment Report for further background on the LTCP performance goals.

(2) Value represents 25% of 0.13 MG, the sum of overflows at upstream regulators. 25% of the 0.13 MG upstream overflow is estimated to discharge at outfall MWR023 (0.03 MG), and 75% is estimated to discharge to Back Bay Fens through Boston Gatehouse No. 1 at outfall BOS046 (0.10 MG).

3.2 CSO Variance Related Optimization

Optimization evaluations in the Charles River area were conducted at outfalls CAM005, CAM007, CAM017, MWR010, MWR018, MWR019, MWR020, MWR201, and at regulators upstream of outfall MWR023 that activated in at least the 5-year, 24-hour storm or smaller storms (regulators RE046-19, RE046-100, RE046-105 and RE046-381; refer to Table 1-3). These evaluations are presented below.

3.2.1 CAM005

Regulator RE-051 discharges to outfall CAM005, and is located on Mount Auburn Street at Longfellow Road at the entrance to Mount Auburn Hospital. The influent to regulator RE-051 is a 2.33 x 3-foot combined sewer that transitions to a 4.5-foot diameter conduit at the regulator. During dry weather, flow from the upstream combined sewer is conveyed to the North Charles Metropolitan Sewer (NCMS) through a 42-inch DWF connection. During wet weather, when the water level in the regulator exceeds an elevation of 108.34 ft, overflow is discharged to a 4.25 x 4.5 foot outfall pipe to the Charles River. Table 3-2 presents the activations at outfall CAM005 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 3-3 presents a profile through the regulator structure with the peak HGL during the Typical Year.

Table 3-2: CAM005 Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
5/2/1992	0.07
6/6/1992	0.01
8/11/1992	0.18
8/18/1992	0.07
9/9/1992	0.11
9/23/1992	0.07
10/23/1992	0.48
2-Year, 24-Hour Storm Volume (MG)	
1.08	
5-Year, 24-Hour Storm Volume (MG)	
2.05	

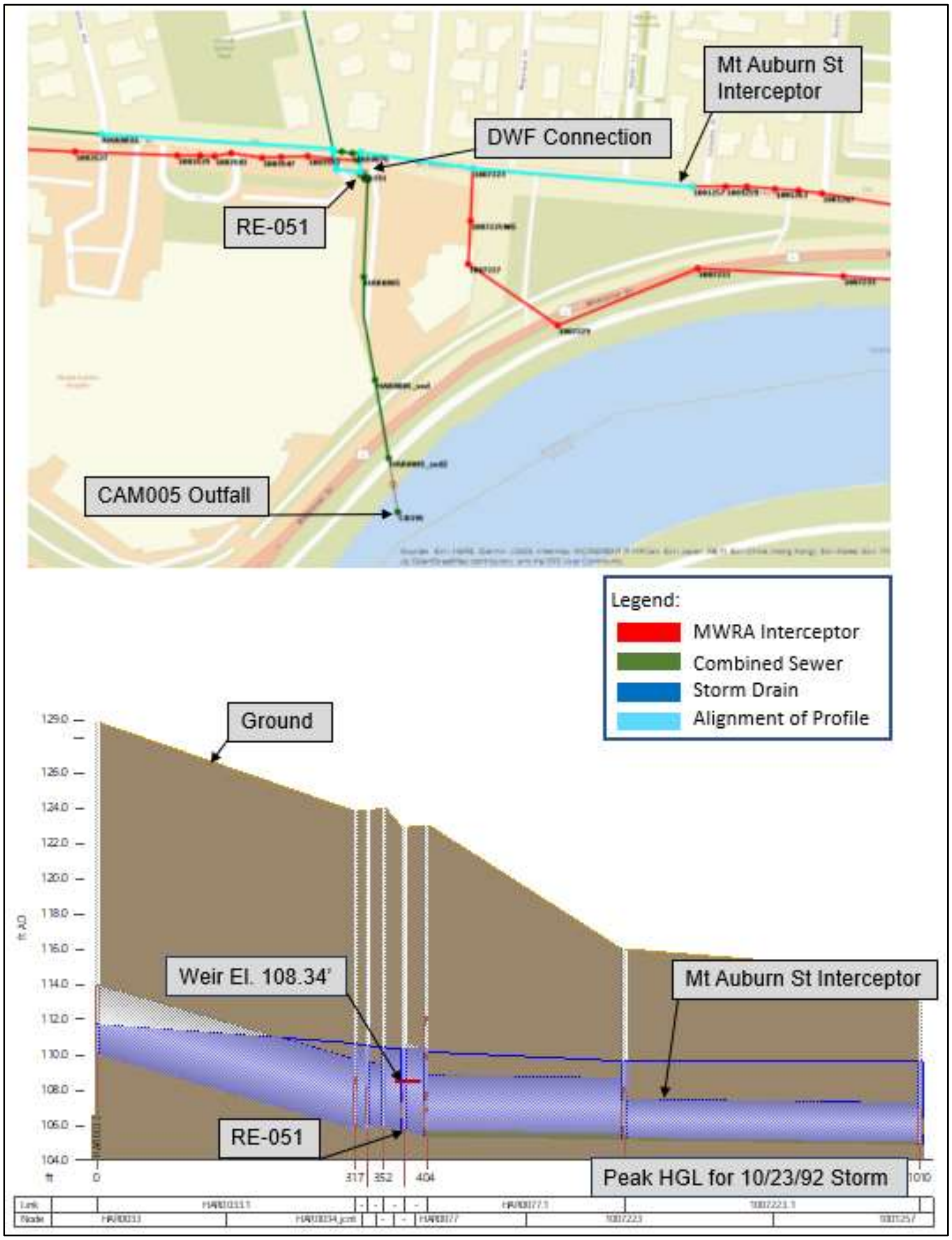

Figure 3-3: CAM005 Typical Year Regulator Profile

As indicated in Table 3-2, outfall CAM005 activates seven times during the Typical Year, discharging 0.99 MG of untreated CSO to the Charles River. As indicated in the profile in Figure 3-3, some upstream storage appears to be available during the largest storm in the Typical Year, although the slope of the upstream pipe may limit the ability to access that storage by raising the weir. Initial evaluations of raising the weir by 0.25 feet, 0.5 feet and 1 foot were predicted to produce modest reductions in activation frequency and volume at outfall CAM005, but these alternatives resulted in predicted increases in the peak HGL at the regulator. Although the increases in HGL did not exceed the screening-level guideline described in approach step No. 5 in Section 1.3, the City of Cambridge has experienced flooding in an area upstream of regulator RE051 and has expressed concern with alternatives that could potentially affect the flooded area or affect options to mitigate the flooding. Given the sensitivity of this location, these alternatives were re-assessed with the weir in regulator RE051 lengthened from the existing 3.5 feet, as modelled, to

10 feet to offset impacts to the HGL. Raising the weir by 1 foot and lengthening the weir to 10 feet reduced the activation frequency at outfall CAM005 by two and the discharge volume by 0.32 MG compared to baseline without increasing the peak HGL in regulator RE051 in the 5-year, 24-hour storm. However, these changes caused the Cottage Farm treated CSO Facility treated CSO discharge volume to increase by 0.06 MG (see Table 3-3).

While the analysis conducted with the 5-year, 24-hour storm predicted no increase in the HGL in regulator RE051 compared to the baseline condition, the City of Cambridge requested that the alternative be assessed with a 10-year, 24-hour storm that the City uses as a basis for level of service evaluations. The hyetograph for this storm was provided by Cambridge, and the model was run for this storm. The model predicted that with the weir at regulator RE051 raised by 1 foot and lengthened to 10 feet, the peak HGL in regulator RE051 on the upstream side of the weir was predicted to drop by about 0.25 feet. Downstream of regulator RE051, no HGL increases exceeding approach step No. 5 in Section 1.3 were noted.

Table 3-3. CAM005 Optimization Performance

Outfall	Regulator ID	Future Condition Baseline		CAM005 Weir Raised 1 ft and Lengthened to 10 ft		Typical Year Rainfall w/ Long Term CSO Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Upper Charles							
CAM005	RE-051	7	0.99	5	0.67	3	0.84
CAM007	RE-071	2	0.21	2	0.21	1	0.03
Sum		**7 (max)**	**1.20**	**5 (max)**	**0.88**	**3 (max)**	**0.87**
Lower Charles							
MWR201	Cottage Farm	2	8.90	2	8.96	2	6.3

Based on record drawings, the existing regulator RE051 structure appears to have sufficient space to accommodate a 10-foot-long weir. However, the location of the extended weir may interfere with access to the regulator structure and would require relocation of the existing floatables baffle. Figure 3-4 presents a concept sketch of a potential layout for this alternative. This sketch shows the new weir in a “V” configuration in an attempt to minimize interference with the access opening in the roof slab. Other configurations could be considered, depending in part on the desired materials of construction. Given the likely non-standard configuration of the weir, CFD modelling may be needed to confirm the hydraulic performance. Due to the location of the regulator structure in the driveway of the Mount Auburn Hospital, access is limited and modifications would need to be installed manually from inside the structure.

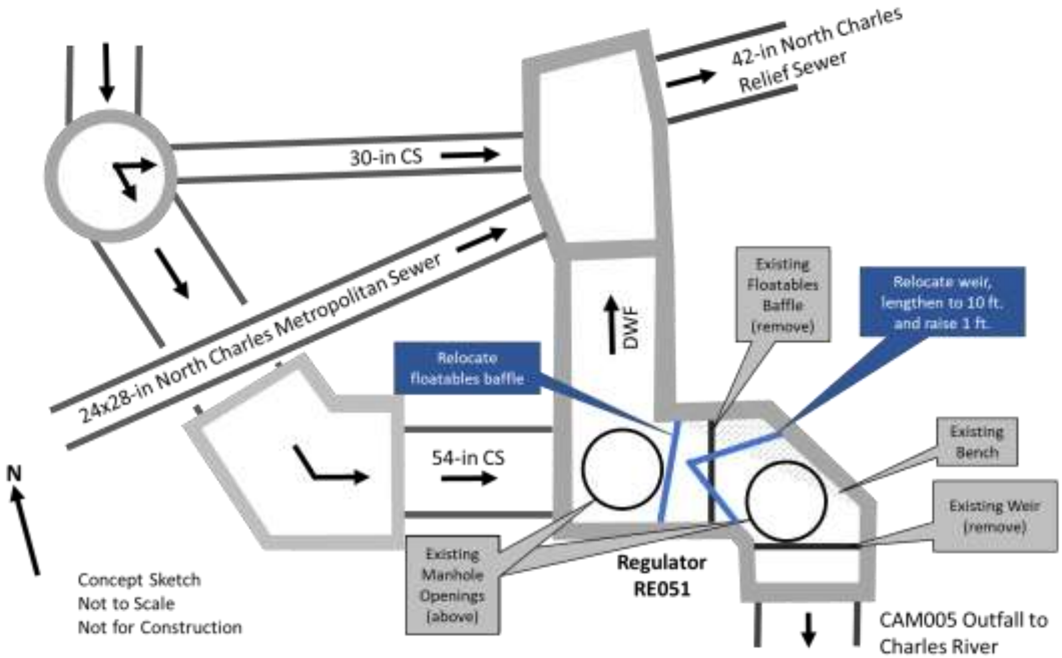

Figure 3-4. Concept Sketch for Raising and Lengthening Weir at CAM005

The 4.5 foot influent conduit to regulator RE-051 transitions to an approximately 5-ft wide x 8-ft high box conduit through the regulator. The profile in Figure 3-3 showed little head loss through this connection, so further optimization of the DWF connection was not evaluated.

In summary, for outfall CAM005, the concept of raising the weir at regulator RE051 by 1 foot and lengthening the weir to 10 feet is recommended to be implemented. As part of the implementation process, additional information will be gathered on the regulator structure by conducting a laser scan. In addition, further analysis of the optimal configuration for the raised and lengthened weir, including assessment of materials of construction, as well as a construction feasibility analysis is recommended. CFD analysis or additional flow monitoring in the regulator structure is being considered to further understand complex system hydraulics and potential benefits of this alternative. The construction cost of this optimization measure would depend on the final configuration and materials of construction. However, the total cost for implementation (additional analysis, design, construction procurement, and construction) would likely be under $200,000.

3.2.2 CAM007

Regulator RE-071 discharges to outfall CAM007, and is located just south of Memorial Drive opposite Hawthorn Street. The regulator is on the 3.5-foot diameter North Charles Relief Sewer (NCRS) and serves as a side-outlet relief for the interceptor. The regulator also receives flow from 4-foot and 3-foot diameter influent conduits from Cambridge. During dry weather, flow enters the regulator and continues down the NCRS towards Ward Street Headworks. During wet weather, when the HGL in the regulator exceeds the weir elevation of 107.51 ft, the overflow enters a 4.50-foot diameter outfall pipe with a flap gate that discharges to the Charles River. Table 3-4 presents the activations at outfall CAM007 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 3-5 presents a profile through the regulator structure with the peak HGL during the Typical Year.

Table 3-4: CAM007 Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
9/9/1992	0.03
10/23/1992	0.18
2-Year, 24-Hour Storm Volume (MG)	
1.47	
5-Year, 24-Hour Storm Volume (MG)	
3.56	

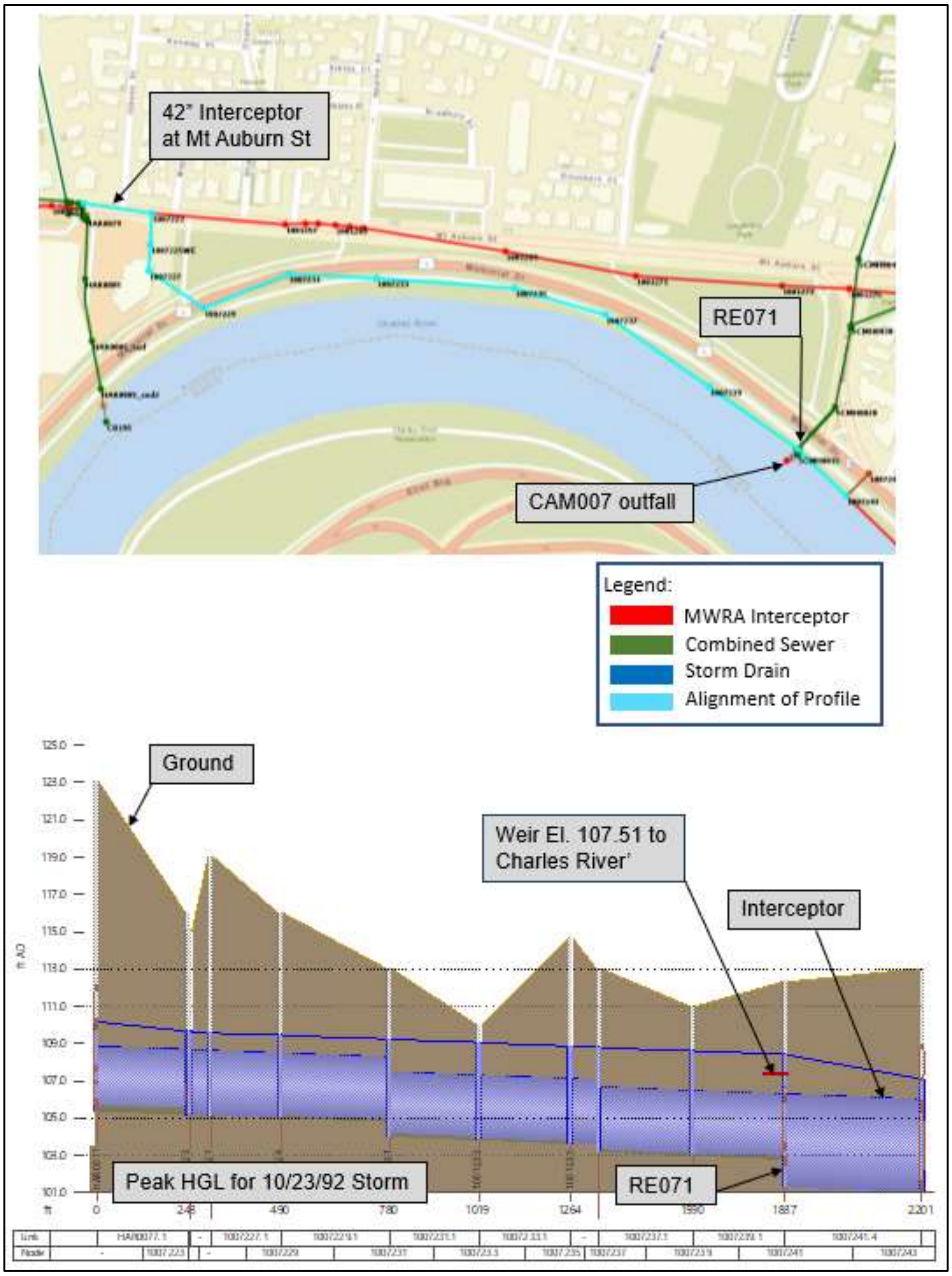

Figure 3-5. CAM007 Typical Year Regulator Profile

As indicated in Table 3-4, during the Typical Year outfall CAM007 activates twice, discharging 0.21 MG of untreated CSO to the Charles River. Figure 3-5 shows the interceptor upstream of regulator RE-071 is fully surcharged during the largest storm in the Typical Year. Nevertheless, raising the weir in regulator RE-071 was evaluated for the Typical Year and the 5-year, 24-hour storm. Raising the weir by 0.5 feet resulted in very little net reduction in volume to the Charles River but resulted in an HGL increase greater than the screening-level guideline described in approach step No. 5 in Section 1.3. Similar to outfall CAM005, runs were then conducted with the regulator RE-071 weir raised and lengthened, in this case lengthened from the existing modelled length of 6.33 feet to 11.5 feet. Raising the weir by 1 foot and lengthening the weir reduced the activation frequency at outfall CAM007 by one and provided a net reduction in untreated CSO volume to the Charles River of 0.05 MG. This alternative also increased the treated discharge volume at Cottage Farm by 0.02 MG, resulting in a net total reduction in treated and untreated discharge of 0.03 MG (see Table 3-5).

Table 3-5. CAM007 Optimization Performance

Outfall	Regulator ID	Future Condition Baseline		CAM007 Weir Raised 1 ft and Lengthened to 11.5 ft		Typical-Year Rainfall w/ Long Term CSO Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Upper Charles							
CAM005	RE-051	7	0.99	7	1.02	3	0.84
CAM007	RE-071	2	0.21	1	0.13	1	0.03
Sum		**7 (max)**	**1.20**	**7 (max)**	**1.15**	**3 (max)**	**0.87**
Lower Charles							
MWR201	Cottage Farm	2	8.90	2	8.92	2	6.3

Due to the hydraulic connectivity between the regulators for outfalls CAM005 and CAM007, model runs were conducted with both regulator weirs raised by 1 foot and lengthened as described above. This alternative resulted in a reduction of the outfall CAM005 activation frequency by two activations, and a net reduction in untreated CSO volume to the Charles River of 0.35 MG. The activation frequency at outfall CAM007 did not change, and the volume of treated discharge at Cottage Farm increased by 0.06 MG (see Table 3-6).

Table 3-6. CAM005 and CAM007 Combined Optimization Performance

Outfall	Regulator ID	Future Condition Baseline		CAM007 Weir Raised 1 ft Lengthened to 11.5 ft + CAM005 Weir Raised 1 ft and lengthened to 10 ft		Typical-Year Rainfall w/ Long Term CSO Control Plan	
		Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)	Activation Frequency	Volume (MG)
Upper Charles							
CAM005	RE-051	7	0.99	5	0.70	3	0.84
CAM007	RE-071	2	0.21	2	0.15	1	0.03
Sum		**7 (max)**	**1.20**	**7 (max)**	**0.85**	**3 (max)**	**0.87**
Lower Charles							
MWR201	Cottage Farm	2	8.90	2	8.96	2	6.3

This joint alternative only produced a marginal additional net CSO volume reduction to the Charles River of 0.03 MG compared to the alternative for raising and lengthening the weir at outfall CAM005 by itself.

Figure 3-6 presents a sketch of the existing regulator RE-071 (outfall CAM007). The existing weir is located in a side-outlet opening, and a floatables baffle extends across the opening into the main part of the regulator chamber. The flap gate chamber opens directly to the Charles River. It would not be feasible to lengthen the weir by moving it into the main part of the regulator chamber, as that would force the underflow baffle directly into the flow path of the North Charles Relief Sewer. To lengthen the weir and move it into the flap gate chamber would require complete reconstruction of that chamber, which is located on the bank of the Charles River. This work would likely require a cofferdam, dewatering, and extensive permitting which would be beyond the scope of a typical optimization project. Given the very nominal CSO volume reduction that would be achieved by raising and lengthening the weir at regulator RE-071, and the extensive construction work that would be required, this alternative was not recommended. The combination CAM005/CAM007 optimization alternative was similarly not recommended.

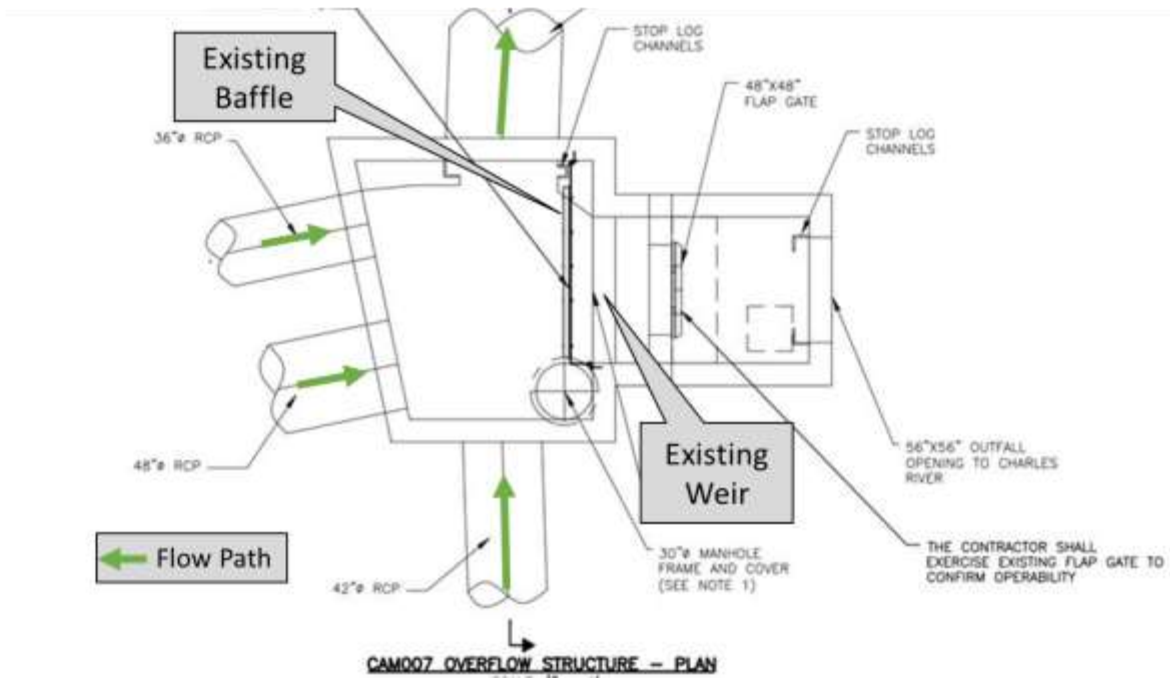

Figure 3-6. Existing Regulator RE-071 (CAM007)

3.2.3 CAM017

The CAM017 regulator is located at the intersection of Land Boulevard and Binney Street on the Cambridge Marginal Conduit (CMC) upstream of the MWRA's Prison Point CSO facility. The regulator is a complex structure with three channels and three bending weirs. During dry weather, flow enters the regulator and continues down the CMC towards Prison Point. The crest elevation of one of the bending weirs is at el. 109.86 ft, while the crests of the other two bending weirs are set at el. 109.97 ft. However, the bending weirs have been set such that when the HGL in the regulator reaches el. 109.17 ft all three weirs start to bend to provide upstream flooding relief. Table 3-7 presents the activations at outfall CAM017 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms.

Table 3-7: CAM017 Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
0	0
2-Year, 24-Hour Storm Volume (MG)	
2.33	
5-Year, 24-Hour Storm Volume (MG)	
4.53	

The City of Cambridge has invested significantly over the years to optimize the CAM017 regulator and bring flood relief to the Port neighborhood. The CAM017 regulator structure was specifically modified from a fixed weir to multiple bending weirs to reduce flooding in this neighborhood during large storms without increasing CSO volume in the Typical Year. Increasing the hydraulic grade line in this area of the collection system has been documented in the City's facility plans over the years to have a significant, negative impact. Therefore, further optimization is not recommended at this location.

3.2.4 MWR010

Regulators RE036-9 and RE037 discharge to outfall MWR010. These regulators are both located on Commonwealth Avenue at St. Mary's Street. The influent to regulator RE036-9 is a 2.67 x 3.5-foot combined sewer. Dry weather flow is conveyed to the Charles River Valley Sewer. When the depth in regulator RE036-9 exceeds the invert elevation of the 1.5-foot diameter overflow pipe, overflow is discharged to the Charles River. Regulator RE037 is located directly on the Charles River Valley Sewer, and functions as a high-outlet relief. When the depth in regulator RE037 exceeds the invert elevation of the 1.5-foot diameter overflow pipe, overflow is discharged to the Charles River. Regulator RE036-9 is not predicted to activate in the 5-year, 24-hour storm. Table 3-8 presents the activations at regulator RE037 (outfall MWR010) by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms.

Table 3-8: Regulator RE037 (Outfall MWR010) Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
0	0
2-Year, 24-Hour Storm Volume (MG)	
0	
5-Year, 24-Hour Storm Volume (MG)	
0.60	

Preliminary investigations indicated that installing a weir in the high-outlet relief pipe in regulator RE037 would create a hydraulic restriction which would result in an HGL increase greater than the screening-level guideline described in approach step No. 5 in Section 1.3. Since this regulator functions as a high-outlet relief directly on the Charles River Valley Sewer, there was no opportunity to increase the DWF capacity. As a result, no optimization measures were recommended for outfall MWR010.

3.2.5 MWR018/MWR019/MWR020

The regulator structures associated with outfalls MWR018, MWR019 and MWR020 provide relief to the Boston Marginal Conduit (BMC) along the Esplanade in Boston during wet weather. During dry weather, water flows down the 6.33 x 7.67-foot BMC towards the Prison Point CSO Facility where the flow is pumped to the interceptor system tributary to the Chelsea Creek Headworks. As the HGL rises in the BMC during wet weather, flow passes into large, complex weir structures associated with outfalls MWR018, MWR019 and MWR020. The controlling elevations at each structure, however, are established by stop logs in chambers located just downstream of each of the large weir chambers. The stop log elevation controlling overflow at outfall MWR018, located across Storrow drive from Hereford Street, is elevation 108.68. For outfall MWR019, located across Storrow Drive from Gloucester Street, the elevation is 109.03. For outfall MWR020, located across Storrow Drive from Berkeley Street, the elevation is 109.05. The MWR018 and MWR019 outfall pipes are both 6.5 x 6.5-foot rectangular pipes, while the MWR020 outfall pipe is a 7 x 10-foot rectangular pipe. Outfalls MWR018, MWR019 and MWR020 all discharge to the Charles River. Table 3-9 presents the activations at outfalls MWR018, MWR019 and MWR020 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 3-7, Figure 3-8, and Figure 3-9 present profiles through each of the regulator structures with the peak HGL during the Typical Year.

Table 3-9: MWR018/MWR019/MWR020 Activations by Storm Event

MWR018		MWR019		MWR020	
Typical Year		Typical Year		Typical Year	
Date	Volume (MG)	Date	Volume (MG)	Date	Volume (MG)
9/23/1992	0.70	9/23/1992	0.27	9/23/1992	0.06
10/23/1992	0.42	10/23/1992	0.21	10/23/1992	0.41
2 Year Storm Volume (MG)		2 Year Storm Volume (MG)		2 Year Storm Volume (MG)	
1.56		1.07		4.41	
5 Year Storm Volume (MG)		5 Year Storm Volume (MG)		5 Year Storm Volume (MG)	
2.02		1.57		5.62	

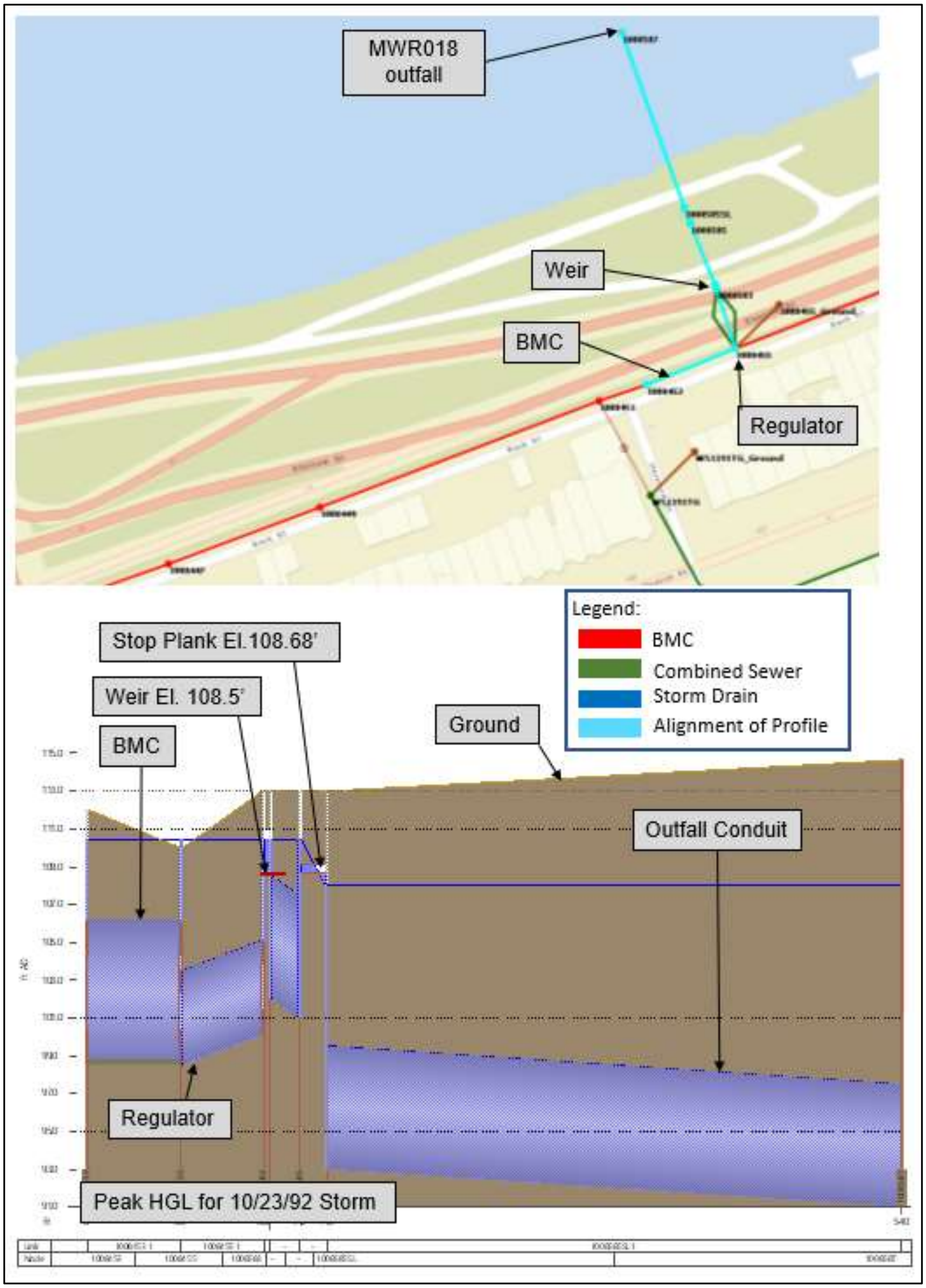

Figure 3-7: MWR018 Typical Year Regulator Profile

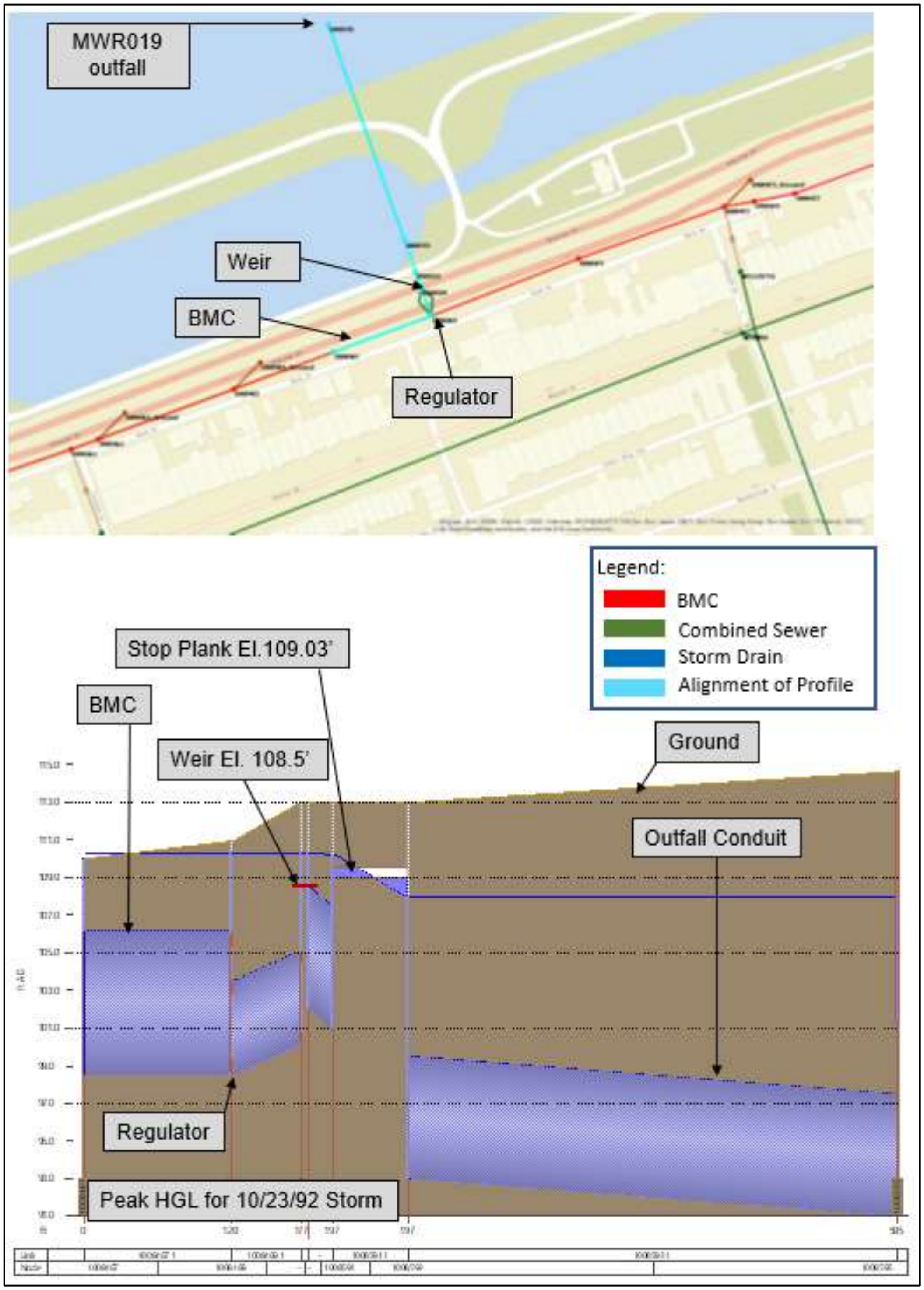

Figure 3-8: MWR019 Typical Year Regulator Profile

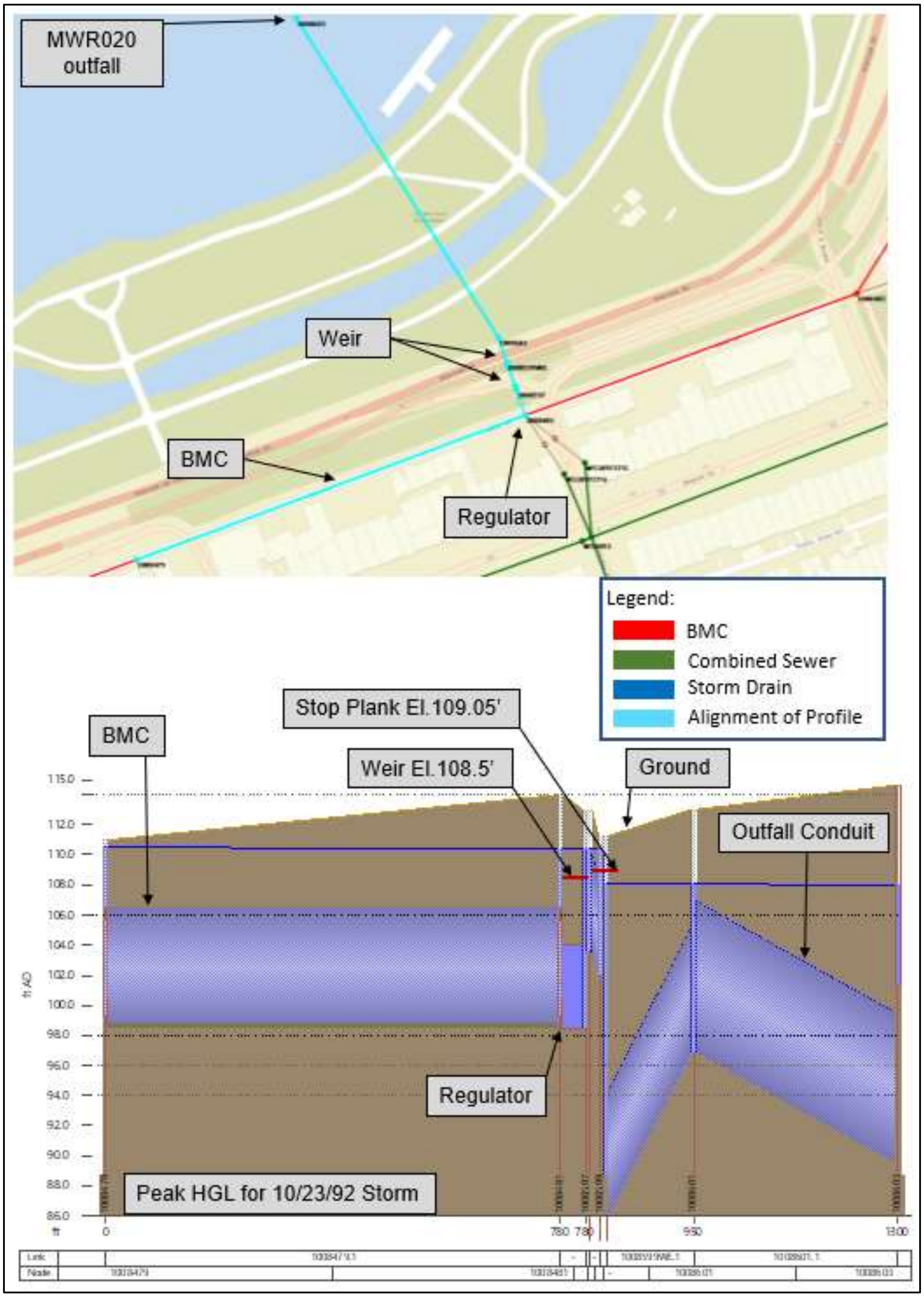

Figure 3-9: MWR020 Typical Year Regulator Profile

As indicated in Table 3-9, during the Typical Year outfalls MWR018, MWR019 and MWR020 each activate two times, discharging 1.11 MG, 0.48 MG, and 0.47 MG of untreated CSO to the Charles River respectively. These outfalls are hydraulically related through the connections to the BMC. As shown in the profile figures above, the HGL in the BMC is approaching the ground surface during the Typical Year resulting in limited opportunity for optimization. The model indicated that raising the weir crests by 0.25 feet and 0.5 feet did not reduce CSO discharge volume to the Charles River during the Typical Year or the 5-year design storm while slightly increasing the HGL along the BMC. Since the outfalls serve as side-outlet relief points directly off the BMC, there are no DWF connections to potentially modify. As a result, no optimization is recommended at outfalls MWR018, MWR019 and MWR020.

3.2.6 Cottage Farm (MWR201)

The Cottage Farm CSO Facility is a CSO treatment facility which detains and treats CSO before it is discharged to the Charles River. The facility provides relief to the North Charles Metropolitan Sewer/Relief Sewer and to the South Charles Relief Sewer. Weir chambers on each of the interceptors divert flow towards the Cottage Farm facility. The weirs on the North Charles diversion structure are set at elevation 93, and the weirs on the South Charles diversion structure are set at elevation 92.7. When flow first passes over the weirs in the diversion structures, it is conveyed to the facility influent chamber, where it is initially directed to the 4.5-foot diameter Brookline Connection, which is a third siphon barrel under the Charles River conveying flow towards Ward Street Headworks. To fully utilize the in-system storage, when the water surface in the influent gate structure reaches elevation 98, the influent gates open, and flow is introduced into the Cottage Farm Facility. The influent gates close when the water surface elevation in the influent gate structure drops back to elevation 95.

Table 3-10 presents the activations at Cottage Farm by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Note that CSOs discharged from the Cottage Farm facility are treated CSOs. Figure 3-10 presents a profile through the South Charles Relief Sewer to the Cottage Farm facility with the peak HGL during the Typical Year. Figure 3-11 presents a profile through the North Charles Relief Sewer to the Cottage Farm facility with the peak HGL during the Typical Year.

Table 3-10: Cottage Farm Activations by Storm Event

Date	Volume (MG)
Typical Year	
9/23/1992	7.22
10/23/1992	1.68
2-Year, 24-Hour Storm Volume (MG)	
19.82	
5-Year, 24-Hour Storm Volume (MG)	
28.19	

As indicated in Table 3-10, during the Typical Year the Cottage Farm CSO Facility (outfall MWR201) is predicted to activate twice discharging 8.90 MG of treated CSO to the Charles River. As noted above, the water surface elevation upstream of the facility influent gates dictates when the facility activates. Therefore, optimization at Cottage Farm consisted of adjusting the elevations for opening and closing the influent gates to the facility. In the future baseline model, the influent gates open when the HGL in the influent wet well reaches el. 98 ft and close when the HGL reaches el. 95 ft. Altering the setpoint elevations to open the influent gates when the HGL reaches 98.5 feet and close the gates when the HGL reaches 96 feet resulted in a CSO volume reduction of 1.75 MG in the Typical Year but did not reduce the activation frequency. In practice, the gate opening and closing elevations of 98.0 and 95.0 are considered general targets. During actual storm events, MWRA facility operators consider weather forecasting and in-system conditions in operating the influent gates, and the actual gate-opening and gate-closing elevations may vary. It is recommended that the MWRA continue to operate the Cottage Farm facility consistent with current practice, as defining absolute elevations for the gate opening and closing operations does not allow for consideration of the specific hydraulic and hydrologic conditions that may exist for individual storm events of the size that may cause activation of the facility.

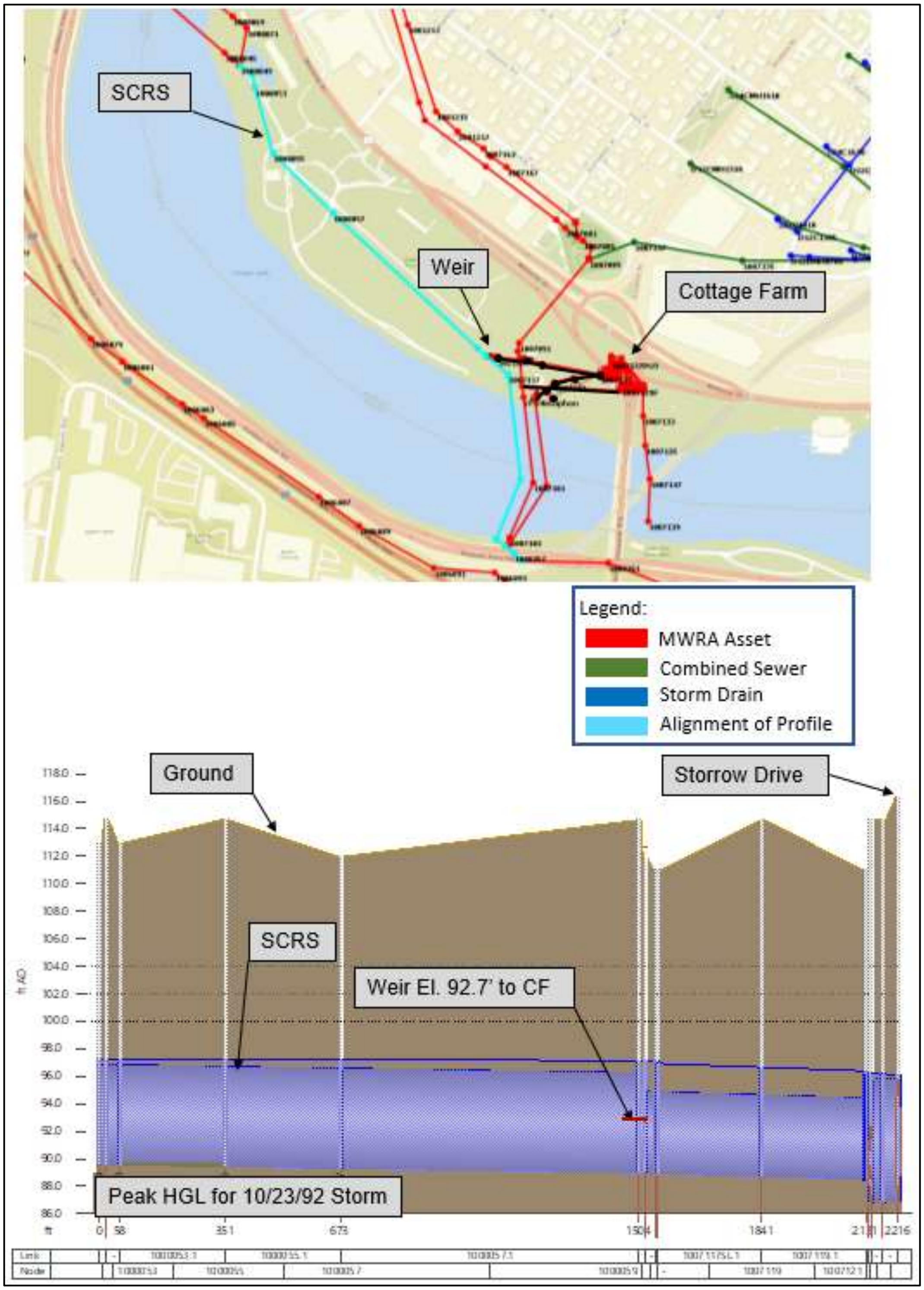

Figure 3-10: Cottage Farm (MWR201) Typical Year Profile – South Charles Relief Sewer

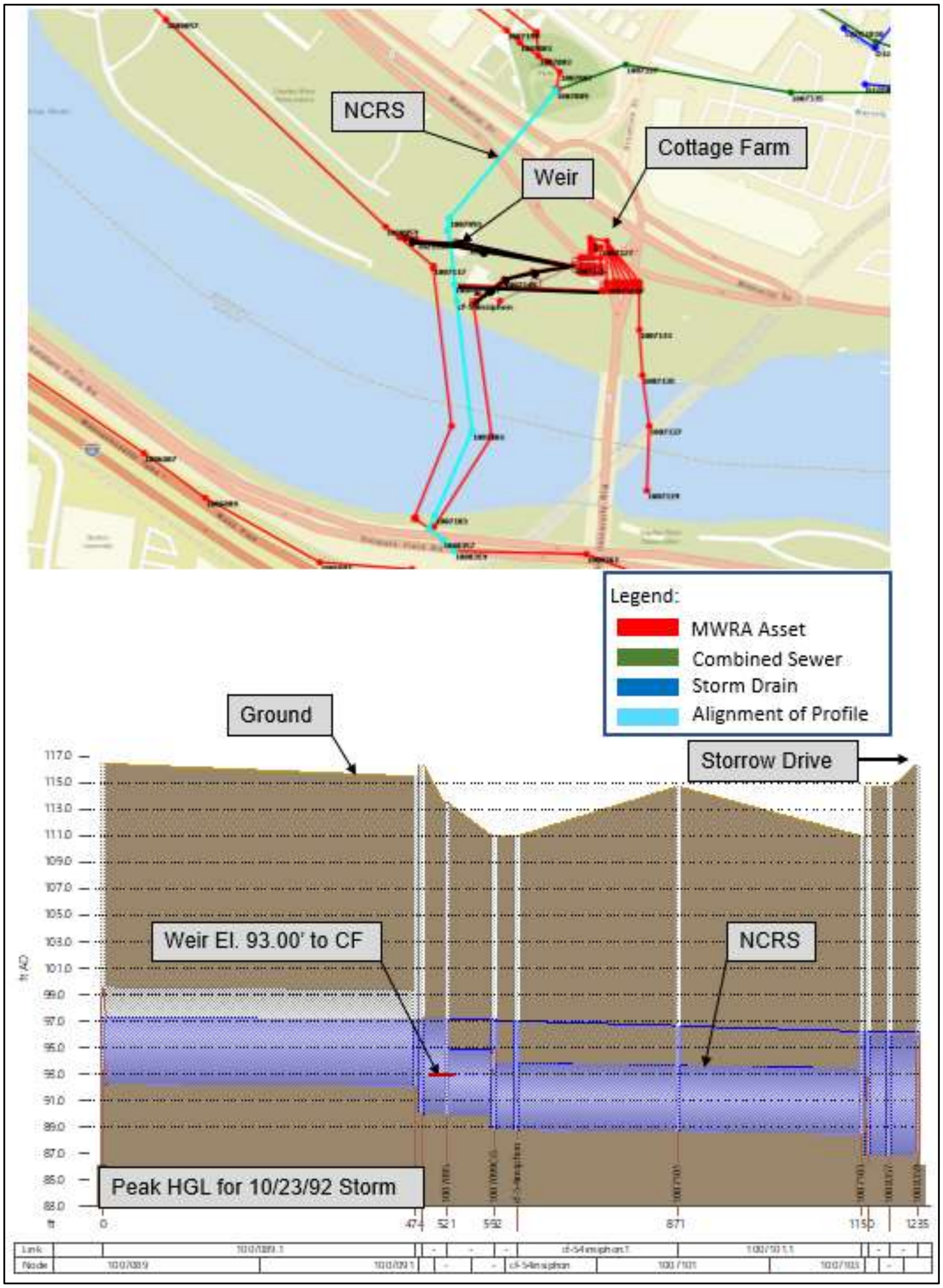

Figure 3-11: Cottage Farm (MWR201) Typical Year Profile – North Charles Relief Sewer

3.2.7 Regulator RE046-19

Regulator RE046-19 is located at the intersection of South Street and McBride Street in Boston. The influent to regulator RE046-19 is modelled as a 2.5 x 3.25-foot egg-shaped pipe from the Forest Hills area in Boston. During dry weather, flow is directed through a 2.5 x 3.25-foot egg-shaped DWF connection to the Southwest Corridor Interceptor which drains to Ward Street Headworks via the Boston Main Drain Relief Sewer (BMDRS). During wet weather, the regulator functions as a high-outlet relief. When the HGL reaches an elevation of 140.91 ft, combined sewage enters a 1.5-foot diameter high pipe into the Stony Brook Conduit (SBC). Most of the flow in the SBC discharges to the Charles River at outfall MWR023. In larger storms, when the HGL in the SBC exceeds the overflow elevation at Boston Gatehouse No. 1 (el. 112.92 ft), a portion of the flow in the SBC can discharge to the Muddy River through the Gatehouse. Table 3-11 presents the activations at regulator RE046-19 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 3-12 presents a profile through the regulator structure with the peak HGL during the 5-year storm.

Table 3-11: Regulator RE046-19 Activation Volumes by Storm

Typical Year	
Date	**Volume (MG)**
NA	NA
2-Year, 24-hour Storm Volume (MG)	
NA	
5-Year, 24-hour Storm Volume (MG)	
0.11	

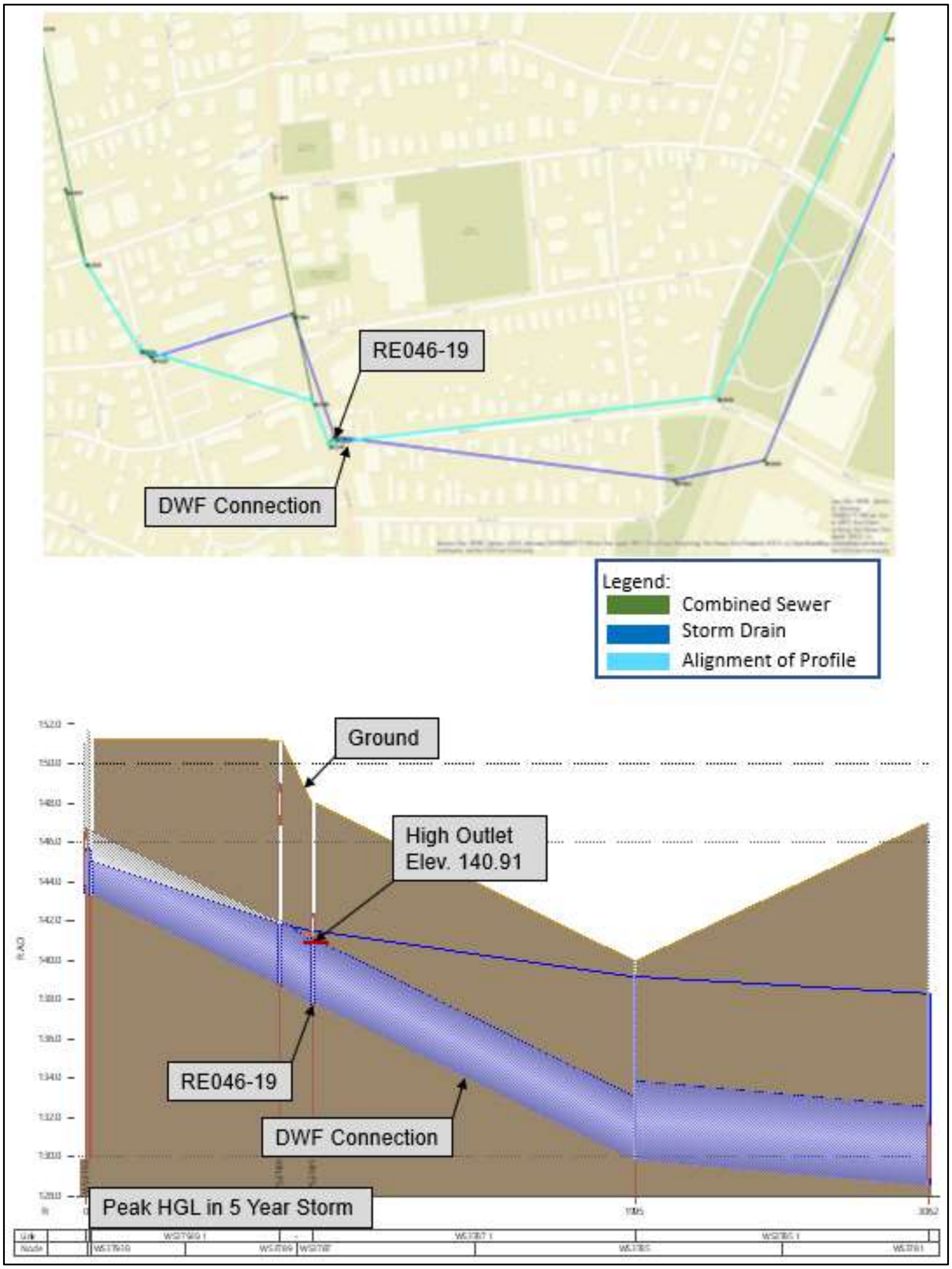

Figure 3-12: Regulator RE046-19 5-year, 24-hour Storm Regulator Profile

As indicated in Table 3-11, regulator RE046-19 does not activate during the Typical Year or the 2-year, 24-hour storm, but it does activate during the 5-year, 24-hour storm, discharging 0.04 MG of combined sewage to the SBC. Under baseline conditions during the 5-year, 24-hour storm, the HGL at a downstream manhole along the dry weather flow path rises to within 0.83 feet of the ground surface. Adding a weir plate to the invert of the high relief pipe would cause the HGL to rise along the dry weather flow path and increase the risk of flooding. Since the regulator functions as a high outlet relief for flows passing through, there is no DWF connection to optimize. As a result, no optimization is recommended at regulator RE046-19.

3.2.8 Regulator RE046-100

RE-046-100 is located at 139 Lamartine Street. The influent conduits to regulator RE046-100 include a 1.5-foot and a 2-foot diameter circular pipe from the Jamaica Plain area. During dry weather, flows is directed through a 2-foot diameter DWF connection to the Southwest Corridor Interceptor which drains to Ward Street Headworks via the BMDRS. During wet weather, the regulator functions as a high-outlet relief. When the HGL reaches an elevation of 126.34 ft, combined sewage enters a 1.5-foot diameter high pipe which transfers flow to the SBC. As noted for regulator RE046-19, most of the flow in the SBC discharges to the Charles River at outfall MWR023. In larger storms, when the HGL in the SBC exceeds the overflow elevation at Boston Gatehouse No. 1 (el. 112.92 ft), a portion of the flow in the SBC can discharge to the Muddy River through the Gatehouse. An upstream cross connection between regulator RE046-100 and regulator RE046-105 exists, which under baseline conditions contributes to the Typical Year activation volume at regulator RE046-100 due to water backing up from regulator RE046-105. Table 3-12 presents the activations at regulator RE046-100 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 3-13 presents a profile through the regulator structure with the peak HGL during the Typical Year.

Table 3-12: Regulator RE046-100 Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
10/23/1992	0.10
2-Year, 24-Hour Storm Volume (MG)	
0.34	
5-Year, 24-Hour Storm Volume (MG)	
0.53	

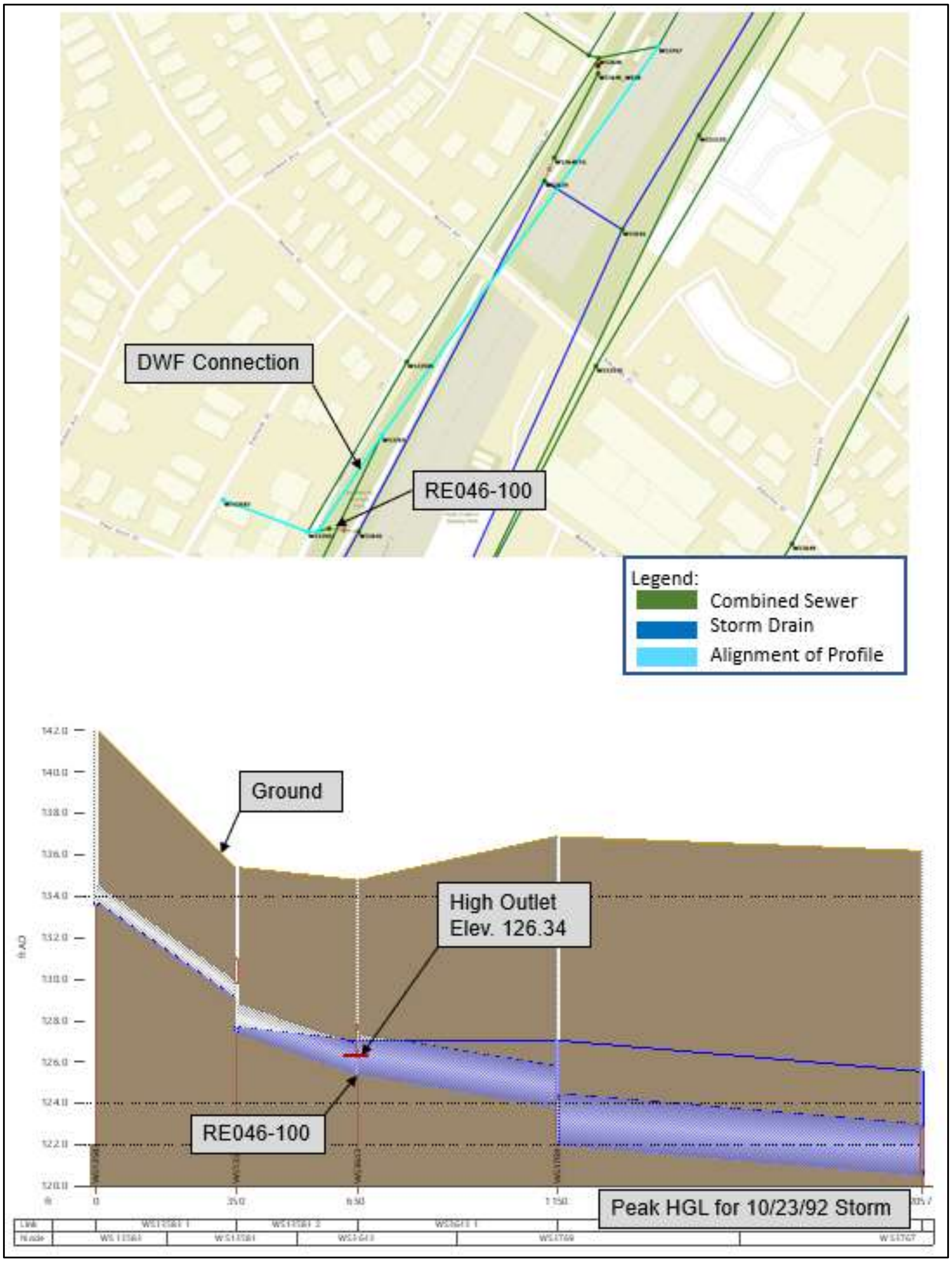

Figure 3-13: BOS046-100 Typical Year Regulator Profile

As indicated in Table 3-12, regulator RE046-100 activates once during the Typical Year, discharging 0.1 MG of combined sewage to the SBC. An increase in the overflow elevation at regulator RE046-100 was simulated by modelling a weir to represent a steel plate installed across the high-outlet pipe, raising the overflow elevation by 1 foot. This alternative did not eliminate the Typical Year activation and resulted in the HGL in the regulator increasing by 1.83 feet to within 5.94 feet of grade. This predicted HGL increase would be greater than the screening-level guideline described in approach step No. 5 in Section 1.3. Further raising of the steel plate would cause increase the HGL and potentially cause flooding during the 5-year, 24-hour storm. Since the regulator functions as a high outlet relief there is no DWF connection to optimize. In addition, the peak HGL in the Typical Year in the downstream interceptor system is above the weir elevation, so increasing the size of the downstream pipe would only increase the overflow volume via backflow from the interceptor. As a result, no optimization is recommended at regulator RE046-100.

3.2.9 Regulator RE046-105

Regulator RE046-105 is located at the intersection of Hoffman and Lamartine Streets in Boston. The influent to regulator RE046-105 is modelled as a 4.5-foot diameter circular influent pipe from the Jamaica Plain area. During dry weather, flow is directed through a 0.83-foot diameter DWF connection to the Southwest Corridor Interceptor which drains to Ward Street Headworks via the BMDRS. During wet weather, when the HGL reaches an elevation of 130.01 ft, combined sewage flows over a weir to the SBC. Combined sewage in the SBC can discharge to the Charles River through outfall MWR023, or to the Back Bay Fens through Boston Gatehouse No. 1. An upstream cross connection between regulator RE046-105 and regulator RE046-100 exists, which under baseline conditions contributes to the regulator RE046-100 Typical Year activation volume due to water backing up from regulator RE046-105. Table 3-13 presents the activations at regulator RE046-105 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 3-14 presents a profile through the regulator structure with the peak HGL during the 2-year, 24-hour storm.

Table 3-13: Regulator RE046-105 Activation by Storm Event

Typical Year	
Date	**Volume (MG)**
NA	NA
2-Year, 24-Hour Storm Volume (MG)	
0.02	
5-Year, 24-Hour Storm Volume (MG)	
0.08	

As indicated in Table 3-13, regulator RE046-105 does not activate during the Typical Year, but does activate during the 2-year, 24-hour storm, discharging 0.02 MG of combined sewage to the SBC. As indicated in Figure 3-14, the influent pipe upstream of regulator RE046-105 is surcharged in the 2-year, 24-hour storm, suggesting little available upstream storage. Nevertheless, evaluations were conducted to assess raising the regulator RE046-105 weir by 0.25 feet and 0.5 feet. Raising the weir by 0.5 feet eliminated the activation in the 2-year, 24-hour storm. However, the total volume of overflow to the SBC from all regulators was not reduced as the overflow volume shifted to regulator RE046-100. This result was also observed for the 5-year, 24-hour storm. As a result, no weir raising optimization is recommended at regulator RE046-105.

Figure 3-14 showed a noticeable head loss across the DWF connection at regulator RE046-105 in the 2-year, 24-hour storm. Accordingly, a run was conducted where the 0.83-foot diameter DWF connection was enlarged to 1.25 feet. By enlarging the DWF pipe, the backwater condition through the upstream cross connection between regulators RE046-100 and RE046-105 was alleviated and no longer contributed to the overflow volume at regulator RE046-100. However, the enlarged DWF connection resulted in an HGL increase greater than the screening-level guideline described in approach step No. 5 in Section 1.3. It also resulted in increased reverse flow through the DWF connection at regulator RE046-100 and over the high pipe to the SBC during the 5-year, 24-hour storm. Due to the increased HGL in the interceptor and adverse impacts to regulator RE046-100, no optimization is recommended at regulator RE046-105.

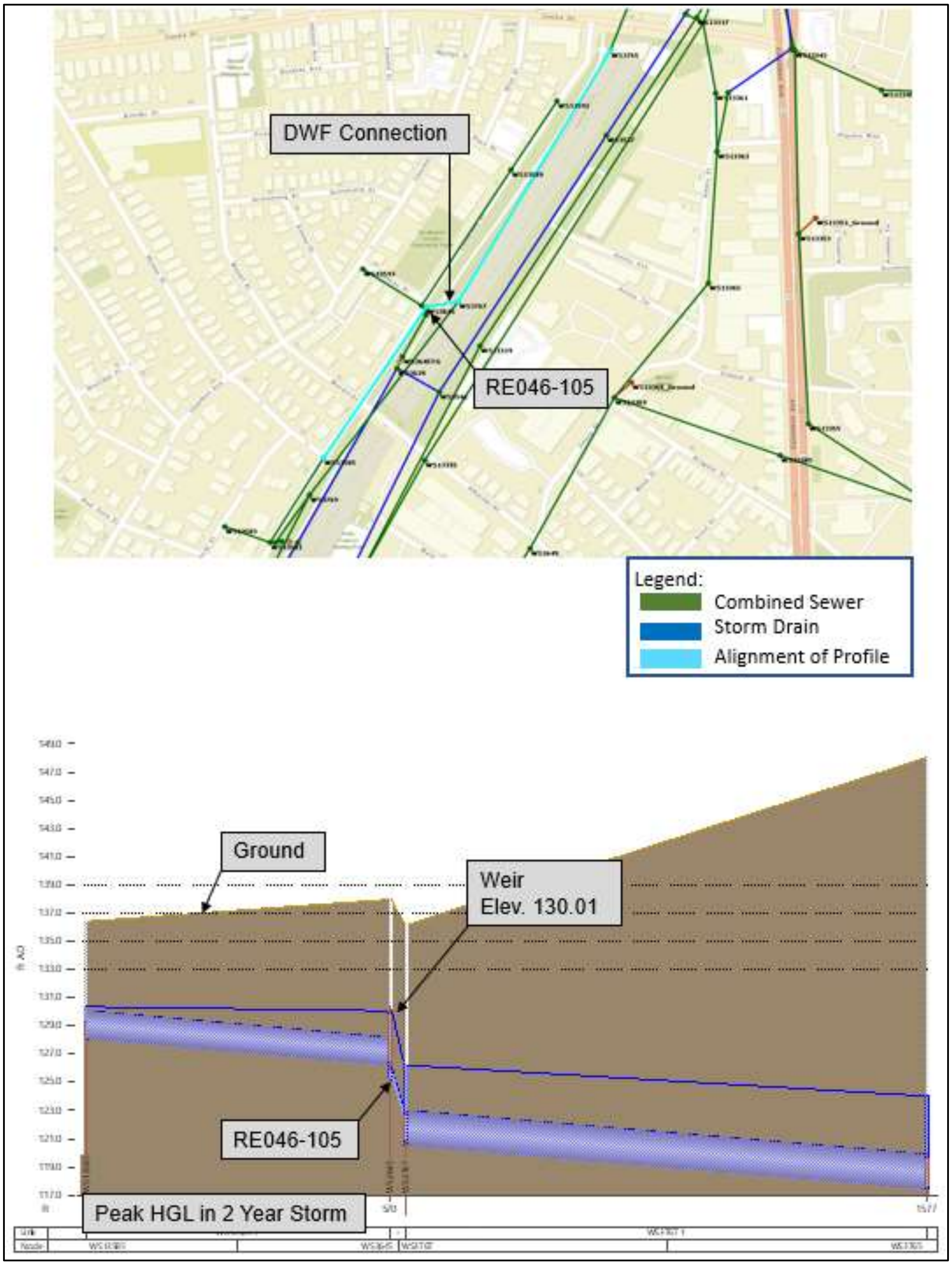

Figure 3-14: BOS046-105 2-Year Regulator Profile

3.2.10 Regulator RE046-381

Regulator RE046-381 is located at the intersection of Hoffman and Lamartine Streets in Boston. The influent to regulator RE046-381 is modelled as a 2.5-foot diameter circular pipe from the Forest Hills area. During dry weather, flow continues through the regulator through a 2.5-foot diameter DWF connection to the Southwest Corridor Interceptor which drains to Ward Street Headworks via the BMDRS. During wet weather, when the HGL reaches an elevation of 132.68 ft, combined sewage flows over a weir into multiple 3-foot diameter high pipes to the SBC. The weir is formed by a chimney pipe in the RE046-381 regulator structure. Table 3-14 presents the activations at regulator RE046-381 by storm event for the Typical Year, as well as the predicted volumes for the 2-year and 5-year, 24-hour storms. Figure 3-15 presents a profile through the regulator structure with the peak HGL during the Typical Year.

Table 3-14: Regulator RE046-381 Activations by Storm Event

Typical Year	
Date	**Volume (MG)**
10/23/1992	0.03
2 Year Storm Volume (MG)	
0.54	
5 Year Storm Volume (MG)	
0.88	

As indicated in Table 3-14, during the Typical Year, regulator RE046-381 activates once, discharging 0.03 MG of combined sewage to the SBC. As indicated in Figure 3-15, the influent pipe upstream of regulator RE046-381 is surcharged in the Typical Year, suggesting little available upstream storage. Nevertheless, evaluations were conducted to assess raising the regulator RE046-105 weir. Raising the regulator RE046-381 weir/chimney pipe to an elevation of 133 ft, approximately 0.33 feet, did not eliminate the Typical Year activation and resulted in the upstream HGL rising by 0.14 feet to within 4.45 feet of grade. Since raising the weir did not eliminate the single 0.03 MG typical year overflow and given the proximity of the upstream HGL to grade raising the weir was not considered further.

Since this regulator does not have a reduced-capacity DWF connection to the interceptor system, optimizing the DWF connection was not evaluated. As a result, no optimization is recommended at regulator RE046-381.

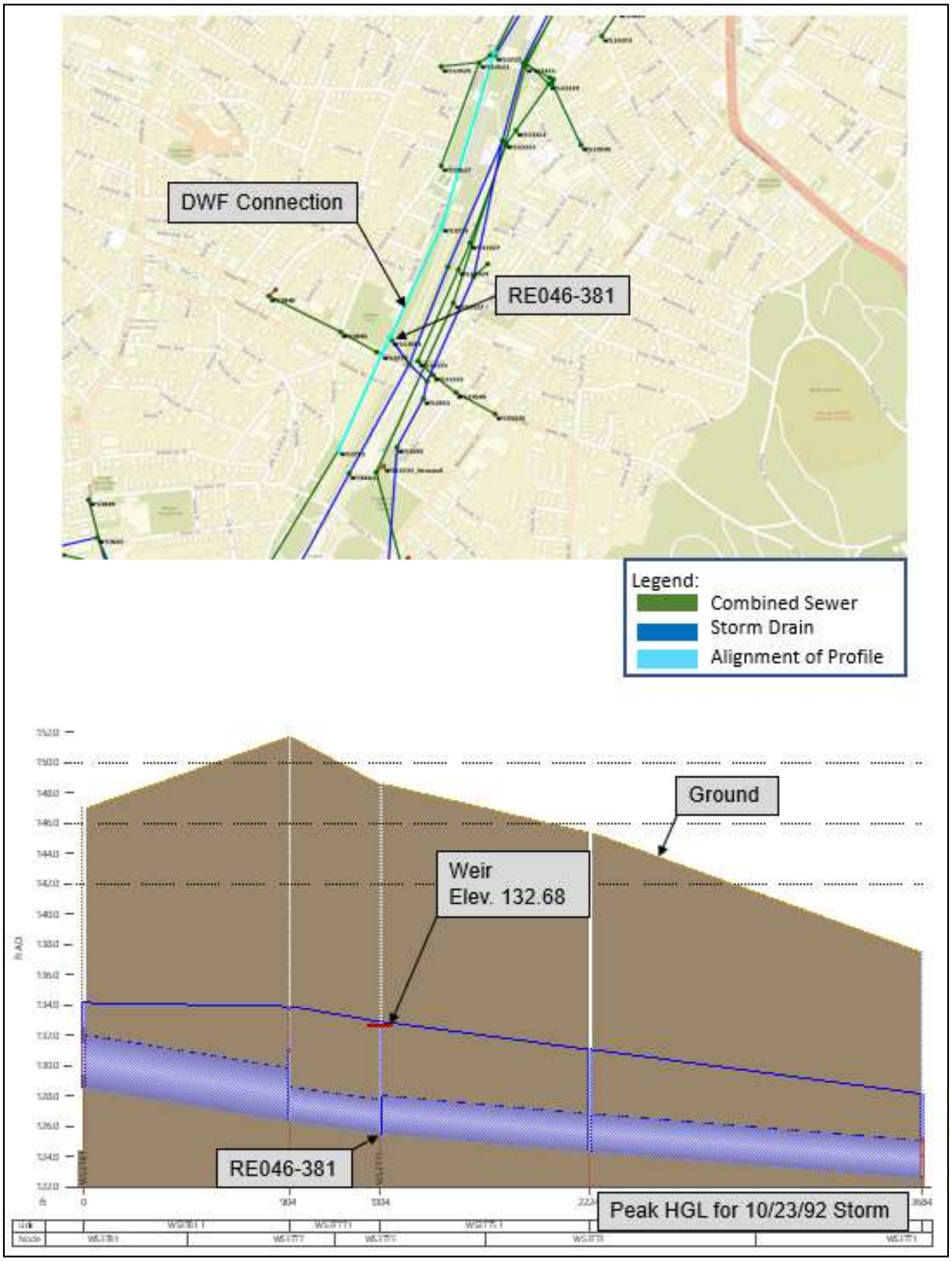

Figure 3-15: Regulator RE046-381 Typical Year Profile

3.3 Charles River Summary and Conclusions

A summary of the Charles River optimization evaluations is presented in Table 3-15 and Table 3-16 below. Table 3-15 summarizes the results of alternatives involving raising of weirs, and Table 3-16 summarizes the results of alternatives involving increasing the capacity of the DWF connections. As indicated in Table 3-15, the only weir-raising alternatives that provided a net decrease in CSO volume to the Charles River without resulting in an HGL increase greater than the screening-level guideline described in approach step No. 5 in Section 1.3 were the alternatives to raise and lengthen the weirs at outfalls CAM005 and CAM007. As described above under Section 3.2.2, lengthening the weir in regulator RE-071 would require complete reconstruction of the flap gate chamber downstream of the existing weir. This structure is located on the bank of the Charles River. The work would likely require a cofferdam, dewatering, and extensive permitting which would be beyond the scope of a typical optimization project. Given the very nominal CSO volume reduction that would be achieved by this alternative and the extensive construction work needed to implement it, this alternative was not recommended. The same conclusion applies to the combination of CAM005 and CAM007 weir raising, where the projected performance was only marginally better than for raising the weir at outfall CAM005 alone.

For outfall CAM005, raising the weir in regulator RE051 by 1 foot and lengthening the weir to 10 feet was predicted to reduce the activation frequency at outfall CAM005 by two and the discharge volume by 0.32 MG in the Typical Year compared to baseline without increasing the peak HGL in regulator RE051 in the 5-year, 24-hour storm. The peak HGL in the regulator was also not predicted to increase in a 10-year, 24-hour storm provided by the City of Cambridge. As a result, the concept of raising the weir at regulator RE051 by 1 foot and lengthening the weir to 10 feet is recommended to be implemented. As part of the implementation process, further analysis of the optimal configuration for the raised and lengthened weir, including assessment of materials of construction., is recommended. CFD analysis or additional flow monitoring in the regulator structure is being considered to further understand complex system hydraulics and potential benefits of this alternative.

Legend for Tables 3-15 and 3-16:

Symbol	Decrease CSO at Outfall?	Net CSO Decrease to Alewife Brook?	Adverse HGL Impacts? (1)
✓	Yes	Yes	No
■	Yes	Yes	Yes
●	Yes	No	Yes
X	Yes, but less than 0.005 MG	No	Yes

1. Adverse hydraulic impacts are as defined by the screening-level guideline described in approach step No. 5 in Section 1.3 of this report.

Table 3-15: Charles River Weir Optimization Summary

Regulator	Raise Weir 3"	Raise Weir 6"	Raise Weir 12"	Lengthening and Raising Weir	Recommendation
CAM005	■	■	■	✓	Raising the weir at regulator RE051 by 1 foot and lengthening the weir to 10 feet is recommended to be implemented, with further analysis of configuration, hydraulics, and constructability.
CAM007	■	■	■	✓	Weir optimization not recommended
CAM005/CAM007	-	-	■	✓	
MWR010 (RE037)	-	-	■	-	
MWR018	X	X	-	-	
MWR019	X	X	-	-	
MWR020	X	X	-	-	
Cottage Farm (MWR201)	■	■	-	-	
BOS046-19*	-	-	-	-	
BOS046-100	-	-	■	-	
BOS046-105	●	●	-	-	
BOS046-381	■	-	-	-	

* Due to existing condition HGL concerns, no optimization was conducted.

Table 3-16. Charles River DWF Connection Optimization Summary

Outfall/Regulator	Alternatives Evaluated	Result	Description	Recommendation
CAM005	N/A: The 4.5 foot influent conduit to regulator RE-051 transitions to an approximately 5-ft wide x 8-ft high box conduit through the regulator. The hydraulic profile showed little head loss through this connection, so further optimization of the DWF connection was not evaluated.	N/A	N/A	N/A
CAM007	N/A: Regulator functions as side outlet weir so there is no dry weather flow connection to be optimized.	N/A	N/A	N/A
MWR010 (RE036-9)	N/A: Regulator was not predicted to activate in the 5-year, 24-hour storm	N/A	N/A	N/A
MWR010 (RE037)	N/A: Regulator functions as side outlet weir so there is no dry weather flow connection to be optimized.	N/A	N/A	N/A

Table 3-16. Charles River DWF Connection Optimization Summary

Outfall/Regulator	Alternatives Evaluated	Result	Description	Recommendation
CAM017	CAM017 is a complex bending weir structure with three channels and is not suitable for typical optimization measures.	N/A	N/A	N/A
MWR018/MWR019/ MWR020	N/A: Regulators function as side outlet weirs so there is no dry weather flow connection to be optimized.	N/A	N/A	N/A
Cottage Farm (MWR201)	N/A: Facility functions as side outlet to the North Charles Relief Sewer and South Charles Relief Sewer, so there are no dry weather flow connections to be optimized.	N/A	N/A	N/A
MWR023 (RE046-19)	N/A: Regulator functions as side outlet weir so there is no dry weather flow connection to be optimized.	N/A	N/A	N/A
MWR023 (RE046-100)	N/A: Hydraulic profile indicates that the DWF pipe is not a restriction. Interceptor HGL is above overflow pipe invert. Increasing the diameter of the DWF connection would result in increased overflow volume.	N/A	N/A	N/A
MWR023 (RE046-105)	The existing 0.83 foot DWF connection restricted flow to the interceptor during the Typical Year causing backwater to influence RE046-100 through an upstream cross connection. The DWF connection was increased to 1.25 feet to relieve the restriction to the interceptor.	■	• Enlarging the DWF connection alleviated the backwater condition • However, the HGL in the interceptor increased and caused additional overflows at RE046-100 during large storm events. • During the 5 yr storm, adverse HGL impacts [1] were observed at RE046-100.	Optimization not recommended
MWR023 (RE046-381)	N/A: Regulator functions as side outlet weir so there is no dry weather flow connection to be optimized.	N/A	N/A	N/A

1. Adverse hydraulic impacts are as defined by the screening-level guideline described in approach step No. 5 in Section 1.3 of this report.

As indicated in Table 3-16, very few opportunities were identified to optimize the DWF connections in the regulators discharging to the Charles River. Many of these regulators function as high-outlet relief points on through-pipe systems and do not have a restricted DWF connection. For two of the regulators (RE-051 and RE046-100), the DWF connections were not found to be restricting flow to the downstream system. For the one potential location where relieving the DWF connection seemed like it might provide a benefit (RE046-105), adverse HGL impacts as defined by the screening-level guideline described in approach step No. 5 in Section 1.3 were predicted. As a result, no DWF connection optimization alternatives were recommended.

4. References

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