TECHNICAL MEMO

ARCADIS Design & Consultancy for natural and built assets

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Date:

Friday, June 21, 2019

Arcadis Project No.:

26980001.0000

Subject:

City of Portland, ME – Department of Public Works
Planning and Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System –Progress Report June 2019

This progress report summarizes the work completed to date on the Planning and Engineering Services for the Infiltration and Inflow Program of the Sanitary Sewer System for the City of Portland, Maine. This progress report also includes information on the project budget and schedule.

Overall, the project is on schedule and within budget. While the contract duration is approximately 67% expired, through May 2019, we have billed approximately 50% of the Total Contract Fee. This is expected, as a lot of the costs will be incurred over the coming months as we continue SSES field work of our subcontractors and Arcadis' in-house engineering evaluation of the field data.

Task 1 – Project Management

Task 1 includes project management throughout the three-year contract duration and includes: coordination and meetings with the City of Portland and other City entities, stakeholders, staff and subcontractors, presentations to the City at the completion of each task or key milestone, scheduling and management of staff resources, quality assurance/quality control, budgeting, cost controls and monthly billing, progress reports and development and enforcement of a project-specific Health and Safety Plan. Task 1 deliverables include preparation of meeting agendas and meeting minutes, Health and Safety Plan, progress reports, schedules and budget updates, slide show presentation to the City annually or at the completion of key milestone tasks, and updates and suggested budgets for anticipated, related work and costs to be incurred as required to complete the services under the I/I program. ***Task 1 is ongoing***

and currently on schedule and on budget. Through May 2019, we have billed approximately 22% of this Task's original budget.

Task 2 – Kickoff Workshop, Data Gathering, Public Participation

Task 2 includes a Kickoff Workshop, data gathering and public participation meetings over the three-year contract term. Task 2 key deliverables include a meeting agenda and goals for the Kickoff Workshop, summary of Kickoff Workshop discussions, public participation agendas and sample public information notices and bulletins for the City to disseminate through the City website.

At the project Kickoff Workshop on May 16, 2017, all facets of the project were discussed, including establishment of project goals and schedule for initiation and completion of all tasks. Data gathering took place mostly over the first two months of the project and continues on an as needed basis as we continue to request and obtain information from the City. Public participation has not yet begun, but Arcadis is prepared to discuss with the City the best way to initiate public notification and involvement. ***Task 2 is ongoing and currently on schedule and on budget. Through May 2019, we have billed approximately 84% of this Task's original.***

Task 3 – Data Gap Analysis

Task 3 includes utilizing Arcadis Data Profiler to complete a gap analysis of the City's GIS and prepare a GIS Gap Analysis report for the City. Task 3 also includes an evaluation of the City's hydraulic model to determine if the modeled network should be expanded and if the model should be re-calibrated. ***Task 3 is mostly complete, with a minor, on-going level of effort as necessary to revisit or update previously identified data gaps. Final versions of the "GIS Gap Analysis Report" and the "Hydraulic Model Gap Analysis Letter Report" were delivered to the City on November 5, 2018 and have been uploaded to the project Sharepoint website. Through May 2019, we have billed approximately 93% of this Task's budget.***

Task 4 – Flow Monitoring Program

The scope of services under Task 4 includes the development and implementation of a flow monitoring program, including the installation, maintenance and monitoring of 40 flow meters (over a two-year program) for a period of 12 weeks; installation of two permanent groundwater gauges and two rain gauges; and monitoring of additional gauges which already exist within the City. Task 4 includes engineering analysis of flow data, including the calculation of average daily flow, peak daily flow and peak hourly flow for each meter area. Task 4 key deliverables include meeting with the City to discuss the flow monitoring program strategy and implementation; and a "Flow Monitoring Letter Report" with findings, results and SSES recommendations. ***Task 4 is ongoing and currently on schedule and on budget. Through May 2019, we have billed approximately 87% of this Task's original budget.***

The following is a summary of completed and on-going flow monitoring program activities:

Completed in 2018:

- Development of 20 flow meter subareas throughout the City. This was done by Arcadis based with input from the City of Portland's engineering department and DPW.
- Installation, maintenance and monitoring of 20 flow meters by Flow Assessment Services. Flow meters were installed from March 7, 2018 – July 9, 2018 for a total of 16 weeks.
    - Meters were installed in sub-areas 1, 2, 3, 4, 5, 7, 8, 9, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 28 and 29.

- Two rain gauges were installed at the Fore River Pump Station and the Riverton Fire Station. Rain gauge data was supplemented with data from the Riverside Pump Station for the infiltration and inflow analysis.
- Two permanent groundwater gauges were installed. One groundwater gauge located at the intersection of Martin Street and Bartley Street and the other is located on Leland Street at Baxter Pines Trail Head.
- An Infiltration and inflow analysis was performed on the 16 weeks of flow data for each of the 20 meter areas. The analysis included calculation of average daily flow, peak daily flow, base infiltration, rainfall induced infiltration and inflow. Infiltration was calculated based on gallons per day per LF as well as gallons per day per inch-diameter mile.
- High infiltration and inflow sub-areas were established and SSES recommendations were developed. Recommendations were developed based on flow metering results as well as data provided by the City – known problem areas, segments previously televised, and upcoming rehabilitation plans.
- Preliminary meter areas for 2019 were developed based on 2018 flow meter results and areas not included in the 2018 metering program.

Completed in 2019

- Development of 15 flow meter subareas throughout the City. This was done by Arcadis with input from the City of Portland DPW.
- Installation, maintenance and monitoring of 20 telemetry flow meters (2 meters were installed for subtraction and balancing and 3 sub-areas required 2 meters each). Flow meters were installed in sub-areas 6, 10, 11, 12, 23, 23A, 24, 24A, 25, 26, 26A, 27, 27A, 30 and 31 on February 15, 2019 and removed on May 31, 2019.
- The use of telemetry flow meters in Spring 2019 allowed Arcadis to view flow data in real-time and make immediate follow-on SSES recommendations for flow isolation and CCTV. This maximizes the amount of work that can completed during the Spring high groundwater season.
- Rain gauges were installed at the Allen Ave Fire Department and the Ocean Ave Fire Department. Rain data from these two gauges is being supplemented with data from the Riverside Pump Station for the infiltration and inflow analysis.

Ongoing in 2019

- Arcadis is currently performing a detailed flow metering analysis calculating average daily flow, peak daily flow, base infiltration and rainfall induced infiltration and inflow.
- High infiltration and inflow sub-areas are being established and SSES recommendations are being developed, scheduled and completed.
- Upon completion of the Phase 2 Flow Monitoring Program, Arcadis will prepare a final "Flow Monitoring Program Letter Report", summarizing findings, results and SSES recommendations from both phase of the program.

<u>Task 5 – Investigation of Major I/I Sources – Sewer System Evaluation Survey (SSES)</u>

Task 5 includes the development and implementation of a collection system I/I investigation strategy that includes flow isolation, closed circuit television (CCTV) inspections, manhole inspections, smoke testing, dye testing, building inspection as appropriate to identify major sources of I/I. **Task 5 began in**

the Fall of 2018 after the first round of SSES recommendations were developed based on the Phase 1 flow monitoring results. This task is ongoing and currently on schedule and budget. ***Through May 2019, we have billed 31% of this Task's original budget.***

- Flow Isolation was conducted in the Fall of 2018 and the Spring of 2019 based on 2018 metering results and preliminary 2019 metering results. A total of 315,000 LF of flow isolation was completed and follow on CCTV recommendations were developed.
- CCTV investigations started in December 2018 by Ted Berry Company based on the Fall 2018 flow isolation results and is ongoing. To date, 96,900 LF of CCTV has been completed and an additional 55,100 LF is planned based on the 2019 flow isolation results. Arcadis is performing CCTV review and preparing rehabilitation recommendations.
- Flow Assessment services is currently performing 469 manhole inspections. An additional 490 manholes are planned for the Fall of 2019.
- Inflow investigations typically performed during low groundwater periods will be conducted in the Summer of 2019. Arcadis is currently working to identify the locations to focus the inflow investigations based on the 2018 and 2019 metering results. Inflow investigations include 45 large building inspections, 126,000 LF of smoke testing, and 10 days of dye testing.

Task 6 – Wastewater Collection System Analysis and Action Plan

Task 6 includes the development of a Wastewater Collection System Analysis and Action Plan Report and a presentation of the Final Report and recommendations to the City. **This task has not yet begun. It is anticipated that this task will begin in the Fall of 2019.**

Schedule

A revised project schedule has been attached to this progress report.

Project Schedule

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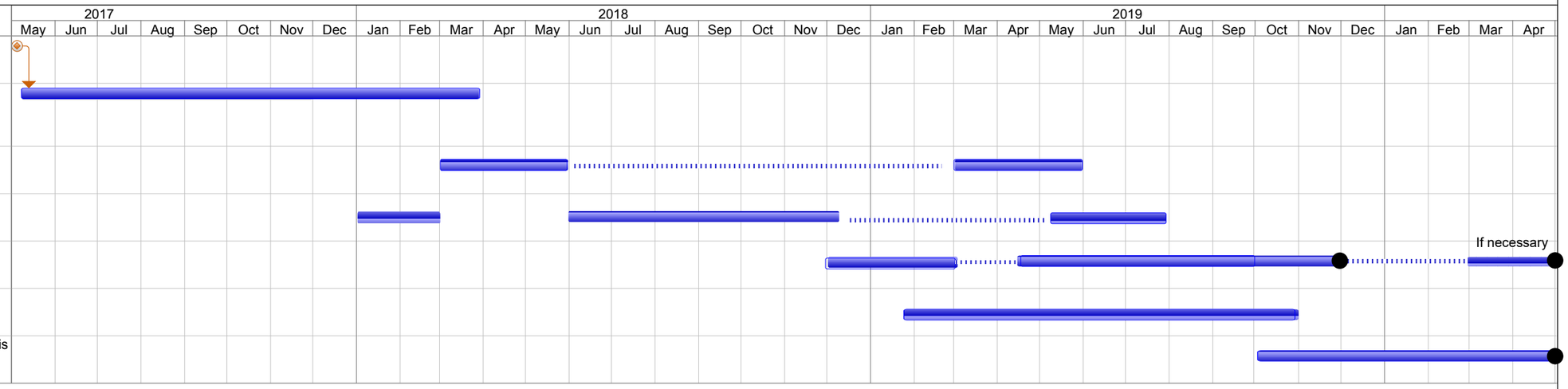
ID	Task Name
1	Execute Contract for I/I Program
2	Data gathering and gap analysis
3	Flow monitoring program
4	Selection of meter areas, analysis of flow data, I/I source identification, select SSES activities
5	Conduct SSES activities in high priority I/I areas
6	Identification of I/I rehabilitation needs
7	Draft and Final "Wastewater Collection System Analysis and Action Plan" Report



City of Portland, Maine

CITY-WIDE INFILTRATION AND INFLOW PROGRAM

Phase 2 Identification Of Major Infiltration And Inflow Sources

JUNE 2019

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Appendix A Phase 1 – Investigation of Flows – 2018 Monitoring Report

ACRONYMS AND ABBREVIATIONS

BSF	Base Sanitary Flow
CCTV	Closed-Circuit Television
CMOM	Capacity Management Operation and Maintenance
GPDIM	Gallons Per Day Per Inch Diameter Mile
GWI	Groundwater Infiltration
I/I	Infiltration and Inflow
LF	Linear Feet
NASSCO	Nation Association of Sewer Service Companies
PACP	Pipeline Assessment Certification Program
RDII	Rainfall Derived Infiltration and Inflow
RII	Rainfall Induced Infiltration
SSO	Sanitary Sewer Overflow
WWTF	Wastewater Treatment Facility

1 INTRODUCTION

1.1 Scope of Work

On September 29, 2012, the EPA issued an Order for Compliance and Complaint, including a proposed civil penalty, for sanitary sewer overflows (SSOs) from non-permitted portions of the City of Portland's collection system. In accordance with that Order, the City completed a "Capacity, Management, Operation and Maintenance (CMOM) and Corrective Action Plan" Report in November of 2013. The recommendations of the CMOM Report included Infiltration and Inflow (I/I) Reduction Measures, as well as continued improvements to the City's Collection System Mapping by supplementing and correcting data gaps in their GIS system as they are identified. This I/I Reduction Measures Program will address those recommendations and set the course for I/I mitigation and the City of Portland's continuing efforts to abate SSOs from their collection system under three Phases of work:

Phase 1 – Investigation and Quantification of I/I Flows

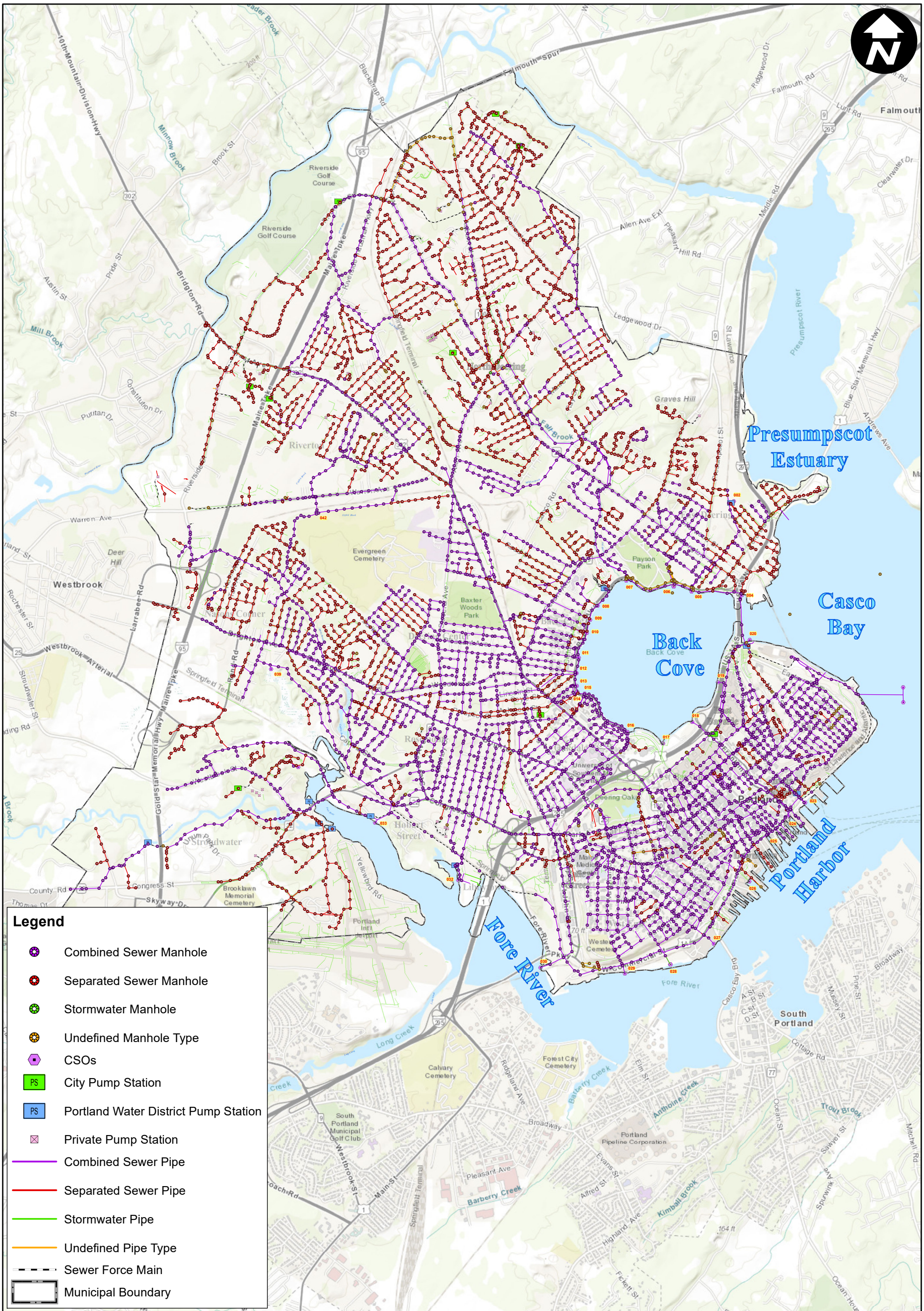
Phase 2 – Identification of Major I/I Sources

Phase 3 – Schedule of Target Opportunities for Cost-effective Mitigation

This report includes summarized findings from the Phase 1 and the activities completed and planned under Phase 2.

1.2 Collection System Background and Description

The City of Portland's wastewater collection system, shown on Figure 1, contains approximately 240 miles of separated and combined sewers and 24 pump stations, 9 of which are owned and operated by the City. The collection system and pump stations convey wastewater to the East End Wastewater Treatment Facility (WWTF) in Portland, which is owned and operated by the Portland Water District.



City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Phase 2 Identification of Major I/I Sources

Citywide Collection System

0 0.25 0.5 0.75 1 Miles

Figure 1

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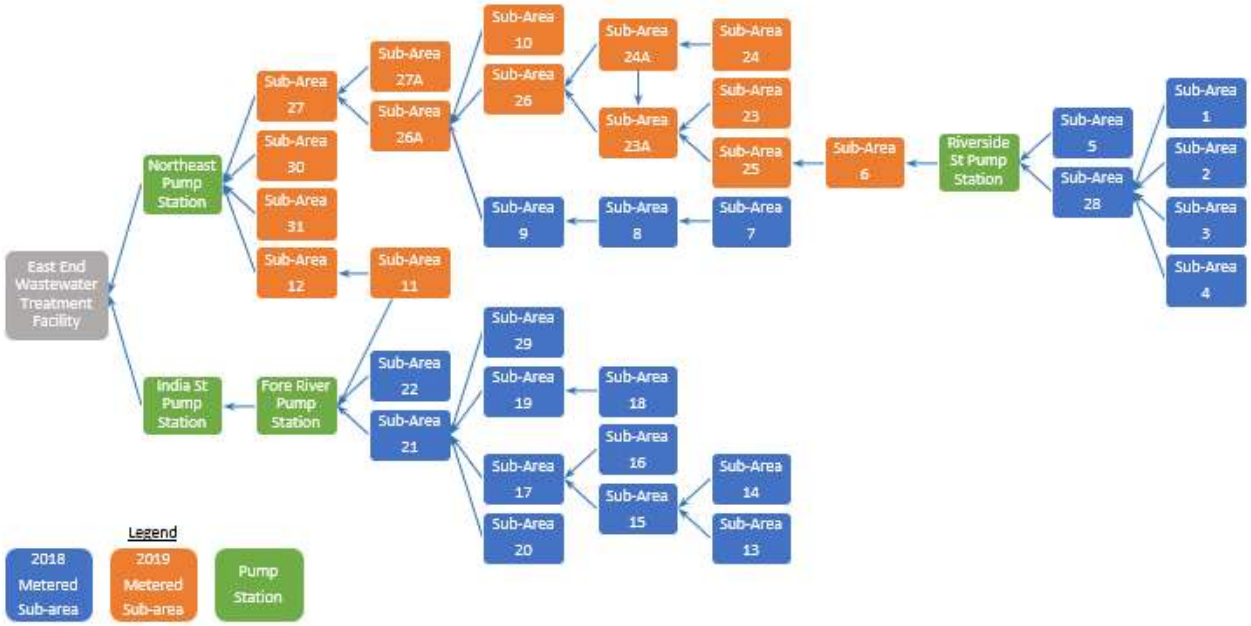
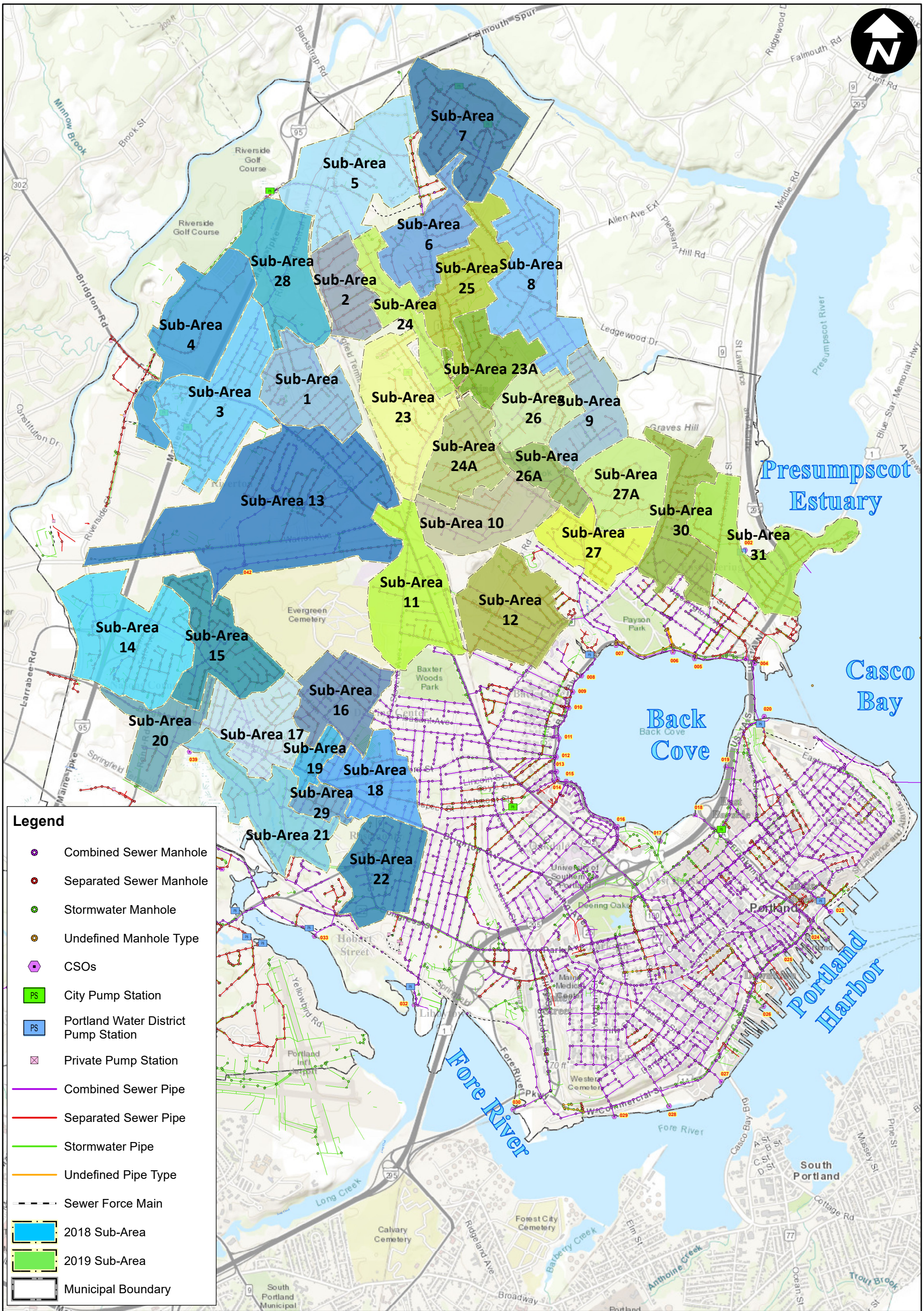
June 2019

1.2.1 Sub-Area Delineation

Sub-areas were delineated during Phase 1 of the I/I Reduction Measures Program. 20 Sub-areas were assessed as part of the 2018 flow metering program, and an additional 15 Sub-areas were assessed as part of the 2019 flow metering program. Each Sub-area was created to contain approximately 20,000 linear feet (LF) of pipe or less, as is optimal for isolating and identifying I/I sources. Due to ongoing sewer separation projects and the extent of combined sewers in the downtown area of Portland, efforts were focused on the north and west areas of the City. Prioritization of meter areas was based on recent and on-going flow monitoring and available CCTV data, historic and recently discovered problem areas where backups, surcharging and overflows occurred, areas tributary to known problem areas, areas where the hydraulic model identified potential I/I capacity issues, and areas near water bodies that could be contributing I/I to the system. Figure 2 shows a flow vector diagram for the 35 Sub-areas included in the metering program. The flow vector diagram is a visual representation of tributary flow within the system. Sub-areas delineated and included in the 2018 and 2019 metering program are shown on Figure 3.

Figure 2: Flow Vector Diagram





City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Phase 2 Identification of Major I/I Sources

Sub-Area Delineations

0 0.25 0.5 0.75 1 Mi

Figure 3

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\Phase 2 Technical Memo\Figure 3 - Sub-Area Delineations.mxd

June 2019

2 PHASE 1 FLOW METERING PROGRAMS

2.1 Methodology

There are four major components of wastewater flow in a sanitary sewer system, base sanitary flow (BSF), groundwater infiltration (GWI), rainfall induced infiltration (RII), and Inflow. The Environmental Protection Agency's "Guide for Estimating Infiltration and Inflow", June 2014, provides the following definitions:

Base Sanitary Flow (BSF) – The portion of wastewater which includes domestic, commercial, institutional, and industrial sewage and specifically excludes infiltration and inflow.

Groundwater Infiltration (GWI) – Measured during average dry weather flow period. The average of the low nighttime flows (midnight to 6am) per day for the same time period, minus significant industrial or commercial nighttime users

Rainfall Induced Infiltration (RII) – The short-term increase in infiltration which is the result of a rain event. Rainfall-induced infiltration is a portion of delayed inflow.

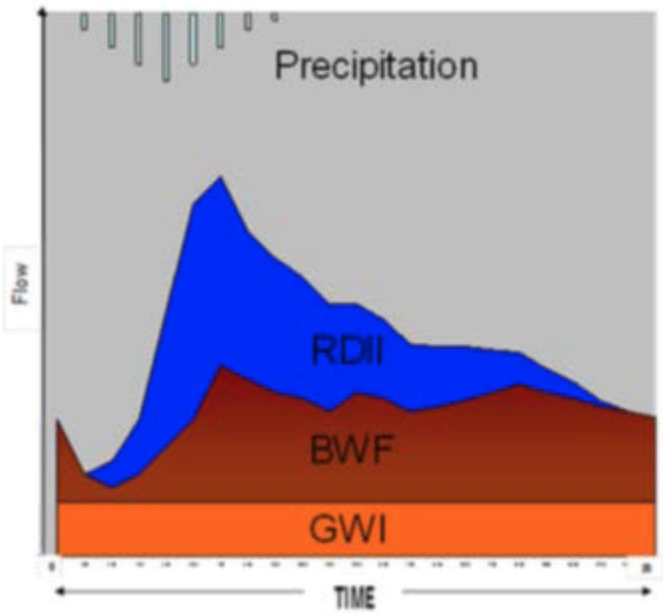
Inflow – Water other than sanitary wastewater that enters a sewer system from sources such as roof leaders, cellar/foundation drains, yard drains, area drains, drains from springs and swampy areas, manhole covers, cross connections between storm sewers and sanitary sewers, and catch basins. Inflow does not include infiltration.

Delayed Inflow Volume – The portion of total inflow which is generated from indirect connections to the collection system or connections which produce inflow after a significant time delay from the beginning of a storm. Delayed inflow sources include sump pumps, foundation drains, indirect sewer/drain cross connections, etc. Rainfall-induced infiltration cannot be distinguished from delayed inflow and is therefore included as part of delayed inflow. Delayed inflow sources have a gradual impact on the collection system and flow decreases gradually upon conclusion of the rainfall event, and after peak inflow caused by direct connections.

Furthermore, Inflow and Delayed Inflow can be group into a category of rainfall derived infiltration and inflow (RDII – commonly referred to as the total inflow volume).

Figure 4 highlights the three key components of wastewater flow during a precipitation event. The GWI (orange line) remains constant and is not impacted by precipitation, the BWF (brown line) is a diurnal pattern based on actual usage and not impacted by precipitation, and the RDII (blue line) shows a very clear increase in flows as a direct response to precipitation that dissipates after the completion of the storm.

Figure 4: Components of Wastewater Flow During Wet Weather (US EPA, 2007)



As part of Phase 1 of the Inflow and Infiltration Program two flow metering programs were conducted in the consecutive springs of 2018 and 2019. These flow metering programs were intended to isolate sub-areas of the City's collection system that contain excessive GWI rates and high RDII. GWI over 4000 gallons per day per inch diameter mile (GPDIM) is considered excessive for any given sub-area of pipe and should be considered for corrective action. Mitigation of RDII in a separated system is typically to address subsets within a study area that comprise the top 80% of the total inflow volume in the study area, however, because the City's collection system is still combined, rain induced infiltration will be used in assessing areas with excessive inflow which is not related to designed stormwater collection.

2.2 2018 Flow Metering Program

A 16-week flow metering program was conducted in 2018 that monitored flows in 20 sub-areas within the City's collection system. As a result of the 2018 flow monitoring program, high rates of infiltration were identified in Sub-areas 4, 16, 18, 20, and 29, and high RDII was identified in Sub-areas 13, 22, 18, 20, 16, 29, 19, 14, 9, 7, 8, 15, 21.

A copy of the Phase 1 Investigation of Flows – 2018 Monitoring report is included as Appendix A of this report.

2.3 2019 Flow Metering Program

The 2019 flow monitoring program was conducted in 15 sub-areas for 12-weeks of continuous monitoring. Flow meters were installed on February 15, 2019 and removed on May 31, 2019. Data collection for all sub-areas began early March and continued for 12 consecutive weeks. Data was

recorded for collection system flows, rainfall, and groundwater by enlisting 20 telemetry flow meters, 2 rain gauges, and 2 groundwater gauges, respectively.

The 2019 flow metering program was conducted following the same methodology of the 2018 flow metering program. A traditional infiltration and inflow analysis will be conducted in the separated portion of the collection system, while a modified approach will be used in the combined portion of the system. In sub-areas where 75% or more of the collection system is separated, the I/I analysis will focus on identifying groundwater infiltration, rainfall-inducted infiltration and direct inflow. In the combined areas, the I/I analysis will focus on identifying groundwater infiltration and rainfall-inducted infiltration (delayed inflow).

Table 1 includes a summary of the total pipeline footage and the percentage of combined pipes and the approach method for each sub-area.

Table 1: Sub-area Characteristics

Sub-area	Total Footage (LF)	Percent Combine0d (%)	Approach
6	15,241	13%	Traditional
10	13,417	77%	Modified
11	21,085	87%	Modified
12	20,125	33%	Modified
23	15,048	19%	Traditional
23A	10,072	27%	Modified
24	11,037	37%	Modified
24A	15,091	13%	Traditional
25	16,547	7%	Traditional
26	11,664	25%	Traditional
26A	8,109	62%	Modified
27	12,520	81%	Modified
27A	9,922	26%	Modified
30	20,905	50%	Modified
31	22,861	15%	Traditional

2.3.1 Results and Findings

Table 2 identifies the average daily flow (ADF), peak daily flow (PDF) and peak hourly flow (PHF) measured for each of the fifteen sub-areas. Average daily flow is calculated by summing all metered flows and dividing by the duration of the metering period. Peak daily flow is the maximum daily flow measured over 24-hours throughout the metering period. Peak hourly flow is the maximum 1-hr flow rate measured. Peaking factor is calculated by dividing the peak hourly flow by the average daily flow for each sub-area. Table 2 shows the net average daily flow within each sub-area itself (with upstream tributary flows subtracted out), net peak hourly flow and the hourly peaking factor.

Table 2: Flow Metering Results – ADF, PDF, PHF and Hourly Peaking Factor

Sub-area	Average Daily Flow (GPD)	Peak Daily Flow (GPD)	Peak Hourly Flow (GPD	Hourly Peaking Factor
6	565,514	1,605,250	735,837	3
10	313,380	920,000	772,000	3
11	499,056	4,065,000	1,362,000	8
12	484,472	2,211,000	1,063,000	5
23	244,075	1,541,000	535,000	6
23A	494,695	1,622,000	762,000	3
24	205,434	870,000	437,000	4
24A*	-	-	-	-
25	101,759	1,381,000	1,266,000	14
26*	-	-	-	-
26A	255,792	1,756,000	735,000	7
27	470,204	1,644,000	1,157,000	3
27A	84,469	267,000	140,000	3
30	380,652	3,015,000	1,250,000	8
31	199,308	1,629,000	470,000	8

*Data is still being reviewed and analyzed. Finalized values will be incorporated in the Final 2019 Flow Metering Report.

Preliminary data was used to produce a generalized assessment of sub-areas with excessive infiltration and provide sub-areas in which flow isolation could be conducted prior to the completion of flow metering.

Preliminary data indicated high infiltration in Sub-areas 6, 23A, 27, 11, 24, 10, 12, 30 and 23. Inflow analyses in these sub-areas will be conducted upon completion of the 2019 flow metering program.

Final infiltration and inflow analyses have not been completed for the 2019 flow metering period. These results will be included in the 2019 Flow Metering Report.

3 PHASE 2 INVESTIGATIONS

3.1 Methodology

Following the Phase 1 Flow metering programs, the isolation of defects within collection system assets is determined. The quantity, location, and severity of defects or defective assets are necessary in determining a cost-effective mitigation plan in the removal of infiltration and inflow from a collection system. Investigative technologies and techniques have been devised that have become an industry standard in isolating defects and defective assets. The typical investigation methods used in isolating the location of I/I and assessing the severity and frequency of defects and defective assets used in this Infiltration and Inflow Removal and Monitoring Program include:

Flow Isolation – a method of investigation that uses a portable volumetric weir that is placed at the downstream end of a pipe when sanitary system usage is at its lowest, typically between 12am and 5am. The weir has set values that allow for the estimation of flows between two points, typically manhole-to- manhole or approximated stretches of 1,000 LF of pipe. Conducting flow isolation while the sanitary sewer system is at a theoretical usage of virtually zero indicates an approximate flow rate derived from groundwater infiltration. Flow Isolation is typically conducted while groundwater elevation is high.

Closed-Circuit Television (CCTV) Inspection – one of the most common ways to assess the structural condition of pipes and determine the need for maintenance and rehabilitation. Inspections are conducted by inserting a camera into a pipe that is remotely directed from one end of the pipe to the other. CCTV operators actively identify and call out defects within the pipe during the inspection using the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment Certification Program (PACP) standards to identify defects. CCTV inspection conducted to identify defects contributing infiltration into the system are typically conducted when groundwater elevation is high.

Manhole Inspections – conducted to identify structural defects, infiltration sources, and the potential for inflow into a collection system. Manhole inspections can be conducted both externally and internally depending on the detail requirements of the inspection. Inspections conducted to identify infiltration is typically conducted during times when groundwater elevation is high.

Smoke Testing – used as a means in the identification of direct and indirect sources of inflow into a collection system. This is performed by introducing smoke or smokeless vapor into an isolated section of the collection system using a blower or fan and observing the surrounding buildings and landscape for escaping smoke. This method is typically conducted while groundwater elevation is low.

Building Inspections – typically conducted as precision investigations as follow on to more generalized investigations such as smoke testing, CCTV inspections, or flow isolation. Building

inspections are used in the confirmation of inflow sources and identification of illicit cross connections or faulty plumbing and can be conducted under various conditions, usually dependent on the nature of the inspection.

Dye Testing – used for multiple applications where tracking the flow of water from a point source is required. This method of investigation can be used in the determination of inflow sources, cross connections, faulty plumping and various other deficiencies within a collection system. Dye testing can be conducted under various conditions depending on the nature of the dye testing investigation.

Phase 2 investigations have been separated into three sub-phases of work that coincide with the completion and analyses of the Phase 1 flow metering programs and follow-on to preceding sub-phases of Phase 2 investigations.

3.2 Phase 2.1 Investigations

Phase 2.1 investigation were recommended as following the flow monitoring program conducted in the spring of 2018 and included flow isolation of 197,710 LF of pipe, CCTV inspection of 27,611 LF of pipe, and 496 manhole inspections in sub-areas identified as having excessive infiltration. A breakdown of investigations recommended for Phase 2.1 is included in Table 3. Phase 2.1 investigations began in December of 2018 and are ongoing. Flow Isolation and CCTV Inspections have been completed, and manhole inspections are scheduled to be completed in the Fall of 2019.

Table 3: Phase 2.1 Investigation Quantities

Sub-Area	Flow Isolation (LF)	CCTV Inspection (LF)	Manhole Inspection (Qty)
Sub-Area 4	8,893		46
Sub-Area 5	21,962		6
Sub-Area 7	23,684		4
Sub-Area 8	19,179		26
Sub-Area 9		9,165	20
Sub-Area 14	23,488		8
Sub-Area 15	19,404		23
Sub-Area 16	21,410		100
Sub-Area 17			28
Sub-Area 18	19,962		4
Sub-Area 19		4,667	
Sub-Area 20		8,685	
Sub-Area 21	12,431		2
Sub-Area 22	19,133		112
Sub-Area 28	5,164		55
Sub-Area 29		5,094	35
Total	**194,710**	**27,611**	**469**

3.3 Phase 2.2 Investigations

Phase 2.2 investigations were recommended in the spring of 2019 congruent to the 2019 flow monitoring program and include 120,377 LF of flow isolation for pipes identified as having excessive infiltration in the preliminary analysis of 2019 flow metering data, and 62,263 LF of CCTV inspections as follow on to the flow isolation conducted as part of Phase 2.1 investigations. A breakdown of investigations recommended for Phase 2.2 is included as Table 4. The flow isolation recommendations under Phase 2.2 investigations have been completed and CCTV inspections are ongoing.

Table 4: Phase 2.2 Investigation Quantities

Sub-Area	Flow Isolation (LF)	CCTV Inspection (LF)
Sub-Area 4		636
Sub-Area 5		3,018
Sub-Area 6	15,813	
Sub-Area 7		5,479
Sub-Area 8		10,092
Sub-Area 11	20,485	
Sub-Area 12	13,949	
Sub-Area 14		4,827
Sub-Area 15		11,628
Sub-Area 16		7,964
Sub-Area 17		1,914
Sub-Area 18		8,701
Sub-Area 21		4,952
Sub-Area 22		9,052
Sub-Area 23	12,442	
Sub-Area 23A	6,635	
Sub-Area 24	10,450	
Sub-Area 24A	12,625	
Sub-Area 26	7,907	
Sub-Area 27	9,293	
Sub-Area 28		1,000
Sub-Area 30	10,778	
Total	120,377	69,263

3.4 Phase 2.3 Investigations

The planning for Phase 2.3 Investigations include the recommendation of up approximately 56,000 LF of CCTV inspections as follow-on to Phase 2.2 Flow Isolation results, 490 manhole inspections, 126,000 LF of smoke testing, 45 building inspections, and 10 days of dye testing. Phase 2.3 Investigations are scheduled to be conducted throughout the remainder of 2019 and the spring of 2020.

4 SUMMARY

The following Phase 2 investigations for the identification of major I/I sources have effectively been completed or are in the process of being completed:

- 315,087 LF of flow isolation
- 96,874 LF of CCTV inspections; and
- 469 manhole inspections

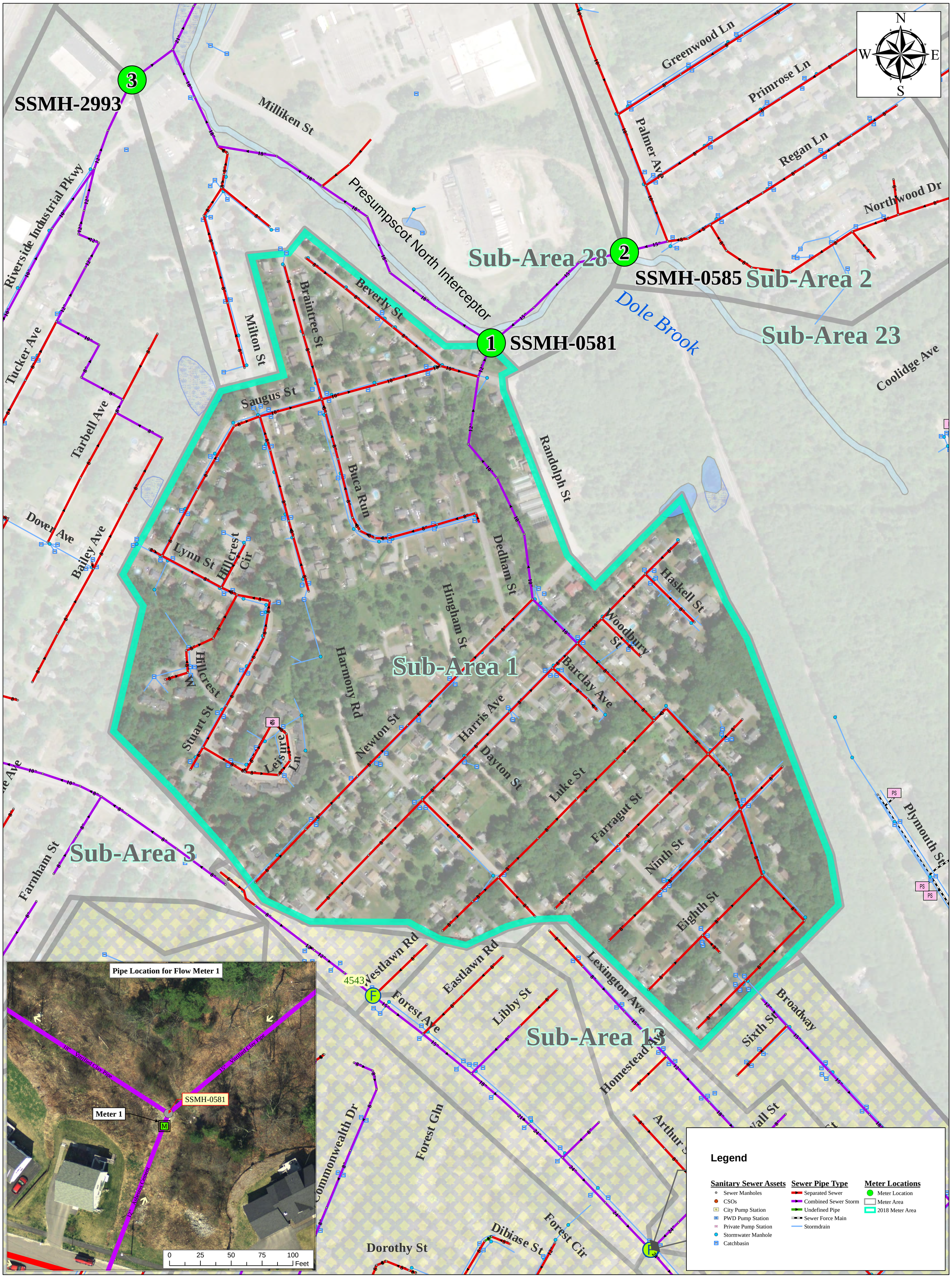
In addition, the planning and execution of the following investigations will be conducted during the remainder of 2019 and through the spring of 2020:

- 56,000 LF of CCTV inspections
- 490 manhole inspections
- 126,000 LF of smoke testing
- 45 building inspections
- 10 days of dye testing

As illustrated in this report, the city has made considerable strides in identifying major I/I sources. As this effort continues, the City remains committed to meeting the goals and requirements of the EPA's Order for Compliance and the City's I/I Reduction Program.

APPENDIX A

Phase 1 – Investigation of Flows – 2018 Monitoring Report



0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 1

ARCADIS

Sub-Area Details

Area = 124 ACRES
Length of pipe = 20,000 LF
Sewer Manholes = 102 MHs
Buildings = 371 Bldgs

March 2018

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 2

ARCADIS

Sub-Area Details

Area = 86 ACRES
Length of pipe = 11,919 LF
Sewer Manholes = 59 MHs
Buildings = 196 Bldgs

March 2018

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

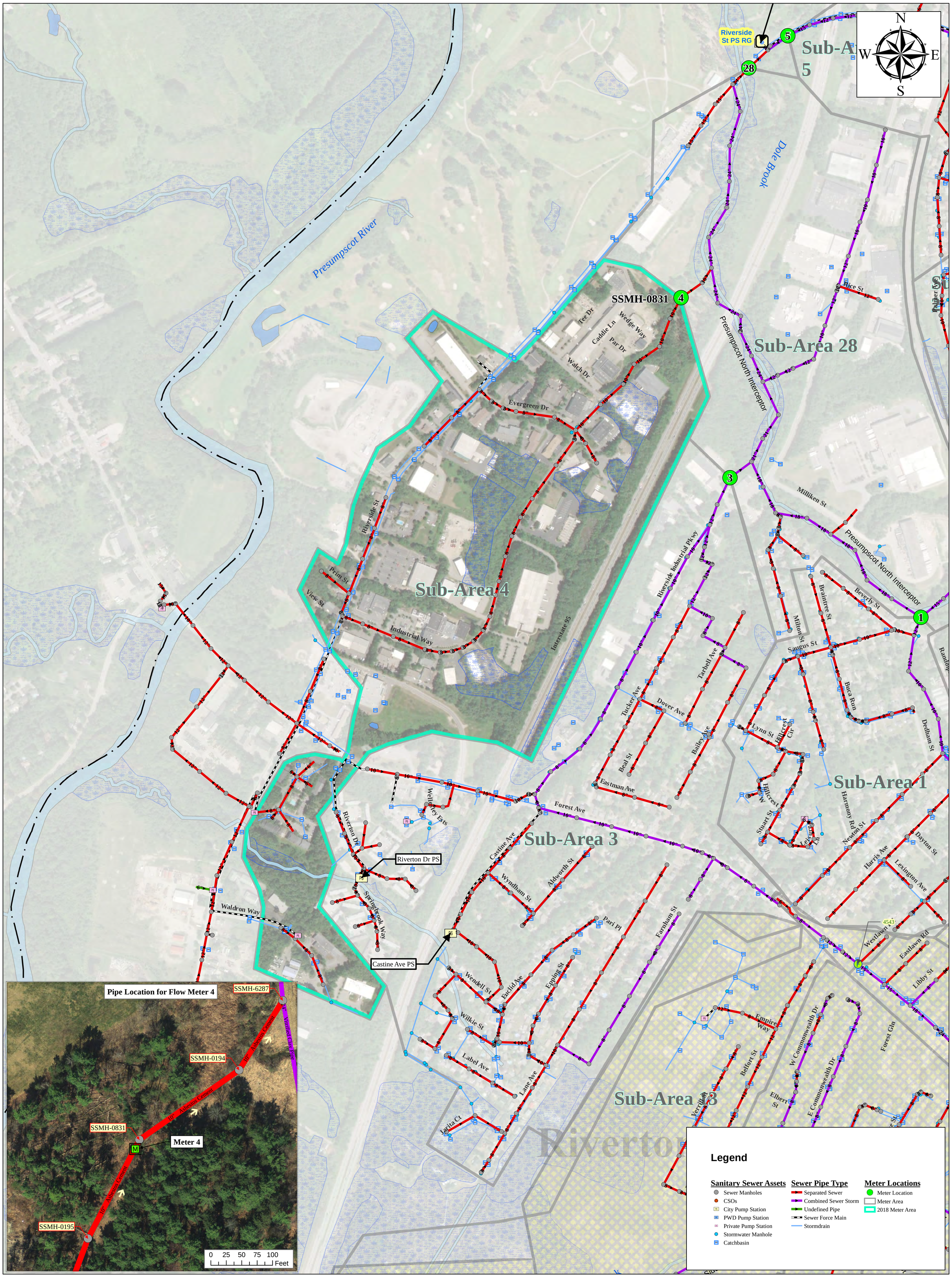
Sub-Area 3

ARCADIS

Sub-Area Details

Area = 218 ACRES
Length of pipe = 28,692 LF
Sewer Manholes = 148 MHs
Buildings = 515 Bldgs

March 2018



CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

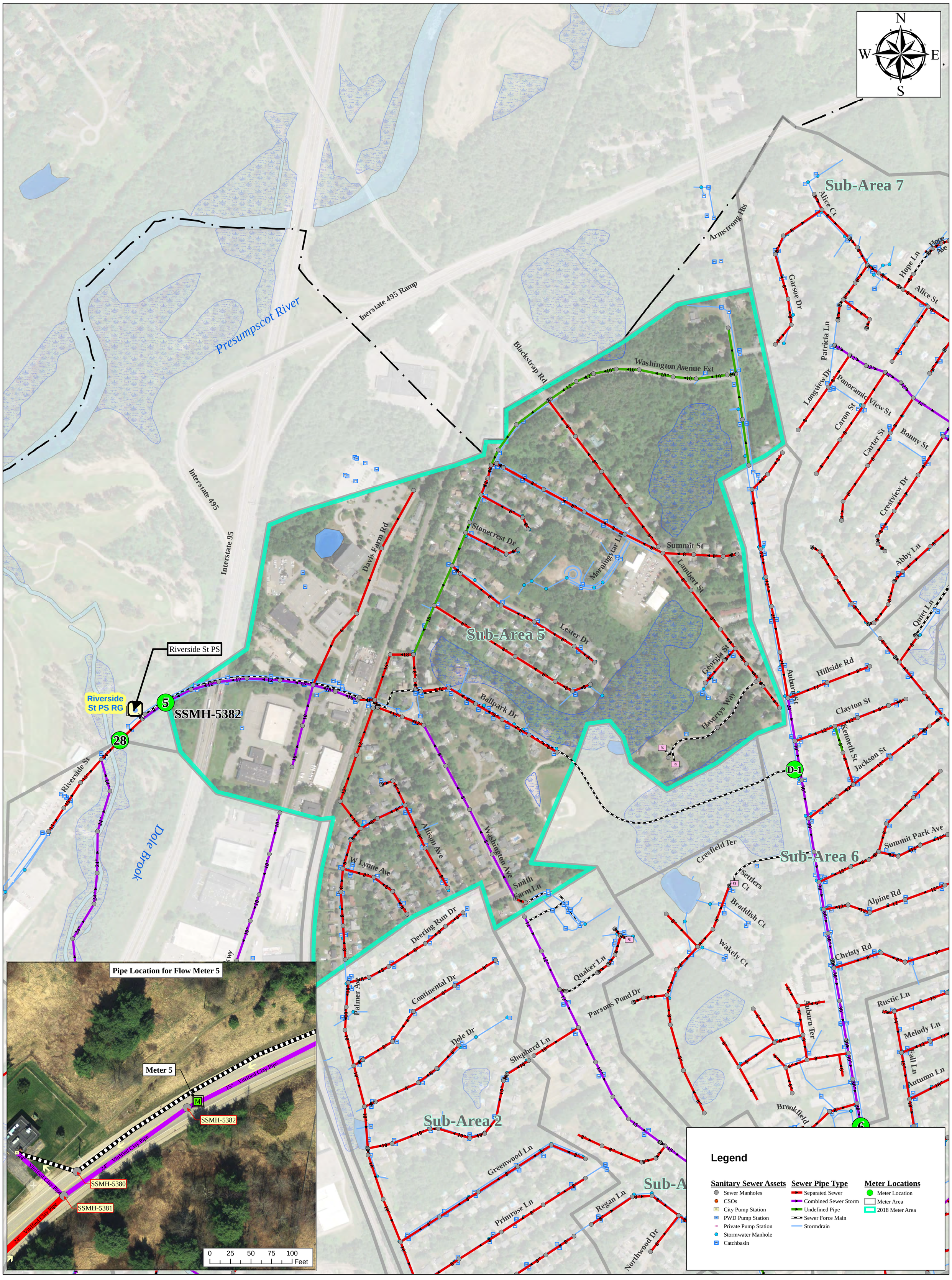
Sub-Area 4

ARCADIS

Sub-Area Details

Area = 187 ACRES
Length of pipe = 8,893 LF
Sewer Manholes = 47 MHs
Buildings = 104 Bldgs

March 2018



0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 5

ARCADIS

Sub-Area Details

Area = 220 ACRES
Length of pipe = 21,962 LF
Sewer Manholes = 111 MHs
Buildings = 275 Bldgs

March 2018

0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

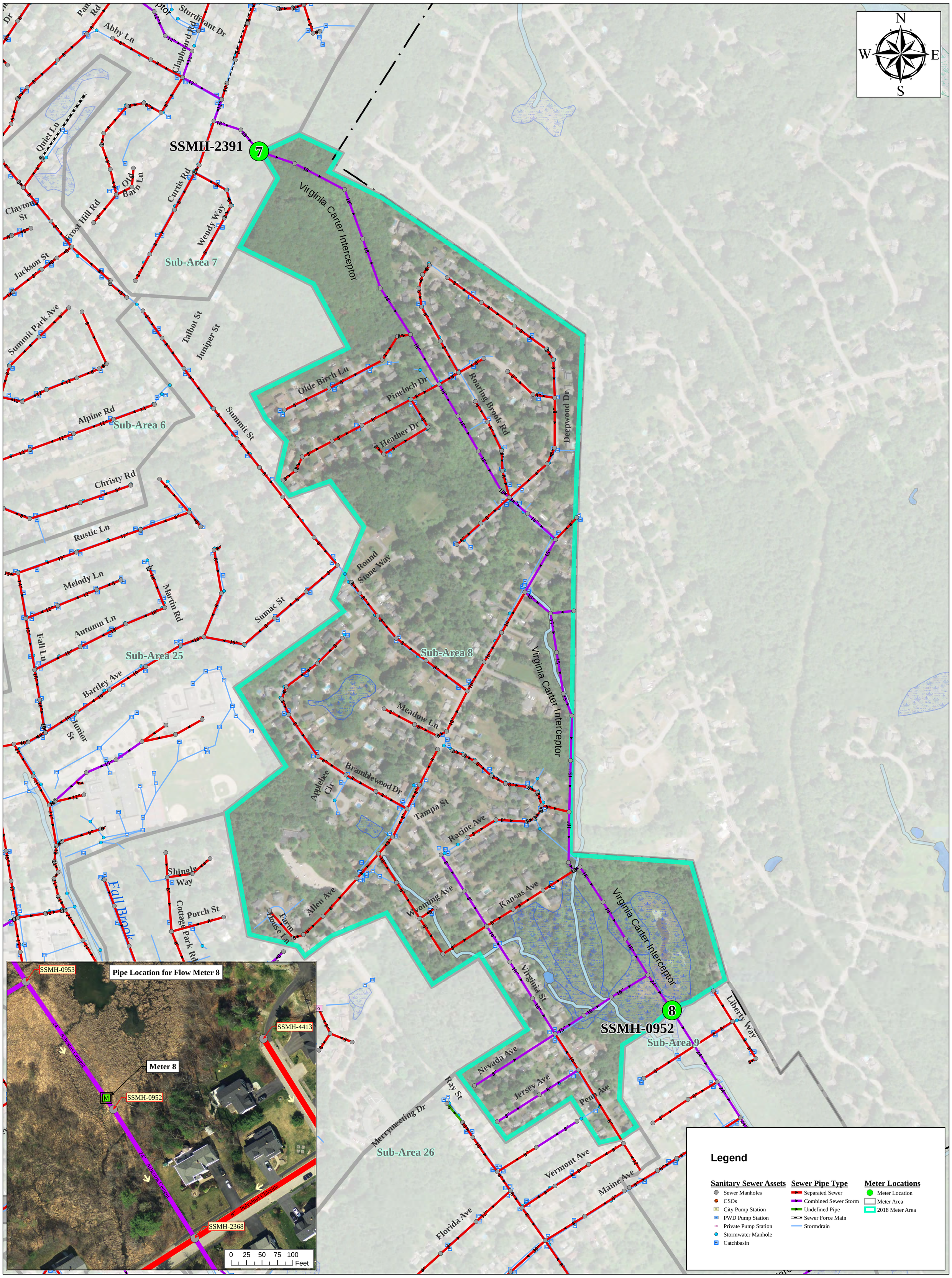
Sub-Area 7

ARCADIS

Sub-Area Details

Area = 198 ACRES
Length of pipe = 23,684 LF
Sewer Manholes = 148 MHs
Buildings = 367 Bldgs

March 2018



0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

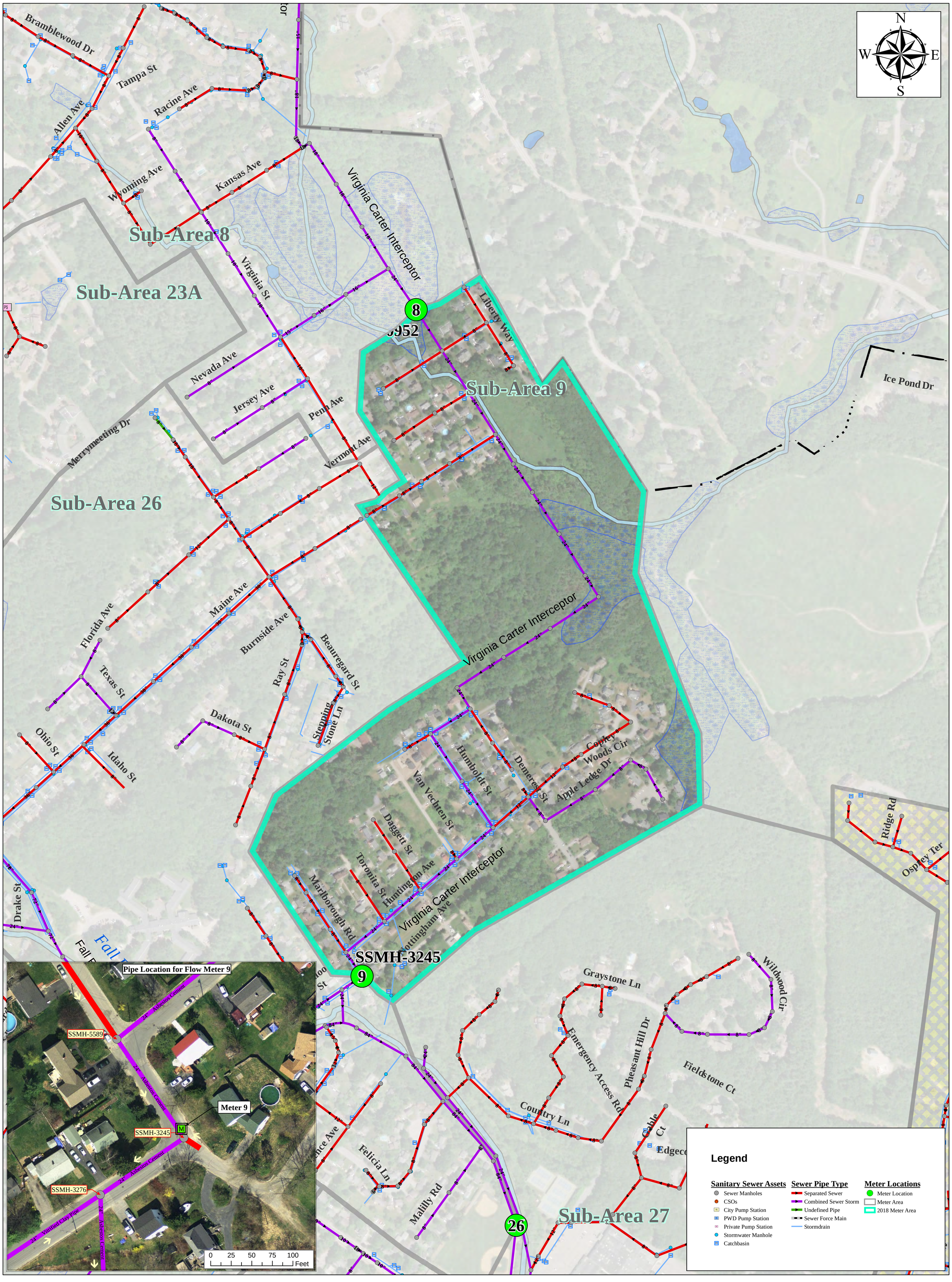
Sub-Area 8

ARCADIS

Sub-Area Details

Area = 203 ACRES
Length of pipe = 25,298 LF
Sewer Manholes = 128 MHs
Buildings = 416 Bldgs

March 2018



0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

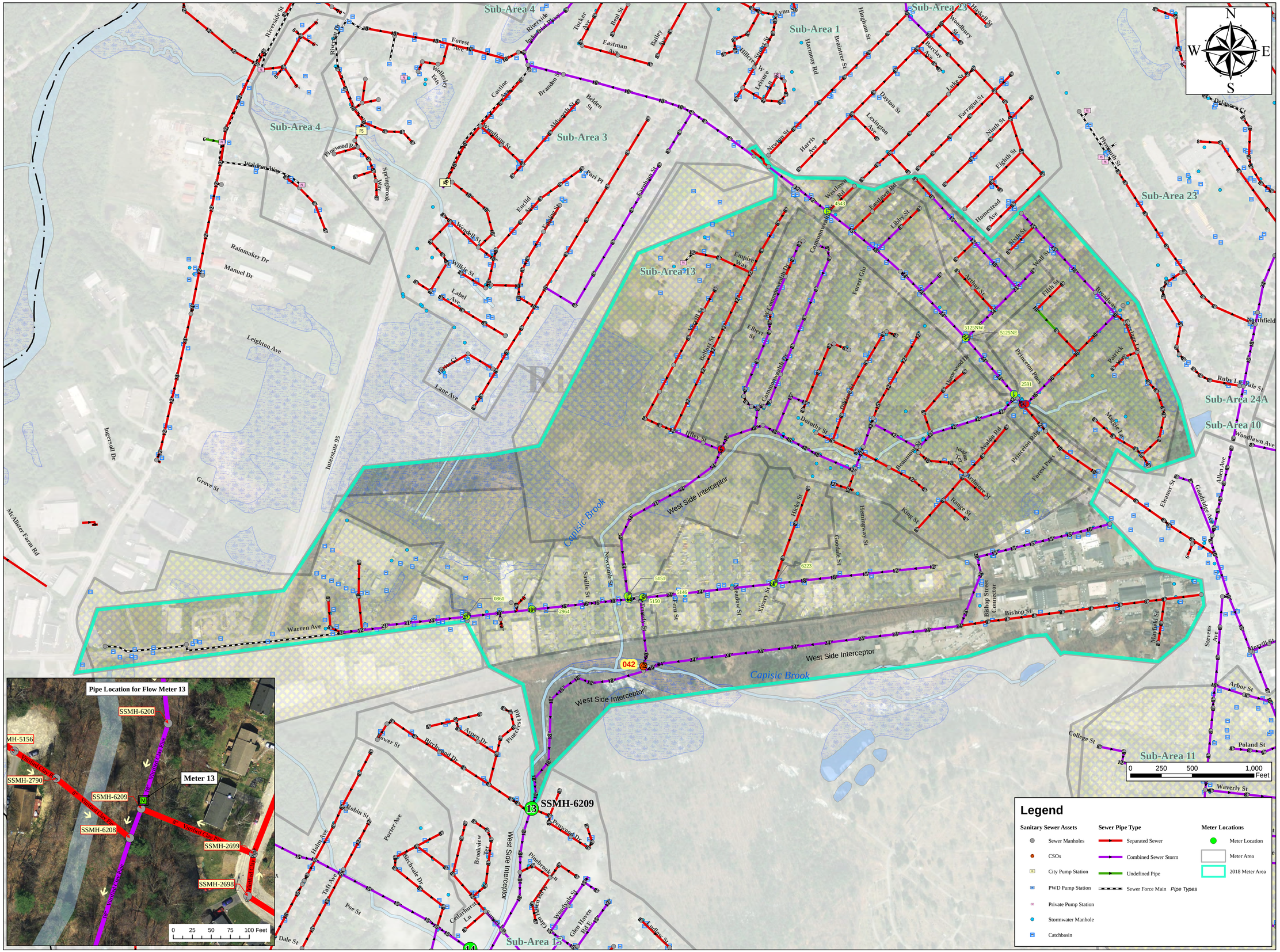
Sub-Area 9

ARCADIS

Sub-Area Details

Area = 103 ACRES
Length of pipe = 11,176 LF
Sewer Manholes = 51 MHs
Buildings = 193 Bldgs

March 2018



Sub-Area Details

Area = 499 ACRES
Length of pipe = 48,470 LF
Sewer Manholes = 270 MHs
Buildings = 774 Bldgs

March 2018

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 13

ARCADIS

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 14

ARCADIS

Sub-Area Details

Area = 234 ACRES
Length of pipe = 23,488 LF
Sewer Manholes = 124 MHs
Buildings = 319 Bldgs

March 2018

Sub-Area 13

Sub-Area 14

Sub-Area 15

Sub-Area 16

Sub-Area 17

Sub-Area 21

SSMH-6209

SSMH-5188

SSMH-0266

SSMH-5248

West Side Interceptor

Capisic Brook

Pipe Location for Flow Meter 15

SSMH-5213

SSMH-4074

Meter 15

SSMH-0266

SSMH-5203

Legend

Sanitary Sewer Assets: Sewer Manholes, CSOs, City Pump Station, PWD Pump Station, Private Pump Station, Stormwater Manhole, Catchbasin

Sewer Pipe Type: Separated Sewer, Combined Sewer Storm, Undefined Pipe, Sewer Force Main, Stormdrain

Meter Locations: Meter Location, Meter Area, 2018 Meter Area

0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 15

ARCADIS

Sub-Area Details

Area = 146 ACRES
Length of pipe = 22,812 LF
Sewer Manholes = 126 MHs
Buildings = 457 Bldgs

March 2018

0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

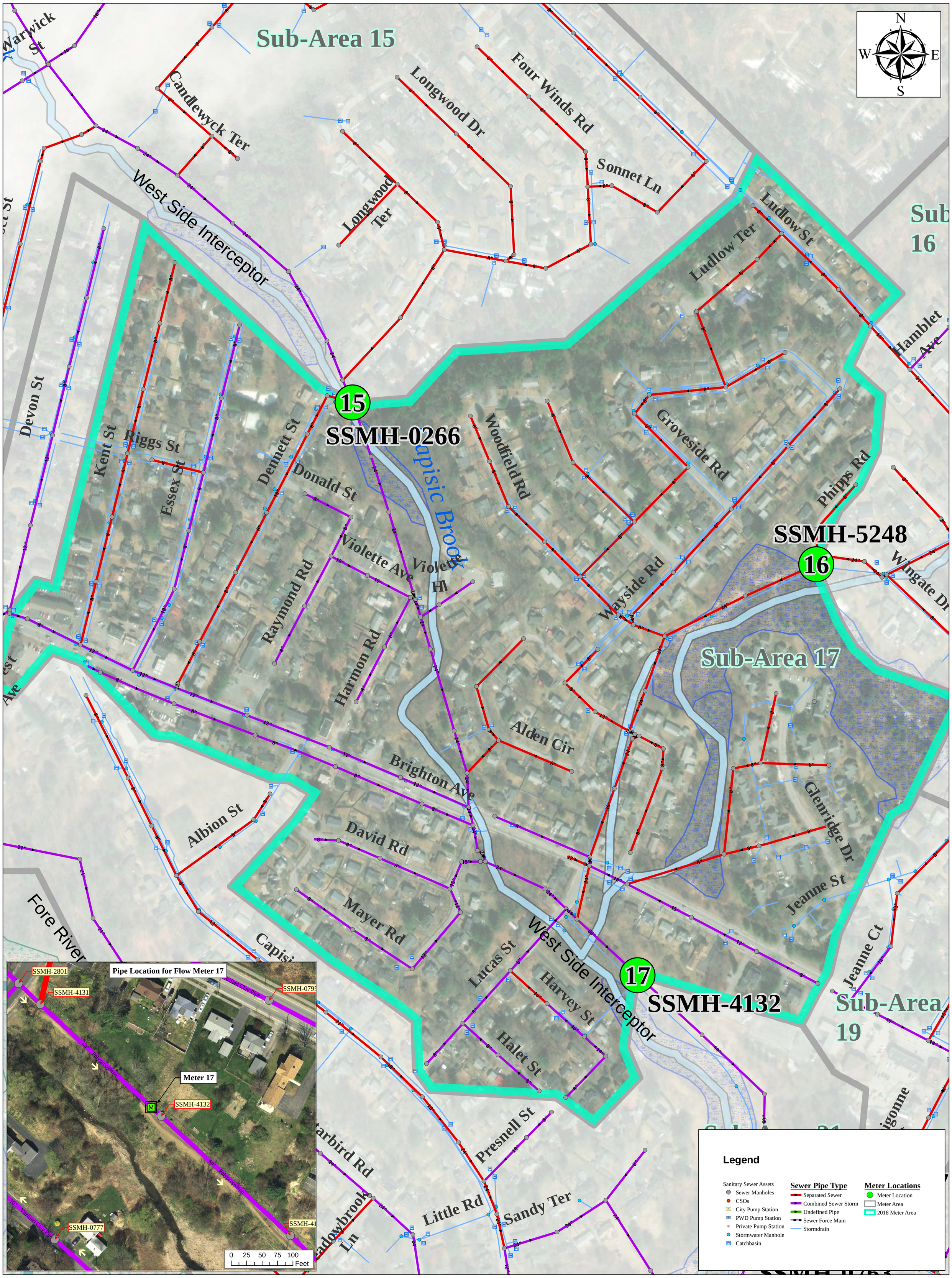
Sub-Area 16

ARCADIS

Sub-Area Details

Area = 124 ACRES
Length of pipe = 21,410 LF
Sewer Manholes = 101 MHs
Buildings = 442 Bldgs

March 2018



0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 17

ARCADIS

Sub-Area Details

Area = 127 ACRES
Length of pipe = 24,822 LF
Sewer Manholes = 142 MHs
Buildings = 427 Bldgs

March 2018

Sub-Area 16

Sub-Area 19

Sub-Area 18

Sub-Area 29

Sub-Area 22

SSMH-2849

18

Pipe Location for Flow Meter 18

SSMH-4327

SSMH-2846

SSMH-5263

SSMH-5262

SSMH-2847

SSMH-2849

Meter 18

SSMH-2881

SSMH-0262

SSMH-5293

0 25 50 75 100 Feet

Legend

Sanitary Sewer Assets
- Sewer Manholes
- CSOs
- City Pump Station
- PWD Pump Station
- Private Pump Station
- Stormwater Manhole
- Catchbasin

Sewer Pipe Type
- Separated Sewer
- Combined Sewer Storm
- Undefined Pipe
- Sewer Force Main
- Stormdrain

Meter Locations
- Meter Location
- Meter Area
- 2018 Meter Area

0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 18

ARCADIS

Sub-Area Details

Area = 111 ACRES
Length of pipe = 19,962 LF
Sewer Manholes = 94 MHs
Buildings = 469 Bldgs

March 2018

Sub-Area 16

Sub-Area 17

Sub-Area 18

Sub-Area 19

Sub-Area 29

SSMH-5248 16

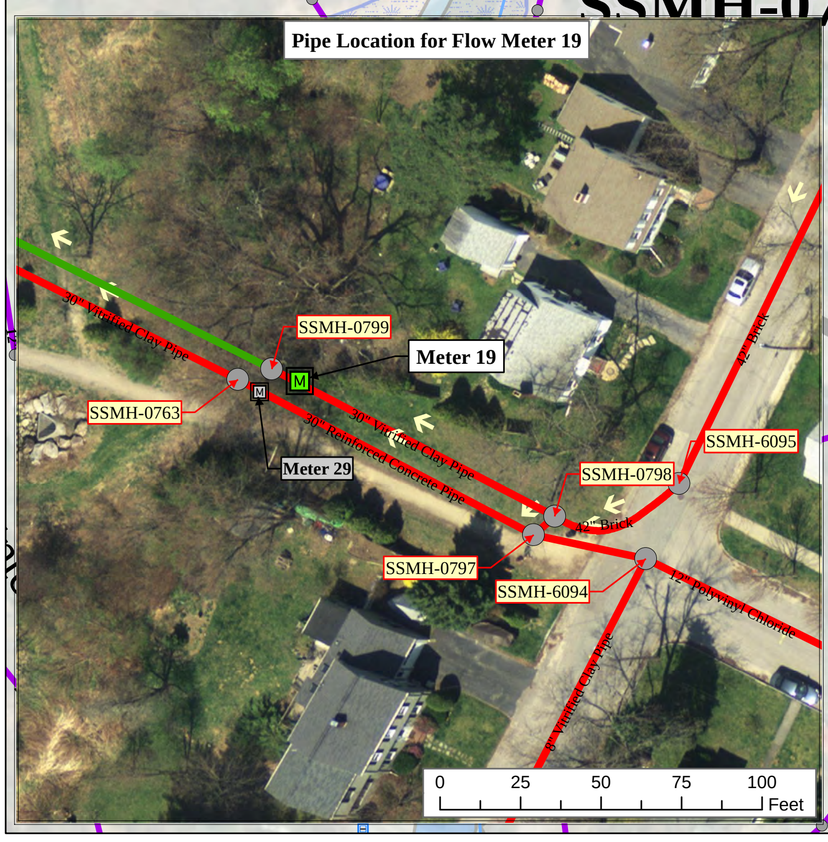
SSMH-4132 17

SSMH-2849 18

SSMH-0799 19

SSMH-0763 29

Hamblet Ave
Best St
Madeline St
Bartlett St
Hale St
Mabel St
Alba St
Groveside Rd
Woodfield Rd
Phipps Rd
Fuller St
Concord St W
Wingate Dr
Wayside Rd
Ludlow St
Leland St
Alden Cir
Jeanne St
Glenridge Dr
Edgeworth Ave
Westminster Ave
Leeman St
Merriam St
Lucas St
Columbia Rd
Columbia Ter
Rosemont Ave
Jeanne Ct
West Side Interceptor
Harvey St
Hillis St
Caldwell St
Marlow St
Gay St
Presnell St
Machigonne St
Woodford St
Brighton Ave
Montrose Ave
Sandy Ter
Fellows St
Runnells St
Rockland Ave
Fleetwood St
Hastings St
Colonial Rd
Kenilworth St
Motley St
Caroline St
Belfield St
Wolcott St
Bancroft St
Colonial Ct
Pomeroy St



Legend

Sanitary Sewer Assets	Sewer Pipe Type	Meter Locations
Sewer Manholes	Separated Sewer	Meter Location
CSOs	Combined Sewer Storm	Meter Area
City Pump Station	Undefined Pipe	
PWD Pump Station	Sewer Force Main	
Private Pump Station	Stormdrain	
Stormwater Manhole		
Catchbasin		

0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

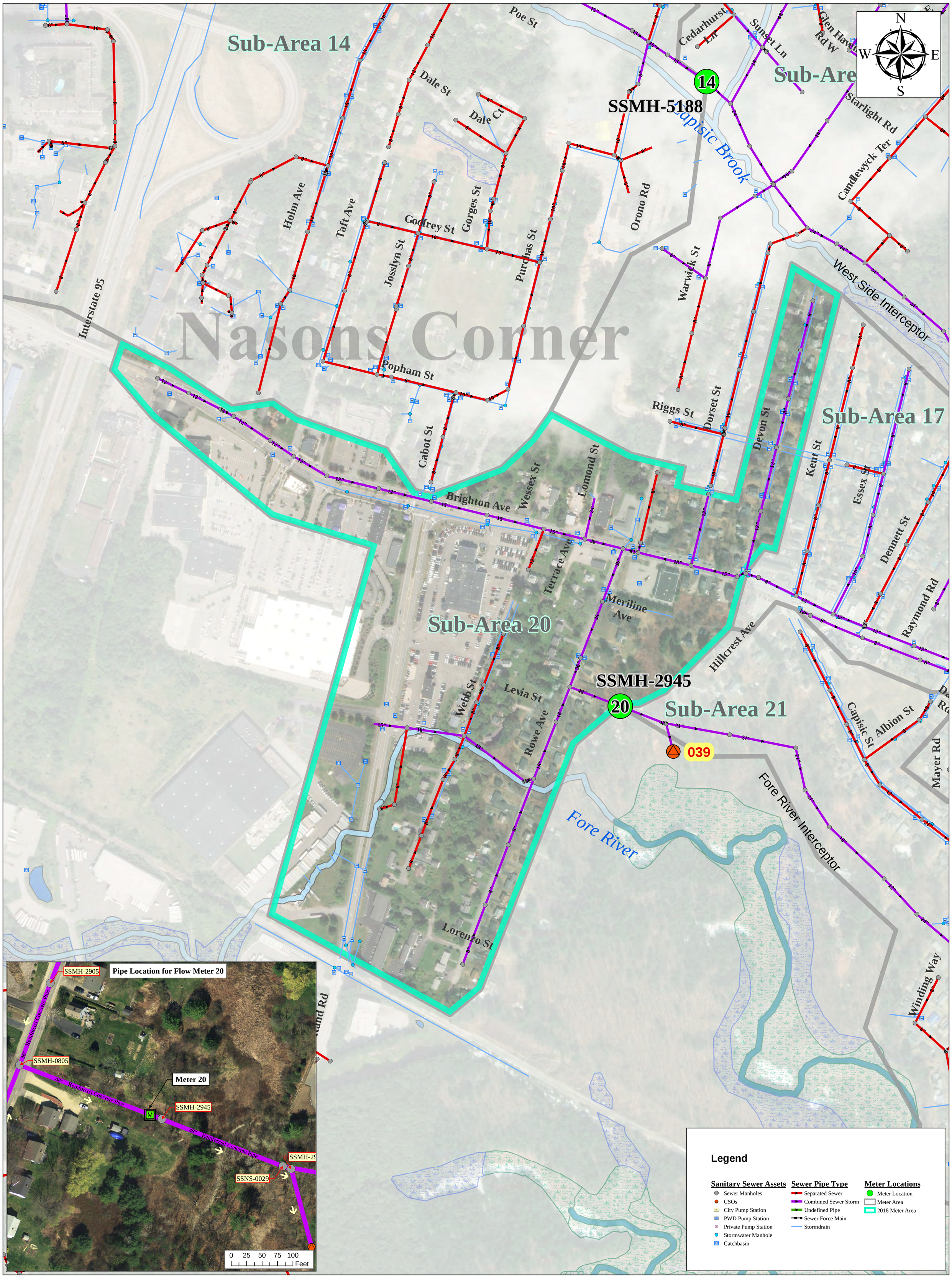
Sub-Area 19

ARCADIS

Sub-Area Details

Area = 30 ACRES
Length of pipe = 5,677 LF
Sewer Manholes = 33 MHs
Buildings = 140 Bldgs

March 2018



0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 20

ARCADIS

Sub-Area Details

Area = 93 ACRES
Length of pipe = 9,924 LF
Sewer Manholes = 47 MHs
Buildings = 185 Bldgs

March 2018

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

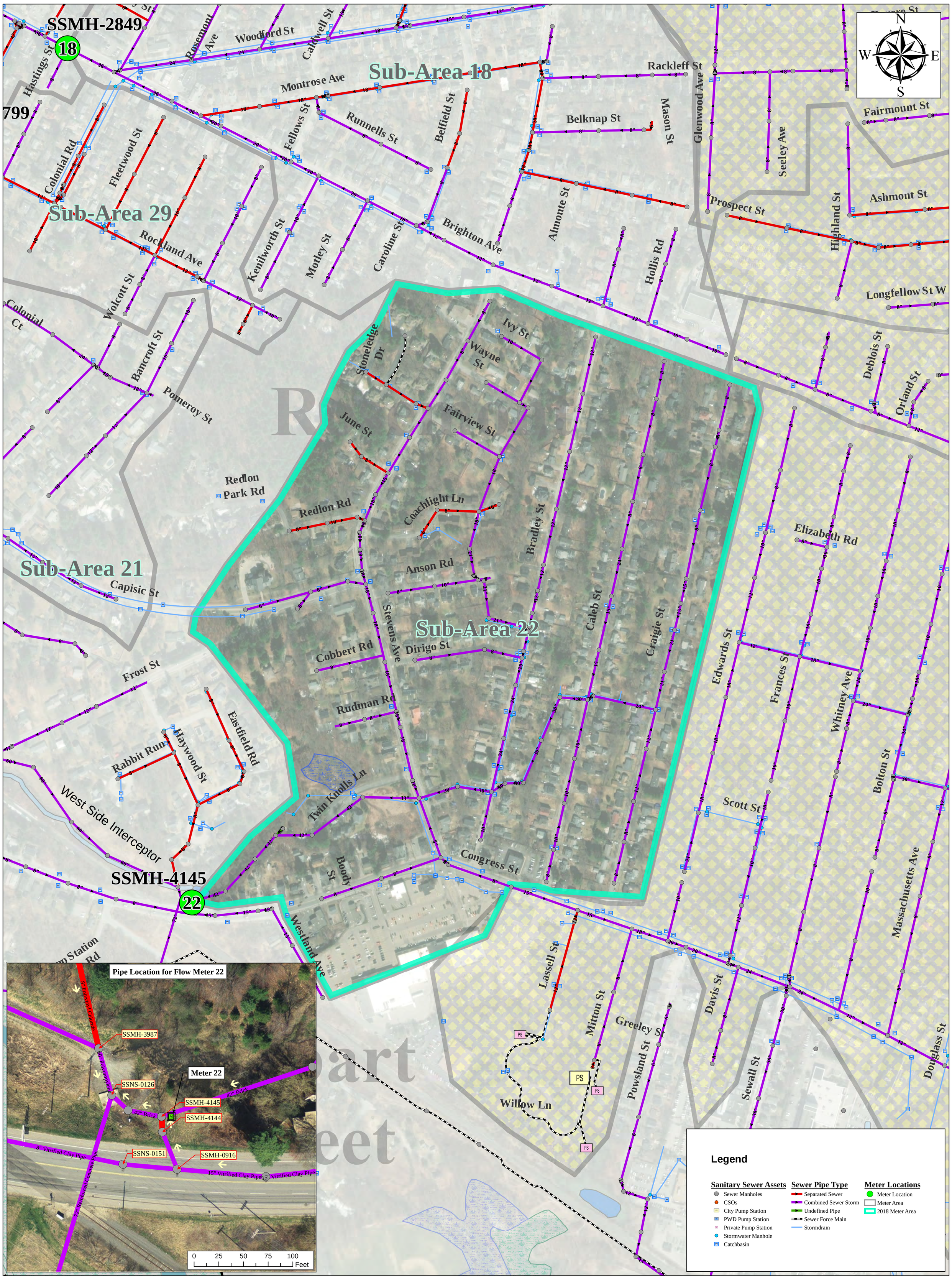
Sub-Sub-Area 21

ARCADIS

Sub-Area Details

Area = 149 ACRES
Length of pipe = 21,047 LF
Sewer Manholes = 108 MHs
Buildings = 308 Bldgs

March 2018



CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

Sub-Area 22

Sub-Area Details

Area =
Length of pipe = 19,134 LF
Sewer Manholes = 113 MHs
Buildings = 377 Bldgs

March 2018

Riverside St PS

Riverside St PS RG

SSMH-5382

SSMH-5384

SSMH-0831

SSMH-2993

SSMH-0585

SSMH-0531

Sub-Area 5

Sub-Area 28

Sub-Area 4

Sub-Area 1

Sub-Area 2

Sub-Area 23

Pipe Location for Flow Meter 30

SSMH-5380

SSMH-5381

SSMH-5385

SSMH-5384

Meter 30

SSMH-0837

SSMH-0834

0 25 50 75 100 Feet

Legend

Sanitary Sewer Assets	Sewer Pipe Type	Meter Locations
Sewer Manholes	Separated Sewer	Meter Location
CSOs	Combined Sewer Storm	Meter Area
City Pump Station	Undefined Pipe	2018 Meter Area
PWD Pump Station	Sewer Force Main	
Private Pump Station	Stormdrain	
Stormwater Manhole		
Catchbasin		

0 250 500 1,000 Feet

CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

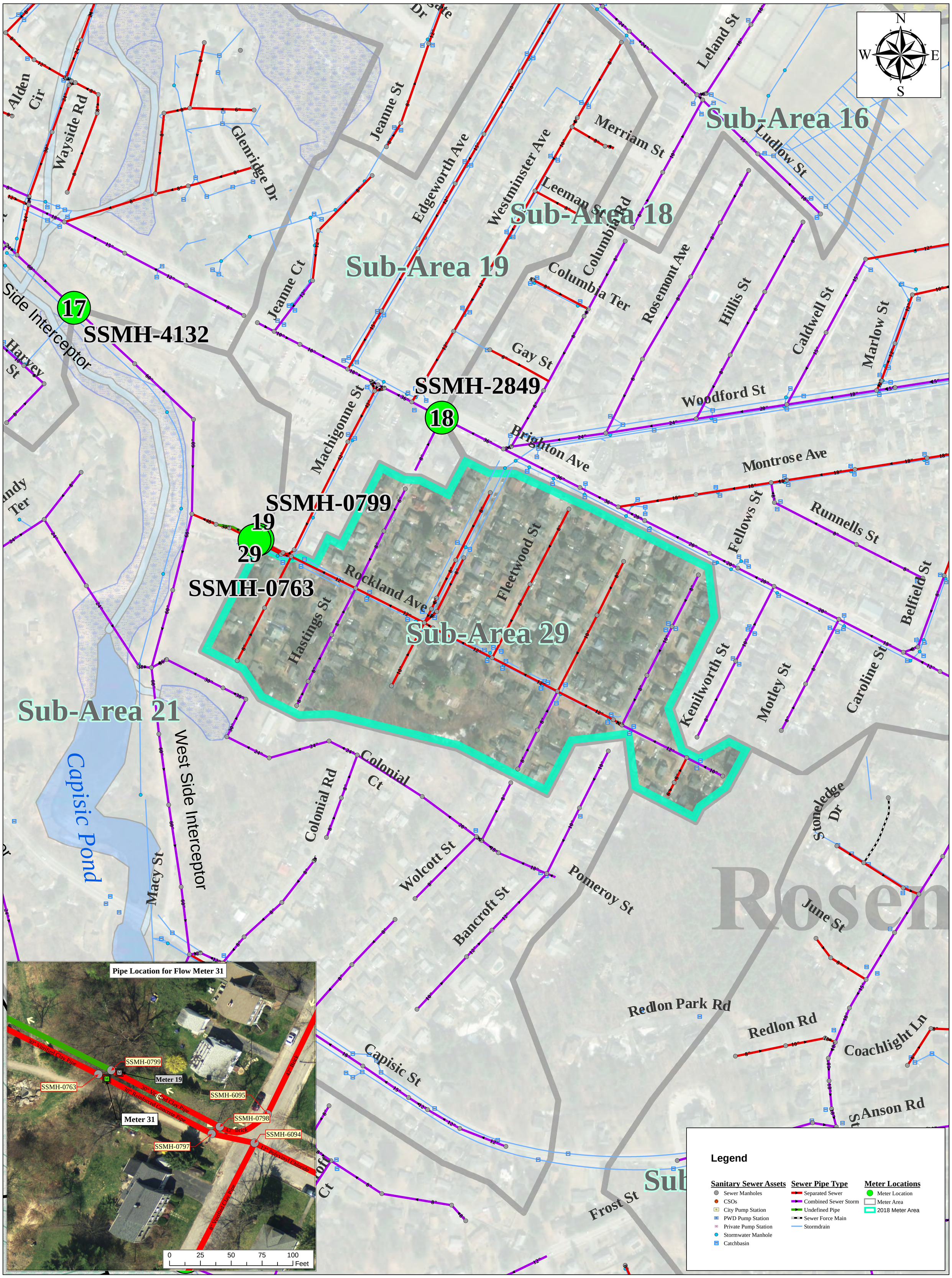
Sub-Area 28

ARCADIS

Sub-Area Details

Area = 162 ACRES
Length of pipe = 10,942 LF
Sewer Manholes = 58 MHs
Buildings = 42 Bldgs

March 2018



CITY OF PORTLAND, MAINE

Planning & Engineering Services for an Infiltration and Inflow Program of the Sanitary Sewer System

2018 Sanitary Flow Metering

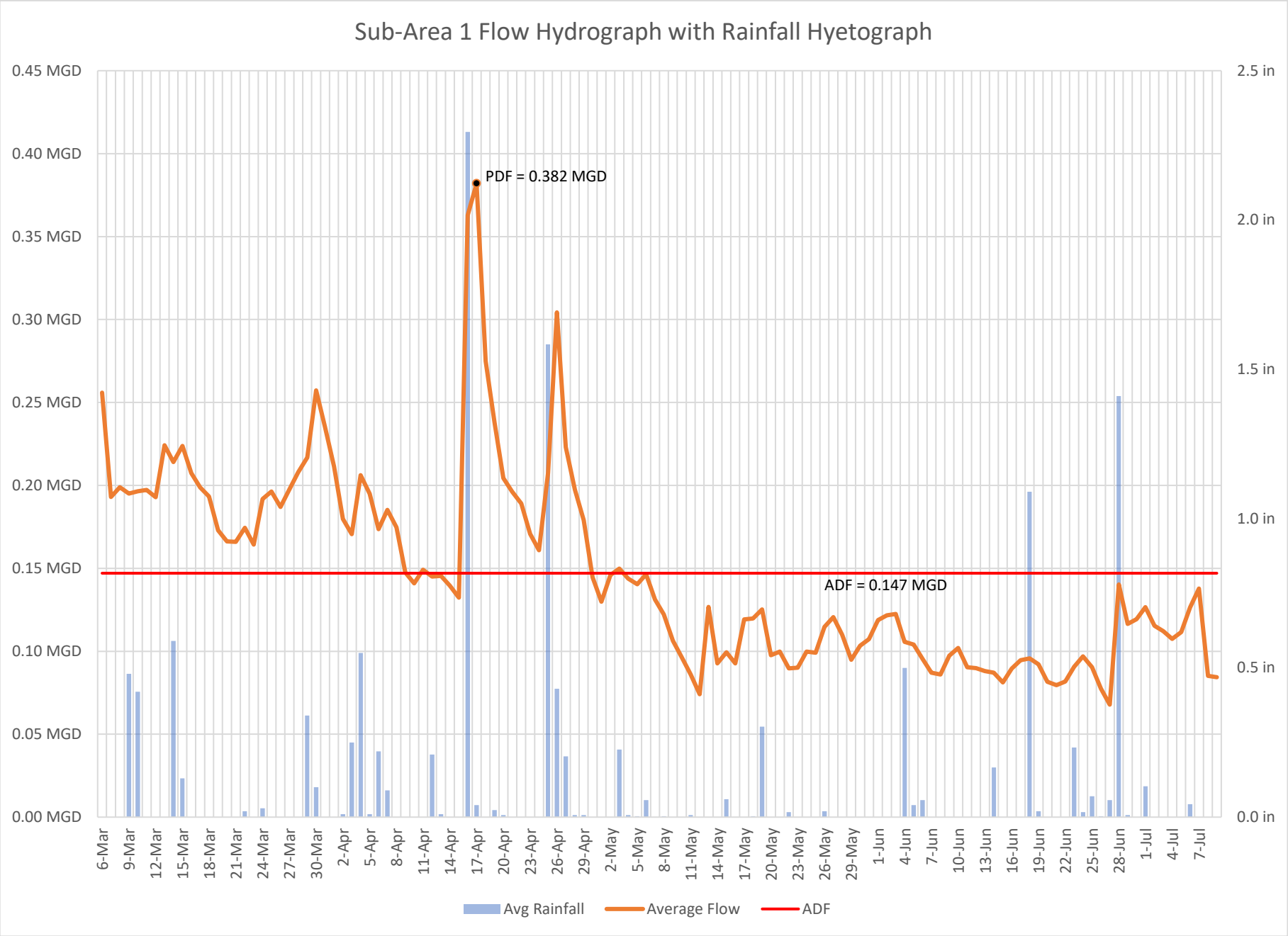
Sub-Area 29

ARCADIS

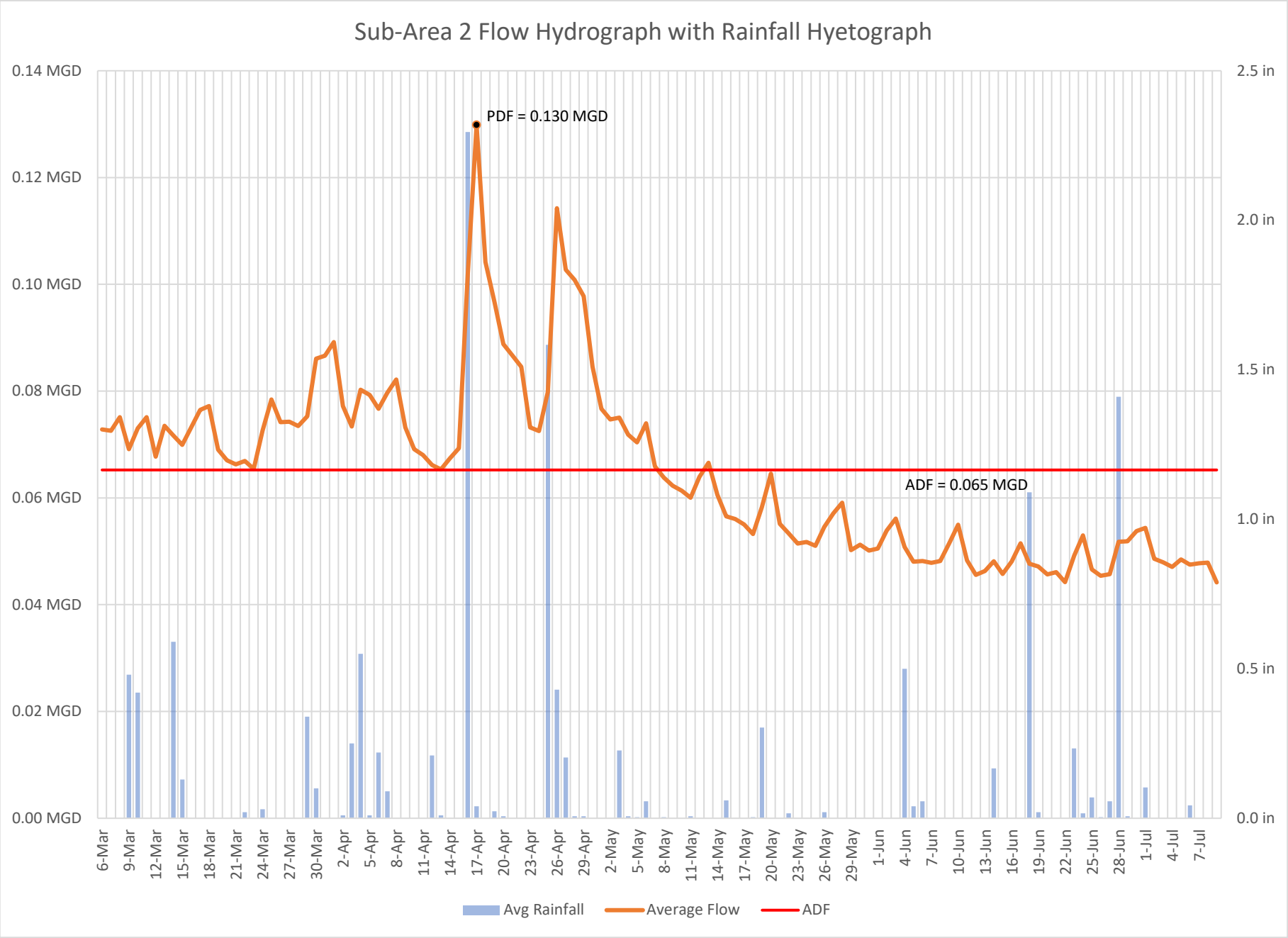
Sub-Area Details

Area = 31 ACRES
Length of pipe = 6,165 LF
Sewer Manholes = 35 MHs
Buildings = 155 Bldgs

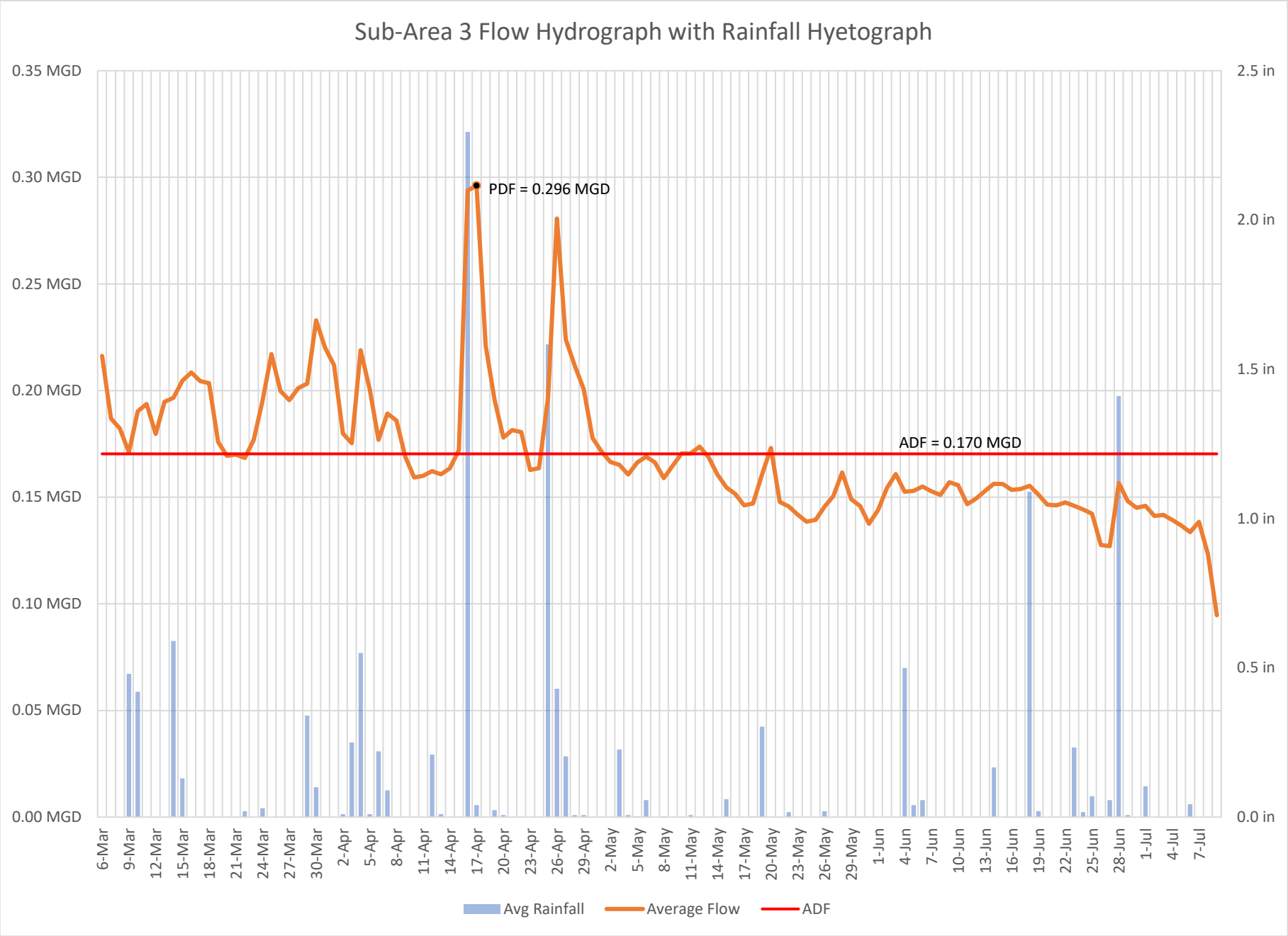
March 2018


Sub-Area 1 Flow Hydrograph with Rainfall Hyetograph
0.45 MGD
0.40 MGD
0.35 MGD
0.30 MGD
0.25 MGD
0.20 MGD
0.15 MGD
0.10 MGD
0.05 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.382 MGD
ADF = 0.147 MGD
6-Mar
9-Mar
12-Mar
15-Mar
18-Mar
21-Mar
24-Mar
27-Mar
30-Mar
2-Apr
5-Apr
8-Apr
11-Apr
14-Apr
17-Apr
20-Apr
23-Apr
26-Apr
29-Apr
2-May
5-May
8-May
11-May
14-May
17-May
20-May
23-May
26-May
29-May
1-Jun
4-Jun
7-Jun
10-Jun
13-Jun
16-Jun
19-Jun
22-Jun
25-Jun
28-Jun
1-Jul
4-Jul
7-Jul
Avg Rainfall
Average Flow
ADF

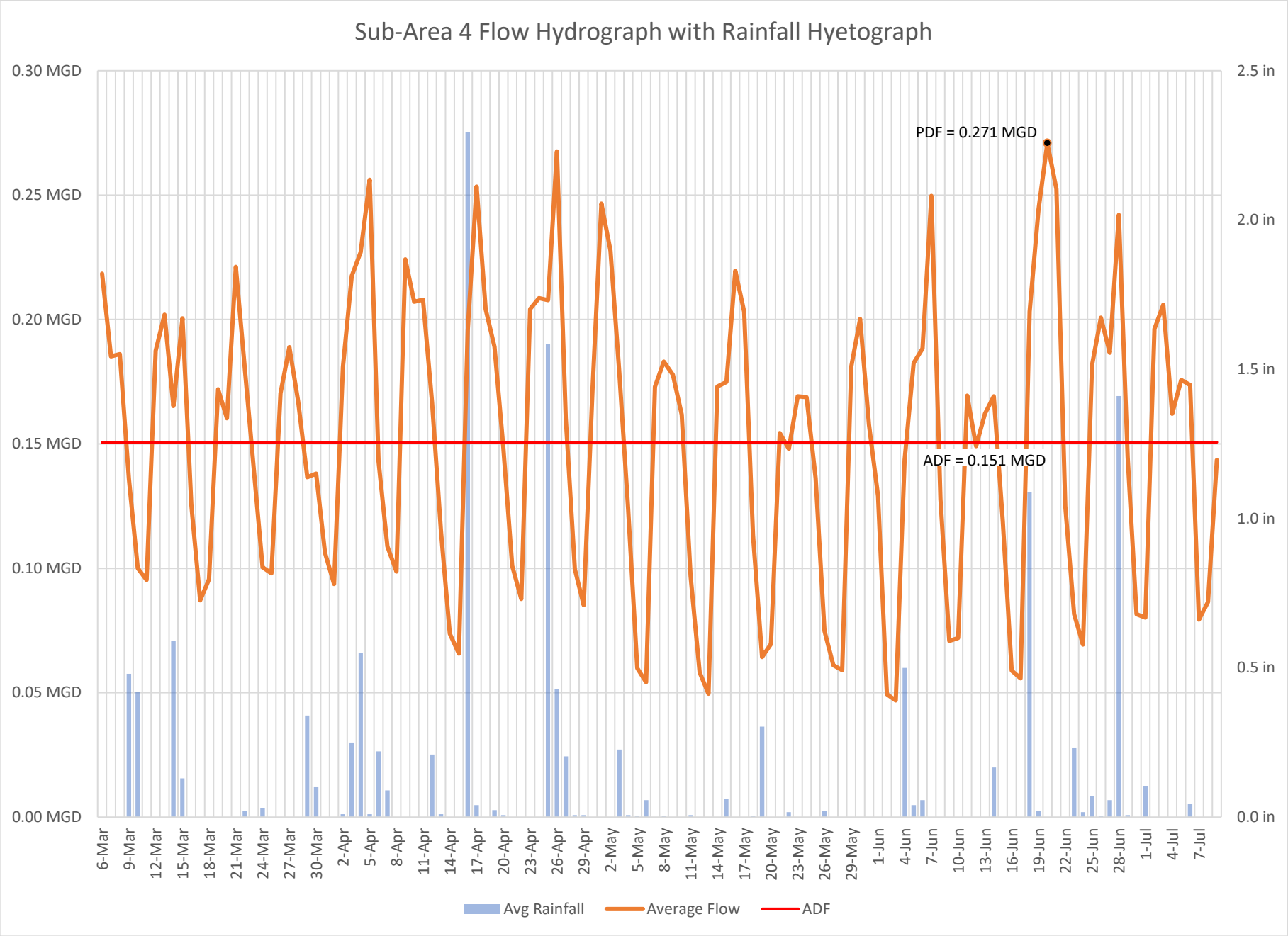
12/17/2018


Sub-Area 2 Flow Hydrograph with Rainfall Hyetograph
0.14 MGD
0.12 MGD
0.10 MGD
0.08 MGD
0.06 MGD
0.04 MGD
0.02 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.130 MGD
ADF = 0.065 MGD
6-Mar
9-Mar
12-Mar
15-Mar
18-Mar
21-Mar
24-Mar
27-Mar
30-Mar
2-Apr
5-Apr
8-Apr
11-Apr
14-Apr
17-Apr
20-Apr
23-Apr
26-Apr
29-Apr
2-May
5-May
8-May
11-May
14-May
17-May
20-May
23-May
26-May
29-May
1-Jun
4-Jun
7-Jun
10-Jun
13-Jun
16-Jun
19-Jun
22-Jun
25-Jun
28-Jun
1-Jul
4-Jul
7-Jul
Avg Rainfall
Average Flow
ADF

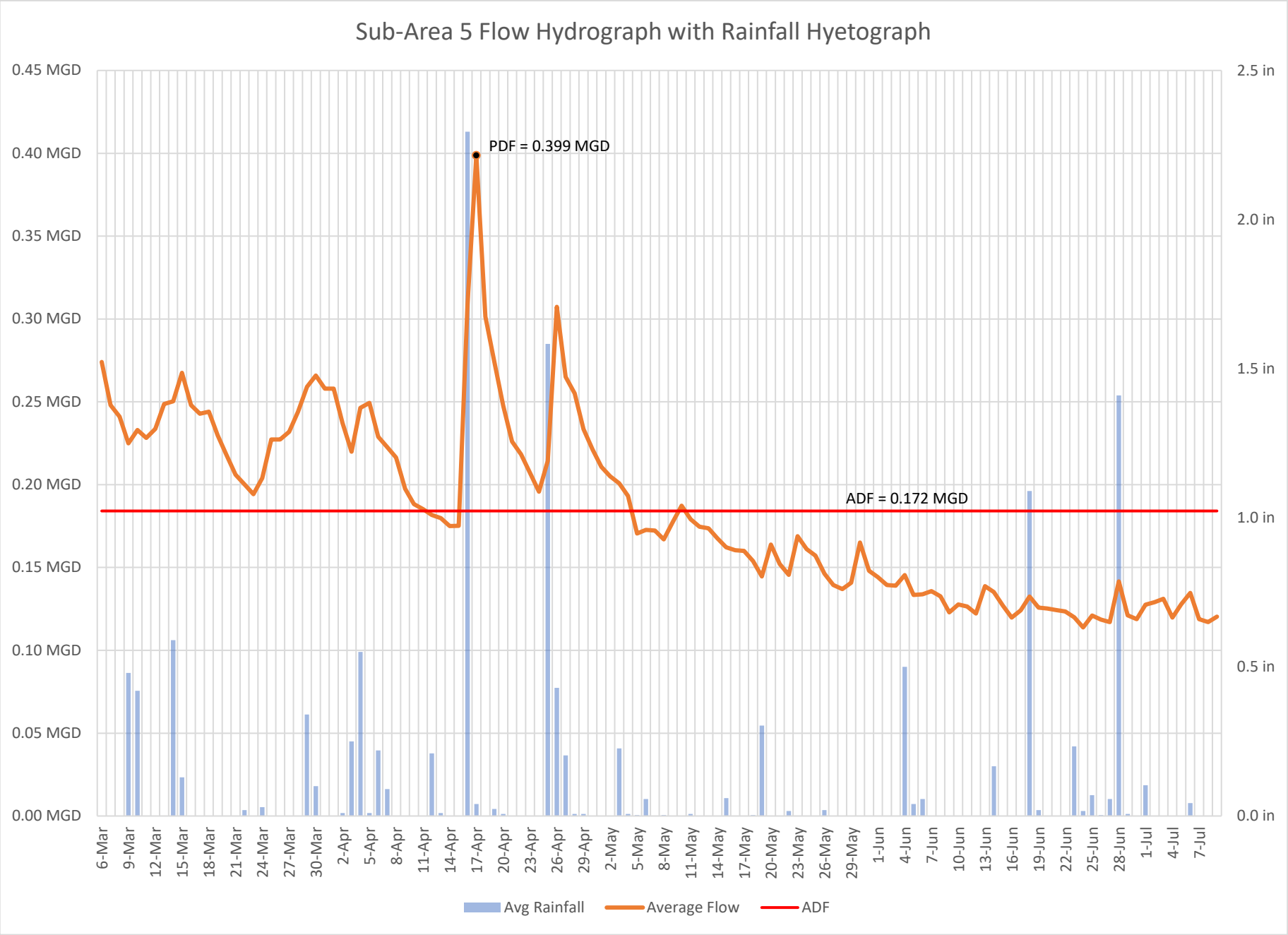
12/17/2018


Sub-Area 3 Flow Hydrograph with Rainfall Hyetograph
0.35 MGD
0.30 MGD
0.25 MGD
0.20 MGD
0.15 MGD
0.10 MGD
0.05 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.296 MGD
ADF = 0.170 MGD
6-Mar
9-Mar
12-Mar
15-Mar
18-Mar
21-Mar
24-Mar
27-Mar
30-Mar
2-Apr
5-Apr
8-Apr
11-Apr
14-Apr
17-Apr
20-Apr
23-Apr
26-Apr
29-Apr
2-May
5-May
8-May
11-May
14-May
17-May
20-May
23-May
26-May
29-May
1-Jun
4-Jun
7-Jun
10-Jun
13-Jun
16-Jun
19-Jun
22-Jun
25-Jun
28-Jun
1-Jul
4-Jul
7-Jul
Avg Rainfall
Average Flow
ADF

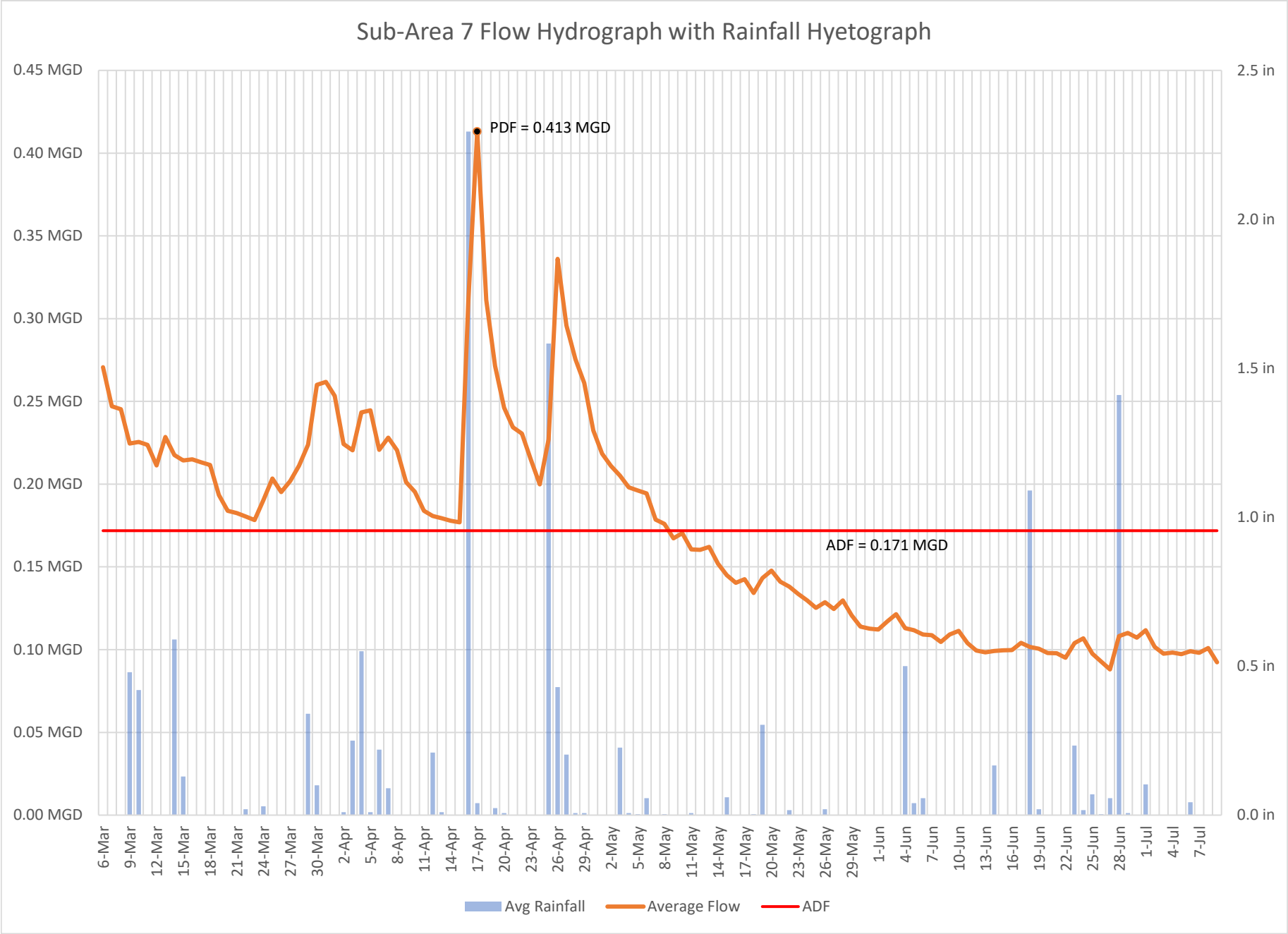
12/17/2018


Sub-Area 4 Flow Hydrograph with Rainfall Hyetograph
0.30 MGD
0.25 MGD
0.20 MGD
0.15 MGD
0.10 MGD
0.05 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.271 MGD
ADF = 0.151 MGD
6-Mar
9-Mar
12-Mar
15-Mar
18-Mar
21-Mar
24-Mar
27-Mar
30-Mar
2-Apr
5-Apr
8-Apr
11-Apr
14-Apr
17-Apr
20-Apr
23-Apr
26-Apr
29-Apr
2-May
5-May
8-May
11-May
14-May
17-May
20-May
23-May
26-May
29-May
1-Jun
4-Jun
7-Jun
10-Jun
13-Jun
16-Jun
19-Jun
22-Jun
25-Jun
28-Jun
1-Jul
4-Jul
7-Jul
Avg Rainfall
Average Flow
ADF

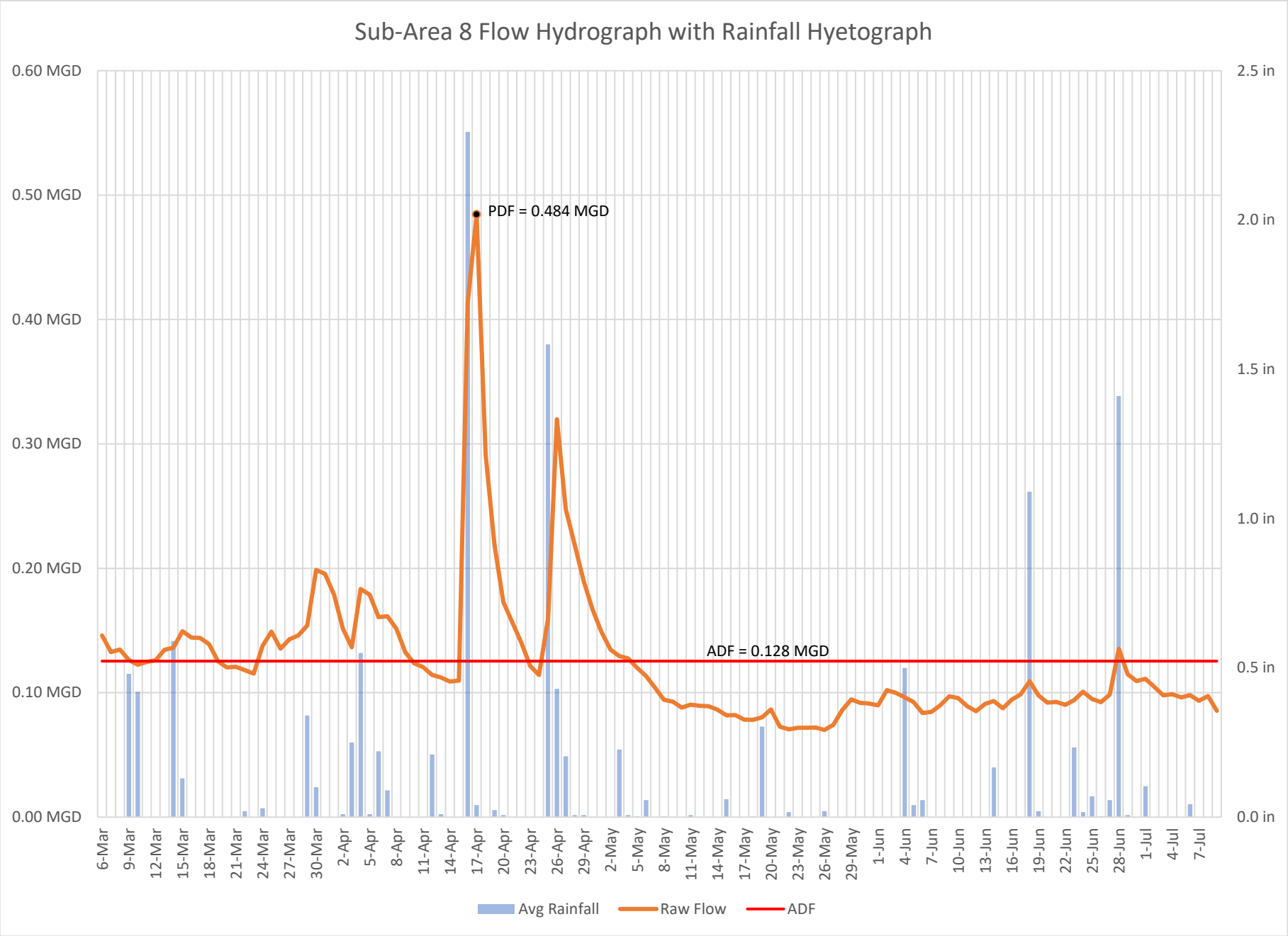
12/17/2018


Sub-Area 5 Flow Hydrograph with Rainfall Hyetograph
0.45 MGD
0.40 MGD
0.35 MGD
0.30 MGD
0.25 MGD
0.20 MGD
0.15 MGD
0.10 MGD
0.05 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.399 MGD
ADF = 0.172 MGD
6-Mar
9-Mar
12-Mar
15-Mar
18-Mar
21-Mar
24-Mar
27-Mar
30-Mar
2-Apr
5-Apr
8-Apr
11-Apr
14-Apr
17-Apr
20-Apr
23-Apr
26-Apr
29-Apr
2-May
5-May
8-May
11-May
14-May
17-May
20-May
23-May
26-May
29-May
1-Jun
4-Jun
7-Jun
10-Jun
13-Jun
16-Jun
19-Jun
22-Jun
25-Jun
28-Jun
1-Jul
4-Jul
7-Jul
Avg Rainfall
Average Flow
ADF

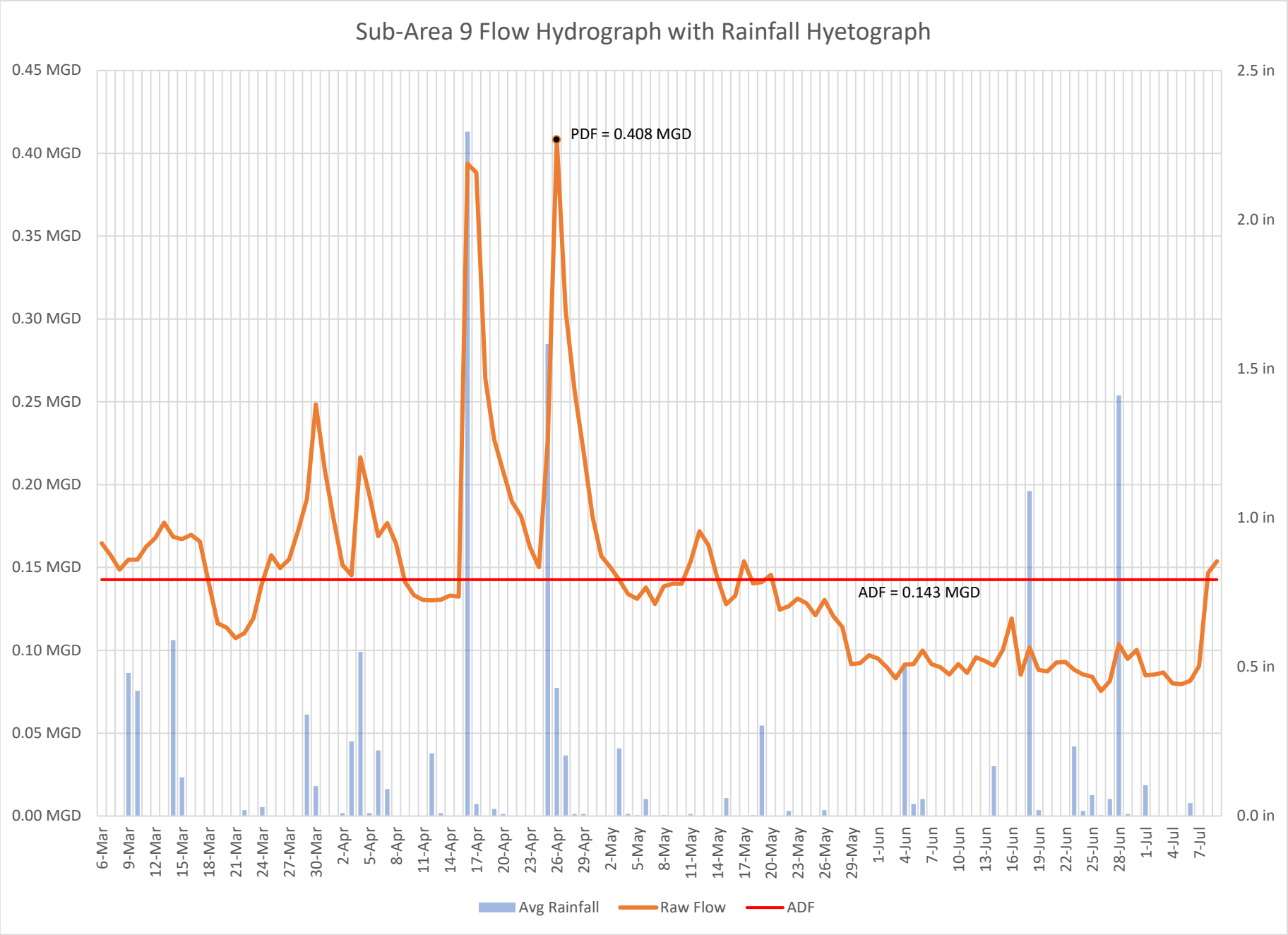
12/17/2018


Sub-Area 7 Flow Hydrograph with Rainfall Hyetograph
0.45 MGD
0.40 MGD
0.35 MGD
0.30 MGD
0.25 MGD
0.20 MGD
0.15 MGD
0.10 MGD
0.05 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.413 MGD
ADF = 0.171 MGD
6-Mar
9-Mar
12-Mar
15-Mar
18-Mar
21-Mar
24-Mar
27-Mar
30-Mar
2-Apr
5-Apr
8-Apr
11-Apr
14-Apr
17-Apr
20-Apr
23-Apr
26-Apr
29-Apr
2-May
5-May
8-May
11-May
14-May
17-May
20-May
23-May
26-May
29-May
1-Jun
4-Jun
7-Jun
10-Jun
13-Jun
16-Jun
19-Jun
22-Jun
25-Jun
28-Jun
1-Jul
4-Jul
7-Jul
Avg Rainfall
Average Flow
ADF

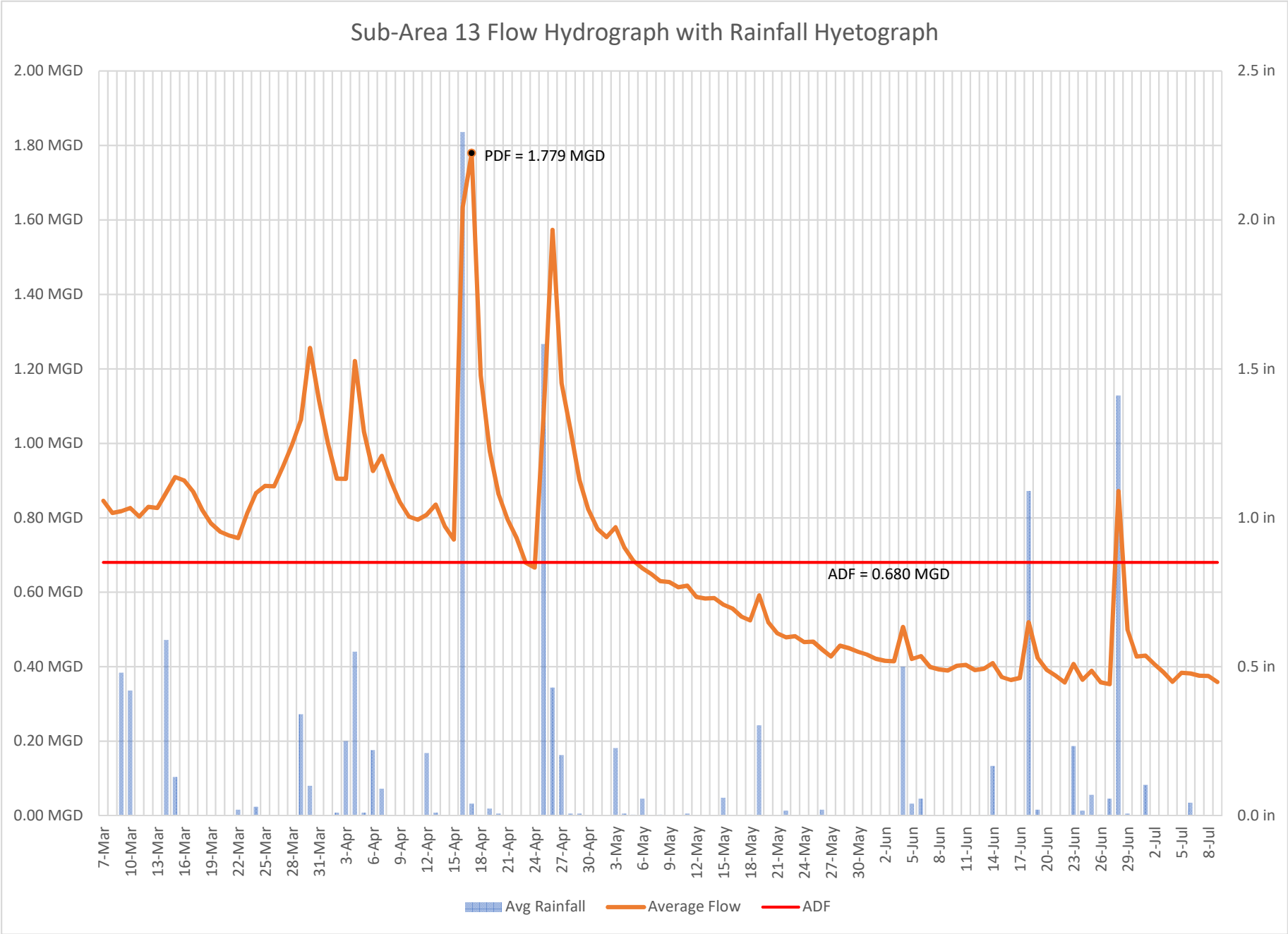
12/17/2018


Sub-Area 8 Flow Hydrograph with Rainfall Hyetograph
0.60 MGD
0.50 MGD
0.40 MGD
0.30 MGD
0.20 MGD
0.10 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.484 MGD
ADF = 0.128 MGD
6-Mar
9-Mar
12-Mar
15-Mar
18-Mar
21-Mar
24-Mar
27-Mar
30-Mar
2-Apr
5-Apr
8-Apr
11-Apr
14-Apr
17-Apr
20-Apr
23-Apr
26-Apr
29-Apr
2-May
5-May
8-May
11-May
14-May
17-May
20-May
23-May
26-May
29-May
1-Jun
4-Jun
7-Jun
10-Jun
13-Jun
16-Jun
19-Jun
22-Jun
25-Jun
28-Jun
1-Jul
4-Jul
7-Jul
Avg Rainfall
Raw Flow
ADF

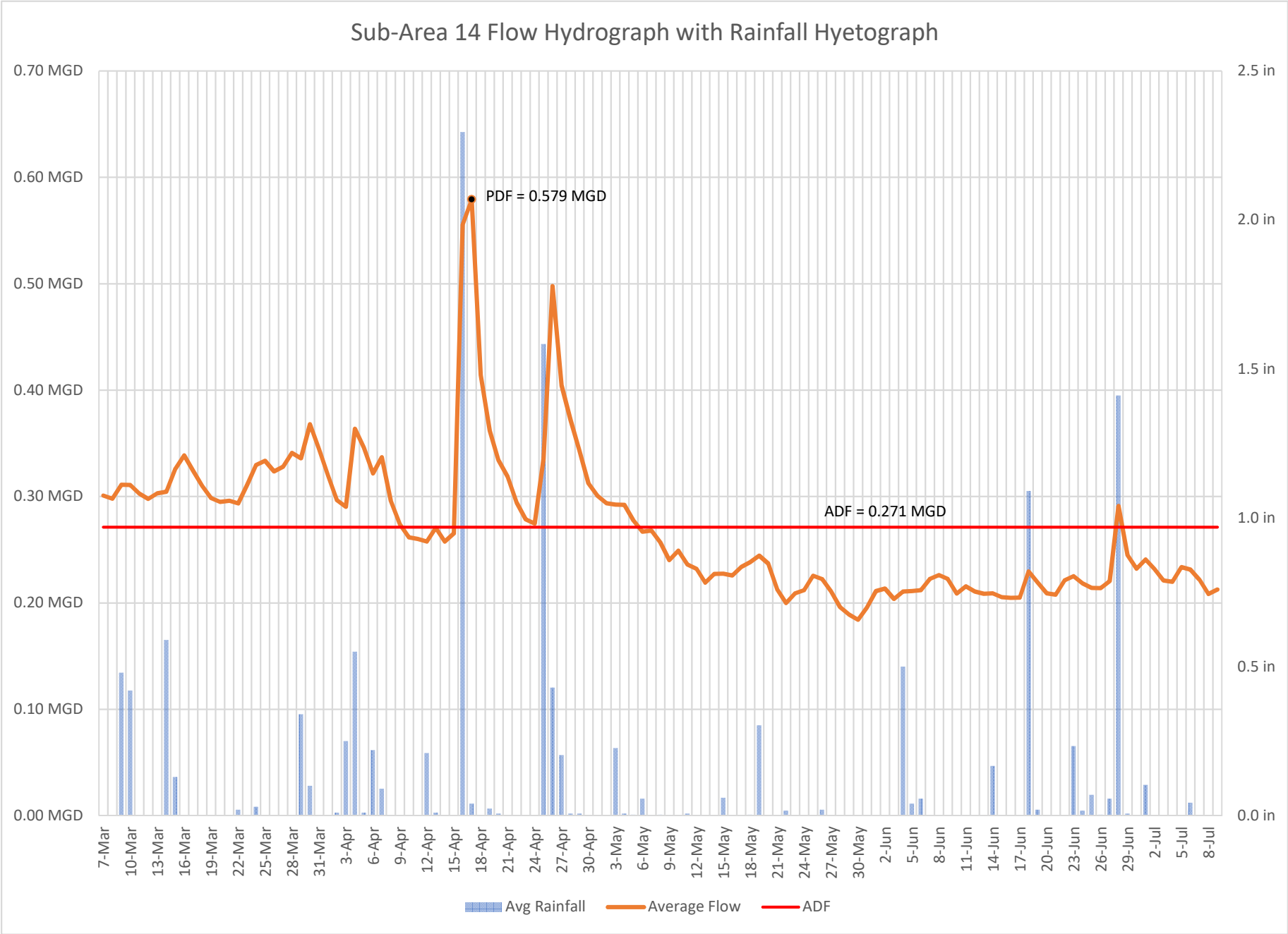
12/17/2018


Sub-Area 9 Flow Hydrograph with Rainfall Hyetograph
0.45 MGD
0.40 MGD
0.35 MGD
0.30 MGD
0.25 MGD
0.20 MGD
0.15 MGD
0.10 MGD
0.05 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.408 MGD
ADF = 0.143 MGD
6-Mar
9-Mar
12-Mar
15-Mar
18-Mar
21-Mar
24-Mar
27-Mar
30-Mar
2-Apr
5-Apr
8-Apr
11-Apr
14-Apr
17-Apr
20-Apr
23-Apr
26-Apr
29-Apr
2-May
5-May
8-May
11-May
14-May
17-May
20-May
23-May
26-May
29-May
1-Jun
4-Jun
7-Jun
10-Jun
13-Jun
16-Jun
19-Jun
22-Jun
25-Jun
28-Jun
1-Jul
4-Jul
7-Jul
Avg Rainfall
Raw Flow
ADF

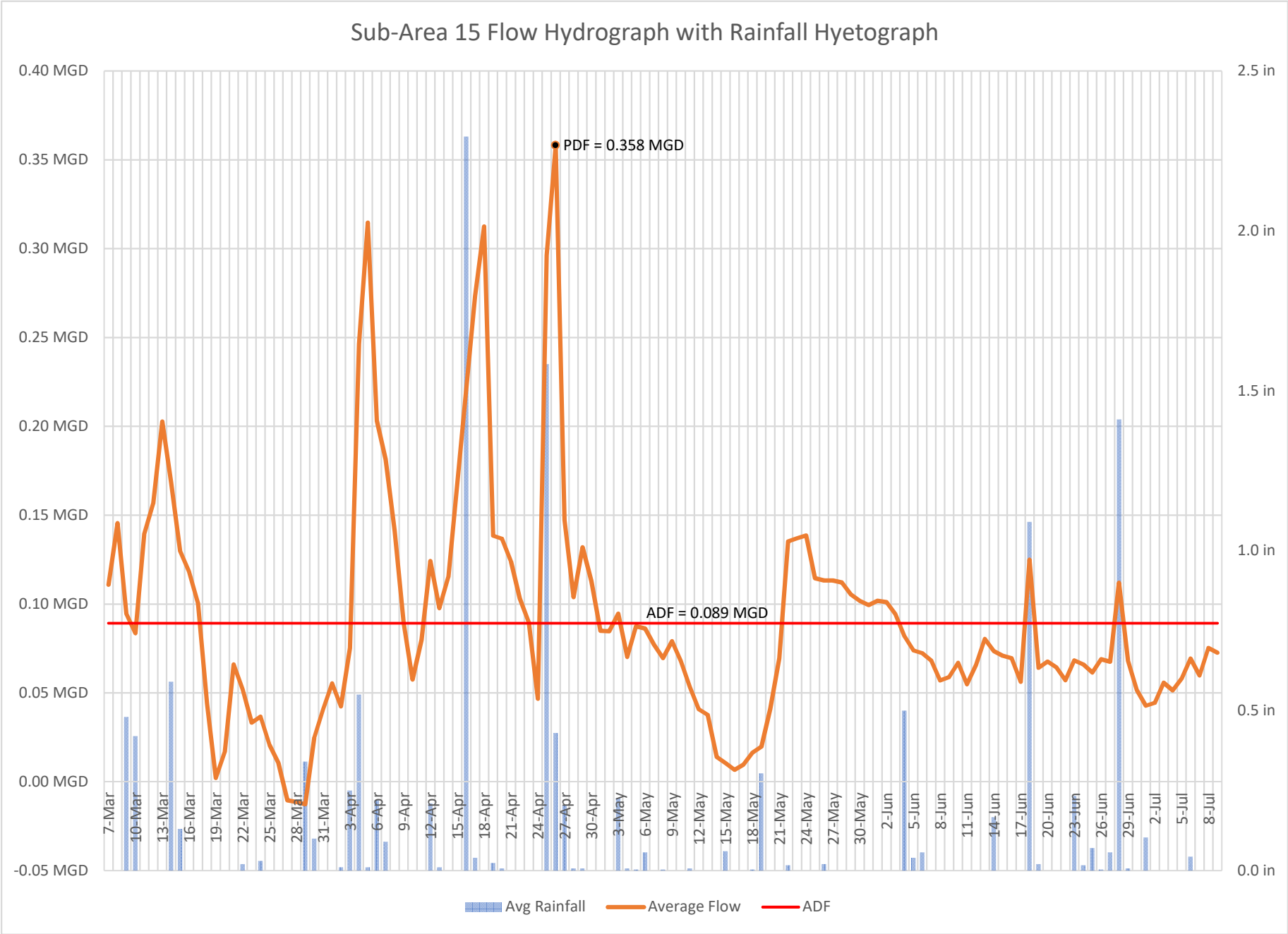
12/17/2018


Sub-Area 13 Flow Hydrograph with Rainfall Hyetograph
2.00 MGD
1.80 MGD
1.60 MGD
1.40 MGD
1.20 MGD
1.00 MGD
0.80 MGD
0.60 MGD
0.40 MGD
0.20 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 1.779 MGD
ADF = 0.680 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Average Flow
ADF

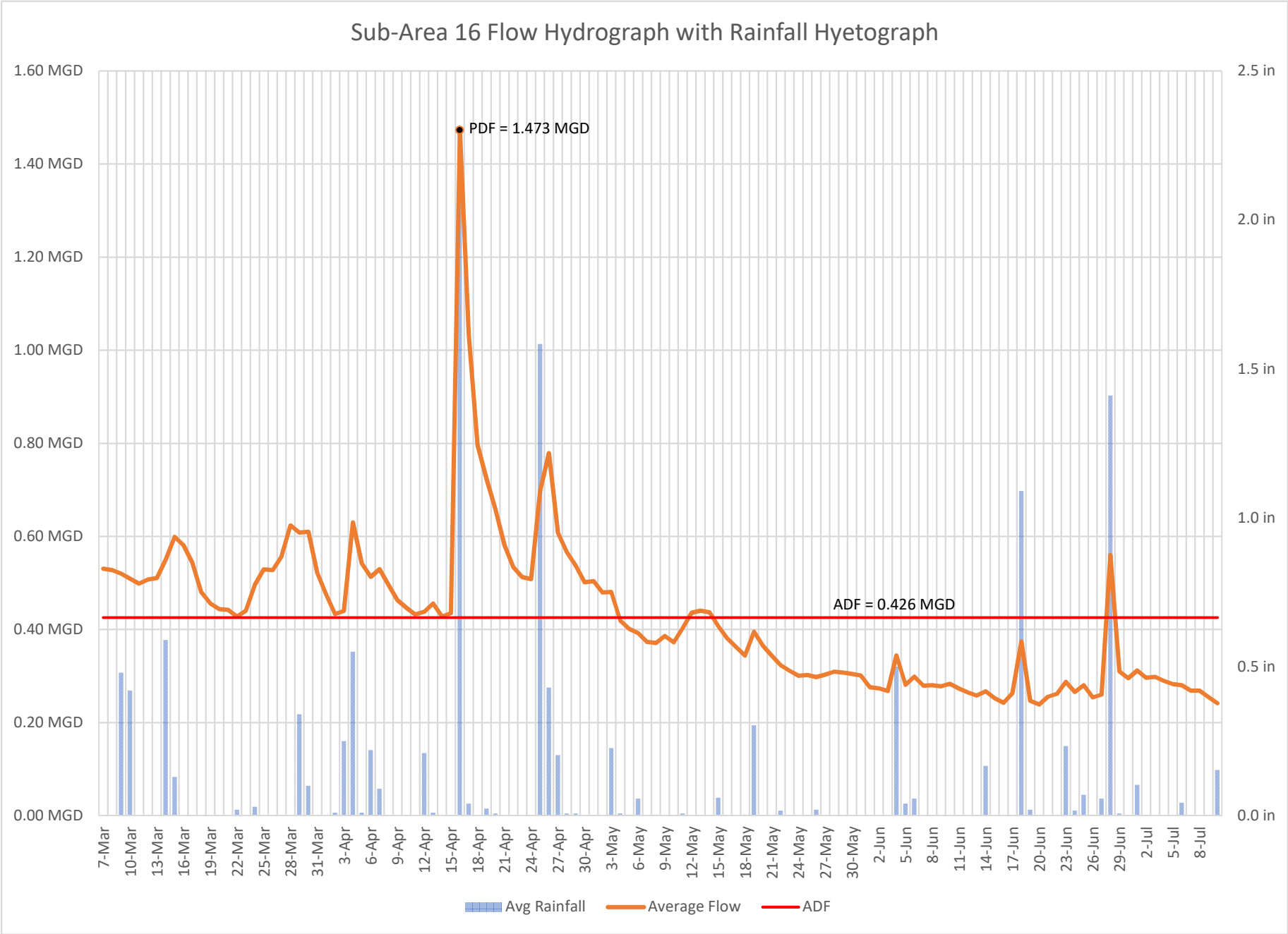
12/17/2018


Sub-Area 14 Flow Hydrograph with Rainfall Hyetograph
0.70 MGD
0.60 MGD
0.50 MGD
0.40 MGD
0.30 MGD
0.20 MGD
0.10 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.579 MGD
ADF = 0.271 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Average Flow
ADF

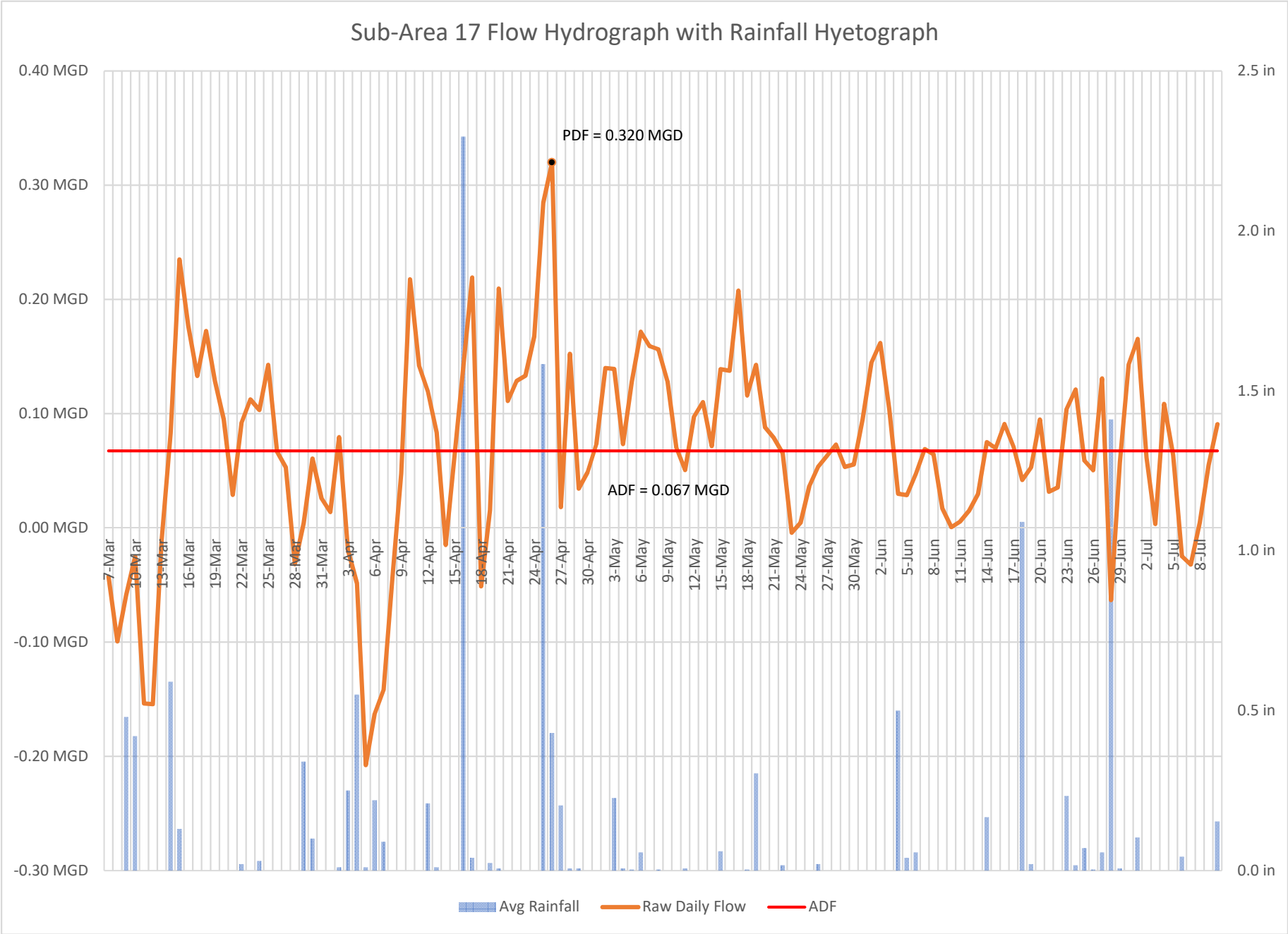
12/17/2018


Sub-Area 15 Flow Hydrograph with Rainfall Hyetograph
0.40 MGD
0.35 MGD
0.30 MGD
0.25 MGD
0.20 MGD
0.15 MGD
0.10 MGD
0.05 MGD
0.00 MGD
-0.05 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.358 MGD
ADF = 0.089 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Average Flow
ADF

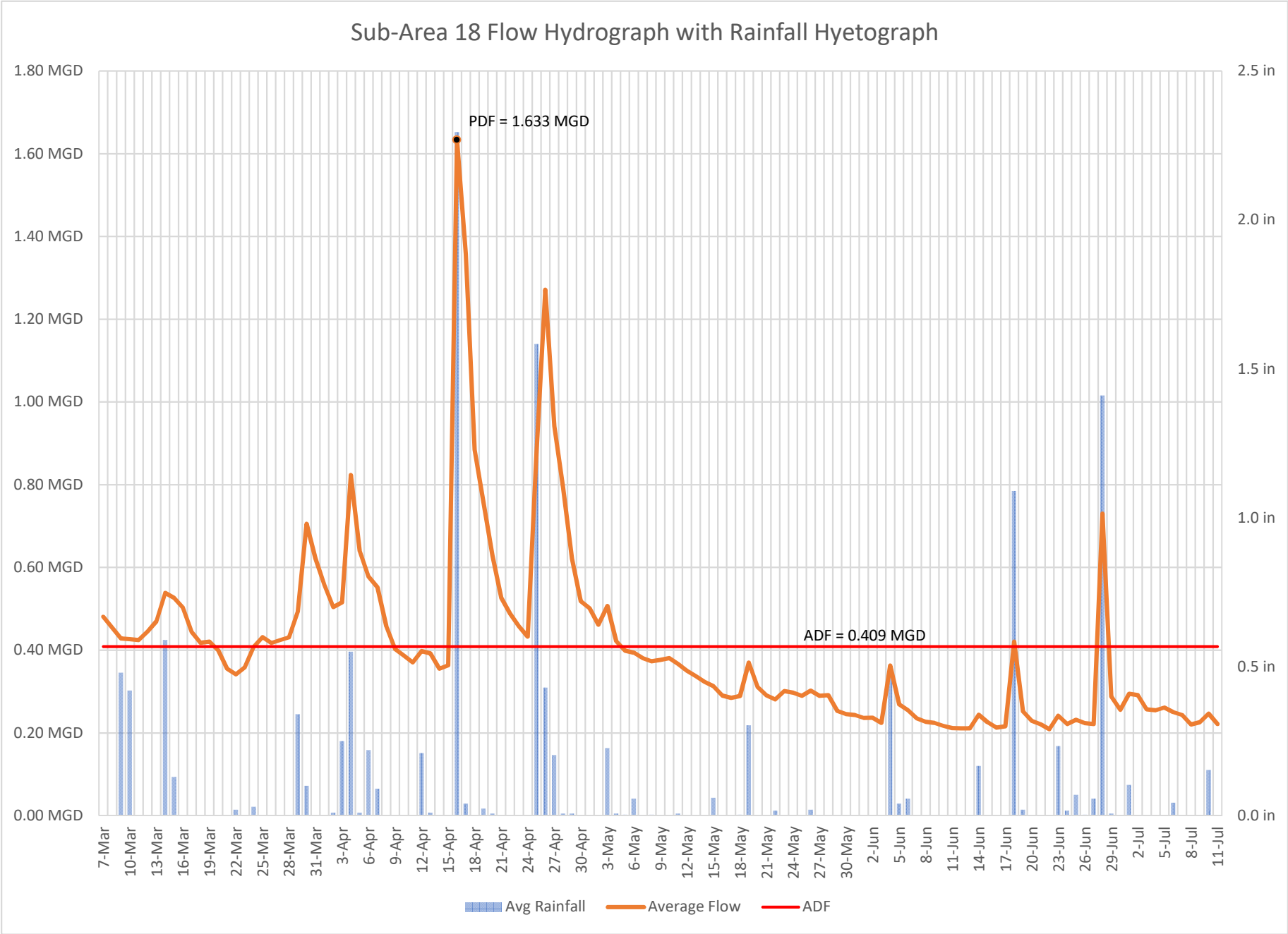
12/17/2018


Sub-Area 16 Flow Hydrograph with Rainfall Hyetograph
1.60 MGD
1.40 MGD
1.20 MGD
1.00 MGD
0.80 MGD
0.60 MGD
0.40 MGD
0.20 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 1.473 MGD
ADF = 0.426 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Average Flow
ADF

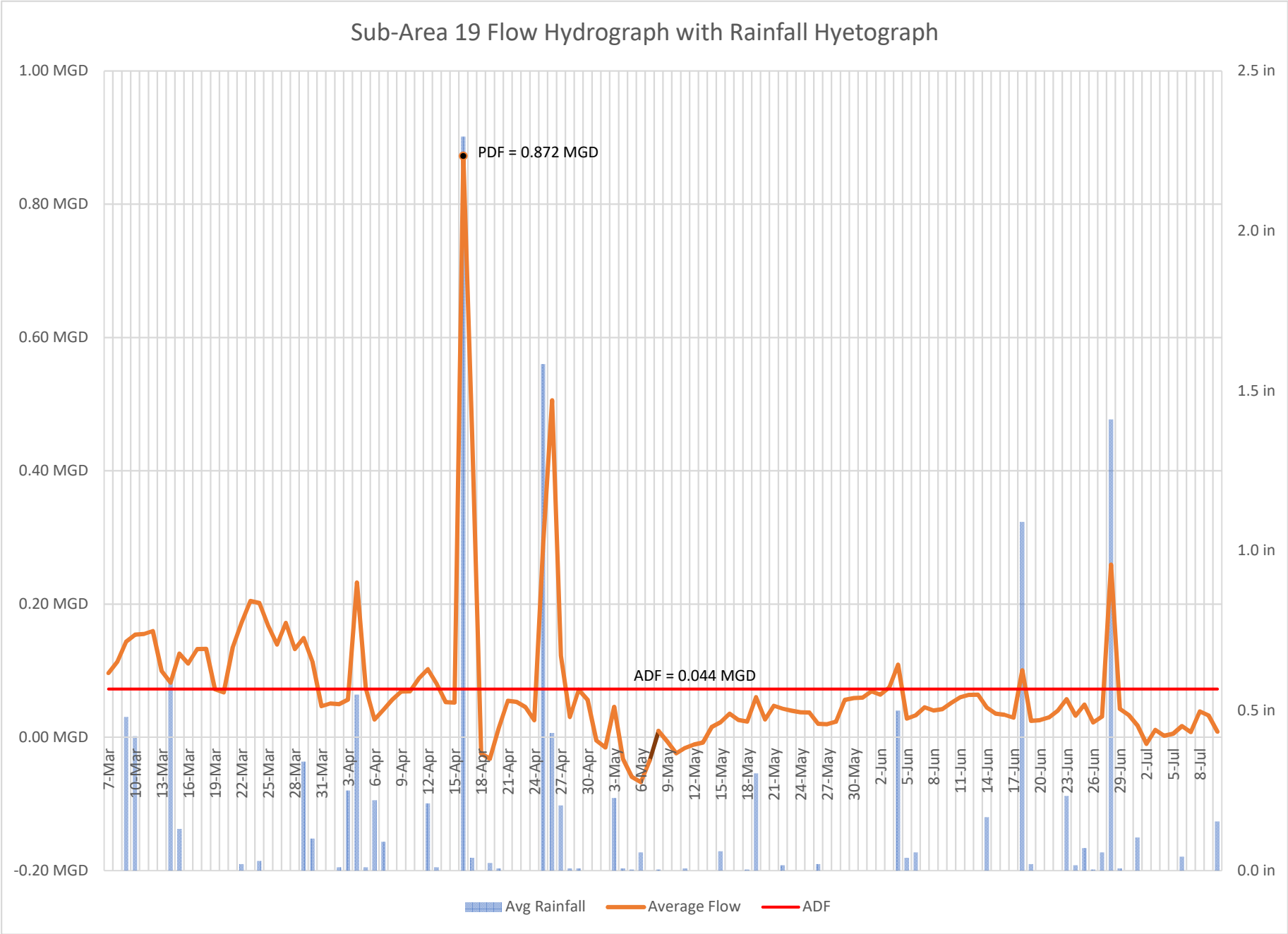
12/17/2018


Sub-Area 17 Flow Hydrograph with Rainfall Hyetograph
0.40 MGD
0.30 MGD
0.20 MGD
0.10 MGD
0.00 MGD
-0.10 MGD
-0.20 MGD
-0.30 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.320 MGD
ADF = 0.067 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Raw Daily Flow
ADF

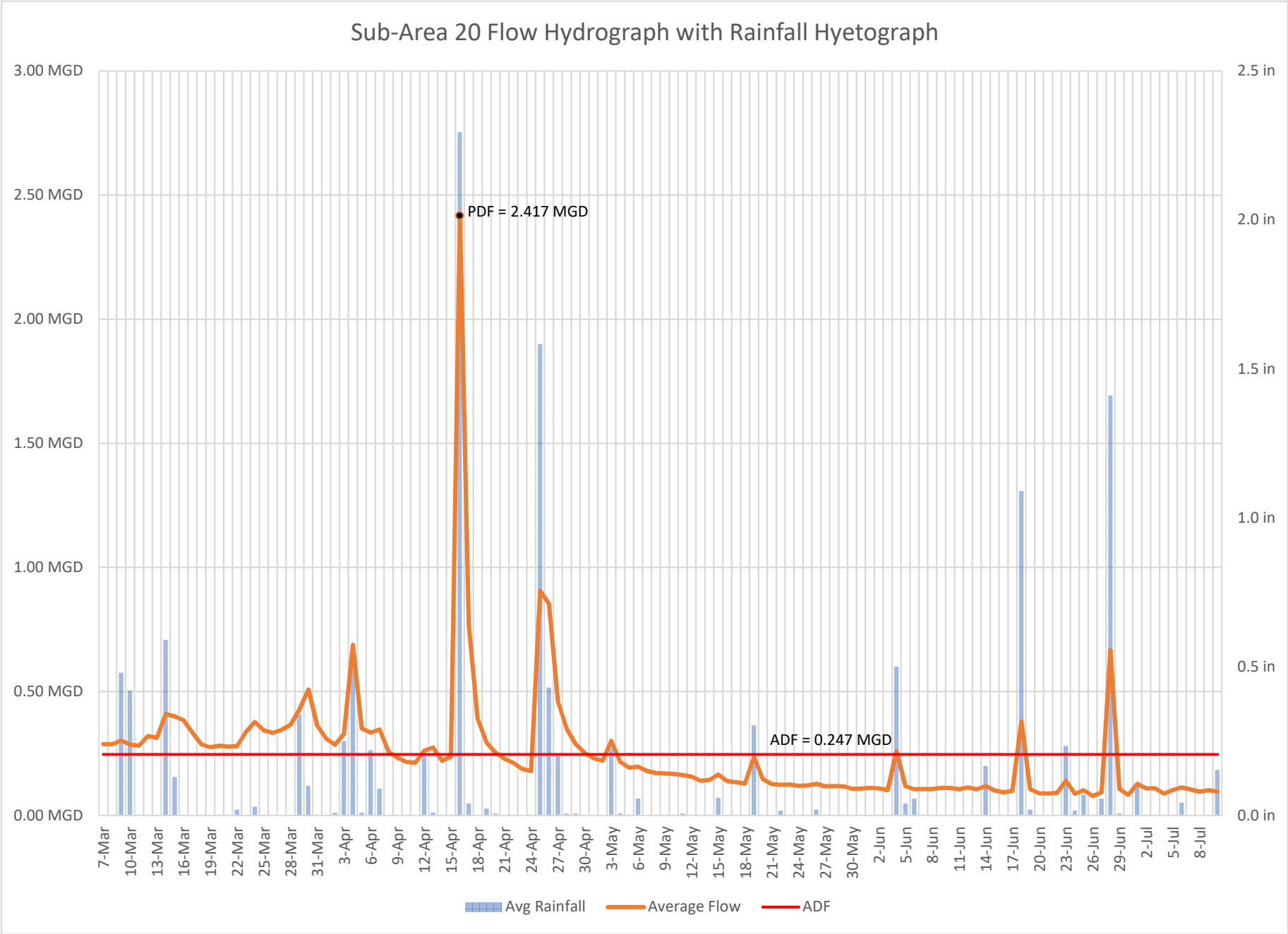
12/17/2018


Sub-Area 18 Flow Hydrograph with Rainfall Hyetograph
1.80 MGD
1.60 MGD
1.40 MGD
1.20 MGD
1.00 MGD
0.80 MGD
0.60 MGD
0.40 MGD
0.20 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 1.633 MGD
ADF = 0.409 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
11-Jul
Avg Rainfall
Average Flow
ADF

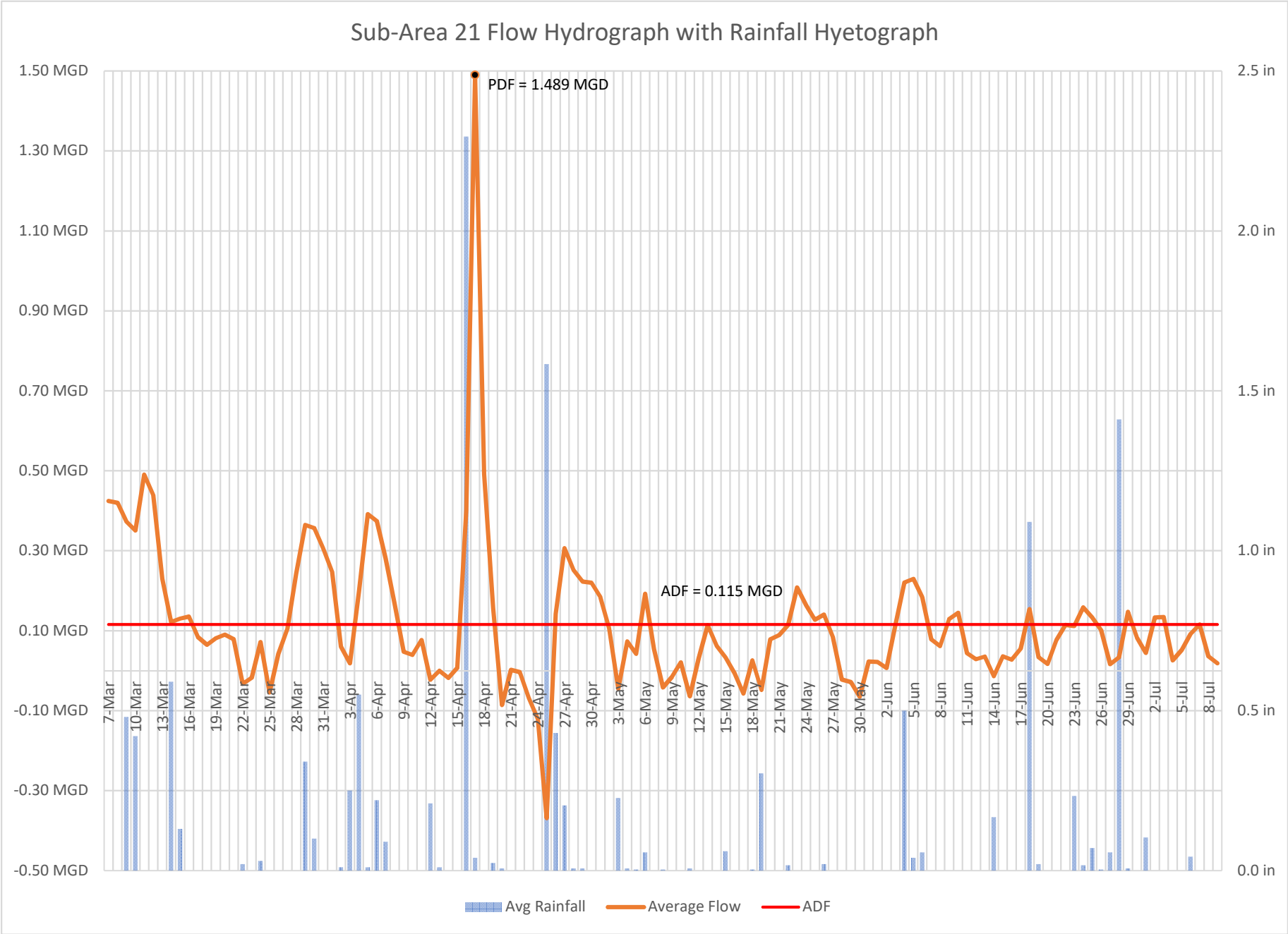
12/17/2018


Sub-Area 19 Flow Hydrograph with Rainfall Hyetograph
1.00 MGD
0.80 MGD
0.60 MGD
0.40 MGD
0.20 MGD
0.00 MGD
-0.20 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.872 MGD
ADF = 0.044 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Average Flow
ADF

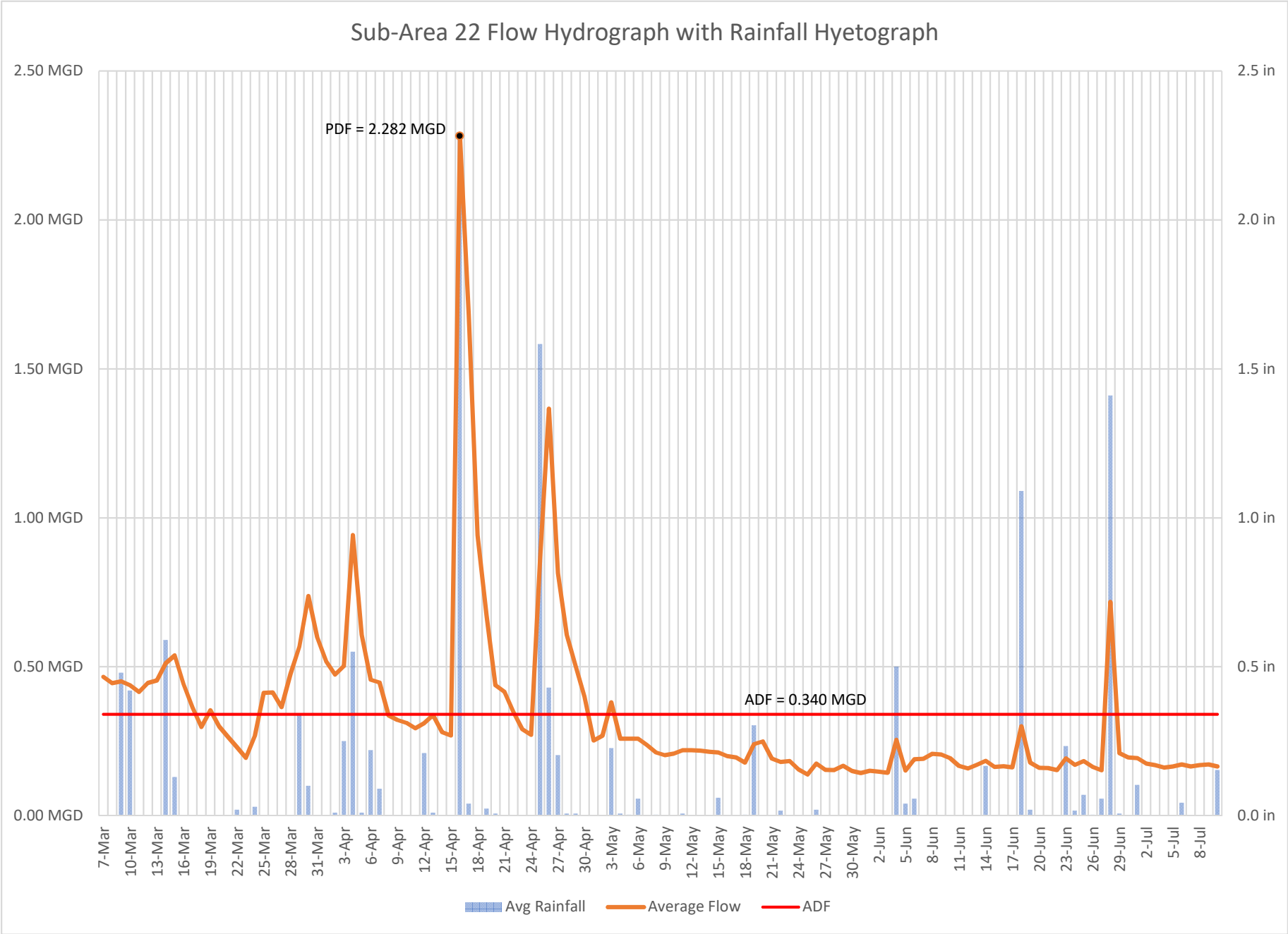
12/17/2018


Sub-Area 20 Flow Hydrograph with Rainfall Hyetograph
3.00 MGD
2.50 MGD
2.00 MGD
1.50 MGD
1.00 MGD
0.50 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 2.417 MGD
ADF = 0.247 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Average Flow
ADF

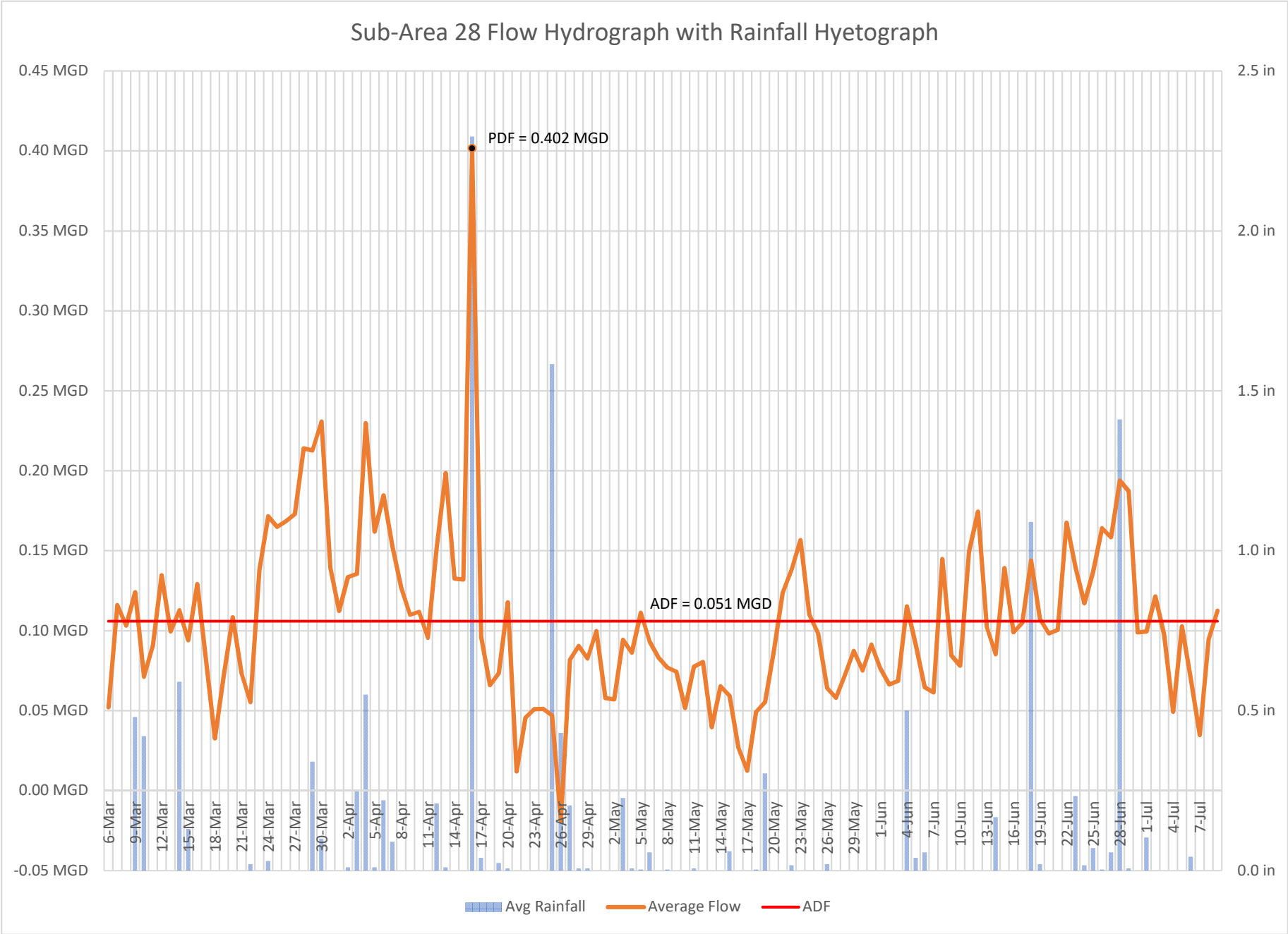
12/17/2018


Sub-Area 21 Flow Hydrograph with Rainfall Hyetograph
PDF = 1.489 MGD
ADF = 0.115 MGD
1.50 MGD
1.30 MGD
1.10 MGD
0.90 MGD
0.70 MGD
0.50 MGD
0.30 MGD
0.10 MGD
-0.10 MGD
-0.30 MGD
-0.50 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Average Flow
ADF

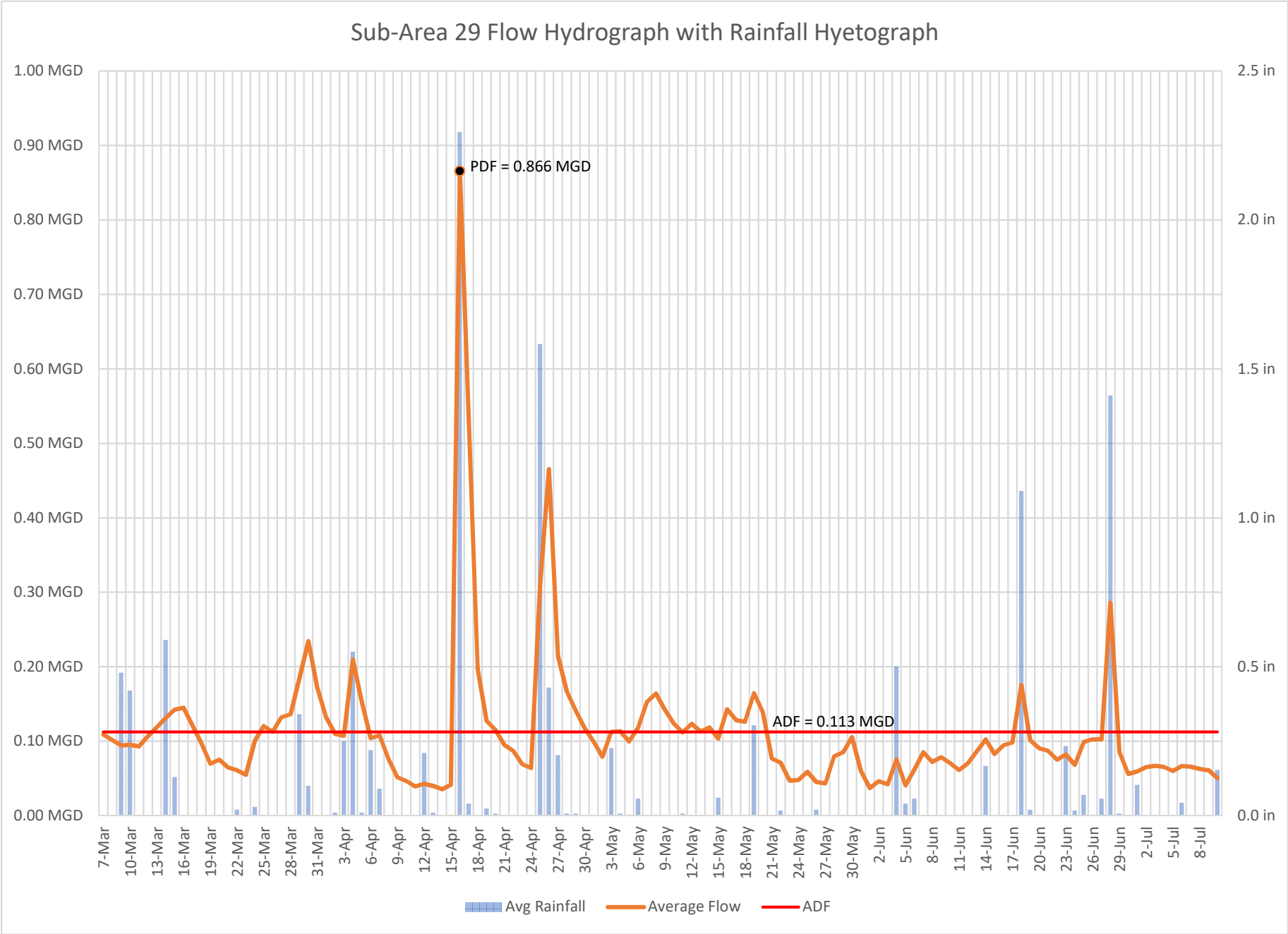
12/17/2018


Sub-Area 22 Flow Hydrograph with Rainfall Hyetograph
2.50 MGD
2.00 MGD
1.50 MGD
1.00 MGD
0.50 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 2.282 MGD
ADF = 0.340 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Average Flow
ADF

12/17/2018


Sub-Area 28 Flow Hydrograph with Rainfall Hyetograph
0.45 MGD
0.40 MGD
0.35 MGD
0.30 MGD
0.25 MGD
0.20 MGD
0.15 MGD
0.10 MGD
0.05 MGD
0.00 MGD
-0.05 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.402 MGD
ADF = 0.051 MGD
6-Mar
9-Mar
12-Mar
15-Mar
18-Mar
21-Mar
24-Mar
27-Mar
30-Mar
2-Apr
5-Apr
8-Apr
11-Apr
14-Apr
17-Apr
20-Apr
23-Apr
26-Apr
29-Apr
2-May
5-May
8-May
11-May
14-May
17-May
20-May
23-May
26-May
29-May
1-Jun
4-Jun
7-Jun
10-Jun
13-Jun
16-Jun
19-Jun
22-Jun
25-Jun
28-Jun
1-Jul
4-Jul
7-Jul
Avg Rainfall
Average Flow
ADF

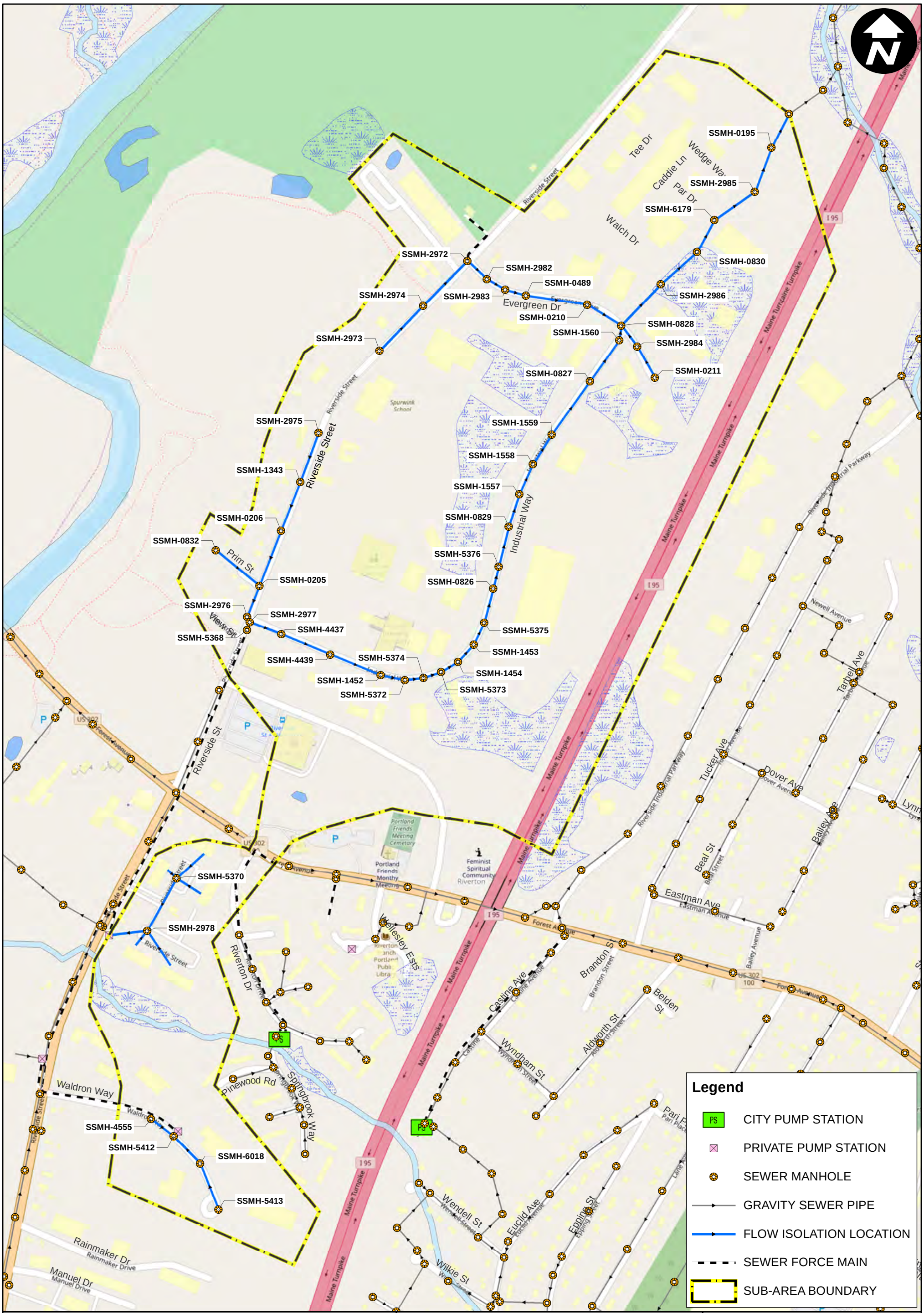
12/17/2018


Sub-Area 29 Flow Hydrograph with Rainfall Hyetograph
1.00 MGD
0.90 MGD
0.80 MGD
0.70 MGD
0.60 MGD
0.50 MGD
0.40 MGD
0.30 MGD
0.20 MGD
0.10 MGD
0.00 MGD
2.5 in
2.0 in
1.5 in
1.0 in
0.5 in
0.0 in
PDF = 0.866 MGD
ADF = 0.113 MGD
7-Mar
10-Mar
13-Mar
16-Mar
19-Mar
22-Mar
25-Mar
28-Mar
31-Mar
3-Apr
6-Apr
9-Apr
12-Apr
15-Apr
18-Apr
21-Apr
24-Apr
27-Apr
30-Apr
3-May
6-May
9-May
12-May
15-May
18-May
21-May
24-May
27-May
30-May
2-Jun
5-Jun
8-Jun
11-Jun
14-Jun
17-Jun
20-Jun
23-Jun
26-Jun
29-Jun
2-Jul
5-Jul
8-Jul
Avg Rainfall
Average Flow
ADF

12/17/2018

INFILTRATION AND INFLOW INVESTIGATIONS:

FLOW ISOLATION LOCATIONS



City of Portland, Maine

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Sewer System
Evaluation Survey

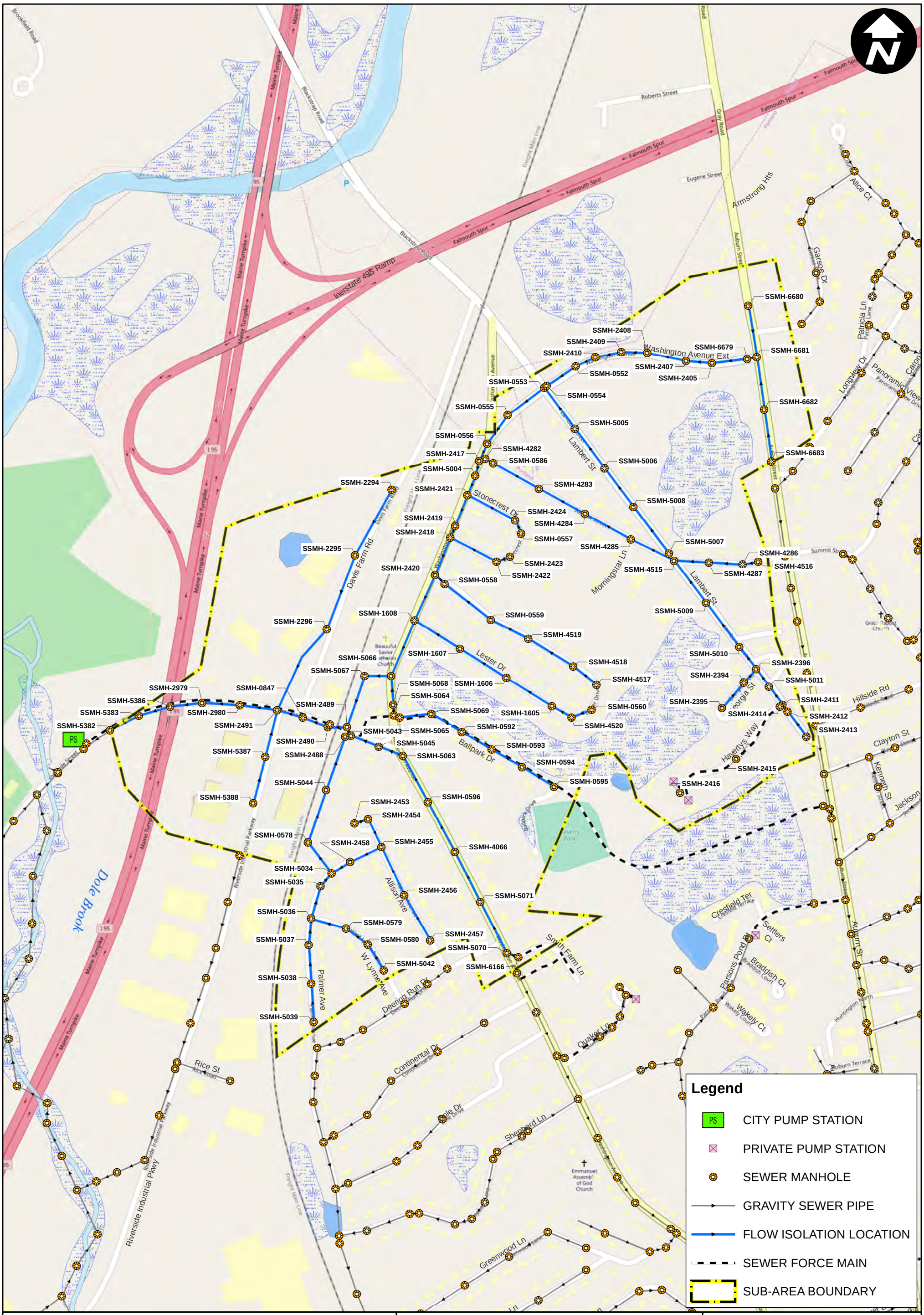
Sub-Area 4

Flow Isolation Locations

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 FLOW ISOLATION SUB AREA 4.mxd



City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Sub-Area 5

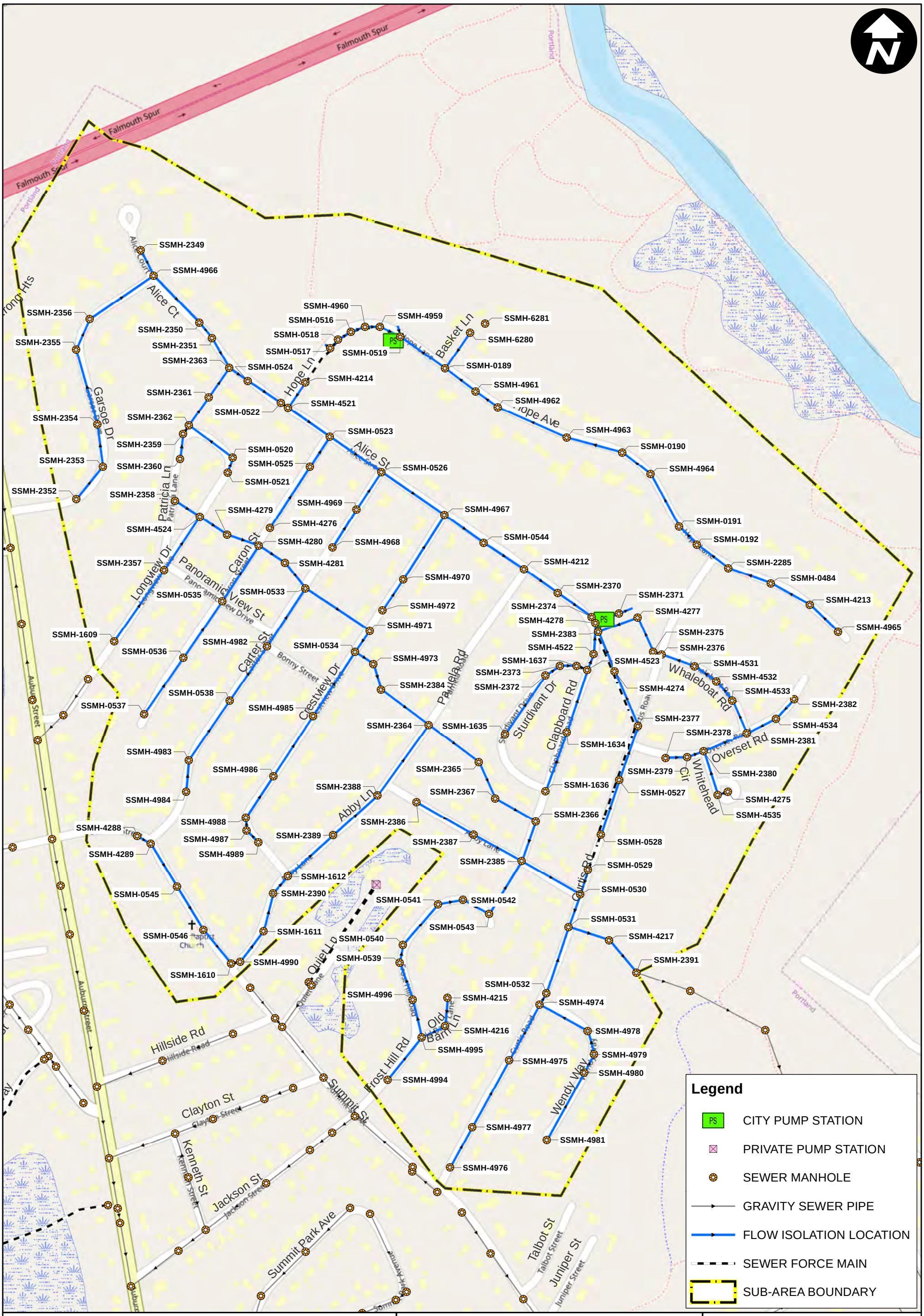
Flow Isolation Locations

0 200 400 600 800 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 FLOW ISOLATION SUB AREA 5.mxd



City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Sub-Area 7

Flow Isolation Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

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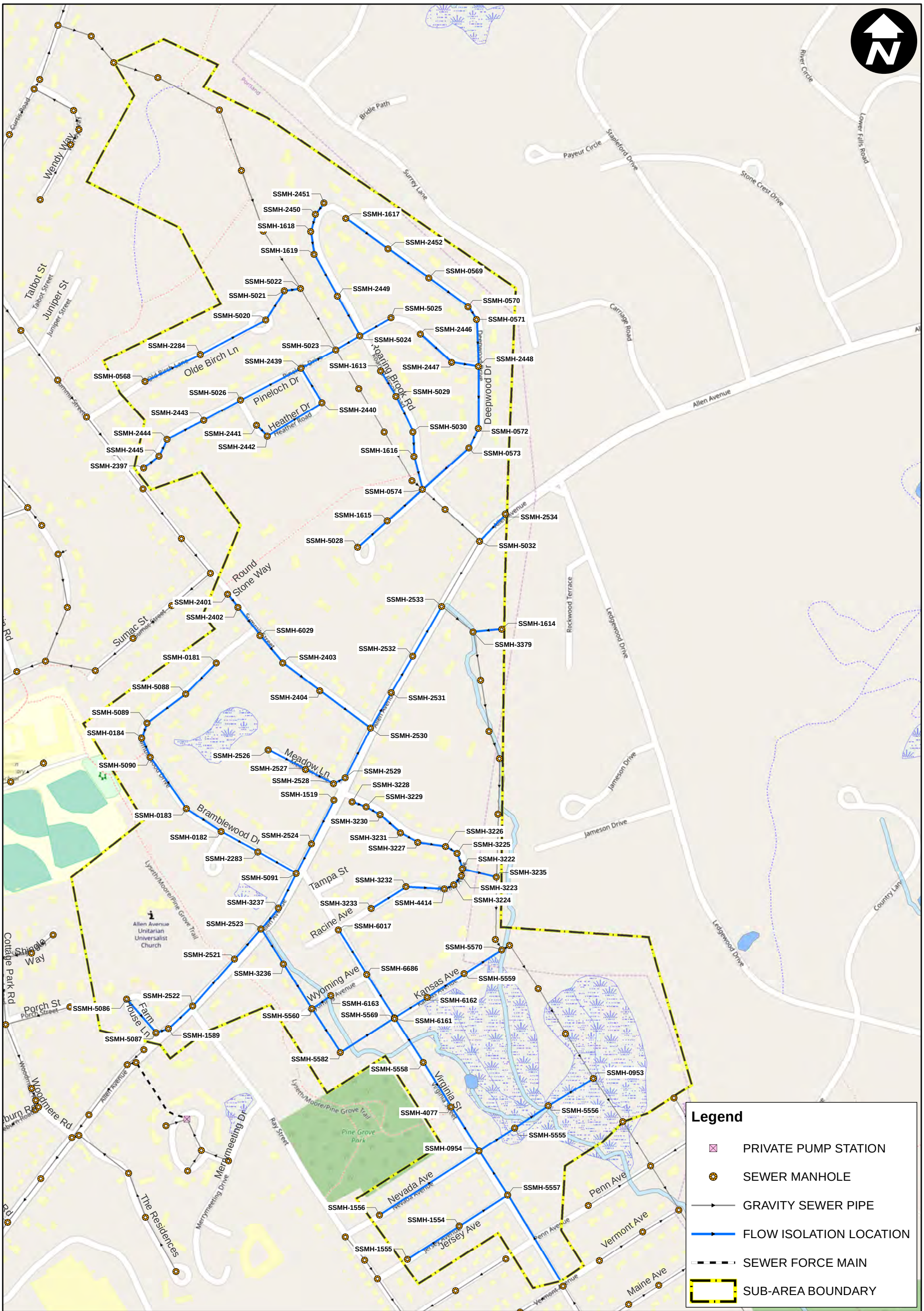

City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Sub-Area 8

Flow Isolation Locations

0 200 400 600 800 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

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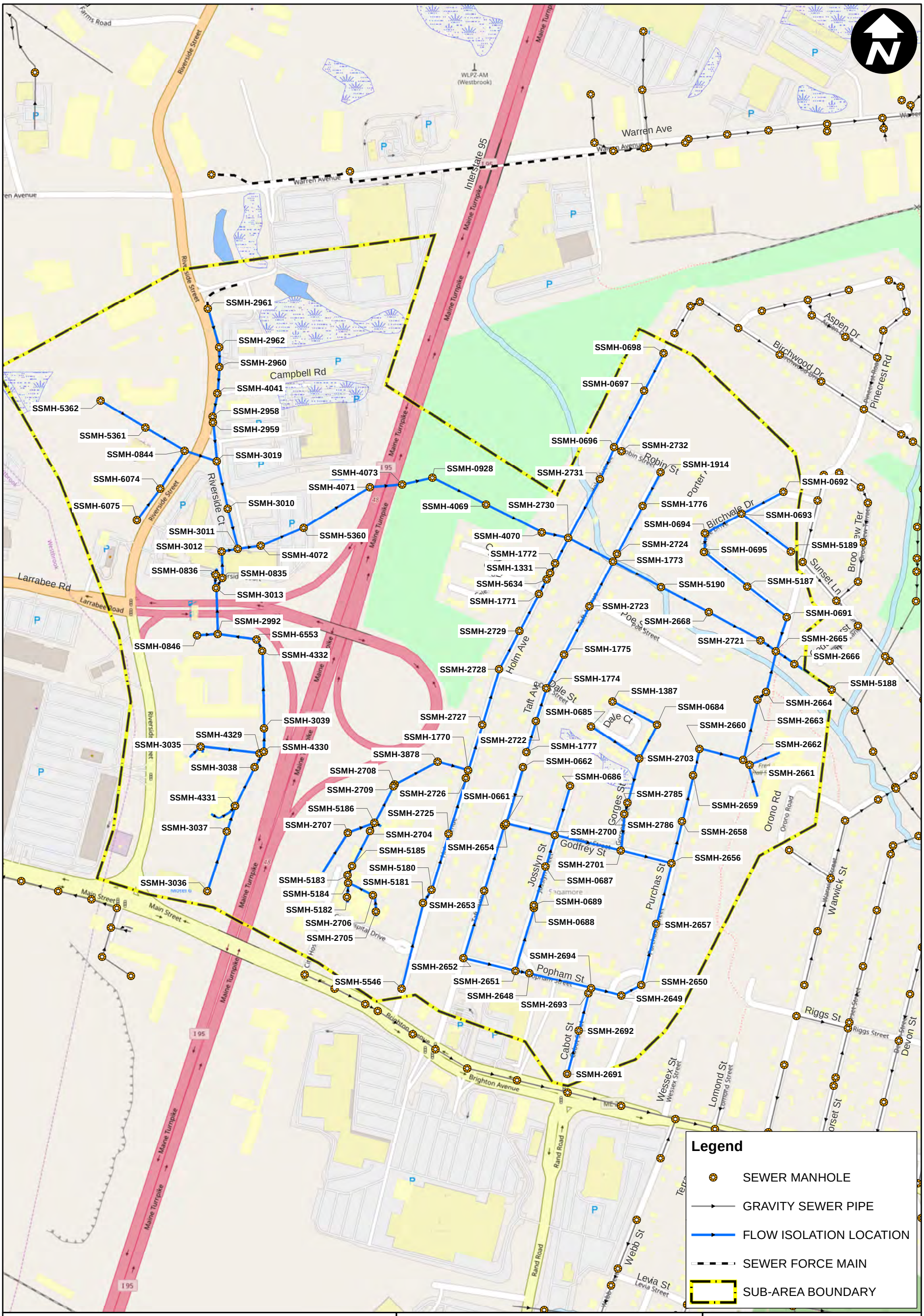


City of Portland, Maine

Planning & Engineering Sewer System Evaluation Survey

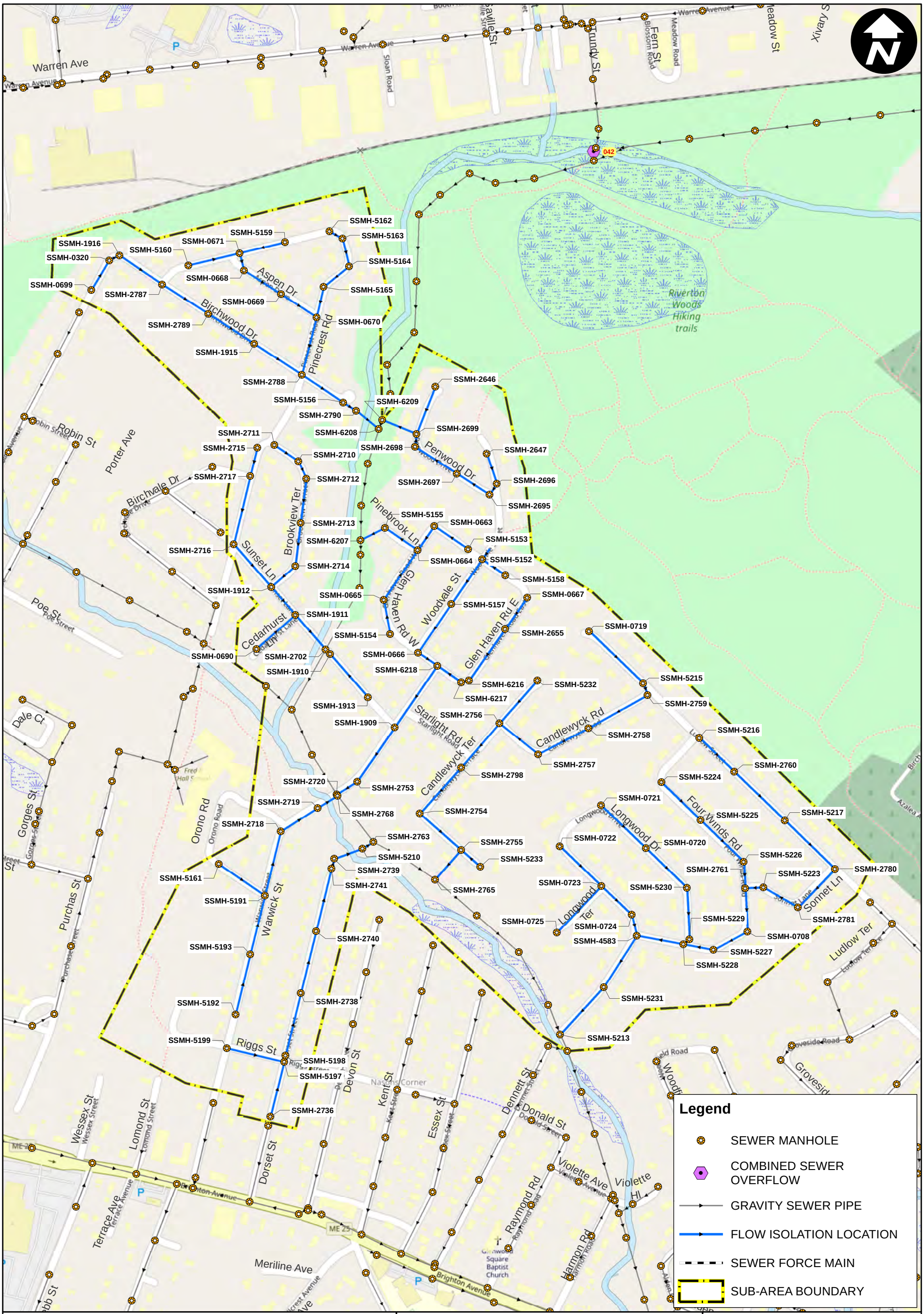
Sub-Area 14

Flow Isolation Locations

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 FLOW ISOLATION SUB AREA 14.mxd



City of Portland, Maine

Planning & Engineering Sewer System Evaluation Survey

Sub-Area 15

Flow Isolation Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

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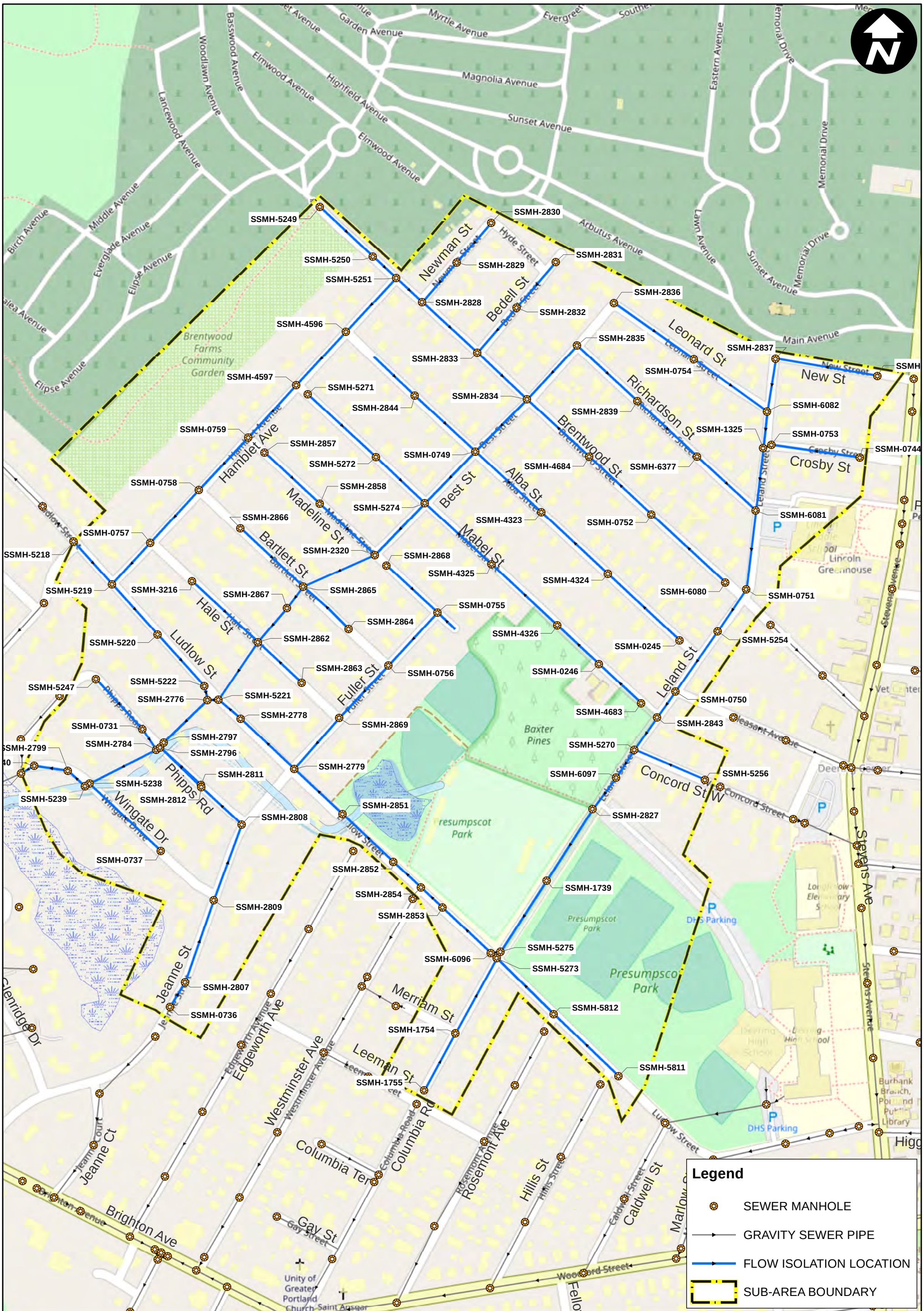

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Evaluation Survey

Sub-Area 16

Flow Isolation Locations

December 2018

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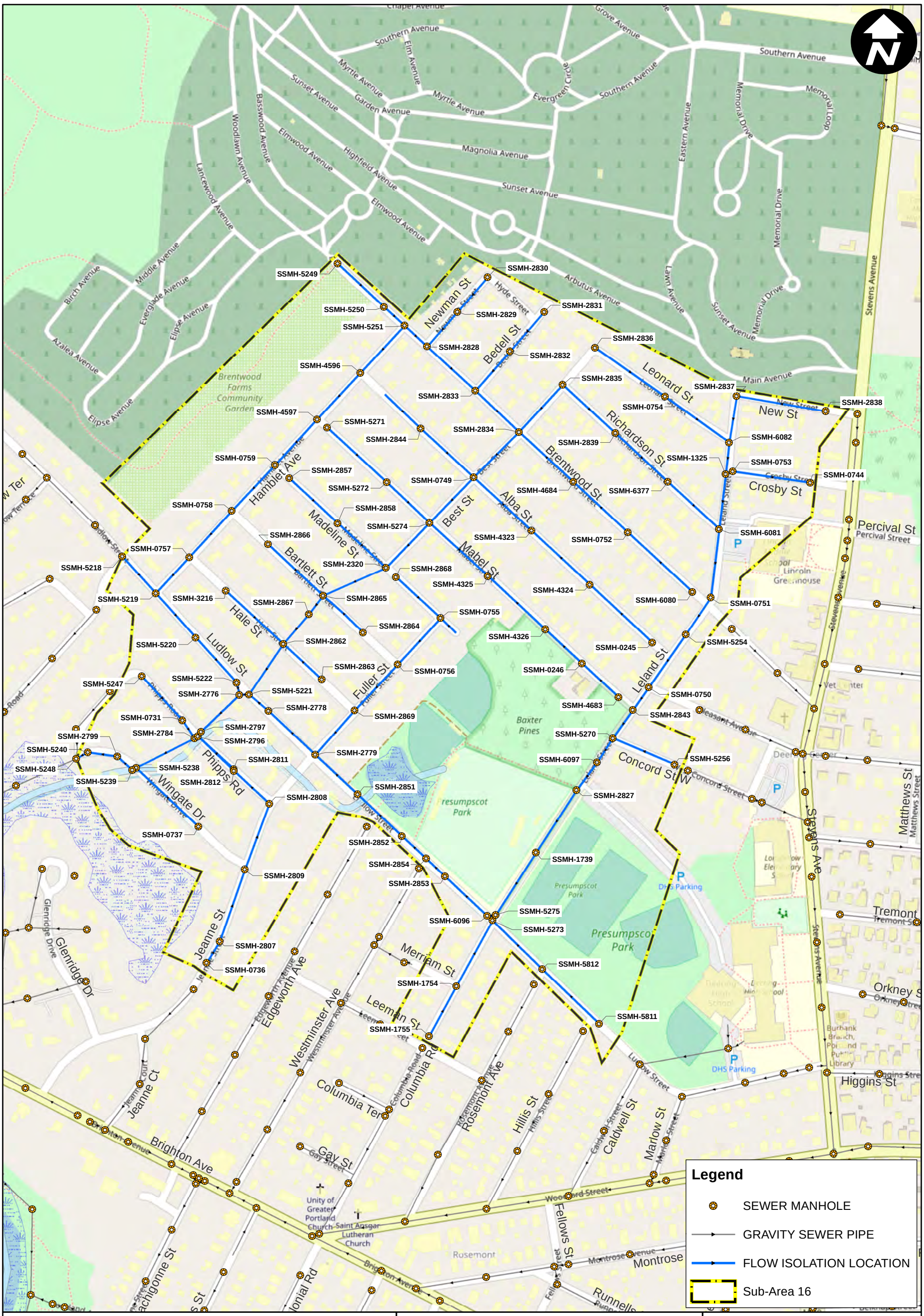

City of Portland, Maine

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Sewer System
Evaluation Survey

Sub-Area 16

Flow Isolation Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

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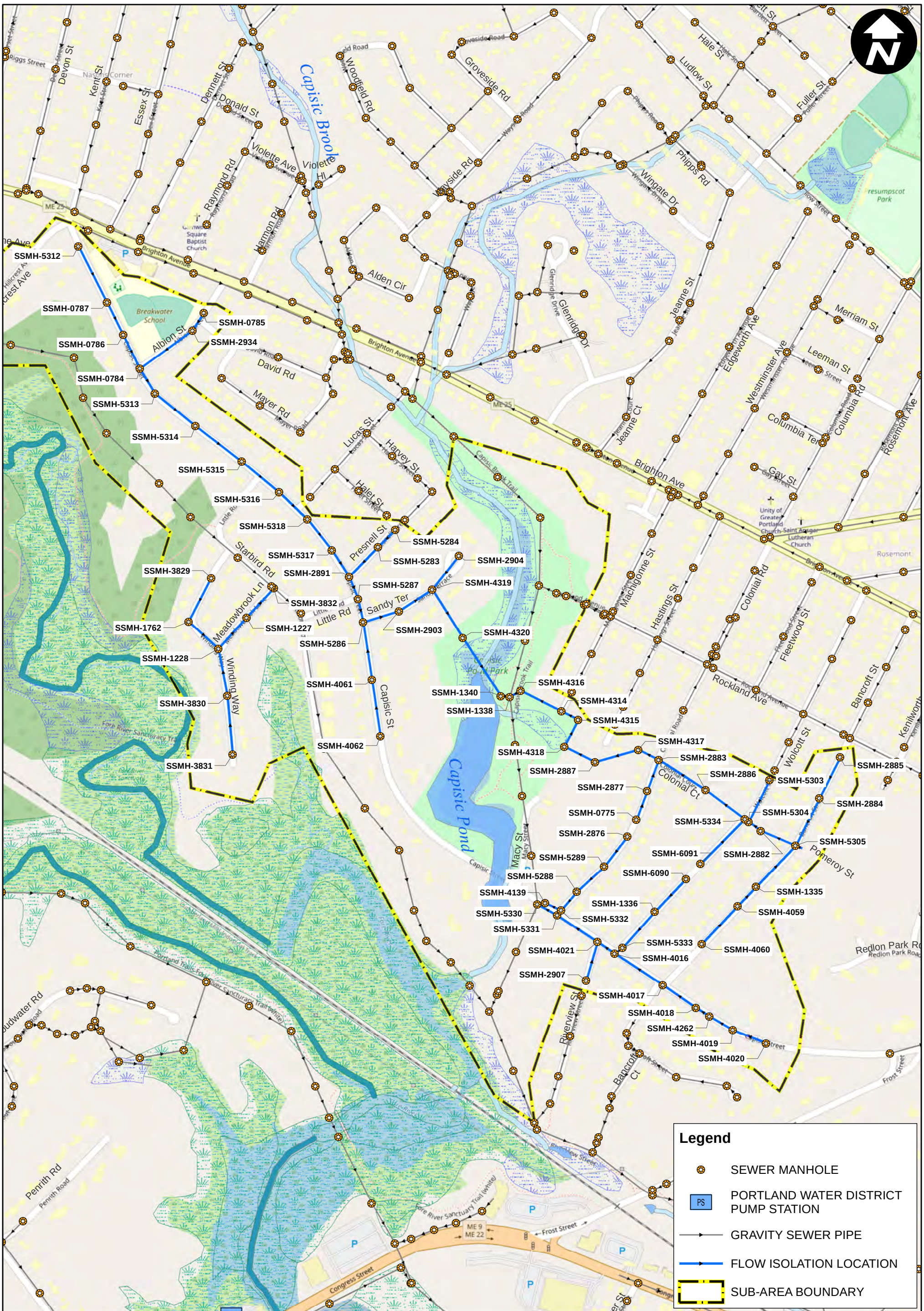

City of Portland, Maine

Planning & Engineering Sewer System Evaluation Survey

Sub-Area 21

Flow Isolation Locations

December 2018

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City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Sub-Area 22

Flow Isolation Locations

0 200 400 600 Feet

December 2018

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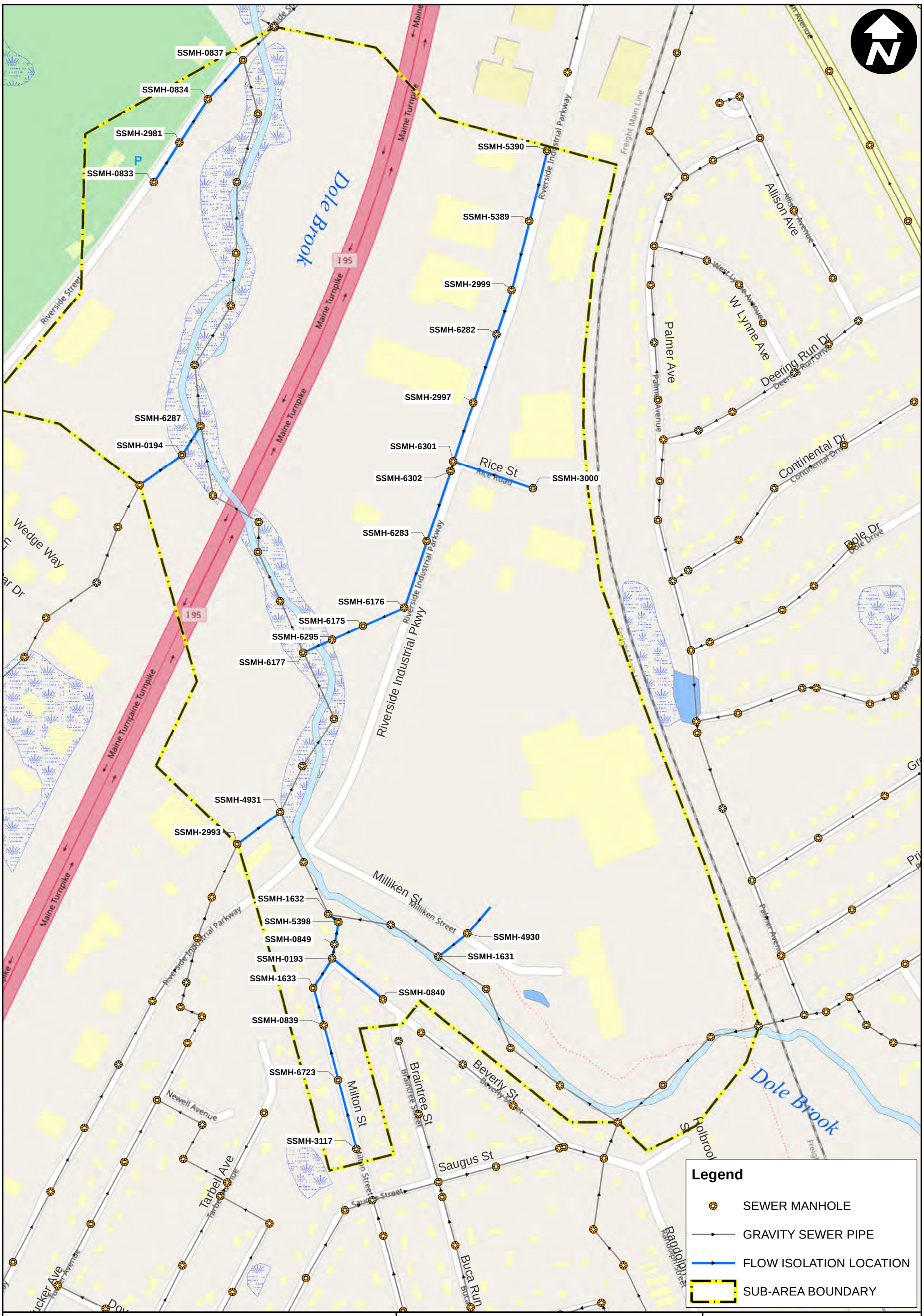

City of Portland, Maine

Planning & Engineering Sewer System Evaluation Survey

Sub-Area 28

Flow Isolation Locations

December 2018

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INFILTRATION AND INFLOW INVESTIGATIONS:

CCTV INSPECTION LOCATIONS

City of Portland, Maine

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Evaluation Survey

Sub-Area 9

Closed-Circuit Televised Inspection Locations

December 2018

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City of Portland, Maine

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Sub-Area 19

Closed-Circuit Televised Inspection Locations

0 100 200 300 Feet

December 2018

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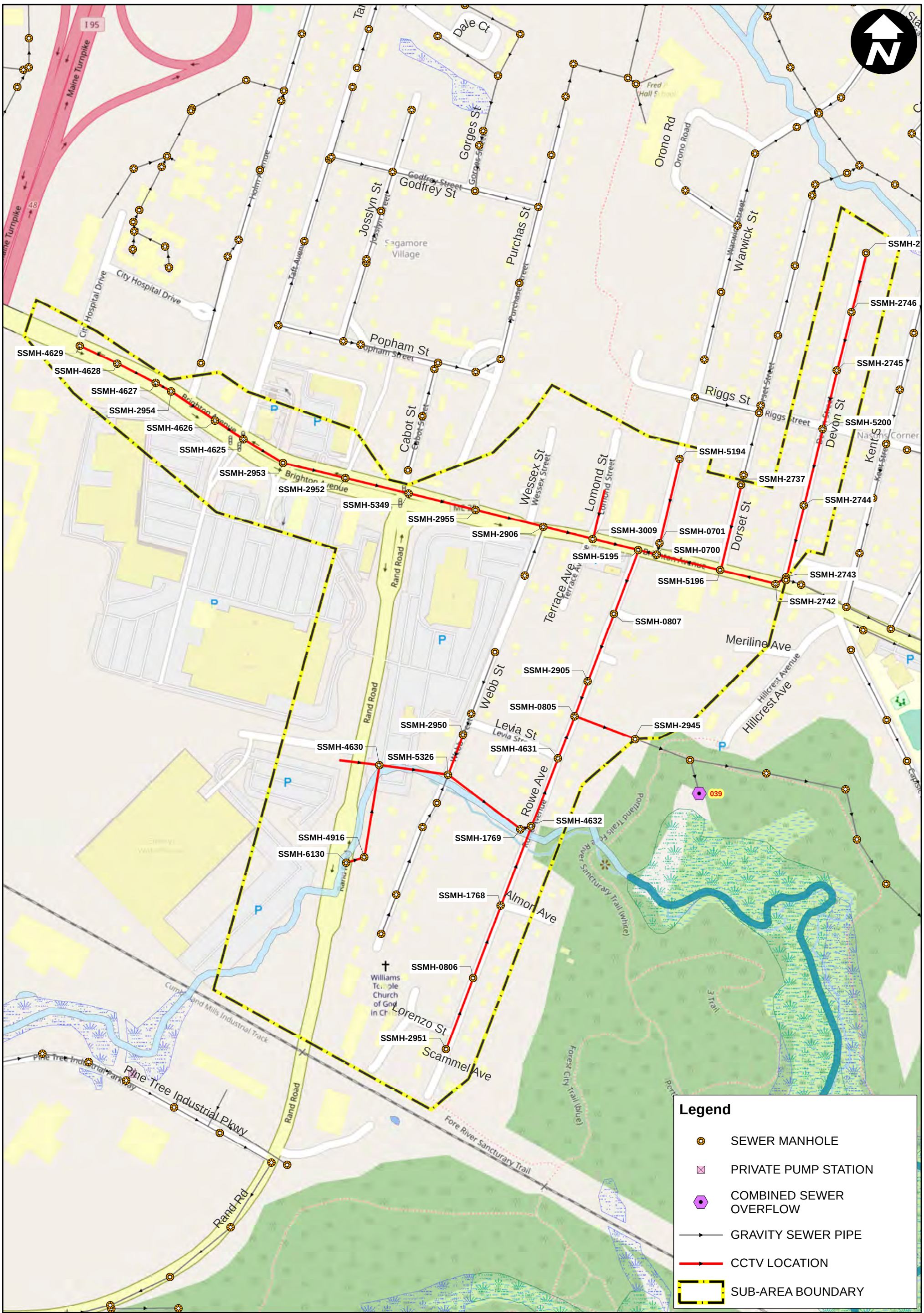

City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Sub-Area 20

Closed-Circuit Televised Inspection Locations

0 200 400 600 Feet

December 2018

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City of Portland, Maine

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Sub-Area 29

Closed-Circuit Televised Inspection Locations

0 100 200 300 400 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

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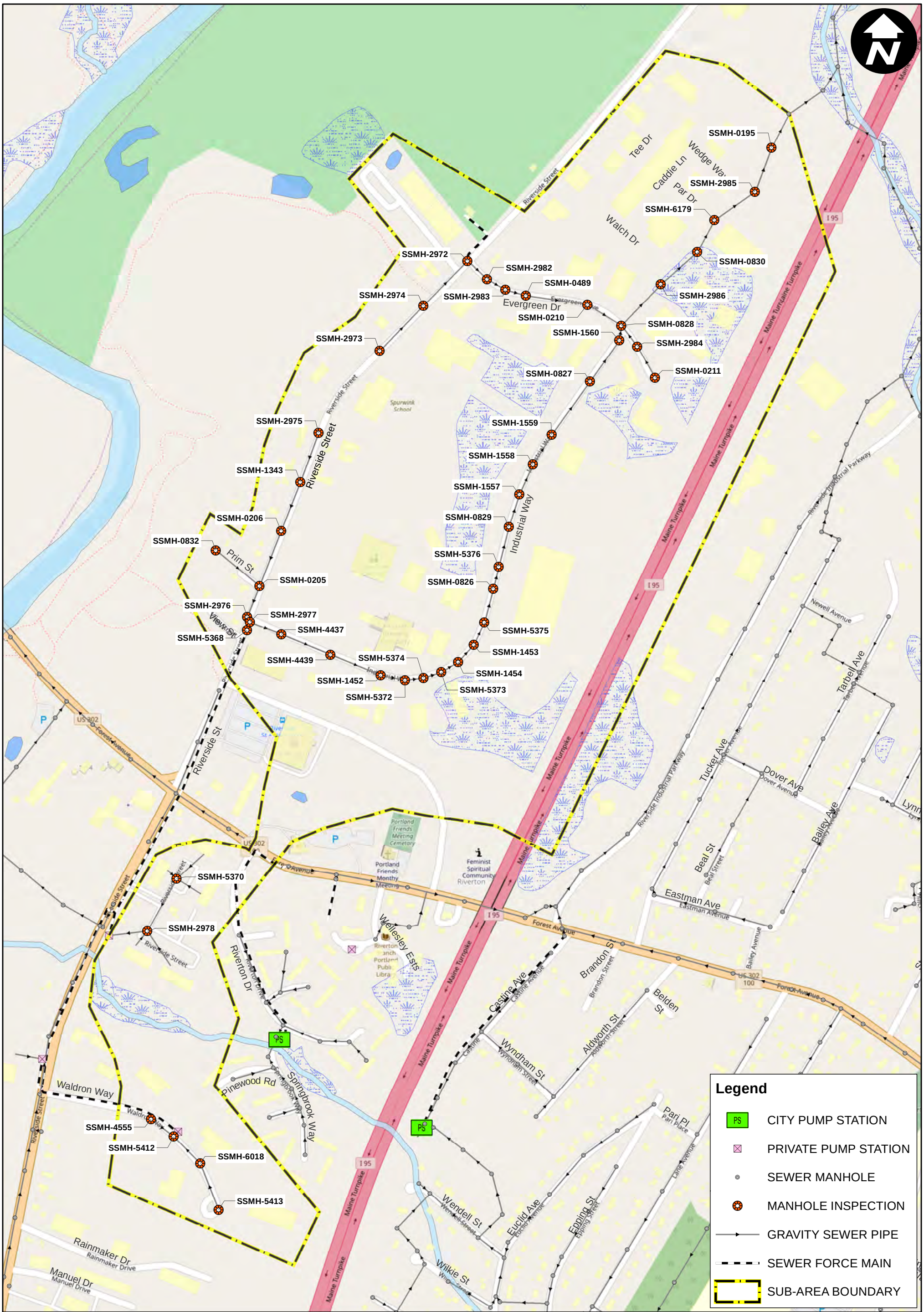
INFILTRATION AND INFLOW INVESTIGATIONS:

MANHOLE INSPECTION LOCATIONS



City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Sub-Area 4

Manhole Inspection Locations

December 2018

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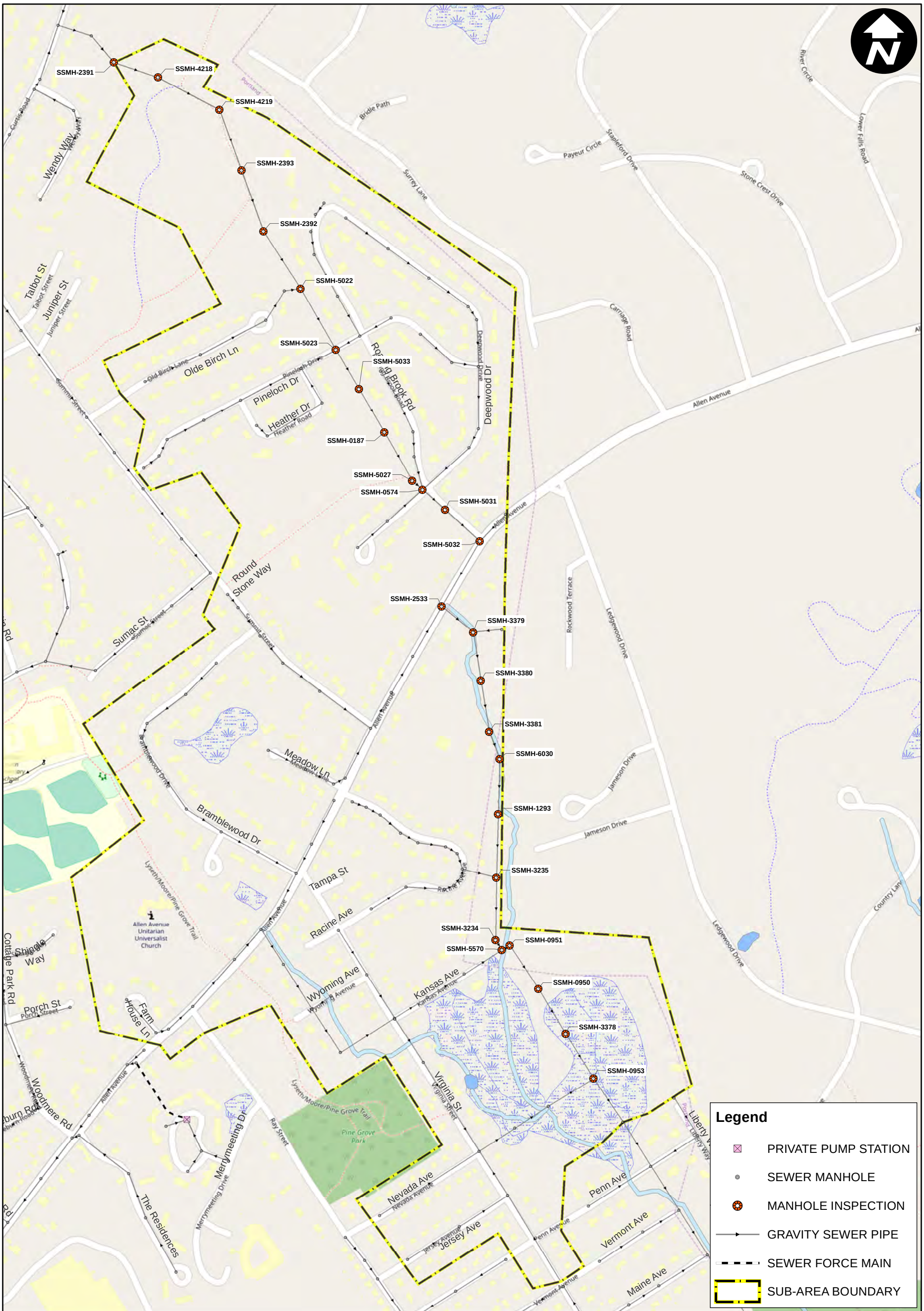

City of Portland, Maine

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Sub-Area 8

Manhole Inspection Locations

December 2018

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City of Portland, Maine

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Sub-Area 9

Manhole Inspection Locations

December 2018

ARCADIS Design & Consultancy for natural and built assets

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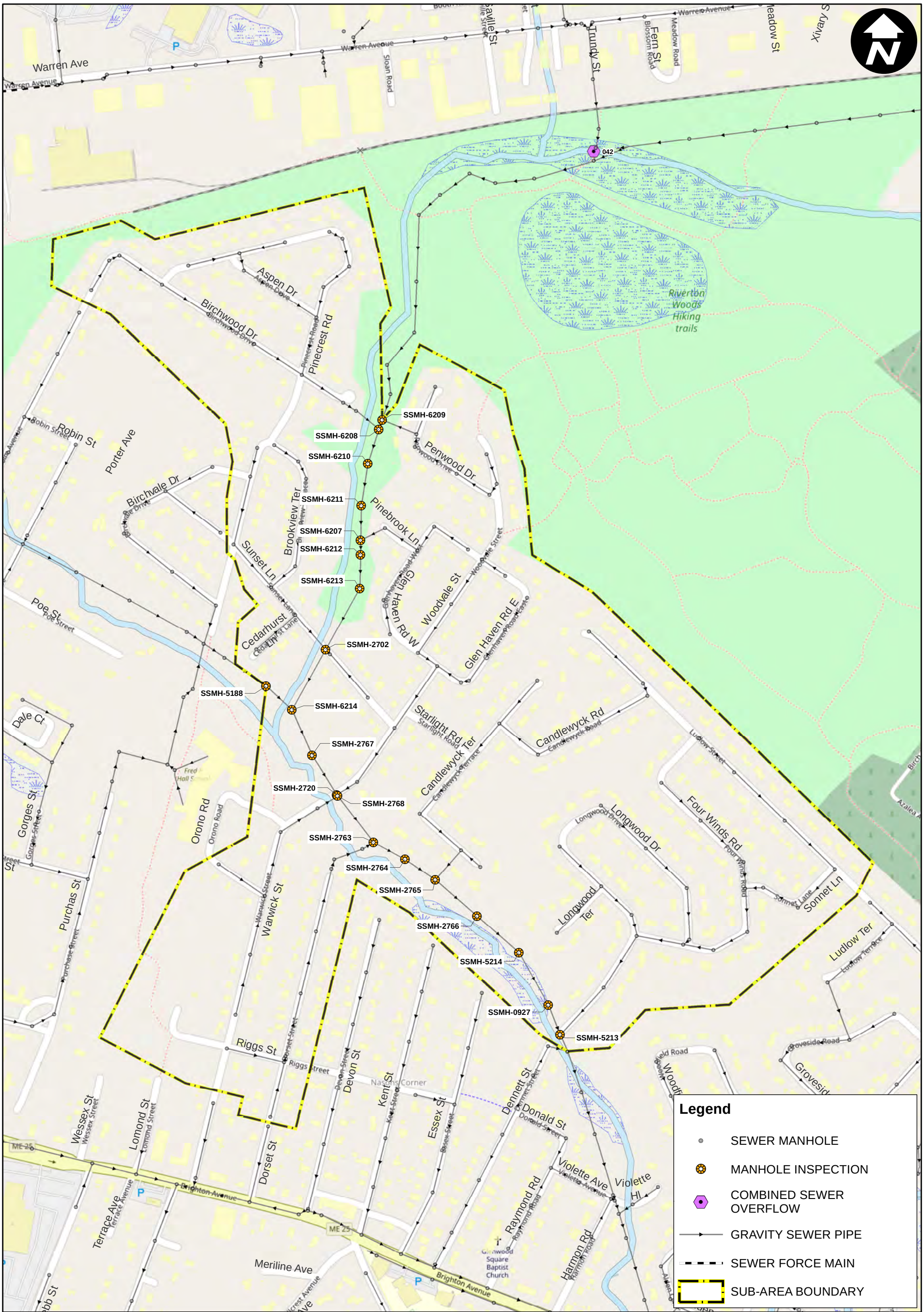

City of Portland, Maine

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Sub-Area 15

Manhole Inspection Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

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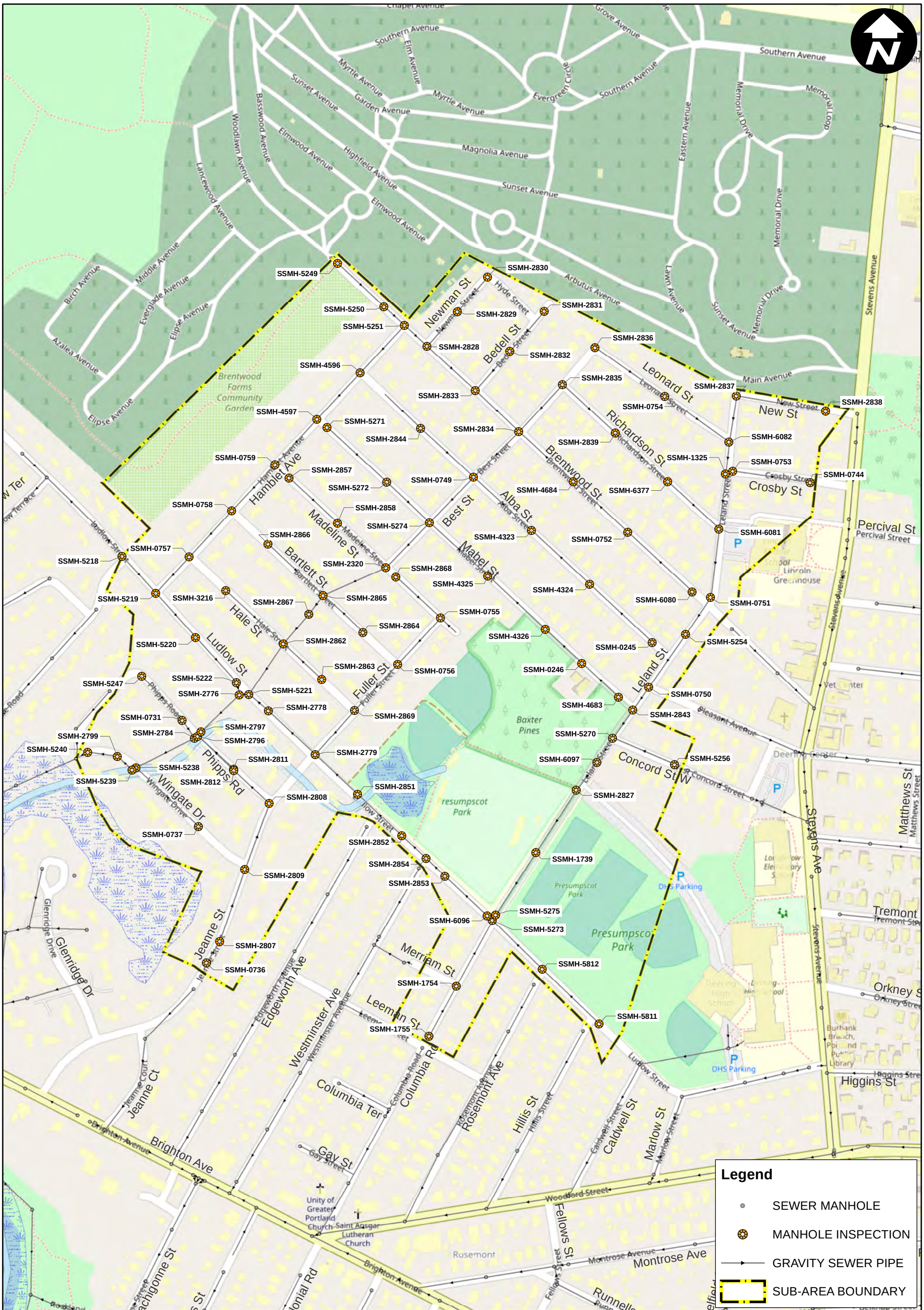

RESURGAM CITY OF PORTLAND, MAINE

City of Portland, Maine

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Sewer System
Evaluation Survey

Sub-Area 16

Manhole Inspection Locations

December 2018

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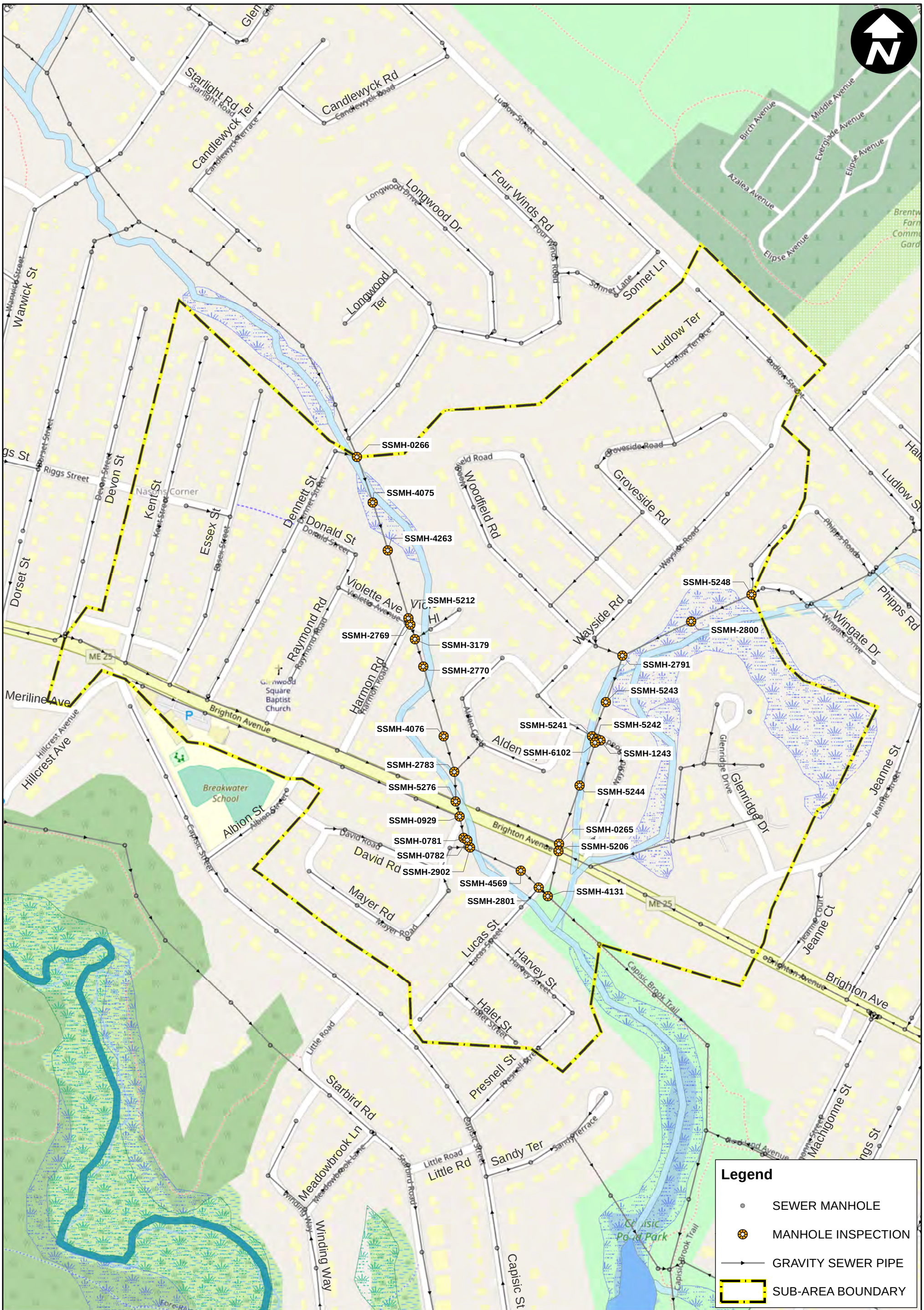

City of Portland, Maine

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Sub-Area 17

Manhole Inspection Locations

December 2018

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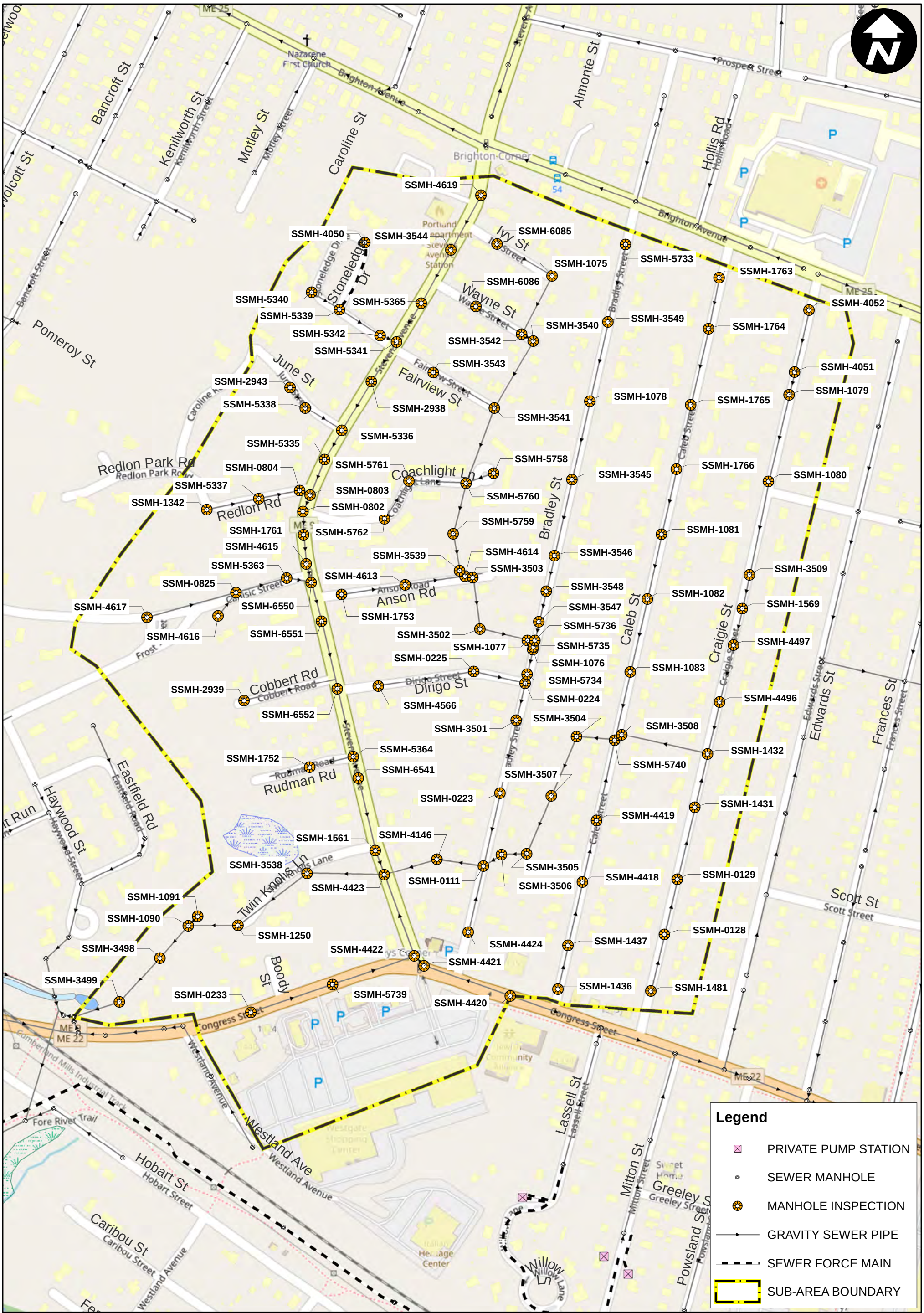

City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Sub-Area 22

Manhole Inspection Locations

December 2018

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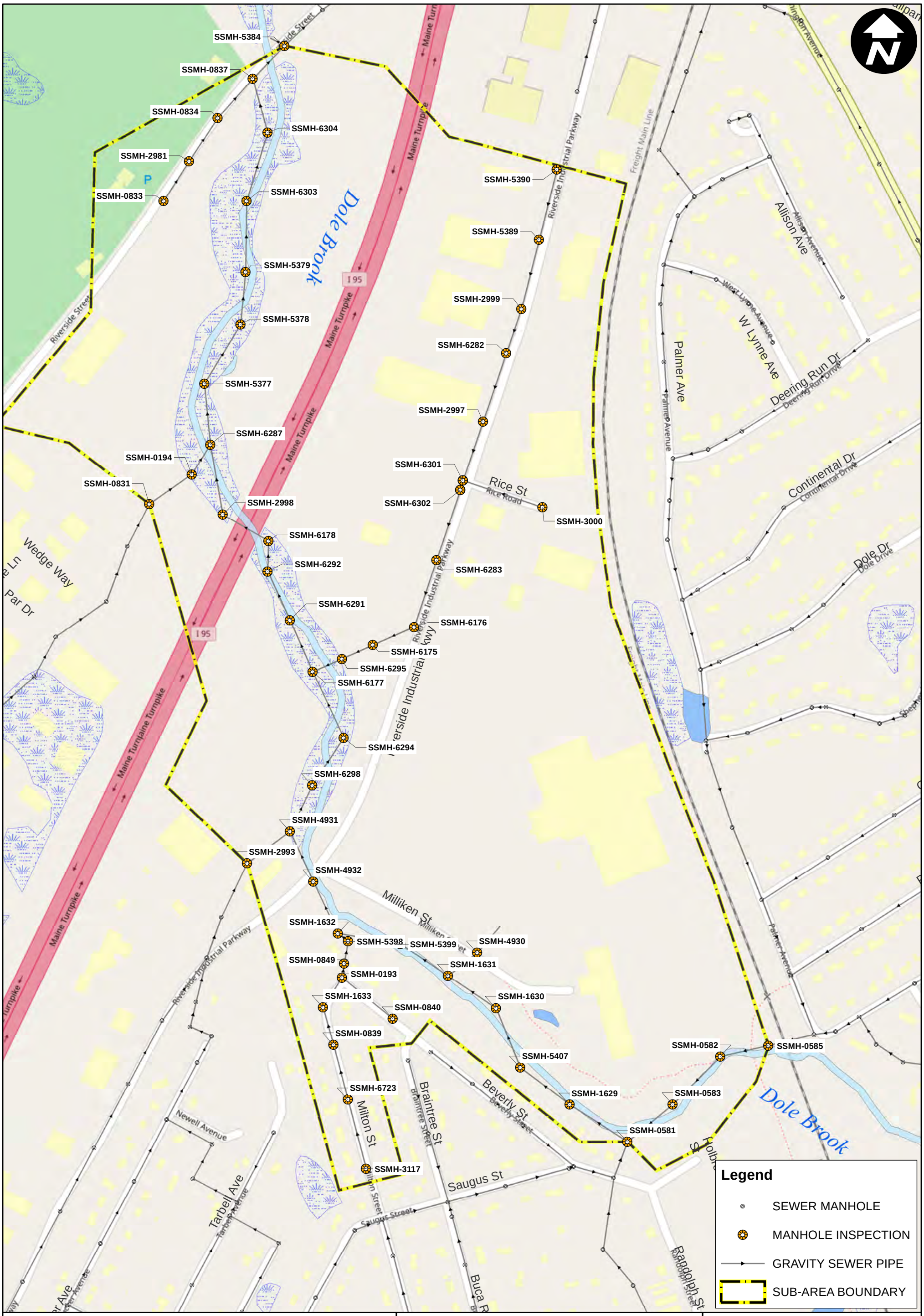

City of Portland, Maine

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Sub-Area 28

Manhole Inspection Locations

November 2018

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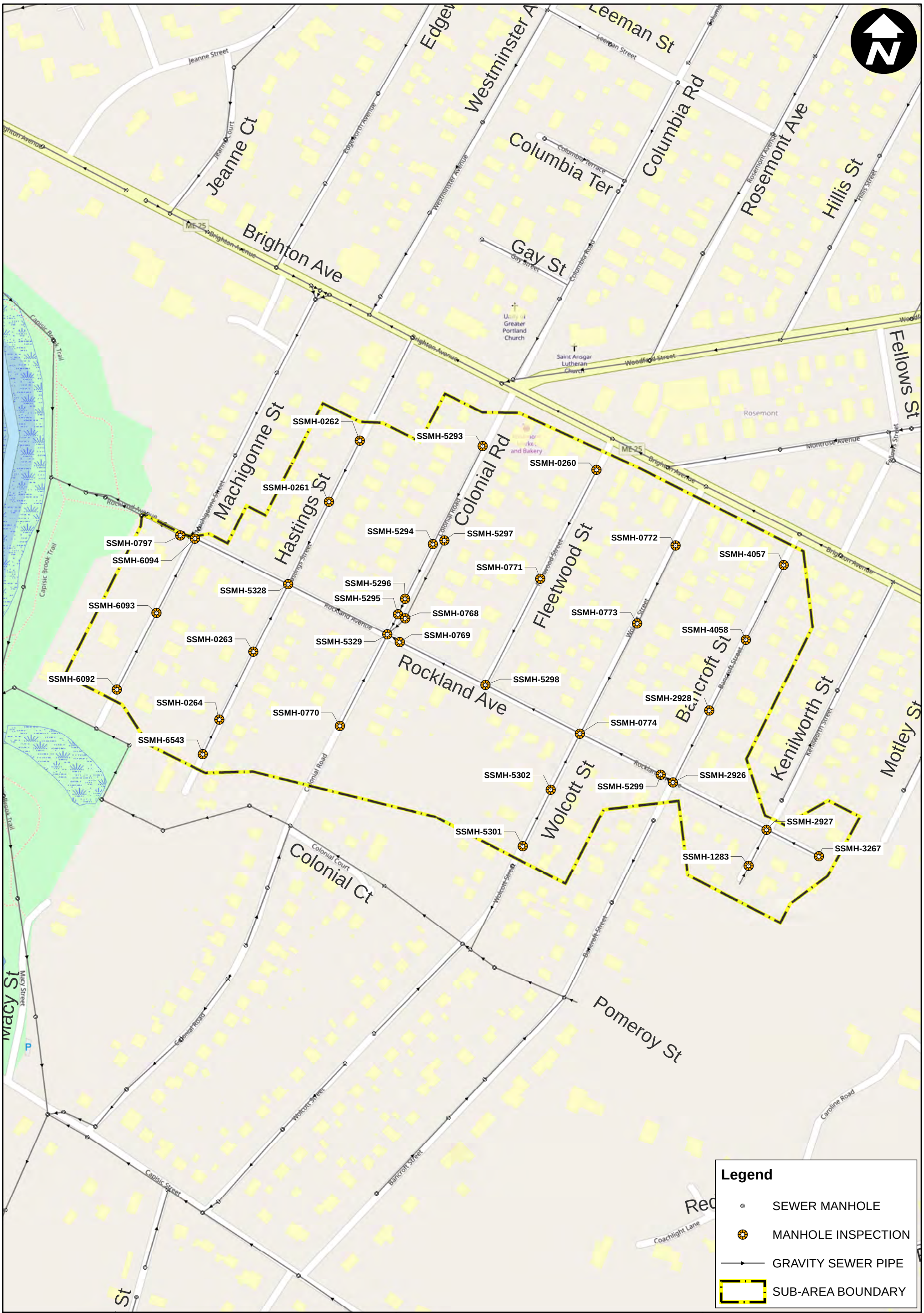

City of Portland, Maine

Planning & Engineering
Sewer System
Evaluation Survey

Sub-Area 29

Manhole Inspection Locations

0 100 200 300 400 Feet

December 2018

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