2019 STORMWATER QUALITY AND QUANTITY MONITORING PROGRAM

CITY OF ST. PAUL

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Prepared for:
City of St. Paul
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LIST OF ABBREVIATIONS

BMP	Best Management Practices
CCB	Capital City Bikeway
CRWD	Capital Region Watershed District
Cu-ft	Cubic feet
DP	Dissolved phosphorus
EMC	Event mean concentration
ft	Feet
FWA	Flow-weighted average
HDPE	High-density polyethylene
In/hr	Inches per hour
IR	In-rock
lbs	Pounds
mg/L	Milligrams per liter
MS4	Municipal Separate Storm Sewer System
MSWM	Minnesota Stormwater Manual
MPN	Most probable number
MnDOT	Minnesota Department of Transportation
NPDES	National Pollutant Discharge Elimination System
OCS	Outlet control structure
SP	Poorly graded sand
SPCD	Saint Paul City Datum
SRP	Soluble reactive phosphorus
TP	Total phosphorus
TSS	Total suspended solids

1. INTRODUCTION

The purpose of this report is to present the findings of the City of Saint Paul's (City) 2019 Stormwater Monitoring Program. The monitoring was conducted to fulfill requirements of the City's National Pollutant Discharge Elimination System (NPDES) MS4 Phase I Permit. Data collected and analyzed is used to quantify stormwater volumes and loads from the Municipal Separate Storm Sewer System (MS4) and assist in the assessment of effectiveness of the City's Stormwater Management Program.

Since 2006, the City has been required by local watershed agencies to construct stormwater volume reduction Best Management Practices (BMPs) concurrent with City projects that generate or reconstruct impervious surfaces. The watershed requirements stipulate that these BMPs must provide volume reduction for the runoff from a one-inch rainfall event over the impervious surfaces of the project. In 2015, the watershed updated their standard to require that the BMP provide volume reduction for the runoff from a 1.1-inch rainfall event over the impervious surface of the project. The City has typically achieved this by constructing infiltration BMPs.

The focus of the City's stormwater monitoring program has been to monitor the effectiveness and maintenance needs of stormwater BMPs. Outfall monitoring data, collected by Capitol Region Watershed District (CRWD), is used to evaluate pollutant loading from major sub-watersheds and to estimate City-wide pollutant loading from the MS4. That information is provided in the annual MS4 Report submitted to the MPCA and is not further evaluated in this report.

Four BMPs and two drainage areas monitored via storm pipe were monitored in 2019 to quantify progress toward meeting the City's stormwater management goals and to refine current design and maintenance practices. Rainfall was also measured at four locations in the City. The 2019 monitoring sites are shown on **Figure 1-1** and listed in **Table 1-1**. This effort focused on evaluating four major parameters during the monitoring period:

- Water level/infiltration rate
- Volume reduction
- Pollutant capture
- BMP maintenance

To evaluate these parameters, electronic monitoring equipment was used to continuously measure system water levels, inflow/outflow volumes, and rainfall amounts. In addition, visual inspections and measurements of sediment accumulation were conducted periodically for each system to assess maintenance needs.

Three of the monitored BMPs are pervious pavement sites, evaluated for infiltration performance. Long-term monitoring at these sites is completed to research the benefits, feasibility, and sustainability of pervious surface parking lanes, alleyways, and bike trails in the City.

This report describes the procedures and methods used to collect water quality and quantity data, provides background information for each site monitored, and presents the results of the monitoring that was completed.

Table 1-1: 2019 City of Saint Paul Monitoring Site Summary

BMP/Site Name	BMP/Site Type	Monitored Parameters[1]
Beacon Bluff	Underground Infiltration Gallery & Rain Garden	WL, Q, WQ, GW
St. Albans Street	Underground Infiltration Gallery	WL, Q, WQ
Hampden Park	Underground Infiltration Gallery	WL, Q, WQ, GW
Hamline Midway Library Pervious Alleyway	Pervious Asphalt	Infiltration
Victoria Street	Pervious Pavers & Underground Infiltration Gallery	WL, Q, WQ, Infiltration
Jackson Street Pervious Bike Path	Pervious Asphalt	Infiltration
Battle Creek	Storm Pipe/Creek	WL, Q, WQ
Sackett Park	Storm Pipe/Flood Plain	WL, Q, WQ
Wilder Recreation Center	Rainfall Monitoring Location	R
Fire Station 18	Rainfall Monitoring Location	R
Hampden Park Co-op	Rainfall Monitoring Location	R
Frost Elementary School	Rainfall Monitoring Location	R

1 WL- Water Level, Q – Flow Rate, WQ – Water Quality, GW – Groundwater, R – Rainfall

2. PROCEDURES AND METHODOLOGY

This section outlines the procedures and methods followed to perform monitoring and data analysis. For more detailed information related to equipment use monitoring protocols that were followed for this monitoring program, see the 2019 Stormwater Monitoring Protocols document located in **Appendix F**.

2.1. Infiltration Rate

The infiltration rate was measured at applicable locations by collecting water level data on a continual basis. The data was then analyzed to estimate the average infiltration rates observed during the monitoring period. The following provides a detailed description of how this was completed. The water level data collected at those sites was reviewed to determine level fluctuation over the monitoring period and to compare against normal and high-water elevations.

2.1.1 Data Collection

Water levels were monitored using electronic level loggers. The loggers were configured at each site to log data at a minimum of one reading per hour for groundwater and once every 15 minutes for BMPs.

Enclosures for the infiltration gallery level loggers were installed at Beacon Bluff, St. Albans Street, and Hampden Park. These consisted of three-inch-diameter PVC pipes with four rows of half-inch-diameter holes drilled along the pipe achieving approximately twenty holes per foot. The enclosures were then wrapped with a highly permeable geotextile fabric and secured with zip ties to protect the instrument from fine sediment accumulation. Enclosures were secured to the system floor and to the access riser wall (**Photo 2-1**). Groundwater and rain garden locations were monitored from permanent monitoring wells (**Photo 2-2**).

Photo 2-1:
Infiltration Gallery Level Monitoring Enclosure

Photo 2-2:
Beacon Bluff Rain Garden and In-Rock Wells

2.1.2 Data Analysis

The data collected at each site reflected hydrograph-type curves resulting from the rise and fall of water within the systems during and after significant rainfall events. The data was analyzed in Microsoft Excel to develop stage/infiltration rate relationships for each system. Since the infiltration rates increase exponentially at higher depths in the systems, this relationship was developed by calculating the infiltration rate at each half foot height increment. These calculations also accounted for the volume of runoff entering the system while drawdown was occurring. Infiltration of water in the horizontal direction through the vertical surfaces of the trenches was not included in this analysis, as the policies of the watershed districts only recognize infiltration through the bottom horizontal surface. The infiltration rates calculated at each increment were averaged and plotted on a graph.

The following equation was used to perform these calculations at each half foot increment:

$$\boldsymbol{Infiltration\ Rate}\left(\frac{\boldsymbol{in}}{\boldsymbol{hr}}\right)=\frac{\mathbf{0.5}\,\boldsymbol{ft}+\frac{\mathbf{V_{in}}}{\mathbf{WHSA}}}{\boldsymbol{\Delta t}}$$

where:

V_{in} = Inflow Volume (cu-ft)
WHSA = Wetted Horizontal Surface Area (sq-ft)
Δt = Time it takes for water level to drop by 0.5 ft

Monitored Infiltration rates were evaluated against design infiltration rates as described in the Minnesota Stormwater Manual (MPCA, 2008) and infiltration rates observed during pre-construction field testing.

2.2. Flow & Volume Reduction

Stormwater runoff volume was measured at Beacon Bluff, Victoria Street, St. Albans Street, Hampden Park, Sackett Park, and Battle Creek using continuous flow monitoring equipment. At BMP Sites, the data was utilized to determine the total volume of water draining to and captured by each system. Collected data was analyzed using Flowlink software and Microsoft Excel to quantify the volumes measured during each discrete rainfall event recorded during the monitoring periods. The following section provides brief descriptions of the methods and procedures used to quantify flow at each system.

2.2.1 Data Collection

Teledyne ISCO 2150 area velocity flow modules and sensors were used to monitor runoff volumes. These devices measure water level and flow velocity. Combining this information with a known conduit shape, the flow rate, and flow volume through the conduit were calculated. Each of the monitored systems received stormwater runoff from a diversion structure located along the storm sewer system. The 2150 flow sensors were positioned at the upstream and downstream pipes in these structures to measure the total volume draining to each BMP and the total volume that bypassed each BMP. **Photos 2-3** and **2-4** show the flow meters installation in Battle Creek and Sackett Park, respectively.

The flow modules were configured at each site to log data at one-minute intervals once the water level in the upstream pipe was greater than one-inch above the pipe invert to increase the resolution of the flow data.

Photo 2-3: Flow Monitoring Module Install Process

Photo 2-4: Flow Sensor in Downstream Pipe in Victoria Diversion Structure

2.2.2 Data Analysis

Flow data was regularly imported into Flowlink 5.1 for storage and analysis. Data was analyzed and validated using built-in velocity error checking parameters. The flow level and velocity data were converted to total flow volumes and exported to a Microsoft Excel spreadsheet for further analysis. Each rainfall event and associated inflow and outflow volumes were tabulated.

For the Beacon Bluff, Saint Albans Street, and Hampden Park BMPs, runoff volume was estimated for un-monitored system inlets by taking the monitored flow data and multiplying by the ratio of the respective drainage areas.

2.3. Water Quality

Water quality was monitored at the Beacon Bluff BMP, Victoria Street BMP, Battle Creek, Hampden Park, Sackett Park, and St. Albans Street. The following section provides a summary of the methods and procedures used to collect and test water quality samples and analyze the data.

2.3.1 Data Collection

**Photo 2-7:
ISCO 6712 Sampler at
Battle Creek**

**Photo 2-8:
ISCO Bottle Configuration**

ISCO 6712 automatic samplers were installed at all water quality locations. (**Photos 2-7** and **2-8**).

The automatic samplers were configured to collect 250 mL samples at constant volume intervals. The flow pacing intervals were initially estimated for each site to provide a minimum of six samples during a quarter-inch storm, but less than 120 samples for the three-inch storm. Flow pacing was refined during the monitoring period to achieve this objective.

Samples from sufficiently sized rainfall events were submitted to the Metropolitan Council Environmental Services (MCES) Laboratory for analysis. The samples were composited using a batch mixing technique to create one sample for the event. All water quality monitoring site composite samples were analyzed for the parameters listed in the **Table 2-1** as volumes allowed, in accordance with the City's NPDES Permit. Grab samples were also collected during select storm events and analyzed for *E. Coli* and grease. The most probable number (MPN) procedure was used to determine the concentration of *E. Coli* in the stormwater runoff.

Table 2-1: Water Quality Parameters

Monitoring Parameters			
Parameters	**Method**	**Sample Type**	**Frequency**
Oil and Grease	SM 5210B	Grab	Quarterly
Chloride, Total	SM4500	Composite	10/year
Copper, Total (as Cu)	EPA 200.7	Composite	10/year
E. coli	MPN	Grab	Quarterly
Flow	NA	Measurement	NA
Hardness, Carbonate (as CaCo3)	SM 2340B	Composite	10/year
Lead, Total (as Pb)	EPA 200.7	Composite	10/year
Nitrite Plus Nitrate, Total (asN)	SM4500/NO3F	Composite	10/year
Nitrogen, Ammonia, Un-ionized (as N)	EPA 350.1	Composite	10/year
Nitrogen, Kjeldahl, Total	EPA 351.2	Composite	10/year
pH	EPA 9045D	Grab	Quarterly
Phosphate, total Dissolved or Ortho	EPA 365.1	Composite	10/year
Phosphorus, Total as P	EPA 365.1	Composite	10/year
Precipitation	NA	Measurement	1 x Day
Solids, Total Dissolved (TDS)	SM2540 C-97	Composite	10/year
Solids, Total Suspended (TSS)	ASTM D3977-97	Composite	10/year
Chemical Oxygen Demand (COD)	EPA 9056A	Composite	10/year
Organic Dissolved Carbon	EPA 9060A	Composite	10/year
Volatile Suspended Soilds (VSS)	EPA 160.4	Composite	10/year
Zinc, Total (as Zn)	EPA 200.7	Composite	10/year

2.3.2 Data Analysis

The event mean concentrations (EMCs) derived from sampling events were multiplied by the corresponding volume measurements taken at each site for every rainfall event sampled. For storm events with no sampling data, a flow weighted EMC concentration from that site's entire monitoring period was used. This information was tabulated and summed to determine the total amount of pollutants generated in the contributing drainage areas and the amount of pollutants captured by the BMP, at applicable sites.

2.4. Maintenance Inspections

BMP inspections were conducted at Beacon Bluff, St. Albans Street, Hampden Park, and Victoria Street sites periodically during the monitoring period. Pre-treatment structures were inspected for accumulated sediment depth and floatable debris. Underground chambers were inspected from the level monitoring location for accumulation of sediment, debris, and standing water. Inspection photos are included in the photo log (**Appendix E**).

2.5. Pervious Surface Infiltration Rate

The infiltration rate of the permeable surfaces was measured at the Victoria Street, Hamline Midway Library, and Jackson Street pervious pavement sites following the protocols outlined in ASTM method C1701 (**Appendix G**). The following section provides a summary of those methods.

2.5.1 Data Collection

Infiltration tests were conducted according to the modified ASTM C1701 methods for measuring infiltration rates (**Photo 2-11**). Five locations at Victoria Street, 18 locations at Jackson Street, and nine locations at Hamline Midway Library were evaluated to develop an average infiltration rate measurement for each site. Tests were taken at locations that remained consistent year to year and included a combination of high and low traffic areas. At each test location, a pre-wet test was conducted, followed by two infiltration tests. The two infiltration tests were averaged to generate the infiltration rate for each location. If after 15 minutes of monitoring during a pre-wet test no infiltration was observed, the test was concluded, and no subsequent tests were completed.

Photo 2-11: Permeable Pavement Infiltration Test

3. PRECIPITATION SUMMARY

As part of the City's stormwater monitoring program, seasonal precipitation monitoring is conducted at the following locations: Hampden Park Co-op, Saint Paul Fire House 18, Wilder Recreation Center, and Frost Lake Elementary School (**Figure 1-1**). The precipitation data collected at these locations provides localized rainfall totals which are utilized for calculating rainfall intensity and runoff yield at monitored BMP sites. Each station is equipped with an automated tipping bucket that records continuously throughout the season.

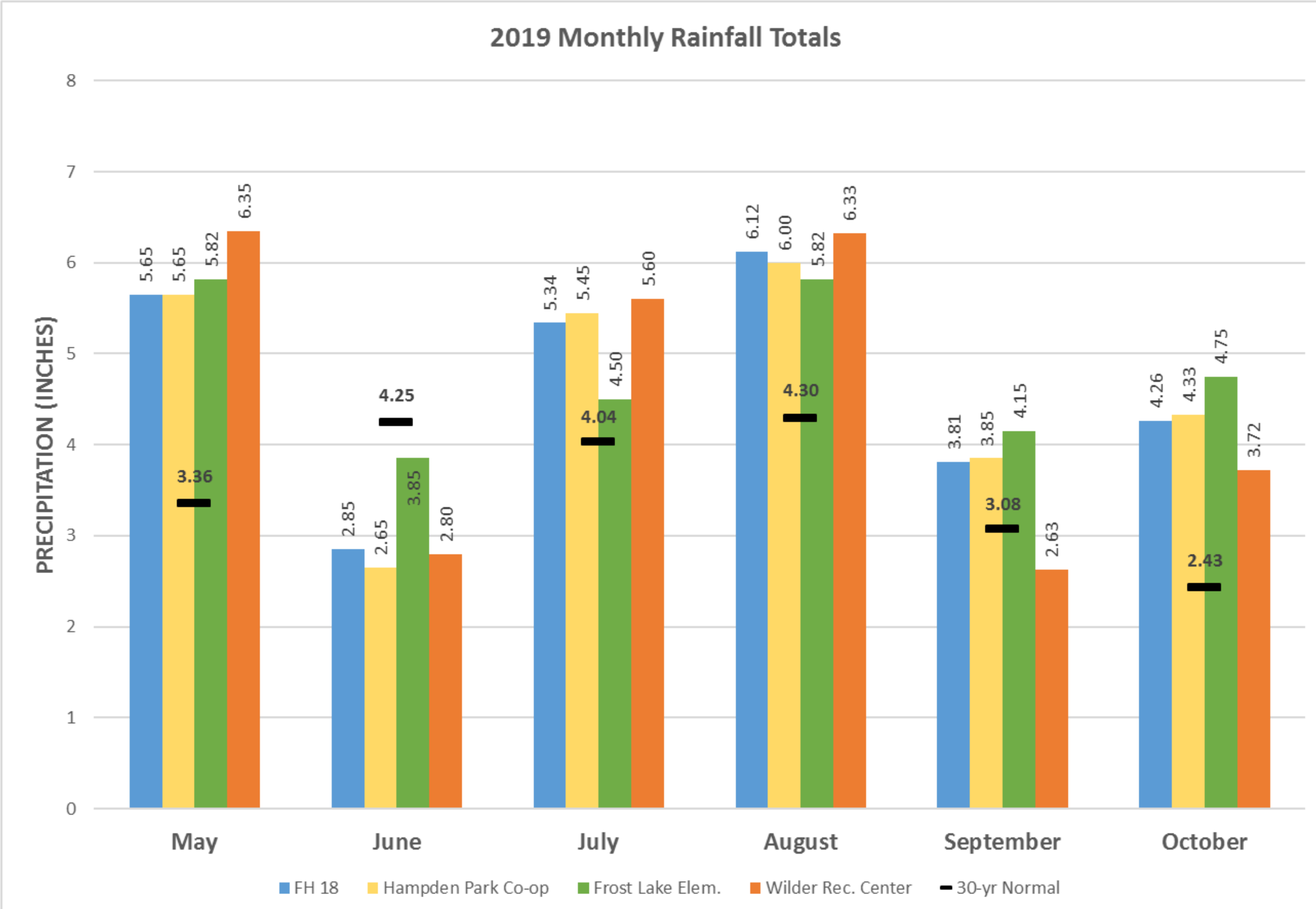
Precipitation data collected by MCES, Minnesota Climatology Working Group (MCWG), and the National Weather Service (NWS) is used to supplement the City's data as needed. This includes any data gaps in seasonally monitored stations as well as parameters, such as snowfall and snowpack depth, which exceed the limitations of the City's monitoring equipment. These stations also provide a longer period of record which is valuable for analyzing rainfall trends. Data collected by MCWG and NWS is accessible through the Midwest Regional Climate Center online database (MCWG, 2019).

Table 3-1 and **Chart 3-1** show 2019 monthly precipitation totals for seasonally monitored sites compared to the 30-year normal. The 30-year normal reflect data collected from 1981-2010 and are updated every ten years, with the most recent update being in 2010.

May through October rainfall ranged from 27.43 inches at Wilder Recreation Center to 28.89 inches at Frost Lake Elementary. The City-wide average for those months was 28.07 inches which is 3.95 inches more than the 30-year normal. The greatest variability between stations was observed during the month of September with 1.52 inches more rainfall recorded at Frost Lake Elementary than Wilder Recreation Center. The month of May saw the greatest departure from the 30-year normal (+2.51 inches).

Table 3-1: 2019 Seasonal Precipitation Summary

Month	FH 18	Hampden Park Co-op	Frost Lake Elem.	Wilder Rec. Center	City-Wide Average	30-yr Normal[1]	Departure from 30-yr Normal
May	5.65	5.65	5.82	6.35	5.87	3.36	2.51
June	2.85	2.65	3.85	2.80	3.04	4.25	-1.21
July	5.34	5.45	4.50	5.60	5.22	4.04	1.18
August	6.12	6.00	5.82	6.33	6.07	4.30	1.77
September	3.81	3.85	4.15	2.63	3.61	3.08	0.53
October	4.26	4.33	4.75	3.72	4.27	2.43	1.84
Seasonal Total	**28.04**	**27.93**	**28.89**	**27.43**	**28.07**	**24.12**	**3.95**


2019 Monthly Rainfall Totals
PRECIPITATION (INCHES)
0
1
2
3
4
5
6
7
8
5.65
5.65
5.82
6.35
3.36
2.85
2.65
3.85
2.80
4.25
5.34
5.45
4.50
5.60
4.04
6.12
6.00
5.82
6.33
4.30
3.81
3.85
4.15
2.63
3.08
4.26
4.33
4.75
3.72
2.43
May
June
July
August
September
October
FH 18
Hampden Park Co-op
Frost Lake Elem.
Wilder Rec. Center
30-yr Normal

Major rainfall events in 2019 are provided in **Table 3-2** below:

Table 3-2: 2019 Significant Rainfall Events

Date	Rainfall Total (in)[1]	Duration (hr)	Intensity (in/hr)
May 27, 2019	1.93	10.37	0.19
June 23, 2019	1.26	2.03	0.62
July 1-2. 2019	1.23	5.87	0.21
July 15-16, 2019	2.46	23.03	0.11
July 20, 2019	1.28	4.12	0.31
August 18, 2019	2.40	3.68	0.65
September 2, 2019	1.00	0.37	2.73
October 21, 2019	1.27	6.98	0.18

1 - Rainfall event totals may not reflect total daily rainfall

Table 3-3 below provides a five-year monthly precipitation summary as recorded at the University of Minnesota Saint Paul Campus. Annual precipitation has exceeded the 30-year normal every year for the last five years. Total precipitation in 2019 was 42.95 inches, 12.34 inches above normal. Most months saw above average rainfall amounts with August seeing the most at 6.88 inches, 2.58 inches above the 30-year normal for that month (4.30 inches).

Table 3-3: 5-year Precipitation Summary (UMN – Saint Paul Campus)

Month	2015	2016	2017	2018	2019	30-yr Normal
January	0.26	0.28	0.93	1.07	0.36	0.90
February	0.22	0.79	0.70	1.24	2.31	0.77
March	0.71	2.15	0.58	1.38	2.09	1.89
April	2.07	3.66	3.68	2.37	3.37	2.66
May	4.94	2.05	6.54	3.52	6.44	3.36
June	3.31	3.65	3.16	4.64	2.85	4.25
July	6.19	5.97	2.45	4.07	4.75	4.04
August	2.79	9.90	8.89	2.91	6.88	4.30
September	3.82	5.19	1.25	7.19	4.88	3.08
October	2.87	3.32	4.84	3.4	4.93	2.43
November	4.58	2.70	0.42	1.41	1.67	1.77
December	2.13	2.01	0.62	1.32	2.42	1.16
Total	**33.89**	**41.67**	**34.06**	**34.52**	**42.95**	**30.61**
Departure from 30-yr Normal	**+3.28**	**+11.06**	**+3.45**	**+3.91**	**+12.34**	**N/A**

4. BEACON BLUFF

This system, shown in **Figure 4-1**, is owned and operated by the City. The Saint Paul Port Authority contributed financially to the project and oversaw its construction. Volume reduction credits were split between the City and the Saint Paul Port Authority based on the respective financial contribution. Performance monitoring of the system has been conducted since 2012 and rainfall monitoring for the site is conducted at the Wilder Recreation Center, located 0.8 miles to the west. The BMP system details are provided in **Table 4-1**.

The system is comprised of three connected stormwater treatment structures, which include a stormwater pond west of the Duchess Street cul-de-sac (west pond), an infiltration basin east of the cul-de-sac (rain garden) (**Photo 4-1**), and an underground infiltration chamber (**Photo 4-2**) constructed directly beneath the rain garden. The underground chamber consists of three, parallel, 215-foot-long, ten-foot-diameter perforated metal pipes for infiltration.

The Beacon Bluff system has a total drainage area of 143.6 acres, which consists of three subwatersheds. Stormwater from a 136.8-acre drainage area is routed to a diversion structure in the storm sewer along Duchess Street (MH7). The diverted stormwater passes through a manhole equipped with a SAFL Baffle pre-treatment system for particle settling, and then discharges to the rain garden. Two inlets on the eastern side of the rain garden discharge stormwater from a 4.7-acre drainage area immediately surrounding the BMP. Stormwater from a 2.1-acre drainage area discharges to the west pond, which outlets directly to the underground chamber.

Overflow grates within the rain garden allow stormwater to spill from the rain garden, directly into the underground chamber. When the underground chamber reaches capacity, stormwater discharges from the underground system, through an outlet control structure, back to the main storm sewer line.

Table 4-1: Beacon Bluff BMP Details

Total Drainage Area to BMP	143.6 acres
Sub-watershed to Diversion Structure (discharge to rain garden)	*136.8 acres*
Sub-watershed to Eastern Inlet Pipes (discharge to rain garden)	*4.7 acres*
Sub-watershed to West Pond (discharge from west pond to underground chamber)	*2.1 acres*
Year Constructed	2011
Total Construction Cost	$980,000
Storage Volume[1]	159,350 cu-ft
Volume Reduction Credit Received by the City of Saint Paul	116,435 cu-ft
Volume Reduction Credit Received by Saint Paul Port Authority	42,925 cu-ft

Photo 4-1: Underground Infiltration Chamber (Facing West)

Photo 4-2: Rain Garden Located above Infiltration Chambers (Facing East)

4.1. Water Level and Infiltration Rate Monitoring

Water level was monitored by a logger placed directly in the BMP Pipe. Water level in the rain garden was measured in 2020 due to piezometer damage following a dredge in the Spring. An additional logger was installed within the outlet control structure of the system to confirm when flow was being conveyed back to the storm sewer from the underground chamber. Groundwater elevation was also measured in two locations at the site. Water level elevations within the system and groundwater, and daily rainfall totals are presented on **Chart A.1** and **A.2** of **Appendix A**.

Photo 4-3: Water being conveyed back to the storm sewer from the underground chamber in the outlet control structure.

Overflow in the outlet control structure to the storm sewer, (**Photo 4-3**), occurred during fifteen treatment events. The 2019 rain garden infiltration rate and infiltration rate trends are provided on **Charts A.3** and **A.5** of **Appendix A**, respectively. The 2018 average infiltration rate for the rain garden was 0.40 inches per hour (in/hr), which is less than the Minnesota Stormwater Manual (MSWM) recommended infiltration rate for SP (poorly graded sand) soils of 0.80 in/hr. This is slightly less than the rates observed in 2017 (0.50 in/hr) and 2017 (0.43 in/hr) (**Table 4-2**). Sediment accumulation has been observed ranging from 0.5 ft to 1.5 ft of depth, across the basin. The 141.5-acre drainage area discharging directly to the pond conveys a significant amount of sediment and debris, which has accumulated primarily around the diversion inlet pipe. Dredge maintenance was completed on the rain garden over the winter of 2018-2019.

Table 4-2: Beacon Bluff Infiltration Rates

Location	Average Infiltration Rate (in/hr)							
	2012	2013	2014	2015	2016	2017	2018	2019
Beacon Bluff Rain Garden (IR-31)	2.9	0.85	0.70	0.29	0.43	0.50	0.40	NA
Beacon Bluff Underground System (IR-32)	2.6	0.57	0.64	0.30	0.15	0.11	0.12	0.12

Water level in the underground system ranged from 8.3 ft to 20.8 ft deep. Depths greater than 10 feet indicate the water is rising into the substrate above the 10-ft diameter corrugated metal infiltration pipes. The data indicates that the system did not drain to empty during the 2019 monitoring period, including over the winter months. The underground system discharged back to the storm sewer (system outflow) during 15 storm events in 2019. This is an increase from discharge events occurring in 2012-2014 (zero), 2015 (five), 2016 (nine), 2017 (ten), and 2018 (fourteen). The increased frequency of system discharge events is a result of the standing water in the underground system and the capacity it utilizes. Groundwater elevations at the site were a minimum of 10 ft below the bottom of the underground chamber, which suggests that groundwater mounding is not the cause of standing water in the system.

The 2019 underground chamber infiltration rate and infiltration rate trends are provided on **Charts A.4** and **A.6** of **Appendix A**. The 2019 average infiltration rate for underground chamber was 0.12 in/hr, which is less than MSWM recommended infiltration rate for SP soils of 0.8 in/hr. From 2012 to 2018, the infiltration rate has decreased from 2.6 in/hr to 0.11 in/hr, with the largest decline following the first year of monitoring in 2012. As mentioned above, standing water in the underground system has resulted in a decrease in infiltration rates each year.

4.2. Volume Reduction Monitoring

Stormwater flowing into the BMP was measured in the Duchess Street diversion structure and at the outlet of the west pond, which discharges directly to the underground chamber. Volume that bypassed the system was measured with a flow meter downstream of the Duchess Street diversion structure. Inflow volume from the inlets discharging into the eastern side of the rain garden was modeled using the Duchess upstream flow data and the ratio of drainage areas. Level logger data from within outlet control structure was used to identify when the underground system was at capacity, and estimate the volume being conveyed back to the storm sewer system from the BMP. Flow rates and daily rainfall are depicted on **Chart B.1** of **Appendix B**. An event-based volume reduction summary is provided with the pollutant loading data in **Table C.2** of **Appendix C**. A summary of the 2019 Beacon Bluff Volume Reduction is included in **Table 4-3** below.

In 2019, total runoff to the Beacon Bluff system was 1,932,561 cubic feet (cu-ft). Of that volume, 840,462 cu-ft was captured by the system, resulting in a 43.5% volume reduction. The total flow conveyed back to the storm sewer from the underground system was 317,601 cu-ft, which is 30.8% of the volume that was diverted to the BMP. For the 136.8-acre drainage area to the diversion structure, the total water yield was 13,197cu-ft/acre which is equivalent to 3.64 inches of runoff as a result of 22.94 inches of rain (16%). The greatest volume captured by the BMP was 81,724 cu-ft on May 18th, 2019. This volume represents 51% of the total storage capacity of the system.

Table 4-3: Beacon Bluff Volume Reduction

Monitoring Period	5/10/2019 – 10/28/2019		
Total Rainfall		22.94	in.
Diversion Structure Water Balance			
Runoff Volume:		1,805,393	cu-ft
Runoff Yield		3.64	in/acre
Bypassed Volume:		711,003	cu-ft
Volume Diverted into BMP:		1,030,895	cu-ft
Beacon Bluff Rain Garden and Infiltration Gallery Inputs			
Inflow Volume from Diversion Structure:	SubWSHD A	1,030,895	cu-ft
Inflow Volume from West Pond:	SubWSHD B	43,965	cu-ft
Inflow Volume from Eastern Inlets	SubWSHD C	83,204	cu-ft
System Discharge (conveyed back to storm sewer from OCS)		317,601	cu-ft
Beacon Bluff System Performance			
Total Runoff Volume:		1,932,561	cu-ft
Total Runoff Volume Captured:		840,462	cu-ft
Percent of Total Runoff Volume Captured:		43.5	%
Maximum Percentage of Storage Volume Utilized [1]		51	%

1- This is the maximum volume infiltrated by the BMP for a treatment event as a percentage of the total storage volume. The system exceeded 100% capacity on several occasions, but only a portion of the total capacity was available for infiltration due to standing water in the BMP.

4.3. Pollutant Removal Monitoring

A water quality sampler was placed in the Duchess Street diversion structure to collect samples during runoff events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC during each event for each parameter analyzed. Grab samples were collected in the diversions structure near the automated sampler quarterly and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 4-4 below provides a load reduction summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period, 3,315 pounds of TSS and 21.2 pounds of TP were captured by the system. Over the past seven years of monitoring, 99,737 pounds of TSS and 384 pounds of TP have been captured at the Beacon Bluff Site.

Table 4-4: Beacon Bluff Load/Capture Summary

Monitoring Period		5/10/2019 – 10/28/2019		
Total Rain		24.38		
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**	**Load Captured (lbs)**	**Percent Reduction %**
Total Suspended Solids	64	7,307	3,315	45.4
Volatile Suspended Solids	27	3,123	1,452	46.5
Inorganic Suspended Solids	37	4,184	1,863	44.5
Total Phosphorus	0.38	43.3	21.2	49.0
Ortho-phosphate	0.07	8.9	4.4	49.7
Chloride	3.32	385.8	187.1	48.5
Total Kjeldahl Nitrogen	2.19	254.8	123.6	48.5
Nitrate + Nitrite as N	0.36	42.2	19.7	46.8

4.4. Maintenance Inspection

Visual inspections of the pretreatment structure, rain garden, and underground system were completed during site visits to determine performance and maintenance needs. As shown in **Table 4-5**, sediment depths in the pretreatment device were approximately 1.25 ft to 2.1 ft throughout the 2019 season. Floatables were observed in the pretreatment structure all visits and within the rain garden.

Standing water was observed in the underground system on all visits, as discussed in **Section 4.1**. The last chamber inspection was completed in November 2014 when the system was mostly empty. At that time, roughly 0.25 ft of sediment was observed within the grooves of the corrugated pipe, along the bottom. See **Appendix E** for photos of the BMP inspections.

Table 4-5: Beacon Bluff Maintenance Inspections

Date	Sediment Depth in Pre-treatment (ft)	Sediment Depth in Infiltration Gallery (ft)[1]	Standing Water in Infiltration Gallery?	Observations
May 6, 2019	Maintenance – Whole system cleaned, included 72" SAFL baffle manhole.			
May 13, 2019	0.2	NM	Y	Damage to monitoring wells in rain garden
July 10, 2019	1.0	NM	Y	Trash in in pretreatment
August 5, 2019	1.25	NM	Y	Some trash in pre-treatment and rain garden. Sheen in both pre-treatment and infiltration pipe.
November 19, 2019	2.1	NM	Y	Trash present in pre-treatment and rain garden. No trash observed in infiltration gallery.

1-Not Measured – Sediment levels could not be evaluated in the infiltration galley due to the depth of standing water and the total depth of the system.

5. ST. ALBANS STREET

This system, shown in **Figure 5-1**, was constructed in 2010 to provide volume reduction along the Central Corridor light rail transit way. Volume and flow have been monitored at the site since 2012, with water quality monitored in 2014, 2015, and 2019.

A manhole structure positioned along the main storm sewer under Aurora Avenue diverts stormwater into the underground infiltration system (**Photo 5-1**) via a 30-inch elliptical pipe. The system is also connected to the University Avenue storm sewer system. Any runoff that does not get treated by infiltration trenches and tree planters along University Avenue is directed to this system (**Photo 5-1**). When the system reaches its storage capacity, water flows west through the existing storm sewer system. The system includes a pretreatment structure comprised of a grit chamber and baffled weir to provide settling for sediment and skimming. Rainfall monitoring for the site is conducted on the roof of Fire Station 18, located across the street from the BMP. The BMP system details are provided in **Table 5-1.**

Table 5-1: St. Albans Street BMP Details

Total Drainage Area to BMP	25.2 acres
Year Constructed	2010
Total Construction Cost	$381,903
Storage Volume	31,189 cu-ft
Volume Reduction Credit Received by the City of Saint Paul	31,189 cu-ft

Photo 5-1: St. Albans 48" Perforated HDPE Installation

5.1. Water Level and Infiltration Rate Monitoring

BMP water level was monitored in the access manhole at the northwest corner of the system. The 2019 water elevations and daily rainfall is provided on **Chart A.11** of **Appendix A**. Water level monitoring indicated that the infiltration gallery reached 100% capacity 12 times in 2019. Every treatment event monitored in 2019 resulted in the infiltration gallery drawing down to empty in less than a 24-hour period.

Infiltration rates are presented on **Chart A.12** of **Appendix A**. In 2019, the average infiltration rate of the BMP pipe was 9.6 in/hr (**Table 5-2**), which is above the MSWM recommended infiltration rate for SP soils of 0.8 in/hr, but below the design infiltration rate of 26.0 in/hr. Infiltration rate trends for the St. Albans Street BMP pipe are depicted on **Chart A.13**.

Table 5-2: St. Albans Infiltration Rate

Location	Average Infiltration Rate (in/hr)							
	2012	2013	2014	2015	2016	2017	2018	2019
St. Albans Street BMP Pipe	38.5	35.7	64.8	55.3	36.2	20.6	21.3	9.6

5.2. Volume Reduction Monitoring

Two flow meters were installed in the storm sewer diversion manhole located in the intersection of St. Albans Street and Aurora Avenue. One meter was installed in the elliptical pipe to capture flows into the system from the south, and the other was installed in the downstream pipe to measure flows bypassing the system to the west. The difference in volume recorded by the two meters is assumed to be diverted into, and infiltrated by, the BMP. An additional flow meter was installed in the 30-inch pipe at the corner of St. Albans Street and University Avenue to capture flows into the system from along University Avenue. Flow rates and daily rainfall are depicted on **Chart B.3** of **Appendix B**.

In 2019, total runoff for the St. Albans Street system was 709,403 cu-ft. Of that volume, 688,438 cu-ft was captured and infiltrated by the system, resulting in a volume reduction of 97% (**Table 5-3**). On average, 28% of the total volume of flow diverted into the BMP was from the University Avenue inlet pipe. The total water yield for the 25.2-acre drainage area is 28,151 cu-ft/acre which is equivalent to 7.8 inches of runoff resulting from 23.2 inches of rain (33.6%). The greatest volume infiltrated by the BMP was 65,310 cu-ft, which represents 209% of the total storage capacity of the system. Storm-specific rainfall and volume reduction data is provided on **Chart B.4** of **Appendix B**.

Table 5-3: St. Albans Street Volume Reduction

Monitoring Period	5/2/2019 – 10/30/2019	
Total Rainfall	23.23	in
System Water Balance		
Aurora Runoff Volume:	509,211	cu-ft
Aurora Bypassed Volume:	20,965	cu-ft
St. Albans and University Volume	200,193	cu-ft
St. Albans System Performance		
Total Runoff Volume	709,403	cu-ft
Runoff Yield	7.8	in/acre
Total Runoff Volume Captured	688,438	cu-ft
Percent of Runoff Volume Captured:	97	%
Maximum Volume Discharge to BMP	65,310	cu-ft
Maximum Percentage of Storage Volume Utilized[1]	209	%

1- This is the maximum volume infiltrated by the BMP for a treatment event as a percentage of the total storage volume

5.3. Pollutant Removal Monitoring

A water quality sampler was placed in the diversion structure at the intersection of St. Albans and Aurora Ave. to collect samples during runoff events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC during each event for each parameter analyzed. Grab samples were collected in the diversions structure near the automated sampler quarterly and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 5-4 below provides a load reduction summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period, 1,682 pounds of TSS and 7.6 pounds of TP were captured by the system. Percent captured for all parameters were above 96% in 2019.

Table 5-4: St. Albans Load/Capture Summary

Monitoring Period		5/2/2019 – 10/30/2019		
Total Rain		23.23		
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**	**Load Captured (lbs)**	**Percent Reduction %**
Total Suspended Solids	38.2	1,729	1,682	97.3
Volatile Suspended Solids	17.3	783	764	97.6
Inorganic Suspended Solids	20.9	946	918	97.0
Total Phosphorus	0.18	7.8	7.6	97.3
Ortho-phosphate	0.039	1.7	1.7	97.7
Chloride	8.4	385.8	370.9	96.1
Total Kjeldahl Nitrogen	1.03	45.9	44.7	97.2
Nitrate + Nitrite as N	0.37	16.2	15.7	97.1

5.4. Maintenance Inspection

The pretreatment device and the underground infiltration system were inspected during site visits to evaluate maintenance needs of the BMP. As shown in **Table 5-4**, minimal sediment was observed in both the pretreatment device and the infiltration gallery. Garbage was observed in the pretreatment and infiltration gallery. Water level monitoring in the infiltration gallery confirms that the system is regularly drawing down to empty, which is consistent with no standing water observed during most BMP inspection visits. See **Appendix E** for the **Photolog**.

Table 5-4: St. Albans Maintenance Inspections

Date	Sediment Depth in Pre-treatment (ft)	Sediment Depth in Infiltration Gallery (ft)	Standing Water in Infiltration Gallery?	Observations
May 16, 2019	0.4	0.1	Y	Water in BMP minimal
July 10, 2019	0.4	.01	Y	Water in BMP minimal
August 28, 2019	0.4	0.0	Y	Large amounts of trash in pre-treatment, some trash in infiltration pipe.
September 20, 2019	Maintenance – System Cleaned			
November 19, 2019	0.4	0	Y	No sediment in East pretreatment MH. Organic debris present in infiltration pipe. Minimal water present.

6. HAMPDEN PARK

The Hampden Park infiltration gallery, shown in **Figure 6-1,** was constructed in 2014. The system consists of eight parallel perforated pipes that are 5 ft in diameter, and range in length from 40 to 100 ft. Runoff is routed to the system via a 24-inch RCP from the storm sewer line near Hampden and Raymond Avenues. Prior to entering the infiltration gallery, stormwater passes through a Vortechs pre-treatment chamber for particle settling. The infiltration gallery receives flow from a second inlet location along Hampden Avenue, farther to the north. When the system reaches full capacity, stormwater is routed back to the storm sewer via a 24-inch pipe from the southeast side of the system. Rainfall monitoring is conducted on top of the Hampden Park Co-Op across the street from the park. Monitoring has been conducted at the site since 2014. The BMP system details are provided in **Table 6-1** below.

Photo 6-1: Hampden Park BMP Construction

Table 6-1 Hampden Park BMP Details

Total Drainage Area to BMP	7.8 acres
Year Constructed	2014
Total Construction Cost	$687,132
Total Storage Volume	31,808 cu-ft
Volume Reduction Credit Received by the City of Saint Paul – Public Works	24,908 cu-ft
Volume Reduction Credit Received by the City of Saint Paul – Parks and Recreation	6,900 cu-ft

6.1. Water Level and Infiltration Rate Monitoring

Water levels were monitored within the underground infiltration system and groundwater (P2), using electronic water level loggers. Water levels and daily rainfall for 2019 are provided on **Chart A.14** and **A.15** of **Appendix A**. Water level within the BMP, ranged from 0 to 3.2 ft. The BMP water level must exceed 6.5 ft for the system to reach capacity and for water to be conveyed back to the sewer system. Based on the 2019 level data, no flow discharged back to the sewer system. Groundwater monitoring data showed that groundwater elevation fluctuated by 1.9 ft in 2019 with a minimum separation of 16.5 ft from the bottom of the BMP.

The 2019 infiltration rates are presented on **Chart A.16** of **Appendix A** and are adjusted for incremental volume flow. The adjusted average infiltration rate for the BMP was 11.57 in/hr, which is greater than the MSWM recommended infiltration rate for SP soils of 0.8 in/hr and the design infiltration rate of 1.8 in/hr. Infiltration rates at the base of site during construction were calculated to be, on average, 60 in/hr using a Double Ring Infiltrometer (DRI). Infiltration rate trends are depicted on **Chart A.17**. Water level data shows that all 2019 events were infiltrated within 24 hours of a treatment event.

Table 6-2: Hampden Park Infiltration Rate

Location	Average Infiltration Rate (in/hr)			
	2016	2017	2018	2019
Hampden Park BMP	14.38	8.30	11.19	11.57

6.2. Volume Reduction Monitoring

One flow meter was installed within the 24-inch RCP diverting flow from the storm sewer to the BMP from the intersection of Hampden and Raymond Avenues. The metered drainage area consists of 6.7 acres of the total 7.8-acre drainage area to the BMP. The 2019 flow rates and daily rainfall are depicted on Chart B.6 of Appendix B. No discharge was observed at the system outlet therefore that data is not plotted.

In 2019, the total runoff was 524,242 cu-ft. Since monitored level within the BMP did not reach the discharge outlet, 100% of the runoff was infiltrated by the system (**Table 6-3**). The total water yield for the 7.8-acre drainage area is 67,211 cu-ft/acre which is equivalent to 18.52 inches of runoff as a result of 24.2 inches of rain (77%). The greatest volume received by the BMP was 110511 cu-ft as a result of a 2.4-inch rain event on August 18, 2019. This volume represents 347% of the total storage capacity of the system. Storm-specific rainfall and volume reduction data is provided on **Chart B.5** of **Appendix B**.

Table 6-3: Hampden Park Volume Reduction

Monitoring Period	5/2/2019 – 10/28/2019	
Total Rainfall	24.2	in
Hampden Park Water Balance		
Raymond/Hampden Runoff Volume	449,994	cu-ft
System Bypass Volume	0	cu-ft
Hampden Park System Performance		
Total Runoff Volume	524,242	cu-ft
Runoff Yield	18.55	in/acre
Total Runoff Volume Captured	524,242	cu-ft
Percent of Runoff Volume Captured	100	%
Maximum Event Volume Captured by BMP	110511	cu-ft
Maximum Percentage of Storage Volume Utilized[2]	347	%

1 – The second system inlet along Hampden Avenue is not monitored, and the volume discharged to the system from that location is estimated based on monitored data at Hampden/Raymond and the ratio of the drainage areas

2- This is the maximum volume infiltrated by the BMP for a treatment event as a percentage of the total storage volume

6.3. Pollutant Removal Monitoring

A water quality sampler was placed at the intersection of Hampden and Raymond Avenues to collect samples during runoff events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC during each event for each parameter analyzed. Grab samples were collected in the 24 in RCP near the automated sampler quarterly and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 6-4 below provides a load reduction summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period, 1,522 pounds of TSS and 3.76 pounds of TP were captured by the system. Percent captured for all parameters were 100% in 2019.

Table 6-4: St. Albans Load/Capture Summary

Monitoring Period		5/2/2019 – 10/28/2019		
Total Rain		24.2		
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**	**Load Captured (lbs)**	**Percent Reduction %**
Total Suspended Solids	38.2	1,522	1,522	100
Volatile Suspended Solids	15.4	504.7	504.7	100
Inorganic Suspended Solids	31.1	1017	1017	100
Total Phosphorus	0.11	3.76	3.76	100
Ortho-phosphate	0.010	0.329	0.329	100
Chloride	3.82	125.0	125.0	100
Total Kjeldahl Nitrogen	0.94	30.7	30.7	100
Nitrate + Nitrite as N	0.55	18.1	18.1	100

6.4. Maintenance Inspection

Sediment depths in the pretreatment structure and in the underground infiltration system were measured during site visits to determine performance and maintenance needs. As shown in **Table 6-5**, minimal sediment was observed in both the pretreatment device and infiltration gallery.

Table 6-5: Hampden Park BMP Maintenance Inspection

Date	Sediment Depth in Pre-treatment (ft)	Sediment Depth in Infiltration Gallery (ft)[1]	Standing water in Infiltration Gallery?	Observations
May 17, 2019	0.3	0.1	N	Very little sediment in BMP.
July 10, 2019	0.4	0.1	N	Only sediment in vortechs manhole.
August 12, 2019	Maintenance – System Cleaned			
November 19, 2019	0.1	0.1	N	Minimal sediment obs. trash and some leaves in both pre-treatment and infiltration gallery.

7. VICTORIA STREET

Victoria Street monitoring site is located just East of Orchard Recreation Center and includes a permeable paver parking lane. Stormwater runoff within the 19.1 acre subwatershed is diverted from the main storm sewer to the underground system. When the system has reached its storage capacity, runoff continues to flow downstream through the storm sewer. The system includes a pretreatment structure consisting of a grit chamber for sediment capture and a baffled weir for skimming. In addition, the runoff from Victoria Street flows to the permeable paver parking lane, passes through a layer of stone aggregate below the pavers and is collected by a drain tile pipe. The drain tile discharges the runoff into the underground infiltration system. Rainfall monitoring is conducted on top of the Orchard Park Recreation Center located 0.1 miles to the west of the BMP. The BMP system details are provided in Table 7-1 below.

Table 7-1 Victoria Street BMP Details

Total Drainage Area to BMP	19.1 acres
Year Constructed	2010
Total Construction Cost	$174,000
Total Storage Volume	16,714 cu-ft
Volume Reduction Credit Received by the City of Saint Paul – Public Works	16,714 cu-ft
Volume Reduction Credit Received by the City of Saint Paul – Parks and Recreation	

This system consists of one 384-foot-long, 60-inch-diameter perforated HDPE pipe located below a permeable paver parking lane. It was constructed to meet the volume reduction requirements for the Front/Victoria Residential Street Vitality Program (RSVP) project.

7.1. Water Level and Infiltration Rate Monitoring

Water level and infiltration have not been monitored in the BMP since 2013. In 2019, water levels were monitored continuously in the access manhole at the north end of the underground system along Victoria Street. Water levels were monitored within the underground infiltration using an electronic water level logger. Water levels and daily rainfall for 2019 are provided on **Chart A.14** and **A.15** of **Appendix A**. Water level within the BMP, ranged from 0 to over 5 ft. The BMP water level must exceed 5 ft for the system to reach capacity and for water to flow to the sewer system. Based on the 2019 level data, the system reached capacity 7 times.

The 2019 infiltration rates are presented on **Chart A.16** of **Appendix A** and are adjusted for incremental volume flow. The adjusted average infiltration rate for the BMP was 21.08 in/hr, which is greater than the MSWM recommended infiltration rate for SP soils of 0.8 in/hr and the design infiltration rate of 12.8 in/hr. Infiltration rates at the base of site during construction were calculated to be, on average, 95.9 in/hr using a Double Ring Infiltrometer (DRI). Infiltration rate trends are depicted on **Chart A17**. Water level data shows that all 2019 events were infiltrated within 24 hours of a treatment event.

Table 7-2: Victoria Street Infiltration Rate

Location	Average Infiltration Rate (in/hr)		
	2012	2013	2019
Victoria Street BMP	46.56	48.04	21.08

7.2. Volume Reduction Monitoring

One flow meter was installed upstream of the system and one flow meter downstream of the diversion structure located near the intersection of Victoria Street and Orchard Avenue. The metered drainage area consists of 19.1 acres and drains to the BMP. The 2019 flow rates and daily rainfall are depicted on **Chart B.6** of **Appendix B**. Discharge was observed during six events at the system outlet therefore that data is not plotted.

In 2019, the total run off to the Victoria Street system was 431,238 cu-ft. Of that volume, 401,070 cu-ft was captured by the system, resulting in a 93% volume reduction. The total flow that bypassed the system and back to the storm sewer was 30,168 cu-ft (**Table 7-3**). The total water yield for the 19.1-acre drainage area is 22,578 cu-ft/acre which is equivalent to 6.22 inches of runoff as a result of 21.3 inches of rain (29%). The greatest volume received by the BMP was 30,533 cu-ft as a result of a 1.0-inch rain event on October 21, 2019. This volume represents 183% of the total storage capacity of the system. Storm-specific rainfall and volume reduction data is provided on **Chart B.5** of **Appendix B**.

Table 7-3: Victoria Street Volume Reduction

Monitoring Period	5/27/2019 – 10/22/2019	
Total Rainfall	21.3	in
Victoria Street Water Balance		
Raymond/Hampden Runoff Volume	431,238	cu-ft
System Bypass Volume	30,168	cu-ft
Victoria Street System Performance		
Total Runoff Volume	431,238	cu-ft
Runoff Yield	6.22	in/acre
Total Runoff Volume Captured	401,070	cu-ft
Percent of Runoff Volume Captured	93	%
Maximum Event Volume Captured by BMP	30,533	cu-ft
Maximum Percentage of Storage Volume Utilized[1]	183	%

1- This is the maximum volume infiltrated by the BMP for a treatment event as a percentage of the total storage volume

7.3. Pollutant Removal Monitoring

A water quality sampler was placed in the diversion structure to collect samples during runoff events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC's for each event for each parameter analyzed. Grab samples were also collected in the diversion manhole near the automated sampler quarterly and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 7-4 below provides a load reduction summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period, 1,322 pounds of TSS and 8.75 pounds of TP were captured by the system. Percent captured for all parameters was above 92.5% in 2019.

Table 7-4: Victoria Street Load/Capture Summary

Monitoring Period		5/2/2019 – 10/28/2019		
Total Rain		24.2		
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**	**Load Captured (lbs)**	**Percent Reduction %**
Total Suspended Solids	53.2	1,429	1,322	92.6
Volatile Suspended Solids	26.5	722.3	669.3	92.7
Inorganic Suspended Solids	26.7	706.4	653.1	92.5
Total Phosphorus	0.35	9.38	8.75	93.3
Ortho-phosphate	0.11	2.83	2.67	94.5
Chloride	2.78	75.2	70.4	93.6
Total Kjeldahl Nitrogen	2.31	62.2	58.0	93.3
Nitrate + Nitrite as N	0.33	8.90	8.31	93.4

7.4. Maintenance Inspection

Sediment depths in the pretreatment structure and in the underground infiltration system were measured during site visits to determine performance and maintenance needs. As shown in **Table 7-5**, minimal sediment was observed in both the pretreatment device and infiltration gallery.

Table 7-5: Victoria Street BMP Maintenance Inspection

Date	Sediment Depth in Pre-treatment (ft)	Sediment Depth in Infiltration Gallery (ft)[1]	Standing water in Infiltration Gallery?	Observations
June 7, 2019	0.5	0.2	N	Leaves in pretreatment
July 10, 2019	0.5	0.3	N	Trash in infiltration chamber
August 28, 2019	0.6	0.3	N	Oily pretreatment, trash and dense organic matter in infiltration pipe.
October 15, 2019	Maintenance – System Cleaned			
November 19, 2019	0.1	0.1	N	Trash and leaves present, no standing water.

8. BATTLE CREEK

The Battle Creek monitoring location is on the eastern edge of St. Paul and provides upstream data of water flowing west from Maplewood into St. Paul. The monitoring location is positioned in a sizeable greenspace on Battle Creek in a tunnel that connects the creek underneath McKnight Road N. This site was newly monitored in 2019.

8.1. Water Level Monitoring

A level logger was installed in the creek near the inlet into the 72" arch pipe and configured to record water elevations once every 10 minutes. Water elevations and rainfall are presented on **Chart A.22** of **Appendix A.** A summary of select runoff events from 2019 is presented in **Table 8-1** below.

Table 8-1: Battle Creek Water Level Summary (Select Flow Events)

Date	Rainfall (in)	Rainfall Intensity (in/hr)	Level Increase (ft)	Peak Water Elevation (ft SPCD)
July 20, 2019	1.24	0.32	2.06	201.82
August 15-16, 2019	1.26	0.17	2.78	202.44
August 18, 2019	1.99	0.55	5.50	206.09
September 2-3, 2019	1.04	0.28	3.22	203.07
October 21, 2019	1.28	0.17	3.69	203.82

Photo 8-1: Debris in Battle Creek 72" Arch RCP pipe

In 2019, water levels ranged from 199.4 ft SPCD on July 15, 2019 to 206.1 ft SPCD on August 18, 2019. The maximum level occurred as a result of 1.99 inches of rain on August 18th, 2019, which increased the level by 5.50 ft. In 2019, 50 rain events ranging from 0.07 inches to 1.99 inches resulted in water level elevations that kept creek levels high and continuous flow through the pipe. The inlet grate into 72" arch pipe was often blocked with debris, possibly causing a longer time for the level to drop.

8.2. Volume Monitoring

One flow meter was installed on the bottom of the pipe where Battle Creek crosses underneath McKnight Road N. The metered drainage area consists of 19.1 acres of Maplewood and drains into St. Paul. The 2019 flow rates and daily rainfall are depicted on **Chart B.6** of **Appendix B**.

During the 2019 monitoring period, the total volume moving through the system into St. Paul was 21,611,356 cu-ft (Table 8-2). The total water yield for the 662-acre drainage area is 37,745 cu-ft/acre. The greatest event-based volume moving through the system was 2,890,920 cu-ft as a result of a 0.13-inch rain event on July 26, 2019 and came right after a 1.24-inch rain event.

Table 8-2: Battle Creek Volume Summary

Monitoring Period	6/20/2019 – 10/27/2019	
Total Rainfall	16.94	in
Battle Creek Water Balance		
Total Volume	21,611,356	cu-ft
Maximum Event Volume	2,890,920	cu-ft

8.3. Pollutant Monitoring

A water quality sampler was placed in the structure to collect samples during high flow/rain events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC's for each event for each parameter analyzed. Grab samples were also collected in the stream, near the automated sampler and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 8-3 below provides a pollutant load summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period 10,794 pounds of TSS and 117 pounds of TP passed through the creek during storm events.

Table 8-3: Battle Creek Pollutant Load Summary

Monitoring Period		6/20/2019 – 10/27/2019
Total Rain		16.94 in
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**
Total Suspended Solids	8.00	10,794
Volatile Suspended Solids	4.53	6,129
Inorganic Suspended Solids	3.47	4,665
Total Phosphorus	0.09	117
Ortho-phosphate	0.009	11.7
Chloride	157.43	212,392
Total Kjeldahl Nitrogen	0.82	1101
Nitrate + Nitrite as N	0.31	414

9. SACKETT PARK POND

The Sackett Park Pond is situated in a wooded area between the Boys and Girls Club and the Chicago Northwestern Railroad on St. Paul's East Side. The basin receives runoff from the east via a storm sewer inlet pipe. The runoff flows northwest through a shallow channel, until it reaches an outlet control structure that conveys water away from the site through a 42-inch RCP pipe (**Photo 9-1**). When runoff exceeds the banks of the channel, it spills into the surrounding flood plain (**Photo 9-2**). Water elevations were monitored within the Sackett Park Pond to evaluate water level fluctuation in the basin, and to provide hydrology data for future improvements at that location. The pond location is provided as **Figure 9-1**.

Photo 9-1: Level Logger Configuration and Outlet Control Structure

9.1. Water Level Monitoring

A level logger was installed near the pond outlet control structure and configured to record water elevations once every 8 minutes. Water elevations and rainfall are presented on **Chart A.22** of **Appendix A**. A summary of select runoff events from 2019 is presented in **Table 9-1** below. The elevation of the top of the outlet control structure is 194 ft SPCD. Groundwater monitoring was conducted during the 2015 monitoring season and those results indicated that a continuous artesian condition was present at the site. Groundwater has not been monitored since the 2015 season.

Table 9-1: Sackett Park Pond Water Level Summary (Select Flow Events)

Date	Rainfall (in)	Rainfall Intensity (in/hr)	Level Increase (ft)	Peak Water Elevation (ft SPCD)	Depth above OCS (ft)
June 23, 2019	1.26	0.56	1.552	194.194	0.194
July 15, 2019	0.88	0.64	1.688	194.935	0.935
July 20, 2019	1.23	0.32	2.336	195.509	1.509
August 18, 2019	2.01	0.45	2.851	195.665	1.665
September 2, 2019	1	2.73	2.418	195.391	1.391

In 2019, water levels ranged from 192.5 ft SPCD on June 6, 2019 to 195.67 ft SPCD on August 18, 2019. The maximum level occurred as a result of 2.01 inches of rain on August 18th, 2019, which increased the level by 2.85 ft. In 2019, 26 rain events ranging from 0.08 inches to 2.01 inches resulted in water level elevations that exceeded the top of the outlet control structure. Following those events, the level decreased to below the top of the outlet control structure within 10 hours, but for most events the level decreased within 2 hours. Outlet control structure was often blocked with debris.

Photo 9-2: Sackett Park Pond Outlet Control Structure Submerged – Runoff Exceeds Channel Bank, Enters Flood Plain and Flows over Ball Fields (9/18/2019)

Photos 9-3 and 9-4: Path of Water Overflow across Ball Fields from Flood Plain (9/18/2019)

9.2. Volume Monitoring

One flow meter was installed inside of the 42" RCP pipe downstream of the pond. The metered drainage area consists of 19.1 acres of. The 2019 flow rates and daily rainfall are depicted on **Chart B.6** of **Appendix B**.

During the 2019 monitoring period, the total volume moving through the system was 1,616,352 cu-ft (Table 9-2). The total water yield for the 19.1-acre drainage area is 84,626 cu-ft/acre. The greatest event-based volume moving through the system was 173,743 cu-ft as a result of a 1.27-inch rain event on October 21, 2019.

Table 9-2: Sackett Park Volume Summary

Monitoring Period	5/27/2019 – 10/28/2019	
Total Rainfall	20.08 in	
Sackett Park Water Balance		
Total Volume	1,616,352	cu-ft
Maximum Event Volume	173,743	cu-ft

9.3. Pollutant Monitoring

A water quality sampler was placed inside of the 42" RCP pipe downstream of the pond near the flow meter to collect samples during high flow/rain events. The sampler was paced to collect samples at equal volume intervals to provide a representative sampling of each storm event. Samples for each event were tested as a composite to provide EMC's for each event for each parameter analyzed. Grab samples were also collected in the stream, near the automated sampler and tested for *E. Coli*. See **Charts C.1** and **C.2** of **Appendix C** for the complete water quality summary and pollutant loading calculations.

Table 9-3 below provides a pollutant load summary for the loading parameters defined in NPDES Permit issued to the City in addition to ortho-phosphate. During the monitoring period 10,794 pounds of TSS and 117 pounds of TP passed through the monitored area during storm events.

Table 9-3: Sackett Park Pollutant Load Summary

Monitoring Period		5/27/2019 – 10/28/2019
Total Rain		20.04 in
Water Quality Parameter	**Flow Weighted Average (mg/L)**	**Total Pollutant Load (lbs)**
Total Suspended Solids	68.4	6,903
Volatile Suspended Solids	22.0	2,222
Inorganic Suspended Solids	46.4	4,681
Total Phosphorus	0.26	26.2
Ortho-phosphate	0.052	5.42
Chloride	33.1	3,250
Total Kjeldahl Nitrogen	1.21	122.3
Nitrate + Nitrite as N	0.78	79.1

10. PERVIOUS SURFACE INFILTRATION ASSESSMENT

The City has been monitoring the performance of pervious pavement BMPs constructed in the City since 2012. Pervious pavement is constructed with substantial void space to allow for infiltration or filtration of stormwater through the pavement surface as a means of stormwater management. Pervious pavement BMPs monitored in the City include porous asphalt and permeable interlocking concrete pavers. The purpose of the infiltration testing is to monitor the change in site conditions and infiltration capability of the BMPs overtime. Pavement maintenance is also monitored to study the effect of routine and rehabilitative maintenance on these BMPs.

Infiltration testing was completed at the Jackson Street Pervious Bike Path BMP in July and October 2019. Testing was also completed at the Victoria Street pervious pavement BMP in July and Hamline Midway Library testing was completed in November 2019. This section presents the results of the 2019 infiltration testing. The Infiltration testing methodologies are described in **Section 2.5.** A photolog of infiltration testing is provided in **Appendix E**.

10.1. Victoria Street

The Victoria Street pervious surface consists of a parking area completed with permeable concrete pavers designed to receive stormwater runoff from Victoria Street and the properties adjacent to it. The pavers themselves are non-permeable and they are separated with aggregate fill (**Photo 10-1** and **10-2**). The spaces between the pavers allow stormwater runoff to infiltrate into the parking surface instead of running off and being collected by the storm sewer system. The pavers were installed in 2011 and infiltration rates have been monitored annually since 2012. The site and the infiltration test locations are provided on **Figure 10-1**.

Photo 10-1: Victoria Street Pavers

Photo 10-2: Victoria Street Infiltration Testing

Infiltration Test Results and Observations

Five locations were tested for infiltration at the Victoria Street site. In 2015, the exact test locations from 2014 could not be located, so new locations were established in the immediate area and identified as A-E (these locations were used since 2016). Those locations are depicted on **Figure 10-1** and the results of the testing are presented in **Table 10-1** and **Chart D.1** in **Appendix D**.

Table 10-1: Victoria Street Infiltration Rate Summary

Infiltration Ring Location	2012 Infiltration Rate (in/hr)	2013 Infiltration Rate (in/hr)	2014 Infiltration Rate (in/hr)	2015 Infiltration Rate (in/hr)		2016 Infiltration Rate (in/hr)		2017 Infiltration Rate (in/hr)		2018 Infiltration Rate (in/hr)		2019 Infiltration Rate (in/hr)	
IR-1	168.60	18.10	0.00	E	15.11	E	17.77	E	3.41	E	14.51	E	15.89
IR-2	266.60	75.70	12.93	A	0.00	A	19.38	A	3.78	A	11.47	A	4.06
IR-3	271.10	92.20	18.56	B	3.44	B	22.97	B	10.05	B	16.92	B	4.35
IR-4	69.10	24.00	9.72	C	0.00	C	6.55	C	28.91	C	6.25	C	4.03
IR-5	149.80	49.20	30.81	D	0.00	D	0.00	D	0.00	D	1.92	D	4.21
Average	185.04	51.84	14.40	3.71		13.33		9.23		10.21		6.51	

A summary of the 2019 infiltration test results is provided below:

- The overall site infiltration rate decreased in 2019 (6.51 in/hr) compared to 2018 (10.21 in/hr).
- The 2019 infiltration rates were, on average, less than 4 percent of 2012 infiltration rates.
- Locations A and B saw over a 50% decrease in 2019 compared to 2018.
- Infiltration rates at Locations E and D were greater in 2019, compared to 2018, while infiltration rates at Locations A, B and C were less in 2019 than 2018.

Photo 10-3: Location D Pre-test

Photo 10-4: Location D Infiltration Test

10.2. Jackson Street

The Jackson Street BMP (**Photo 10-5** and **10-6**) is a designated bike path constructed of pervious asphalt. It is a section of the Capital City Bikeway (CCB), a system of off-street bicycle trails in downtown Saint Paul. The BMP is eight blocks long, stretching from Kellogg Street to 11th Street, and consists of 2,750 square yards of pervious asphalt. Stormwater runoff filters through the asphalt and underlying media and is then conveyed to the storm sewer system via drain tile.

Monitoring locations JS-1 through JS-11 were established In November 2016 upon completion of the four-block stretch from Kellogg Boulevard to 7th Place East. Monitoring locations JS-12 through JS-18 were established in November 2017 upon completion of the four-block stretch from 7th Place East to 11th street. The monitoring locations were carefully selected to evaluate sediment loading and asphalt compaction from varying levels of pedestrian and vehicular traffic. Each site was characterized into one of three groups, identified in **Table 10-2**, based on their location and surroundings. The site and infiltration test locations are depicted on **Figure 10-2**. Site photos are provided in **Appendix E**.

Table 10-2: Monitoring Site Traffic Characterization

Site Traffic Characterization
Low: No driving and minimal foot traffic area. Adjacent to planter or minimal impervious surface.
Medium: Pedestrian cross walks or adjacent to large areas of impervious surface.
High: Driveways for parking or businesses, heavy vehicular traffic.

Photo 10-5: Capital City Bikeway (CCB) – Jackson Street/Kellogg Avenue

Photo 10-6: Jackson Street Infiltration Test

<u>Infiltration Test Results and Observations</u>

The site was tested for infiltration in July 2019 and October 2019. The infiltration test results from the 18 locations are summarized in **Table 10-3** and **Chart D.2** in **Appendix D**, which includes all infiltration test results completed to-date. **Table 10-3** is color coded to identify the site traffic characterizations described above. The infiltration tests results are also summarized in **Table 10-4**, which presents an average infiltration rate based on the monitoring location traffic characterization. The infiltration test locations are depicted on **Figure 10-2**.

Table 10-3: Jackson Street Infiltration Rate Summary (in/hr)

Infiltration Ring Location	Test Location Description	Nov 2016 Infiltr. Rate	Jun 2017 Infiltr. Rate	Nov 2017 Infiltr. Rate	Jul 2018 Infiltr. Rate	Oct 2018 Infiltr. Rate	Jul 2019 Infiltr. Rate	Oct 2019 Infiltr. Rate
JS-1	Northern half of Securian ramp entrance. Non-painted surface east of path center line.	572.6	9.3	3.9	0	0	0	0
JS-2	Midline of Securian ramp entrance. Non-painted surface east of path center line.	750.4	6.3	0	0	0	0	0
JS-3	Jackson Street pedestrian cross south of 6th Street. Near midline of bike path.	1282.1	1069.0	793.8	642.2	247.1	67.1	30.4
JS-4	Midblock between 6th & 5th Street. North of skyway. Near midline of bike path.	2122.2	1520.1	1372.0	1026.7	733.7	1050.1	764.4
JS-5	345 parking ramp entrance. Non-painted surface just north of the midline of the entrance. Midline of bike path.	385.9	4.5	0	0	0	0	0
JS-6	345 parking ramp entrance. Green painted stripe farthest south. West side of bike path.	118.7	12.1	0	0	0	0	0
JS-7	Jackson Street pedestrian cross north of 4th Street. Near midline of bike path.	533.7	353.9	181.7	73.7	29.4	0	0
JS-8	Midblock between 4th & Kellogg. Western edge of bike path (adjacent to concrete).	177.5	275.3	90.8	0	0	0	0
JS-9	Midblock between 4th & Kellogg. Eastern side of bike path.	277.9	56.1	2.4	0	0	0	0
JS-10	In line with the southern wall of the US Courthouse (facing Kellogg). Western edge of bike path adjacent to concrete.	557.9	125.5	2.1	0	0	0	0
JS-11	In line with the southern wall of the US Courthouse (facing Kellogg). Eastern side of the bike path.	471.5	125.4	35.5	0	0	0	0
JS-12	N of Credit Union Driveway between 11th St. and 10th St Midline of bike path, next to a planter.	NE	NE	843.3	827.2	877.1	710.5	633.3
JS-13	In front of Child Care Center between 11th St. and 10th St. Western edge of bike path, next to a planter.	NE	NE	1246.7	1696.9	1179.2	889.5	809.6
JS-14	S of 10th St. Adjacent to planter (2nd weir). Between Western edge and bike path midline.	NE	NE	464.4	575.1	447.5	323.3	211.4
JS-15	Firestone driveway, N of 2nd stripe from the S.	NE	NE	100.0	0	0	0	0
JS-16	Pedestrian cross, SW intersection of Jackson and 9th	NE	NE	1104.4	190.1	9.0	0	0
JS-17	Mid-block of 9th St. and 7th St. Adjacent to planter (southern-most tree). Just W of bike path midline.	NE	NE	1670.0	1605.0	1369.7	1329.5	1082.1
JS-18	Pedestrian cross, NW intersection of Jackson and 7th Pl. Adjacent to large concrete area.	NE	NE	665.4	589.6	521.5	215.7	327.7
Site Average:		659.1	323.4	476.5	401.5	300.8	254.8	214.4
Average of Sites JS-1 through JS-11 (established Nov 2016):				225.6	158.4	91.8	558.6	72.3
Average of Sites JS-12 through JS-18 (established Nov 2017):				870.6	783.4	629.1	693.7	437.7

NM – Not Measured

Table 10-4: Jackson Street Infiltration Summary by Site Traffic Characterization

Site Traffic Characterization	Nov 2016 Infiltr. Rate	Jun 2017 Infiltr. Rate	Nov 2017 Infiltr. Rate	Jul 2018 Infiltr. Rate	Oct 2018 Infiltr. Rate	Jul 2019 Infiltr. Rate	Oct 2019 Infiltr. Rate
Low: No driving and minimal foot traffic area. Adjacent to planter or minimal impervious surface.	2122.2	1520.1	1119.3	1146.2	921.4	860.6	700.2
Medium: Pedestrian cross walks or adjacent to large areas of impervious surface.	550.1	334.2	359.5	187.0	100.9	35.3	44.8
High: Driveways for parking or businesses, heavy vehicular traffic.	456.9	8.0	20.8[1]	0.0	0.0	0.0	0.0

1 - The increase in the site average for high traffic areas from June 2017 to November 2017 is a result of a new location added in November 2017

A summary of the 2019 infiltration testing completed at the Jackson Street Pervious Pavement Site is provided below:

- The overall site infiltration rate was 254.8 inches per hour (in/hr) in July 2019 and 214.4 in/hr in October 2019.
  - 11 of 18 locations showed no infiltration during both July and October testing events.
  - Of the remaining seven locations where infiltration occurred, October 2019 infiltrations rates ranged from 30.4 in/hr to 1082.1 in/hr.
- Low traffic areas had an average infiltration rate of 860.6 in/hr in July 2019 and 700.2 in/hr in October 2019.
  - All five monitoring locations exhibited infiltration ranging from 211.4 in/hr to 1082.1 in/hr in October 2019.
  - Four of the five low traffic testing locations were established in November 2017. The average infiltration rate in October 2019 was 63% of the infiltration rate observed in November 2017 at those locations.
- Medium traffic areas had an average infiltration rate of 35.3 in/hr in July 2019 and 44.8 in/hr in October 2019.
  - Six of eight monitoring locations showed no infiltration during both July and October 2019 testing events.
  - Of the remaining two locations where infiltration occurred, October 2019 infiltration rates ranged from 30.4 in/hr to 327.7 in/hr.
  - Locations JS-7 through JS-11 are within the first constructed section of the pervious pavement near the Jackson Street and Kellogg Boulevard intersection. These sites exhibited no infiltration as of the October 2019 monitoring event.
- High traffic areas had an average infiltration rate of 0.0 in/hr in July 2019 and October 2019.
  - No infiltration was observed at all five high traffic monitoring locations in July and October 2019.

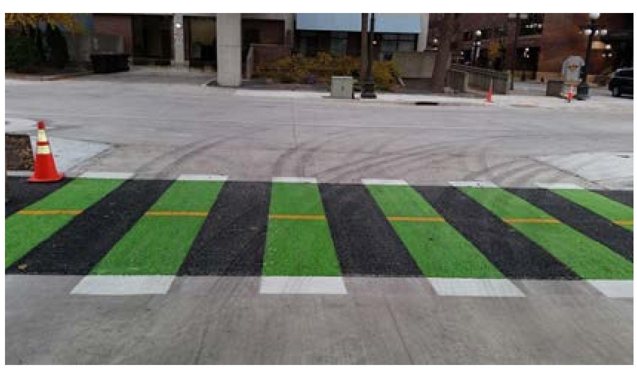


Photo 10-7: Test Locations JS-1 and JS-2 (high traffic)

10.3. Hamline Midway Library

The Hamline Midway Library pervious surface consists of 920 square yards of porous asphalt within the two alleyways adjacent to the Hamline Midway Library and the center alleyway connecting the sections. The asphalt content of the mix is 6.3 percent and the specific voids ratio is 18 percent. Prior to construction, the sub-surface soil infiltration rate was determined to be 29.0 inches per hour (in/hr) and 59.1 in/hr using a double ring infiltrometer. The asphalt was installed in 2012 and infiltration rate monitoring has been conducted from 2013 through 2019. After installation of the pavement, infiltration rates from 2013 to 2014 severely diminished at the site, with only two of nine locations exhibiting any infiltration. Photo documentation at the site confirmed areas with significant sediment accumulation within the pore space of the asphalt. Maintenance treatments were completed with the objective of determining if the pervious pavement could be restored. This years and prior years test results are shown in **Table 10-5**.

Table 10-5: Hamline Midway Library Infiltration Rate Summary

Infiltration Ring Location	2013 Infiltration Rate (in/hr)	2014 Infiltration Rate (in/hr)[1]	2015 Infiltration Rate (in/hr)[1]	2019 Infiltration Rate (in/hr)[1]
IR-1	102.4	0.0	0	0
IR-2	14.9	0.0	0	0
IR-3	11.4	0.0	0	0
IR-4	172.7	0.0	0	0
IR-5	0.0	0.0	605.97	218.96
IR-6	1125.3	206.4	502.41	10.30
IR-7	290.2	73.1	0	0
IR-8	28.4	0.0	0	0
IR-9	115.6	0.0	0	0
Average	**206.8**	**31.1**	**123.15**	**25.47**

1 - Locations were monitored for a maximum of 25 minutes during the pre-wet test. If no infiltration was observed, no subsequent tests were completed, and infiltrations rates were documented to be 0.0 in/hr.
BLUE – Dry sweep maintenance
RED – Wet sweep maintenance
GREEN – Power wash and vacuum sweep

Photo 10-8: Recently Constructed Hamline Midway Library Porous Asphalt (2012)

Photo 10-9: Hamline Midway Library Asphalt (2019)

11. CITY-WIDE LOADING ASSESMENT

11.1. 2019 Pollutant Loading Calculations

Monitoring of major outfalls within the City of Saint Paul was completed by Capitol Region Watershed District (CRWD) in 2019. Annual and seasonal pollutant loads were estimated for each subwatershed within the City for the loading parameters identified in the City's MS4 permit which include: chloride (Cl), total kjeldahl nitrogen (TKN), total phosphorus (TP), nitrate plus nitrite (NO3 +NO2), total suspended solids (TSS), and volatile suspended solids (VSS). The subwatersheds within the City are included in **Table 11-1** below.

Monitoring data collected by CRWD from the following subwatersheds was utilized for this assessment: East Kittsondale, St. Anthony Park, Trout Brook, and Hidden Falls. Monitoring of the Phalen Creek subwatershed was done only in the Fall in 2019 due to a tunnel replacement at that location. Monitoring of each subwatershed was completed at or near the outfall. The stations were configured to collect continuous flow measurements, and water quality, in accordance with the City's MS4 Permit.

Table 11-1 Watershed Inventory

Watershed	Area [acre]	Runoff Coefficient [.]	Rainfall Station
Battle Creek	1106	0.54	Wilder
Beaver Lake	192	0.33	Wilder
Belt Line	3014	0.55	Wilder
Crosby	1679	0.45	Hampden Park Co-op
Davern	1302	0.55	Hampden Park Co-op
Downtown	550	0.75	Engine House 18
East Kittsondale	1872	0.62	Engine House 18
Fish Creek	46	0.52	Wilder
Goodrich/Western	424	0.63	Engine House 18
Griffith/Pt. Douglas	460	0.61	Wilder
Hidden Falls	313	0.55	Hampden Park Co-op
Highwood	1123	0.50	Wilder
Lake Como	1294	0.47	Hampden Park Co-op
Lake Phalen	1013	0.42	Wilder
Mississippi River Blvd.	2391	0.58	Hampden Park Co-op
MRWMO	135	0.70	Hampden Park Co-op
Phalen Creek	1405	0.62	Wilder
Pigs Eye	3001	0.40	Wilder
Riverview	1017	0.57	Wilder
St. Anthony Hill	2651	0.64	Engine House 18
St. Anthony Park	2481	0.68	Hampden Park Co-op
Trout Brook	3963	0.62	Wilder
Urban	327	0.57	Wilder
West Kittsondale	1042	0.67	Hampden Park Co-op
West Seventh	451	0.60	Fire House 18

Monitored Subwatershed

Annual and seasonal city-wide flow-weighted averages were calculated for each of the loading pollutants from the monitored outfall data. TKN, TP, TSS and VSS loads were generated by CRWD in the WISKI data management program. This allowed for the extraction of baseflow and the associated load from the event load for those parameters. Cl and NO_2+NO_3 loads were calculated for the event-based volume (baseflow volume extracted), although the base flow loading for those parameters was not extracted. The following formula was used to calculate the annual/seasonal flow weighted mean concentrations (**Table 11-2**):

$$C = \frac{\sum(F_i \times C_i)}{\sum(F_i)}$$

C = annual/seasonal flow weighted mean concentration [mg/L]*
F_i = the event based flow for an individual event [cf]
C_i = the pollutant concentration for an individual event [mg/L]

*As described above, the flow-weighted mean concentration for TKN, TP, TSS, and VSS, was calculated from loads generated in the WISKI program, which extracted baseflow loading (not reflected in the formula above)

Table 11-2: City-wide Annual and Seasonal Flow-weighted Mean Concentrations

Parameter	Cl	TKN	TP	NO_2+NO_3	TSS	VSS
Units	**[mg/L]**	**[mg/L]**	**[mg/L]**	**[mg/L]**	**[mg/L]**	**[mg/L]**
Annual	102.8	1.9	0.4	0.4	132.9	46.7
Q1 (Jan-Mar)	417.9	4.0	0.5	0.7	103.8	34.0
Q2 (Apr-Jun)	47.3	2.0	0.4	0.4	180.2	72.5
Q3 (Jul-Sep)	20.5	1.5	0.3	0.4	152.9	49.2
Q4 (Oct-Dec)	41.2	0.8	0.3	0.3	69.3	25.3

Based on these calculated flow-weighted mean concentrations, the Simple Method was used to calculate each subwatershed's pollutant loading. Loads for the four monitored subwatersheds were generated using actual monitored loads. The Simple Method is show below:

$$L = 2.72\left(\frac{PP_jR_v}{12}\right)(CA)$$

L = pollutant loading for the year/season [lb]
P = rainfall depth for the year/season [in]
P_j = correction factor for storms that produce no runoff [.]
R_v = runoff coefficient [.]
C = flow-weighted mean concentration [mg/L]
A = area of the watershed [acre]

Values used in loading calculations:
R_v and A = Table 1
C = Table 2
P = Table 3
P_j = 0.85

The annual/seasonal precipitation totals for three different rainfall monitoring locations in St. Paul are provided in **Section 3** the **Table 3-1**. Each subwatershed was assigned precipitation data from the nearest precipitation monitoring site (see **Table 11-1** for assignments). The rainfall data was used as an input to the Simple Method for load calculations, as described above. Rain data outside the seasonal monitoring period was supplemented with data from the University of Minnesota – St. Paul.

The annual and seasonal pollutant loads for each of the City's subwatersheds are presented in **Tables 11-3 – 11-7**. Loads for the four monitored sites are actual totals calculated for each station. Those sites are highlighted blue.

Table 11-3. Annual Pollutant Loadings (lbs)

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	442193	8240	1635	1799	571865	200970
Beaver Lake	48931	912	181	199	63280	22238
Belt Line	1280187	23855	4734	5209	1655598	581825
Crosby	571221	10644	2112	2324	738730	259611
Davern	541396	10088	2002	2203	700159	246056
Downtown	312436	5822	1155	1271	404056	141997
East Kittsondale	407848	8586	1374	1505	444016	173126
Fish Creek	17710	330	65	72	22904	8049
Goodrich/Western	202322	3770	748	823	261652	91952
Griffith/Pt. Douglas	207755	3871	768	845	268678	94421
Hidden Falls	130151	2425	481	530	168318	59152
Highwood	415731	7747	1537	1692	537644	188944
Lake Como	459805	8568	1700	1871	594641	208974
Lake Phalen	328569	6123	1215	1337	424921	149329
Mississippi River Blvd.	1048452	19537	3877	4266	1355908	476506
MRWMO	71445	1331	264	291	92396	32471
Phalen Creek	644958	12018	2385	2624	834090	293123
Pigs Eye	888769	16561	3287	3617	1149399	403932
Riverview	429199	7998	1587	1747	555061	195064
St. Anthony Hill	1285068	23946	4752	5229	1661911	584044
St. Anthony Park	619683	8495	1559	2354	590036	210466
Trout Brook	355203	7813	1993	1540	675781	219525
Urban	138002	2572	510	562	178471	62720
West Kittsondale	527817	9835	1952	2148	682598	239885
West Seventh	204958	3819	758	834	265061	93150

Monitored Locations

Table 11-4: Q1 (Jan-Mar) Pollutant Loading (lbs)

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	228885	2194	282	359	56865	18625
Beaver Lake	24282	233	30	38	6033	1976
Belt Line	635293	6089	782	997	157835	51695
Crosby	289555	2775	356	454	71938	23562
Davern	274436	2630	338	431	68182	22331
Downtown	158085	1515	195	248	39275	12864
East Kittsondale	361825	3427	431	436	72035	32670
Fish Creek	9167	88	11	14	2277	746
Goodrich/Western	102370	981	126	161	25433	8330
Griffith/Pt. Douglas	107536	1031	132	169	26717	8750
Hidden Falls	65974	632	81	103	16391	5368
Highwood	215188	2062	265	338	53462	17510
Lake Como	233077	2234	287	366	57907	18966
Lake Phalen	163052	1563	201	256	40509	13268
Mississippi River Blvd.	531466	5094	654	834	132040	43247
MRWMO	36216	347	45	57	8998	2947
Phalen Creek	333838	3200	411	524	82940	27165
Pigs Eye	460038	4409	566	722	114294	37434
Riverview	222159	2129	273	349	55194	18078
St. Anthony Hill	650216	6232	800	1020	161542	52909
St. Anthony Park	508001	3947	555	959	148243	40555
Trout Brook	159507	2492	280	220	35454	10534
Urban	71432	685	88	112	17747	5813
West Kittsondale	267553	2564	329	420	66472	21771
West Seventh	103704	994	128	163	25765	8439

Monitored Locations

Table 11-5: Q2 (Apr-Jun) Pollutant Loading (lbs)

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	69613	2921	603	594	265250	106644
Beaver Lake	7691	323	67	66	29306	11782
Belt Line	201224	8444	1744	1718	766735	308266
Crosby	82419	3459	714	704	314046	126262
Davern	78116	3278	677	667	297648	119669
Downtown	45636	1915	395	390	173891	69913
East Kittsondale	20551	2336	384	425	149261	63163
Fish Creek	2788	117	24	24	10623	4271
Goodrich/Western	29553	1240	256	252	112606	45273
Griffith/Pt. Douglas	32706	1372	283	279	124622	50104
Hidden Falls	1276	83	17	14	11351	2033
Highwood	65447	2746	567	559	249376	100262
Lake Como	66343	2784	575	567	252791	101635
Lake Phalen	51646	2167	447	441	196788	79119
Mississippi River Blvd.	151276	6348	1311	1292	576417	231749
MRWMO	10309	433	89	88	39279	15792
Phalen Creek	101533	4261	880	867	386878	155544
Pigs Eye	139916	5871	1212	1195	533128	214344
Riverview	67567	2835	585	577	257455	103510
St. Anthony Hill	187706	7877	1626	1603	715227	287557
St. Anthony Park	22647	1309	228	290	130690	58129
Trout Brook	98678	2279	611	494	254158	95978
Urban	21725	912	188	186	82781	33282
West Kittsondale	76156	3196	660	650	290183	116668
West Seventh	29938	1256	259	256	114073	45863

Monitored Locations

Table 11-6: Q3 (Jul-Sep) Pollutant Loading

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	34405	2496	585	601	256147	82424
Beaver Lake	3627	263	62	63	27006	8690
Belt Line	94905	6886	1613	1657	706568	227363
Crosby	46126	3347	784	805	343407	110503
Davern	43717	3172	743	763	325476	104733
Downtown	25020	1815	425	437	186271	59939
East Kittsondale	13897	2298	416	487	186182	64271
Fish Creek	1378	100	23	24	10259	3301
Goodrich/Western	16202	1176	275	283	120622	38814
Griffith/Pt. Douglas	16164	1173	275	282	120345	38725
Hidden Falls	1307	136	27	33	14797	3074
Highwood	32346	2347	550	565	240819	77492
Lake Como	37129	2694	631	648	276425	88949
Lake Phalen	24358	1767	414	425	181345	58354
Mississippi River Blvd.	84662	6143	1438	1478	630308	202824
MRWMO	5769	419	98	101	42951	13821
Phalen Creek	5925	1365	319	266	172293	137370
Pigs Eye	69151	5017	1175	1207	514834	165666
Riverview	33394	2423	567	583	248620	80002
St. Anthony Hill	102907	7466	1748	1797	766146	246534
St. Anthony Park	29336	2520	467	660	227756	83092
Trout Brook	62810	2548	860	615	340515	96956
Urban	10737	779	182	187	79940	25723
West Kittsondale	42621	3092	724	744	317313	102107
West Seventh	16413	1191	279	287	122194	39320

Monitored Locations

Table 11-7: Q4 (Oct-Dec) Pollutant Loading (lbs)

Subwatershed	Cl	TKN	Total P	NO2+NO3	TSS	VSS
Battle Creek	36567	713	256	299	61507	22423
Beaver Lake	4468	87	31	37	7515	2740
Belt Line	116899	2280	818	957	196625	71681
Crosby	50700	989	355	415	85278	31089
Davern	48053	937	336	393	80826	29466
Downtown	27680	540	194	227	46559	16973
East Kittsondale	577	15	4	7	963	254
Fish Creek	1465	29	10	12	2463	898
Goodrich/Western	17925	350	125	147	30150	10991
Griffith/Pt. Douglas	17180	335	120	141	28898	10535
Hidden Falls	1307	136	27	33	14797	3074
Highwood	34379	671	241	281	57826	21081
Lake Como	40811	796	286	334	68645	25025
Lake Phalen	10900	900	191	231	69455	26343
Mississippi River Blvd.	93058	1815	651	762	156525	57063
MRWMO	6341	124	44	52	10666	3888
Phalen Creek	7745	961	260	66	45183	25459
Pigs Eye	73497	1433	514	602	123623	45068
Riverview	35493	692	248	291	59699	21764
St. Anthony Hill	113851	2221	797	932	191499	69813
St. Anthony Park	59699	719	309	445	83347	28690
Trout Brook	35957	577	257	222	50408	17698
Urban	11412	223	80	93	19195	6998
West Kittsondale	46848	914	328	384	78799	28727
West Seventh	18158	354	127	149	30542	11135

Monitored Locations

12. 2019 SUMMARY

In 2019, seven (7) stormwater BMPs were monitored along with two (2) locations that provide upstream stormwater data. All locations were evaluated for performance in 2019 to help the City meet its Phase I MS4 Permit monitoring requirements. The BMP systems that were monitored include underground infiltration systems, a rain garden, and pervious pavement. The systems were monitored to evaluate infiltration rates, volume reduction, and pollutant removal efficiencies. Long-term monitoring data has shown how the effectiveness of these systems change over time.

12.1. Underground Infiltration Systems/Outfall

Four underground infiltration BMPs (Beacon Bluff, St. Albans, Hampden Park, and Victoria Street) were monitored for flow to evaluate runoff and volume reduction at BMP Sites. The runoff data for each site was normalized over the individual drainage areas to evaluate drainage characteristics that contribute to each Site. A summary of runoff and volume reduction data is presented in **Table 11-1** below.

Table 11-1: Runoff Summary

BMP Site	Drainage Area (acres)[1]	Total Monitored Runoff (cf)	% Runoff Captured	Water Yield (in/acre)[1]	Water Yield (cu-ft/acre)[1]	Rainfall/Runoff Coefficient
Beacon Bluff	136.8	1,932,561	43.5	3.64	13,197	0.16
St. Albans	25.2	709,403	97	7.8	28,151	0.34
Hampden Park	7.8	524,242	100	18.52	67,211	0.77
Victoria Street	118	431,238	93	6.22	22,578	0.29

1-For the Beacon Bluff and Hampden Park Sites, the drainage area and total runoff presented in the table includes the total for the BMP system. The water yield calculations were generated from the monitored/modeled runoff volume and the corresponding drainage area

Of the four sites, the Hampden Park site received the greatest amount of runoff per drainage acre, resulting in a rainfall to runoff coefficient of 0.77. Beacon Bluff's drainage area showed the least amount of runoff, having a coefficient of 0.16.

TSS and TP loads captured by the monitored BMPs are summarized in **Table 11-2**. TSS and TP loads were calculated using 2019 flow data and flow-weighted averages. Beacon Bluff takes in the largest runoff volume and also captured the largest amount of TSS and TP. The total TSS load and TP load captured by the four systems was 7,841 pounds and 41.31 pounds, respectively.

Table 11-2: Underground Infiltration System Pollutant Capture Summary

BMP Site	TSS Captured (pounds)	TP Captured (pounds)
Beacon Bluff	3,315	21.2
St. Albans	1,682	7.60
Hampden Park	1,522	3.76
Victoria Street	1,322	8.75
Total	**7,841**	**41.31**

A summary of the 2019 infiltration rates for the underground infiltration systems is provided below.

- The infiltration rate for the Beacon Bluff underground system was 0.12 in/hr, which is 5% of the post-construction infiltration rate. The underground system no longer drains to empty, and groundwater mounding does not appear to be the cause of standing water, based on groundwater elevation data. Even with standing water observed in the BMP and an increase in system discharge events, the BMP infiltrated 43.5% of the total volume monitored.
- The 2019, St. Albans infiltration rate of 9.6 in/hr is greater than the MSWM infiltration rate, but less than design rate of 26.0 in/hr. The St. Albans BMP system regularly drained to empty within 24 hours of a runoff event.
- The infiltration rate for the Hampden Park BMP was 11.6 in/hr, which exceeded the design rate of 1.8 in/hr and is slightly greater than the 2018 infiltration rate. No overflow bypass was observed, therefor 100% of the volume received by the BMP was infiltrated.
- The infiltration rate for the Victoria Street BMP was 21.1 in/hr, which decreased to 45% of the post-construction infiltration rate but is still greater than the designed rate. The Victoria Street BMP regularly drained to empty with 24 hours of a runoff event.

12.2. Pervious Pavement

Infiltration testing was conducted at the Victoria Street permeable pavers, Jackson Street pervious asphalt, and Hamline Midway library pervious asphalt sites in 2019. The Victoria Street 2019 average infiltration rate of 6.5 in/hr is 3.5% of post-construction monitored infiltration rate.

The October 2019 infiltration rate at the Jackson Street Site was 214.4 in/hr, which is 32.5% of the infiltration rate observed during the first year of monitoring (2016). Low traffic areas were observed to have a significantly greater infiltration rates on average (700.2 in/hr) than medium traffic (44.8 in/hr) and high traffic (0.0 in/hr) areas. Maintenance of both pervious pavement BMPs consists of street sweeping two times annually.

12.3. 2019 Recommendations

The recommendations for the 2020 Monitoring Program include:

- Continue to perform inspections and regular maintenance on BMP pre-treatment systems and infiltration galleries.
- Continue to notify of potential illicit discharges observed at flow monitoring locations.
- Evaluate the change in infiltration rate within the Beacon Bluff as a result of dredge maintenance that was completed.
- Complete additional infiltration testing at Jackson Street Pervious Bike Path to further evaluate changes in pervious surface performance with respect to pavement traffic.

13. REFERENCES

City of Saint Paul, 2018. 2017 Water Quality and Quantity Monitoring Report. Saint Paul, MN.

Erickson, Andrew J., John S. Gulliver, and Peter T. Weiss. "Capturing phosphates with iron enhanced sand filtration." *Water Research* 46.9 (2012): 3032-3042.

Erickson, Andrew J., John S. Gulliver, and Peter T. Weiss. "Monitoring an Iron-Enhanced Sand Filter Trench for the Capture of Phosphate from Stormwater Runoff." Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/175078, 2015.

Erickson, Andrew J. "Removing Dissolved Pollutants from Stormwater Runoff." St. Anthony Falls Laboratory, University of Minnesota. Presentation, October 3, 2012.

Minnesota Climatology Working Group. St. Paul Campus Climatological Observatory: precipitation data. Saint Paul, MN. Accessed 2017. http://mrcc.isws.illinois.edu.

Minnesota Pollution Control Agency 2008. Minnesota Stormwater Manual. Version 2. Accessed 2017. https://stormwater.pca.state.mn.us/index.php?title=Main_Page.

Minnesota Department of Transportation, 2015. Study: "Permeable Pavements in Cold Climates: State of the Art and Cold Climate Case Studies". Accessed 2017. https://lrrb.org/pdf/201530.pdf.

Figures

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2019 Water Quantity & Quality Monitoring Program

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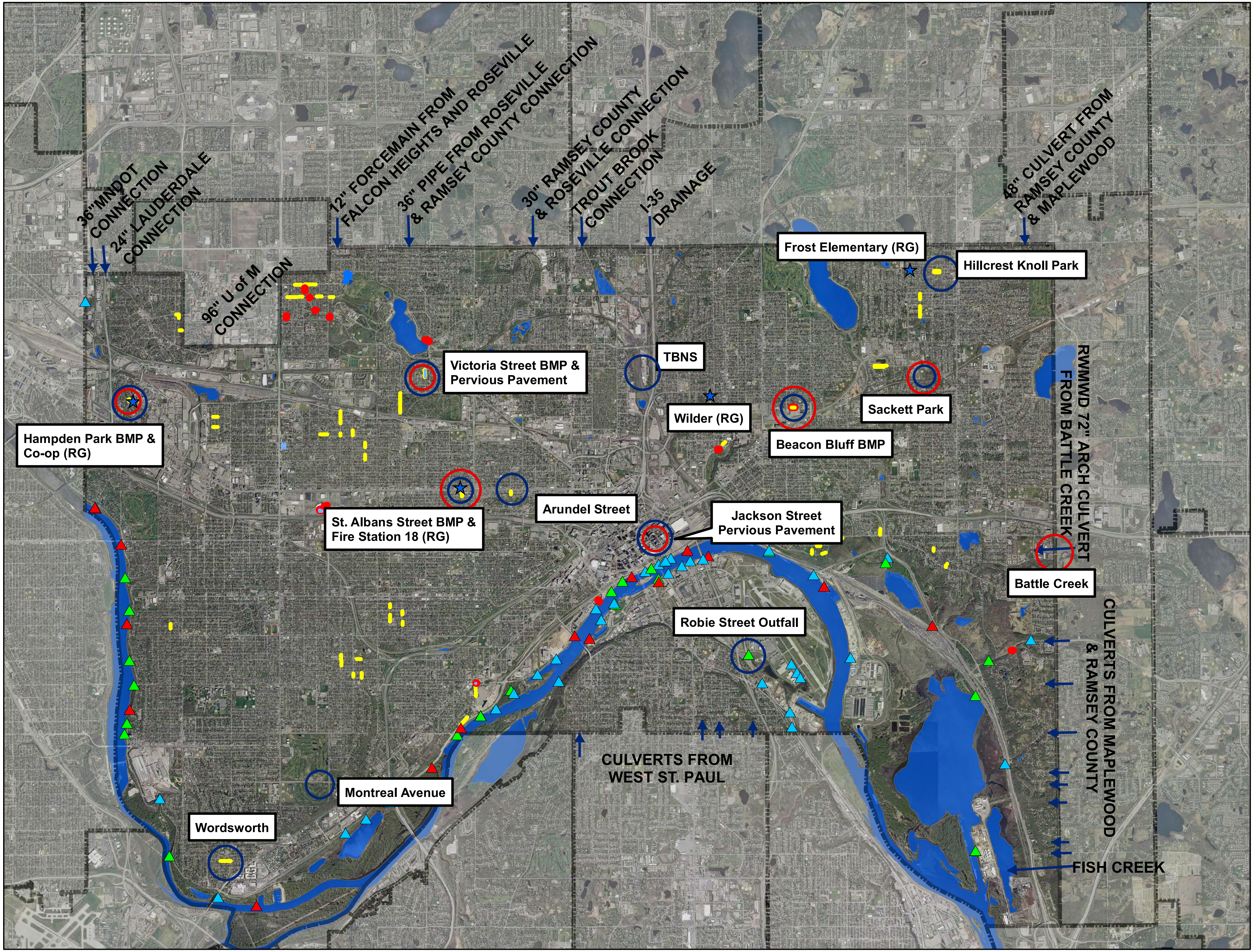
Figure 1-1

2019 Monitoring Site Locations



N
W E
S

0 2,500 5,000 10,000 Feet

Legend

- Raingarden/Infiltration Basin
- Infiltration Trench
- Pervious Pavement
- Capitol Region Watershed District
- Lower Mississippi River WMO
- Mississippi WMO
- Ramsey/Washington/Metro WD
- 2018 Monitoring Locations
- 2019 Monitoring Locations
- Rain Gauge Locations

Outfalls

- 30" - 48"
- 50" - 72"
- > 72"

wsb

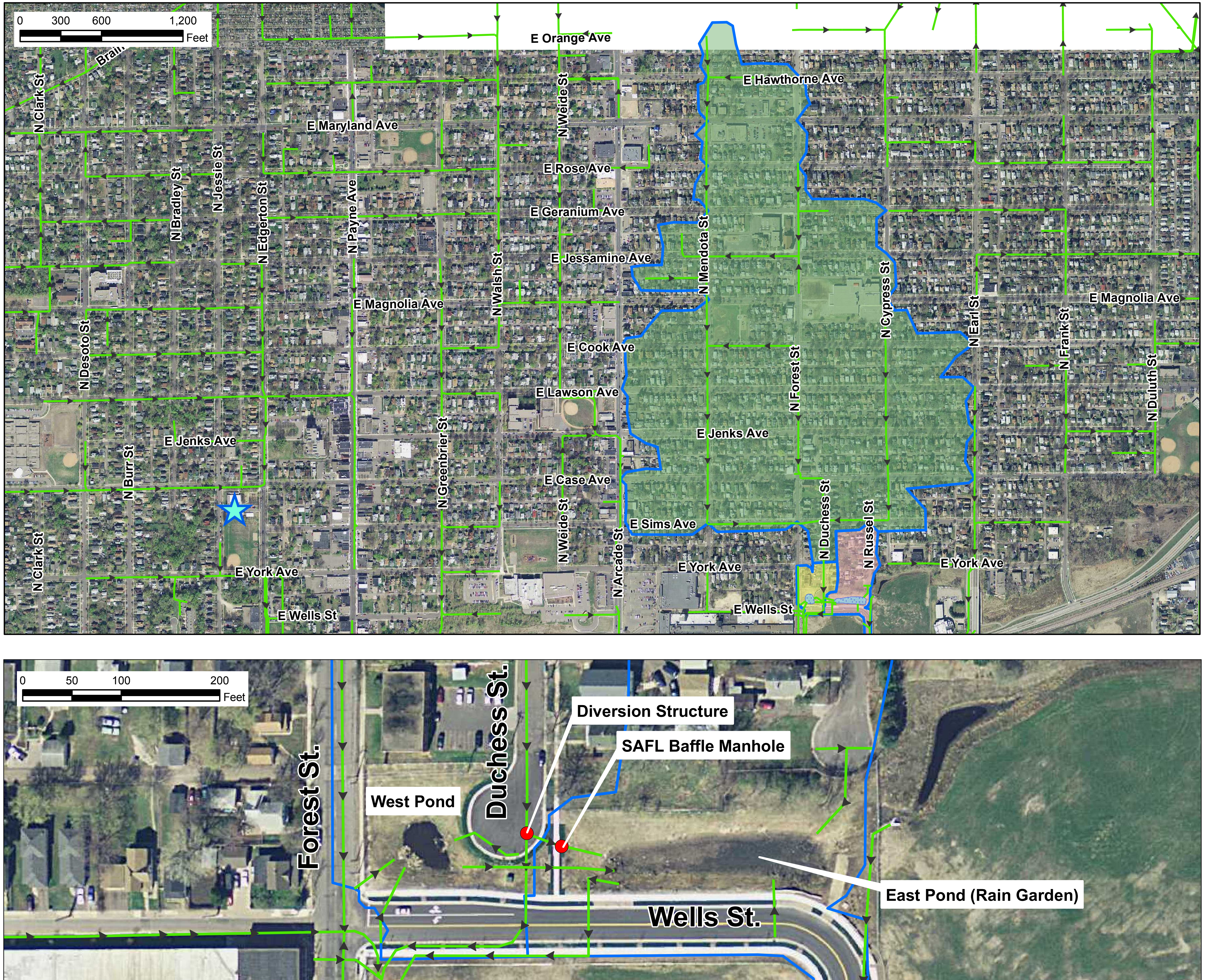


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FIGURE 4-1
Beacon Bluff Infiltration BMP Drainage Areas

N W E S

Legend

- Underground Chamber
- Storm Pipe
- Rain Gauge Location

Drainage Areas

- Subwatershed A - Diversion Structure (136.8 ac)
- Suwatershed B - East Pond (4.7 ac)
- Subwatershed C - West Pond (2.1 ac)

wsb

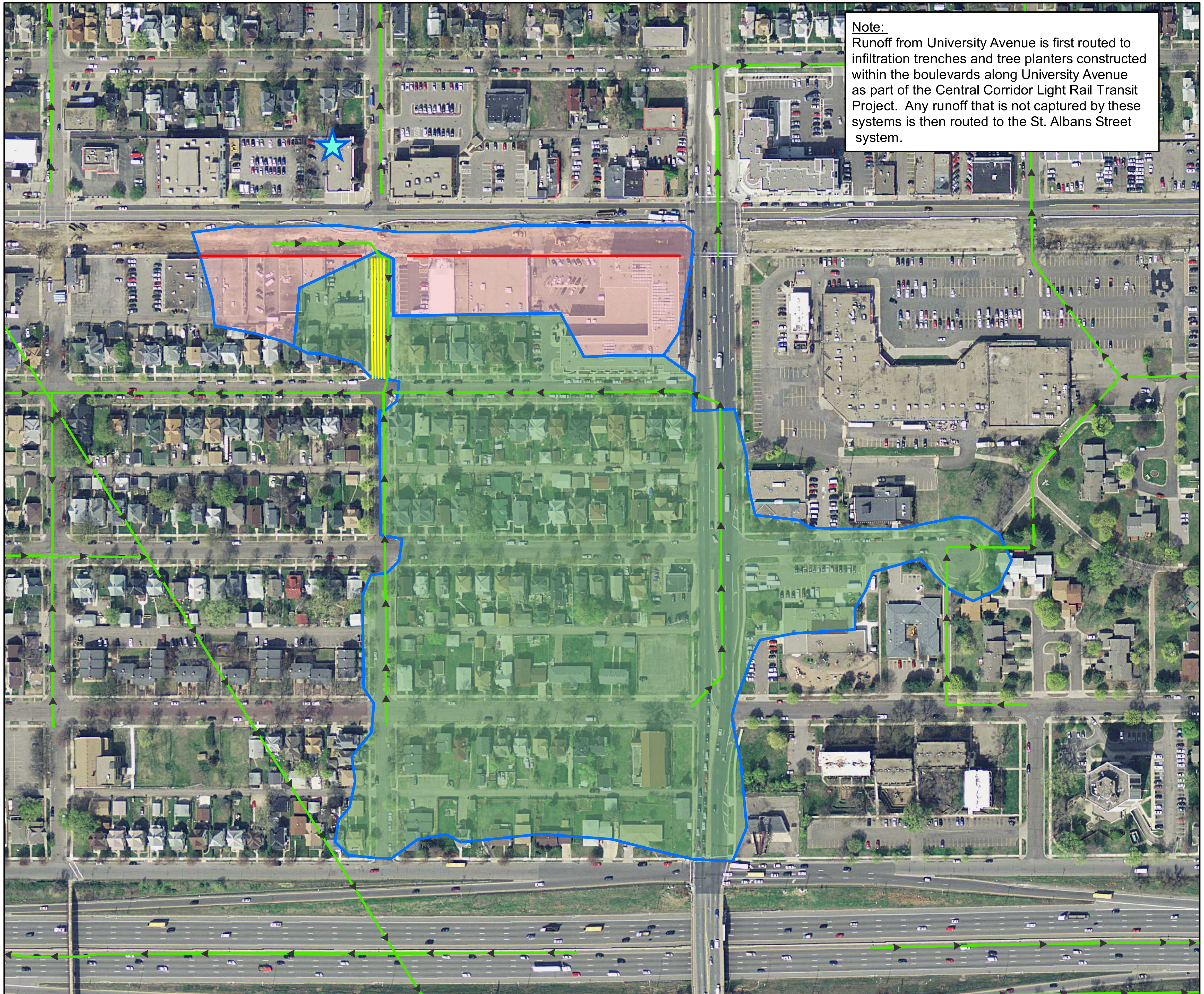

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FIGURE 5-1

St. Albans Street Infiltration BMP Drainage Areas

N W E S

0 100 200 400 Feet

Legend

- Infiltration Trench
- CCLRT Infiltration Trench (Not monitored)
- Storm Pipe
- Rain Gauge Location

Drainage Areas

- St. Albans Infiltration System (20.3 ac)
- CCLRT Infiltration Trenches (4.9 acres)

wsb

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FIGURE 6-1 Hampden Park Infiltration BMP Drainage Area

N

W E

S

0 50100 200 300 400 Feet

Legend

Storm Pipe

Rain Gauge Location

Hampden Park BMP

Hampden Park BMP Drainage Area

wsb

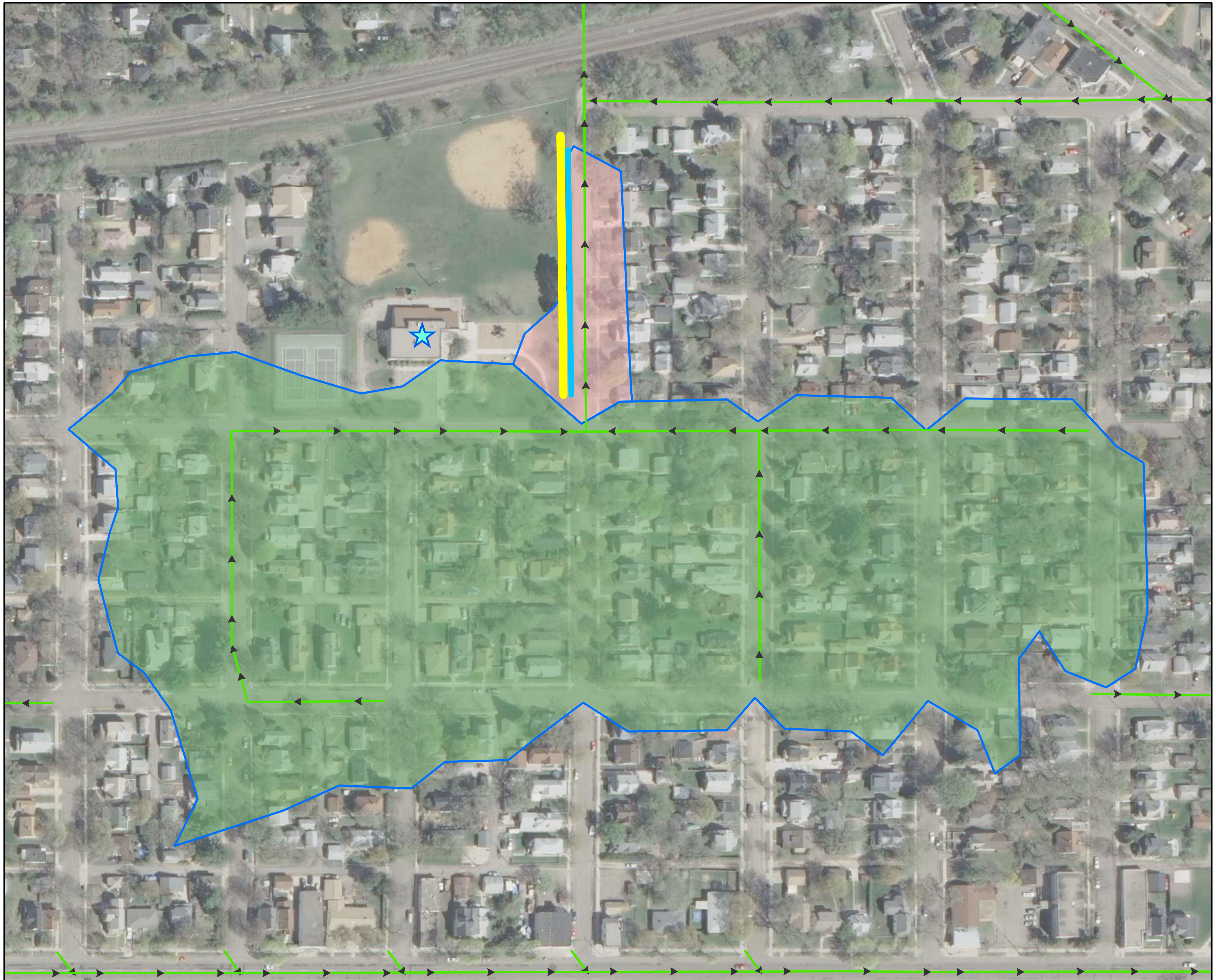

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FIGURE 7-1
Victoria Street Infiltration BMP Drainage Areas

N
W E
S

0 75 150 300 Feet

Legend

Infiltration BMPs

- Infiltration Trench
- Pervious Pavement
- Storm Pipe
- Rain Gauge Location

Drainage Areas

- Infiltration Trench (19.1 ac)
- Pervious Pavement (1.0 ac)

wsb

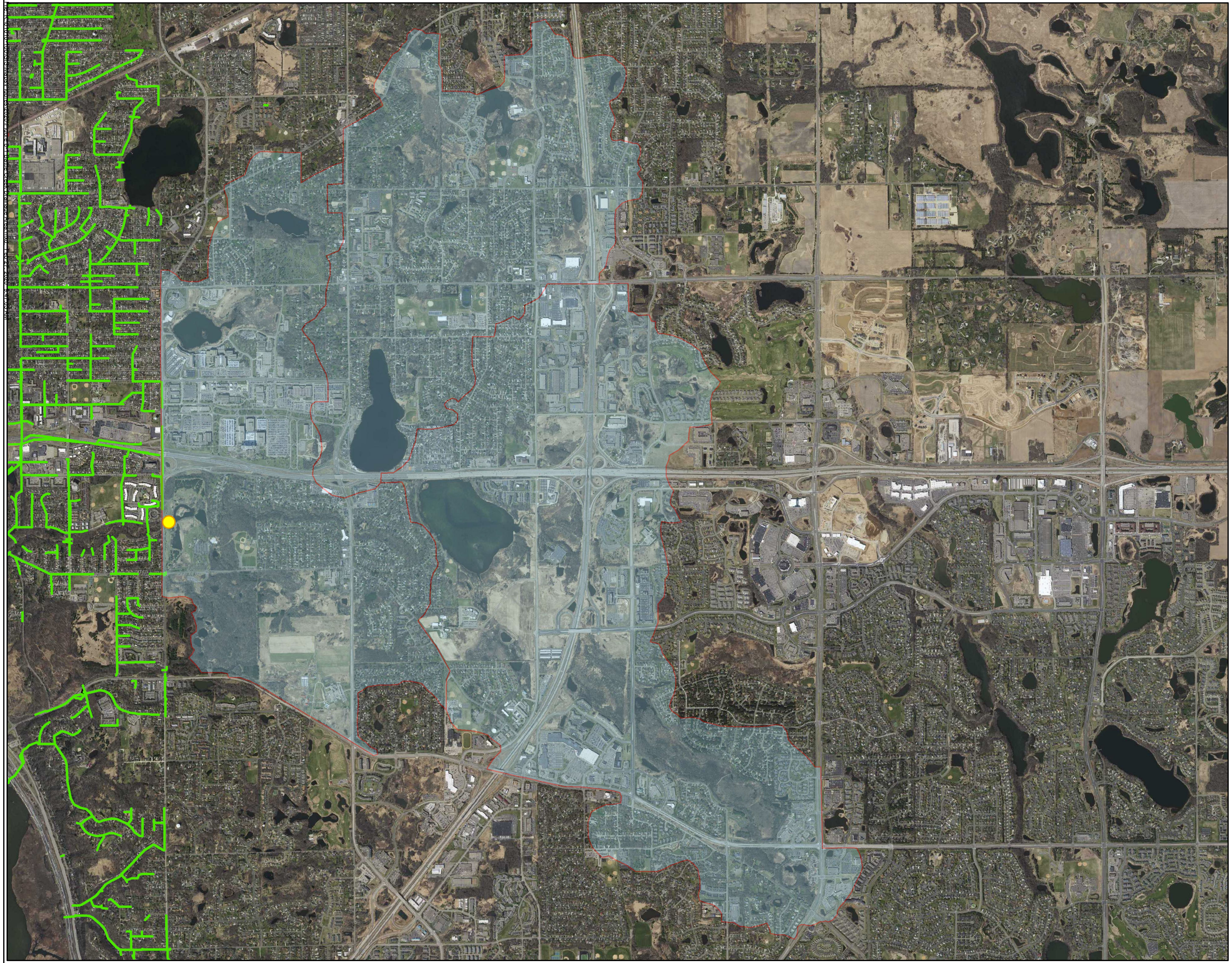

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Figure 8-1

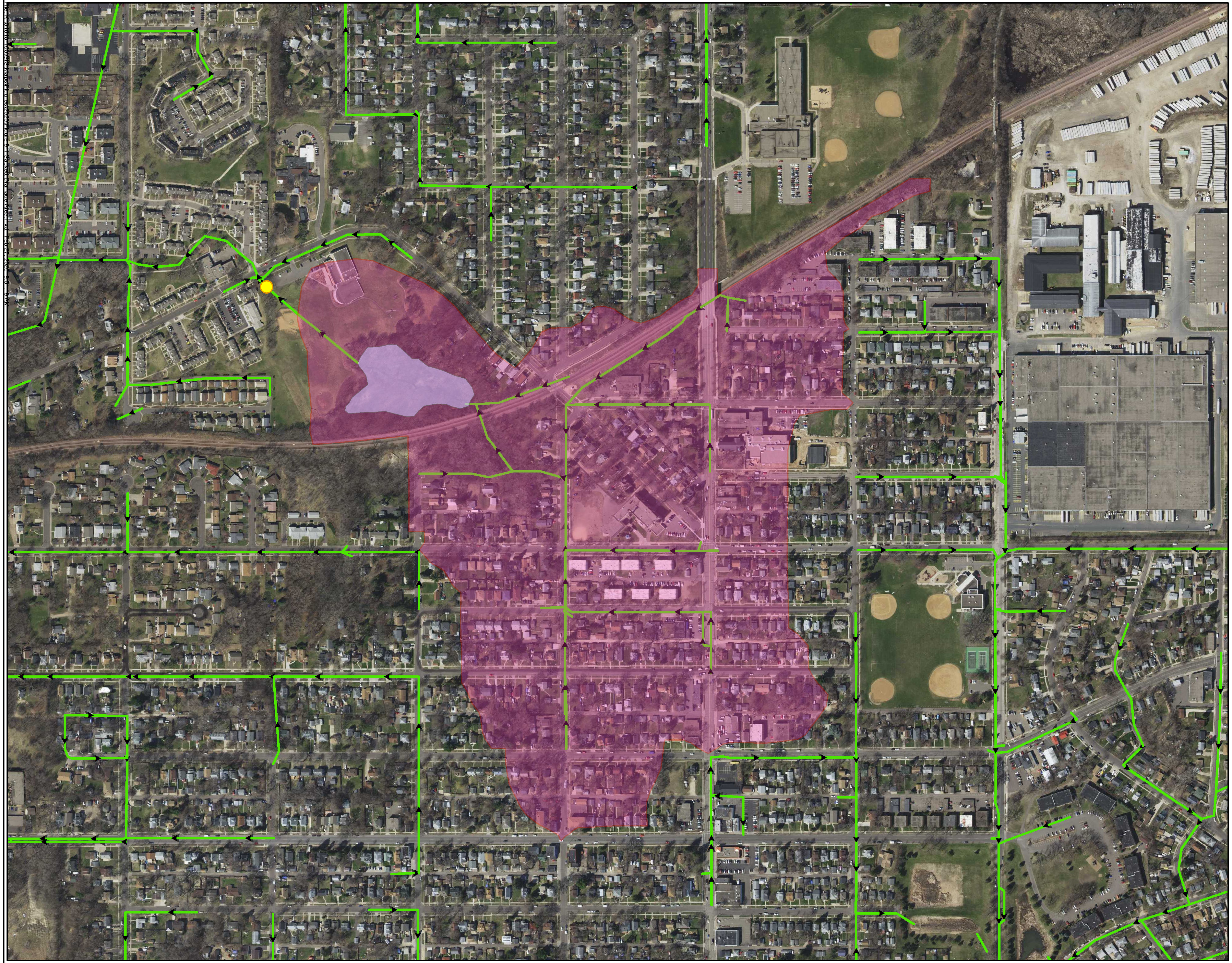
Battle Creek Monitoring Location
Drainage Area:661.7 acres

Rain Gauge Location -
Frost Lake Elementary
1505 Hoyt Ave E

(yellow dot)	Monitoring Locations
(pink)	Sackett Park Drainage Area
(light blue)	Battle Creek Drainage Area
(purple)	BMP Location
(green line)	Storm Pipe

0 1,300 2,600 5,200 Feet

wsb



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N
W E
S

Figure 9-1

Sackett Park Monitoring Location
Drainage Area:93.3 acres

Rain Gauge Location -
Frost Lake Elementary
1505 Hoyt Ave E

Monitoring Locations
Sackett Park Drainage Area
Battle Creek Drainage Area
BMP Location
Storm Pipe

0 215 430 860 Feet

wsb

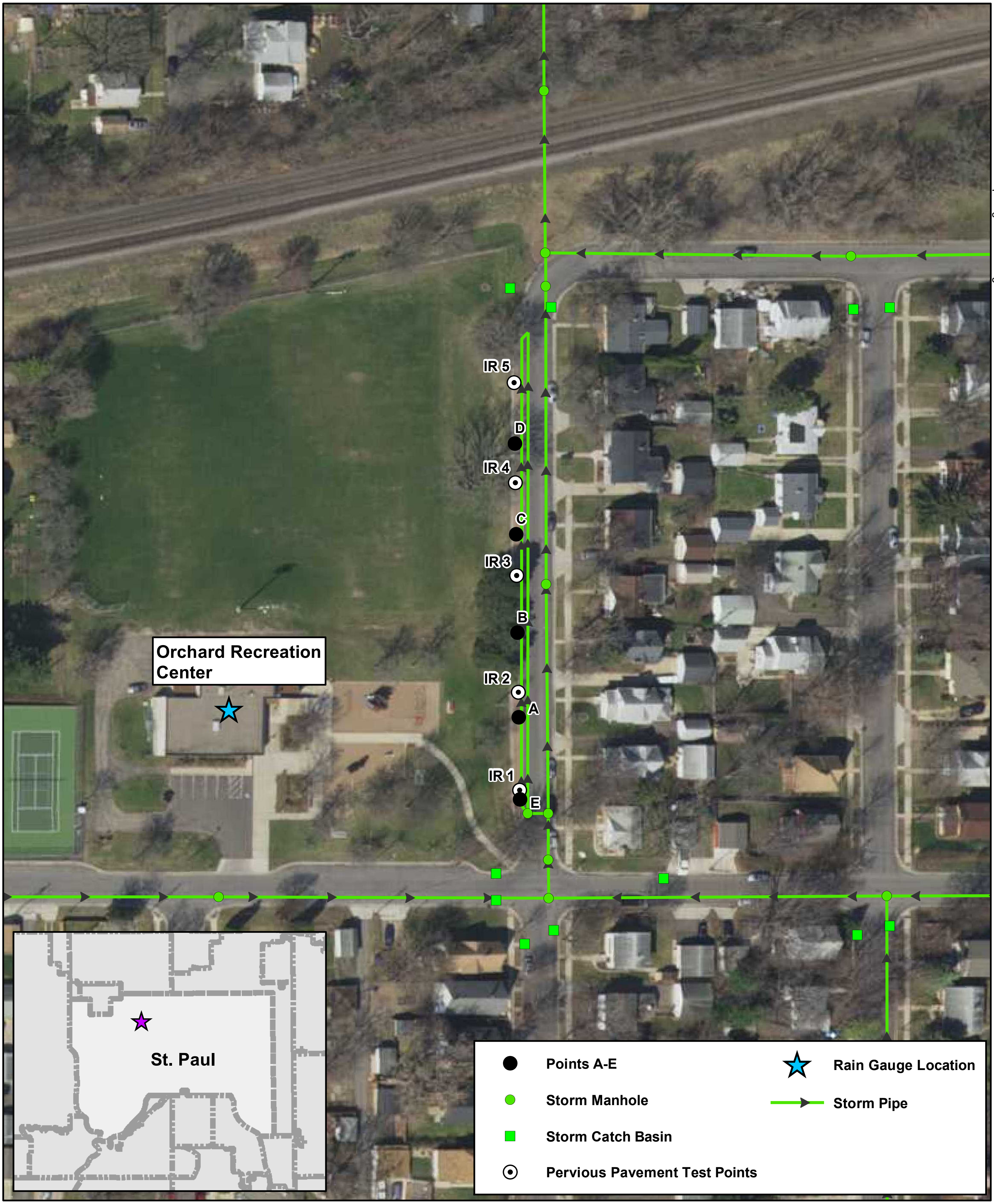

Figure 10-1 - Victoria Street Pervious Pavement Test Locations

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Figure 10-2 Jackson Street (pg 1of2)

JS-1 - JS-11 Pervious Test Locations

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Document Path: K:\01610-100\GIS\Maps\Figures\2020\Figure 13-2 JacksonStPerviousPavement.mxd Date Saved: 5/12/2019 5:34:46 PM

Document Path: K:\01610-100\GIS\Maps\Figures\2020\Figure 13-2 JacksonStPerviousPavement (sec 2).mxd Date Saved: 5/12/2019 5:32:04 PM

Figure 10-2 Jackson Street (pg 2of2)
JS-12 - JS-18 Pervious Test Locations
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- Pervious Pavement Testing Locations
- Pervious Asphalt Bike Path

0 50 Feet
1 inch = 42 feet

wsb

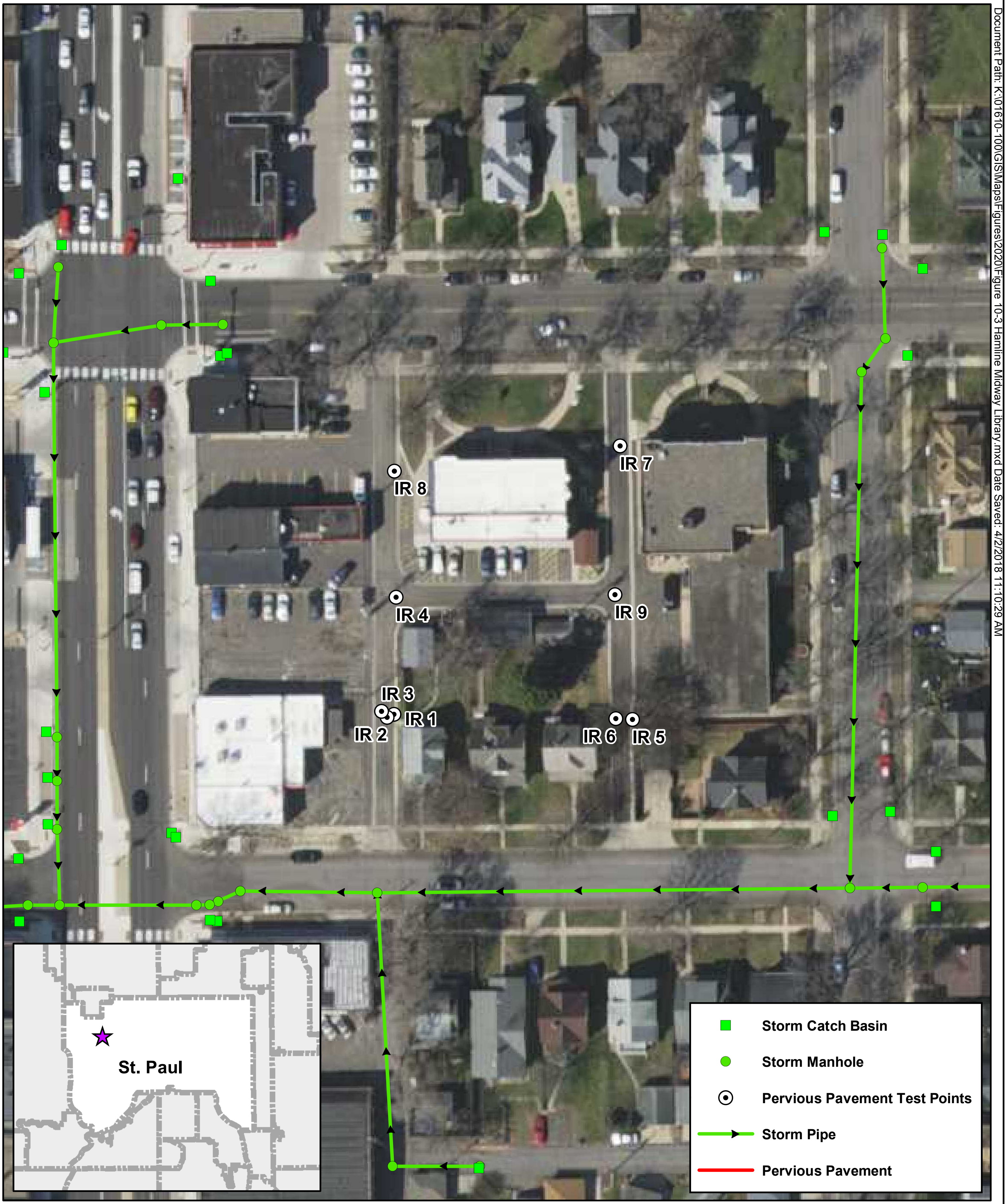

Figure 10-3 - Hamline Midway Library Pervious Pavement Test Locations

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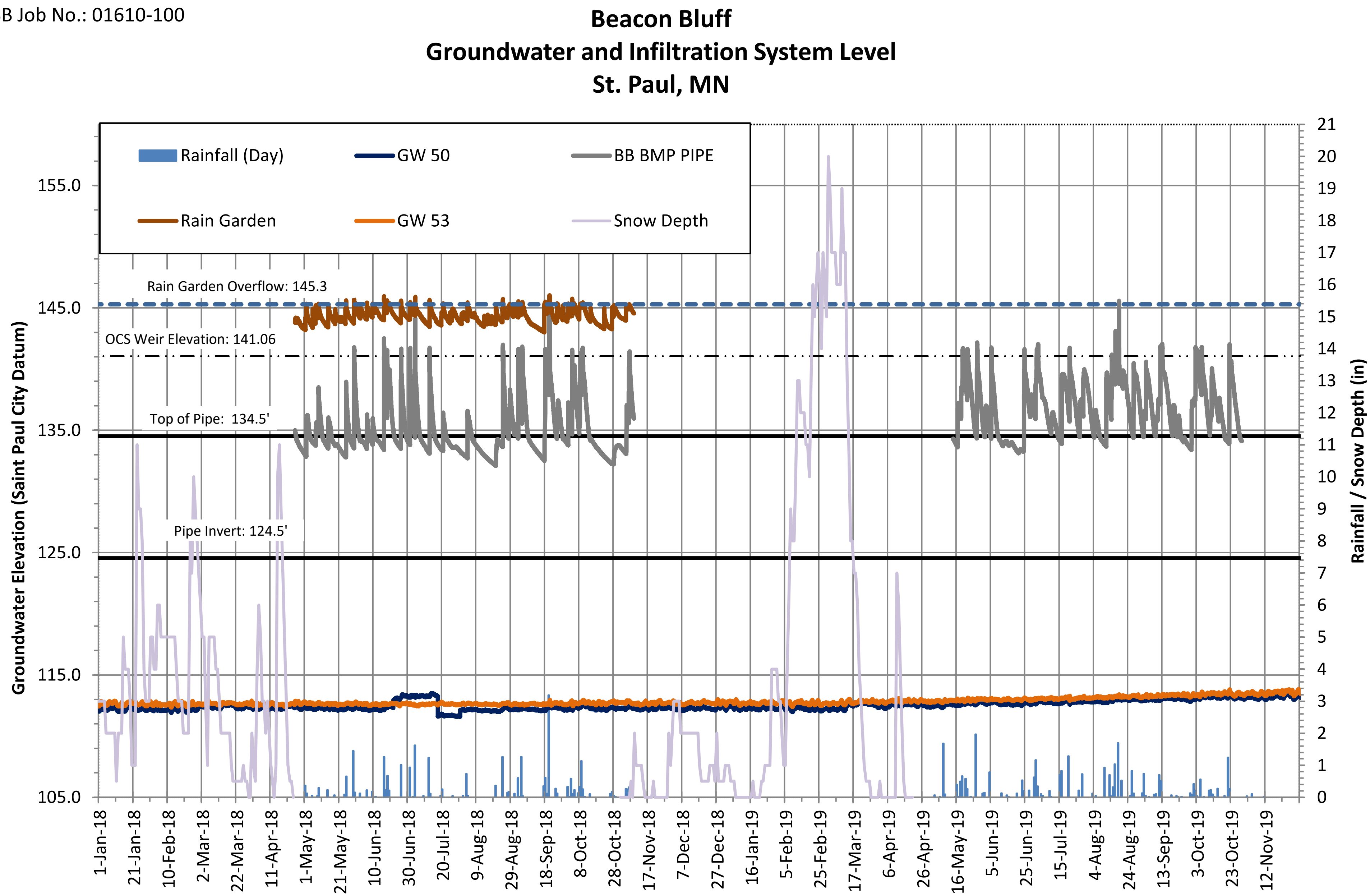
Appendix A – Infiltration/Water Level Charts

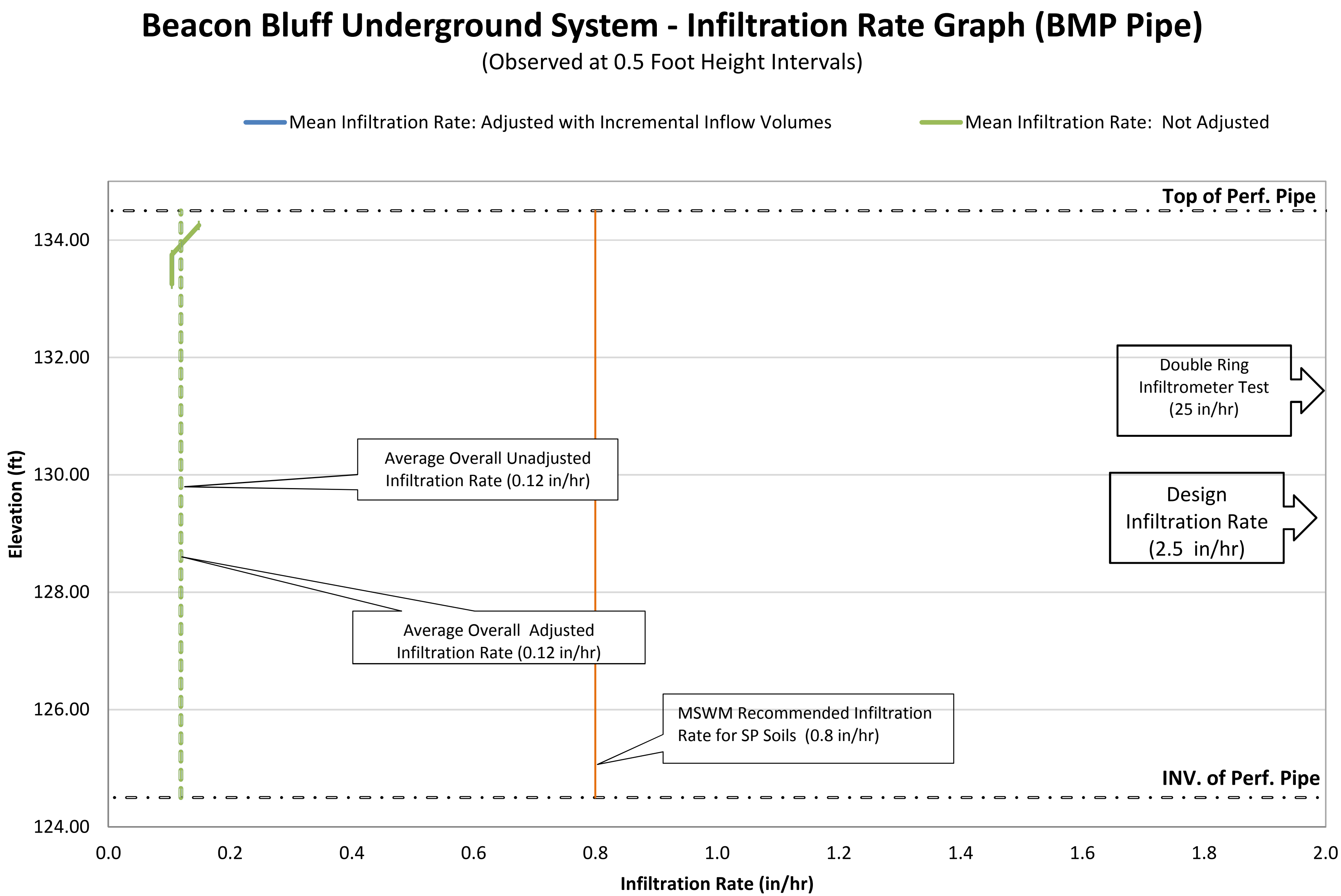
Chart A.1 Beacon Bluff

Water Level and Rainfall (SPCD)

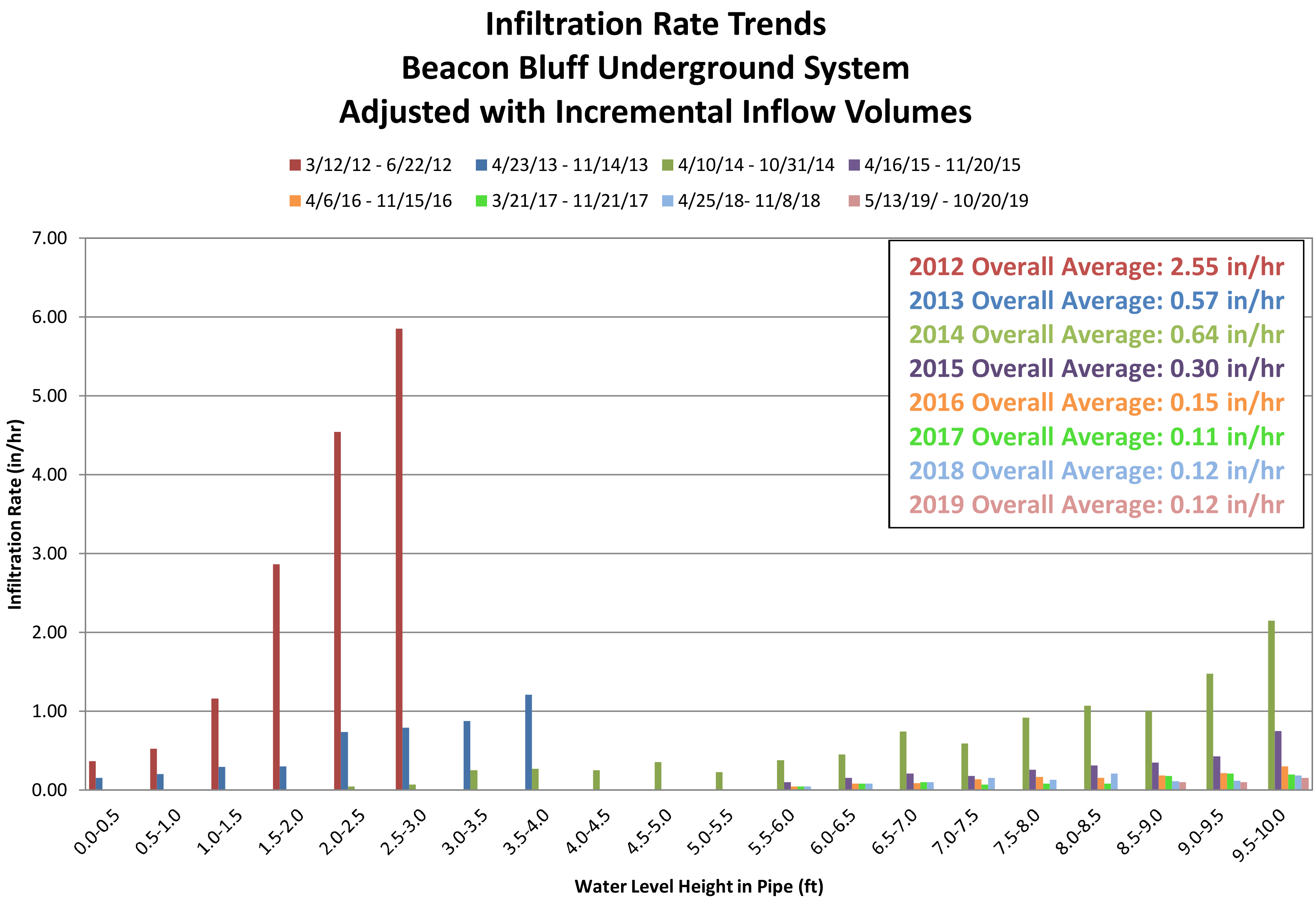
City of Saint Paul
2019 Beacon Bluff Groundwater and System Level
Chart A.2
WSB Job No.: 01610-100



City of Saint Paul
2019 Water Quality and Quantity Report
Chart A.3
WSB Project No.: 01610-100



Note: Pipe Invert is 124.5'
Pipe perforated around circumference of pipe


Infiltration Rate Trends
Beacon Bluff Underground System
Adjusted with Incremental Inflow Volumes
3/12/12 - 6/22/12
4/23/13 - 11/14/13
4/10/14 - 10/31/14
4/16/15 - 11/20/15
4/6/16 - 11/15/16
3/21/17 - 11/21/17
4/25/18- 11/8/18
5/13/19/ - 10/20/19
2012 Overall Average: 2.55 in/hr
2013 Overall Average: 0.57 in/hr
2014 Overall Average: 0.64 in/hr
2015 Overall Average: 0.30 in/hr
2016 Overall Average: 0.15 in/hr
2017 Overall Average: 0.11 in/hr
2018 Overall Average: 0.12 in/hr
2019 Overall Average: 0.12 in/hr
Infiltration Rate (in/hr)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.0-0.5
0.5-1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-3.5
3.5-4.0
4.0-4.5
4.5-5.0
5.0-5.5
5.5-6.0
6.0-6.5
6.5-7.0
7.0-7.5
7.5-8.0
8.0-8.5
8.5-9.0
9.0-9.5
9.5-10.0
Water Level Height in Pipe (ft)

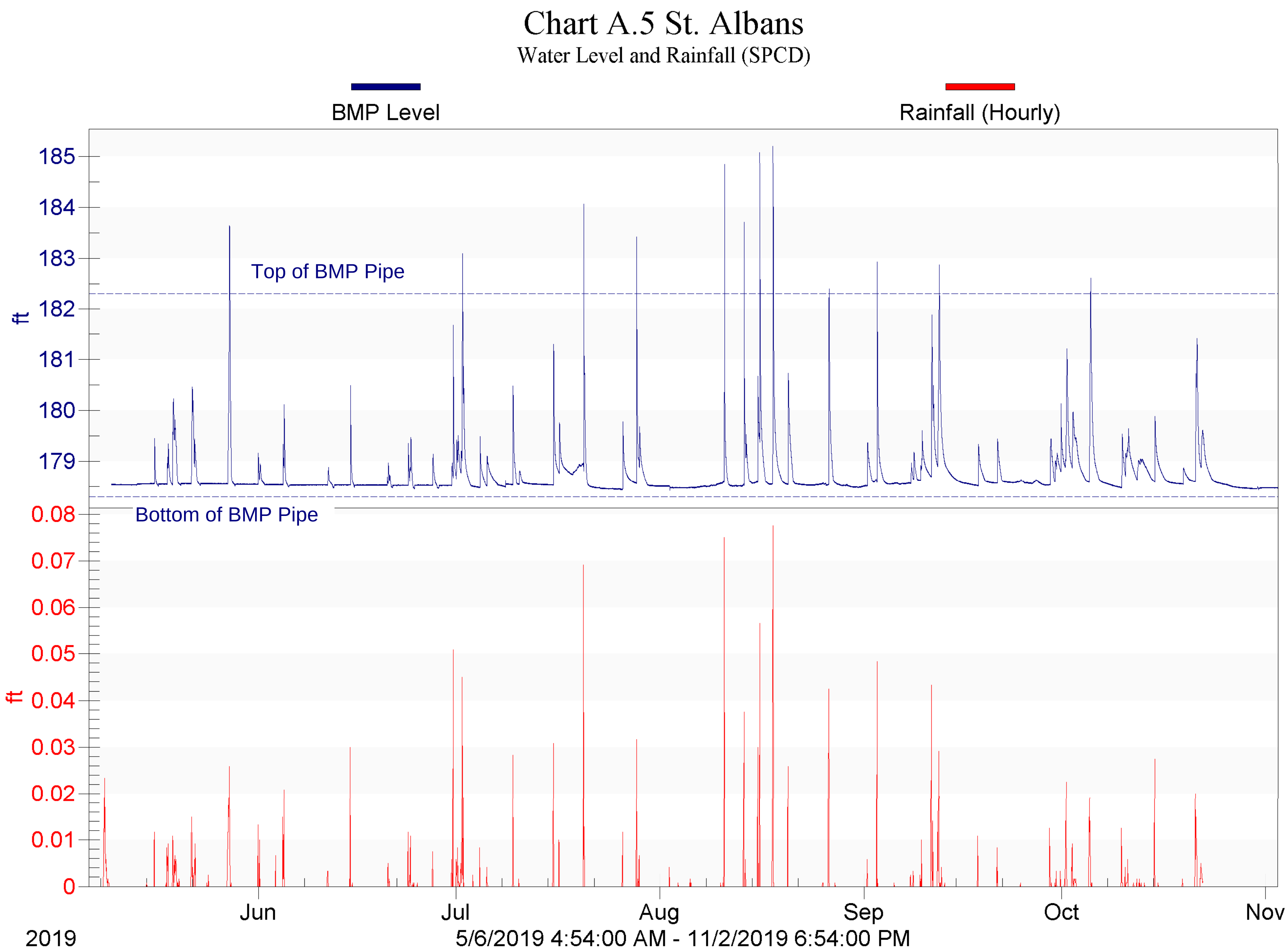
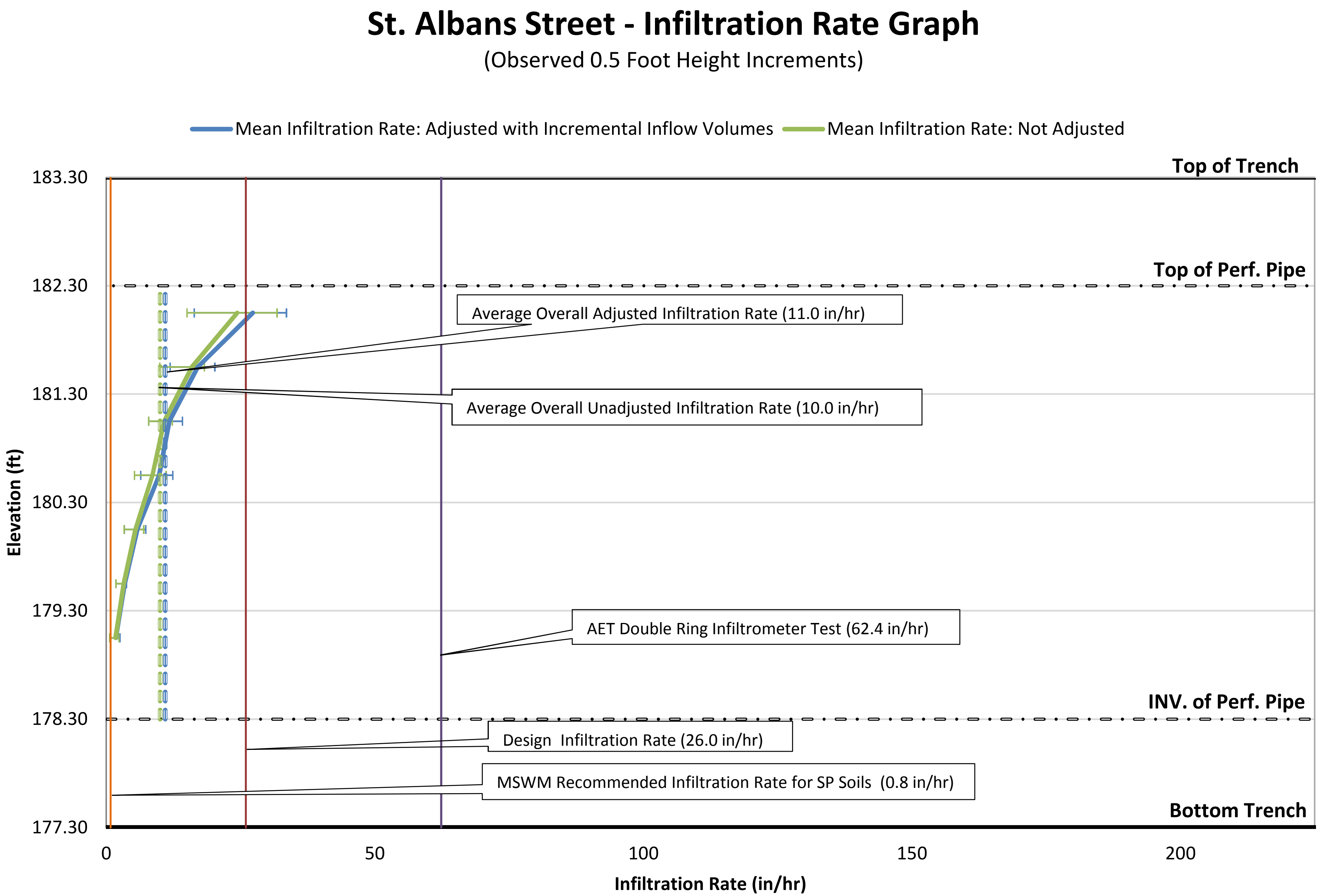


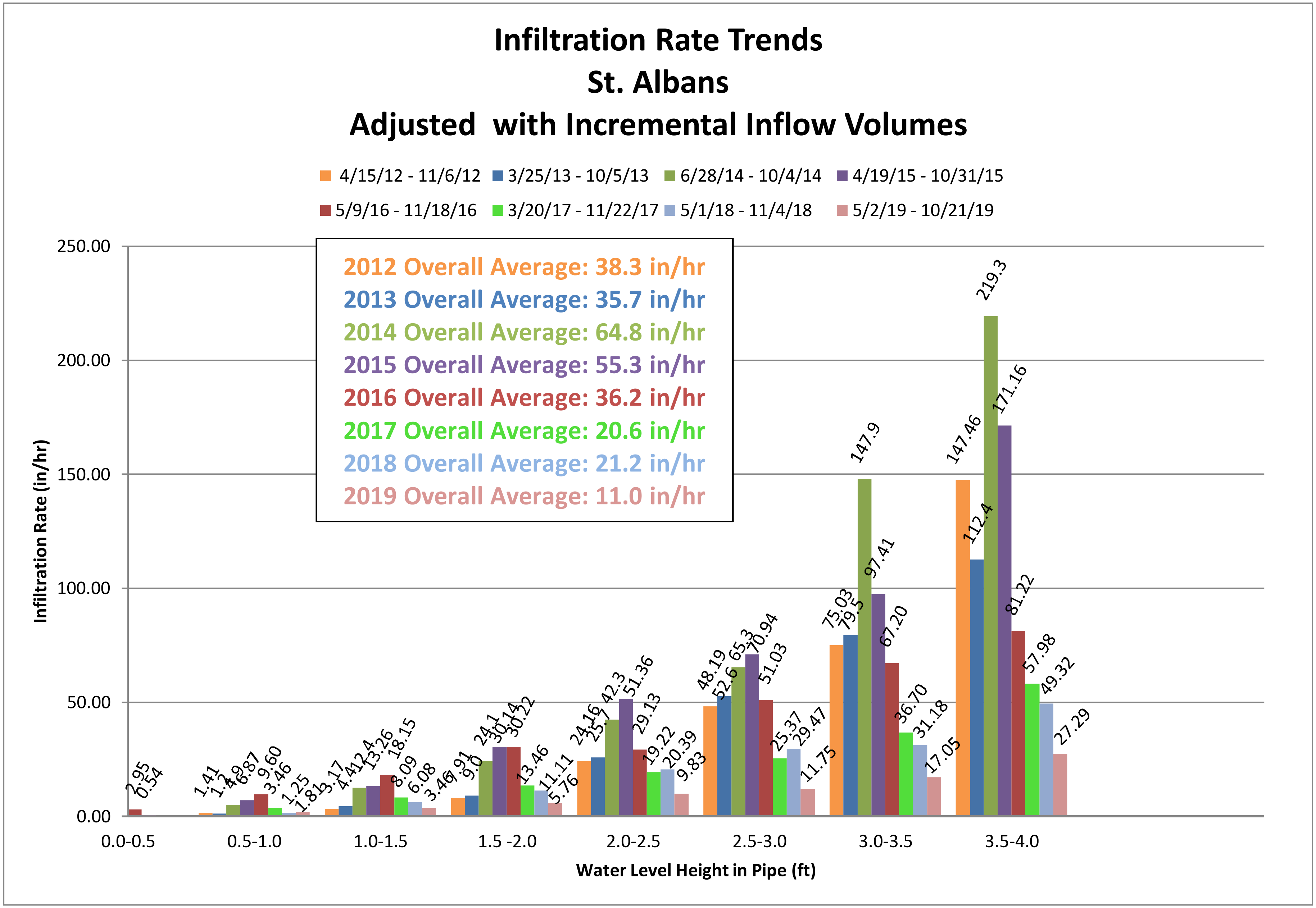
Chart A.5 St. Albans
Water Level and Rainfall (SPCD)
BMP Level
Rainfall (Hourly)
Top of BMP Pipe
Bottom of BMP Pipe
ft
185
184
183
182
181
180
179
ft
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jun
Jul
Aug
Sep
Oct
Nov
2019
5/6/2019 4:54:00 AM - 11/2/2019 6:54:00 PM

City of Saint Paul
2019 Water Quality and Quantity Report
Chart A.6
WSB Job No.: 01610-100



Note: Pipe Invert is 178.3'
Error Bars Represent 25th and 75th Percentiles
Pipe perforated w/ 2 rows of holes at Elev: 178.9' and 179.2'

City of Saint Paul
2019 Water Quality and Quantity Report
Chart A.7
WSB Project No.: 01610-100



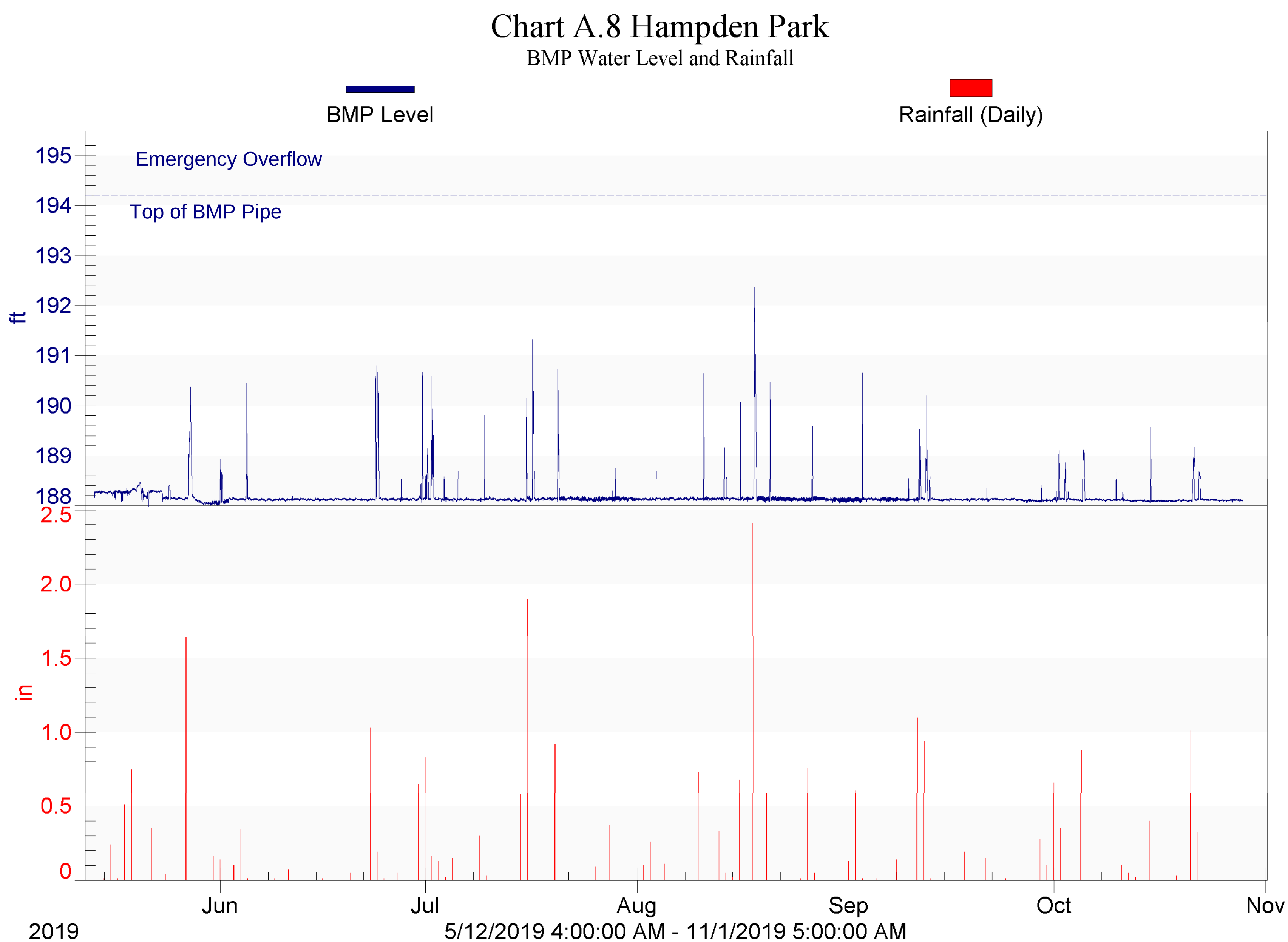
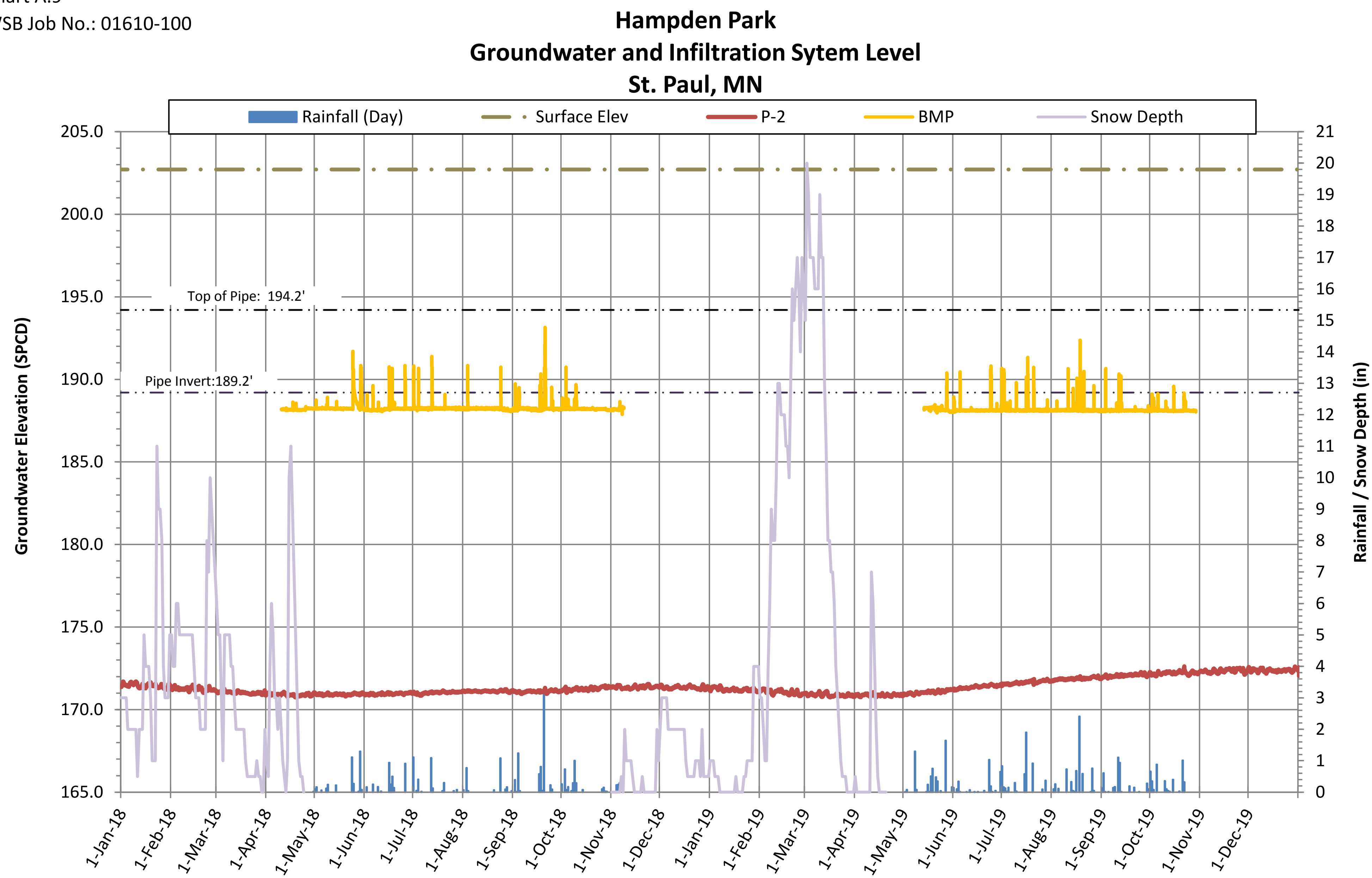
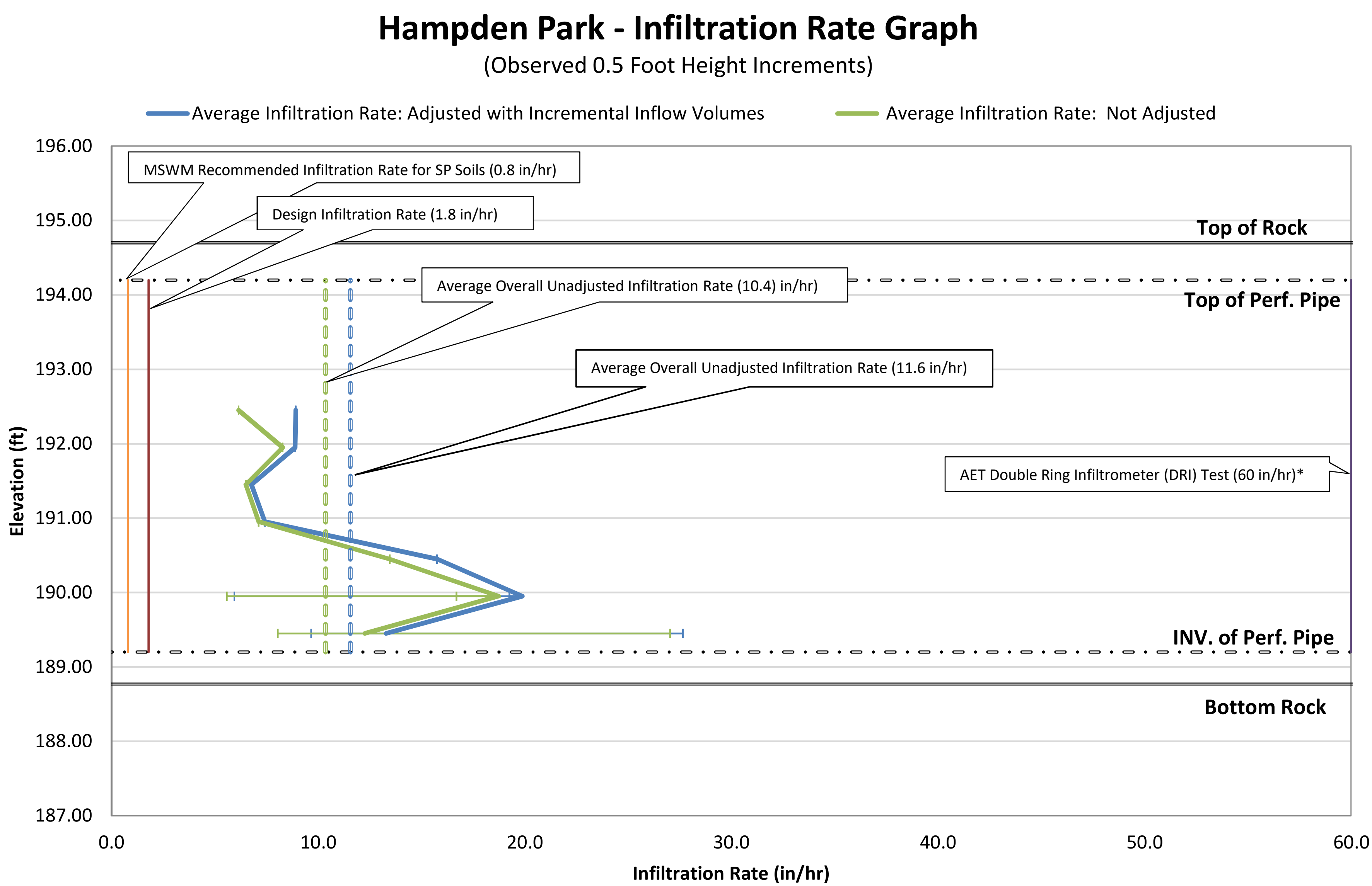


Chart A.8 Hampden Park
BMP Water Level and Rainfall
BMP Level
Rainfall (Daily)
Emergency Overflow
Top of BMP Pipe
ft
195
194
193
192
191
190
189
188
in
2.5
2.0
1.5
1.0
0.5
0
Jun
Jul
Aug
Sep
Oct
Nov
2019
5/12/2019 4:00:00 AM - 11/1/2019 5:00:00 AM

City of Saint Paul
2019 Water Quality and Quantity Report
Chart A.9
WSB Job No.: 01610-100

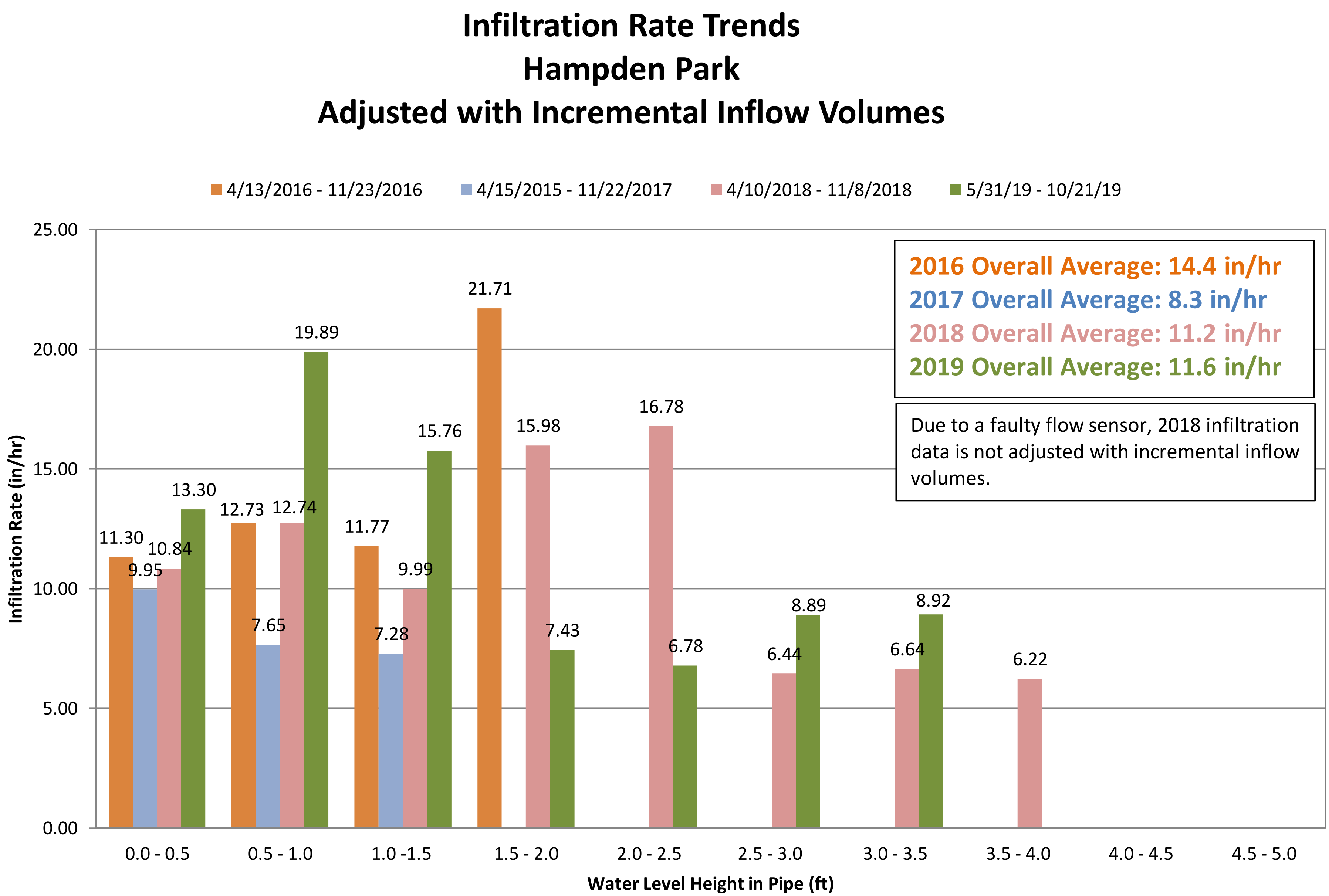


City of Saint Paul
2019 Water Quality and Quantity Monitoring
Chart A.10
WSB Job No.: 01610-100



Note: Pipe Invert is 189.2'
Error Bars Represent 25th and 75th Percentiles
* The DRI testing was completed on top of a 5 ft layer of fine filter aggregate that was constructed above the native soils, per the design.

City of Saint Paul
2019 Water Quality and Quantity Report
Chart A.11
WSB Job No.: 01610-100



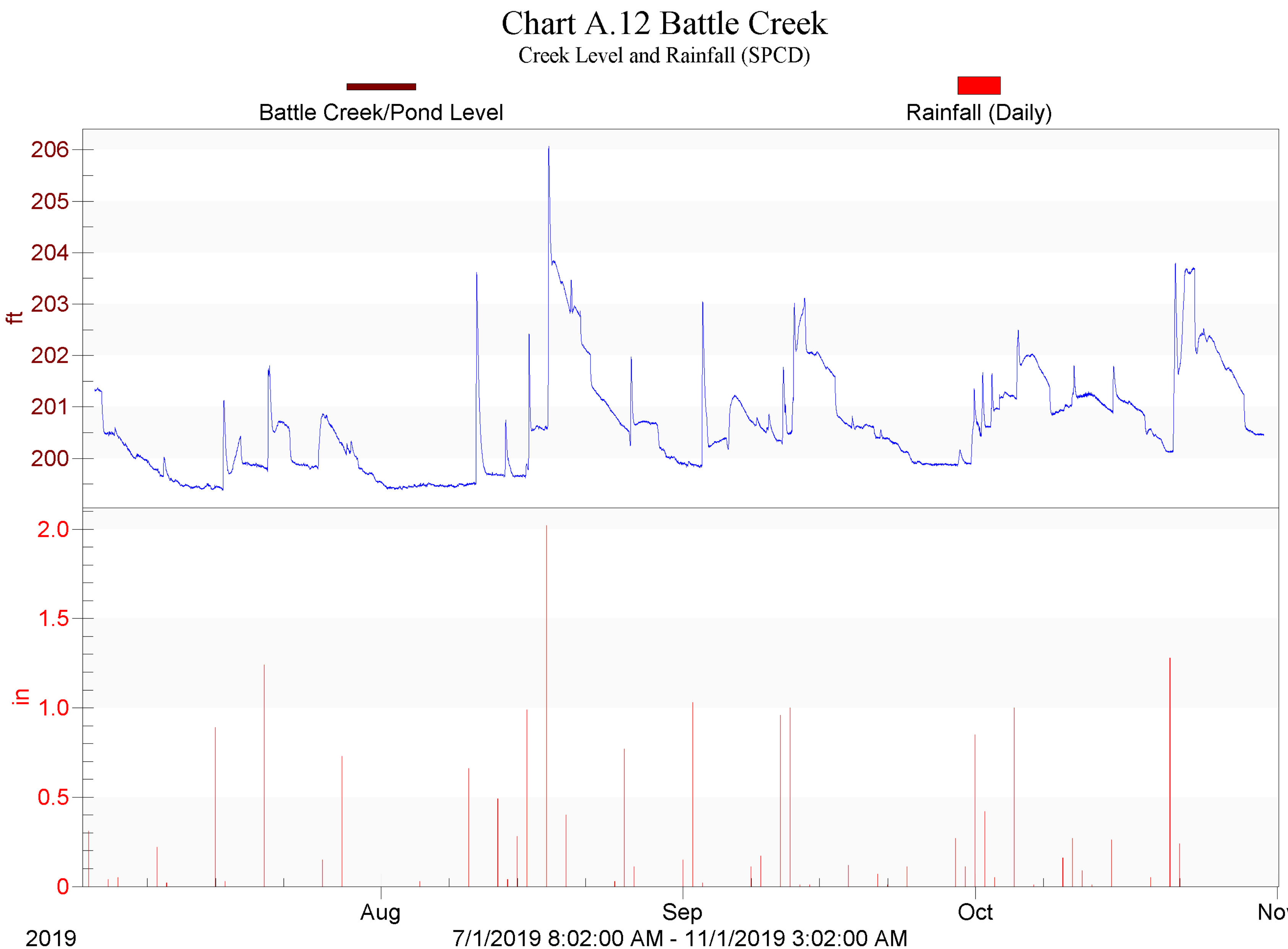
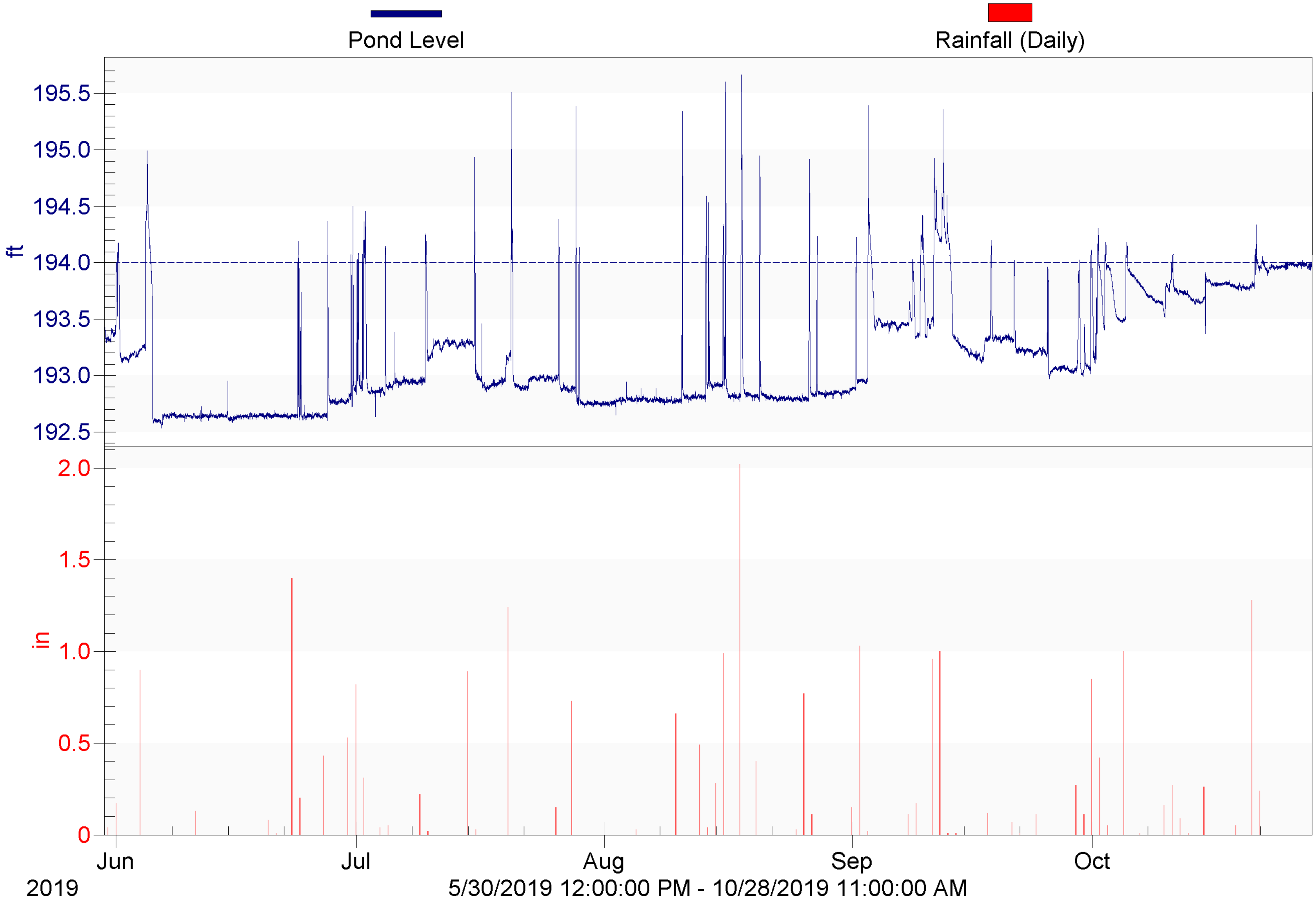


Chart A.12 Battle Creek
Creek Level and Rainfall (SPCD)
Battle Creek/Pond Level
Rainfall (Daily)
ft
206
205
204
203
202
201
200
in
2.0
1.5
1.0
0.5
0
Aug
Sep
Oct
Nov
2019
7/1/2019 8:02:00 AM - 11/1/2019 3:02:00 AM

Chart A.13 Sackett Park

Pond Level and Rainfall (SPCD)



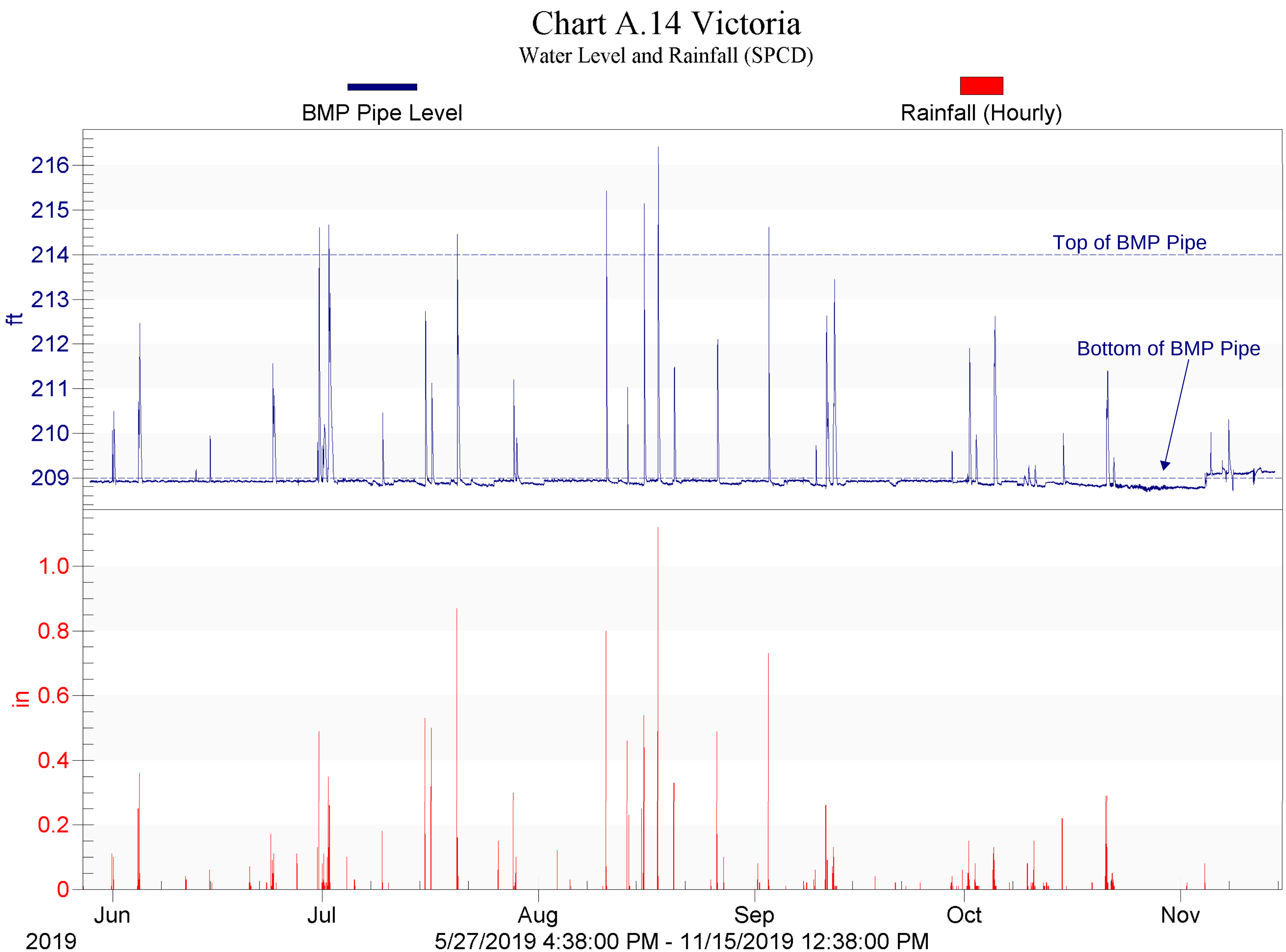
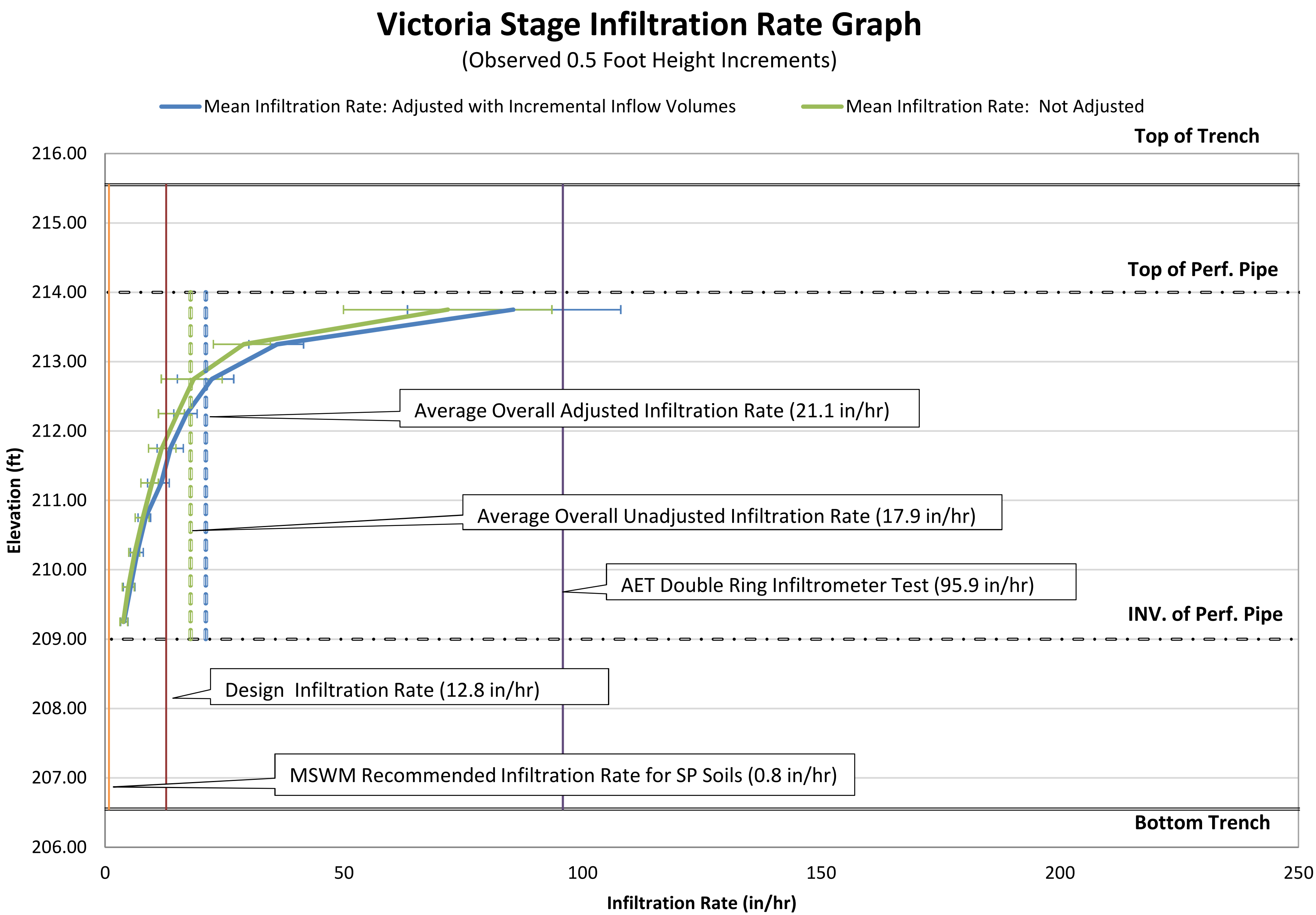


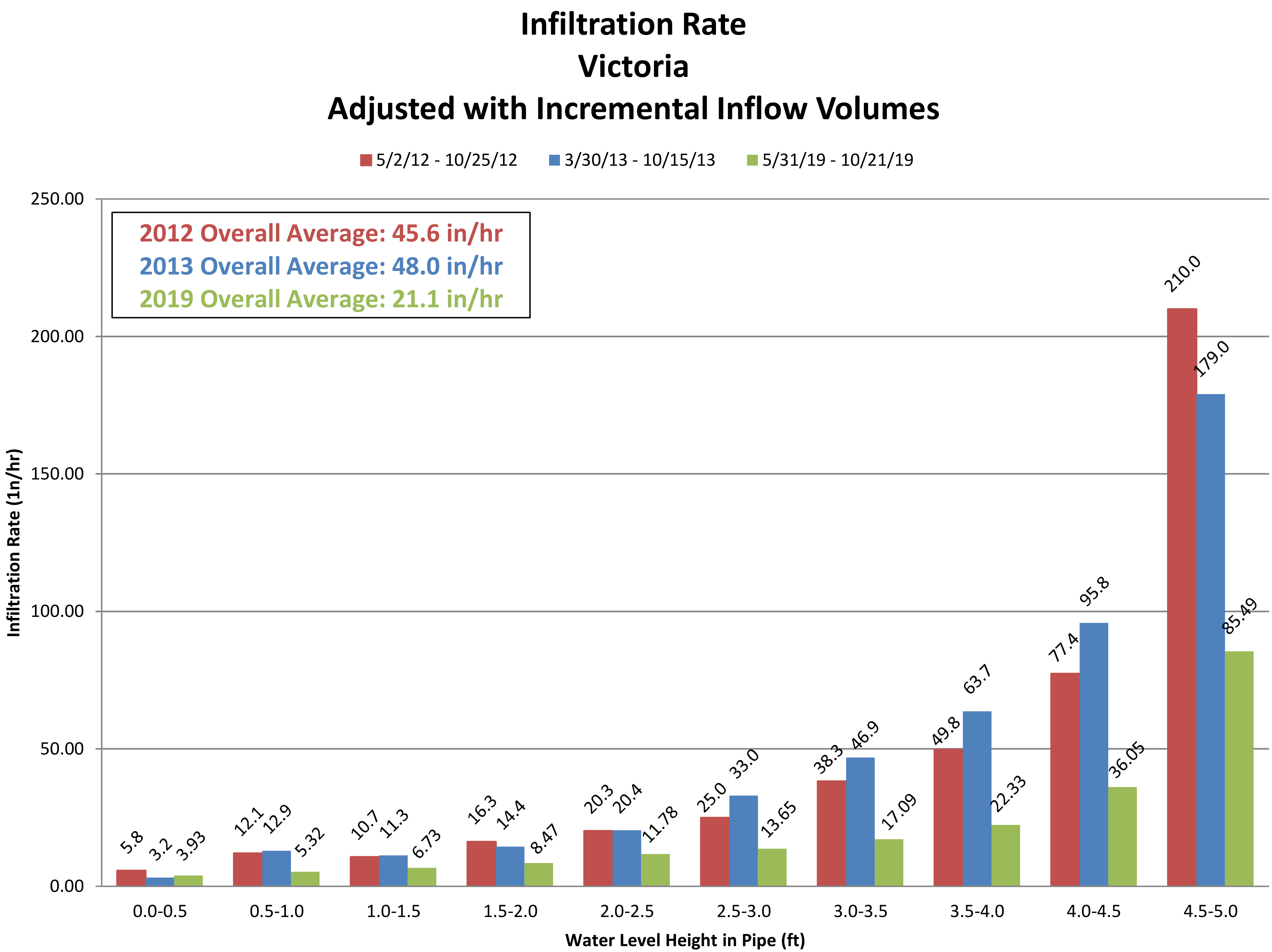
Chart A.14 Victoria
Water Level and Rainfall (SPCD)
BMP Pipe Level
Rainfall (Hourly)
Top of BMP Pipe
Bottom of BMP Pipe
ft
216
215
214
213
212
211
210
209
in
1.0
0.8
0.6
0.4
0.2
0
Jun
Jul
Aug
Sep
Oct
Nov
2019
5/27/2019 4:38:00 PM - 11/15/2019 12:38:00 PM

City of Saint Paul
2019 Water Quality and Quantity Report
Chart A.15
WSB Job No.: 01610-100



Pipe Invert is 209.0
Error Bars Represent 25th and 75th Percentiles

City of Saint Paul
2019 Water Quality and Quantity Report
Chart A.16
WSB Job No.: 01610-100



Appendix B – Flow Rate Charts

Chart B.1 Beacon Bluff

Flow Rates and Rainfall

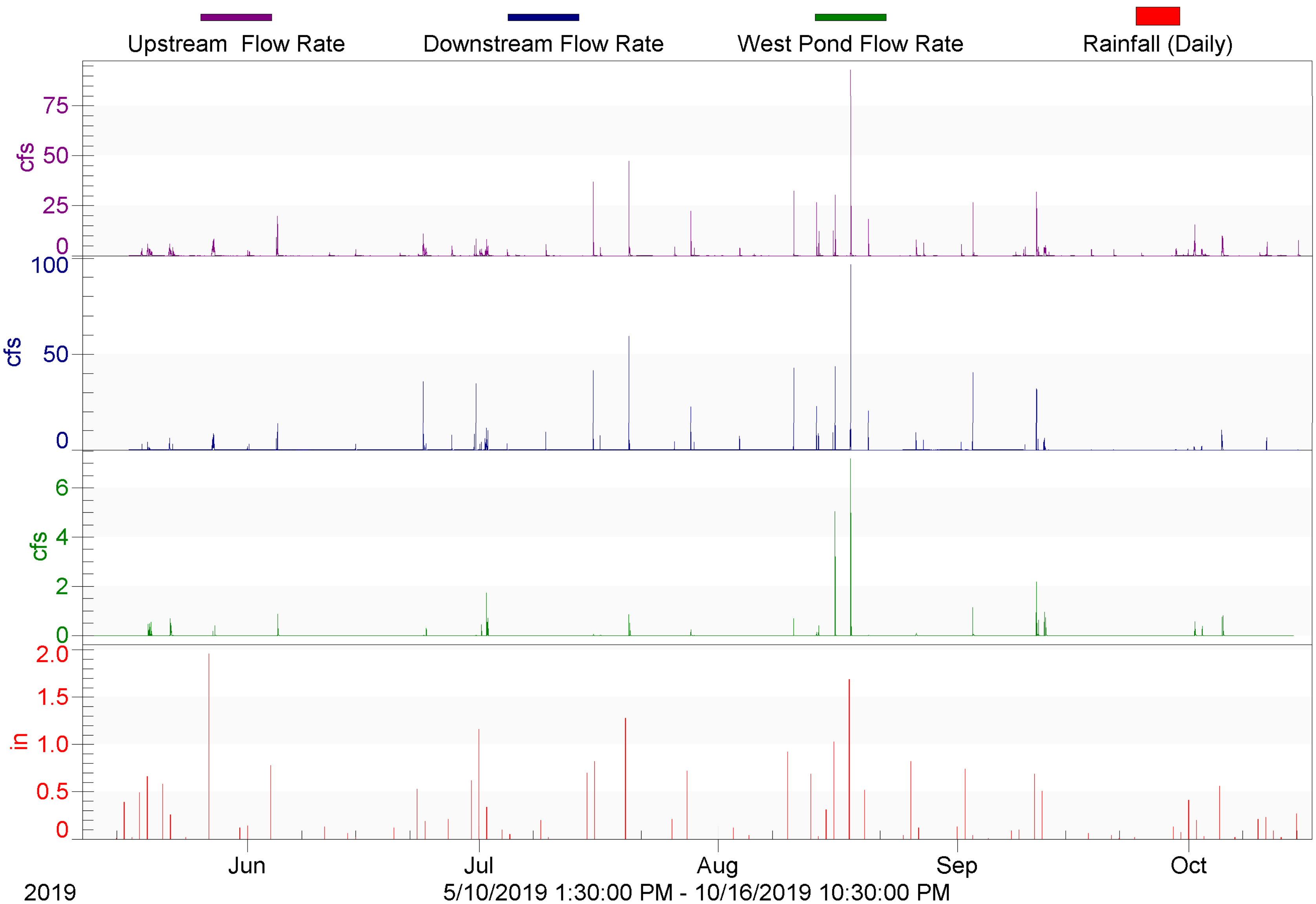


Chart B.2 St. Albans

Flow Rates and Rainfall

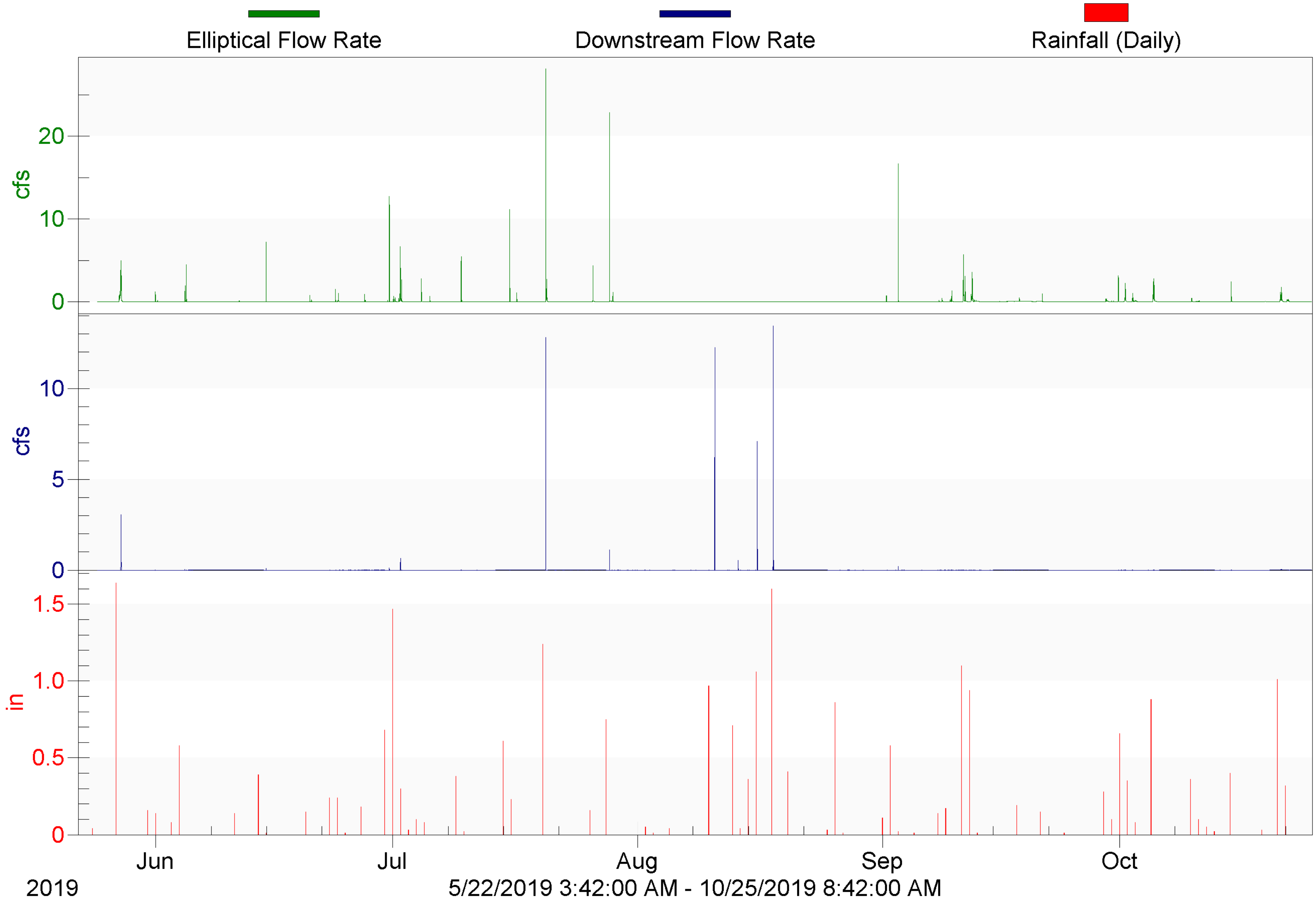


Chart B.3 Hampden Park

Flow Rates and Rainfall

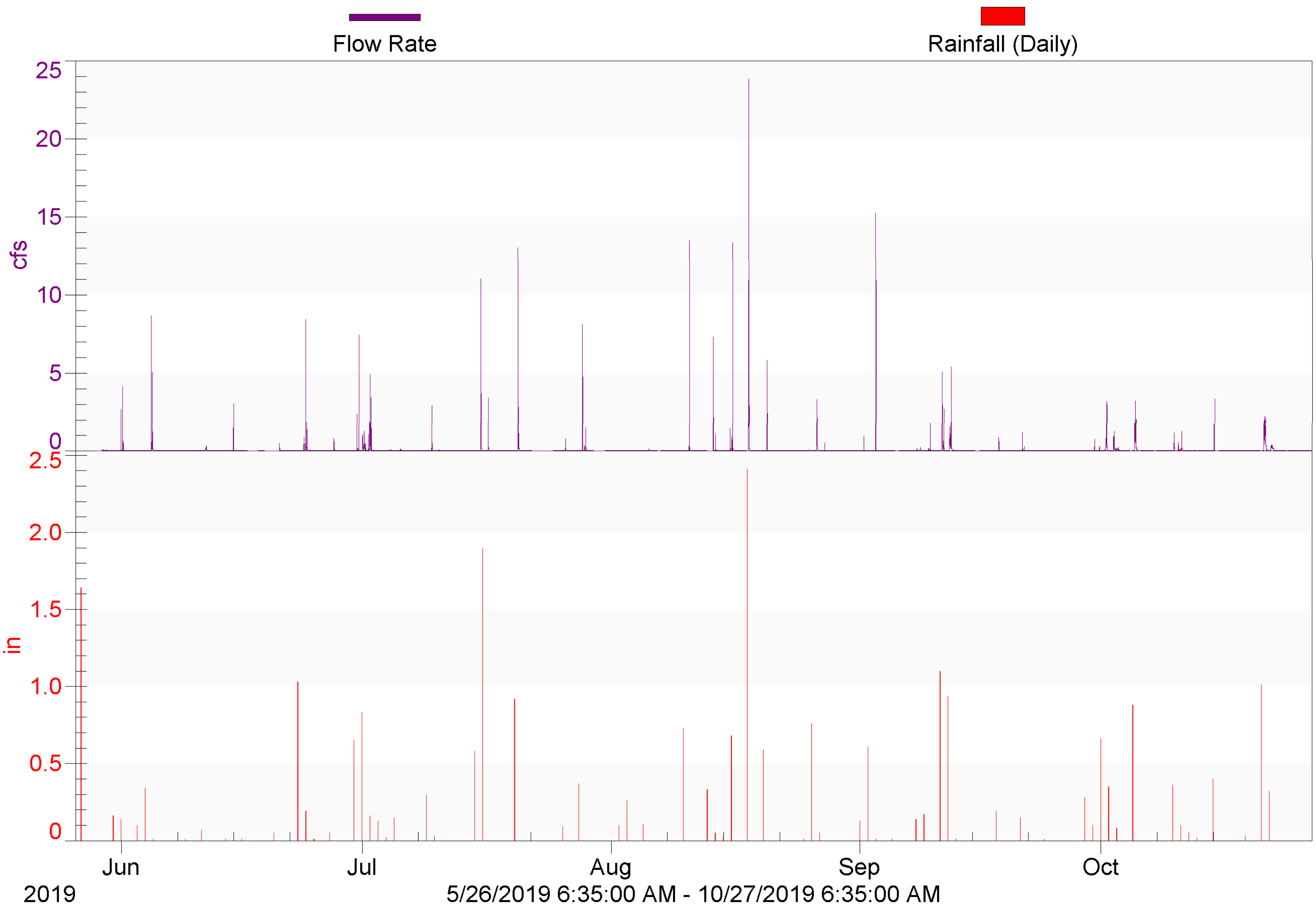


Chart B.4

Flow Rates and Rainfall

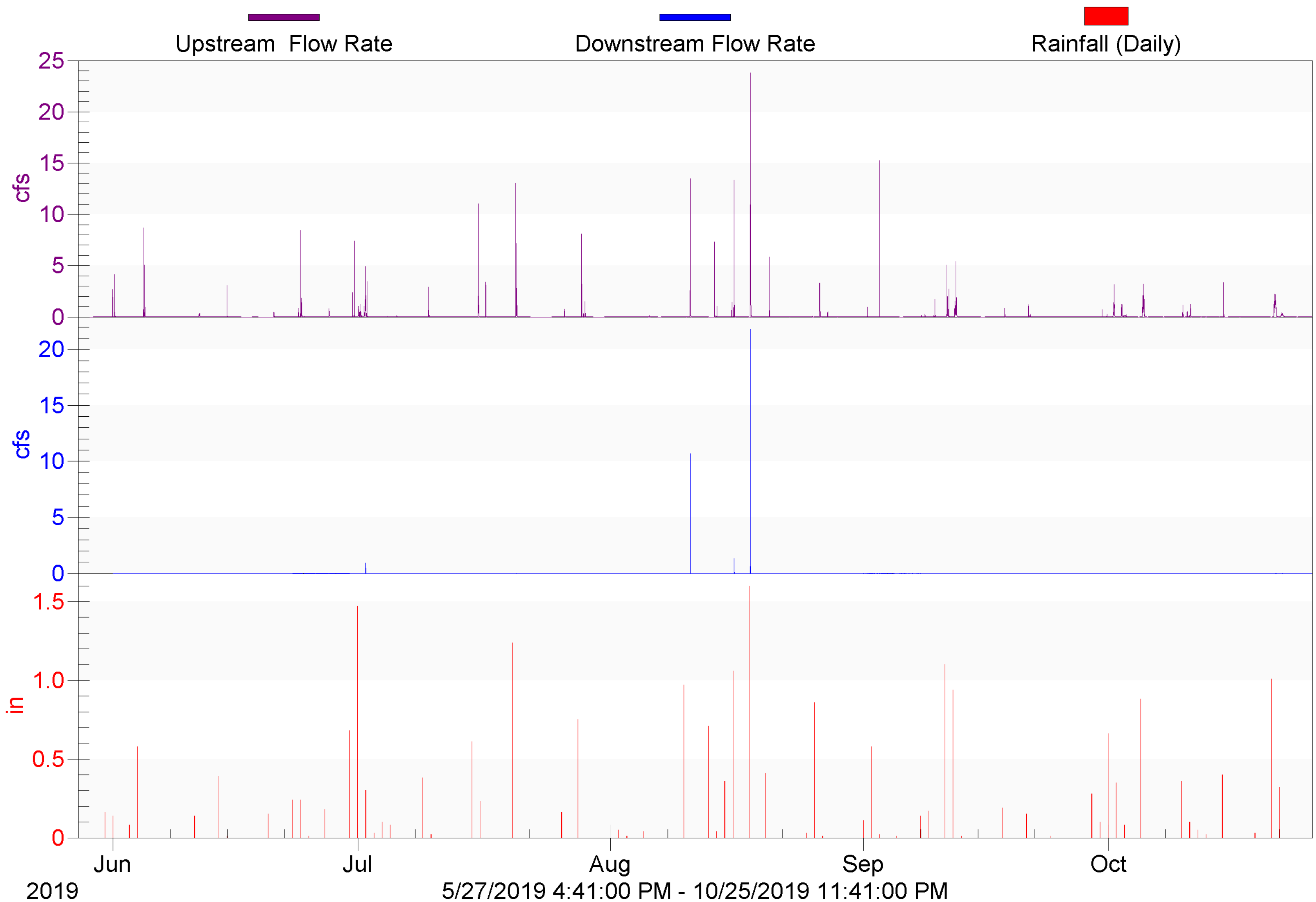


Chart B.5 Battle Creek

Flow Rates and Rainfall

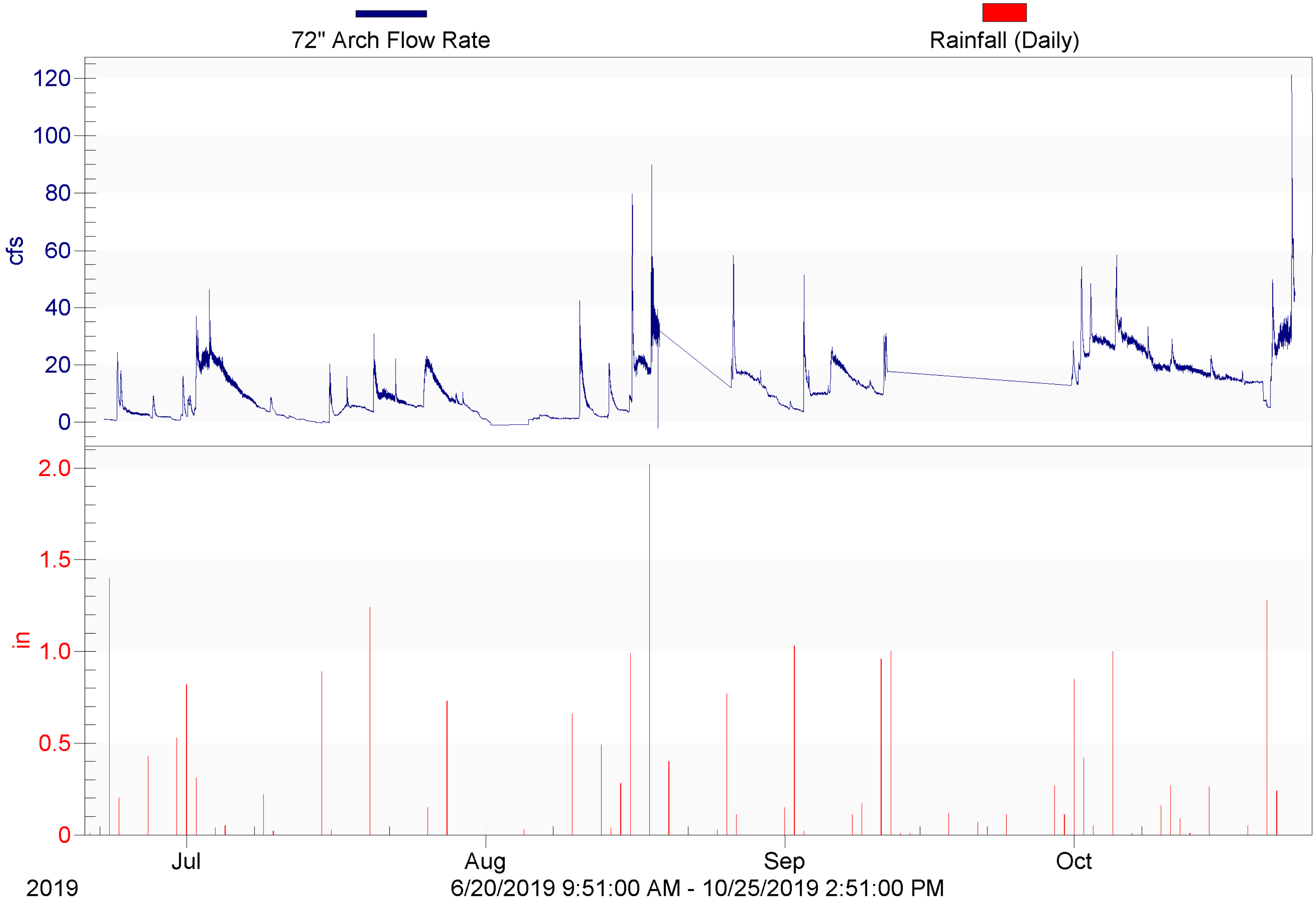
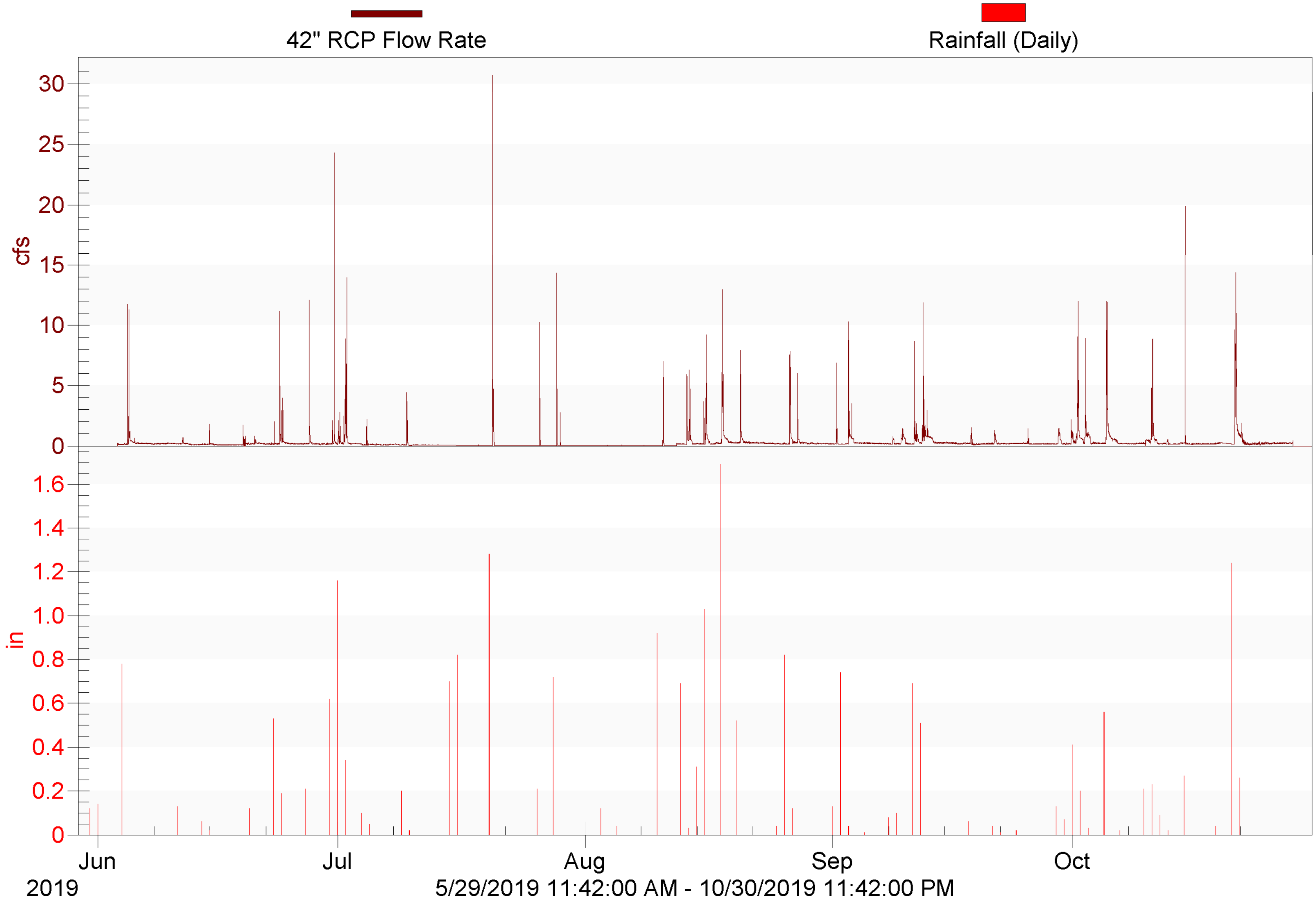


Chart B.6 Sackett Park

Flow Rates and Rainfall



Appendix C – Water Quality Summary and Pollutant Load Calculations

City of Saint Paul
2019 Water Quality and Quantity Report
Table C.1
WSB Project Number: 01610-100

BEACON BLUFF WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	Sulfate (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2745065	3/12/2019 13:07	3/12/2019 13:07	13.0	10640.0	8.0	0.22	0.068	8448.1	2.38	4.88	1.040	365	0.0182	0.0027 J	0.15200		68.40	7.2		10900
2746821	3/19/2019 11:01	3/19/2019 11:01	26.0	1736.0	16.0	0.84	0.632	1048.1	1.74	4.15	0.415	96	0.0146	0.0090	0.07020	13.5000			126.0	
2768098	5/18/2019 23:18	5/19/2019 0:48	34.0	46.0	18.0	0.29	0.033	2.4	0.23	1.83	0.460 <	14 J	0.0089	0.0121	0.04650	9.9800			79.0	
2772690	6/4/2019 16:48	6/5/2019 0:01	116.0	58.0	46.0	0.48	0.104	3.3	0.36	2.89	0.516	18 J	0.0141	0.0232	0.07840	14.3496			110.0	
2774260	6/11/2019 12:00	6/11/2019 12:00																6.8		15800
2774632	6/11/2019 12:18	6/11/2019 16:44	74.0		58.0 J	2.01		31.7		9.00	0.260 <									
2777856	6/23/2019 17:03	6/24/2019 6:34	72.0	55.0	38.0	0.50	0.127	4.2	0.26	2.82	0.362 <	14 J	0.0085	0.0097	0.03820	13.5311			93.0	
2779296	6/27/2019 10:18	6/27/2019 15:01	95.0	72.0	45.0	0.60	0.183	5.4	0.28	3.69	0.463	23 J	0.0135	0.0122	0.07360	22.1000			122.0	
2779852	7/1/2019 1:03	7/1/2019 9:50	21.0	70.0	13.0	0.21	0.037	2.8	0.13	1.50	0.513 <	23 J	0.0059	0.0041	0.02270	11.3403			57.0	
2780357	7/1/2019 18:18	7/2/2019 5:48	32.0	38.0	15.0	0.16	0.029	2.7	0.12	1.14	0.260 <	8 <	0.0047	0.0074	0.02360	5.9000			35.0	
2782802	7/9/2019 15:18	7/9/2019 19:20	208.0	115.0	120.0	3.17	0.008 J	9.1	0.05 J	35.90	0.260 <	24 J	0.0199	0.0123	0.11600	32.6000			205.0	
2784670	7/15/2019 18:18	7/15/2019 22:08	181.0	50.0	74.0	0.57	0.084	3.4	0.02 <	2.95	0.260 <	18 J	0.0197	0.0358	0.10000	12.0000			117.0	
2785210	7/16/2019 16:03	7/16/2019 18:41		63.0		0.33	0.060	4.9	0.20	1.95	0.864	22 J	0.0140	0.0140	0.05790	17.5000			97.0	
2786818	7/20/2019 8:33	7/20/2019 15:07	31.0	40.0	11.0	0.18	0.094	2.3	0.21	0.96		10 J	0.0051	0.0080	0.02450	5.6000			38.0	
2789152	7/28/2019 10:03	7/28/2019 13:58	88.0	57.0	27.0	0.31	0.053	2.3	0.10	1.71	0.415 <	8 <	0.0098	0.0172	0.04580	10.7000			65.0	
2791268	8/5/2019 13:37	8/5/2019 13:37																		4100
2793332	8/10/2019 16:33	8/10/2019 21:05	81.0	47.0	31.0	0.37	0.093	2.8	0.02 <	1.98	0.377 <	8 <	0.0124	0.0189	0.06940	9.0000			82.0	
2797700	8/20/2019 10:03	8/20/2019 13:24	71.0	31.0	27.0	0.21	0.022	2.1	0.07	1.01	0.386 <	11 J	0.0085	0.0177	0.04620	14.4000			91.0	
2799525	8/26/2019 14:03	8/26/2019 17:03	45.0	33.0	21.0	0.16	0.012	3.0	0.02 <	0.84	0.260 <	9 J	0.0062	0.0102	0.03460	10.0000			58.0	
2801320	9/2/2019 22:49	9/3/2019 3:03	114.0	35.0	35.0	0.35	0.073	2.0 <	0.03 J	1.62	0.310 <	8 <	0.0094	0.0287	0.05260	6.1000			69.0	
2804317	9/12/2019 3:48	9/12/2019 6:34	15.0	40.0	6.0	0.14	0.055	2.0 <	0.04 J	0.71	0.260 <	13 J	0.0049	0.0071	0.02110	7.2000			26.0	
2804347	9/11/2019 4:03	9/11/2019 12:33	43.0	37.0	14.0	0.19	0.072	2.7	0.02 <	0.87	0.260 <	8 <	0.0064	0.0143	0.02920	6.1000			44.0	
2809851	9/29/2019 4:48	9/29/2019 11:03	28.0	110.0	21.0	0.67	0.386	6.9	0.02 J	1.71	0.260 <	23 J	0.0103	0.0040	0.04000	28.9371			125.0	
2809940	10/1/2019 13:26	10/1/2019 13:26																		2420 >
2810911	10/2/2019 10:33	10/3/2019 5:33	21.0	48.0	12.0	0.21	0.088	2.8	0.02 <	0.72	0.260 <	8 <	0.0051	0.0052	0.02480	8.0000			45.0	
2810913	10/2/2019 10:34	10/3/2019 5:34	16.0	131.0	9.0	0.20	0.087	2.7	0.02 <	0.70	0.260 <	11 J	0.0049	0.0051	0.02530	7.7000			46.0	
2814923	10/15/2019 3:03	10/15/2019 5:33	109.0	57.0	50.0	0.55	0.231	3.7	0.51	2.38	0.557 <	22 J	0.0137	0.0232	0.08040	19.7000			162.0	
	10/22/2019 0:42	10/22/2019 0:42																6.9		
MINIMUM			**13.0**	**31.0**	**6.0**	**0.1**	**0.0**	**2.0**	**0.0**	**0.7**	**0.3**	**7.9**	**0.0**	**0.0**	**0.0**	**5.6**	**68.4**	**6.8**	**26.0**	**2420.0**
AVERAGE			**66.7**	**591.7**	**31.1**	**0.5**	**0.1**	**400.1**	**0.3**	**3.7**	**0.4**	**33.2**	**0.0**	**0.0**	**0.1**	**13.0**	**68.4**	**7.0**	**86.0**	**8305.0**
MEDIAN			**45.0**	**55.0**	**21.0**	**0.3**	**0.1**	**2.9**	**0.1**	**1.8**	**0.4**	**14.0**	**0.0**	**0.0**	**0.0**	**11.0**	**68.4**	**6.9**	**80.5**	**7500.0**
MAXIMUM			**208.0**	**10640.0**	**120.0**	**3.2**	**0.6**	**8448.1**	**2.4**	**35.9**	**1.0**	**364.8**	**0.0**	**0.0**	**0.2**	**32.6**	**68.4**	**7.2**	**205.0**	**15800.0**

Laboratory analysis was completed by Metroplian Council Environmental Services
Grab Sample Duplicate
< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported
J - Result reported as estimated between the MDL and Reporting Limit (RL)
> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

City of Saint Paul
2019 Beacon Bluff Pollutant Loading
Table C.2
WSB Job No.: 01610-100

BEACON BLUFF VOLUME AND POLLUTANT REDUCTION SUMMARY

Event Time Interval		Sampling Data									Event Loading and Volume Data[1]																	
												Diversion Structure on Duchess Street																
		TSS	TDS	VSS	TP	Ortho-P	Chloride	Ammonia as N	Total Kjeldahl Nitrogen	Nitrate + Nitrite as N	Interval Rain	Runoff Volume Draining to Diversion Structure (Subwatershed A)[2]	Volume Directed from Diversion Structure to Downstream Storm Sewer (Bypassed Volume)	Volume Directed from Diversion Structure into Surface Basin (1)	Inflow Volume from West Pond (Subwatershed B - Discharges to Underground System) (2)	Inflow Volume from Eastern Inlet (Subwatershed C - Discharges to Surface Basin)[3] (3)	Underground System Discharged Volume (4)	Volume Captured by BMP (1+2+3)-4	% of Total Inflow to BMP from Diversion Structure	Overall Volume reduction	Captured TSS	Captured TDS	Captured VSS	Captured TP	Captured Ortho-P	Captured Chloride	Captured Ammonia as N	Captured Total Kjeldahl Nitrogen	Captured Nitrate + Nitrite as N
Start		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	In.	cf	cf	cf	cf	cf	cf	cf			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5/18/2019 0:00	5/18/2019 9:45	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.24	21704	1732	19972	0	1037	0	21008	95.1%	92.4%	83.8	67.3	35.2	0.50	0.09	4.4	0.20	2.87	0.48
5/18/2019 22:45	5/19/2019 16:00	34	46	18	0.3	0.03	2	0.2	1.8	0.46 <	0.90	94629	12143	82486	2901	4520	8183	81724	91.5%	80.1%	173.5	234.7	91.8	1.50	0.17	12.4	1.16	9.32	2.35
5/19/2019 23:15	5/20/2019 1:15	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.03	741	4	737	0	35	0	772	95.4%	99.5%	3.1	2.5	1.3	0.02	0.00	0.2	0.01	0.11	0.02
5/21/2019 18:01	5/22/2019 4:30	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.69	58825	15594	43230	1738	2810	3150	44628	90.1%	70.4%	178.0	142.9	74.8	1.06	0.20	9.2	0.43	6.11	1.01
5/22/2019 6:30	5/22/2019 13:45	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.15	18375	1395	16981	38	878	0	17896	94.9%	92.8%	71.4	57.3	30.0	0.42	0.08	3.7	0.17	2.45	0.40
5/24/2019 10:00	5/24/2019 13:00	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.02	238	6	232	0	11	0	243	95.3%	97.5%	1.0	0.8	0.4	0.01	0.00	0.1	0.00	0.03	0.01
5/27/2019 7:15	5/27/2019 19:49	64	51	27	0.4	0.07	3	0.2	2.2	0.36	1.93	123859	66730	57129	852	5916	54693	9204	89.3%	7.0%	36.7	29.5	15.4	0.22	0.04	1.9	0.09	1.26	0.21
5/31/2019 22:30	6/1/2019 0:45	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.12	4985	1182	3803	0	238	0	4041	94.1%	77.4%	16.1	12.9	6.8	0.10	0.02	0.8	0.04	0.55	0.09
6/1/2019 3:45	6/1/2019 7:36	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.14	9780	984	8797	0	467	0	9264	95.0%	90.4%	37.0	29.7	15.5	0.22	0.04	1.9	0.09	1.27	0.21
6/4/2019 16:30	6/4/2019 23:57	116	58	46	0.5	0.10	3	0.4	2.9	0.52	0.78	80992	36830	44163	300	3869	4586	43746	91.3%	51.4%	316.8	158.4	125.6	1.32	0.28	9.1	0.98	7.90	1.41
6/11/2019 12:00	6/11/2019 17:00	74	51	58	2.0	0.07	32	0.2	9.0	0.26 <	0.13	7820	16	7804	0	374	0	8178	95.4%	99.8%	37.8	26.2	29.6	1.03	0.04	16.2	0.08	4.59	0.13
6/14/2019 23:00	6/15/2019 1:00	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.06	4759	1734	3026	0	227	0	3253	93.0%	65.2%	13.0	10.4	5.5	0.08	0.01	0.7	0.03	0.45	0.07
6/15/2019 8:30	6/15/2019 10:45	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.02	36	5	31	0	2	0	33	94.8%	88.0%	0.1	0.1	0.1	0.00	0.00	0.0	0.00	0.00	0.00
6/20/2019 16:15	6/20/2019 20:00	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.11	4950	8	4941	0	236	0	5178	95.4%	99.8%	20.7	16.6	8.7	0.12	0.02	1.1	0.05	0.71	0.12
6/23/2019 2:30	6/23/2019 4:52	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.02	1916	6	1910	0	92	0	2002	95.4%	99.7%	8.0	6.4	3.4	0.05	0.01	0.4	0.02	0.27	0.05
6/23/2019 17:00	6/24/2019 4:55	72	55	38	0.5	0.13	4	0.3	2.8	0.36 <	0.68	81662	43625	38037	856	3901	1761	41033	88.7%	47.5%	184.4	140.9	97.3	1.29	0.33	10.7	0.68	7.22	0.93
6/24/2019 11:30	6/24/2019 13:34	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.02	535	6	529	0	26	0	555	95.4%	98.9%	2.2	1.8	0.9	0.01	0.00	0.1	0.01	0.08	0.01
6/27/2019 10:15	6/27/2019 13:59	95	72	45	0.6	0.18	5	0.3	3.7	0.46	0.20	21804	6499	15305	0	1041	0	16346	93.6%	71.6%	96.9	73.5	45.9	0.62	0.19	5.5	0.29	3.77	0.47
6/30/2019 8:15	6/30/2019 9:53	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.13	8581	5474	3107	0	410	0	3517	88.3%	39.1%	14.0	11.3	5.9	0.08	0.02	0.7	0.03	0.48	0.08
6/30/2019 13:30	6/30/2019 15:40	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.49	13808	10150	3658	10	660	0	4327	84.5%	29.9%	17.3	13.9	7.3	0.10	0.02	0.9	0.04	0.59	0.10
7/1/2019 1:00	7/1/2019 11:22	21	70	13	0.2	0.04	3	0.1	1.5	0.51 <	0.37	36283	8035	28248	201	1733	3009	27173	93.5%	71.1%	35.6	118.7	22.1	0.36	0.06	4.8	0.22	2.55	0.87
7/1/2019 14:00	7/1/2019 15:37	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.02	581	4	576	0	28	0	604	95.4%	99.3%	2.4	1.9	1.0	0.01	0.00	0.1	0.01	0.08	0.01
7/1/2019 18:00	7/2/2019 6:58	32	38	15	0.2	0.03	3	0.1	1.1	0.26 <	1.10	73108	43589	29520	3728	3492	36740	0	78.1%	0.0%	0.0	0.0	0.0	0.00	0.00	0.0	0.00	0.00	0.00
7/4/2019 15:00	7/4/2019 17:15	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.10	7228	802	6426	0	345	0	6772	94.9%	89.4%	27.0	21.7	11.3	0.16	0.03	1.4	0.07	0.93	0.15
7/5/2019 16:30	7/5/2019 22:15	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.05	1773	13	1760	0	85	0	1844	95.4%	99.3%	7.4	5.9	3.1	0.04	0.01	0.4	0.02	0.25	0.04
7/9/2019 15:15	7/9/2019 18:31	208	115	120	3.2	0.01 J	9	0.1 J	35.9	0.26 <	0.20	11945	5092	6854	0	571	0	7424	92.3%	59.3%	96.4	53.3	55.6	1.47	0.00	4.2	0.02	16.64	0.12
7/10/2019 13:45	7/10/2019 15:00	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.02	57	3	54	0	3	0	56	95.2%	95.1%	0.2	0.2	0.1	0.00	0.00	0.0	0.00	0.01	0.00
7/15/2019 18:15	7/15/2019 21:00	181	50	74	0.6	0.08	3	0.0 <	2.9	0.26 <	0.69	39218	28615	10603	120	1873	0	12596	84.0%	30.6%	142.3	39.3	58.2	0.45	0.07	2.7	0.02	2.32	0.20
7/16/2019 16:00	7/16/2019 17:58	64	63	27	0.3	0.06	5	0.2	2.0	0.86	0.82	9148	3892	5256	46	437	0	5739	91.5%	59.6%	22.9	22.6	9.6	0.12	0.02	1.8	0.07	0.70	0.31
7/20/2019 8:30	7/20/2019 14:20	31	40	11	0.2	0.09	2	0.2	1.0	0.36	1.28	77047	44721	32327	1526	3680	11644	25889	85.5%	31.5%	50.1	64.6	17.8	0.30	0.15	3.8	0.34	1.55	0.59
7/26/2019 7:00	7/26/2019 9:45	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.21	14123	8079	6045	0	675	0	6719	90.0%	45.4%	26.8	21.5	11.3	0.16	0.03	1.4	0.06	0.92	0.15
7/28/2019 10:00	7/28/2019 11:45	88	57	27	0.3	0.05	2	0.1	1.7	0.42 <	0.53	31056	20366	10691	250	1483	0	12424	85.8%	37.9%	68.3	44.2	20.9	0.24	0.04	1.8	0.08	1.32	0.32
7/28/2019 16:00	7/28/2019 19:00	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.03	1056	8	1048	0	50	0	1098	95.4%	99.3%	4.4	3.5	1.8	0.03	0.00	0.2	0.01	0.15	0.02
7/28/2019 20:00	7/28/2019 21:59	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.15	10147	4717	5430	7	485	0	5922	91.7%	55.7%	23.6	19.0	9.9	0.14	0.03	1.2	0.06	0.81	0.13
8/3/2019 18:04	8/3/2019 19:53	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.11	5779	2814	2965	0	276	0	3241	91.5%	53.5%	12.9	10.4	5.4	0.08	0.01	0.7	0.03	0.44	0.07
8/5/2019 14:00	8/5/2019 16:00	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.03	836	5	831	0	40	0	871	95.4%	99.4%	3.5	2.8	1.5	0.02	0.00	0.2	0.01	0.12	0.02
8/10/2019 16:30	8/10/2019 19:50	81	47	31	0.4	0.09	3	0.0 <	2.0	0.38 <	0.89	36196	25696	10499	691	1729	0	12919	80.2%	33.5%	65.3	37.9	25.0	0.30	0.08	2.2	0.02	1.60	0.30
8/13/2019 17:15	8/13/2019 18:56	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.46	19171	11922	7248	185	916	0	8350	86.5%	41.2%	33.3	26.7	14.0	0.20	0.04	1.7	0.08	1.14	0.19
8/13/2019 23:45	8/14/2019 1:44	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.22	16316	10341	5975	625	779	0	7379	79.2%	41.6%	29.4	23.6	12.4	0.17	0.03	1.5	0.07	1.01	0.17
8/15/2019 20:15	8/15/2019 21:46	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.29	18875	5712	13163	0	902	0	14064	93.6%	71.1%	56.1	45.0	23.6	0.33	0.06	2.9	0.14	1.92	0.32
8/16/2019 0:30	8/16/2019 5:20	64	51	27	0.4	0.07	3	0.2	2.2	0.36	1.03	54624	35995	18629	5080	2609	23310	3008	63.8%	4.8%	12.0	9.6	5.0	0.07	0.01	0.6	0.03	0.41	0.07
8/18/2019 1:45	8/18/2019 6:25	64	51	27	0.4	0.07	3	0.2	2.2	0.36	1.67	112914	44657	68258	11776	5394	85427	0	76.7%	0.0%	0.0	0.0	0.0	0.00	0.00	0.0	0.00	0.00	0.00
8/20/2019 10:00	8/20/2019 12:23	71	31	27	0.2	0.02	2	0.1	1.0	0.39 <	0.52	29532	17958	11574	37	1411	0	13022	88.9%	42.0%	57.7	25.2	21.9	0.17	0.02	1.7	0.05	0.82	0.31
8/25/2019 17:30	8/25/2019 20:00	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.04	252	6	247	0	12	0	259	95.3%	97.8%	1.0	0.8	0.4	0.01	0.00	0.1	0.00	0.04	0.01
8/26/2019 14:00	8/26/2019 18:09	45	33	21	0.2	0.01	3	0.0 <	0.8	0.26 <	0.81	36290	26038	10253	368	1733	0	12354	82.5%	32.2%	34.7	25.5	16.2	0.13	0.01	2.3	0.02	0.65	0.20
8/27/2019 14:00	8/27/2019 15:55	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.11	9106	2058	7049	0	435	0	7484	94.2%	78.4%	29.9	24.0	12.5	0.18	0.03	1.6	0.07	1.02	0.17
9/1/2019 11:00	9/1/2019 13:28	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.11	10529	2653	7876	0	503	0	8379	94.0%	75.9%	33.4	26.8	14.0	0.20	0.04	1.7	0.08	1.15	0.19
9/2/2019 22:45	9/3/2019 3:57	114	35	35	0.3	0.07	2 <	0.0 J	1.6	0.31 <	0.78	29743	10849	18894	1567	1421	0	21881	85.3%	66.9%	155.7	47.8	47.8	0.48	0.10	2.7	0.04	2.21	0.42
9/8/2019 2:15	9/8/2019 6:15	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.03	846	9	837	0	40	0	877	95.4%	99.0%	3.5	2.8	1.5	0.02	0.00	0.2	0.01	0.12	0.02
9/8/2019 11:30	9/8/2019 15:16	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.05	6676	9	6668	0	319	0	6986	95.4%	99.9%	27.9	22.4	11.7	0.17	0.03	1.4	0.07	0.96	0.16
9/9/2019 12:15	9/9/2019 13:32	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.03	5004	44	4960	0	239	0	5199	95.4%	99.2%	20.7	16.6	8.7	0.12	0.02	1.1	0.05	0.71	0.12
9/9/2019 16:35	9/9/2019 20:11	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.07	10301	1572	8729	0	492	0	9221	94.7%	85.4%	36.8	29.5	15.5	0.22	0.04	1.9	0.09	1.26	0.21
9/11/2019 4:00	9/11/2019 12:49	43	37	14	0.2	0.07	3	0.0 <	0.9	0.26 <	0.69	72212	44942	27270	2448	3449	15268	17900	80.8%	22.9%	48.0	41.3	15.6	0.21	0.08	3.0	0.02	0.97	0.29
9/12/2019 3:45	9/12/2019 11:48	15	40	6	0.1	0.06	2 <	0.0 J	0.7	0.26 <	0.48	69065	22678	46387	4413	3299	32787	21313	84.5%	27.8%	20.0	53.2	8.0	0.19	0.07	2.7	0.05	0.94	0.35
9/18/2019 7:00	9/18/2019 10:35	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.06	10609	139	10470	0	507	0	10977	95.4%	98.8%	43.8	35.1	18.4	0.26	0.05	2.3	0.11	1.50	0.25
9/21/2019 5:00	9/21/2019 7:41	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.04	6394	25	6369	0	305	0	6674	95.4%	99.6%	26.6	21.4	11.2	0.16	0.03	1.4	0.06	0.91	0.15
9/24/2019 19:00	9/24/2019 20:37	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.02	2145	0	2145	0	102	0	2248	95.4%	100.0%	9.0	7.2	3.8	0.05	0.01	0.5	0.02	0.31	0.05
9/29/2019 4:45	9/29/2019 12:06	28	110	21	0.7	0.39	7	0.0 J	1.7	0.26 <	0.11	23218	315	22904	0	1109	0	24013	95.4%	98.7%	42.0	164.9	31.5	1.00	0.58	10.4	0.03	2.56	0.39
9/30/2019 20:00	9/30/2019 23:43	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.06	7789	334	7455	0	372	0	7827	95.2%	95.9%	31.2	25.1	13.1	0.19	0.04	1.6	0.08	1.07	0.18
10/1/2019 14:28	10/1/2019 20:53	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.39	84082	8550	75532	1117	4016	13762	66903	93.5%	75.0%	266.9	214.2	112.1	1.59	0.30	13.9	0.64	9.15	1.51
10/2/2019 13:30	10/3/2019 6:47	19	90	11	0.2	0.09	3	0.0 <	0.7	0.26 <	0.23	42454	4782	37672	872	2028	101	40470	92.7%	89.2%	46.7	226.1	26.5	0.52	0.22	7.1	0.05	1.79	0.66
10/5/2019 4:30	10/5/2019 12:19	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.54	97463	48263	49200	2212	4655	23180	32887	87.2%	31.5%	131.2	105.3	55.1	0.78	0.15	6.8	0.32	4.50	0.74
10/10/2019 2:45	10/10/2019 6:03	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.09	4286	0	4286	0	205	0	4491	95.4%	100.0%	17.9	14.4	7.5	0.11	0.02	0.9	0.04	0.61	0.10
10/10/2019 20:45	10/11/2019 4:32	64	51	27	0.4	0.07	3	0.2	2.2	0.36	0.29	30467	10574	19893	0	1455	0	21348	93.2%	66.9%	85.2	68.3	35.8	0.51	0.10	4.4	0.21	2.92	0.48
10/15/2019 3:00	10/15/2019 5:31	109	57	50	0.5	0.23	4	0.5	2.4	0.56 <	0.26	15949	4	15945	0	762	0	16707	95.4%	100.0%	113.7	59.5	52.1	0.57	0.24	3.8	0.53	2.49	0.58
Sum											22.94	1,805,393	711,003	1,030,895	43,965	83,204	317,601	**840,462**			**3,315**	**2,867**	**1,452**	**21.2**	**4.45**	**187.1**	**8.4**	**123.6**	**19.7**
Average		73.8	57.2	34.0	0.56	0.092	4.89	0.14	3.72	0.378	0.35	1,157	10,939	15,860	676	52	4,886	12,930			51	44	22	0.33	0.07	2.9	0.1	1.9	0.3
Weighted Ave		63.9	51.3	26.8	0.38	0.072	3.32	0.15	2.19	0.362																			
STDEV		52.9	24.1	27.0	0.72	0.089	6.38	0.14	7.59	0.154																			
Median		71.5	52.5	27.0	0.33	0.073	2.84	0.10	1.71	0.336																			
Min		15.0	31.0	6.0	0.14	0.008	2.00	0.02	0.71	0.260																			
Max		208.0	115.0	120.0	3.17	0.386	31.67	0.51	35.90	0.864																			
Percent Capture of Total Runoff																		**43%**			**45%**	**48%**	**47%**	**49%**	**50%**	**48%**	**48%**	**49%**	**47%**

< Sample Was not detected above the method detection limit (MDL) - MDL is reported
J Result reported as estimated between the MDL and the Reporting Limit (RL)
BOLD Sampled Event
GREY Events with no sampling data (weighted average used)
1 See Figure 2 for Locations of Subwatersheds
2 Erroneous flow data was recorded at the diversion upstream, on occasion, as a result of turbulent and high velocity flow. Runoff to the diversion was modeled for those events using a rainfall to runoff ratio developed using historical monitoring data. The events are shaded brown.
3 Volume calculated based on ratio of Subwatershed C area to Subwatershed A area - (4.66 ac)/(136.77 ac)*(Upstream Volume)
* Flow events under 1000 cf runoff volume without samples are hidden from chart, but included in totals

City of Saint Paul
2019 Water Quality and Quantity Report
Table C.3
WSB Project Number: 01610-100

SAINT ALBANS WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2770316	5/27/2019 7:24	5/27/2019 13:44	56.0	68.0	23.0	0.22	0.016	20.3	0.06 J	1.26	0.313 <	8 <	0.0126	0.0119	0.06640	8.5700		69.0	
2772696	6/4/2019 16:33	6/4/2019 22:18	73.0	87.0	33.0	0.38	0.018	18.3	0.20	2.30	0.500 <	23 J	0.0203	0.0126	0.09630	17.4397		103.0	
2774258	6/11/2019 14:00	6/11/2019 14:00															7.6		14800
2777860	6/23/2019 16:57	6/24/2019 3:29	91.0	83.0	44.0	0.24	0.017	20.1	0.14	1.71	0.524	9 J	0.0166	0.0079	0.08110	13.2787		94.0	
2779300	6/27/2019 10:13	6/27/2019 12:30	174.0	168.0	90.0	0.49	0.015	53.2	0.04 J	3.36	0.441	37	0.0344	0.0198	0.19100	23.4598		173.0	
2780353	7/1/2019 18:05	7/2/2019 2:41	25.0	20.0	11.0	0.09	0.005 <	3.0	0.03 J	0.66	0.260 <	10 J	0.0072	0.0065	0.03950	3.5000		34.0	
2781829	7/4/2019 14:45	7/5/2019 17:06	82.0	118.0	48.0	0.45	0.081	27.6	0.17	2.78		37	0.0224	0.0206	0.09190	19.2000		130.0	
2782808	7/9/2019 15:01	7/9/2019 16:11	109.0	79.0	49.0	0.42	0.023	13.3	0.02 J	2.00	0.380 <	24 J	0.0267	0.0170	0.11800	13.3000		99.0	
2784672	7/15/2019 18:08	7/15/2019 19:18	94.0	93.0	46.0	0.47	0.059	22.9	0.04 J	2.70	0.444 <	30	0.0290	0.0174	0.12000	18.8000		118.0	
2785214	7/16/2019 15:53	7/16/2019 17:12	25.0	78.0	14.0	0.21	0.039	20.6	0.17	1.98	1.223	17 J	0.0138	0.0029	0.04010	15.1000		58.0	
2786810	7/20/2019 8:34	7/20/2019 11:10	24.0	56.0	9.0	0.13		6.6	0.18	0.80		11 J	0.0592	0.0085	0.06850	6.3000		35.0	
2789158	7/28/2019 9:54	7/28/2019 12:58	27.0	38.5	11.0	0.17	0.051	3.7	0.29	1.04	0.573 <	8 <	0.0079	0.0051	0.02900	5.6000		28.0	
2793334	8/10/2019 16:14	8/10/2019 20:19	26.0	36.0	14.0	0.19	0.071	2.8	0.17	1.07	0.467 <	8 <	0.0101	0.0076	0.04690	3.9000		24.0	
2797706	8/20/2019 10:02	8/20/2019 11:48	36.0	31.0	16.0	0.15	0.026	5.2	0.15	0.86	0.409 <	8 <	0.0092	0.0089	0.05020	8.1000		49.0	
2799529	8/26/2019 13:45	8/26/2019 16:32	24.0	31.0	11.0	0.12	0.036	5.1	0.04 J	0.63	0.260 <	8 <	0.0087	0.0059	0.04320	5.9000		51.0	
2799531	8/26/2019 13:46	8/26/2019 16:33	23.0	27.0	10.0	0.14	0.034	5.1	0.02 <	0.61	0.260 <	10 J	0.0085	0.0055	0.03900	5.2000		35.0	
2801322	9/2/2019 22:43	9/3/2019 0:07	21.0	25.0	9.0	0.12	0.043	3.3	0.14	0.81	0.400 <	8 <	0.0067	0.0064	0.03070	5.6000		27.0	
2803902	9/11/2019 12:48	9/11/2019 12:48																	29500
2803908	9/11/2019 3:55	9/11/2019 10:50	33.0	40.0	14.0	0.11	0.092	4.2	0.19	0.68	0.343 <	8 J	0.0078	0.0062	0.04460	5.2000		40.0	
2804315	9/12/2019 3:43	9/12/2019 10:20	34.0	29.0	15.0	0.06	0.029	2.0	0.04 J	0.38	0.260 <	17 J	0.0055	0.0051	0.02680	3.5000		22.0	
2809847	9/29/2019 5:18	9/29/2019 23:16	24.0	106.0	21.0	0.32	0.035	15.8	0.02 J	1.87	0.260 <	15 J	0.0186	0.0017	0.04560	21.4521		107.0	
2810909	10/2/2019 14:12	10/2/2019 17:01	25.0	49.0	15.0	0.14	0.019	4.9	0.02 <	0.47	0.260 <	8 <	0.0081	0.0049	0.04120	5.9000		30.0	
2816610	10/21/2019 14:06	10/21/2019 14:06															7.3		464
MINIMUM			**21.0**	**20.0**	**9.0**	**0.1**	**0.0**	**2.0**	**0.0**	**0.4**	**0.3**	**7.9**	**0.0**	**0.0**	**0.0**	**3.5**	**7.3**	**22.0**	**464**
AVERAGE			**51.3**	**63.1**	**25.2**	**0.2**	**0.0**	**12.9**	**0.1**	**1.4**	**0.4**	**15.1**	**0.0**	**0.0**	**0.1**	**10.5**	**7.4**	**66.3**	**14921**
MEDIAN			**30.0**	**52.5**	**15.0**	**0.2**	**0.0**	**5.9**	**0.1**	**1.1**	**0.4**	**10.0**	**0.0**	**0.0**	**0.0**	**7.2**	**7.4**	**50.0**	**14800**
MAXIMUM			**174.0**	**168.0**	**90.0**	**0.5**	**0.1**	**53.2**	**0.3**	**3.4**	**1.2**	**37.4**	**0.1**	**0.0**	**0.2**	**23.5**	**7.6**	**173.0**	**29500**

Laboratory analysis was completed by Metroplian Council Environmental Services

Grab Sample | Duplicate

< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported

J - Result reported as estimated between the MDL and Reporting Limit (RL)

> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

City of Saint Paul
2019 St. Albans Volume Reduction Pollutant Loading
Table C.4
WSB Project No.: 01610-100

SAINT ALBANS INFILTRATION SYSTEM VOLUME REDUCTION AND POLLUTANT LOADING

Sampling Data

Event Time Interval Start	Event Time Interval End	TSS	TDS	VSS	TP	Ortho-P		Chloride	Ammonia as N		Total Kjeldahl Nitrogen	Nitrate + Nitrite as N	
		mg/L	mg/L	mg/L	mg/L	mg/L		mg/L	mg/L		mg/L	mg/L	
5/27/19 7:22	5/27/19 17:41	56.0	68.0	23.0	0.22	0.016		20.3	0.06	J	1.26	0.31	<
5/31/19 22:29	5/31/19 23:17	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
6/1/19 3:53	6/1/19 5:41	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
6/4/19 16:31	6/4/19 22:13	73.0	87.0	33.0	0.38	0.018		18.3	0.20		2.30	0.50	<
6/11/19 12:00	6/11/19 15:15	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
6/14/19 22:35	6/14/19 23:33	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
6/20/19 16:04	6/20/19 17:38	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
6/23/19 16:54	6/24/19 3:24	91.0	83.0	44.0	0.24	0.017		20.1	0.14		1.71	0.52	
6/27/19 10:10	6/27/19 12:25	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
6/30/19 8:16	6/30/19 8:37	174.0	168.0	90.0	0.49	0.015		53.2	0.04	J	3.36	0.44	
6/30/19 13:12	6/30/19 14:04	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
7/1/19 0:58	7/1/19 2:44	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
7/1/19 5:09	7/1/19 7:28	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
7/1/19 18:02	7/2/19 3:44	25.0	20.0	11.0	0.09	0.005	<	3.0	0.03	J	0.66	0.26	<
7/4/19 14:42	7/5/19 17:02	82.0	118.0	48.0	0.45	0.081		27.6	0.17		2.78	0.37	
7/9/19 15:08	7/9/19 17:28	109.0	79.0	49.0	0.42	0.023		13.3	0.02	J	2.00	0.38	<
7/15/19 18:05	7/15/19 20:24	94.0	93.0	46.0	0.47	0.059		22.9	0.04	J	2.70	0.44	<
7/16/19 15:50	7/16/19 17:17	25.0	78.0	14.0	0.21	0.039		20.6	0.17		1.98	1.22	
7/20/19 8:30	7/20/19 13:22	24.0	56.0	9.0	0.13	0.039		6.6	0.18		0.80	0.37	
7/26/19 7:00	7/26/19 11:28	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
7/28/19 9:51	7/28/19 12:54	27.0	38.5	11.0	0.17	0.051		3.7	0.29		1.04	0.57	<
7/28/19 19:53	7/28/19 21:12	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
8/10/19 15:10	8/10/19 18:12	26.0	36.0	14.0	0.19	0.071		2.8	0.17		1.07	0.47	<
8/13/19 16:57	8/13/19 17:30	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
8/13/19 23:58	8/14/19 0:19	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
8/15/19 19:48	8/15/19 20:02	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
8/16/19 0:15	8/16/19 0:42	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
8/16/19 2:34	8/16/19 3:28	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
8/18/19 2:12	8/18/19 5:46	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
8/20/19 9:58	8/20/19 11:53	36.0	31.0	16.0	0.15	0.026		5.2	0.15		0.86	0.41	<
8/26/19 13:41	8/26/19 16:43	23.5	29.0	10.5	0.13	0.035		5.1	0.03	J	0.62	0.26	<
9/1/19 11:06	9/1/19 11:46	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
9/2/19 22:39	9/3/19 0:32	21.0	25.0	9.0	0.12	0.043		3.3	0.14		0.81	0.40	<
9/8/19 2:00	9/8/19 3:23	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
9/8/19 11:13	9/8/19 16:34	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
9/9/19 12:12	9/9/19 19:11	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
9/11/19 3:51	9/11/19 13:02	33.0	40.0	14.0	0.11	0.092		4.2	0.19		0.68	0.34	<
9/12/19 3:39	9/12/19 11:06	34.0	29.0	15.0	0.06	0.029		2.0	0.04	J	0.38	0.26	<
9/18/19 6:45	9/18/19 11:00	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
9/21/19 4:43	9/21/19 7:22	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
9/29/19 4:27	9/29/19 14:30	24.0	106.0	21.0	0.32	0.035		15.8	0.02	J	1.87	0.26	<
9/30/19 5:06	9/30/19 9:00	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
9/30/19 19:44	9/30/19 21:16	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
10/1/19 14:27	10/1/19 20:00	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
10/2/19 13:45	10/3/19 5:07	25.0	49.0	15.0	0.14	0.019		4.9	0.02	<	0.47	0.26	<
10/5/19 4:07	10/5/19 11:42	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
10/10/19 2:15	10/10/19 5:35	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
10/10/19 15:38	10/10/19 17:43	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
10/10/19 20:32	10/11/19 3:07	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
10/15/19 2:45	10/15/19 5:15	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
10/21/19 6:25	10/21/19 17:54	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
10/22/19 4:00	10/22/19 11:58	38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
Sum													
Average		52.8	64.9	25.9	0.24	0.037		13.3	0.11		1.44	0.43	
Weighted Avg		38.2	46.7	17.3	0.18	0.039		8.4	0.11		1.03	0.37	
STDEV		41.2	38.7	21.0	0.14	0.025		12.8	0.08		0.88	0.23	
Min		21.0	20.0	9.0	0.06	0.01		2.0	0.02		0.38	0.26	
Max		174.0	168.0	90.0	0.49	0.09		53.2	0.29		3.36	1.22	
Percent Capture													

Event Loading and Volume Data

Start	End	Interval Rain	Eliptical Volume (1)	University 1 Volume (2)	Bypass Volume (3)	Volume Captured by BMP (1+2-3)	Captured TSS	Captured TDS	Captured VSS	Captured TP	Captured Ortho-P	Captured Chloride	Captured Ammonia as N	Captured Total Kjeldahl Nitrogen	Captured Nitrate + Nitrite as N
		In.	cu-ft	cu-ft	cu-ft	cu-ft	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5/27/19 7:22	5/27/19 17:41	1.63	40691.8	27264	7681	60273.9	210.7	ND	86.5	0.83	0.060	76.4	0.2	4.7	1.2
5/31/19 22:29	5/31/19 23:17	0.16	955.0	640	0	1594.8	3.8	4.6	1.7	0.02	0.004	0.8	0.0	0.1	0.0
6/1/19 3:53	6/1/19 5:41	0.14	239.4	160	0	399.7	1.0	1.2	0.4	0.00	0.001	0.2	0.0	0.0	0.0
6/4/19 16:31	6/4/19 22:13	0.57	6636.0	4446	0	11082.1	50.5	60.2	22.8	0.26	0.012	12.7	0.1	1.6	0.3
6/11/19 12:00	6/11/19 15:15	0.14	602.6	404	0	1006.3	2.4	2.9	1.1	0.01	0.002	0.5	0.0	0.1	0.0
6/14/19 22:35	6/14/19 23:33	0.39	5798.7	3885	0	9683.9	23.1	28.2	10.5	0.11	0.024	5.1	0.1	0.6	0.2
6/20/19 16:04	6/20/19 17:38	0.12	581.9	390	0	971.8	2.3	2.8	1.1	0.01	0.002	0.5	0.0	0.1	0.0
6/23/19 16:54	6/24/19 3:24	0.46	4902.2	3284	0	8186.6	46.5	42.4	22.5	0.12	0.009	10.3	0.1	0.9	0.3
6/27/19 10:10	6/27/19 12:25	0.17	1065.8	714	0	1779.9	4.2	5.2	1.9	0.02	0.004	0.9	0.0	0.1	0.0
6/30/19 8:16	6/30/19 8:37	0.07	171.8	115	0	287.0	3.1	3.0	1.6	0.01	0.000	1.0	0.0	0.1	0.0
6/30/19 13:12	6/30/19 14:04	0.6	9658.4	6471	0	16129.5	38.4	47.0	17.5	0.18	0.040	8.5	0.1	1.0	0.4
7/1/19 0:58	7/1/19 2:44	0.18	1288.7	863	0	2152.1	5.1	6.3	2.3	0.02	0.005	1.1	0.0	0.1	0.0
7/1/19 5:09	7/1/19 7:28	0.18	1590.2	1065	0	2655.6	6.3	7.7	2.9	0.03	0.007	1.4	0.0	0.2	0.1
7/1/19 18:02	7/2/19 3:44	1.35	26701.6	17890	750	43841.7	68.4	54.7	30.1	0.25	0.014	8.2	0.1	1.8	0.7
7/4/19 14:42	7/5/19 17:02	0.18	2784.8	1866	0	4650.6	23.8	34.3	13.9	0.13	0.024	8.0	0.0	0.8	0.1
7/9/19 15:08	7/9/19 17:28	0.36	5385.9	3609	0	8994.4	61.2	44.4	27.5	0.24	0.013	7.5	0.0	1.1	0.2
7/15/19 18:05	7/15/19 20:24	0.6	10802.8	7238	0	18040.6	105.9	104.7	51.8	0.53	0.066	25.8	0.0	3.0	0.5
7/16/19 15:50	7/16/19 17:17	0.23	2365.0	1585	0	3949.5	6.2	19.2	3.5	0.05	0.010	5.1	0.0	0.5	0.3
7/20/19 8:30	7/20/19 13:22	1.24	23742.5	15907	11532	28118.3	42.1	98.3	15.8	0.23	0.069	11.6	0.3	1.4	0.6
7/26/19 7:00	7/26/19 11:28	0.16	4120.8	2761	0	6881.7	16.4	20.1	7.5	0.08	0.017	3.6	0.0	0.4	0.2
7/28/19 9:51	7/28/19 12:54	0.57	14377.7	9633	1003	23008.1	38.8	55.3	15.8	0.24	0.073	5.3	0.4	1.5	0.8
7/28/19 19:53	7/28/19 21:12	0.14	2041.5	1368	0	3409.3	8.1	9.9	3.7	0.04	0.008	1.8	0.0	0.2	0.1
8/10/19 15:10	8/10/19 18:12	0.96	35664.4	23895	0	59559.6	96.7	133.9	52.1	0.71	0.264	10.4	0.6	4.0	1.7
8/13/19 16:57	8/13/19 17:30	0.63	20749.0	13902	0	34650.8	82.6	101.0	37.5	0.38	0.085	18.2	0.2	2.2	0.8
8/13/19 23:58	8/14/19 0:19	0.1	830.0	556	0	1386.1	3.3	4.0	1.5	0.02	0.003	0.7	0.0	0.1	0.0
8/15/19 19:48	8/15/19 20:02	0.35	8831.0	5917	0	14747.8	35.1	43.0	16.0	0.16	0.036	7.7	0.1	0.9	0.3
8/16/19 0:15	8/16/19 0:42	0.06	78.0	52	0	130.3	0.3	0.4	0.1	0.00	0.000	0.1	0.0	0.0	0.0
8/16/19 2:34	8/16/19 3:28	0.99	37040.0	24817	0	61856.8	147.4	180.3	67.0	0.68	0.152	32.4	0.4	4.0	1.4
8/18/19 2:12	8/18/19 5:46	1.58	65310.0	43758	0	109067.7	259.9	317.9	118.1	1.19	0.268	57.1	0.7	7.0	2.5
8/20/19 9:58	8/20/19 11:53	0.41	11273.0	7553	0	18825.9	42.3	36.4	18.8	0.18	0.031	6.1	0.2	1.0	0.5
8/26/19 13:41	8/26/19 16:43	0.85	30640.0	20529	0	51168.8	75.1	92.6	33.5	0.42	0.112	16.3	0.1	2.0	0.8
9/1/19 11:06	9/1/19 11:46	0.11	706.8	474	0	1180.3	2.8	3.4	1.3	0.01	0.003	0.6	0.0	0.1	0.0
9/2/19 22:39	9/3/19 0:32	0.56	12584.3	8432	0	21015.8	27.6	32.8	11.8	0.16	0.056	4.3	0.2	1.1	0.5
9/8/19 2:00	9/8/19 3:23	0.06	638.4	428	0	1066.1	2.5	3.1	1.2	0.01	0.003	0.6	0.0	0.1	0.0
9/8/19 11:13	9/8/19 16:34	0.08	1716.4	1150	0	2866.4	6.8	8.4	3.1	0.03	0.007	1.5	0.0	0.2	0.1
9/9/19 12:12	9/9/19 19:11	0.16	3347.3	2243	0	5590.0	13.3	16.3	6.1	0.06	0.014	2.9	0.0	0.4	0.1
9/11/19 3:51	9/11/19 13:02	1.08	22446.1	15039	0	37485.0	77.2	93.6	32.8	0.26	0.215	9.8	0.4	1.6	0.8
9/12/19 3:39	9/12/19 11:06	0.86	21650.1	14506	0	36155.7	76.7	65.5	33.9	0.14	0.065	4.5	0.1	0.9	0.6
9/18/19 6:45	9/18/19 11:00	0.19	1977.7	1325	0	3302.7	7.9	9.6	3.6	0.04	0.008	1.7	0.0	0.2	0.1
9/21/19 4:43	9/21/19 7:22	0.15	1052.2	705	0	1757.2	4.2	5.1	1.9	0.02	0.004	0.9	0.0	0.1	0.0
9/29/19 4:27	9/29/19 14:30	0.27	3719.8	2492	0	6212.0	9.3	41.1	8.1	0.12	0.014	6.1	0.0	0.7	0.1
9/30/19 5:06	9/30/19 9:00	0.05	305.3	205	0	509.9	1.2	1.5	0.6	0.01	0.001	0.3	0.0	0.0	0.0
9/30/19 19:44	9/30/19 21:16	0.04	2639.1	1768	0	4407.4	10.5	12.8	4.8	0.05	0.011	2.3	0.0	0.3	0.1
10/1/19 14:27	10/1/19 20:00	0.63	10324.8	6918	0	17242.5	41.1	50.3	18.7	0.19	0.042	9.0	0.1	1.1	0.4
10/2/19 13:45	10/3/19 5:07	0.43	6128.6	4106	0	10234.8	16.0	31.3	9.6	0.09	0.012	3.1	0.0	0.3	0.2
10/5/19 4:07	10/5/19 11:42	0.86	20286.7	13592	0	33878.8	80.7	98.7	36.7	0.37	0.083	17.8	0.2	2.2	0.8
10/10/19 2:15	10/10/19 5:35	0.24	1310.9	878	0	2189.2	5.2	6.4	2.4	0.02	0.005	1.1	0.0	0.1	0.1
10/10/19 15:38	10/10/19 17:43	0.05	207.7	139	0	346.9	0.8	1.0	0.4	0.00	0.001	0.2	0.0	0.0	0.0
10/10/19 20:32	10/11/19 3:07	0.13	675.5	453	0	1128.1	2.7	3.3	1.2	0.01	0.003	0.6	0.0	0.1	0.0
10/15/19 2:45	10/15/19 5:15	0.38	1921.8	1288	0	3209.4	7.6	9.4	3.5	0.04	0.008	1.7	0.0	0.2	0.1
10/21/19 6:25	10/21/19 17:54	1.01	15136.5	10141	0	25278.0	60.2	73.7	27.4	0.28	0.062	13.2	0.2	1.6	0.6
10/22/19 4:00	10/22/19 11:58	0.32	3514.0	2354	0	5868.4	14.0	17.1	6.4	0.06	0.014	3.1	0.0	0.4	0.1
Sum		23.23	509211	341171	20966	829416	1980	2146	902	9.1	2.05	430.7	5.6	53.2	19.0
Average		0.45	9793	6561	403	15950	38	42	17	0.2	0.04	8.3	0.1	1.0	0.4
Weighted Avg															
STDEV															
Min															
Max															
Percent Capture						**98%**	**98%**	**84%**	**96%**	**96%**	**96%**	**94%**	**94%**	**95%**	**95%**

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling event Sampled Event
1 University Volumes after are estimated flow based on the relationship between the elipital and unvisity volumes for previous flow events

City of Saint Paul
2019 Water Quality and Quantity Report
Table C.5
WSB Project Number: 01610-100

HAMPDEN WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2768100	5/18/2019 23:09	5/19/2019 9:04	11.0	39.0	5.0	0.04 J	0.005 J	2.7	0.15	0.54	0.260 <	8 <	0.0029	0.0015	0.01480	3.6100		25.0	
2769214	5/22/2019 6:14	5/22/2019 11:59	69.0	47.0	17.0	0.13	0.005 J	3.8	0.25	0.95	0.616 <	14 J	0.0065	0.0039	0.05140	4.9100		54.0	
2772692	6/4/2019 16:34	6/4/2019 22:07	90.0	86.0	33.0	0.20	0.005 <	6.9	0.40	1.96	0.606	24 J	0.0145	0.0062	0.08760	19.2542		120.0	
2774261	6/11/2019 12:50	6/11/2019 12:50															7.2		1000
2774634	6/11/2019 11:24	6/11/2019 15:17	51.0		41.0	0.28		28.9		3.16	0.737								
2777193	6/20/2019 15:39	6/20/2019 18:06		175.0			0.052		0.18		0.530 <	55				50.7090		240.0	
2777858	6/23/2019 21:24	6/24/2019 3:55	31.0	37.0	9.0	0.06	0.007 J	2.0 <	0.16	0.52	0.281 <	13 J	0.0035	0.0017	0.01880	3.6869		19.0	
2779298	6/27/2019 10:14	6/27/2019 12:30	119.0	99.0	59.0	0.20	0.010	14.5	0.15	2.46	0.752	33	0.0205	0.0109	0.09810	19.5300		117.0	
2779854	6/30/2019 23:44	7/1/2019 7:20	41.0	55.0	17.0	0.12	0.012	4.7	0.29	1.09	0.704 <	22 J	0.0078	0.0041	0.04920	9.5000		58.0	
2780359	7/1/2019 21:19	7/2/2019 4:19	17.0	27.0	7.0	0.05 J	0.005 J	2.5	0.15	0.50	0.288 <	12 J	0.0038	0.0018	0.02450	3.7000		20.0	
2785212	7/16/2019 15:34	7/16/2019 17:51	62.0		20.0	0.15		3.0	0.14	1.16	0.762 <	29						69.0	
2789154	7/28/2019 9:54	7/28/2019 21:33	59.0	85.0	22.0	0.18	0.005 J	6.4	0.39	2.01	0.698	17 J	0.0159	0.0053	0.11200	18.8000		112.0	
2799527	8/26/2019 13:36	8/26/2019 16:15	37.0	39.0	13.0	0.07	0.005 <	6.9	0.02 <	0.49	0.260 <	11 J	0.0107	0.0033	0.05590	8.0000		53.0	
2803906	9/11/2019 12:21	9/11/2019 12:21	15.0	94.0	6.0	0.06	0.018	8.2	0.17	0.61	0.353	32	0.0087	0.0040	0.06040	8.0000		41.0	6300
2810478	10/2/2019 13:28	10/2/2019 13:28																	687
2810905	10/2/2019 13:37	10/2/2019 20:07	28.0	53.0	13.0	0.10	0.014	2.8	0.04 J	0.54	0.260 <	21 J	0.0066	0.0029	0.00448	8.6000		45.0	
	10/21/2019 13:43	20/21/2019 13:43															7.3		
MINIMUM			**11.0**	**27.0**	**5.0**	**0.0**	**0.0**	**2.0**	**0.0**	**0.5**	**0.3**	**7.9**	**0.0**	**0.0**	**0.0**	**3.6**	**7.2**	**19.0**	**686.7**
AVERAGE			**48.5**	**69.7**	**20.2**	**0.1**	**0.0**	**7.2**	**0.2**	**1.2**	**0.5**	**22.4**	**0.0**	**0.0**	**0.1**	**13.2**	**7.2**	**74.8**	**2662.2**
MEDIAN			**41.0**	**54.0**	**17.0**	**0.1**	**0.0**	**4.7**	**0.2**	**0.9**	**0.6**	**21.0**	**0.0**	**0.0**	**0.1**	**8.3**	**7.2**	**54.0**	**1000.0**
MAXIMUM			**119.0**	**175.0**	**59.0**	**0.3**	**0.1**	**28.9**	**0.4**	**3.2**	**0.8**	**54.7**	**0.0**	**0.0**	**0.1**	**50.7**	**7.3**	**240.0**	**6300.0**

Laboratory analysis was completed by Metroplian Council Environmental Services
Grab Sample Duplicate
< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported
J - Result reported as estimated between the MDL and Reporting Limit (RL)
> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

City of Saint Paul
2019 Water Quality and Quantity Report
Table C.6
WSB Project No.: 01610-100

HAMPDEN PARK VOLUME AND POLLUTANT REDUCTION SUMMARY

Event Time Interval		Sampling Data									Event Loading and Volume Data													
		TSS	TDS	VSS	TP	Ortho-P	Chloride	Ammonia as N	Total Kjeldahl Nitrogen	Nitrate + Nitrite as N	Interval Rain	Hampden/Raymond Inflow Volume (1)	Eastern Hampden Modeled Inflow Volume[1] (2)	Bypass Volume2 (3)	Volume Captured by BMP (1+2-3)	Captured TSS	Captured TDS	Captured VSS	Captured TP	Captured Ortho-P	Captured Chloride	Captured Ammonia as N	Captured Total Kjeldahl Nitrogen	Captured Nitrate + Nitrite as N
Start	End	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	In.	cu-ft	cu-ft	cu-ft	cu-ft	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5/18/19 0:15	5/18/19 8:45	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.37	3141.2	518	0	3659.5	10.6	13.0	3.5	0.03	0.002	0.87	0.04	0.21	0.13
5/18/19 23:06	5/19/19 17:15	**11**	**39**	**5**	**0.04** J	**0.005** J	**2.69**	**0.153**	**0.540**	**0.260** <	0.86	5857.5	966	0	6824.0	4.7	16.6	2.1	0.02	0.002	1.15	0.07	0.23	0.11
5/21/19 18:00	5/22/19 3:15	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.54	3952.6	652	0	4604.8	13.4	16.4	4.4	0.03	0.003	1.10	0.05	0.27	0.16
5/22/19 6:11	5/22/19 12:30	**69**	**47**	**17**	**0.13**	**0.005** J	**3.83**	**0.245**	**0.948**	**0.616** <	0.29	2647.8	437	0	3084.7	13.3	9.1	3.3	0.03	0.001	0.74	0.05	0.18	0.12
5/24/19 9:51	5/24/19 10:45	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.03	263.0	43	0	306.3	0.9	1.1	0.3	0.00	0.000	0.07	0.00	0.02	0.01
5/27/19 6:45	5/27/19 18:15	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	1.63	7724.1	1274	0	8998.6	26.1	32.0	8.7	0.06	0.006	2.15	0.09	0.53	0.31
5/31/19 22:21	5/31/19 23:30	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.16	691.7	114	0	805.9	2.3	2.9	0.8	0.01	0.001	0.19	0.01	0.05	0.03
6/1/19 3:36	6/1/19 6:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.14	471.4	78	0	549.2	1.6	2.0	0.5	0.00	0.000	0.13	0.01	0.03	0.02
6/4/19 16:30	6/4/19 22:15	**90**	**86**	**33**	**0.20**	**0.005** <	**6.92**	**0.402**	**1.956**	**0.606**	0.34	3439.9	568	0	4007.5	22.5	21.5	8.3	0.05	0.001	1.73	0.10	0.49	0.15
6/11/19 11:21	6/11/19 16:45	**51**	57	**41**	**0.28**	0.01	**28.94**	0.16	**3.163**	**0.737**	0.07	1368.1	226	0	1593.8	5.1	5.7	4.1	0.03	0.001	2.88	0.02	0.31	0.07
6/20/19 15:30	6/20/19 18:30	46	**175**	15	0.11	**0.052**	3.8	**0.175**	0.94	**0.530** <	0.05	1057.0	174	0	1231.4	3.6	13.5	1.2	0.01	0.004	0.29	0.01	0.07	0.04
6/23/19 15:45	6/24/19 3:17	**31**	**37**	**9**	**0.06**	**0.007** J	**2.00** <	**0.156**	**0.516**	**0.281** <	1.17	41057.1	6774	0	47831.5	92.6	110.5	26.9	0.19	0.021	5.97	0.47	1.54	0.84
6/27/19 10:11	6/27/19 12:30	**119**	**99**	**59**	**0.20**	**0.010**	**14.45**	**0.146**	**2.458**	**0.752**	0.05	879.5	145	0	1024.6	7.6	6.3	3.8	0.01	0.001	0.92	0.01	0.16	0.05
6/30/19 8:11	6/30/19 8:34	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.03	226.6	37	0	264.0	0.8	0.9	0.3	0.00	0.000	0.06	0.00	0.02	0.01
6/30/19 13:06	6/30/19 14:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.59	1167.4	193	0	1360.0	3.9	4.8	1.3	0.01	0.001	0.32	0.01	0.08	0.05
6/30/19 23:41	7/1/19 10:15	**41**	**55**	**17**	**0.12**	**0.012**	**4.66**	**0.293**	**1.089**	**0.704** <	0.31	1429.4	236	0	1665.3	4.3	5.7	1.8	0.01	0.001	0.48	0.03	0.11	0.07
7/1/19 18:15	7/2/19 4:05	**17**	**27**	**7**	**0.05** J	**0.005** J	**2.46**	**0.148**	**0.499**	**0.288** <	0.65	1647.8	272	0	1919.7	2.0	3.2	0.8	0.01	0.001	0.29	0.02	0.06	0.03
7/3/19 17:06	7/3/19 18:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.09	382.0	63	0	445.1	1.3	1.6	0.4	0.00	0.000	0.11	0.00	0.03	0.02
7/5/19 17:30	7/5/19 19:45	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.15	860.1	142	0	1002.0	2.9	3.6	1.0	0.01	0.001	0.24	0.01	0.06	0.03
7/9/19 15:00	7/9/19 15:52	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.27	1363.7	225	0	1588.7	4.6	5.7	1.5	0.01	0.001	0.38	0.02	0.09	0.05
7/15/19 17:56	7/16/19 18:00	**62**	57	**20**	**0.15**	0.01	**2.96**	**0.142**	**1.161**	**0.762** <	2.46	84989.4	14023	0	99012.7	383.2	352.4	123.6	0.93	0.062	18.30	0.88	7.18	4.71
7/20/19 8:36	7/20/19 13:24	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.92	26302.3	4340	0	30642.2	88.9	109.1	29.5	0.22	0.019	7.31	0.30	1.79	1.06
7/26/19 7:26	7/26/19 9:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.09	562.5	93	0	655.3	1.9	2.3	0.6	0.00	0.000	0.16	0.01	0.04	0.02
7/28/19 9:51	7/28/19 22:00	**59**	**85**	**22**	**0.18**	**0.005** J	**6.40**	**0.390**	**2.009**	**0.698**	0.37	2327.8	384	0	2711.8	10.0	14.4	3.7	0.03	0.001	1.08	0.07	0.34	0.12
8/3/19 18:06	8/3/19 20:30	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.26	1477.1	244	0	1720.8	5.0	6.1	1.7	0.01	0.001	0.41	0.02	0.10	0.06
8/5/19 13:26	8/5/19 14:30	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.05	283.6	47	0	330.4	1.0	1.2	0.3	0.00	0.000	0.08	0.00	0.02	0.01
8/5/19 17:00	8/5/19 18:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.06	305.2	50	0	355.5	1.0	1.3	0.3	0.00	0.000	0.08	0.00	0.02	0.01
8/10/19 16:00	8/10/19 19:11	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.7	29705.8	4901	0	34607.2	100.5	123.2	33.3	0.25	0.022	8.25	0.34	2.03	1.19
8/13/19 16:56	8/13/19 18:30	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.3	1326.3	219	0	1545.1	4.5	5.5	1.5	0.01	0.001	0.37	0.02	0.09	0.05
8/13/19 23:51	8/14/19 1:45	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.07	501.5	83	0	584.3	1.7	2.1	0.6	0.00	0.000	0.14	0.01	0.03	0.02
8/16/19 0:30	8/16/19 4:15	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.68	3094.6	511	0	3605.3	10.5	12.8	3.5	0.03	0.002	0.86	0.04	0.21	0.12
8/18/19 1:30	8/18/19 5:33	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	2.4	94858.9	15652	0	110510.6	320.8	393.3	106.4	0.79	0.069	26.35	1.08	6.47	3.81
8/20/19 9:51	8/20/19 11:45	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.59	3112.9	514	0	3626.5	10.5	12.9	3.5	0.03	0.002	0.86	0.04	0.21	0.13
8/26/19 13:26	8/26/19 17:30	**37**	**39**	**13**	**0.07**	**0.005** <	**6.94**	**0.020** <	**0.489**	**0.260** <	0.76	3129.8	516	0	3646.2	8.4	8.9	3.0	0.02	0.001	1.58	0.00	0.11	0.06
8/27/19 14:06	8/27/19 14:32	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.03	194.4	32	0	226.5	0.7	0.8	0.2	0.00	0.000	0.05	0.00	0.01	0.01
9/1/19 10:30	9/1/19 12:30	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.13	762.6	126	0	888.4	2.6	3.2	0.9	0.01	0.001	0.21	0.01	0.05	0.03
9/2/19 22:36	9/3/19 0:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.61	37794.6	6236	0	44030.8	127.8	156.7	42.4	0.32	0.028	10.50	0.43	2.58	1.52
9/8/19 1:15	9/8/19 3:30	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.06	336.3	55	0	391.8	1.1	1.4	0.4	0.00	0.000	0.09	0.00	0.02	0.01
9/8/19 11:00	9/8/19 13:45	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.08	559.6	92	0	651.9	1.9	2.3	0.6	0.00	0.000	0.16	0.01	0.04	0.02
9/9/19 15:36	9/9/19 19:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.13	966.8	160	0	1126.4	3.3	4.0	1.1	0.01	0.001	0.27	0.01	0.07	0.04
9/11/19 3:51	9/11/19 13:30	**15**	**94**	**6**	**0.06**	**0.018**	**8.19**	**0.173**	**0.613**	**0.353**	1.09	20242.2	3340	0	23582.2	22.1	138.4	8.8	0.09	0.026	12.06	0.25	0.90	0.52
9/12/19 3:41	9/12/19 20:15	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.94	12889.8	2127	0	15016.6	43.6	53.4	14.5	0.11	0.009	3.58	0.15	0.88	0.52
9/18/19 5:51	9/18/19 9:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.19	1781.1	294	0	2074.9	6.0	7.4	2.0	0.01	0.001	0.49	0.02	0.12	0.07
9/21/19 4:41	9/21/19 8:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.15	1344.5	222	0	1566.3	4.5	5.6	1.5	0.01	0.001	0.37	0.02	0.09	0.05
9/29/19 4:21	9/29/19 10:15	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.27	2782.2	459	0	3241.2	9.4	11.5	3.1	0.02	0.002	0.77	0.03	0.19	0.11
9/30/19 4:56	9/30/19 7:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.05	673.0	111	0	784.0	2.3	2.8	0.8	0.01	0.000	0.19	0.01	0.05	0.03
9/30/19 19:41	9/30/19 21:15	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.04	405.2	67	0	472.0	1.4	1.7	0.5	0.00	0.000	0.11	0.00	0.03	0.02
10/1/19 11:45	10/1/19 18:50	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.66	4409.8	728	0	5137.4	14.9	18.3	4.9	0.04	0.003	1.23	0.05	0.30	0.18
10/2/19 13:06	10/3/19 5:15	**28**	**53**	**13**	**0.10**	**0.014**	**2.80**	**0.040** J	**0.536**	**0.260** <	0.43	3139.9	518	0	3658.0	6.4	12.1	3.0	0.02	0.003	0.64	0.01	0.12	0.06
10/5/19 4:00	10/5/19 20:36	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.88	12864.8	2123	0	14987.5	43.5	53.3	14.4	0.11	0.009	3.57	0.15	0.88	0.52
10/10/19 2:00	10/10/19 10:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.25	4956.1	818	0	5773.8	16.8	20.6	5.6	0.04	0.004	1.38	0.06	0.34	0.20
10/10/19 15:36	10/11/19 6:15	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.18	6082.3	1004	0	7085.8	20.6	25.2	6.8	0.05	0.004	1.69	0.07	0.41	0.24
10/12/19 9:36	10/13/19 4:45	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.06	3318.3	548	0	3865.9	11.2	13.8	3.7	0.03	0.002	0.92	0.04	0.23	0.13
10/15/19 2:41	10/15/19 9:00	46	57	15	0.11	0.01	3.8	0.16	0.94	0.55	0.38	2599.9	429	0	3028.9	8.8	10.8	2.9	0.02	0.002	0.72	0.03	0.18	0.10
Sum											24.17	449994	74249	0	**524242**	1522	1866	505	3.8	0.33	125.0	5.1	30.7	18.1
Average		48.5	69.7	20.2	0.13	0.012	7.2	0.19	1.23	0.51	0.43	8036	1326	0	9361	27	33	9	0.1	0.01	2.2	0.1	0.5	0.3
Weighted Avg		46.5	57.0	15.42	0.11	0.010	3.82	0.16	0.94	0.55														
STDEV		31.4	41.4	15.7	0.07	0.013	7.4	0.12	0.89	0.21														
Min		11.0	27.0	5.0	0.04	0.005	2.0	0.02	0.49	0.26														
Max		119.0	175.0	59.0	0.28	0.052	28.9	0.40	3.16	0.76														
Percent Capture															**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling event
1 - Additional stormwater is conveyed to the system from the east via a pipe along Hampden Avenue. This flow is modeled using the monitored flow from the Hampden/Raymond location and the ratio of drainage areas.
2 - Water Levels in the BMP did not exceed the system outlet elevation
*Samples identified as outliers have been omitted from annual flow weighted averages

City of Saint Paul
2019 Water Quality and Quantity Report
Table C.7
WSB Project Number: 01610-100

VICTORIA WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	Sulfate (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2772698	6/4/2019 16:37	6/4/2019 23:17	109.0	57.0	50.0	0.83	0.104	3.2	0.21	4.32	0.309 <	20 J	0.0104	0.0165	0.06020	16.7341			119.0	
2774259	6/11/2019 12:35	6/11/2019 12:35																6.8		2000
2774630	6/11/2019 11:37	6/11/2019 16:49	37.0	198.0	35.0	1.73		10.0	0.36	7.60	0.260 <	44	0.0105	0.0007 J	0.02770					
2777194	6/20/2019 16:02	6/20/2019 19:55	59.0	253.0	54.0	2.38	0.993	14.5	1.44	10.22	1.348	46	0.0139	0.0015	0.04410	101.2690			330.0	
2777864	6/23/2019 21:52	6/24/2019 3:18	32.0	38.0	18.0	0.36	0.096	2.6	0.33	2.03	0.365 <	8 <	0.0051	0.0056	0.02410	9.0063			51.0	
2779302	6/27/2019 10:12	6/27/2019 14:19	47.0	93.0	32.0	0.67	0.126	5.6	0.09	5.59	0.260 <	39	0.0087	0.0041	0.04120	23.4511			117.0	
2779858	7/1/2019 0:58	7/1/2019 4:28	12.0	60.0	9.0	0.20	0.034	2.2	0.27	1.47	0.625	12 J	0.0034	0.0015	0.01030	10.4000			44.0	
2782810	7/9/2019 15:13	7/9/2019 18:53	141.0	82.0	64.0	0.75	0.138	4.7	0.02 <	3.36	0.260 <	19 J	0.0152	0.0257	0.10100	36.2000			188.0	
2784674	7/15/2019 18:03	7/15/2019 22:26	93.0	33.0	40.0	0.42	0.104	3.3	0.03 J	2.00	0.260 <	16 J	0.0086	0.0156	0.03690	8.7000			57.0	
2785208	7/16/2019 15:43	7/16/2019 19:26	10.0	25.0	6.0	0.16	0.066	2.0 <	0.19	0.85	0.659 <	13 J	0.0031	0.0026	0.01020	8.5000			22.0	
2786814	7/20/2019 8:38	7/20/2019 11:09	27.0	36.0	10.0	0.17		2.0 <	0.22	0.93		8 J	0.0038	0.0071	0.03400	5.7000			32.0	
2789160	7/28/2019 9:58	7/28/2019 22:46	74.0	57.0	32.0	0.41	0.005 <	2.8	0.02 <	2.20	0.260 <	8 <	0.0087	0.0121	0.03600	15.7000			84.0	
2793336	8/10/2019 5:58	8/10/2019 18:53	65.0	38.0	31.0	0.30	0.029	2.0 <	0.02 <	2.02	0.260 <	8 <	0.0074	0.0144	0.04050	14.8000			82.0	
2797702	8/20/2019 9:53	8/20/2019 13:24	23.0	89.0	11.0	0.13	0.009 J	2.0 <	0.06	0.86	0.348 <	8 <	0.0028	0.0043	0.01410	5.9000			37.0	
2799519	8/26/2019 13:38	8/26/2019 14:50	54.0	37.0	42.0	0.18	0.005 J	3.6	0.02 <	1.00	0.260 <	13 J	0.0034	0.0044	0.01830	14.0000			83.0	
2803904	9/11/2019 13:25	9/11/2019 13:25																		9700
2804319	9/12/2019 3:43	9/12/2019 8:21	19.0	26.0	7.0	0.10	0.048	2.0 <	0.03 J	0.54	0.260 <	8 <	0.0024	0.0049	0.01190	4.2000			19.0	
2810477	10/2/2019 13:50	10/2/2019 13:50																		37300
2815278	10/15/2019 2:54	10/15/2019 4:49	73.0	44.0	34.0	0.36	0.086	2.2	0.12	1.89	0.548 <	18 J	0.0070	0.0199	0.04690	10.3000			84.0	
	10/21/2019 13:58	10/21/2019 13:58																7.30		
MINIMUM			**10.0**	**25.0**	**6.0**	**0.1**	**0.0**	**2.0**	**0.0**	**0.5**	**0.3**	**7.9**	**0.0**	**0.0**	**0.0**	**4.2**	**0.0**	**6.8**	**19.0**	**2000.0**
AVERAGE			**52.3**	**71.2**	**29.3**	**0.6**	**0.1**	**4.1**	**0.2**	**2.7**	**0.4**	**17.6**	**0.0**	**0.0**	**0.0**	**18.6**	**#DIV/0!**	**7.1**	**88.1**	**16333.3**
MEDIAN			**48.0**	**50.5**	**32.0**	**0.4**	**0.1**	**3.0**	**0.1**	**1.9**	**0.3**	**13.0**	**0.0**	**0.0**	**0.0**	**14.0**	**#NUM!**	**7.1**	**79.0**	**9700.0**
MAXIMUM			**141.0**	**253.0**	**64.0**	**2.4**	**1.0**	**14.5**	**1.4**	**10.2**	**1.3**	**45.8**	**0.0**	**0.0**	**0.1**	**101.3**	**0.0**	**7.3**	**330.0**	**37300.0**

Laboratory analysis was completed by Metroplian Council Environmental Services

Grab Sample | Duplicate

< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported

J - Result reported as estimated between the MDL and Reporting Limit (RL)

> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

City of Saint Paul
2019 Victoria Volume Reduction Pollutant Monitoring
Table C.8
WSB Project No.: 01610-100

Event Time Interval		Sampling Data									Event Loading and Volume Data												
		TSS	TDS	VSS	TP	Ortho-P	Chloride	Ammonia as N	Total Kjeldahl Nitrogen	Nitrate + Nitrite as N	Interval Rain	Runoff Volume (1)	Bypassed Volume (2)	Volume Captured by BMP (1-2)	Captured TSS	Captured TDS	Captured VSS	Captured TP	Captured Ortho-P	Captured Chloride	Captured Ammonia as N	Captured Total Kjeldahl Nitrogen	Captured Nitrate + Nitrite as N
Start	End	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	In.	cu-ft	cu-ft	cu-ft	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
5/31/2019 22:21	5/31/2019 23:32	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.16	3121	0	3121	10.3	9.2	5.3	0.1	0.020	0.5	0.02	0.5	0.1
6/1/2019 3:30	6/1/2019 4:43	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.12	2996	0	2996	9.9	8.8	5.1	0.1	0.020	0.5	0.02	0.4	0.1
6/1/2019 5:12	6/1/2019 5:49	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.02	538	0	538	1.8	1.6	0.9	0.0	0.004	0.1	0.00	0.1	0.0
6/4/2019 16:26	6/4/2019 22:24	**109**	**57**	**50**	**0.83**	**0.104**	**3.2**	**0.21**	**4.32**	**0.309** <	0.57	16129	0	16129	109.8	57.4	50.3	0.8	0.105	3.2	0.21	4.3	0.3
6/11/2019 11:30	6/11/2019 15:24	**37**	**198**	**35**	**1.73**	0.11	**10.0**	**0.36**	**7.60**	**0.260** <	0.14	2074	0	2074	4.8	25.6	4.5	0.2	0.014	1.3	0.05	1.0	0.0
6/14/2019 22:40	6/14/2019 23:38	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.37	2562	0	2562	8.5	7.5	4.3	0.1	0.017	0.4	0.02	0.4	0.1
6/20/2019 16:01	6/20/2019 18:30	**59**	**253**	**54**	**2.38**	**0.993**	**14.5**	**1.44**	**10.22**	**1.348**	0.12	1365	0	1365	5.0	21.6	4.6	0.2	0.085	1.2	0.12	0.9	0.1
6/23/2019 16:42	6/23/2019 18:41	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.18	2114	0	2114	7.0	6.2	3.6	0.0	0.014	0.4	0.02	0.3	0.0
6/23/2019 21:51	6/24/2019 0:06	**32**	**32**	**18**	**0.36**	**0.096**	**2.6**	**0.33**	**2.03**	**0.365** <	0.05	7251	0	7251	14.5	14.5	8.1	0.2	0.043	1.2	0.15	0.9	0.2
6/24/2019 1:35	6/24/2019 3:58	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.21	5606	0	5606	18.5	16.4	9.4	0.1	0.037	1.0	0.04	0.8	0.1
6/27/2019 10:11	6/27/2019 13:09	**47**	**93**	**32**	**0.67**	**0.126**	**2.6**	**0.09**	**5.59**	**0.260** <	0.17	3100	0	3100	9.1	18.0	6.2	0.1	0.024	0.5	0.02	1.1	0.1
6/30/2019 8:06	6/30/2019 9:02	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.07	1982	0	1982	6.6	5.8	3.3	0.0	0.013	0.3	0.01	0.3	0.0
6/30/2019 13:15	6/30/2019 14:25	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.60	9870	0	9870	32.7	29.0	16.6	0.2	0.065	1.7	0.07	1.4	0.2
7/1/2019 0:56	7/1/2019 3:12	**12**	**60**	**9**	**0.20**	**0.034**	**2.2**	**0.27**	**1.47**	**0.625**	0.17	3422	0	3422	2.6	12.8	1.9	0.0	0.007	0.5	0.06	0.3	0.1
7/1/2019 4:56	7/1/2019 10:44	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.20	5497	0	5497	18.2	16.1	9.3	0.1	0.036	1.0	0.04	0.8	0.1
7/1/2019 18:00	7/1/2019 19:45	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.08	1839	0	1839	6.1	5.4	3.1	0.0	0.012	0.3	0.01	0.3	0.0
7/1/2019 21:09	7/2/2019 3:45	53	47	27	0.4	0.11	3	0.12	2.31	0.330	1.23	21630	951	20679	68.4	60.7	34.9	0.5	0.136	3.6	0.15	3.0	0.4
7/4/2019 15:26	7/4/2019 17:45	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.10	108	0	108	0.4	0.3	0.2	0.0	0.001	0.0	0.00	0.0	0.0
7/5/2019 17:45	7/5/2019 20:13	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.08	333	0	333	1.1	1.0	0.6	0.0	0.002	0.1	0.00	0.0	0.0
7/9/2019 15:11	7/9/2019 16:18	**141**	**82**	**64**	**0.75**	**0.138**	**4.7**	**0.02** <	**3.36**	**0.260** <	0.33	4200	0	4200	37.0	21.5	16.8	0.2	0.036	1.2	0.01	0.9	0.1
7/9/2019 16:52	7/9/2019 17:58	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.03	550	0	550	1.8	1.6	0.9	0.0	0.004	0.1	0.00	0.1	0.0
7/10/2019 13:15	7/10/2019 13:40	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.02	40	0	40	0.1	0.1	0.1	0.0	0.000	0.0	0.00	0.0	0.0
7/15/2019 18:00	7/15/2019 20:27	**93**	**33**	**40**	**0.42**	**0.104**	**3.3**	**0.03**	**2.00**	**0.260** <	0.60	14178	0	14178	82.3	29.2	35.4	0.4	0.092	2.9	0.03	1.8	0.2
7/16/2019 15:41	7/16/2019 17:39	**10**	**25**	**6**	**0.16**	**0.660**	**2.0** <	**0.19**	**0.85**	**0.659** <	0.23	8186	0	8186	5.1	12.8	3.1	0.1	0.337	1.0	0.10	0.4	0.3
7/20/2019 8:36	7/20/2019 13:21	**27**	**36**	**10**	**0.17**	0.11	**2.0** <	**0.22**	**0.93**	0.330	1.24	19215	39	19176	32.3	43.1	12.0	0.2	0.126	2.4	0.26	1.1	0.4
7/26/2019 6:51	7/26/2019 8:53	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.16	1865	0	1865	6.2	5.5	3.1	0.0	0.012	0.3	0.01	0.3	0.0
7/28/2019 9:56	7/28/2019 11:27	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.57	6082	0	6082	20.1	17.8	10.3	0.1	0.040	1.1	0.05	0.9	0.0
7/28/2019 15:41	7/28/2019 21:35	**74**	**57**	**32**	**0.10**	**0.005** <	**2.8**	**0.02** <	**2.20**	**0.260** <	0.17	4295	0	4295	19.8	15.3	8.6	0.0	0.001	0.8	0.01	0.6	0.1
8/10/2019 16:06	8/10/2019 19:55	**65**	**38**	**31**	**0.30**	**0.029**	**2.0** <	**0.02** <	**2.02**	**0.260** <	0.96	17791	8691	9100	36.9	21.6	17.6	0.2	0.016	1.1	0.01	1.1	0.1
8/13/2019 17:00	8/13/2019 18:38	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.63	5833	0	5833	19.3	17.1	9.8	0.1	0.038	1.0	0.04	0.8	0.1
8/13/2019 23:41	8/14/2019 1:11	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.11	1127	0	1127	3.7	3.3	1.9	0.0	0.007	0.2	0.01	0.2	0.0
8/15/2019 19:56	8/15/2019 21:02	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.35	1062	0	1062	3.5	3.1	1.8	0.0	0.007	0.2	0.01	0.2	0.0
8/16/2019 0:26	8/16/2019 1:38	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.06	1248	0	1248	4.1	3.7	2.1	0.0	0.008	0.2	0.01	0.2	0.0
8/16/2019 2:33	8/16/2019 4:59	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.99	15321	1329	13992	46.3	41.1	23.6	0.3	0.092	2.4	0.10	2.0	0.3
8/18/2019 1:30	8/18/2019 6:15	53	47	27	0.4	0.11	3	0.12	2.31	0.330	1.58	43701	19143	24557	81.3	72.1	41.4	0.5	0.161	4.3	0.18	3.5	0.5
8/20/2019 9:51	8/20/2019 11:40	**23**	**89**	**11**	**0.13**	**0.009**	**2.0** <	**0.06**	**8.56**	**0.348** <	0.41	7895	0	7895	11.3	43.9	5.4	0.1	0.004	1.0	0.03	4.2	0.2
8/26/2019 13:36	8/26/2019 17:20	**54**	**37**	**42**	**0.18**	**0.005**	**3.6**	**0.02** <	**1.00**	**0.260** <	0.85	16306	0	16306	55.0	37.7	42.8	0.2	0.005	3.7	0.02	1.0	0.3
8/27/2019 13:56	8/27/2019 14:59	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.01	730	0	730	2.4	2.1	1.2	0.0	0.005	0.1	0.01	0.1	0.0
9/1/2019 10:51	9/1/2019 12:15	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.11	1146	0	1146	3.8	3.4	1.9	0.0	0.008	0.2	0.01	0.2	0.0
9/2/2019 22:41	9/2/2019 23:55	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.56	11360	14	11345	37.5	33.3	19.1	0.2	0.074	2.0	0.08	1.6	0.2
9/8/2019 1:56	9/8/2019 3:21	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.05	385	0	385	1.3	1.1	0.6	0.0	0.003	0.1	0.00	0.1	0.0
9/8/2019 11:15	9/8/2019 13:12	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.07	979	0	979	3.2	2.9	1.7	0.0	0.006	0.2	0.01	0.1	0.0
9/9/2019 12:30	9/9/2019 13:52	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.03	274	0	274	0.9	0.8	0.5	0.0	0.002	0.0	0.00	0.0	0.0
9/9/2019 15:56	9/9/2019 16:52	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.02	141	0	141	0.5	0.4	0.2	0.0	0.001	0.0	0.00	0.0	0.0
9/9/2019 17:31	9/9/2019 18:54	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.09	2139	0	2139	7.1	6.3	3.6	0.0	0.014	0.4	0.02	0.3	0.0
9/11/2019 3:52	9/11/2019 7:45	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.87	16642	0	16642	55.1	48.8	28.1	0.4	0.109	2.9	0.12	2.4	0.3
9/11/2019 9:30	9/11/2019 12:18	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.20	5674	0	5674	18.8	16.6	9.6	0.1	0.037	1.0	0.04	0.8	0.1
9/12/2019 3:41	9/12/2019 10:41	**19**	**26**	**7**	**0.10**	**0.048**	**2.0** <	**0.03**	**0.54**	**0.260** <	0.86	23578	0	23578	28.0	38.3	10.3	0.1	0.071	2.9	0.04	0.8	0.4
9/12/2019 18:15	9/12/2019 19:47	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.06	66	0	66	0.2	0.2	0.1	0.0	0.000	0.0	0.00	0.0	0.0
9/18/2019 6:36	9/18/2019 8:36	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.19	1791	0	1791	5.9	5.3	3.0	0.0	0.012	0.3	0.01	0.3	0.0
9/21/2019 4:51	9/21/2019 7:56	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.15	1810	0	1810	6.0	5.3	3.1	0.0	0.012	0.3	0.01	0.3	0.0
9/30/2019 5:06	9/30/2019 6:54	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.05	1060	0	1060	3.5	3.1	1.8	0.0	0.007	0.2	0.01	0.2	0.0
9/30/2019 19:56	9/30/2019 21:15	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.04	555	0	555	1.8	1.6	0.9	0.0	0.004	0.1	0.00	0.1	0.0
10/1/2019 14:30	10/1/2019 20:00	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.63	16490	0	16490	54.6	48.4	27.8	0.4	0.108	2.9	0.12	2.4	0.3
10/2/2019 13:30	10/2/2019 17:33	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.27	5958	0	5958	19.7	17.5	10.0	0.1	0.039	1.0	0.04	0.9	0.1
10/2/2019 19:08	10/2/2019 20:35	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.02	433	0	433	1.4	1.3	0.7	0.0	0.003	0.1	0.00	0.1	0.0
10/2/2019 22:04	10/3/2019 5:48	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.12	2144	0	2144	7.1	6.3	3.6	0.0	0.014	0.4	0.02	0.3	0.0
10/5/2019 4:11	10/5/2019 11:39	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.86	26916	0	26916	89.1	79.0	45.4	0.6	0.176	4.7	0.20	3.9	0.6
10/10/2019 2:15	10/10/2019 5:13	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.24	4553	0	4553	15.1	13.4	7.7	0.1	0.030	0.8	0.03	0.7	0.1
10/10/2019 15:41	10/10/2019 17:26	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.05	977	0	977	3.2	2.9	1.6	0.0	0.006	0.2	0.01	0.1	0.0
10/10/2019 19:59	10/11/2019 3:40	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.13	3661	0	3661	12.1	10.7	6.2	0.1	0.024	0.6	0.03	0.5	0.1
10/15/2019 2:51	10/15/2019 4:58	**73**	**44**	**34**	**0.36**	**0.086**	**2.2**	**0.12**	**1.89**	**0.548** <	0.38	4835	0	4835	22.0	13.3	10.3	0.1	0.026	0.7	0.04	0.6	0.2
10/21/2019 6:26	10/21/2019 17:25	53	47	27	0.4	0.11	3	0.12	2.31	0.330	1.00	30533	0	30533	101.0	89.6	51.5	0.7	0.200	5.3	0.23	4.4	0.6
10/22/2019 3:57	10/22/2019 13:31	53	47	27	0.4	0.11	3	0.12	2.31	0.330	0.28	5976	0	5976	19.8	17.5	10.1	0.1	0.039	1.0	0.04	0.9	0.1
Sum											21.27	431,238	30,168	**401,070**	**1322**	**1178**	**669**	**8.7**	**2.67**	**70.4**	**3.1**	**58.0**	**8.3**
Average		55	73	30	0.55	0.174	3.9	0.21	3.41	0.42	0.33	6,738	471	6,267	21	18	10	0.1	0.04	1.1	0.05	0.9	0.1
Weighted Ave		53	47	27	0.35	0.105	2.8	0.12	2.31	0.33													
STDEV		37	64	18	0.64	0.288	3.5	0.35	3.01	0.29													
Median		51	51	32	0.33	0.091	2.6	0.11	2.03	0.26													
Min		10	25	6	0.10	0.005	2.0	0.02	0.54	0.26													
Max		141	253	64	2.38	0.993	14.5	1.44	10.22	1.35													
Percent Capture														**93%**	**93%**	**93%**	**93%**	**93%**	**94%**	**94%**	**95%**	**93%**	**93%**

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling Sampled Event

City of Saint Paul
2019 Water Quality and Quantity Report
Table C.9
WSB Project Number: 01610-100

BATTLE CREEK WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2777862	6/23/2019 18:24	6/24/2019 0:06	4.0	575.0	3.0	0.11	0.006 J	252.4	0.14	0.99	0.402 <	207	0.0015	0.0003 <	0.00940	8.2220		31.0	
2779860	6/30/2019 13:42	7/1/2019 2:51	6.0	475.0	3.0	0.11	0.008 J	202.4	0.11	1.06	0.328 <	184	0.0015	0.0003 <	0.00610	7.0000		31.0	
2780355	7/1/2019 18:48	7/2/2019 23:38	3.0	205.0	2.0 J	0.08	0.025	69.7	0.17	0.77	0.416 <	61	0.0017	0.0003 <	0.00470 J	7.9000		24.0	
2780382	7/1/2019 18:48	7/1/2019 23:39	3.0	206.0	2.0 J	0.08	0.022	69.6	0.20	0.72	0.429 <	67	0.0015	0.0003 <	0.01210	8.0000		27.0	
2782812	7/9/2019 16:08	7/9/2019 20:12	5.0	522.0	3.0	0.11	0.005 <	196.2	0.03 J	0.88	0.260 <	156	0.0019	0.0003 <	0.01670	12.7000		52.0	
2784676	7/15/2019 18:47	7/16/2019 0:48	8.0	498.0	4.0	0.12	0.005 <	212.1	0.02 <	0.92	0.305 <	150	0.0016	0.0005 J	0.00710	7.4000		29.0	
2786816	7/20/2019 8:56	7/20/2019 13:11	6.0	463.0	5.0	0.08		171.8	0.05 J	0.97		143	0.0007 J	0.0003 <	0.00290 J	6.6000		32.0	
2791267	8/5/2019 14:04	8/5/2019 14:04																	8
2793338	8/10/2019 17:48	8/10/2019 21:02	15.0	504.0	7.0	0.10	0.005 <	203.6	0.02 <	0.93	0.260 <	183	0.0016	0.0006 J	0.00860	7.5000		38.0	
2795569	8/13/2019 18:01	8/13/2019 23:16	11.0	355.0	7.0	0.11	0.005 <	138.7	0.02 <	0.69	0.260 <	138	0.0023	0.0003 J	0.00650	6.3000		44.0	
2799523	8/26/2019 14:27	8/26/2019 17:27	6.0	376.0	5.0	0.05	0.005 <	150.7	0.02 <	0.64	0.260 <	123	0.0007 J	0.0004 J	0.00610	10.1000		33.0	
2801324	9/2/2019 23:06	9/3/2019 5:56	13.0	358.0	5.0	0.09	0.005 <	135.9	0.02 <	0.78	0.260 <	117	0.0014	0.0007 J	0.00800	7.4000		70.0	
2809943	10/1/2019 9:47	10/1/2019 9:47																	2420 >
2809944	9/30/2019 17:17	10/1/2019 4:22	8.0	396.0	5.0	0.07	0.007 J	162.5	0.03 J	0.78	0.260 <	170	0.0012	0.0003 <	0.00470 J	9.6224		34.0	
	10/21/2019 12:21	10/21/2019 12:21															7.0		
MINIMUM			**3.0**	**205.0**	**2.0**	**0.1**	**0.0**	**69.6**	**0.0**	**0.6**	**0.3**	**60.9**	**0.0**	**0.0**	**0.0**	**6.3**	**7.0**	**24.0**	**7.5**
AVERAGE			**7.3**	**411.1**	**4.3**	**0.1**	**0.0**	**163.8**	**0.1**	**0.8**	**0.3**	**141.6**	**0.0**	**0.0**	**0.0**	**8.2**	**7.0**	**37.1**	**1213.8**
MEDIAN			**6.0**	**429.5**	**4.5**	**0.1**	**0.0**	**167.2**	**0.0**	**0.8**	**0.3**	**146.8**	**0.0**	**0.0**	**0.0**	**7.7**	**7.0**	**32.5**	**1213.8**
MAXIMUM			**15.0**	**575.0**	**7.0**	**0.1**	**0.0**	**252.4**	**0.2**	**1.1**	**0.4**	**206.5**	**0.0**	**0.0**	**0.0**	**12.7**	**7.0**	**70.0**	**2420.0**

Laboratory analysis was completed by Metroplian Council Environmental Services
Grab Sample Duplicate
< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported
J - Result reported as estimated between the MDL and Reporting Limit (RL)
> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

BATTLE CREEK VOLUME AND POLLUTANT SUMMARY

Sampling Data

Event Time Interval: Start	Event Time Interval: End	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)
6/23/19 18:15	6/24/19 9:34	**4**	**575**	**3**	**0.11**	**0.006** J	**252.4**	**0.14**	**0.99**	**0.402** <
6/27/19 10:45	6/27/19 20:05	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
6/30/19 8:45	6/30/19 22:35	**6**	**475**	**3**	**0.11**	**0.008** J	**202.4**	**0.11**	**1.06**	**0.328** <
7/1/19 1:45	7/1/19 16:50	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
7/1/19 18:52	7/2/19 11:53	**3**	**206**	**2**	**0.08**	**0.024**	**69.7**	**0.19**	**0.75**	**0.423** <
7/9/19 15:45	7/9/19 21:45	**5**	**522**	**3**	**0.11**	**0.005** <	**196.2**	**0.03** J	**0.88**	**0.260** <
7/15/19 18:51	7/16/19 3:30	**8**	**498**	**4**	**0.12**	**0.005** <	**212.1**	**0.02** <	**0.92**	**0.305** <
7/17/19 13:45	7/17/19 18:45	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
7/20/19 9:00	7/20/19 19:33	**6**	**463**	**5**	**0.08**	*0.009*	**171.8**	**0.05** J	**0.97**	*0.307*
7/25/19 13:00	7/27/19 15:42	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
7/28/19 21:03	7/29/19 18:15	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
8/5/19 22:00	8/6/19 12:30	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
8/10/19 17:52	8/11/19 6:39	**15**	**504**	**7**	**0.10**	**0.005** <	**203.6**	**0.02** <	**0.93**	**0.260** <
8/13/19 17:58	8/14/19 8:39	**11**	**355**	**7**	**0.11**	**0.005** <	**138.7**	**0.02** <	**0.69**	**0.260** <
8/16/19 3:10	8/16/19 12:29	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
8/18/19 2:33	8/18/19 10:07	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
8/26/19 14:45	8/27/19 0:45	**6**	**376**	**5**	**0.05**	**0.005** <	**150.7**	**0.02** <	**0.64**	**0.260** <
9/2/19 23:00	9/3/19 15:45	**13**	**358**	**5**	**0.09**	**0.005** <	**135.9**	**0.02** <	**0.78**	**0.260** <
9/11/19 5:30	9/11/19 15:10	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
9/30/19 20:05	10/1/19 3:00	**8**	**396**	**5**	**0.07**	**0.007** J	**162.5**	**0.03** J	**0.78**	**0.260** <
10/1/19 12:00	10/2/19 0:20	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
10/2/19 14:35	10/2/19 23:20	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
10/5/19 6:15	10/5/19 22:00	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
10/10/19 22:35	10/11/19 12:15	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
10/15/19 3:15	10/15/19 12:25	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
10/21/19 7:45	10/21/19 19:15	*8*	*391*	*5*	*0.09*	*0.009*	*157.4*	*0.06*	*0.82*	*0.307*
Sum										
Average		7.08	429.77	4.45	0.09	0.01	172.35	0.06	0.85	0.30
Weighted Avg		8.00	390.62	4.53	0.09	0.009	157.43	0.06	0.82	0.31
STDEV		3.80	103.92	1.63	0.02	0.01	49.00	0.06	0.13	0.06
Min		3.00	205.50	2.00	0.05	0.01	69.65	0.02	0.64	0.26
Max		15.00	575.00	7.00	0.12	0.02	252.40	0.19	1.06	0.42

Event Loading and Volume Data

Start	End	Interval Rain (In.)	Flow Volume (cu-ft)	TSS (lbs.)	TDS (lbs.)	VSS (lbs.)	TP (lbs.)	Ortho-P (lbs.)	Chloride (lbs.)	Ammonia as N (lbs.)	Total Kjeldahl Nitrogen (lbs.)	Nitrate + Nitrite as N (lbs.)
6/23/19 18:15	6/24/19 9:34	0.16	617155.0	154.1	22153.4	115.6	4.2	0.231	9724.4	5.5	38.3	15.5
6/27/19 10:45	6/27/19 20:05	0.43	178441.2	89.1	4351.4	50.5	1.0	0.096	1753.7	0.7	9.1	3.4
6/30/19 8:45	6/30/19 22:35	0.52	286670.9	107.4	8500.7	53.7	1.9	0.143	3621.5	1.9	18.9	5.9
7/1/19 1:45	7/1/19 16:50	0.37	312741.3	156.2	7626.5	88.4	1.7	0.169	3073.6	1.3	15.9	6.0
7/1/19 18:52	7/2/19 11:53	0.73	1142323.0	213.9	14654.8	142.6	5.7	1.676	4966.9	13.2	53.1	30.1
7/9/19 15:45	7/9/19 21:45	0.21	154890.1	48.3	5047.5	29.0	1.1	0.048	1897.4	0.3	8.5	2.5
7/15/19 18:51	7/16/19 3:30	0.87	272683.9	136.2	8477.5	68.1	2.0	0.085	3610.1	0.3	15.7	5.2
7/17/19 13:45	7/17/19 18:45	0.03	157635.9	78.7	3844.1	44.6	0.9	0.085	1549.2	0.6	8.0	3.0
7/20/19 9:00	7/20/19 19:33	1.24	589106.6	220.7	17027.6	183.9	3.1	0.318	6317.5	1.8	35.7	11.3
7/25/19 13:00	7/27/19 15:42	0.13	2890919.7	1443.9	70497.5	817.5	15.6	1.562	28411.3	11.6	147.3	55.4
7/28/19 21:03	7/29/19 18:15	0.73	548310.1	273.9	13371.0	155.1	3.0	0.296	5388.7	2.2	27.9	10.5
8/5/19 22:00	8/6/19 12:30	0.03	73541.7	36.7	1793.4	20.8	0.4	0.040	722.8	0.3	3.7	1.4
8/10/19 17:52	8/11/19 6:39	0.66	801426.3	750.5	25215.8	350.2	5.0	0.250	10184.4	1.0	46.5	13.0
8/13/19 17:58	8/14/19 8:39	0.53	585375.4	402.0	12973.0	255.8	3.9	0.183	5066.8	0.7	25.3	9.5
8/16/19 3:10	8/16/19 12:29	1.26	984111.4	491.5	23998.4	278.3	5.3	0.532	9671.6	4.0	50.1	18.9
8/18/19 2:33	8/18/19 10:07	1.99	1150902.3	574.8	28065.7	325.5	6.2	0.622	11310.8	4.6	58.6	22.1
8/26/19 14:45	8/27/19 0:45	0.76	1054791.9	395.1	24759.0	329.2	3.4	0.329	9920.7	1.3	41.9	17.1
9/2/19 23:00	9/3/19 15:45	1.04	1028797.6	834.9	22992.8	321.1	5.5	0.321	8728.3	1.3	49.9	16.7
9/11/19 5:30	9/11/19 15:10	0.96	784668.1	391.9	19134.8	221.9	4.2	0.424	7711.6	3.2	40.0	15.0
9/30/19 20:05	10/1/19 3:00	0.07	529612.4	264.5	13092.8	165.3	2.4	0.231	5374.0	1.0	25.8	8.6
10/1/19 12:00	10/2/19 0:20	0.85	1360032.8	679.3	33165.6	384.6	7.3	0.735	13366.1	5.5	69.3	26.1
10/2/19 14:35	10/2/19 23:20	0.47	1079748.2	539.3	26330.6	305.3	5.8	0.583	10611.5	4.3	55.0	20.7
10/5/19 6:15	10/5/19 22:00	1.00	2109635.3	1053.7	51445.3	596.6	11.4	1.140	20733.0	8.5	107.5	40.4
10/10/19 22:35	10/11/19 12:15	0.36	1107142.2	553.0	26998.6	313.1	6.0	0.598	10880.8	4.5	56.4	21.2
10/15/19 3:15	10/15/19 12:25	0.26	640254.5	319.8	15613.2	181.1	3.5	0.346	6292.3	2.6	32.6	12.3
10/21/19 7:45	10/21/19 19:15	1.28	1170438.4	584.6	28542.1	331.0	6.3	0.632	11502.8	4.7	59.6	22.4
Sum		16.94	21611356	10794	529673	6129	116.7	11.7	212392	87.0	1100.9	414.3
Average			831206	415	20372	236	4.5	0.4	8169	3.3	42.3	15.9
Weighted Avg												
STDEV												
Min												
Max												

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling event

City of Saint Paul
2019 Water Quality and Quantity Report
Table C.11
WSB Project Number: 01610-100

SACKETT WATER QUALITY SUMMARY

LAB ID	Date Composite Sampling Started	Date Composite Sampling Ended	TSS (mg/L)	TDS (mg/L)	VSS (mg/L)	TP (mg/L)	Ortho-P (mg/L)	Chloride (mg/L)	Ammonia as N (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate + Nitrite as N (mg/L)	Hardness as CaCO3 (mg/L)	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Total Organic Carbon (mg/L)	pH	COD (mg/L)	E. Coli (MPN/ 100 mL)
2772694	6/4/2019 16:34	6/4/2019 23:22	74.0	127.0	27.0	0.33	0.047	17.8	0.19	1.77	0.741	52	0.0088	0.0075	0.04840	9.1656		66.0	
2774257	6/11/2019 11:30	6/11/2019 11:30															7.6		41
2779856	7/1/2019 1:59	7/1/2019 2:32	15.0	174.0	7.0	0.14	0.032	27.1	0.35	1.15	0.321 <	80	0.0077	0.0017	0.01880	11.6000		42.0	
2780349	7/1/2019 21:39	7/2/2019 1:09	42.0	76.0	13.0	0.15	0.038	9.9	0.05 J	0.74	0.336 <	37	0.0054	0.0064	0.02400	4.3000		29.0	
2782806	7/9/2019 16:59	7/9/2019 17:23	52.0	145.0	19.0	0.26	0.045	21.5	0.13	1.40	0.894	54	0.0095	0.0061	0.04100	12.1000		79.0	
2788600	7/26/2019 6:54	7/26/2019 7:46	288.0	206.5	107.0	1.05	0.224	31.6	0.92	4.50	1.295	105	0.0286	0.0228	0.17700	46.3000		282.0	
2789156	7/28/2019 20:14	7/28/2019 20:40	279.0	501.0	48.0	0.42	0.027	109.8	0.06 J	2.46	2.440 <	353	0.0130	0.0185	0.05790	8.9000		96.0	
2795572	8/13/2019 23:30	8/14/2019 0:10	59.0	170.5	18.0	0.20	0.048	35.4	0.02 J	0.85	0.816 <	84	0.0071	0.0067	0.03260	6.9000		49.0	
2797704	8/20/2019 10:00	8/20/2019 11:25	120.0	105.0	32.0	0.33	0.030	19.6	0.15	1.58	0.682 <	48	0.0114	0.0167	0.05890	7.9000		74.0	
2803134	9/8/2019 12:15	9/8/2019 12:45	15.0	618.5	7.0	0.18	0.017	144.0	0.02 <	0.89	2.744 <	468	0.0036	0.0016	0.01640	5.7762		28.0	
2803136	9/8/2019 12:16	9/8/2019 12:46	12.0	617.0	5.0	0.13	0.017	150.3	0.02 <	0.81	2.911 <	446	0.0034	0.0012	0.01280	5.7164		24.0	
2803900	9/11/2019 13:57	9/11/2019 13:57																	2420 >
2809942	10/1/2019 10:18	10/1/2019 10:18																	1046
2810907	10/2/2019 13:40	10/2/2019 16:17	41.0	180.0	14.0	0.21	0.055	40.4	0.02 <	0.75	0.669 <	109	0.0055	0.0046	0.02620	5.5000		43.0	
	10/21/2019 13:03	10/21/2019 13:03															7.3		
2817304	10/22/2019 4:16	10/22/2019 4:57	3.0	453.0	2.0 J	0.11	0.041	93.8	0.02 <	0.46	1.700 <	319	0.0021	0.0004 J	0.01260	5.7000		11.0 J	
MINIMUM			**3.0**	**76.0**	**2.0**	**0.1**	**0.0**	**9.9**	**0.0**	**0.5**	**0.3**	**37.1**	**0.0**	**0.0**	**0.0**	**4.3**	**7.3**	**11.0**	**40.7**
AVERAGE			**83.3**	**281.1**	**24.9**	**0.3**	**0.1**	**58.4**	**0.2**	**1.4**	**1.3**	**179.4**	**0.0**	**0.0**	**0.0**	**10.8**	**7.4**	**68.6**	**1169.0**
MEDIAN			**47.0**	**177.0**	**16.0**	**0.2**	**0.0**	**33.5**	**0.1**	**1.0**	**0.9**	**94.4**	**0.0**	**0.0**	**0.0**	**7.4**	**7.4**	**46.0**	**1046.2**
MAXIMUM			**288.0**	**618.5**	**107.0**	**1.1**	**0.2**	**150.3**	**0.9**	**4.5**	**2.9**	**467.8**	**0.0**	**0.0**	**0.2**	**46.3**	**7.6**	**282.0**	**2420.0**

Laboratory analysis was completed by Metroplian Council Environmental Services

Grab Sample | Duplicate

< - Analyte not detected above the Method Detection Limit (MDL), MDL value reported

J - Result reported as estimated between the MDL and Reporting Limit (RL)

> - Analyte exceeded the maximum dection level (was not fully diluted prior to analysis)

SACKETT PARK VOLUME AND POLLUTANT SUMMARY

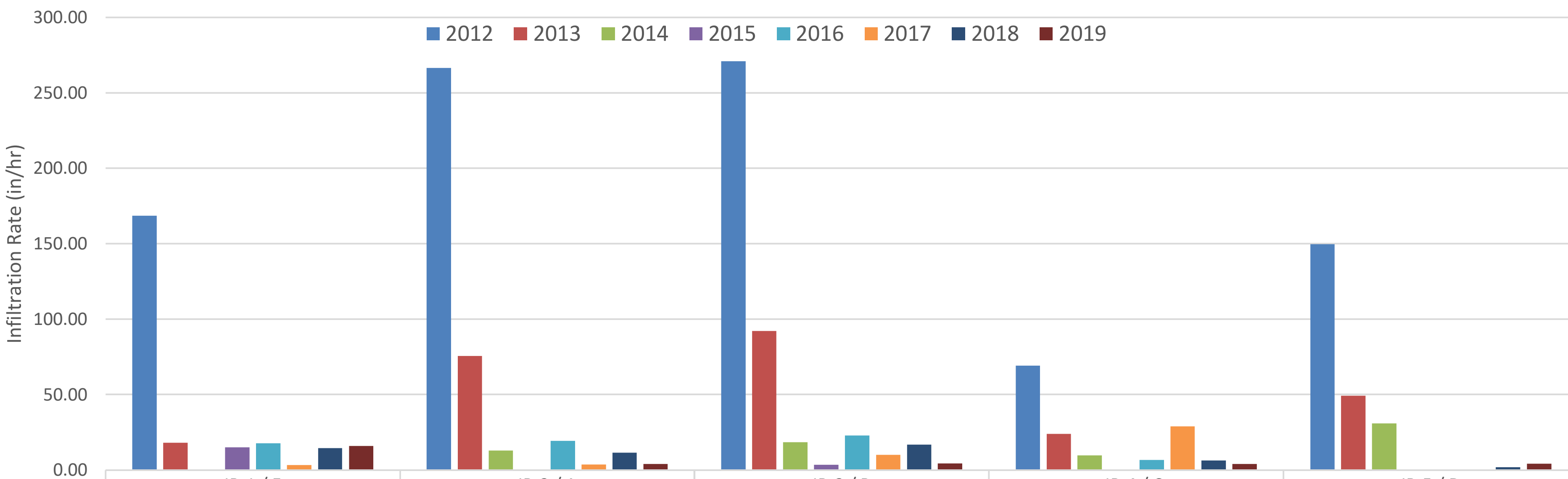
Event Time Interval		Sampling Data												Event Loading and Volume Data										
		TSS	TDS	VSS		TP	Ortho-P	Chloride	Ammonia as N		Total Kjeldahl Nitrogen	Nitrate + Nitrite as N		Interval Rain	Flow Volume	TSS	Captured TDS	VSS	TP	Ortho-P	Chloride	Captured Ammonia as N	Kjeldahl Nitrogen	Nitrate + Nitrite as N
Start	End	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L		mg/L	mg/L		In.	cu-ft	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
6/4/19 16:30	6/5/19 0:15	74	127	27		0.33	0.047	17.8	0.19		1.77	0.741		0.16	35394.9	163.5	280.6	59.7	0.73	0.104	39.33	0.43	3.90	1.64
6/11/19 12:15	6/11/19 17:30	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.13	8075.5	34.5	86.5	11.1	0.13	0.026	16.67	0.06	0.61	0.40
6/20/19 16:15	6/20/19 22:30	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.08	7053.1	30.1	75.6	9.7	0.11	0.023	14.56	0.05	0.53	0.35
6/23/19 2:26	6/23/19 2:45	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.04	1729.8	7.4	18.5	2.4	0.03	0.006	3.57	0.01	0.13	0.08
6/23/19 16:51	6/23/19 20:00	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		1.26	28464.6	121.6	305.1	39.1	0.46	0.092	58.74	0.22	2.15	1.39
6/23/19 23:30	6/24/19 3:45	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.21	21108.5	90.2	226.2	29.0	0.34	0.068	43.56	0.16	1.60	1.03
6/27/19 10:11	6/27/19 13:30	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.42	21283.6	91	228	29	0.34	0.069	43.92	0.16	1.61	1.04
6/30/19 8:11	6/30/19 10:00	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.13	4993.8	21	54	7	0.08	0.016	10.31	0.04	0.38	0.24
6/30/19 13:15	6/30/19 15:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.4	34895.2	149	374	48	0.57	0.113	72.01	0.27	2.64	1.71
7/1/19 1:00	7/1/19 3:45	15	174	7		0.14	0.032	27.1	0.35		1.15	0.321	<	0.18	10139.2	9	110	4	0.09	0.020	17.18	0.22	0.73	0.20
7/1/19 5:15	7/1/19 8:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.19	13398.5	57	144	18	0.22	0.043	27.65	0.10	1.01	0.66
7/1/19 18:15	7/1/19 20:30	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.09	8021.3	34	86	11	0.13	0.026	16.55	0.06	0.61	0.39
7/1/19 21:30	7/2/19 6:00	42	76	13		0.15	0.038	9.9	0.05	J	0.74	0.336	<	0.61	76448.1	200	363	62	0.70	0.181	47.01	0.24	3.52	1.60
7/4/19 15:06	7/4/19 16:30	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.04	5472.9	23	59	8	0.09	0.018	11.29	0.04	0.41	0.27
7/9/19 15:15	7/9/19 18:15	52	145	19		0.26	0.045	21.5	0.13		1.40	0.894		0.21	14924.4	48	135	18	0.24	0.042	19.98	0.12	1.30	0.83
7/20/19 8:30	7/20/19 14:30	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		1.24	80948.5	346	868	111	1.31	0.261	167.06	0.63	6.12	3.96
7/26/19 6:56	7/26/19 9:15	288	207	107		1.05	0.224	31.6	0.92		4.50	1.295		0.14	16642.6	299	215	111	1.09	0.233	32.83	0.96	4.67	1.35
7/28/19 9:56	7/28/19 12:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.53	36008.4	154	386	50	0.58	0.116	74.31	0.28	2.72	1.76
7/28/19 20:00	7/28/19 20:39	279	501	48		0.42	0.027	109.8	0.06	J	2.46	2.440	<	0.15	4136.2	72	129	12	0.11	0.007	28.35	0.02	0.64	0.63
8/5/19 13:45	8/5/19 14:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.02	110.3	0	1	0	0.00	0.000	0.23	0.00	0.01	0.01
8/10/19 16:45	8/10/19 20:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.66	31216.8	133	335	43	0.51	0.101	64.42	0.24	2.36	1.53
8/13/19 17:00	8/13/19 21:00	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.42	24717.7	106	265	34	0.40	0.080	51.01	0.19	1.87	1.21
8/13/19 23:30	8/14/19 2:15	59	171	18		0.20	0.048	35.4	0.02	J	0.85	0.816	<	0.07	22660.0	83	241	25	0.28	0.068	50.13	0.03	1.21	1.15
8/14/19 3:00	8/14/19 5:00	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.02	9949.6	42	107	14	0.16	0.032	20.53	0.08	0.75	0.49
8/15/19 20:06	8/15/19 21:51	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.26	13086.0	56	140	18	0.21	0.042	27.01	0.10	0.99	0.64
8/16/19 0:30	8/16/19 7:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.98	51035.3	218	547	70	0.83	0.165	105.32	0.39	3.86	2.50
8/18/19 1:45	8/18/19 8:00	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		1.99	93504.4	399	1002	129	1.52	0.302	192.97	0.72	7.07	4.57
8/20/19 10:00	8/20/19 13:30	120	105	32		0.33	0.030	19.6	0.15		1.58	0.682	<	0.4	41386.9	310	271	83	0.84	0.078	50.59	0.40	4.09	1.76
8/26/19 13:56	8/26/19 18:45	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.75	60891.3	260	653	84	0.99	0.196	125.66	0.47	4.61	2.98
8/27/19 14:00	8/27/19 16:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.09	16095.0	69	172	22	0.26	0.052	33.22	0.12	1.22	0.79
9/1/19 10:56	9/1/19 14:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.14	20347.4	87	218	28	0.33	0.066	41.99	0.16	1.54	1.00
9/2/19 22:41	9/3/19 0:16	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		1.00	18745.7	80	201	26	0.30	0.060	38.69	0.14	1.42	0.92
9/8/19 11:15	9/8/19 17:00	15	619	7		0.18	0.017	144.0	0.02	<	0.89	2.744	<	0.08	9982.0	9	385	4	0.11	0.011	89.72	0.01	0.55	1.71
9/9/19 12:15	9/10/19 2:00	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.17	35736.1	153	383	49	0.58	0.115	73.75	0.28	2.70	1.75
9/11/19 4:15	9/11/19 7:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.8	16046.0	69	172	22	0.26	0.052	33.11	0.12	1.21	0.78
9/11/19 10:34	9/11/19 12:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.15	5883.7	25	63	8	0.10	0.019	12.14	0.05	0.45	0.29
9/12/19 3:45	9/12/19 11:15	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.95	45235.1	193	485	62	0.73	0.146	93.35	0.35	3.42	2.21
9/18/19 6:45	9/18/19 10:23	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.12	11819.9	50	127	16	0.19	0.038	24.39	0.09	0.89	0.58
9/21/19 5:06	9/21/19 12:00	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.07	17163.9	73	184	24	0.28	0.055	35.42	0.13	1.30	0.84
9/25/19 9:15	9/25/19 13:45	68	172	22		0.26	0.105	10.8	0.12		1.21	0.784		0.09	6302.3	27	68	9	0.10	0.041	4.24	0.05	0.48	0.31
9/29/19 4:45	9/29/19 16:15	68	172	22		0.26	0.105	10.8	0.12		1.21	0.784		0.23	31310.4	134	336	43	0.51	0.205	21.07	0.24	2.37	1.53
9/30/19 19:56	10/1/19 3:20	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.07	25778.1	110	276	35	0.42	0.083	53.20	0.20	1.95	1.26
10/1/19 14:59	10/1/19 21:07	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.79	86238.3	368	924	119	1.40	0.278	177.97	0.67	6.52	4.22
10/2/19 13:41	10/3/19 6:45	41	180	14		0.21	0.055	40.4	0.02	<	0.75	0.669	<	0.47	78159.6	200	878	68	1.00	0.268	196.93	0.10	3.66	3.26
10/5/19 4:37	10/5/19 16:04	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.95	136476.5	583	1463	188	2.21	0.440	281.65	1.05	10.33	6.68
10/10/19 20:30	10/11/19 6:00	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		0.33	61813.1	264	662	85	1.00	0.199	127.57	0.48	4.68	3.02
10/12/19 20:30	10/13/19 0:30	68	172	22		0.26	0.105	10.8	0.12		1.21	0.784		0.05	6308.8	27	68	9	0.10	0.041	4.25	0.05	0.48	0.31
10/15/19 2:45	10/15/19 3:25	68	172	22		0.26	0.105	10.8	0.12		1.21	0.784		0.24	17693.0	76	190	24	0.29	0.116	11.91	0.14	1.34	0.87
10/21/19 7:21	10/21/19 15:23	68	172	22		0.26	0.052	33.1	0.12		1.21	0.784		1.27	173742.8	742	1862	239	2.82	0.560	358.56	1.34	13.14	8.50
10/22/19 4:15	10/22/19 11:43	3	453	2	J	0.11	0.041	93.8	0.02	<	0.46	1.700	<	0.24	17776.9	3	503	2	0.12	0.046	104.13	0.02	0.51	1.89
Sum														20.08	1616352	6903	17322	2222	26.2	5.42	3250.1	12.5	122.3	79.1
Average		90	251	27		0.31	0.055	50	0		2	1			32327	138	346	44	0.5	0.11	65.0	0.2	2.4	1.6
Weighted Avg		68	172	22		0.26	0.052	33.1	0.12		1.21	0.78												
STDEV		101	183	30		0.26	0.057	45	0		1	1												
Min		3	76	2		0.11	0.017	10	0		0	0												
Max		288	619	107		1.05	0.224	144	1		4	3												

< Sample was not detected above the method detection limit (value reported)
GREY FONT Events with no sampling data (weighted average concentration used)
BOLD Sampling event

Appendix D – Pervious Pavement Infiltration Charts

City of Saint Paul
2019 Water Quality and Quantity Report
Chart D.1
WSB Project No.: 01610-100

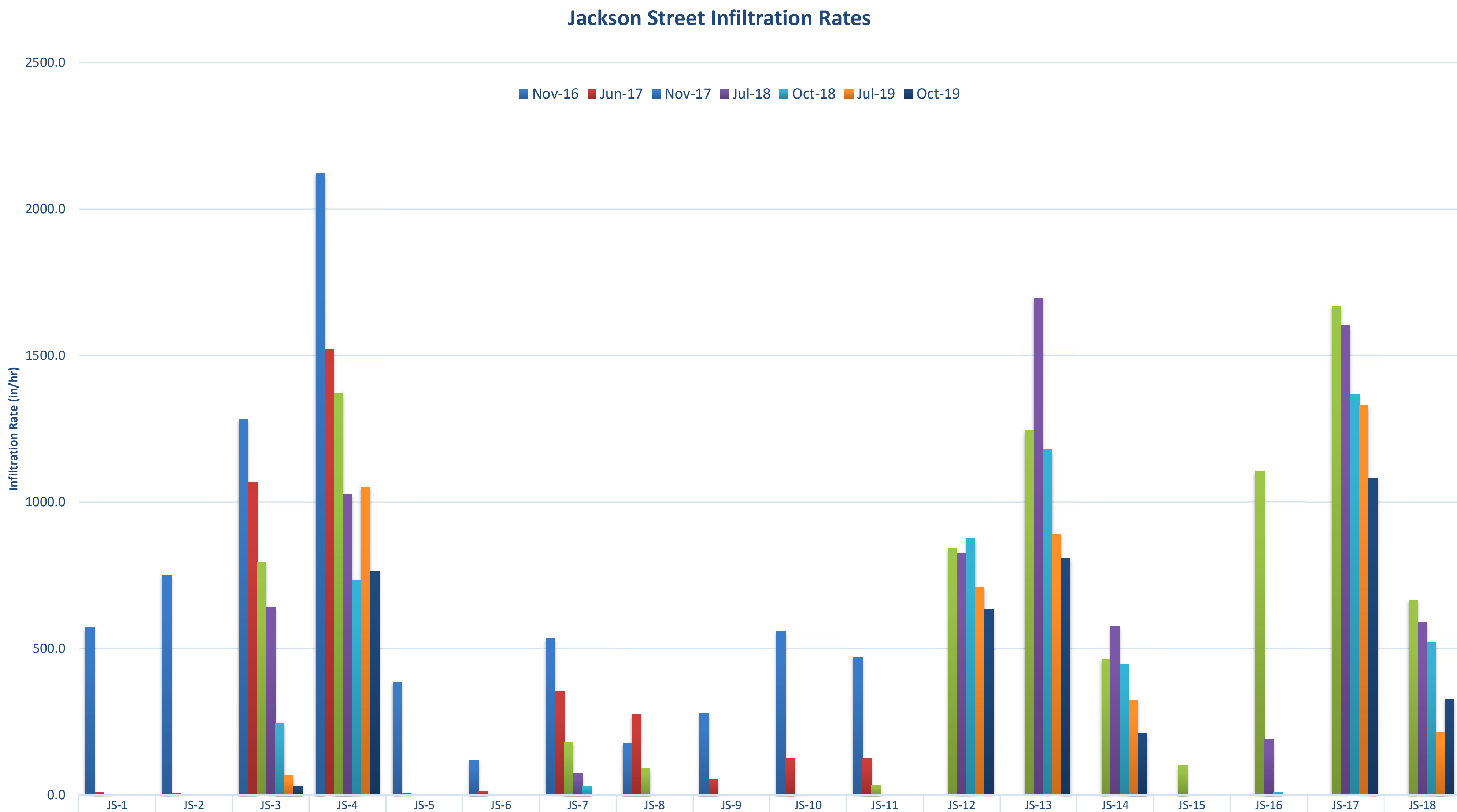
Victoria Street Infiltration Rates



	IR-1 / E	IR-2 / A	IR-3 / B	IR-4 / C	IR-5 / D
2012	168.60	266.60	271.10	69.10	149.80
2013	18.10	75.70	92.20	24.00	49.20
2014	0.00	12.93	18.56	9.72	30.81
2015	15.11	0.00	3.44	0.00	0.00
2016	17.77	19.38	22.97	6.55	0.00
2017	3.41	3.78	10.05	28.91	0.00
2018	14.51	11.47	16.92	6.25	1.92
2019	15.89	4.06	4.35	4.03	4.21

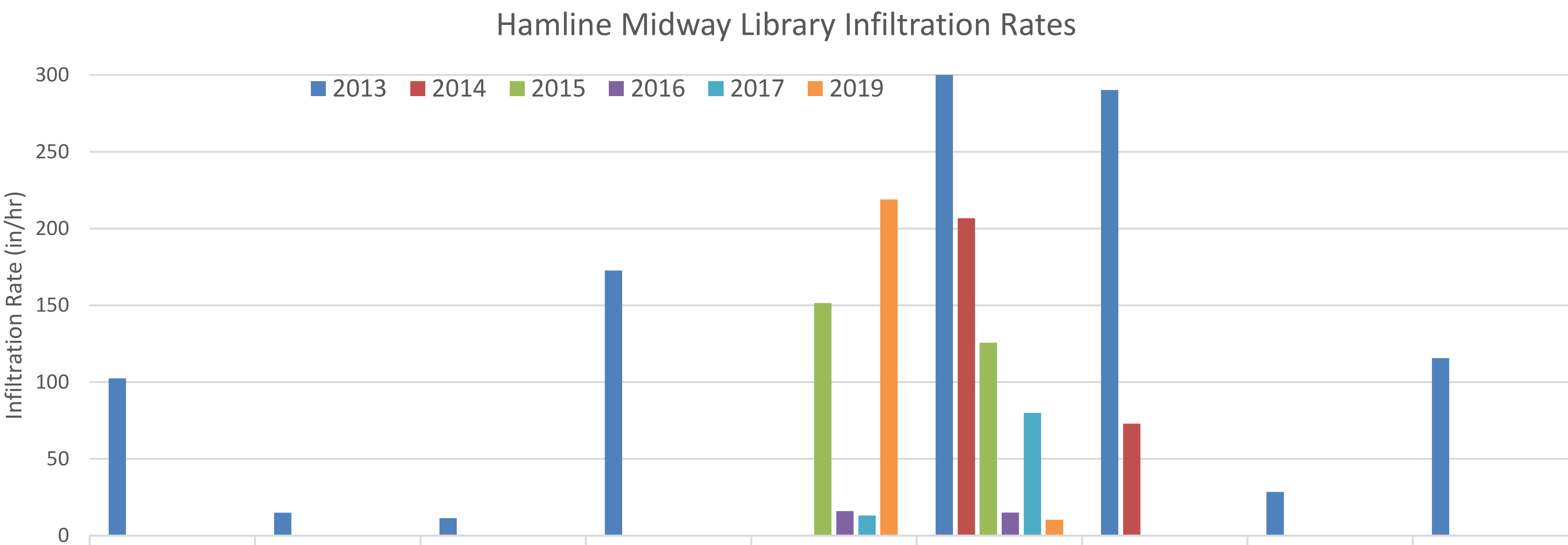
Monitoring Location

City of Saint Paul
2019 Water Quality and Quantity Report
Chart D.2
WSB Project No.: 01610-100



	JS-1	JS-2	JS-3	JS-4	JS-5	JS-6	JS-7	JS-8	JS-9	JS-10	JS-11	JS-12	JS-13	JS-14	JS-15	JS-16	JS-17	JS-18
Nov-16	572.6	750.4	1282.1	2122.2	385.9	118.7	533.7	177.5	277.9	557.9	471.5							
Jun-17	9.3	6.3	1069.0	1520.1	4.5	12.1	353.9	275.3	56.1	125.5	125.4							
Nov-17	3.9	0	793.8	1372.0	0	0	181.7	90.8	2.4	2.1	35.5	843.3	1246.7	464.4	100.0	1104.4	1670.0	665.4
Jul-18	0	0	642.2	1026.7	0	0	73.7	0	0	0	0	827.2	1696.9	575.1	0	190.1	1605.0	589.6
Oct-18	0	0	247.1	733.7	0	0	29.4	0	0	0	0	877.1	1179.2	447.5	0	9.0	1369.7	521.5
Jul-19	0	0	67.065	1050.08	0	0	0	0	0	0	0	710.515	889.485	323.255	0	0	1329.45	215.695
Oct-19	0	0	30.35	764.415	0	0	0	0	0	0	0	633.28	809.615	211.395	0	0	1082.13	327.7

City of Saint Paul
2019 Water Quality and Quantity Report
Chart D.
WSB Project No.: 01610-100



	IR-1	IR-2	IR-3	IR-4	IR-5	IR-6	IR-7	IR-8	IR-9
2013	102.4	14.9	11.4	172.7	0	1125.3	290.2	28.4	115.6
2014	0	0	0	0	0	206.7	73	0	0
2015	0	0	0	0	151.5	125.6	0	0	0
2016	0	0	0	0	16	15	0	0	0
2017	0	0	0	0	13.11	79.89	0	0	0
2019	0.00	0.00	0.00	0.00	218.96	10.30	0.00	0.00	0.00

Monitoring Location

Appendix E – Photolog

Beacon Bluff Rain Garden Dredge Damage - 5/13/19

Beacon Bluff 5/13/19

Beacon Bluff 8/5/19

Beacon Bluff OCS 10/21/19

West Pond Outlet 10/21/19

Beacon Bluff 11/19/19

Hampden Park 11/19/19

Saint Albans 8/29/19

Saint Albans – 11/19/19

Sackett Park 5/24/19



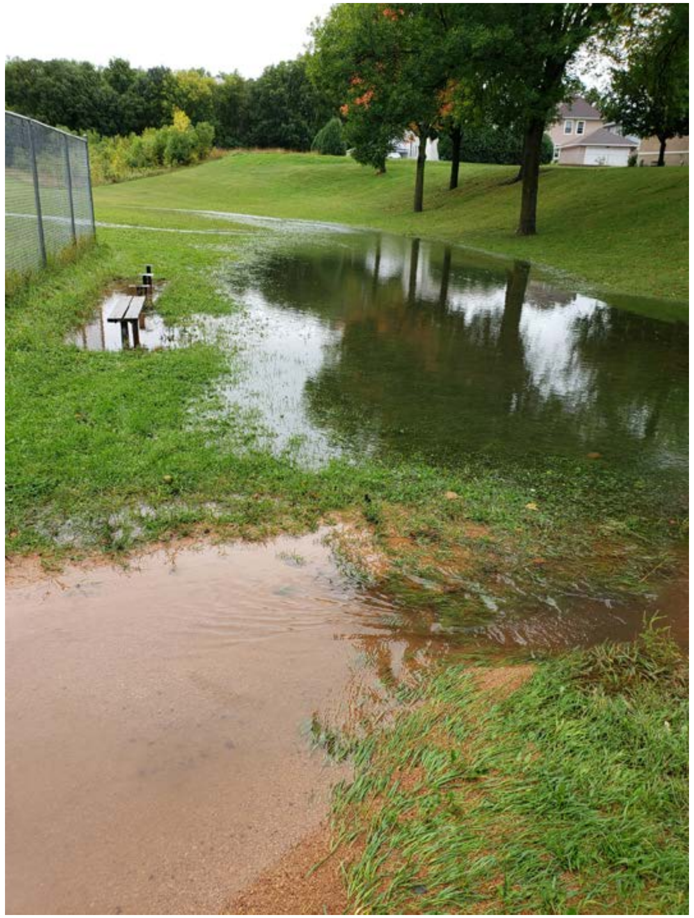

Sackett Park 5/24/19

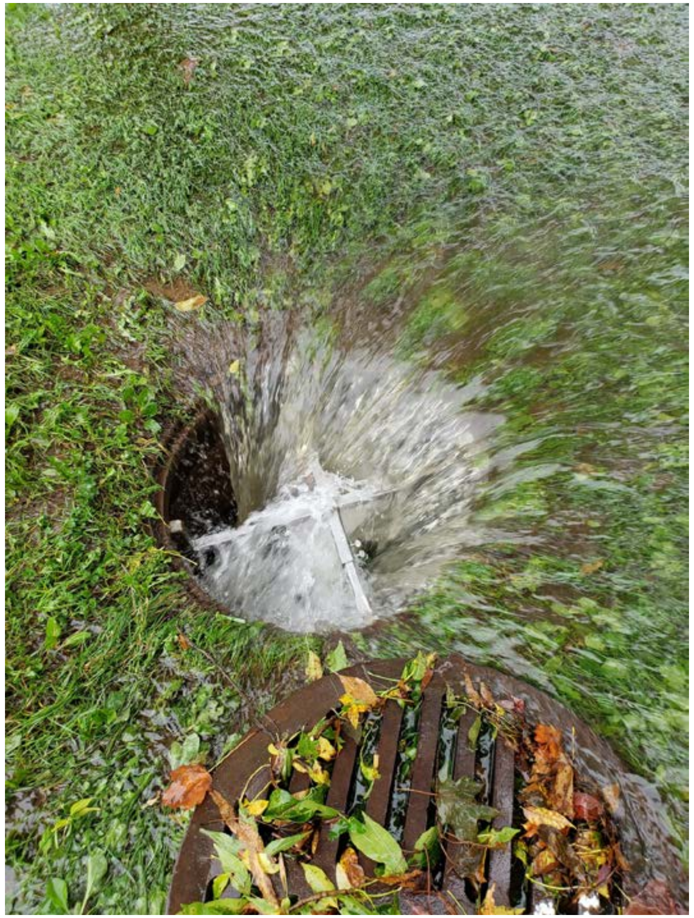
Sackett Playground Rain Event 9/11/19

Sackett Playground Rain Event 9/11/19

Sackett Playground Rain Event 9/11/19

Sackett Park Rain Event 9/18/19





Sackett Playground Rain Even 9/18/19

Sacket Playground 10/21/19

Battle Creek 6/20/19

Battle Creek Rain Event 10/21/19

Saint Albans 8/29/19

Saint Albans 11/19/19

Victoria 5/29/19

Victoria 8/29/19

Victoria 11/19/19

Appendix F – 2017 Monitoring Protocols

STORMWATER MONITORING PROTOCOL

2019 Stormwater Monitoring Program
Field Standard Operating Procedures

FOR THE CITY OF
ST. PAUL, MINNESOTA

SAINT PAUL
The Most Livable City in America

wsb

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Attachments:

WSB Confined Space Entry Permit

Metropolitan Council Environmental Services Laboratory Chain-of-Custody (BMP Infiltration Sites)

I. Objectives

This section provides a summary of objectives for this monitoring effort. These objectives are presented in question form anticipating that the answers will be obtained through analysis of the data collected as part of this monitoring program.

a) How do team members maintain a safe work environment?

b) How much stormwater runoff volume reduction is achieved by each BMP on an event and annual basis?

c) What is the average measured infiltration rate of each BMP?

d) How often does each BMP require maintenance?

e) How many volume reduction credits are available at each BMP? Do they perform in accordance with or exceed watershed district rules?

f) What is the cost per cubic-foot of volume reduction actually being achieved by each BMP?

g) What is the mass of pollutants (TP, TSS, chlorides, etc.) removed from the stormwater system by each BMP on an average annual basis?

II. Safety Overview

The following safety guidelines have been developed to ensure that all WSB team members are providing and maintaining a safe work environment. Proper planning and situational awareness can help team members identify and eliminate potentially dangerous situations. Every team member has stop work authority if they feel endangered by unsafe working conditions. All team members are encouraged to report unsafe acts or unsafe working conditions to their supervisor as soon as possible. The following sections describe potentially hazardous working conditions and hazard mitigation procedures.

II.1 Adverse Weather Conditions:

Field team members will likely encounter a wide range of weather conditions during field duties. Field staff should be aware of the weather conditions and take proper measures to protect themselves from the elements.

- During excessive heat and sun conditions, field staff should stay hydrated, don skin protective clothing, and apply sunscreen .During excessive cold conditions, field staff should dress in layers and avoid perspiration
- During lightning producing conditions, field staff must seek shelter in a work vehicle or other safe location if a lightning strike or thunder is observed. The field staff should wait at least 30 minutes from the last lightning strike before resuming outdoor activities. Lightning safety is especially important due to the likelihood of thunderstorms during stormwater sampling events
- Field staff should be aware of the signs of heat exhaustion, heat stroke, hypothermia, and frostbite, and have an understanding of basic first aid procedures

II.2 Working in the street:

At times, it will be necessary for team members to access manholes in roadways.

- While working in roadways, field staff should be visible to traffic, don reflective vests and hardhats, and utilize vehicle hazard lights
- Field staff should park close to the manhole and encompass work area with safety cones
- Field staff should be aware of any unauthorized entry into the work area by untrained personnel or the public

II.3 Confined Space Entry[1]

Only staff with OSHA Confined Space Entry training can complete a confined space entry. When entry to confined spaces is required for monitoring activities, the following checklist must be reviewed and adhered to:

Permits/Notifications:

- Execute a confined space entry permit form and follow appropriate protocols (**Confined Space Entry Permit Attached**). See WSB's safety office, Trent Noeker, for a copy of the form
- Obtain a no fee lane use right-of-way permit if work is to be done in the street:
    - St. Paul ROW: 651-266-6151

[1] Review Entering and Working in Confined Spaces, Confined Space Entry Program for WSB & Associates, Inc. for WSB's confined space entry protocols prior to entering a confined space.

- ☐ Notify City staff
    - St. Paul Sewer Maintenance: 651-266-9836
- ☐ Notify local fire department of planned confined space entry

Required Safety Gear:

- ☐ Hard hat
- ☐ Sturdy boots
- ☐ Reflective safety vest
- ☐ 4-Gas Monitor
- ☐ Tripod
- ☐ 3-way lifeline winch
- ☐ Body harness
- ☐ Air ventilation blower and generator
- ☐ 28" reflective traffic cones and vehicle hazard lighting

Gear Maintenance:

- ☐ **Calibrate 4-gas monitor every 180 days:** The 4-gas monitor will indicate when calibration is needed. Viking Safety Products will calibrate the device free of charge. Call Viking for more information: 651-646-6374.
- ☐ **Inspect the tripod for wear and damage annually:** Viking Safety Products will inspect the equipment and provide a formal certificate of inspection. Call Viking for more information: 651-646-6374

General Confined Space Entry Procedures:

- ☐ Never complete a confined space entry during a rain event. Check the weather forecast and ensure clear conditions for the duration of the entry.
- ☐ Prior to leaving the office, confirm all equipment is functioning and that monitoring equipment is in compliance with the calibration schedule.
- ☐ Secure the area from untrained personnel and pedestrians.
- ☐ Ensure team members are knowledgeable of the roles and responsibilities of the confined space entrant, attendant, and supervisor.
- ☐ Complete air monitoring prior to, and for the duration of the confined space entry. Ensure team members are knowledgeable of the 4-gas monitor alarms and unsafe gas levels that prompt an evacuation of the confined space.
- ☐ Utilize a rope and bucket to deliver equipment to the entrant.
- ☐ Ensure there is a reliable method of communication between all team members completing the confined space entry.

III. Monitoring Sites

Below is a summary of sites which are included in this monitoring effort. Equipment and methods used and monitoring parameters analyzed for each site are provided for quick reference. (See Figures for site locations and monitoring configuration.)

III.1 Beacon Bluff:

This site consists of an infiltration basin situated over the top of an underground infiltration pipe gallery system. Stormwater flows into the infiltration basin from three storm sewer outfalls and into the underground chambers from a single storm sewer pipe. An outlet pipe connected directly to the underground chambers conveys overflow back to the storm sewer when the system reaches capacity.

Equipment:

3 – ISCO 2150 Area velocity sensors (Upstream, Downstream, WPO)
5 – System Level Loggers
- BMP Pipe
- OCS
- BaroTroll (atmospheric logger)

2 – Rugged Troll 100
- GW-50
- GW-53

1 – ISCO 6712 Portable Water Quality Sampler

Monitoring Parameters:

- Rainfall
- Flow Rate/Volume
- Water Level/Infiltration rate
- Water Quality **(NPDES Permit Required Parameters)**

III.2 Battle Creek:

Battle Creek flow from Battle Lake, passing through residental areas of Maplewood and St. Paul before it empties into Pigs Eye Lake. Water flows into a 72” arch pipe and daylights on the west side of McKinght Road. The sensor is located on the east side of McKight Road near the inlet into the storm sewer system.

Equipment:

1 – ISCO 2150 Area Velocity Sensors (72” Arch Pipe)
1 – Level Troll 500
- Battle Creek

1 – ISCO 712 Portable Water Quality Sampler

Monitoring Parameters:

- Rainfall
- Flow Rate/Volume

- Water Level
- Water Quality **(NPDES Permit Required Parameters)**

III.3 St. Albans:

The St. Albans Street infiltration system was constructed in 2010 to provide volume reduction along the Central Corridor. The system was constructed in an offline configuration. When the system reaches its storage capacity, water stops flowing into the system and continues through the storm sewer. The system includes a pretreatment structure which consists of box culvert sections and baffled weirs to provide skimming and settling of runoff prior to entering the infiltration chamber.

<u>Equipment:</u>

3 – ISCO 2150 Area Velocity Sensors (Upstream, Downstream)
1 – ISCO 6712 Portable Water Quality Sampler
1 - Level Troll 500
BMP Pipe

<u>Monitoring Parameters:</u>

- Rainfall
- Flow Rate/Volume
- Water Level/Infiltration Rate
- Water Quality **(NPDES Permit Required Parameters)**

III.4 Sackett Playground:

Sackett Playground consists of ball fields and a roughly 6 acre wooded area containing a flood plain that takes stormwater from Flandrau and Case Street. Water not infiltrated in the flood plain is conveyed from an outlet structure underneath a ball field through a 42” round pipe towards Ames Avenue.

<u>Equipment:</u>

1 - Level Troll 500
OCS Structure in floodplain
1 – ISCO 2150 Area Velocity Sensor (48” pipe)
1 – ISCO 6712 Portable Water Quality Sampler

<u>Monitoring Parameters:</u>

- Rainfall
- Water Level/Infiltration Rate
- Flow Rate/Volume
- Water Quality **(NPDES Permit Required Parameters)**

III.5 Hampden Park

The Hampden Park infiltration gallery was constructed in 2014. The system consists of eight parallel perforated pipes that are five feet in diameter and range in length from 40 to 100 feet. Runoff is routed to the pretreatment system via a 24" RCP from main storm sewer near Hampden and Raymond Avenues. From that location, stormwater enters a pretreatment structure which consists of a box culvert section and baffled weir to provide skimming and settling of runoff prior to entering the infiltration chamber. The infiltration gallery receives flow from a second inlet location along Raymond Avenue, farther to the north. When the system reaches full capacity, stormwater is routed back to the storm sewer via a 24" pipe from the southeast side of the system.

Equipment:

1 – ISCO 2150 Area Velocity Sensor (Upstream)
1 – ISCO 6712 Portable Water Quality Sampler
1 – Rugged Troll 100
BMP

Monitoring Parameters:

- Rainfall
- Water level/Infiltration rate
- Flow Rate
- Water Quality **(NPDES Permit Required Parameters)**

III.6 Victoria Street

This site was constructed in an offline configuration. Flow is diverted from the main storm sewer to the system. When the system has reached its storage capacity, water stops flowing into the system and continues through the storm sewer. The system includes a pretreatment structure which consists of a box culvert section and a baffled weir to provide skimming and settling of runoff prior to entering the infiltration chamber. A permeable paver parking area is located above this system and discharges filter stormwater into it via an 8-inch drain tile.

Equipment (Complete set at each of the three ponds) :

2 – ISCO 2150 Area velocity sensors (Upstream and Downstream)
1 – ISCO 6712 Portable Water Quality Sampler
1 – Rugged Troll 100
BMP

Monitoring Parameters:

- Rainfall
- Water Level
- Flow Rate
- Water Quality **(NPDES Permit Required Parameters)**

IV. Preparation and Logistics

Preparedness is crucial to successful implementation of this monitoring program. Anticipation of target storm events, readiness with field equipment, and understanding of confined space entry procedures play a role in this process. This section provides essential information related to these items.

IV.1 Storm Selection Criteria for Water Quality Sampling

The activities below should be completed at least weekly to determine the potential need to prepare sampling equipment and mobilize crews to undertake water quality samplings:

- ☐ Track storms using local ALERT systems and by accessing National Weather Service forecasts: www.nws.noaa.gov
- ☐ Determine Quantity of Precipitation Forecast (QPF) for an impending storm
- ☐ If QPF is greater than 0.1-inches initiate sample collection preparation procedures (see **Section VI**)

IV.2 Portable Sampler (ISCO 6712) Preparation

This is to be done after all sampling events and or when receive a low battery alarm.

- ☐ Change out samples bottles in automated sampler with clean bottles
- ☐ Reset automated sampler for a new event. Update the sample flow volume interval if more or less samples need to be collected based on lab requirements, storm event size, or modification to protocols
- ☐ Ensure that batteries are adequately charged and positioned
- ☐ Make sure clean grab sample bottles are on hand

V. Visual Inspection and Manual Data Collection

Routine BMP inspections conducted on a visual basis will provide information related to specific maintenance needs and provide information that may be pertinent to any anomalies in the water quality sampling results. Additionally, the pervious pavement infiltration studies will consist of manual data collection in accordance with ASTM method C1701. The following section provides field guidance for those tasks.

Infiltration SystemsFrequency:

- Once per month

Visual Inspection:

- Identify significant obstructions present in the source pipes
- Indicate whether there is standing water in the infiltration system
- Indicate whether there is evidence of illicit discharges
- Identify any structural issues in the system
- Describe other observations
- Sketch inspection observations as appropriate

Manual Data Collection:

- Take digital photos of all visual inspection parameters
- Quantify the amount of sediment present in the system's:
  - Sump manhole
  - Pretreatment device
  - Stormwater storage area
- Quantify the amount of floatables present in the system's:
  - Sump manhole
  - Pretreatment device
  - Stormwater storage area

Required Equipment:

- Measuring rod
- Digital camera

Required Forms:

- Infiltration BMP Inspection and Maintenance Form

V.1 Pervious Pavement Infiltration Tests

Frequency:

- Once per year

Visual Inspection:

- Identify number and location of missing pavers (if present)
- Identify significant cracking, chips, or other damage
- Identify location and approximate depth of deflection

Manual Data Collection:

- Take digital photos of all visual inspection parameters
- Record depth of aggregate at six (6) locations (if pavers)
- Measure infiltration rate in six (6) locations
  - Follow the modified ASTM method C1701
  - Locations should be marked by a drill hole or a nail so that the same locations can be tested each time
  - 3 locations should be within 1 foot of the concrete strip separating the permeable surface from the roadway

Equipment:

- Infiltration measurement apparatus
- Water tank and feeder hose
- Digital camera
- Scale
- 12” PVC Pipe
- Plumbers putty

Required Forms:

- Permeable paver inspection form

Monitoring Parameters:

- Infiltration rate
- BMP visual inspection

VI. Sample Collection, Preservation, and Laboratory Analysis

The following procedures must be followed to maintain a consistent approach for obtaining composite water quality samples and to reduce the risk of cross contamination when retrieving and transporting samples to the laboratories:

VI.1 Composite Sampling Using Automated Sampler:

Estimating pollutant loads as part of this monitoring program will include determination of the event mean concentration (EMC) for the target storm events using composite samples. To obtain composite samples that are representative of the storm events analyzed, the following minimum number of aliquots and percent capture values should be met:

Total Event Precipitation (in.)	Minimum Acceptable Number of Aliquots	Percent Capture Requirement[2]
0 – 0.25	6	85
0.25 – 0.50	8	80
0.50 – 1.0	10	80
> 1.0	12	75

To meet these requirements the automatic samplers should be programmed to collect samples at flow-paced intervals. Determination of the flow volume between sampling events should be based on the following information:

Total Event Precipitation (in.)	Robie Street Outfall	Beacon Bluff
	Runoff Volume (cu-ft)	Runoff Volume (cu-ft)
0.10-0.15"	30,840	4,500
0.25"	51,400	20,986
0.5"	102,800	63,000
1.0"	205,600	156,756
2.0"	411,200	373,550
3.0"	616,800	657,879

<u>Program Automated Sampling Parameters:</u>

Based on the information above and other considerations, the following provides the parameters that should be used for programming the automated samplers:

- **Start Time:** Begin sampling at specific water level depths
  - Hampden Park: 0.75-inches
  - Beacon Bluff: 1.25-inches
  - Saint Albans: 1.1-inches

[2] $Percent\ storm\ capture = \frac{flow\ volume\ that\ passed\ during\ sample\ collection}{total\ flow\ that\ passed\ during\ the\ entire\ monitoring\ event}$

- Victoria: 1.15-inches
- Sackett: 3.5-inches
- Battle Creek: 4-inches

- **Pacing:** Set sampler to collect samples at constant flow volume intervals
  - Beacon Bluff: minimum 1,500 cu-ft
  - Saint Albans: 200 cu-ft
  - Victoria: 175 cu-ft
  - Hampden Park: 300 cu-ft
  - Sackett: 250 cu-ft
  - Battle Creek: 1,500 cu-ft
- **Distribution:** Multiple samples per bottle - sample aliquot volume should be no less than 200 mL

Multiple bottles will be collected for each event. The testing laboratory should be directed to develop a composite sample with the collection of bottles by either batch mixing or by combining equal fractions of each bottle into a single bottle or container.

VI.2 Grab Sample Collection

Grab samples will be collected for E coli analysis at all monitoring locations Samples will be collected from the influent stormwater stream prior to entering the systems. The purpose of E. coli analysis is to ensure that human effluent is not contaminating the water. The following provides the process for obtaining the grab samples:

Sampling Locations:

- Man holes up stream of the automatic samplers

Procedures:

- Collect 3 samples (one every 10 minutes for composite testing) while it is raining.
- Use sterile sample bottles with an unbroken seal when testing for e-coli
- Place sample bottle directly below or in outfall water stream to collect the sample

Required Equipment:

- Personal rain gear
- Powder-free nitrile gloves
- 1-Liter plastic sample bottles and lids
- Sterile bacteria sample bottles and lids from laboratory
- Bottle labels and water proof pen
- Chain of custody forms for laboratory
- Manhole pick
- Cooler with ice
- Grab sample collection rod

VI.3 Analytical Parameters:

The following table provides a list of parameters and the sampling frequency as established by Permit No. MN0061263. Samples collected from the automated samplers will be analyzed for the water quality parameters in Table 1 of the City of St. Paul's MS4 permit (when volumes allow).

Monitoring Parameters		
Parameters	**Sample Type**	**Frequency**
BOD, Carbonaceous 5-Day (20 Deg C)	Composite or Grab	Quarterly
Chloride, Total	Composite or Grab	As noted for loading calculations (Par V.C7.f)
Copper, Total (asCu)	Composite or Grab	Monthly
E. coli	Grab	Quarterly
Flow	Measurement	
Hardness, Carbonate (as CaCo3)	Composite or Grab	Monthly
Lead, Total (as Pb)	Composite or Grab	Monthly
Nitrite Plus Nitrate, Total (asN)	Composite	As noted for loading calculations (Par V.C7.f)
Nitrogen, Ammonia, Un-ionized (as N)	Composite	Quarterly
Nitrogen, Kjeldahl, Total	Composite	As noted for loading calculations (Par V.C7.f)
pH	Composite or Grab	Quarterly
Phosphorus, total Dissolved or Ortho	Composite	Quarterly
Phosphorus, Total as P	Composite	As noted for loading calculations (Par V.C7.f)
Precipitation	Measurement	1 x Day
Solids, Total Dissolved (TDS)	Composite	Quarterly
Solids, Total Suspended (TSS)	Composite	As noted for loading calculations (Par V.C7.f)
Sulfate	Composite or Grab	2 x Year
Volatile Suspended Solids (VSS)	Composite	As noted for loading calculations (Par V.C7.f)
Zinc, Total (as Zn)	Composite or Grab	Monthly

VI.4 Sample Preservation

- Collect samples from automated sampler within 24 hours
- Composite individual sample containers from the autosampler into one, clean, 4-liter jug, provided by MCES Lab
  - If the storm event produced volume in exceess of 4 liters, the sample volume shall be composited in the churn sampler splitter.
  - Fill the churn will all samples collected from the event. One staff shall provide constant mixing using the paddle, while the other staff shall open the spickot, gradually filling the lab container with the mixed sample
  - The churn sampler splitter shall be cleaned between uses
- The sample containers shall be labeled with the relevant Site and sample information which shall include:

- Site Name [**See attached Chain of Custody (CoC)** examples for Site IDs].
    - The composite start and end time, as indicated on the autosampler
    - Name of staff collecting the sample
- The sampler shall complete a CoC form to submit with the sampler or communicate sample information to the Project Manager to complete the form electronically, and submit to the lab
- Place all samples to be analyzed in a cooler with ice
    - Target holding temperature for samples is 4˚C
- Deliver samples to lab

VI.5 Cleaning of Sample Equipment and Bottles

- **Clean sample bottles and churn splitter after every use:** wash them with a brush and soapy water or use a dishwasher
- **Clean the suction line, strainer, and pump tubes twice per year:** Place the end of the suction line in a cleaning solution and pump it through the system. Rinse with clean water

VI.6 Quality Assurance/Quality Control:

- Before samples are collected, make sure that all sampling equipment and bottles are cleaned using the appropriate cleaning procedures
- Wear powder-free nitrile gloves when handling bottles, lids, tubing, or strainers.
- Never touch the inside surface or exposed end of a sample bottle or lid, even with a gloved hand
- Never let any material other than sample water touch the inside surface or exposed end of sample bottle
- Avoid allowing rain water to drip from rain gear or other surfaces into sample bottles

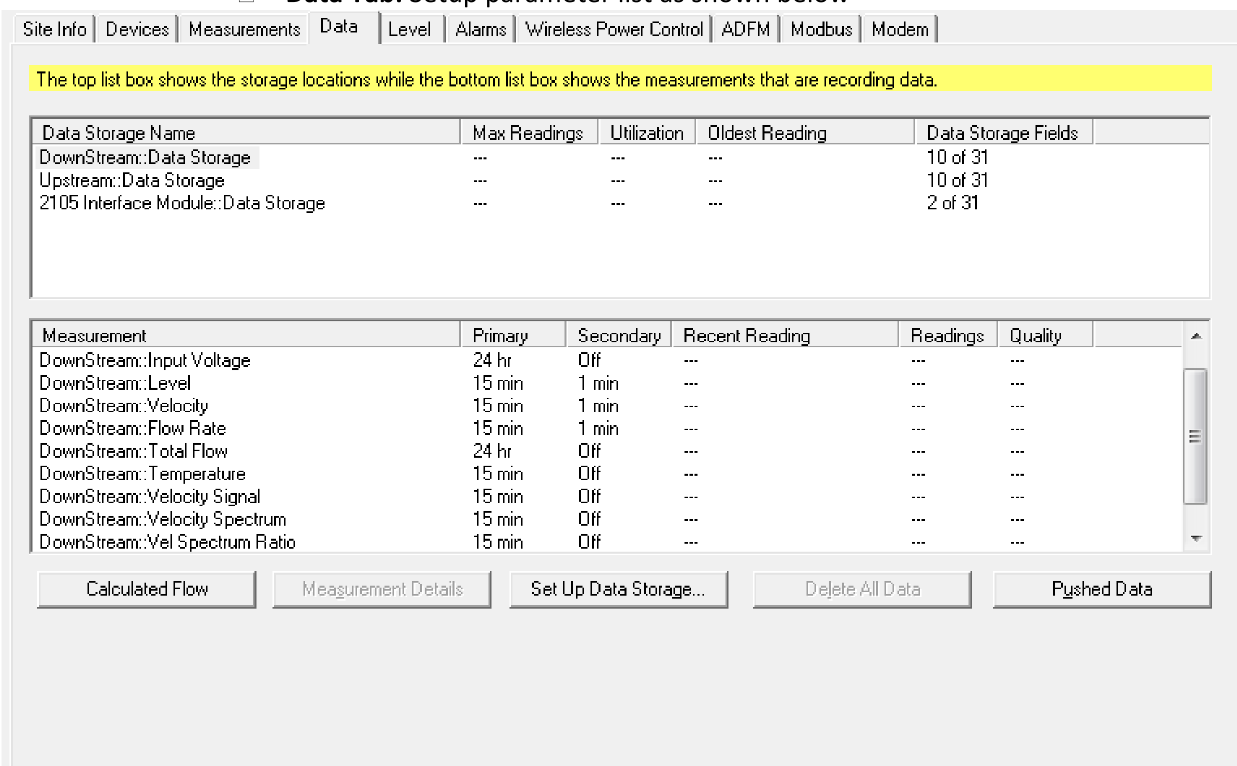
VII. Operation and Maintenance of Monitoring Equipment

The following provides a summary of procedures to follow for operating and maintaining monitoring equipment for collection of flow, rainfall, water level, and sampling data. These procedures should be followed when the devices are initially setup and during routine data dumps and maintenance activities.

VII.1 Flow Meters (ISCO 2150)[3] and Interface Modules (ISCO 2105/2103)[4]:

<u>Setup/Initialization:</u>

- **Software Required:** Flowlink
- **Quick Connect:** Connect the device to a laptop using the communication cable. Start Flowlink and select Quick Connect Icon in the tool bar. Use "Direct" Type Connection and check "Create New Site" for new instillation. Click on the large *2100 Instruments* button to connect
- **Site Info Tab:** Add applicable information and "Synchronize Site's Time to Computer's"
- **Devices Tab:** Change Module Names for Area Velocity Meters to reflect location
- **Data Tab:** Setup parameter list as shown below



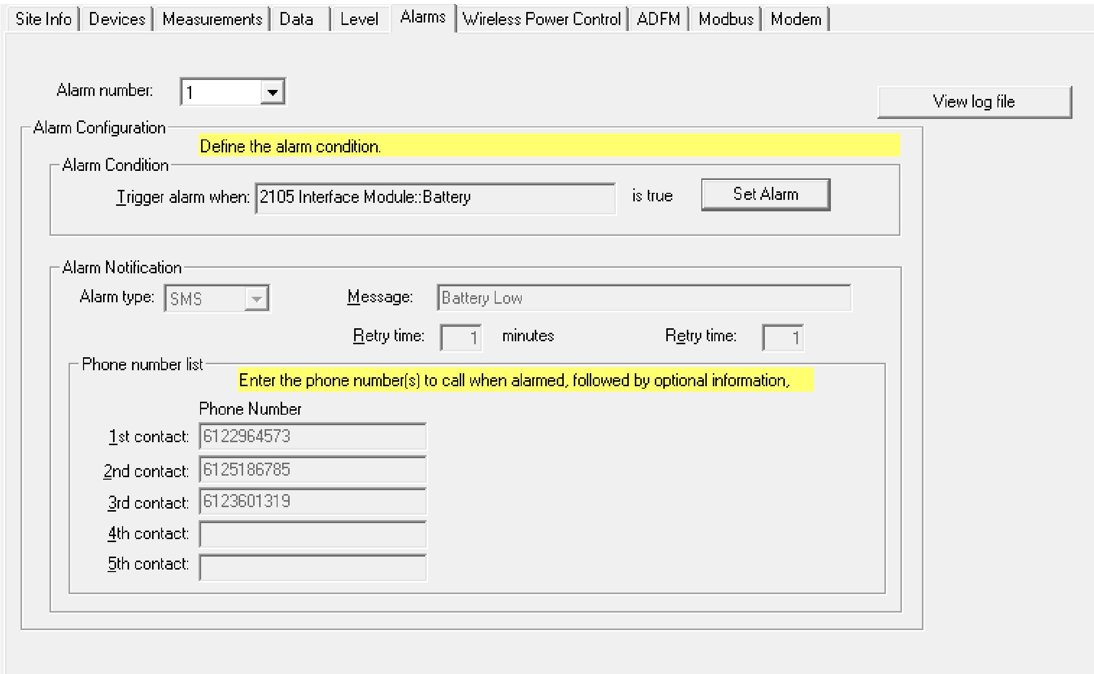
- **Measurement Details:** Set units for all measurements (in, cfs, or cf)
  - **Level:** If flow is present, measure the water depth from the water surface to the channel bottom. Enter the value on the *Level*

[3] See <u>2150 Area Velocity Flow Module and Sensor – Installation and Operation Guide</u>, Teledyne ISCO, Rev. March 9, 2011.

[4] See <u>2105 Interface Module – Installation and Operation Guide</u>, Teledyne ISCO, Rev. July 8, 2010.

measurement tab in FLowlink. If no flow is present, enter a value of zero. (Level measurements may drift over time, so it is important to do this routinely.)

   - **Velocity Measure Tab:**
     - **No Velocity Data:** Uncheck the *"Set flow rate to zero if no velocity data"* checkbox on the *Velocity* measurement tab in Flowlink. Data can be post processed to remove low level velocity noise
     - **Synchronize Velocity Measurements:** Check the Prevent *interference box* on the *Velocity* measurement tab in Flowlink to prevent velocity signal interference at sites with multiple modules
   - **Flow Rate Tab:** Input pipe shape and diameter.
- **Data Storage Rates:** Click on *Set Up Data Storage…* button on a measurement tab in Flowlink to set storage rate.
   - Level, Velocity, Flow Rate, Total flow,: Primary = *15 min*, Secondary = *1 min* (Flow Depth > 1in)
   - Temperature, Velocity Signal, Velocity Spectrum, Velocity Spectrum Ratio: Primary = 15 min
   - Input Voltage, Wireless Signal: Primary = *24 hours*
     Note: In "Condition Builder" set Hysteresis to 0.5" and Duration to 5 min for all Sampler Level Triggers.
- **Pushed Data Capability:** Click the Pushed Data button to set up a schedule for the data to be pushed
   - **Set IP address:** 207.173.231.99, Port 1700
   - Use Primary Data Transmission interval of *4 hours*
- **Alarms Tab:**
   - **Alarm Condition:** Define alarm condition using Equation Builder
     - Low Battery: When Modem Input voltage drops below 10V



- **Sampler Interface:**
  - **Set Up Data Storage:** Select "Enable Logging"
  - **Sampler enable:** Enable on Trigger - using equation builder to specify level threshold to enable sampler

    Note: In "Condition Builder" set Hysteresis to 0.5" and Duration to 5 min for all Sampler Level Triggers
  - **Sampler Pacing:** input desired flow pulsing interval in cubic feet

<u>Routine Data Retrieval and Re-initialization:</u>

- **Frequency:** Once per month
- **Quick Connect:** Connect the device to a laptop using the communication cable Start Flowlink and click on the large *2100 Instruments* button to connect
- Download data and transfer to WSB server folder K:\01610-100\WR\Flow Data
- Set water level to zero. (Make sure to annotate date and time of level reset)

<u>Routine Maintenance:</u>

The following maintenance activities must be completed routinely and during every field visit:

- **Check desiccant cartridges:** When entire length of the cartridge turns pink or green, the desiccant needs to be replaced
- **Check battery voltage:** Replace both batteries when voltage is below 10
- **Check hydrophobic filter:** Rinse and dry if the filter is plugged
- **Check connector O-rings:** Replace or lubricate as needed
- **Check flow sensor:** Remove debris and clean sensor as needed
- **Check sensor cable for damage:** Replace if needed. Loose cable should be fastened to the structure

VII.2 Portable Sampler (ISCO 6712)[5]:

Setup/Initialization:

- **Software Required:** Flowlink
- **Measure length of suction hose:** Length will be a required input during Program setup. Cut hose to whole ft. Increments if required. Hose should generally slope downward toward the sampling probe
- **Use Standard Program:** Follow Steps in Table 4-2 of the operation guide for flow pacing. Make the corresponding deviations listed below. Standard Programing Flow Charts can also be found in Appendix A in the operation guide (Figures A-2 & A-3)
  - (3)Set appropriate Site Description (i.e. Robie Street, Beacon Bluff)
  - (8) Select 1 pulse between sample events
  - (9) Samples/Bottle
  - (11) 5 Samples/Bottle (200 mL each)
  - (12) No Delay to Start
- **Automatically index to next bottle when sampler is enabled:** This will allow each storm event to be composited separately, but may decrease the overall available sampling volume during multiple events
  - From home screen, enter 6712.9 and hit enter
  - Enter Code: 1199 and hit enter (Sampler should report Code Accepted)
- **Calibration:** The Sampler delivers accurate sample volumes without calibration. If you find that sample volumes vary significantly from the programmed values, first check the suction line for proper installation. Be sure it slopes continuously downhill to the liquid source and drains completely after each sampling cycle. Refer to Section 4.12 of the operation guide for additional calibration notes
  - Note: If sampler does not disable when the program is set to run, check all cable connections and then make sure the 2105 is configured correctly. If the water level is below the trigger threshold, the 2105 should be indicating that the Sampler is disabled. If the sampler is still not disabling, the cable or the sampler may be malfunctioning. The cable can be diagnosed by removing the sampler cable and using a paper clip to short pins “B” and “F” on the back of the sampler control head

Routine Data Retrieval and Re-initialization:

- **Frequency:** Once per month
- **Interrupt Program:** Press the Stop button once to pause the program. Scroll down to “VIEW DATA” and check for errors with sampling. See page 4-19 in the operators guide for more information. When complete, select “RESUME PROGRAM”

Routine Maintenance:

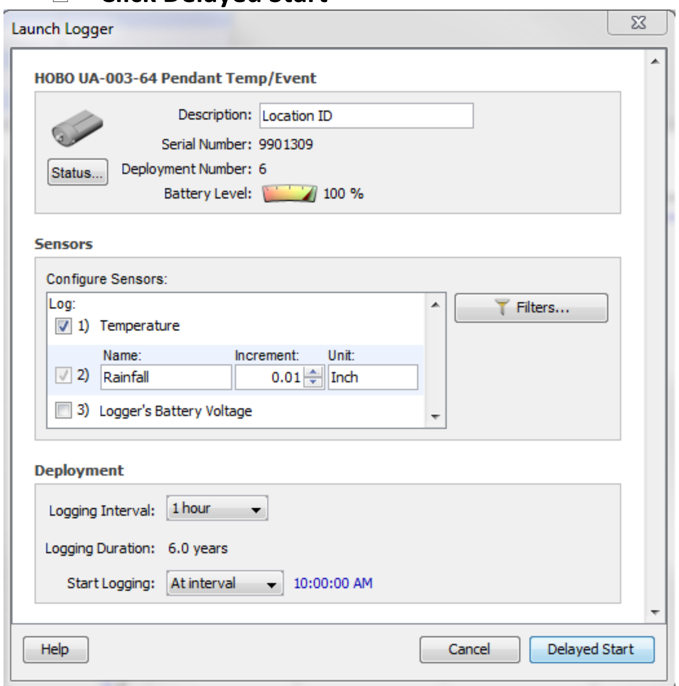
[5] See 6712 Portable Samplers – Installation and Operation Guide, Teledyne ISCO, Rev. April 11, 2011.

- ☐ **Check the pump tube for wear:** Replace if necessary
- ☐ **Check the pump tubing housing:** Clean if necessary
- ☐ **Check the suction line:** Change if necessary
- ☐ **Check the humidity indicator:** Desiccant should be replaced when all indicator areas turn light pink or white
- ☐ **Check the controller's internal battery status:** Replace the battery every five years
- ☐ **Check the keypad label:** If it has bubbles under it, the air inside the controller has expanded, and pressure can be released by unscrewing the flow meter cable or connector cap on the back of the controller

VII.3 Data Logging Rain Gauge:

Setup/Initialization:

- **Software Required:** Onset HOBOware.
- **Connect Rain Gauge:** Open HOBOware and select Launch Device.
- **Configure Sensors:**
  - Log 1) Temperature
  - Log 2) Rainfall
    - Name: Rainfall
    - Increment: 0 .01
    - Unit: Inch
- **Deployment**
  - Logging Interval: 1 hour
  - Start Logging: At Interval
- **Click Delayed Start**



Routine Data Retrieval and Re-initialization:

- **Frequency:** Once per month
- **Connect to device using HOBOware:**
- Download data using readout device and transfer to WSB server folder K:\01610-100\WR\Exported Data. (Do not stop logging before reading out the logger until the end of the season)

Routine Maintenance:

- **Check the filter screen, funnel, and tipping mechanism for debris** (dirt, bugs, bird droppings, etc.): Clean with mild soap and water
- **Check the needle bearings and apply light oil annually**

VII.4 Water Level Logger (Level Troll 500)[6]:

Setup/Initialization:

- **Software Required:** Win-Situ 5
- **Piezometer Specifications:** 3" PVC Pipe should be used as a Piezometer for underground stormwater structures. Drill ½" holes on four sides of the pipe so that there are approximately 20 holes per foot of length in the pipe. Holes do not need to be drilled above top of BMP structure. Wrap section expected to be submerged in highly permeable geotextile fabric, and secure with zip ties. Secure the pipe to the floor, the manhole, and the overhead casting wall
- Hang the Logger from the eye bolt installed inside of PVC pipe piezometer. This will allow a more accurate set up of the reference elevation
- **Stabilization Time:** Allow the Level TROLL to stabilize to the water conditions for *about an hour* before logging data. A generous stabilization time is always desirable, especially in long-term deployments. Even though the cable is shielded, temperature stabilization, stretching, and unkinking can cause apparent changes in the probe reading. If you expect to monitor water levels to the accuracy of the probe, it's worth allowing the extra time for the probe to stabilize to its environment
- **Connection:** With the Troll Com plugged into a USB port, launch Win-Situ Software
- **Win-Situ Launches:** the screen shows the "My Data Tab".
  - On first connection, be sure to select the correct COM port for a USB connection
  - Then connect to the device
- When Connected, the focus shifts to the Home tab. Readings are shown in "meter" view. Values in gray are not being updated in real time
- **Set up a site**: Click the Site Button, select the Default Site or Click the New button to set up a custom site. The site name can have up to 32 characters. Location coordinates are optional
- **Set up a data log:** follow the steps in the logging setup wizard.
  - **Log Name:** Site_2017
  - **Log Parameters:** Pressure (PSI), Temperature (F), Elevation (ft.)
  - **Choose Logging Method:** Long-Term Monitoring – Event
  - **Choose Event Parameter:**
    - Check event parameter every 1 min
    - Log all parameters when the event is greater than 0.25 ft. above BMP invert, or normal water level elevation (sites with standing water in the BMP should utilize a threshold that will prevent the "event" setting from being continuously triggered)
    - Default record data every 60 measurements
  - **Schedule Start time:** on Next Hour
  - **Output:** Depth (BMP Sites) Depth to water (Groundwater Sites)

[6] See Level TROLL – Operator's Manual, In-Situ Inc., March 2010.

        - Be sure to note the casting invert reference elevation used, and the calculated elevation of the bottom of the sensor probe in the Notes option in the Site Data Folder for future reference
    - **Specific Gravity Value**: Custom 0.999
- **Finished Programing:** Disconnect the Troll Com and reattach the desiccant

<u>Routine Data Retrieval and Re-initialization:</u>

- **Frequency:** Once per month
- **Connect to device using Win-Situ 5:**
- Download data and transfer to WSB server folder K:\01610-100\WR\Exported Data. (Do not stop logging until the end of the season)
- Re-reference water level elevation
    - Select “Sensor Tab” then click on calibrate sensor.
    - **Adjust Level Reference:** input the New Reference if required

<u>Routine Maintenance:</u>

- **Check desiccant cartridge:** When entire length of the cartridge changes color, the desiccant needs to be replaced
- **Check minimum cable bend radius:** Half the cable diameter = Approx. 0.54”.
- **Check the holes in the nose cone:** If they are plugged, swish the Level TROLL in a bucket of water, rinse under a tap, or soak in a mild acidic solution such as vinegar overnight
    - DON’T dig or scrape in the pressure sensor openings!
    - DON’T touch the pressure sensor diaphragm when the nose cone is removed!
- **Check twist-lock connectors**: Keep pins on all connectors free of dirt and moisture
- **Field Recalibration:** Sensor should be factory recalibrated every 12-18 months. The following procedure may be used, <u>**with caution,**</u> to “zero” the offset of a vented pressure sensor to correct for electronic drift. The drifted offset is visible when the sensor is in air and reading other than zero. It is recommended you **do not** zero the offset if it is outside the specified accuracy of your pressure sensor (30 PSI Sensor: ±0.03 PSI). If the reading in air deviates from zero by more than this amount, you may want to consider a factory recalibration

Attachments

WSB Confined Space Entry Permit

Metropolitan Council Environmental Services Laboratory Chain-of-Custody (BMP Infiltration Sites)

Metropolitan Council Environmental Services Laboratory Chain-of-Custody (TBNS Infiltration Sites)

wsb

Permit Number ______________ Date ____________________

Location & Description of Confined Space:

____

____

Purpose of Entry:

____

____

Scheduled Start ________________________________ a.m. / p.m.
Day / Date / Time

Scheduled Finish ________________________________ a.m. / p.m.
Day / Date / Time

Employee(s) in charge of entry: ____

Entrants:

____

____

Attendants:

____

____

Pre-Entry Authorization: ____

{Check those items below which are applicable to your confined space permit.}

TYPES OF HAZARDS

- ❑ Oxygen-Deficient Atmosphere
- ❑ Oxygen-Enriched Atmosphere
- ❑ Welding/Cutting
- ❑ Engulfment
- ❑ Toxic Atmosphere
- ❑ Flammable Atmosphere
- ❑ Energized Electrical Equipment
- ❑ Entrapment
- ❑ Hazardous Chemical

Note: If welding/cutting operations are to be performed, attach form (3039) to entry form.

SAFETY PRECAUTIONS

- ❑ Self-Contained Breathing Apparatus
- ❑ Air-Line Respirator
- ❑ Fire-Retardant Clothing
- ❑ Ventilation
- ❑ Remarks ____
- ❑ Protective Gloves
- ❑ Lifelines
- ❑ Respirators
- ❑ Lockout/Tagout
- ❑ Fire Extinguishers
- ❑ Barricade Job Area
- ❑ Signs Posted
- ❑ Clearances Secured
- ❑ Lighting
- ❑ Ground Fault Interrupter

ENVIRONMENTAL CONDITIONS

TESTS TO BE TAKEN	DATE / TIME	RE-TESTING	DATE / TIME
Oxygen: ________%	____________ a/p	Oxygen: ________%	____________ a/p
Lower Explosive Limit: ______%	____________ a/p	Lower Explosive Limit: ______%	____________ a/p
Toxic Atmosphere: ____________		Toxic Atmosphere: ____________	
Instruments Used: ____________		Instruments Used: ____________	

Employee Conducting Safety Checks **SIGNATURE:** ____

Remark on the overall condition of the confined space.

____

____

____

ENTRY AUTHORIZATION

All actions and/or conditions for safe entry have been performed.

Person in Charge of Entry ______________________________
PLEASE PRINT

ENTRY CANCELLATION

Entry has been completed and all entrants have exited permit space.

Person in Charge of Entry ______________________________
PLEASE PRINT

IN CASE OF EMERGENCY CALL 911

{CFR 1910.146 (f)(11)}

City of Saint Paul/ WSB and Associates

Date Submitted: ______________________________

Sampler: ______________________________

WSB Contact: Dan O'Neill 612-400-5382
doneill@wsbeng.com
MCES Sample Receiving: 651-602-8293

Client ID: 140
Project #: 5543-16-01

PAGE of

Location ID:	**BEACON_BL**	**LIQ (Loading)**	**LIQ (Loading)**	**FILT (Loading)**
Sample PT:	**MH7**	[X] CL-AV	[X] CU-MSV	[X] ORTHO-AV
Sample Name:	[ ] Grab [ ] Comp	[X] N_N-AV2	[X] HARD-HL	[X] TOC-AV
Start Date/Time:		[X] NUT-AV [X] TSSVSS-GF	[X] PB-MSV [X] ZN-MSV	**LIQ (Quarterly)** [ ] Oil and Grease [ ] ECOLI-MPNT**
End Date/Time:		[X] TDS-180	[X] COD-A2 [X] NH3N-AV	
Location ID:	**BEACON_BL**	**LIQ (Loading)**	**LIQ (Loading)**	**FILT (Loading)**
Sample PT:	**MH7**	[ ] CL-AV	[ ] CU-MSV	[ ] ORTHO-AV
Sample Name:	[ ] Grab [ ] Comp	[ ] N_N-AV2	[ ] HARD-HL	[ ] TOC-AV
Start Date/Time:		[ ] NUT-AV [ ] TSSVSS-GF	[ ] PB-MSV [ ] ZN-MSV	**LIQ (Quarterly)** [ ] Oil and Grease [ ] ECOLI-MPNT**
End Date/Time:		[ ] TDS-180	[ ] COD-A2 [ ] NH3N-AV	
Location ID:	**HAMP_PRK**	**LIQ (Loading)**	**LIQ (Loading)**	**FILT (Loading)**
Sample PT:	**MH8100793**	[X] CL-AV	[X] CU-MSV	[X] ORTHO-AV
Sample Name:	[ ] Grab [ ] Comp	[X] N_N-AV2	[X] HARD-HL	[X] TOC-AV
Start Date/Time:		[X] NUT-AV [X] TSSVSS-GF	[X] PB-MSV [X] ZN-MSV	**LIQ (Quarterly)** [ ] Oil and Grease [ ] ECOLI-MPNT**
End Date/Time:		[X] TDS-180	[X] COD-A2 [X] NH3N-AV [X] TOC-AV	
Location ID:	**HAMP_PRK**	**LIQ (Loading)**	**LIQ (Loading)**	**FILT (Loading)**
Sample PT:	**MH8100793**	[ ] CL-AV	[ ] CU-MSV	[ ] ORTHO-AV
Sample Name:	[ ] Grab [ ] Comp	[ ] N_N-AV2	[ ] HARD-HL	[ ] TOC-AV
Start Date/Time:		[ ] NUT-AV [ ] TSSVSS-GF	[ ] PB-MSV [ ] ZN-MSV	**LIQ (Quarterly)** [ ] Oil and Grease [ ] ECOLI-MPNT**
End Date/Time:		[ ] TDS-180	[ ] COD-A2 [ ] NH3N-AV [ ] TOC-AV	

Comments:
BLUE: Analysis Priority List
** Dilution needed – High concentrations anticipated
Proceed with ORTHO-AV & N_N-AV2 if outside of hold time

Appendix G – ASTM C1701 Procedures

Designation: C1701/C1701M – 09

Standard Test Method for Infiltration Rate of In Place Pervious Concrete[1]

This standard is issued under the fixed designation C1701/C1701M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the field water infiltration rate of in place pervious concrete.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 The text of this standard references notes that provide explanatory material. These notes shall not be considered as requirements of the standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C125 Terminology Relating to Concrete and Concrete Aggregates

C920 Specification for Elastomeric Joint Sealants

2.2 *Other Standards*

Federal Specification A-A-3110 (TT-P-1536A) Plumbing Fixture Setting Compound[3]

3. Terminology

3.1 *Definitions:*

3.1.1 The terms used in this test method are defined in Terminology C125.

4. Summary of Test Method

4.1 An infiltration ring is temporarily sealed to the surface of a pervious pavement. After prewetting the test location, a given mass of water is introduced into the ring and the time for the water to infiltrate the pavement is recorded. The infiltration rate is calculated in accordance with 9.1.

5. Significance and Use

5.1 Tests performed at the same location across a span of years may be used to detect a reduction of infiltration rate of the pervious concrete, thereby identifying the need for remediation.

5.2 The infiltration rate obtained by this method is valid only for the localized area of the pavement where the test is conducted. To determine the infiltration rate of the entire pervious pavement multiple locations must be tested and the results averaged.

5.3 The field infiltration rate is typically established by the design engineer of record and is a function of the design precipitation event.

5.4 This test method does not measure the influence on in-place infiltration rate due to sealing of voids near the bottom of the pervious concrete slab. Visual inspection of concrete cores is the best approach for determining sealing of voids near the bottom of the pervious concrete slab.

6. Apparatus

6.1 *Infiltration Ring*—A cylindrical ring, open at both ends (See Fig. 1). The ring shall be watertight, sufficiently rigid to retain its form when filled with water, and shall have a diameter of 300 ± 10 mm [12.0 ± 0.5 in.] with a minimum height of 50 mm [2.0 in.]. The bottom edge of the ring shall be even. The inner surface of the ring shall be marked or scored with two lines at a distance of 10 and 15 mm [0.40 and 0.60 in.] from the bottom of the ring. Measure and record the inner diameter of the ring to the nearest 1 mm [0.05 in.].

NOTE 1—Ring materials that have been found to be suitable include steel, aluminum, rigid plastic, and PVC.

6.2 *Balance*—A balance or scale accurate to 10 g [0.02 lb].

6.3 *Container*—A cylindrical container typically made of plastic having a volume of at least 20 L [5 gal], and from which water may be easily poured at a controlled rate into the infiltration ring.

6.4 *Stop Watch*—Accurate to 0.1 s.

6.5 *Plumbers Putty (Non-Hardening)*—Meeting Specification C920 or Federal Specification A-A-3110.

6.6 *Water*—Potable water.

[1] This test method is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.49 on Pervious Concrete.

Current edition approved Aug. 1, 2009. Published September 2009. DOI: 10.1520/C1701_C1701M-09.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] http://www.everyspec.com

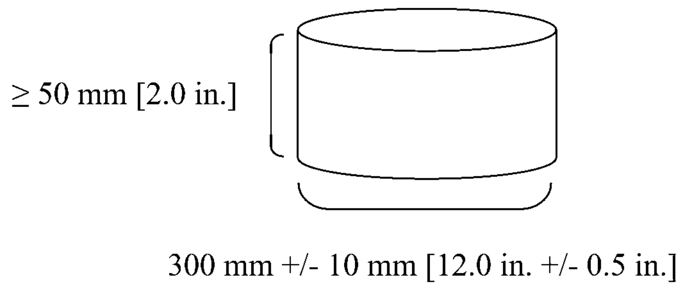


FIG. 1 Dimensions of Infiltration Ring

7. Test Locations

7.1 Perform tests at multiple locations at a site as requested by the purchaser of testing services. Unless otherwise specified, use the following to determine the number of tests to perform:

7.1.1 Three test locations for areas up to 2,500 m^2 [25,000 ft^2].

7.1.2 Add one test location for each additional 1,000 m^2 [10,000 ft^2] or fraction thereof.

7.2 Provide at least 1 m [3 ft] clear distance between test locations, unless at least 24 h have elapsed between tests.

7.3 Do not test if there is standing water on top of the pervious concrete. Do not test within 24 h of the last precipitation.

8. Procedure

8.1 *Infiltration Ring Installation*—Clean the pavement surface by only brooming off trash, debris, and other non-seated material. Apply plumbers putty around the bottom edge of the ring and place the ring onto the pervious concrete surface being tested. Press the putty into the surface and around the bottom edge of the ring to create a watertight seal. Place additional putty as needed

NOTE 2—In a hot environment where the surface temperature is over 38 °C [100 °F] plumbers putty may not adhere to the concrete surface easily. Therefore it is advisable to perform this test during cooler temperature.

8.2 *Prewetting*—Pour water into the ring at a rate sufficient to maintain a head between the two marked lines. Use a total of 3.60 ± 0.05 kg [8.0 ± 0.1 lb] of water. Begin timing as soon as the water impacts the pervious concrete surface. Stop timing when free water is no longer present on the pervious surface. Record the amount of elapsed time to the nearest 0.1 s.

8.3 *Test*—The test shall be started within 2 min after the completion of the prewetting. If the elapsed time in the prewetting stage is less than 30 s, then use a total of 18.00 ± 0.05 kg [40.00 ± 0.1 lb] of water. If the elapsed time in the prewetting stage is greater than or equal to 30 s, then use a total of 3.60 ± 0.05 kg [8.0 ± 0.1 lb] of water. Record the weight of water to the nearest 10 g [0.02 lb] (M). Pour the water into the ring at a rate sufficient to maintain a head between the two marked lines and until the measured amount of water has been used. Begin timing as soon as the water impacts the pervious concrete surface. Stop timing when free water is no longer present on the pervious surface. Record the testing duration (t) to the nearest 0.1 s.

NOTE 3—If a sloped pavement is being measured, maintain head between the two marked lines at the lowest point of the slope.

8.4 If a test is repeated at the same location, the repeat test does not require pre-wetting if conducted within 5 min after completion of the first test. If more than one test is conducted at a location on a given day, the infiltration rate at that location on that day shall be calculated as the average of the two tests. Do not repeat this test more than twice at the same location on a given day.

9. Calculation

9.1 Calculate the infiltration rate (I) using consistent units as follows:

$$I = \frac{KM}{(D^2 * t)}$$

where:

I = Infiltration rate, mm/h [in./h],
M = Mass of infiltrated water, kg [lb],
D = Inside diameter of infiltration ring, mm [in.],
t = time required for measured amount of water to infiltrate the concrete, s, and
K = 4 583 666 000 in SI units or 126 870 in [inch-pound] units.

NOTE 4—The factor K has units of $(mm^3s)/(kgh)$ [$(in.^3s)/(lbh)$] and is needed to convert the recorded data (W, D, and t) to the infiltration rate I in mm/h [in./h].

10. Report

10.1 Report the following information:

10.1.1 Identification number,

10.1.2 Location,

10.1.3 Date of test,

10.1.4 Age and thickness of concrete (label Unknown if not known),

10.1.5 Time elapsed during prewetting, s,

10.1.6 Amount of rain during last event, if known, mm [in.],

10.1.7 Weight of infiltrated water, kg [lb],

10.1.8 Inside diameter of infiltration ring, mm [in.],

10.1.9 Time elapsed during infiltration test, s,

10.1.10 Infiltration rate, mm/h [in./h], and

10.1.11 Number of tests performed at each location, if applicable.

11. Precision and Bias

11.1 Repeatability testing was performed by a single laboratory by making 2 replicate measurements at three locations on a newly placed pervious concrete pavement. The replicate measurements were repeated daily from day 1 to day 10. The single-operator coefficient of variation of the infiltration rate at one test location was found to be 4.7 %.

11.2 The multi-operator variability data has not been developed. The reproducibility of this test method is being determined and will be available on or before October 1, 2014.

11.3 This test method has no bias because the infiltration rate of in-place pervious concrete is defined only in terms of this test method.

12. Keywords

12.1 concrete; infiltration; pervious; water