Christopher C. Branch, P.E.
Director of Public Works

Via Electronic Mail
December 28, 2018

Mr. Alex Rosenberg, Compliance Officer
Office of Environmental Stewardship
U.S. Environmental Protection Agency – Region 1
5 Post Office Square – Suite 100
Mail Code OES04-4
Boston, MA 02109-3912

Re: Inflow and Infiltration Phase 1 Report – 2018 Flow Monitoring

Dear Mr. Rosenberg:

As required in the Administrative Order Docket Number CWA-R1-AO-12-009, the City of Portland (City) is hereby submitting this Inflow and Infiltration Phase 1 Report for flow monitoring completed in 2018 as part of the Inflow and Infiltration Program. The Inflow and Infiltration Program was awarded to Arcadis through a Request for Qualification based process in May of 2017 and is currently on schedule for completion by April 2020 as required.

The attached report includes information regarding the two-year flow monitoring approach currently underway which will include the installation, maintenance, and monitoring of approximately 40 flow meters over two years. A second year of flow monitoring was planned to allow for potentially unfavorable weather conditions, the ability to meter small subsections of each sub-area, and time to allow for corrections to the City's GIS. This report summarizes the results of the first 20 flow meters for monitoring completed in 2018.

Currently, Arcadis is utilizing subcontractors Flow Assessment Services and Ted Berry Company to begin the Investigation of Major Inflow and Infiltration Sources as part of Phase 2 for areas identified in Phase 1 as having greater than 4,000 gallons per day per inch diameter/mile. Flow isolation for several areas has already been completed in December 2018. During the spring of 2019, Arcadis will continue working with Flow Assessment Services to complete additional flow monitoring work, including 11 more sub-areas, and to begin manhole inspections. Investigations to identify direct inflow will occur in the summer of 2019.

You may notice within the report that sub-area 13 is specifically called out as being investigated through another project and recommendations are not provided within Appendix C. Sub-area 13 was identified as an area that would benefit from a fast-tracked investigation because Combined Sewer Overflow (CSO) #42 is located within it. Past separation projects within this sub-area have not yielded enough reduction in flow to allow for the closure of the CSO. To achieve a more expedient result utilizing the same processes as the overall Inflow and Infiltration Program, the City added a specific task simply titled CSO 42. Arcadis has implemented Inflow and Inflow Program processes in a shorter time frame that the overall program which has included flow monitoring, large building investigations, smoke testing, and flow isolation. The City will continue to work with Arcadis to investigate Inflow and Infiltration in the sub-area and to determine the most efficient

method to reduce Inflow and Infiltration in order to close the CSO. Additional funding was added to the Payable Order and Arcadis has assigned separate resources to this task to ensure that it does not take away from the broader Inflow and Infiltration Program. You will find this project title within the invoices and status report included in the Annual Report to be submitted at the end of January.

The City continues to look forward to working with Arcadis and its subcontractors to identify sources of Inflow and Infiltration throughout the collection system. Should you have any questions or want to discuss this report or the program in general, please reach out to me at your convenience.

Thank you,

Benjamin Pearson

Benjamin N. Pearson, PE
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City of Portland, Maine

# PHASE 1 INVESTIGATION OF FLOWS – 2018 MONITORING

DECEMBER 2018

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# EXECUTIVE SUMMARY

On September 29, 2012, the United States Environmental Protection Agency (US EPA) issued an Order for Compliance and Complaint to the City of Portland for sanitary sewer overflows (SSOs) from non-permitted portions of the City's sewer 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 an Infiltration/Inflow (I/I) Removal and Monitoring Program.

This report summarizes the results of Phase 1 of the I/I Program and provides recommendations for Phase 2 flow monitoring and investigations. In conjunction with the implementation of the flow monitoring program, Phase 1 includes engineering analysis of flow data, including calculation of average daily flow, peak daily flow and peak hourly flow, and estimation of infiltration and inflow for each meter area. Meter areas were evaluated and ranked by quantities of infiltration and inflow, and follow-on investigation recommendations were developed based on these evaluations and rankings.

The two-phase flow monitoring program includes installation, maintenance and monitoring of approximately 40 flow meters over a period of 2 years. This report summarizes the results of the first 20 meters. The program was planned as a 2-year program to allow for potentially unfavorable weather conditions (low precipitation or groundwater), the ability to meter small subsections of each sub-area in Year 2 (as established by the first year of data), and time to allow for corrections to the City's collection system mapping and pipeline connectivity.

## Results and Recommendations

Based on the Phase 1 metering results summarized in Section 3.1 of this report and ongoing sewer system investigations, Phase 2 follow-on recommendations were developed. Recommendations, as detailed in Section 3 of this Report, include:

- Flow isolation of 194,740 linear feet (LF) of pipe
- Closed circuit television inspection (CCTV) of 27,611 LF of pipe
- Four hundred and forty-three (443) manhole inspections
- Implementation of a Spring 2019 flow monitoring program

Individual sub-area maps showing follow-on recommendations are included in Appendix C of this report.

In accordance with the Phase 1 metering results, flow isolation was completed in December 2018 and CCTV inspections are currently being conducted. Manhole inspections will be conducted in the Spring of 2019.

Investigations to identify direct inflow (i.e., smoke testing, dye testing and large building inspections), will be conducted in the Summer of 2019 upon completion of the Spring 2019 flow metering program.

The second phase of the flow monitoring program (Spring 2019), will include eleven (11) sub-areas that were not included in the first phase of flow metering. Metering data will be evaluated in the same fashion as the 2018 metering data (as presented herein), and follow-on investigations will be developed to further identify and eliminate I/I.

# 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 an Infiltration/Inflow (I/I) Removal and Monitoring Program, as well as making improvements to the City's collection system GIS by supplementing and correcting data gaps. This I/I 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 the sanitary collection system.

This report summarizes the results of Phase 1 of the I/I Program, a comprehensive flow monitoring program, and provides recommendations for Phase 2, investigation and rehabilitation. Phase 1 includes development of a flow monitoring strategy that includes review of recommended meter sites from the CMOM report, identification of other suitable sites, field verification of these sites, recommendation of initial sites, installation of flow monitoring equipment and data collection and maintenance procedures for the flow monitoring equipment. In conjunction with implementation of the flow monitoring program, Phase 1 includes engineering analysis of flow data, including calculation of average daily flow, peak daily flow, peak hourly flow, infiltration and inflow for each meter area. Meter areas were ranked by quantity of infiltration and inflow and follow-on investigation recommendations were developed.

The flow monitoring program includes installation, maintenance and monitoring of 40 flow meters over a period of 2 years. This report summarizes the results of the first 20 meters installed. The program was planned as a 2-year program to allow for potentially unfavorable weather conditions (low precipitation or groundwater), the ability to meter small subsections of each sub-area in year 2 (if required based on the first's year's data), and time to allow for corrections to the City's collection system mapping and pipeline connectivity.

## 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.

# THE CITY OF PORTLAND, MAINE

*Phase 1: Investigation of Flows - 2018 Monitoring*

0 0.25 0.5 1 Miles

December 2018

# FIGURE 1 - CITY OF PORTLAND COLLECTION SYSTEM MAP

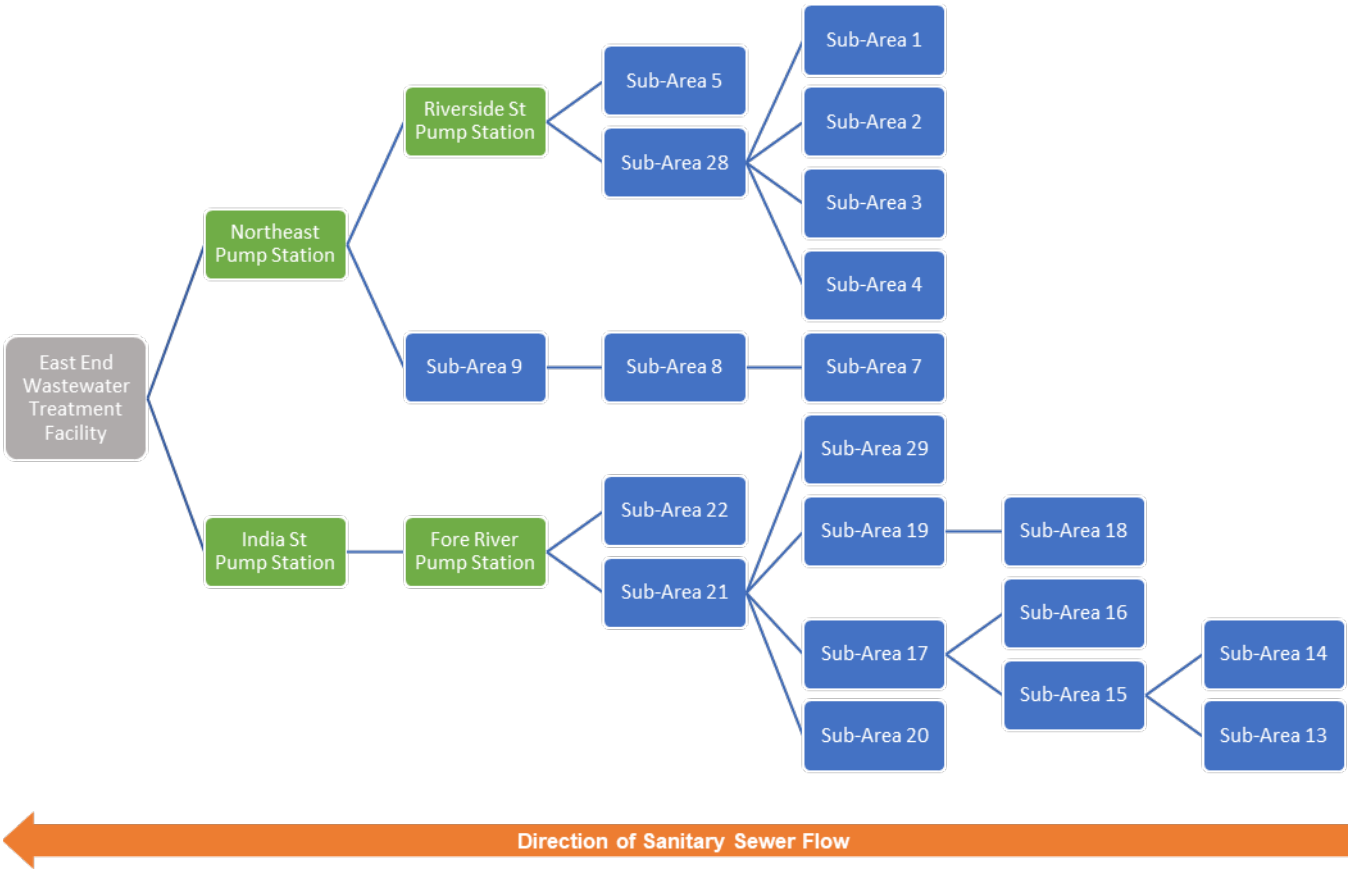
ARCADIS Design & Consultancy for natural and built assets

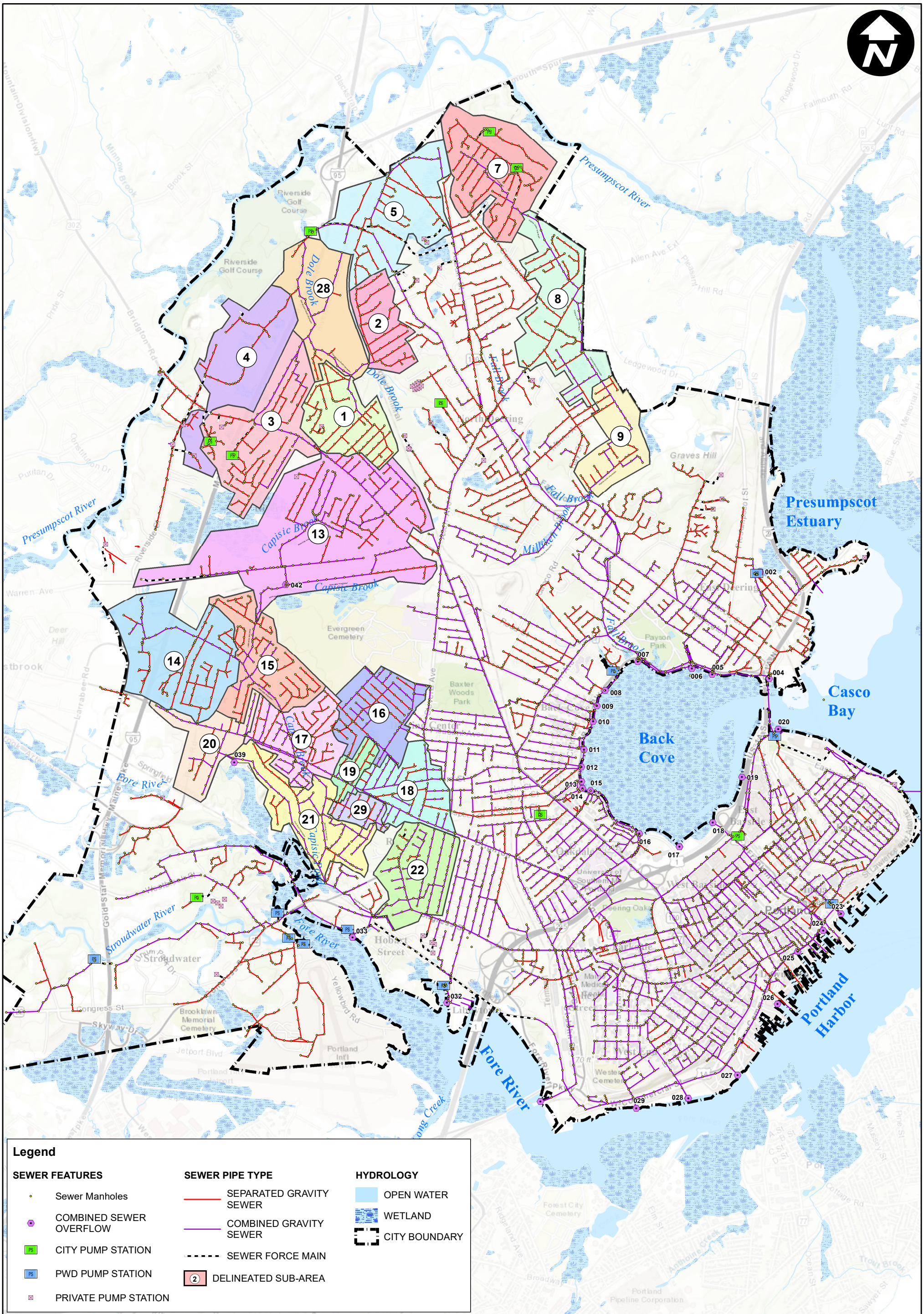
G:\GIS\Portland\2018 I-I Report\FIGURE 1 - CITYWIDE SANITARY SEWER SYSTEM.mxd

## 1.2.1 Sub-Area Delineation

The first phase of the metering program included the delineation of 20 sub-areas throughout the City. 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 20 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 metering program are shown on Figure 3.

**Figure 2. Flow Vector Diagram**






# THE CITY OF PORTLAND, MAINE

*Phase 1: Investigation of Flows - 2018 Monitoring*

0 0.25 0.5 1 Miles

December 2018

# FIGURE 3 - 2018 SUB-AREA DELINEATION

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 I-I Report\FIGURE 3 - 2018 SUB-AREA DELINEATION.mxd

# 2 2018 METERING ANALYSIS

In March 2018, Arcadis and its subcontractor, Flow Assessment Services (FAS) completed a 16-week flow monitoring program of 20 sub-areas throughout the City of Portland. Meters were installed by FAS in the most downstream manhole of each sub-area where hydraulic conditions were conductive for metering. Metering was performed using continuous monitoring devices incorporating depth and velocity sensors to measure velocity, depth and flow rate. Two record tipping bucket rain gauges measuring rainfall every fifteen minutes were installed on the roof of the Fore River Pump Station and the Riverton Fire Station. Rain gauge data was supplemented with data from the City-owned rainfall gauge at the Riverside Street Pump Station.

Two permanent groundwater monitoring wells were installed on May 6, 2018 at the intersection of Martin Street and Bartley Street and on Leland Street across from the Deering High School parking lot. Maintenance and data collection for the groundwater gauges, rainfall gauges and flow meters was conducted bi-weekly by Flow Assessment Services.

## 2.1 Wastewater Characteristics

There are three major components of wastewater flow in a sanitary sewer system, base sanitary flow (BSF), groundwater infiltration (GWI) and rainfall derived inflow and infiltration (RDII - commonly referred to as 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.

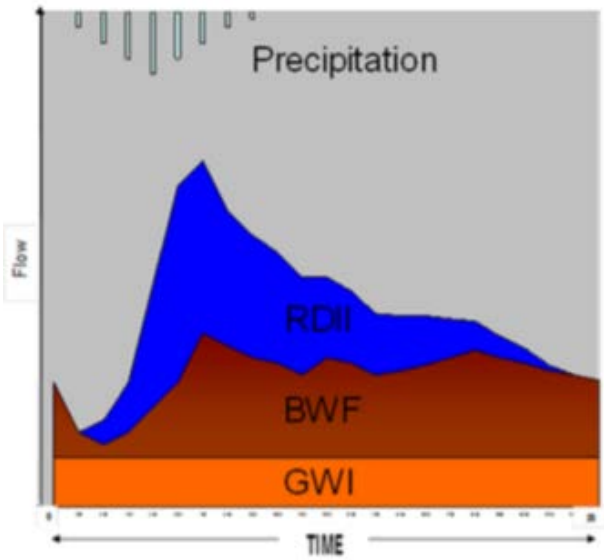
*Delayed Inflow Volume* – The portion of total inflow which is generated from indirect connections to the collection system or connections which produce inflow after a significant time delay from the beginning of a storm. Delayed inflow sources include: sump pumps, foundation drains, indirect sewer/drain 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.

*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.

Rainfall derived infiltration and inflow includes both rainfall-induced infiltration and inflow. 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.

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




The City of Portland's collection system consists of approximately 240 miles of separated and combined sewers. A traditional infiltration and inflow analysis was conducted in the separated portion of the collection system, while a modified approach was used in the combined portion of the collection system. In the sub-areas where 75% or more of the collection system was separated, the I/I analysis focused on identifying groundwater infiltration, rainfall-induced infiltration and direct inflow. In the combined subareas, the I/I analysis focused on identifying groundwater infiltration and rainfall-induced infiltration (delayed inflow). Large volumes of direct inflow are expected in a combined system due to known cross connections between the sanitary system and the drainage system. While direct inflow values were calculated in these sub-areas, they were not used to develop follow-on investigation recommendations. Table 1 includes a summary of the total pipeline footage, percentage of combined pipes and the approach method for each sub-area.

**Table 1. Sub-area Characteristics**

| Sub-area | Total Footage (LF) | Percent Combined (%) | Approach |
|---|---|---|---|
| Sub-Area 1 | 19,997 | 7% | Traditional |
| Sub-Area 2 | 11,918 | 2% | Traditional |
| Sub-Area 3 | 28,692 | 36% | Modified |
| Sub-Area 4 | 8,893 | 0% | Traditional |
| Sub-Area 5 | 21,962 | 16% | Traditional |
| Sub-Area 7 | 23,684 | 13% | Traditional |
| Sub-Area 8 | 25,297 | 40% | Modified |
| Sub-Area 9 | 10,989 | 53% | Modified |
| Sub-Area 13 | 48,470 | 57% | Modified |
| Sub-Area 14 | 23,488 | 24% | Traditional |
| Sub-Area 15 | 22,812 | 30% | Modified |
| Sub-Area 16 | 21,410 | 67% | Modified |
| Sub-Area 17 | 24,822 | 48% | Modified |
| Sub-Area 18 | 19,962 | 85% | Modified |
| Sub-Area 19 | 5,677 | 35% | Modified |
| Sub-Area 20 | 9,924 | 79% | Modified |
| Sub-Area 21 | 21,047 | 76% | Modified |
| Sub-Area 22 | 19,133 | 93% | Modified |
| Sub-Area 28 | 11,010 | 75% | Modified |
| Sub-Area 29 | 6,174 | 34% | Modified |

## 2.2 Results and Findings

Table 2 identifies the average daily flow (ADF), peak daily flow (PDF) and peak hourly flow (PHF) measured from March 7, 2018 through July 16, 2018 for each of the twenty 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 over 24-hours measured throughout the metering period. Peak hourly flow is the maximum 1-hour 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 net average daily flow within each sub-area itself (with upstream tributary flows subtracted out), net peak daily flow, net peak hourly flow and the hourly peaking factor.

**Table 2. Flow Metering Results – ADF, PDF, PHF**

| Sub-Area | Average Daily Flow (GPD) | Peak Daily Flow (GPD) | Peak Hourly Flow (GPD) | Hourly Peaking Factor |
|---|---|---|---|---|
| Sub-Area 1 | 147,060 | 382,063 | 870,000 | 6 |
| Sub-Area 2 | 65,234 | 129,833 | 180,750 | 3 |
| Sub-Area 3 | 170,348 | 296,042 | 570,000 | 3 |
| Sub-Area 4 | 150,666 | 270,896 | 765,500 | 5 |
| Sub-Area 5 | 184,123 | 398,698 | 630,750 | 3 |
| Sub-Area 7 | 171,871 | 413,010 | 701,000 | 4 |
| Sub-Area 8* | 125,390 | 484,365 | 1,104,750 | 9 |
| Sub-Area 9* | 142,673 | 408,188 | 957,000 | 7 |
| Sub-Area 13 | 680,228 | 1,779,313 | 2,589,750 | 4 |
| Sub-Area 14 | 271,125 | 579,698 | 1,220,500 | 5 |
| Sub-Area 15* | 89,215 | 358,104 | 2,902,875 | 33 |
| Sub-Area 16 | 425,703 | 1,472,542 | 4,129,000 | 10 |
| Sub-Area 17* | 67,371 | 319,948 | 1,257,500 | 19 |
| Sub-Area 18 | 408,780 | 1,633,229 | 4,159,000 | 10 |
| Sub-Area 19* | 72,388 | 872,031 | 2,812,750 | 39 |
| Sub-Area 20 | 247,097 | 2,416,948 | 7,569,000 | 31 |
| Sub-Area 21* | 115,428 | 1,489,417 | 1,607,250 | 14 |
| Sub-Area 22 | 340,367 | 2,281,698 | 6,500,250 | 19 |
| Sub-Area 28* | 105,904 | 401,594 | 847,750 | 8 |
| Sub-Area 29 | 112,546 | 865,542 | 2,859,000 | 25 |

*Denotes net values with tributary sub-areas subtracted.

Hyetographs showing average daily flow and rainfall for each of the 20 sub-areas are included in Appendix B.

## 2.3 Groundwater Infiltration

Groundwater infiltration is defined as groundwater that enters or leaks into a sanitary sewer system through defective pipes, pipe joints, service connections, or manholes. The average groundwater infiltration rate is defined as 85% of the nighttime sanitary flow measured on dry days from 12:00am to 6:00am throughout the entire metering period. Only data for days that follow a minimum of 72-hours without a rainfall event are considered “dry days” to avoid inclusion of indirect inflow and rainfall induced infiltration (RII) in the infiltration estimate.

Groundwater levels were monitored throughout the metering period using the two groundwater monitoring wells installed. The groundwater depth during the metering period was analyzed in relation to the average sewer pipe elevations in the area, as shown in Figure 5, as groundwater depth can have a significant influent on the amount of groundwater infiltration entering a collection system.

Groundwater infiltration for each sub-area is normalized by calculating the gallons per day per inch diameter mile of pipe (gpd/in-mi). The inch-diameter-mile of pipe, or inch-miles (in-mi), in a sub-area is calculated by multiplying the sum of the miles of for each diameter of pipe by its respective inch diameter. As an example, if a system contained 1 mile of 10-inch diameter, 1.5 miles of 12-inch diameter, and 0.5 miles of 25-inch diameter of gravity sewers, the calculated inch-miles would be as follows:

(10-inch x 1 mile) + (12-inch x 1.5 miles) + (24-inch x 0.5 mile) = 40 in-mi

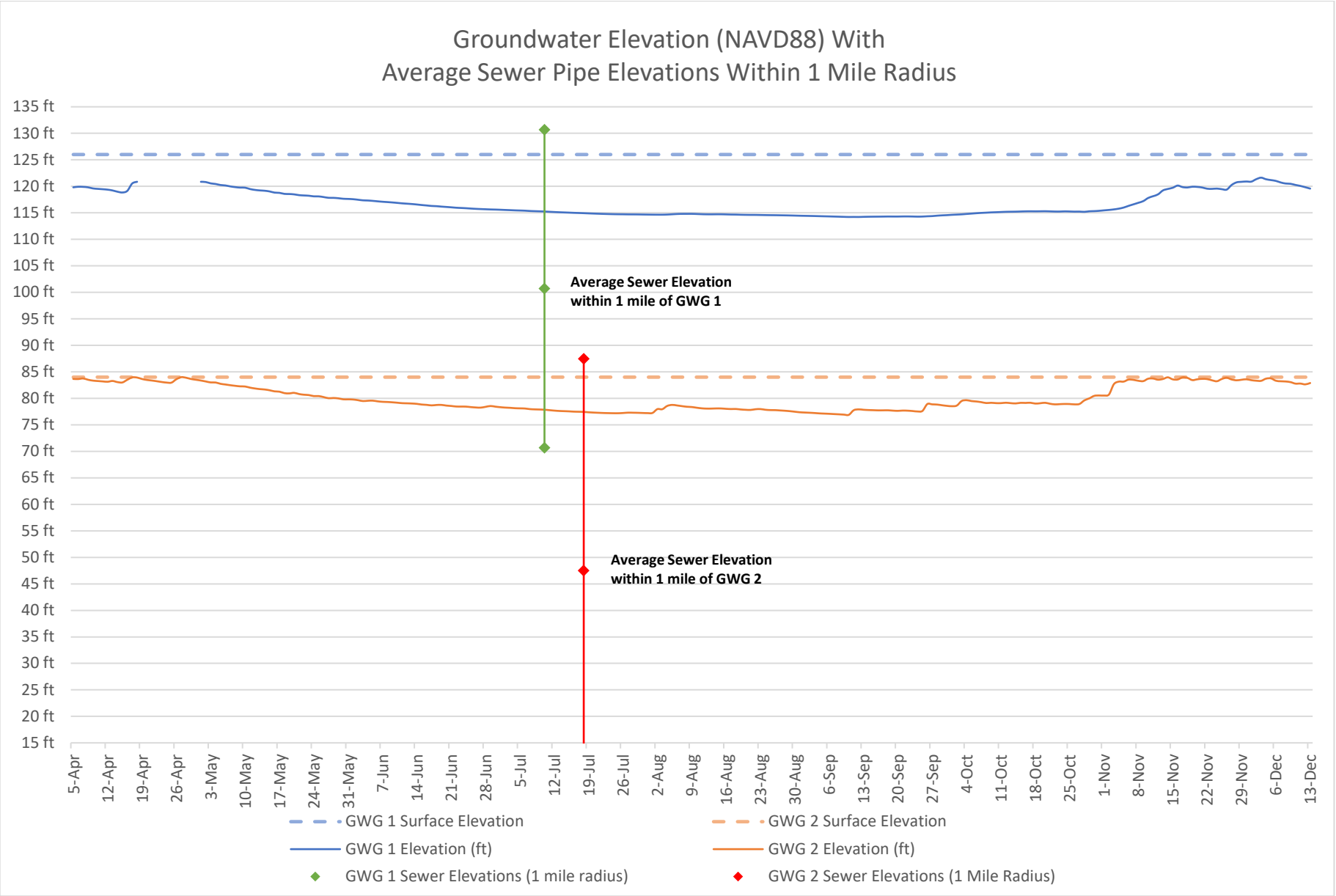
Groundwater infiltration rates for each sub-area were calculated by dividing the sub-area’s total groundwater infiltration by the number of inch-miles of sanitary sewer within the sub-area. The total groundwater infiltration rates for each sub-area during the metering period are shown in Table 3.

**Table 3. Flow Metering Results – Infiltration**

| Sub-Area | Average Daily Flow (gpd) | Net Average Infiltration (gpd) | Infiltration GPD/Total LF (GPD/LF) | Gallons per Day per Inch-Mile (GPDIM) |
|---|---|---|---|---|
| Sub-Area 1 | 147,060 | 78,910 | 3.9 | 2,515 |
| Sub-Area 2 | 65,234 | 36,879 | 3.1 | 1,884 |
| Sub-Area 3 | 170,348 | 91,912 | 3.2 | 1,968 |
| Sub-Area 4 | 150,666 | 83,726 | 9.4 | 6,055 |
| Sub-Area 5 | 184,123 | 97,130 | 4.4 | 2,444 |
| Sub-Area 7 | 171,871 | 97,191 | 4.1 | 2,505 |
| Sub-Area 8 [1, 2] | 125,390 | 69,114 | 2.7 | 1,355 |
| Sub-Area 9 [1, 2] | 142,673 | 75,325 | 6.9 | 2,427 |
| Sub-Area 13 | 680,228 | 374,236 | 7.7 | 2,354 |
| Sub-Area 14 | 271,125 | 152,698 | 6.5 | 3,489 |
| Sub-Area 15 [1, 2] | 89,215 | 66,479 | 2.9 | 1,411 |
| Sub-Area 16 | 425,703 | 279,739 | 13.1 | 5,375 |
| Sub-Area 17 [1, 2] | 67,371 | 70,823 | 2.9 | 1,310 |
| Sub-Area 18 | 408,780 | 209,635 | 10.5 | 4,487 |
| Sub-Area 19 [1, 2] | 72,388 | 43,517 | 7.7 | 2,469 |
| Sub-Area 20 | 247,097 | 118,081 | 11.9 | 4,235 |
| Sub-Area 21 [1, 2] | 115,428 | *N/A* | *N/A* | *N/A* |
| Sub-Area 22 | 340,367 | 128,450 | 6.7 | 2,367 |
| Sub-Area 28 [1, 2] | 105,904 | 50,821 | 9.6 | 1,527 |
| Sub-Area 29 | 112,546 | 50,357 | 8.2 | 4,445 |

Notes: 1. Collects flows from tributary sub-areas 2. Flow meter results indicate some negative net flows when tributary sub-areas are subtracted. Further investigations will be done during the next phase to account for negative values.

Figure 5 - Groundwater Depth with Average Sewer Pipe Elevations



## 2.4 Rainfall Derived Infiltration and Inflow (RDII)

Four rainfall events from the metering period were analyzed to calculate rainfall derived infiltration and inflow. Precipitation data was used from rain gauges at the Riverside Road Pump Station, Riverton Fire Station and the Fore River Pump Station. Table 4 outlines the duration, total rainfall and peak intensity of the four selected storms. The rainfall data from the April 16, 2018 storm event was only available from the Riverside Pump Station rain gauge and therefore was used in the inflow analysis for all sub-areas for that storm event. For the additional three storm events, the analysis used rainfall data from the closest rain gauge to the flow meter. The Riverside Pump Station rain gauge serviced sub-areas 1, 2, 3, 4, 5, 7, 8 and 9. The Riverton Fire Station rain gauge serviced sub-areas 13, 14, 15, 16 and 17 and the Fore River Pump Station rain gauge serviced sub-areas 18, 19, 20, 21, 22, 28 and 29.

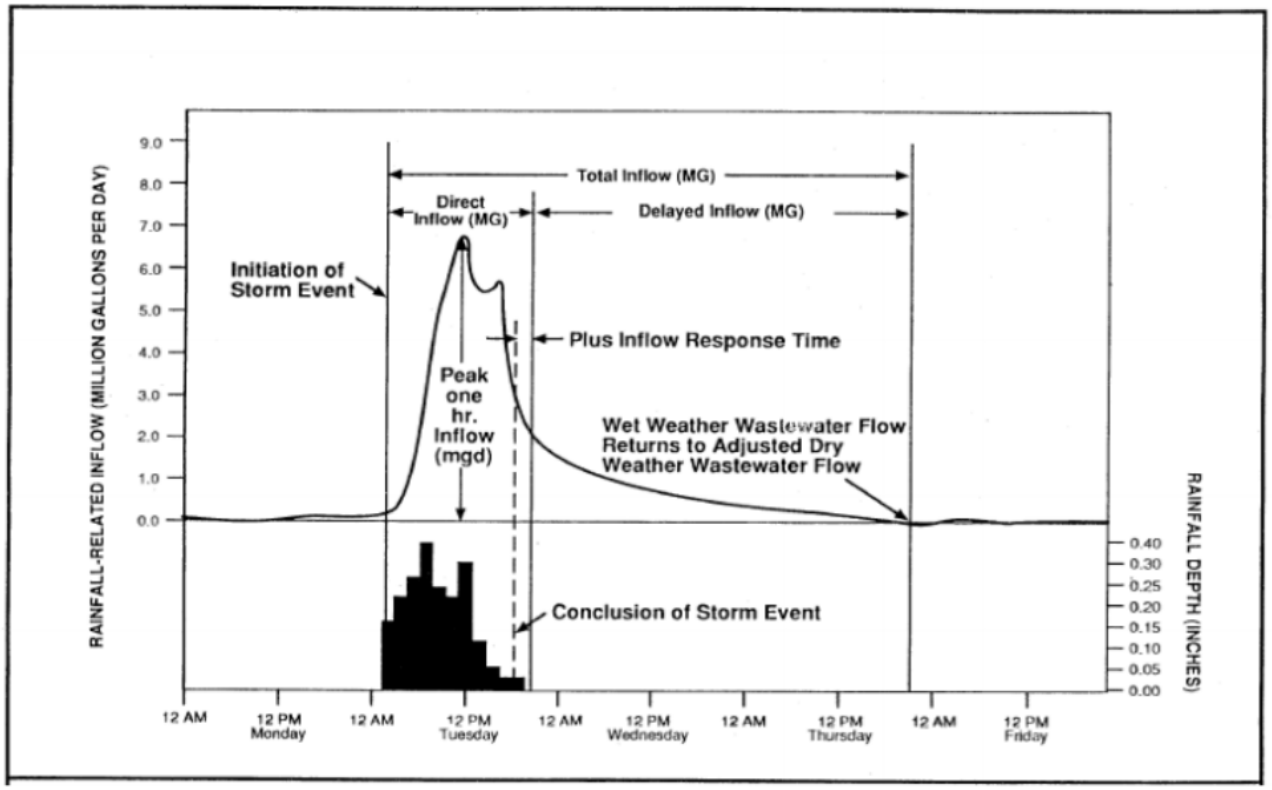
**Table 4. Inflow Analysis – Selected Rainfall Events**

| Location | Rainfall Event | Duration (min) | Total Rainfall (in) | Peak Intensity (in/hr) |
|---|---|---|---|---|
| Riverside PS | 4/16/18 8:00 AM | 960 | 2.9 | 0.59 |
| Riverside PS | 4/25/18 12:45 PM | 1215 | 2.59 | 0.48 |
| Riverside PS | 6/18/18 4:00 PM | 165 | 1.07 | 0.77 |
| Riverside PS | 6/27/18 10:45 PM | 1215 | 1.43 | 0.28 |
| Riverton RG | 4/25/18 12:45 PM | 1230 | 1.67 | 0.29 |
| Riverton RG | 6/18/18 4:15 PM | 165 | 1.13 | 0.85 |
| Riverton RG | 6/27/18 10:45 PM | 1200 | 1.34 | 0.2 |
| Fore River PS | 4/25/18 12:45 PM | 1245 | 1.76 | 0.28 |
| Fore River PS | 6/18/18 4:15 PM | 135 | 0.96 | 0.75 |
| Fore River PS | 6/27/18 10:45 PM | 1245 | 1.56 | 0.3 |

A wet weather hydrograph from each storm event was compared to a dry weather period on the same day of the week as each storm event. The dry weather flow is subtracted from the wet weather flow resulting in the inflow volumes presented in Table 5. The dry weather flow is calculated as an average of all dry days during the metering period for each day during the week. For example, all dry “Mondays” in the metering period are averaged together to determine the dry weather flow for each individual day.

The hydrograph shown as Figure 6 shows a typical inflow response to wet weather flow. The portion of inflow occurring during the storm event is identified as direct inflow and the portion of inflow that occurs once the storm has concluded is delayed inflow. Total inflow encompasses both direct and delayed inflow.

**Figure 6. Wet Weather Hydrograph (MassDEP, 1993)**




For the purposes of this study, direct inflow was calculated for all sub-areas; however, where the modified approach was used, only the delayed inflow results were used in the development of follow-on investigation recommendations.

Table 5 – Flow Metering Results - Inflow

| Sub-Area | 4/16/2018 Storm Event | | | 4/25/2018 Storm Event | | | 6/18/2018 Storm Event | | | 6/27/2018 Storm Event | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Direct (gal) | Delayed (gal ) | Total (gal) | Direct (gal) | Delayed (gal) | Total (gal) | Direct (gal) | Delayed (gal) | Total (gal) | Direct (gal) | Delayed (gal) | Total (gal) |
| Sub-Area 1 | **237,480** | **236,470** | **473,951** | **141,300** | **121,100** | **262,400** | **600** | **0** | **600** | **2,900** | **4,200** | **7,100** |
| Sub-Area 2 | **42,099** | **66,764** | **108,863** | **37,500** | **46,000** | **83,500** | **0** | **0** | **0** | **1,700** | **400** | **2,100** |
| Sub-Area 3 | 138,499 | **133,903** | 272,402 | 90,600 | **91,300** | 181,900 | 6,800 | **800** | 7,600 | 15,700 | **3,600** | 19,300 |
| Sub-Area 4 | **30,853** | **79,721** | **110,574** | **80,500** | **61,000** | **141,500** | **11,000** | **6,200** | **17,200** | **63,100** | **11,400** | **74,500** |
| Sub-Area 5 | **172,264** | **214,393** | **386,657** | **97,800** | **119,700** | **217,500** | **2,500** | **600** | **3,100** | **0** | **2,500** | **2,500** |
| Sub-Area 7 | **157,521** | **246,923** | **404,444** | **132,800** | **170,100** | **302,900** | **0** | **0** | **0** | **0** | **900** | **900** |
| Sub-Area 8 | 312,306 | **366,043** | 678,349 | 134,500 | **162,100** | 296,600 | 6,300 | **0** | 6,300 | 330,000 | **8,400** | 338,400 |
| Sub-Area 9 | 285,422 | **260,439** | 545,861 | 227,900 | **211,900** | 439,800 | 500 | **2,500** | 3,000 | 0 | **4,500** | 4,500 |
| Sub-Area 13 | **975,293** | **1,142,995** | **2,118,288** | **930,700** | **857,700** | **1,788,400** | **86,500** | **0** | **86,500** | **396,100** | **89,200** | **485,300** |
| Sub-Area 14 | **300,579** | **310,003** | **610,582** | **197,500** | **220,300** | **417,800** | **9,100** | **2,300** | **11,400** | **63,700** | **20,700** | **84,400** |
| Sub-Area 15 | *N/A* | ***N/A*** | *N/A* | 385,900 | **155,800** | 541,700 | 32,200 | **42,200** | 74,400 | 26,200 | **0** | 26,200 |
| Sub-Area 16 | 1,076,962 | **609,352** | 1,686,314 | 457,200 | **348,800** | 806,000 | 945,000 | **0** | 945,000 | 243,300 | **25,500** | 268,800 |
| Sub-Area 17 | *N/A* | ***N/A*** | *N/A* | 283,800 | **23,900** | 307,700 | 0 | **0** | 0 | 0 | **0** | 0 |
| Sub-Area 18 | 1,284,107 | **984,596** | 2,268,703 | 989,800 | **734,400** | 1,724,200 | 148,800 | **8,800** | 157,600 | 451,200 | **64,500** | 515,700 |
| Sub-Area 19 | 810,736 | **389,442** | 1,200,178 | 473,000 | **240,200** | 713,200 | 63,100 | **2,900** | 66,000 | 223,300 | **0** | 223,300 |
| Sub-Area 20 | 2,166,025 | **553,500** | 2,719,525 | 1,162,800 | **393,600** | 1,556,400 | 221,900 | **15,700** | 237,600 | 549,400 | **20,300** | 569,700 |
| Sub-Area 21 | 398,523 | **1,397,997** | 1,796,520 | 0 | **129,700** | 129,700 | 0 | **145,200** | 145,200 | 0 | **131,700** | 131,700 |
| Sub-Area 22 | 1,980,560 | **1,400,988** | 3,381,548 | 1,174,200 | **812,100** | 1,986,300 | 102,100 | **0** | 102,100 | 543,100 | **54,800** | 597,900 |
| Sub-Area 28 | 249,721 | **0** | 249,721 | 0 | **0** | 0 | 300 | **0** | 300 | 88,300 | **31,800** | 120,100 |
| Sub-Area 29 | 812,737 | **443,994** | 1,256,731 | 434,300 | **246,400** | 680,700 | 73,500 | **17,500** | 91,000 | 207,600 | **37,400** | 245,000 |

# 3 SUB-AREA PRIORITIZATION AND RECOMMENDATIONS

## 3.1 High Infiltration and High RDII Sub-Areas

Infiltration within a sanitary sewer system is considered excessive if a subarea no greater than 20,000 linear feet of pipe exceeds a dry weather infiltration rate average of 4,000 gallons per day per inch diameter mile (gpd/idm). Sub-areas with infiltration rates exceeding 4,000 gpd/in-mi (Sub-areas 4, 16, 18, 20 and 29) are highlighted in Table 6.

**Table 6. High Infiltration Sub-areas**

| Sub-Area | Groundwater Infiltration (GWI) | Infiltration GPD/Total LF (GPDLF) | Gallons per Day per Inch-Mile (GPDIM) |
|---|---|---|---|
| Sub-Area 4 | 83,726 | **9.4** | 6,055 |
| Sub-Area 16 | 279,739 | **13.1** | 5,375 |
| Sub-Area 18 | 209,635 | **10.5** | 4,487 |
| Sub-Area 29 | 50,357 | **8.2** | 4,445 |
| Sub-Area 20 | 118,081 | **11.9** | 4,235 |
| Sub-Area 14 | 152,698 | **6.5** | 3,489 |
| Sub-Area 1 | 78,910 | 3.9 | 2,515 |
| Sub-Area 7 | 97,191 | **4.1** | 2,505 |
| Sub-Area 19 [1, 2] | 43,517 | **7.7** | 2,469 |
| Sub-Area 5 | 97,130 | **4.4** | 2,444 |
| Sub-Area 9 [1, 2] | 75,325 | **6.9** | 2,427 |
| Sub-Area 22 | 128,450 | **6.7** | 2,367 |
| Sub-Area 13 | 374,236 | **7.7** | 2,354 |
| Sub-Area 3 | 91,912 | 3.2 | 1,968 |
| Sub-Area 2 | 36,879 | 3.1 | 1,884 |
| Sub-Area 28 [1, 2] | 50,821 | **9.6** | 1,527 |
| Sub-Area 15 [1, 2] | 66,479 | 2.9 | 1,411 |
| Sub-Area 8 [1, 2] | 69,114 | 2.7 | 1,355 |
| Sub-Area 17 [1, 2] | 70,823 | 2.9 | 1,310 |
| Sub-Area 21 [1, 2] | *N/A* | *N/A* | *N/A* |

Notes: 1. Collects flows from tributary sub-areas 2. Flow meter results indicate some negative net flows when tributary sub-areas are subtracted. Further investigations will be done during the next phase to account for negative values.

The gallons per day of GWI per total liner footage of each sub-area was also calculated. Sub-areas with a total GPD/LF greater than 4 were also deemed high infiltration areas and are shown as bold in Table 6.

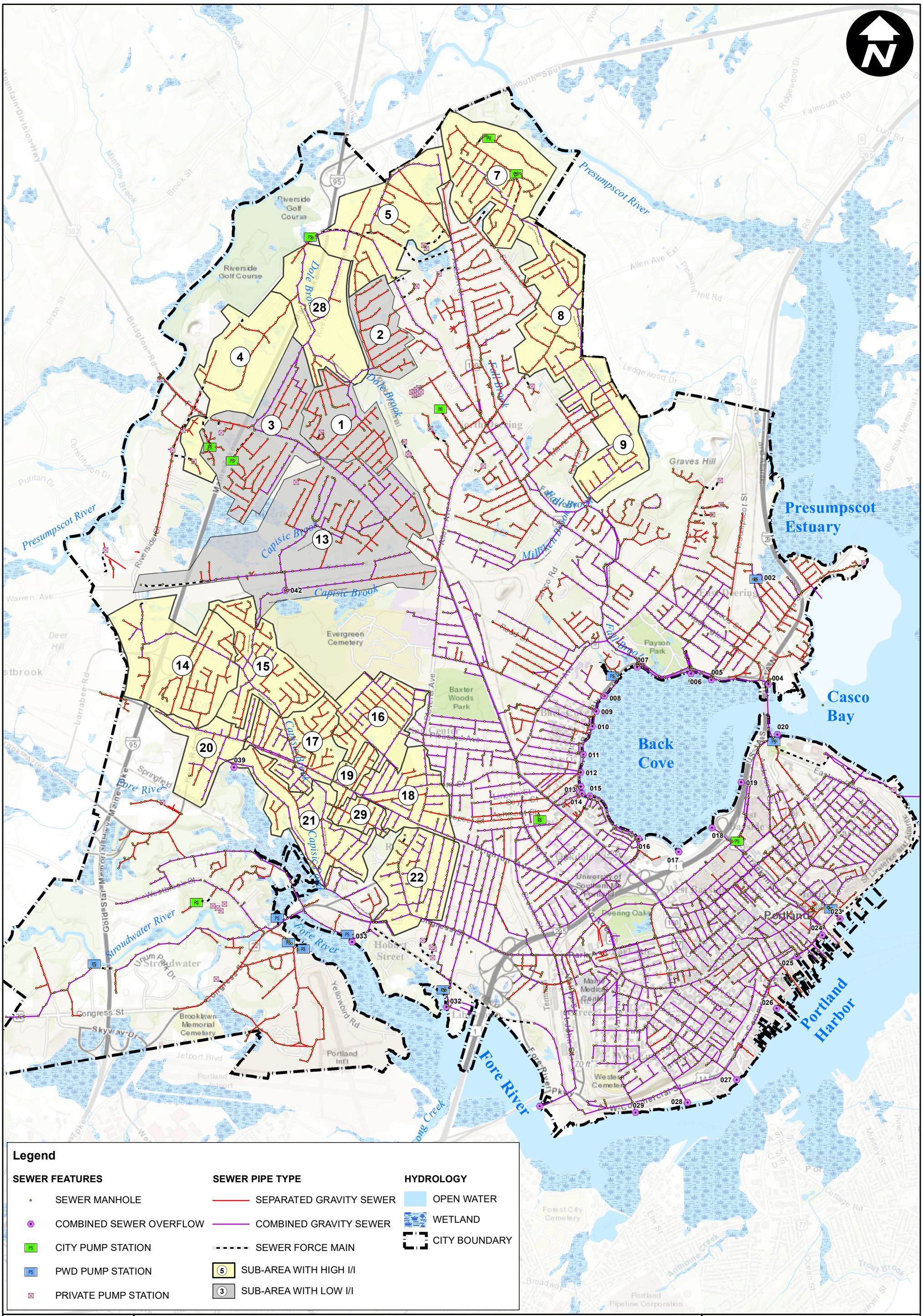
Inflow results were analyzed for the April 25, 2018 storm event to determine which sub-areas contribute excessive volumes of delayed inflow to the collection system. High delayed inflow sub-areas are shaded in Table 7.

**Table 7. High Delayed Inflow Sub-areas – April 25, 2018 Storm Event**

| Subarea | Direct Inflow (Gal) | Delayed Inflow (Gal) | Total Inflow (Gal) |
|---|---|---|---|
| Sub-Area 13 | **930,700** | **857,700** | **1,788,400** |
| Sub-Area 22 | 1,174,200 | **812,100** | 1,986,300 |
| Sub-Area 18 | 989,800 | **734,400** | 1,724,200 |
| Sub-Area 20 | 1,162,800 | **393,600** | 1,556,400 |
| Sub-Area 16 | 457,200 | **348,800** | 806,000 |
| Sub-Area 29 | 434,300 | **246,400** | 680,700 |
| Sub-Area 19[1] | 473,000 | **240,200** | 713,200 |
| Sub-Area 14 | **197,500** | **220,300** | **417,800** |
| Sub-Area 9[1] | 227,900 | **211,900** | 439,800 |
| Sub-Area 7 | **132,800** | **170,100** | **302,900** |
| Sub-Area 8[1] | 134,500 | **162,100** | 296,600 |
| Sub-Area 15[1] | 385,900 | **155,800** | 541,700 |
| Sub-Area 21[1] | 0 | **129,700** | 129,700 |
| Sub-Area 1 | **141,300** | **121,100** | **262,400** |
| Sub-Area 5 | **97,800** | **119,700** | **217,500** |
| Sub-Area 3 | 90,600 | **91,300** | 181,900 |
| Sub-Area 4 | **80,500** | **61,000** | **141,500** |
| Sub-Area 2 | **37,500** | **46,000** | **83,500** |
| Sub-Area 17[1] | 283,800 | **23,900** | 307,700 |
| Sub-Area 28[2] | 0 | **0** | 0 |

Notes: 1. Collects flows from tributary sub-areas 2. Flow meter results indicate some negative net flows when tributary sub-areas are subtracted. Further investigations will be done during the next phase to account for negative values.

High infiltration and inflow sub-areas are highlighted in Figure 7.




# THE CITY OF PORTLAND, MAINE

*Phase 1: Investigation of Flows - 2018 Monitoring*

0 0.25 0.5 1 Miles

December 2018

# FIGURE 7 - HIGH INFILTRATION AND INFLOW SUB-AREAS

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 I-I Report\FIGURE 7 - HIGH I AND I SUB-AREAS.mxd

## 3.2 Investigation Recommendations

Based on the metering results summarized in Section 3.1 and ongoing investigation and construction within the City of Portland, Phase 2 follow-on recommendations were developed. Recommendations, summarized in Table 8 and shown on Figure 8 include flow isolation, CCTV and manhole inspections. Individual sub-area maps showing follow-on recommendations are included in Appendix C.

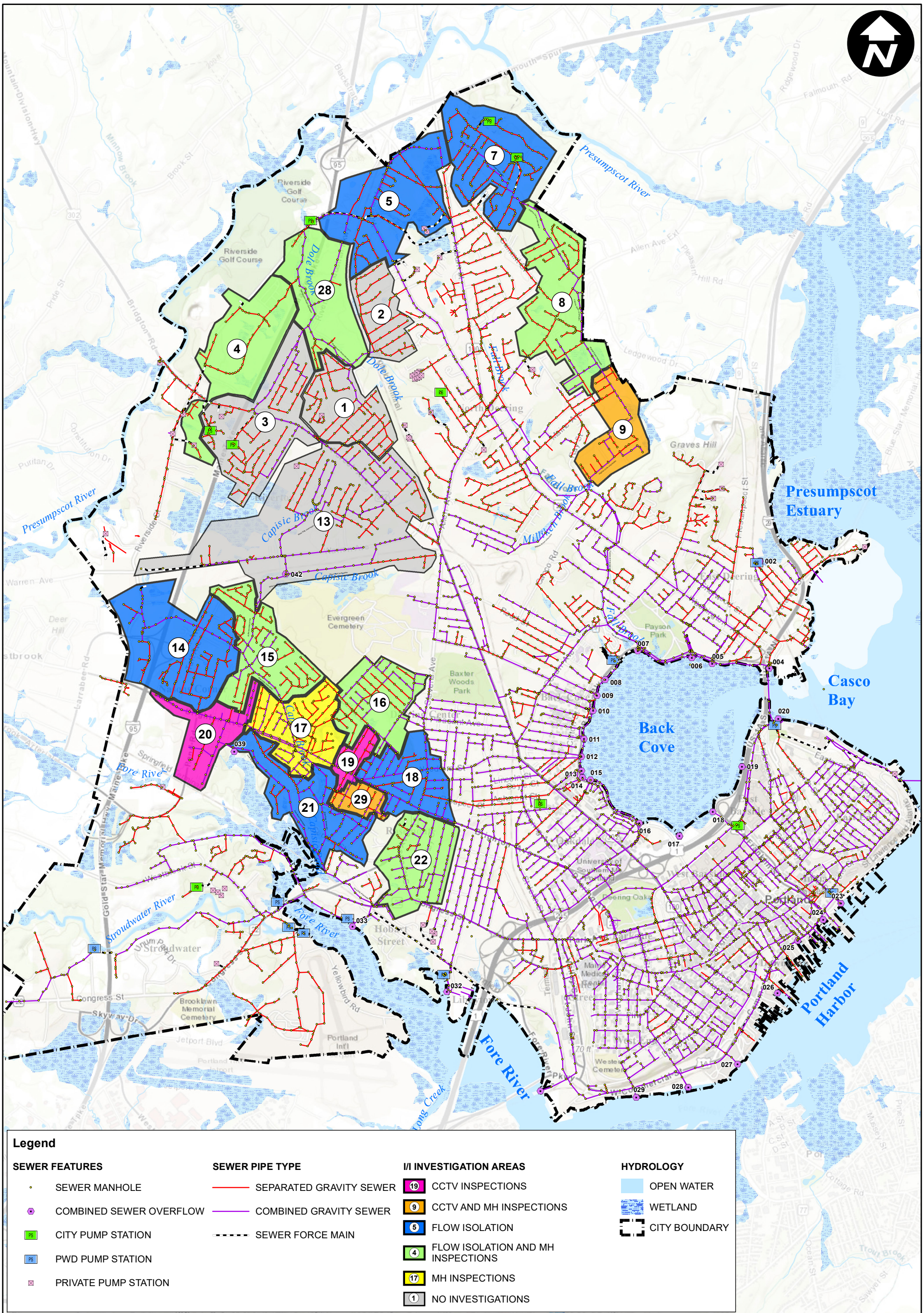
**Table 8. Follow-on Investigation Recommendations**

| Sub-Area | High Infiltration Sub-areas | High Delayed Inflow Sub-area | Recommendations | | |
|---|---|---|---|---|---|
| | | | Flow Isolation (LF) | CCTV (LF) | Manhole Inspections |
| Sub-Area 4 | X | | 8,893 | | 46 |
| Sub-Area 5 | X | | 21,962 | | |
| Sub-Area 7 | X | X | 23,684 | | |
| Sub-Area 8 | | X | 19,179 | | 26 |
| Sub-Area 9 | | X | | 9,165 | 20 |
| Sub-Area 13[1] | X | X | - | - | - |
| Sub-Area 14 | X | X | 23,488 | | |
| Sub-Area 15 | | X | 19,404 | | 20 |
| Sub-Area 16 | X | X | 21,410 | | 100 |
| Sub-Area 17 | | | | | 28 |
| Sub-Area 18 | X | X | 19,962 | | |
| Sub-Area 19 | X | X | | 4,667 | |
| Sub-Area 20 | X | X | | 8,685 | |
| Sub-Area 21 | | X | 12,431 | | |
| Sub-Area 22 | X | X | 19,133 | | 112 |
| Sub-Area 28 | X | | 5,164 | | 56 |
| Sub-Area 29 | X | X | | 5,094 | 35 |
| ***Total*** | | | ***194,740*** | ***27,611*** | ***443*** |

Notes: 1. Investigation work in Sub-area 13 is ongoing through another project and therefore not included in these recommendations

Flow isolation was completed in December 2018 and CCTV is currently ongoing. Manhole inspections will be conducted in the Spring of 2019.

Investigations to identify direct inflow such as smoke testing, dye testing and large building inspections will be conducted in the summer of 2019 once the 2019 flow metering program is completed.




# THE CITY OF PORTLAND, MAINE

*Phase 1: Investigation of Flows - 2018 Monitoring*

0 0.25 0.5 1 Miles

December 2018

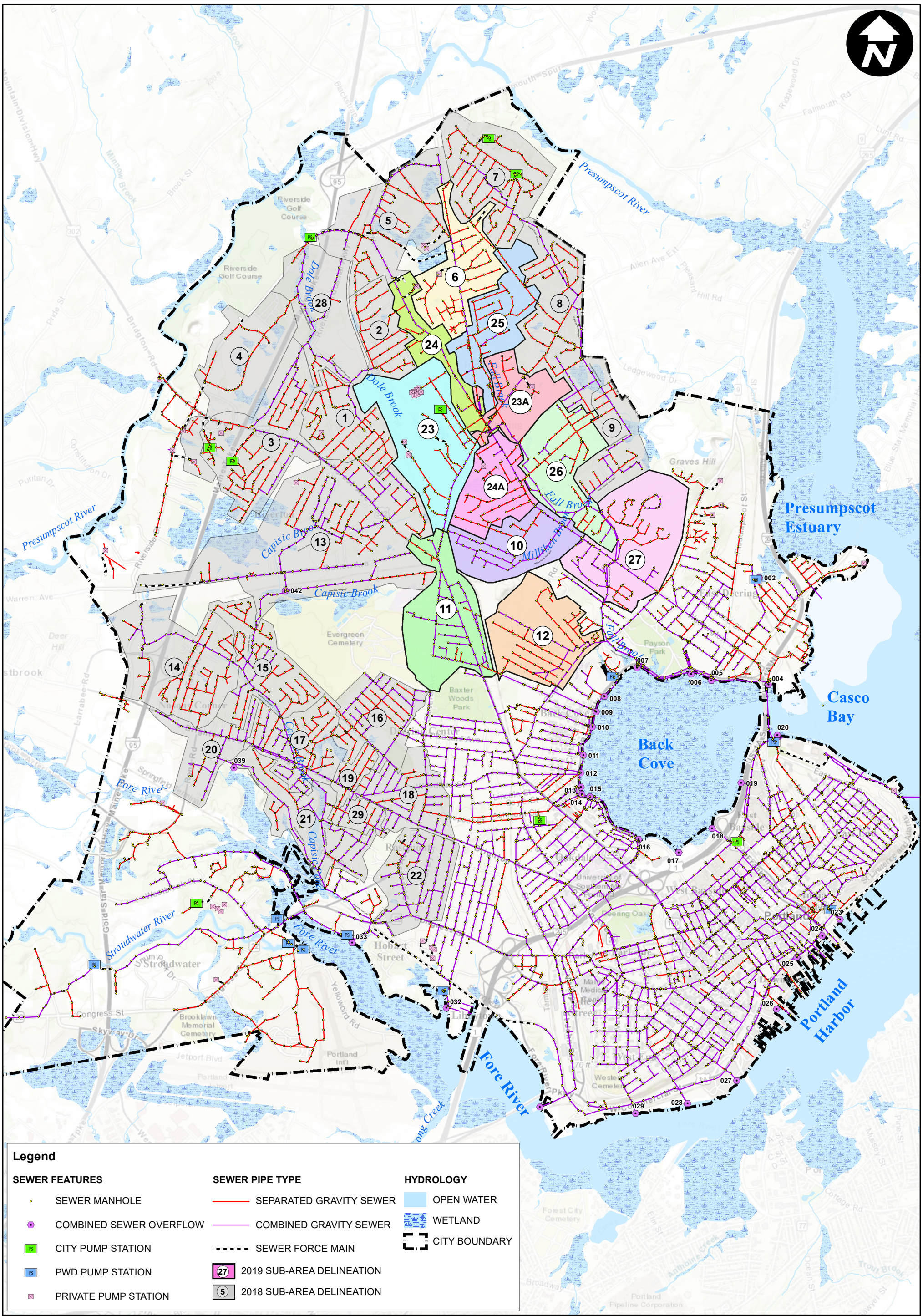
# FIGURE 8 - INVESTIGATION RECOMMENDATIONS

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 I-I Report\FIGURE 8 - I AND I INVESTIGATION SUB-AREAS.mxd

## 3.3 2019 Flow Metering Program

A second phase of flow metering is scheduled to be conducted in April 2019 in 11 sub-areas that were not included in the first phase of flow metering. The metering program includes 11 meters, as shown on Figure 9, as well as 3 additional deduction meters in sub-areas 6, 11 and 26. Additional meters may be added to the 2019 flow metering program if results from the ongoing SSES activities identify the need for additional meter data.




# THE CITY OF PORTLAND, MAINE

*Phase 1: Investigation of Flows - 2018 Monitoring*

0 0.25 0.5 1 Miles

December 2018

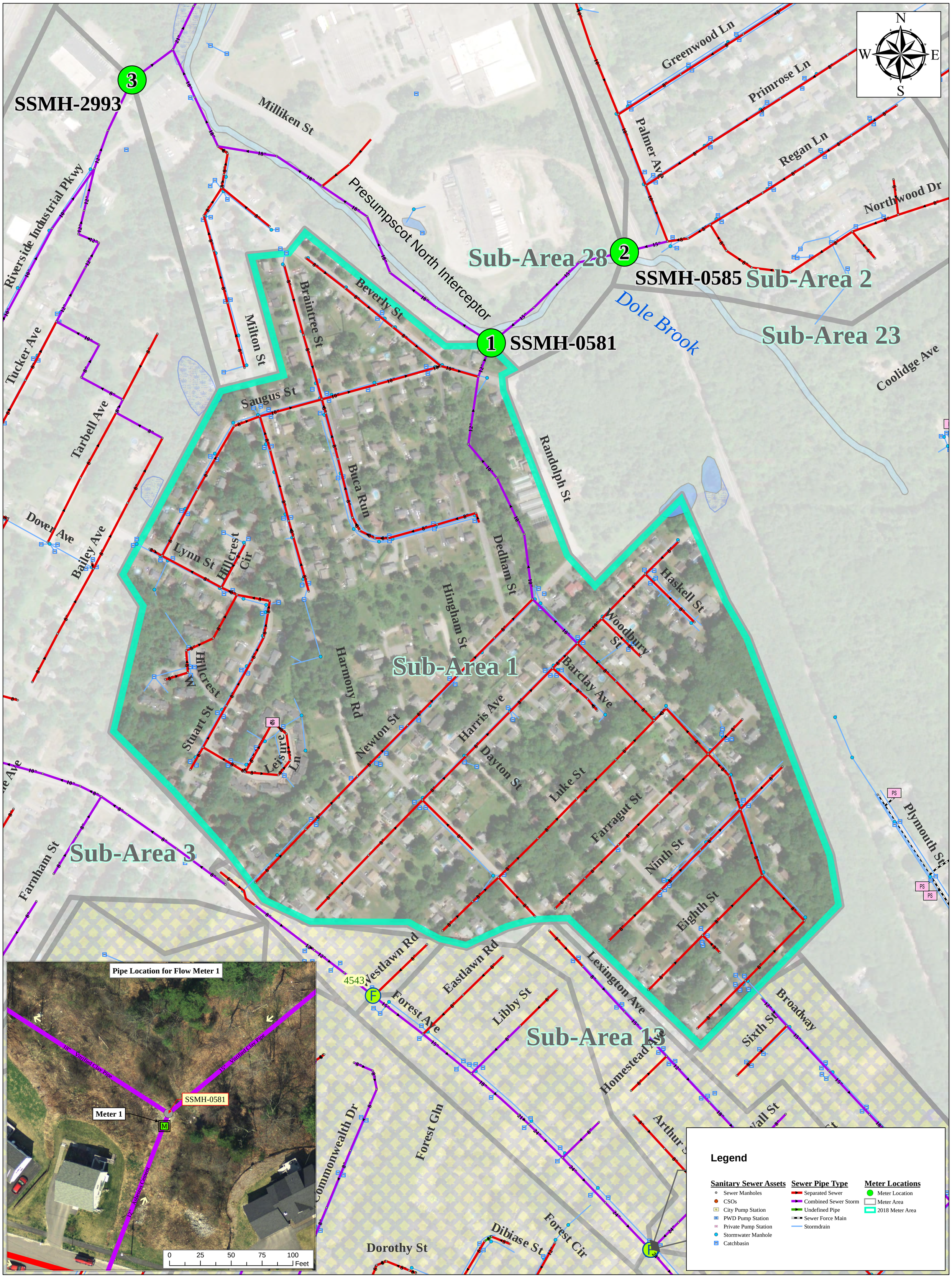
# FIGURE 9 - 2019 FLOW METER LOCATIONS

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 I-I Report\FIGURE 9 - 2019 SUB-AREA DELINEATION.mxd

# APPENDIX A

## 2018 Meter Area Figures




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*

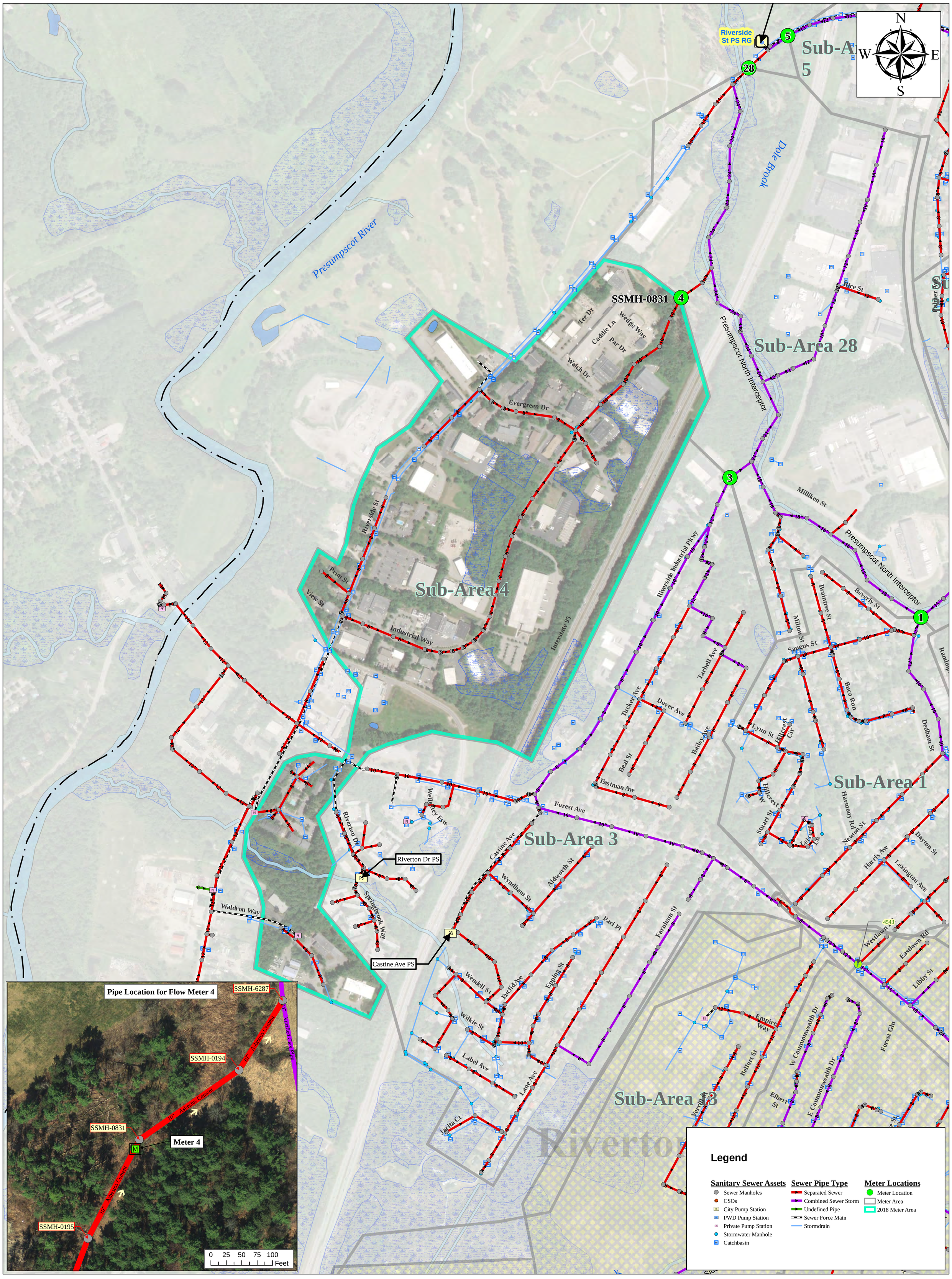
**Sub-Area 3**

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*

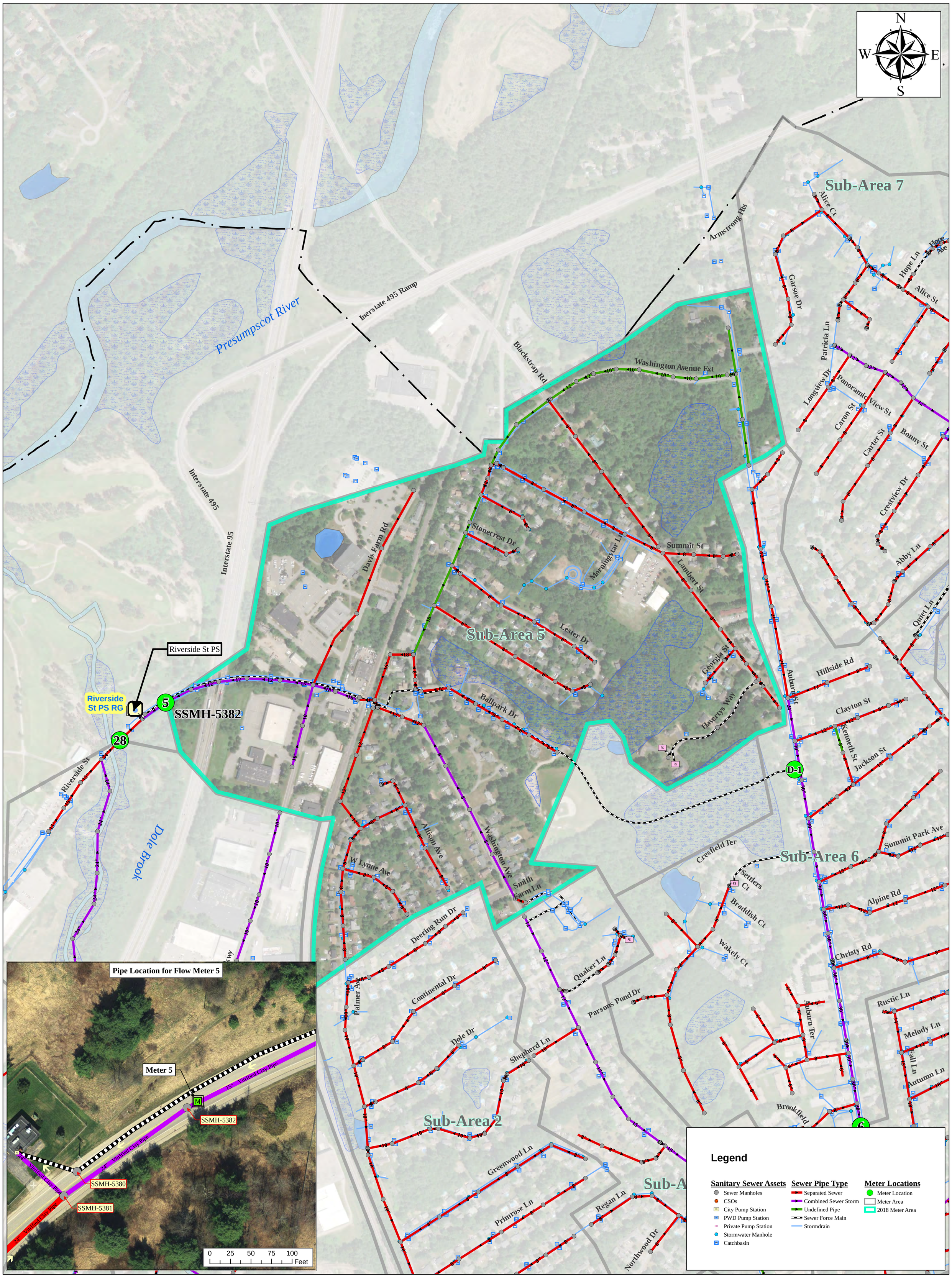
**Sub-Area 4**

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*

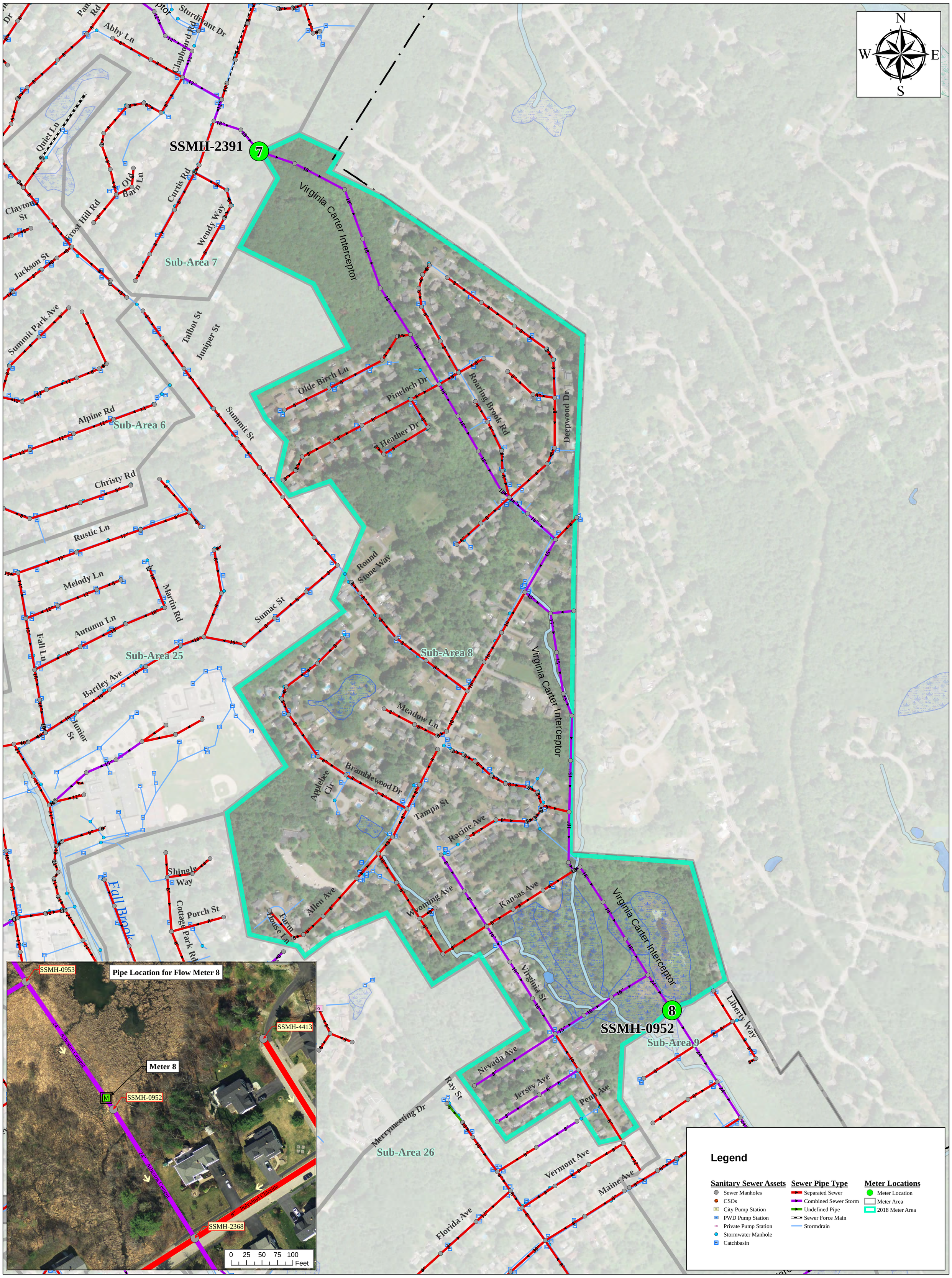
**Sub-Area 7**

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*

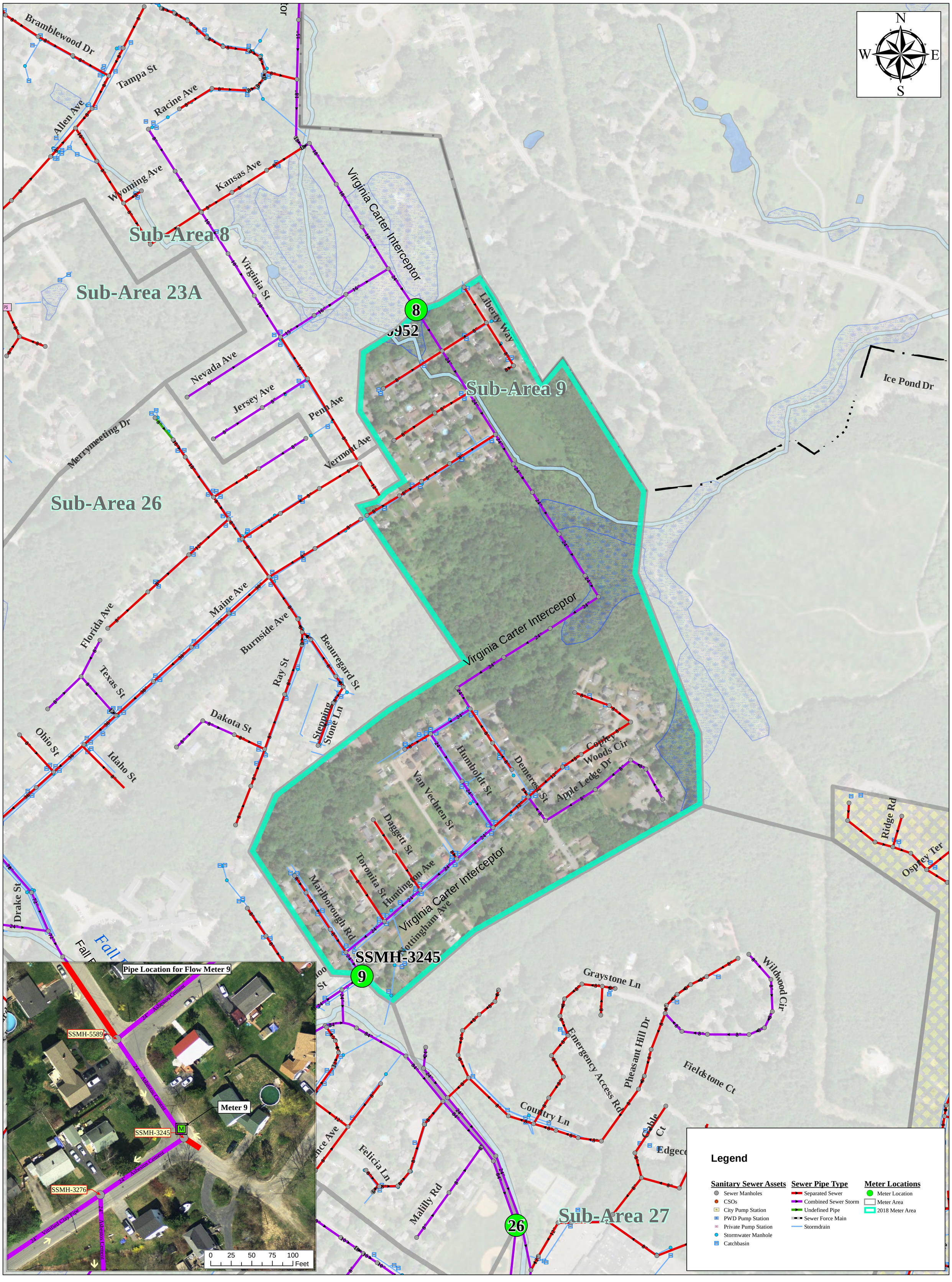
**Sub-Area 8**

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*

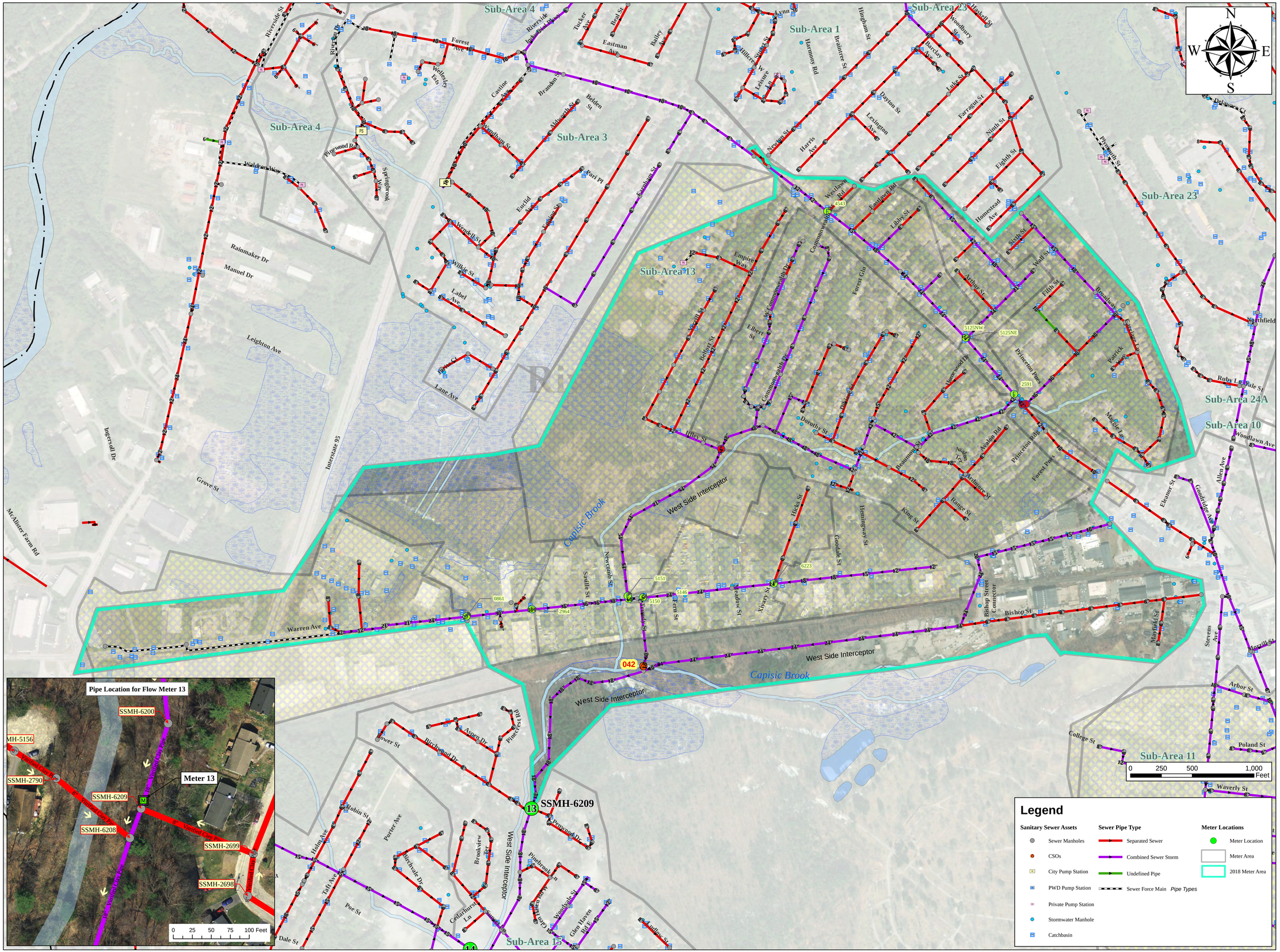
**Sub-Area 9**

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*

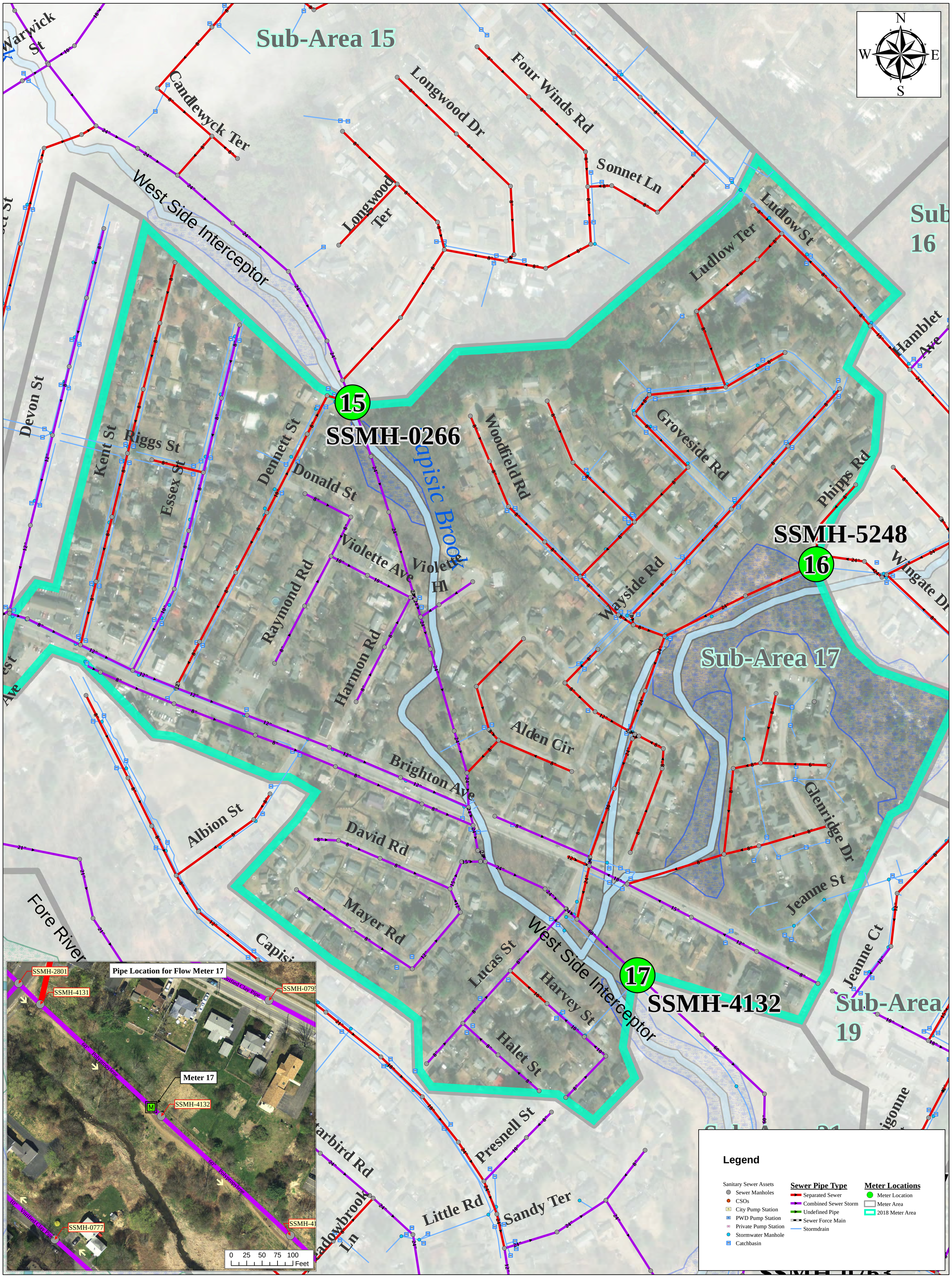
**Sub-Area 16**

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

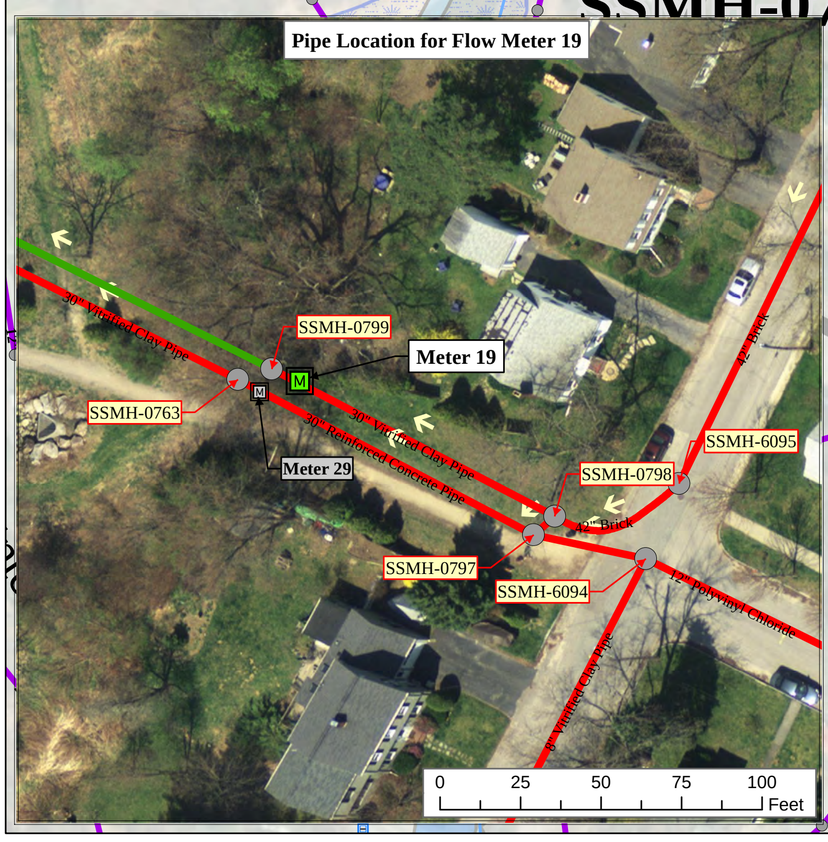
SSMH-4132 17

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*

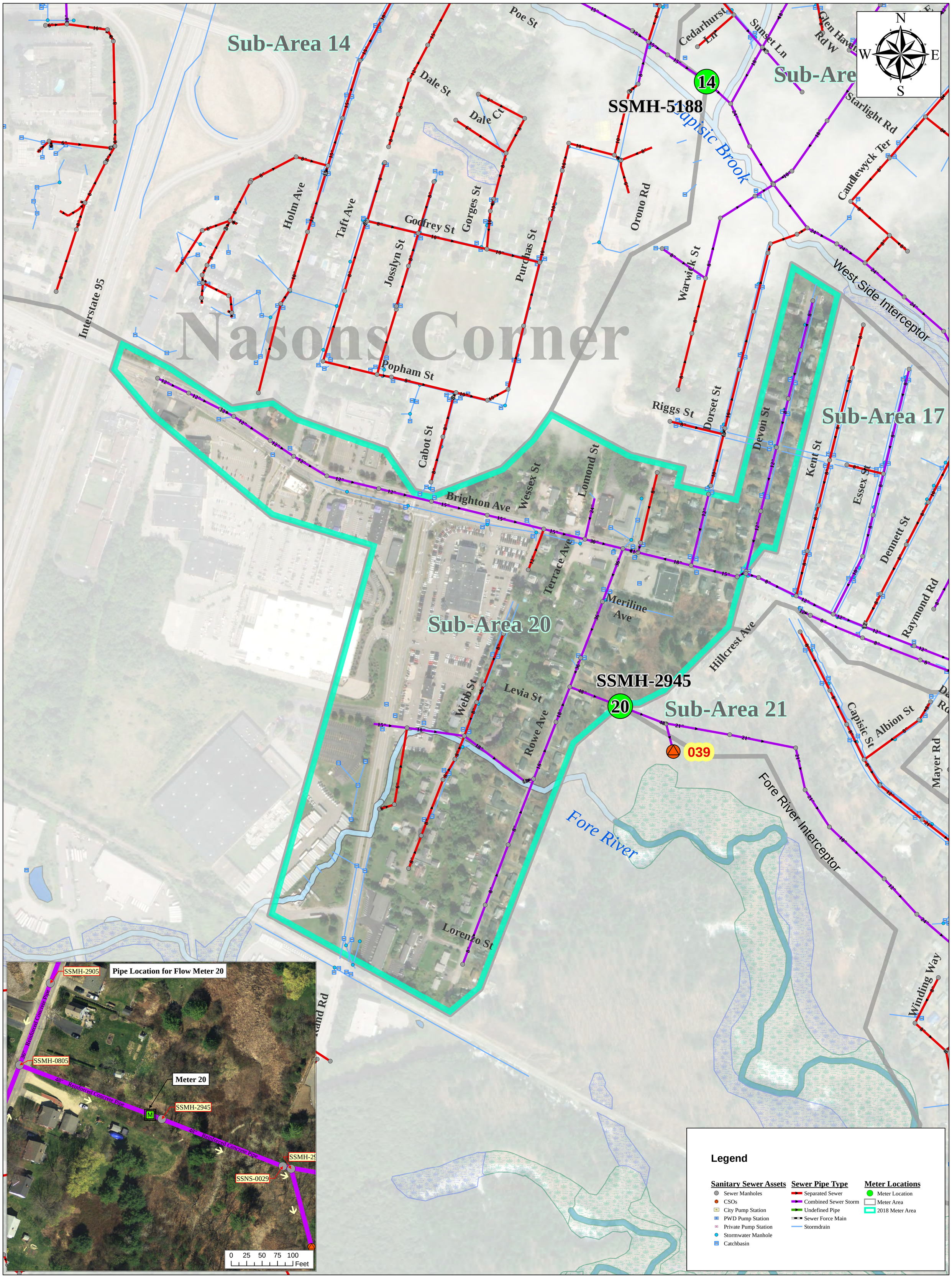
**Sub-Area 19**

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*

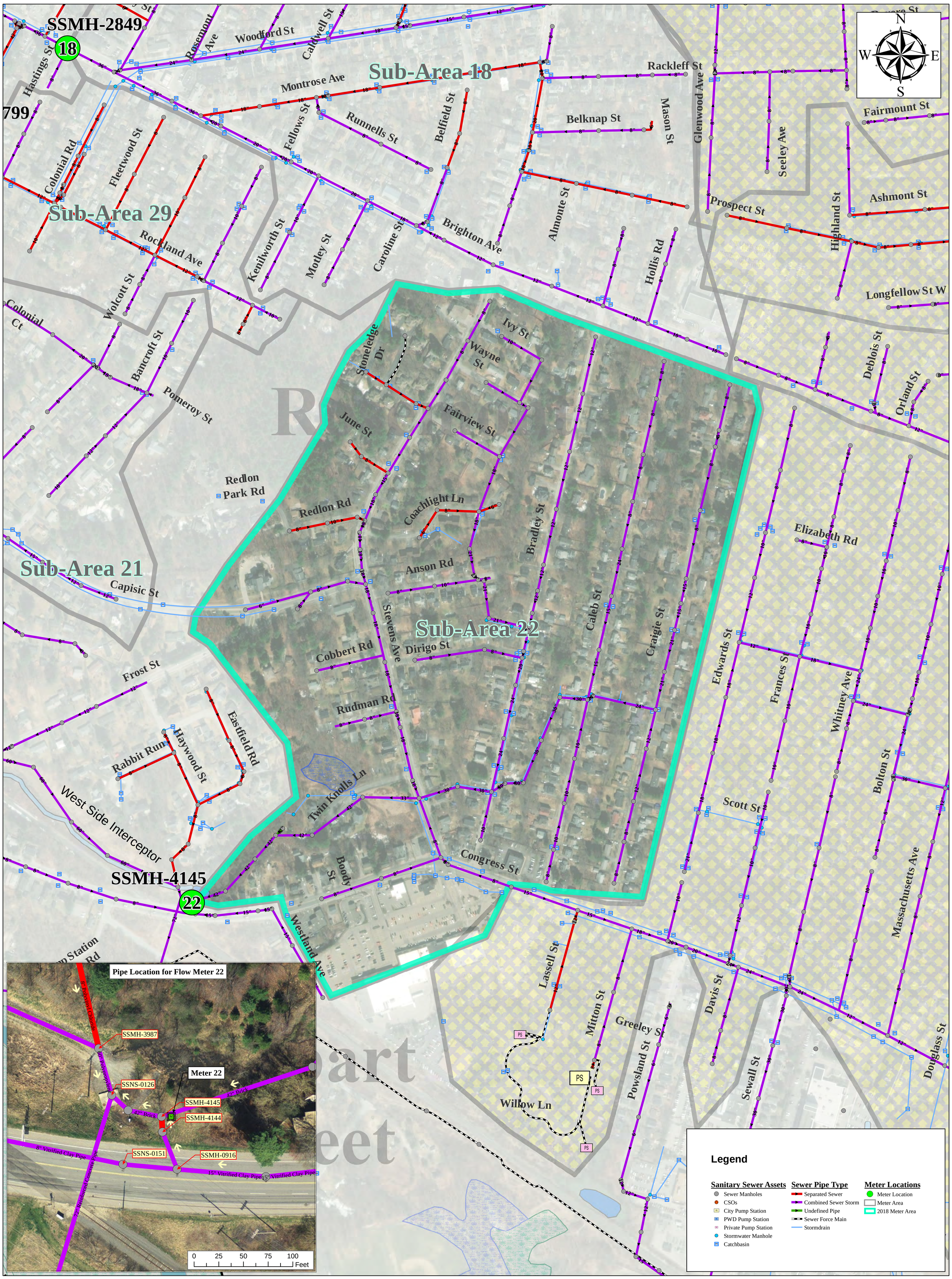
**Sub-Sub-Area 21**

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*

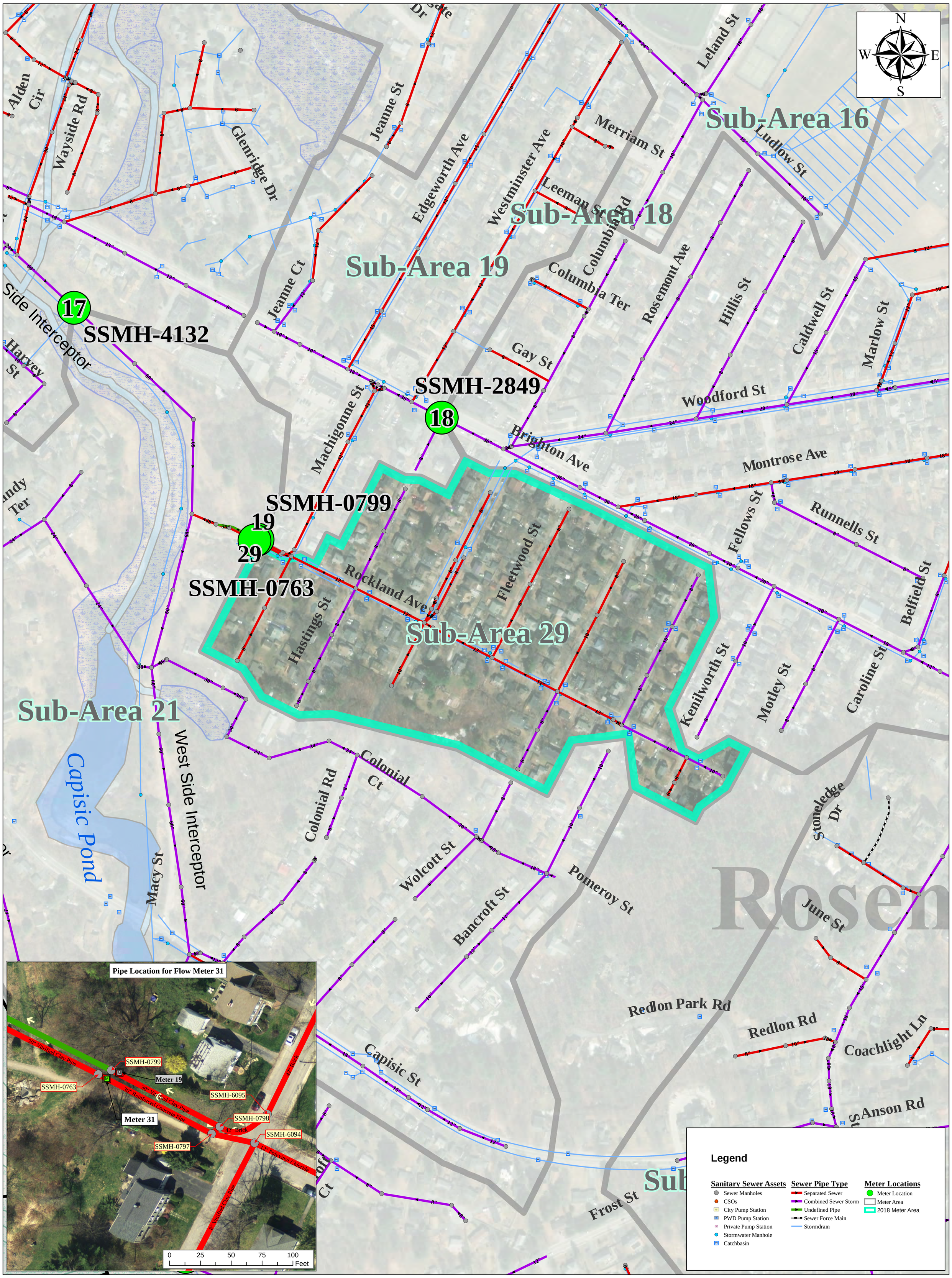
**Sub-Area 28**

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

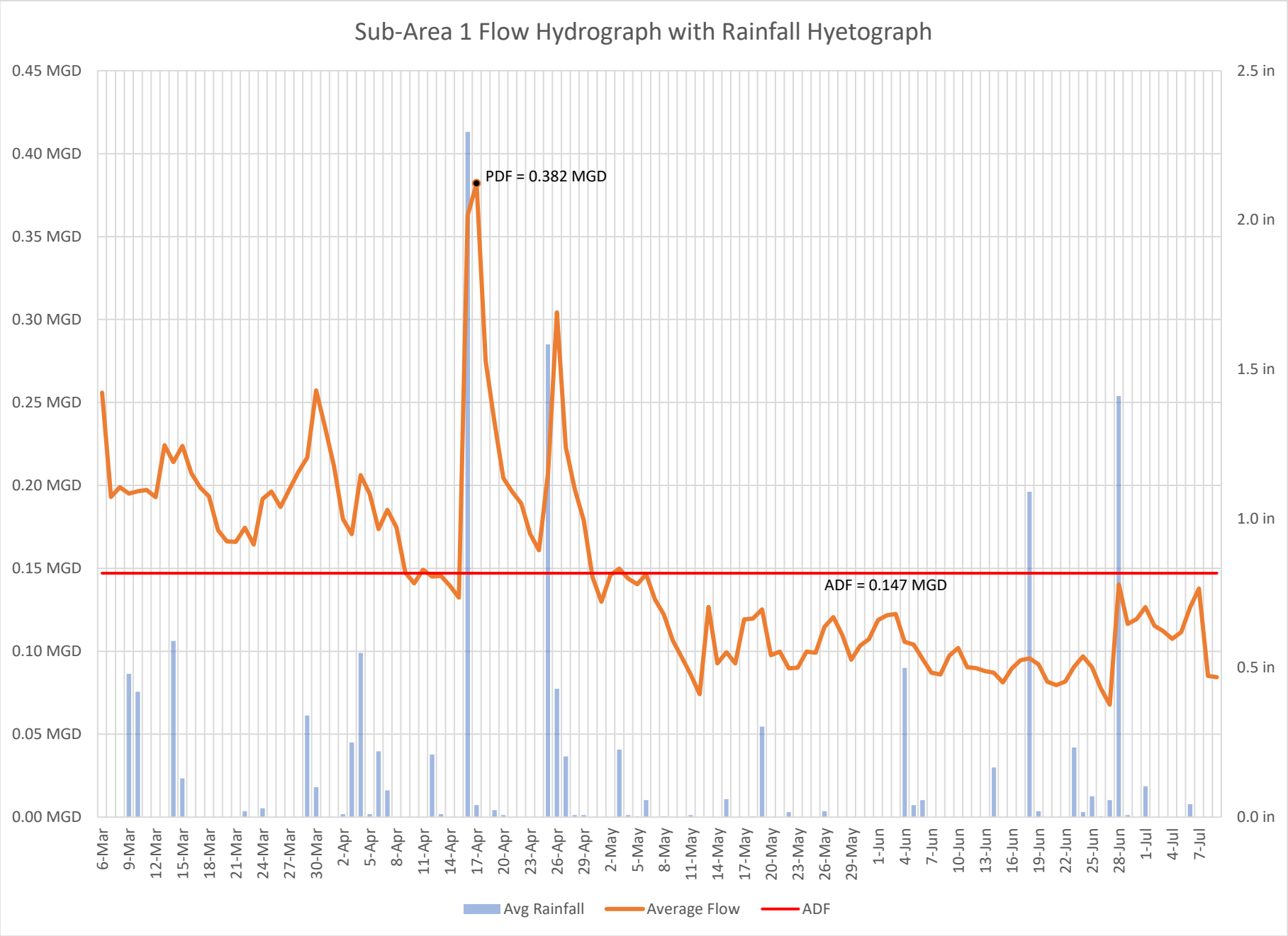
**Sub-Area Details**

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

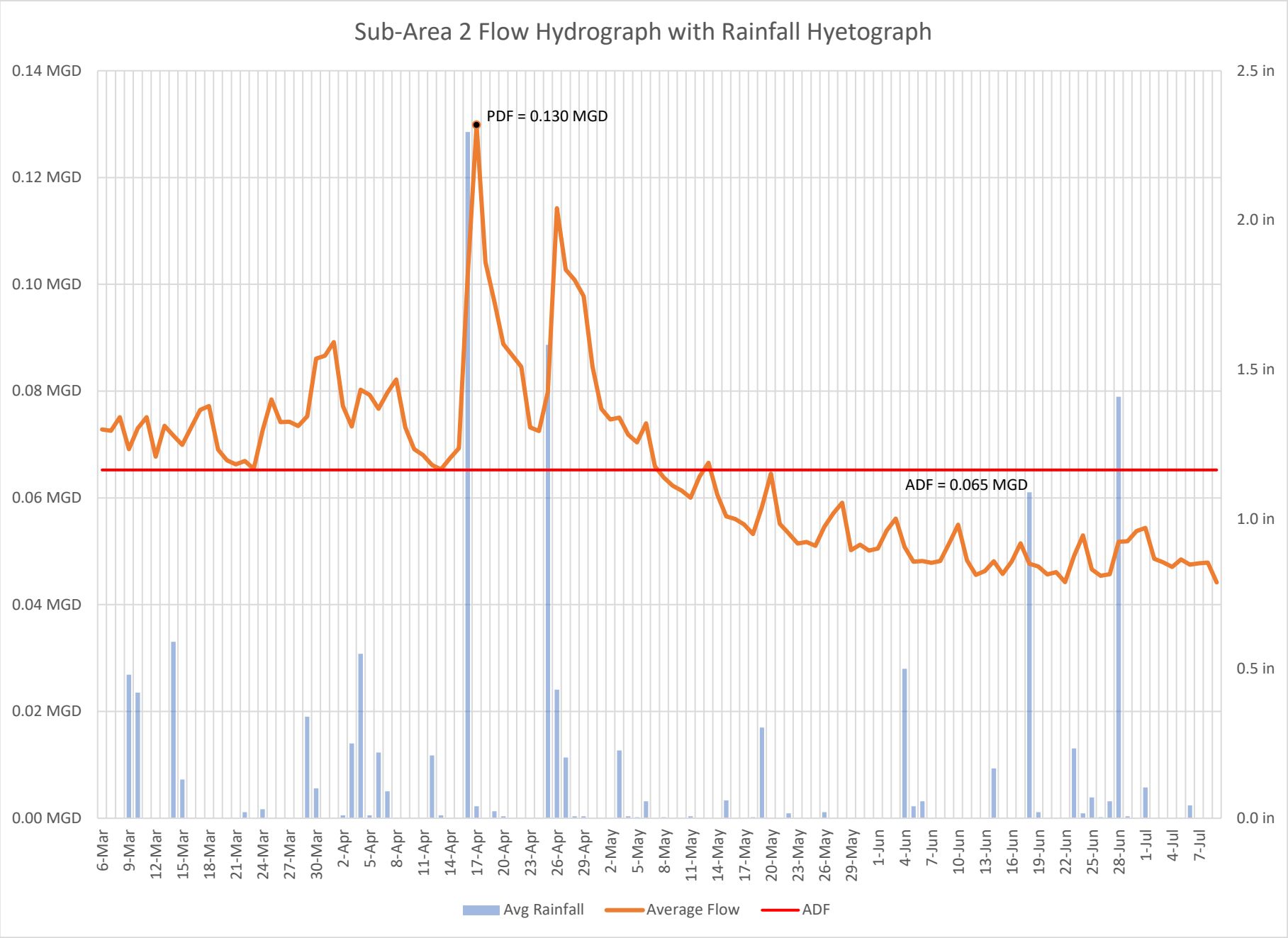
March 2018

# APPENDIX B

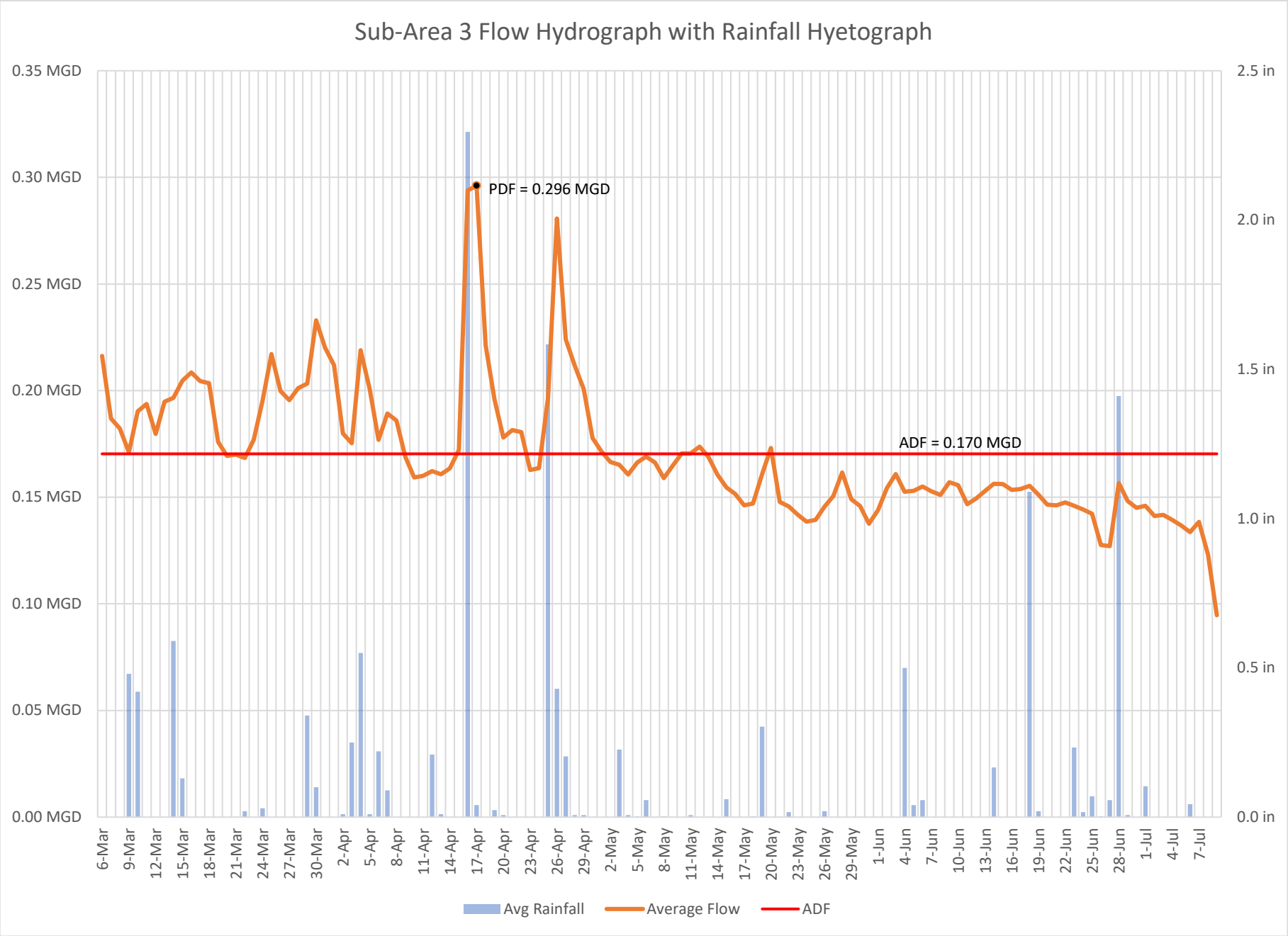
## Flow Meter Hydrographs with Related Rainfall Hyetographs


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

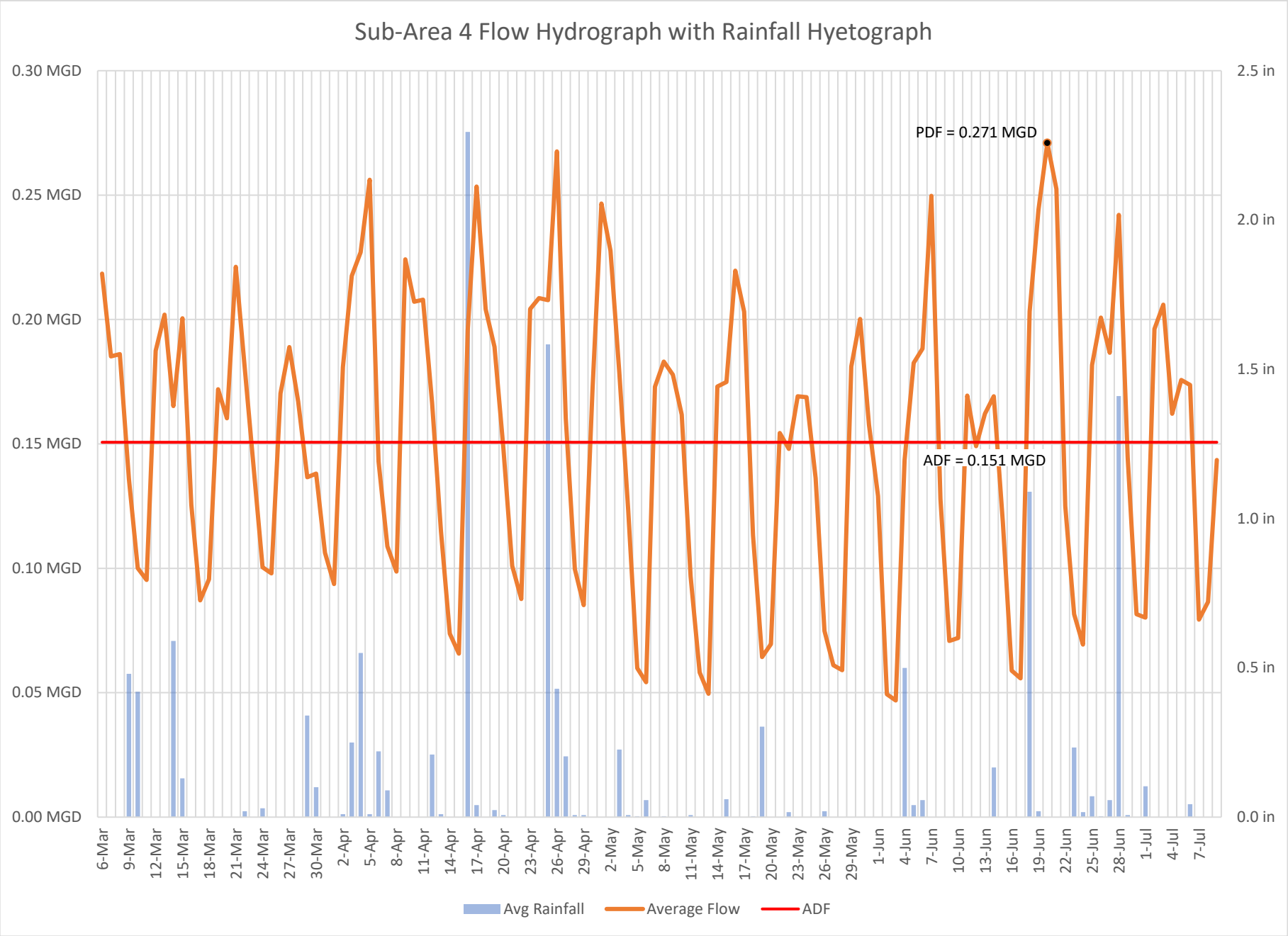
12/17/2018


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

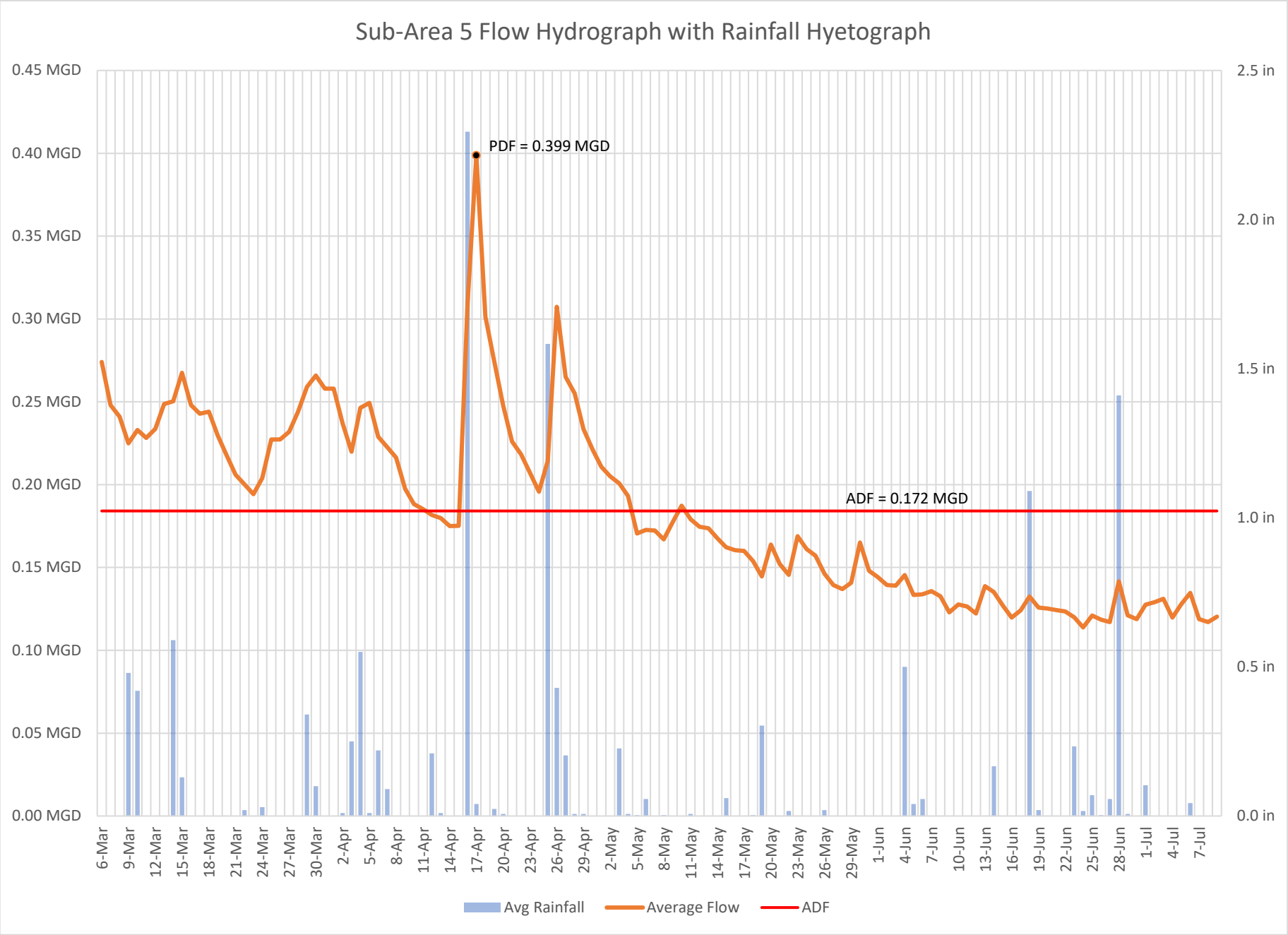
12/17/2018


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

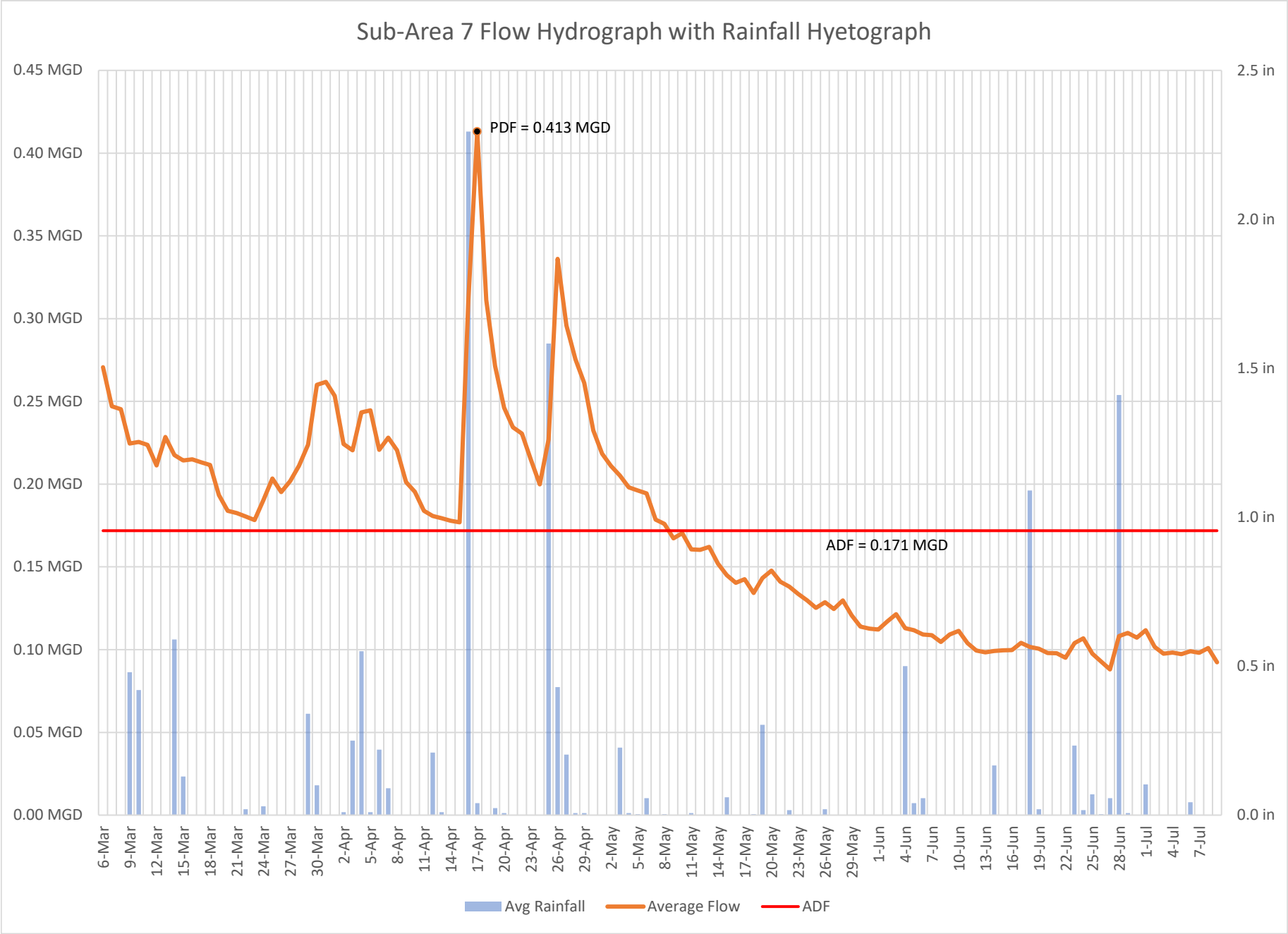
12/17/2018


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

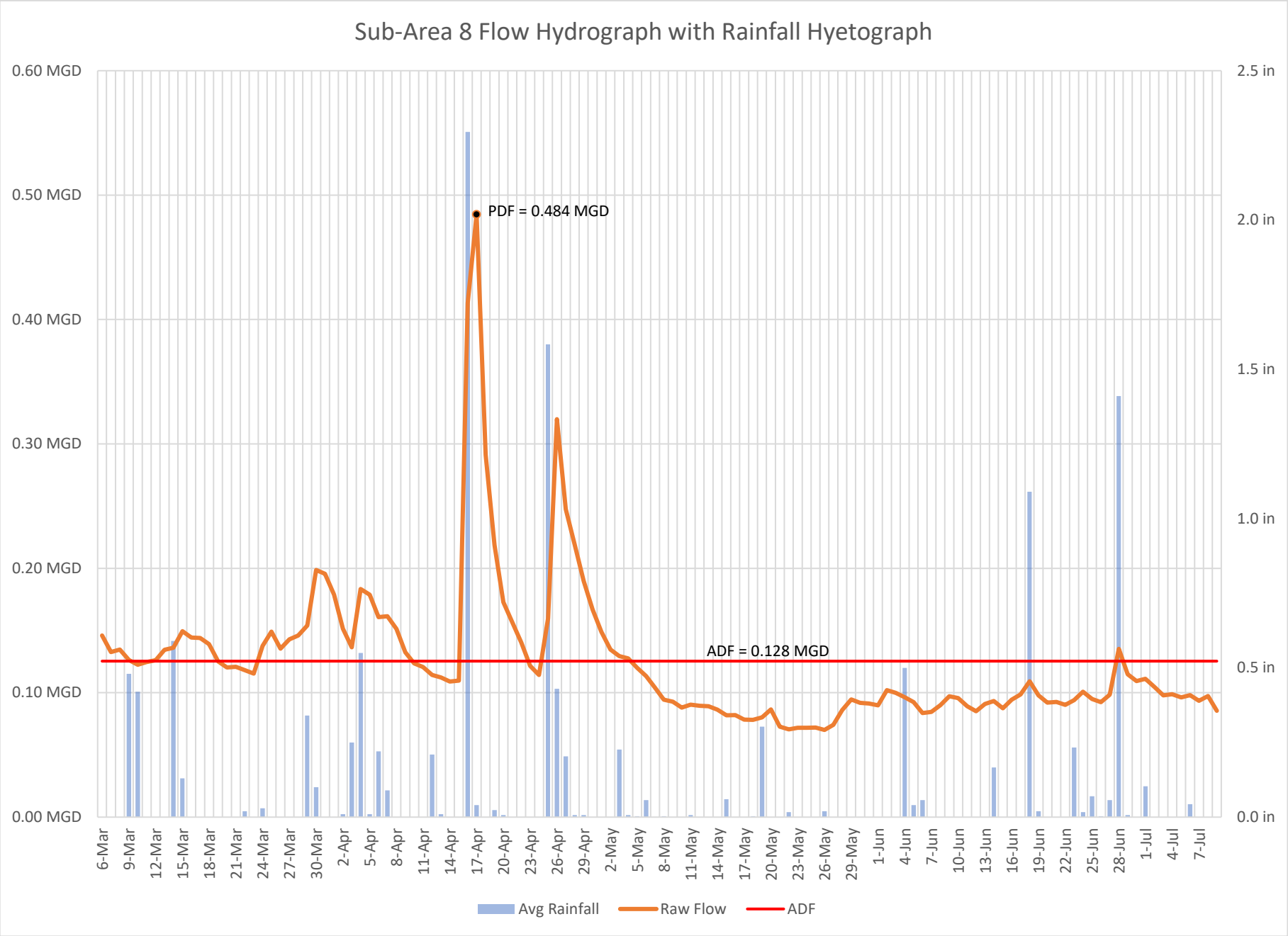
12/17/2018


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

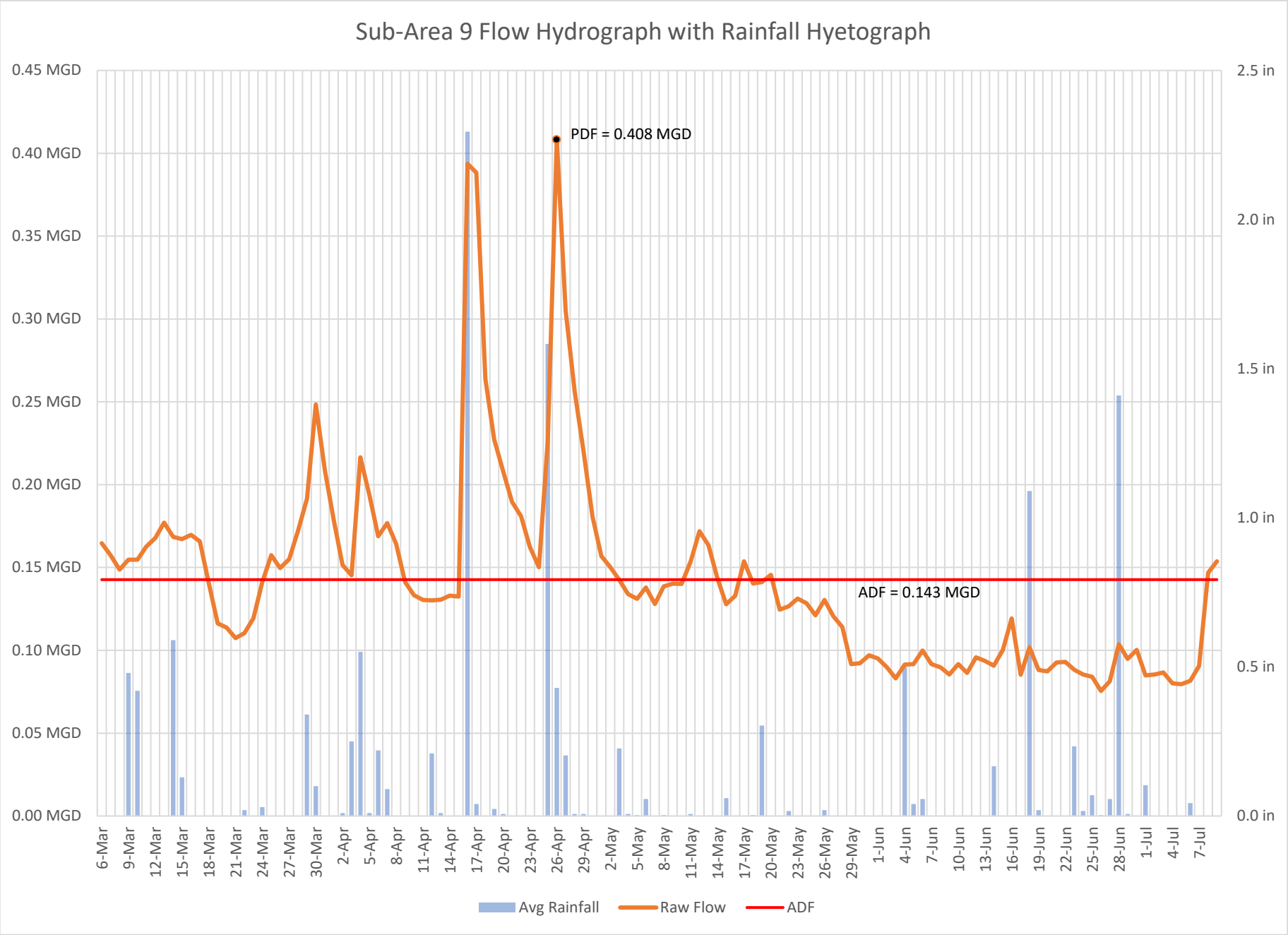
12/17/2018


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

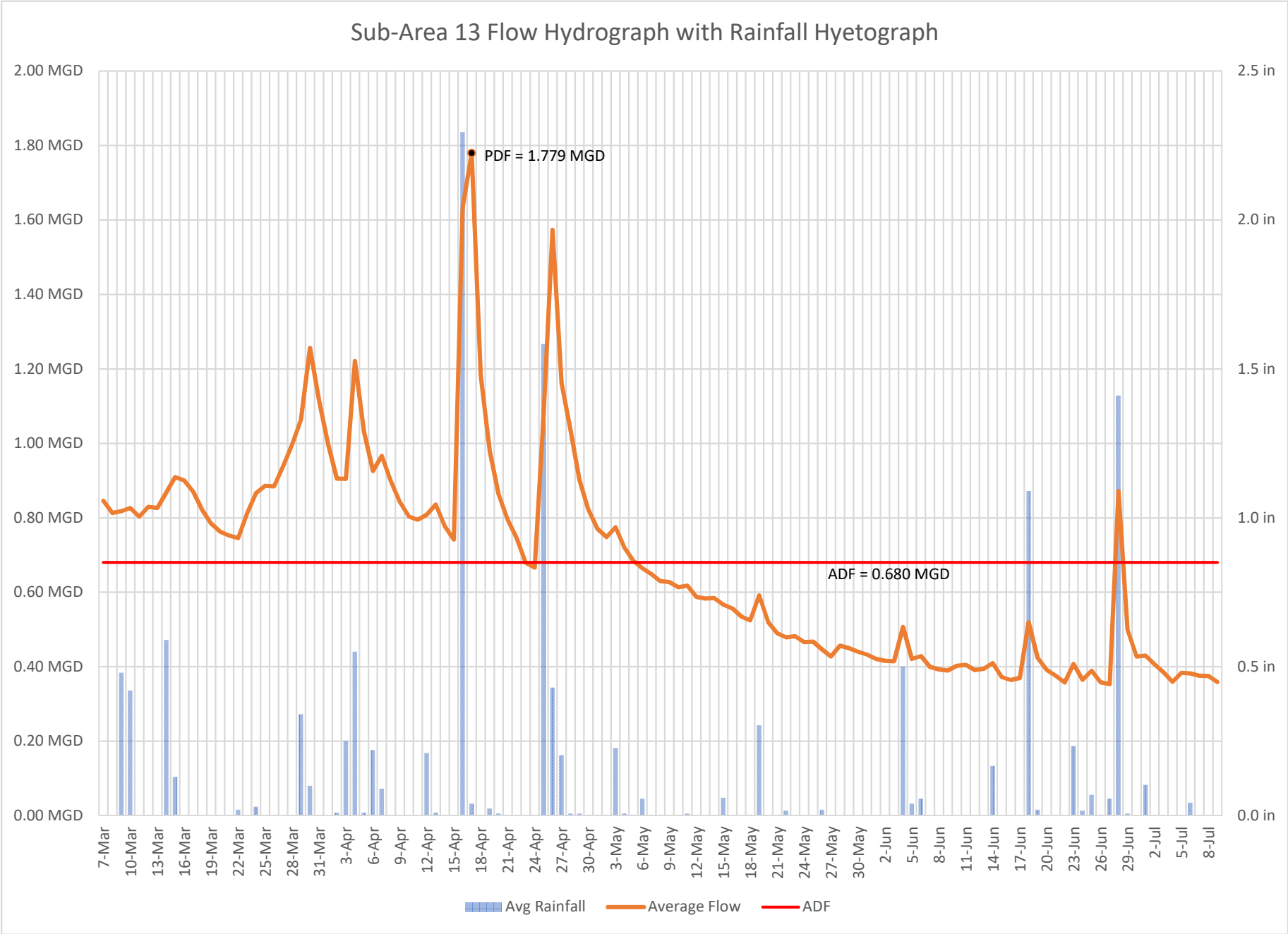
12/17/2018


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

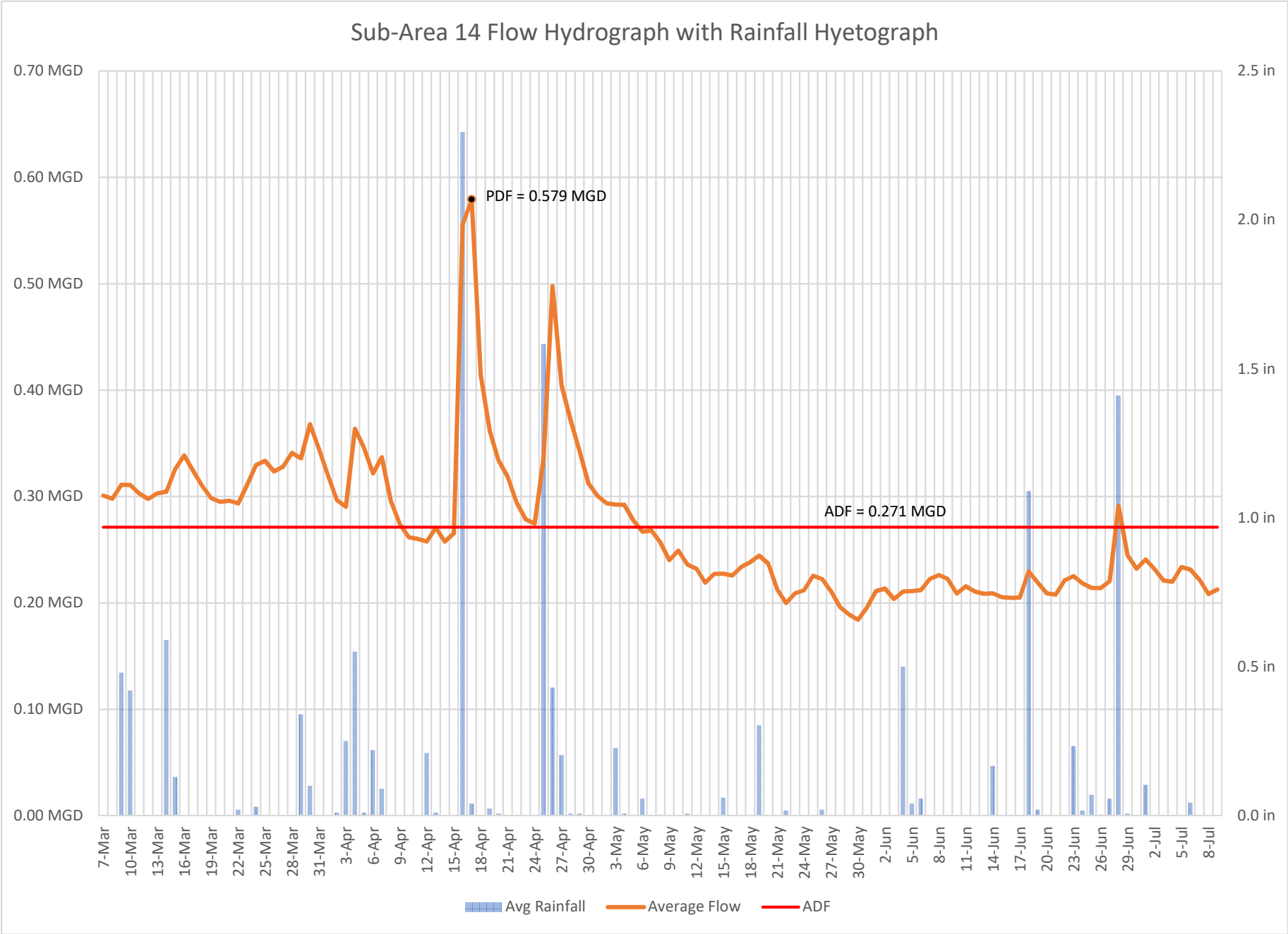
12/17/2018


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

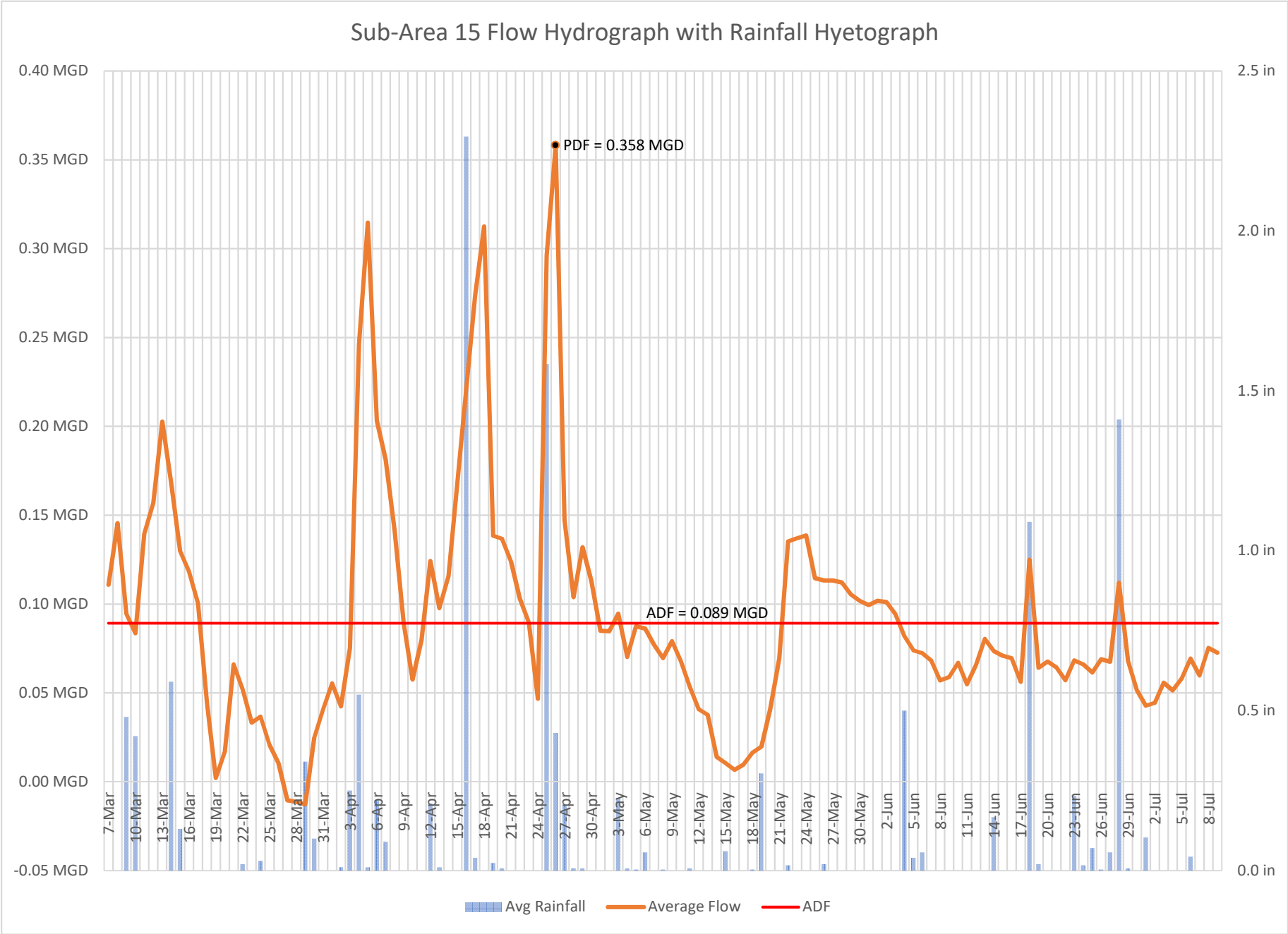
12/17/2018


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

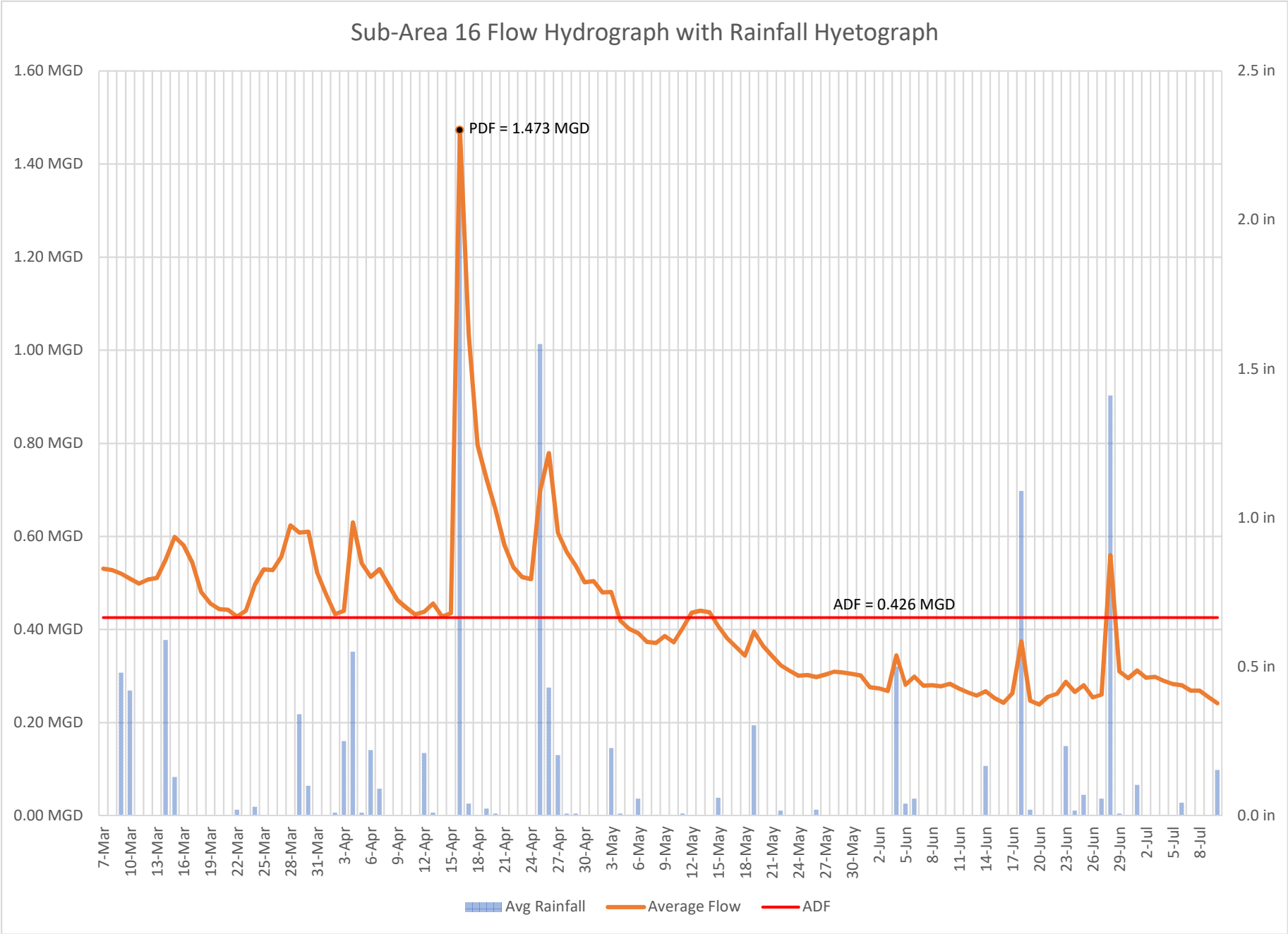
12/17/2018


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

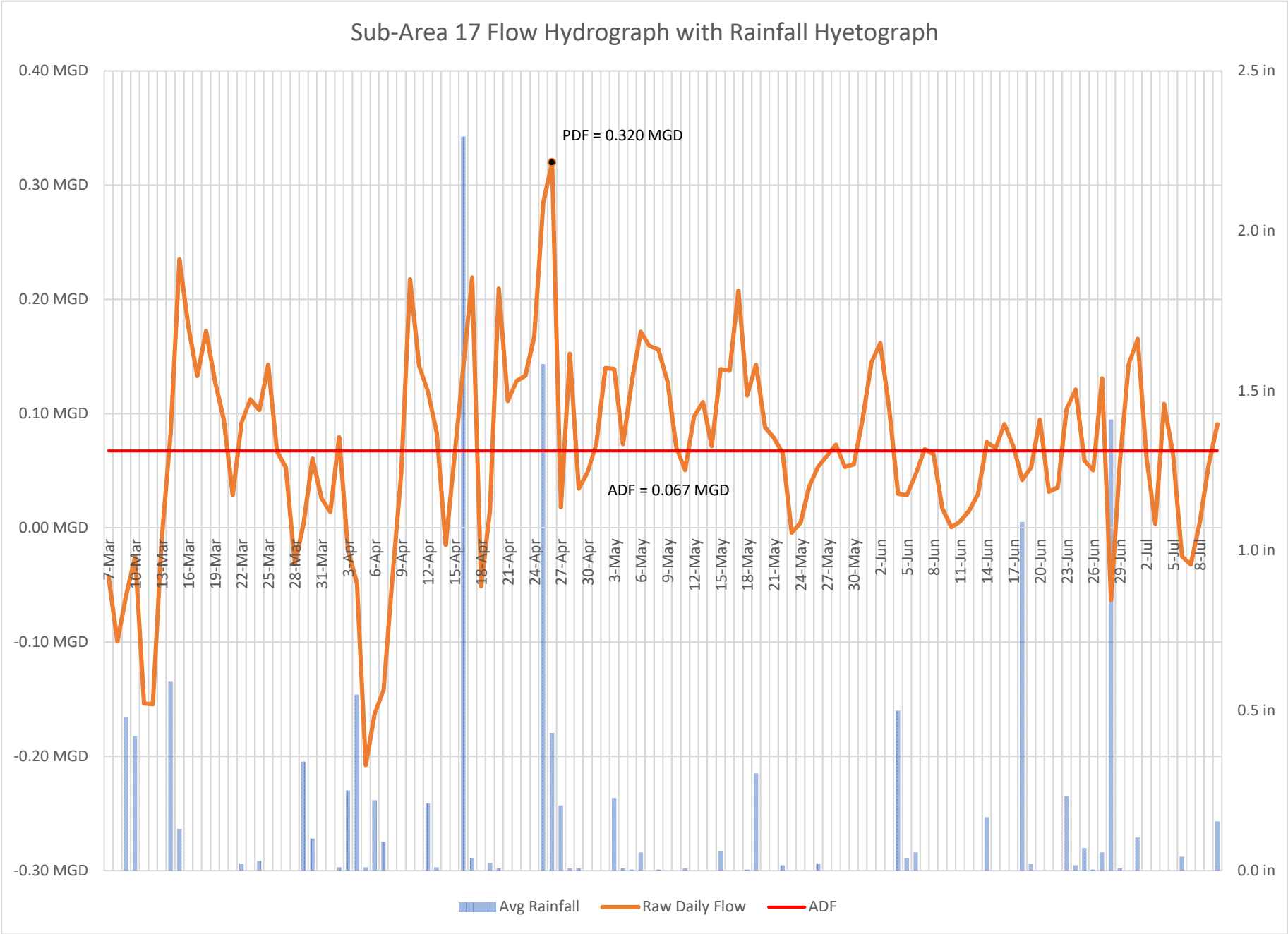
12/17/2018


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

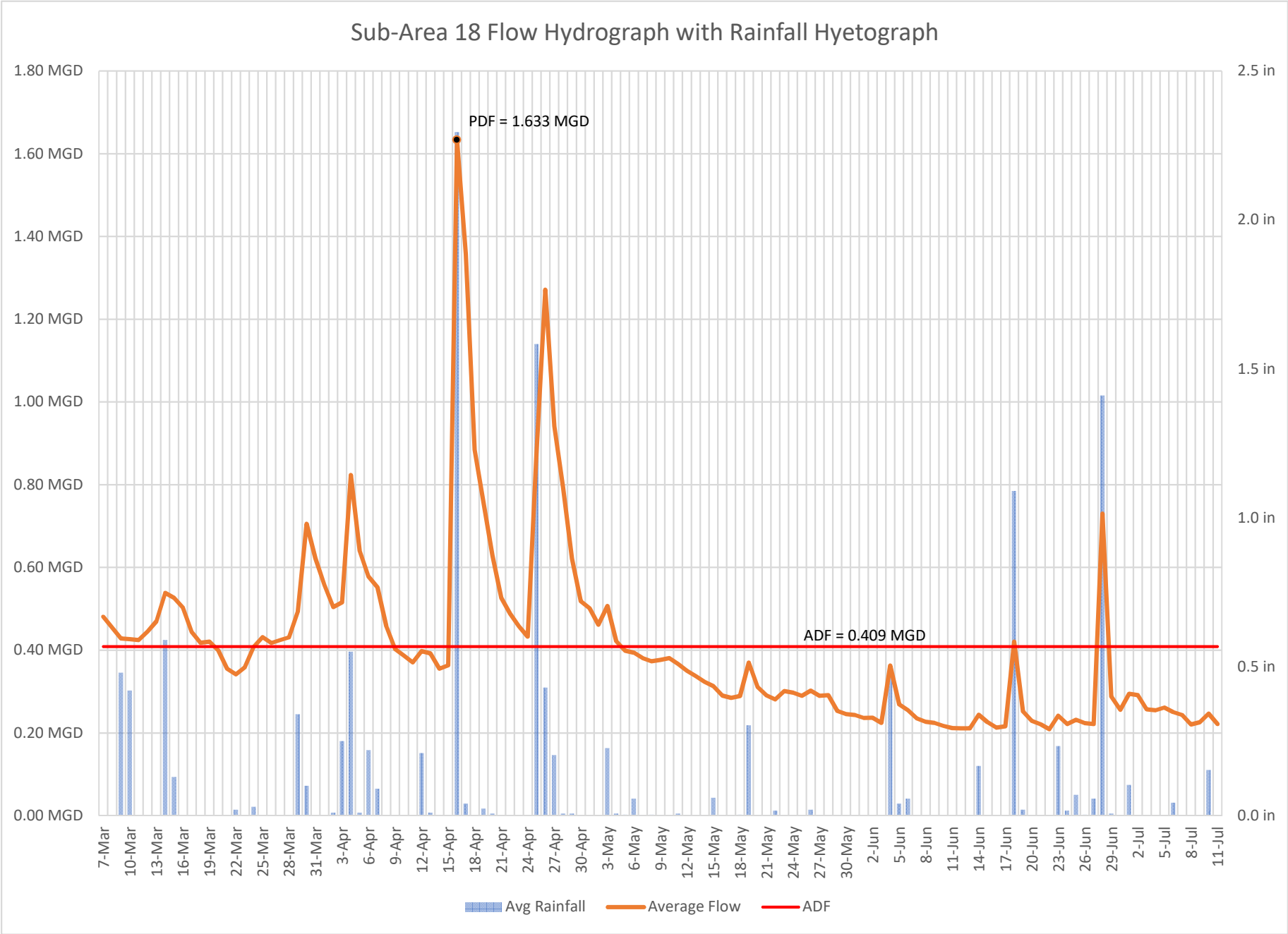
12/17/2018


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

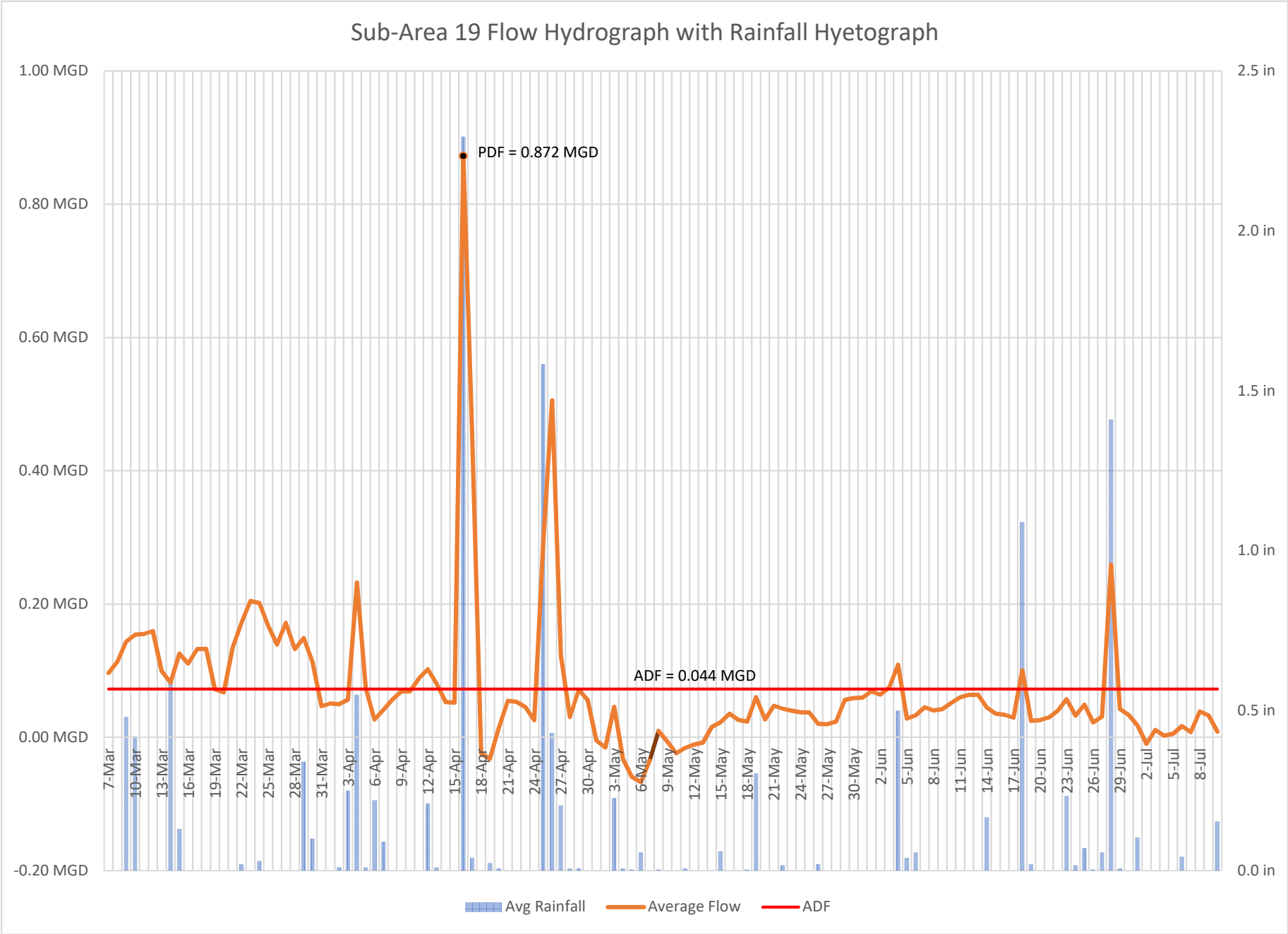
12/17/2018


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

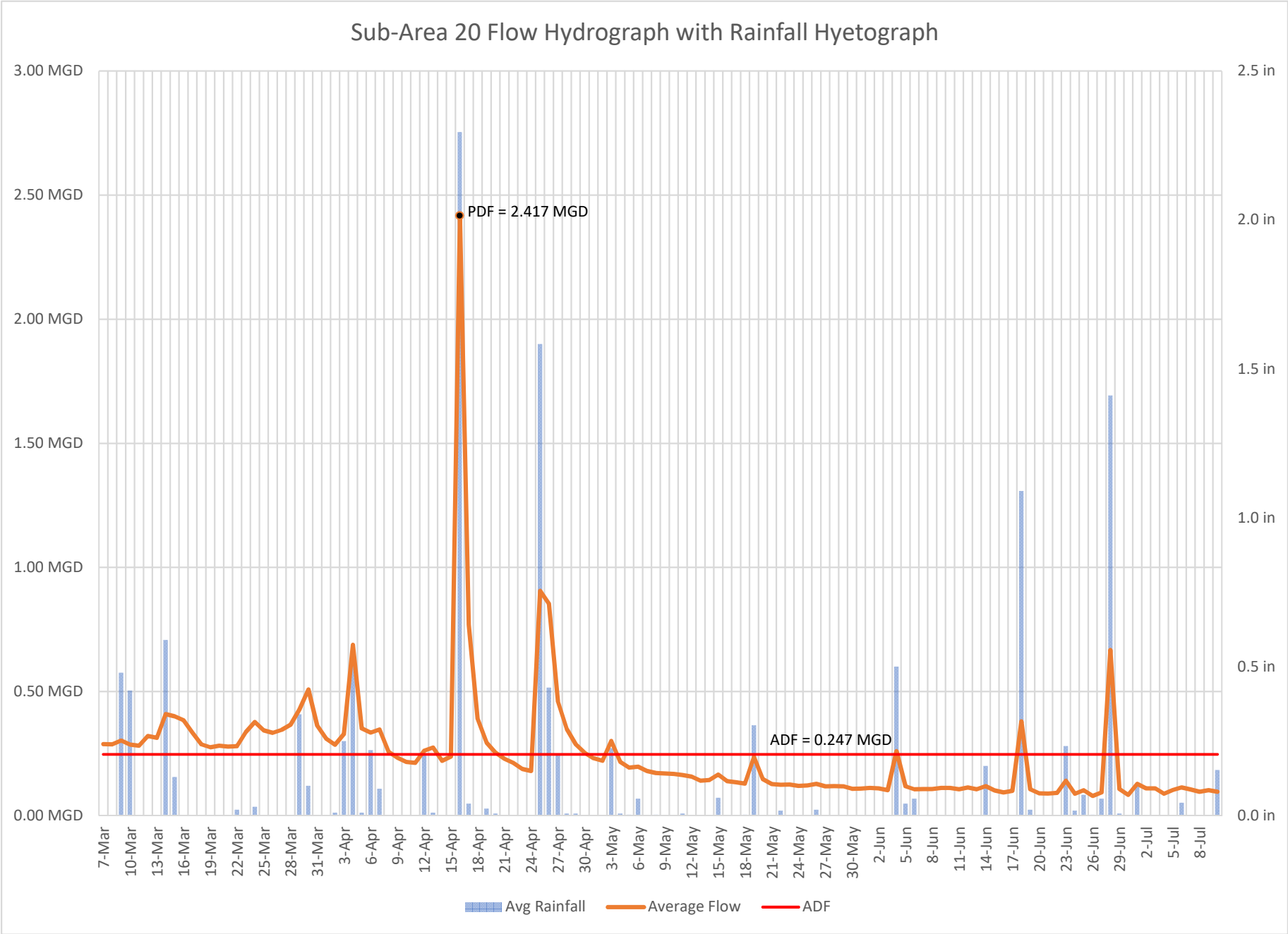
12/17/2018


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

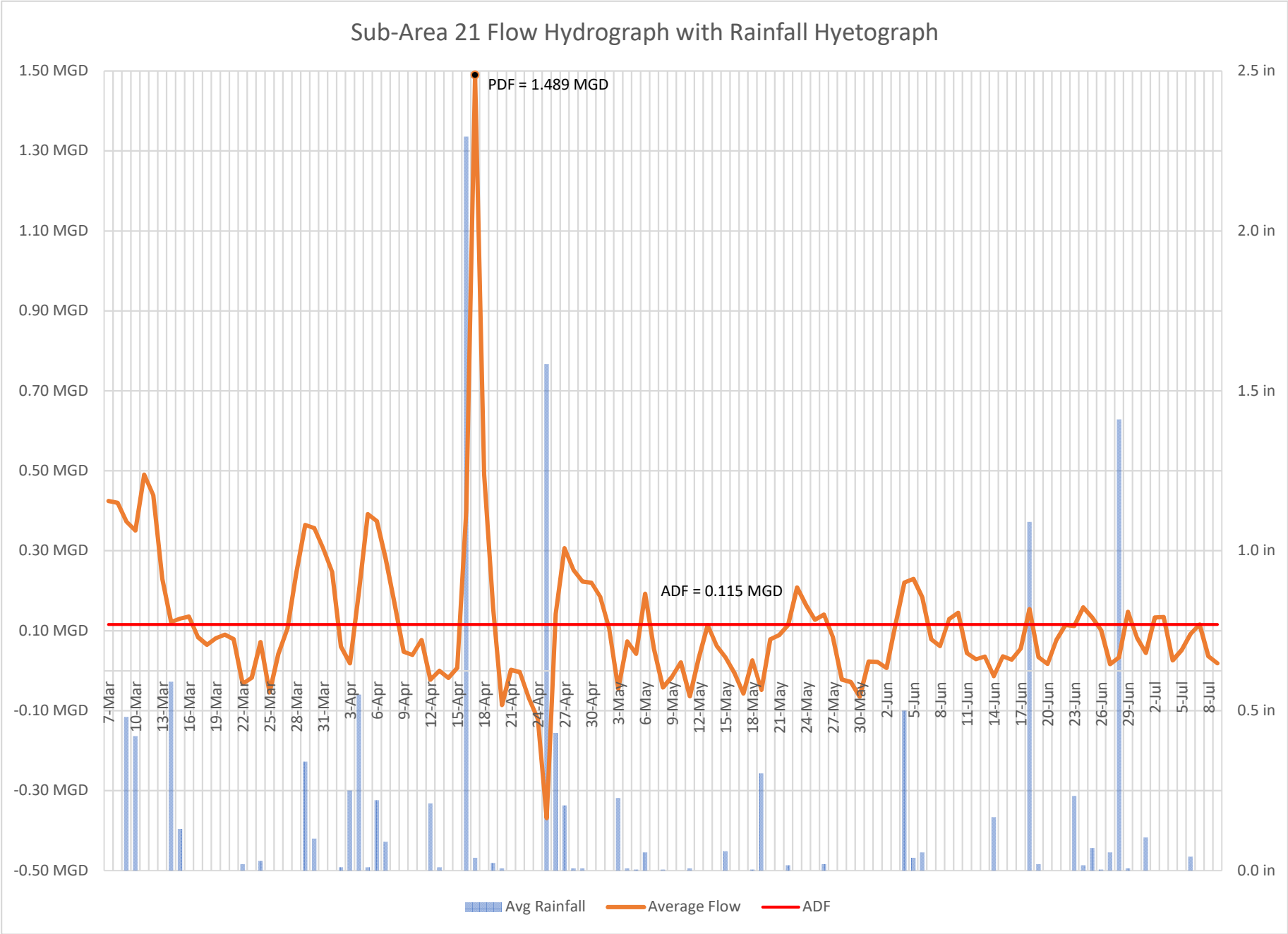
12/17/2018


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

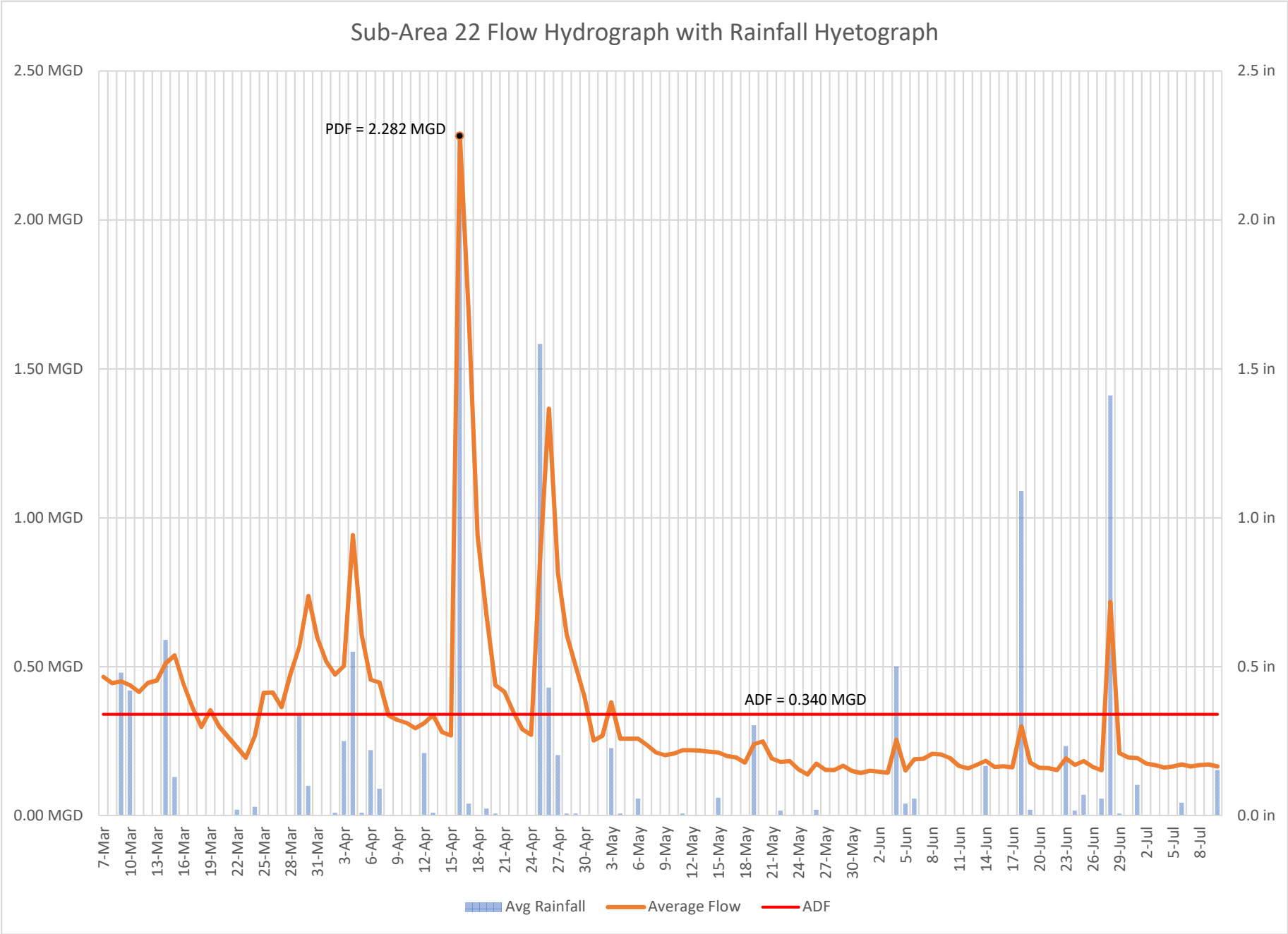
12/17/2018


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

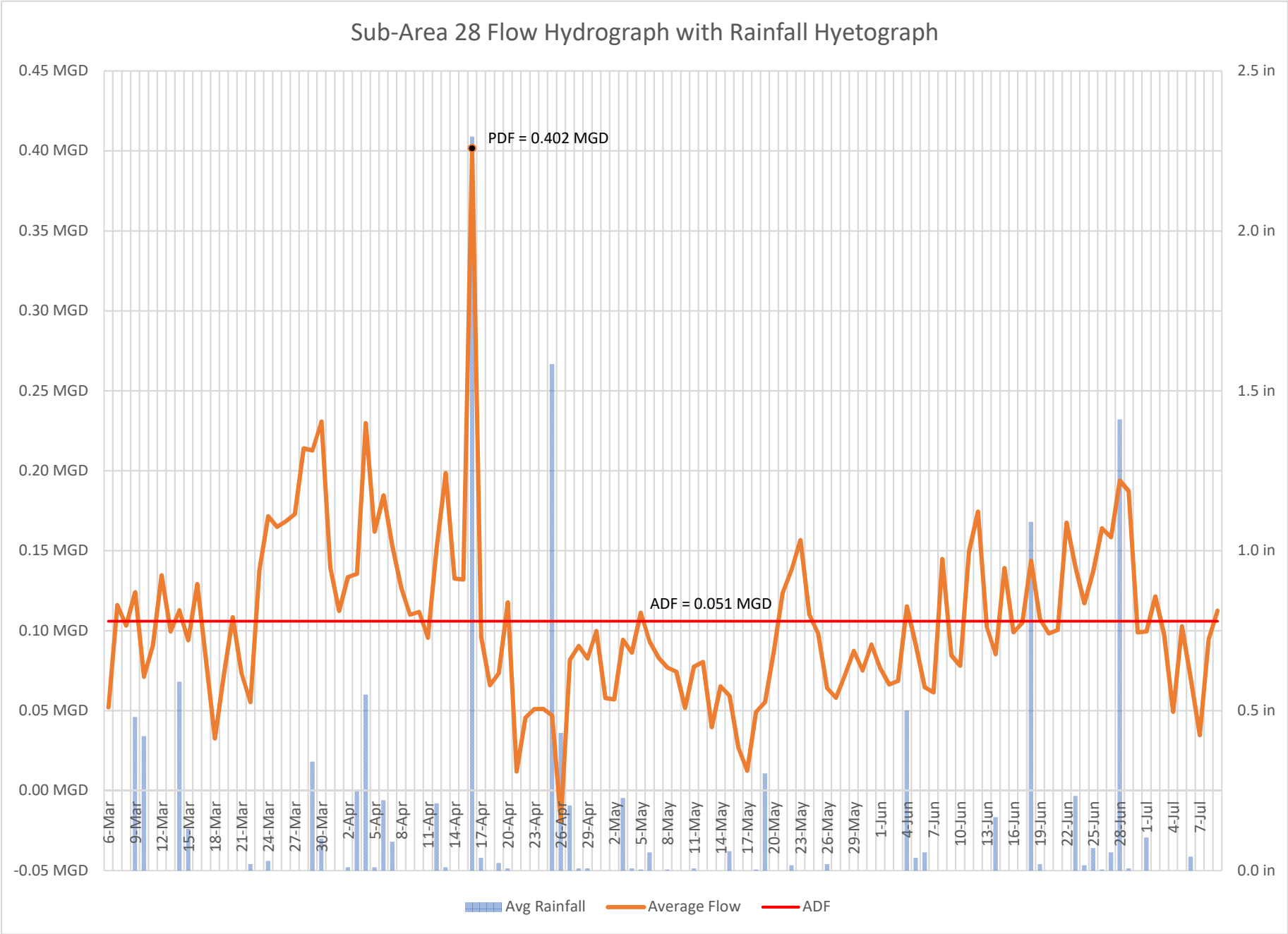
12/17/2018


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

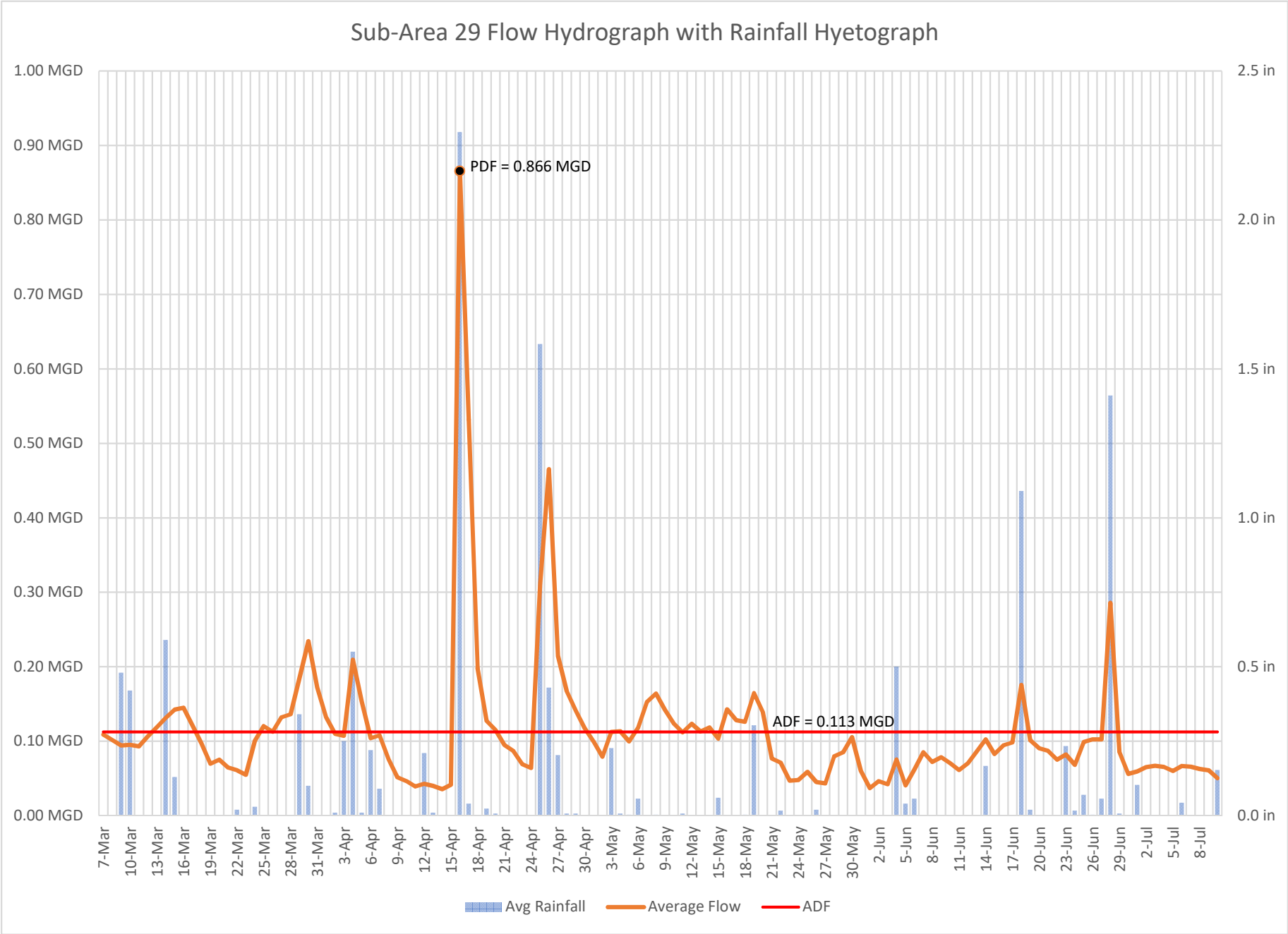
12/17/2018


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

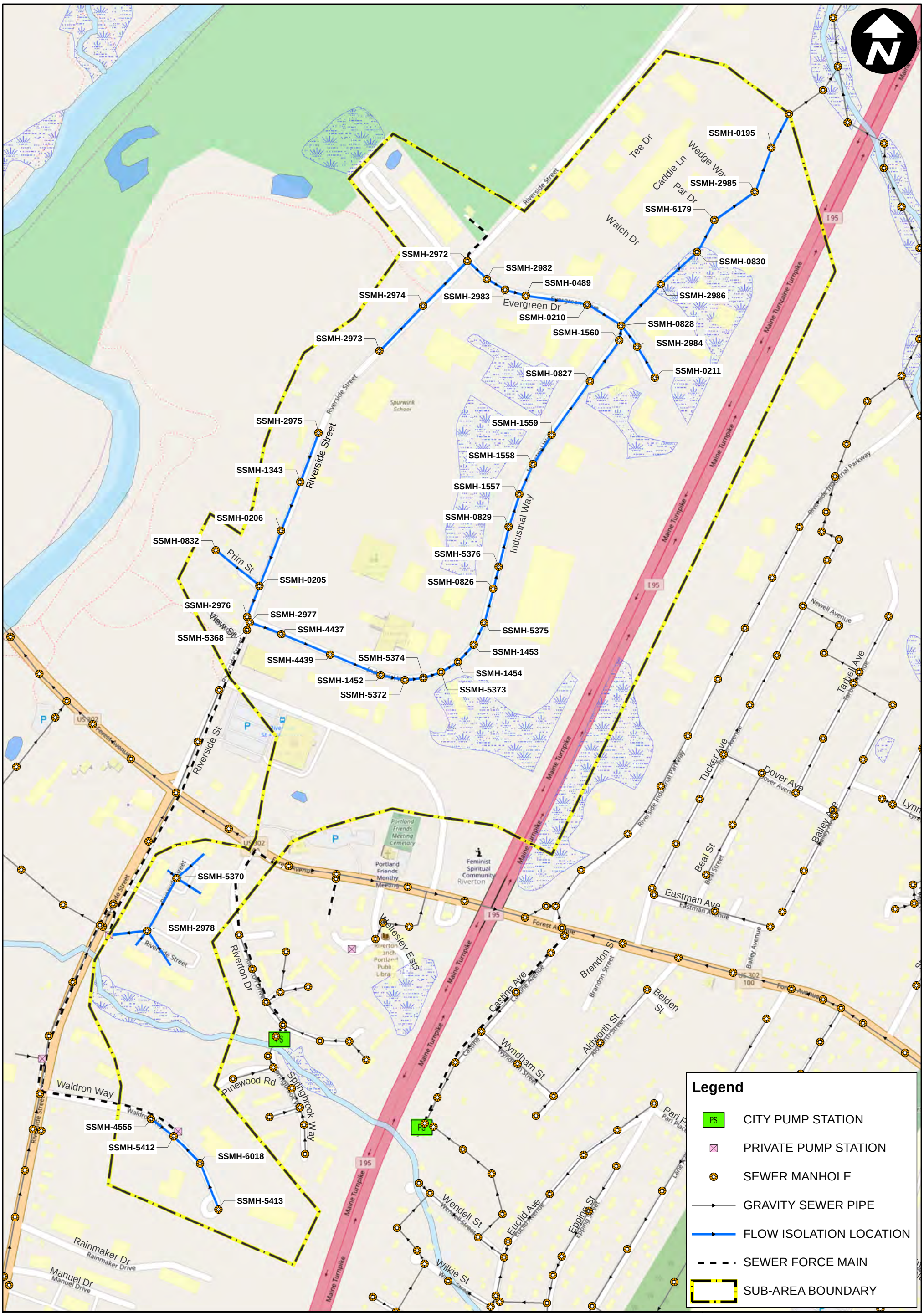
12/17/2018

# APPENDIX C

## Follow-on Investigation Sub-Area Figures

# INFILTRATION AND INFLOW INVESTIGATIONS:

# FLOW ISOLATION LOCATIONS

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*Sewer System*
*Evaluation Survey*

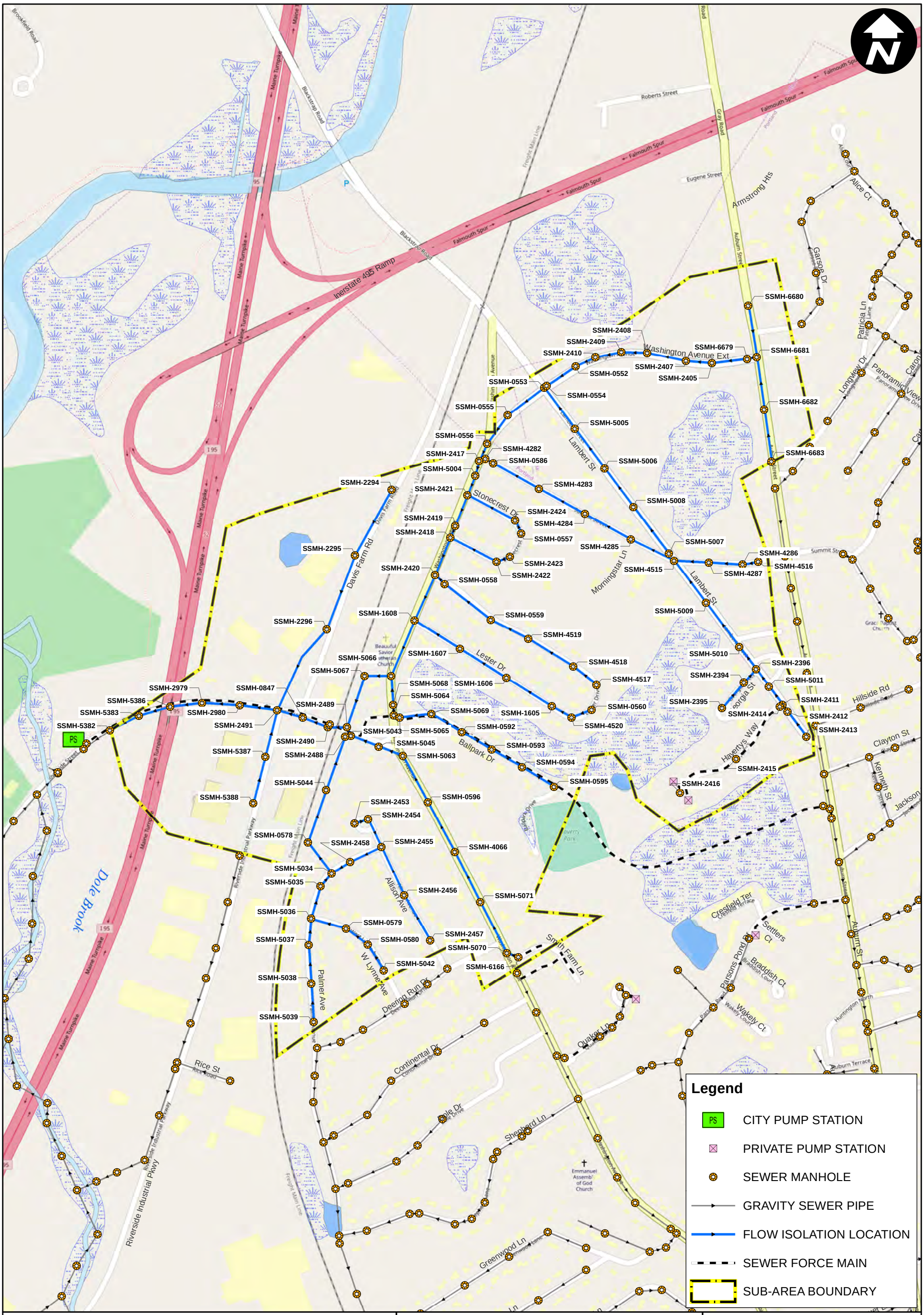
# Sub-Area 4

## 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

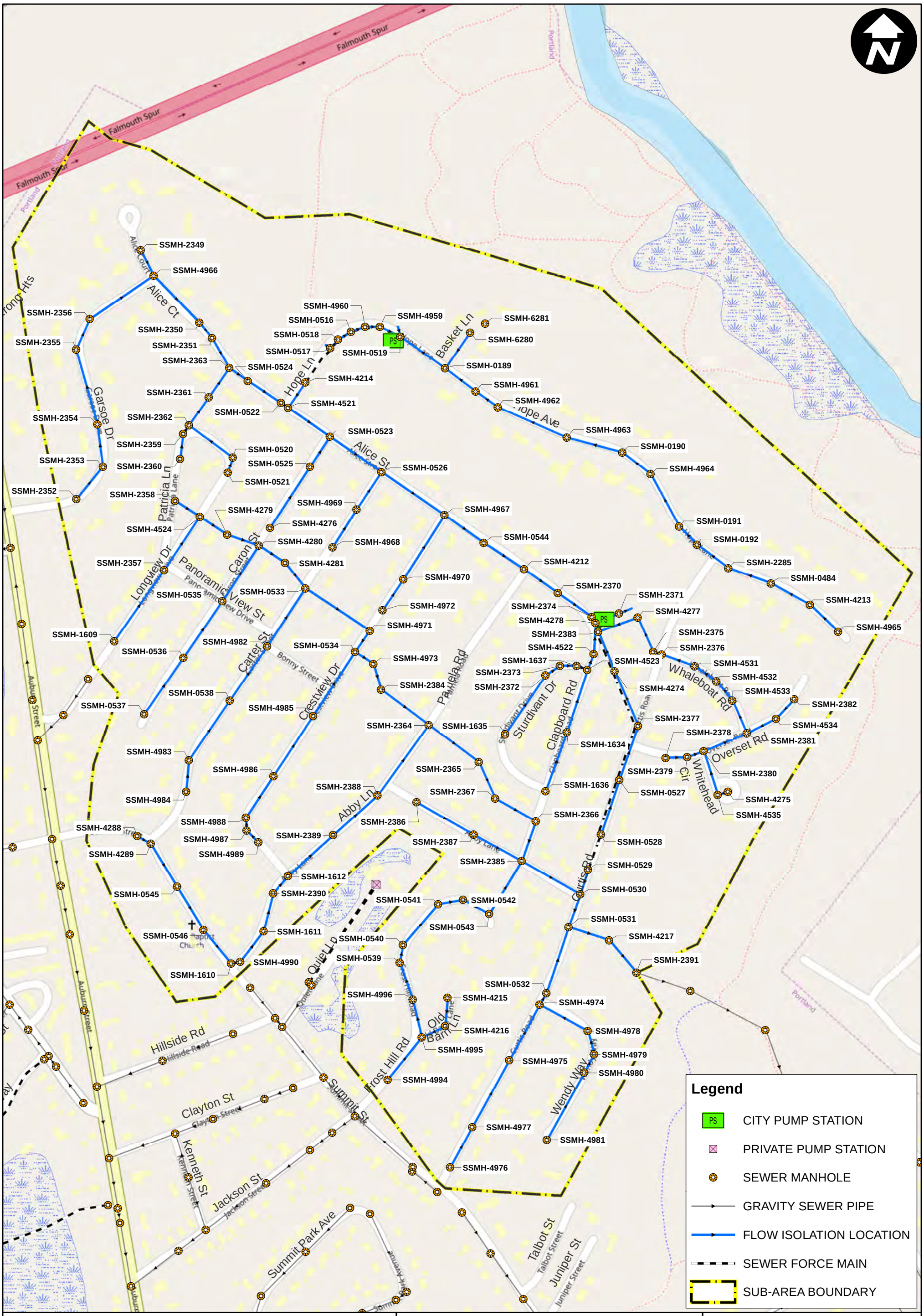
## Flow Isolation Locations

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

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*Sewer System*
*Evaluation Survey*

# Sub-Area 7

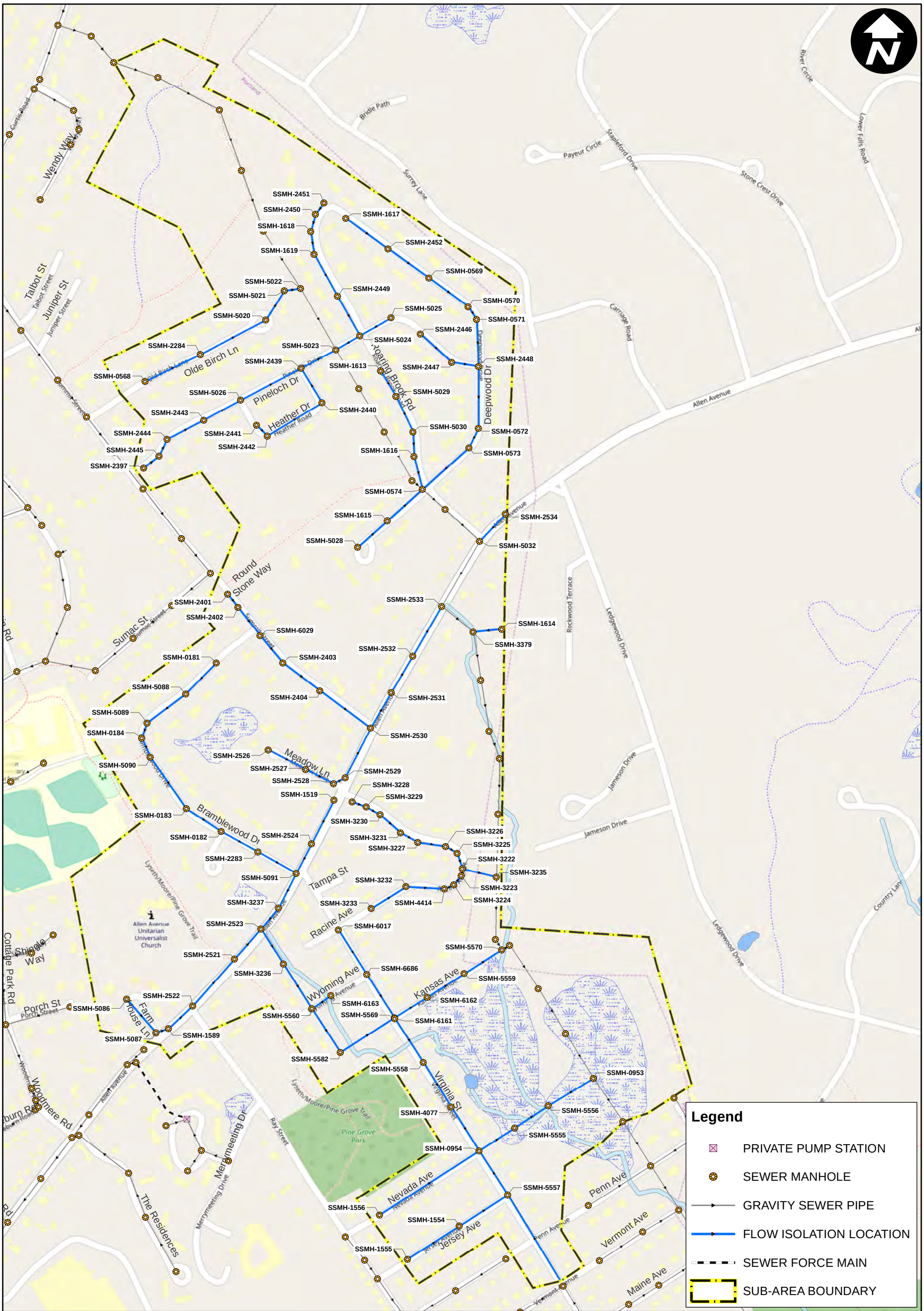
Flow Isolation Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 FLOW ISOLATION SUB AREA 7.mxd




# City of Portland, Maine

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*Evaluation Survey*

# Sub-Area 8

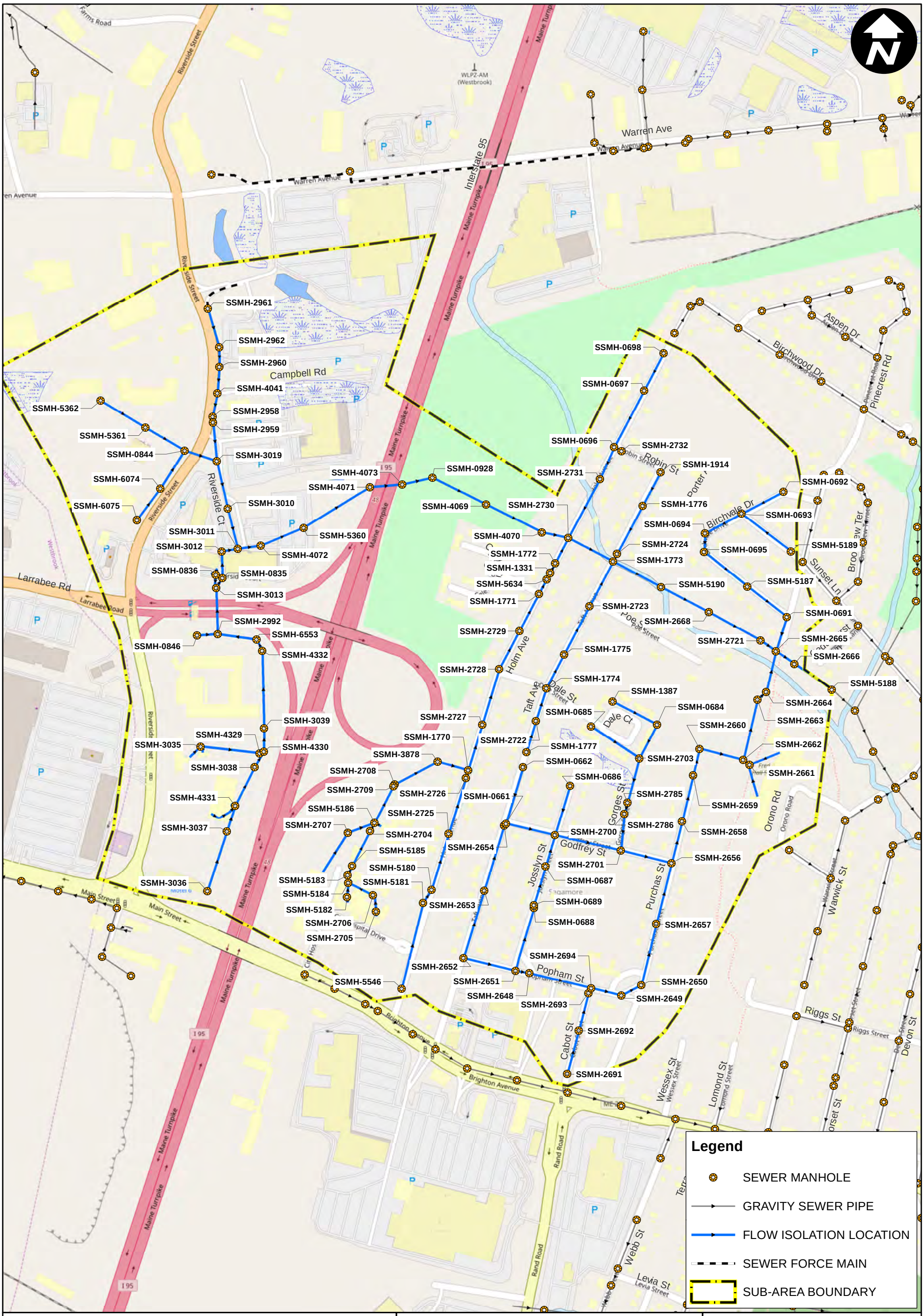
## Flow Isolation Locations

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 8.mxd

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*Planning & Engineering Sewer System Evaluation Survey*

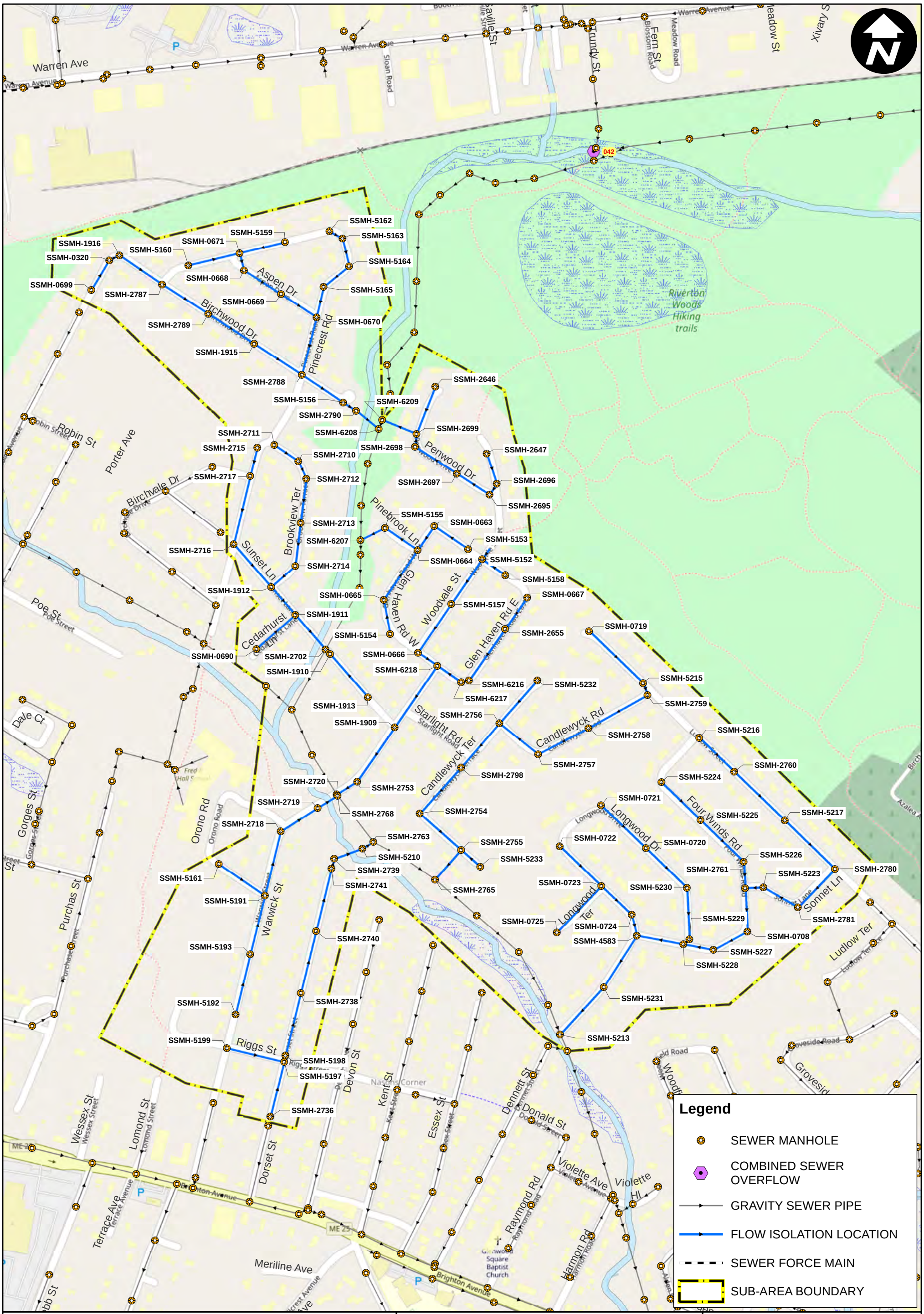
# Sub-Area 14

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

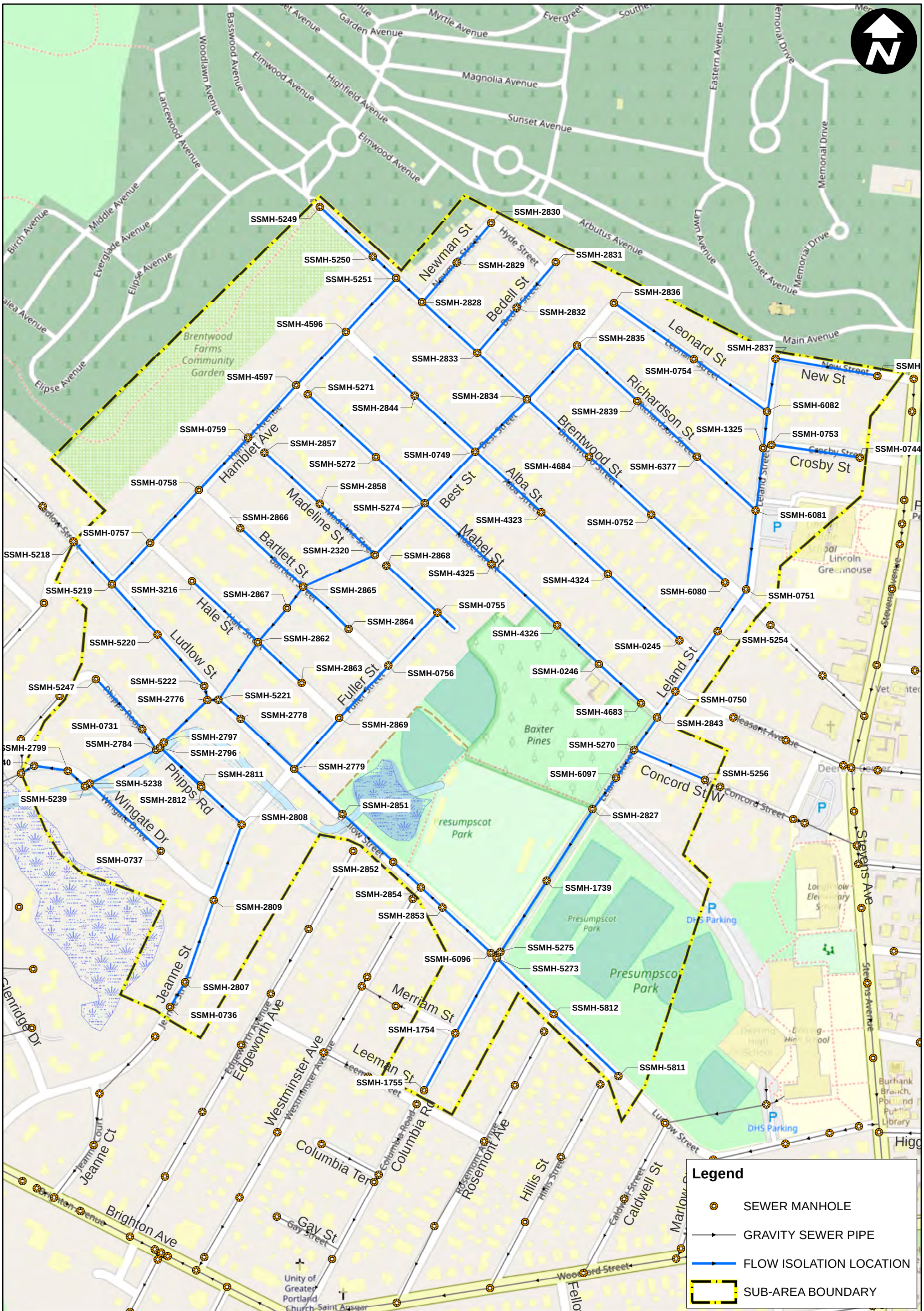
Flow Isolation Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 FLOW ISOLATION SUB AREA 15.mxd




# City of Portland, Maine

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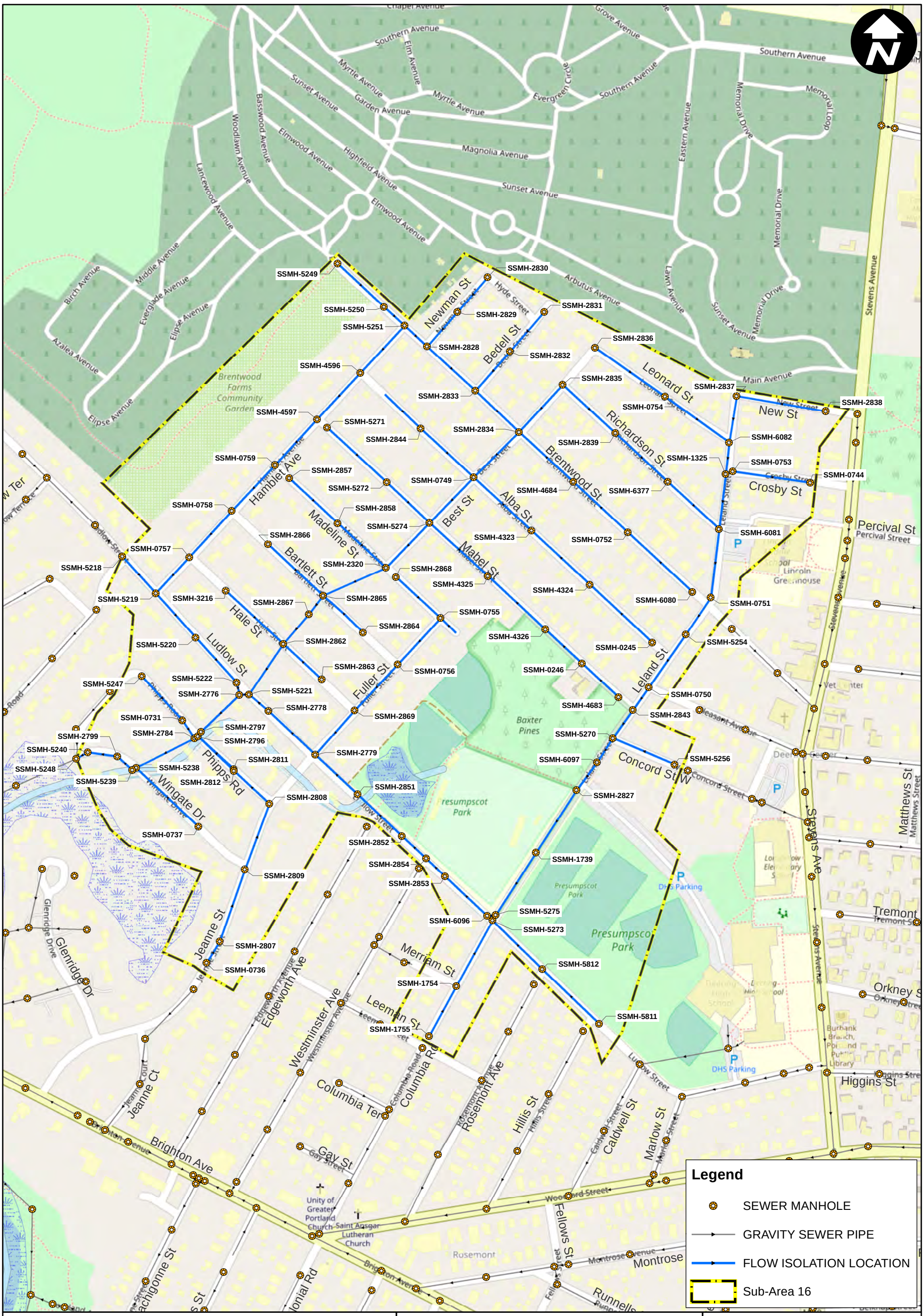
# Sub-Area 16

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 16.mxd

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# Sub-Area 16

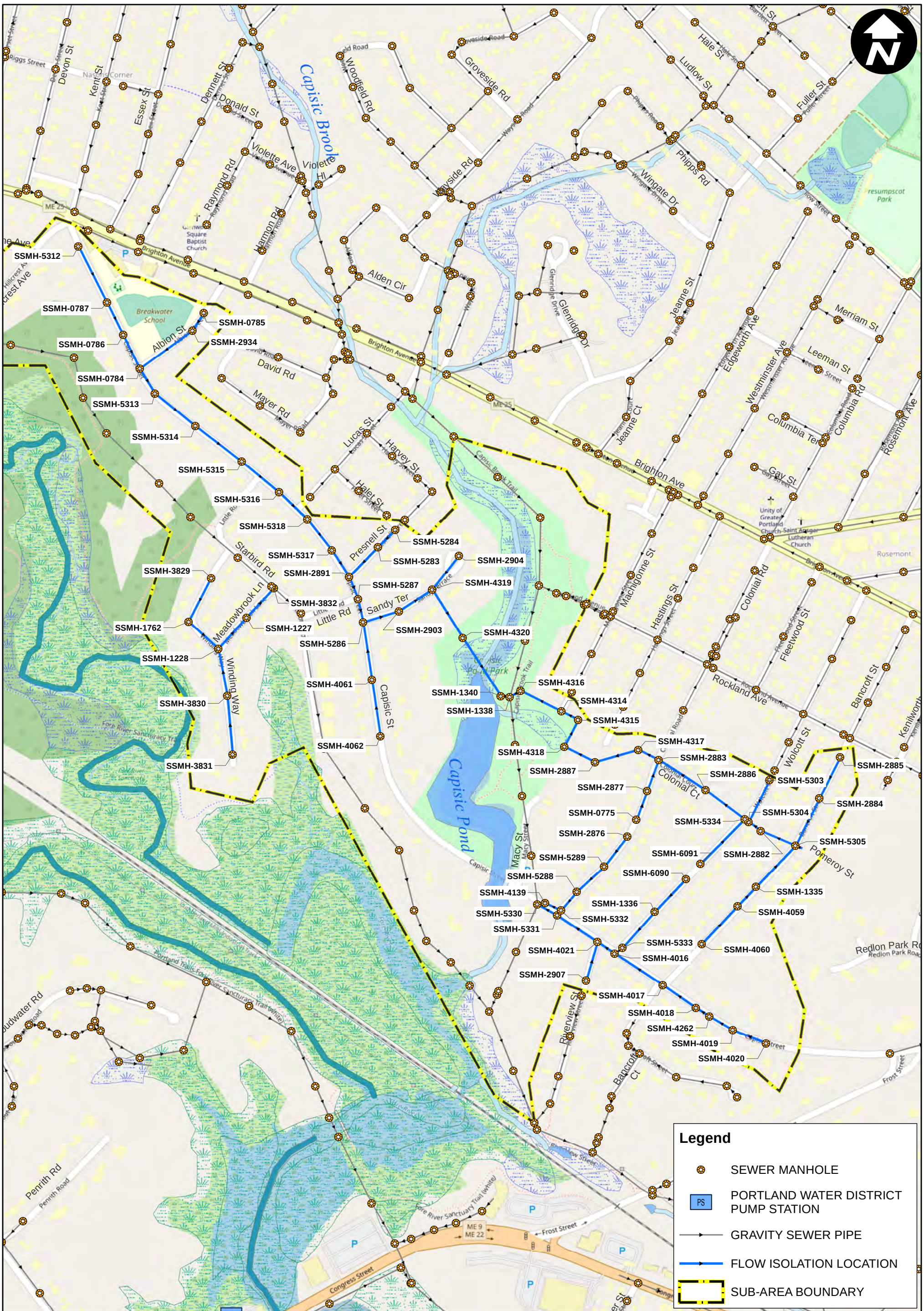
Flow Isolation Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 FLOW ISOLATION SUB AREA 18.mxd




**City of Portland, Maine**

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# Sub-Area 21

Flow Isolation Locations

December 2018

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# Sub-Area 22

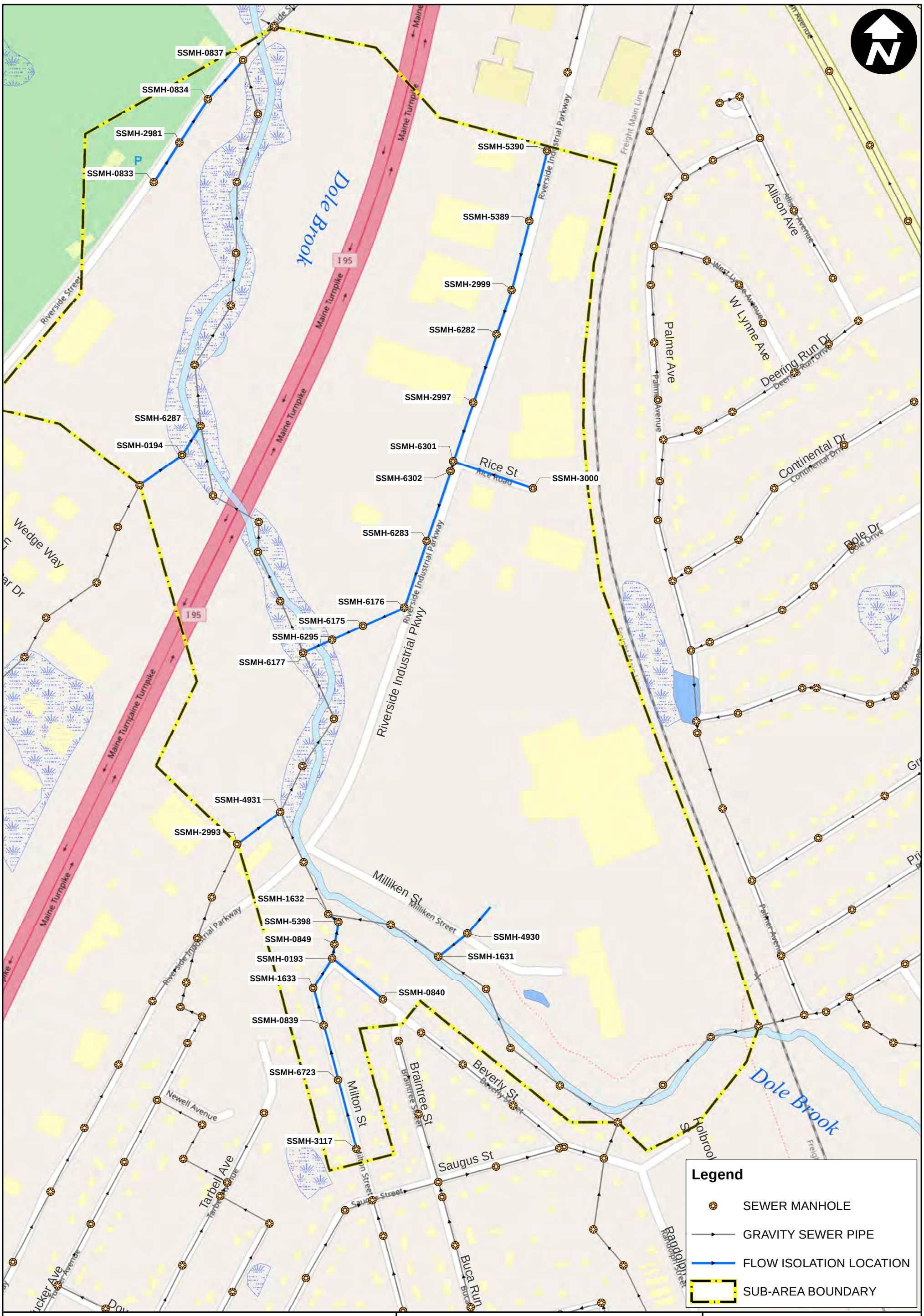
Flow Isolation Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 FLOW ISOLATION SUB AREA 22.mxd




# City of Portland, Maine

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# Sub-Area 28

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 28.mxd

# INFILTRATION AND INFLOW INVESTIGATIONS:

# CCTV INSPECTION LOCATIONS

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*Sewer System*
*Evaluation Survey*

# Sub-Area 9

Closed-Circuit Televised Inspection Locations

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 CCTV SUB-AREA 9.mxd

**City of Portland, Maine**

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*Sewer System*
*Evaluation Survey*

# Sub-Area 19

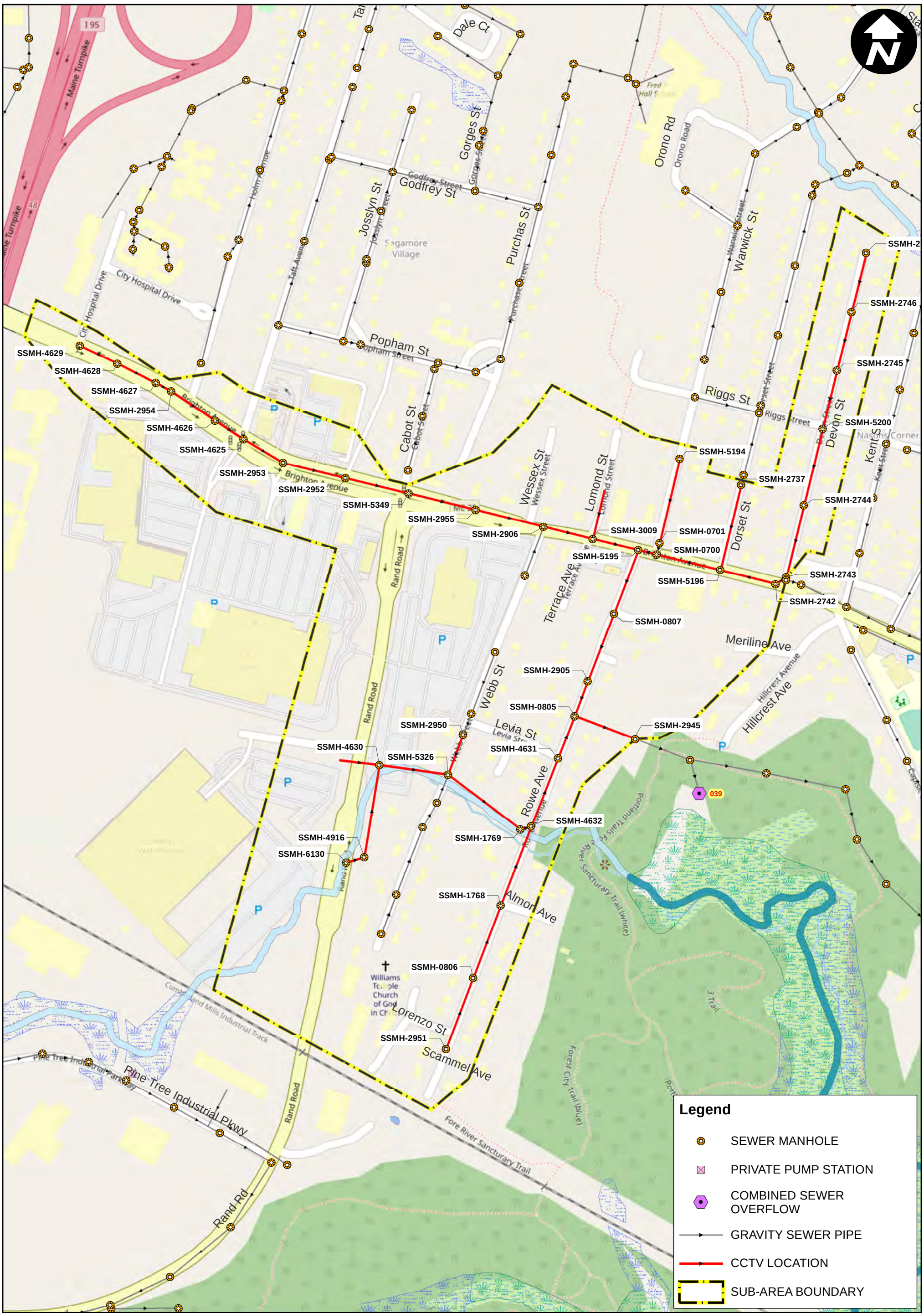
Closed-Circuit Televised Inspection Locations

0 100 200 300 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 CCTV SUB-AREA 19.mxd




# City of Portland, Maine

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*Evaluation Survey*

# Sub-Area 20

Closed-Circuit Televised Inspection Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 CCTV SUB-AREA 20.mxd

**City of Portland, Maine**

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# Sub-Area 29

Closed-Circuit Televised Inspection Locations

0 100 200 300 400 Feet

December 2018

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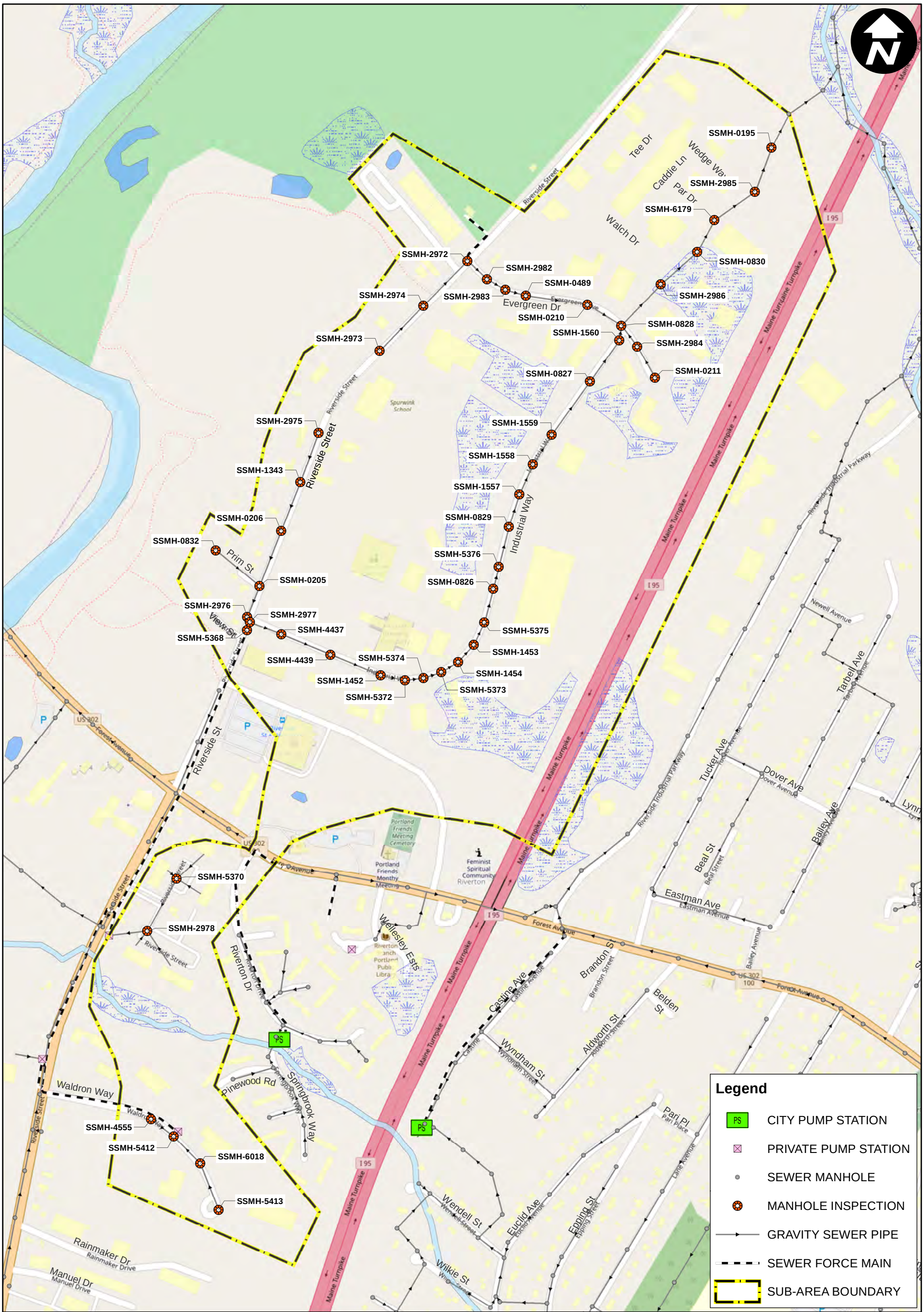
G:\GIS\Portland\2018 - 2019 SSES Maps\2018 CCTV SUB-AREA 29.mxd

# INFILTRATION AND INFLOW INVESTIGATIONS:

# MANHOLE INSPECTION LOCATIONS




# City of Portland, Maine

*Planning & Engineering*
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*Evaluation Survey*

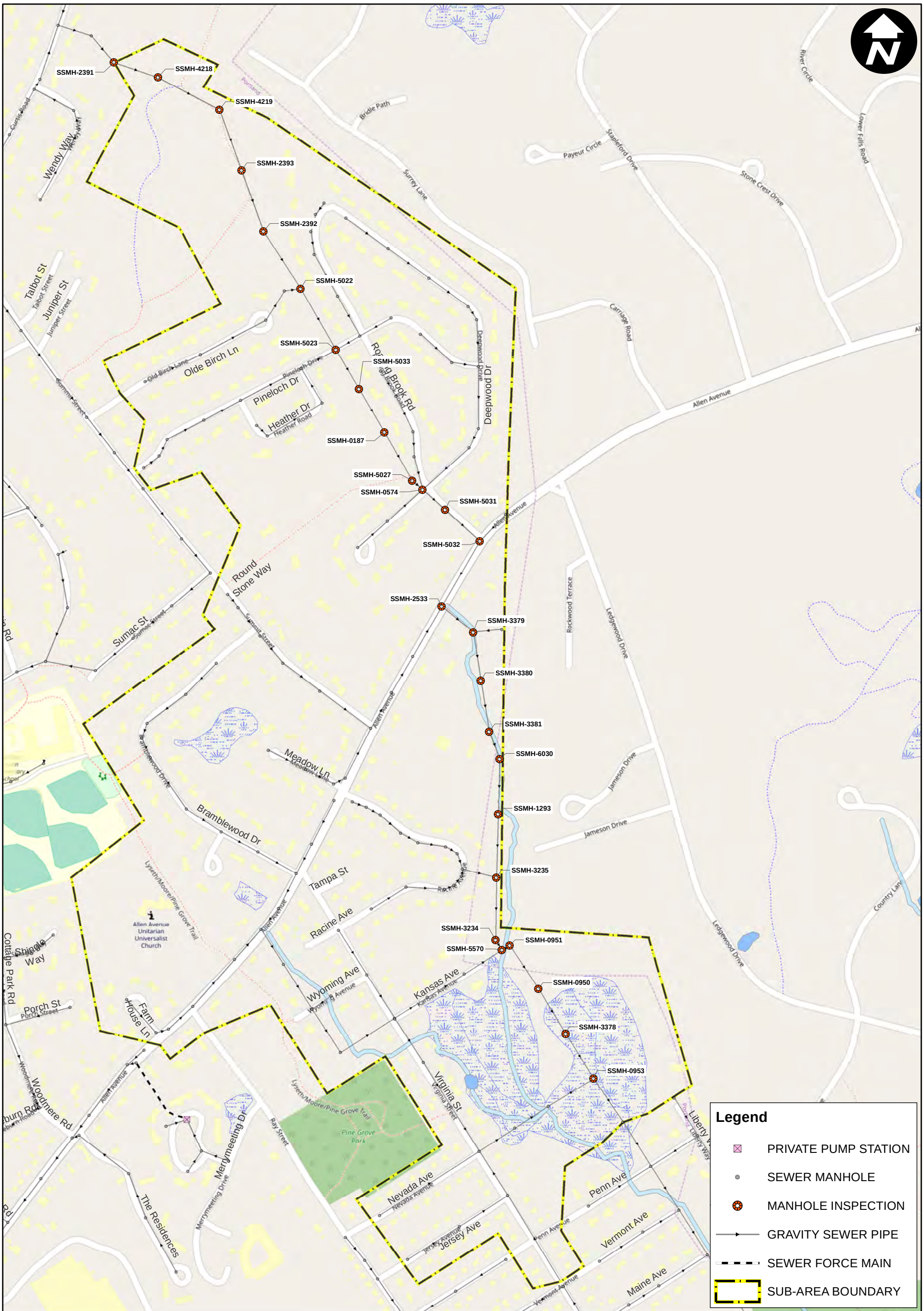
# Sub-Area 4

## Manhole Inspection Locations

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 MANHOLE INSPECTION SUB-AREA 4.mxd




# City of Portland, Maine

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# Sub-Area 8

## Manhole Inspection Locations

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 MANHOLE INSPECTION SUB-AREA 8.mxd

# City of Portland, Maine

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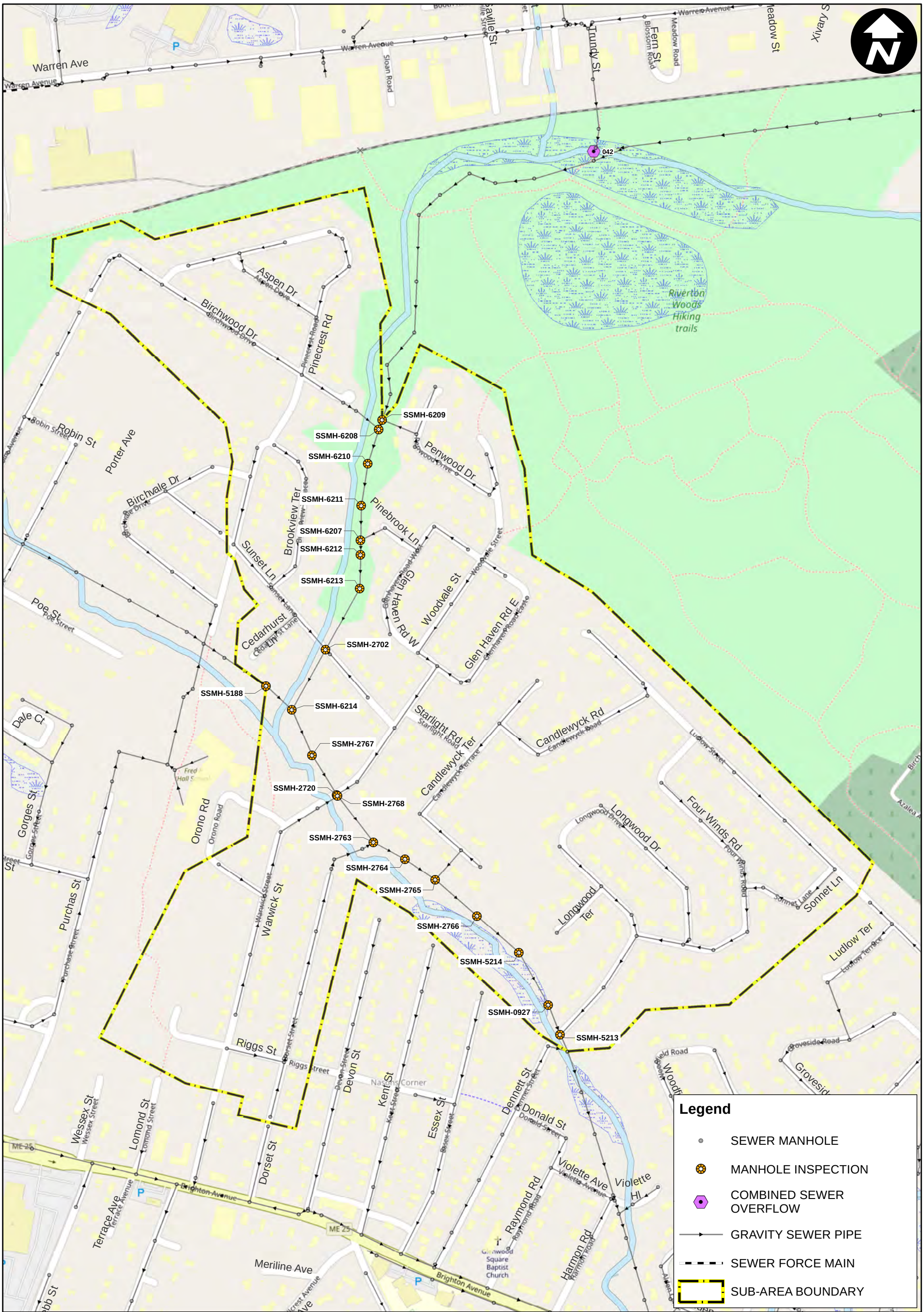
# Sub-Area 9

Manhole Inspection Locations

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 MANHOLE INSPECTION SUB-AREA 9.mxd




**City of Portland, Maine**

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# Sub-Area 15

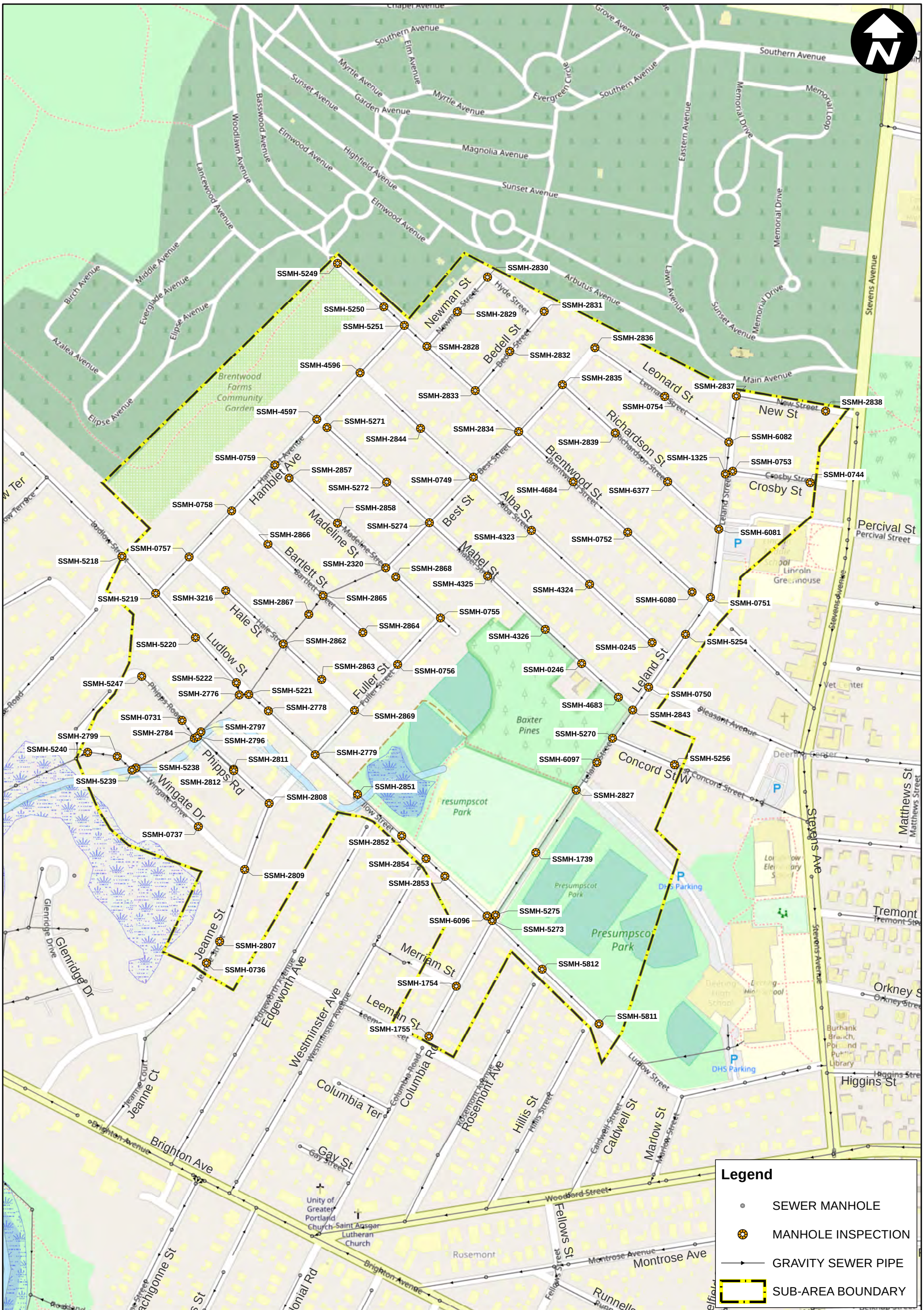
## Manhole Inspection Locations

0 200 400 600 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 MANHOLE INSPECTION SUB-AREA 15.mxd




RESURGAM CITY OF PORTLAND, MAINE

# City of Portland, Maine

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# Sub-Area 16

## Manhole Inspection Locations

December 2018

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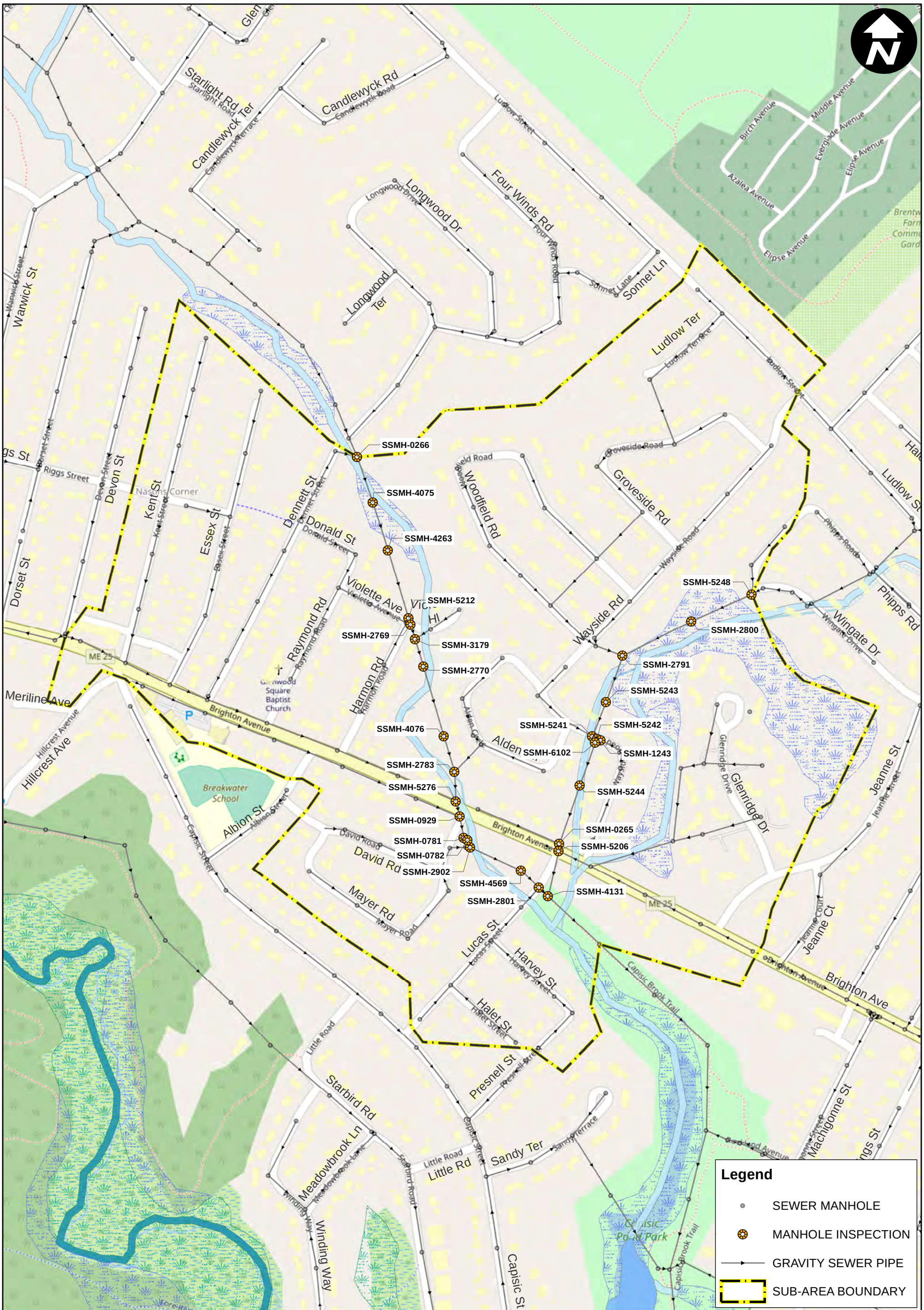
G:\GIS\Portland\2018 - 2019 SSES Maps\2018 MANHOLE INSPECTION SUB-AREA 16.mxd




**City of Portland, Maine**

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*Sewer System*
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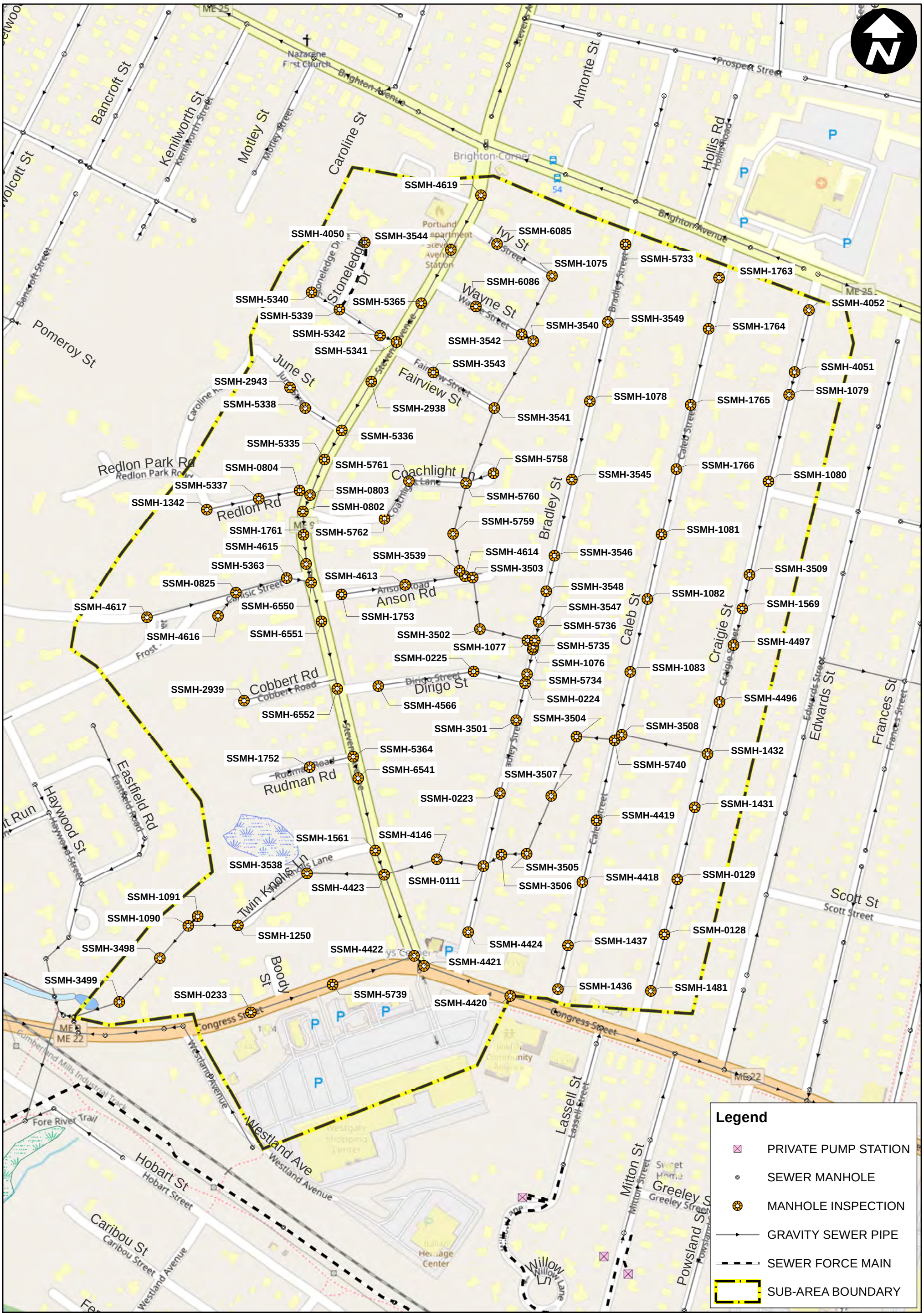
# Sub-Area 17

Manhole Inspection Locations

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 MANHOLE INSPECTION SUB-AREA 17.mxd




# City of Portland, Maine

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*Sewer System*
*Evaluation Survey*

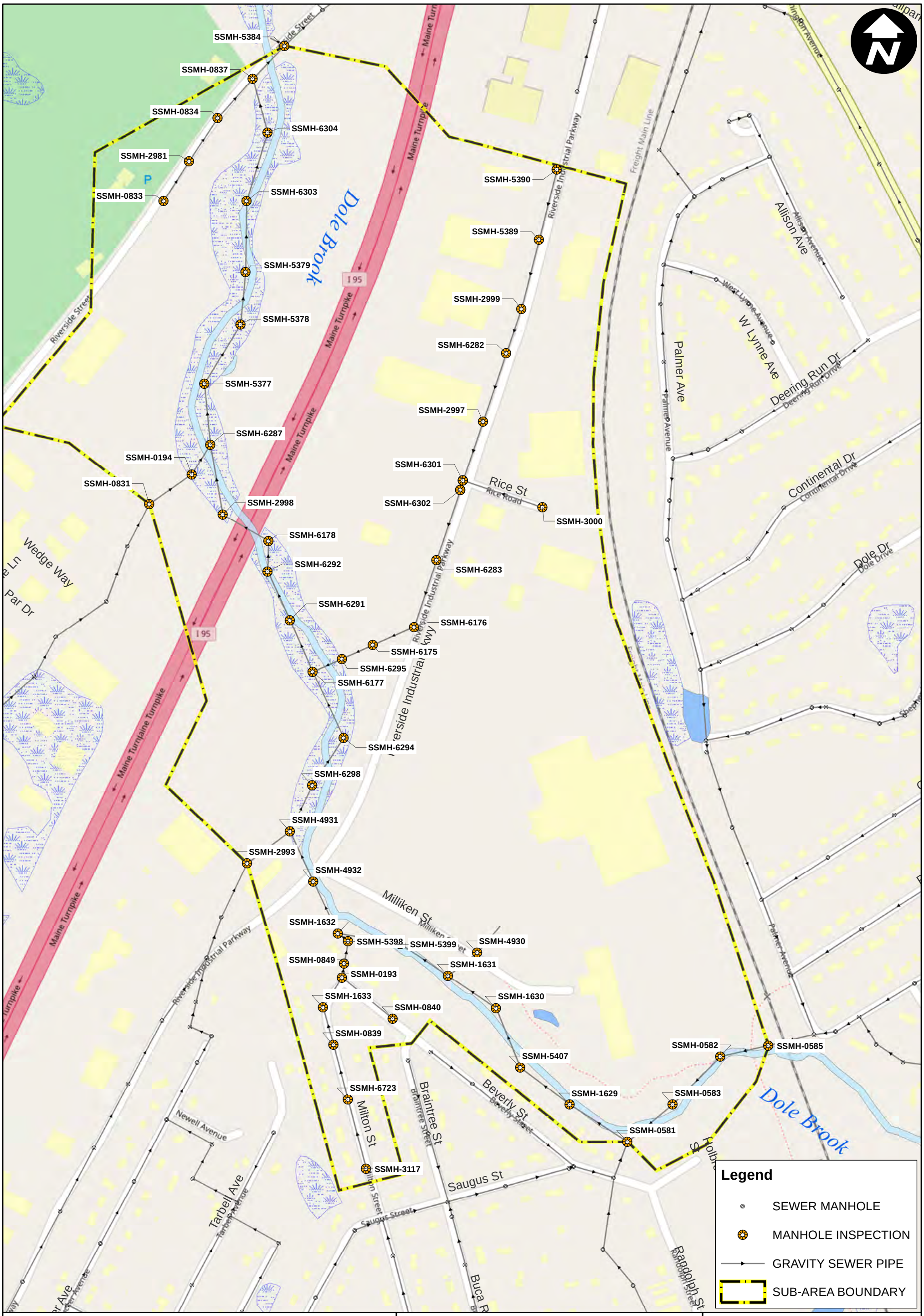
# Sub-Area 22

## Manhole Inspection Locations

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 MANHOLE INSPECTION SUB-AREA 22.mxd




# City of Portland, Maine

*Planning & Engineering*
*Sewer System*
*Evaluation Survey*

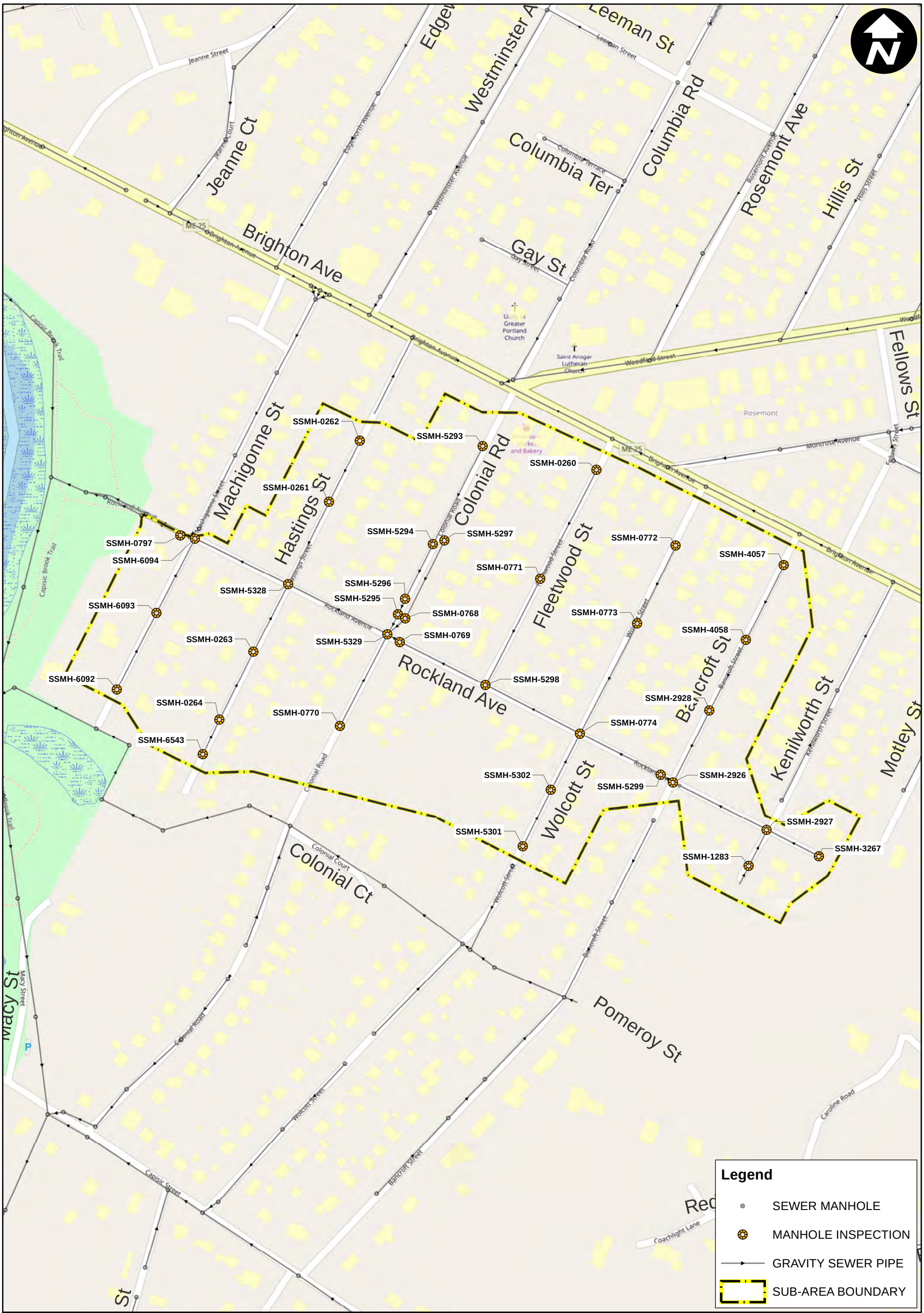
# Sub-Area 28

Manhole Inspection Locations

November 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 MANHOLE INSPECTION SUB-AREA 28.mxd




**City of Portland, Maine**

*Planning & Engineering*
*Sewer System*
*Evaluation Survey*

# Sub-Area 29

Manhole Inspection Locations

0 100 200 300 400 Feet

December 2018

ARCADIS Design & Consultancy for natural and built assets

G:\GIS\Portland\2018 - 2019 SSES Maps\2018 MANHOLE INSPECTION SUB-AREA 29.mxd