Dept. of Public Works

Highway, TPC (*Tree/Park/Cemetery*), Water, Sewer,
Engineering, Refuse/Recycling & Snow/Ice Divisions

Robert L. Desmarais, P.E., Director
Department of Public Works
City of Amesbury

December 31, 2021

U.S. Environmental Protection Agency - Region 1
James Chow, Deputy Director
Enforcement and Compliance Assurance Division
5 Post Office Square, Suite 100
Boston, MA 02109-3912

RE: MS4 Permit Compliance Progress
City of Amesbury – Docket No. CWA-AO-R01-FY21-19

As required by the Clean Water Act Audit Report finalized on October 27, 2020 and the Administrative Order for Compliance (Order) issued on September 8, 2021 by the U.S. Environmental Protection Agency (EPA), this letter and attachment represents the City of Amesbury's response.

The City of Amesbury worked with an outside consultant through October of 2021 to address audit deficiencies. With several tasks remaining, the City later obtained the services of Comprehensive Environmental Inc. (CEI) to assist with the outstanding compliance items required by the end of December 2021. The attached table provides a summary of required items, work completed to date, any remaining work for completion, and a status/anticipated completion date. The following standalone plans/documents which collectively comprise the City's Stormwater Management Program contain the requested information and may be downloaded from the following website: https://www.amesburyma.gov/public-works/links/ms4-stormwater-program;

- Illicit Discharge, Detection, and Elimination (IDDE) Plan;
- Operation and Maintenance (O&M) Plan; and
- Stormwater Pollution Prevention Plan (SWPPP).

CEI is also under contract for additional tasks required by the end of Year 3 (June 30, 2021) and Year 4 (June 30, 2022) under the MS4 permit since completion of the audit as noted above. Tasks include assisting with the remaining dry weather outfall screening, evaluation of regulations for Low Impact Development (LID) and green infrastructure, and evaluating municipal properties for retrofit opportunities.

The City of Amesbury also worked with MPH Environmental to complete the study of the Macy Street Siphon. The report is attached. The City has chosen an alternative to pursue and has funds appropriated already for the task.

Please feel free to contact me at 978-388-8116 or rob@amesburyma.gov or Stephanie Hanson of Comprehensive Environmental at 508-281-5160 x318 or shanson@ceiengineers.com with any questions or concerns.

Sincerely,

Robert Desmarais
Public Works Director Enclosure

City of Amesbury MS4 Program Status – December 31, 2021

Item/Submission	Status	Completion Date
a. Updated SWMP to include SSO inventory, IDDE program document, discussion of minimizing impacts to surface drinking supply sources, catchment investigation procedures and MS4 map.	The City completed an updated SWMP Plan to address the requested items, including an update of work performed since completion of the original SWMP Plan, a discussion of the City's approach to minimizing impacts to surface drinking supply sources as Section 2.4, updated MS4 map as Appendix C, an inventory of City-owned facilities as Appendix D (see item g. below), a street sweeping plan as Appendix E, and list of stormwater BMPs as Appendix G (see item f. below). The City also updated its IDDE Plan which in part includes written procedures to identify and eliminate illicit discharges, written catchment investigation procedures, references to the City's adopted IDDE ordinance, system mapping with outfall catchment delineations as Appendix A (see item b. below), an updated Sanitary Sewer Overflow (SSO) inventory as Appendix B, an outfall classification and ranking as Appendix C (see item c. below), outfall dry weather screening results as Appendix H (see item j. below), and IDDE training logs as Appendix I (see item d. below).	Completed by December 31, 2021
b. Updated MS4 map to include initial catchment delineations.	The City completed initial catchment delineations for all 240 known outfalls. Catchment delineations are provided in Appendix A of the IDDE Plan.	Completed by December 31, 2021
c. Priority ranking of the City's outfalls.	The City completed an inventory and priority ranking of all known outfalls. All 240 outfalls were ranked as "High" as they are located in densely developed areas and in close proximity to sewer more than 40 years old. Outfalls were further prioritized based on other parameters as specified in the permit. Results are provided in Appendix C of the IDDE Plan.	Completed by December 31, 2021

Item/Submission	Status	Completion Date
d. A description of the City's efforts to train employees involved in the IDDE program since the Audit, to include a list of employees trained and dates of training.	Training on IDDE program and SWPPP implementation was provided to relevant staff on December 15, 2021. Attendance logs are provided in Appendix I of the IDDE Plan. Training will be conducted annually during future years as required by the permit.	Completed by December 31, 2021 and annually thereafter
e. Written procedures for site inspections and enforcement of erosion and sediment control measures at construction sites.	The City developed written procedures for site inspections and enforcement of erosion and sediment control measures at construction sites, most of which were contained in the City's various regulations such as Site Plan Review and Subdivision Rules and Regulations. Requirements were then incorporated into the City's recently developed O&M Plan under the "Construction Management" section to provide a concise and easy to follow summary.	Completed by December 31, 2021
f. A description of the City's efforts to routinely inspect and maintain post-construction stormwater BMPs since the Audit, to include inspection reports.	The SWMP Plan (Appendix G) and O&M Plan provide an inventory and map of known City-owned structural stormwater BMPs, as well as general inspection and maintenance procedures under the "Municipal Infrastructure" section subsection "BMP Inspection and Maintenance". Inspections will be completed in spring 2021 to better assess vegetated BMPs during the growing season. Inspections will in part note any deficiencies and maintenance recommendations.	Inspections to be completed in spring 2021 and annually thereafter
g. An inventory of all City owned facilities.	The SWMP Plan (Appendix D) and O&M Plan provide an inventory and map of known City-owned facilities. Facilities will be further investigated during Year 4 for potential BMP modification or retrofit opportunities.	Completed by December 31, 2021

Item/Submission	Status	Completion Date
h. SWPPPs for all City-owned facilities.	The City completed a SWPPP for its DPW Facility located at 39 South Hunt Road and meets all permit requirements for this facility. The SWPPP also addresses a satellite storage facility at 56 South Hunt Road that is used for storage of catch basin cleanings, street sweepings, and winter snow dumping, however, does not adequately address pollutant sources and stormwater controls at the satellite storage area. The SWPPP document will be updated by March 31, 2022 to address remaining permit requirements.	SWPPP for DPW Facility completed by December 31, 2021. SWPPP for satellite storage facility to be completed by March 31, 2022.
i. A description of the City's efforts to maintain its City-owned facilities since the Audit, to include operation and maintenance procedures, inspection reports, number of catch basins cleanings and inspections performed, and any other records related to the Good Housekeeping and Pollution Prevention Program for Permittee Owned Operations required under Minimum Control Measure 6.	The City completed a comprehensive O&M Plan that in part includes O&M procedures for municipal activities (parks and open space, buildings and facilities, vehicles and equipment) and stormwater infrastructure. The O&M Plan also includes a street sweeping plan, catch basin cleaning and inspections, and procedures for winter options and salt management. Catch basin and street sweeping numbers are provided as part of the annual report provided to EPA by the end of each September.	Completed by December 31, 2021
j. A description of when the City plans on completing inspections of all outfalls/interconnections (excluding Problem and excluded Outfalls) for the presence of dry weather flow.	To date, approximately 215 outfalls have been inspected out of 240 known outfalls and no sampling results indicated that sewer input indicators were highly likely to contain illicit discharges from sanitary sources. Results are provided in Appendix H of the IDDE Plan and were incorporated into the outfall classification and priority ranking completed as addressed under part c. above. CEI is currently under contract to attempt to locate and inspect the remaining outfalls, anticipated to occur by June 30, 2022.	Description completed December 31, 2021. Additional outfall screening to be completed by June 30, 2022

MPH Project Management, P.C.

103 Old Pool Road
Biddeford, ME 04005

Cell: 508-320-7269
E-mail: mphartford@verizon.net

December 28, 2021

Mr. Robert L. Desmarais, P.E.
Director of Public Works
Amesbury Department of Public Works
39 School South Hunt Road
Amesbury, MA 01913

Subject: Macy Street Siphon Study

Dear Mr. Desmarais:

The purpose of this letter report is to summarize the findings of the evaluations performed for the existing siphon crossing of the Powow River at the Macy Street bridge west of Route 495. The purpose of this study was to identify alternatives to eliminate sanitary sewer overflows (SSOs) from occurring at MH No. 3-1-63 located upstream of the siphon crossing near the Route 495 northbound off ramp. During periods of wet weather, high groundwater conditions, SSOs have been reported at this location due to surcharged flow conditions in the sewer system.

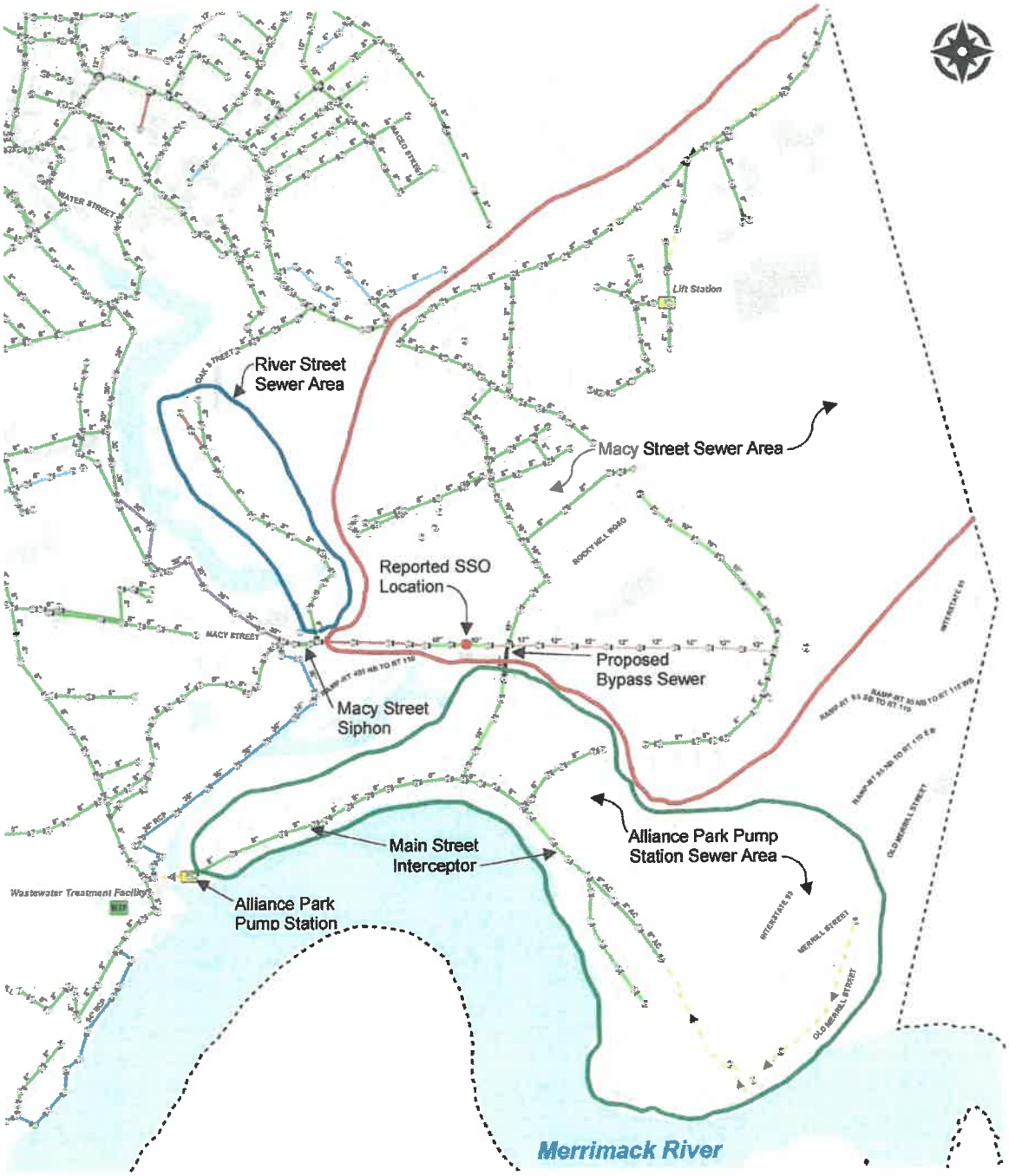
In preparing this report, a series of technical memos were prepared to provide Town personnel with a detailed summary of the results from each evaluation task. For record purposes, copies of each memo are attached to this report, and are referenced throughout the report as a source of additional details on the evaluation findings.

Review of Existing Record Information

Figure 1 attached is map of the study area showing the sewer areas tributary to the siphon crossing of the Powow River on Macy Street. The map also shows the sewer area tributary to the Alliance Park pump station since constructing a bypass sewer to divert flow from the Macy Street Sewer to the Rocky Hill Road sewer was identified as an alternative to eliminating the SSO. To confirm whether this alternative was feasible, a limited field survey was conducted at the outset of the study, and it was determined that there is sufficient grade for the installation of a bypass sewer. Consequently, the further evaluation of alternatives to eliminate the SSO focused primarily on the sewer bypass option as opposed to other options that may require a new pump station and force main crossing of the Powow River. Aside from the significant costs associated with the construction and operation and maintenance of a new pump station, there are legal and institutional concerns with this alternative. For example, the land required for siting a new pump station is within the Route 495 corridor which is owned by the state. Therefore, MassDOT approval would be required throughout the planning, design and construction phases, adding another level of complexity to this alternative.

Flow Monitoring Program

A flow monitoring program was conducted to determine the existing base wastewater (sanitary) flow and estimated amount of infiltration and inflow (I/I) entering the Macy Street siphon tributary sewer area. The results of the flow monitoring program are detailed in the technical memo attached and summarized in the table on the following page.



Source: Amesbury Sewer System Map, dated January 2021, prepared by Tighe & Bond under MassDEP's Water Utility Resilience Program.

FIGURE 1. STUDY AREA MAP

Flow Component	Macy Street Sewer	River Street Sewer
Dry Weather Average Daily Flow	125,800 gpd	11,400 gpd
Average Minimum Hourly Daily Flow	73,000 gpd	2,100 gpd
Estimated Infiltration	65,700 gpd	1,900 gpd
Infiltration as % of Dry Weather Average Daily Flow	52.2%	16.6%
Base Wastewater (Sanitary) Flow	60,100 gpd	9,500 gpd

As indicated, the majority of flow tributary to the existing sewer is conveyed by the Macy Street sewer, and it appears there is a significant amount of extraneous flow (I/I) entering this area. Conversely, the River Street sewer collects flow from a relatively small sewer subarea, and the amount of I/I entering the system does not appear to be excessive.

The total volume of inflow entering the system during wet weather conditions was also evaluated. Although neither area appears to have any direct sources of inflow resulting in sudden flow increases in response to rainfall, the Macy Street area is subject to rainfall induced rainfall as the flow gradually increases in response to rainfall and stays elevated for several days afterwards. Therefore, it was recommended that the Town perform additional investigations, including TV inspection of 20,000 feet of sewer and physical inspection of 160 manholes. The purpose of these investigations would be to identify sources of infiltration for subsequent rehabilitation. For planning purposes, the total estimated cost for this work is $80,000, and should be completed in the spring of 2022 when groundwater levels are typically highest.

Hydraulic Capacity Analysis

A hydraulic capacity analysis was performed on the sewer system tributary to the Macy Street siphon to identify where bottlenecks may exist; limiting the flow conveyed by the sewer and resulting in SSOs during extreme periods of wet weather, high groundwater conditions. The results of the hydraulic capacity analysis are detailed in the technical memo attached and summarized in the paragraphs below.

Macy Street Sewer. The hydraulic capacity analysis determined there is a capacity limitation within the last section of sewer that connects to the Powow River Interceptor. This was determined using Manning's Equation, and calculating the full-flow capacity for each section of sewer as follows:

Sewer Section	D.S. MH #	U.S. MH #	Length (ft)	Slope (ft/ft)	Flow Capacity (mgd)
Connection to Powow River Interceptor	32+69	18	85	0.0025	0.70
Downstream of Macy Street Siphon	18	6	97	0.0040	0.89
Siphon Crossing of Powow River(1)	6	5	125	0.0020	1.10
Upstream of Macy Street Siphon	5	2	628	0.0040	0.89
Macy Street Sewer w/MH Subject to SSOs	2	14+95	641	0.0030	0.78
Upstream to Rocky Hill Road Intersection	14+95	18+46	351	0.0300	2.44
Macy St./Rocky Hill Road Sewer Connection	18+46	19+11	66	0.0040	0.89

Note:
(1) The siphon is an 8-inch diameter, cast-iron pipe. All other pipe sections are 10-inch diameter, asbestos cement pipe.

As indicated, the full-flow capacity of the Macy Street sewer at the downstream connection to the Powow River Interceptor is limited to 0.70 mgd. Following this determination, the location where SSOs may occur was then predicted by extending the hydraulic grade line (HGL) in the upstream direction and increasing its slope until it exceeded the grade elevation of road the to simulate a surcharged condition within the sewer. This exercise confirmed that the HGL would cross the grade of the road in the vicinity of the manhole where SSOs have been report in the past. The height of the HGL is approximately 20 feet at the manhole that overflows.

Although the hydraulic capacity evaluation determined that the full-flow capacity of the existing siphon (1.10 mgd) is not a limiting factor, the Town is still concerned that the siphon is a potential bottleneck following repair of the pipe in July 2006. To this end, it was recommended that a thorough cleaning and TV inspection be performed during dry weather, low flow conditions. For planning purposes, the total estimated cost for this work is $15,000, and should be completed once the construction of a bypass sewer on Rocky Hill Road is completed in late spring / early summer 2022.

River Street Sewer. For the most part, the River Street sewer was constructed at the minimum slope for an 8-iunch sewer of 0.004 which results in a full-flow capacity of 0.50 mgd. However, there is one section of sewer that was constructed below the recommended minimum slope (0.004 vs. 0.0016). Although the full-flow capacity is limited to 0.31 mgd at this location, it is not a significant concern based on the relatively small tributary area served by the River Street sewer. For maintenance purposes though, it was recommended that the Town clean this section of sewer on a routine basis (i.e., annually) to ensure that solids / debris do not accumulate and result in blockages or other flow related problems in the future. This work would be performed by Town personnel utilizing its own forces and equipment.

The hydraulic capacity analysis also determined that the cross-country section of the River Street sewer may be subject to sewer surcharging due to the capacity limitations at the connection to the Powow River Interceptor. Similar to the Macy Street sewer, when the height of the HGL reaches 20 feet, it is at or near the grade elevation at the upstream end of the cross-country section of the River Street sewer. Although there have been no previous reports and/or evidence of SSOs or back-ups occurring at this location, it was recommended that the easement be maintained by the Town to locate and allow access to the existing sewer manholes for periodic inspection. For planning purposes, the total estimated cost for this work is $25,000, and should be completed in early spring 2022 prior to growth.

Alliance Park Pump Station

The Alliance Park pump station was evaluated to determine if it had the capacity to convey additional flow redirected from the Macy Street sewer via construction of a new bypass sewer on Rocky Hill Road. The results of the pump station evaluation are detailed in the technical memo attached and summarized in the paragraphs below.

Based on analysis of pump run-time data, it was determined that the station conveys approximately 96,000 gpd, and the pumps are operational for only 3.5 hours per day, or roughly 15% of the time. This indicates that the station had the capacity to convey additional flow. However, since the existing pumps are well beyond their expected service life (i.e., 20 years), it was recommended that the pumps be removed and replaced in their entirety as part of the recommended plan. For planning purposes, the total estimated cost for this work is $100,000, and should be designed and bid for construction in the spring of 2022.

The hydraulic capacity of the Rocky Hill Road sewer and Main Street Interceptor were then evaluated to determine the amount of additional flow that could be redirected from the Macy Street sewer without negatively impacting the downstream system. Since the existing Rocky Hill Road sewer was basically constructed at the minimum slope for an 8-inch pipe, it was recommended that the proposed bypass sewer be designed to convey no more than 50 percent of its full-flow capacity, or 0.25 mgd. This would be accomplished by installing an adjustable weir within the upstream manhole to allow wastewater flow under normal, dry weather conditions continue downstream in the Macy Street sewer and to divert a

portion of the excess flow occurring during wet weather, high groundwater conditions to the existing Rocky Hill Road sewer.

Based on review of the hydraulic capacity of the existing 12-inch Main Street Interceptor, it does not appear that redirecting up to 0.25 mgd of wastewater flow from the Macy Street area would have an adverse impact on flows within the interceptor or the pump Station. Accordingly, it was recommended that the Town install a bypass sewer on Rocky Hill Road to eliminate the potential for SSOs to occur along the Macy Street sewer. For planning purposes, the total estimated cost for this work is $160,000, and should be designed and bid for construction in the spring of 2022.

Recommended Plan

The recommended plan includes further investigation work in combination with the removal and replacement of the existing pumps at the Alliance Park pump station and the design and construction of a new bypass sewer on Rocky Hill Road. The purpose of the investigation work is two-fold: 1) To identify where infiltration may be entering the sewer system tributary to the Macy Street siphon for subsequent rehabilitation, and 2) To address on-going concerns that the previous repair of the siphon crossing may have impacted its capacity to convey flow further downstream.

In accordance with MassDEP's I/I Guidelines, the TV inspection of 20,000 feet of sewer and physical inspection of 160 manholes should be completed during springtime, high groundwater conditions. Conversely, the cleaning and TV inspection of the existing siphon should be conducted during dry weather, flow conditions in the summer. Further, it is recommended that this work be scheduled after the new bypass sewer has been constructed so that the wastewater flow may be diverted temporarily to facilitate the cleaning and TV inspection of the siphon.

Both the pump replacement work and the bypass sewer installation should be designed and bid for construction in the spring of 2022. The table below presents a summary of the costs associated with the recommended plan.

Component	Estimated Cost
TV Inspection of Sewers and Physical Inspection of Manholes	$80,000
Cleaning and TV inspection of Macy Street Siphon	$15,000
Hydraulic Cleaning of River Street Sewer (by Town Forces)	N/A
Maintaining River Street Sewer Cross-Country Easement	$25,000
Removal and Replacement of Existing Pumps at Alliance Park Pump Station	$100,000
Installation of New 8-inch Bypass Sewer on Rocky Hill Road	$160,000
Total	$380,000

Should you have any questions or require additional information, please call the undersigned.

Regards,

Michael P. Hartford, P.E.
President
MPH Project Management, P.C.

ATTACHMENT 1
TECHNICAL MEMO ON FLOW MONITORING PROGRAM

MPH Project Management, P.C.

Memo

To: Rob Desmarais

From: M.P. Hartford MPH

Date: December 9, 2021

Re: Macy Street (Route 110) Siphon Study
Flow Monitoring Program

The purpose of this memo is to document the results from the flow monitoring program conducted for the Macy Street siphon tributary sewer area. The program included the installation of continuous recording flow meters within the two main sewers upstream of the siphon to determine the existing base wastewater (sanitary) flow and estimated amount of I/I entering the tributary sewer area. In addition, rainfall data were obtained from Lawrence Municipal Airport to facilitate the analysis of wet weather flows in the sewer system. The field work was performed by Flow Assessment Services under subcontract with MPH Project Management, and in accordance with MassDEP's *Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Survey.*

Flow Monitoring

As shown on Figure 1 attached, two meters were installed at the downstream most accessible locations for the Macy Street and River Street sewers. The meters were installed on May 10, 2021, and subsequently removed on June 9, 2021.

In addition, Table 1 attached presents a summary of the rainfall data recorded at the Lawrence Municipal Airport during the course of the flow monitoring period. As indicated, there were several days of significant rainfall (i.e., greater than 0.5 inches of rainfall), with the most significant rainfall occurring at the end of May when 2.62 inches of rainfall was recorded over a five-day period.

Flow Analysis

The flow monitoring and rainfall data were analyzed to estimate I/I rates for each meter location. This was accomplished by preparing a series of hydrograph plots of the continuous flow monitoring data from each meter location together with the rainfall data. The first hydrograph plot in the series presents the data for the duration of the monitoring period while the next five hydrographs are plots of the data from one week to the next. The latter figures were prepared to better illustrate whether there is a corresponding increase in flow due to recorded rainfall as discussed in more detail later in this report. Figures 2 through 7 attached are the hydrograph plots for the Macy Street meter location, and Figures 8 through 13 are the same for the River Street meter location.

Infiltration. The flow monitoring data were analyzed to estimate the quantity of infiltration entering the sewer system under dry-weather conditions. This was accomplished by multiplying the minimum hourly flow recorded for each dry weather day by 0.90. Typically, it is assumed that 90% of the

average minimum hourly flow measured between the hours of midnight and 6:00 a.m. is infiltration. During this time period, the sanitary waste entering the sewer system is considered to be minimal.

For the purposes of this study, it was assumed that any day without rainfall was a dry weather day unless a rainfall event occurred within the proceeding four days. The latter condition is to account for the fact that following a rainfall event, it generally takes 3-4 days for the flows within the system to level off (see Figures 2 through 13 attached). The first three days following any day with rainfall, therefore, would be considered wet weather days, and excluded from the calculation of infiltration. The results of the infiltration analysis are presented in the table below.

Metering Site	Dry Weather Average Daily Flow(1)	Average Minimum Hourly Daily Flow	Estimated Infiltration	Infiltration as % of Dry Weather Average Daily Flow
Macy Street	125,800 gpd	73,000 gpd	65,700 gpd	52.2%
River Street	11,400 gpd	2,100 gpd	1,900 gpd	16.6%

Note:
(1) Based on dry weather average daily flow data for May 17-25, 2021.

The infiltration rates calculated above were then used to estimate the base wastewater (sanitary) flow entering each sewer area by subtracting the estimated infiltration from the dry weather average daily flow. For the Macy Street area, this yielded a base wastewater flow of 60,100 gpd, and for the River Street area, a flow of 9,500 gpd.

Inflow. The total volume of inflow entering the system for each sewer area was estimated by subtracting the flow during a non-rainfall period from the flow during and after a storm event. To be consistent, it was assumed that the total estimated inflow occurred over a period of approximately four days. After this point, it was observed that the flows within the tributary sewer areas generally leveled off.

As previously noted, the most significant rainfall occurred at the end of May when 2.62 inches of rainfall was recorded over a five-day period. This storm was selected for analysis since the next significant rainfall occurred on June 8th just prior to the removal of the flow meters; limiting the data available for analysis. For each metering location, three different hydrographs were plotted. The first hydrograph (Figures 14 and 17 attached) is a plot of the flows measured during a non-rainfall period (May 19-25,2021) versus the flows measured around the time of the storm (May 26-June 3, 2021) without any adjustments. Based on review of the Macy Street hydrograph (Figure 14), it appears there is a difference of approximately 0.03 mgd between the two curves prior to the storm event. Similarly, a difference of 0.001 mgd may be observed for the River Street hydrograph (Figure 17.

In the second set of hydrograph plots (Figures 15 and 18), the dry weather flow for each site has been adjusted by either adding or subtracting the difference noted in the paragraph above from each flow measurement. This adjustment is made so that the dry weather flow curve matches the wet weather flow curve prior to the start of the storm. Based on review of the Macy Street hydrograph (Figure 15), the response to rainfall appears to be a gradual increase in flow; indicating that the sewer area is subject to rainfall induced infiltration as opposed to direct inflow sources which produce sudden flow spikes in response to rainfall. Conversely, the hydrograph for the River Street sewer (Figure 18) appears to show slight increases in flow immediately following rainfall (i.e., higher peaks). However, it is difficult to draw any conclusions from the hydrograph plot since the dry and wet weather curves are fairly similar. This may be due to the nature of the rainfall that occurred throughout the five-day period which was relatively low in intensity (i.e., less than 0.12 inches per hour). At the same time, it should be noted that neither sewer area showed much of a response to the rainfall that occurred on June 8,

2021 when 0.77 inches of rainfall was recorded in a two-hour period. The lack of response to higher intensity rainfall (average 0.39 inches per hour) suggests that there are no direct sources of inflow within these areas.

In the third and final set of hydrograph plots (Figures 16 and 19), the adjusted dry weather flow for each site has been subtracted from the corresponding wet weather flow. The result is a hydrograph plot of the actual inflow that occurred during the storm event. Based on review of the Macy Street hydrograph (Figure 16), it is clear that the area is subject to rainfall induced infiltration as the amount of extraneous flow gradually increases with each period of rainfall that occurred between May 26th and May 31st. During this time period, the total amount of extraneous flow entering the Macy Street sewer area was estimated at 420,000 gallons.

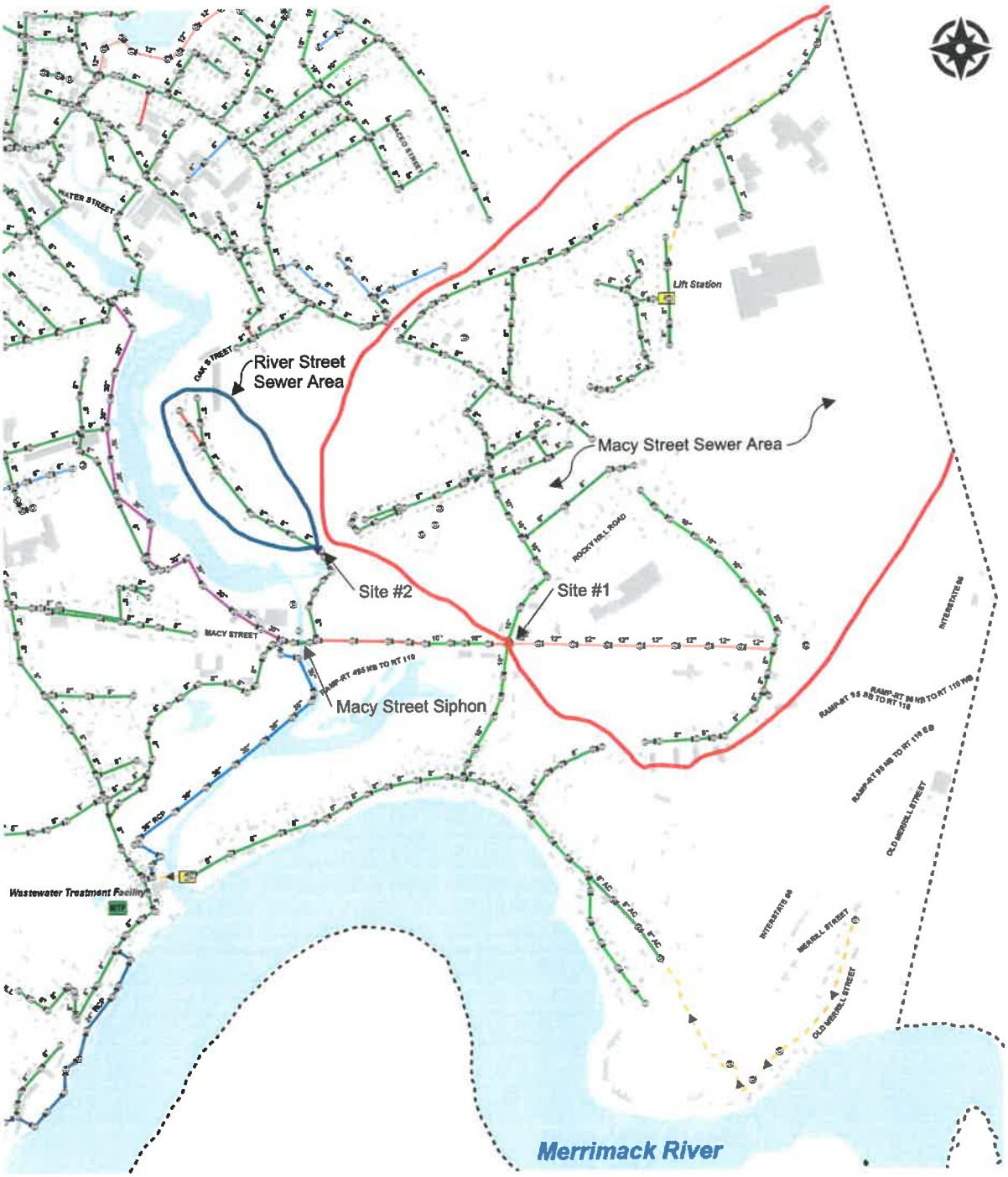
The last hydrograph plot for the River Street sewer area (Figure 19) is not as straightforward to interpret since the dry and wet weather flow curves were almost identical. Although it appeared that the flow increased slightly in response to rainfall, a comparison of the total dry- versus wet-weather flow measured from one day to the next showed a difference of only ±1,000 gallons without any adjustments. Therefore, inflow was assumed to be negligible in this area.

Recommendations

The flow monitoring results for the Macy Street area show there is a significant amount of infiltration entering the tributary sewers on a daily basis (52.2% of average dry weather flow). Further, the inflow analysis showed the area is highly susceptible to rainfall induced infiltration based on the elevated flows observed during and after periods of rainfall. To address the extraneous flow entering the system, it is recommended that the Town perform additional investigations to identify sources of infiltration for subsequent rehabilitation.

Figure 20 attached is a map of the study area showing the sewers previously TV inspected by the Town. As indicated, only a small portion of the sewers within the Macy Street area have been inspected whereas the entire River Street area has been completed. Therefore, it is recommended that the Town complete the TV inspection of all remaining sewers within the Macy Street area, a total of approximately 20,000 feet. In addition, it is recommended that the Town complete the physical inspection of all the manholes within both tributary sewer areas, a total of approximately 160 manholes. The purpose of this program would be to identify sewer manholes and pipelines with active infiltration or signs of previous leakage and to assess the general condition and structural integrity of the system. Based on the results of this investigation, a manhole and sewer pipeline rehabilitation program may be developed for subsequent implementation by the Town.

For budgeting purposes, the total estimated cost for the sewer investigation recommended above is approximately $80,000. This work should be conducted in the spring of 2022 when groundwater levels are typically highest.



Source: Amesbury Sewer System Map, dated January 2021, prepared by Tighe & Bond under MassDEP's Water Utility Resilience Program.

FIGURE 1. FLOW MONITORING LOCATIONS

TABLE 1. SUMMARY OF RAINFALL DATA DURING 2021 FLOW MONITORING PERIOD[1]

Day	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1					0.01							
2												
3												
4												
5						0.07						
6												
7												
8						0.78						
9						0.04	<End 6/9					
10				Start 5/10>	0.34							
11						0.01						
12						0.47						
13												
14						0.35						
15						0.53						
16												
17												
18												
19												
20												
21												
22						0.30						
23												
24												
25						0.03						
26					0.27							
27					0.06							
28					0.49							
29					0.86							
30					0.79	0.64						
31					0.15							
Totals					2.97	3.22						

Note:

(1) Rainfall data obtained from Lawrence Municipal Airport.

Shading indicates dry weather days as defined in the Inflow Analysis.

FIGURE 2. CONTINUOUS FLOW MONITORING LOCATION: MACY STREET SEWER
(5/10/21 @ 11:00 a.m. to 6/9/21 @ 7:00 a.m.)

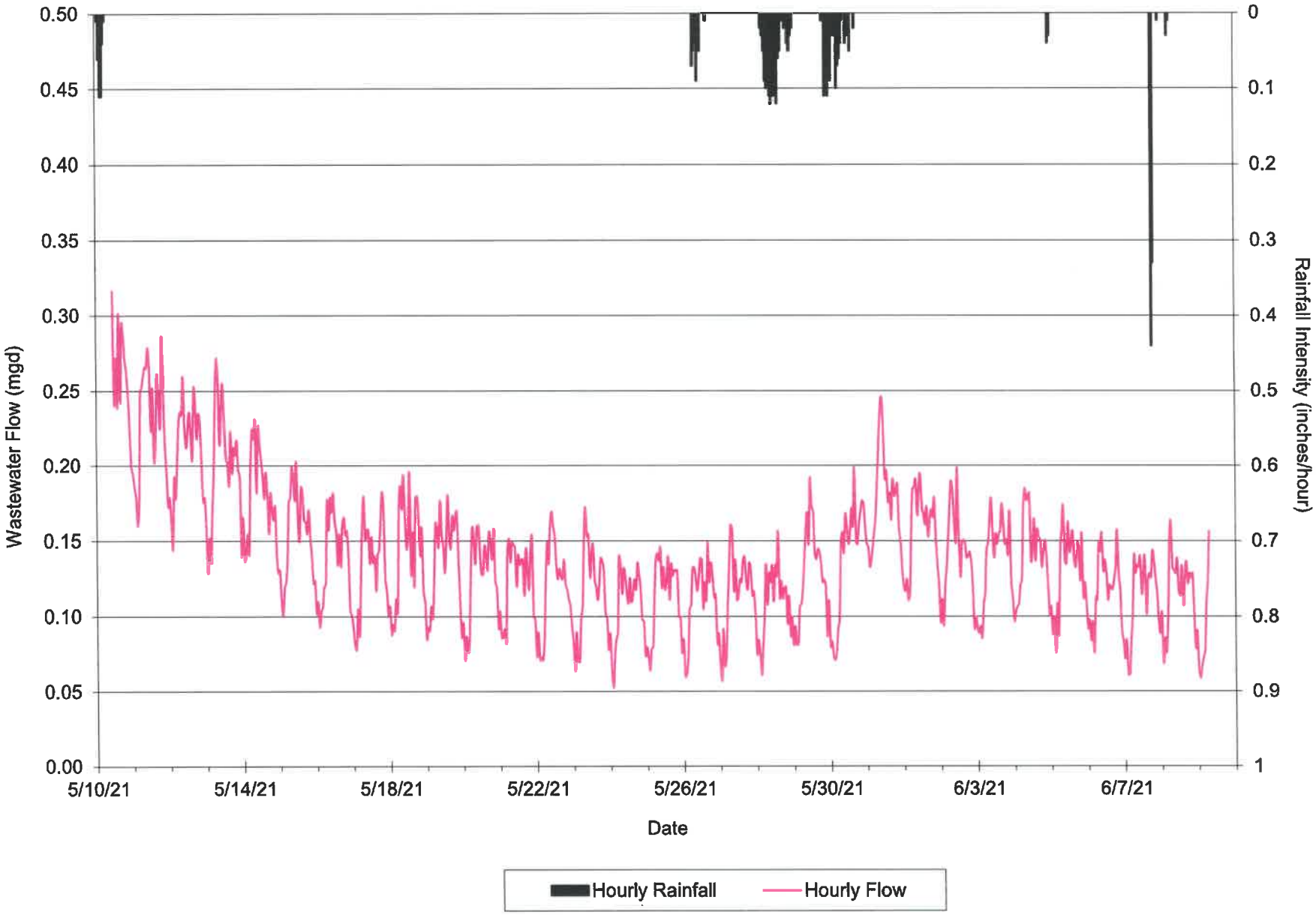


FIGURE 3. CONTINUOUS FLOW MONITORING LOCATION: MACY STREET SEWER
Week 1 (5/10/21 to 5/16/21)

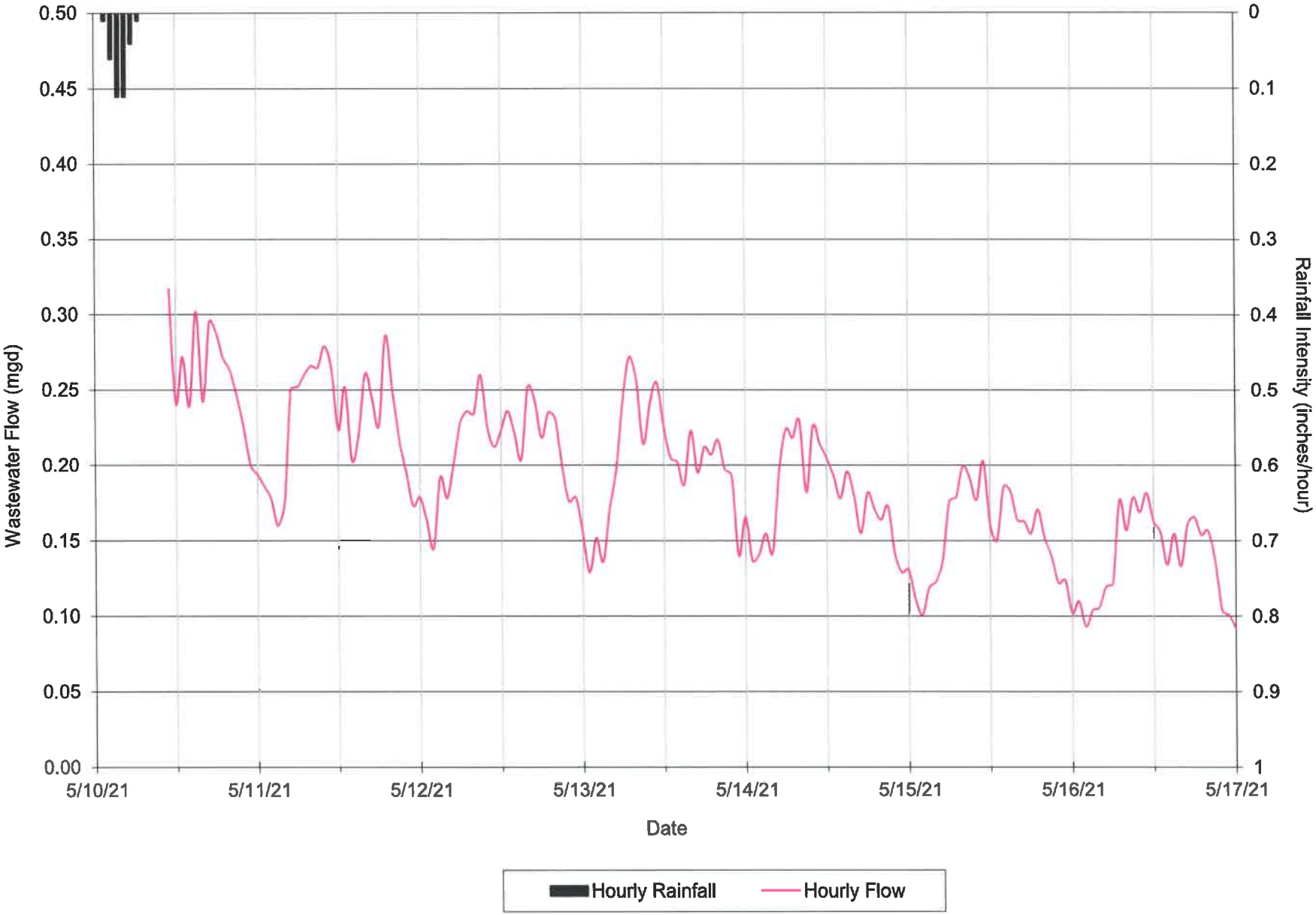


FIGURE 4. CONTINUOUS FLOW MONITORING LOCATION: MACY STREET SEWER
Week 2 (5/17/29 to 5/23/21)

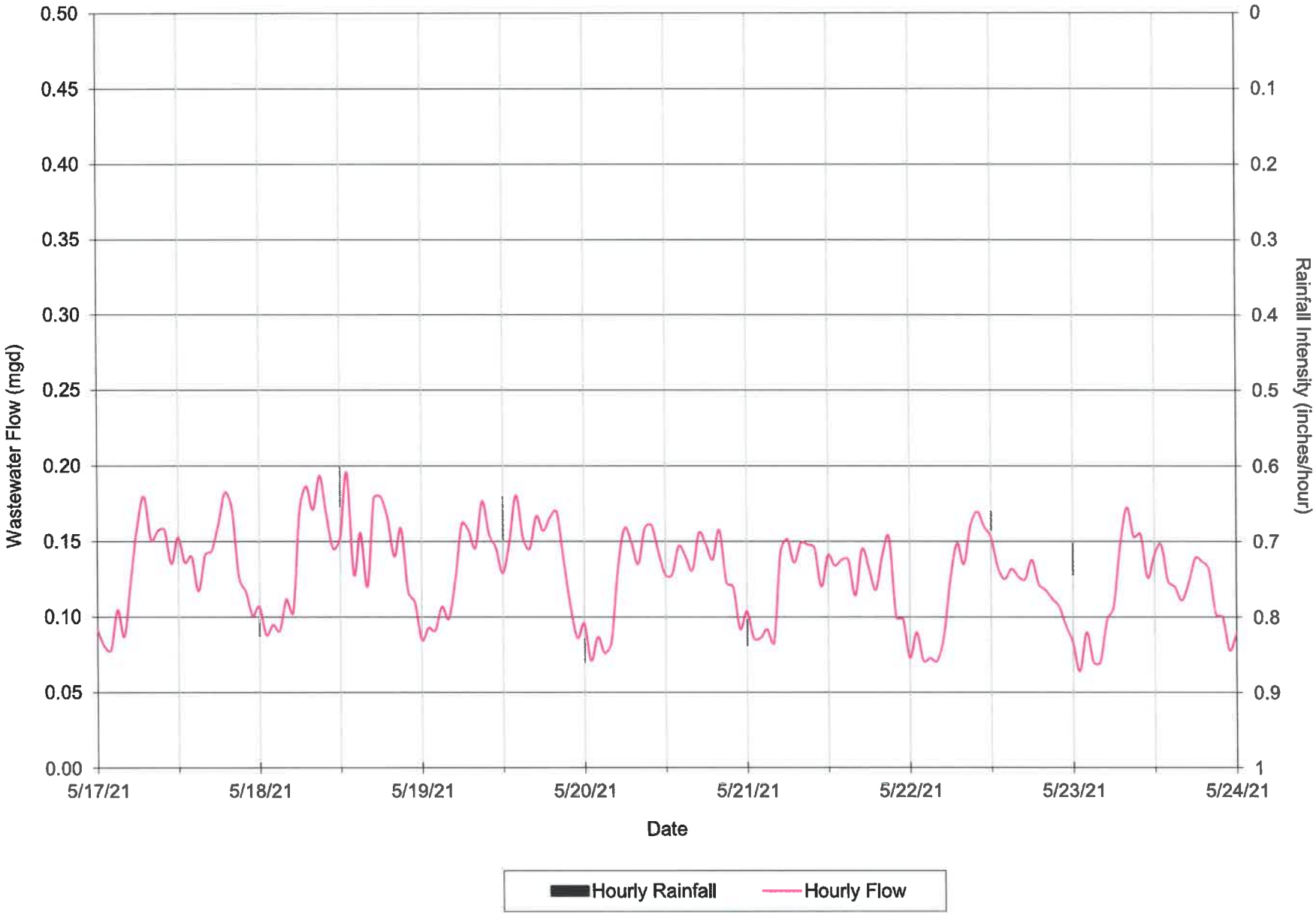


FIGURE 5. CONTINUOUS FLOW MONITORING LOCATION: MACY STREET SEWER
Week 3 (5/24/21 to 5/30/21)

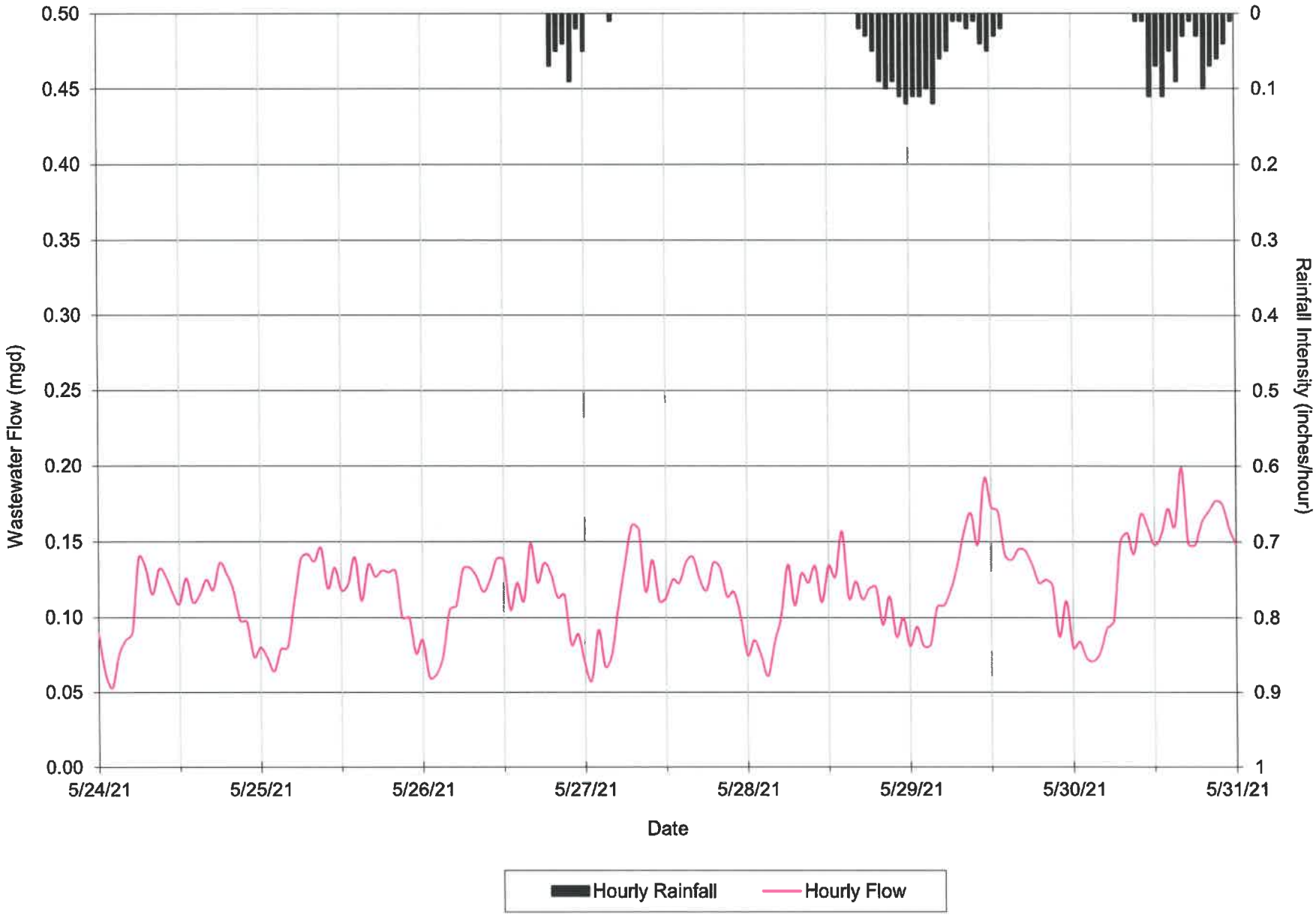


FIGURE 6. CONTINUOUS FLOW MONITORING LOCATION: MACY STREET SEWER
Week 4 (5/31/21 to 6/6/21)

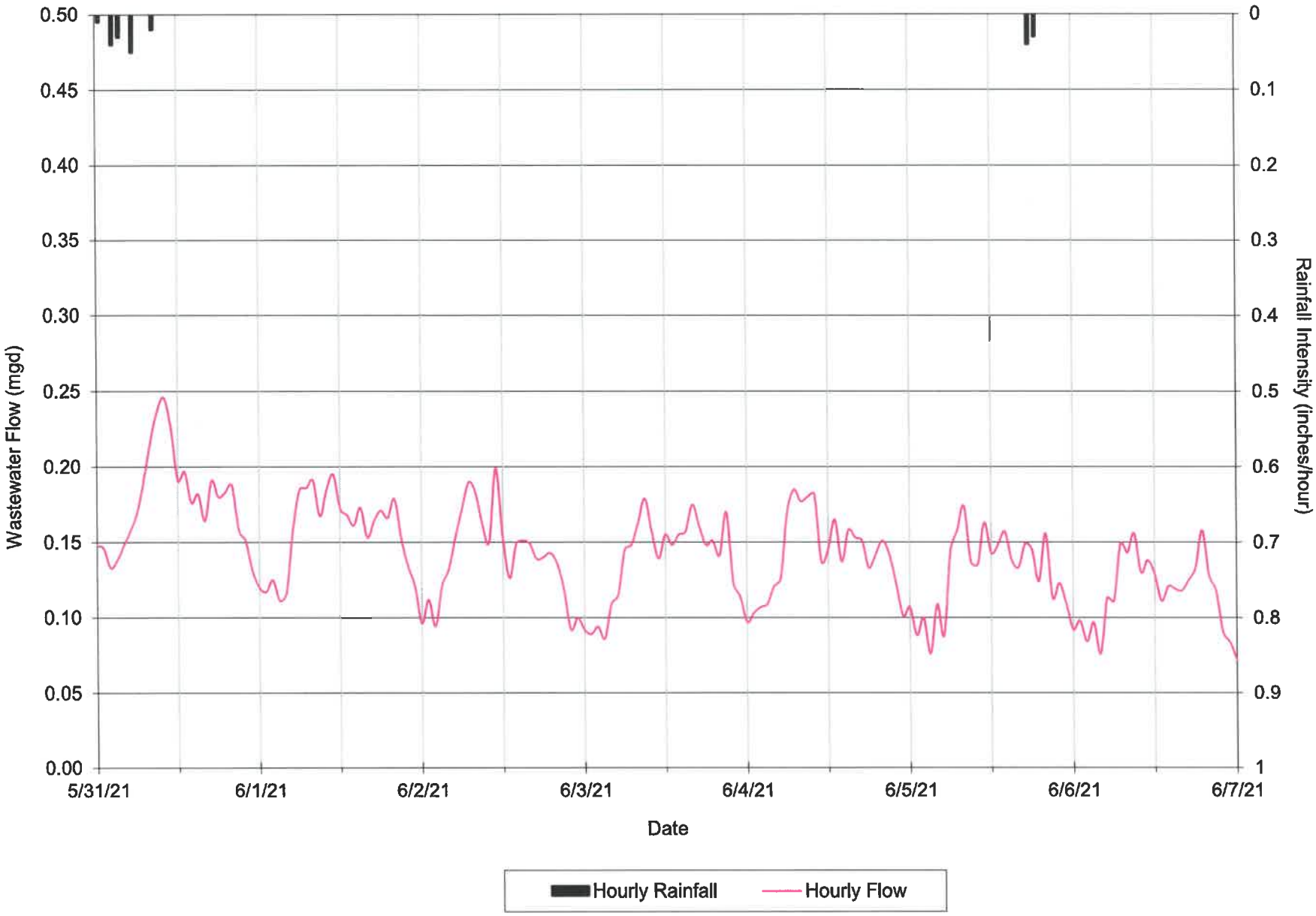


FIGURE 7. CONTINUOUS FLOW MONITORING LOCATION: MACY STREET SEWER
Week 5 (6/7/21 to 6/13/21)

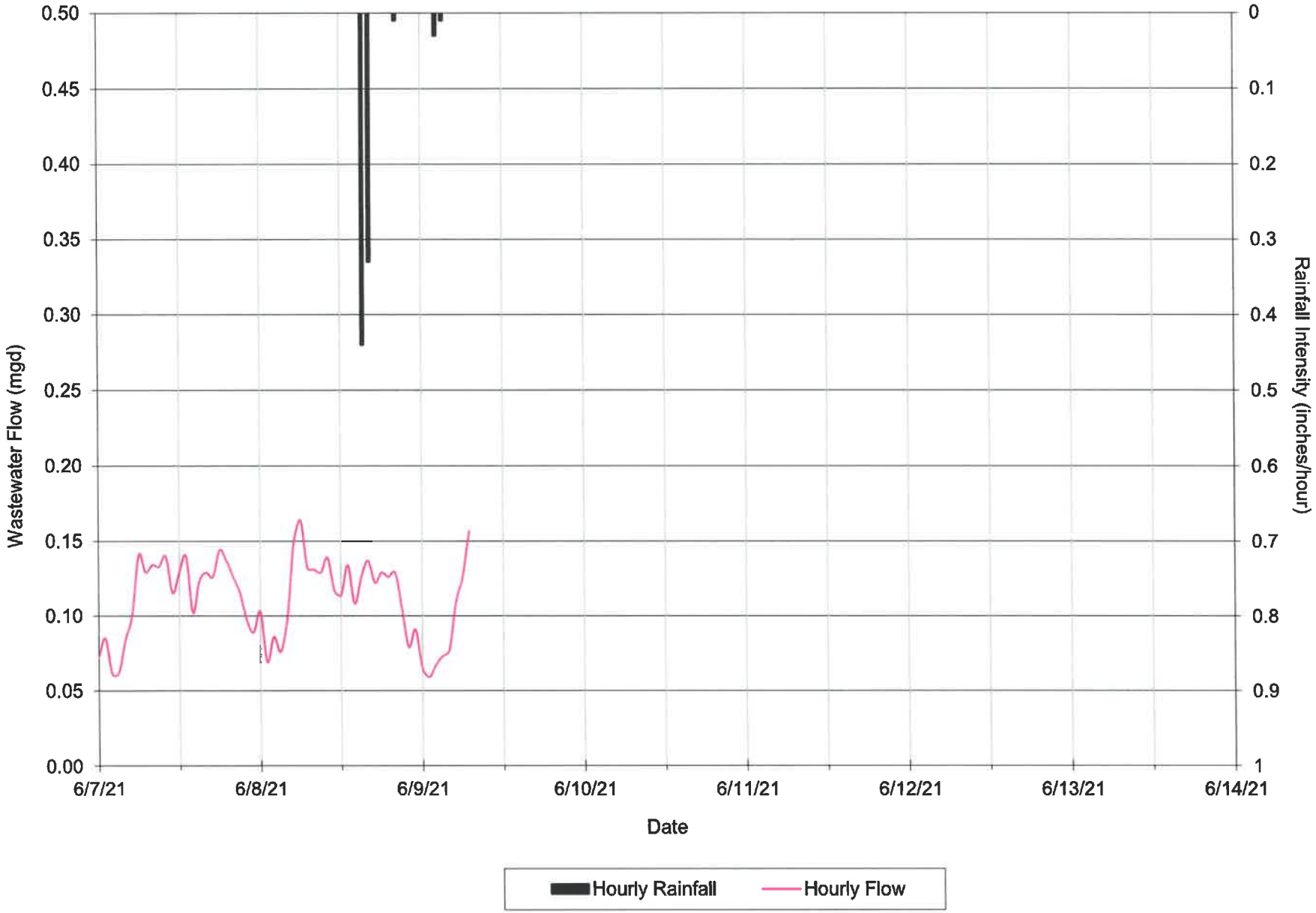


FIGURE 8. CONTINUOUS FLOW MONITORING LOCATION: RIVER STREET SEWER
(5/10/21 @ 12:00 p.m. to 6/9/21 @ 7:00 a.m.)

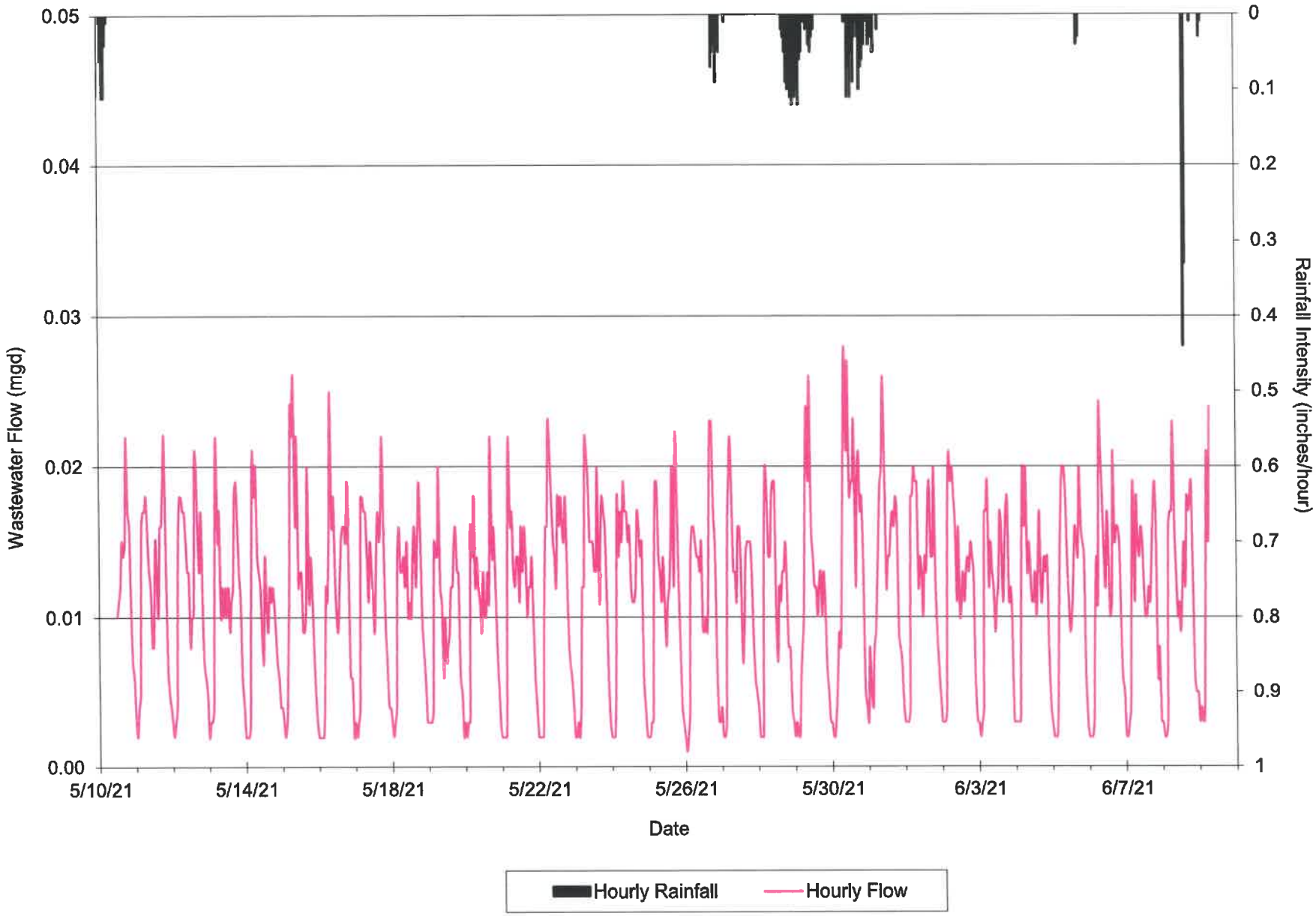


FIGURE 9. CONTINUOUS FLOW MONITORING LOCATION: RIVER STREET SEWER
Week 1 (5/10/21 to 5/16/21)

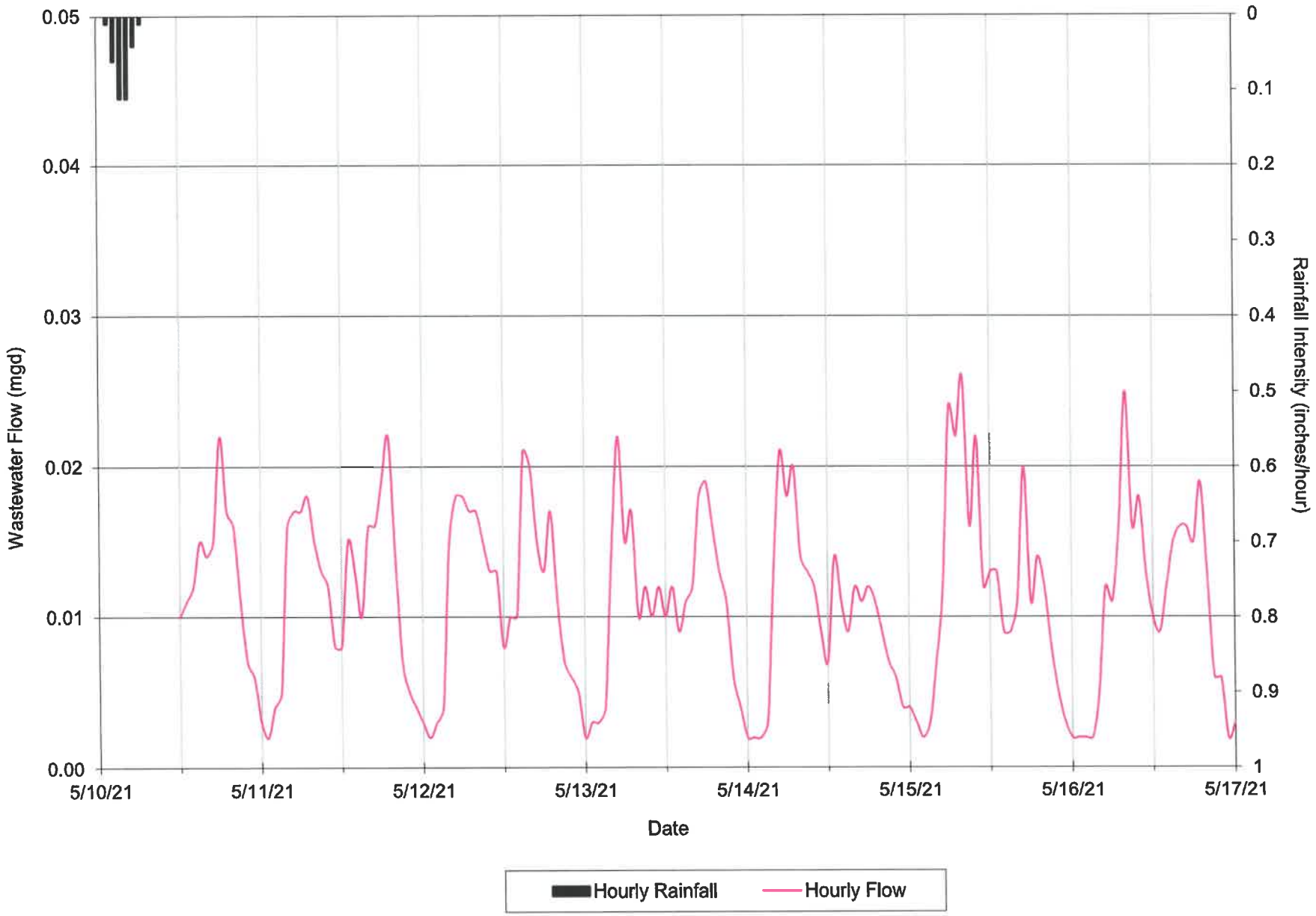


FIGURE 10. CONTINUOUS FLOW MONITORING LOCATION: RIVER STREET SEWER
Week 2 (5/17/29 to 5/23/21)

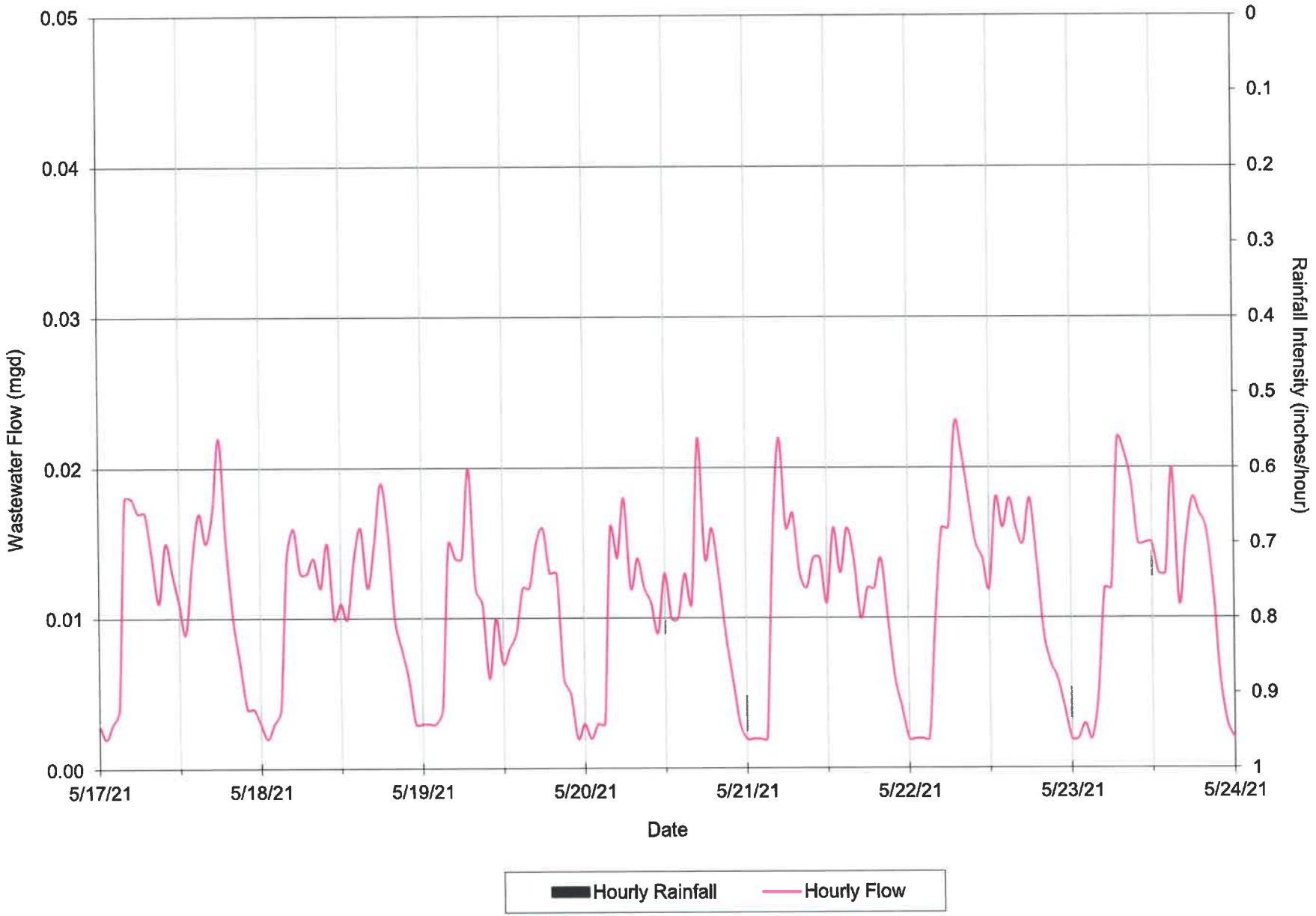


FIGURE 11. CONTINUOUS FLOW MONITORING LOCATION: RIVER STREET SEWER
Week 3 (5/24/21 to 5/30/21)

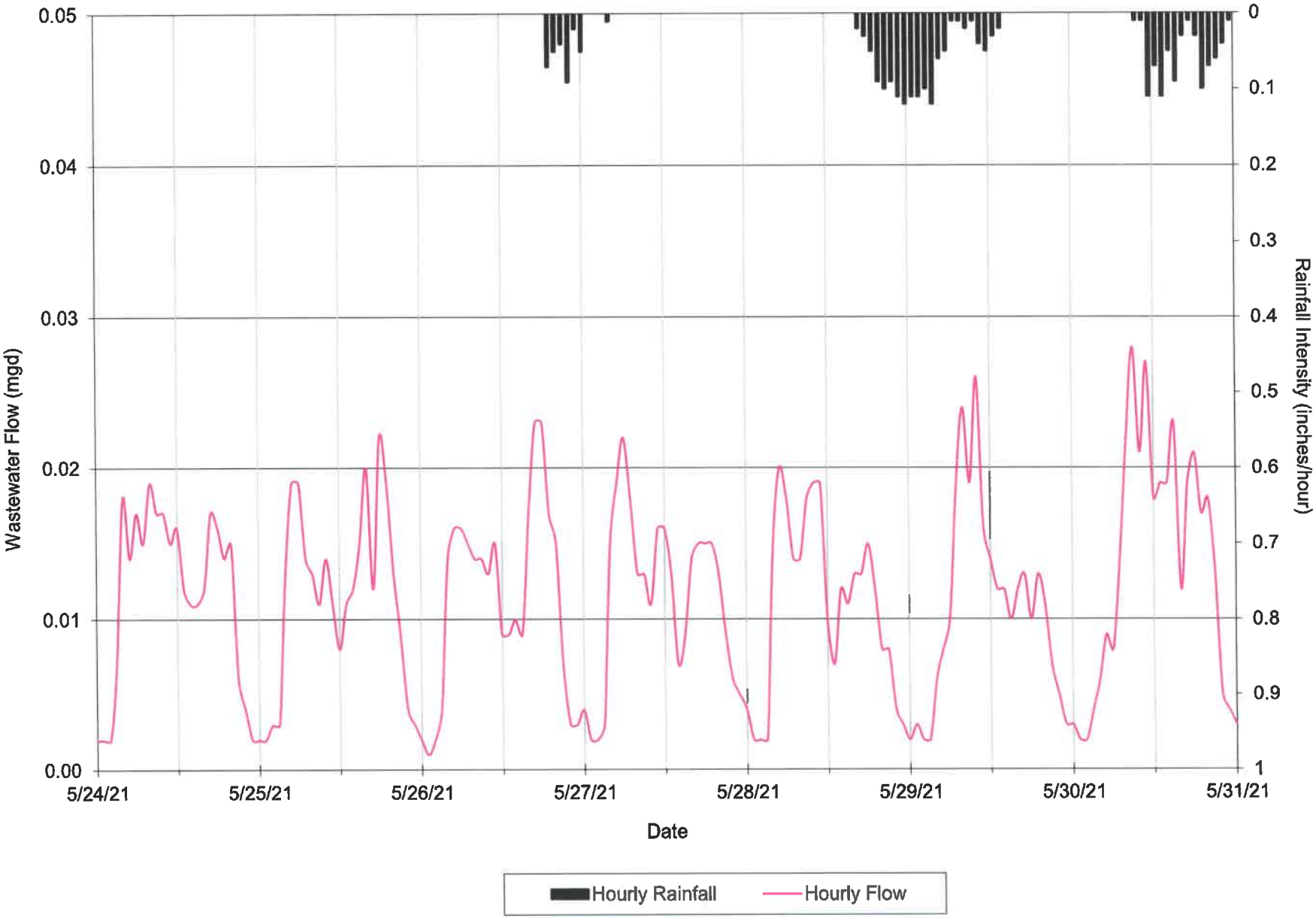


FIGURE 12. CONTINUOUS FLOW MONITORING LOCATION: RIVER STREET SEWER
Week 4 (5/31/21 to 6/6/21)

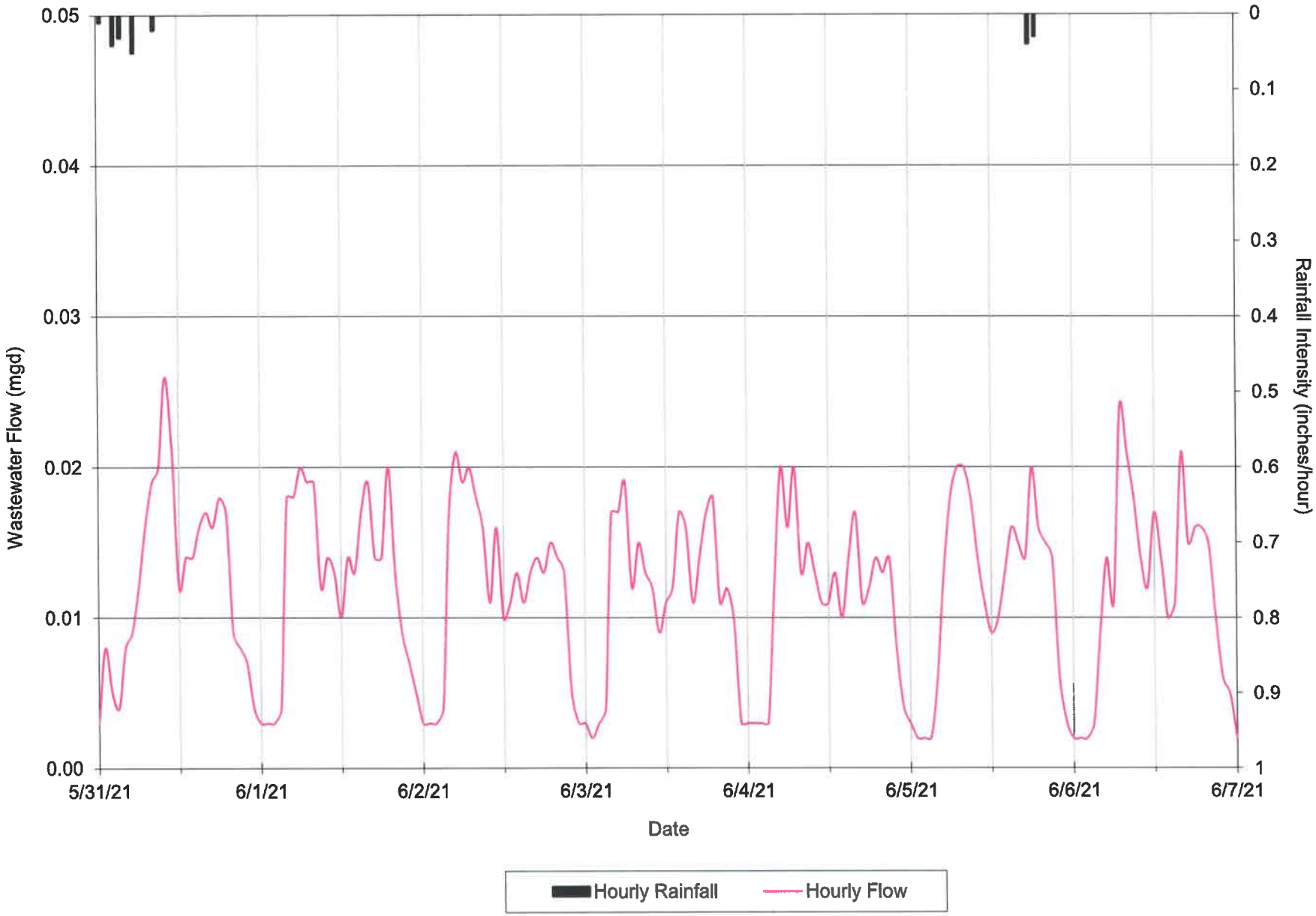


FIGURE 13. CONTINUOUS FLOW MONITORING LOCATION: RIVER STREET SEWER
Week 5 (6/7/21 to 6/13/21)

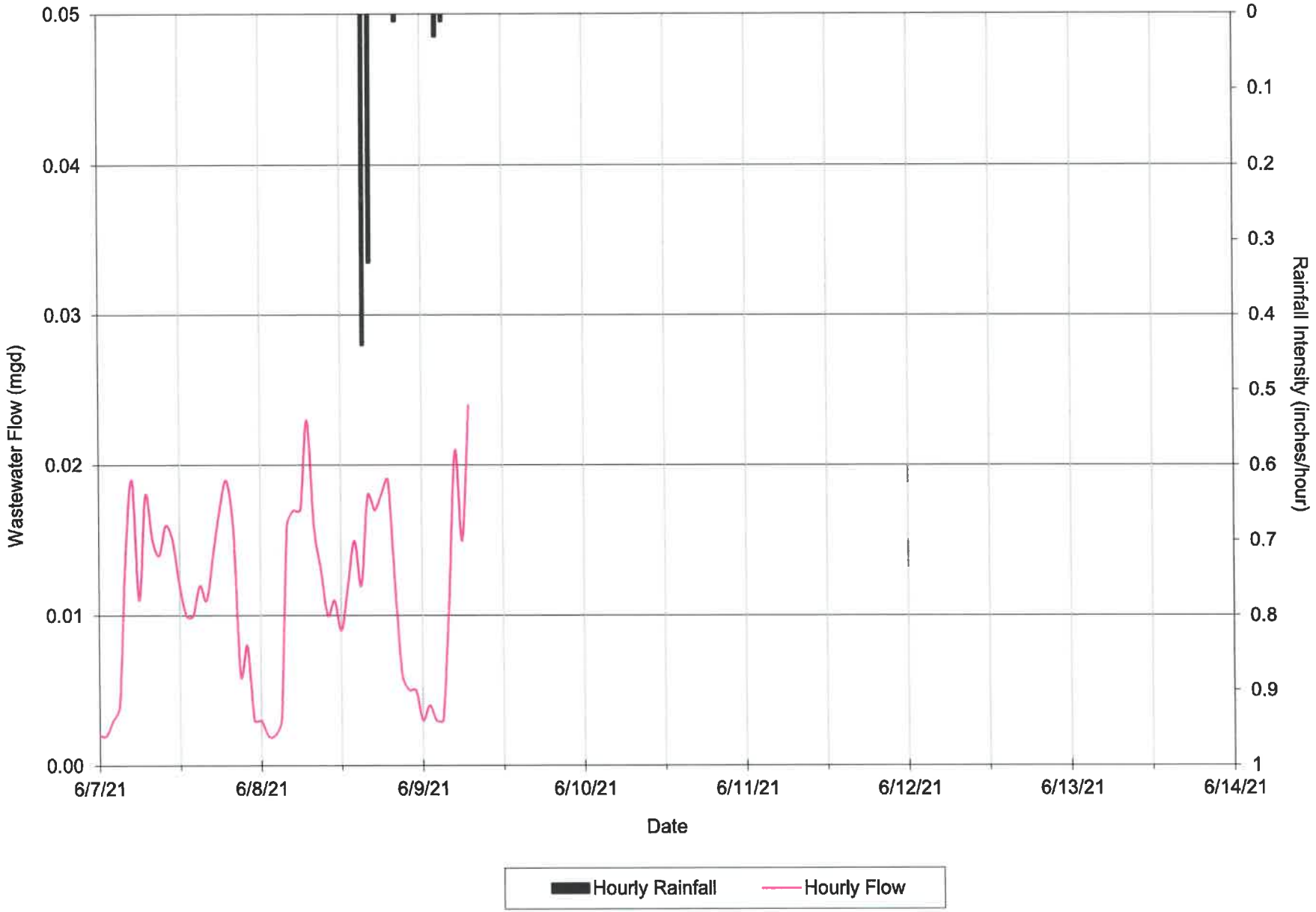


FIGURE 14. MACY STREET INFLOW HYDROGRAPH PLOT #1
(May 26-31, 2021 Rainfall Event)

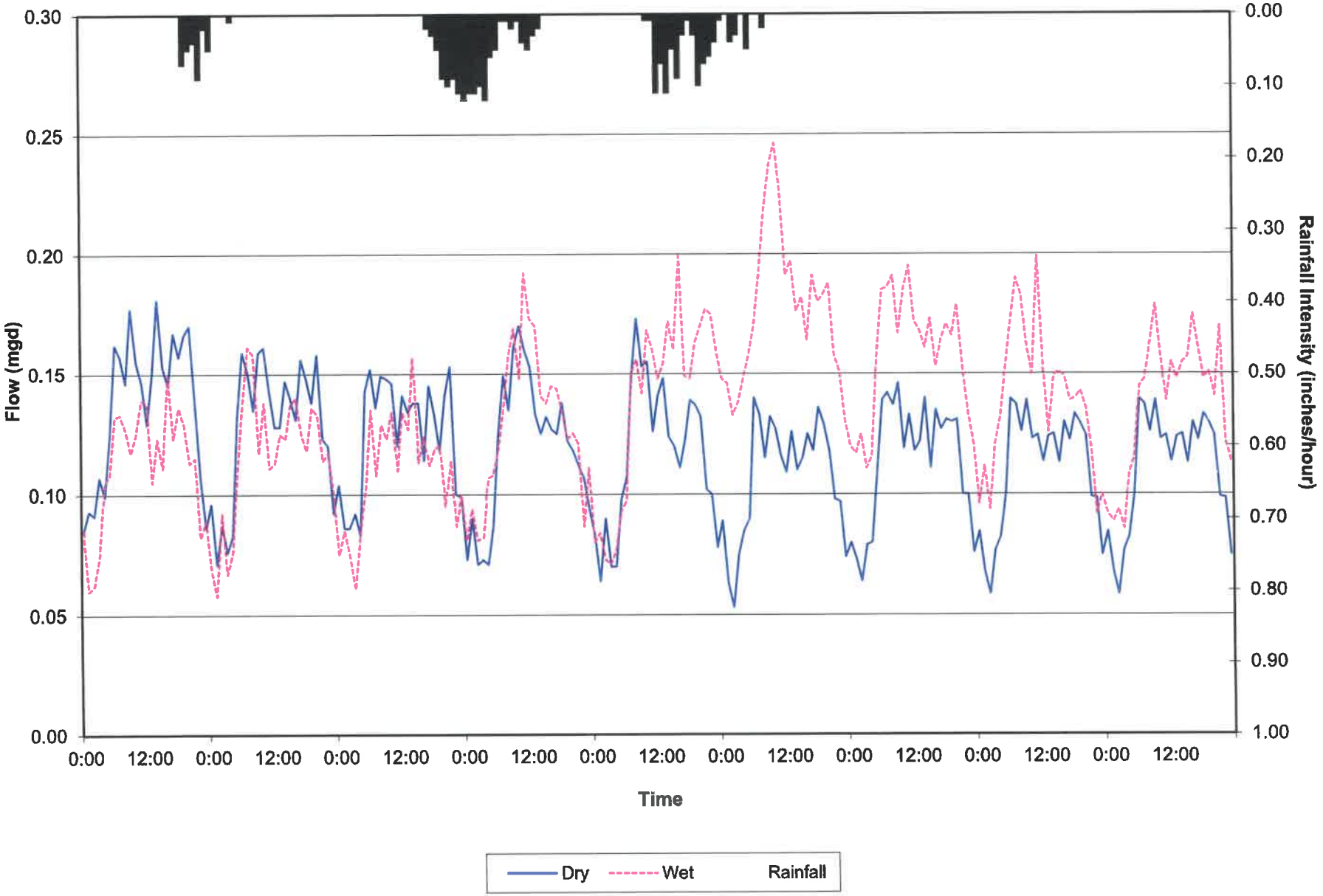


FIGURE 15. ADJUSTED MACY STREET INFLOW HYDROGRAPH PLOT #2
(May 26-31, 2021 Rainfall Event)

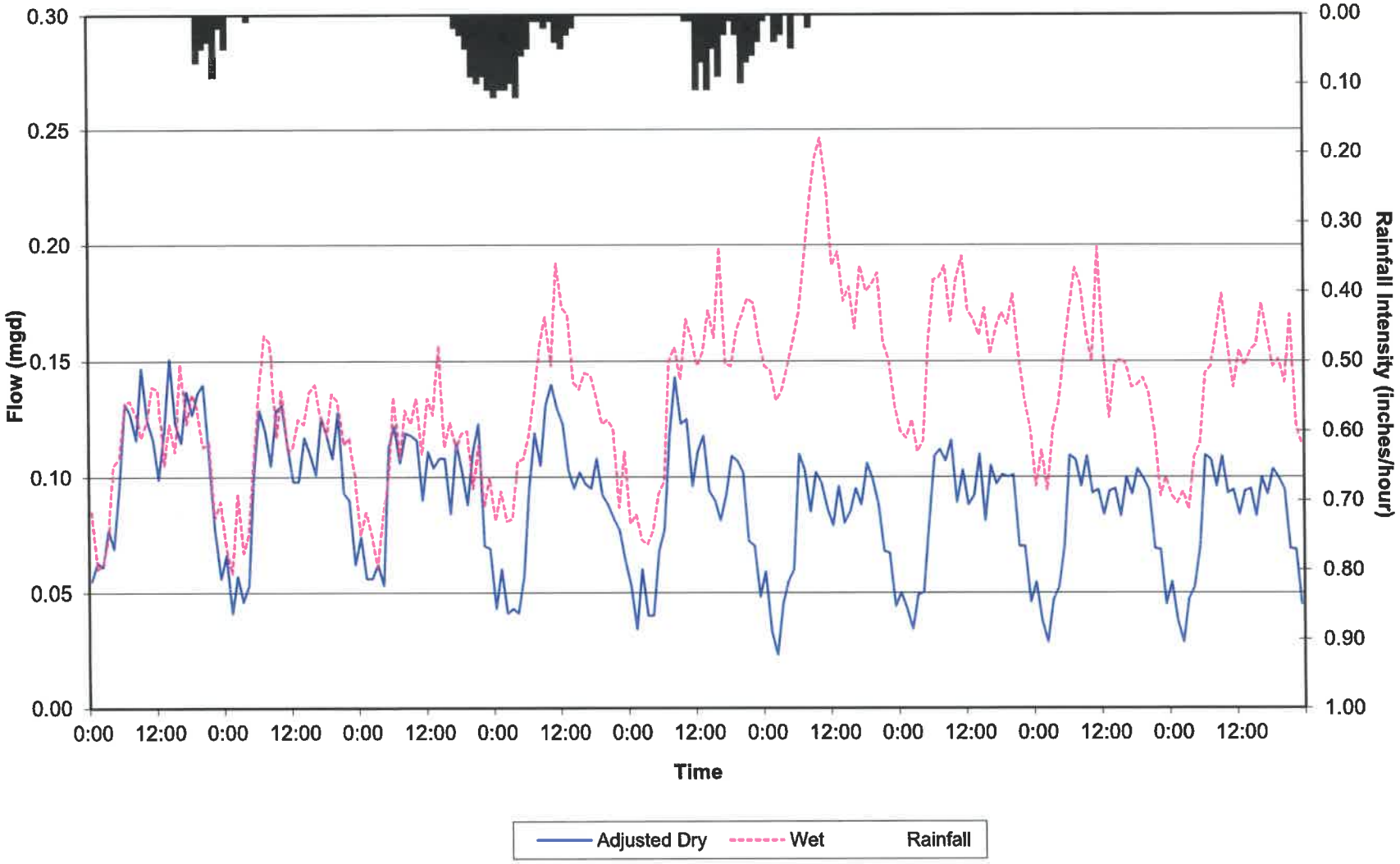


FIGURE 16. MACY STREET TOTAL INFLOW HYDROGRAPH PLOT #3
(May 26-31, 2021 Rainfall Event)

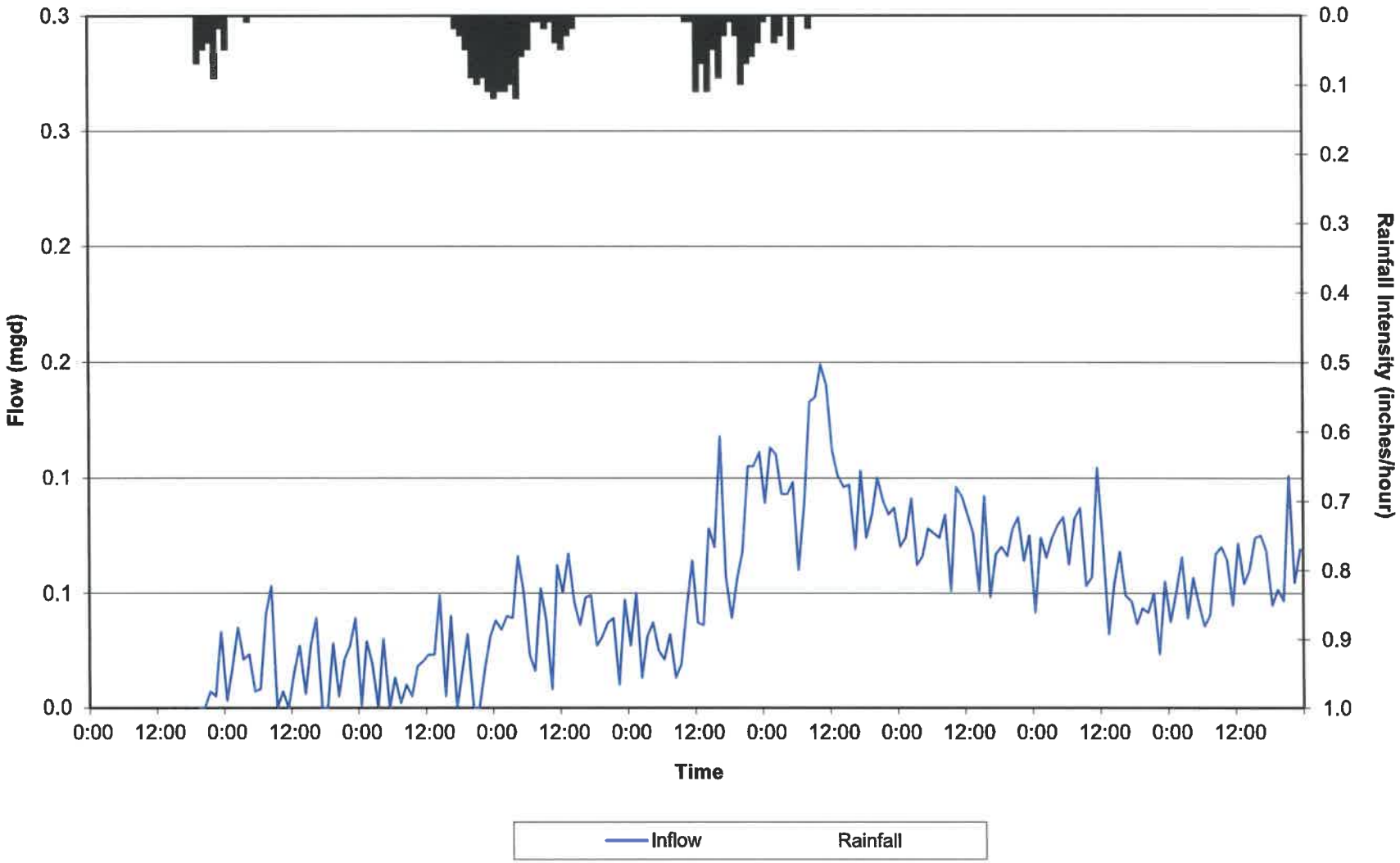


FIGURE 17. RIVER STREET INFLOW HYDROGRAPH PLOT #1
(May 26-31, 2021 Rainfall Event)

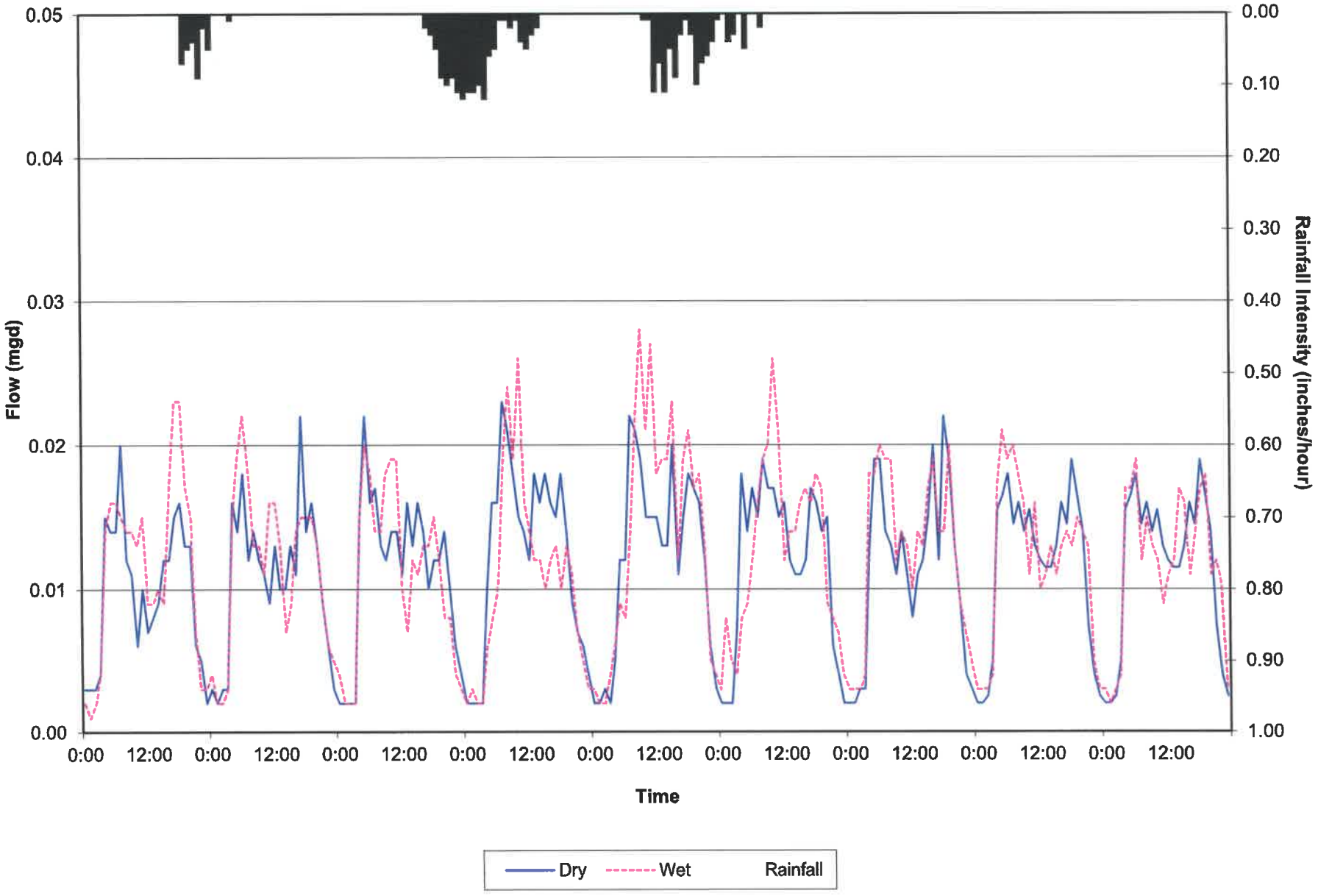


FIGURE 18. ADJUSTED RIVER STREET INFLOW HYDROGRAPH PLOT #2
(May 26-31, 2021 Rainfall Event)

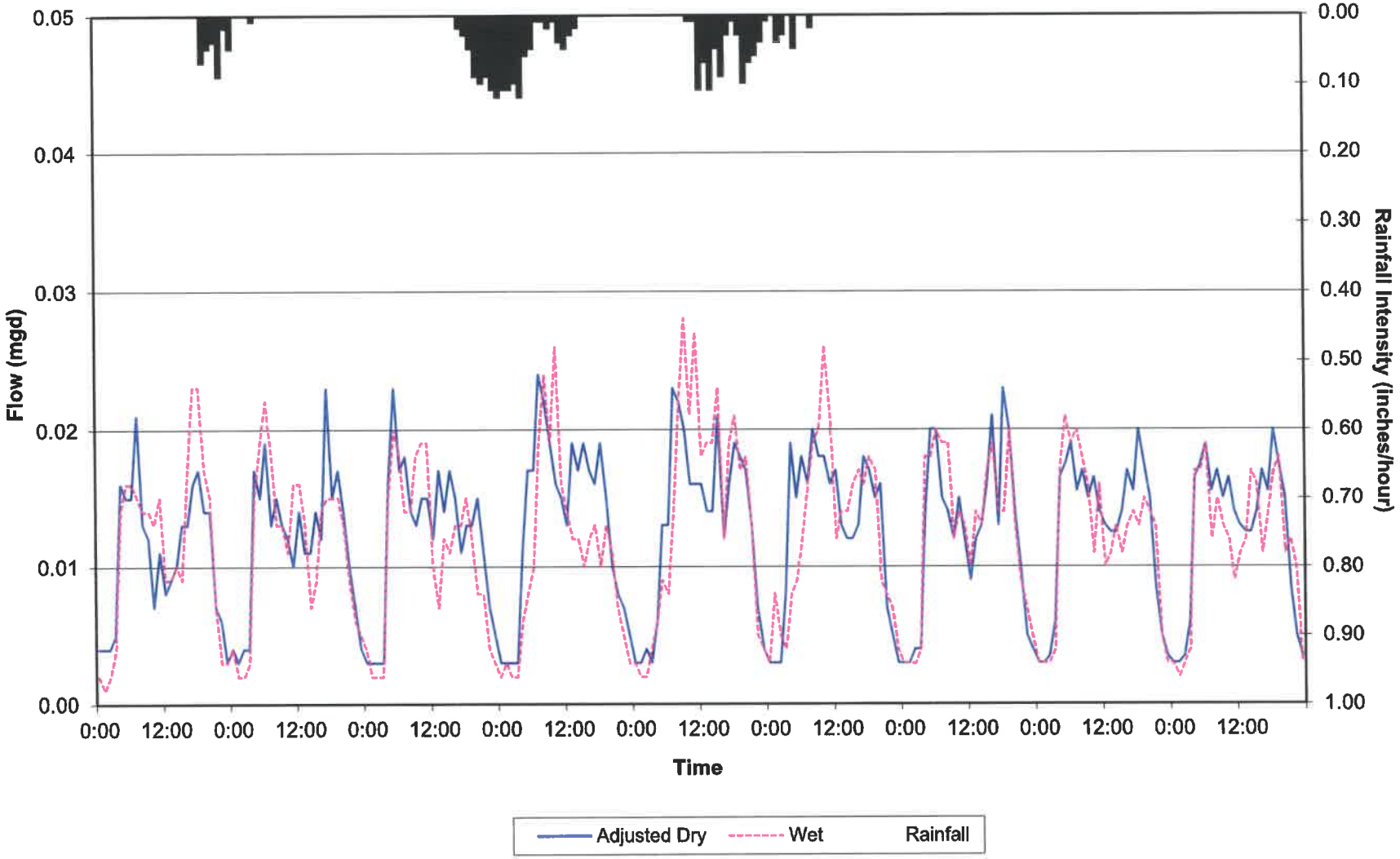
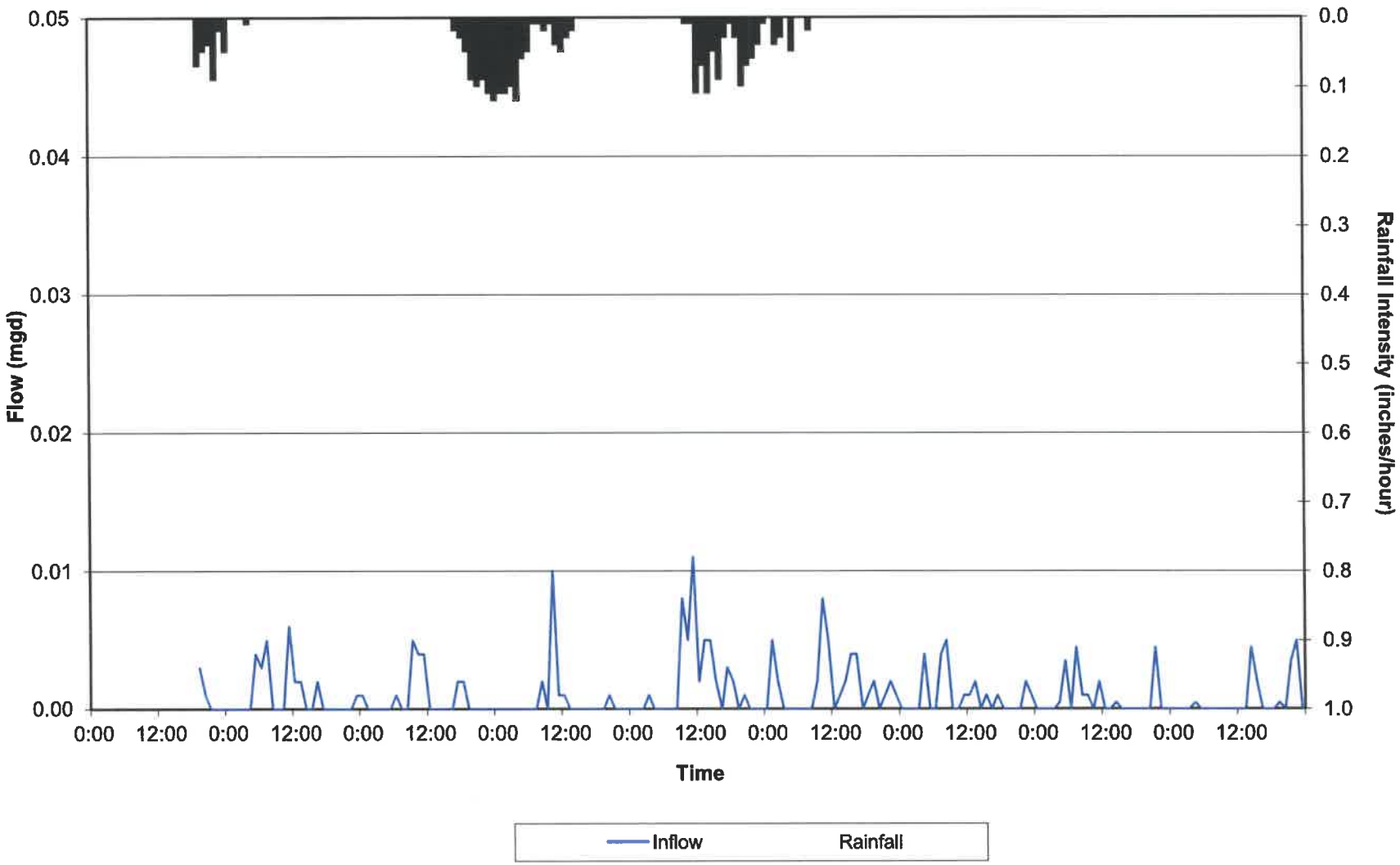
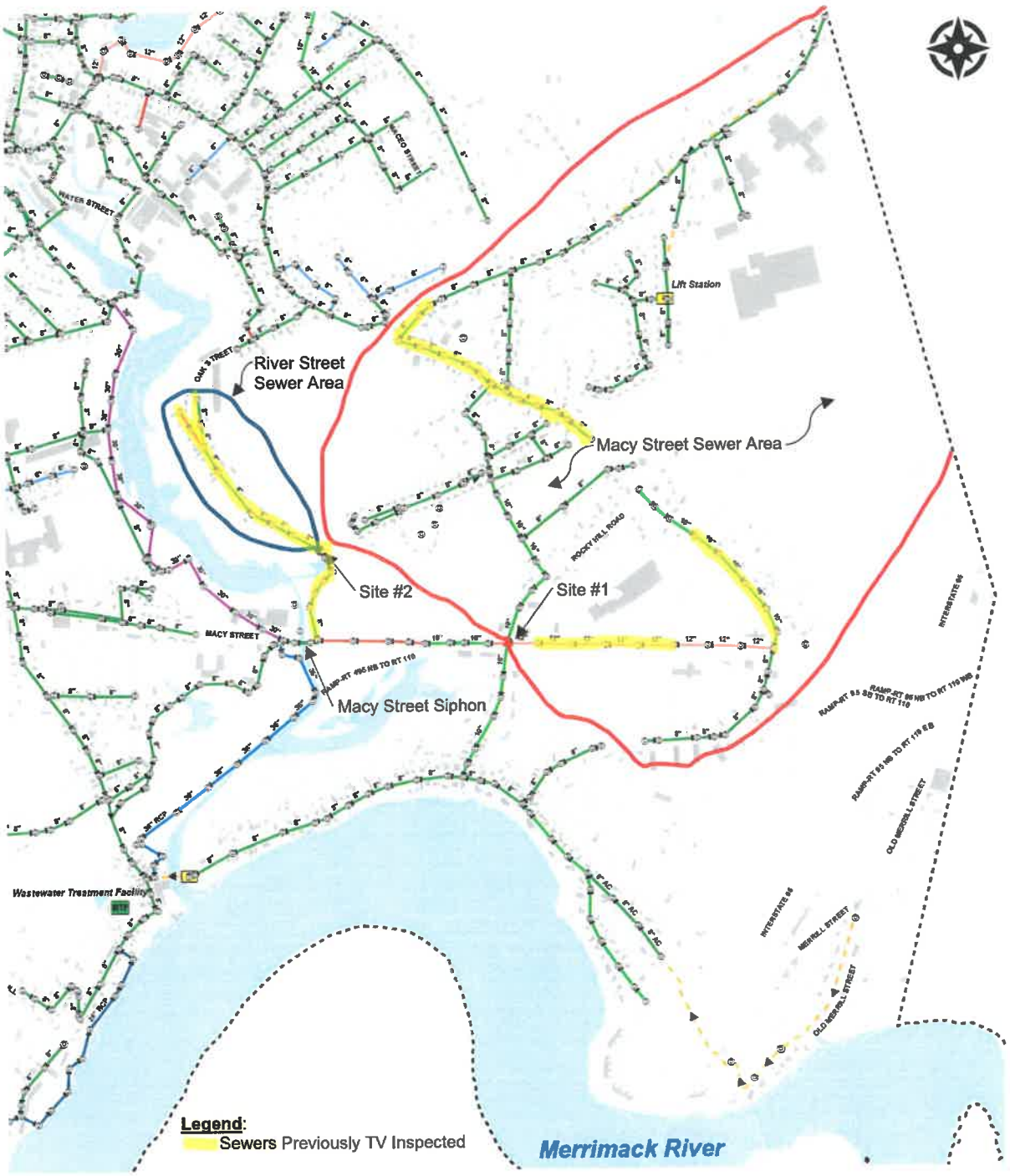


FIGURE 19. RIVER STREET TOTAL INFLOW HYDROGRAPH PLOT #3
(May 26-31, 2021 Rainfall Event)





Source: Amesbury Sewer System Map, dated January 2021, prepared by Tighe & Bond under MassDEP's Water Utility Resilience Program.

FIGURE 20. SEWERS TV INSPECTED

ATTACHMENT 2
TECHNICAL MEMO ON HYDRAULIC CAPACITY ANALYSIS

MPH Project Management, P.C.

Memo

To: Rob Desmarais

From: M.P. Hartford MPH

Date: December 17, 2021

Re: Macy Street (Route 110) Siphon Study
Hydraulic Capacity Analysis

The purpose of this memo is to summarize the results of the hydraulic capacity analysis performed on the sewer system tributary to the Macy Street siphon crossing of the Powow River. Figure 1 attached is a map of the tributary sewer area. As indicated, the majority of the area flows either by gravity or force main to the Macy Street sewer. In addition, there is a small area tributary to the River Street sewer which ties into the Macy Street sewer just upstream of the siphon. Figure 1 also highlights the manhole that is subject to sanitary sewer overflows (SSOs) during extreme periods of wet weather, high groundwater conditions.

Existing (As-Built) Conditions

Macy Street Sewer. Based on review of as-built records, the first section of sewer on Macy Street was constructed in 1953; connecting to the original 24" Powow River Interceptor and running up Macy Street to Rocky Hill Road. The sewer then continued up Rocky Hill Road approximately 630 feet before turning north; running cross-country to Cote Street via Bergeron Avenue and Lafayette Street. From Cote Street, the sewer headed out to Elm Street where it was run in both directions to Monroe Street and Portsmouth Road. The sewer was constructed of 10-inch asbestos cement (AC) pipe from the connection to the Powow River Interceptor to a cross-country sewer manhole located north of Lafayette Street where the sewer transitions to 8-inch AC pipe for the remaining sections.

The downstream end of the Macy Street sewer was originally suspended on a bridge that crossed over the Powow River. However, as a result of the construction of Route 495 in the early 1960s, the Powow River was relocated which required reconstruction of the downstream end of the Macy Street, a total of approximately 1,300 feet. As part of the reconstruction, a depressed section of sewer, often referred to as a siphon, was constructed under the relocated portion of the Powow River just prior to discharging into the Power River Interceptor. The siphon is approximately 125 feet long and constructed of 8-inch cast-iron (CI) pipe.

In 1967, the Macy Street sewer was extended to the intersection with Elm Street and Clarks Road, a distance of approximately 2,180 feet. The downstream end of this section of sewer (1,110 feet) was constructed of 12-inch AC pipe; transitioning to 10-inch AC pipe for the remainder of its length. At the intersection, the sewer was run in both directions, down Clarks Road approximately 620 feet with 8-inch AC pipe, and up Elm Street to Rocky Hill Road with 8- and 10-inch AC pipe.

In 1977, the Town constructed a new 36-inch Powow River Interceptor south of Macy Street; abandoning the 24-inch section that received flow from the Macy Street siphon. To accomplish this, a new section of 10-inch AC pipe was constructed from the old sewer manhole on the abandoned interceptor to a manhole on the new interceptor. Based on scaling off the as-built plans, it was determined that approximately 85 feet of additional 10-inch AC pipe was installed between the two manholes. However, there was no information on the slope of the new sewer which was "to be determined in the field" according to the plans.

As part of this study, therefore, Town personnel were asked to measure the height between the crown of the 10-inch AC pipe and the crown of the 36-inch reinforced concrete (RC) pipe. The invert elevation of the 10-inch sewer was then determined the height difference between the pipe crowns (17 inches) and the pipe diameter (10 inches) from the crown elevation of the 36-inch pipe (7.50 feet). This yielded an invert elevation of 5.25 for the Macy Street sewer as compared to the invert elevation of 4.50 for the Powow River Interceptor. This is important to note since typically the design of a sewer lateral connection to a main trunk line or interceptor would attempt to match the crowns of the incoming and outgoing pipes. However, in this case, it was not possible to match crowns since the crown elevation of the 10-inch AC pipe at the upstream manhole was approximately 15 inches below the crown of the downstream 36-inch RC pipe. This was likely the reason the sewer lateral connection was installed at the minimum slope of 0.0025 for a 10-inch sewer.

Finally, in July 2005, the Town performed an emergency repair on the siphon crossing of the Powow River after a report of a possible sewer break was received. Following inspection, a construction contractor was mobilized to the site to make the necessary repairs. In addition, Town personnel set up a bypass pumping system to prevent further leakage of sewage into the river. Due to the tidal action of the river, the repairs to the siphon crossing took several days to complete. Although the contractor was reportedly successful in restoring the siphon crossing to its original condition, the Town has been concerned ever since the repair that the hydraulic capacity of the siphon may have been impacted, and is a contributing factor to the SSOs that have occurred upstream in the Macy Street sewer. For this reason, the Town implemented a program to clean the siphon with a Vactor truck every three months to minimize the potential for SSOs from occurring until a long-term plan is developed.

River Street Sewer. In 1976, the Town constructed the River Street Sewer Extension to collect flow from the River Court, River Street, and Water Street area. As indicated on Figure 1, the River Street Sewer connects to the Macy Street Sewer just upstream of the siphon crossing of the Powow River and travels cross-country to River Street. The entire length of sewer is constructed of 8-inch AC pipe. Although there have been no reported sewer back-ups or SSOs along this sewer, the hydraulic layout and configuration of the sewer was evaluated to determine the impact(s) of surcharged conditions on both the Macy Street and River Street sewers.

Hydraulic Capacity Analysis

The hydraulic capacity of the Macy Street and River Street sewers were evaluated using Manning's Equation as follows:

$$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$$

Where:

Q = flow in cubic feet per second
n = Manning's roughness coefficient
A = Area in square feet
R = Hydraulic radius in feet
S = Slope

For analysis purposes, the flow capacity of each section of sewer was calculated assuming full-flow conditions and a Manning's roughness coefficient, or "n" value of 0.013 for gravity flow in asbestos cement sewers. Additionally, the slope of each section was calculated by dividing the difference between the upstream and downstream invert elevations by the length of sewer. The area and hydraulic radius for each section of sewer were calculated utilizing basic geometry equations for circular pipe.

Macy Street Sewer. Table 1 attached summarizes the results of the hydraulic capacity analysis for the Macy Street Sewer. Not surprisingly, the furthest downstream section of sewer is where a potential bottleneck may occur under peak flow conditions. As previously noted, this section of sewer was installed at minimum slope in order to allow connection of the Macy Street sewer to the Powow River Interceptor. Based on Manning's Equation, the full flow capacity of this section of sewer is limited to 0.70 mgd as compared to 0.90 mgd on either side of the siphon crossing. Further, it appears that the hydraulic capacity of the siphon is not a limiting factor since its full-flow capacity is 1.10 mgd. Of course, this assumes that the previous repair of the siphon did not affect its capacity.

If flow is restricted at the downstream end, then the location where SSOs may occur can be predicted by extending the hydraulic grade line (HGL) in the upstream direction and increasing its slope until it exceeds the grade elevation; simulating a surcharged condition within the sewer. Figure 2 attached illustrates the existing Macy Street sewer profile from the Powow River Interceptor to the intersection with Rocky Hill Road. The profile was created based on the pipe data presented in Table 1 as well as rim elevations obtained from various MassDOT plans such as the Route 110 Widening Project, dated June 2009. The HGL was then drawn from the point where flow is restricted to the point where it exceeds the grade elevation of the road and beyond. As expected, the HGL crosses the approximate grade line of the road in the vicinity of the manhole where SSOs have been reported in the past. The height of the HGL is approximately 20 feet at the manhole that overflows.

The HGL also indicates that the next upstream manhole is subject to sewer surcharging to roughly the mid-section of the manhole. This was confirmed during installation of the flow meter for the Macy Street sewer since this manhole was inspected for suitability of metering. After observing the level of previous surcharging in the manhole, however, it was determined that the manhole in the intersection with Rocky Hill Road would be more suitable for flow metering purposes.

Finally, as noted in Table 1, the three sections of sewer immediately downstream of the manhole subject to SSOs have slightly less flow capacity (0.78 mgd) than the upstream sewer at the intersection with Rocky Hill Road (0.89 mgd). For the purposes of this analysis, the flow capacity of the sewer immediately upstream of the SSO manhole has been ignored since its capacity (2.44 mgd) is a function of the downhill grade. According to Town personnel, there is only one service connection to this downhill section of sewer. Therefore, the sewer downstream of the SSO manhole conveys roughly the same amount of flow as the upstream sewer at the intersection with Rocky Hill Road. Consequently, if the upstream sewer is flowing full, then flow is going to be restricted as is flows through the three sections of sewer immediately downstream of the SSO manhole; resulting in a surcharged condition. However, it appears that regardless of where the flow restriction occurs (i.e., the connection to the Powow River Interceptor, the siphon crossing, the three sections of sewer downstream of the SSO manhole), the HGL will cross the approximate grade of the road in the vicinity of the manhole subject to SSOs.

River Street Sewer. Table 2 attached summarizes the results of the hydraulic capacity analysis for the River Street Sewer. As indicated, almost the entire length of sewer was constructed at a minimum slope of 0.004 for an 8-inch sewer which results in a full-flow capacity of approximately 0.50 mgd; based on Manning's Equation. However, there is one section of pipe that was constructed at a slope of 0.0016 which is below the recommended minimum slope; resulting in a full-flow capacity of only 0.31 mgd. Where the River Street sewer serves a relatively small tributary area, the potential for sewer back-ups or other flow problems to occur as a result of the limited capacity in this section of sewer is

not a significant concern. For maintenance purposes though, it is recommended that the Town clean this section of sewer on a routine basis (i.e., annually) to ensure that solids/debris do not accumulate and result in blockages or other flow related problems in the future.

Similar to above, a profile of the existing sewer was created to determine whether surcharging at the downstream end of the Macy Street sewer also impacts the flow within the River Street sewer. Figure 3 attached shows the profile, and as indicated, there appears to be the potential for SSOs at the end of the cross-country section of sewer. At this point, the elevation of the HGL reaches 20 feet which is roughly equivalent to the elevation at the manhole subject to SSOs on Macy Street.

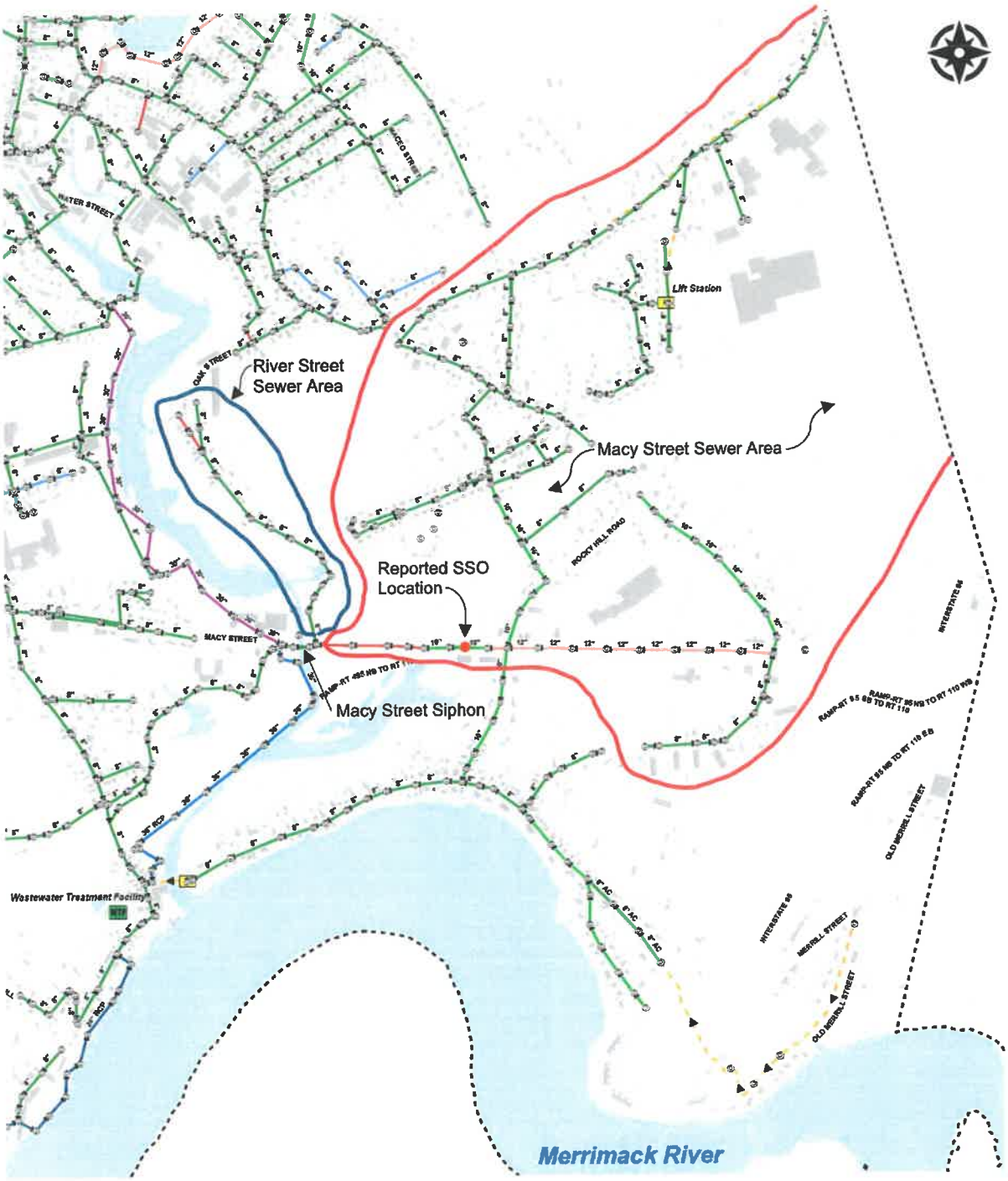
According to Town personnel, there have been no previous reports and/or evidence of SSOs or back-ups occurring at this location. However, it should be noted that the sewer is not inspected that often since the majority of its length runs through a cross-country easement which is not maintained; making it difficult to locate the existing sewer manholes. For maintenance purposes, therefore, the Town should consider taking the steps necessary to maintain the easement, such as clearing any growth on a routine schedule to locate and allow access to the existing sewer manholes in the future.

Recommendations

Due to the Town's on-going concern with the physical condition of the siphon crossing, it is recommended that a thorough cleaning and TV inspection be performed during low flow conditions. In consideration of the recommended plan for eliminating SSOs, this work should be completed once the construction of a bypass sewer on Rocky Hill Road is completed in late spring / early summer of 2022. Although the intent of the bypass sewer is to redirect only a portion of the tributary wastewater flow, it is anticipated that the bypass sewer will be used to divert all of the flow temporarily to facilitate the cleaning and TV inspection of the siphon.

For budgeting purposes, the estimated cost to clean and TV inspect the siphon is approximately $15,000. This estimate includes the cost to remove and dispose of debris material at the Amesbury Water Pollution Abatement Facility, conduct internal TV inspection of the siphon, provide police details (two officers for up to two days), and an allowance for engineering and contingencies.

In addition, as noted above, it is recommended that the Town conduct routine maintenance work on the River Street sewer, including cleaning of the section with less than minimum slope, clearing of the cross-country easement to facilitate access, and physically locating and inspecting all manholes. For budgeting purposes, the estimated cost for clearing the easement is approximately $25,000. This estimate includes the cost for permitting, clearing the shrub / tree growth, and restoring the easement for access purposes. As for the cleaning of the existing sewer, it is anticipated that Town personnel would be responsible for this work utilizing its own forces and equipment.



Source: Amesbury Sewer System Map, dated January 2021, prepared by Tighe & Bond under MassDEP's Water Utility Resilience Program.

FIGURE 1. MACY STREET SIPHON TRIBUTARY SEWER AREAS

TABLE 1. HYDRAULIC CAPACITY ANALYSIS OF MACY STREET SEWER

Station	Location	Downstream MH #	Downstream MH Invert	Upstream MH #	Upstream MH Invert	Length (ft)	Slope (ft/ft)	Pipe Size (in)	Pipe Area (ft^2)	Hydraulic Radius (ft)	Pipe Capacity (cfs)	Pipe Capacity (mgd)	Comments
16018	Connection to PRI	32+69	5.25	18	5.46	85	0.0025	10	0.55	0.208	1.08	0.70	Powow River Interceptor SHT #5, SEA, Oct-77
16103	Siphon to Existing SMH #18	18	5.46	6	5.85	97	0.0040	10	0.55	0.208	1.38	0.89	Rt 495 Powow River Relo Plans, MassDOT, circa 1964 (File Scans 51-03 & 53-7)
16200	Siphon Crossing	6	5.85	5	8.35	125	0.0200	8	0.35	0.167	1.70	1.10	
16325	Upstream of Siphon	5	8.35	4	8.57	55	0.0040	10	0.55	0.208	1.38	0.89	
16380	River St Sewer Connection	4	8.57	3	9.71	285	0.0040	10	0.55	0.208	1.38	0.89	
16665		3	9.71	2	10.85	288	0.0040	10	0.55	0.208	1.37	0.89	
16953		2	10.85	1	11.75	297	0.0030	10	0.55	0.208	1.20	0.78	
17250		1	11.75	12+94	12.18	143	0.0030	10	0.55	0.208	1.20	0.77	
17393	Connection to Old MSS[1]	12+94	12.18	14+95	12.79	201	0.0030	10	0.55	0.208	1.20	0.78	See link to table below
17594	MH Subject to SSOs	14+95	12.79	16+80	18.34	185	0.0300	10	0.55	0.208	3.78	2.44	
17779		16+80	18.34	18+46	23.32	166	0.0300	10	0.55	0.208	3.78	2.44	
17945	Macy St/Rocky Hill Rd Inter.	18+46	23.32	21+30	23.58	66	0.0040	10	0.55	0.208	1.38	0.89	
18011	Macy St Connection to RHR Sewer	19+11	23.58										
Stationing and pipe data below are used to convert stationing and invert elevations above to same datum.													
1096		8	94.73	9	95.32	198	0.0030	10	0.55	0.208	1.19	0.77	Stationing & invert elevations
1294		9	95.32	10	95.93	201	0.0030	10	0.55	0.208	1.20	0.78	based on Macy Street, Rocky Hill
1495		10	95.93	11	101.48	185	0.0300	10	0.55	0.208	3.78	2.44	Road, Private Lands, Cote Street,
1680		11	101.48	12	106.46	166	0.0300	10	0.55	0.208	3.78	2.44	and Elm Street SHT #2, Weston &
1846		12	106.46	13	107.60	284	0.0040	10	0.55	0.208	1.38	0.89	Sampson, Jul-53
2130		13	107.60										

Notes:

Lines highlighted in yellow indicate where potential bottlenecks exist due to hydrualic capacity limitations (i.e., upstream flow capacity > downstream flow capacity).

(1) Assumed El. 12.18 from Powow River Relocation Plans is equivalent to El. 95.32 from old Macy Street Sewer plan.

FIGURE 2. MACY STREET SEWER PROFILE

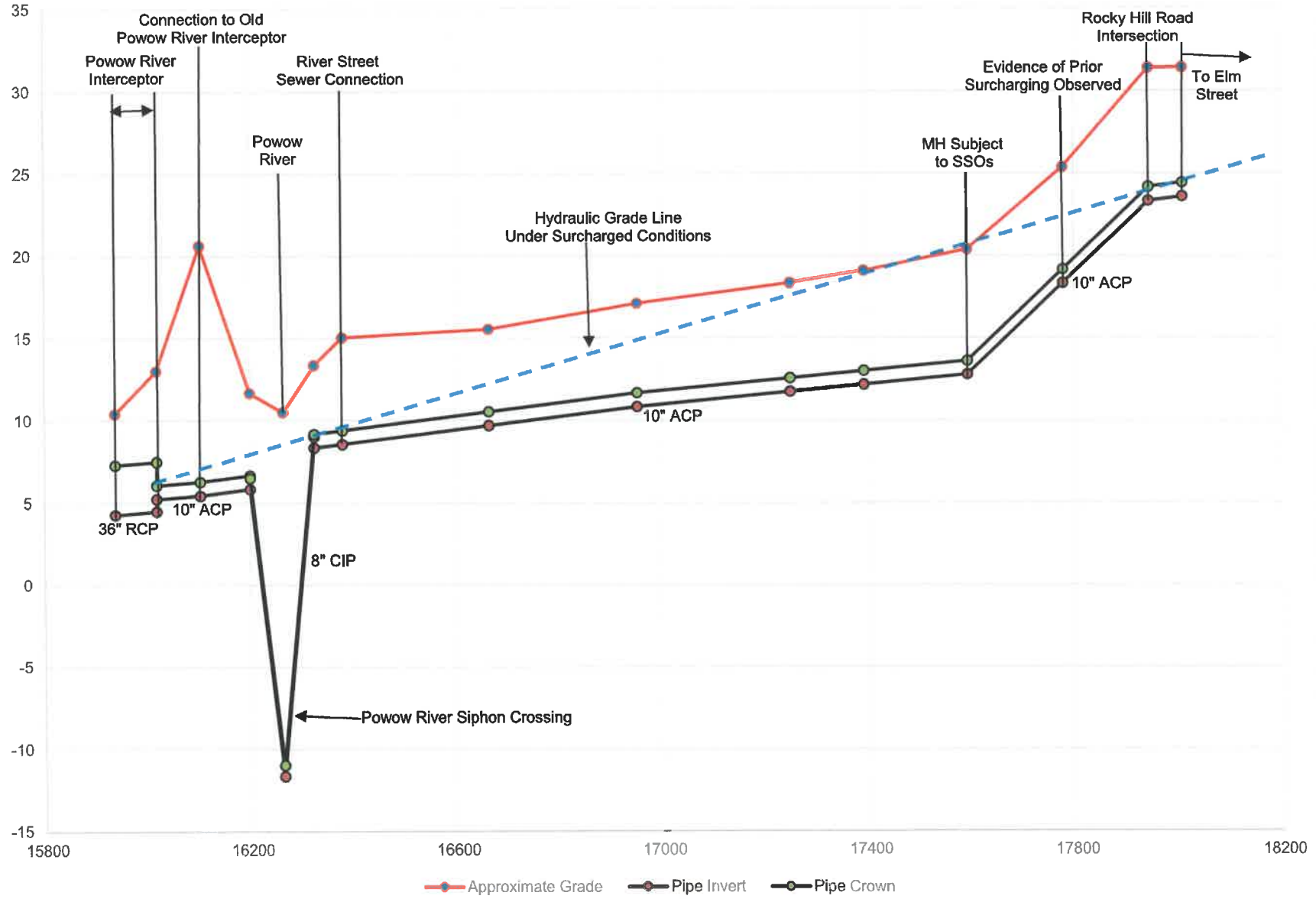
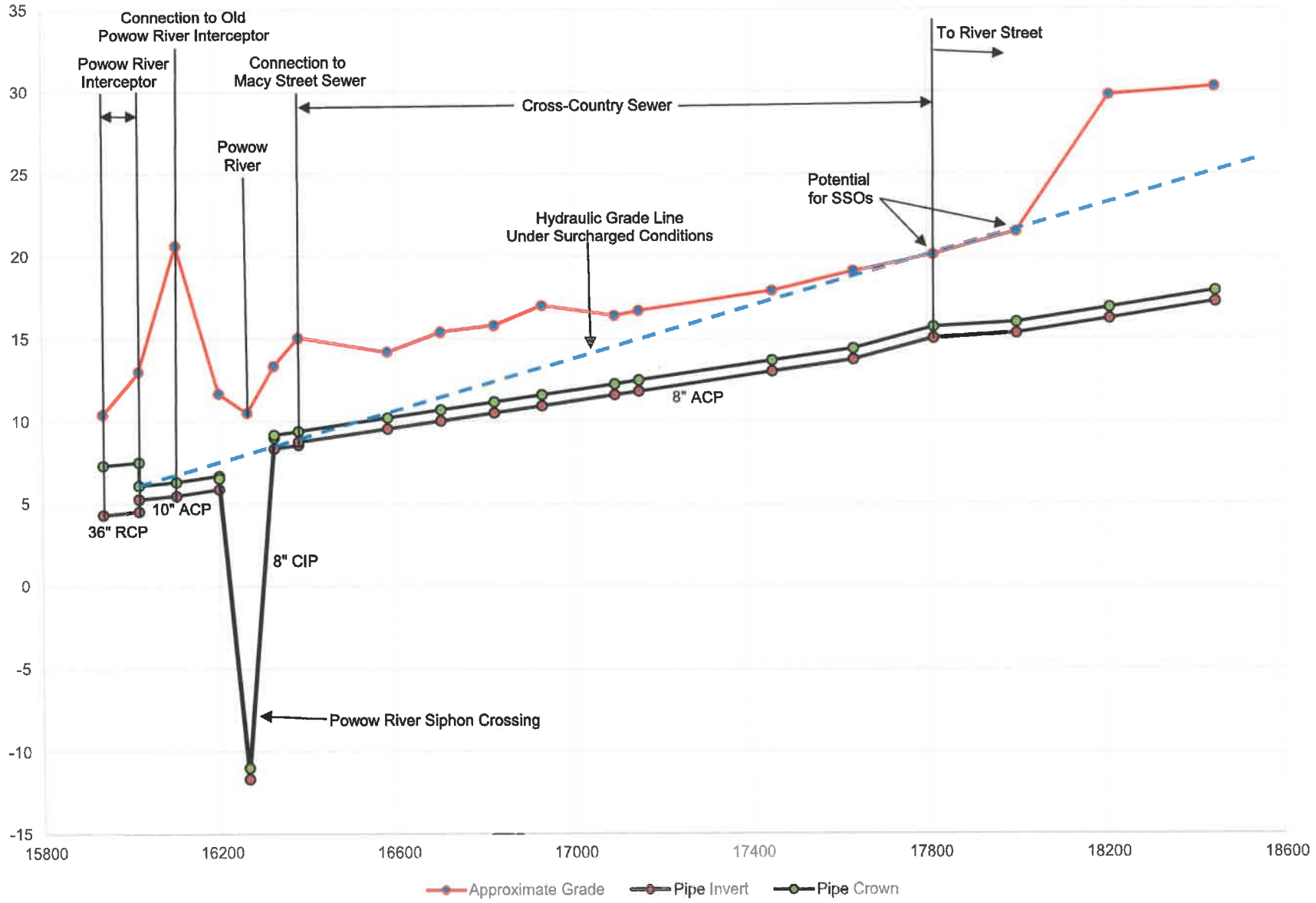


TABLE 2. HYDRAULIC CAPACITY ANALYSIS OF RIVER STREET SEWER

Station	Location	Downstream MH #	Downstream MH Invert	Upstream MH #	Upstream MH Invert	Length (ft)	Slope (ft/ft)	Pipe Size (in)	Pipe Area (ft^2)	Hydraulic Radius (ft)	Pipe Capacity (cfs)	Pipe Capacity (mgd)	Comments
0+00	Connection to MSS	MSS4	8.75	1	9.56	202	0.0040	8	0.35	0.167	0.76	0.49	See Table 1 for continuation
2+02	X-Country Sewer	1	9.56	2	10.04	120	0.0040	8	0.35	0.167	0.76	0.49	River Street Extension SHT #2,
3+22		2	10.04	3	10.52	121	0.0040	8	0.35	0.167	0.76	0.49	SEA, Jan-76
4+43		3	10.52	4	10.95	108	0.0040	8	0.35	0.167	0.76	0.49	
5+51		4	10.95	5	11.61	164	0.0040	8	0.35	0.167	0.76	0.49	
7+15		5	11.61	6	11.83	55	0.0040	8	0.35	0.167	0.76	0.49	
7+71		6	11.83	7	13.04	301	0.0040	8	0.35	0.167	0.76	0.49	
10+72		7	13.04	8	13.77	183	0.0040	8	0.35	0.167	0.76	0.49	River Street Extension SHT #3,
12+55		8	13.77	9	15.06	181	0.0071	8	0.35	0.167	1.01	0.66	SEA, Jan-76
14+36		9	15.06	10	15.36	187	0.0016	8	0.35	0.167	0.48	0.31	
16+23	Near end of River Street	10	15.36	11	16.26	209	0.0043	8	0.35	0.167	0.79	0.51	
18+32		11	16.26	12	17.28	238	0.0043	8	0.35	0.167	0.79	0.51	River Street Extension SHT #4,
20+70		12	17.28	13	18.29	220	0.0046	8	0.35	0.167	0.81	0.53	SEA, Jan-76
22+90													

Note:
Lines highlighted in yellow indicate where potential bottlenecks exist due to hydrualic capacity limitations (i.e., upstream flow capacity > downstream flow capacity).

FIGURE 3. RIVER STREET SEWER PROFILE



ATTACHMENT 3
TECHNICAL MEMO ON ALLIANCE PARK PUMP STATION

MPH Project Management, P.C.

Memo

To: Rob Desmarais

From: M.P. Hartford MPH

Date: December 22, 2021

Re: Macy Street (Route 110) Siphon Study
Alliance Park Pump Station

The purpose of this memo is to summarize the evaluation of the Alliance Park pump station.to convey additional wastewater flow redirected from the Macy Street sewer via construction of a new bypass sewer on Rocky Hill Road. Based on a limited field survey, it was determined that there is sufficient grade to install a new bypass sewer; connecting the existing sewer on Macy Street at the intersection with Rocky Hill Road to the existing sewer on the south side of Rocky Hill Road. The bypass sewer would allow redirection of a portion of the wastewater flow tributary to the Macy Street sewer; eliminating the potential for sanitary sewer overflows (SSOs) during extreme periods of wet weather, high groundwater conditions due to capacity limitations within the downstream sewer system. Of course, this assumes that the sewer system downstream of the proposed bypass sewer, including the Alliance Park pump station, have the capacity to accommodate the additional flow.

Figure 1 attached is a map of the study area highlighting the proposed bypass sewer as well as the location of the Alliance Park Pump Station. As indicated, the existing pump station receives wastewater flow collected by the Main Street Interceptor, including sewer lateral sewer connections from Rocky Hill Road, Clarks Road, and Evans Place. The interceptor was constructed in 1977 and consists of 10- and 12-inch asbestos cement (AC) pipe while the three sewer lateral connections were constructed of 8-inch AC pipe. The Alliance Park pump station then conveys the flow to the Powow River Interceptor via 6-inch cast-iron (CI) force main suspended from the Main Street bridge.

Alliance Park Pump Station

The Alliance Park pump station was constructed in 1977, and is a pre-fabricated (factory built) dry-pit underground station with a separate wet well. Access to the station is through an aboveground hatch mounted on top of a manhole barrel section. The pump station has two levels below ground. The upper-level is where the pump station controls are located, and according to Town personnel, the controls were updated in 2016.

The lower-level houses the pumps which are the original Deming dry-pit solids handling centrifugal pumps manufactured by Crane Co., each with a rated capacity of 460 gpm at 32 feet of total dynamic head. The pumps are set-up to run on an alternating basis. Over the years, Town personnel have changed the pump impellers and rewound the pump motors to extend their service life. However, the pumps are showing signs of their age and are long overdue for replacement, especially when considering that the design life for mechanical equipment such as pumps, blowers, etc., is typically 20 years.

The station is also equipped with an aboveground diesel engine standby generator manufactured by CAT.

Pump Run Time. At the outset of the project, Town personnel installed run-time meters for both pumps to allow estimation of the wastewater flow conveyed by the station. Table 1 attached is a summary of the run-time data collected from April 15 to May 10, 2021. During this period, the most significant rainfall (i.e., greater than 0.50 inches) occurred on April 16-17, 2021 when approximately 1.9 inches of rainfall was recorded at the Lawrence Municipal Airport.

Based on review of Table 1, the two pumps ran for a total of 3.5 hours per day; resulting in an average daily flow of approximately 96,000 gpd based on the rated capacity of the pumps. This would suggest that the pump station is capable of conveying additional flow from the Macy Street sewer area since the pumps are operational for only 15% of the time on a daily basis. However, it would be prudent to remove and replace the existing pumps in their entirety based on their age and years of service.

Sewer Capacity Analysis

The hydraulic capacity of the Rocky Hill Road sewer and Main Street Interceptor were evaluated to determine the amount of additional flow that could be redirected from the Macy Street sewer area without negatively impacting the downstream system. This was accomplished using Manning's Equation as follows:

$$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$$

Where:

Q = flow in cubic feet per second
n = Manning's roughness coefficient
A = Area in square feet
R = Hydraulic radius in feet
S = Slope

For analysis purposes, the flow capacity of each section of sewer was calculated assuming full-flow conditions and a Manning's roughness coefficient, or "n" value of 0.013 for gravity flow in asbestos cement sewers. Additionally, the slope of each section was calculated by dividing the difference between the upstream and downstream invert elevations by the length of sewer. The area and hydraulic radius for each section of sewer were calculated utilizing basic geometry equations for circular pipe.

Rocky Hill Sewer. Table 2 attached summarizes the results of the hydraulic capacity analysis for the Rocky Hill Road sewer, including the proposed bypass sewer. As indicated, the majority of the existing sewer was constructed at a minimum slope of 0.004 for an 8-inch sewer which results in a full-flow capacity of approximately 0.50 mgd. To be conservative, the proposed bypass sewer should be designed to convey no more than 50 percent of the existing flow capacity within the Rocky Hill Road sewer, or 0.25 mgd. This would likely be accomplished by constructing an adjustable weir within the existing manhole at the intersection of Macy Street and Rocky Hill Road. The height of the weir would then be set to allow the flow under normal dry weather conditions to continue down Macy Street. However, as the flow level in the sewer increases to the height of the weir, it would be split; allowing excess flow to be diverted to the existing Rocky Hill Road sewer via the proposed 8-inch bypass sewer.

Figure 2 attached shows the existing Rocky Hill Road sewer profile from the Main Street Interceptor to the Macy Street sewer. The profile was created based on the pipe data presented in Table 2 as well as rim-to-invert elevation data obtained from a limited field survey conducted in June 2021 as part of this study. As indicated, the invert elevation at the upstream end of the Rocky Hill Road sewer is

approximately eight feet lower than the invert elevation of the Macy Street sewer within the intersection. Accordingly, there is sufficient grade for the installation of approximately 265 feet of new 8-inch sewer which will serve as a bypass for excess flows occurring during extreme periods of wet weather, high groundwater conditions.

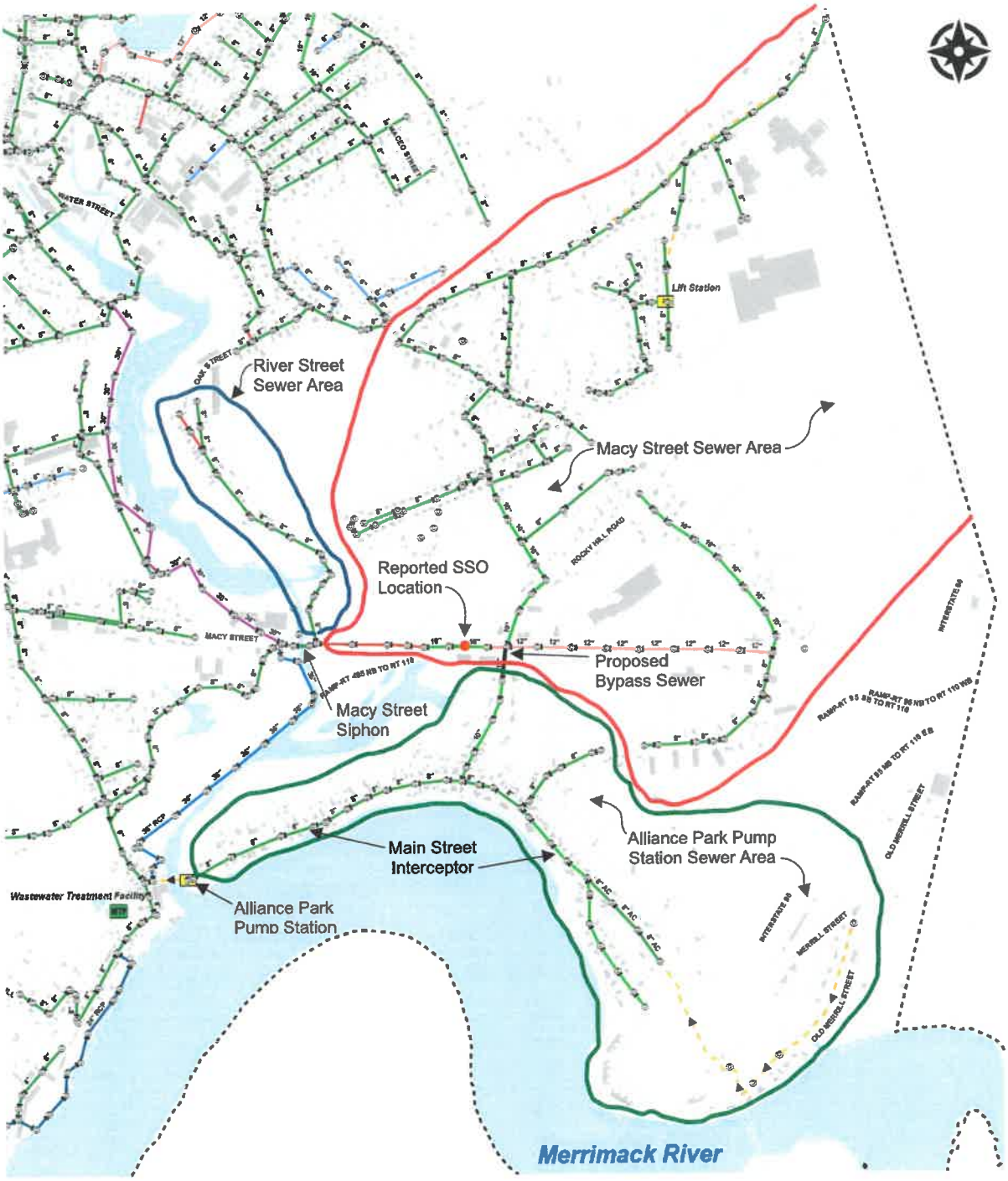
Main Street Interceptor. Table 3 attached summarizes the results of the hydraulic capacity analysis for the Main Street Interceptor. Although there are a few sections of the interceptor where the slope is below the minimum of 0.002 for a 12-inch sewer, this is not a significant concern because the minimum flow capacity of the interceptor (0.88 mgd) is significantly higher than the average daily flow conveyed by the Alliance Park pump station based on the run-time data presented in Table 1. Further, it does not appear that redirecting up to 0.25 mgd of wastewater flow from the Macy Street area would have an adverse impact on flows within either the interceptor or the pump station.

Recommendations

As noted above, it is recommended that the Town remove and replace the existing pumps at the Alliance Park pump station in their entirety. For budgeting purposes, the total estimated cost for this work is approximately $100,000. This estimate includes the cost to purchase the pumps, remove and dispose of the existing pumps, install and wire the new pumps, start-up and training, and an allowance for engineering and contingencies.

In addition, it is recommended that the Town install a new bypass sewer on Rocky Hill Road to eliminate the potential for SSOs to occur along the Macy Street sewer. For budgeting purposes, the total estimated cost for this work is approximately $160,000. This estimate includes the cost to install approximately 265 feet of new 8-inch sewer, remove and replace two existing brick manholes with new concrete manholes, build an adjustable weir for flow diversion purposes, provide police details (two officers for up to ten days), and an allowance for engineering and contingencies.

Both projects above should be designed and bid for construction in the spring of 2022.



Source: Amesbury Sewer System Map, dated January 2021, prepared by Tighe & Bond under MassDEP's Water Utility Resilience Program.

FIGURE 1. STUDY AREA MAP

TABLE 1. RUN-TIME ANALYSIS FOR ALLIANCE PARK PUMP STATION

Reading Date	Pump #1			Pump #2			Totals	
	Run-Time Hours	Average Hrs/Day	GPD	Run-Time Hours	Average Hrs/Day	GPD	Average Hrs/Day	GPD
15-Apr	7177.8			11397.2				
16-Apr	7179.0	1.2	33120	11398.5	1.3	35880	2.5	69000
21-Apr	7186.9	1.6	43608	11410.5	2.4	66240	4.0	109848
23-Apr	7189.6	1.4	37260	11414.4	1.9	53820	3.3	91080
28-Apr	7195.6	1.2	33120	11423.0	1.7	47472	2.9	80592
30-Apr	7198.5	1.4	40020	11427.2	2.1	57960	3.6	97980
4-May	7204.2	1.4	39330	11435.4	2.0	56580	3.5	95910
5-May	7205.7	1.5	41400	11437.5	2.1	57960	3.6	99360
6-May	7207.4	1.7	46920	11440.0	2.5	69000	4.2	115920
10-May	7213.4	1.5	41400	11448.5	2.1	58650	3.6	100050
Averages		**1.4**	**39575**		**2.0**	**55951**	**3.5**	**95527**

TABLE 2. HYDRAULIC CAPACITY ANALYSIS OF ROCKY HILL ROAD SEWER

Station	Location	Downstream MH #	Downstream MH Invert	Upstream MH #	Upstream MH Invert	Length (ft)	Slope (ft/ft)	Pipe Size (in)	Pipe Area (ft^2)	Hydraulic Radius (ft)	Pipe Capacity (cfs)	Pipe Capacity (mgd)	Comments
22+92	Main Street	12	2.82	13	3.18	126	0.0029	12	0.79	0.250	1.90	1.23	
0+00	Drop Connection to MSI	13	10.72	1	11.68	103.7	0.0093	8	0.35	0.167	1.16	0.75	Main Street Interceptor Plans,
1+03.7		1	11.68	2	12.35	134.8	0.0050	8	0.35	0.167	0.85	0.55	SHT #10, SEA, Mar-78
2+38.5		2	12.35	3	13.56	316	0.0038	8	0.35	0.167	0.74	0.48	
5+54.5		3	13.56	4	14.37	174	0.0047	8	0.35	0.167	0.82	0.53	
7+28.5		4	14.37	5	15.17	172.2	0.0046	8	0.35	0.167	0.82	0.53	
9+00.7	Proposed Bypass Sewer	5	15.17	18+46	23.06	264	0.0299	8	0.35	0.167	2.08	1.34	
18+46	Connection to Macy Street Sewer(1)	18+46	23.06										

Notes:

(1) Invert El. 23.06 determined based on field survey conducted in Jun-21; measuring sewer depths at upstream and downstream manholes referenced to assumed datum.

FIGURE 2. ROCKY HILL ROAD SEWER PROFILE

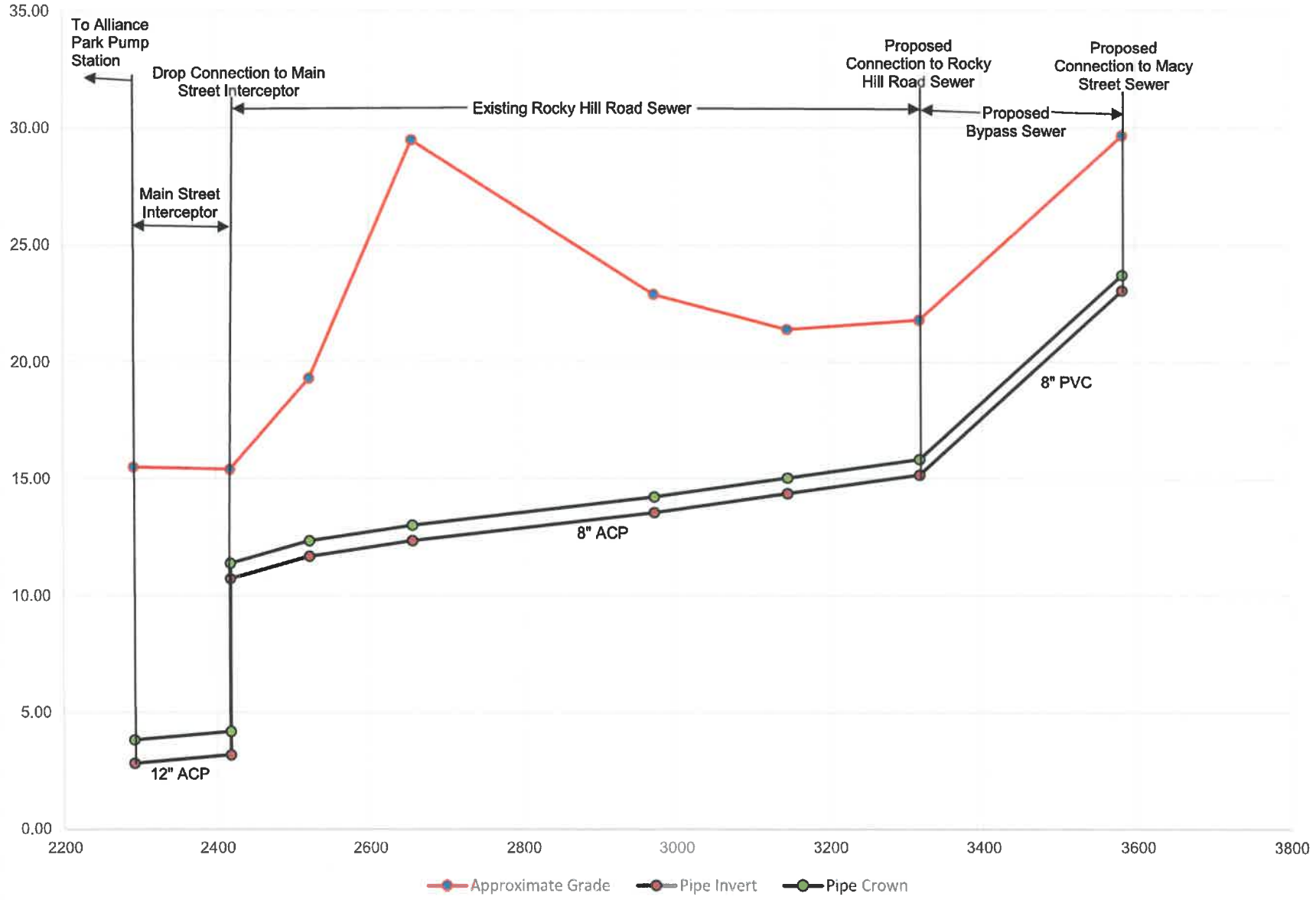


TABLE 3. HYDRAULIC CAPACITY ANALYSIS OF MAIN STREET INTERCEPTOR

Station	Location	Downstream MH #	Downstream MH Invert	Upstream MH #	Upstream MH Invert	Length (ft)	Slope (ft/ft)	Pipe Size (in)	Pipe Area (ft^2)	Hydraulic Radius (ft)	Pipe Capacity (cfs)	Pipe Capacity (mgd)	Comments
0+00	Connection to Alliance Park PS	Wet Well	-2.9	1	-2.84	23.2	0.0026	12	0.79	0.250	1.80	1.17	Main Street Interceptor Plans,
0+23.2		1	-2.84	2	-2.44	121.8	0.0033	12	0.79	0.250	2.03	1.31	SHT #4, SEA, Mar-77
1+45		2	-2.44	3	-1.81	240.6	0.0026	12	0.79	0.250	1.81	1.17	
3+85.6		3	-1.81	4	-1.26	147.5	0.0037	12	0.79	0.250	2.17	1.40	
5+33.1		4	-1.26	5	-0.56	300.0	0.0023	12	0.79	0.250	1.71	1.11	
8+33.1		5	-0.56	6	-0.13	293.9	0.0015	12	0.79	0.250	1.36	0.88	Main Street Interceptor Plans,
11+27		6	-0.13	7	0.53	101.0	0.0065	12	0.79	0.250	2.87	1.85	SHT #5, SEA, Mar-77
12+28		7	0.53	8	0.85	200.0	0.0016	12	0.79	0.250	1.42	0.92	
14+28		8	0.85	9	1.15	188.0	0.0016	12	0.79	0.250	1.42	0.92	
16+16		9	1.15	10	1.50	171.0	0.0020	12	0.79	0.250	1.60	1.04	
17+87		10	1.50	11	2.19	256.0	0.0027	12	0.79	0.250	1.84	1.19	Main Street Interceptor Plans,
20+43		11	2.19	12	2.82	249.0	0.0025	12	0.79	0.250	1.78	1.15	SHT #6, SEA, Mar-77
22+92		12	2.82	13	3.18	126.0	0.0029	12	0.79	0.250	1.90	1.23	
24+18	Rocky Hill Road Sewer Connection	13	3.18	14	3.46	140.5	0.0020	12	0.79	0.250	1.58	1.02	
25+58.5		14	3.46	15	3.82	129.3	0.0028	12	0.79	0.250	1.87	1.21	
26+87.8		15	3.82	16	4.60	285.0	0.0027	12	0.79	0.250	1.86	1.20	
29+72.8	Clarks Road Sewer Connection	16	4.60	17	5.01	90.0	0.0046	10	0.55	0.208	1.47	0.95	Main Street Interceptor Plans,
30.62.8		17	5.01	18	5.93	284.9	0.0032	10	0.55	0.208	1.24	0.80	SHT #7, SEA, Mar-77
33+47.7		18	5.93	19	6.60	199.5	0.0034	10	0.55	0.208	1.26	0.82	
35+47.2		19	6.60	20	7.18	221.8	0.0026	10	0.55	0.208	1.11	0.72	
37+69	Evans Place Sewer Connection	20	7.18	21	7.51	134.8	0.0024	10	0.55	0.208	1.08	0.70	
39+03.8		21	7.51	22	8.30	243.0	0.0033	10	0.55	0.208	1.24	0.80	Main Street Interceptor Plans,
41+46.8		22	8.30	23	8.88	201.6	0.0029	10	0.55	0.208	1.17	0.76	SHT #8, SEA, Mar-77
43+48.4		23	8.88	24	9.47	254.7	0.0023	10	0.55	0.208	1.05	0.68	
46+03.1		24	9.47	25	10.05	222.0	0.0026	10	0.55	0.208	1.11	0.72	
48+25.1													