REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Rainfall and Flow Monitoring Quarterly Report No. 4.

I certify under penalty of law that the document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

DELCORA MANAGEMENT		
Executive Director	Signature	4/25/17 Date
DELCORA ENGINEERING		
Director of Engineering	Signature	4/25/17 Date
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	Signature	4/26/17 Date

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES

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Section 1 Introduction

The Delaware County Regional Water Quality Control Authority (DELCORA) entered into a Consent Decree (CD) with the United States Government in August 2015. The purpose of the Consent Decree is to establish a schedule for implementation of Long Term Control Plan Update (LTCPU) to achieve full compliance with the Clean Water Act and the regulations and Clean Streams Law and regulations. The lodging of this Consent Decree was entered by the court on August 17, 2015, it was signed and filed on November 10, 2015 by the United States District Court for the Eastern District of Pennsylvania.

According to the Consent Decree, DELCORA's Hydrologic and Hydraulic Model (H&H Model) must be updated to meet the requirements in Section V.A.14 of the Consent Decree. A detailed plan to update, calibrate and validate the H&H model has been submitted and approved by the USEPA on March 1, 2016. Additional rainfall and flow monitoring is required to calibrate and validate the H&H model. Requirements of rainfall and flow monitoring are detailed in the Consent Decree Section V.A.14.d and e, which is included in the following:

> "*d.* *Rainfall and flow monitoring shall be carried out in accordance with current good industry practice for a period of at least twelve* ***(12) months****, in accordance with the schedule included in the approved plan. Rainfall data shall be obtained at a minimum effective density of 1 gauge/virtual radar-based gauge per square kilometer, for the entire Model Area. Flow monitoring shall be carried out using sufficient monitors to allow the accurate characterization of dry and wet weather flows from the entire Model Area, and the response of each CSO to wet weather flows.*
>
> *e.* *For all rainfall and flow monitoring carried out in support of efforts to update and calibrate the H&H Model, DELCORA shall prepare and submit to Plaintiffs for review and comment in accordance with the requirements of Section VI (Review and Approval of Submittals) quarterly technical memoranda documenting the results and quality of the rainfall and flow monitoring data."*

In summary, rainfall and flow monitoring shall be conducted for at least 12 months, and quarterly technical memoranda shall be submitted to Plaintiffs for review.

To satisfy the above mentioned rainfall and flow monitoring requirements, and in accordance with the submitted DELCORA H&H Model Update and Calibration Plan, DELCORA has installed 5 new rain gauges and 39 new flow meters in its sewer collection system. Starting from March 18, 2016, most of the newly installed rain gauges and flow meters were in service and began generating data.

This report is a summary of the Rainfall and Flow Monitoring during January 1, 2017 to April 1, 2017.

Section 2 Rainfall Monitoring

2.1 Rainfall Monitoring Locations

The site locations of the four existing and five newly installed rain gauges are shown in **Figure 1**. These rain gauges provide an effective spatial coverage of the entire WRTP's service area.

The four (4) existing rainfall gauges are in Delaware County that record precipitation in 15-minute increments. The gauges are located at the following DELCORA owned facilities:

- Western Regional Treatment Plant (WRTP, will be used for model calibration)
- Central Delaware County Pump Station (CDPS, will be used for model calibration)
- Muckinipates Pump Station (MPS, will be used for model calibration)
- Darby Creek Pump Station (DCPS, will NOT be used for model calibration)

The five (5) newly installed rain gauges are listed in **Table 1** with detail information of rain gauge location, service starting date, and data recording interval.

Table 1: Newly Installed Rain Gauges

	Rain Gauge ID	Location	Service Start Date	Data Interval
1	RG_Rose Valley	18 N. Longpoint Lane, Media, PA	3/05/16	5-minute
2	RG_Chester-PS	55 East 2nd Street, Chester, PA	3/05/16	5-minute
3	RG_NCPS	1628 Naamans Creek Rd., Marcus Hook, PA	3/05/16	5-minute
4	RG_Springfield	217 Saxer Avenue, Springfield, PA	4/03/16	5-minute
5	RG_UCT	1671 N. Upper Providence Road, Media, PA	4/16/16	5-minute

2.2 Rain Gauge Calibration/Verification Procedure

Rain Gauge calibrations were performed during the rain gauge installation. Additional calibrations will be performed to the manufacturer's specifications on a bi-annual basis or as needed if irregular data is observed. Rain gauges are routinely checked for debris, and cleared after snow/ice storms.

Each "tip" of the rain gauge bucket should correspond with 0.01" of rain. To ensure the modem is reading the tipping bucket pulse accurately, the tech will tip the bucket 10 times in rapid succession. The tech should see that 0.1" of rain is recorded.

2.3 Rainfall Event Summary

Rainfall events were analyzed for each individual rain gauge based on the inter-event time of 12 hours. In total there were 33 rainfall events during reporting period. **Table 2** lists all 18 rainfall events with total precipitation greater than 0.1 inch.

Figure 1: Rain Gauge Locations

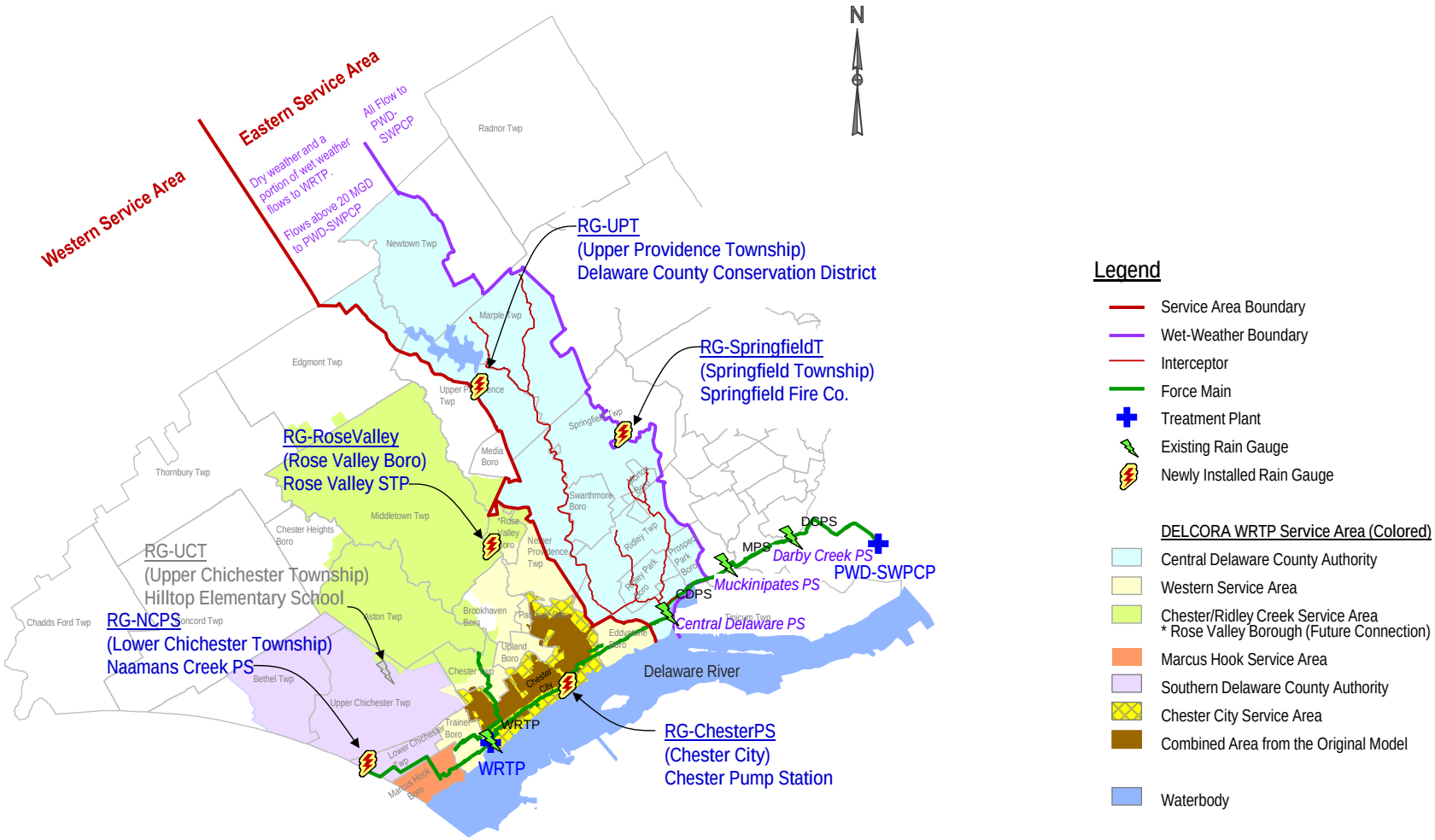


Figure 2 shows rainfall amounts at each rain gauge in each month for January, February and March. It is obvious that rainfall in the area has significant spatial and temporal variance. As an example, during this reporting period, the rain gauge at the Chester Pump Station (Chester PS) recorded a total rainfall of 7.63 inches while the gauge at the Upper Providence Township (UPT) recorded 9.23 inches. **Figure 3** shows the 1-hour rainfall profile for all of the 5 rain gauges.

Table 2: Rainfall Event Summary, 1/1/17 - 4/1/17

	Rain Event Starting Time	Rose Valley	Chester-PS	NCPS	Springfield	UPT
1	1/2/2017 4:25	0.9	0.78	0.95	0.84	0.93
2	1/10/2017 12:20	0.4	0.25	0.42	0.23	0.39
3	1/11/2017 20:05	0.21	0.22	0.33	0.18	0.28
4	1/17/2017 10:15	0.51	0.29	0.41	0.66	0.57
5	1/20/2017 11:35	0.28	0.19	0.26	0.19	0.11
6	1/21/2017 23:15	0.89	0.82	0.95	1.02	1.01
7	2/7/2017 9:45	0.06	0.03	0.07	0.1	0.08
8	2/9/2017 1:35	0.5	0.53	0.65	0.37	0.45
9	2/11/2017 10:30	0.06	0	0	0.12	0.31
10	2/12/2017 9:50	0.23	0.21	0.27	0.31	0.4
11	2/25/2017 16:30	0.6	0.59	0.25	0.69	0.66
12	2/28/2017 11:55	0.4	0.19	0.25	0.22	0.33
13	3/10/2017 7:00	0.37	0.31	0.38	0.36	0.29
14	3/14/2017 4:30	0.35	0.67	0.67	0.1	0.01
15	3/16/2017 9:20	0.24	0.17	0.54	0.41	0.34
16	3/26/2017 22:00	0.16	0.14	0.16	0.15	0.28
17	3/28/2017 7:05	0.45	0.41	0.49	0.66	0.52
18	3/30/2017 20:50	2.18	1.83	2.51	1.83	2.27
	Subtotal (1/1/17-4/1/17)	8.79	7.63	9.56	8.44	9.23

Figure 2: Rainfall Event Summary, 1/1/17 - 4/1/17

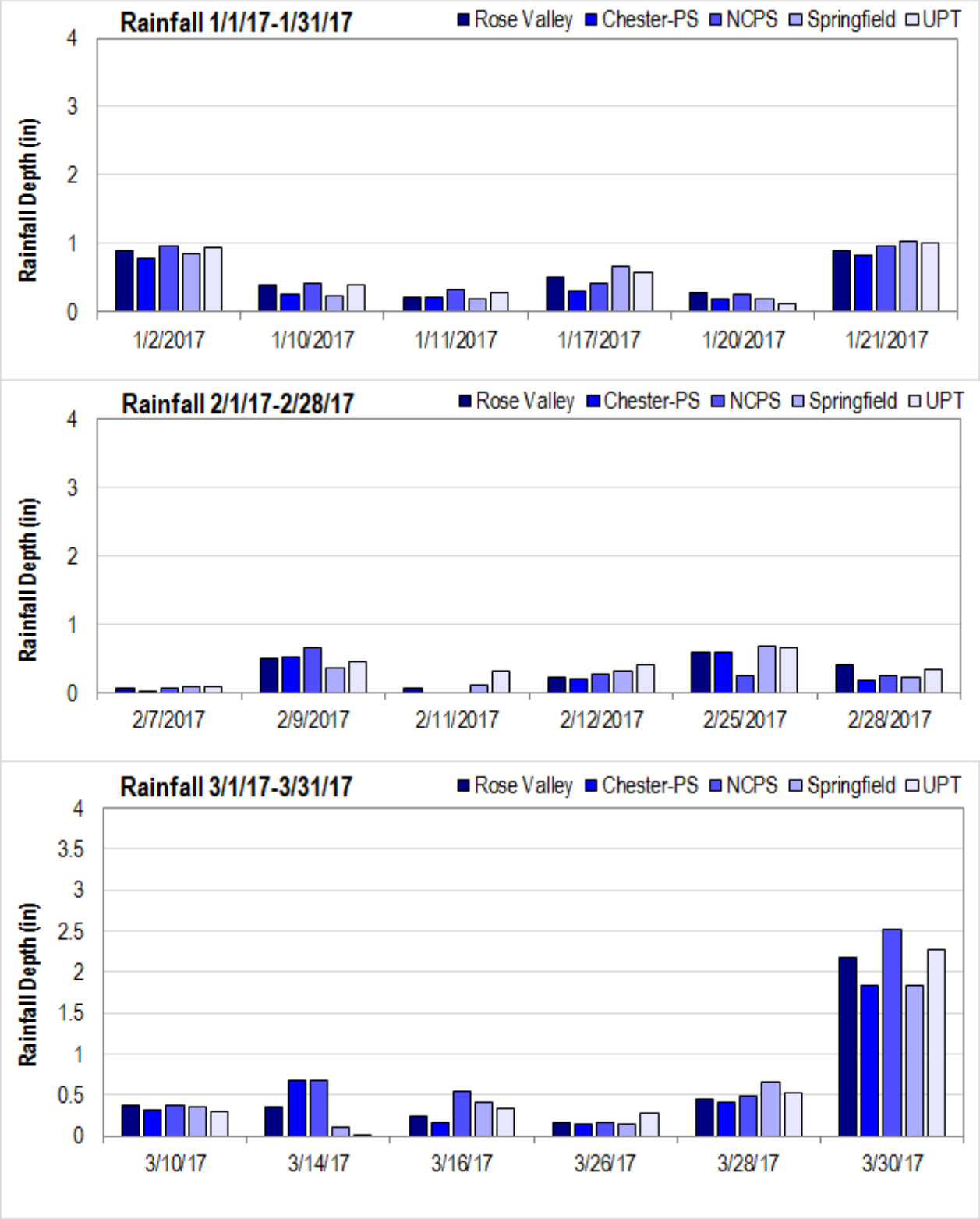
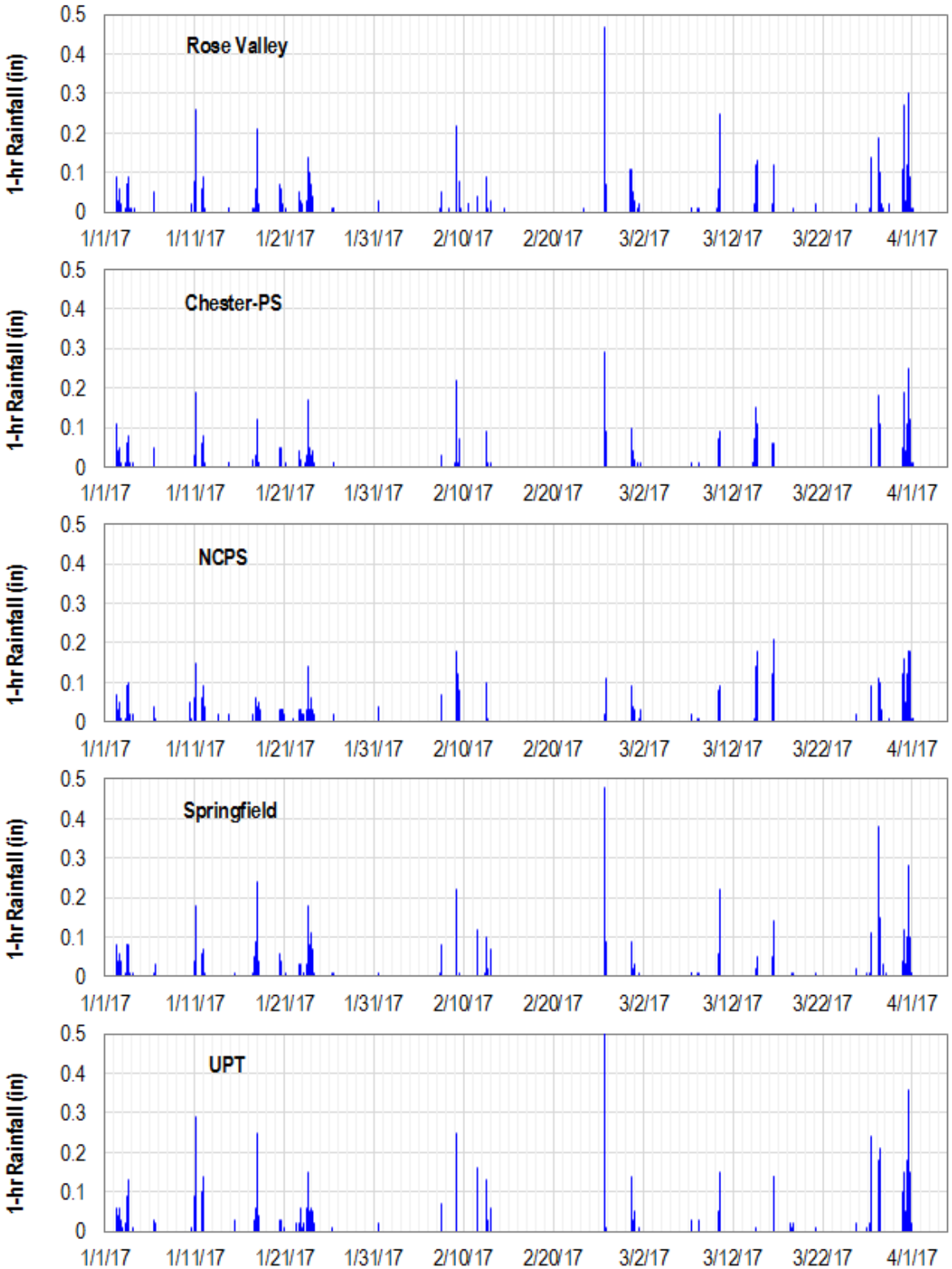


Figure 3: Hourly Rainfall Profile



2.3.1 Rainfall Return Frequency

Rainfall return frequency was analyzed for rain gauges RG_NCPS and RG_UPT because they usually record greater rainfall amounts than the others. The frequency analysis was also performed for RG_ChesterPS because it is located in the combined area.

Figure 4 shows Duration-Depth-Frequency (DDF) plot for RG_NCPS. One storm was recorded with total precipitation volumes greater than 1 inch. The event (3/30/17) is less than a 1-year event.

Figure 4: Duration-Depth-Frequency (DDF) Plot, RG_NCPS

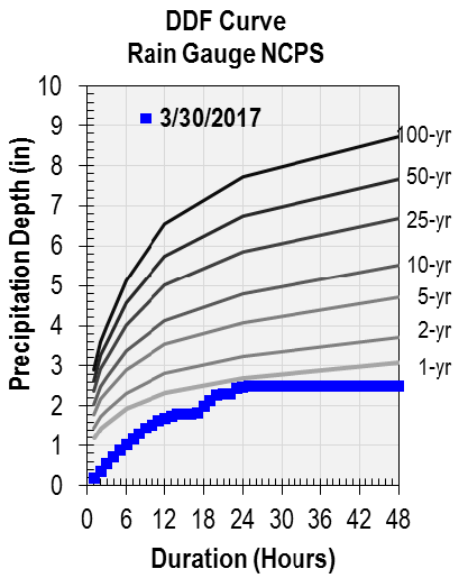


Figure 5 shows two Duration-Depth-Frequency (DDF) plots for RG_UPT. Two storms were recorded with total precipitation volumes greater than 1 inch. Both events (1/22/17 and 3/31/17) are less than 1-year events.

Figure 5: Duration-Depth-Frequency (DDF) Plot, RG_UPT

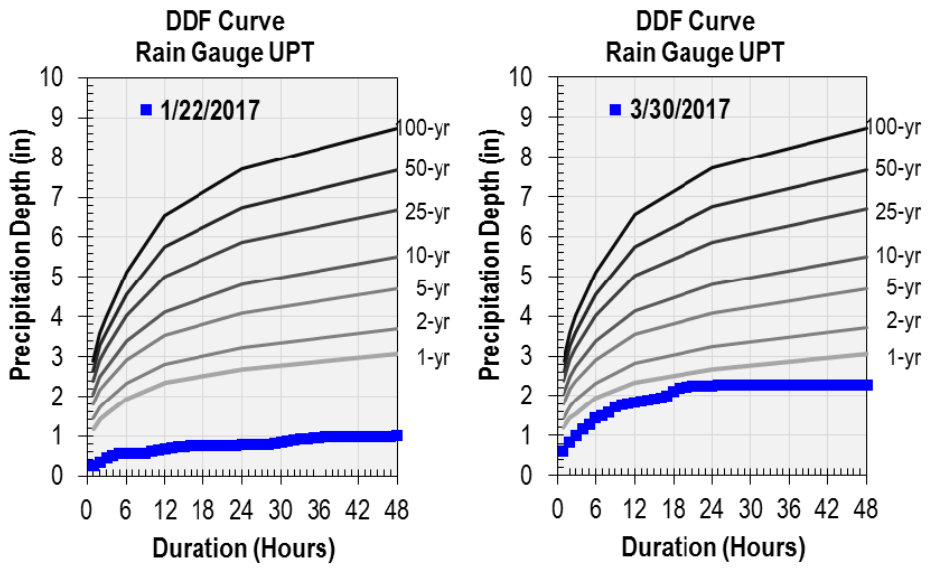


Figure 6 shows Duration-Depth-Frequency (DDF) plot for RG_ChesterPS. Only one storm (11/29/17) was recorded with a total precipitation volume greater than 1 inch. It is less than a 1-year event.

Figure 6: Duration-Depth-Frequency (DDF) Plot, RG_Chester PS

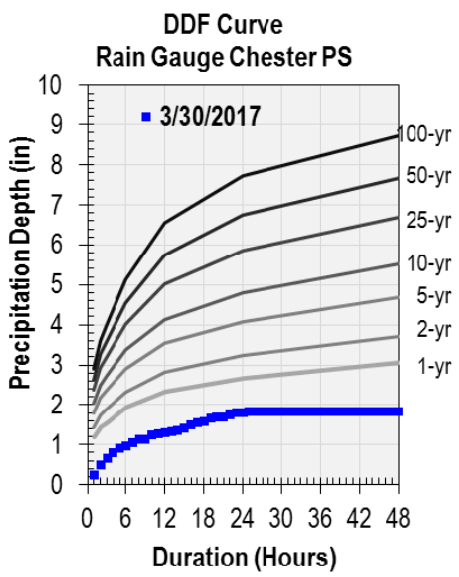
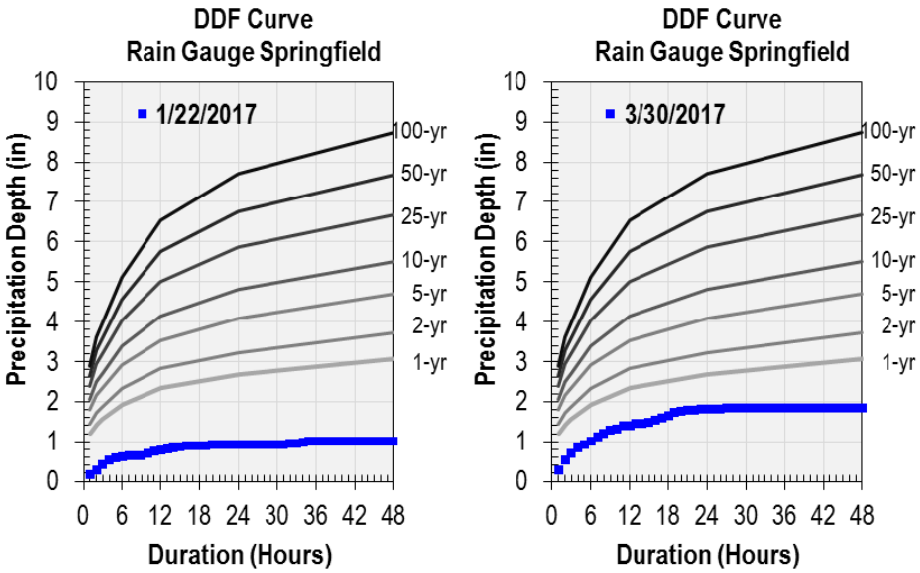


Figure 7 shows two Duration-Depth-Frequency (DDF) plots for RG_Springfield. Two storms (1/22/17 and 3/30/17) were recorded with a total precipitation volume greater than 1 inch. They are both less than a 1-year event.

Figure 7: Duration-Depth-Frequency (DDF) Plot, RG_Springfield



Section 3 Flow Meter Monitoring

3.1 Flow Monitoring Program

The site locations of the existing and newly installed flow meters are shown in **Figure 8**. **Figure 9** shows the newly installed flow meters on a larger scale, mostly in the combined area. These new meters were installed to investigate surface runoff from the combined area and CSO discharges, rainfall-derived inflow and infiltration (RDII) from the separated area, and system response to the wet weather conditions. The schematic of the newly installed flow meters is included in **Figure 10**.

The newly installed flow meter locations are categorized into the following four types:

- Category 1: Located on the influent pipe to CSO regulators, this is to measure the influent flow to CSO regulators and for combined area runoff calibration. Sixteen (16) meters were installed for this category.
- Category 2: Located on the effluent pipe and overflow pipe of CSO regulators, this is to measure the CSO overflows and calibrate CSO regulator parameters. Twelve (12) meters were installed for this category. They are on the effluent and overflow pipe of CSOs 02, 03, 05, 08, 14, & 19.
- Category 3: Located on the side-line from the combined areas (flows from the combined area tie into interceptor instead of CSO regulator). This is to measure flows from the combined area and to calibrate combined area runoff parameters. Two (2) meters were installed for this category.
- Category 4: Located upstream of the combined area, this is to measure flows from the upstream separated area for RDII characterization. Three (3) meters were installed for this category.
- Category 5: Located in the main interceptors to measure level and flows in the major interceptors. Five (5) meters were installed for this category.

One meter was proposed at manhole MH3029 to measure flow from the separated area upstream of the combined area (CSO#018). The site was severely surcharged during field investigation. Meanwhile it was found that at manhole MH3002 (four manholes upstream of MH3029, approximately 800 feet upstream) another CSL flow meter (Ridley Creek MH-28) was already installed for DELCORA. It was determined that instead of installing a new flow meter around the site, the team will use the existing meter Ridley Creek MH-28 for this flow monitoring program.

In total, 39 flow meters are included in this monitoring program. Details of the installed flow meters are included in **Table 3**.

3.2 Flow Meters Field Calibration/Verification Procedures

As part of the operation of flow meters, verifications of meter accuracy are performed on a regular basis. Calibrations are performed at a minimum every eight weeks, or more as needed.

The procedure used for performing meter calibrations is outlined below. This procedure only defines the required result. Any specific equipment function issues should be referred to the equipment manual or the manufacturer's technical support department.

Table 3: Details of the Newly Installed Flow Meters

Meter ID	GIS ID	Location	Pipe Size (in)	Material	Evidence of Surcharge	Category
CSO 02	3462	DS	36	Brick	Yes	2
CSO 03	2726	DS	38	Brick	Yes	2
CSO 05	2634	DS	48	Concrete	Yes	2
CSO 08	3463	DS	60	Concrete	Yes	2
CSO 14	3481	DS	45"x53"	Brick	Yes	2
CSO 19	690	DS	42"x43"	Concrete	Yes	2
Eff-02	3460	US	8	Clay	Yes	2
Eff-03	3454	DS	14.25	Concrete	Yes	2
Eff-05	2635	DS	12	Concrete	Yes	2
Eff-08	2246	DS	18.2	PVC	Yes	2
Eff-14	3482	DS	18	Concrete	Yes	2
Eff-19	***	DS	36	Concrete	Yes	2
In-03	2721	US	36	Brick	Yes	1
In-05	2634	US	28	Brick	Yes	1
In-08	3463	US	60	Concrete	Yes	1
In-09	1987	US	48	Cast Iron	Yes	1
In-10	1670	US	36	Brick	Yes	1
In-11	1770	US	49	Cast Iron	Yes	1
In-13	3479	US	48	Concrete	Yes	1
In-14	3481	DS	43"x47"	Brick	Yes	1
In-16	752	US	60	Concrete	No	1
In-17	691	US	36	Brick	Yes	1
In-18	3033	US	66"x43"	Concrete	Yes	1
In-19-1	625	DS	49”x47.5”	Clay	No	1
In-19-2	688	US	42”	Concrete	Yes	1
In-2	2751	DS	36	Corrugated PVC	No	1
In-25	3502	US	36	Concrete	Yes	1
In-26	1192	US	36	Brick	No	1
INT- 2nd St	1548	DS	40	Concrete	No	5
INT-DRI	2743	US	24	Clay	Yes	5
INT-Ridley 2	1487	US	44	Concrete	Yes	5
INT-Ridley 3	1509	US	48	Concrete	Yes	5
INT-WestEnd	2755	US	53	Concrete	No	5
Sep-1	2135	US	15	Clay	Yes	4
Sep-2	2134	DS	12	Clay	No	4
Sep-3	798	US	24	Clay	No	4
Sep-4 (Existing, Ridley Creek MH-28)			30	Concrete	No	4
Side-1	1571	US	36	Concrete	No	3
Side-2	2135	US	8	Clay	Yes	3

Figure 8: Existing and Newly Installed Flow Meter Locations

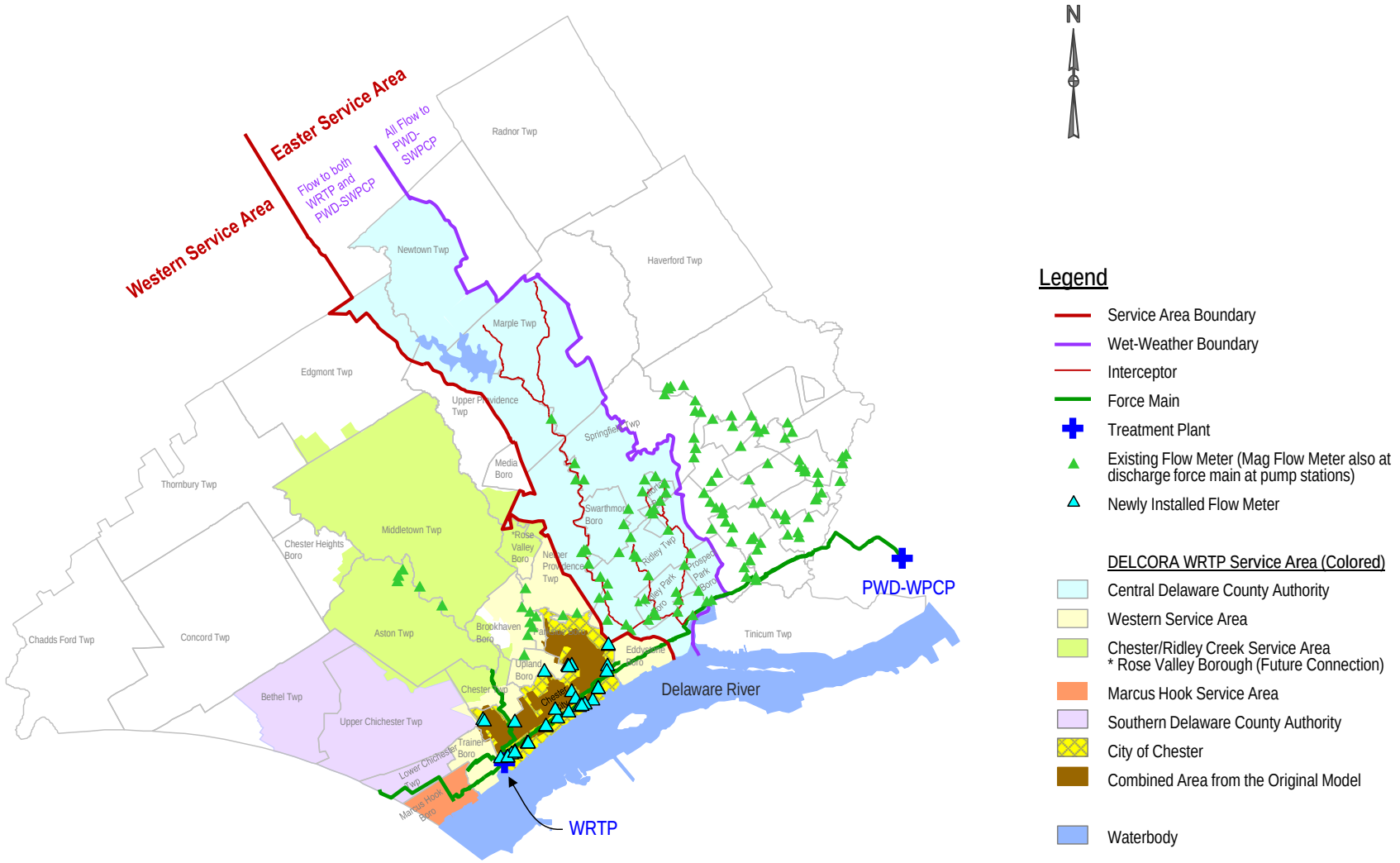


Figure 9: Newly Installed Flow Meter Locations

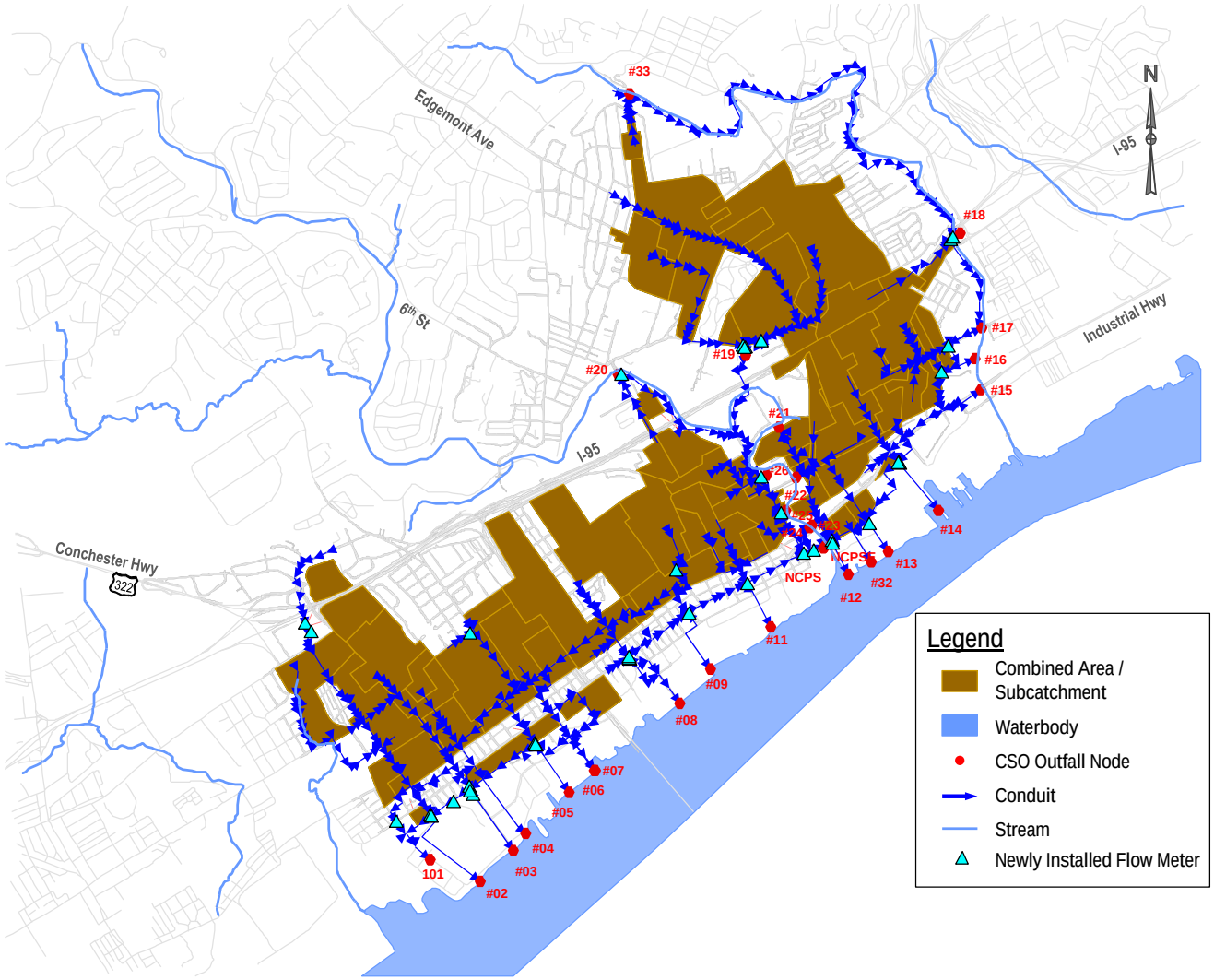
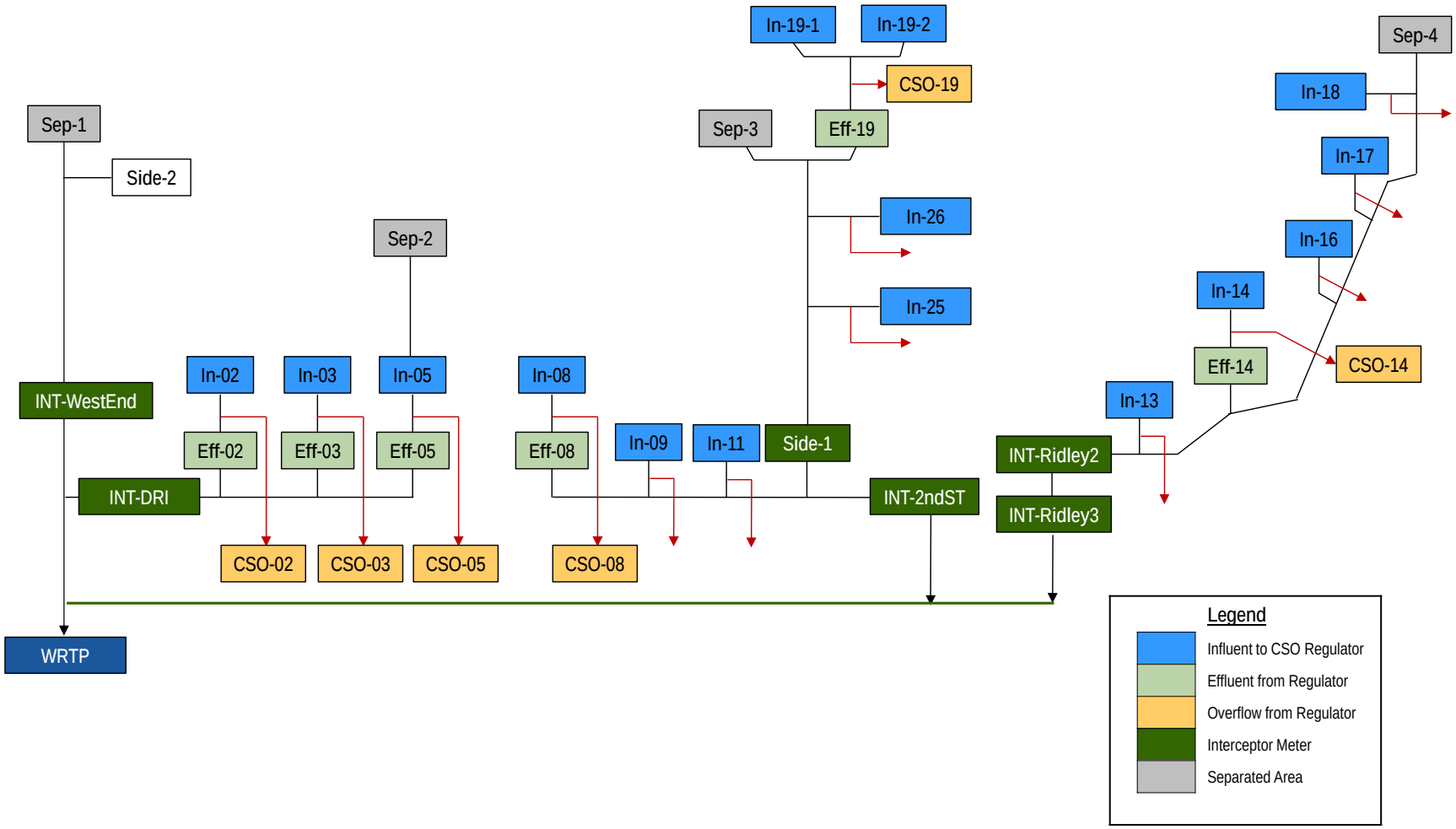


Figure 10: Flow Monitoring Schematic



Manually Downloaded Meters
This method is used for any meter that cannot be interrogated remotely by the data analyst. Field technicians use the *Daily Field Download Sheet* for recording the calibration results.

- Record the date.
- Record the field time, which is the local time.
- Record the meter time.
- Record the instantaneous depth reading from the meter.
- Measure the peak velocity.
- Record the instantaneous average or peak, whichever is applicable.
- Note any service performed at the site, included sensor scrubbing.

The resulting meter readings should be within 0.25" for depth and within 10% for peak-to-peak or average-to-average for velocity. Should readings be outside these guidelines, troubleshooting is conducted per the manufacturer guidelines. If this does not resolve the discrepancy, the data manager is notified.

Remote Connection Meters
This method is used for any meter that can be interrogated remotely. The data analyst uses the *Daily Field Download Sheet* for single depth and velocity meters and the *Multi- Sensor Calibration Sheet* for meter types that record multiple depth and/or velocity readings.

- Fill all site visit information fields on form.
- Have the field tech measure the depth of flow and record with time.
- Record the time and instantaneous depth reading from the meter or the depth sensor, whichever is applicable. All available depth sensors should be activated and compared to the field measurement.
- Have the field tech measure the peak the velocity or have them perform a velocity profile if the depth is sufficient then record with time.
- Record the time and instantaneous velocity reading from the meter or the velocity sensor, whichever is applicable. All available velocity sensors should be activated and compared to the field measurement.
- Note any service performed at the site, included sensor scrubbing.

The resulting meter readings should be within 0.25" for depth and within 10% for peak-to-peak or average-to-average for velocity. Should readings be outside these guidelines, troubleshooting is conducted per the manufacturer guidelines. If this does not resolve the discrepancy, the data manager is notified.

Special Cases

- Blind Verifications: A blind verification occurs when a field technician's only role is to measure the depth and velocity of the flow and report the values to the data analyst. In these cases, the crew is "blind" to what the meter is reading. The data analyst will then compare the readings to current/recent data or live readings. Should the blind verification be out of tolerance, the analyst can direct the crew to perform additional blind verifications or perform a conventional verification and/or troubleshoot as necessary.

- Installations/Removals: When installing or removing meters, the above calibration method should be used for three consecutive verifications, performed at 5 minute intervals.
- Third Party Audit: When performing a calibration at a meter that is not maintained by CSL and where CSL is to verify the meter function, the CSL Audit report should be used.

3.3 Flow Monitoring Data Summary

Flow, level and velocity data are received for each flow monitoring site at 5-minute intervals (Sep-4 has 15-min interval data). Metering data is analyzed for dry weather flows (DWF), hourly peak flows, and hourly peaking factors for each monitoring site. A "dry weather" condition was defined as a period with no precipitation that begins three days after the last wet weather event and lasts until the beginning of the next precipitation event.

Table 4 shows dry weather flow (DWF), hourly peak flow, hourly peaking factor and flow condition observations.

The dry weather flows are also shown in the schematic in **Figure 11**. Generally the downstream dry weather flow is greater than the upstream locations for all of the meters. For meters immediately upstream and downstream of CSO regulators, the upstream and downstream dry weather flows should be similar. **Figure 12** shows the influent and effluent from CSO#08 as an example to indicate that the dry weather of the two are similar.

The hourly peaking factor in the combined area is in the range of 7 to 99 and average at 27. The hourly peaking factor for the interceptor is between 2.8 and 5.2 with an average of 3.9. The hourly peaking factor is between 2.7 and 3.6 for the separated area, with an average of 3.1.

A detailed hydrograph and scattergraph for each flow monitoring site is shown in **Figure 13** to **Figure 51**, each includes:

- The flow hydrographs show hourly flow and rainfall profile. Hourly Rainfall data is included for the convenience of reviewing flow response to the wet weather conditions. Hourly flow and rainfall were calculated from the 5-min interval.
- The scattergraphs (based on 5-min data, excepting 15-min data for Sep-4) are essentially a plotting of flow rate versus depth. This plotting helps to understand the flow patterns and conditions on the individual monitored sewer pipes.
- For CSOs 02, 03, 05, 08, 14, & 19, flows including influent, effluent and overflows were plotted in the same plot.

Table 4: Flow Monitoring Summary

Meter ID	Hourly Peak (MGD)DWF	DWF (MGD)	Hourly Peaking Factor	Comments
In-02	6.66	0.28	23.66	Free flow most of the time
Eff-02	0.68	0.28	2.43	Surcharged under common conditions
CSO-02	4.86	0.01		Free flow most of the time
In-03	4.94	0.23	21.49	Free flow most of the time
Eff-03	0.67	0.22	3.02	Surcharged under large storms
CSO-03	3.76	0.00		Free flow most of the time
In-05	12.00	0.77	15.65	Backwater observed
Eff-05	2.55	0.70	3.66	Severely surcharged under common conditions
CSO-05	10.83	0.01		Free flow most of the time, backwater observed
In-08	17.92	1.00	17.98	Free flow most of the time
Eff-08	6.55	0.90	7.25	Free flow most of the time
CSO-08	10.22	0.02		Free flow most of the time
In-09	5.54	0.14	40.05	Free flow most of the time
In-10	4.18	0.17	24.72	Free flow most of the time
In-11	6.09	0.19	32.57	Free flow most of the time
In-13	29.03	0.25	115.46	Free flow most of the time, backwater during large storms
In-14	7.50	0.42	17.66	Backwater observed
Eff-14	4.97	0.42	11.86	Free flow mostly, backwater and surcharge during large storms
CSO-14	3.04	0.00		Free flow most of the time
In-16	3.36	0.30	11.33	Free flow most of the time, backwater during large storms
In-17	4.81	0.16	29.36	Backwater observed
In-18	9.67	0.11	91.49	Free flow most of the time
In-19-1	6.49	0.68	9.53	Free flow most of the time
In-19-2	6.31	0.50	12.71	Free flow most of the time
Eff-19	3.66	1.25	2.92	Free flow most of the time
CSO-19	11.53	0.01		Free flow most of the time
In-25	5.94	0.11	55.13	Free flow mostly, backwater observed
In-26	4.47	0.22	20.41	Free flow mostly
INT-2nd St	12.85	3.58	3.59	Free flow mostly, surcharge and backwater during large storms
INT-DRI	3.47	1.57	2.21	Severe surcharge and backwater observed
INT-Ridley 2	15.86	3.28	4.84	Free flow mostly, surcharge and backwater observed
INT-Ridley 3	17.64	3.60	4.90	Free flow mostly, surcharge and backwater observed
INT-WEI	7.16	1.40	5.10	Free flow mostly
Sep-1	0.78	0.13	5.83	Free flow mostly
Sep-2	0.61	0.13	4.66	Free flow mostly
Sep-3	2.40	0.46	5.21	Free flow mostly
Sep-4	5.64	1.52	3.70	Free flow mostly
Side-1	7.36	2.19	3.37	Free flow mostly, surcharge and backwater observed
Side-2	1.08	0.22	4.82	Free flow mostly

Figure 11: Dry Weather Flow Balance Schematic

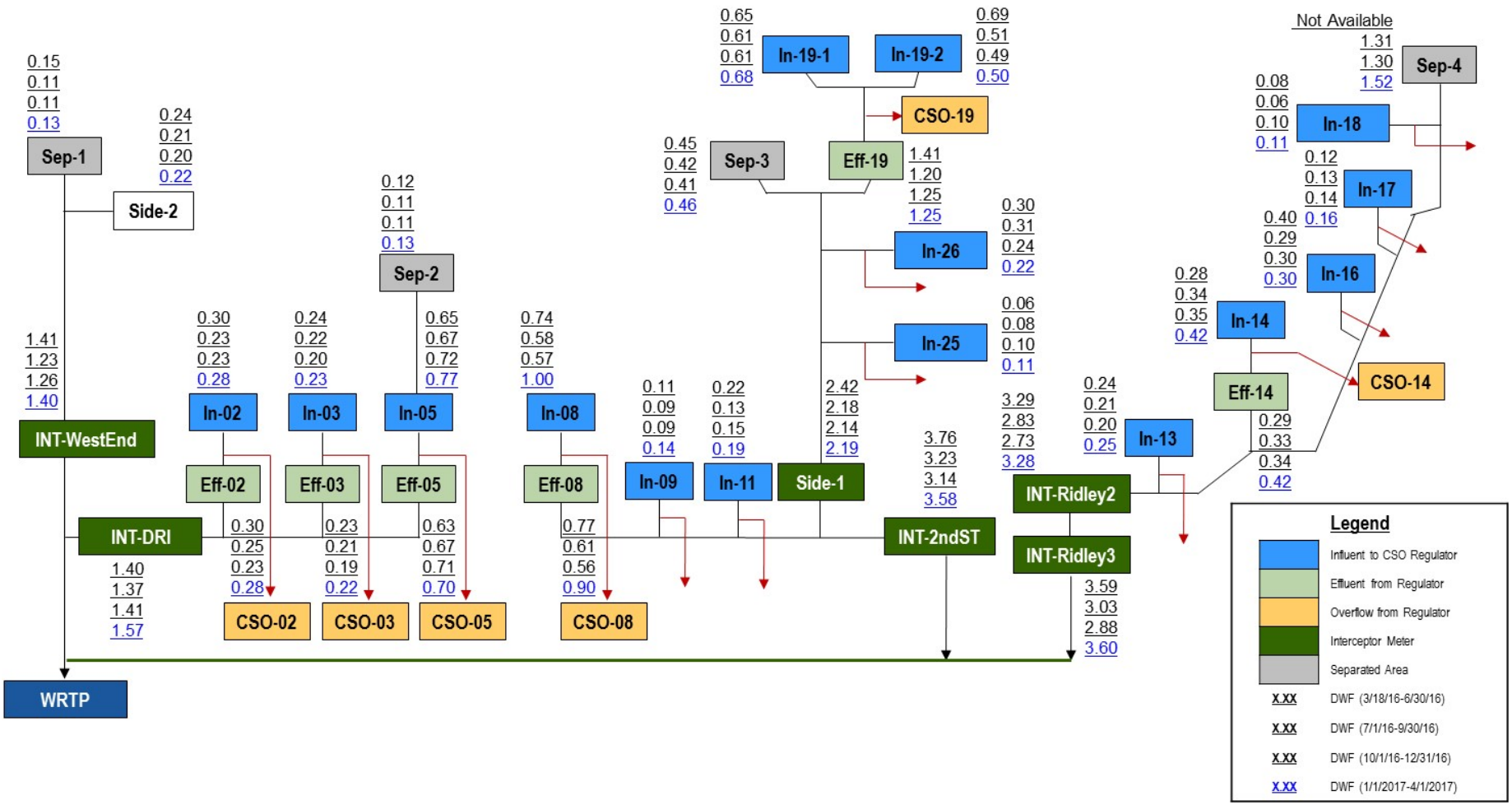


Figure 12: Flow Hydrograph In-08 and Eff-08

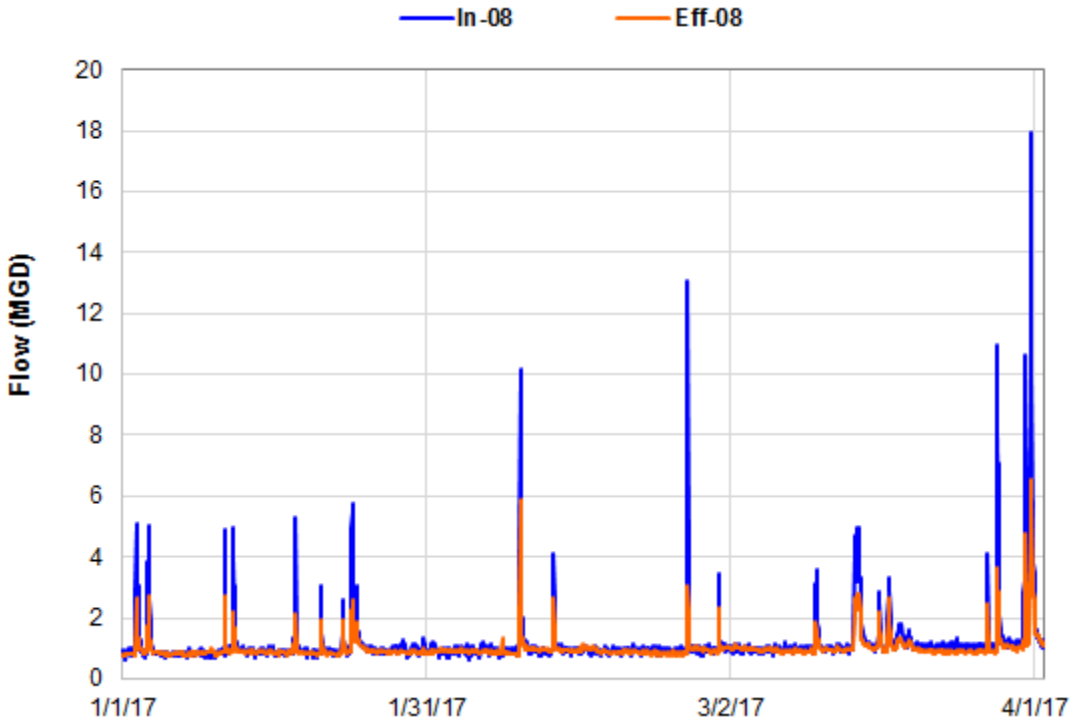
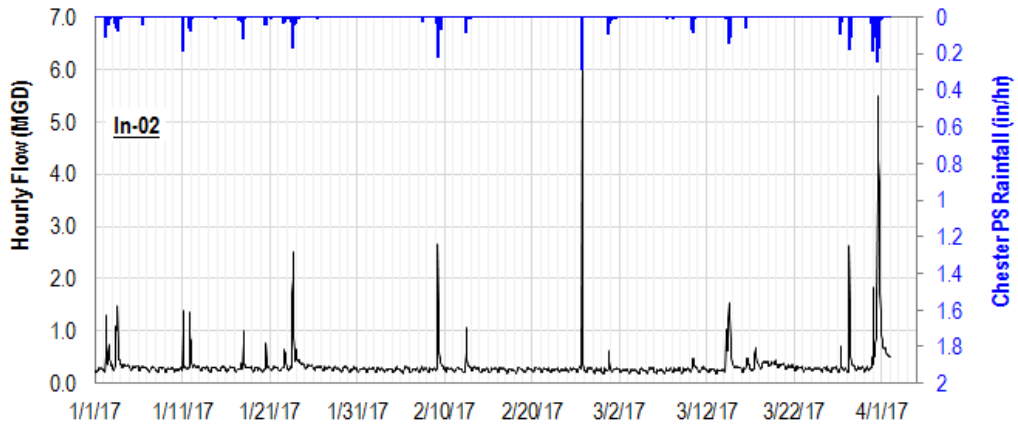
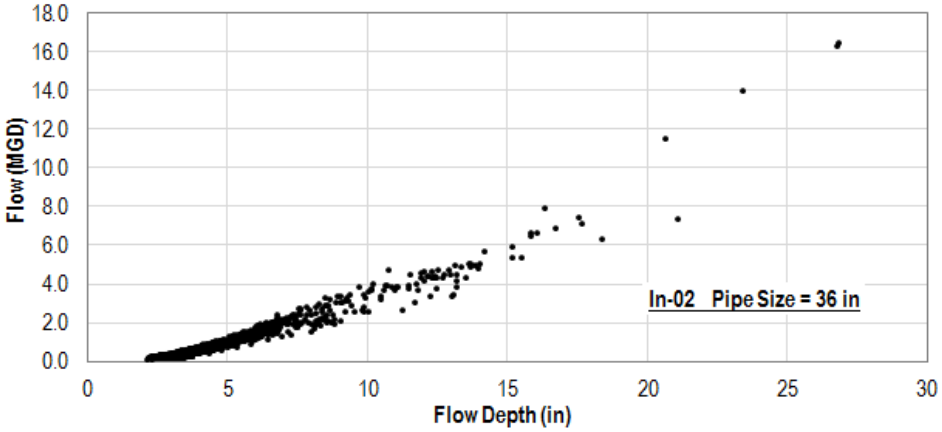


Figure 13: Flow Monitoring Data, In-02

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#02 Influent , Effluent and Overflow

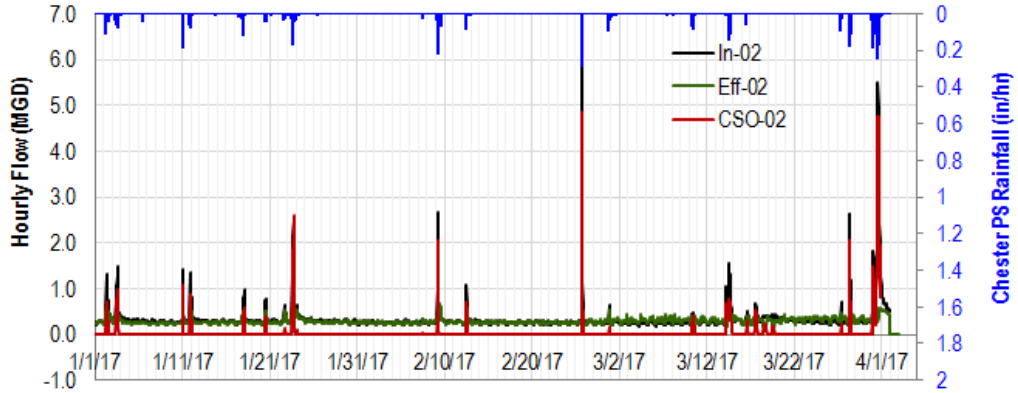
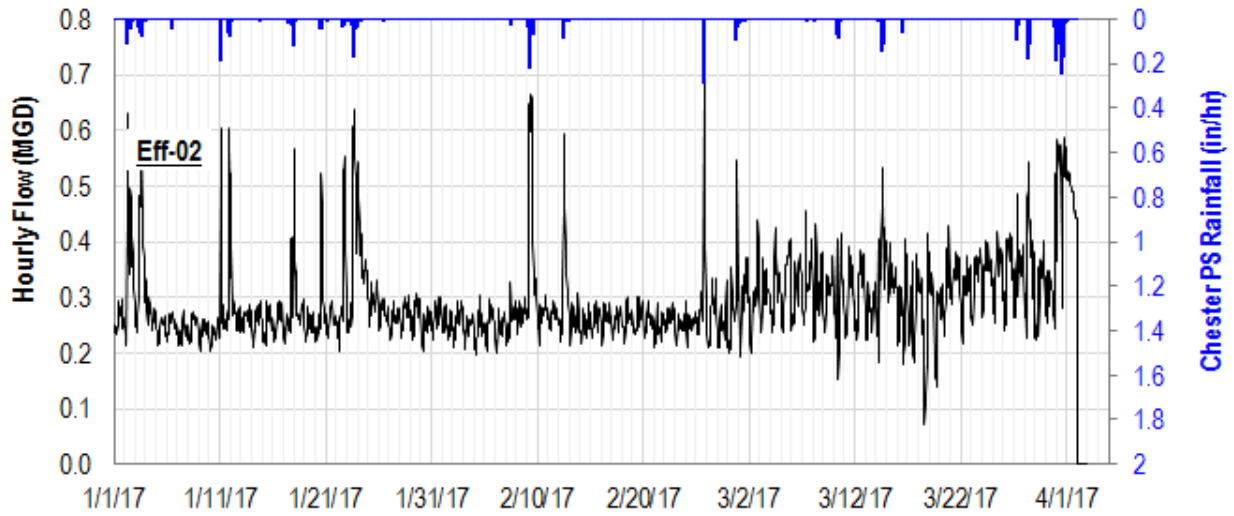


Figure 14: Flow Monitoring Data, EFF-02

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

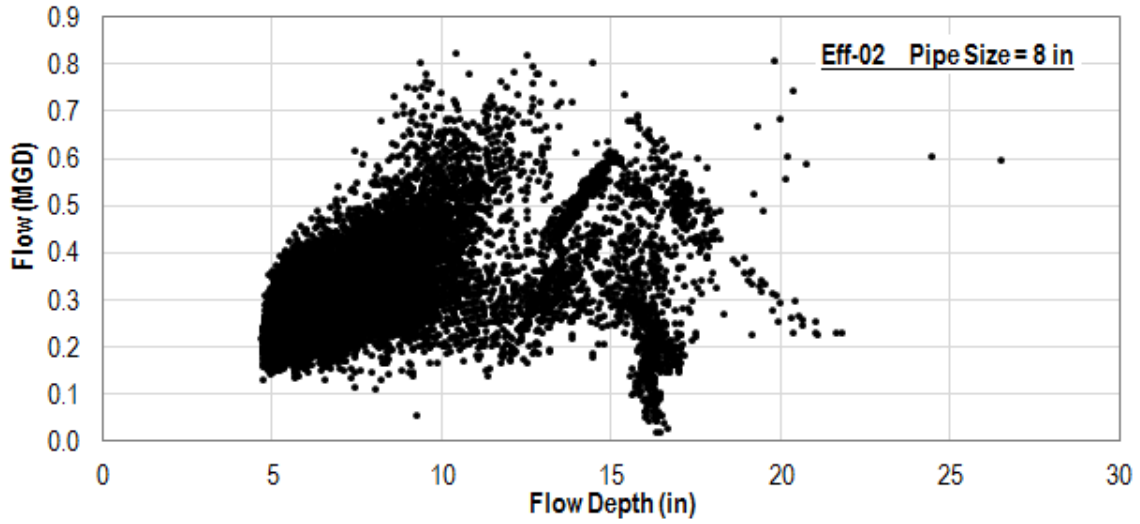
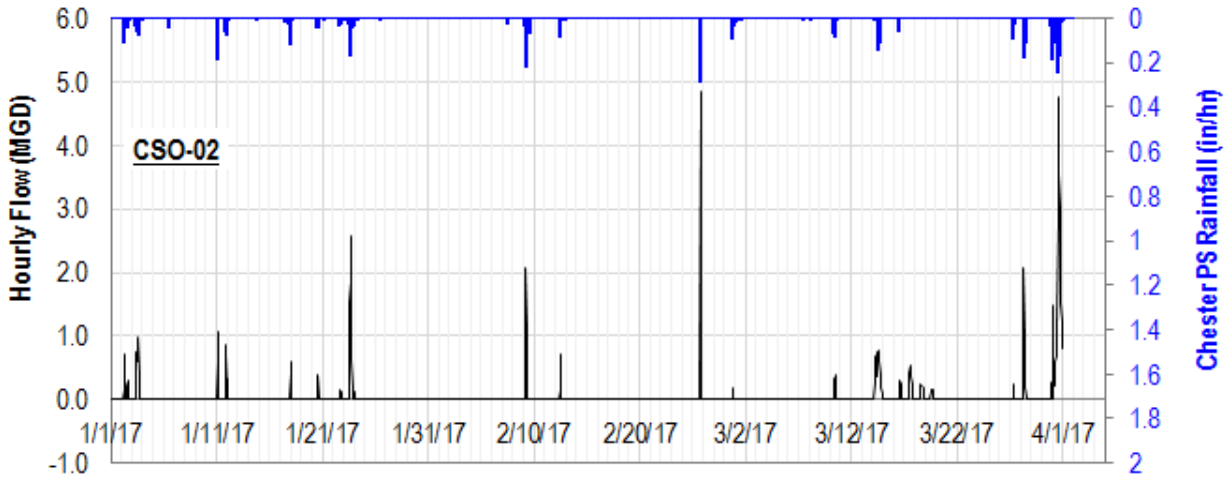


Figure 15: Flow Monitoring Data, CSO-02

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

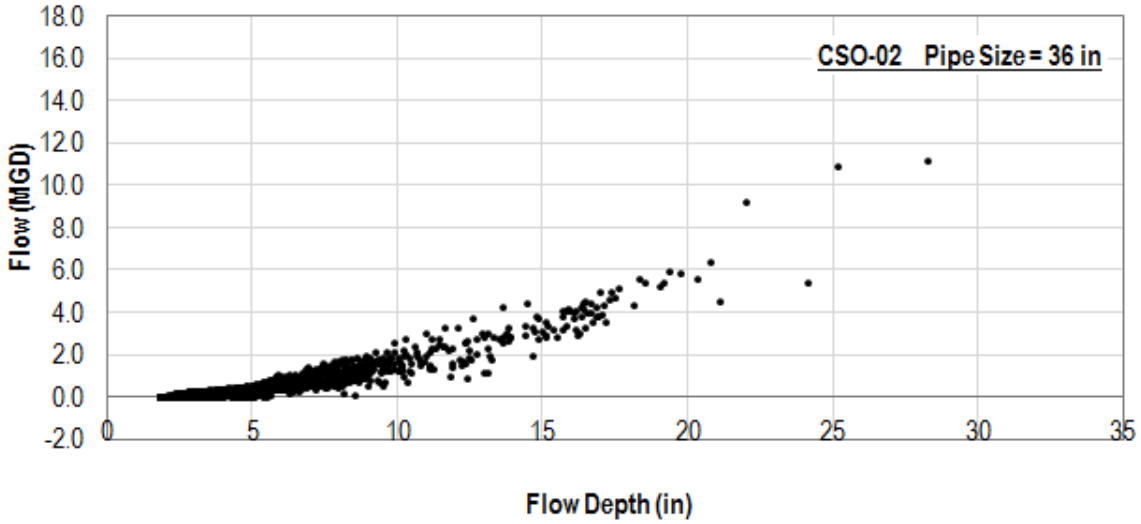
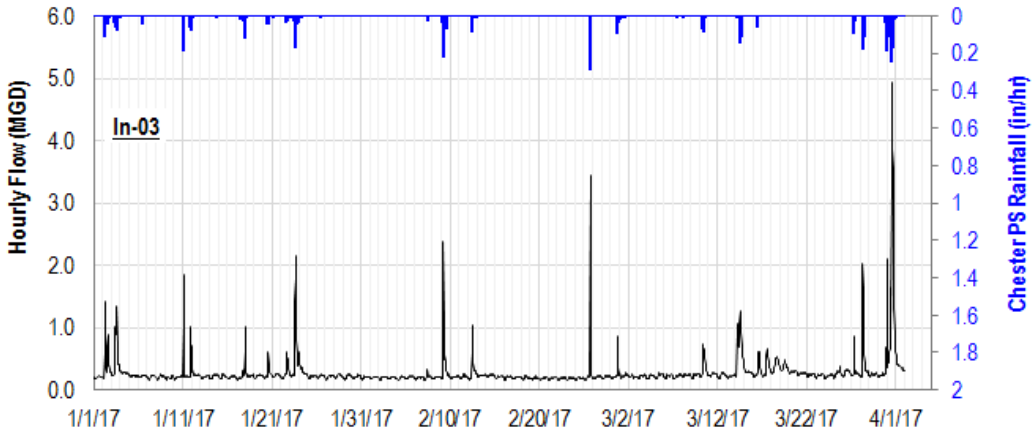
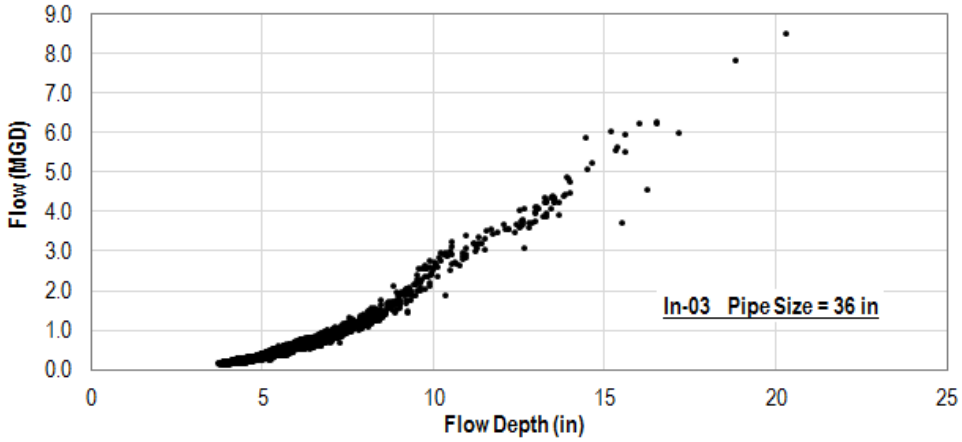


Figure 16: Flow Monitoring Data, IN-03

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#03 Influent , Effluent and Overflow

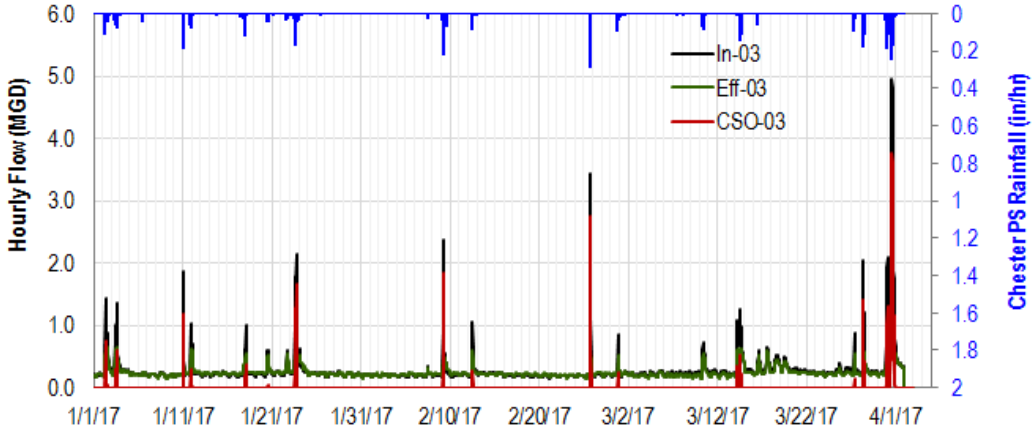
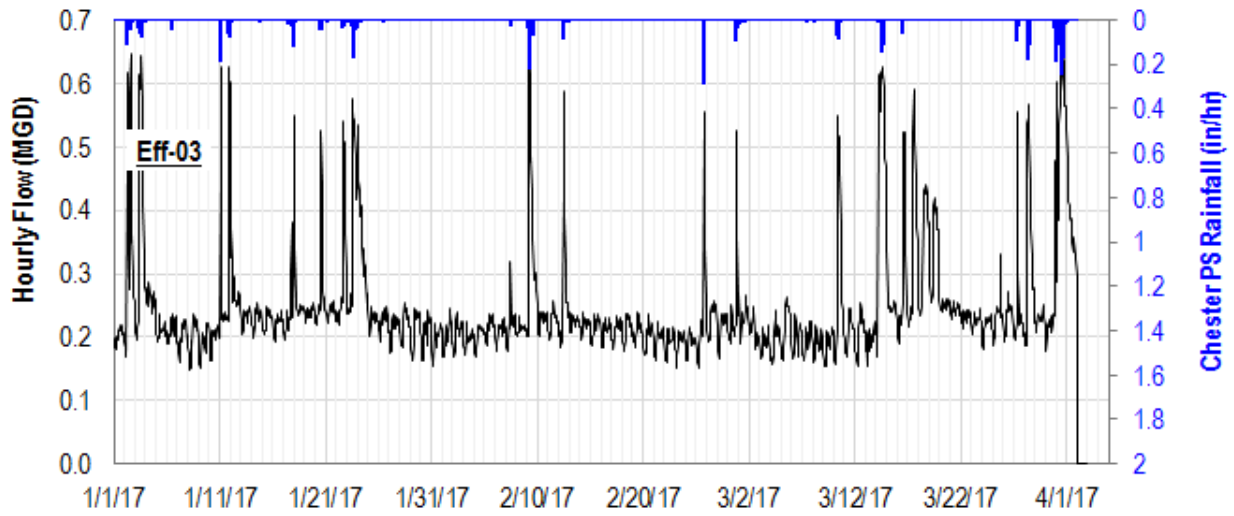


Figure 17: Flow Monitoring Data, Eff-03

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

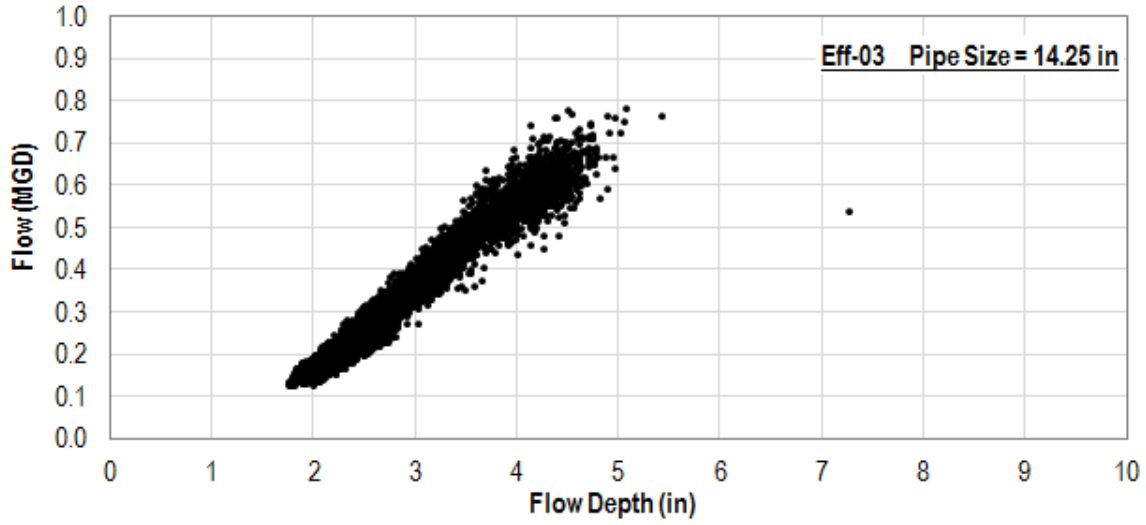
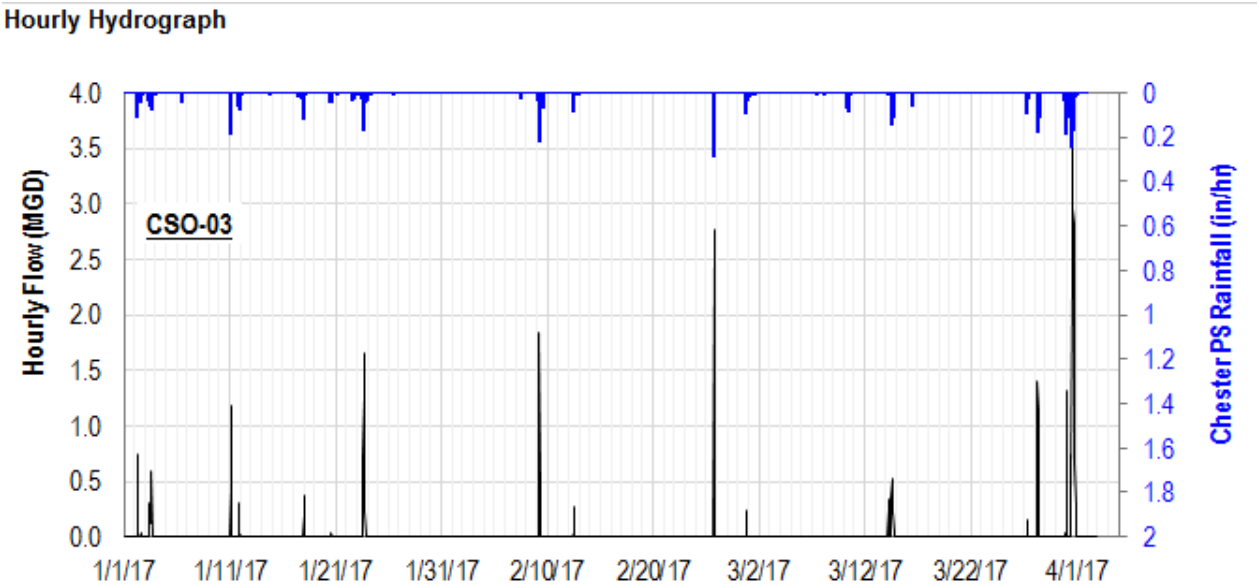


Figure 18: Flow Monitoring Data, CSO-03



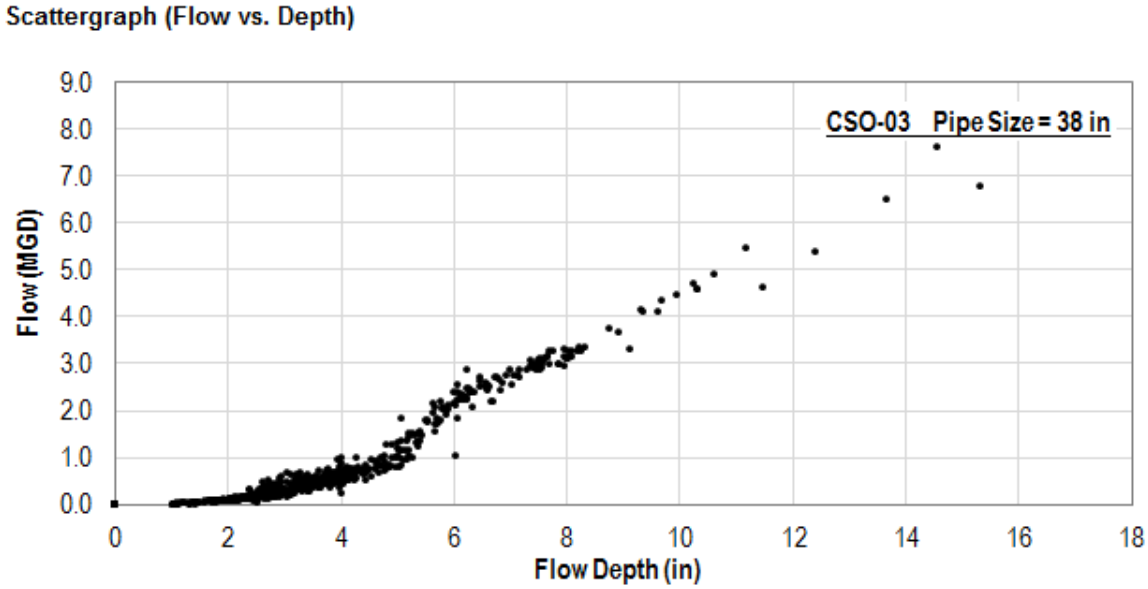
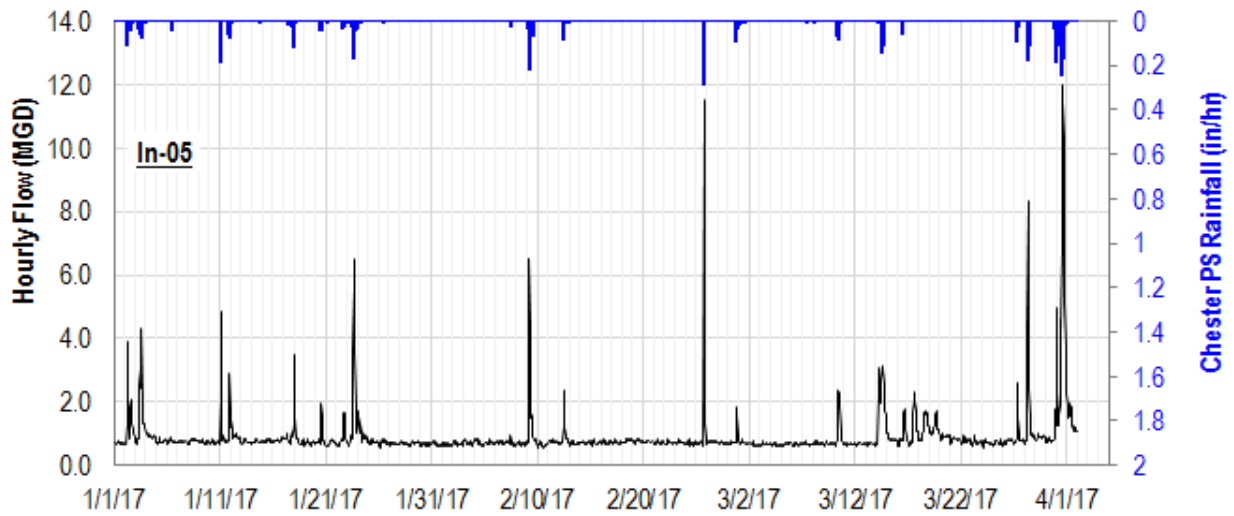


Figure 19: Flow Monitoring Data, IN-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

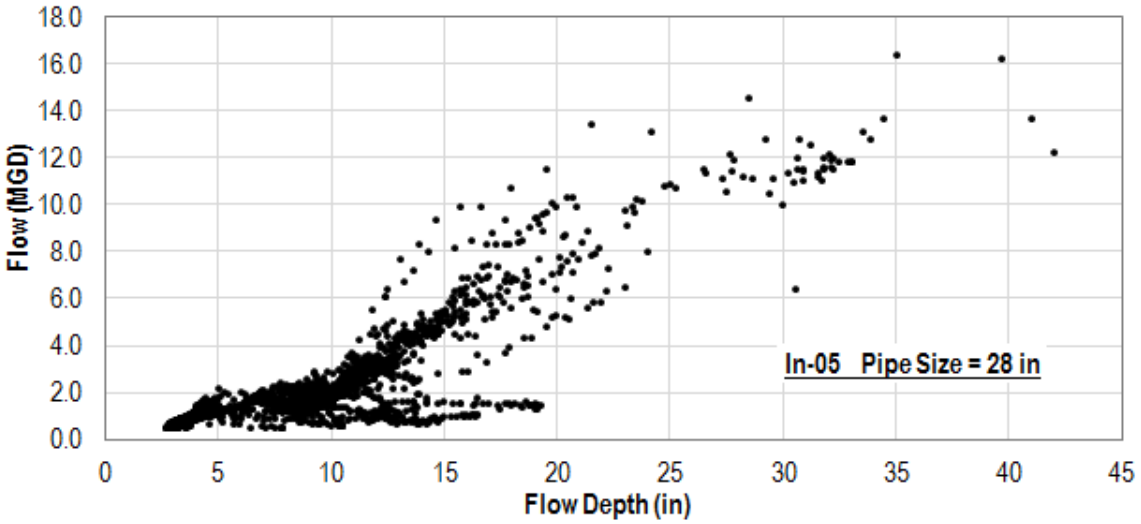
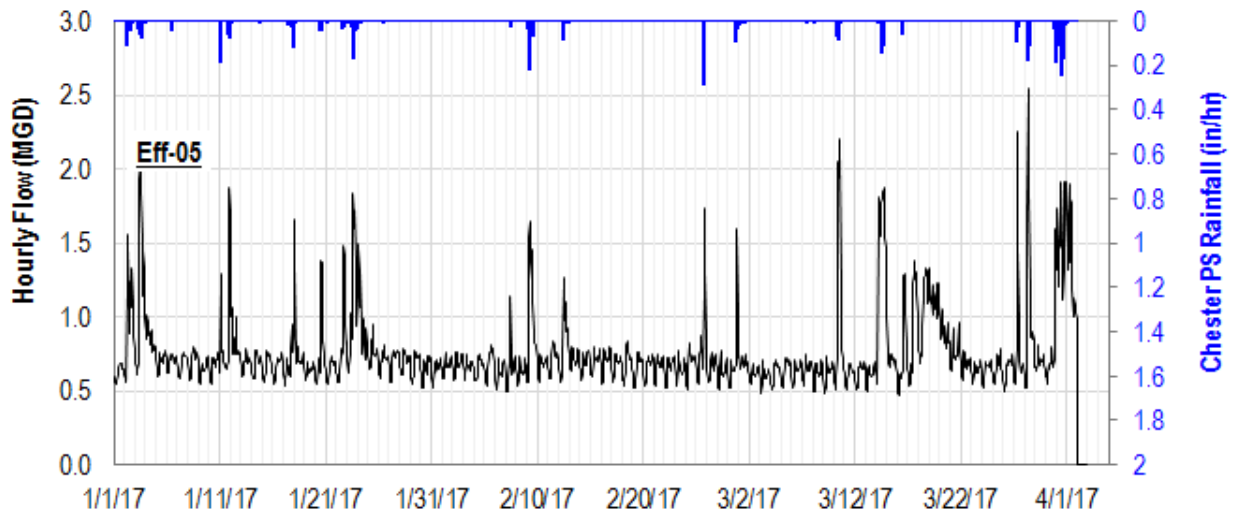


Figure 20: Flow Monitoring Data, Eff-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

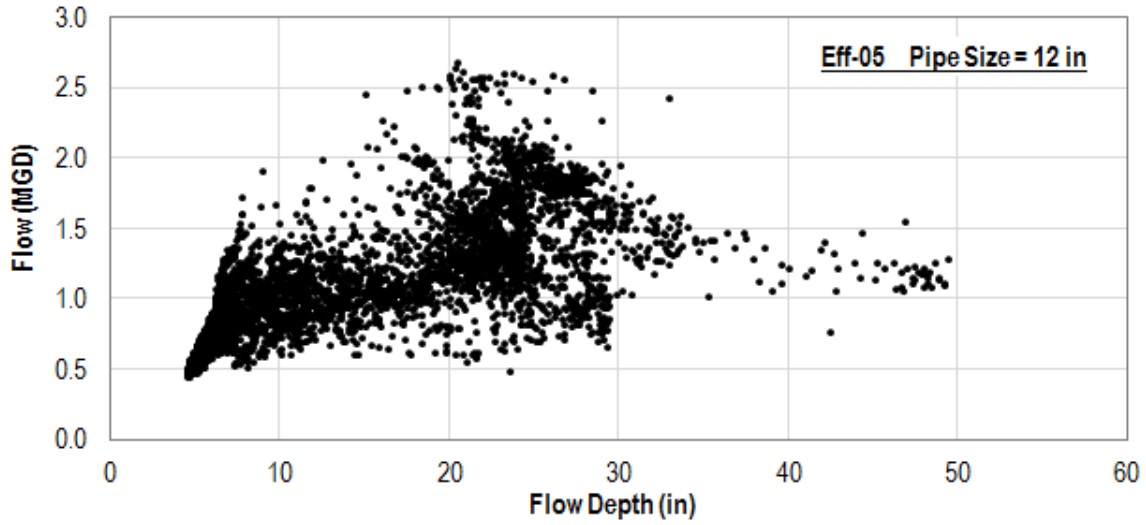
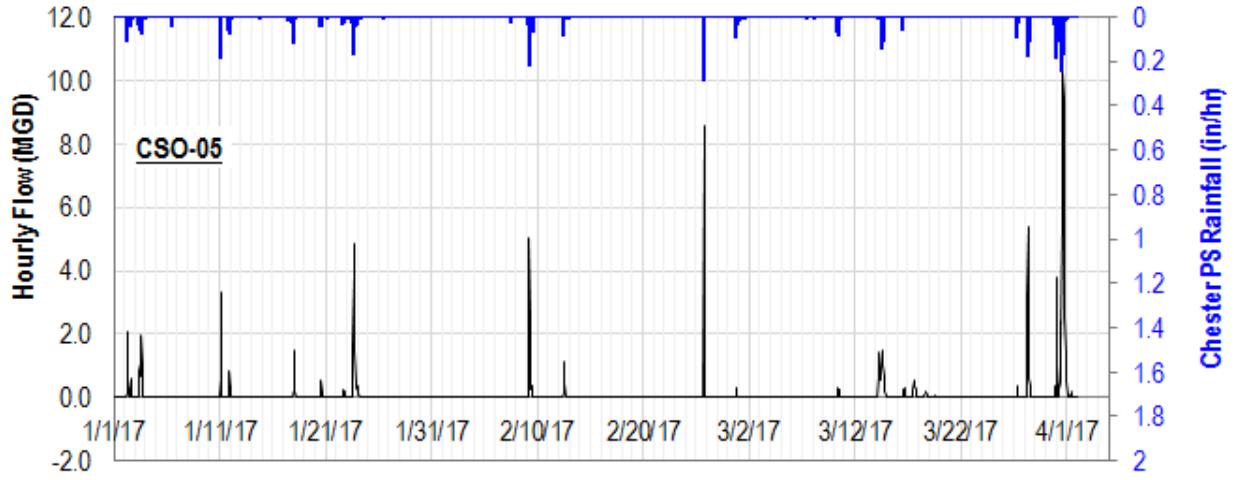


Figure 21: Flow Monitoring Data, CSO-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

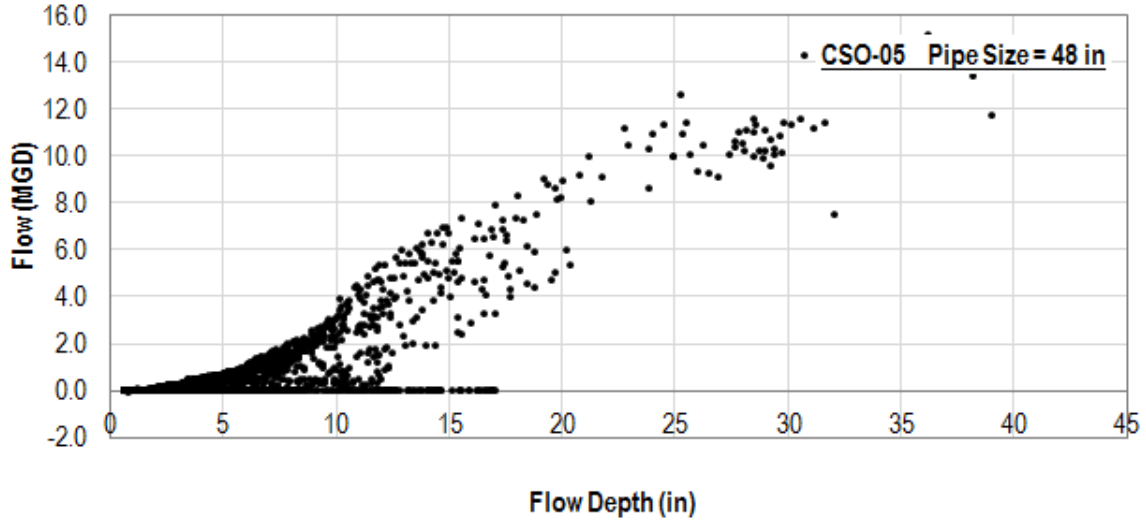
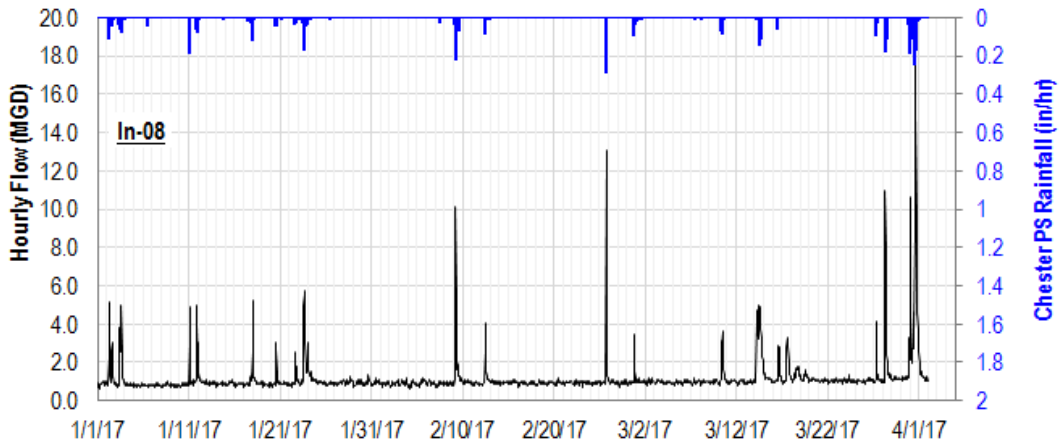
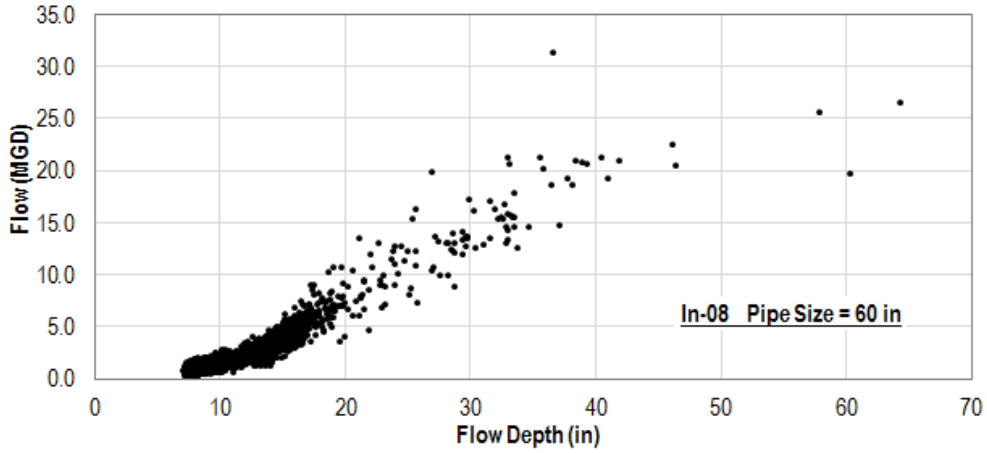


Figure 22: Flow Monitoring Data, IN-08

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#08 Influent , Effluent and Overflow

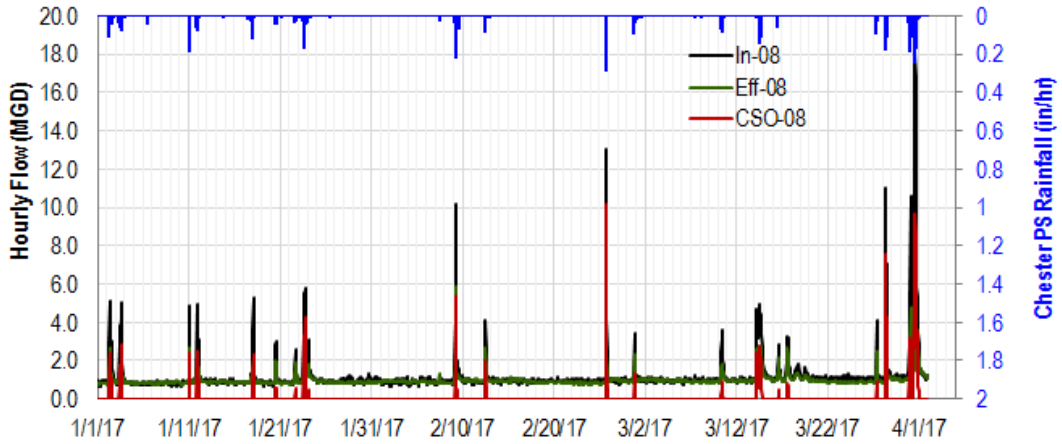


Figure 23: Flow Monitoring Data, Eff-08

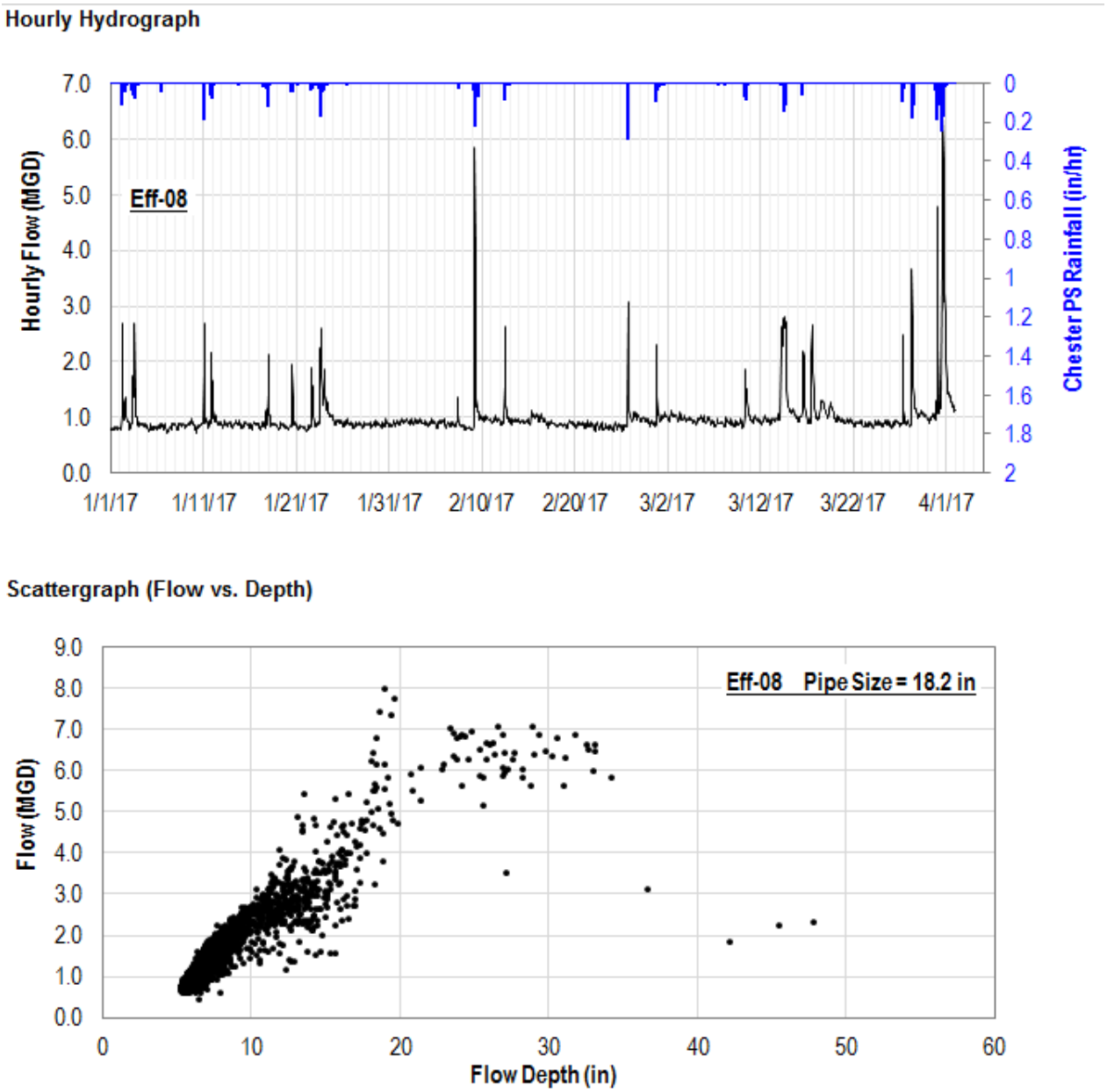


Figure 24: Flow Monitoring Data, CSO-08

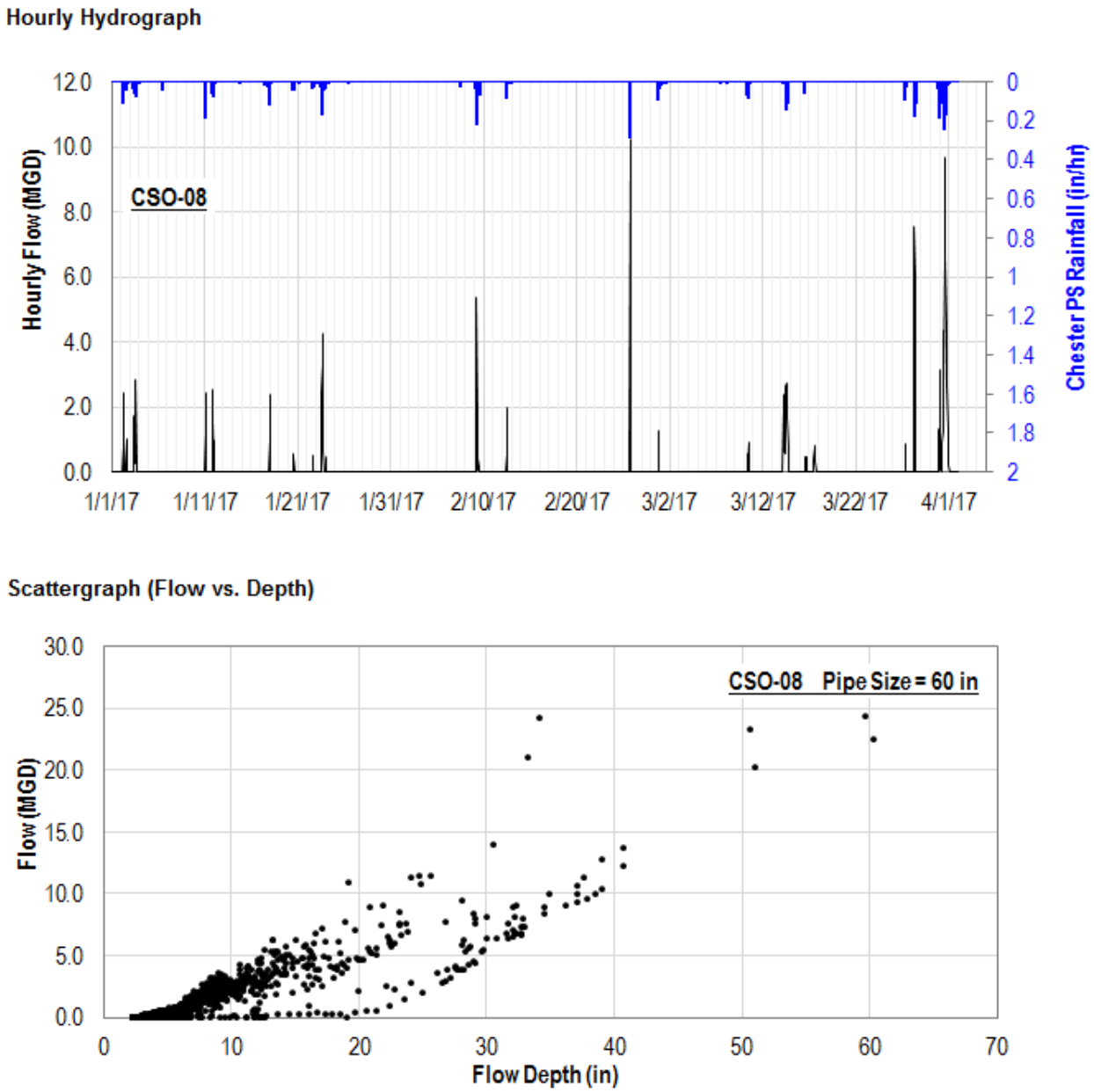
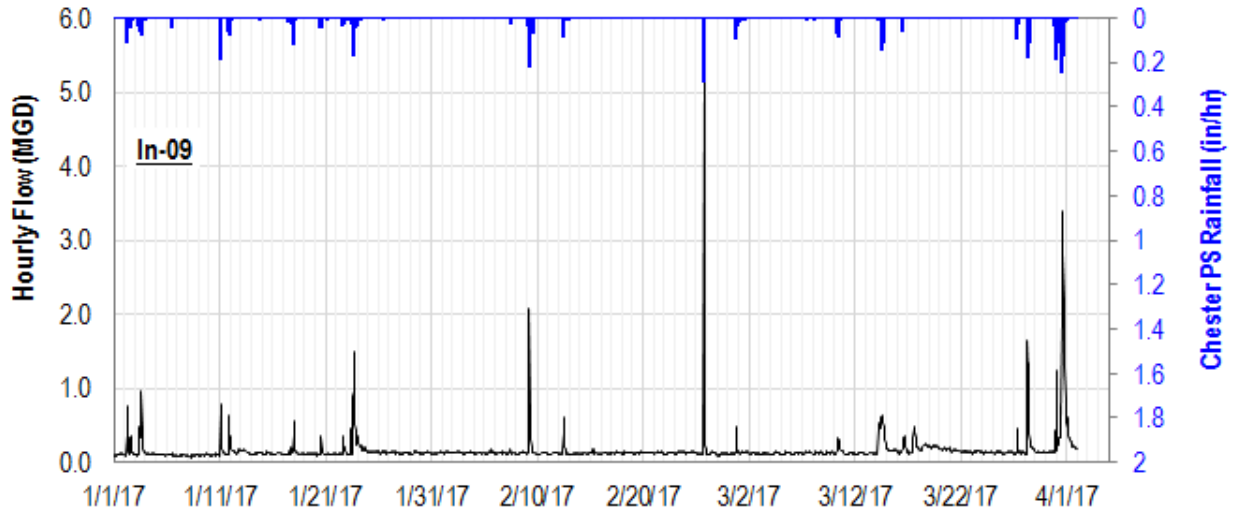


Figure 25: Flow Monitoring Data, In-09

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

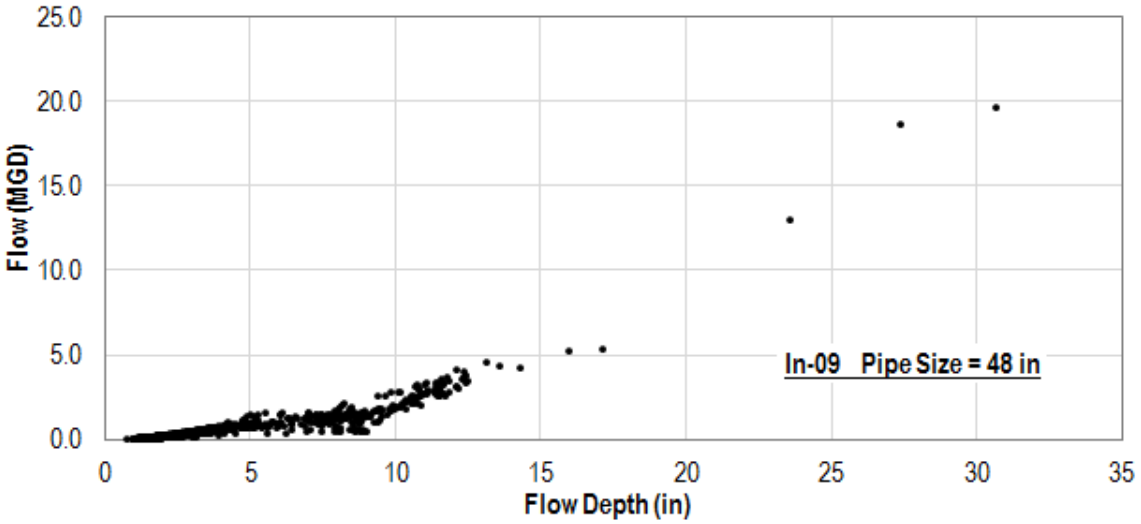
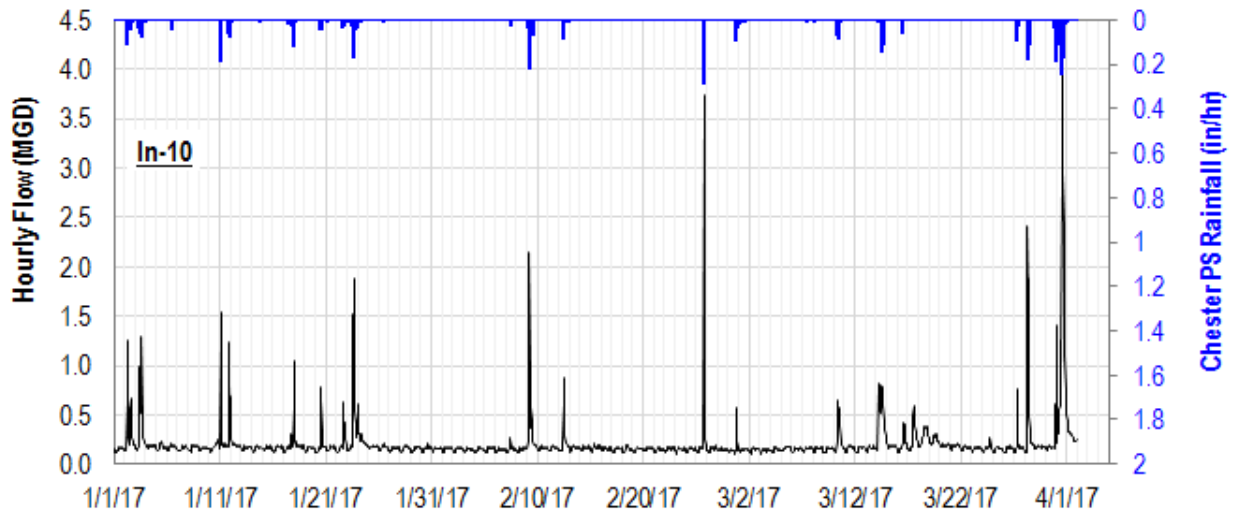


Figure 26: Flow Monitoring Data, In-10

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

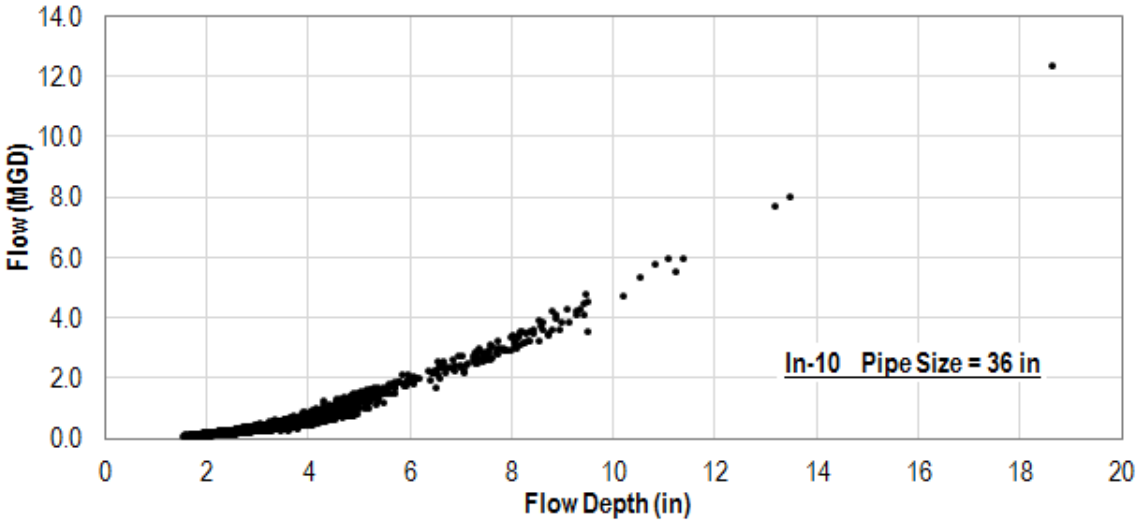
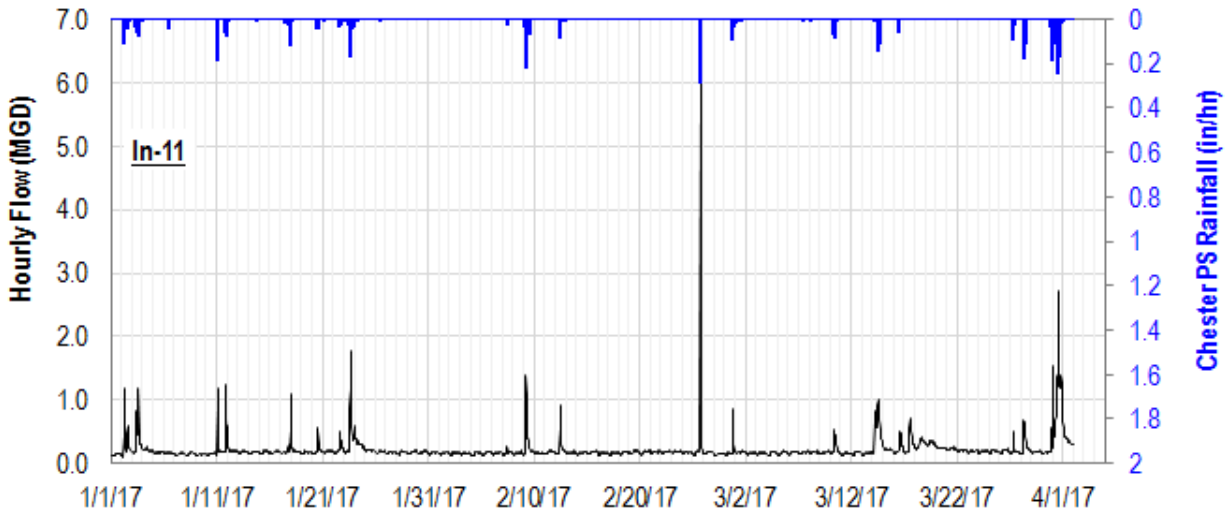


Figure 27: Flow Monitoring Data, In-11

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

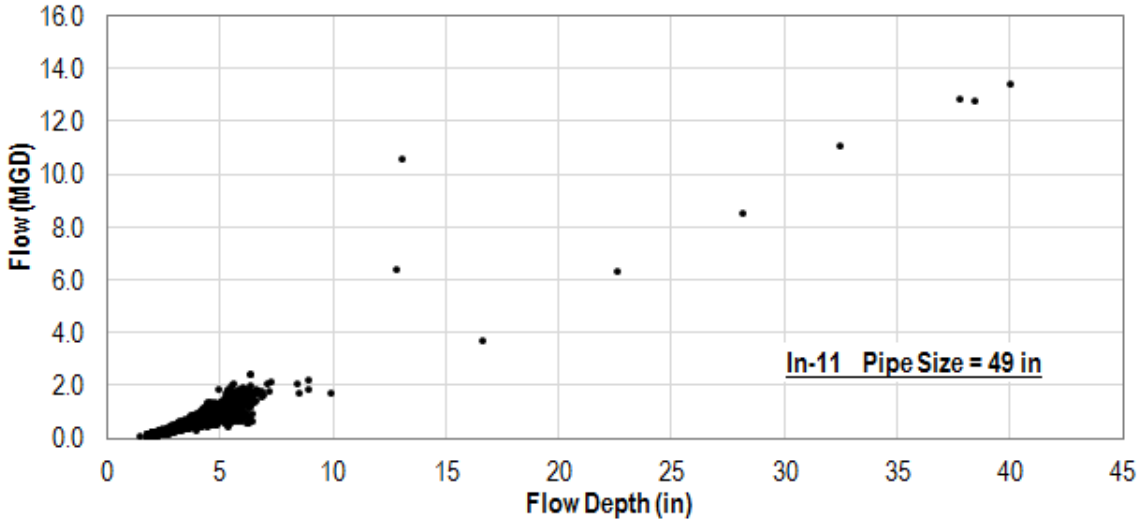


Figure 28: Flow Monitoring Data, In-13

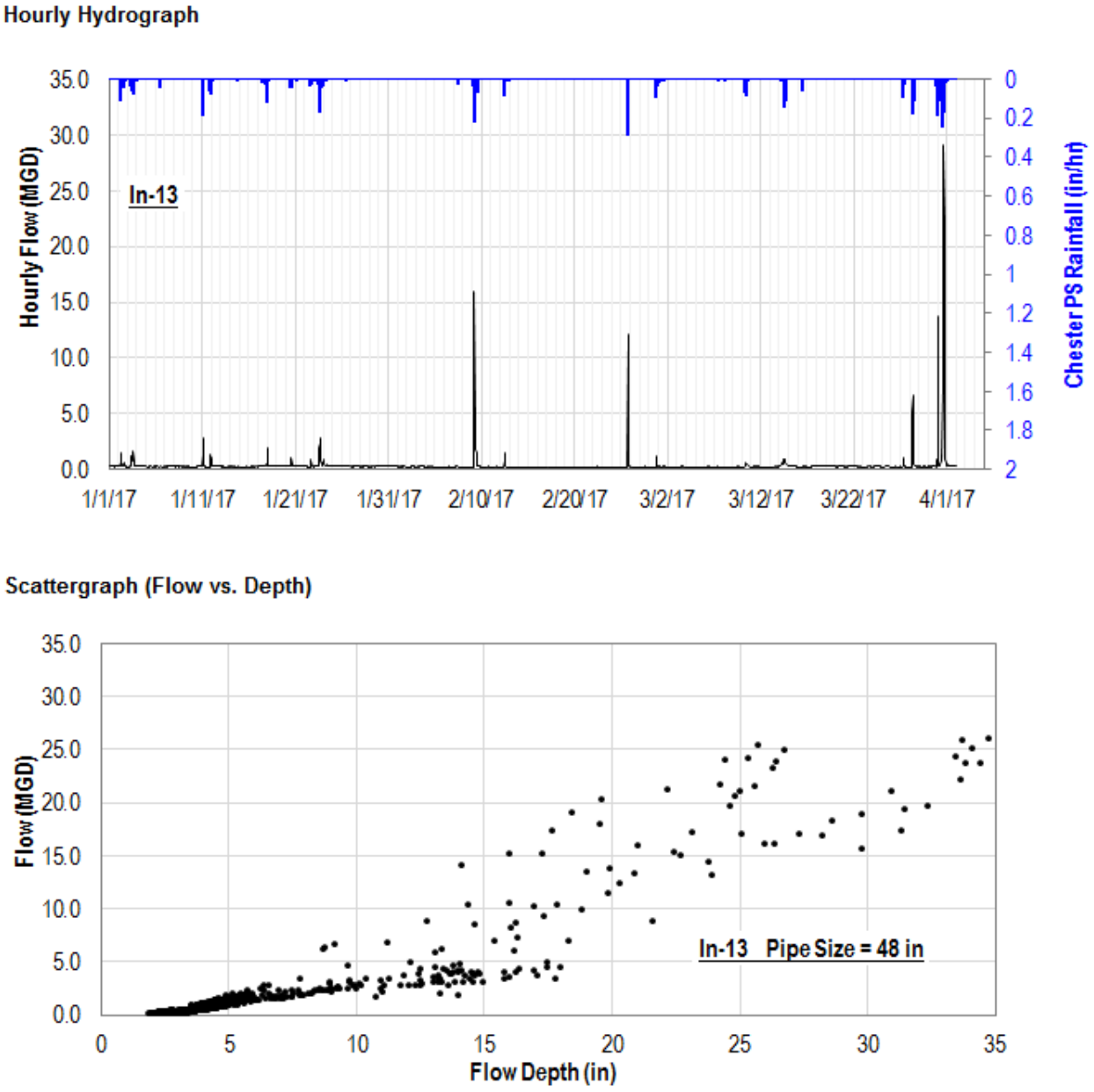
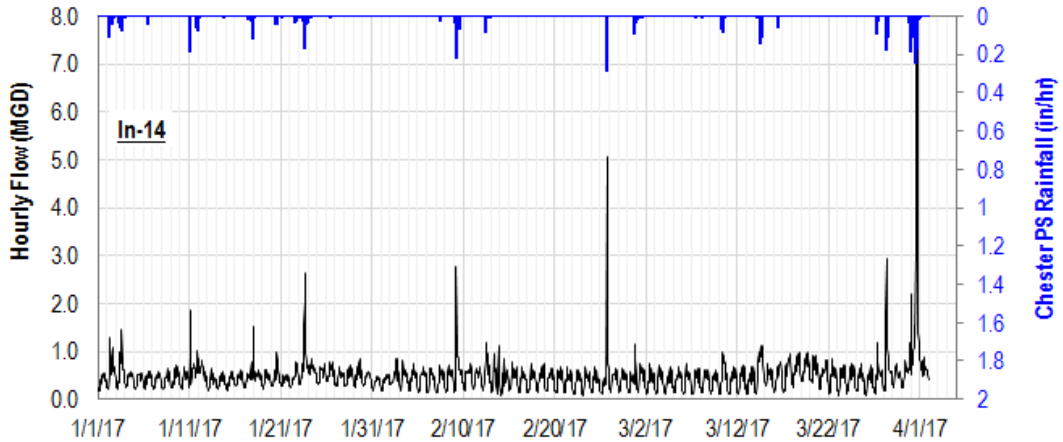
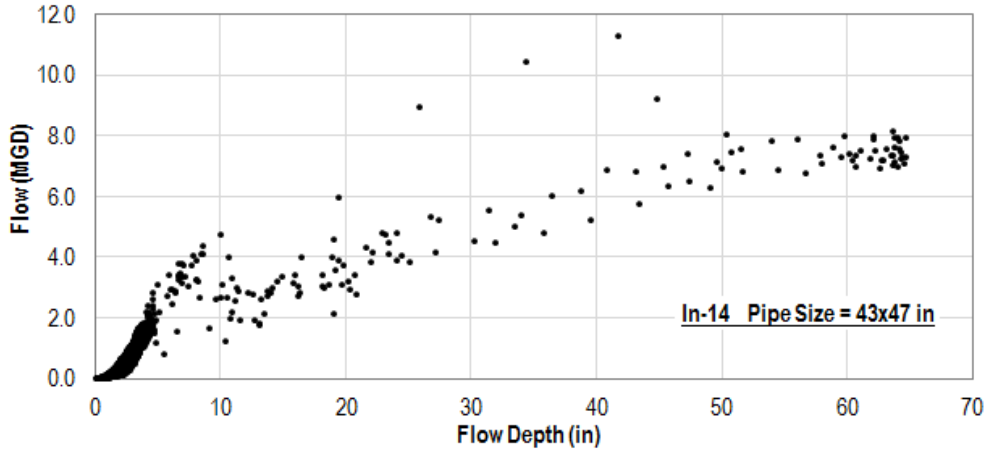


Figure 29: Flow Monitoring Data, In-14

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#14 Influent , Effluent and Overflow

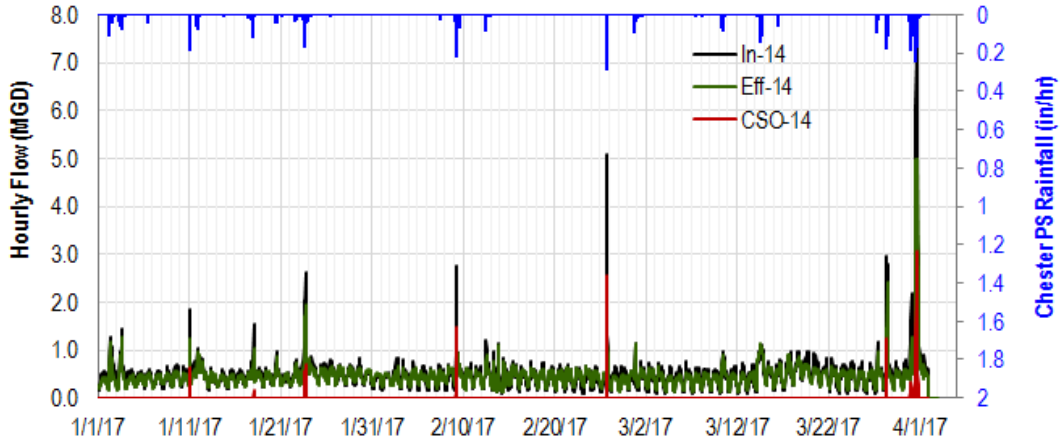
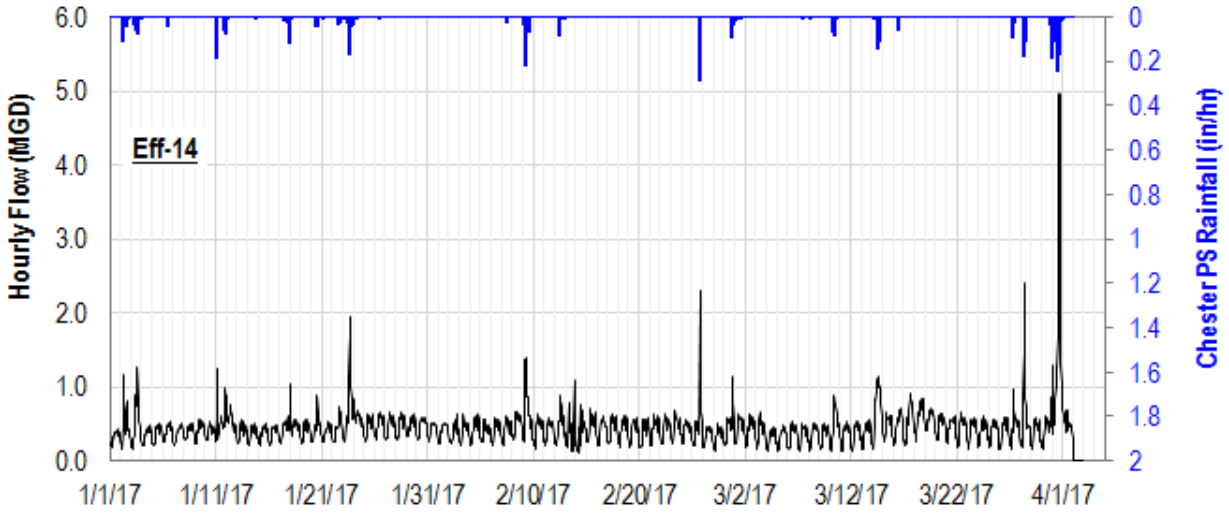


Figure 30: Flow Monitoring Data, Eff-14

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

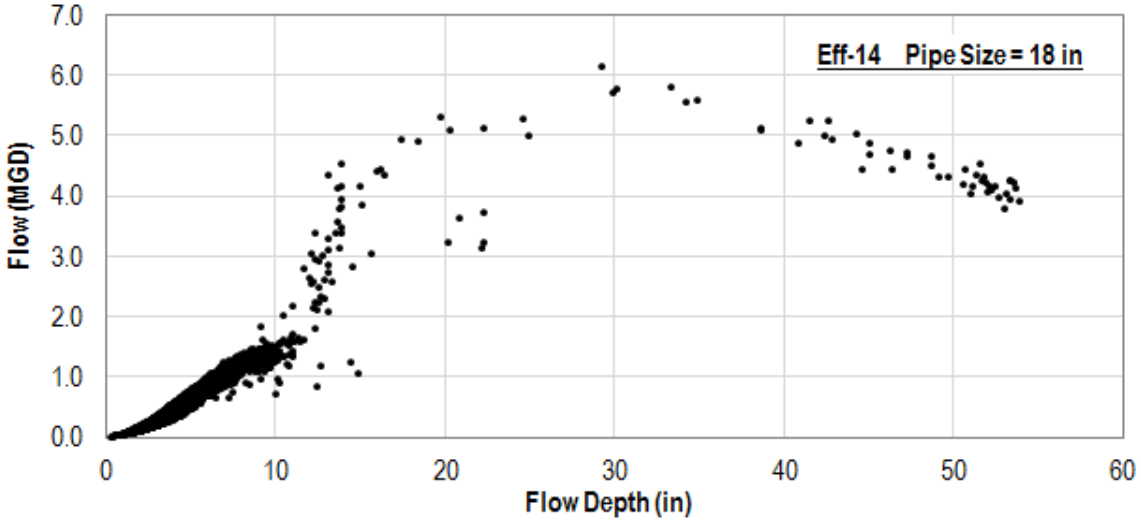


Figure 31: Flow Monitoring Data, CSO-14

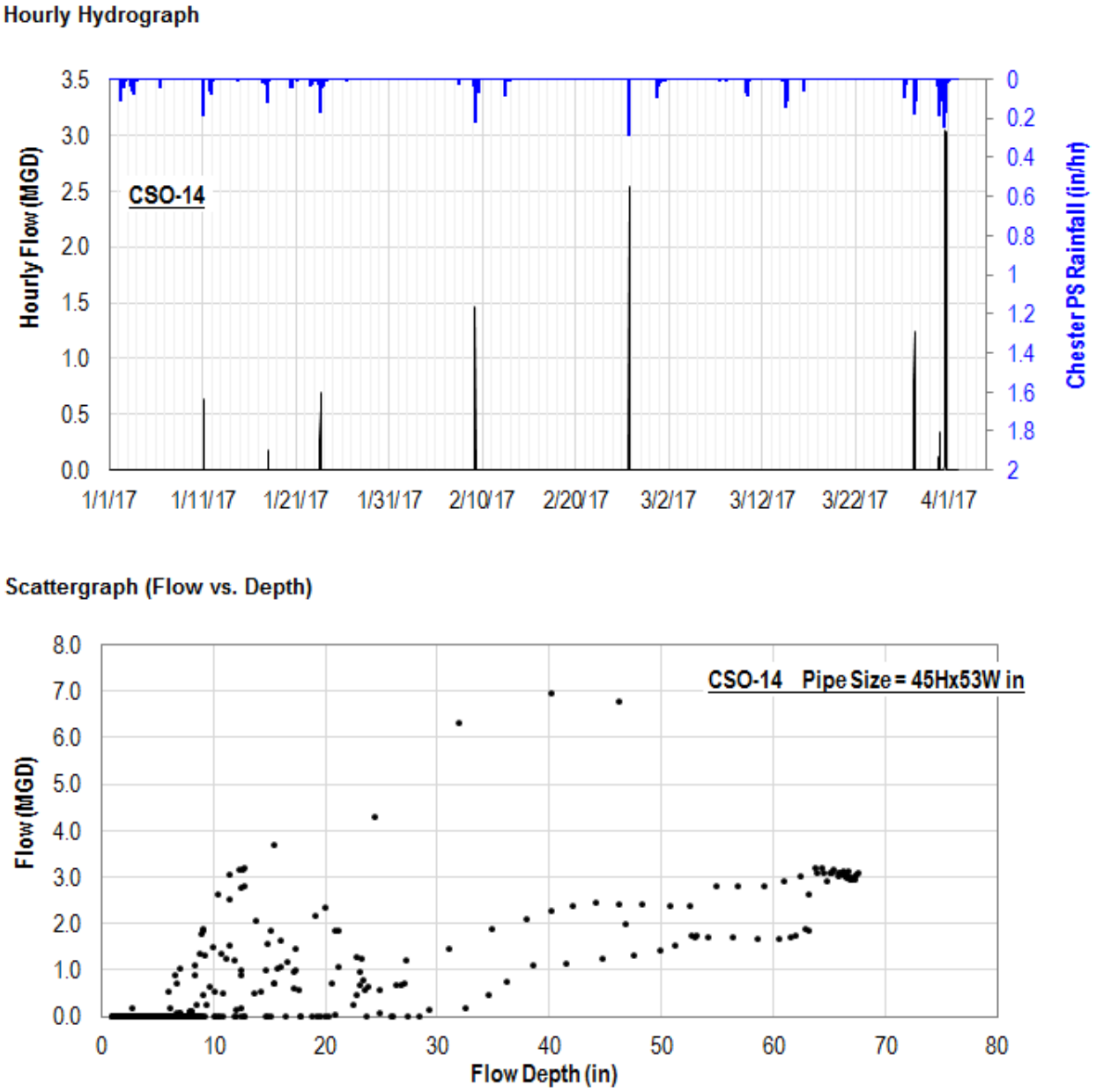
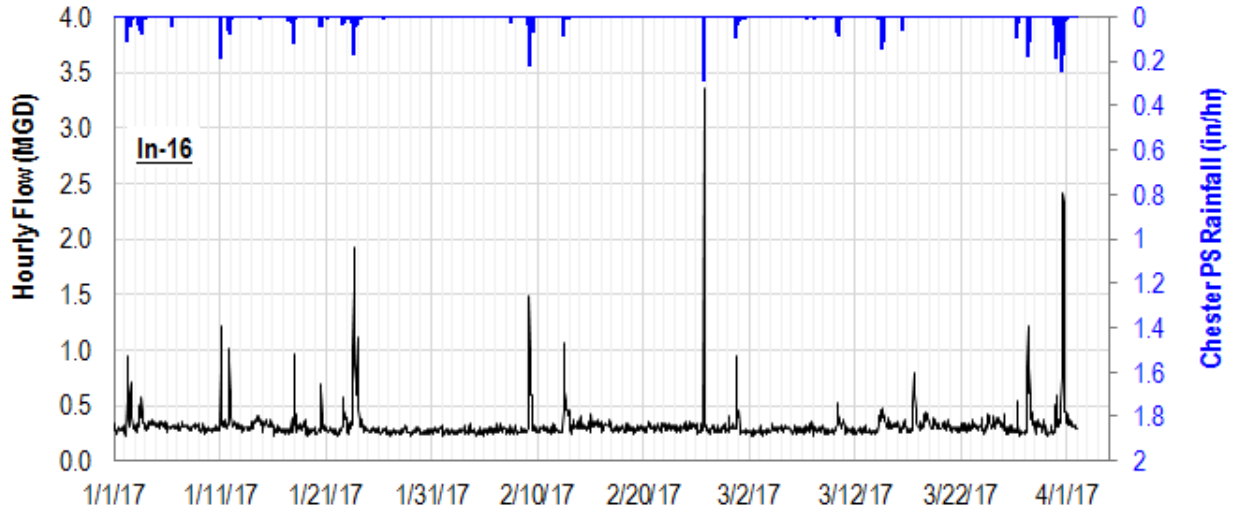


Figure 32: Flow Monitoring Data, In-16

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

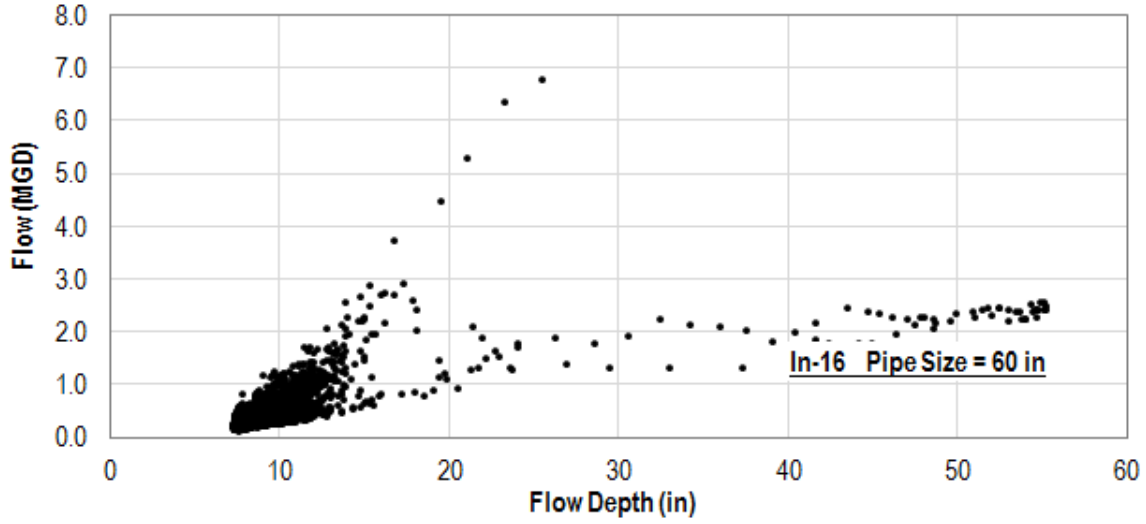


Figure 33: Flow Monitoring Data, In-17

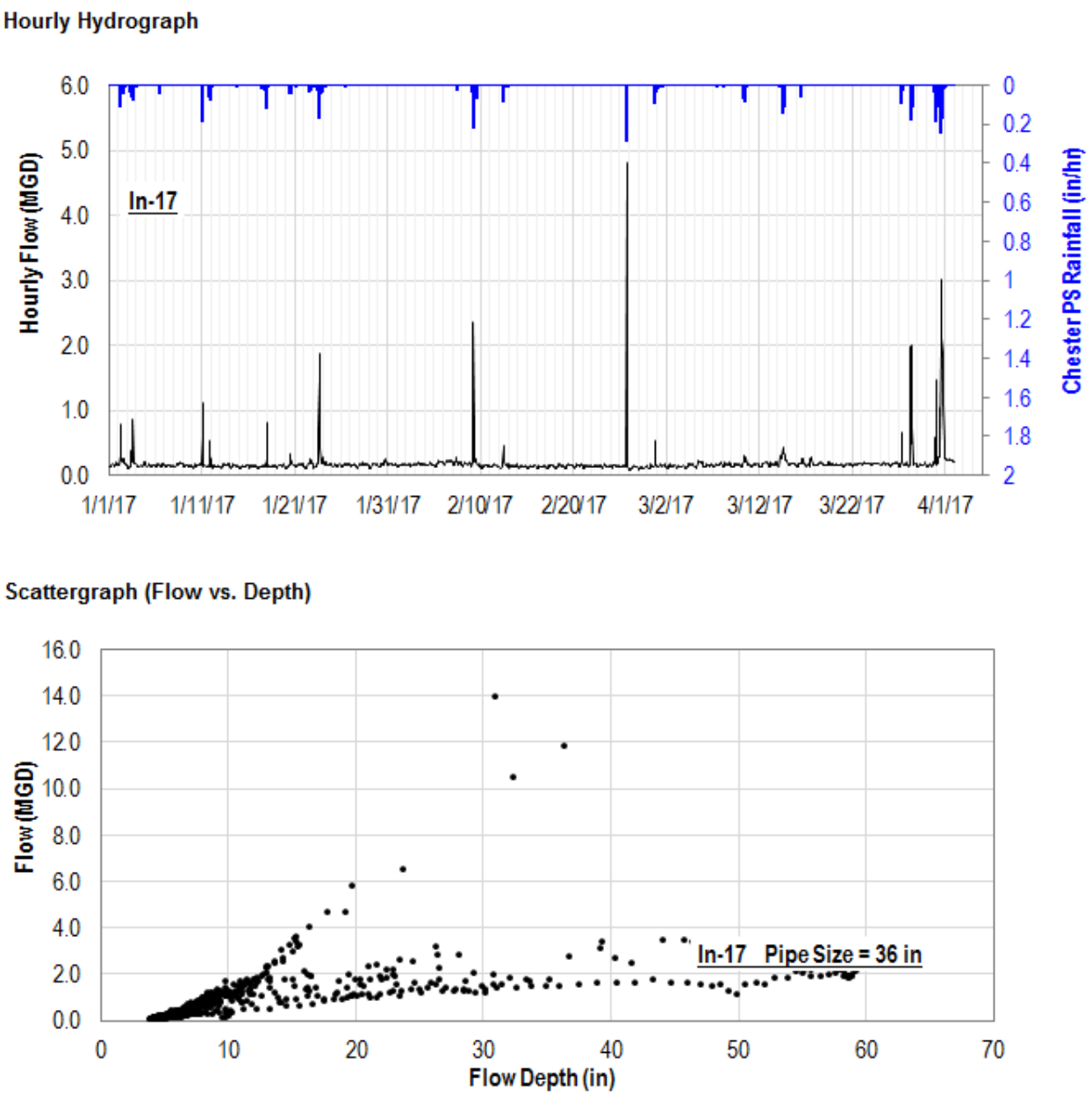


Figure 34: Flow Monitoring Data, In-18

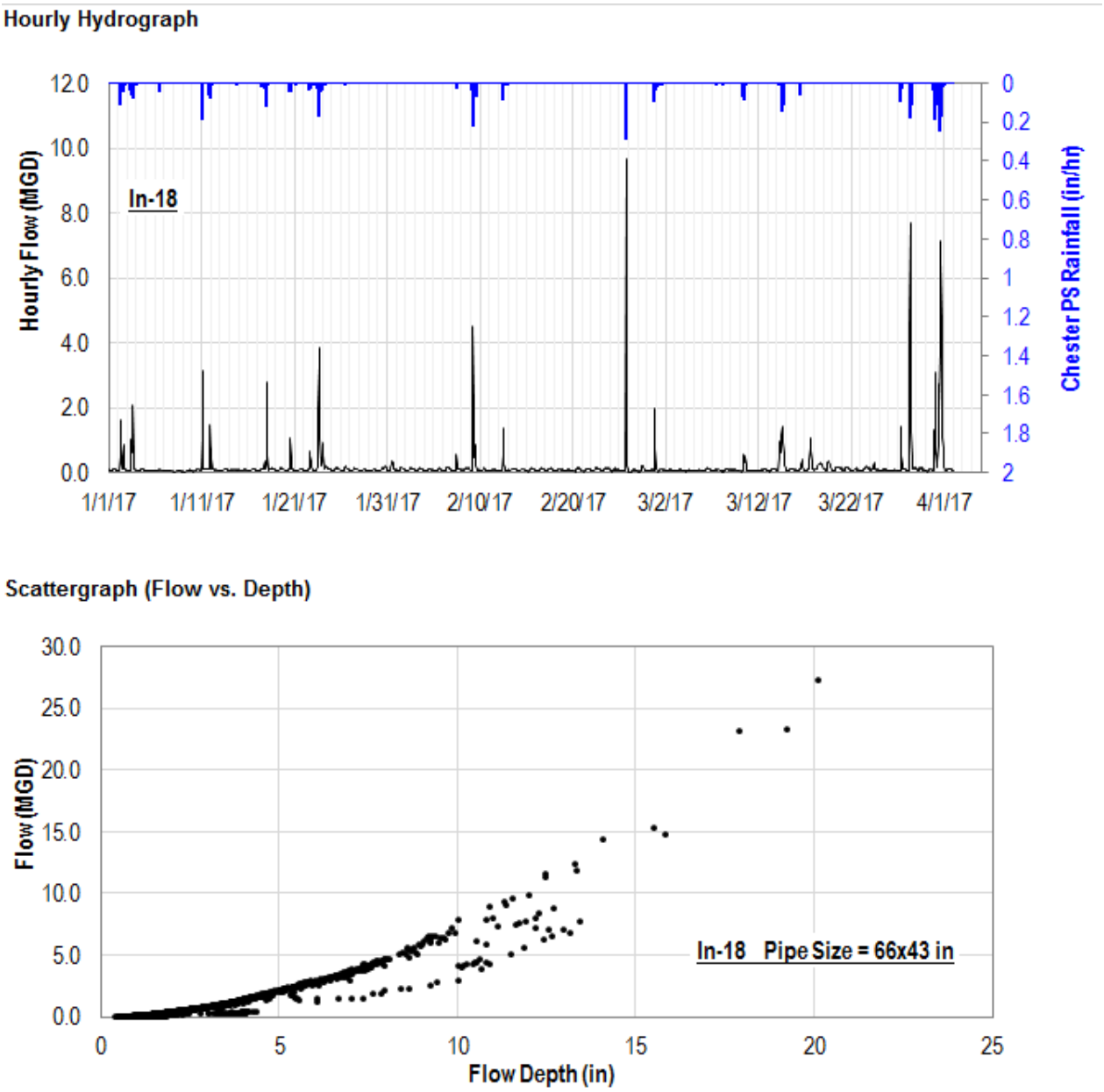


Figure 35: Flow Monitoring Data, In-19-1

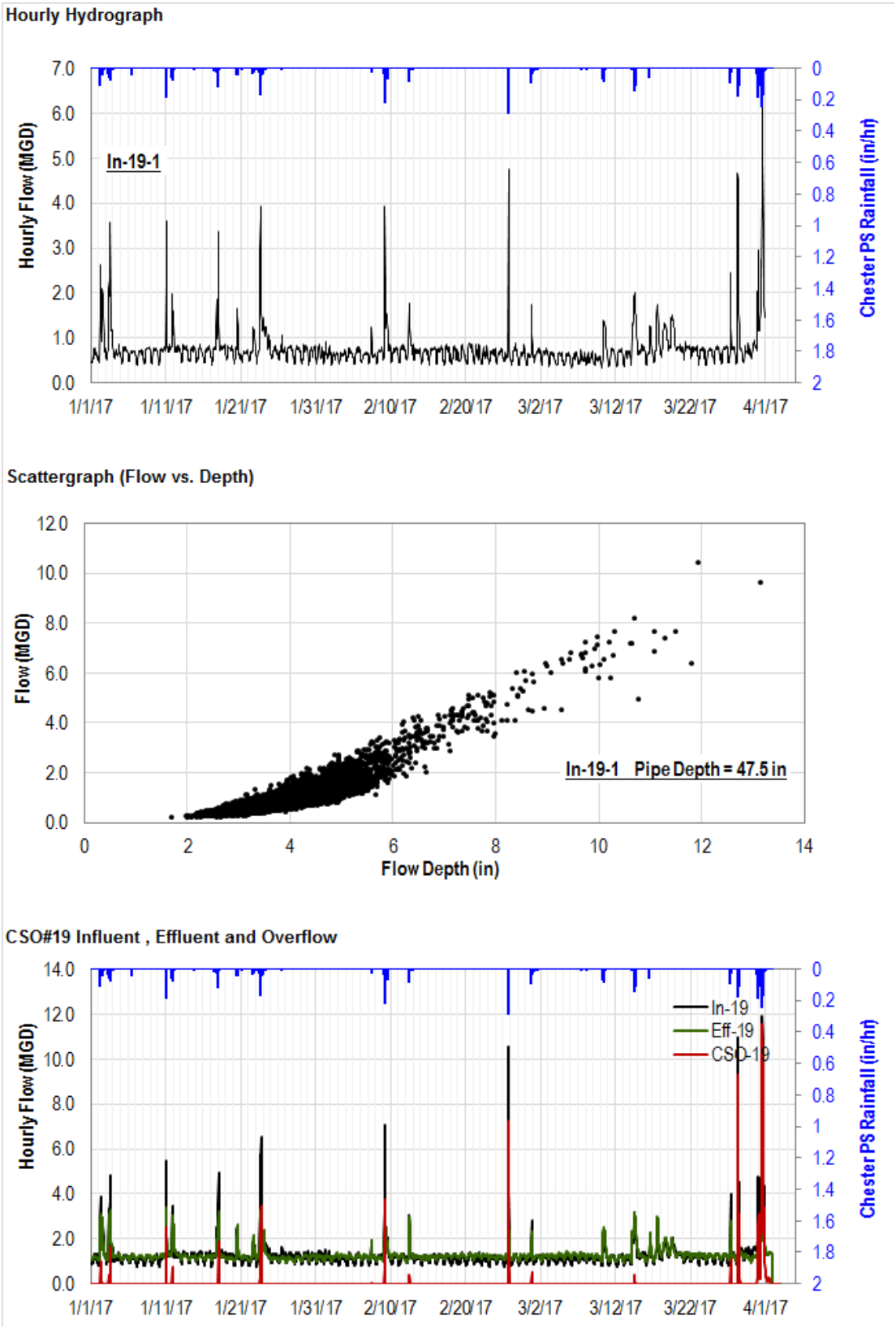
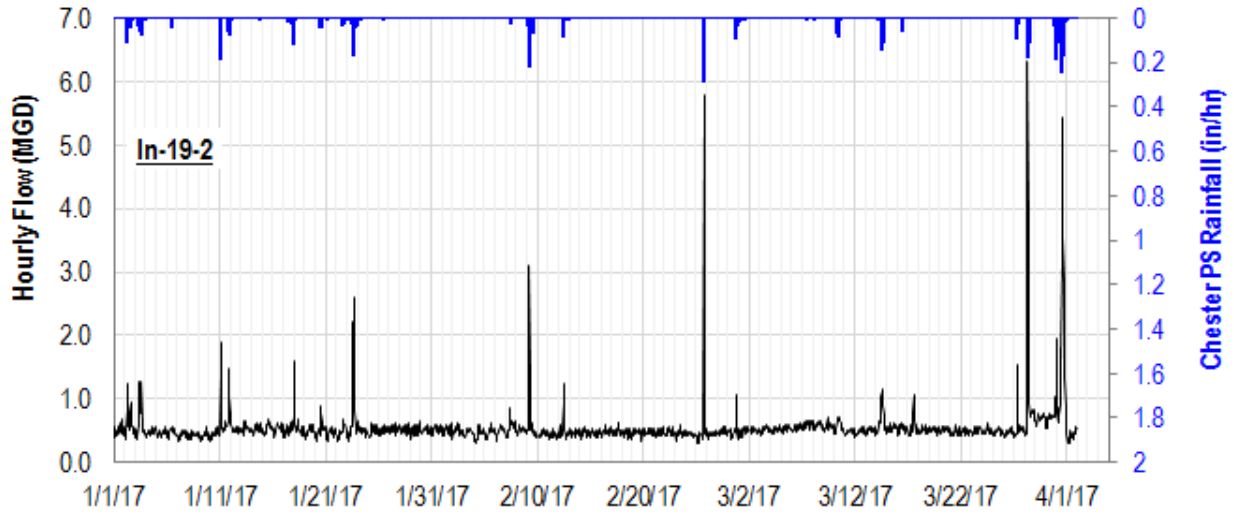


Figure 36: Flow Monitoring Data, In-19-2

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

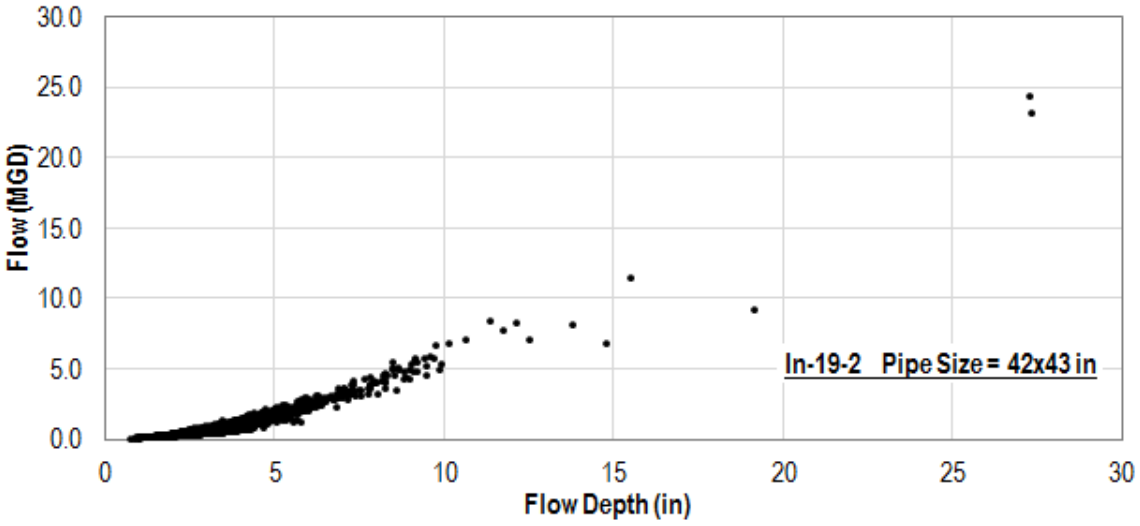
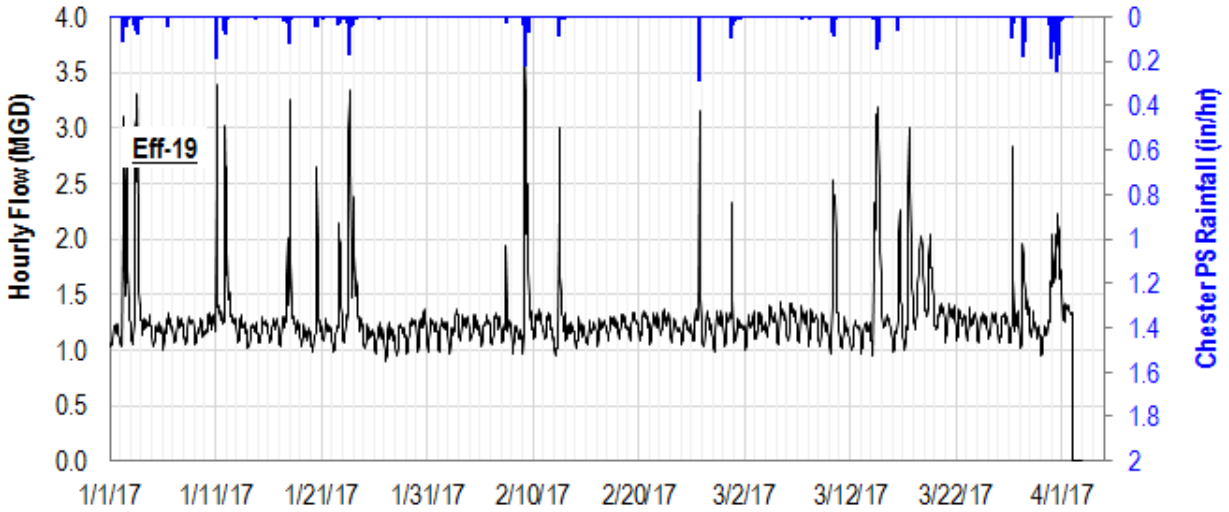


Figure 37: Flow Monitoring Data, Eff-19

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

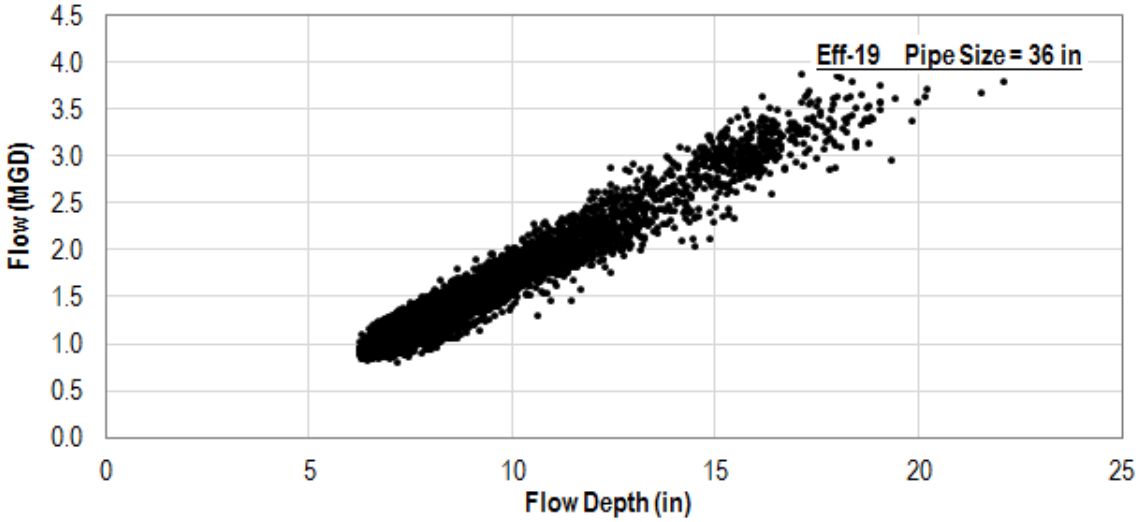
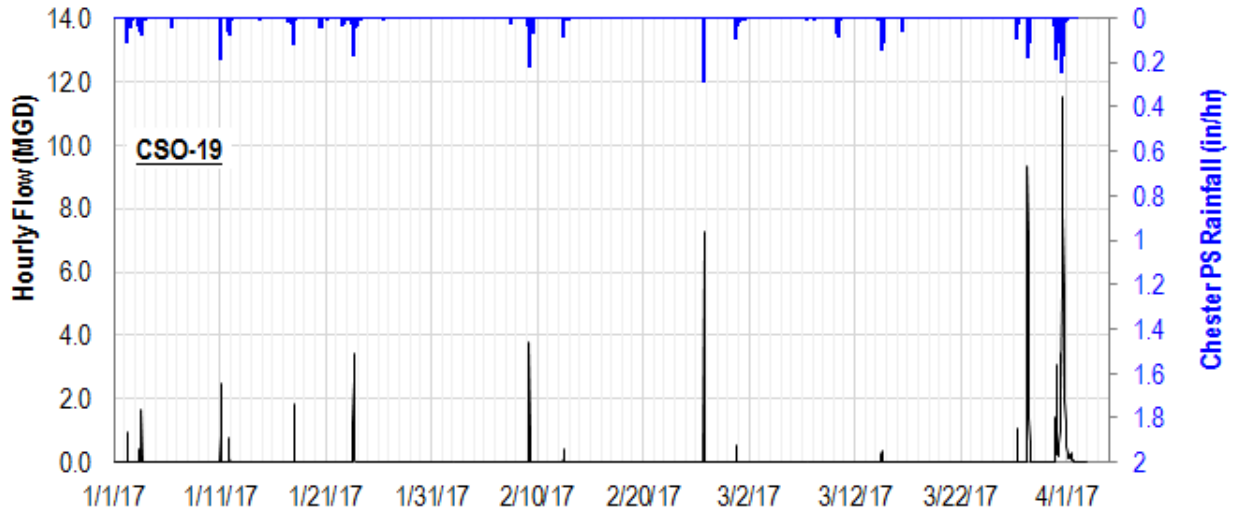


Figure 38: Flow Monitoring Data, CSO-19

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

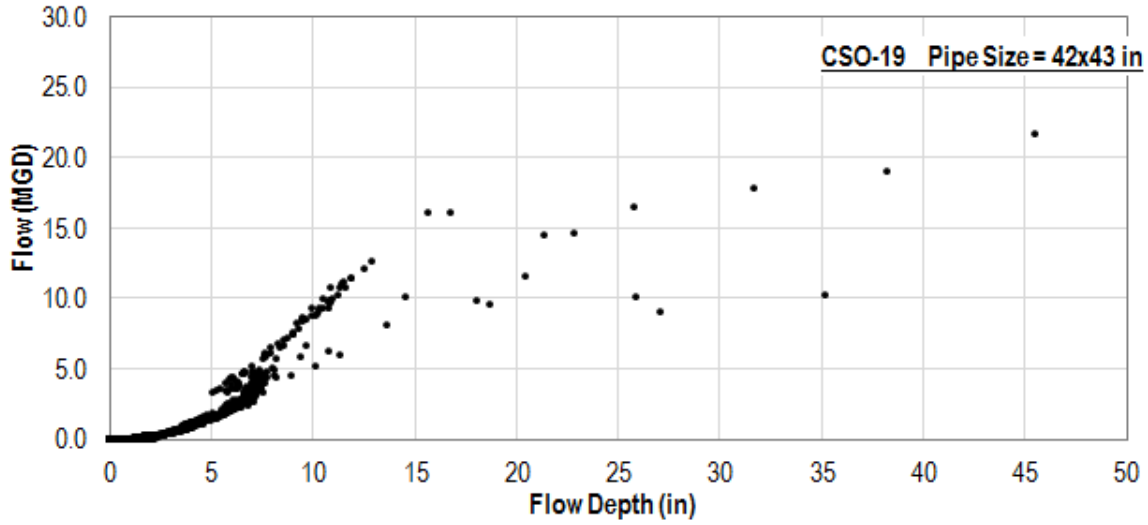


Figure 39: Flow Monitoring Data, In-25

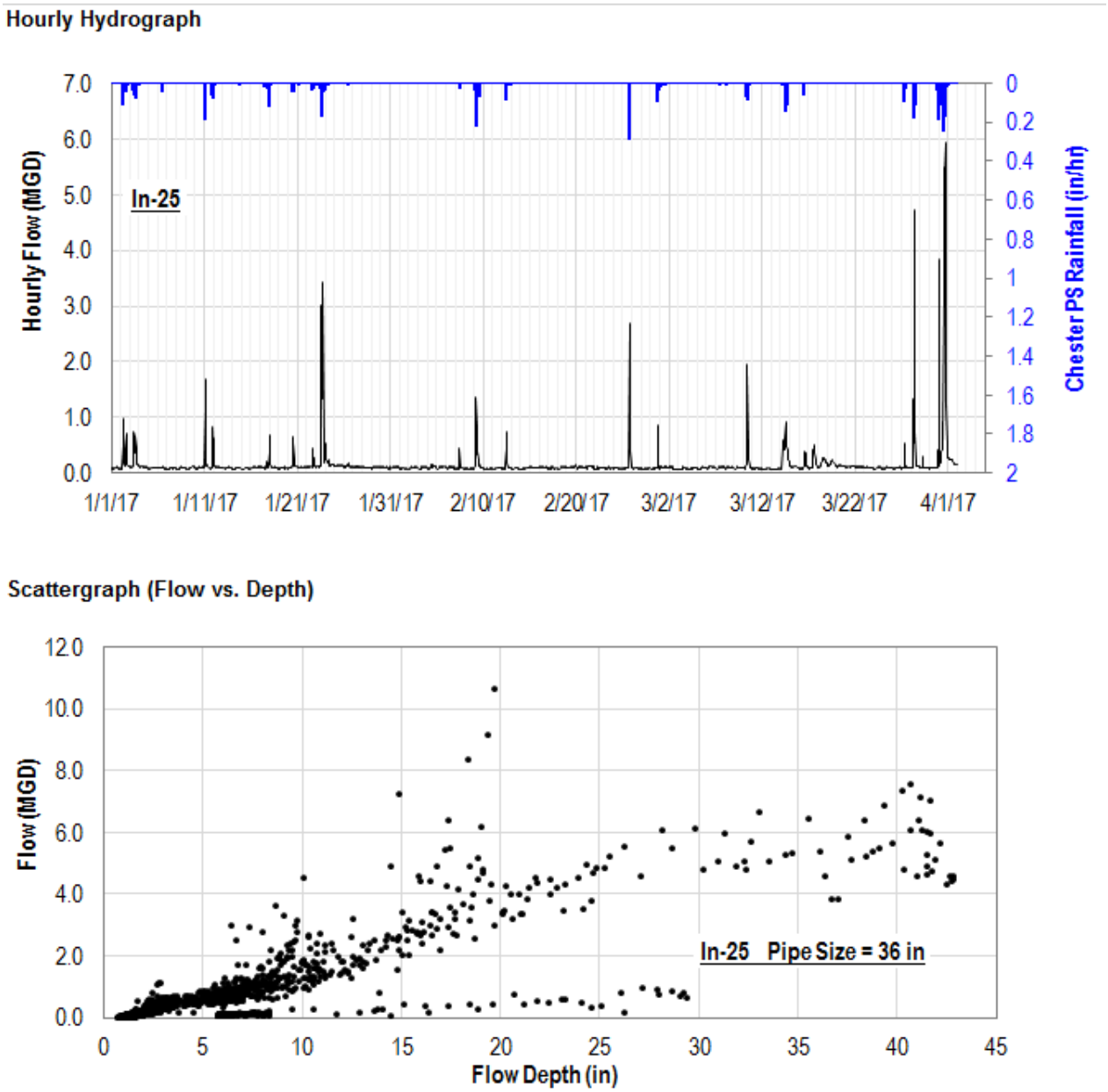
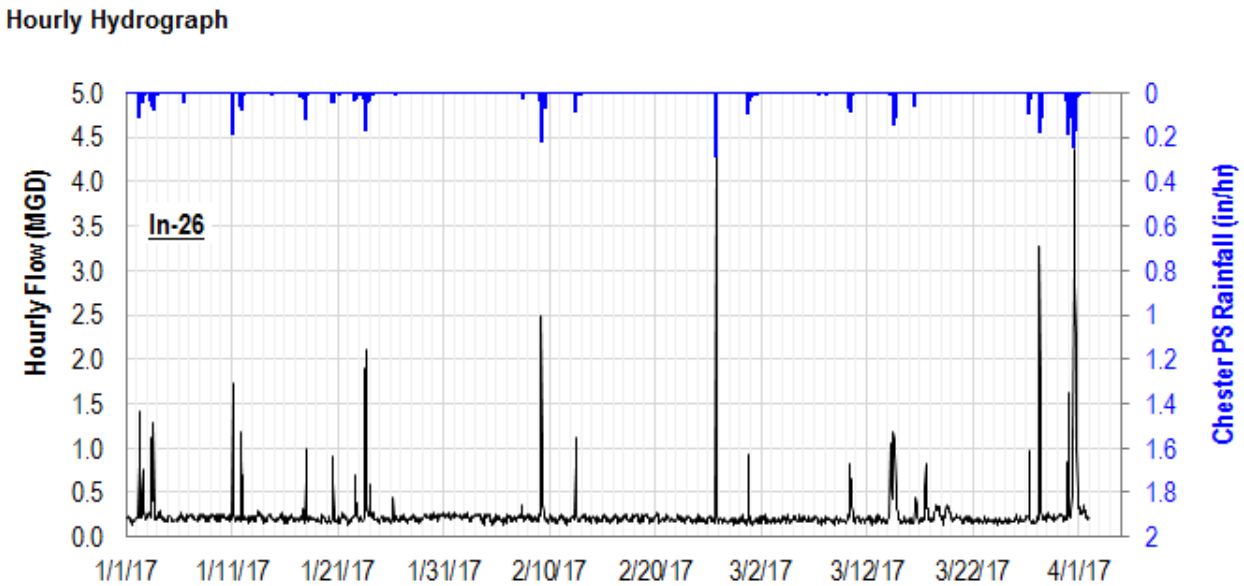


Figure 40: Flow Monitoring Data, In-26



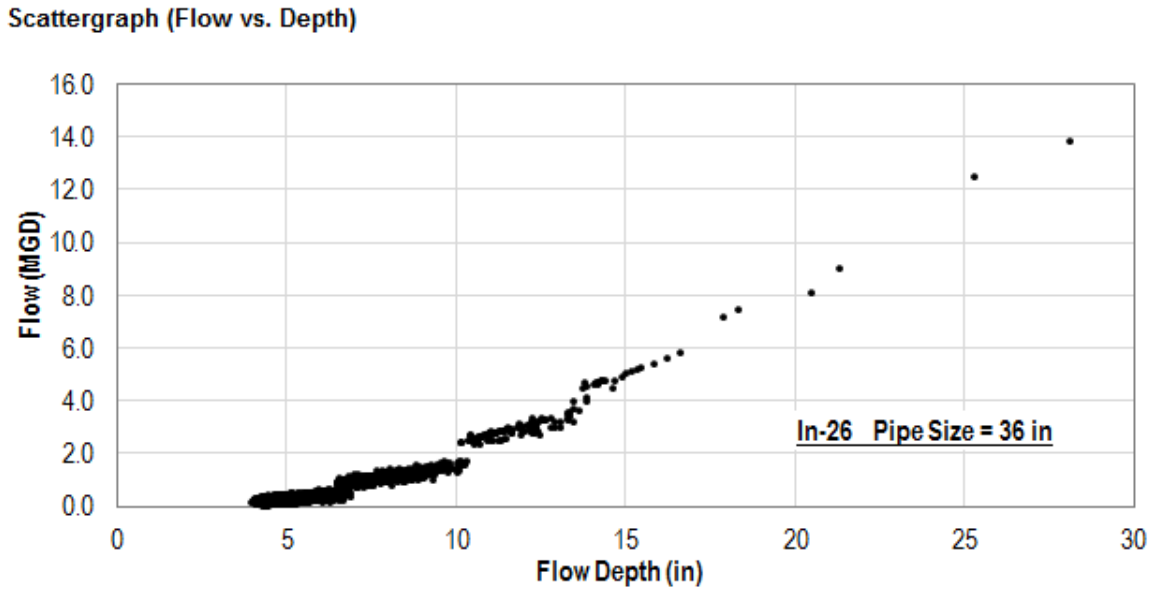
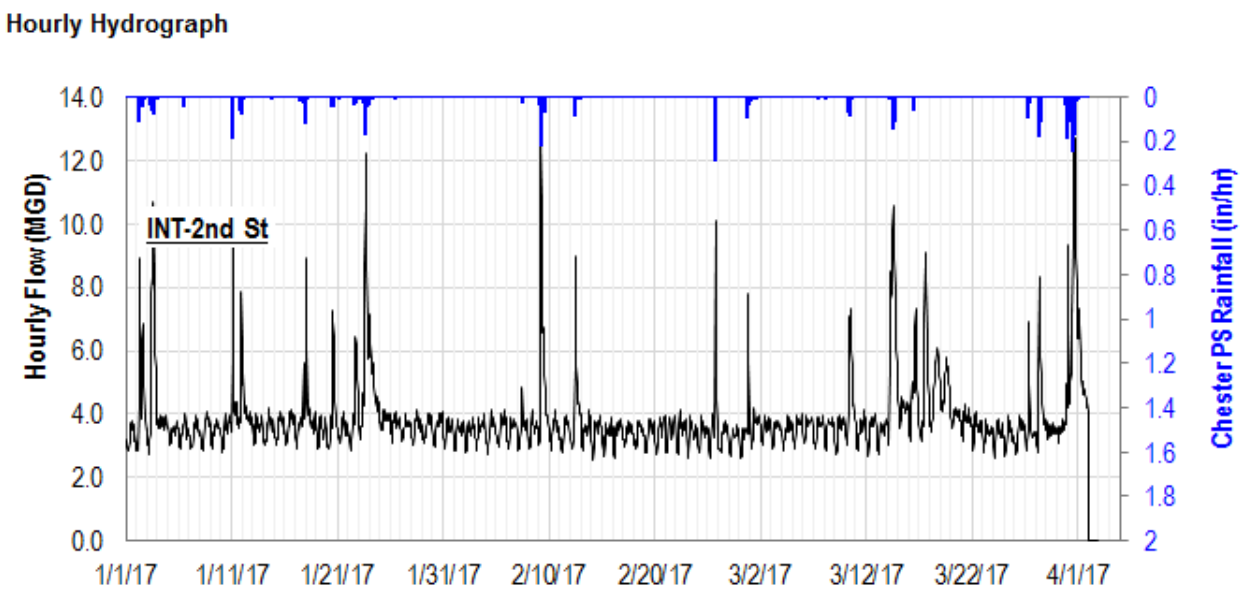


Figure 41: Flow Monitoring Data, INT-2nd St



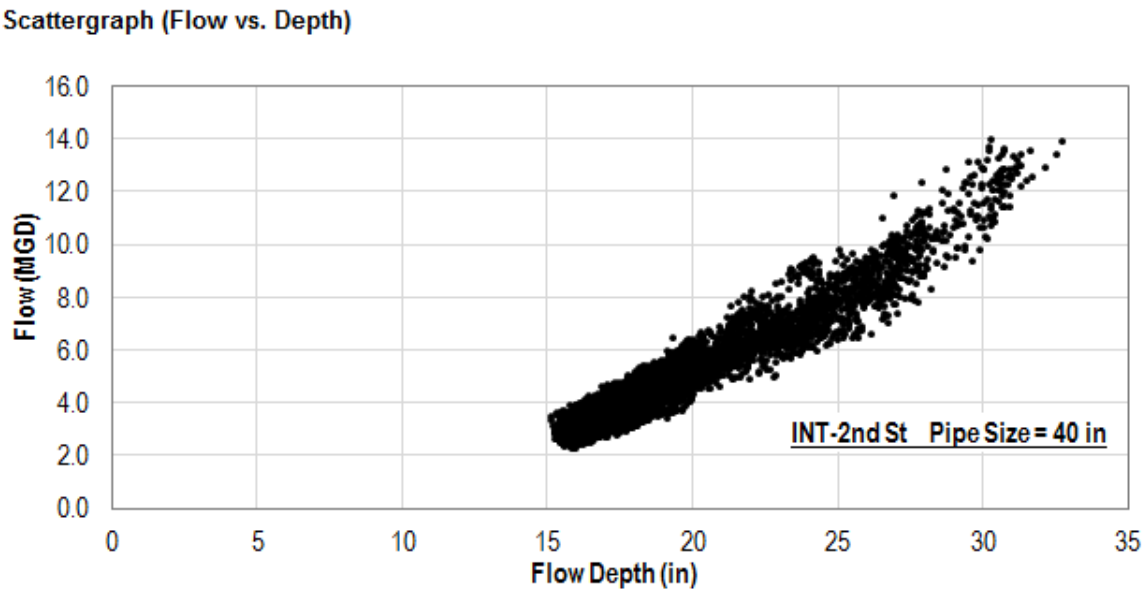


Figure 42: Flow Monitoring Data, INT-DRI

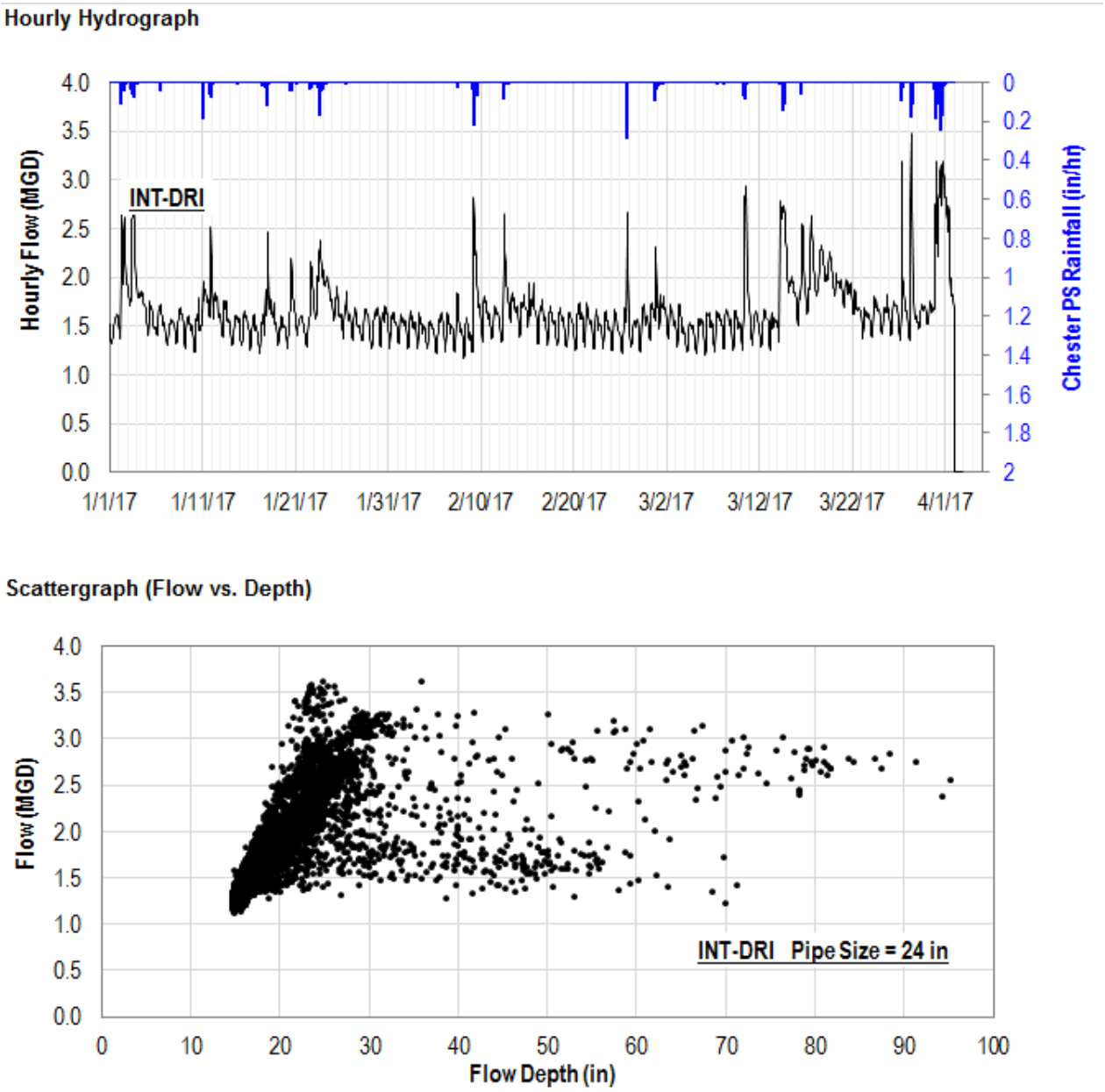


Figure 43: Flow Monitoring Data, INT-Ridley 2

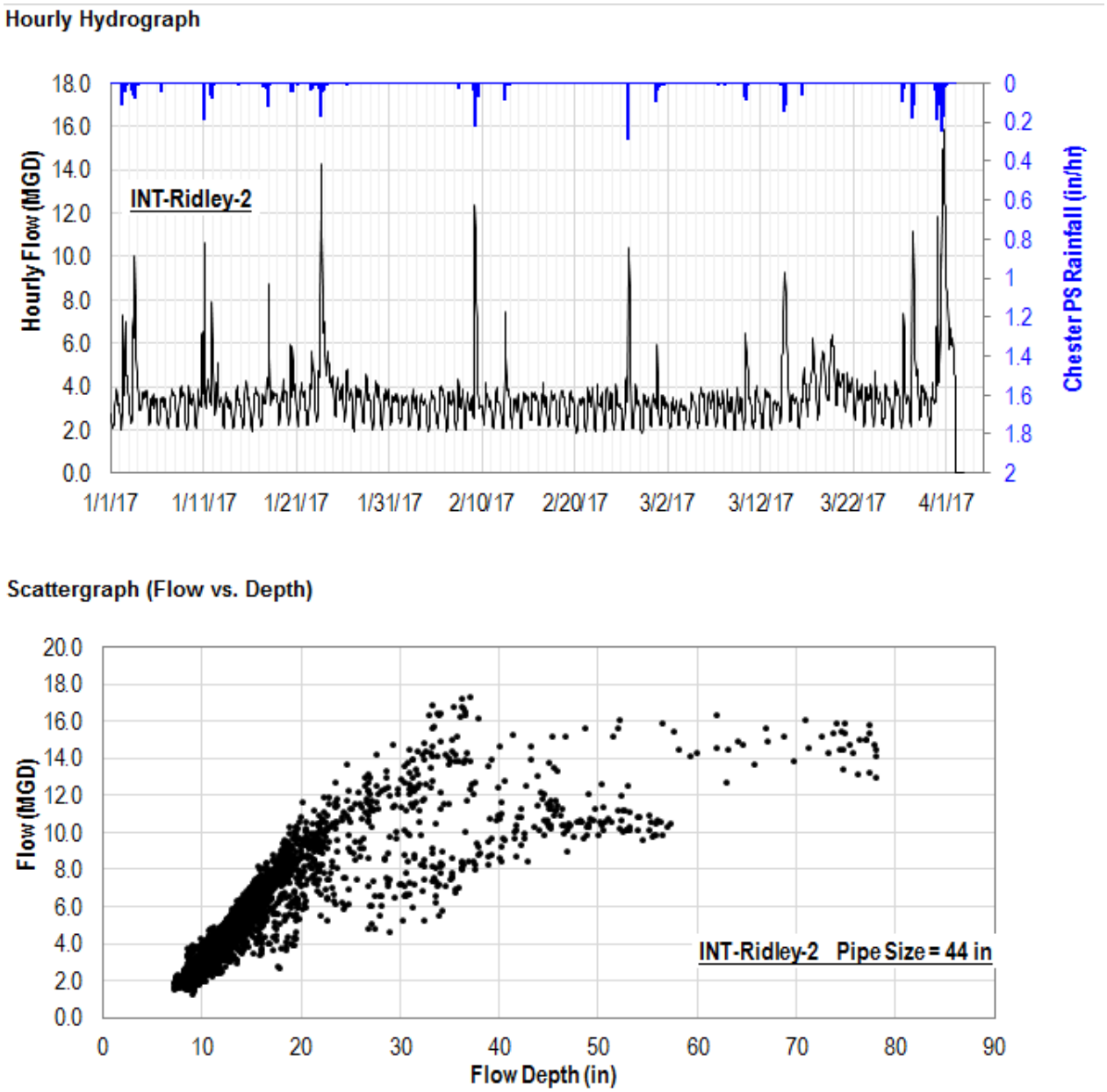


Figure 44: Flow Monitoring Data, INT-Ridley 3

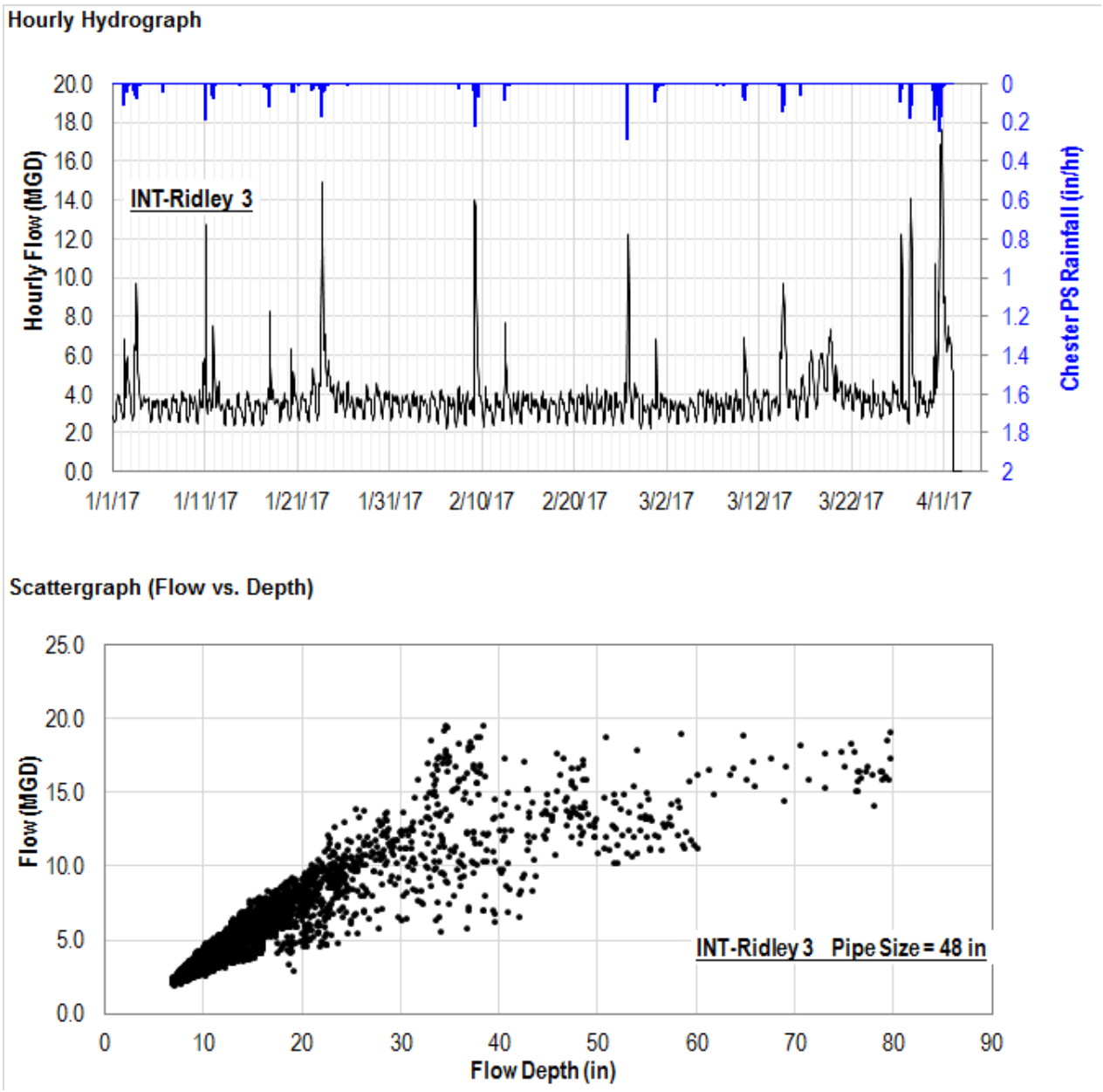
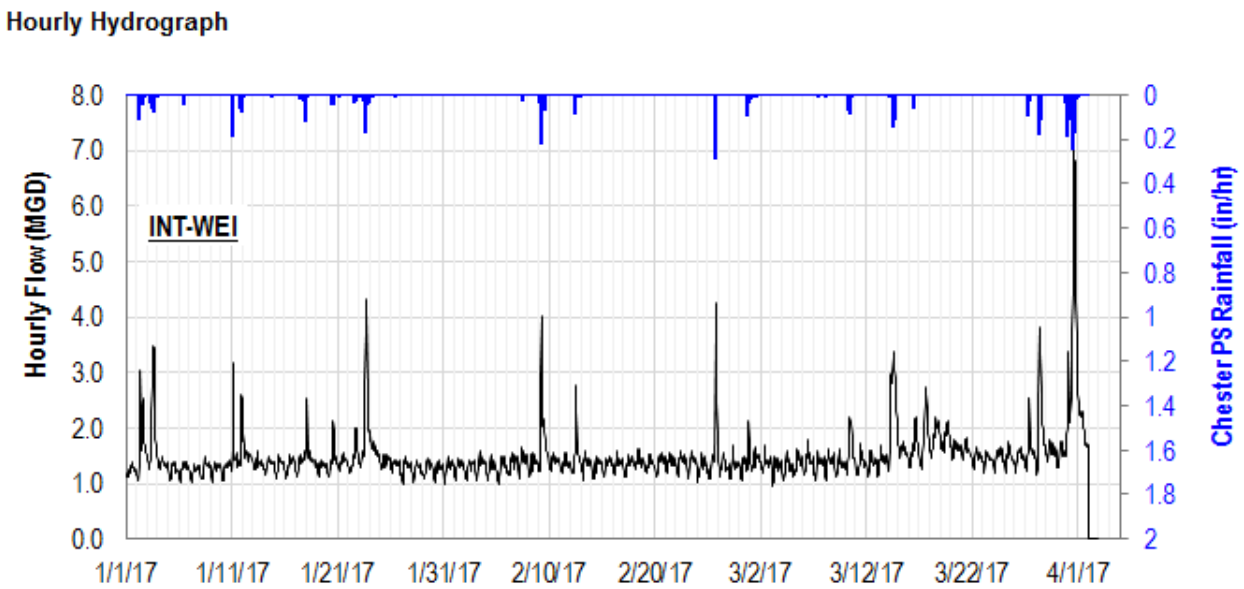


Figure 45: Flow Monitoring Data, INT-WEI



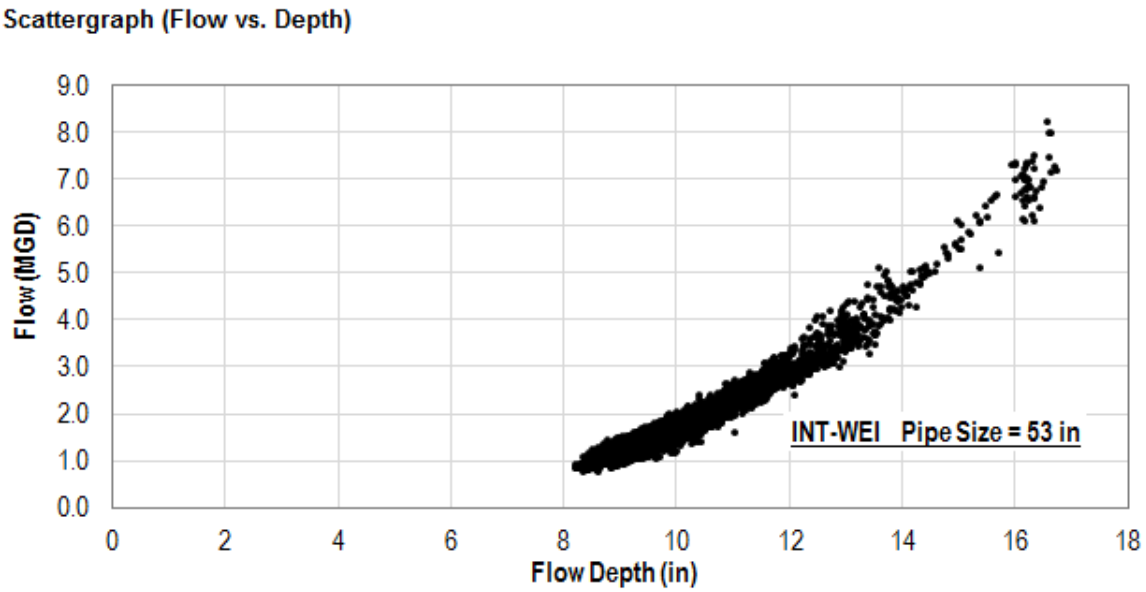


Figure 46: Flow Monitoring Data, Sep-1

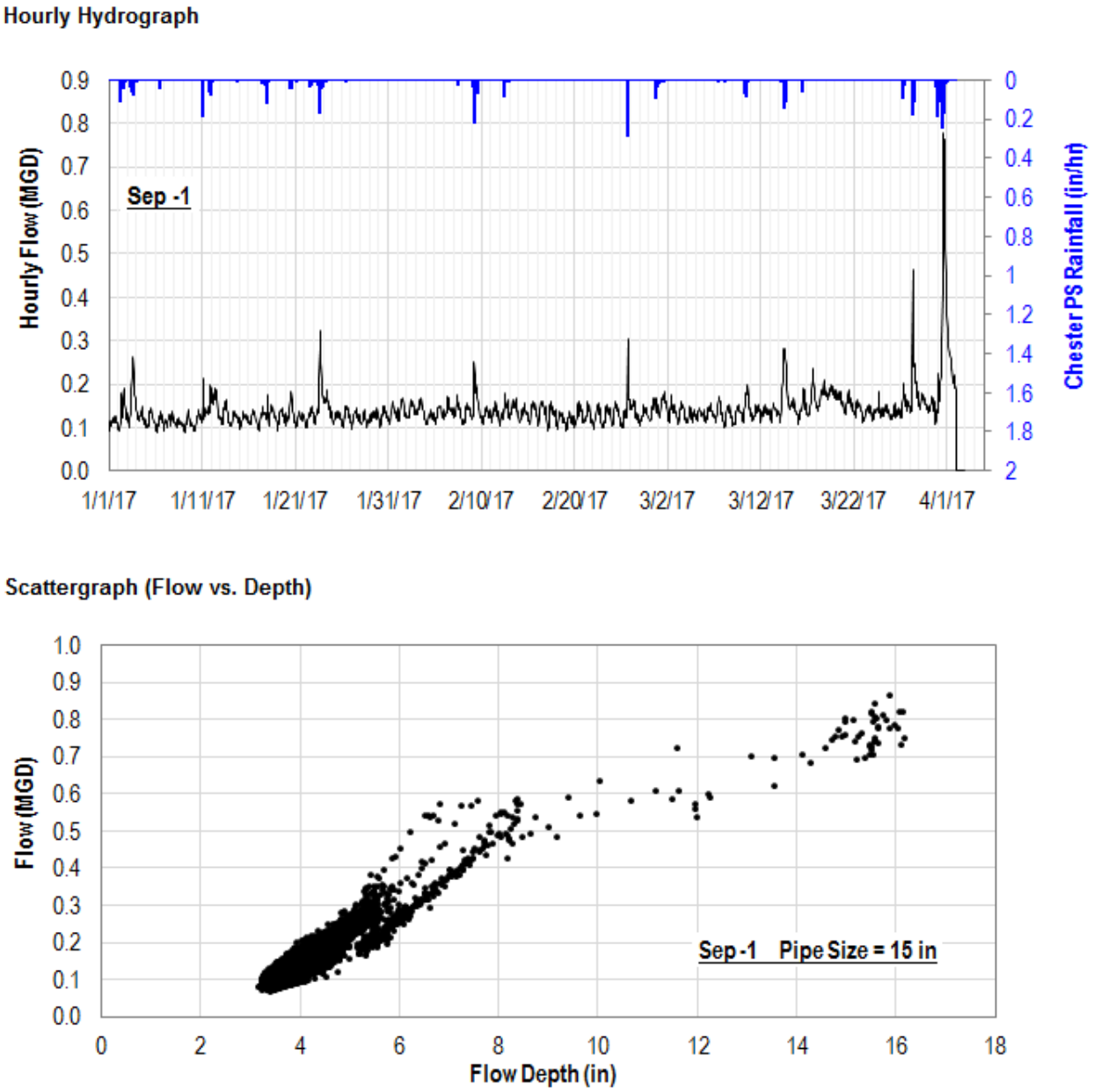
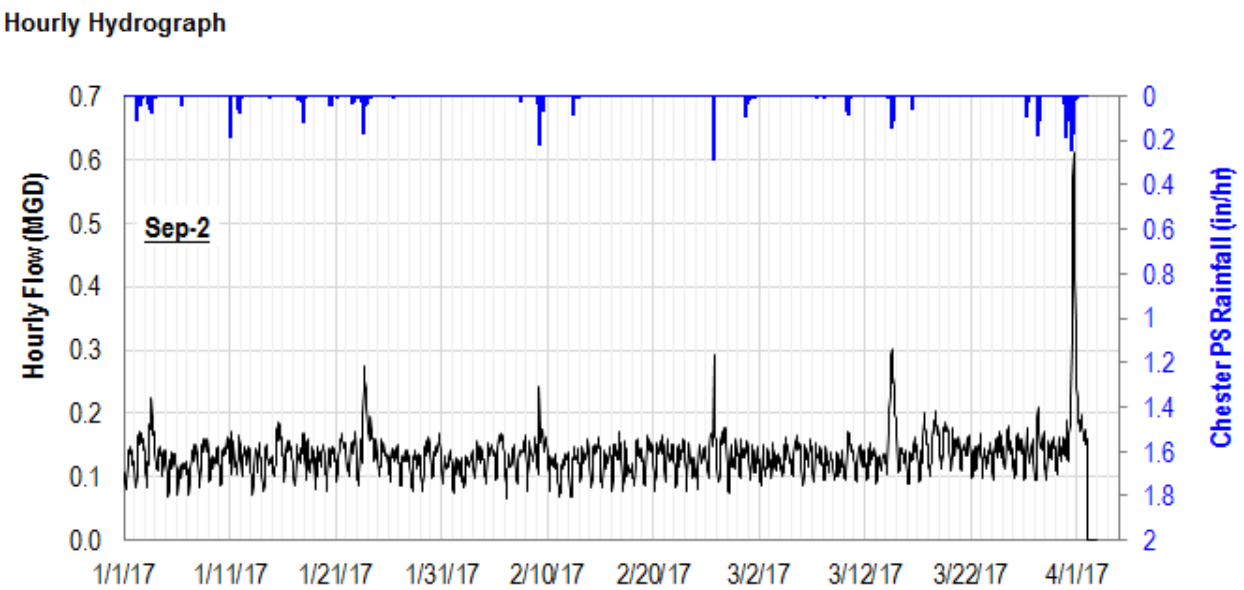


Figure 47: Flow Monitoring Data, Sep-2



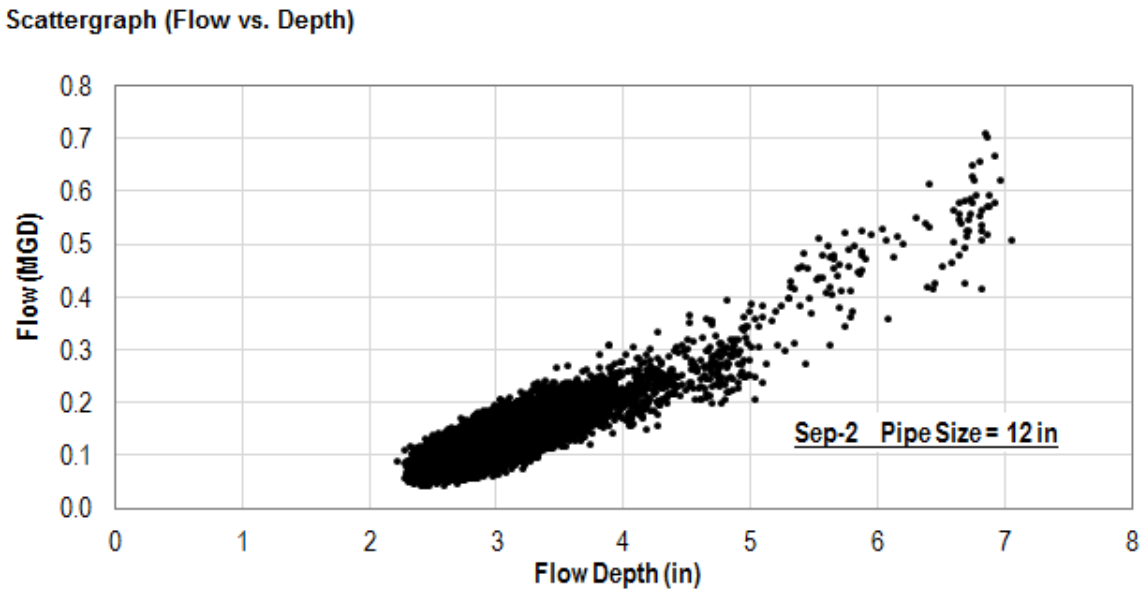


Figure 48: Flow Monitoring Data, Sep-3

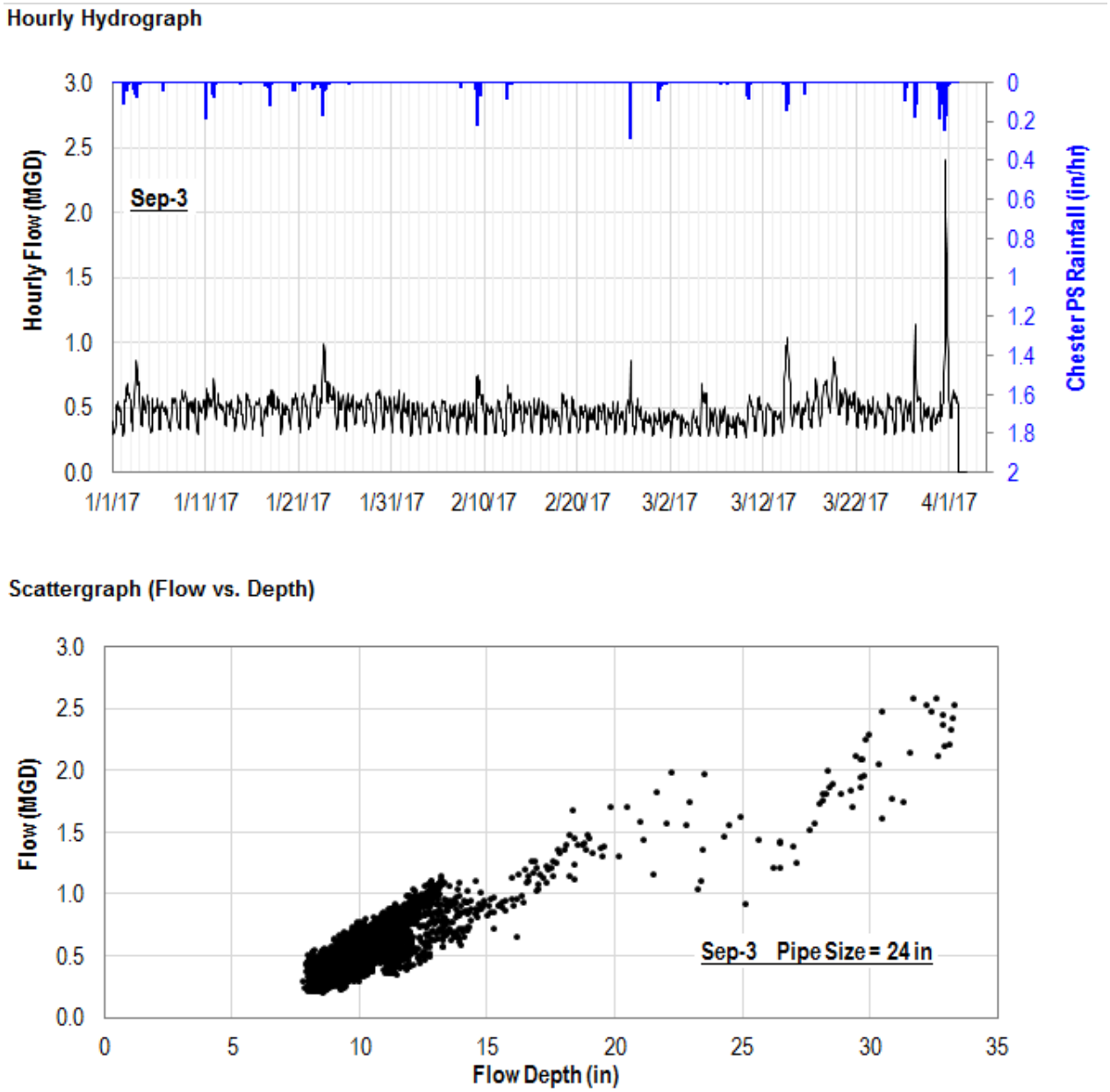
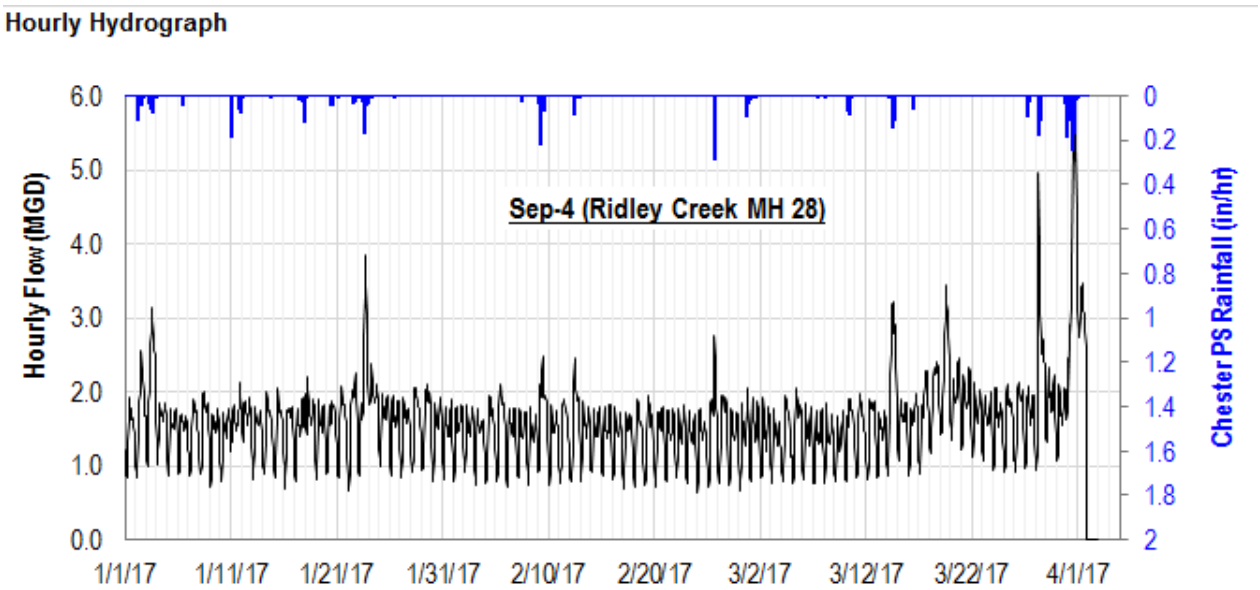


Figure 49: Flow Monitoring Data, Sep-4



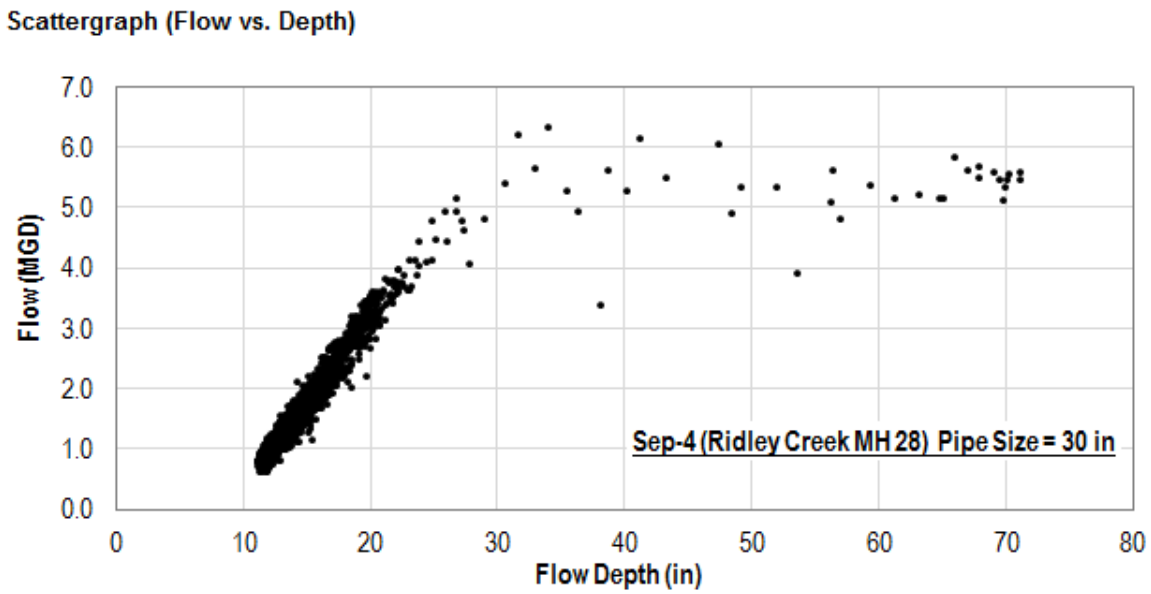


Figure 50: Flow Monitoring Data, Side-1

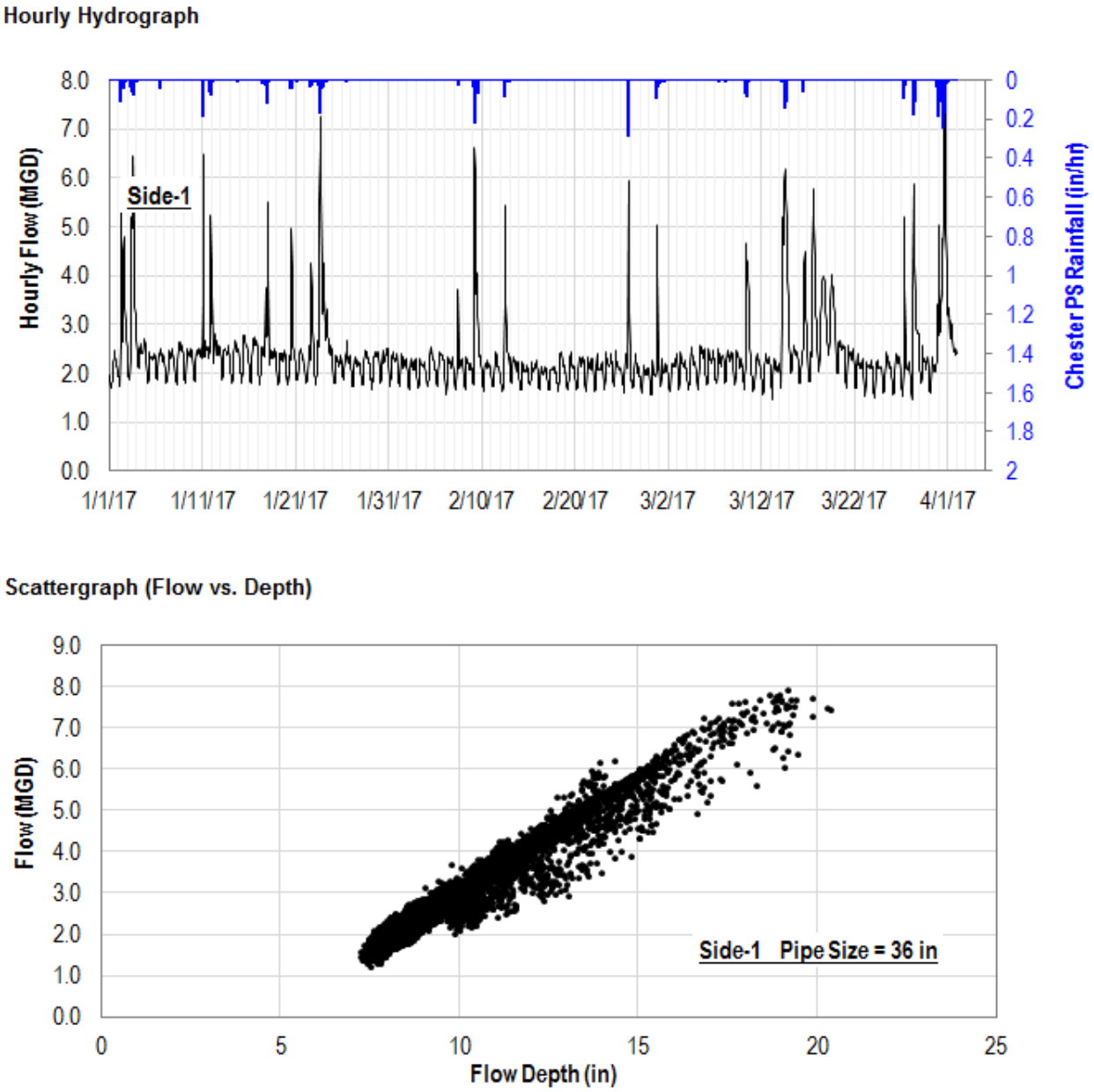
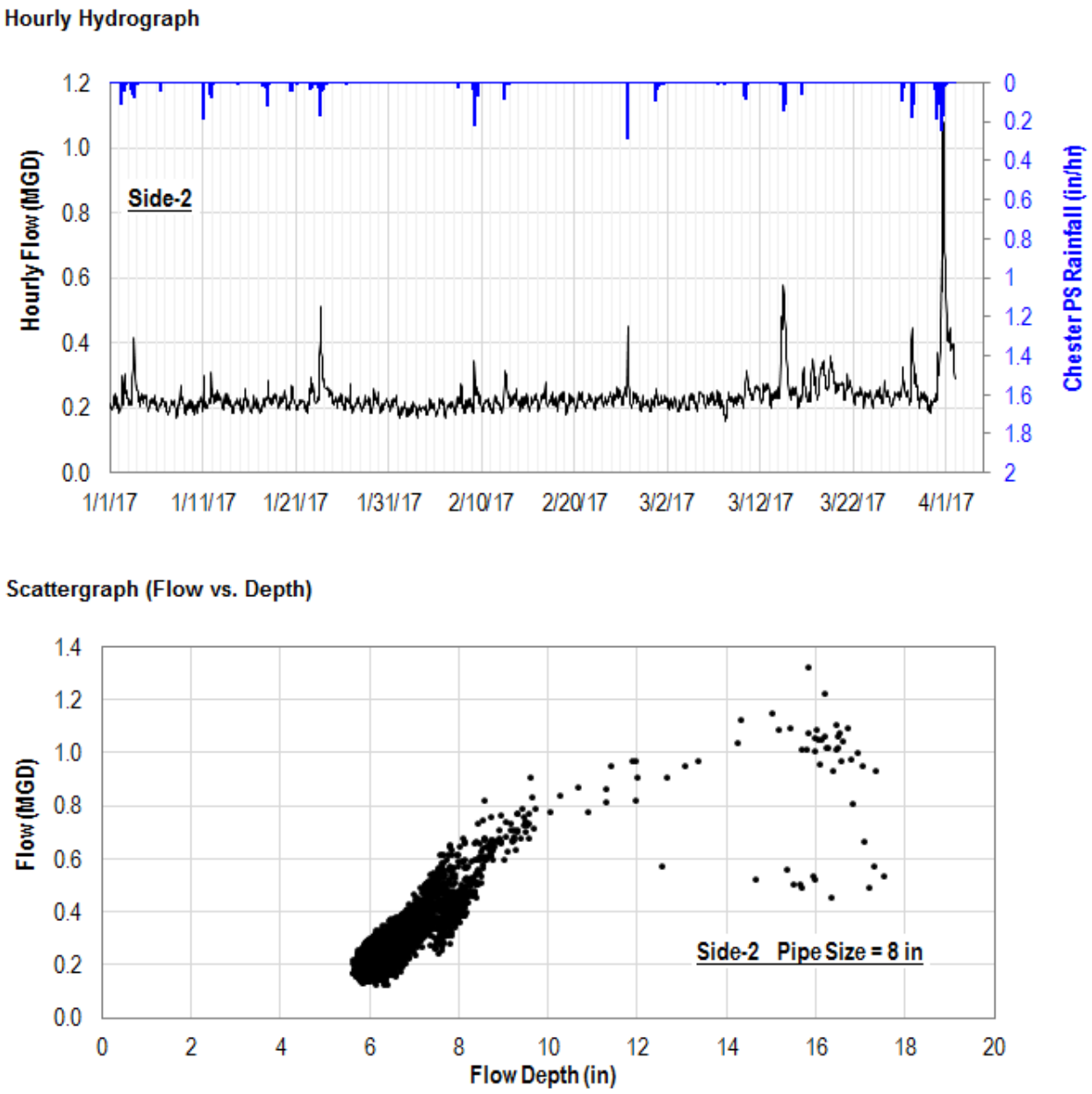


Figure 51: Flow Monitoring Data, Side-2



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www.greeley-hansen.com

GREELEY AND HANSEN

DELAWARE COUNTY REGIONAL WATER QUALITY CONTROL AUTHORITY
P.O. Box 999 • Chester, PA 19016-0999

July 29, 2016

FED EX – NEXT DAY

Chief, Environmental Enforcement
Section
Environment and Natural
Resources Division
U.S. Department of Justice
601 D Street NW
Washington, DC 20004
Re: DOJ No. 90-5-1-1-10972

Philip Yeany
Office of Regional Counsel (3RC20)
U.S. EPA, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

Chief
NPDES Enforcement Branch (3WP42)
Water Protection Division
U.S. EPA, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

Program Manager – Clean Water Program
PA DEP
Southeast Regional Office
2 East Main Street
Norristown, PA 19401

RE: Civil Action Number Case 2:15-cv-04652-RB
& DOJ Case Number 90-5-1-1-10972
Rainfall and Flow Monitoring Quarterly Report No. 1
Period of March 18, 2016 – June 30, 2016

Dear Sir/Madam:

By this letter, the Delaware County Regional Water Quality Control Authority is enclosing a copy of the above mentioned report in accordance with the requirements of the Consent Decree.

If there are any questions, please contact me. Thank you.

Sincerely,

Michael J. DiSantis
Director of Operations & Maintenance

MJD:bab
enclosure

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☐FAX: 610-876-2728

CUSTOMER SERVICE/BILLING
☐610-876-5526
☐FAX: 610-876-1460

PURCHASING & STORES
☐610-876-5523
☐FAX: 610-497-7959

PLANT & MAINTENANCE
☐610-876-5523
☐FAX: 610-497-7950

cc: via email
Margaret Hill, Blank Rome
Marlene Finizio, Greeley and Hansen
Michael Hope, Greeley and Hansen
Ed Bothwell, DELCORA
Charles Hurst, DELCORA
Michael DiSantis, DELCORA
John Pileggi, DELCORA
Robert Willert, DELCORA
File – Consent Order – LTCP CSO

DELAWARE COUNTY REGIONAL WATER QUALITY CONTROL AUTHORITY
P.O. Box 999 • Chester, PA 19016-0999

October 25, 2016

FED EX – NEXT DAY

Chief, Environmental Enforcement
Section
Environment and Natural
Resources Division
U.S. Department of Justice
601 D Street NW
Washington, DC 20004
Re: DOJ No. 90-5-1-1-10972

Philip Yeany
Office of Regional Counsel (3RC20)
U.S. EPA, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

Chief
NPDES Enforcement Branch (3WP42)
Water Protection Division
U.S. EPA, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

Program Manager – Clean Water Program
PA DEP
Southeast Regional Office
2 East Main Street
Norristown, PA 19401

RE: Civil Action Number Case 2:15-cv-04652-RB
& DOJ Case Number 90-5-1-1-10972
Rainfall and Flow Monitoring Quarterly Report No. 2
Period of July 1, 2016 – September 30, 2016

Dear Sir/Madam:

By this letter, the Delaware County Regional Water Quality Control Authority is enclosing a copy of the above mentioned report in accordance with the requirements of the Consent Decree.

If there are any questions, please contact me. Thank you.

Sincerely,

Michael J. DiSantis
Director of Operations & Maintenance

MJD:bab
enclosure

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Michael DiSantis, DELCORA
John Pileggi, DELCORA
Robert Willert, DELCORA
File – Consent Order – LTCP CSO

DELAWARE COUNTY REGIONAL WATER QUALITY CONTROL AUTHORITY
P.O. Box 999 • Chester, PA 19016-0999

January 26, 2017

FED EX – NEXT DAY

Chief, Environmental Enforcement
Section
Environment and Natural
Resources Division
U.S. Department of Justice
601 D Street NW
Washington, DC 20004
Re: DOJ No. 90-5-1-1-10972

Philip Yeany
Office of Regional Counsel (3RC20)
U.S. EPA, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

Chief
NPDES Enforcement Branch (3WP42)
Water Protection Division
U.S. EPA, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

Program Manager – Clean Water Program
PA DEP
Southeast Regional Office
2 East Main Street
Norristown, PA 19401

RE: Civil Action Number Case 2:15-cv-04652-RB
& DOJ Case Number 90-5-1-1-10972
Rainfall and Flow Monitoring Quarterly Report No. 3
Period of October 1, 2016 – December 31, 2016

Dear Sir/Madam:

By this letter, the Delaware County Regional Water Quality Control Authority is enclosing a copy of the above mentioned report in accordance with the requirements of the Consent Decree.

If there are any questions, please contact me. Thank you.

Sincerely,

Michael J. DiSantis
Director of Operations & Maintenance

MJD:bab
enclosure

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John Pileggi, DELCORA
Robert Willert, DELCORA
File – Consent Order – LTCP CSO

DELAWARE COUNTY REGIONAL WATER QUALITY CONTROL AUTHORITY
P.O. Box 999 • Chester, PA 19016-0999

April 28, 2017

FED EX – NEXT DAY

Chief, Environmental Enforcement
Section
Environment and Natural
Resources Division
U.S. Department of Justice
601 D Street NW
Washington, DC 20004
Re: DOJ No. 90-5-1-1-10972

Philip Yeany
Office of Regional Counsel (3RC20)
U.S. EPA, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

Chief
NPDES Enforcement Branch (3WP42)
Water Protection Division
U.S. EPA, Region 3
1650 Arch Street
Philadelphia, PA 19103-2029

Program Manager – Clean Water Program
PA DEP
Southeast Regional Office
2 East Main Street
Norristown, PA 19401

RE: Civil Action Number Case 2:15-cv-04652-RB
& DOJ Case Number 90-5-1-1-10972
Rainfall and Flow Monitoring Quarterly Report No. 4
Period of January 1, 2017 – April 1, 2017

Dear Sir/Madam:

By this letter, the Delaware County Regional Water Quality Control Authority is enclosing a copy of the above mentioned report in accordance with the requirements of the Consent Decree.

If there are any questions, please contact me. Thank you.

Sincerely,

Michael J. DiSantis
Director of Operations & Maintenance

MJD:bab
enclosure

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Charles Hurst, DELCORA
Michael DiSantis, DELCORA
John Pileggi, DELCORA
Robert Willert, DELCORA
File – Consent Order – LTCP CSO

APPENDIX H

WATER QUALITY MONITORING AND MODELING WORK PLAN

- DELCORA Water Quality Modeling and Monitoring Work Plan - Final dated January 2017 (Revised July 2017)
- USEPA Approval of the Water Quality Modeling and Monitoring Work Plan Update dated April 16, 2018

Note: This Appendix includes a report by Greeley & Hansen which rebranded to TYLin in 2023.

Delaware County Regional Water Quality Control Authority
CSO Long Term Control Plan Update

Water Quality Modeling and Monitoring Work Plan

Final

January 2017

(Revised July 2017)

GREELEY AND HANSEN

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REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Water Quality Modeling and Monitoring Work Plan.

I certify under penalty of law that the document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

DELCORA MANAGEMENT		
Executive Director	Signature	1/9/17 Date
DELCORA ENGINEERING		
Director of Engineering	Signature	1/9/17 Date
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	Signature	1/9/17 Date

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES
0	1/11/2017	G&H/LimnoTech	Initial submittal to US EPA
1	July 2017	G&H/LimnoTech	• Updated Table of Contents • Page 1-8: Updated Figure 1-5 Project Team • Page 2-5: Updated Tables 2-1 and 2-2 • Page 2-7: Updated Table 2-3 • Page 3-6/3-7: Updated Appendix reference • Page 3-7: Changed DR-03 to DR-04 • Page 3-8: Updated Figure 3-2 • Page 3-9: Updated Table 3-1 • Page 3-10: Updated Table 3-2 • Page 3-11: Updated Table 3-3 • Page 3-13: Revised last paragraph for clarity • Page 3-14: Revised first, second and fifth paragraphs for clarity • Page 3-15: Revised second paragraph and Item 3 for clarity • Page 3-16: Revised items 1 & 4 • Page 3-17: Updated Sec. 3.5 appendix reference • Page 3-18: Updated Sec. 3.5.2 appendix reference • Page 3-21: Updated Sec. 3.5.4 appendix reference • Page 3-23: Updated Table 3-8 • Page 3-27: Updated Sec. 3.8.4 appendix reference

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Section 1 Introduction

1.1 Background of DELCORA's Facilities

Delaware County Regional Water Quality Control Authority (DELCORA) is responsible for the collection, transmission, treatment and disposal of approximately 65 million gallons per day (MGD) of wastewater generated in southeastern Pennsylvania. DELCORA's facilities serve residential, commercial, institutional, and industrial customers in Delaware County. DELCORA owns and operates an extensive system of pump stations, force mains, and sewers that provide the core infrastructure for the transmission of wastewater to treatment facilities in Delaware County and the City of Philadelphia as shown diagrammatically in Figure 1-1. The total service area served by DELCORA, as shown on Figure 1-2, is approximately 82,977 acres which illustrates that DELCORA serves a significant and widespread portion of Delaware County.

The combined sewer area simulated in DELCORA's existing Hydrologic and Hydraulic model is located within the City of Chester and consists of a drainage area of approximately 1,510 acres. It comprises approximately half of Chester City's serviced area. To support the service area, DELCORA owns and operates over 129 miles of separate and combined sewers. Included in the 129 miles of sewers are: 11.7 miles of an interceptor system; 3,209 manholes; and twenty-five (25) combined sewer outfall regulators controlling storm overflows. The location of Chester City's service area is illustrated on Figure 1-2.

Historically, DELCORA has characterized its service areas as "Eastern" and "Western." The Western service area discharges to DELCORA's Western Regional Treatment Plant (WRTP). The Eastern service area discharges to the Philadelphia Water Department's Southwest Water Pollution Control Plant (PWDSWPCP). In 2002, DELCORA completed the installation of a force main that connects the Eastern Service Area's Central Delaware Pump Station (CDPS) to the Chester Force Main. This connection allows DELCORA to send flow from the CDPS to the WRTP. Flows above 20 MGD are directed to the PWDSWPCP. As such, dry weather flows and a portion of the wet weather flows (total flow less than 20 MGD) from the Central Delaware County Authority in the Eastern Service Area are discharged to the WRTP.

There are a total of 26 combined sewer overflow outfalls listed with 25 discharge points (Outfall #009 and #010 both discharge at Outfall #009) in DELCORA's existing National Pollutant Discharge Elimination System (NPDES) Permit. Under its NPDES Permit No. PA0027103, issued and administered by the Pennsylvania Department of Environmental Protection (PADEP), DELCORA is authorized to discharge from the Western Regional Treatment Plant (Outfall #001), four storm water outfalls at the WRTP (028-031) and from 26 combined sewer overflow outfalls (#002-#026, #032, #033) that ultimately discharge to the Delaware River, Chester Creek and/or Ridley Creek.

Figure 1-1: DELCORA's Conveyance System

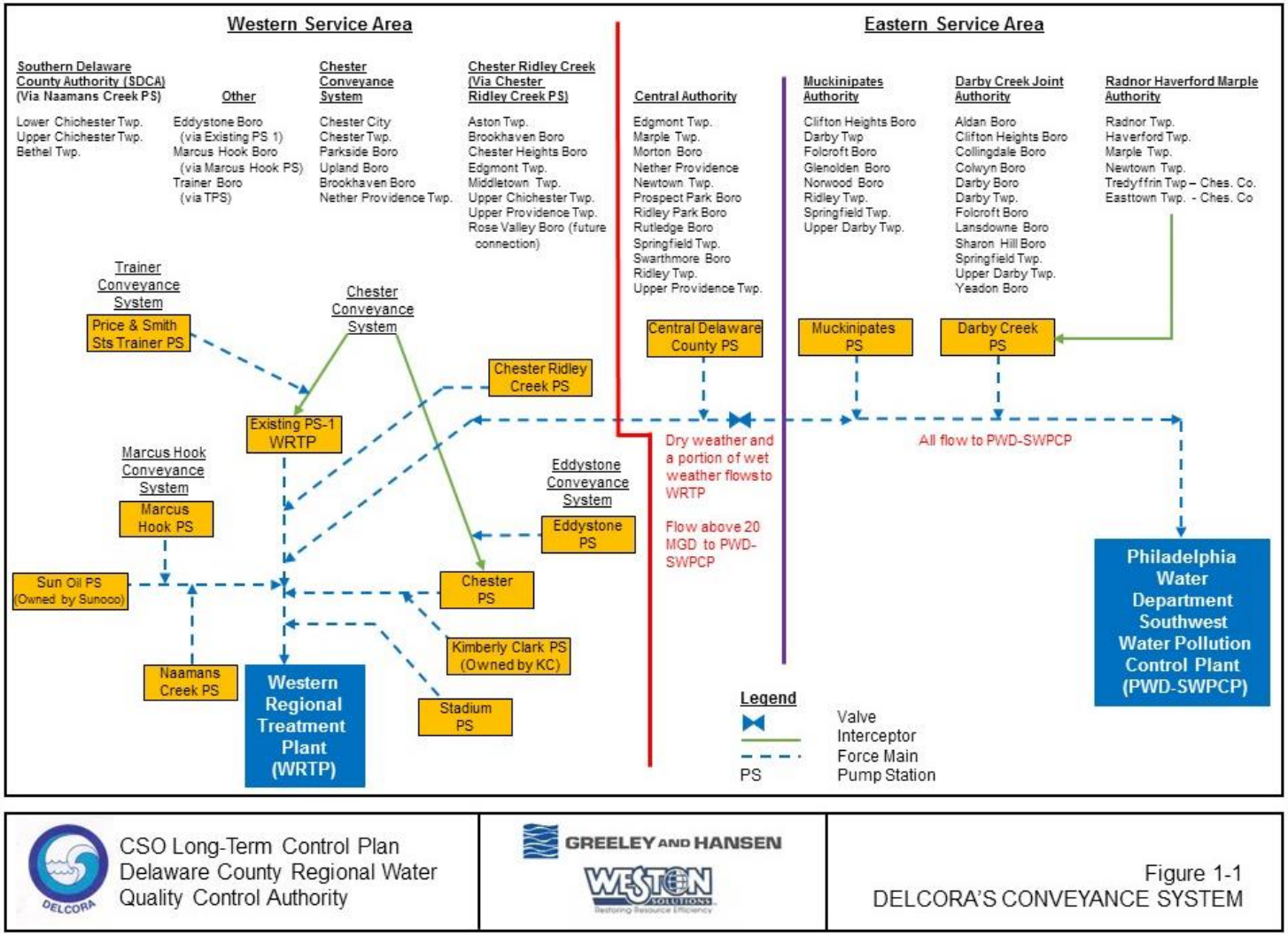
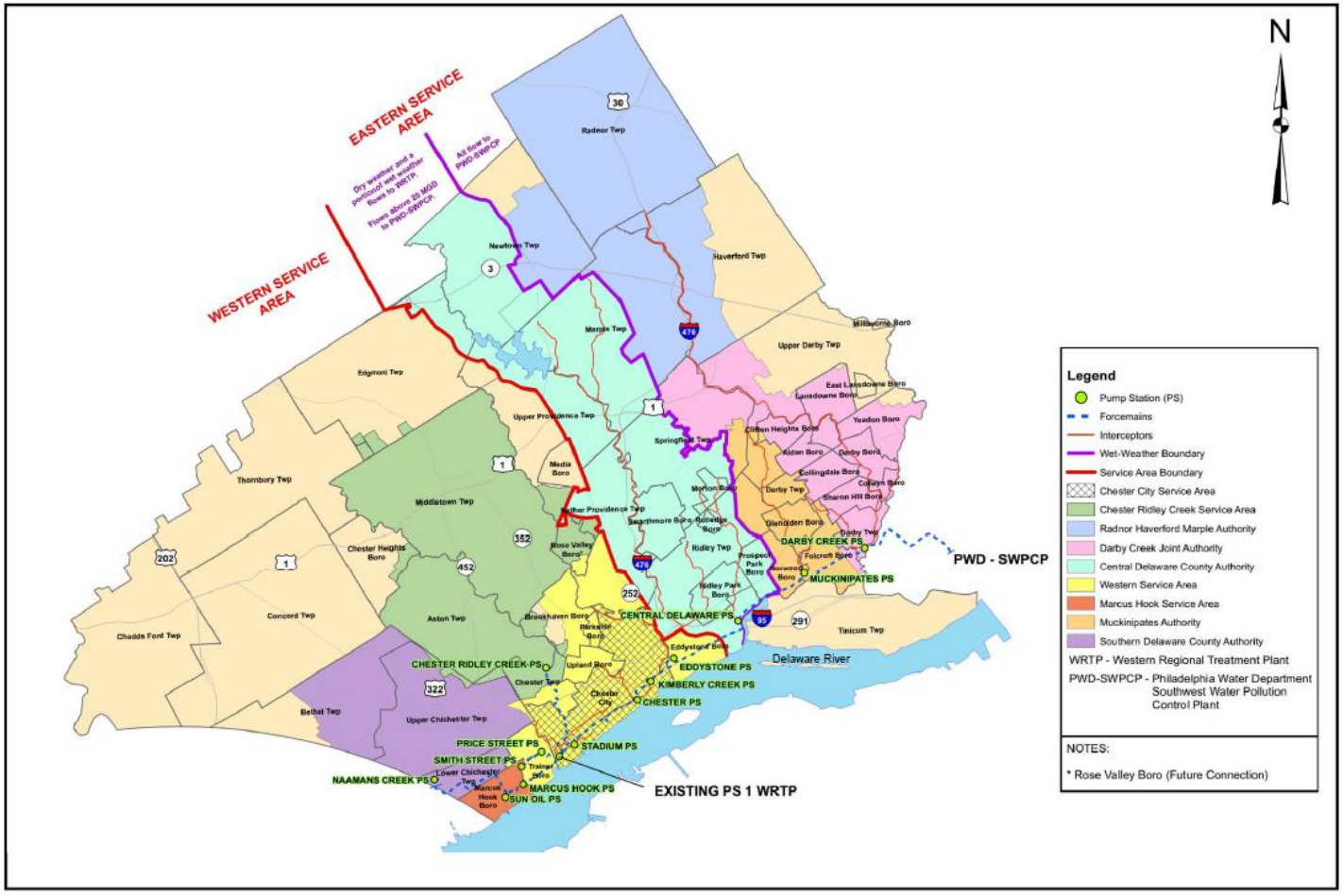


Figure 1-2: DELCORA's Service Area



Part C – Other Requirements, Section V – Combined Sewer Overflows of the NPDES Permit details DELCORA's responsibilities with respect to the CSO system including reporting, continued implementation of and continued compliance with the Nine Minimum Controls (NMC), and implementation of the existing Long-Term Control Plan (LTCP) dated April 1999 and the July 2008 addendum to the LTCP until the updated LTCP is approved.

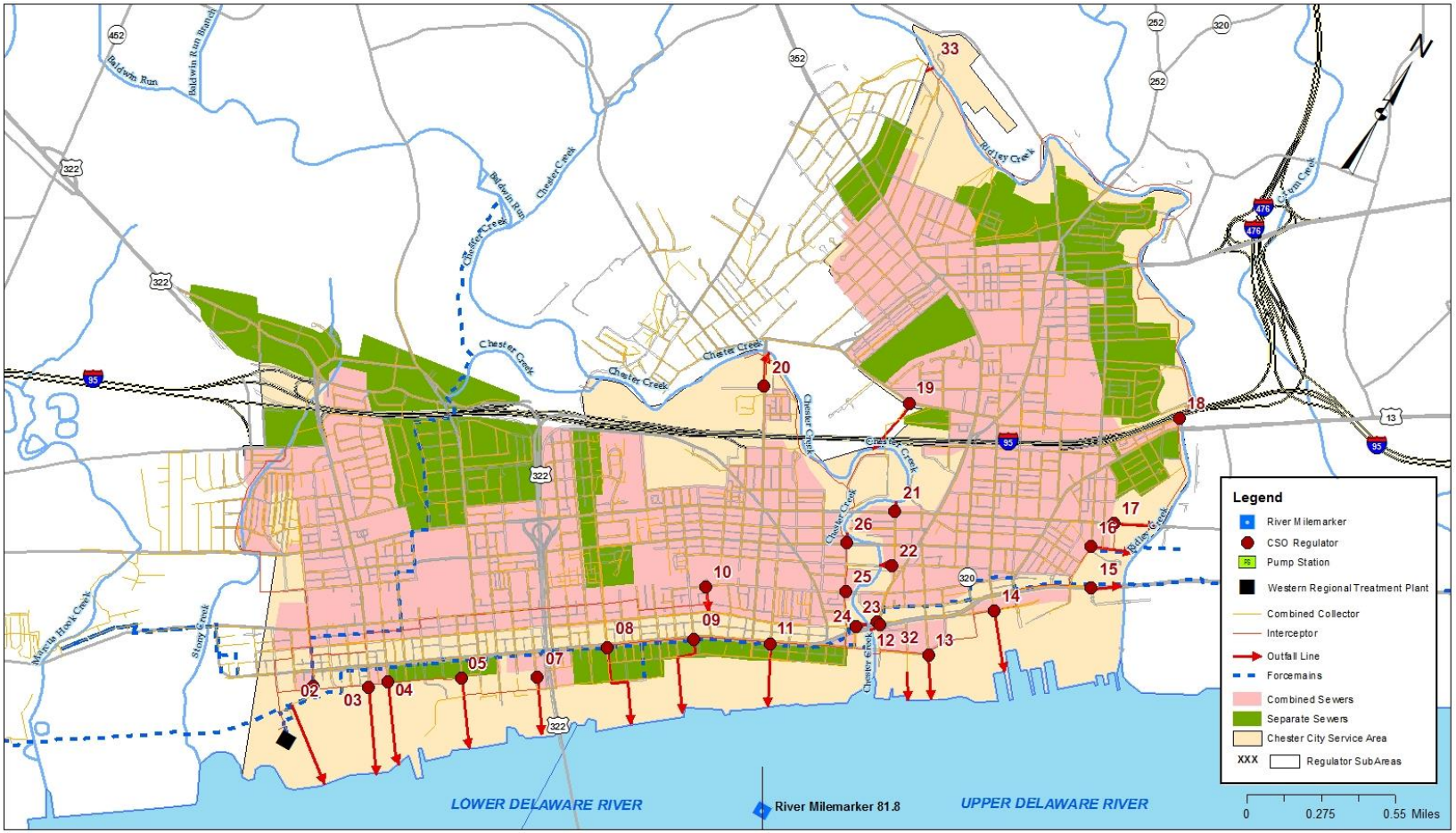
1.2 Consent Decree

On August 17, 2015, a Consent Decree was lodged in the United States District Court for the Eastern District of Pennsylvania that requires DELCORA to complete and submit a revised and updated LTCP to the United States Environmental Protection Agency (USEPA or EPA) and the Pennsylvania Department of Environmental Protection (PADEP or DEP) for review and approval. Consent Decree Paragraph V.A.15 (Water Quality Model Plan) requires that within ninety (90) days after EPA reviews and approves the Alternatives Evaluation Approach, DELCORA shall submit to EPA and PADEP a Water Quality Model Plan for review and approval. Details of the Consent Decree requirements for Water Quality Modeling and Monitoring Plan are respectively found in Section 2.1 and 3.1.1.

1.3 CSO and Receiving Water System Description

The combined portion of DELCORA's sewer system is located within the City of Chester (City), and it comprises approximately half of the City's serviced area. The combined wastewater/stormwater system in the City of Chester is complicated by the fact that parts of the system are owned, operated and maintained by two governmental entities, the City and DELCORA. DELCORA owns, operates and maintains the parts of the system that convey wastewater, such as the street sewers, collectors, interceptors, and CSO regulators and CSO outfalls. The City owns, operates and maintains the inlets, stormwater-only sewers that connect to the combined sewer system and any stormwater-only outfalls. The City is also responsible for the maintenance and cleaning of the streets, planning, zoning, and development controls. The Chester CSO system contains 26 permitted outfalls and they discharge to three receiving water bodies: the Delaware River, Chester Creek, and Ridley Creek. However, there are only 25 CSO discharge locations, as CSO #010 discharges to the Delaware River through CSO #009. Figure 1-3 depicts the locations of CSO regulators and outfalls that are DELCORA's responsibility. Figure 1-3 also provides a sewer system characterization and illustrate the breakdown of each outfall and how each drainage area has combined sewers and separate sewers. Figure 1-4 is a schematic of the Chester CSO system and shows the outfalls and the interceptors that are connected to each CSO.

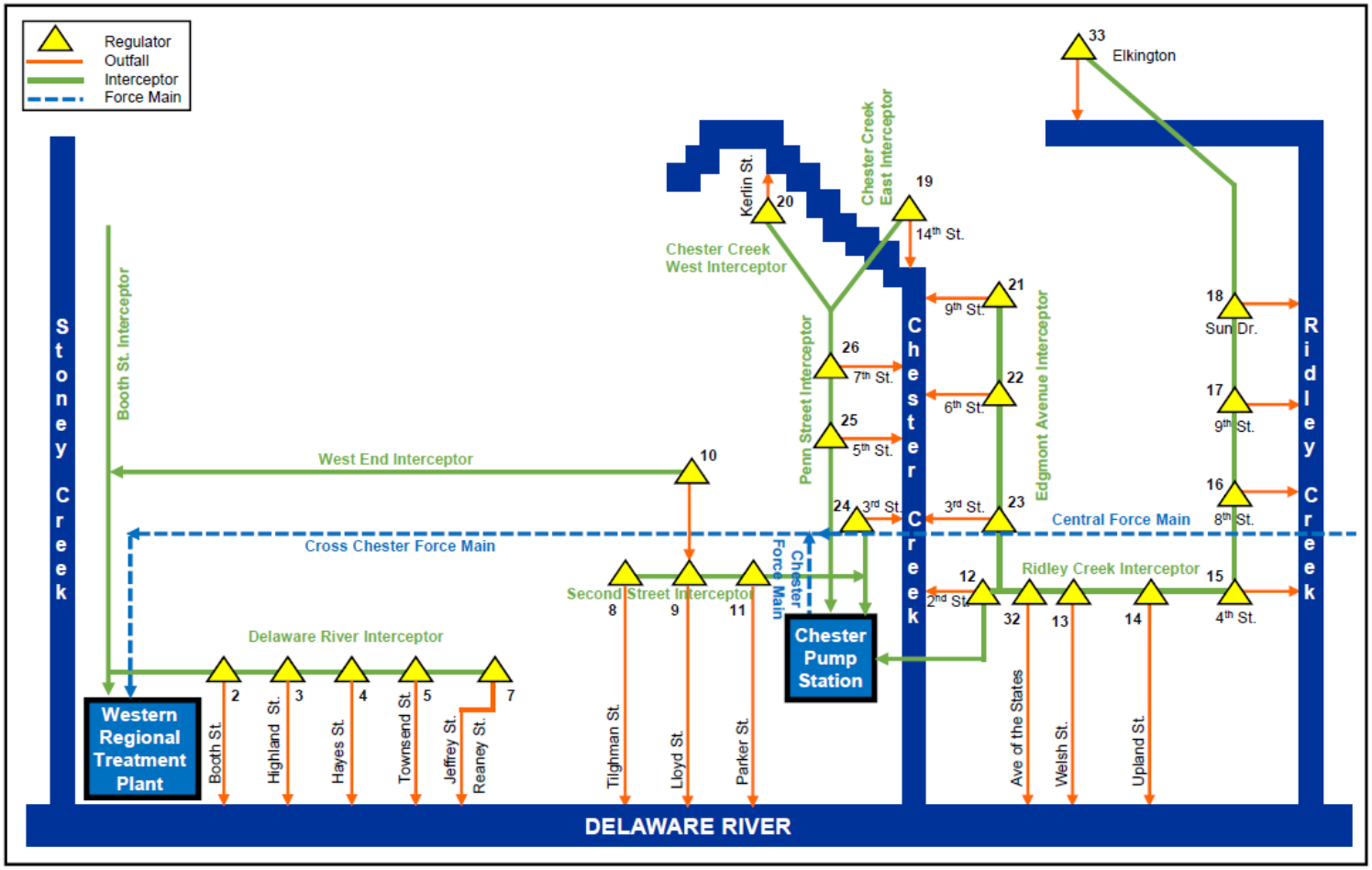
Figure 1-3: Location of Regulators and Combined Sewer Outfalls with Drainage Areas



CSO Long Term Control Plan Update
Delaware County Regional Water Quality Control Authority

GREELEY AND HANSEN

Figure 1-4: Schematic of Chester CSO System



CSO Long-Term Control Plan
Delaware County Regional Water Quality Control Authority

GREELEY AND HANSEN

Figure 1-4
SCHEMATIC OF CHESTER CSO SYSTEM

1.4 Work Plan Purpose and Objectives

The purpose and objective of the Water Quality Monitoring and Modeling Work Plan is to provide a blueprint for the water quality modeling and monitoring work that will be consistent with EPA requirements as listed in DELCORA's Consent Decree.

1.5 Project Team Organization

The proposed project team organization, including key project personnel and their corresponding responsibilities, are shown in Figure 1-5.

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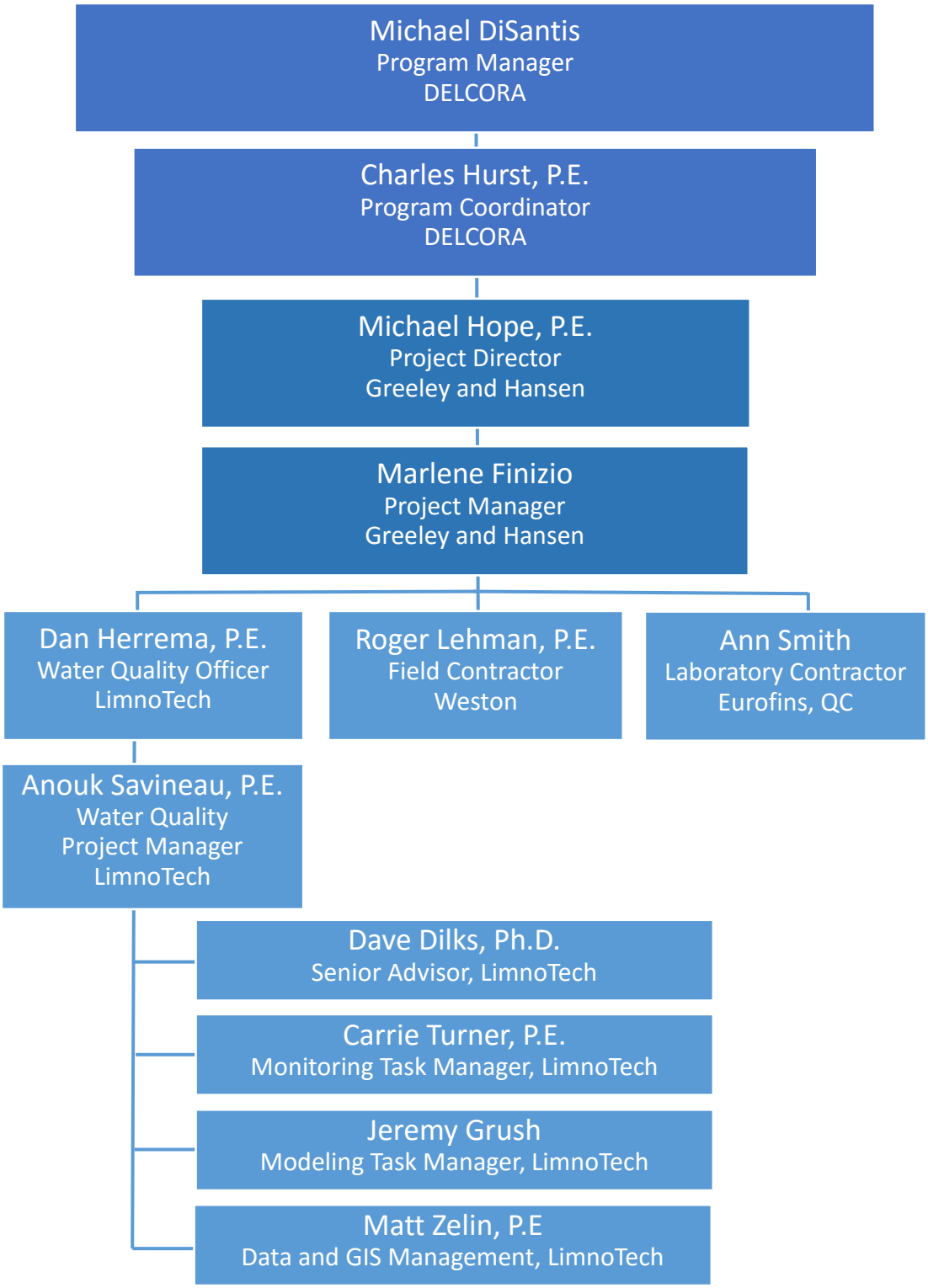
Figure 1-5: Project Team Organization



Section 2 Water Quality Model Plan

2.1 Regulatory Requirements

2.1.1 Consent Decree Requirements

The Consent Decree was lodged in the United States District Court for the Eastern District of Pennsylvania on August 17, 2015, and was approved by the Federal District Court on November 10, 2015. The Consent Decree requires DELCORA to complete and submit a revised and updated LTCP to the USEPA and the PADEP for review and approval. Consent Decree Paragraph V.A.15 (Water Quality Model Plan) requires that within ninety (90) days after EPA reviews and approves the Alternatives Evaluation Approach, DELCORA shall submit to EPA and PADEP a Water Quality Model Plan for review and approval. For each water body[1] in which the Demonstration Approach is to be used, the Water Quality Model Plan shall address:

i. Background, Scope and Purpose, Description of System;

ii. Water quality modeling software to be employed;

iii. Model configuration and development, including reaches to be modeled, and segmentation and boundary conditions;

iv. Calibration and validation (dry weather and wet weather, including events and data to be employed, detailed information regarding all additional data collection activities (if needed), quantitative and qualitative calibration criteria, and utilization of H&H Model outputs;

v. Use of the Water Quality Model to evaluate Typical Year instream conditions for each identified pollutant of concern;

vi. Schedule for model development and implementation, including integration into LTCP development consistent with other dates required pursuant to the Consent Decree.

The Consent Decree further specifies that within sixty (60) days after the approved Water Quality Model Plan is fully implemented according to the schedule included therein, DELCORA shall submit to EPA and PADEP a Water Quality Model Report for review and approval pursuant to Section VI (Review and Approval of Submittals) which shall specifically address each item set forth in Paragraph 15(a)(i)-(vi).

[1] Water bodies include the Delaware River, Chester Creek and Ridley Creek.

2.2 Model Selection/Software

This section describes the objectives and criteria used to select the appropriate modeling approach and model software.

2.2.1 Objectives

The objective of the water quality modeling is to assess the impacts of the DELCORA combined sewer system overflows on the bacteria concentrations in the receiving waters, both under existing conditions and future LTCP alternatives conditions, and assess these impacts against applicable water quality standards. In order to achieve these objectives, a linked CSO, watershed, and receiving water model will be created. The CSO model, also called the "H&H" model, is currently being developed for the Long Term Control Plan, with calibration and validation to be completed in April 2017. The H&H model is designed to simulate CSO discharges from the DELCORA service area within the City of Chester. The watershed model is a new model that will be created to model the non-CSO areas that are within the DELCORA service area and the extent of the receiving water model. The receiving water quality model is also a new model that will be developed to simulate the bacteria concentrations in the receiving waters, including the Delaware River, Chester Creek and Ridley Creek. The receiving water quality model will account for bacteria load contributions from various sources such as upstream, CSO, and stormwater loads, as well as processes that account for bacteria transport and decay.

There are several objectives to consider when selecting appropriate modeling software for the watershed and receiving water model, including:

- Technical objectives: Can the model software adequately represent the physical, chemical, and temporal characteristics of the project site? Can it address the complexities of the project site without being overly complex or overly simplistic?
- Regulatory objectives: Can the model software produce results that can be used to evaluate water quality against applicable water quality standards? Does it have a proven track record with similar regulatory projects? Will it help fulfill regulatory requirements as described in the Consent Decree?
- User objectives: Does the end user have the necessary hardware and expertise to properly apply the model software to its fullest potential? Are there financial constraints to be considered with the model?

These objectives and how they were applied to select the watershed and receiving water models are further described in sections 2.2.3 and 2.2.4 respectively. The selection of the CSO H&H model was previously described in the H&H Model Update and Calibration Plan (DELCORA, 2015).

2.2.2 Review of Existing Studies

There have been numerous water quality modeling studies performed on the Delaware River and its associated tributaries. Some of these studies were used to inform the DELCORA work plan, and may be used in the future to further inform or develop the water quality modeling and monitoring efforts. A brief overview of these studies is provided below.

- The Philadelphia Water Department's "Tidal Waters Water Quality Model for Bacteria and Dissolved Oxygen Model" was completed in June 2015 (PWD, 2015) using EFDC as the model framework. The model was developed in response to requirements in the 2011 Consent Order and Agreement between the Pennsylvania Department of Environmental Protection (PDEP) and the Philadelphia Water Department (PWD). The objectives of the model were to represent bacteria and DO in the tidal receiving waters. The model's extent is from the head of tide at Trenton, New Jersey to near Delaware City, Delaware. Also included were 28 tributaries to the Delaware River including eight miles of the tidal portion of the Schuylkill River.
- The Delaware River Basin Commission's "DYNHYD5 Hydrodynamic Model (Version 2.0) and Chloride Water Quality Model for the Delaware Estuary" was completed in December 2003 (DRBC, 2003). The model was used for the development of the Stage 1 TMDLs for polychlorinated biphenyls (PCBs) for the Delaware River Estuary. The model's extent is from Trenton, NJ to the Mouth of the Delaware River. PCBs and chloride were the only water quality parameters modeled. Note that DRBC is currently evaluating the nutrient criteria strategy for the Delaware River and has an initiative to create a new eutrophication model to address dissolved oxygen issues in the river (DRBC, 2012). The new model would include an improved hydrodynamic model of the tidal Delaware River and a dissolved oxygen and nutrient water quality model.
- The University of Delaware's Center for Applied Coastal Research developed a "Hydrodynamic Model of Delaware Bay and the Adjacent Coastal Region" (UD 2011) using the Regional Ocean Modeling System (ROMS) framework. The latest model update was performed in 2011, with other similar studies performed since the 1990s. The purpose of this model is further characterize the hydrodynamics of the Delaware Bay and surrounding area. Salinity is the only water quality parameter modeled. The models domain extends into the offshore into the Atlantic Ocean and into the Delaware Bay.
- Hydraulic models have also been created for the purpose of FEMA's National Flood Insurance Program to analyze risk of flooding. These models were developed for FEMA by federal contractors. For Chester and Ridley Creek, the most recent modeling effort is likely from the 1970's. These models were only used to assess flood risk so no water quality parameters are modeled. The model extent for these two creeks extends from their confluence with Delaware River upstream into Delaware County.

Limited topographic and bathymetric surveys were performed for these models which will be useful in characterizing the bathymetry of Chester and Ridley Creek.

2.2.3 Watershed Model Selection

Many watershed model software packages are available and these models vary in their recognition by USEPA and their applicability to the Delaware River and its tributaries. The proposed watershed model framework for this project is EPA Storm Water Management Model (SWMM), which is supported by the USEPA and has been successfully applied by the project team at similar sites and for related purposes, including in East Rutherford, NJ, Washington, DC, and Richmond, VA. SWMM is a dynamic rainfall-runoff simulation model used for single event or continuous simulation of runoff quantity and quality from primarily urban areas (USEPA, 2015). A review of the Chester Creek and Ridley Creek watersheds using the USGS StreamStats[2] tool show that these two watersheds are 42% and 37% urban respectively. Additionally, the current H&H model for the DELCORA service area is also built using the SWMM software, so choosing SWMM for the watershed model provides consistency in the suite of models used by DELCORA.

A variety of enhanced SWMM platforms are available that integrate the EPA SWMM software with user friendly interfaces and GIS capabilities. For this project, PCSWMM, developed by CHI, will be used. Once the watershed model is built, the model files can be provided as PCSWMM or EPA SWMM files.

2.2.3.1 Attributes

The main attributes of the proposed watershed model are that it will be able to predict dry and wet weather flows and associated bacteria loads. The watershed model will provide necessary spatial resolution to account for different subcatchment physical characteristics such as slope, imperviousness, length and width, and soils. Additional, it will be able to predict variations in timing, peak flows, and flow volumes.

The inputs and outputs of the SWMM model are described in more detail in the following section.

2.2.3.2 Inputs and Outputs

Model inputs are site-specific estimates of environmental conditions or assumptions that influence modeled water quantity and quality. Model outputs are results of model calculations that describe conditions related to water quantity and quality. Table 2-1 describes the SWMM watershed model inputs and outputs that will be used for this project.

[2] http://water.usgs.gov/osw/streamstats/

Table 2-1: Watershed Model Inputs and Outputs

Process	Inputs	Outputs
Runoff Calculations	Area, width, imperviousness, slope, roughness, depression storage, soil infiltration, meteorology (precipitation, temperature)	Catchment runoff volume and flow rate, hydrograph of flow vs. time.
Water Quality Calculations	Event Mean Concentration for stormwater and CSO outfalls	Bacteria concentrations in dry and wet weather flows, pollutographs of pollutant concentration vs. time
Routing Calculations	Pipe and/or channel geometry, slope, roughness.	Dry and wet weather flow volumes and rates, hydrographs of flow vs. time

The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff and pollutant loads according to their landuse, landcover, and soil characteristics (USEPA, 2014). Additional information on the main model inputs that will have to be defined for the runoff component of SWMM are shown in Table 2-2.

Table 2-2: SWMM Runoff Model Inputs

Inputs	Source of Information
Area	Delineated in GIS using topography and sewer network data
Width	Calculated in GIS based on the watershed delineation
Slope	Calculated in GIS using topography
Imperviousness	Calculated in GIS using NLCD data or estimated from landuse data
Roughness	Based on published values for impervious and pervious area
Depression Storage	Based on published values for different land covers
Soil Infiltration	Based on soil data and characteristics published by USGS (SSURGO). The Horton method is the preferred method to account for infiltration losses for this project.
Meteorology	Precipitation, temperature, evaporation data obtained from nearby weather stations

To calculate the bacteria loads associated with the watershed flows, bacteria event mean concentrations (EMCs) will be assigned to the flows. An EMC represents the average pollutant (bacteria) concentration present in runoff. The appropriate EMCs will be obtained through the sampling efforts as described in Section 3.

For the purpose of this project, the predicted runoff from the watershed model will be directly connected to the receiving water quality model. In other words, routing through the pipe/channel system will not be simulated unless the calibration of the receiving water model demonstrates a need for additional resolution in flow timing is needed. If explicit routing is needed, pipe and/or channel attributes such as slope, roughness, or cross-sectional geometry will be obtained from DELCORA or field studies. Routing would further be accomplished by applying the kinematic or dynamic wave routing method.

2.2.4 Receiving Water Quality Model Selection

Many water quality model frameworks are available and these models vary in their recognition by USEPA, adaptability for project-specifics needs, and their applicability to the Delaware River and its tributaries. The proposed water quality model framework for this project is EFDC (Environmental Fluid Dynamics Code), which is supported by the USEPA and has been successfully applied by the project team at similar sites and for related purposes. It may be beneficial to couple EFDC with another model to reduce simulation run times. EFDC could be used to compute hydrodynamics and those results could be linked to the RCA (Row-column AESOP) water quality model for water quality calculations. This potential approach would reduce model run times by allowing for a longer time step and for a smaller water quality model extent. RCA, like EFDC, is a highly regarded water quality model that has been applied at numerous sites.

EFDC is a state-of-the-art finite difference model that can be used to simulate hydrodynamic and water quality behavior in one, two, or three dimensions in riverine, lacustrine, and estuarine environments (TetraTech 2007a, 2007b). The model was developed by John Hamrick at the Virginia Institute of Marine Science in the 1980s and 1990s, and it is currently maintained under support from the USEPA. The model has been applied to hundreds of water bodies, including Chesapeake Bay and the Delaware River. Recently, LimnoTech has successfully applied EFDC to a number of estuarine sites including Newark Bay, East Rutherford, NJ, and San Diego Bay. The EFDC model is both public domain and open source, meaning that the model can be used free of charge, and the original source code can be modified to tailor the model to the specific needs of a particular application. As a result, EFDC provides a powerful and highly flexible framework for simulating hydrodynamic behavior and water quality dynamics for the Delaware River and Chester Creek and Ridley Creek.

The RCA model is a part of a family of generalized water quality models developed by HydroQual, Inc. and known as AESOP (Advanced Ecological Systems Operating Program) (HydroQual, 2004). The RCA model framework is capable of simulating water quality dynamics on a fine-scale, multi-dimensional computational grid based on linkage to an external hydrodynamic model application. RCA is specifically designed to interface with the EFDC model via a series of binary files generated by the latter model. The general transport fields predicted by EFDC (or another hydrodynamic model) are used by RCA to advect and disperse water quality constituents throughout the water column.

2.2.4.1 Attributes

To compute the movement (transport) and concentrations of pollutants, a water quality model must represent the primary physical and kinetic processes that influence transport and pollutant concentrations. It is anticipated that the following processes will be necessary to represent in this model application:

- Loading of local bacterial pathogens from the watershed, MS4s, CSOs, treatment plant(s), and other known sources to Chester Creek, Ridley Creek, and the Delaware River;
- Transport of pathogens from the riverine portions of creeks to the Delaware River estuary;
- Transport of pathogens via tidal currents and mixing within the Delaware River estuary; and,
- Net losses of pathogens during transport.

These attributes are described in more detail in the following section.

2.2.4.2 Inputs and Outputs

Model inputs are site-specific estimates of environmental conditions or assumptions that influence modeled water quality. Model outputs are results of model calculations that describe conditions related to water quality. Table 2-3 below describes model inputs and outputs relating to the primary physical and kinetic processes described in the previous section.

Table 2-3: EFDC Model Inputs and Outputs

Water Quality Model Process	Related Inputs	Related Outputs
Bacterial pathogen loadings	Pollutant concentrations for: • Delaware River boundaries • Chester Creek upstream watershed • Ridley Creek upstream watershed • CSOs • MS4 areas • WWTPs	• Pollution in-stream concentrations
Transport of pathogens within the riverine portions of creeks	Flow rates for: • Creeks • CSOs • MS4 areas • WWTPs Stream bathymetry	• Water depths and velocities in the creeks
Transport of pathogens via tidal currents and mixing within the Delaware River estuary	• Delaware River and major tributary flow rates, • Tidal water levels, and • Delaware River bathymetry	• Water depths and velocities in the Delaware River
Net losses of pathogens during transport	• First order bacteria decay rate • Water temperatures • Parameters influencing dependence of decay on water temperature	• Pollutant in-stream concentrations

2.2.5 Data Sources

Table 2-4 below describes data sources that are expected to help inform model inputs relating to the primary physical and kinetic processes described above.

Table 2-4: Data Sources Supporting Model Inputs

Water Quality Model Process	Related Inputs	Data Sources
Bacterial pathogen loadings	Pollutant concentrations for: • Creeks • CSOs • MS4 areas • WWTPs	• Bacterial pathogen concentration data (existing data and data proposed in Section 3 of this work plan to be collected) • WWTP DMR (discharge monitoring report data) • Literature-based event mean concentration data
Transport of pathogens within the riverine portions of local creeks	Flow rates for: • Creeks • CSOs • MS4 areas • WWTPs Stream bathymetry	• USGS flow data • Collection system model overflow rates • Watershed model flow rates • Bathymetric data
Transport of pathogens via tidal currents and mixing within the Delaware River estuary	• Delaware River and major tributary flow rates • Tidal water levels • Delaware River bathymetry	• USGS flow data • NOAA water level data • NOAA Delaware River bathymetric data
Net losses of pathogens during transport	• First order bacteria decay rate • Water temperatures • Parameters influencing dependence of decay on water temperature	• USGS and/or NOAA water temperature data • Bacterial pathogen concentration data (existing data and data proposed in Section 3 of this work plan to be collected)

2.3 Model Development and Configuration

2.3.1 Watershed Model

The watershed model will be developed and configured in order to calculate the runoff and bacteria loads generated by the Ridley Creek and Chester Creek watersheds, as well as by the separate stormwater areas within the DELCORA service area.

2.3.1.1 Extent

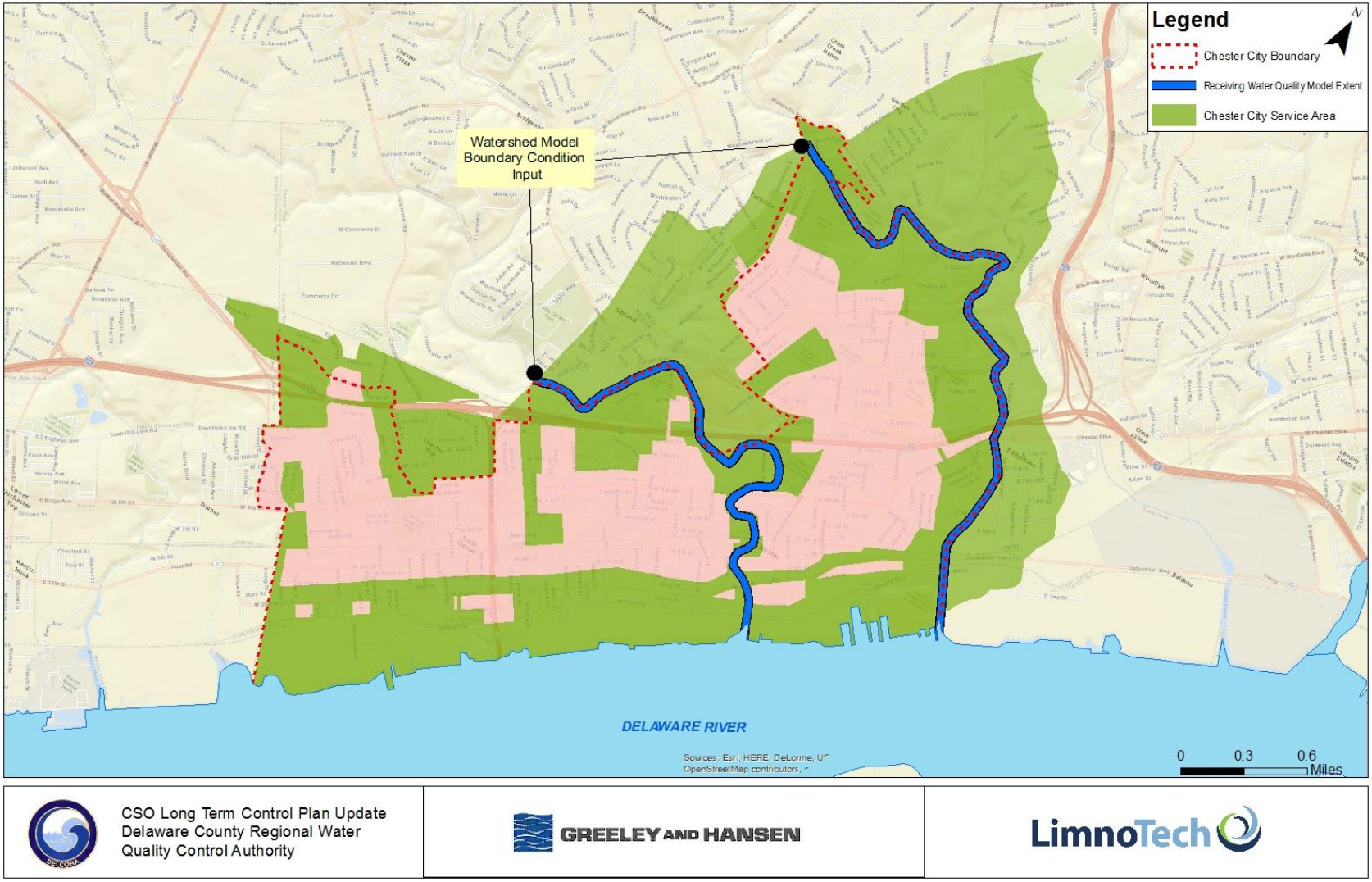
The flows and bacteria loads from the upstream portion of the Ridley Creek and Chester Creek watershed area will be represented through the use of boundary conditions. These boundary

conditions will be determined through an analysis of USGS flow gage data and bacteria monitoring data. The portions of the Ridley Creek and Chester Creek watersheds that are within the DELCORA service area (and a small area upstream of the DELCORA service area) will be explicitly modeled using SWMM. Figure 2-1 below shows the extent of the proposed watershed model.

2.3.1.2 Segmentation

As described in the section above, the Ridley Creek and Chester Creek watersheds will be divided into upstream and downstream areas. The upstream area will be represented through the use of boundary conditions that describe the flow and load that are generated from the upstream area under different meteorological conditions. The downstream area will be divided into relatively small and homogenous catchments.

Figure 2-1: Proposed Extent of the Watershed Model



2.3.2 Receiving Water Quality Model

A few considerations guide the design of a receiving water quality model. First, models are designed to cover the locations of interest with respect to site-specific management questions. Second, the spatial extent of a model should be chosen to allow for accurate calculations of transport. This requires that the model's edges (boundaries) occur at locations where environmental conditions (e.g. flow rates) are well known and readily defined. For instance, it is often beneficial to locate a model boundary at the head of tide where tidal flows are zero, or at a monitoring location where tidal water levels are known. Third, an appropriate spatial resolution should be determined to balance the level of detail in the model against the run times of simulations. Finally, the model boundaries should be sufficiently distant from the source such that the pollutant mass assumptions from these boundaries would not significantly affect conditions simulated in the area of interest. The proposed model extent and spatial resolution are described in the following sections.

2.3.2.1 Extent and Reaches

On the Delaware River, we propose that the receiving water model extends from NOAA station 8551762 (Delaware City, DE) to the head of tide at Trenton near USGS station 01463500 (Delaware River at Trenton, NJ). Environmental conditions at these locations are well defined by data and the locations are sufficiently far from Delaware County that model results are not expected to be strongly influenced by water quality assumptions at the boundaries.

We propose that the receiving water model extends through the tidally influenced portion of the creeks and through all reaches adjacent to the DELCORA combined sewer system. This is because the receiving water model is better suited for representing tidal conditions at the mouth of the creeks than the watershed model, and representing CSOs exclusively in the receiving water model simplifies the modeling process. Tidal transport will likely influence the duration of time that pathogen sources influence the lower reaches of each creek. In some cases, it may be beneficial to extend the model farther in to the creeks (i.e. upstream of the tidally influenced reaches) to a sampling or monitoring location.

2.3.2.2 Segmentation

The segmentation of a model defines the degree of spatial detail in the model results and also determines how much time is required for a simulation to run. Determining an appropriate degree of spatial detail is related to both the detail necessary to address management questions and the degree of detail necessary to accurately model the processes of an environmental system. Occasionally, model segmentation must be iteratively refined during the model development process to reach a suitable degree of detail.

We propose that the receiving water quality model have roughly the following characteristics:

- Five to ten cells spanning the Delaware River cross section;
- One cell spanning the cross section of each creek;
- 2,000 to 4,000 total grid cells within the model extent;
- Typical Delaware River cell dimensions of roughly 150-300 feet (width) by 1,000 to 2,000 feet (length). Typical creek cell lengths of 200 to 400 feet; and,
- Five cells spanning the water depth.

The Delaware River is relatively deep (30-40 feet deep) near the location of maximum DELCORA impact, so a three-dimensional model is recommended for computing near-surface pathogen concentrations, which are occasionally elevated relative to those at greater depths due to discharge of CSOs near the water surface. A depth-averaged (two-dimensional) model would instantaneously mix pollutant concentrations over the water depth and understate near-surface concentrations.

2.3.2.3 Linkage with CSO (H&H) Model

The CSO H&H model will be linked to the receiving water quality model. The H&H model will be run for the calibration period as well as for each CSO alternative of interest, and CSO outfall results will be inserted into the EFDC model at the appropriate grid location in EFDC.

2.3.3 Linkage with Watershed Model

The watershed model will be linked to the receiving water quality model. The watershed model will be run for the appropriate meteorological period and results will be inserted into the EFDC model at the appropriate grid locations in EFDC.

2.3.4 Water Quality Parameters

The water quality parameters that will be evaluated in the water quality model are fecal coliform bacteria, *Enterococcus* bacteria, and *Escherichia coliform* (*E. coli*). These parameters are discussed in detail in the Identification of Sensitive Areas and Pollutants of Concern Report (DELCORA, 2016).

2.3.5 Boundary Conditions

Boundary conditions define environmental conditions at the edges of the model spatial domain and influence model calculations within the model domain. Boundary conditions will be used in both the watershed model and receiving water quality model.

Two types of boundary conditions are required in the watershed model: flow boundary conditions and water quality boundary conditions. As explained in Section 2.3.1, the flows

and loads from the upstream portion of the Ridley Creek and Chester Creek watersheds will be represented through the use of boundary conditions. These boundary conditions will be determined through the analysis of USGS flow gage data and bacteria monitoring data. The flow and bacteria boundary conditions will vary according to meteorological and seasonal conditions.

Two types of boundary conditions are also required in the receiving water quality model: hydrodynamic boundary conditions and water quality boundary conditions. Hydrodynamic boundary conditions will include a water level boundary condition, which will define how water levels vary with the tides and other atmospheric conditions, and inflow boundary conditions, which will define flow rates into the model from freshwater sources such as from the Delaware River above Trenton, major tributaries, creeks of interest, MS4s, CSOs, and treatment plants. Water quality boundary conditions define the pollutant concentrations associated with all inflows to the model. Water quality boundary conditions will be defined based on the available sampling data for all pollutant sources of interest.

2.4 Model Calibration and Validation

Model calibration is described in USEPA guidance (USEPA, 1994) as the "process of adjusting model parameters within physically defensible ranges until the resulting predictions give the best possible fit to the observed data." Calibration will occur for the runoff and water quality components of the watershed model, as well for the hydrodynamic and water quality components of the receiving water quality model. Calibration will occur through the use of available monitoring data.

2.4.1 Calibration Objectives

The objectives for the hydrodynamic model calibration are to determine a set of model inputs (primarily bed roughness and turbulent mixing parameters) that produce model results consistent with the observed data. During the hydrodynamic model calibration, comparisons between modeled and observed water surface elevations and velocities will be made. The comparisons will allow for any adjustments to be made.

The objectives for the water quality model calibration are to interpret the water quality data to improve initial estimates of pollutant loads and potentially constrain assumptions related to bacterial decay. For instance, model tests would be run with different assumptions about pollutant concentrations in combined sewer overflows. Those tests would be evaluated for consistency with the receiving water sampling data to determine a range of pollutant concentration assumptions that are supportable. Likewise, model tests would be run with different assumptions about bacterial decay, and those tests would be evaluated to refine inputs related to decay.

2.4.2 Data for Calibration/Validation

Data available for the hydrodynamic model calibration include NOAA water level and velocity data, and USGS water level and flow data. Primary hydrodynamic model calibration stations include the following NOAA stations:

- Water level gages: #8540433 (Philadelphia, PA), #8546252 (Bridesburg, PA), #8539094 (Burlington, NJ), and #8548989 (Newbold, PA).
- Current velocity meter: Station dB0301 (Philadelphia, PA).

Model results will be compared to hourly water level and current velocity data at these locations.

Data available for the water quality calibration are pathogen grab sample data. Section 3 of this work plan summarizes the currently available water quality data by sample location. We propose to supplement these data with an additional sampling program described in Section 3 of this work plan.

2.4.3 Calibration Criteria

Hydraulic calibration will primarily focus on reproducing observed water levels and current velocities in the Delaware River. This approach provides a robust calibration by focusing on the hydraulic attributes that are the primary dependent variables of the hydrodynamic model. Calibration goodness will be determined by qualitative visual comparison of model and data time series, one-to-one plots, and cumulative frequency distributions (CFDs). Calibration will involve adjustment of the roughness height to values that best replicate water level and velocities at NOAA stations.

Bacteria models are often evaluated qualitatively with multiple tools such as time series plots, CFDs, and 1:1 plots. Because bacteria concentrations vary over many orders of magnitude and sources can be numerous, distributed, and highly variable with time, bacteria model results are not often held to quantitative calibration criteria. Instead, a rule of thumb is that modeled bacteria concentrations should mostly be consistent with observed bacteria concentrations within an order of magnitude. Agreement of model and data within a factor of two indicates a high degree of model performance.

2.4.4 Model Sensitivity

Model sensitivity tests complement and illustrate the model calibration. Model sensitivity tests are model simulations in which uncertain inputs are varied to assess their significance in determining, for instance, pollutant concentrations. These tests are useful for evaluating whether the model calibration is optimized within the limits of the available data, and for identifying uncertainty in significant model inputs. For instance, model sensitivity tests varying the assumed CSO pollutant concentrations would illustrate how a range of assumptions are more or less consistent with stream sampling data.

Model sensitivity tests will be conducted for the following inputs:

- Major pollutant loads (including at least CSO, MS4, and local watershed loads).
- Parameters influencing bacteria decay rates.

Results of model sensitivity tests will be summarized using plots such as CFDs, box plots, or time series plots.

2.5 Model Typical Year Application

An evaluation of the typical hydrologic period was conducted for DELCORA and is detailed in the report entitled "Typical Hydrologic Period Report" (DELCORA, 2016). The typical year that will be applied to evaluate CSO scenarios will also be used for the receiving water quality model. The recommended period for typical year application is 1994-1996.

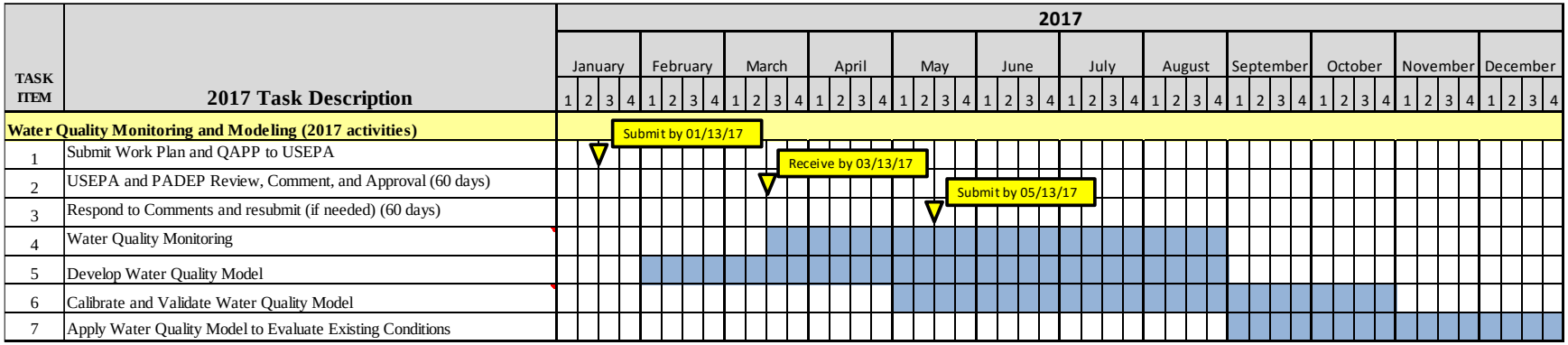
2.6 Model Development Schedule

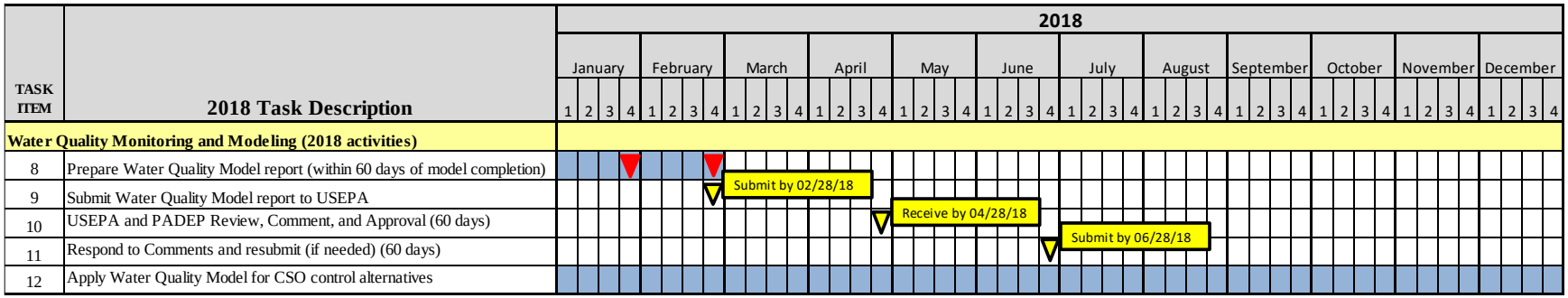
The schedule for model development and application is shown in Figure 2-2 below. All tasks related to the water quality modeling development and application are included in the schedule. The schedule is integrated into the LTCP development consistent with other dates required to the Consent Decree.

2.7 Model Documentation

A report will be provided that summarizes the development, calibration, application, and results of the receiving water model. In accordance with the Consent Decree, this report will be submitted to EPA and PADEP within sixty (60) days after the approved Water Quality Model Plan is fully implemented according to the schedule included herein.

Figure 2-2: Schedule for Model Development and Application





NOTES:

Consent Order Deadline

Draft and Final Submittals

Section 3 Monitoring Work Plan

3.1 Regulatory Requirements

3.1.1 Consent Decree Requirements

On August 17, 2015, a Consent Decree was lodged in the United States District Court for the Eastern District of Pennsylvania that requires DELCORA to complete and submit a revised and updated LTCP to the United States Environmental Protection Agency (USEPA or EPA) and the Pennsylvania Department of Environmental Protection (PADEP or DEP) for review and approval. Consent Decree Paragraph V.A.10.e and V.A.10.f require that the development of the LTCP include

V.A.10.e. Develop and implementation of a Water Quality Model

V.A.10.f Characterization of the service area and the Receiving Waters as required by CSO Control Policy Paragraph II.C.1 and associated guidance.

Consent Decree Paragraph V.A.15 (Water Quality Model Plan) requires that within 90 days after review and approval of the Alternatives Evaluation Approach, DELCORA shall submit a report to the USEPA and PADEP that describes the use of the Water Quality Model to support the Demonstration Approach consistent with Section II.C.4 of the CSO Control Policy and the Paragraph V.13 of the Consent Decree (Alternatives Evaluation). Section V.A.15.a of the Consent Decree specifically states:

For each water body in which the Demonstration Approach is to be used, the Water Quality Model Plan shall address:

(i) Background, Scope and Purpose, Description of the System;

(ii) Water quality modeling software to be employed;

(iii) Model configuration and development, including reaches to be modeled, and segmentation and boundary conditions;

(iv) Calibration and validation (dry and wet weather), including events and data to be employed, detailed information regarding all additional data collection activities (if needed), quantitative and qualitative calibration criteria, and utilization of H&H Model outputs;

(v) Use of the Water Quality Model to evaluate Typical Year in-stream conditions for each identified pollutant of concern;

(vi) Schedule for model development and implementation, including integration into LTCP development consistent with other dates required pursuant to this Consent Decree.

3.3 Existing Water Quality Monitoring Overview

The Water Quality Monitoring Program (WQMP) is designed to collect data that will be used to assess water quality concerns identified in the Delaware River watershed and its tributaries, Chester Creek and Ridley Creek, in the vicinity of Chester, PA. Pollutants of concern (POCs) were identified in the Identification of Sensitive Areas and Pollutants of Concern Report (Greeley and Hansen, 2016). These POCs are fecal coliform, *E. coli*, and *Enterococcus* and are the primary focus of the WQMP. In completing the initial step of characterizing the watershed, historical data was compiled, reviewed and assessed to determine the need to augment existing data to address the watershed issues identified. This review indicated that one of the POCs, *E. coli*, has not been sampled in all the receiving waters and the data that have been collected for the remaining POCs are of insufficient frequency and spatial density to be useful in the modeling process.

3.3.1 Historic Sampling

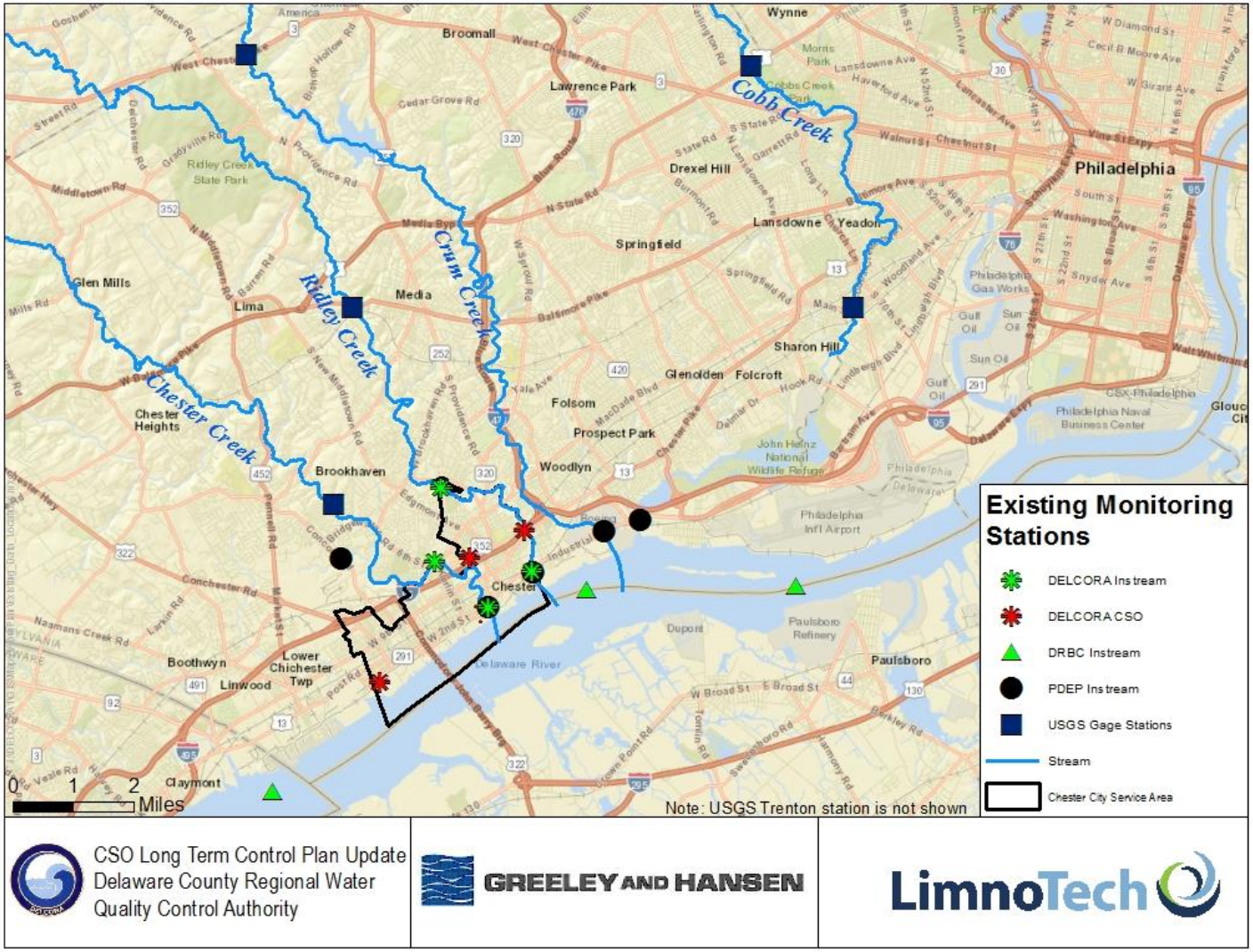
The Water Quality Model requires robust flow and water quality datasets to build confidence in its use as a tool for CSO planning. Data are needed in the modeled receiving waters for use in model calibration and validation as well as for the predominant wet weather sources, such as DELCORA's CSOs and the City of Chester's MS4 runoff to estimate pollutant loadings to the model. The existing water quality data were reviewed for their adequacy in meeting the data needs of the water quality model for the POCs (fecal coliform, *E. coli*, and *Enterococcus*). The review indicated that Chester Creek and Ridley Creek have limited POC data. Although the Delaware River has more extensive POC data, it lacks the temporal frequency needed to characterize wet weather impacts from DELCORA's CSOs. It would be difficult to constrain the Water Quality Model's representation of DELCORA's sources on the receiving waters without additional monitoring data designed specifically for calibrating and validating a robust water quality model. Existing flow data were also reviewed for adequacy; reports of mean daily stream discharge are available from several stream gages along the Delaware River and in tributaries near the DELCORA service area, ranging from as early as 1912 to the present. The existing flow and water quality data are described in this section.

Flow data for the Delaware River and tributaries in the DELCORA service area were obtained from the USGS National Water Information System. Reports of mean daily stream discharge were available from five stream gages in DELCORA service area measuring daily mean discharge: Crum Creek near Newtown Square, PA (1980-2016); Chester Creek near Chester, PA (1931-2016); Ridley Creek near Media, PA (1986-2016); Cobbs Creek at U.S. Highway No. 1 at Philadelphia, PA (1964-2016); and Cobbs Creek at Mt. Moriah Cemetery, Philadelphia, PA (2005-2016). Though not in service area, mean daily discharge data were also obtained from the gage at the Delaware River at Trenton, NJ (1912-2016) because it is expected that these data will be used to inform the upstream boundary for the hydraulic portion of the water quality model. The USGS Pennsylvania Water Science Center has conducted water quality sampling at various points in the state. However, none of their sampling locations are near to the DELCORA service area or local waterways.

Monthly effluent data from DELCORA's WWTP are available from the Pennsylvania Department of Environmental Protection's (PADEP) eDMR website (*www.dep.pa.gov/edmr*). Reported data include monthly geometric mean and instantaneous maximum values for fecal coliform from 2009 through 2016. PADEP also monitors water quality of tidal streams that empty into the Delaware River, through the Pennsylvania Water Quality Tributary Project funded by the Delaware River Basin Commission (DRBC). This program monitored for fecal coliform levels in Chester Creek, Ridley Creek, Darby Creek, Crum Creek, and others twice annually from 2007-2010. PADEP also operates the PA Surface Water Quality Monitoring Network, through which Baldwin Run (a tributary to Chester Creek) was sampled monthly for fecal coliform from 1998-1999.

The Delaware River Basin Commission operates its Boat Run program to monitor ambient, sampling for *E. coli*, *Enterococcus*, and fecal coliform at various sites along the Delaware River (Figure 3-1). Samples were collected from each station between one and three times each month from March through November every year since 1999. Through this program, data are available at three sites near DELCORA: Eddystone (2005-2016), Paulsboro (1999-2016), and Marcus Hook (1999-2016).

Figure 3-1: Historical Flow and Water Quality Sampling Locations Near DELCORA Service Area.



Since 2009, DELCORA has also done their own sampling at CSO outfall sites and in receiving waters. In 2010, a survey was conducted to measure fecal coliform levels in Ridley and Chester Creeks during wet and dry weather. There were two sample sites in each creek, and over the course of the study, six surveys were conducted. Four surveys occurred during dry weather, one during a wet event, and one during a wet event after a storm. During each survey, one sample was collected at each site. In 2009, DELCORA began sampling in the CSO system as required by their NPDES permit. Four outfalls and pump stations were sampled once annually for fecal coliform from 2009-2011, and three outfalls were sampled once annually for fecal coliform from 2012-2014. In 2015, four outfalls and pump stations were sampled for fecal coliform and *Enterococcus*, on three separate occasions. *E. coli* was not measured in any of these surveys.

The extent of existing water quality data and its adequacy to support the Water Quality Model development and calibration can be summarized as follows:

- Some CSO water quality data has been collected but mostly for fecal coliform. There are no CSO data for *E. coli*. Another limitation in the CSO data is that the CSO samples did not coincide with in-stream sampling, making it difficult to directly link CSO loads to in-stream impacts.
- No water quality sampling for the POCs has been done of the stormwater runoff in the separated areas of the DELCORA service area.
- Delaware River has the most data of the receiving waters and it has data for all three POCs. However, the data were collected at regular intervals, independent of weather condition, and typically only one sample per location per survey was collected. These periodic sampling events do not provide enough data to characterize DELCORA loads on the river.
- The tributaries (Chester Creek and Ridley Creek) have been sampled sporadically and rarely within the tidal zone adjacent to DELCORA's service area. Wet weather data collected by DELCORA, consisting of only one sample per event, are not sufficient to characterize the magnitude and duration of the POCs' pollutographs over a storm event. Data are most robust for fecal coliform. There is less data for *Enterococcus* and none for *E. coli*. In addition, no sampling has been conducted in these tributaries since 2010.

The monitoring program presented in this work plan and QAPP builds on the sampling that has already been done while addressing the limitations identified in the existing data. This work plan includes a comprehensive monitoring assessment of all of the POCs to characterize loads and in-stream conditions. These data will be used to inform the Water Quality Model development, calibration and validation.

3.3.2 Ongoing Sampling

There is no routine on-going monitoring for the pollutants of concern in the tributary waterways adjacent to the DELCORA service area. The Delaware River Basin Commission samples the Delaware River near Chester approximately once a month between April and October. The analysis of these samples includes fecal coliform, *E. coli*, and *Enterococcus*, which are the pollutants of concern (POCs).

3.4 Sampling and Analysis Plan Overview

The WQMP is designed to collect data that will be used to develop and calibrate watershed and receiving water quality models which will be used to assess water quality concerns for the POCs identified in the Identification of Sensitive Areas and Pollutants of Concern Report (Greeley and Hansen, 2016). These POCs are fecal coliform, *E. coli*, and *Enterococcus*. Additional *in situ* parameters, such as salinity, temperature, and conductivity will also be collected to inform the development of the Water Quality Model.

Water quality monitoring will be undertaken at up to thirteen (13) in-stream locations (seven of which are Delaware River sampling locations), four (4) CSO locations in the DELCORA combined sewer system area, and two (2) stormwater locations in the City of Chester municipal separate storm sewer system, as shown in Figure 3-2. Water quality monitoring and sampling will be conducted as follows:

- Eleven (11) in-stream locations in the vicinity of the DELCORA CSO area will be sampled for water quality for (3) dry weather events; one of which will be targeted for collection during a tributary low-flow period (less than 25th percentile flow). The mid-stream and far-shore Delaware River locations will not be sampled during the dry weather surveys because it is expected that water quality in the river will be relatively uniform laterally due to the lack of active sources during dry weather. These dry weather events would preferably be distributed across the sampling season, which is assumed to be March through June of 2017. Grab samples and *in situ* measurements will be collected at each location during each event.
- All thirteen (13) in-stream locations will be sampled for water quality using grab samples and *in situ* monitoring for three (3) discrete wet weather events, according to the surface water quality monitoring program protocols described in this Monitoring Work Plan.
- Up to four (4) CSO and two (2) stormwater outfall locations will be sampled for water quality for the same three (3) discrete wet weather events according to the outfall monitoring program protocols described in this Monitoring Work Plan. Samples for all outfalls will be collected as grab samples.
- Field Standard Operating Procedures (SOPs) and the Sampling Analysis Plan (SAP) referenced in the following sections of the Water Quality Monitoring Work Plan are

provided in Appendix C of the Water Quality Modeling and Monitoring Quality Assurance Project Plan (QAPP).

The sampling events are planned to be distributed across the sampling season, which is assumed to be March through June 2017. Additionally, bathymetry surveys in the lower portion of the tributaries may be required to inform the development of the Water Quality Model, pending delivery of HEC models with transect information for these portions of the receiving waters.

3.4.1 Sampling Locations

Monitoring locations have been selected to characterize the watershed at a sub-watershed level, recognizing various political and hydrologic features, land uses and potential pollutant sources. Site selection and analytical parameters are designed to characterize stormwater outfalls, CSOs, tributaries upstream and within the Chester CSO discharge area, and the main stem of the Delaware River in the project area. The sampling locations are shown in Figure 3-2 and listed in Table 3-1, Table 3-2, and Table 3-3.

The tables include summaries of the rationales for each sampling location selected. The Chester Creek and Ridley Creek locations were selected to distinguish, to the extent possible, between upstream, stormwater and Chester CSO pollutant loads. The Delaware River sampling locations will provide a characterization of water quality entering the Chester CSO area from either tidal direction as well as water quality within the CSO discharge area. During wet weather, three samples will be collected across the transect corresponding to the DR-04 sampling location during each sampling round, when sampling across the river is feasible, to characterize lateral variability in the Delaware River during storm events. Delaware River conditions may be too hazardous for safe collection of one or more samples and/or sampling rounds (e.g. during periods of heavy barge traffic, small craft advisories, lightning, etc.). When these conditions occur, sampling will not be conducted in the river for safety reasons.

The CSO sampling locations were selected based on their outfall discharge location, relatively high frequency of overflow, their overflow volume, and their accessibility. The stormwater sampling locations were selected to characterize the water quality associated with the predominant land uses (residential and commercial/industrial) in the study area. Each stormwater sampling location is in an area that is representative of the land use elsewhere in the City's stormwater area.

Note that it may be necessary to adjust the one or more sampling locations in response to hazards, construction or other factors that affect the safety of field sampling personnel. The CSO and stormwater sampling locations will be finalized prior to the initiation of the sampling program based on accessibility of sampling, safety of sampling personnel, equipment risk, and available resources.

Figure 3-2: Proposed Receiving Water (RW), Combined Sewer (CSO), and Stormwater (SW) Monitoring Locations

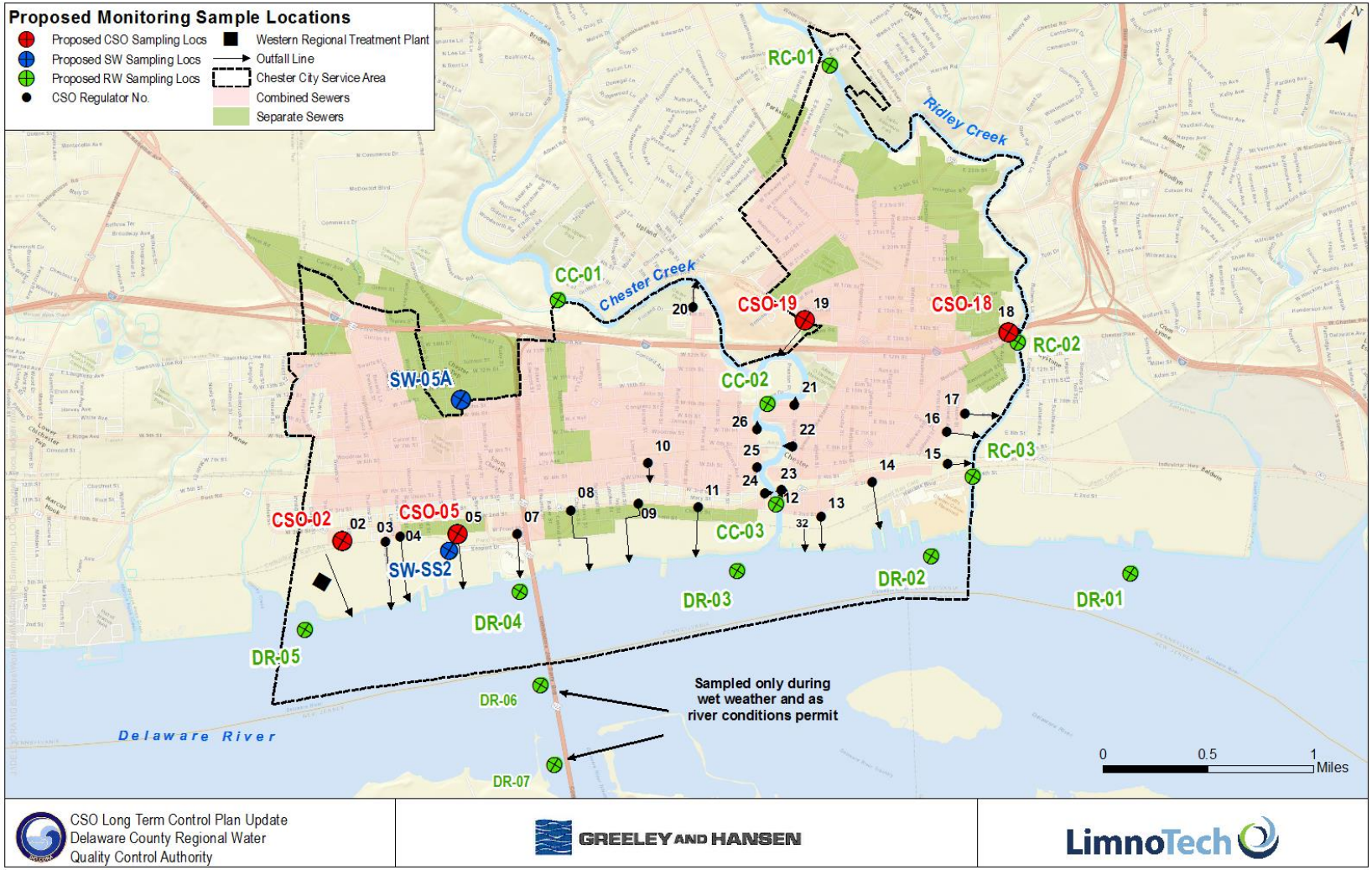


Table 3-1. Tributary Receiving Water Sampling Locations

Station ID	Latitude[1]	Longitude[1]	Receiving Water	Type	Description	Rationale
CC-01	39.850122	-75.386348	Chester Creek	Tributary	Chester Creek at Upland-Incinerator Rd.	Upstream of all City sources and upstream of tidal influence
CC-02	39.850709	-75.365530	Chester Creek	Tributary	Chester Creek at the 9th St Bridge; 54 W 9th St	Characterize impacts from non-CSO urban runoff sources
CC-03	39.845227	-75.360284	Chester Creek	Tributary	Chester Creek at E 2nd St., William Penn's Landing Park	Characterize impacts from all CSOs discharging to Chester Creek
RC-01	39.873264	-75.375183	Ridley Creek	Tributary	Ridley Creek at Chester Park Drive Bridge; 298 East Elkington Blvd	Upstream of all City sources and upstream of tidal influence
RC-02	39.863016	-75.348686	Ridley Creek	Tributary	Ridley Creek at Morton Ave. Bridge; 1300 Sun Drive	Characterize impacts from non-CSO urban runoff sources
RC-03	39.853435	-75.346350	Ridley Creek	Tributary	Ridley Creek at East 4th St. (Harrah's) Bridge	Characterize impacts from all CSOs discharging to Ridley Creek

Notes:
[1] **GPS Coordinates, WGS 1984**

Table 3-2. Main Stem Receiving Water Sampling Locations

Station ID	Latitude[1]	Longitude[1]	Receiving Water	Type	Description	Rationale
DR-01	39.85282	-75.3299	Delaware River	Main stem	Delaware River between Ridley Creek and Crum Creek	"Upstream" of DELCORA's CSO discharges[2]
DR-02	39.84715	-75.3462	Delaware River	Main stem	Delaware River between CSO-14 and Ridley Creek	Characterize Ridley Creek impacts on Delaware River, in the upper Delaware River (Secondary contact area)
DR-03	39.8398	-75.3606	Delaware River	Main stem	Delaware River between CSO-11 and Chester Creek	Characterize Chester Creek impacts on Delaware River, in the upper Delaware River (Secondary contact area)
DR-04	39.83132	-75.3766	Delaware River	Main stem	Delaware River at the boat launch off Highway 322	Priority area, in the lower Delaware River (Primary contact area)
DR-05	39.82182	-75.3917	Delaware River	Main stem	Delaware River between CSO-002 and Stony Creek	"Downstream" of DELCORA's CSO discharges[2], in the Atlantic sturgeon sensitive area
DR-06[3]	39.82636	-75.371	Delaware River	Main stem	Delaware River mid-stream along the transect of DR-04	Characterize lateral variability in the Delaware River during storm events
DR-07[3]	39.82203	-75.3665	Delaware River	Main stem	Delaware River far shore (left descending bank) along the transect of DR-04	Characterize lateral variability in the Delaware River during storm events

Notes:

[1] GPS Coordinates, WGS 1984

[2] "Upstream" and "downstream" subject to tidal conditions at time of sampling

[3] These locations will be sampled during the wet weather events only, when river conditions permit. POC concentrations are assumed to be laterally well-mixed during dry weather due to the absence of significant pollutant sources.

Table 3-3. CSO and Stormwater Sampling Locations

Station ID	Latitude[1]	Longitude[1]	Receiving Water	Type	Description	Rationale
CSO-19	39.857132	-75.366105	Chester Creek	CSO	14th and Crozer Hospital; 1 Medical Center Blvd	Discharges to Chester Creek, one of the largest volume CSOs in DELCORA system
CSO-05	39.832598	-75.383958	Delaware River	CSO	Front and Townsend; 101 Townsend St	Discharges to Delaware River, one of the largest volume CSOs in DELCORA system
CSO-02	39.828334	-75.392570	Delaware River	CSO	Front and Booth; 100 Booth St	Aggregates cumulative effect of CS conditions, one of the largest volume CSOs in DELCORA system
CSO-18	39.863501	-75.349203	Ridley Creek	CSO	Sun Drive and Hancock St.; 1310 Sun Dr	Discharges to Ridley Creek
SW-05A	39.838501	-75.387708	Chester Creek	SW	7th and Engle Street; by tennis courts	Characterize runoff quality from predominantly residential area representative of the residential portion of the study area
SW-SS2	39.832853	-75.384193	Delaware River	SW	Front and Townsend; 105 Townsend St	Characterize runoff quality from predominantly commercial/industrial area representative of the commercial/industrial portion of the study area

Notes:
[1] GPS Coordinates, WGS 1984

3.4.2 Analytical Parameters

All of the in-stream dry and wet weather samples will be analyzed for the parameters shown in Table 3-4. The outfall samples will be analyzed for only *E. coli*, *Enterococcus* and fecal coliform.

Table 3-4: Analytical and Field Parameters

Parameter	Description	Sampling Program	Type of Measurement
E. coli	Escherichia coli	Dry, Wet	Grab
Enterococcus	Enterococcus sp.	Dry, Wet	Grab
Fecal coliform	Fecal coliform	Dry, Wet	Grab
wTemp	Water temperature	Dry, Wet, Receiving Water Only	In-situ
Cond	Conductivity	Dry, Wet, Receiving Water Only	In-situ
Salinity	Salinity	Dry, Wet, Receiving Water Only	In-situ

3.4.3 Sampling Schedule

3.4.3.1 Dry Weather Sampling

Collection of water quality samples will be performed for three (3) dry weather events; with one dry weather sampling event planned to be collected during a low-flow period (less than 25th percentile flow) in Chester Creek and Ridley Creek (if possible). Two rounds of sampling will be conducted for each dry weather survey: one round to be completed during ebb (outgoing) tide and the second round to be completed during flood (incoming) tide.

Dry weather event samples will be taken at up to eleven (11) locations:

- **Three (3) locations on Chester Creek** that will characterize water quality upstream of DELCORA's service area as well as in the portion of the creek adjacent to DELCORA's CSO discharges and the area adjacent to the City of Chester outside the combined sewer service area. Additionally, because DELCORA's CSO discharges are within the tidal extent of the Delaware Bay, the downstream sampling locations will also reflect these tidal influences on water quality.
- **Three (3) locations on Ridley Creek** that will characterize water quality upstream of DELCORA's service area as well as in the portion of the creek adjacent to DELCORA's CSO discharges and the area adjacent to the City of Chester outside the combined sewer service area. Additionally, because DELCORA's CSO discharges are within the tidal extent of the Delaware Bay, the downstream sampling locations will also reflect these tidal influences on water quality.
- **Five (5) locations on the Delaware River** that will characterize water quality in the vicinity of DELCORA's CSO discharges. Sampling locations have been selected to

separate to the extent possible the effect of DELCORA's CSOs on water quality from other sources contributing pollutants to the waterways. Sampling will be conducted near the shoreline adjacent to the City of Chester.

The locations of these stations are shown in Figure 3-2. Details for these stations are provided in Table 3-1, Table 3-2, and Table 3-3. The set of parameters for which the samples will be analyzed is provided in Table 3-4. In-situ measurements of physical parameters, such as salinity, temperature, and conductivity will be collected at each sampling location with a sonde. In the Delaware River, *in situ* measurements will be made at three depths at each sampling location during each round of sampling.

3.4.3.2 Wet Weather Sampling

Collection of water quality samples will be performed for three (3) wet weather events. The purpose of the wet weather sampling is to characterize the impact of CSO discharges and non-CSO source runoff on in-stream water quality. The wet weather events will span a range of precipitation, flow and seasonal conditions.

Wet weather event samples will be taken at all 13 in-stream locations as well as at up to six source locations in the intervals described below:

- **Six (6) In-Stream Tributary Sampling Locations:** Three (3) locations will be on Chester Creek and three (3) locations on Ridley Creek. The locations will be the same locations used for the dry weather surveys. Tributary locations will be sampled up to five times per event at the following approximate intervals: Hour 0.5-2.5, Hour 4.5-6.5, Hour 8.5-10.5, Hour 14.5-16.5, and Hour 22-24. Sampling intervals will be defined by the start of rainfall rather than CSO or SSO activation. A total of 30 samples will be collected during each wet weather sampling event from in-stream locations. One field blank and one field duplicate will be collected during each event to be used as field quality control (QC).
- **Up to Seven (7) In-Stream Delaware River Locations:** Up to seven locations will be on the Delaware River and will be sampled up to ten times per event at the following approximate intervals: Hour 0, Hour 2, Hour 4, Hour 6, Hour 9, Hour 12, Hour 15, Hour 18, Hour 21, and Hour 24. Sampling intervals will be defined by the start of rainfall rather than CSO or SSO activation. The frequency of sampling is intended to capture in-stream impacts in the vicinity of DELCORA's service area from both DELCORA's CSOs as well as upstream sources. Two additional locations on the Delaware River, one at mid-stream and one near the far shore, have been added to characterize lateral variability in water quality during storm event conditions, when sampling across the river is feasible. The sampling regimen is also designed to allow a semi-quantitative mass balance to be computed over a complete tidal cycle. A total of 70 samples may be collected during each wet weather sampling event. If river conditions are unsafe for sampling (e.g. small craft advisories, heavy barge traffic, etc.), sampling may be suspended for one or more locations and/or sampling rounds. One field blank and one field duplicate will be collected during each event to be used as field QC.

- **Up to Six (6) Outfall Locations:** Sampling will be conducted at up to two (2) stormwater outfalls and up to four (4) combined sewer overflow outfalls. It is assumed that each of the outfall locations will have up to eight sets of samples collected for each event at the following intervals: 1st flush, 30 minutes, and 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, 24 hours. If a location is not flowing, no sample will be collected. As many as 48 samples may be collected during each wet weather sampling event, depending on the number of monitored outfalls and if all monitored outfalls discharge for 24 hours. However, the actual number of samples is likely to be less than the amount indicated since it is unlikely that all of the monitored outfalls will discharge for the full 24 hour monitoring period. One field blank and one field duplicate will be collected during each event to be used as field QC.

The locations of these stations are shown in Figure 3-2. Details for these stations are provided in Table 3-1, Table 3-2, and Table 3-3. The set of parameters for which the samples will be analyzed are summarized in Table 3-4. *In-situ* measurements will not be collected at the outfall locations.

Sampling crews will conduct all wet weather event sampling using the protocols described in the Quality Assurance Project Plan. Samples will be delivered to the laboratory where the samples will be analyzed for the laboratory parameters identified in Table 3-4.

Determination to mobilize for a Wet Weather Event will be a collaborative effort between Greeley and Hansen, LimnoTech, the Weston Solutions, and Eurofins QC. The intent is to identify a 4 to 6 hour window in which a wet weather event may commence 24 hours in advance to assist in mobilization of the sampling crews.

3.4.3.3 Bathymetric Sampling

The project team has requested HEC models of the receiving waters from the U.S. Army Corps of Engineers. However, in the absence of these models, additional bathymetry data is needed for the tributaries to inform the development of the water quality model. If required, bathymetry surveys will be conducted in approximately the lower three miles of both Chester Creek and Ridley Creek, corresponding to the approximate extent of the water quality model domain. Because these reaches are in the tidal zone, they are unlikely to be wadeable so each transect will be characterized using a boat and a combination of sonar and ADCP profiler equipment. Transects will be spaced approximately every 0.25 miles or at significant morphometric features (e.g. dams, islands, etc.).

3.4.4 Sample Event Initiation Protocol

This section describes the protocols that will be used to initiate the dry and wet weather sampling events.

3.4.4.1 Dry Weather Sampling Protocol

Collection of dry weather water quality samples will be performed for three (3) events; one of which occurred during a low-flow period (less than 25th percentile flow). These events will be distributed across the sampling season, March through June of 2017. The criteria used to define a dry weather event are the following:

- No precipitation within the upstream watershed at least 48 hours before the event;
- No precipitation forecasted for a minimum of three days; and,
- For the low-flow survey, conditions when the in-stream flow at the USGS gage in Chester Creek (01477000) is less than the 25th percentile flow at this location will be targeted for sampling.

Decisions to initiate a dry weather event are given below:

1. Authorization for dry weather events will be determined by Greeley and Hansen, LimnoTech, the field sampling and laboratory contractor personnel as described in Section 3.4.1. LimnoTech will monitor predicted rainfall conditions to identify potential sampling event dates.
2. When the criteria described in the previous section are met (e.g. no rainfall the previous 48 hours), the Chester Creek and Ridley Creek flows are at a desirable level, and no rain is in the near forecast, the team members will be notified of an upcoming dry weather sampling event. The sampling teams will begin mobilizing equipment, bottles and personnel so that they can get into the field before conditions change.
3. The Field Manager will notify the laboratory contact that the sampling teams are planning on conducting a dry weather sampling event.
4. The Field Manager will notify LimnoTech if weather conditions change during the event.
5. Once the decision to conduct sampling has been determined, the Field Manager will confirm with the laboratory that sampling has begun.

3.4.4.2 Wet Weather Sampling Protocol

Three (3) wet weather events will be monitored over the study period. The wet weather events will span a range of precipitation, flow, and seasonal conditions. The goal is to sample storms of at least 0.5 inches of precipitation. The criteria used to define a wet weather event include:

- No precipitation within the upstream watershed 48 hours before the event;

- Forecasts for a 60% (or greater) chance of rain over the entire DELCORA project area; and,
- Approximately 0.50 inches of rainfall forecasted over a six-hour period.

Decisions to initiate and continue sampling for wet weather events are given below:

1. Authorization for wet weather events will be determined by Greeley and Hansen, LimnoTech, the field and laboratory contractor personnel as described in Section 3.4.2. LimnoTech will monitor predicted rainfall conditions to identify potential sampling event dates.
2. Sampling will begin approximately in March and conducted until approximately the end of June. If the water temperature is below 10°C when samples are collected, it is noted that the sample results are not reflective of conditions to assess the potential risk to human health.
3. When precipitation is forecasted meeting the criteria for a wet weather sampling event, the wet weather sampling teams will be put on alert. This alert will be considered "Go" status, unless otherwise notified. The sampling teams will begin mobilizing equipment, bottles and personnel so that they can get into the field as soon as possible after the precipitation begins.
4. The Water Quality Project Manager will notify the laboratory contact that the sampling teams are on alert.
5. The Field Manager's sampling teams will mobilize approximately 2-3 hours before the precipitation is forecasted to begin. Forecast tools include the National Weather Service website (forecast.weather.gov), Weather Underground website (www.wunderground.com), the Weather Channel website (www.twc.com), the Aviation forecast model (http://weather.rap.ucar.edu/model/index.php?model=gfs), local TV weather forecasts, and DELCORA's rain gage network data.
6. Sampling at the outfalls will begin during the first flush when water begins flowing out of the discharges. The field crews will be at the outfall locations waiting to collect the first flush water as soon as it happens.
7. The in-stream locations will be initiated at 0.5 hour after the start of rainfall for the first round of sampling. Subsequent in-stream sampling will be conducted at the intervals described in Section 3.4.3.2. The Field Manager will confirm with the laboratory Technical Director that sampling has begun.
8. Greeley and Hansen, LimnoTech and the Field Manager will continue to monitor the precipitation as the rain event progresses. If the storm conditions are significantly smaller than forecasted (either in rainfall depth or geographical extent), the sampling event will be aborted as soon as can be reasonably determined by Greeley and Hansen, LimnoTech and/or the Field Manager Local rain gages within the study area will be monitored for the event precipitation totals.

9. Samples collected during an aborted wet weather event will be discarded when directed by LimnoTech, after consultation with Greeley and Hansen. The laboratory will be notified as soon as possible by LimnoTech to stop the analysis on any samples they may have already received.

In-stream wet weather sampling will be conducted by 3 crews of two-person teams. Each crew will be responsible for sampling one of the receiving waters. For the outfall locations, a one or two person team will be deployed to each outfall to collect the samples in each round as individual grab samples. Due to the timing of sampling rounds, additional crews will be needed to relieve the sampling teams collecting the first few rounds of samples.

3.5 Field Sampling Methods and Procedures

This section provides a description of the field sampling collection methods, sampling equipment, and decontamination procedures that will be used during the monitoring program. The field sampling methods and procedures will be in accordance with the SOPs provided in Appendix C of the Water Quality Modeling and Monitoring QAPP.

3.5.1 Receiving Water and Source Sample Collection Methods

The physical, microbiological and chemical data that will be collected from the waterbodies are obtained either through direct (*in situ*) measurements or through analysis of a water sample. The microbiological and chemical data collected from the outfall discharges will be obtained through laboratory analysis of the water samples. The general collection procedures for receiving water and outfall sampling are as follows:

1. Clean all sampling equipment prior to sample collection according to the procedures in the SOP for Equipment Cleaning.
2. Don appropriate personal protective equipment (as required by the Field Safety Instructions).
3. Collect samples by dipping a container on a pole, into the water. The water is then poured into a bucket (until enough sample volume has been collected) and then poured from the bucket into the clean sample containers.
4. Care should be taken to avoid capturing bottom sediment or surface foam/scum during sample collection.
5. If field preservation is required, the appropriate preservative will be placed into the sample container prior to sample collection.
6. If field filtering is required, an appropriate sample aliquot will be filtered into the sample container.
7. Label all sample containers with the date, time, site location, sampling personnel, and other requested information.

8. Record sample collection information on the field logs and then store the samples in a cooler with ice as described in the SOP for the Shipping and Handling of Samples.
9. Handle, pack, and ship samples according to the procedures in the SOP for the Shipping and Handling of Samples, including the completion of a Chain-of-Custody (COC) form for each cooler shipped to the laboratory for analyses.

3.5.2 In situ Measurements (Receiving Water Only)

Instantaneous water quality measurements (such as salinity, temperature, and conductivity) using field instruments will be collected at the receiving water locations as specified in the following sections of this Water Quality Monitoring Work Plan. These measurements, along with calibration and maintenance, will be conducted following the SOPs for Water Quality Field Measurements in Appendix C of the Water Quality Modeling and Monitoring QAPP.

Field instruments will be calibrated before initiating monitoring activities for each event and a post-monitoring calibration check will be conducted at the end of the event. All calibration and maintenance activities will be documented on the Instrument Calibration Sheet (see Appendix C of the Water Quality Modeling and Monitoring QAPP). The field instrument calibration must be conducted in accordance with the SOP.

Salinity, temperature, and conductivity will be measured at all in-stream sampling locations using a YSI 6920 or similar instrument during both wet and dry sampling events, prior to sample collection. Measurements will be made mid-channel at mid-depth in the tributaries, whenever possible. In the Delaware River, measurements will be made at the surface, mid-depth and near the bottom, whenever possible. Measurements will be documented in the field logs. Documentation will include: date/time, location, type of measurement, personnel, equipment identification, and general site observations (e.g. weather, stream conditions).

3.5.3 Sampling Equipment

The sampling equipment required for the DELCORA monitoring program is included in Table 3-5.

Table 3-5: Sampling Equipment List

Sampling Activity	Required Equipment	
General Equipment (Required for all sampling activities)	Field log book with weather-proof paper and pen ("Rite-in-the-Rain") or field data sheets Pens and pencils Maps Sample bottles Sample bottle labels Chain-of-custody in zip lock bag Coolers with ice Stainless steel sample bucket and rope	Sample pole Sampling gloves Hand spray bottles with Liquinox solution Scrub brush Distilled water (10 gallons) Hip or chest waders Sun screen PPE as specified in FSI Monitoring Work Plan/QAPP Phone Emergency Contact List Field Safety Instruction
Wet Weather In-Stream Sampling	General Equipment Rain Gear Headlamps for night sampling & extra batteries Hydrolab/YSI multi-parameter sonde and instrument Instrument (sonde) calibration sheet Calibration materials and solutions Sonde instrument manual Sonde service kit Extra batteries for instruments (sondes) Laptop with appropriate power cable, data download cables, and software	
Wet Weather Outfall Sampling	General Equipment Rain Gear Headlamps for night sampling & extra batteries	
Dry Weather Sampling	General Equipment Hydrolab/YSI multi-parameter sonde and instrument Instrument (sonde) calibration sheet Calibration materials and solutions Sonde instrument manual Sonde service kit Extra batteries for instruments (sondes) Laptop with appropriate power cable, data and download cables, and software	

Table 3-6 presents a summary of the number of bottles and coolers needed for each day of each dry weather event. Table 3-7 presents a summary of the number of bottles and coolers needed for each crew for each wet weather sampling circuit. Three (3) bottles at each location are needed to collect the volume of sample required for the laboratory analyses (see footnote in Table 3-6 and Table 3-7). The laboratory will supply the bottles for each location and sample round to the Field Manager in advance of the event.

Table 3-6: Cooler and Bottle Requirements for Each Dry Weather Event

Sample Type	# of Two Person Teams	# of Locations	Locations per Team	Sampling Rounds	Number of Field QC Samples[1]	Number of Bottle Sets per Crew[2]	Number of Coolers per Crew
Chester Creek Tributary	1	3	3	2	1 FB 1 FDUP	8	2
Ridley Creek Tributary	1	3	3	2	1 FDUP	7	2
Delaware River	1	5	5	2	1 FB 1 FDUP	12	2

Notes:
[1] FB = field blank; FDUP = field duplicate
[2] The Bottle Set at each sampling location requires 3 125 ml plastic sterile bottles (bacteria)

Table 3-7: Cooler and Bottle Requirements for Each Wet Weather Event

Sample Type	# of Two Person Teams	# of Locations	Locations per Team	Sampling Rounds	Number of Field QC Samples[1]	Number of Bottle Sets per Crew[2]	Number of Coolers per Crew[3]
Chester Creek Tributary In-Stream	1	3	3	5	1 FB[4] 1 FDUP	17	3
Ridley Creek Tributary In-Stream	1	3	3	5	1 FB[4] 1 FDUP	17	3
Delaware River In-stream	1	7	7	10	1 FB[5] 2 FDUP	73	3
Outfall-Manual	6	6	1	8	1 FB 1 FDUP	8 (10 for crew doing field QC)	3

Notes:
[1] FB = field blank; FDUP = field duplicate.
[2] The Bottle Set at each sampling location requires 3 125 ml plastic sterile bottles (bacteria)
[3] The number of coolers is based on the frequency of sample delivery to the lab to maintain the 8-hour hold time for bacteria samples.
[4] It is assumed that each crew will also collect 1 field duplicate and prepare 1 field blank during one of the first three rounds of sampling (HR 0.5, HR 4.5, HR 8.5).
[5] It is assumed that the crew will collect 1 field duplicate in the first three rounds of sampling (HR 0, HR 2, HR 4), and will prepare 1 field blank and collect 1 field duplicate again in the remaining seven rounds of sampling (HR 6, HR 9, HR 12, HR 15, HR 18, HR 21, HR 24).

3.5.4 Equipment Decontamination

If sampling equipment, such as buckets, etc., are to be reused at more than one location in the field, they must be cleaned prior to collecting the next sample. Prior to leaving a site, the equipment must be rinsed at least three (3) times with distilled water. A brush may be used to remove deposits of material or sediment if necessary. At the next sampling site, the equipment must be rinsed at least three (3) times at each location with creek water prior to sampling.

Standard cleaning procedures for equipment decontamination are provided in SOP (included as Appendix C in the Water Quality Modeling and Monitoring QAPP).

3.6 Sample Handling, Storage and Shipment

Sample handling will be performed so as to collect, store, submit to the laboratory, and analyze representative samples using methods as specified in this section. Sample containers, volumes, preservatives and holding times are summarized in Table 3-8. Sample bottles (including those requiring preservative) will be provided by the laboratory in advance of each event. The laboratory will notify the Field Manager when sample bottles are ready for pickup. Sample bottles will be stored by the Field Manager until use.

3.6.1 Sample Handling

Sample packaging and shipping procedures are designed to ensure that the samples and the chain-of-custody forms will arrive at the laboratory intact and together.

1. All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. The laboratory will pre-label each bottle with all information except for the date and time of sample collection using the method described below. The person collecting the sample will complete the label with date and time. No bottle sets will be distributed without the pre-labeling unless specifically agreed upon among Greeley and Hansen, LimnoTech, the field sampling and laboratory contractors prior to the sampling event.

   Use indelible waterproof marking pen and include:

   - *Sample identification code (ID)*– will include*:*
     - Site designation number - sampling round number, as follows:

       __ __ - __ __ __ - __ - __
       1 2 3 4 5 6 7

       Where,

       Characters 1-5: Sample Site ID (column 1 in Table Table 3-1, Table 3-2 and Table 3-3)

       Character 6: Sampling round number

Character 7: B - Blank sample qualifier (if required)

- Duplicate samples will be labeled with a sample ID of:

"DUP ___ ___ ___- ___ ___".
1 2 3 4 5

Where

Characters 1-3: Duplicate ID number (numbers will be assigned to each sampling crew)

Characters 4-6: Designation of RW for receiving water sample duplicate or OF for outfall sample duplicate

A blank line will be placed in the location, date and time boxes of the sample label so the laboratory does not know where the sample was collected. The duplicate number in the duplicate sample ID will be assigned in the field and recorded in the field log book.

- Blank samples will be given a normal sample ID, with a B qualifier at the end of the ID.

  - *Sample type (water);*
  - *Analysis required;*
  - *Date sampled;*
  - *Time sampled;*
  - *Name or initials of person who collected the sample;*
  - *Mode of collection (composite or grab);*
  - *Preservation added, if applicable.*

2. Check the caps on the sample containers so that they are tightly sealed.
3. Cover the label with clear packing tape to secure the label onto the container and prevent the label from being illegible if wet.
4. Store samples in coolers with ice to maintain the samples at ≤6 degrees Celsius until they are received in the laboratory.
5. Complete the information needed on the field log book and the chain-of-custody, primarily sample date and time and any notes regarding deviations from the planned sampling protocol (e.g. limited volume precluded collecting the full volume required).

Table 3-8: Guidelines for Water Sample Container Preparation and Preservation

Parameter	Sample Container	Sample Volume	Storage Requirement	Preservative	Sample Holding Time	Analytical Method	Detection Limit
Fecal coliform	Plastic-Sterile	125 ml	Refrigerate to ≤6°C	Sodium Thiosulfate	8 Hours	SM 9222D	10 no./100 ml
E coli	Plastic-Sterile	125 ml	Refrigerate to ≤6°C	Sodium Thiosulfate	8 Hours	EPA 1603	10 no./100 ml
Enterococcus	Plastic-Sterile	125 ml	Refrigerate to ≤6°C	Sodium Thiosulfate	8 Hours	EPA 1600	10 no./100 ml

3.6.2 Sample Transport

Samples will be properly packaged for transport to the laboratory as summarized below.

1. Using packaging tape, secure the outside and inside of the drain plug at the bottom of the cooler that is used for sample transport;
2. Place the sealed container upright in the cooler;
3. Place additional cushioning material around the sides of each sample container as needed;
4. Place ice on top of sample containers. Do not pack ice so tightly that it may prevent the addition of sufficient cushioning material. Ensure that bottle caps will not be submerged in water if ice melts;
5. Fill the remaining space in the cooler with vermiculite or other cushioning material if the coolers are being shipped;
6. Place the chain-of-custody forms in a large Ziploc© type bag and tape the forms to the inside of the cooler lid; and,
7. Close the cooler lid and fasten with packaging tape. Wrap strapping or packaging tape around both ends of the cooler at least twice, if coolers are being shipped.

All shipments will be accompanied by the chain-of-custody form identifying the contents. It is preferred that a separate chain-of-custody form be completed for and placed in each shipping container/cooler. The original form will accompany the shipment and copies will be retained by the sampler for the project records.

During the dry weather and wet weather sampling events, representatives from the firm conducting the field sampling will be responsible for delivering the samples to the laboratory quickly enough so that hold times can be achieved for the bacteria parameters (8 hours from the time of sample collection). The Field Manager will manage the coordination of field crews and couriers during the sampling event.

3.7 Sample Documentation

3.7.1 Field Data Collection Forms

The field log book will serve as a daily record of events, observations and measurements during all field activities. All information pertinent to sampling activities will be recorded in the field logs and will include:

- Names of field crew and specifically the author of the field log;
- Date and time of the sample round beginning and ending;
- Location of sampling activity;
- Date and time of collection;
- Sample identification numbers; and,
- Field measurements.

Field observations and details related to analysis or integrity of samples (e.g., weather conditions, noticeable odors, colors, stream flow description, etc.)

The field log book may also include:

- Sampling method;
- Sampling equipment used;
- Number and volume of samples collected ;
- Type of sample;
- Summary of any meetings or discussions with the public, state agency, etc.; and,
- Levels of safety protection.

Field meters will be calibrated daily in accordance with the manufacturer's recommendations. Standards, solutions used, concentrations and readings taken will be recorded daily in Instrument Calibration Sheet.

3.7.2 Sample Chain-of-Custody Forms

A chain-of-custody is a legally-binding record of the date and time periods that samples were in the possession (e.g. custody) of the parties indicated. Transfers between parties are documented by the custodial party signing over custody to the receiving party and the receiving party signing for receipt of the samples. Completed chain-of-custody forms will be required for all samples to be analyzed.

Chain-of-custody forms will be prepared in advance by the laboratory for each sampling location and round of sampling. Chain-of-custody forms will be initiated by the sampling crews in the field

during the sampling events and must remain with the samples at all times. The samples and signed chain-of-custody form will remain in the possession of the sampling crew until samples are either delivered to the lab or placed in the custody of the personnel responsible for their delivery to the laboratory.

The chain-of-custody form will contain the sample's unique identification number, sample date and time, sample description, sample type and analyses required. Copies will be made prior to shipment for field documentation. The original chain-of-custody form will accompany the samples to the laboratory.

3.7.3 Data Submittal

Instrument Calibration Sheets and copies of the field log book will be turned over to the LimnoTech Water Quality Monitoring Program Task Manager following each monitoring event. Following review by the LimnoTech Water Quality Monitoring Program Task Manager, all field logs, photographs and chain-of-custody forms will be included in the project database.

3.8 Quality Control

The purpose of any quality assurance/quality control (QA/QC) program is to ensure that all sampling protocols and procedures are followed such that samples are representative of the water quality to which they are associated. The monitoring data that will be collected is intended to meet the quality assurance objectives described in the QAPP. Data quality will be measured in terms of accuracy and precision, completeness, representativeness, comparability, and the required detection limits for the analytical methods. Each of these data quality indicators is defined in the QAPP. QC samples will be collected in the field to support the assessment of data quality. The QA/QC program includes the following elements:

- Training of all field staff;
- Field quality control procedures;
- QA/QC samples; and,
- Equipment calibration.

3.8.1 Training

All field staff will receive training covering the QAPP and this Water Quality Monitoring Work Plan. The training will include proper procedures for sample collection, handling and submission and general field procedures. Specific emphasis will be placed on QA/QC issues as well as on health and safety. The training will also cover the operation, maintenance, and calibration of field equipment including multi-parameter sondes and all other on-site equipment used throughout the field program. SOPs for all program elements will be distributed to staff and will be available at all times.

3.8.2 Field Quality Control

The quality of data generated in a laboratory depends primarily on the integrity of the samples that arrive at the laboratory. Consequently, necessary precautions must be taken to protect samples from contamination and deterioration. Procedures detailed in SOPs for Collection of Discrete Water Samples and SOPs for Water Quality Field Measurements will be followed to ensure field quality control.

3.8.3 QA/QC Samples

This section describes the type and frequency of QC samples for the monitoring program.

3.8.3.1 Field Blanks

Field accuracy will be assessed through the use of field or equipment blanks. In order for the accuracy assessment to be relevant, all appropriate protocols concerning sample collection, handling, preservation, and hold times must be maintained. Equipment that is used to collect samples for analysis may become cross-contaminated through the normal course of monitoring. If not properly cleaned and rinsed, samples may be contaminated during sampling from previous locations.

Field blanks will consist of a distilled water rinse of sampling equipment collected into separate sample containers and submitted to the laboratory to assess the quality of the data resulting from the monitoring program. Field blanks should be collected after the sampling equipment has been cleaned in accordance with appropriate specified cleaning procedures. The laboratory will provide the sampling crews with the water to be used to prepare the field blanks.

Field blanks will be collected at a frequency of one blank during each sampling event per sampling crew.

3.8.3.2 Field Duplicates

Precision is a measure of the agreement between two or more measurements. Duplicate or replicate samples will be taken for a portion of the samples to assess field precision. A field duplicate is defined as a sample produced when a single sample is split into two or more aliquots immediately after the sample is collected. Each aliquot is placed into a separate container and analyzed separately.

Field duplicates will be collected at a frequency at least one field duplicate per sampling crew.

3.8.4 Calibration of Field Equipment

Instantaneous water quality measurements (such as salinity, temperature, and conductivity) using field instruments will be collected as specified in the preceding sections of this Water Quality Monitoring Work Plan. Salinity, temperature, and conductivity will be measured at the specified sampling locations using an YSI 6920 or similar instrument, prior to sample collection. All field

instruments will be calibrated at the beginning of the day of sampling and checked again at the end of each day, as required by the QAPP. Field instrument calibration and sample measurement data will be recorded on the Instrument Calibration Sheet and in the field log book, respectively.

The field instrument calibration must be conducted in accordance with the SOP included in Appendix C of the Water Quality Modeling and Monitoring QAPP.

3.9 Program Safety

The most critical component of a sampling program is crew safety. Safety is of paramount importance as stream sampling can be extremely dangerous. The conditions are often wet and dark adding to the dangers. The element of danger is accentuated if personnel are unfamiliar with their surroundings and/or procedures. Consequently, staff must be properly trained in both safety and monitoring procedures, following a well thought out program.

Field Safety Instructions (FSI) have been developed by LimnoTech for the Water Quality Monitoring Program. The FSI include safety precaution information and emergency procedures. The LimnoTech FSI is the governing health and safety document for the sampling program.

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Section 4 References

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Mr. Robert Willert, Executive Director
Delaware County Regional Quality Control Authority
100 East Fifth Street
Chester, PA 19013

RE: Civil Action 2:15-cv-04652-RB

Dear Mr. Willert:

The United States Environmental Protection Agency (EPA) has received the Delaware County Regional Quality Control Authority (DELCORA) Water Quality Modeling and Monitoring Work Plan Update WQMMWP dated July 31, 2017. EPA has consulted with the Pennsylvania Department of the Environment (PaDEP). This letter served to iterate the original approval and formally notify you that EPA accepted the updated WQMMWP and is approved.

Sincerely,

Andrew F. Seligman, Environmental Scientist
Water Enforcement Branch

cc: P. Yeany, EPA
M. DeSantis, DELCORA
Tom Magee, PaDEP, SERO
C. Hurst, DELCORA

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APPENDIX I

WATER QUALITY MONITORING AND MODELING QUALITY ASSURANCE PROJECT PLAN

- DELCORA Water Quality Monitoring and Modeling Quality Assurance Project Plan - Final dated January 2017 (Revised July 2017)
- USEPA Approval of the Water Quality Water Quality Modeling and Monitoring Work Plan Update dated April 16, 2018

Note: This Appendix includes a report by Greeley & Hansen which rebranded to TYLin in 2023.

Delaware County Regional Water Quality Control Authority
CSO Long Term Control Plan Update

Water Quality Monitoring and Modeling Quality Assurance Project Plan

Final

January 2017

(Revised July 2017)

GREELEY AND HANSEN

LimnoTech

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REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Water Quality Monitoring and Modeling Quality Assurance Project Plan.

I certify under penalty of law that the document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

DELCORA MANAGEMENT		
Executive Director	Signature	1/9/17 Date
DELCORA ENGINEERING		
Director of Engineering	Signature	1/9/17 Date
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	Signature	1/9/17 Date

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES
0	1/11/2017	G&H/LimnoTech	Initial submittal to US EPA
1	July 2017	G&H/LimnoTech	• Updated Table of Contents and List of Appendices • Page 1-9, Revised 2nd paragraph for clarity • Page 2-1: Updated Table 2-1 • Page 2-3: Formatted Figure 2-1 • Page 2-5: Revised paragraph under Section 2.2.1 for clarity • Page 2-8: Changed DR-03 to DR-04 • Page 2-9: Updated Figure 2-3 • Page 2-10: Updated Table 2-2 • Page 2-11: Updated Table 2-3 • Page 2-12: Updated Table 2-4 • Page 2-15, Revised Table 3-1 to Table 2-5. • Page 2-19: Updated Table 2-6 • Page 2-24: Revised Paragraph "Grit development" for clarity • Page 2-25: Revised first paragraph under 2.4.2.2 for clarity • Page 2-26: Revised the first paragraph under *EFDC Model Water Quality Calibration and Validation* for clarity • Page 2-30: Revised the first paragraph on the page for clarity • Page 2-30: Updated Appendix references • Page 3-4: Updated Appendix references • Page 4-5: Updated first bullet for clarity • Added Appendices A through C

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Appendix B EuroFins Laboratory Standard Operating Procedures

Appendix C Weston Field Sampling Analysis Plan and Standard Operating Procedures

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Section 1 Introduction

1.1 Background of DELCORA's Facilities

Delaware County Regional Water Quality Control Authority (DELCORA) is responsible for the collection, transmission, treatment and disposal of approximately 65 million gallons per day (MGD) of wastewater generated in southeastern Pennsylvania. DELCORA's facilities serve residential, commercial, institutional, and industrial customers in Delaware County. DELCORA owns and operates an extensive system of pump stations, force mains, and sewers that provide the core infrastructure for the transmission of wastewater to treatment facilities in Delaware County and the City of Philadelphia as shown diagrammatically in Figure 1-1. The total service area served by DELCORA, as shown on Figure 1-2, is approximately 82,977 acres which illustrates that DELCORA serves a significant and widespread portion of Delaware County.

The combined sewer area simulated in DELCORA's existing Hydrologic and Hydraulic model is located within the City of Chester and consists of a drainage area of approximately 1,510 acres. It comprises approximately half of Chester City's serviced area. To support the service area, DELCORA owns and operates over 129 miles of separate and combined sewers. Included in the 129 miles of sewers are: 11.7 miles of an interceptor system; 3,209 manholes; and twenty-five (25) combined sewer outfall regulators controlling storm overflows. The location of Chester City's service area is illustrated on Figure 1-2.

Historically, DELCORA has characterized its service areas as "Eastern" and "Western." The Western service area discharges to DELCORA's Western Regional Treatment Plant (WRTP). The Eastern service area discharges to the Philadelphia Water Department's Southwest Water Pollution Control Plant (PWDSWPCP). In 2002, DELCORA completed the installation of a force main that connects the Eastern Service Area's Central Delaware Pump Station (CDPS) to the Chester Force Main. This connection allows DELCORA to send flow from the CDPS to the WRTP. Flows above 20 MGD are directed to the PWDSWPCP. As such, dry weather flows and a portion of the wet weather flows (total flow less than 20 MGD) from the Central Delaware County Authority in the Eastern Service Area are discharged to the WRTP.

There are a total of 26 combined sewer overflow outfalls listed with 25 discharge points (Outfall #009 and #010 both discharge at Outfall #009) in DELCORA's existing National Pollutant Discharge Elimination System (NPDES) Permit. Under its NPDES Permit No. PA0027103, issued and administered by the Pennsylvania Department of Environmental Protection (PADEP), DELCORA is authorized to discharge from the Western Regional Treatment Plant (Outfall #001), four storm water outfalls at the WRTP (028-031) and from 26 combined sewer overflow outfalls (#002-#026, #032, #033) that ultimately discharge to the Delaware River, Chester Creek and/or Ridley Creek.

Figure 1-1: DELCORA's Conveyance System

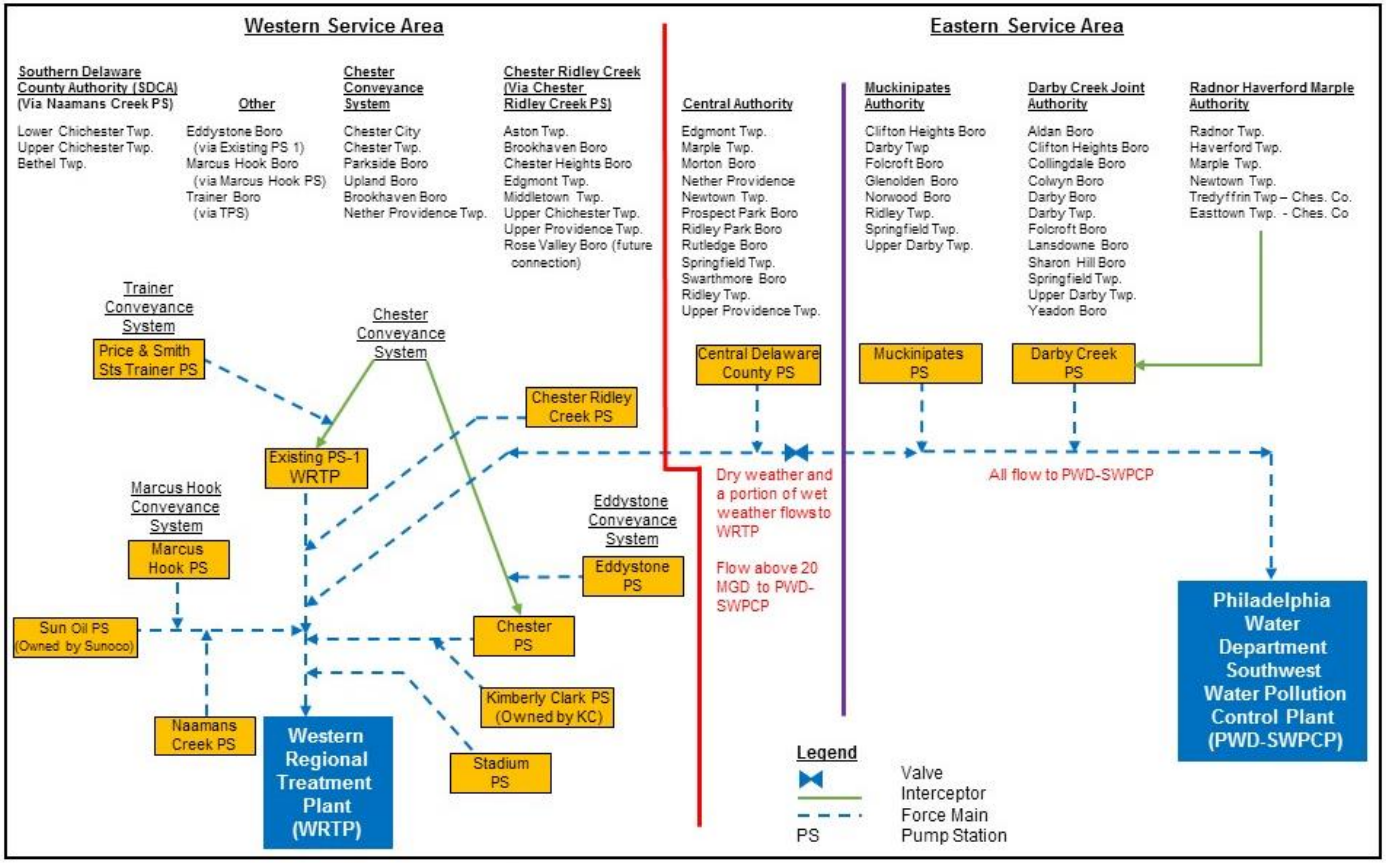
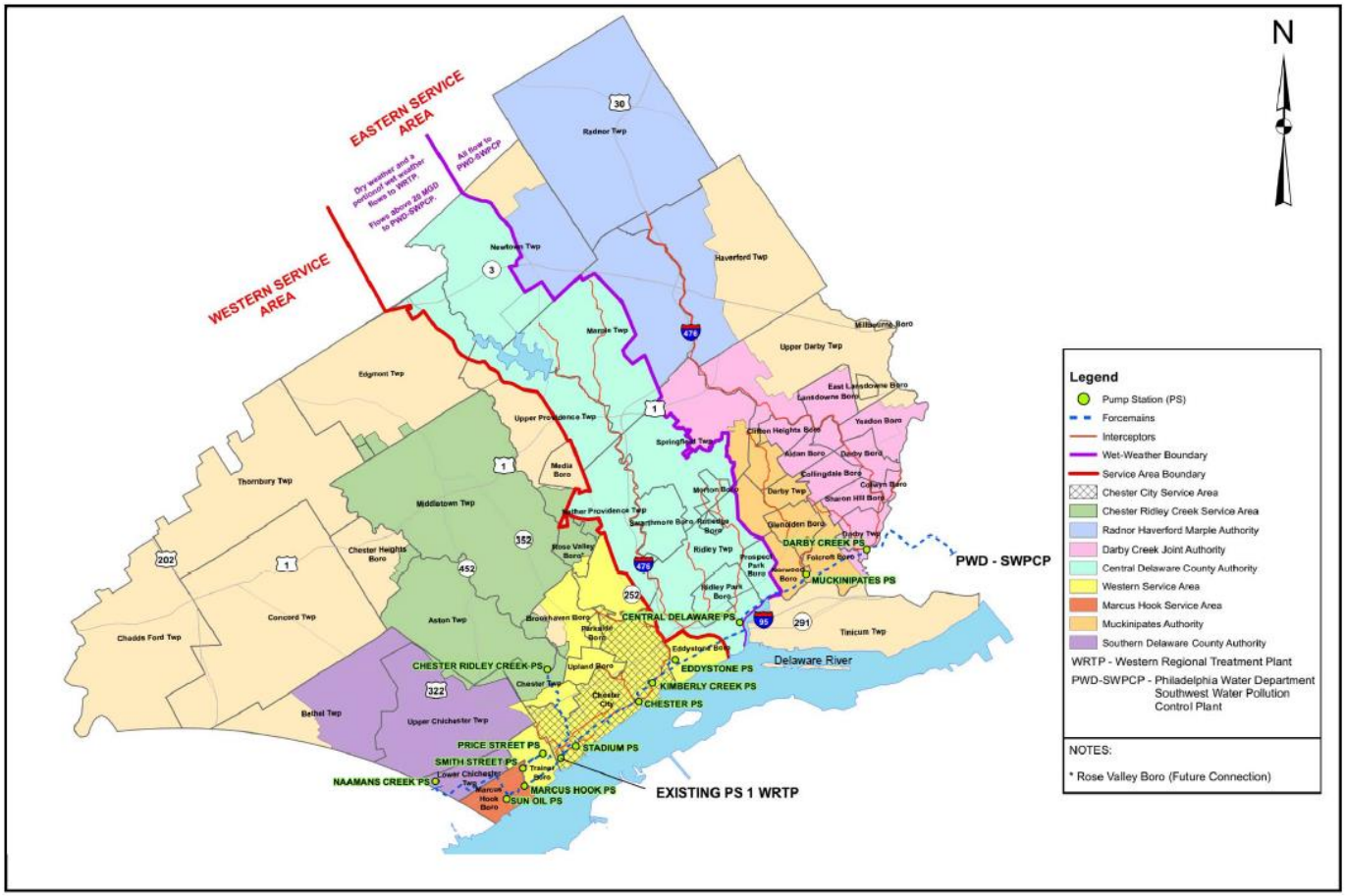


Figure 1-2: DELCORA's Service Area



CSO Long-Term Control Plan
Delaware County Regional Water Quality Control Authority

GREELEY AND HANSEN

Figure 1-2
DELCORA'S SERVICE AREA

Part C – Other Requirements, Section V – Combined Sewer Overflows of the NPDES Permit details DELCORA's responsibilities with respect to the CSO system including reporting, continued implementation of and continued compliance with the Nine Minimum Controls (NMC), and implementation of the existing Long-Term Control Plan (LTCP) dated April 1999 and the July 2008 addendum to the LTCP until the updated LTCP is approved.

1.2 DELCORA Facilities

DELCORA's Western service area wastewater is treated at the WRTP located at 3201 W. Front Street in Chester, Pennsylvania. The WRTP treats all wastewater from Southern Delaware County Authority, Marcus Hook Borough, Trainer Borough, Upland Borough, Parkside Borough, Eddystone Borough, Chester Township and the City of Chester as well as a portion of the wastewater from Brookhaven Borough and Nether Providence Township. The City of Chester CSO system is described in detail in Section 1.3.2.

One of the facilities in the City of Chester is the 40-MGD Chester Pump Station and the 48-inch-diameter, PCCP force main that runs to the WRTP. DELCORA has completed construction of a 54-inch-diameter ductile iron force main to replace the existing force main. In 2002, DELCORA completed a force main that connects the Central Delaware Pump Station via a 3.4-mile, 24-inch ductile iron force main to the Chester Force Main. This connection allows DELCORA to send up to 27 MGD of flow from the CDPS to the WRTP, however, DELCORA's operating policy limits this flow to 20 MGD, with flows above this point to be directed to PWD SWPCP. Figure 1-1 shows the interconnections in DELCORA's system. The left side of the figure indicates the Western service area and the right side indicates the Eastern service area. This interconnectivity coupled with the legal agreements DELCORA maintains with the municipalities and conveyance authorities in Delaware County creates the complicated legal/financial framework under which DELCORA operates.

1.2.1 City of Chester CSO System

As noted in Section 1.1, the combined portion of DELCORA's sewer system is located within the City of Chester (City), and it comprises approximately half of the City's service area. The combined wastewater/stormwater system in the City of Chester is complicated by the fact that parts of the system are owned, operated and maintained by two governmental entities, the City and DELCORA. DELCORA owns, operates and maintains the parts of the system that convey wastewater, such as the street sewers, collectors, interceptors, and CSO regulators and CSO outfalls. The City owns, operates and maintains the inlets, stormwater-only sewers that connect to the combined sewer system and any stormwater-only outfalls. The City is also responsible for the maintenance and cleaning of the streets, planning, zoning, and development controls.

The Chester CSO system contains 26 permitted outfalls as listed in Table 1-1, and they discharge to three receiving water bodies: the Delaware River, Chester Creek, and Ridley Creek. Figure 1-1 depicts the locations of CSO regulators and outfalls that are DELCORA's responsibility.

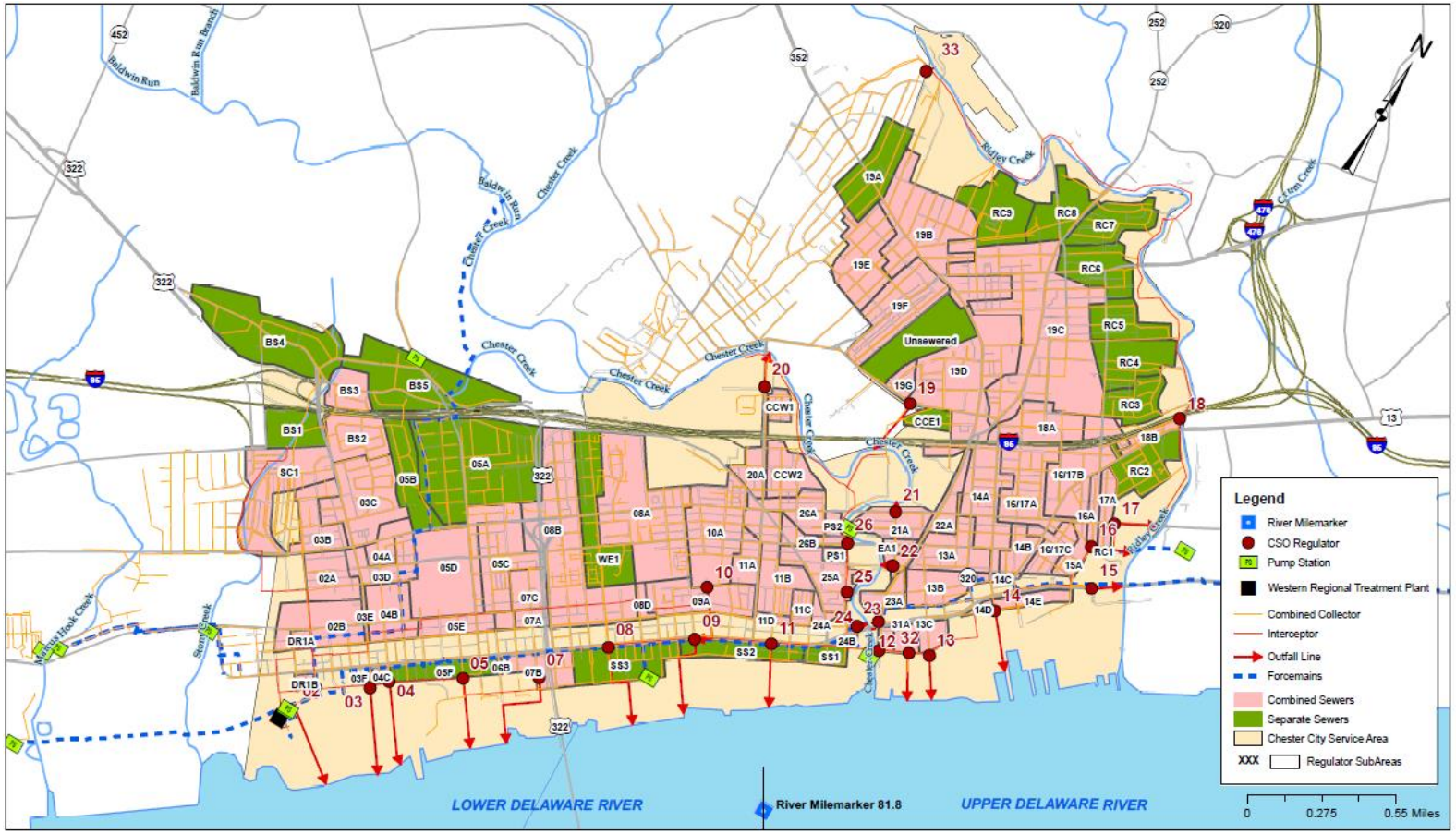
Table 1-1: Permitted CSOs in the City of Chester

Name of Receiving Stream	CSO Outfall	Interceptor/CSO Regulator Location	Latitude	Longitude
Delaware River	002	Front and Booth	39°49'30"N	75°23'31"W
Delaware River	003	Front and Highland	39°49'34"N	75°23'11"W
Delaware River	004	Front and Haves	39°50'36"N	75°23'07"W
Delaware River	005	Front and Townsend	39°49'46"N	75°22'53"W
Delaware River	007	Delaware and Reaney	39°49'51"N	75°22'45"W
Delaware River	008	2nd and Tilghman	39°50'05"N	75°22'22"W
Delaware River	009	2nd and Lloyd	39°50'14"N	75°22'10"W
Delaware River(1)	010	5th and Pusey	39°50'26"N	75°22'19"W
Delaware River	011	2nd and Parker	39°50'26"N	75°21'54"W
Delaware River	013	2nd and Welsh	39°50'37"N	75°21'17"W
Delaware River	014	3rd and Upland	39°50'50"N	75°21'05"W
Delaware River(2)	032	2nd and Avenue of The States	39°50'34"N	75°21'25"W
Chester Creek	012	2nd and Edgmont	39°50'42"N	75°21'38"W
Chester Creek	019	14th and Crozer Hospital	39°51'24"N	75°21'54"W
Chester Creek	020	Kerlin and Finland	39°51'24"N	75°22'27"W
Chester Creek	021	9th and Sproul	39°51'08"N	75°21'49"W
Chester Creek	022	6th and Sproul	39°50'56"N	75°21'47"W
Chester Creek	023	3rd and Edgmont	39°50'45"N	75°21'42"W
Chester Creek	024	3rd and Dock	39°50'44"N	75°21'43"W
Chester Creek	025	5th and Penn	39°50'49"N	75°21'50"W
Chester Creek	026	7th and Penn	39°50'58"N	75°21'55"W
Ridley Creek	015	4th and Melrose	39°51'03"N	75°20'48"W
Ridley Creek	016	8th and McDowell	39°51'15"N	75°20'53"W
Ridley Creek	017	9th and Campbell	39°51'16"N	75°20'51"W
Ridley Creek	018	Sun Drive and Hancock Street	39°51'47"N	75°20'57"W
Ridley Creek(2)	033	Elkington Blvd & Ridley Creek	39°52'22"N	75°22'29"W

Notes:
(1) CSO #010 discharges to the Delaware River through CSO #009.
(2) No mechanical regulator used for this outfall.

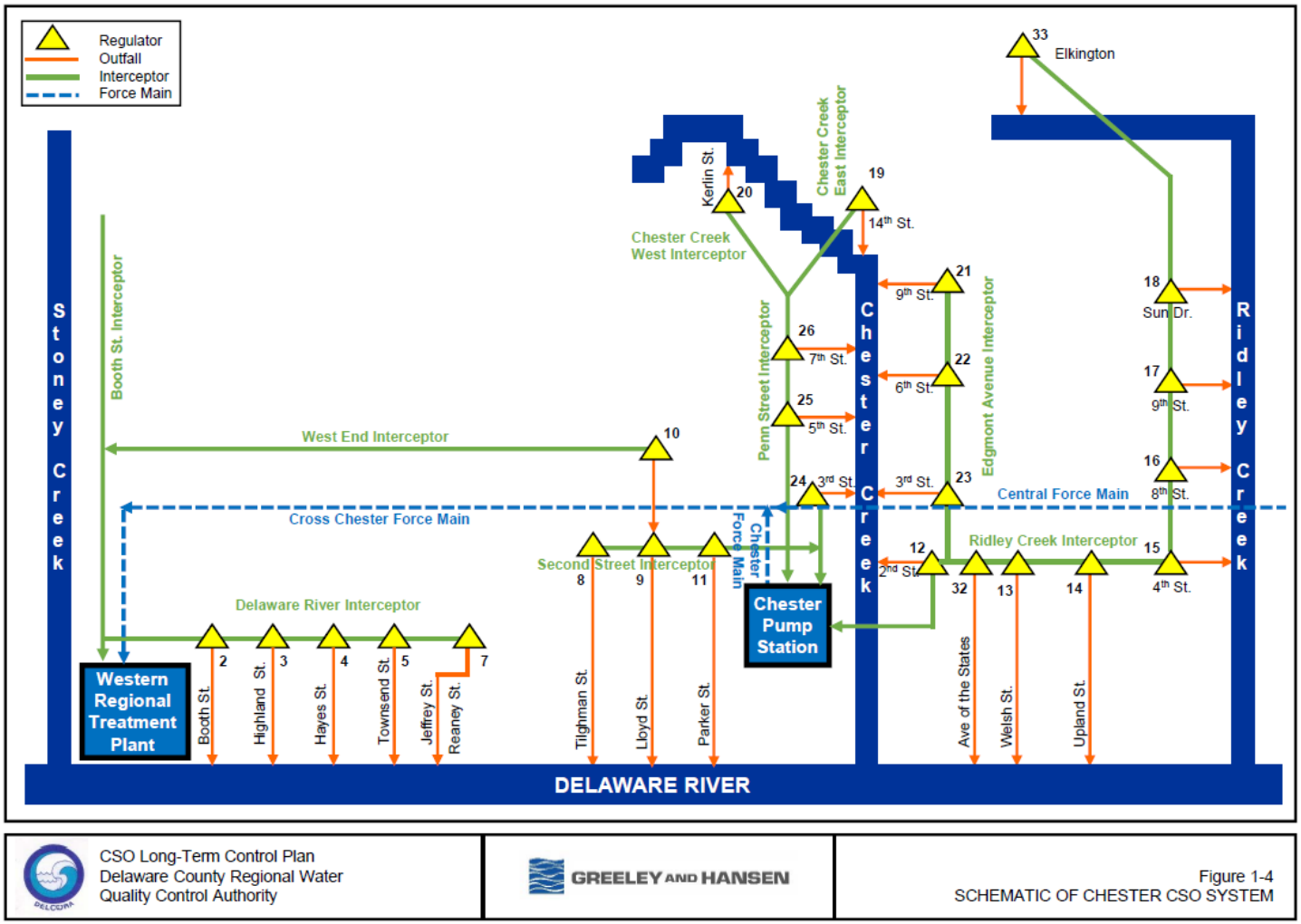
Figure 1-3 provides a sewer system characterization and illustrate the breakdown of each outfall and how each drainage area has combined sewers and separate sewers. Figure 1-4 is a schematic of the Chester CSO system and shows the outfalls and the interceptors that are connected to each CSO.

Figure 1-3: Location of Regulators and Combined Sewer Outfalls With Drainage Areas



CSO Long Term Control Plan Update Delaware County Regional Water Quality Control Authority	GREELEY AND HANSEN	Identification of Sensitive Areas and Pollutants of Concern Report Figure 1-3 Location of Regulators and Combined Sewer Outfalls With Drainage Areas

Figure 1-4: Schematic of Chester CSO System



1.3 Consent Decree

On August 17, 2015, a Consent Decree was lodged in the United States District Court for the Eastern District of Pennsylvania that requires DELCORA to complete and submit a revised and updated LTCP to the United States Environmental Protection Agency (USEPA or EPA) and the Pennsylvania Department of Environmental Protection (PADEP or DEP) for review and approval. Consent Decree Paragraphs V.A.10.e and V.A.10.f require that the development of the LTCP include:

V.A.10.e. Develop and implementation of a Water Quality Model;

V.A.10.f Characterization of the service area and the Receiving Waters as required by CSO Control Policy Paragraph II.C.1 and associated guidance.

Consent Decree Paragraph V.A.15 (Water Quality Model Plan) requires that within 90 days after review and approval of the Alternatives Evaluation Approach, DELCORA shall submit a report to the USEPA and PADEP that describes the use of the Water Quality Model to support the Demonstration Approach consistent with Section II.C.4 of the CSO Control Policy and the Paragraph V.13 of the Consent Decree (Alternatives Evaluation). Section V.A.15.a of the Consent Decree specifically states:

For each water body in which the Demonstration Approach is to be used, the Water Quality Model Plan shall address:

(i) Background, Scope and Purpose, Description of the System;

(ii) Water quality modeling software to be employed;

(iii) Model configuration and development, including reaches to be modeled, and segmentation and boundary conditions;

(iv) Calibration and validation (dry and wet weather), including events and data to be employed, detailed information regarding all additional data collection activities (if needed), quantitative and qualitative calibration criteria, and utilization of H&H Model outputs;

(v) Use of the Water Quality Model to evaluate Typical Year in-stream conditions for each identified pollutant of concern;

(vi) Schedule for model development and implementation, including integration into LTCP development consistent with other dates required pursuant to this Consent Decree.

1.4 QAPP Purpose and Objectives

This Quality Assurance Project Plan (QAPP) has been developed to meet the requirements of the DELCORA Consent Decree Paragraph Section V.A.15.a.(iv) requiring detailed information regarding all additional data collection and water quality modeling activities. The purpose of the QAPP is to document the necessary procedures required to assure that the project is executed in a manner consistent with applicable U.S. EPA guidance documents and with generally accepted and approved quality assurance objectives. This QAPP is organized in accordance with the basic groups and subgroup elements discussed in the U.S. EPA guidance for QAPPs. The four basic groups include project management (Group A); data generation and acquisition (Group B); assessment and oversight (Group C); and data validation and usability activities (Group D). The groups are subdivided into elements covering specific topics related to each group. The Section and Subsection headings of this QAPP include references to the U.S. EPA QAPP Guidance group letters and element numbers to facilitate cross-reference with the Guidance.

The QAPP integrates quality control policies and project-specific work tasks to successfully conduct water quality monitoring and modeling to support the CSO Long Term Control Plan update. Greeley & Hansen will serve as the contracting authority for the project and provide overall project management. LimnoTech will serve as technical advisors for the sampling program and to provide the data integration and interaction role. The field contractor (Weston Solutions) will conduct the actual sampling program. The laboratory contractor (Eurofin QC) will perform laboratory analysis for the project.

The QAPP has been designed and organized in terms of compliance with U.S. EPA requirements. It is the overall intent of the QAPP to provide professional guidelines for activities by all personnel on the project and to ensure that quality assurance/quality control QA/QC procedures are followed.

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Section 2 Project Management (Group A)

2.1 Project/Task Organization (A.4)

Each of the organizations included in the project team has established an organizational structure for providing technical direction and administrative control to accomplish quality-related activities for the development of the project. Key project personnel and their corresponding responsibilities are listed in Table 2-1 below and shown in Figure 2-1.

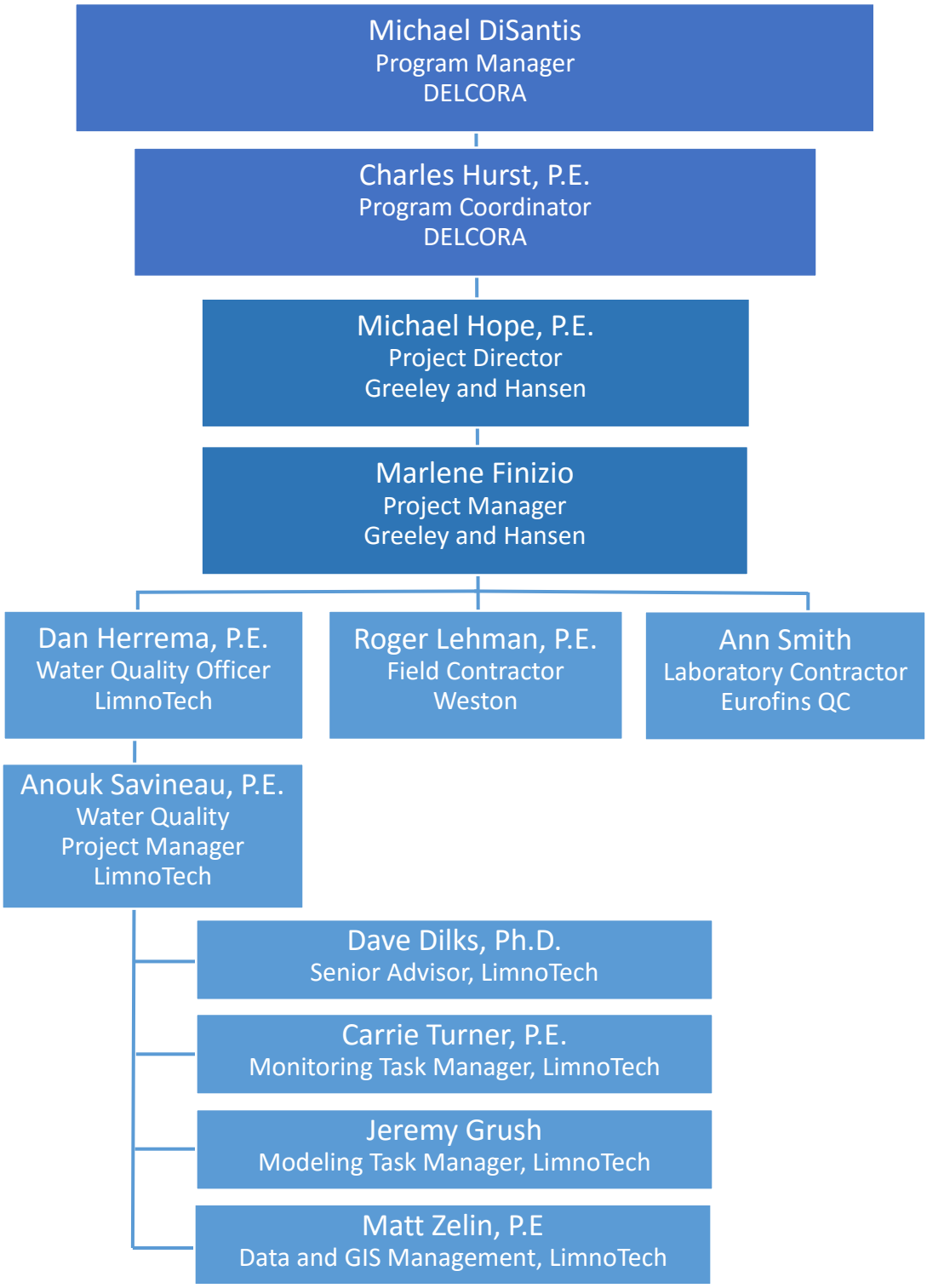
Table 2-1: Key Personnel for the Water Quality Monitoring and Modeling QAPP

Name/Affiliation	Project Title	Responsibility
Michael DiSantis DELCORA	Program Manager	Project oversight
Charles Hurst, P.E. DELCORA	Program Coordinator	Program management and coordination between contractors and DELCORA staff
Michael Hope, P.E. Greeley and Hansen	Project Director	Project direction, review/approval of work products
Marlene Finizio Greeley and Hansen	Project Manager	Project management, coordination of overall work
Anouk Savineau, P.E. LimnoTech	Water Quality Monitoring and Modeling Program Manager	Overall water quality monitoring and modeling task coordination.
Carrie Turner, P.E. LimnoTech	Water Quality Monitoring Program Task Leader	Monitor conditions, decisions to initiate sampling events, compare data to QAPP objectives.
Roger Lehman, P.E. Weston Solutions, Inc.	Field Project Manager	Receiving water and overflow sample collection, manage field staff and equipment development.
Ann Smith Eurofins QC	Laboratory Technical Director	Supply sample bottles and chain-of-custodies. Ensure sample analysis is conducted to meet objectives of QAPP, coordinate sample transfer.
Ray Fratti Eurofins QC	Laboratory QA/QC Manager	QA/QC review of laboratory data to ensure QAPP objectives are met.
Jeremy Grush LimnoTech	Water Quality Modeling Task Leader	Develop, calibrate and validate water quality model consistent with Work Plan.
Matt Zelin, P.E. LimnoTech	Water Quality Data Management Task Leader	Develop, manage, and maintain the water quality database. All data collected during the course of the study will be entered into a database.

The remainder of the project team is made up of engineers, scientists, and technicians. The disciplines represented include environmental assessment and modeling. Staff members within each organization will report to their project manager for technical and administrative direction. Each staff member has responsibility for performance of assigned quality control duties in the course of accomplishing identified sub-tasks. The quality control duties include:

- Completing the assigned task on or before schedule and in a quality manner in accordance with established procedures; and
- Ascertaining that the work performed is technically correct and meets all aspects of the QAPP.

Figure 2-1: Project Team Organization



2.2 Problem Definition/Background (A.5)

The Delaware County Regional Water Quality Control Authority (DELCORA) is responsible for the collection, transmission, treatment and disposal of approximately 65 million gallons per day (MGD) of wastewater generated in southeastern Pennsylvania. DELCORA's facilities, described in Section 1.2 and shown diagrammatically in Figure 1-1, provide the core infrastructure for the transmission of wastewater to treatment facilities in Delaware County and the City of Philadelphia. DELCORA serves a significant and widespread portion of Delaware County and has a total service area of approximately 82,977 acres (Figure 1-2).

The combined portion of DELCORA's sewer system is located within the City of Chester (City), and it comprises approximately half of the City's serviced area. The Chester combined sewer system includes 25 combined sewer overflow outfall locations that discharge to three receiving water bodies: the Delaware River, Chester Creek and Ridley Creek. The combined wastewater/stormwater system in the City of Chester is complicated by the fact that parts of the system are owned, operated, and maintained by two governmental entities, the City and DELCORA. Figure 1-3 shows the CSO regulators and outfalls that are DELCORA's responsibility. DELCORA's responsibilities with respect to the CSO system include reporting, continued implementation of and continued compliance with the Nine Minimum Controls (NMC), and implementation of the existing Long-Term Control Plan (LTCP) dated April 1999 and the July 2008 addendum.

On August 17, 2015, a Consent Decree was lodged in the United States District Court for the Eastern District of Pennsylvania that requires DELCORA to complete and submit a revised and updated LTCP to the United States Environmental Protection Agency (USEPA or EPA) and the Pennsylvania Department of Environmental Protection (PADEP or DEP) for review and approval. The Water Quality Monitoring Program is one component of this Water Quality Model requirements in the Consent Decree (see Section 1.3) that will provide DELCORA with reliable and technically sound data to inform the development, calibration and validation of the Water Quality Model and decisions on CSO control alternatives.

As part of DELCORA's LTCP requirements, pollutants of concern (POCs) were identified and documented in the "Identification of Sensitive Areas and Pollutants of Concern Report" (Greeley and Hansen 2016). Three POCs were identified: fecal coliform, *Escherichia coliform* (*E. coli*), and Enterococcus. Available data for the POCs in the DELCORA combined sewer service area and adjacent watersheds are insufficient for developing a Water Quality Model that meets the requirements of the Consent Decree.

A Water Quality Monitoring Work Plan has been developed to ensure that additional monitoring activities undertaken to support the development of the Water Quality Model and the LTCP update result in representative water quality and quantity information. A Water Quality Model Work Plan has also been developed to ensure that the Water Quality Model meets the requirements set forth in the Consent Decree (Section 1.3). This portion of the work plan describes the water quality model development, methods used to specify CSO and background sources, and the approach to model calibration and validation. This QAPP

describes the quality assurance/quality control component of the sampling program and the water quality model development.

2.2.1 Water Quality Monitoring Objectives

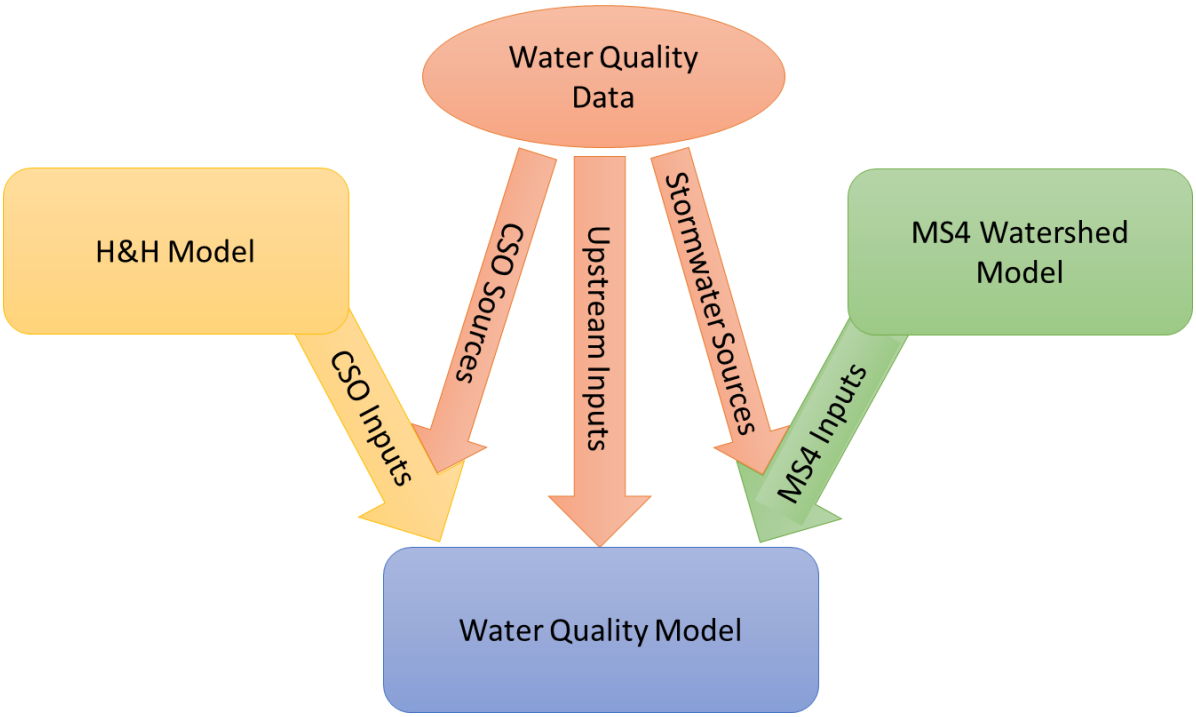
Under the Consent Decree requirements, DELCORA submitted a Pollutant of Concern report in February 2016, subsequently revised in May 2016 (Greeley and Hansen, 2016) that identified three indicator bacteria (fecal coliform, *Escherichia coliform* (*E. coli*), and enterococcus) as pollutants of concern (POC) that are potentially impacting the river during CSO discharges. The water quality monitoring objectives are to collect water quality data for the POCs during dry and wet weather event periods that can be used to characterize the bacteria sources in the Delaware River, Chester Creek, and Ridley Creek in the vicinity of the City of Chester, PA, and to calibrate and validate the Water Quality Model, consistent with the Consent Decree requirements in Paragraph V.A.15.a. Additional in situ parameters, such as salinity, temperature, and conductivity will also be collected to inform the development of the Water Quality Model.

2.2.2 Water Quality Modeling Objectives

The water quality modeling objectives are to develop a calibrated and validated Water Quality Model that can be used to assess impacts of the DELCORA combined sewer system overflows on current POC concentrations in the receiving waters as well as the relative water quality benefits from CSO control alternatives considered for DELCORA's LTCP update consistent with the Consent Decree requirements in Paragraph V.A.15.a described in Section 1.3 of this report. The water quality impacts in the receiving waters will rely primarily on comparisons to applicable water quality standards or guidelines.

In order to achieve these objectives, a CSO, a watershed, and a receiving water quality model will be created and connected (Figure 2-2). The CSO model, also called the "H&H" model, is currently being developed for the Long Term Control Plan, with calibration and validation to be completed in April 2017. The H&H model is designed to simulate CSO discharges from the DELCORA service area within the City of Chester. The watershed model is a new model that will be created to model the non-CSO areas that are adjacent to the spatial domain of the receiving water model. The watershed model will simulate discharges from these non-CSO or background sources. The receiving water model is also a new model that will be used to simulate the bacteria POC concentrations in the receiving waters, including the Delaware River, Chester Creek and Ridley Creek.

Figure 2-2: DELCORA Water Quality Modeling Framework



This project requires development and calibration of a receiving water quality model that can accurately simulate water quality in the Delaware River, Chester Creek and Ridley Creek. The project also requires a watershed model that can accurately simulate water quality in the portion of the watershed in the vicinity of Chester, PA outside the combined sewer system service area. Both models need to be capable of simulating the system under a range of environmental conditions so that they can be used to evaluate the benefits of CSO reduction scenarios. There are several objectives to consider when selecting appropriate modeling software for the watershed and receiving water model, including:

- Technical objectives: can the model software adequately represent the physical, chemical, and temporal characteristics of the project site? Can it address the complexities of the project site without being overly complex or overly simplistic?
- Regulatory objectives: Can the model software produce results that can be used to evaluate water quality against applicable water quality standards. Does it have a proven track record with similar regulatory projects? Will it help fulfill regulatory requirements as described in the Consent Decree?
- User objectives: does the end user have the necessary hardware and expertise to properly apply the model software to its fullest potential? Are there financial constraints to be considered with the model?

Careful selection of the most suitable modeling platform was conducted prior to model development as discussed in the Water Quality Model Work Plan. A number of factors were considered in selecting the watershed and water quality models, including understanding of the project, knowledge of the available data gained through review of existing data, the project modeling objectives defined in the Consent Decree, and knowledge of available modeling platforms The modeling objectives, the model attributes to support model objectives, and the recommended modeling platform are described in the following sections of this QAPP.

2.3 Project/Task Description (A.6) and Schedule

The Water Quality Monitoring Program (WQMP) is designed to collect data that will be used to develop and calibrate watershed and receiving water quality models which will be used to assess water quality concerns for the POCs identified in the Identification of Sensitive Areas and Pollutants of Concern Report (Greeley and Hansen, 2016). Existing water quality data provide insight into the conditions in rivers and streams in the project area but are of insufficient frequency and spatial density to fully support the modeling process. In addition, *E. coli*, one of the identified POCs, was not monitored in the available data.

The monitoring program will start in early spring 2017. The sampling events are planned to be distributed across the sampling season, which is assumed to be March through June 2017. Monitoring and sampling locations have been selected to characterize the watershed at a sub-watershed level, recognizing various political and hydrologic features, land uses and potential pollutant sources. Site selection and analytical parameters are designed to characterize stormwater outfalls, CSOs, tributaries upstream and within the Chester CSO discharge area, and the main stem of the Delaware River in the project area. The sampling locations are shown in Figure 2-3 and listed in Table 2-2, Table 2-3, and Table 2-4. Sampling locations may be moved slightly if the accessibility and safety of the selected locations of the stations are below expectations.

The WQMP is designed to collect data that will be used to assess water quality concerns identified in the Delaware River watershed and its tributaries, Chester Creek and Ridley Creek, in the vicinity of Chester, PA. In completing the initial step of characterizing the watershed, historical data was compiled, reviewed and assessed to determine the need to augment existing data to address the watershed issues identified. This review indicated that several of the POCs have not been sampled in the receiving waters and the data that have been collected are of insufficient frequency and spatial density to be useful in the modeling process.

As a result of the data review, the need for additional water quality information was identified. The need to further characterize the Delaware River, Chester Creek and Ridley Creek under dry and wet weather conditions is required to support water quality modeling, pollutant source identification, the subsequent development of a preferred alternative for controlling DELCORA's combined sewer overflows (CSO), and to allow DELCORA to complete its LTCP consistent with the Consent Decree. The need to characterize the watershed adjacent to

Chester's combined sewer system under wet weather conditions is also required to support water quality modeling and to allow DELCORA to complete its LTCP consistent with the Consent Decree.

Monitoring stations have been selected to characterize the watershed at a subwatershed level recognizing various political and hydrologic features, land use and potential pollutant sources. Site selection and analytical parameters are designed to characterize stream segments and pollutant sources primarily along the main stem and select tributaries. The sampling locations are shown in Figure 2-3 and listed in Table 2-2, Table 2-3, and Table 2-4. The tables include summaries of the rationales for each sampling location selected. The Chester Creek and Ridley Creek locations were selected to distinguish, to the extent possible, between upstream, stormwater and Chester CSO pollutant loads. The Delaware River sampling locations will provide a characterization of water quality entering the Chester CSO area from either tidal direction as well as water quality within the CSO discharge area. During wet weather, three samples will be collected across the transect corresponding to the DR-04 sampling location during each sampling round, when sampling across the river is feasible, to characterize lateral variability in the Delaware River during storm events. Delaware River conditions may be too hazardous for safe collection of one or more samples and/or sampling rounds (e.g. during periods of heavy barge traffic, small craft advisories, lightning, etc.). When these conditions occur, sampling will not be conducted in the river for safety reasons.

The CSO sampling locations were selected based on their outfall discharge location, relatively high frequency of overflow, their overflow volume, and their accessibility. The stormwater sampling locations were selected to characterize the water quality associated with the predominant land uses (residential and commercial/industrial) in the study area. Each stormwater sampling location is in an area that is representative of the land use elsewhere in the City's stormwater area.

Note that it may be necessary to adjust the one or more sampling locations in response to hazards, construction or other factors that affect the safety of field sampling personnel. The CSO and stormwater sampling locations will be finalized prior to the initiation of the sampling program based on accessibility of sampling, safety of sampling personnel, equipment risk, and available resources.

Figure 2-3: Proposed Receiving Water (RW), Combined Sewer (CSO) and Stormwater (SW) Monitoring Locations

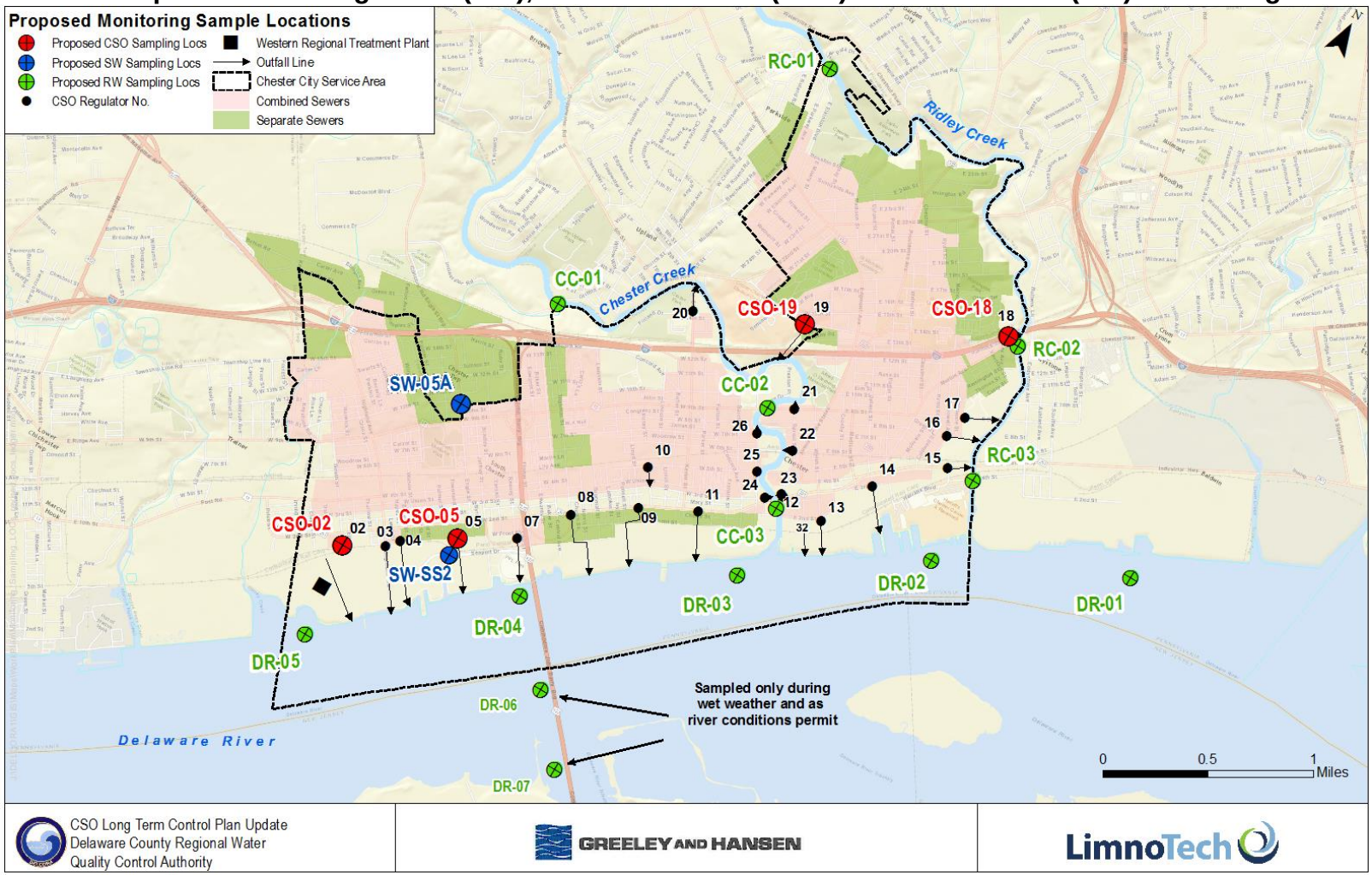


Table 2-2. Tributary Receiving Water Sampling Locations

Station ID	Latitude[1]	Longitude[1]	Receiving Water	Type	Description	Rationale
CC-01	39.850122	-75.386348	Chester Creek	Tributary	Chester Creek at Upland-Incinerator Rd.	Upstream of all City sources and upstream of tidal influence
CC-02	39.850709	-75.365530	Chester Creek	Tributary	Chester Creek at the 9th St Bridge; 54 W 9th St	Characterize impacts from non-CSO urban runoff sources
CC-03	39.845227	-75.360284	Chester Creek	Tributary	Chester Creek at E 2nd St., William Penn's Landing Park	Characterize impacts from all CSOs discharging to Chester Creek
RC-01	39.873264	-75.375183	Ridley Creek	Tributary	Ridley Creek at Chester Park Drive Bridge; 298 East Elkington Blvd	Upstream of all City sources and upstream of tidal influence
RC-02	39.863016	-75.348686	Ridley Creek	Tributary	Ridley Creek at Morton Ave. Bridge; 1300 Sun Drive	Characterize impacts from non-CSO urban runoff sources
RC-03	39.853435	-75.346350	Ridley Creek	Tributary	Ridley Creek at East 4th St. (Harrah's) Bridge	Characterize impacts from all CSOs discharging to Ridley Creek

Notes:
[1] GPS Coordinates, WGS 1984

Table 2-3. Main Stem Receiving Water Sampling Locations

Station ID	Latitude[1]	Longitude[1]	Receiving Water	Type	Description	Rationale
DR-01	39.85282	-75.3299	Delaware River	Main stem	Delaware River between Ridley Creek and Crum Creek	"Upstream" of DELCORA's CSO discharges[2]
DR-02	39.84715	-75.3462	Delaware River	Main stem	Delaware River between CSO-14 and Ridley Creek	Characterize Ridley Creek impacts on Delaware River, in the upper Delaware River (Secondary contact area)
DR-03	39.8398	-75.3606	Delaware River	Main stem	Delaware River between CSO-11 and Chester Creek	Characterize Chester Creek impacts on Delaware River, in the upper Delaware River (Secondary contact area)
DR-04	39.83132	-75.3766	Delaware River	Main stem	Delaware River at the boat launch off Highway 322	Priority area, in the lower Delaware River (Primary contact area)
DR-05	39.82182	-75.3917	Delaware River	Main stem	Delaware River between CSO-002 and Stony Creek	"Downstream" of DELCORA's CSO discharges[2], in the Atlantic sturgeon sensitive area
DR-06[3]	39.82636	-75.371	Delaware River	Main stem	Delaware River mid-stream along the transect of DR-04	Characterize lateral variability in the Delaware River during storm events
DR-07[3]	39.82203	-75.3665	Delaware River	Main stem	Delaware River far shore (left descending bank) along the transect of DR-04	Characterize lateral variability in the Delaware River during storm events

Notes:

[1] GPS Coordinates, WGS 1984

[2] "Upstream" and "downstream" subject to tidal conditions at time of sampling

[3] These locations will be sampled during the wet weather events only, when river conditions permit. POC concentrations are assumed to be laterally well-mixed during dry weather due to the absence of significant pollutant sources.

Table 2-4. CSO and Stormwater Sampling Locations

Station ID	Latitude[1]	Longitude[1]	Receiving Water	Type	Description	Rationale
CSO-19	39.857132	-75.366105	Chester Creek	CSO	14th and Crozer Hospital; 1 Medical Center Blvd	Discharges to Chester Creek, one of the largest volume CSOs in DELCORA system
CSO-05	39.832598	-75.383958	Delaware River	CSO	Front and Townsend; 101 Townsend St	Discharges to Delaware River, one of the largest volume CSOs in DELCORA system
CSO-02	39.828334	-75.392570	Delaware River	CSO	Front and Booth; 100 Booth St	Aggregates cumulative effect of CS conditions, one of the volume CSOs in DELCORA system
CSO-18	39.863501	-75.349203	Ridley Creek	CSO	Sun Drive and Hancock St.; 1310 Sun Dr	Discharges to Ridley Creek
SW-05A	39.838501	-75.387708	Chester Creek	SW	7th and Engle Street; by tennis courts	Characterize runoff quality from predominantly residential area representative of the residential portion of the study area
SW-SS2	39.832853	-75.384193	Delaware River	SW	Front and Townsend; 105 Townsend St	Characterize runoff quality from predominantly commercial/industrial area representative of the commercial/industrial portion of the study area

Notes:
[1] GPS Coordinates, WGS 1984

2.3.1 Scope of Sampling

This section describes the scope of water quality sampling to be completed for this project.

Dry Weather Sampling

Collection of water quality samples will be performed for three (3) dry weather events; with one dry weather sampling event planned to be collected during a low-flow period (less than 25th percentile flow) in Chester Creek and Ridley Creek (if possible). Two rounds of sampling will be conducted for each dry weather survey: one round to be completed during ebb (outgoing) tide and the second round to be completed during flood (incoming) tide.

Dry weather event samples will be taken at up to eleven (11) locations:

- **Three (3) locations on Chester Creek** that will characterize water quality upstream of DELCORA's service area as well as in the portion of the creek adjacent to DELCORA's CSO discharges and the area adjacent to the City of Chester outside the combined sewer service area. Additionally, because DELCORA's CSO discharges are within the tidal extent of the Delaware Bay, the downstream sampling locations will also reflect these tidal influences on water quality.
- **Three (3) locations on Ridley Creek** that will characterize water quality upstream of DELCORA's service area as well as in the portion of the creek adjacent to DELCORA's CSO discharges and the area adjacent to the City of Chester outside the combined sewer service area. Additionally, because DELCORA's CSO discharges are within the tidal extent of the Delaware Bay, the downstream sampling locations will also reflect these tidal influences on water quality.
- **Five (5) locations on the Delaware River** that will characterize water quality in the vicinity of DELCORA's CSO discharges. Sampling locations have been selected to separate, to the extent possible, the effect of DELCORA's CSOs on water quality from other sources contributing pollutants to the waterways. Sampling will be conducted near the shoreline adjacent to the City of Chester.

The locations of these stations are shown in Figure 2-3. Details for these stations are provided in Table 2-2 and Table 2-3. The set of parameters for which the samples will be analyzed is provided in Table 2-4.

In-situ measurements of physical parameters, such as salinity, temperature, and conductivity will be collected at each sampling location with a sonde. In the Delaware River, in situ measurements will be made at three depths at each sampling location during each round of sampling. Grab samples will be collected near the surface in each waterway.

Wet Weather Event Sampling

Collection of water quality samples will be performed for three (3) wet weather events. The purpose of the wet weather sampling is to characterize the impact of CSO discharges and non-CSO source runoff on in-stream water quality. The wet weather events will span a range of precipitation, flow and seasonal conditions.

Wet weather event samples will be taken at all 13 in-stream locations as well as at up to six source locations in the intervals described below:

- **Six (6) In-Stream Tributary Sampling Locations:** Three (3) locations will be on Chester Creek and three (3) locations on Ridley Creek. The locations will be the same locations used for the dry weather surveys. Tributary locations will be sampled up to five times per event at the following approximate intervals: Hour 0.5-2.5, Hour 4.5-6.5, Hour 8.5-10.5, Hour 14.5-16.5, and Hour 22-24. Sampling intervals will be defined by the start of rainfall rather than CSO or SSO activation. A total of 30 samples will be collected during each wet weather sampling event from in-stream locations. One field blank and one field duplicate will be collected during each event to be used as field quality control (QC).
- **Up to Seven (7) In-Stream Delaware River Locations:** Up to seven locations will be on the Delaware River and will be sampled up to ten times per event at the following approximate intervals: Hour 0, Hour 2, Hour 4, Hour 6, Hour 9, Hour 12, Hour 15, Hour 18, Hour 21, and Hour 24. Sampling intervals will be defined by the start of rainfall rather than CSO or SSO activation. The frequency of sampling is intended to capture in-stream impacts in the vicinity of DELCORA's service area from both DELCORA's CSOs as well as upstream sources. Two additional locations on the Delaware River, one at mid-stream and one near the far shore, have been added to characterize lateral variability in water quality during storm event conditions, when sampling across the river is feasible. The sampling regimen is also designed to allow a semi-quantitative mass balance to be computed over a complete tidal cycle. A total of 70 samples may be collected during each wet weather sampling event. If river conditions are unsafe for sampling (e.g. small craft advisories, heavy barge traffic, etc.), sampling may be suspended for one or more locations and/or sampling rounds. One field blank and one field duplicate will be collected during each event to be used as field QC. Final selection of sampling locations and sampling intervals will be determined prior to the start of the sampling program and will be based on logistic considerations (e.g. can seven locations be sampled and dropped off to a courier within the 3 hour sampling window), safety and accessibility to the Delaware River, and available resources.
- **Up to Six (6) Outfall Locations:** Sampling will be conducted at up to two (2) stormwater outfalls and up to four (4) combined sewer overflow outfalls. The CSO and stormwater sampling locations will be finalized prior to the initiation of the sampling

program based on accessibility of sampling, safety of sampling personnel, equipment risk, and available resources.

It is assumed that each of the outfall locations will have up to eight sets of samples collected for each event at the following intervals: 1st flush, 30 minutes, and 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, 24 hours. If a location is not flowing, no sample will be collected. As many as 48 samples may be collected during each wet weather sampling event, depending on the number of monitored outfalls and if all monitored outfalls discharge for 24 hours. However, the actual number of samples is likely to be less than the amount indicated since it is unlikely that all of the monitored outfalls will discharge for the full 24 hour monitoring period. One field blank and one field duplicate will be collected during each event to be used as field QC.

The location of these stations are shown in Figure 2-3. Details for these stations are provided in Table 2-2, Table 2-3, and Table 2-4. The set of parameters for which the samples will be analyzed are summarized in Table 2-5. In situ measurements will not be collected at the outfall locations.

Sampling crews will conduct all wet weather event sampling using the protocols described in the Quality Assurance Project Plan. Samples will be delivered to the laboratory where the samples will be analyzed for the laboratory parameters identified in Table 2-5.

Determination to mobilize for a Wet Weather Event will be a collaborative effort between Greeley and Hansen, LimnoTech, the field sampling contractor and the laboratory contractor personnel. The intent is to identify a 4 to 6 hour window in which a wet weather event may commence 24 hours in advance to assist in mobilization of the sampling crews.

Table 2-5: Analytical and Field Parameters

Parameter	Description	Sampling Program	Type of Measurement
E. coli	Escherichia coliform	Dry, Wet	Grab
Enterococcus	Enterococcus sp.	Dry, Wet	Grab
Fecal coliform	Fecal coliform	Dry, Wet	Grab
wTemp	Water temperature	Dry, Wet Receiving Water Only	In-situ
Cond	Conductivity	Dry, Wet Receiving Water Only	In-situ
Salinity	Salinity	Dry, Wet Receiving Water Only	In-situ

Tributary Bathymetry

The project team has requested HEC models of the receiving waters from the U.S. Army Corps of Engineers. However, in the absence of these models, additional bathymetry data is needed for the tributaries to inform the development of the water quality model. If required, bathymetry surveys will be conducted in approximately the lower three miles of both Chester Creek and Ridley Creek, corresponding to the approximate extent of the water quality model

domain. Because these reaches are in the tidal zone, they are unlikely to be wadeable so each transect will be characterized using a boat and a combination of sonar and ADCP profiler equipment. Transects will be spaced approximately every 0.25 miles or at significant morphometric features (e.g. dams, islands, etc.).

2.3.2 Water Quality Model Attributes and Platform

The Water Quality Model is a tool that computes the movement and concentrations of pollutants in water bodies of interest. Many water quality model codes are available and these models vary in their recognition by USEPA and their applicability to the Delaware River and its tributaries. LimnoTech reviewed a range of potentially applicable hydrodynamic and water quality models and has identified USEPA's Environmental Fluid Dynamics Code (EFDC) as the model framework most appropriate for the DELCORA receiving waters. This modeling framework computes water depths and velocities to inform predictions of bacteria water quality conditions. EFDC is selected over other candidate modeling frameworks due to its flexible and scalable design, computational efficiency and wide application base at similar sites around the United States. This model is supported by USEPA and has been successfully applied by the project team at similar sites and to meet similar project objectives (Ohio River, James River, Berry's Creek).

It may be beneficial to couple EFDC with another model to reduce simulation run times. EFDC could be used to compute hydrodynamics and those results could be linked to the RCA (Row-column AESOP) water quality model for water quality calculations. This potential approach would reduce model run times by allowing for a longer time step and for a smaller water quality model extent. RCA, like EFDC, is a highly regarded water quality model that has been applied at numerous sites by the project team (Lake Erie, Mississippi River, Great Miami River).

LimnoTech also reviewed a range of potentially applicable watershed runoff models and has identified USEPA's Storm Water Management Model (SWMM) as the model framework most appropriate for the DELCORA watershed model. This modeling framework simulates hydrologic and water quality conditions in the watershed to estimate runoff and pollutant concentrations from areas outside the combined sewer system area in the vicinity of Chester, PA. This area is primarily within the City of Chester's municipal separate storm sewer system (MS4).

<u>EFDC Background and General Capabilities</u>

The EFDC model is a state-of-the-art finite difference model that can be used to simulate hydrodynamic and sediment transport behavior in one, two, or three dimensions in riverine, lacustrine, and estuarine environments. EFDC was developed at the Virginia Institute of Marine Science in the 1980s and 1990s, and the model is currently maintained under support from the U.S. EPA. Recently, LimnoTech has successfully applied EFDC to a number of sites, including the James River (near Lynchburg and Richmond), Berry's Creek (NJ), San Diego Bay (CA), the lower Great Miami River, the Ohio River (near Cincinnati (OH), Evansville

(IN) and Wheeling (WV), the lower Licking River (Northern Kentucky), Missisquoi Bay (Lake Champlain), Saginaw Bay (Lake Huron), Maumee Bay (Lake Erie), Saginaw River (Michigan), and the Tittabawassee River (Michigan). The EFDC model is both public domain and open source, meaning that the model can be used free of charge, and the original source code can be modified if necessary to tailor the model to the specific needs of a particular application.

The model input parameters include variable hydrologic inflows and outflows from tributaries and landside sources, their associated bacteria concentrations for the POCs, and water level boundary conditions. EFDC can represent the model grid using either a generalized vertical coordinate (GVC) system or a sigma system. Both options are capable of accurately describing vertical gradients in systems with rapidly changing bathymetry, if necessary. The model outputs will include the movement of water in the river (i.e., flows and velocities), water level, and bacteria densities throughout the model domain.

SWMM Background and General Capabilities

The proposed watershed model framework for this project is SWMM (Storm Water Management Model), which is supported by the USEPA and has been successfully applied by the project team at similar sites and for related purposes, including in East Rutherford, NJ, Washington, DC, and Richmond, VA. SWMM is a dynamic rainfall-runoff simulation model used for single event or continuous simulation of runoff quantity and quality from primarily urban areas (USEPA, 2015). A review of the Chester Creek and Ridley Creek watersheds using the USGS StreamStats[1] tool show that these two watersheds are 42% and 37% urban respectively. Additionally, the current H&H model for the DELCORA service area is also built using the SWMM software, so choosing SWMM for the watershed model provides consistency in the suite of models used by DELCORA.

SWMM can account for different subcatchment physical characteristics such as slope, imperviousness, length and width, and soils through the parameterization of spatial resolution. Additionally, it will be able to predict variations in timing, peak flows, and flow volumes.

A variety of enhanced SWMM platforms are available that integrate the EPA SWMM software with user friendly interfaces and GIS capabilities. For this project, PCSWMM, developed by CHI, will be used. Once the watershed model is built, the model files can be provided as PCSWMM or EPA SWMM files.

2.4 Quality Objectives and Criteria (A.7)

The monitoring information that will be collected to support the development of the updated LTCP will meet the quality assurance objectives outlined in this section. Data quality will be

[1] http://water.usgs.gov/osw/streamstats/

measured in terms of the data's accuracy and precision, completeness, representativeness, comparability, and the required detection limits for the analytical methods.

Model quality will be based on the successful calibration and validation to hydrodynamic and water quality data from the Sampling Program as well as the model's ability to be meet the project objectives.

2.4.1 Water Quality Monitoring

2.4.1.1 Accuracy

Accuracy is the measure of agreement between an observed value and an accepted reference value or true value. Table 2-6 provides a summary of the laboratory and field measurement accuracy objectives.

Table 2-6: Data Quality Objectives

Parameter	Data Accuracy Objectives (% R)		Data Precision Objectives				Required Detection Limits	
			Field Precision (RPD)		Analytical Precision (RPD)			
	Estimated By	Objective	Estimated By	Objective	Estimated By	Objective	Reference Method	RL*
Fecal coliform	Presence/ Absence Control	P/A	Field Duplicates	50%	Lab Replicates	40%	SM 9222D	10 No./ 100 ml
Escherichia coliform (E. coli)	Presence/ Absence Control	P/A	Field Duplicates	50%	Lab Replicates	40%	EPA 1603	10 No./ 100 ml
Enterococcus	Presence/ Absence Control	P/A	Field Duplicates	50%	Lab Replicates	40%	EPA 1600	10 No./ 100 ml
Water Temperature	Factory calibration	NA	Readings	10%	NA	NA	Field Instrument/ EPA 170.1	0.1 °C*
Conductivity	Calibration check standard	Instrument reading within 10% of standard	Readings	10%	NA	NA	Field Instrument/ EPA 120.1	1 uS/cm*
Salinity	Calibration check standard	Successful daily calibration	Readings	10%	NA	NA	Field instrument/ SM 2520 B	0.1 part per thousand

* - Sensitivity value listed for field parameters (Temp., Cond., Salinity) - instrument must be capable of reporting to nearest incremental sensitivity value listed
P/A - method detects presence when bacteria is present in control (P) and method does not detect bacteria when absent in control (A).
NA - not applicable
RL - Reporting Limit
SM - Standard Methods of the Examination of Water and Wastewater, 22nd Edition

Laboratory Accuracy Objectives

Accuracy cannot be directly measured for bacterial samples. Accuracy will be assessed by the laboratory through the analysis of positive and negative controls and laboratory blanks and with field blanks in the field.

Dilution blank samples and method blank samples will be generated by the contract laboratory and used to assess contamination resulting from laboratory procedures. Duplicate analyses will be performed to check for sampling and analytical reproducibility.

Field Accuracy Objectives

Accuracy cannot be directly measured for bacterial samples. Accuracy will be assessed by the laboratory through the analysis of positive and negative controls in the laboratory and with field blanks in the field. In order for the accuracy assessment to be relevant, all appropriate protocols concerning sample collection, handling, preservation, and hold times must be maintained. Field blanks will be collected by each crew during each sampling event. A detailed discussion of these protocols is provided in the Water Quality Monitoring Plan.

Field blanks will be used to determine if samples collected have been contaminated. Equipment that is used to collect samples for analysis may become contaminated through the normal course of monitoring. If not properly cleaned and rinsed, samples may be contaminated during sampling from previous locations or in the laboratory between sample analyses. Field blanks consisting of reagent grade distilled water will be submitted to the analytical laboratory to assess the quality of the data resulting from the field monitoring program. Field blanks will be used to assess cross-contamination of samples by the equipment or sampling techniques. Field blanks will also be analyzed to check for procedural contamination at the laboratory that may cause sample contamination.

Field measurement accuracy will be assessed through pre- and post-monitoring checks to calibration standards. Probe performance within the specifications of the parameter will be used as confirmation of accuracy. Probe performance outside the specifications of the parameter will be qualified using the data validation protocols described in Section 5.

2.4.1.2 Precision

Precision is a measure of agreement between two or more measurements. Duplicates and replicates samples will be taken for a portion of the samples. Table 2-6 provides a summary of the data precision objectives for field and laboratory measurements. Table 2-6 applies if the average result of the duplicate/replicate samples is greater than five times the analysis detection limit. If the average result of the duplicate/replicate samples is less than five times the analysis detection limit, the precision test will not be utilized.

Laboratory Precision Objectives

The precision of the laboratory analysis is assessed by the comparison of laboratory replicate analyses. The RPD is calculated as follows:

$$RPD = \frac{|C_1 - C_2|}{0.5(C_1 + C_2)} \times 100$$

Where: C_1 = measured concentration of the first sample replicate
C_2 = measured concentration of the second sample replicate

Note that the average concentration of C_1 and C_2 must be at least five times greater than the reporting limit (Table 2-6) for the analyte to be in sufficient quantity to provide a reasonable measure of precision.

Field Precision Objectives

Field precision tests are conducted for grab samples and physical parameter readings. The precision of grab samples is assessed by the comparison of field duplicates. The relative percent difference (RPD) between the analyte levels measured in the field duplicates will be calculated as follows:

$$RPD = \frac{|C_A - C_B|}{0.5(C_A + C_B)} \times 100$$

Where: C_A = measured concentration of sample
C_B = measured concentration of duplicate sample

The precision of physical parameter readings is assessed by the comparison of each instrument's calibration readings versus the post check readings. The RPD between the readings will be calculated as follows:

$$RPD = \frac{|R_X - R_Y|}{0.5(R_X + R_Y)} \times 100$$

Where: R_X = calibration reading
R_Y = post check reading

2.4.1.3 Completeness

Completeness is a measure of the amount of valid data obtained from the monitoring program compared to the amount of data that were expected. Events that may contribute to reduction in

measurement completeness include sample container breakage, inaccessibility to proposed sampling locations, automatic sampler failure, and laboratory equipment failures.

The percent completeness (%C) is determined as follows:

$$\%C = \frac{(M_V)}{(M_P)} \times 100$$

Where: M_V = number of valid measurements
M_P = number of planned measurements

If the completeness objectives are not achieved for any particular category of data, the Field Manager will provide documentation why the objective was not met and how the lower percentage impacts the overall study objectives. If the objectives of the study are compromised, re-sampling or re-measurement may be necessary.

Field Completeness Objective

Field completeness is determined by the number of measurements collected versus the number of measurements planned for collection. The details concerning the actual number of field measurements and samples to be collected are discussed in the Water Quality Monitoring Work Plan. The number of measurements collected is validated by the Field Manager. The completeness criterion for all measurements and sample collection is 90 percent, but will be influenced by environmental situations that may alter monitoring schedules.

Laboratory Completeness Objective

Laboratory completeness is a measure of the amount of valid measurements obtained from all samples submitted for each sampling activity. The Laboratory Manager validates the numbers of valid measurements. The completeness criterion for all measurements is 95 percent.

2.4.1.4 Representativeness

Representativeness is the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representative data of dry weather and wet weather conditions are required to support the evaluation and modeling efforts.

For sample collection, representativeness will be assured by following the Water Quality Monitoring Work Plan and applying proper collection techniques including the proper sample sizes and volumes, sampling times, and sampling locations. The volumes of the samples depend on the analytical methods and should allow for QC sample analysis and reanalysis, if required. In the laboratory, representativeness will be ensured by using the appropriate sample preparation

techniques, by following appropriate analytical procedures, and by meeting the recommended sample holding times.

2.4.1.5 Comparability

The objective for data comparability is to generate data for each parameter that related water quality conditions between sampling locations and over time. Data comparability will be promoted by:

1. Using standard U.S. EPA approved methods, where possible.
2. Consistently following the sampling methods detailed in the SAP.
3. Consistently following the analytical methods detailed in the QAPP.
4. Achieving the required detection limits detailed in the QAPP.

All sample collection and analytical methods will be specified, and any deviations from the methods will be documented. All results will be reported in the standard units shown in Table 2-6. All field and laboratory calibrations will be performed using standards traceable to National Institute of Science and Technology (NIST) or other U.S. EPA approved sources.

2.4.1.6 Required Detection Limits

The required detection limits (RL) and methodology for the study is provided in Table 2-6. For the analytes specified for this study, all the RLs are at levels required for calibration of the water quality models to be developed.

Refer to Table 2-7 for the specification limits of the field measurement instruments.

Table 2-7: Specification Limits of Field Measurement Instruments

Parameter	Instrument	Range	Accuracy	Resolution
Temperature	YSI	-5 to 45°C	±0.15°C	0.01°C
Conductivity	YSI	0 to 100 mS/cm	±1% of range	4 digits
Salinity	YSI	0 – 70 ppt	±0.1 ppt	0.01 ppt

2.4.2 Water Quality Modeling

Model development for the DELCORA LTCP consists of four tasks leading to a calibrated and validated EFDC model for use in evaluating CSO control applications in the local waterways of the DELCORA service area. These tasks are addressed in this QAPP and are listed below.

- Model Input Development
- Model Calibration and Validation

- Model Scenario Application
- Documentation and Reporting of Results

Each of these model development tasks is described below.

2.4.2.1 Criteria for Model Inputs/Output

This task includes the processing of the necessary background, input, and calibration datasets for model development. Model development of the hydrodynamic (EFDC) and water quality (RCA) components of the EFDC-RCA model for the DELCORA waterways will occur sequentially, with EFDC development occurring first, followed by development of the RCA model. Model development for each component is discussed below.

EFDC-RCA Water Quality Model

Initial EFDC model development efforts will focus on development of a model grid, followed by processing of data to specify external hydraulic and water quality forcing functions (i.e., flows, loads) into a format that can be input to the model.

The major components of the model development process include the following items:

Grid development – Available bathymetric data will be assembled and used as the basis for development of a model grid with adequate resolution to capture the significant characteristics of the system for purposes of this project. At present, a one-dimensional grid is planned for the tributaries and three dimensional grid for the Delaware River portion of the model domain. The model grid will be an orthogonal grid within a curved perimeter suitable for numerical modeling. Where bathymetric data are not available, previously developed flood models will be obtained and the model bathymetry will be used to fill bathymetric gaps. Additionally, bathymetry surveys as described in Section 2.3.1 will be conducted in the tributaries. If reaches exist where no bathymetric data or hydraulic models exist, bathymetry will be extrapolated from upstream and downstream information.

Input development – Model upstream and tributary flows will be derived from available flow data at USGS gaging stations. CSO flows will be derived from the calibrated and validated hydrologic and hydraulic (H&H) model. Stormwater flows will be derived from a SWMM watershed model. Model upstream and tributary water quality will be based on the data collected during the WQMP. CSO and stormwater quality will be input using event mean concentrations (EMCs) derived from the CSO sampling program data collected during the WQMP.

Available water quality data to support model development and calibration have been compiled and reviewed to develop the WQMP. Available data have been incorporated into a project-specific database that will be used to generate model inputs and included in the pre- and post-processor for the model to facilitate comparisons of model results to observed data during calibration, as appropriate.

SWMM Stormwater Watershed Model

The main attributes of the proposed watershed model are that it will be able to predict dry and wet weather flows and associated bacteria loads. The watershed model will provide necessary spatial resolution to account for different subcatchment physical characteristics such as slope, imperviousness, length and width, and soils. Additional, it will be able to predict variations in timing, peak flows, and flow volumes.

Catchment Development – SWMM simulates surface runoff from catchments that represent physical areas in the watershed. For the DELCORA modeling framework, catchment areas will be developed for the areas outside of the combined sewer system collection system adjacent to the spatial domain of the Water Quality Model. Catchment areas will be defined similarly to the areas shown in Figure 1-3 and will be informed by the physical characteristics of the area, including slope, soils, imperviousness, and topographical or other defined watershed boundaries (e.g. roads).

Input Development – SWMM model inputs include catchment characteristics, such as area, width, imperviousness, and slope. Other characteristics affecting the hydrologic simulation include roughness, depression storage, and soil infiltration rates. Rainfall and temperature are temporal inputs. Runoff water quality will be input using EMCs derived from the stormwater sampling program data collected during the WQMP.

Available water quality data to support model development and calibration have been compiled and reviewed to develop the WQMP. Available data have been incorporated into a project-specific database that will be used to generate model inputs and included in the pre- and post-processor for the model to facilitate comparisons of model results to observed data during calibration, as appropriate.

2.4.2.2 Calibration and Validation

Once each EFDC model component is configured to the DELCORA watershed, the next step in the model development process is model calibration. During the calibration process, model inputs will be adjusted to allow the model to best fit the described observed data. The focus of calibration is the adjustment of model coefficients within an acceptable range (dictated by the field data and laboratory literature values) to achieve the best agreement between model and data within the constraints of both model and data. The model calibration approach will be consistent with the well-accepted methods presented in the EPA guidance manual for development, evaluation, and application of regulatory environmental models (EPA, 2009). Model coefficients will be calibrated independently to the extent possible, with calibrated coefficients left fixed while other coefficients are adjusted. For example, all hydraulic parameters will be calibrated prior to conducting any water quality calibration. Calibration of each model component is discussed further below.

EFDC Model Hydraulic Calibration and Corroboration

The hydraulic calibration will be informed by data from NOAA gages in the Delaware River, as

listed below:

- Water level gages: #8540433 (Philadelphia, PA), #8546252 (Bridesburg, PA), #8539094 (Burlington, NJ), and #8548989 (Newbold, PA)
- Current velocity meter: Station dB0301 (Philadelphia, PA)

Hydraulic calibration will primarily focus on reproducing observed water levels and current velocities in the Delaware River. This approach provides a robust calibration by focusing on the hydraulic attributes that are the primary dependent variables of the hydrodynamic model. Calibration goodness will be determined by qualitative visual comparison of model and data time series, one-to-one plots, and cumulative frequency distributions (CFDs). Calibration will involve adjustment of the roughness height to values that best replicate water level and velocities at NOAA stations.

After satisfactory calibration is achieved, the EFDC hydrodynamic model will be validated by applying the model for a different time period than the calibration. The roughness height used in the calibration will be used for the validation run.

EFDC Model Water Quality Calibration and Validation

Water quality calibration will rely primarily on the dry and wet weather data to be collected in the WQMP in Chester Creek, Ridley Creek and the Delaware River. The model coefficients determined in the calibration process will be independently corroborated (a process that has historically been called validation) via application of the model to a data set independent of that used for model calibration. The LimnoTech standard approach for selecting periods for calibration and validation is to divide the available data into periods of relatively equal duration and to use the most robust (or otherwise most representative) period as the calibration data set. Using this approach, the dry weather data and two of the sampled wet weather events will serve as the calibration dataset and the remaining third sampled wet weather event will serve as the validation data set.

Calibration will involve adjustment of model coefficients within an acceptable range (dictated by the field data and laboratory literature values) until the difference between model computations and measured state variables is within acceptable tolerance. The key calibration parameter for indicator bacteria in EFDC is the loss rate. The loss rate represents the net effect of bacteria settling, die-off and other physical and chemical processes as a first order loss rate.

Calibration will include the use of qualitative (graphical) comparisons of model results to data, such as:

- Time series
- 1:1 plots
- Cumulative frequency distributions

Quantitative comparisons of model to data will also be used to judge the calibration, with the objective of minimizing differences between model and data. For comparisons of simulated vs. observed parameters, these may include:

- Mean absolute error and/or mean relative % difference
- PBIAS (percent bias)

Diagnostic analyses (e.g., sensitivity analyses, mass balance checks, and comparison of results to simple models) will be conducted during the water quality calibration process. LimnoTech experience has shown that conducting these diagnostic analyses helps to:

- Confirm that inputs are being provided to the model in the required format,
- Troubleshoot unstable and unexpected behavior exhibited by model simulations,
- Assess the relative importance of different input parameters and systems simulated within the modeling framework, and
- Provide insights into system behavior based on predictions of the calibrated model.

Model validation will involve running the EFDC water quality model for the validation time period and calculating the same model-data comparison statistics as were used for model calibration.

Quality Objectives and Criteria for Model Inputs/Outputs

LimnoTech will develop and apply the calibrated and corroborated EFDC water quality model to evaluate management option scenarios as described Section 2.2.2 of this QAPP. The two overall modeling objectives for this QAPP follow and are described further below.

- to ensure the performance of the model; and
- to ensure the quality of the model inputs, model outputs, and conclusions made in support of CSO control alternatives evaluation.

Model Performance

During the application of the model, performance will be evaluated after each model run. The output will be compared against previous model runs to ensure that the outcome was expected, and within reasonable ranges. A reasonable range is defined as being within known ranges of possible outcomes. The range of possible outcomes is determined from previous model runs and user experience with the parameters being modified for the current run. For example, if the model is run to steady state with 50% of the annual load, then the steady-state water column concentration is expected to be 50% of the original value. In this example, model results that are not 50% of the original value (for this model run) would be subject to further review.

Model Input Data

Model inputs will be comprised of existing secondary data (i.e., previously collected, reported,

modeled or synthesized data) and will be used for the purposes of receiving water characterization and modeling efforts. Work under this QAPP will not generate any direct environmental data measurements. The data quality objectives (DQO) and associated criteria for the secondary data used for this project are listed below.

- Data are from a known and reliable source. The data sources will be documented. Data will be compiled primarily from reliable local, state, federal and peer-reviewed sources.
- Data are of known quality. The quality of secondary data will be reviewed prior to use for this project.
- Data are appropriate for the intended use as indicated by the following criteria:
    - data satisfy project objectives;
    - data satisfy evaluation and modeling requirements;
    - data exhibit appropriate characteristics (e.g., quality, quantity, temporal, spatial); and,
    - data were generated using appropriate methods.

Data sets to be used in the project will be reviewed for completeness, quality and conformance with the DQOs and associated criteria listed above. Data will be accepted for use if they conform to the DQO and criteria, and all accepted data will be cited appropriately including:

- Type of data and collection dates;
- Originating organization;
- Report title, author and date; and,
- Data format (electronic, hardcopy) and database names.

Identified data limitations will be documented, where applicable, and these datasets will be accepted for use on a case-by-case basis. Data of unknown/non-verifiable quality will be considered suspect and documented accordingly. To ensure transparency and defensibility in the decision making process, related project reports and/or existing data that were not used for this project will be clearly documented.

Model inputs will be carefully reviewed by the technical staff prior to each model run to ensure that the inputs are consistent with the modeling approach and scenario objectives. Any model inputs that are questionable or not fully documented will not be used to generate final results. All modifications to the model inputs will be documented in a separate file that lists the date, run ID, and inputs that were modified. All model inputs will be stored in the same folder as the corresponding model output to keep a complete record of each simulation used for each management scenario.

Model Outputs and Conclusions

Processing of model results will be accomplished through an automated post-processor that ensures the consistent treatment of model output for each model run. Model results will be reviewed by the technical staff as a final quality check to ensure that the model results are within reasonable ranges. Processed model outputs will always be stored in a folder with the run ID and the unprocessed model output.

2.4.2.3 Application

The calibrated EFDC water quality model is intended to be used to evaluate CSO control alternatives wherein indicator bacteria POC loads are reduced by specified amounts to evaluate impact on water quality in the Delaware River and the tributaries adjacent to the DELCORA service area. The list of model scenarios representing the CSO control alternatives to be evaluated will be developed in collaboration with DELCORA and Greeley and Hansen.

A baseline scenario will be developed, against which all load reduction scenarios will be compared. This baseline scenario will be developed in collaboration with DELCORA and Greeley and Hansen and will include:

- A representative time period to capture the range of river conditions including dry, wet and average conditions.
- A representation of current CSO discharge flows and quality.

Once scenarios have been defined, inputs to the calibrated model will be adjusted for each scenario to fit the specific change that the management option is considering. Model results for each scenario will be compared to the baseline scenario for a specific set of water quality response variables, including, but not necessarily limited to:

- Compliance with applicable water quality standards
- Reductions in levels of POCs

Compliance with applicable water quality standards will be evaluated assuming contributions from CSO and non-CSO sources and from CSO sources alone. If non-CSO (e.g. background) sources prevent compliance of water quality standards, the scenarios simulated will be configured assuming that background pollutant levels are reduced such that in-stream concentrations upstream of the CSO outfalls are no more than 75% of the applicable water quality standard.

2.5 Special Training/Certification (A.8)

Special training/certification needed for project, field, laboratory, and modeling staff to successfully complete project work is discussed in this section.

2.5.1 Project Staff

Greeley and Hansen, LimnoTech, Weston Solutions, and Eurofins QC professional staff will be involved in this monitoring program and water quality model development. Project staff will be assigned duties based on their qualifications to accomplish the task. The Field Manager will determine the appropriateness of individuals on their staff to undertake a task.

2.5.2 Field Staff

Training sessions will be carried out for all field staff on proper sampling, sample handling and submission and general field procedures prior to conducting the first sampling event. Specific emphasis will be placed on QA/QC issues as well as on health and safety. Field Safety Instructions will be prepared to outline the safety issues of concern.

Field crews will also receive training involving the operation, maintenance and calibration of field equipment including multi-parameter probes, velocity meters, and all other on-site equipment used throughout the field program.

Standard Operating Procedures (SOPs) for program elements will be distributed to staff and available at all times. The field Standard Operating Procedures (SOPs) and the Sampling Analysis Plan (SAP) referenced in the following sections of this report are provided in Appendix C.

2.5.3 Laboratory Staff

The Laboratory Manager or delegate will be the main point of contact for coordinating all sample drop-offs, pick-ups, etc. The Laboratory Manager or delegate will be assisted by the laboratory QA/QC Manager in performing review and validation of all data generated to assure all data quality objectives have been met. The Laboratory Manager or QA/QC Manager will contact the Field Manager immediately with any problems with samples noted during log in or with analysis. Prior to conducting the first sampling event, the Monitoring Task Manager and Field Manager will meet with the laboratory manager to review details of the planned progression of sampling events.

The laboratory staff will include chemists and technicians with specific experience in receiving water and source sampling analysis. The laboratory staff will be on call 24 hours a day and 7 days a week for wet weather events, including weekends.

All laboratory personnel receive training and have proven proficiency in their designated analytical procedures. Laboratory personnel have been provided copies of the appropriate Standard Analytical Procedures (SAPs), which will be available at all times and are provided in Appendix B.

2.5.4 Model Staff

Staff engineers and scientists comprising the modeling team are trained professionals with advanced technical degrees and skills necessary to successfully develop and apply water quality models for the system. All modeling activities will be overseen by the project's Water Quality

Model Task Manager who has extensive experience in applying water quality models to support CSO LTCP development.

2.6 Documentation and Records (A.9)

The Project Manager is responsible for ensuring that the most current approved version of the QAPP is distributed. The approved QAPP and any approved updates will be distributed to the list of project personnel identified in the Distribution List at the beginning of this document. These personnel are responsible for distributing copies of the QAPP to relevant personnel within their organization.

2.6.1 Monitoring Data

The Project Manager is responsible for initiating project files and for overseeing maintenance of the files during the course of the project. All project files will be properly identified by client, project name, project number, file description, and file number for all appropriate correspondence, memoranda, calculations, technical work products, and other project-related data. In addition, a quality assurance file will be maintained by LimnoTech containing all QA/QC related information. A back up of all computer files containing important project information will also be maintained.

Documents to be generated by field activities include staff notes, field logs, equipment logs, field on-site measurement data sheets, field audit reports, chain of custody forms. Documents to be generated by laboratory activities include QA/QC reports, laboratory bench sheets, laboratory results, and laboratory audit reports. These documents will be included in project reports.

At the conclusion of the project, relevant information from the project files and electronic files will be turned over to DELCORA to be archived.

2.6.2 Model Files

The development, calibration and corroboration of the Water Quality Model will be documented in a Water Quality Model Report. This report will be submitted to EPA and PADEP within 60 days after this Water Quality Model Work Plan is approved and fully implemented. The project report will include discussions of the data collected during the WQMP, additional data analyzed and used to support the modeling, model development and calibration processes and the calibration and corroboration. An initial draft of the report will be prepared for internal review. After this internal review is complete, the draft report will be edited accordingly and then delivered to the EPA and PADEP for their review. The final report will then be prepared.

A daily back up of all computer files containing important project information will also be maintained on LimnoTech's computer network. No files will be maintained on individual personal computers unless they are temporary working files. All data and work products will be saved to their respective network files daily.

Documents to be generated by this project include this modeling QAPP, technical memoranda, and the draft and final project reports.

Records that will be generated during this project include model inputs and output files, model post-processing files (e.g., those produced using Microsoft Excel, databases or other data analysis software programs), and the draft and final Water Quality Model reports. These records will be complete and detailed enough to allow the model to be re-loaded and re-run independently with the same data sets and producing the same results.

At the conclusion of the project, all relevant information from the project files and computer disks will be archived by LimnoTech, with data, deliverables and technical records retained for at least 10 years.

Section 3 Data Generation and Acquisition (Group B)

This section of the Quality Assurance Project Plan (QAPP) addresses quality assurance/quality control (QA/QC) elements related to the monitoring activities. The monitoring program QAPP was developed based on U.S. EPA requirements (EPA, 2001) following U.S. EPA guidance (EPA, 1998).

3.1 Sampling Process Design (B.1)

As described in the previous section, dry weather and wet weather monitoring will be conducted at six tributary in-stream locations, five Delaware River locations, and up to ten CSO and stormwater outfall locations. The sampling process design is discussed in the Water Quality Monitoring Work Plan portion of this Work Plan.

3.2 Sampling Methods (B.2)

SOPs will be employed to provide consistency and reproducibility to the sampling methods used by field personnel. The following sections present or reference the detailed methods for performing sampling activities, including related support procedures for equipment cleaning, field measurements, and calibration and maintenance of field instruments. Sample custody procedures are presented in the Sample Handling and Custody Section of this QAPP. For all sampling related procedures, personnel will use personal protective equipment as required by the Field Safety Instructions for the WQMP.

3.2.1 Surface Water Sample Collection

Surface water and outfall grab samples will be collected as specified in the WQMP Work Plan and/or according to the SOP.

3.2.2 Field Water Quality Measurements and Monitoring

Instantaneous water quality measurements (such as temperature, conductivity, and salinity) and depth data using field instruments will be collected as specified in the WQMP Work Plan and according to the standard operation procedures. All data generated is recorded for transfer to the project files.

3.3 Sample Handling and Custody (B.3)

Sample handling will be performed to collect, store, submit to the laboratory and obtain representative samples using methods as specified in the work plans and according to the SOPs. Sample containers, volumes, preservatives and holding times are summarized in Table 2-6. Proper sample handling and custody procedures will be employed as discussed in the following subsections of this QAPP.

3.3.1 Field Sample Custody

The objective of field sample custody is to ensure that samples are traceable and are not tampered with between sample collection and receipt by the analytical laboratory. A person will have custody of a sample when:

- The person is one of the authorized personnel;
- The sample is in their physical possession;
- The sample is in their view after being in their possession;
- The sample is in their personal possession and secured to prevent tampering; and
- The sample is in a restricted area accessible only to authorized personnel.

Field custody documentation will consist of both field log books and chain of custody forms.

Chain-of-Custody Forms

Completed chain-of-custody forms will be required for all samples to be analyzed. Chain-of-custody forms will be filled-out by the field sampling crew during the sample collection events. The chain-of-custody form will contain the following information for each sample:

- Unique identification number;
- Sample date and time;
- Sample description;
- Sample type;
- Sample preservation (if any);
- Analyses required.

The original chain-of-custody form will accompany the samples to the laboratory. Copies of the chain-of-custody form will be made prior to shipment for separate field documentation. The chain-of-custody forms will remain with the samples at all times. The samples and signed chain-of-custody form will remain in the possession of the sampling crew until the samples are delivered to the courier or to the laboratory.

Sample Packing and Shipping Requirements

Sample packaging and shipping procedures are designed to ensure that the samples and the chain-of-custody forms will arrive at the laboratory intact and together. Samples will be properly packaged for shipment according to the SOPs and submitted to the appropriate laboratory for analysis. Shipping containers will be secured with strapping tape and custody seals, if required, for shipment to the laboratory. The cooler is strapped shut with strapping tape in at least two locations.

All shipments will be accompanied by the chain-of-custody form identifying the contents. It is preferred that a separate chain-of-custody form be completed for and placed in each shipping container. The original form will accompany the shipment and copies will be retained by the sampler for the sampling office records.

3.3.2 Laboratory Sample Custody

Laboratory sample custody will be performed in accordance with the laboratory's Quality Assurance Manual (QAM), consistent with the guidelines set forth in this section of the QAPP, and/or compliance with laboratory accreditation requirements specified in 25 Pa. Code Chapter 252 .

The laboratory must have written SOPs for sample custody to protect the integrity of the samples, including, but not limited to:

- Sample receipt and maintenance of custody;
- Sample storage; and
- Sample tracking.

Sample Receipt and Maintenance of Custody

The laboratory shall have written procedures that document receipt of all sample containers and maintain chain of custody. Although a designated sample custodian responsible for receipt of samples is preferable, it is not required provided the laboratory has procedures for handling environmental samples, including

- Procedures for checking and recording the thermal and/or chemical preservative and sample container(s);
- Use of a record-keeping system that documents receipt of all sample containers that includes pertinent sample and laboratory information describing each sample; and,
- A sample acceptance policy that clearly outlines the circumstances that samples can be accepted or rejected. Departures from acceptable circumstances will be noted to be discussed with the Field Manager.

Sample Storage

After samples are received, they are placed in secure storage in accordance with the individual method requirements referenced by U.S. EPA or Standard Methods (e.g., maintained at less-than-or-equal-to six (6) degrees Celsius).

Consistent with 25 Pa. Code Chapter 252 and/or the National Environmental Laboratory Accreditation Program (NELAP), the laboratory will have documented procedures describing storage areas for samples in the laboratory, and steps taken to prevent sample contamination.

3.4 Analytical Methods (B.4)

The following section details the aspects of the analytical requirements, ensuring that appropriate analytical methods are employed. Appendix A includes the laboratory Quality Assurance Program and Appendix B includes the Standard Operating Procedures (SOPs) of the laboratory subcontractor. Table 2-6 summarizes the analytical methods to be used by the laboratory.

3.4.1 Parameter Specific Information

Table 3-1 displays the required container type, sample volume, preservation, and hold time for each parameter according to the previously referenced methods. The contract laboratory will provide sample containers from a commercial supplier. Sample containers will be new and pre-cleaned by the supplier. In addition, the contract laboratory will provide sample labels for each bottle and add the required preservative for each parameter, if necessary.

Table 3-1: Guidelines for Sample Container Preparation and Preservation.

Parameter	Container	Volume	Preservative	Holding Time
E. coli	Plastic	100 ml	$Na_2S_2O_3$	8 hours[1]
Fecal coliform	Plastic	100 ml	$Na_2S_2O_3$	8 hours[1]
Enterococcus	Plastic	100 ml	$Na_2S_2O_3$	8 hours[1]
Notes: **[1] The desired hold time, 8 hours, is shown in Table 3-1. Laboratory Chain of Custody Procedures**				

3.4.2 Laboratory Chain of Custody Procedures

Use of the chain-of-custody form will terminate when laboratory personnel receive the samples and sign the form. The laboratory custodian will open the sample coolers and carefully check the contents for evidence of leakage and to verify that samples were kept on ice. The laboratory will then verify that all information on the sample container label is correct and consistent with the chain-of-custody form. Any discrepancy between the sample bottle and the chain-of-custody form, any leaking sample containers, or any other abnormal situation will be reported to the Laboratory Manager or his/her designee. The Laboratory Manager will inform the Field Manager of any such problem, and corrective actions will be discussed and implemented.

3.4.3 Analytical Records

The analytical data results and a case narrative will be submitted by the contract laboratory to the Water Quality Monitoring and Modeling Project Manager in an electronic format within a specified time frame from the completion of each sampling event (dry and wet weather). A summary of the laboratory QC results (see Table 2-6 for QC measures and Table 4-1 for QC frequency) generated during the analysis of the samples will be submitted to the Water Quality

Monitoring and Modeling Project Manager in an electronic format. This file will include the accuracy (method blank, presence/absence control results) and precision (replicate RPDs) quality control results (e.g. +/-,and RPDs). Also, the laboratory will maintain copies of all bench sheets generated during the processing of these samples and data sheets that include sample identification information that can be provided as requested by LimnoTech for every sample analyzed.

3.5 Quality Control (B.5)

Analytical quality control will be performed in accordance with the specified analytical methods and as discussed under the Quality Objectives and Criteria Section of this QAPP.

3.6 Instrument/Equipment Testing, Inspection, and Maintenance (B.6)

Field analytical equipment that may be used in this project includes instruments for measuring depth, salinity, conductivity, and temperature, and instruments for collecting water samples. These may be handheld instruments or autosamplers. Testing, inspection and maintenance will be conducted in accordance with manufacturer instructions. Preventative maintenance will be conducted as needed according to the SOPs.

Laboratory instrumentation and equipment testing, inspection and maintenance will follow manufacturer instructions and/or accepted procedures associated with the selected analytical methods, the laboratory's QAM and SAPs.

3.7 Instrument/Equipment Calibration and Frequency (B.7)

Calibration procedures for field equipment will follow manufacturer instructions. To maintain field precision and accuracy, the water quality instruments will be calibrated to known standards.

Laboratory instrument calibration will follow manufacturer instructions and accepted procedures associated with the selected analytical methods, the laboratory's QAM and SAPs.

3.8 Inspection Acceptance of Supplies and Consumables (B.8)

All supplies and consumables for field and laboratory activities will be inspected for compliance with the acceptance criteria by the identified responsible party prior to use. Supplies or consumables not meeting the acceptance criteria upon inspection will not be used. Supplies and consumables will be stored in accordance with individual method requirements referenced by U.S. EPA or Standard Methods.

3.9 Data Acquisition Requirements (Non-direct Measurements) (B.9)

Non-direct measurements will not be used in implementation of the monitoring program.

As described in Section 2.4.2.3, LimnoTech will evaluate multiple CSO control alternatives using the EFDC Water Quality Model. These activities will involve the use of secondary data from

multiple sources, including federal and state databases, peer-reviewed papers, and modeling results. Many of the state and federal datasets have undergone rigorous QA/QC prior to being released for public use. Other data comes from peer-reviewed sources that have also undergone internal QA/QC checks. LimnoTech has extensive experience in dealing with these types of data sources and will review and document the data sources, quality, completeness and appropriateness for use of all data to be considered for this project prior to their use in developing the Water Quality Model.

As described in Section 2.4, the data to be used for this project will be judged acceptable for their intended use if they conform to the DQOs and criteria. Data will be:

- accepted if they pass the screening criteria;
- qualified if the data do not pass the initial screening but the discrepancy is within the range of uncertainty for a given analytical method; or
- rejected.

Limitations in non-direct measurements identified through application of the acceptance criteria will be addressed by either using the data while identifying the implications of its limitations on the study results or, for non-critical non-direct measurements that do not pass acceptance criteria, conducting the tasks or analyses without the use of those non-direct measurements. Any limitation to the use of data and subsequent interpretation of study results will be reported in the final project report.

3.10 Data Management (B.10)

Data generated through field and laboratory activities will be used for developing models and reports. Reporting formats will vary depending on the purpose for which the data has been assembled. The Water Quality Monitoring and Modeling Project Manager has the responsibility of maintaining documents and data associated with field programs. The Laboratory Manager has the same responsibility for laboratory data and information.

3.10.1 Field Data and Information Management

Field data reporting shall be conducted principally through the transmission of data sheets containing tabulated results of all measurements taken in the field, and documentation of all field calibration activities. Copies of the field logs will be turned over to the Field Manager following each monitored event. Following review by the Field Manager, the field logs will be transmitted to the Quality Assurance Officer (QAO) for review and inclusion in the project's data management system. The QAO will transmit the field sheets to the appropriate Project Manager for his/her keeping after their review. Specific QA/QC procedures, including data and records management and QA audits, will be conducted according to the SOPs.

3.10.1.1 Field Logs

The field logs will serve as a daily record of events, observations, and measurements during field activities. All information pertinent to sampling activities will be recorded in field logs. Personal computers may also be used to record field data. Field logs will be maintained by field staff at all times documenting activities and conditions. A copy of the field logs will be turned in by field staff following each monitored event. Copies of all field logs will be made following each monitored event and maintained in the QA/QC project file. Field logs will include the following:

- Names of field crew and specifically the author of the field log
- Date and time of the sample round beginning and ending
- Location of sampling activity
- Date and time of sample collection
- Sample identification numbers
- Field measurements
- Field observations and details related to analysis or integrity of samples (e.g., weather conditions, noticeable odors, colors, stream flow description, etc.)

3.10.1.2 Equipment Logs

As installation, calibration and maintenance functions are completed on equipment, equipment logs will be maintained and included in the QA/QC project file.

3.10.1.3 Field On-Site Measurements – Data Sheets

Field measurement information recorded in the field log book will be compiled and the information transferred into electronic format by office staff. The Field Manager will review the source document and the electronic version to verify the accurate transfer of information. Following this review, electronic field data will be transferred to the QAO for review, then to the appropriate Project Manager for his/her keeping. The original data sheets will be maintained in the QA/QC project file.

3.10.2 Laboratory Data and Information Management

The reporting of laboratory data will begin after the Laboratory Manager or designee has concluded the verification review. The contract laboratory will prepare and submit full analytical and QC reports to the Project Manager that will include the following, as appropriate.

- Case narrative, including a statement of the conditions that samples were received, description of any deviation from standard procedures, explanation of any data qualifiers used, and identification of any problems encountered during analysis.

- Computer-generated report form containing all sample results in the forms of
  - a hard copy version of the report, and
  - an electronic version of the report.
- Hard copy and electronic QC summary report for each parameter by batch including the results of replicates, matrix spikes, matrix spike duplicates, controls, dilution blanks, method blanks, verification tests, etc.
- Copies of all laboratory bench sheets (upon request).
- Copies of all chain-of-custody forms.

Following receipt of laboratory data by the Project Manager, the data will be reviewed and validated by the Quality Assurance Officer following the procedures outlined in Section 4.

3.10.3 Electronic Data Management

All data collected during the course of the study will be entered into a database by LimnoTech for use in the modeling tasks. LimnoTech will manage and maintain the database. All electronic files will be backed up on a regular basis. At the conclusion of the project, relevant information, project files and electronic data will be turned over to Greeley and Hansen. The files will be archived for a minimum of ten years.

3.10.4 Model File Management

Data used during the project will be maintained in electronic format in a centralized project database. Manipulation of the downloaded data is identified as one of the major preventable error sources in the project effort. User-induced error can be identified and corrected under an appropriate level of QA/QC. Multiple steps will be taken to ensure errors are minimized. Data formatting will be reviewed, including the data element type, format, allowable values and ranges, and other parameters. Any manually entered parameter values from paper sources will be evaluated by reviewing hard copy printouts. The review will include a comparison of the original data sources and paper documentation. Any record identified as having issues will be reviewed to determine whether corrected data can be acquired or the record omitted. The project database will be used as a central repository for the data that will be used in model development and calibration.

The management of model code, input files, and output will be handled electronically. All input files are either contained within a specified format in a text file, or contained in an Excel file that is used to keep track of key time series forcing functions. Each set of model runs (input/output files) will be contained within a unique folder identified by a run ID. A log of every model run will be documented and maintained by LimnoTech, and will be a part of the project records. The run log will identify the run and include a brief description of the specifics of the model run.

3.10.4.1 Hardware/Software Configuration

The EFDC Water Quality Model is available as a Windows platform compatible executable. The minimum requirements of the model are easily met by any modern desktop PC. The input files required to run the model are contained in simple text files that can be viewed or edited with any simple word processing software (e.g. Notepad or Wordpad). Pre- and post-processing capabilities are available through several Microsoft Excel files. Any recent Microsoft Excel software (Excel 2007 or later) is capable of viewing and editing the additional processing files. The pre- and post-processors facilitate the writing and reading of the input and output files. In this configuration two copies of the model inputs and results always exist (in the text file and in the Excel file).

LimnoTech use a Microsoft Outlook-based email server for secure electronic communications, and secure access to networked file storage devices is provided for remote employees through the use of Virtual Private Network (VPN) protocols. These means of electronic communications and connectivity (for file transfers and backup) are expected to be secure for the needs of this project. No additional security measures are planned at this time.

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Section 4 Assessment and Oversight (Group C)

The Group C Assessment and Oversight elements are addressed in this section.

4.1 Assessment and Response Actions (C.1)

Internal quality control checks are performed to ensure that the field and laboratory generated measurements meet the project quality assurance objectives. In addition, the quality control checks are intended to identify any need for corrective action.

The EFDC Water Quality Model will be specifically developed to investigate CSO control alternative scenarios for the waterways tributary to the DELCORA service area. The development, calibration, and validation of the EFDC Water Quality Model will be performed as part of this project, as described in the preceding sections of this QAPP.

If potential quality assurance issues are identified following model calibration and/or scenario application, corrective actions required to address these issues will be performed by the modeling team. The LimnoTech Water Quality Model Task Leader and Project Manager will be responsible for ensuring that identified corrective actions are implemented. The modeling team will document these activities as they occur, and the information will be maintained by the project team. This documentation will be included in the project records.

The LimnoTech Water Quality Model Task Leader and Project Manager will review the modeling work conducted for this project, including model results and documentation of the modeling effort to ensure that a scientifically credible product is produced. The modeling team will address technical issues identified from these reviews.

If the review results in detection of unacceptable conditions or data, the LimnoTech Water Quality Model Task Leader will be responsible for developing and initiating corrective action. Staff will be notified if the nonconformance relates to their work. Corrective response actions may include review or validation of data, performing additional model runs, or editing and modifying report deliverables. Determination of the appropriate corrective response will be coordinated by the LimnoTech Project Manager and Water Quality Model Task Leader. Decisions will be documented in the Water Quality Report. LimnoTech will meet all QA requirements prior to approval of the final deliverables.

4.1.1 Field Measurements

Field quality control checks will consist of QA/QC samples that will be collected or prepared by the field crews to be submitted for laboratory analysis. These samples will consist of duplicates/replicates, and field blanks. Each sampling crew will collect a field duplicate per sampling crew, and blanks will be collected at a frequency of one blank per sampling crew during each sampling event. The acceptable control limits are discussed in Section 2.4. Upon receipt of

the data from the monitored event, the Field Managers will assess the adequacy of the quality control checks and identify any problems.

Quality control checks will be conducted in advance of using multi-parameter meters. The checks will involve the review of the previous calibration sheets. Any problems with sensors will be addressed immediately. The result of each review will be recorded on the instrument's calibration sheet. At the conclusion of each monitored event, all calibration sheets will be reviewed by the Field Crew Manager and the Field Manager to assess the adequacy of the quality control checks and to review the instrument's performance to identify any problems.

The Field Manager will inform the Monitoring Task Manager and the Project Manager in writing of any quality control check issues and to discuss corrective actions. All quality control documents will be contained in a file for each monitored event.

4.1.2 Laboratory Measurements

The contract laboratory will perform quality control checks as described in this QAPP. These will include replicates, control samples, and method blanks as appropriate. Quality control procedures for analytical services will be conducted by the contract laboratory in accordance to their standard operation procedures and the individual method requirements referenced by U.S. EPA or Standard Methods. The acceptable control limits for this project are discussed in Section 2.4. The Laboratory Manager or designee will inform the QA/QC Manager immediately of any quality control check issues and to discuss corrective actions.

At the conclusion of each monitored event, the contract laboratory will provide a summary of all QA/QC results. The QA/QC summary will be reviewed by the Laboratory Manager or designee and the QA/QC Manager to assess the adequacy of the quality control checks and to identify any potential problems. Table 4-1 summarizes the laboratory quality control check frequencies.

Table 4-1: Laboratory Quality Control Check Frequencies.

Parameter	QC Check	Frequency
E. coli	Positive/Negative Controls[1]	See footnote 1
	Replicate[3]	20 samples[3]
	Method Blank[2]	See footnote 2
Fecal coliform	Positive/Negative Controls[1]	See footnote 1
	Replicate[3]	20 samples[3]
	Method Blank[2]	See footnote 2
Enterococcus	Positive/Negative Controls[1]	See footnote 1
	Replicate[3]	20 samples[3]
	Method Blank[2]	See footnote 2

Notes:

[1] The frequency for analysis of the bacteria controls can be done at the option that occurs most often: 1) new media lot; 2) one set per event; 3) one set per month.

[2] Method blank frequency depends on the analytical method but the recommendations include, to the extent applicable: 1) check of dilution water; 2) when a low concentration sample (e.g. Delaware River) is analyzed using the same filter apparatus after a high concentration sample (e.g. CSO or SW sample); 3) at the start of a new batch of samples.

[3] When sample volume allows, the replicate should be a DELCORA sample.

4.1.3 System Audits and Technical Reviews

All project team members are committed to providing quality services. The primary responsibility for the quality of work products rests with the individuals doing the work and with their immediate supervisors.

For certain project components an independent technical reviewer will audit or review the work products. This reviewer may be the Monitoring Task Manager or a consultant team member not directly involved with the work being audited. The independent technical reviewer will perform a critical, written evaluation of the work product, and the independent technical audit or review will be incorporated in the project record.

The Monitoring Task Manager is responsible for identifying the work products to be audited/reviewed and the scope of the audit/review, for scheduling independent technical audits/reviews, for assigning competent, qualified independent technical auditors/reviewers, and for making sure that appropriate follow-up actions are taken to correct reported deficiencies.

4.1.3.1 Field System Audits

Field system audits will be completed to ensure that the actual field procedures conform to those documented in the SAP and associated SOPs. The Project Manager or designee will perform the

field system audits. The audit will include a check of all field records and a review of all activities to document if procedures were conducted in compliance with the specified documentation.

4.1.4 Corrective Action

Corrective actions will be implemented as required to rectify problems identified during the course of normal field and laboratory operations. Possible problems requiring corrective action include:

- Equipment malfunctions;
- Analytical methodology errors; or
- Non-compliance with quality control systems.

Equipment and analytical problems that require corrective action may occur during sampling and sample handling, sample preparation, and laboratory analysis.

For non-compliance problems, steps for corrective action will be developed and implemented at the time the problem is identified. The individual who identifies the problem is responsible for immediately notifying the Field Manager.

Any non-conformance with the established quality control procedures outlined in the QAPP will be identified and corrected. The Field Manager will issue a Corrective Action Memorandum for each non-conformance condition. All non-conformance memoranda will be discussed in the final report submitted to the Project Manager.

4.1.4.1 Field Measurements and Sample Collection

Project staff will be responsible for reporting any suspected QA non-conformance or deficiencies to the Field Manager. The Field Manager will be responsible for assessing the suspected problems in consultation with the Monitoring Task Manager to review the sampling protocols and provide additional training if necessary. If it is determined that the situation warrants a corrective action, then a Corrective Action Memorandum will be issued by the Field Manager.

The Field Manager will be responsible for ensuring that the corrective action for non-conformance takes place by:

- Evaluating all reported incidences of non-conformance;
- Controlling additional work on nonconforming items;
- Determining what corrective action is needed;
- Maintaining a log of non-conformance issues;
- Reviewing responses to corrective action memoranda;
- Ensuring that copies of corrective action memoranda and responses are included in the project files

No additional work will be performed until appropriate corrective action has been implemented and documented in response to the corrective action memoranda.

4.1.4.2 Laboratory Analyses

Corrective actions are required whenever laboratory conditions, instrument malfunction or personnel situations have led or could potentially lead to errors in the analytical data. The corrective action taken will be dependent on the analysis and the event.

Laboratory personnel are alerted that corrective actions may be necessary if:

- QC data are outside the acceptable range for precision and accuracy as identified in Section 2 ;
- Blanks contain target analyses above acceptable levels;
- Undesirable trends are detected in spike recoveries or RPD between duplicates;
- Excessive interference is noted; or
- Deficiencies are detected by the QA staff during laboratory system audits as described in Section 4.1.3.

Corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors, checks the instrument calibration, spike and calibration mixes, and instrument sensitivity, etc.

Corrective action taken within the laboratory is the responsibility of the Laboratory Manager who informs the Monitoring Task Manager when a problem occurs and of the steps taken to resolve the problem. All non-conformance memoranda initiated by the contract laboratory will be discussed in the case narrative or included in the laboratory reports.

4.2 Reports to Management (C.2)

The Monitoring Task Manager and Laboratory Manager provide independent reporting to the Project Manager on an as needed basis. This communication is facilitated through the use of electronic mail, which provides ready access. In addition, the team leaders will provide written reports to the Project Manager on quality assurance issues as described in the QAPP.

Field and laboratory system audits will be performed as described in Section 3.1.3 and the results will be provided to the Project Manager. The results of all audits will be summarized in written reports, with copies retained in the Project Files. The audit reports will be completed for field and laboratory system audits according to the general outline described below.

All audit reports will include the following sections:

- Introduction – provides background of the project, laboratory, or program element, description of personnel and affiliation of all staff involved, the name of the auditor, the time and date of the audit, and a description of the activities audited.

- Audit Findings – describes the results of the audit including a deficiency report identifying all instances where the procedures in the SAP, QAPP, or laboratory QAM were not followed.
- Conclusions – summarizes the results of the audit and includes recommended actions to address any noted deficiencies.

The delivered documents and associated data will be accurate, complete, and traceable. The LimnoTech Water Quality Model Technical Leader and Project Manager will also provide independent reporting via emails on quality assurance issues to Greeley and Hansen and DELCORA on an as needed basis. Communication will be initiated concerning any of the following:

- Adherence to project schedule and budget;
- Any deviations from the QAPP;
- Potential uncertainties in decisions based on model predictions and data; or
- Data quality assessment findings regarding input data and model outputs.

Monthly project status reports will be prepared and delivered with monthly invoices. The status reports will describe (by task) activities during the previous month, and upcoming anticipated activities. The Water Quality Model report will document all aspects of the project.

Section 5 Data Validation and Usability (Group D)

The Group D Data Validation and Usability elements are addressed in this section. The purpose of these elements is to determine if the data meet the project's Data Quality Objectives (DQOs) (validation) and to evaluate the data against the method, procedural and/or contractual requirements (verification). Data validation, verification, and usability assessment will be conducted as outlined in this QAPP.

The data generated from the sampling program will be subjected to a multi-tiered review process described below. This process includes:

- A review of the data at the bench and field levels;
- A secondary review of field records by the Field Managers and analytical results within the laboratory by the QA/QC Manager to verify the data against method and SOP requirements;
- A screening level review of the verified data by the Monitoring Task Manager for reasonableness and to identify obvious data anomalies;
- A validation by an objective third party; and finally,
- An assessment of the data by project team members for its usability in the project as described in Section 5.1 of this QAPP.

5.1 Data Review, Verification and Validation (D.1)

All environmental measurement data collected by project staff will be subjected to quality control checks before being utilized in the interpretive reporting. A data generation system that incorporates reviews at several steps in the process is designed to protect the integrity of the data and reduce the number of data that do not meet the DQOs or the project goals. This section describes the requirements of each review step that will be used in this project.

5.1.1 Data Verification Requirements

The definition of data verification, as described in the EPA's "Guidance on Environmental Data Verification and Data Validation" (EPA QA/G-8) is:

> "…the process of evaluating the completeness, correctness, and conformance/compliance of a specific dataset against the method, procedural or contractual requirements."

Data verification will occur at the field and laboratory level as described in Section 2.4. This section describes the requirements of the data verification.

5.1.1.1 Field Activities Data Verification

The Field Manager will be responsible for ensuring that the samples are collected and handled according to the procedures specified in the Water Quality Monitoring Work Plan. Sample collection verification will include confirming that the samples were collected with the proper equipment at the appropriate locations with the appropriate frequency. Sample handling verification will include confirming that the samples were stored in the appropriate containers (see Table 3-1) with the correct preservative, that the samples were stored at the proper temperature during transport from the field to the laboratory, and that all of the appropriate information is logged on the chain-of-custody records.

5.1.1.2 Lab Activities Data Verification

The laboratory QA/QC Manager will be responsible for verification of laboratory-generated data, although the laboratory SAPs for each method require some components of the verification to also be conducted at the bench level. Laboratory verification will include assessing that the procedures used to generate the data are consistent with the method requirements as specified in the laboratory's SOPs and that the QA/QC requirements for each method are met. Examples of method requirements include verifying the calibration and data reduction procedures. However, these requirements vary by analyte and are presented in more detail in the laboratory's QAM and SOPs (Appendices A and B, respectively). Once the data have been verified and approved by the laboratory, they will be released to the Monitoring Task Manager.

5.1.2 Data Review Requirements

The Field Manager will perform data reviews consisting of screening the field and laboratory data sheets according to established criteria listed in this section. If the established screening criteria are violated, an additional review of the quality control checks and any relevant laboratory bench sheets will be conducted. The investigation of the issue will be documented and the data will be discarded or flagged appropriately, identifying the limitations of the data. This is an additional step of review that is designed to provide an early assessment of the data's use in meeting the project goals by evaluating it within the context of well-understood constituent relationships.

5.1.2.1 Field Data Sheet Reviews

The following criteria will be used to screen the recorded physical parameter measurements:

1. Salinity readings – do values seem reasonable?
2. Temperature readings – do values seem reasonable?
3. Conductivity readings – do concentrations seem reasonable?

5.1.2.2 Laboratory Data Sheet Reviews

The following criteria will be used to screen the analytical measurements performed by the contract laboratory:

1. Equipment blanks – are values less than detection limits?
2. Method blanks – are values less than detection limits?
3. Field blanks – are values less than detection limits?
4. Review of all values – do concentrations/densities seem reasonable?

5.1.3 Data Validation Requirements

The purpose of data validation, as described in the EPA's "Guidance on Environmental Data Verification and Data Validation" (EPA QA/G-8) is:

> "…an analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance to determine the analytical quality of a specific data set."

According to U.S. EPA guidance, the data validation is typically performed by someone independent of the project activity and not associated with the organization responsible for producing the dataset. However, the data validator needs to be familiar with both the data validation requirements and the project objectives. The identified QAO from LimnoTech will conduct the data validation.

The first requirement in this project's data validation is to inspect the data verification and review records to ensure that no oversights were made during that process. The second requirement of the data validation is to evaluate the data against the project's DQOs, which are presented in Section 2.4. If data do not meet one or more of the DQOs, the data validation process will include an investigation into causes and an assessment of the impact of the noncompliant data on project objectives. The third requirement of the data validation is to evaluate the data in the context of the project's overall objectives, which are described in Section 2.1. The fourth requirement of the data validation is to communicate the data validation results to the rest of the project team.

5.2 Verification and Validation Methods (D.2)

All environmental measurement data and samples collected by project staff will be subjected to quality control prior to being entered into the project database. This is a multi-step process where the laboratory QA/QC Manager will have primary responsibility for verifying the data and a third party, who is not involved in the data collection or analysis, conducts the data validation. These steps are described in more detail in the following sections.

5.2.1 Data Verification

This section describes the procedures that will be utilized in this project for verifying the data against method, procedural and/or contractual requirements.

5.2.1.1 Field Activities Data Verification

Individual crew leaders will verify the completion of their field data sheets and chain-of-custody forms. In addition, crew leaders will also verify the proper calibration and operation of their multi-parameter instruments. At the completion of each monitored event, the Field Manager will review all field data sheets, calibration sheets, and chain-of-custody forms for accuracy and completeness. The Field Manager will also verify that monitoring QA objectives for all accuracy, precision, completeness, and adherence to the required collection techniques are being met.

5.2.1.2 Laboratory Analytical Results Verification

Individual analysts will verify the completion of the appropriate analytical test and required bench sheets. The Laboratory Manager or designee will review calculations and inspect laboratory bench sheets and log books daily to verify their accuracy, completeness, and adherence to the specified analytical method protocols. Calibration and QC data will be examined daily by the individual analyst. The Laboratory Manager or designee will verify that all instrument systems are under control and that QA objectives for accuracy, precision, completeness, and adherence to the required detection limits are being met.

A summary of all QA/QC results and any non-conformance issues will be included in the laboratory deliverable to the Field Manager.

5.2.2 Data Validation

This section describes the process that will be used to validate the data generated for this project. The first requirement in this project's data validation is to inspect the data, verification and review records to ensure that no oversights were made during that process. A complete set of field and laboratory information will be provided to the data validator for this task. The data management components described in Section 3.10 will be sufficient for this purpose.

The primary objective of the data validation in this project is to evaluate the data against the DQOs presented in Section 2.4. These DQOs include criteria for accuracy, precision, completeness, representativeness, comparability and compliance with required detection limits. The data management components described in Section 3.10 will provide the necessary information to make this evaluation. The following must be checked as part of the measurement data and analytical data validation activities.

1. field measurements data collection
2. field sample collection

3. sample custody
4. laboratory analytical results and case narrative
5. data reviews
6. quality control data

The QAO will conduct a systematic review of the data for compliance with the established quality control criteria based on duplicate, replicate, spiked, control, and blank data results provided by the laboratory. In addition, quality assurance evaluations of data accuracy, precision, and completeness will be performed on the field measurement data and the laboratory analytical results for each monitored event. The data validation qualifiers listed in Table 5-1 will be used when validating the data:

Table 5-1: Data Validation Qualifiers

Qualifier	Definition
U	The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
J	The associated value is an estimated quantity.
R	The data are unusable (note: analyte may or may not be present)
UJ	The material was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.

If quality control checks or objectives were not met, an investigation of the non-conformance will be initiated by the QAO with the project team personnel, including the Field Manager, the laboratory QA/QC Manager, and the Project Manager. The non-conformance will be documented and the affected data set will be flagged appropriately, identifying any limitations.

Another objective of the data validation is to evaluate the data within the context of the project goals. As described in Section 2, these goals include providing datasets that can be used to develop model inputs, to calibrate and validate the models, and to ensure consistency among different sources of data. Suitable datasets for the modeling portion of this project will be based on the data quality assessment described above as well as an assessment of the spatial and temporal extent of the sample collection. Comparability with other sources of data will be evaluated by comparing and, if necessary, plotting the data with previously collected data to identify outliers or anomalous values.

The data validation results will be communicated to the project team in the form of a summary table that lists the validation tasks performed and the associated results and conclusions. If the validated dataset includes non-compliant data, this data will be addressed in a memo that accompanies the summary table. Data qualifiers assigned to the data during validation will be maintained in the project database to ensure communication of validation results with current and future data users.

5.3 Departures from Validation Criteria

This section describes the process to assess the usability of model results. All interim and final model results will be evaluated by the LimnoTech Principal Investigator.

Criteria will be established to decide whether to accept, reject, or qualify the data collected for the project and generated by the model. This work is done by adopting validation and verification criteria. Validation criteria specifies whether data satisfy user requirements, and verification criteria determine if data are sufficient for drawing data quality conclusions and project objectives. For all data, sufficient metadata must be available to allow persons unfamiliar with the data to make intelligent use of them. All data will be reviewed for usability, general quality, and consistency with other available data sources, prior to use in the modeling activities. Limitations in the data sets will be acknowledged and included in discussions of their use. All data entered manually or electronically will be confirmed by checking the source data.

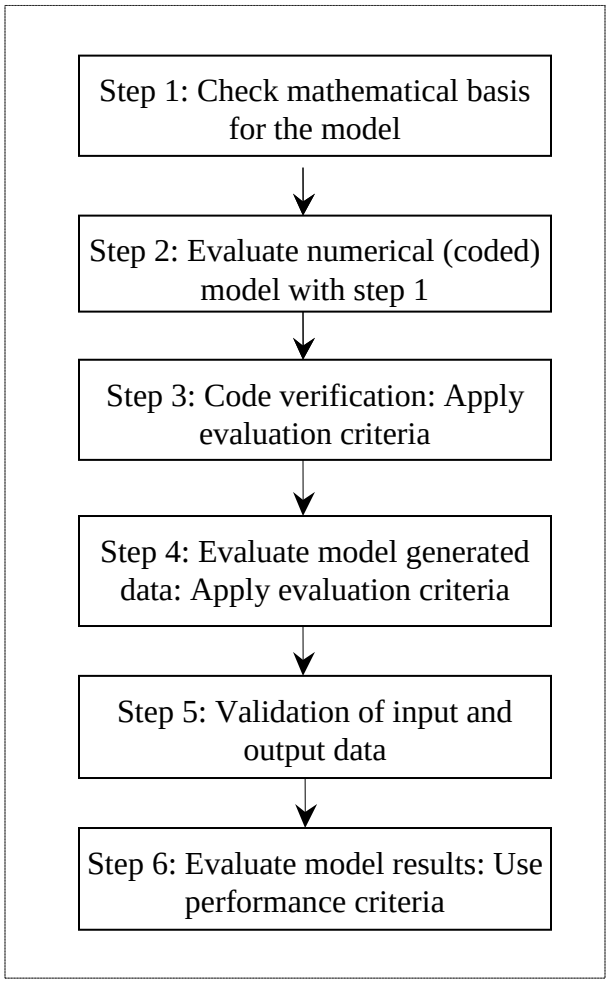
Qualified data will be examined on a case by case basis relative to including it in calculations. The decision to include qualified data will depend on a sensitivity analysis of the effect of uncertainty in the data on the calculation outcome. The data review and compilation task will be performed by experienced personnel.

With regard to the use of data in the modeling, each data set will be categorized according to validation criteria into different groups by its usability, as described in Section 3.2. The categories will include:

- Accepted (results can be used without any restrictions);
- Qualified (acceptable under certain conditions) – the team will specify conditions and provide the validation and usability of the results to satisfy the project objectives; and
- Rejected (cannot be used; will identify the problems and reasons for unsuitability).

The acceptance criteria for the modeling process includes evaluation of the model at various stages of the process as described in Figure 5-1. Model simulations will be compared with an independent data set that was not used for model development and model calibration purposes. Evaluations will be done by comparing plots of data and model predictions. These plots will not only provide the quantitative estimates, but will also provide qualitative assessments. As information is passed from one step of the modeling process to another, different assessments will be planned to determine if they are acceptable to pass on to the next phase. The individual assessments of the steps identified in Figure 5-1 will provide the basis of the overall assessment. The modeling team will discuss all issues identified pertaining to these criteria, alert the LimnoTech Project Manager and Water Quality Model Technical Leader about any identified issues, and will document any procedures used to resolve them. In general, judgments on the accuracy of the model results will be made by comparing the simulated results with previous results that have been peer reviewed, and with observed trends in the data. If the model results do not compare well, the inputs will be reexamined and the model will be run with adjusted inputs if needed.

Figure 5-1: Criteria for Various Stages of Modeling Process



All project deliverables will undergo in-house review and validation by project staff, review by the Field Manager Task Leader, Water Quality Model Task Leader and the Project Manager, and review by Greeley and Hansen.

5.3.1 Validation Methods

The model input data and model results will undergo extensive review for quality control by the project staff, Principal Investigator and Project Manager. As described in Section 4.1, model runs that are used to generate final results will be compared against model results from previous scenario runs to ensure consistent results. Any deviations from previous model runs will be noted and investigated to ensure that the model predictions are accurate and reasonable.

Data used for inputs will be evaluated for adequacy in terms of the common data quality indicators, such as precision, accuracy, comparability, representativeness, and completeness. Judgments on the accuracy of the data will be checked by comparing the data trends and by comparing data with any historical data available. Each data set will be categorized in different groups by its usability, as described in Section 2.4.

The project team is responsible for establishing and maintaining the QA/QC processes outlined in this QAPP to ensure the quality of the project data. The modeling team will discuss all the issues identified pertaining to available data, alert the LimnoTech Project Manager, Water Quality Monitoring and Modeling Task Leaders and Quality Assurance Manager about any identified issues, and will document in the final report the procedures used to resolve them.

5.3.2 Reconciliation with User Requirements (D.3)

Once all field measurements and analytical data have been reviewed, quality control measures assessed, and any problems addressed, the measurement and analytical data will be assessed.

The assessment of the information generated from the monitoring program will be initiated by entering all analytical data and field measurement data into the project database. In addition, precipitation, flow data, velocity data, stage data, field notes, and information on any sampling anomalies will be appended. All of these data will be evaluated and any relationships or correlations will be noted. The compilation of all information surrounding a sampling and/or monitoring event will be available to facilitate reconciliation with user requirements. Ultimately, these data will be used in the development of the watershed and water quality models.

The modeling staff, which includes the LimnoTech Project Manager, Water Quality Model Task Leader and Quality Assurance Manager, will review the model results, incorporating the uncertainty in model predictions, and will check model predictions for reasonableness and relevance based on observed data. The model development and testing are intended to ensure that if the step to develop the cause-effect relationship meets its own internal quality standards, the output of this step (i.e., the output of modeling framework) will meet the requirement for the entire project. Therefore, if the model outputs meet the internal criteria for establishing the cause-effect relationships, as described in this plan, requirements for the overall modeling framework will be met.

Section 6 References

United States Environmental Protection Agency (USEPA), 1998. EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5. Washington, DC.

United States Environmental Protection Agency (USEPA), 2001. EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5. Washington, DC.

United States Environmental Protection Agency (USEPA), 2002a. Guidance on Environmental Verification and Data Validation. EPA QA/G-8. Washington, DC.

United States Environmental Protection Agency (USEPA), December 2002b. Guidance for Quality Assurance Project Plans for Modeling. Office of Environmental Information. Washington, DC. EPA QA/G-5M. EPA/240/R-02/007.

United States Environmental Protection Agency (USEPA), 2009. Council for Regulatory Environmental Modeling (CREM), 2009. Guidance on the Development, Evaluation, and Application of Environmental Models. EPA/100/K-09/003. March 2009. United States Environmental Protection Agency, Office of the Science Advisor, Washington D.C. URL: http://www.epa.gov/crem/library/cred_guidance_0309.pdf

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APPENDIX A

EuroFins QC Laboratory Quality Assurance Program

Eurofins QC, Inc. UNCONTROLLED DOCUMENT
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QUALITY SYSTEMS MANUAL

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1.0 APPROVAL OF IMPLEMENTATION

1.1 The personnel listed on Page 1 of this document authorize the implementation of the management of this Quality Systems Manual (QSM).

2.0 TABLE OF CONTENTS

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3.0 INTRODUCTION AND SCOPE

3.1 Introduction

3.1.1 On May 1, 2015, QC Inc. was acquired by Eurofins Scientific, a global laboratory company based in Europe, and the Company became Eurofins QC, Inc. (EQC), a solely-owned subsidiary of EQC Holdings, Inc., incorporated in the State of Delaware.

3.1.2 EQC was originally founded in 1943 as a dairy testing lab, and since that time, the Company has evolved into a full-service environmental laboratory. The Company has also expanded its product offerings to include food and pharmaceutical testing. Food, dairy, and pharmaceutical operations (collectively referred to as Life Sciences) are now located at the laboratory facility in Horsham, PA. Operations at the Southampton facility consist primarily of environmental laboratory testing and associated support functions. EQC provides analytical services to support testing under the Clean Water Act (CWA) through the National Pollution Discharge Elimination System (NPDES) and the Safe Drinking Water Act (SDWA). EQC supports homeowners and public water suppliers through the analysis of potable water governed by the National Primary and Secondary Drinking Water Regulations (SDWA), the Private Well Testing Act (PWTA) of New Jersey, and other state regulations. Laboratory testing also supports site assessments, hazardous waste determinations, remedial investigations, and other characterizations regulated by Resource Conservation and Recovery Act (RCRA), Toxic Substance Control Act (TSCA), and other state, Federal, or private programs. Accreditations held by EQC are listed in Table 1. The foremost goal of the laboratory is to provide analytical data of the highest quality that are complete, accurate, legally-defensible, and produced in an ethical and timely manner.

3.1.3 EQC also operates satellite facilities in Horsham, PA; East Rutherford, NJ; Vineland, NJ; Wind Gap, PA; Reading, PA; and New Castle, DE.

3.2 Scope

3.2.1 The QSM, previously titled Quality Assurance Program Plan (QAPP), describes measures taken to ensure that laboratory data of known and acceptable quality are provided in compliance with all regulatory requirements. More detailed procedures are contained in the laboratory's Standard Operating Procedures (SOPs), which include operation, maintenance, and quality control procedures practiced routinely in the laboratory. The QSM and SOPs function together to assure laboratory analysis of the highest quality.

3.2.2 Satellite facilities are maintained in strategically-located areas (see Section 3.1.2) and serve primarily as intermediate transfer points for samples en route to the Southampton laboratory. Samples are transferred from satellite facilities to the testing laboratories according to procedures described in SOP QC0432 (Sample Transfers between EQC's Satellite Offices and the Southampton Laboratory) and SOP QC0889 (Sample Handling Details: Addressing Sample Movement from the Field or Deliveries to the Satellite). Satellite facilities also maintain accreditation for a limited number of microbiological and field testing parameters. The EQC-Delaware satellite location is accredited for microbiological and general chemistry parameters.

3.2.3 The QSM, SOPs and other documents referenced in this manual apply to the Environmental Division laboratory operations at EQC-Southampton and its satellite facilities. A separate QSM covers Life Sciences operations at EQC-Horsham.

3.3 References

3.3.1 TNI Standard, adopted by NELAP Board on September 8, 2009.

3.3.2 Environmental Laboratory Accreditation, PA Chapter 252, April 2010.

3.3.3 Regulations governing the certification of laboratories and environmental measurements, NJ AC 7:18, November 2006.

3.3.4 *Manual for the Certification of Laboratories Analyzing Drinking Water*, Criteria *and Procedures Quality Assurance,* January 2005, EPA 815-R-05-004 (CLADW); and *Supplement 1 to the Fifth Edition of the Manual for the Certification of Laboratories Analyzing Drinking Water*, June 2008, EPA 815-F-08-006.

3.4 Glossary and Acronyms

AA	Accrediting Authority
ANSI	American National Standards Institute
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
°C	degrees Celsius
CAS	Chemical Abstract Service
CCV	Continuing calibration verification
COC	Chain of custody
DO	Dissolved oxygen
DOC	Demonstration of Capability
IDOC	Initial Demonstration of Capability
EPA	Environmental Protection Agency
g/L	grams per liter
GC/MS	Gas Chromatography/Mass Spectrometry
ICP-OES	Inductively Coupled Plasma Optical Emission Spectroscopy
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
ICV	Initial calibration verification

ISO/IEC	International Organization for Standardization/International Electrochemical Commission
lb/in2	pound per square inch
LRB	Laboratory Reagent Blank
LCS	Laboratory control sample
LFB	Laboratory fortified blank
LIMS	Laboratory Information Management System
LOD	Limit of Detection
LOQ	Limit of Quantitation
MDL	Method detection limit
mg/Kg	milligrams per kilogram
mg/L	milligrams per liter
MS	Matrix spike
MSD	Matrix spike duplicate
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NIST	National Institute of Standards and Technology
PT	Proficiency Test(ing)
PTOB	Proficiency Testing Oversight Body
PTPA	Proficiency Testing Provider Accreditor
QA	Quality Assurance
QC	Quality Control
QSM	Quality Systems Manual
QAM	Quality Assurance Manager
r	Correlation coefficient
RL	Reporting level
RPD	Relative percent difference
RSD	Relative standard deviation
SOPs	Standard operating procedures
TNI	The NELAC institute
µg/L	micrograms per liter
UV	Ultraviolet
VOC	Volatile organic compound
WET	Whole effluent toxicity

4.0 ORGANIZATION

4.1 Laboratory Organizational Structure

4.1.1 EQC's organization chart structure is shown in Figure 1. Floor plans of EQC's major laboratory facilities are shown as follows: Figures 2A and 2B (EQC-Southampton, PA facility), Figure 2C (EQC-Horsham, PA facility), and Figure 2D (EQC-Delaware, New Castle facility).

4.2 Responsibility and Authority

4.2.1 Support for the overall system is provided by management through the allocation of material and human resources as needed. Implementation of the quality systems described in this manual is an operational responsibility for all employees. Laboratory managers and analytical personnel are trained in the

applicable procedures and decision-making processes for which they are responsible. General oversight of the program rests with the Quality Assurance Director who reports directly to the President. Responsibilities of key personnel are described in Section 20.0 (Personnel).

5.0 MANAGEMENT

5.1 Introduction

5.1.1 The laboratory's quality management system includes documentation of policies and procedures necessary to assure the quality of the test results.

5.2 Quality Policy

5.2.1 EQC is committed and dedicated to providing analytical data of the highest quality to its clients. Data produced and reported must meet the requirements of its clients and also comply with the letter and spirit of regulations and guidelines promulgated by various municipal, state, and federal agencies. Protocols and procedures are based on approved documents developed primarily from methods and regulations issued by various federal or state agencies, e.g. the United States Environmental Protection Agency (USEPA), Pennsylvania Department of Environmental Protection (PADEP), and the New Jersey Department of Environmental Protection (NJDEP), for the analysis of multimedia samples for a broad range of inorganic, organic, microbiological, and biological constituents. EQC's quality program encompasses the requirements for producing and reporting data of known and documented quality to its clients. It is understood that data are to be used by clients to make rational, confident, cost-effective decisions regarding assessment and resolution of their environmental compliance requirements.

5.2.2 It is the policy of EQC to incorporate the highest standard of quality into all analytical programs by adhering to the following practices:

5.2.2.1 EQC will only offer environmental analyses for which it can consistently demonstrate compliance with high-quality, traceable, and legally-defensible performance standards.

5.2.2.2 All EQC personnel are committed to good professional practice and honesty in the production and reporting of data.

5.2.2.3 EQC personnel are employed by or under contract to EQC. All personnel are qualified, supervised, and trained as required by the company's quality system.

5.2.2.4 Staff who become aware of misrepresentation of facts or manipulation of data are required to immediately inform the Quality Assurance Director, Laboratory Director, or Laboratory President.

5.2.3 EQC is operated under an *Open Door Policy* that enables every employee to have free access to senior management. This *Open Door Policy* is intended to foster two-way communication, encourage ethical behavior, and identify inappropriate data production and reporting practices. It is clearly understood that such information is treated confidentially. Any undue pressures to report

non-compliant data, either financial or commercial, from corporate owners, supervisors, employees, or clients, are to be immediately reported to management.

5.2.3.1 The Quality Assurance Department provides oversight that is independent of laboratory operations to ensure that unbiased judgment and integrity are maintained at all times.

5.2.4 Objectives of the Quality Systems Manual

5.2.4.1 The QSM describes the procedures used in the laboratory to ensure that data generated meet the requirements of the relevant standards including: TNI Standards, PA Chapter 252, EPA's *Manual for the Certification of Laboratories Analyzing Drinking Water*, other applicable federal, state and municipal regulations, and the quality objectives of all clients and regulatory programs.

5.2.4.2 The QSM describes procedures for routine data review that facilitate early recognition and remediation of problems which might affect the reliability and reproducibility of the analytical results.

5.2.4.3 The QSM establishes and maintains procedures to ensure the traceability of activities associated with sample analysis beginning with sample collection and continuing through reporting and storage of all associated records, including the following: sample chain of custody; sample preparation and analytical records; methods used and documentation of any deviations from the method; pertinent calibration and continuing calibration verification data, including preparation and traceability of standards; associated quality control data including, but not limited to, matrix spikes, duplicates, laboratory control samples, method blanks, surrogates, and internal standards; records of routine and non-routine equipment maintenance; and analyst training records demonstrating competence in tests performed.

5.2.4.4 The QSM establishes a program to minimize the possibility of loss or damage through administrative SOPs which address data retention, including, but not limited to, archival and storage of data files, computer media, and hard-copy laboratory data.

5.2.4.5 The QSM establishes a program to minimize data integrity issues or tampering with data by administering an ethics training program which describes unethical, fraudulent, and improper laboratory practices. This includes proper manual integration techniques to identify inappropriate instrument manipulation practices.

5.3 Quality Systems Manual Implementation

5.3.1 The Quality Assurance Director is responsible for updating, revising, and distributing the QSM for EQC. The QSM is a numbered, controlled document which enables each copy to be tracked and revisions to be distributed. The QSM is reviewed at least every twelve months and revised as necessary. All

previous versions are archived in compliance with relevant state and federal regulations. A copy of the QSM is maintained in each laboratory department and is available for review by the analysts and supervisors. The QSM is required reading for all laboratory staff during initial training.

5.3.2 The Quality Assurance Director, in cooperation with the Laboratory Director and Department Manager(s), is responsible for training laboratory personnel and implementation of the QSM.

5.3.3 Staff listed on the title page of this document represent the approved laboratory personnel and signatories responsible for the implementation and application of this QSM.

5.4 Ethics and Data Integrity Policies

5.4.1 EQC maintains a data integrity program which includes the following: data integrity and ethics training; an employee-signed ***Eurofins' Ethics Policy Statement*** (Figure 2); monitoring of data integrity using internal audits of laboratory methods and standard operating procedures; and signed documentation of these data integrity procedures by laboratory management.

5.4.2 The ***Ethics Policy Statement*** is signed at the time of hire or within two weeks of receipt of this policy. The agreement, signed by both the employee and a representative of the corporation, is a pledge by the employee that he/she understands the EQC ethics program. By signing the document, the employee commits to the ethical analysis and reporting of data. Any employee violating the agreement is subject to disciplinary action which could include termination of employment or legal action.

5.4.3 Data integrity and ethics training is provided within three months of employment for new employees and annually thereafter within 14 months of the anniversary of the previous training date for all employees. Training documents are issued, which includes the organizational mission, key integrity issues, procedures for reporting data integrity issues, examples of improper practices, and consequences of such practices. Training is mandatory and attendance is documented.

5.4.4 Data integrity procedures are reviewed annually and updated by management as required. Monitoring of data integrity is accomplished primarily through the quality assurance audits conducted by the Quality Assurance Department as described in Section 17.0 (Audits). Adherence to standard operating procedures and laboratory protocols is maintained to ensure data integrity.

5.4.5 Management is responsible for upholding the spirit and intent of the data integrity procedures by effectively implementing the specific requirements of the program. Management support for this program is acknowledged through their approval of implementation of this QSM as well as acceptance of the corrective actions proposed in the laboratory audits.

6.0 DOCUMENT CONTROL

6.1 Controlled Documents

6.1.1 All documents used as part of the quality system and issued to laboratory personnel are considered controlled documents.

6.1.2 Controlled documents are authorized by the Quality Assurance Director, or his/her designee, and Laboratory Director and may include SOPs, policy statements, and other documents required to support the quality system.

6.1.3 Additional information regarding controlled documents is contained in Section 16.0 (Control of Records).

6.2 Obsolete Documents

6.2.1 Invalid or out-of-date documents are removed from use by retrieving documents from the recorded recipients and/or issuing a revised document. The Quality Assurance Department provides the recorded recipient with a notice of expiration for the retired document when the document cannot be retrieved.

6.3 Standard Operating Procedures

6.3.1 Analytical SOPs are prepared to encompass the requirements of the regulatory methods and to document actual laboratory procedures, especially in cases where established methods specifically allow for method flexibility. EQC's analytical SOPs follow a standard format which includes the following:

6.3.1.1 Scope, application, and discussion of the method including applicable matrices, detection limits, and limitations of the method.

6.3.1.2 Definitions of acronyms and terminology.

6.3.1.3 Discussion of potential interferences.

6.3.1.4 Required safety measures.

6.3.1.5 Sample collection preservation, handling, and storage requirements.

6.3.1.6 Apparatus, instrumentation, reagents, and standards.

6.3.1.7 Quality control requirements including criteria and corrective action to be taken in the event of a quality control failure.

6.3.1.8 Step-by-step procedures including calculation and reporting.

6.3.1.9 Requirements of initial demonstration of capability to perform the procedure.

6.3.1.10 Method performance data, either derived from internal laboratory data or taken from the original reference method.

6.3.1.11 Contingencies for handling out-of-control or unacceptable data.

6.3.1.12 Pollution prevention measures and instructions on waste management and techniques to be employed for waste reduction.

6.3.1.13 Reference to the regulatory or reference method from which the laboratory procedure is derived.

6.3.1.14 Tables, diagrams, and flow-charts, when applicable.

6.3.1.15 Signatures of Quality Assurance Director (or designee) and Laboratory Director (or designee)

6.3.1.16 Effective date and records of dates of all previous revisions.

6.3.2 In addition to the laboratory analytical SOPs, EQC's administrative SOPs provide instructions on performing other routine company procedures, including preparation of SOPs and issuance of policy statements.

6.3.2.1 Policy statements are interim documents that are issued to immediately address or define an issue which may not be addressed in an SOP or the QSM.

6.3.2.2 Policy statements are reviewed annually and integrated into an SOP or the QSM as required.

6.3.2.3 Only approved SOPs may be used for laboratory analyses.

6.3.3 SOPs and the QSM are approved and signed by both the Quality Assurance Director and the Laboratory Director, or their designees. All SOPs and the QSM are handled according to EQC's controlled document policies. The Quality Assurance Department maintains and distributes all original copies of SOPs and the QSM.

6.3.3.1 Authorized copies are assigned unique copy numbers, and distribution is controlled and documented allowing the retrieval and replacement of outdated SOPs. When new SOPs are issued, the old version is collected and archived. Analysts performing analyses under the SOP are required to document their understanding as part of their training.

6.3.3.2 Copies of EQC's controlled documents are available for review by outside vendors at the laboratory. Authorization from the Quality Assurance Director must be obtained by any individual wishing to obtain copies of any controlled document(s).

6.3.3.3 Electronic copies (.PDF format) of current SOPs are maintained in a shared directory by the Quality Assurance Director or designee. SOPs may be reviewed but are protected from unauthorized modification. Analysts may not make uncontrolled copies of SOPs.

6.3.3.4 Paper copies or scanned copies (.PDF format) of SOPs are maintained for a period not less than five years following the last date of use.

6.3.4 A listing of EQC SOPs is provided in Table 3.

6.3.5 SOPs may be supplemented by reference documents which are considered part of the controlled SOP. Documents may include all or part of the reference method and manufacturer's operating manuals.

6.3.6 Copies of current SOPs are kept in each department and are easily accessible to all analysts.

6.3.7 Laboratory SOPs are reviewed at least every 12 months by a manager or other authorized staff member. Revisions are made as necessary.

6.4 Control of Quality Assurance Documents

6.4.1 Controlled documents generated by the Quality Assurance Department are uniquely identified and contain a date of issuance, a revision number, and departmental approval signatures.

6.4.2 Controlled documents may be paper copy or electronic media.

6.4.3 Current revisions of controlled documents are available in the general location of usage.

6.4.4 Documents are periodically reviewed and revised by the Quality Assurance Department to ensure suitability and compliance with the intended purpose.

6.4.5 Making copies of controlled documents is strictly prohibited. Confidential, uncontrolled documents may be issued to outside entities, e.g. regulatory authorities and clients, with approval and documentation of the Quality Assurance Department.

6.4.6 Uncontrolled documents are labeled with an expiration date to prevent extended use.

6.4.7 The laboratory uses reference documents from several external sources for a wide range of tests from a variety of method sources that have been nationally and internationally recognized for use in environmental analysis including the following:

- Methods for Chemical Analysis of Water and Wastes (USEPA)
- Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater (USEPA)
- Methods for the Determination of Metals in Environmental Samples (USEPA)
- Methods for the Determination of Inorganic Substances in Environmental Samples (USEPA)
- Methods for the Determination of Organic Compounds in Drinking Water (USEPA)
- Standard Methods for the Examination of Water and Wastewater (APHA, AWWA.WEF)
- Test Methods for Evaluating Solid Waste, SW-846 (USEPA); and
- Technical Standards - American Society for Testing and Materials (ASTM)

7.0 REVIEW OF WORK REQUESTS, TENDERS, AND CONTRACTS

7.1 Procedure for the Review of Work Requests

7.1.1 All new work requests are reviewed to assure that requirements are clearly defined, the laboratory has adequate resources and capability, and the test method is applicable to the needs of the customer. This process ensures that analytical data reported to the customer meet all applicable standards and project objectives.

7.1.2 Contracts for new work may consist of formal bids with signed documents, written or electronic quotes with or without client acknowledgement, or verbal quotes based on published price schedules.

7.1.3 The Laboratory Director or his/her designee shall review tenders, contracts and requests for analytical work in consultation with laboratory or client service staff and/or the Quality Assurance Director, as needed. The review includes, but is not limited to, laboratory accreditation status, analytical capability, laboratory workload, staff requirements, project-specific quality control requirements and/or reporting limits, turn-around time, and cost. EQC only accepts work for which it can meet project-specific objectives, regulatory requirements, and EQC's performance standards.

7.1.4 The Laboratory Director or his/her designee notifies the client of any potential conflict, deficiency, lack of accreditation, or inability of the lab to complete the work satisfactorily.

7.1.5 Test method, target analyte list, project-specific reporting limits, project-specific quality control requirements, turnaround time, and requirements for data deliverables are specified in the contract documentation.

7.1.6 The client is informed of any deviation from the contract including the test method or sample handling processes. All differences between the request and the final contract are resolved and recorded before any work begins. It is necessary that the contract be acceptable to both the laboratory and the client.

7.1.7 The review process is repeated when there are amendments to the original contract by the client. Participating personnel are given copies of the amendments.

7.1.8 The laboratory notifies the customer when the method proposed by the customer is inappropriate or out of date.

7.1.9 Following contract acceptance, the laboratory notifies the customer when there is a change in laboratory accreditation, staffing, instrumentation, or any other area that affects its ability to meet the client's requirements.

7.2 Documentation of Review

7.2.1 Records are maintained for every contract or work request. This includes pertinent discussions relating to the client's requirements or the results of the work during the period of execution of the contract.

7.2.2 Records of all project-related communication with the client (including e-mails, fax or written correspondence, and telephone conversations) are kept on file.

8.0 SUBCONTRACTING

8.1 Samples may be received for analyses for which EQC does not hold accreditation or which exceed the laboratory's current capacity to complete the analysis in a timely manner. In such instances, EQC subcontracts these samples to another NELAP-accredited laboratory or to a laboratory that meets the applicable statutory and regulatory requirements, i.e. a state-certified laboratory for which the samples are

appropriate. EQC notifies the client, as required, of its intention to subcontract any portion of the testing. The Laboratory Director and the Manager of Environmental Laboratory Administration maintain a documented list of approved subcontract laboratories. Subcontractors also may be employed to perform other functions, e.g. sample collection.

8.2 EQC maintains responsibility to the client for the subcontractor's work, except in the case where the client or a regulatory authority specifies which subcontractor is to be used.

8.3 It is the responsibility of the sample custodian or designee to assure that all subcontracted samples are appropriately preserved and that sufficient volume is available to perform the analysis. If sufficient volume has not been provided by the client, the client will be immediately notified and options will be discussed, including but not limited to re-sampling, reporting increased detection limits, or using an alternative method of analysis.

8.4 Samples to be subcontracted are entered into the LIMS according to routine procedures, the containers are assigned unique identification numbers, and the samples are tracked based on their LIMS identification numbers.

8.5 Each subcontracted sample is accompanied by a completed chain of custody form (COC), which includes all information specified in SOP QC0302 (Chain of Custody Procedure). Samples are relinquished by the Sample Custody Department to a laboratory courier or other transportation service for delivery to the subcontract facility. All requirements for maintenance of sample chain of custody apply to subcontracted samples.

8.6 Any analysis performed by the subcontractor is clearly identified in the associated laboratory report.

9.0 PURCHASING SERVICES AND SUPPLIES

9.1 All purchases of supplies and services are made through reputable service providers. The laboratory evaluates the suppliers of critical consumables, supplies and services that will affect the quality of the analyses performed.

9.2 Purchased supplies, reagents, and consumable materials are not used until they have been inspected or otherwise verified as complying with SOP requirements.

9.3 Detailed information about purchasing of services and supplies that affect analytical procedures is available in SOP QC0478 (Purchasing of Services and Supplies).

10.0 SERVICE TO THE CLIENT

10.1 Client Confidentiality

10.1.1 All test reports, analytical data, and information produced by EQC are confidential and will be released by EQC to another party only upon receipt of a written statement of release from the client and acknowledged by laboratory management. Outside parties may not review proprietary client data without first obtaining written permission from both EQC management and the original data end user. A client is that person(s) or entity requesting EQC services who is the responsible party for remuneration of such services. All EQC employees

are required to sign a Confidentiality Agreement (Figure 3) upon employment with the company.

Exceptions to this procedure follow in Sections 10.1.1.1 and 10.1.1.2.

10.1.1.1 EQC will release data if information is requested by a regulating agency with statutory authority, e.g. Pennsylvania Department of Environmental Protection (PADEP), the United States Environmental Protection Agency (USEPA), or other regulatory entity. Information is released only upon the display of acceptable identification.

10.1.1.2 EQC will release data if information is subpoenaed by any entity for enforcement or litigation. In these cases, the client is notified that this information has been supplied, and all information, e.g. requesting entities or individuals, is provided to the client by EQC.

10.1.2 EQC considers all documents governed under the controlled document policy to be proprietary. Therefore, EQC's policy is to distribute them to vendors and clients only with authorization and if required by contract. All documents and data records are available for review at the laboratory by clients, regulatory auditors, or other authorized personnel.

10.1.3 The distribution of any information without authorization is strictly prohibited. This includes verbal communications, electronic communication by FAX, email, text, or other means, written correspondence, or distribution of information in any other manner pertaining to a EQC client. Information subject to confidentiality includes, but is not limited to, specific report results and/or data associated with those results, client projects or programs, and regulatory requirements. EQC's confidentiality policy also protects material such as customer name, address, phone numbers, as well as any information regarding data, sample containers, and disposal methods.

10.1.4 Access to the LIMS is restricted, and employees are allowed access only to programs or authorization levels applicable to their job description. Access is approved by the Laboratory Director.

10.1.5 All data entries in LIMS are traceable to the employee and to the time of entry to ensure data integrity.

10.1.6 Access to archived information at the Southampton facility is controlled and documented with an access log. Laboratory data generated at EQC-Delaware are scanned and archived electronically as password-protected .PDF files to the EQC server. All archived records are protected against fire, theft, loss and environmental deterioration as described in Section 16.0 (Control of Records).

10.2 Customer Feedback

10.2.1 EQC seeks customer feedback from its clients, and positive and negative feedback are evaluated to improve the analytical processes, management system, and customer service.

11.0 COMPLAINTS

11.1 Client inquiries and/or complaints are directed to the Client Services Department. The customer service representative documents all issues and their resolutions in the LIMS Account History File. These include, but are not limited to, client inquiries regarding previously-reported analytical results or possible modifications to test methods, preservation issues, temperature violations, and all other sample issues. Client requests for confirmation of results are documented in LIMS and tracked through the Data Review Request (DRR) Maintenance file. A LIMS procedure is used to track unresolved issues, and a daily report (the "Issues List") is assigned to specific employees for resolution. The "Issues List" report acts as a reminder to staff to address unresolved issues within a reasonable time period. If any reviews indicate that the data quality is suspect, the customer is notified immediately and all relevant information is documented. Additional information is provided in SOP QC0510 (Customer Complaints). The report is reviewed periodically by the Laboratory Director or his/her designee, and repeated issues are investigated by the QA Department and targeted for corrective or preventive actions where necessary.

11.2 Following review of the original data, as discussed in Section 11.1, samples may be reanalyzed for confirmation of questionable results at the laboratory's discretion.

11.3 All resolutions and any changes made to final laboratory reports are recorded in LIMS.

11.4 In the event that the laboratory transfers ownership or goes out of business, all active customers will be notified in writing of the event. Customers will be given ten (10) working days to request custody of their analytical records. Additional information is provided in SOP QC0460 (Archiving and Storage of Data Files and Computer Media).

11.5 As part of EQC's on-going efforts to improve customer satisfaction, a survey is sent periodically to clients. The feedback obtained from these surveys is evaluated to improve performance and customer satisfaction.

12.0 CONTROL OF NON-CONFORMING WORK

12.1 Analytical data that deviate from required standards are reviewed by the Laboratory Director and Quality Assurance Director before reporting to any client or regulatory agency. This process is initiated through the use of a formal Data Variance Request (DVR) which is documented in LIMS. Procedures for initiating, submitting, and approving DVRs are described in SOP QC0515 (Data Variance Requests).

12.2 The Data Variance Request (DVR) is used to document deviations from policies, procedures, or quality control criteria or when it is not possible to comply with required corrective action procedures described in the SOP. Depending on the nature of the deviation, sample analysis may be suspended.

12.3 A DVR may be initiated by the analyst or department supervisor following initial review of the laboratory data. The DVR is initiated before results are entered into LIMS and within 72 hours of the identification of the issue, and the time of analysis.

12.4 A DVR is prepared and tracked in LIMS using a unique tracking number assigned by the system.

12.5 The DVR includes a description of the issue, reasons why it is not possible to meet the required quality control criteria, and any supporting documentation (e.g. raw data or summarized quality control results).

12.6 The DVR also includes the resolution proposed by the laboratory and any corrective or preventive actions taken to prevent a recurrence of the problem.

12.7 The DVR and associated data documentation are initially reviewed by the Department Manager. At this time, the required action for the DVR is logged into LIMS, i.e. it is accepted for further review or rejected as unnecessary. Following entry into LIMS, the Laboratory Director, Quality Assurance Director, and analysts are notified of the status of the DVR.

12.8 The DVR and associated documentation are reviewed by the Department Manager or, if necessary, the Quality Assurance Director and the Laboratory Director, to determine whether results are reportable. Comments or data qualifiers are included in the final report to document deviations from accepted methods that could impact the final results.

12.9 Before releasing analytical results to clients, the Manager of Environmental Administration or designee is responsible to assure that all relevant comments and data qualifiers have been entered into the LIMS.

12.10 Suspended analyses can resume upon the approval by the Quality Assurance Director and Laboratory Director.

13.0 CORRECTIVE ACTIONS

13.1 Selection and Implementation of Corrective Actions

13.1.1 Corrective and preventive actions (CAPA) reports are initiated upon identification of non-conforming work or deviations from policies and procedures in the management system or technical operations. CAPA reports are initiated, reviewed, and approved in LIMS in a manner similar to that for DVRs as described in SOP QC0515.

13.1.2 Deviations may be identified by routine quality control data review, internal or external assessments, client complaints, client queries, management review or feedback from clients.

13.1.3 Corrective action starts with an investigation to determine the root cause(s) of the problem. Once a root cause is determined, correction actions are taken which typically include instrument repair or maintenance, revision of laboratory processes and SOPs, purchase of new reagents or standards, and/or analyst retraining.

13.1.4 Depending on the nature of the deviation, analytical work may be suspended during the investigation. In cases where analytical work has been suspended, analyses may resume after it is verified that the corrective actions have been effective and the CAPA report has been approved.

13.1.5 CAPA reports are reviewed by the Laboratory Director, Department Manager (s), and Quality Assurance Director. Other management staff may be consulted and copied on CAPA reports. Upon approval of the CAPA report, suspended analytical work may resume.

13.1.6 Clients are notified by comments or data qualifiers on the final report that document deviations from accepted methods that could impact the final results.

13.2 Monitoring of Corrective Actions

13.2.1 Corrective and preventive actions are tracked in LIMS using Corrective and Preventive Action (CAPA) reports or Data Variance Requests (DVRs).

13.2.2 DVR and CAPA procedures are described in SOP QC0515.

13.2.3 The effectiveness of corrective actions is monitored by review of procedures and/or follow-up audits.

13.3 Policy of Permitting Departures from Documented Policies and Procedures

13.3.1 See Section 12.0 of this QSM.

14.0 IMPROVEMENT

14.1 EQC continually strives to improve the effectiveness of its management system through the use of the quality policy, quality objectives, audit results, data analysis, corrective and preventive actions, and management review.

14.2 A variety of audit, review, and survey reports are used to evaluate laboratory performance and implement changes for improvement. These include, but are not limited to, review of Proficiency Test (PT) study results, internal blind study results, internal and external audit reports, management review reports, and customer feedback surveys. For any unacceptable PT results, a root cause analysis is performed and documented, and required corrective and preventive actions are taken.

15.0 PREVENTIVE ACTIONS

15.1 Preventive action is a proactive process to identify opportunities for improvement, rather than a reaction to specific problems or complaints. Preventive actions may be taken as a result of trend analysis based on evaluation of quality control samples (e.g. LCS, surrogate, and MS/MSD recoveries), evaluation of proficiency testing results, internal blind study results, internal and external audit reports, management review reports, process changes based on recommendations from staff or clients, and customer feedback surveys.

15.2 Preventive actions typically include instrument repair or maintenance, revision of laboratory processes and SOPs, purchase of new reagents or standards, development of new methods, and/or analyst retraining.

16.0 CONTROL OF RECORDS

16.1 Procedures for archiving and storage of data are described in SOP QC0460. In general, EQC retains all original project records for a minimum of five years, unless otherwise agreed to with the client or required by regulation (e.g. lead/copper testing documentation is maintained for 12 years).

16.2 Laboratory records associated with the quality system include, but are not limited to, client communication records (e.g. letters, email communications, and phone logs), contracts, equipment maintenance and calibration records, employee training documentation, temperature tracking logs, standards and media records, and the applicable QSM and SOPs. Laboratory records are maintained for a period of five years unless otherwise agreed to with the client.

Project and laboratory records are maintained on site for an interim period depending on available storage space and frequency of use. Records are then transferred to a secured, offsite facility for the remainder of the five-year period.

16.3 Paper copies of project and laboratory records are indexed for later retrieval. Electronic files associated with LIMS and instrument workstations are backed up daily on QC Inc. servers.

16.4 Electronic data generated at EQC-Delaware are backed up to the EQC Server. Hard copy records (e.g. logbooks, spreadsheets, instrument printouts, and chain of custody records) are scanned in .PDF format and archived on the EQC server. Backup procedures are described in Section 16.1.

16.5 General records are considered to be company documents that are not related to data generation or data quality, e.g. health and safety records, general personnel files, accounting and financial documents. General records are archived according to guidelines applicable to the specific functional area as summarized below.

16.5.1 Safety-related documents, e.g. Laboratory Safety Procedure Manual, Material Data Safety Sheets (MSDS), Safety Data Sheets (SDS), are maintained indefinitely in hard copy at each facility and are also accessible online. A list of chemicals used by the laboratory is maintained for 30 years after last use.

16.5.2 Accounting, contract, and financial records are maintained for ten years.

16.5.3 Records related to general personnel files, payroll, and benefits plans are maintained in accordance with requirements of the EEOC (Equal Employment Opportunity Commission), ADEA (Age Discrimination in Employment Act), and FLSA (Fair Labor Standards Act). Personnel records are maintained for at least one year following the last date of employment. Payroll records are maintained for at least three years. Benefit plan information is maintained for at least one year following termination of the plan.

17.0 AUDITS

17.1 Internal Audits

17.1.1 The correct and complete implementation of the programs described in this QSM is confirmed periodically by federal and state auditors as well as outside clients. In addition, internal audits are conducted periodically of all analytical systems by the Quality Assurance Department. Findings and recommendations of each internal audit are documented and reported to the appropriate Department Manager(s), the Laboratory Director, and President. Internal audit procedures are documented in SOP QC0488 (Annual Review of Operations and Internal QA Assessments).

17.1.2 Laboratory management is responsible to respond to all audit findings and deficiencies. Corrective actions are monitored by the Quality Assurance Director as part of the audit follow-up process. Responses to audit findings are reviewed by the Quality Assurance Director. Clients are notified no later than the close of the following business day if audit findings affect data quality or will prevent reporting within the required time frame.

17.1.3 Internal audit procedures focus on the following areas:

17.1.3.1 Adherence to standard operating procedures and conformance to reference methods.

17.1.3.2 Evidence of required data reviews and approvals by technical and supervisory personnel.

17.1.3.3 Adequacy of document filing, storage, and retrieval systems.

17.1.3.4 Documentation of required quality summary reports (e.g., control charts, calibration curves) and CAR reports or DVRs documenting corrective actions for deviations and out-of-control analytical events.

17.1.3.5 Evidence of proper training of analysts (e.g. understanding of laboratory SOPs and troubleshooting procedures).

17.1.3.6 Documentation of proper maintenance of laboratory facilities and equipment.

17.1.4 Internal audits are conducted at least monthly to evaluate conformance to applicable regulatory standards. For each audit, one area of the laboratory operation is selected so that each area is audited twice by the end of a biennial cycle.

17.1.5 The Quality Assurance Department also conducts periodic reviews of randomly-selected projects.

17.2 External Audits

17.2.1 EQC cooperates with clients for vendor qualification inspections or any client-required, third-party audits.

17.3 Performance Audits

17.3.1 Review of Proficiency Test (PT) study data is a key element of performance audits. Corrective actions are implemented for non-conforming data and CAR reports are tracked in LIMS.

17.4 System Audits

17.4.1 The quality system is audited at least every year for conformance to applicable standards promulgated by TNI, EPA, or other regulatory authorities.

18.0 MANAGEMENT REVIEWS

18.1 An internal review of the overall quality systems is conducted annually by the Quality Assurance Director and Laboratory Director based on results of quality documentation for the previous 12 months. Documentation that is reviewed includes, PT performance results, customer complaint documentation, internal operational documentation, internal audit reports, reports from certification audits, field service records, DVR and CAR documentation, LIMS documentation, and data package error logs. Internal audit procedures are documented in SOP QC0488 (Annual Review of Operations and Internal QA Assessments). Issues resulting from the annual management review are identified and assigned to staff for action.

19.0 DATA INTEGRITY INVESTIGATIONS

19.1 Investigations resulting from data integrity issues are conducted in a confidential manner. These investigations are tracked and documented using tools including Data Review Request (DRR) forms, CAR reports, or DVR forms in LIMS as well as other internal documentation and memoranda. Clients are notified no later than the close of the following business day if investigation findings affect data quality or will prevent reporting within the required time frame.

20.0 PERSONNEL/JOB DESCRIPTIONS AND TRAINING

20.1 Job Descriptions

Job descriptions are issued to all employees. Each document outlines the employee's duties, responsibilities, education requirements, and minimum level of qualifications. Specific jobs may require additional training or education (e.g. supervisor positions or other specialized technical positions requiring knowledge of specific, complex methods). These requirements are identified in the individual SOPs. Training courses or workshops on specific equipment, analytical techniques, or laboratory procedures are documented in the employee training records.

Job descriptions for key positions are provided below.

20.1.1 Quality Assurance Director

20.1.1.1 Report directly to the President and has direct access to the Laboratory Director(s).

20.1.1.2 Serves as the focal point for implementation of the QSM and is responsible for oversight and review of quality control data.

20.1.1.3 Functions independently from laboratory operations.

20.1.1.4 Determines the effectiveness of the overall quality system within the laboratory and recommends appropriate corrective actions or modifications of laboratory procedures.

20.1.1.5 Monitors laboratory-training records, including but not limited to Initial Demonstrations of Capability, Annual Demonstrations of Proficiency, and documentation of Method Detection Limit (MDL) studies.

20.1.1.6 Serves as a quality resource and advisor for the Laboratory Director and Department Managers.

20.1.1.7 Coordinates laboratory participation in inter-laboratory accreditation and proficiency programs and analysis of internal "blind" quality control samples.

20.1.1.8 Arranges for periodic laboratory audits and the annual management review of technical operations.

20.1.1.9 Supervises all personnel in the Quality Assurance Department.

20.1.1.10 Reviews analytical deviations in cooperation with the Laboratory Director to determine potential effects on validity and reportability

of sample results. Recommends and monitors corrective actions when needed.

20.1.1.11 Has documented training and/or experience-with laboratory quality assurance and quality control procedures and is knowledgeable of the quality systems as defined under applicable EPA, TNI and independent state regulatory programs.

20.1.1.12 Has a general knowledge of the analytical tests for which data review is performed.

20.1.1.13 Is able to evaluate data objectively and perform independent assessments free from outside influence.

20.1.1.14 Has the education and training as outlined in the current EPA, TNI documents with the following minimum requirements: BA/BS/AA degree or greater from an accredited institution in a chemical, physical, biological, or environmental; at least 1-year experience in the chemical analysis of drinking water, water pollution, or solid/hazardous waste samples; and completion of a formal training course in quality assurance practices and NELAP requirements.

20.1.1.15 Is empowered with the authority from company management to execute the duties of the position as described in the EQC QSM.

20.1.1.16 Has the authority to release analytical results to clients.

20.1.2 Laboratory Director

20.1.2.1 Has responsibility of the day-to-day laboratory procedures and reporting of results.

20.1.2.2 Monitors standards of performance in quality control and quality assurance.

20.1.2.3 Monitors the validity of data generated in the laboratory. Interfaces with the Quality Assurance Department to maintain and improve the overall quality system.

20.1.2.4 Ensures that adequate qualified personnel are employed to supervise and perform the work of the laboratory.

20.1.2.5 Is responsible to oversee implementation of corrective actions outlined in the QSM.

20.1.2.6 Ensures availability of sufficient instrumentation, equipment, reagents, gases, and chemicals to perform procedures for which the laboratory is accredited.

20.1.2.7 Provides educational direction to laboratory staff.

20.1.2.8 Reviews analytical deviations in cooperation with Quality Assurance Director to determine the validity and reportability of sample results. Implements corrective action when needed.

20.1.2.9 Designates appropriate deputies to assume responsibilities in the event of a scheduled short-term absence.

20.1.2.10 Reviews quotes for new work as required to evaluate whether the laboratory has the required certifications, facilities and resources to complete the scope of work.

20.1.2.11 Issues periodic ~~a~~ memoranda as required outlining specific contract requirements for MDLs, matrix, frequency of testing, parameters to be tested, turnaround time, data package requirement, start date and any additional customer-specific information.

20.1.2.12 Has the education and training requirements as outlined in the current NELAP or other applicable regulatory documents.

20.1.1.13 Is empowered with the authority from company management to execute the duties of the position as described in the EQC QSM.

20.1.3 Department Manager (also referred to as Supervisor or Technical Director)

20.1.3.1 Reports directly to the Laboratory Director.

20.1.3.2 Take measures to assure that all results issued by the~~ir~~ department meet data quality requirements of SOPs and conform to applicable regulatory and internal quality control standards. Approves final analytical results.

20.1.3.3 Provides oversight of daily activities of laboratory technical staff and all analytical operations within department.

20.1.3.4 Supervises quality control for routine analytical operations as required by SOPs and the QSM.

20.1.3.5 Identifies and resolves technical problems in cooperation with the Laboratory Director and Quality Assurance Director following requirements of the QSM.

20.1.3.6 Reviews all quality control to verify that the department is meeting established criteria.

20.1.3.7 Evaluates new analytical techniques, procedures, instrumentation, and quality control methods, and provides recommendations to the Laboratory Director and Quality Assurance Director as applicable.

20.1.3.8 Has the education and training requirements as outlined in the current NELAP or other applicable regulatory documents.

20.1.3.9 Is required to have an operational understanding of all aspects of departmental SOPs including methodology, instrumentation, and quality control requirements.

20.1.3.10 Is empowered with the authority from company management to execute the duties of the position as described in the EQC QSM.

20.1.4 Analyst/Technician

20.1.4.1 Reports directly to Department Manager.

20.1.4.2 Performs analytical procedures and data processing in accordance with company SOPs. Reviews data for acceptability according to quality control requirements of the SOP.

20.1.4.3 Is responsible for preparation and maintenance of standard curves and the analysis of duplicates, spikes, blanks, and other quality control samples as directed.

20.1.4.4 Is responsible for documentation of routine and non-routine instrument maintenance.

20.1.4.5 Demonstrates acceptable performance on Initial Demonstration of Capability (IDOC) and Method Detection Limit (MDL) studies, quality control samples required by SOPs (e.g. blanks, laboratory control samples, and matrix spikes), PT samples, or internal, blind quality control samples.

20.1.4.6 Immediately reports non-conformances to the Department Manager to ensure that corrective action is taken.

20.1.4.7 Meets the education and training requirements outlined in job description and/or specific SOP.

20.1.5 Sample Custodian

20.1.5.1 Reports directly to the Laboratory Director.

20.1.5.2 Signs chain of custody forms to document sample receipt.

20.1.5.3 Arranges for proper and secure sample storage and distribution to individual departments. Defers distribution of non-compliant samples (i.e. do not meet sample handling and preservation requirements) until receipt of confirmation from client to proceed or resample.

20.1.5.4 Maintains internal custody records of sample transfer to respective laboratory departments.

20.1.5.5 Inspects samples for tampering and proper preservation, including temperature, in accordance with EQC SOPs on sample handling, receipt, and rejection.

20.1.5.6 Is responsible for entry of each sample into the LIMS for tracking throughout analysis.

20.1.5.7 Is responsible to ensure that permanent labels with correct, unique sample identification numbers (assigned by the LIMS) are attached to each sample.

20.1.5.8 Has completed the education and training requirements as outlined in his/her job description.

20.1.5.9 Is empowered with the authority from company management to execute the duties of the position as described in the EQC's QSM.

20.1.6 Deputies

20.1.6.1 In the event of an absence of either the Laboratory Director or the Quality Assurance Director for a period exceeding 16 consecutive calendar days, official notification of the appointment of the deputy director is made through inter-laboratory memo. During the period of absence, the deputy assumes the day-to-day responsibilities of the absent director. Additionally, all primary state accrediting authorities are notified in the event that an absence of either director exceeds 30 consecutive calendar days.

20.1.7 Support Personnel (data reviewers, customer service, forms specialists, computer specialists, scheduling specialists, field staff, and all others)

20.1.7.1 Reports directly to the Department Manager.

20.1.7.2 Has completed the education and training requirements as outlined in the job description.

20.1.7.3 Performs duties in accordance with Company SOPs and QSM.

20.1.7.4 Reports any deviations from the Company's standard operating procedures to the Department Manager.

20.1.8 Manager of Environmental Laboratory Administration

20.1.8.1 Reports to the Laboratory Director.

20.1.8.2 Reviews laboratory data in the final format and approves data for client reports.

20.1.8.3 Manage sub contract data and state forms.

20.1.8.4 Reviews progress of re-analyses and client data challenges.

20.2 Training

20.2.1 Each Department Manager is responsible for training new employees including personnel transferring from other departments. Specific requirements for the initial demonstration of capability to perform the procedure are listed in each method SOP, SOP QC0499 (General Preparation and Evaluation of Demonstration of Capability), and SOP QC0495 (Method Detection Limits). Training documentation is maintained on standardized laboratory training forms along with supporting data as described in SOP QC0499. Summary training records for each analyst are centrally managed by the Quality Assurance Department. Training records are maintained for a minimum of five years following termination of employment.

20.2.2 All new employees are trained in general Company procedures and policies including the Company's quality policy, the QSM and procedures for laboratory data retention, sample collection and handling laboratory documentation, facility access, instrumentation, safety, and good laboratory practices. The Company provides specific training on policies and procedures for data integrity and ethics which is described in Section 5.4. This preliminary training is provided upon hiring and is completed within two weeks from date

of hire. Training for specific method SOPs is performed concurrently with general training.

21.0 ACCOMMODATIONS AND ENVIRONMENTAL CONDITIONS

21.1 EQC facilities meet or exceed requirements for acceptable performance of analytical procedures performed by the Company.

21.2 The laboratory monitors, controls, and records environmental conditions as required by the relevant test methods and procedures. These conditions may include temperature, noise, biological stability, dust, radiation, humidity, or lighting.

21.3 Testing procedures are suspended when environmental conditions jeopardize data quality.

21.4 Adequate separation is maintained between neighboring areas in which incompatible activities are performed.

21.5 Access to EQC facility in Southampton is controlled through the use of key cards issued to each individual employee. Unescorted visitors are not allowed. Visitors, including contractors and janitorial staff, are made aware of safety and security guidelines. Unauthorized personnel are not permitted in laboratory areas. Other EQC satellite locations are locked unless the front door access is monitored by the EQC staff.

21.6 Laboratory facilities at all locations are kept free from mice, rodents, and other infestations by using authorized service providers to apply insecticides and/or pesticides that have been approved for use by laboratory management and will not negatively affect sample analyses.

22.0 ANALYTICAL METHODS AND VALIDATION

22.1 Analytical Method Implementation

Analytical methods used by EQC generally are dictated by the regulatory application of the sample data. Typically, analyses are based on client requests and the approved parameter list from the laboratory certification documents. Special requests for non-routine methods are handled on a case-by-case basis.

To implement a new analytical method, a method SOP is developed and approved by the Laboratory Director and Quality Assurance Director. The Laboratory Director then creates a product in LIMS incorporating the necessary information for sample analysis and reporting. Subsequently, addition, revision, and/or deletion of methods, SOPs, or analytes is centrally-managed by the Quality Assurance Department. The request contains a brief explanation for the revision and is approved by the Department Manager, Laboratory Director, and Quality Assurance Director. LIMS is updated accordingly.

22.2 Initial Method Performance Evaluation

The laboratory conducts initial method performance evaluations of each analytical method to demonstrate the ability to achieve acceptable results. These evaluations are conducted before the analysis of samples and following significant changes in hardware or analytical systems. Required elements of the initial method performance evaluation are described in the following sections.

22.2.1 Method Detection Limit (MDL) and Limit of Detection (LOD)

22.2.1.1 The Method Detection Limit (MDL) is determined as described in SOP QC0495. An MDL is determined by matrix for each test method and target analyte. MDLs are determined during the initial method validation and annually thereafter where required. When the same parameter is analyzed on multiple instruments, the highest MDL value is used for reporting purposes.

22.2.1.2 Procedures for determination of the appropriate concentration for the LOD quality control sample are described in SOP QC0684 (Determination of LOD and LOQ).

22. 2.1.3 An MDL study is not performed for any analysis for which spiking solutions or quality control samples are not available, e.g. temperature, or when MDLs are not applicable to the procedure (e.g. flash point).

22.2.2 Limit of Quantitation (LOQ)

22.2.2.1 When an MDL study has not been performed, a result may not be reported at a value below the LOQ (Limit of Quantitation) which is generally the lowest calibration standard. The LOQ is also referred to as the Reporting Limit (RL). The LOQ is determined according to procedures in SOP QC0684 (Determination of LOD and LOQ). The validity of the LOQ is confirmed by analysis of a quality control sample containing the analyte(s) of concern at a level of 1-2X the reported LOQ.

22.2.2.2 The analysis of the LOQ quality control samples is considered to be acceptable when the recovery of each analyte is within the established test method acceptance criteria or client data quality objectives for accuracy.

22.2.2.3 Analysis of the LOQ quality control sample is not required if the accuracy of the measurement system is evaluated at the LOQ.

22.2.2.4 For tests that do not utilize a calibration curve, e.g. settleable solids and residue tests, the RL is established at a value that is able to be measured with a defined level of accuracy during routine analysis. For settleable solids, the RL is set at 0.5 mL/L, and for residue tests, the RL is calculated using a minimum weight value, typically 1 mg, on an analytical balance.

22.2.3 Evaluation of Precision and Accuracy

22.2.3.1 Precision is defined as the closeness of a set of duplicate observations or measurements of the same property which are obtained under similar conditions. Accuracy is defined as the degree of closeness of a measurement to the actual true value. A typical example of measuring precision is to analyze a sample in duplicate and compare the results. Analysis of a laboratory control standard (LCS) with known concentration may be performed in duplicate for

this purpose. Precision results are reported as a percent difference of measurements, standard deviation, variance, or range. Analysis of a matrix spike (MS) and matrix spike duplicate (MSD) may also be used as a measure of precision of a given method in a specific sample matrix. Trip and Field Blanks are not used as MS/MSD samples. Analysis of an LCS or other sample with a known or certified value may be used to evaluate accuracy.

22.2.3.2 Specific criteria for assessment of precision and accuracy measurements are described in laboratory SOPs or project-specific documents. These procedures conform to the requirements of applicable regulatory programs, including but not limited to the Safe Drinking Water Act (SDWA), the Clean Water Act (CWA), and the Resource Recovery and Conservation Act (RCRA). Where not dictated by regulation, criteria for accuracy and precision of each test method are based on actual laboratory performance in the specific sample matrix. Criteria conform to the standards of TNI. Laboratory samples used as matrix spikes and spike duplicates are selected randomly and rotated between clients based on availability of required tests and sample volume.

22.2.3.3 Precision and accuracy criteria are specified in the various approved methods required by the SDWA (500-series methods), CWA (600-series methods), RCRA (SW-846 methods), or other reference documents, e.g. Standard Methods for the Examination of Water and Wastewater. Additional criteria may be specified in state and federal regulatory programs. Data quality objectives established by EQC meet or exceed the applicable criteria specified by the method or regulatory program. In cases where criteria are not established, quality control limits are calculated internally using historical data tabulated by test method and sample matrix.

Procedures for preparation of control charts and determination of quality control limits are described in SOP QC0916 (Laboratory Quality Control Limits). Upper and lower warning limits are calculated as the mean $\pm 2\sigma$, while upper and lower control limits as the mean $\pm 3\sigma$. Precision warning and control limits are calculated similarly at $+2\sigma$ and $+3\sigma$. Limits are updated periodically with the actual interval dependent upon the total number of samples tested by each method. General data trends and overall analytical system control are tracked through control charts as described in Section 13.0 of SOP QC0499 (General Preparation and Evaluation of Demonstrations of Capability) and SOP QC0916).

22.2.3.4 While overall trends and method performance are tracked through control charts, daily method performance is tracked based on data from individual run sequences. Required corrective actions to be taken in individual instances of data non-conformances are described in the analytical SOPs.

22.2.4 Estimation of Uncertainty

22.2.4.1 The total uncertainty of a measurement is based on many factors including but not limited to, contributions from human factors, environmental conditions, sampling, equipment, test method application, and calibration. Estimations of uncertainty are based on published method performance, previous experience, and specific data validation procedures. Procedures for determination of uncertainty are described in SOP QC0831 (Measurement of Uncertainty).

22.3 Initial Demonstration of Capability (IDOC)

22.3.1 All analysts complete an Initial Demonstration of Capability (IDOC) before independently performing a procedure. Procedures for performing the IDOC are described in SOP QC0499 (General Preparation and Evaluation of Demonstrations of Capability).

22.3.2 A new IDOC is performed whenever there is a change in instrumentation, method, or personnel.

22.4 Continuing or On-going Demonstration of Capability

22.4.1 Continuing or on-going demonstration of capability (DOC) is satisfied and documented as follows:

22.4.1.1 When the analyst successfully analyzes at least four consecutive laboratory control samples from a secondary source and precision and accuracy meet criteria.

22.4.1.2 When the analyst performs another Initial Demonstration of Capability (IDOC).

22.4.1.3 When the analyst performs an acceptable analysis of an internal, single blind sample.

22.4.1.4 When the analyst performs an acceptable analysis of an external, blind Proficiency Test (PT) sample using a similar test method with the same technology.

22.4.1.5 When the analyst completes required activities described in the SOP and a quantitative test is not available, e.g. settleable matter and TCLP extractions.

22.5 Manual Integrations

22.5.1 Eurofins QC, Inc. (EQC) uses software developed by instrument manufacturers or third party suppliers to reduce chromatography data from an analog signal to an accurate concentration present in the sample. Efforts are made during method development to include the best instrument parameters that allow for automatic integration of chromatographic peaks by the data system in most cases. However, instances occur when the automated software does not integrate a peak correctly. Manual integration is employed to correct an improper integration performed by the data system.

22.5.2 All peaks must be integrated consistently in standards, samples, and QC samples. Integration parameters, both automated and manual must adhere to valid scientific chromatographic principles. The reason for manual integration must always be documented. Under no circumstances should manual integration be performed solely for the purpose of meeting quality control criteria. In other words, peak shaving, peak enhancing, or manipulations of the baseline to achieve these ends must never occur as this results in an improper integration rather than correcting a data system

22.5.3 Policies and procedures for manual integrations are described in QC0559 (Proper Manual Integration Techniques for GC and GC/MS).

22.6 Validation of Laboratory-Developed, Non-Standard Methods

22.6.1 Policies and procedures for validation of non-standard methods are described in SOP QC0485 (Acceptance/Rejection Criteria for Unspecified Methods).

23.0 CALIBRATION REQUIREMENTS

23.1 General Equipment Requirements

23.1.1 Analytical Instrumentation and Laboratory Facilities

EQC's laboratory instrumentation and facilities meet or exceed the technical, quality, and capacity requirements of clients, applicable methods, and regulatory agencies. Floor plans of EQC's major laboratory facilities are shown as follows: Figures 2A and 2B (EQC-Southampton, PA facility), Figure 2C (EQC-Horsham, PA facility), and Figure 2D (EQC-Delaware, New Castle facility). A listing of the laboratory's environmental testing equipment is provided in Table 2.

23.1.2 The laboratory's current and anticipated analytical work-load is tracked through the scheduling features of the LIMS and periodically reviewed by laboratory management to assure that incoming projects will not exceed the laboratory's capacity.

23.1.3 The potential need to update and/or purchase new laboratory equipment is reviewed during the preparation of the annual budget.

23.2 Support Equipment

Support equipment includes all devices that are not directly used for laboratory measurements, but are needed to indirectly support laboratory operations. These include, but are not limited to, balances, ovens, refrigerators, incubators, hot blocks, digestion equipment, extraction devices, and volumetric dispensing devices. Procedures for support equipment maintenance and calibration, if applicable, are described in the analytical SOPs, equipment specific SOPs, or manufacturer's operating manuals. Procedures are summarized in the following sections.

23.2.1 Support Equipment Maintenance

23.2.1.1 All support equipment is maintained in proper working order according to the recommendations of the manufacturer or specific

SOP. Records of maintenance are kept in the department where the equipment is located.

23.2.1.2 When support equipment is relocated, the equipment is shut down following recommended procedures. Following shutdown, the equipment is required to meet recommended operating conditions prior to being put back into service.

23.2.2 Support Equipment Calibration

23.2.2.1 Performance of all support equipment is periodically verified and documented according to procedures in the analytical SOPs, equipment-specific SOPs, or manufacturer's operating manuals. In cases where equipment requires calibration, the equipment is calibrated at least annually using standards or calibration materials (e.g. thermometers or weight sets) that are traceable to a recognized entity, such as NIST. Calibration materials are selected to bracket the applicable range of use as required by methods, operating manuals, or regulatory criteria. Applicable acceptance criteria for the calibration of support equipment are described in individual SOPs. Calibration records for thermometers and balances generally are maintained centrally by the Quality Assurance Department, while other operating documentation (e.g. oven or refrigerator logs) are kept in the department where the equipment is located.

Key elements of support equipment calibration are described in the following sections.

23.2.2.2 Analytical balances and weights are serviced and calibrated annually by a certified technician. Class 1 or better weights are used.

23.2.2.3 Except for Class A glassware, the delivery volumes of mechanical volumetric dispensing devices are checked at least quarterly. The accuracy is required to be within 2.5% of the expected value. Volumetric devices that do not meet this criterion are refurbished or taken out of service.

23.2.2.4 Temperature measuring devices such, as liquid-in-glass thermometers, are calibrated at least annually using a NIST-traceable thermometer, which is graduated in at least 0.2 °C increments.

23.2.2.5 A working thermometer is not used if it has a Correction Factor (CF) of 1.0 °C or greater from the reference thermometer. If the calculated CF is less than the graduation increment of the working thermometer, the CF is not applied.

23.2.2.6 Thermometers are graduated in increments of 0.5 °C or less for all analyses except fecal coliform analysis. Thermometers used for fecal coliform analysis have graduations of 0.2 °C or less.

23.2.2.7 Electronic data loggers are calibrated at least annually against NIST thermometers. In addition to the electronic records, calibration records and summary data are maintained in logbooks.

23.2.2.8 Operating conditions of autoclaves are documented in logbooks according to schedules described in laboratory SOPs. Documentation includes demonstration of sterilization through use of biological indicators and verification of cycle temperature.

23.2.2.9 The temperature of each laboratory refrigerator and freezer is documented at least daily. Refrigerators for storing environmental microbiology samples are required to maintain a temperature of 1 to 5 °C. Other samples are stored in refrigerators with a temperature range from 0-6 °C. Freezer temperatures are less than 0 °C to -20 °C.

23.2.2.10 Temperatures of water baths and ovens are verified each day, before use. Temperatures of microbiological incubators and water baths are verified twice daily, and the measurements are taken at least 4 hours apart.

23.2.2.11 Calibration of electronic, dial-type, and other non-glass thermometers, including thermocouples and metal thermometers, is verified on a quarterly basis with a NIST-certified thermometer. Note: Dial-type thermometers for ice cream sampling is calibrated every 6 months as specified by PA Department of Agriculture dairy sampling forms.

23.2.2.12 Certified NIST thermometers are recalibrated at least once every two years by an authorized independent firm. The certificates documenting the traceability to NIST standards are kept on file by the Quality Assurance Department in Southampton. In cases where regulatory authorities require local access to the certification documents, a copy is provided to the individual remote facility.

23.2.2.13 Equipment that does not meet calibration criteria is taken out of service and clearly marked to prevent usage.

23.2.2.14 When equipment is taken out of service, calibration and test data from the analytical run immediately preceding the out-of-service date/time are evaluated. This evaluation ensures that the tests were satisfactory and data were not affected by the equipment malfunction.

23.3 Analytical Instruments

23.3.1 Maintenance for Analytical Instruments

23.3.1.1 When an instrument does not meet the specifications of the approved methods or manufacturer, operation is suspended and maintenance or repair is performed as necessary. Maintenance or repairs are performed by qualified personnel, either experienced EQC operators or outside service personnel. Outside service

personnel generally are representatives of the manufacturer or independent contractors who perform non-routine instrument maintenance and repairs, as well as any periodic maintenance required by manufacturer's service contracts. Potential analytical down-time is minimized through the availability of backup instruments and/or alternate methods. Following maintenance or repair and prior to initiation of sample analysis, instrument performance is verified for conformance to regulatory requirements.

23.3.1.2 Preventative maintenance schedules and procedures are detailed in the individual instrument operations manuals, analytical SOPs, or in specific preventative maintenance SOPs.

23.3.1.3 Records of all routine and non-routine maintenance are maintained in instrument maintenance logs kept in each department.

23.3.1.4 When instruments are taken out of service by moving or placing in storage, EQC follows the applicable manufacturer's instructions and/or applicable SOP to ensure proper functioning and to prevent contamination or deterioration. Following moving or storage, instrument performance is verified for conformance to regulatory requirements prior to initiation of sample analysis and return to service.

23.3.2 Initial Instrument Calibration

23.3.2.1 Intervals for calibration are, at a minimum, those recommended by the manufacturer or those required by the analytical method, whichever is shorter. Calibration standards are prepared and analyzed in concentrations bracketing the range of the samples to be analyzed. Results within the calibration range, but not bracketed by the initial calibration standards, may be reported with a qualifying flag or comment as described in the specific analytical SOP. In cases where calibration is performed with a single standard and calibration blank (e.g. ICP-OES and ICP-MS), a linear dynamic range (LDR) is determined according to the specified method, and results above the single point standard used for calibration, but within the LDR, may be reported.

23.3.2.2 Standards used for initial calibration are verified using a standard (however named) prepared from an independent, second-source material. The second-source standard is obtained from a different manufacturer or from a different lot from the same manufacturer.

23.3.2.3 All sample results are quantitated from the initial instrument calibration and not from any continuing instrument calibration verification.

23.3.2.4 Calibration response may be determined using linear regressions, quadratic fit, or an average calibration response factor (e.g. area response or peak height versus amount injected as is the case with

chromatographic analyses). The required number of calibration standards is described in each analytical SOP. Linear and quadratic calibration acceptability are defined by SOP-defined statistics that establish the minimum value that is acceptable relating to the goodness of fit of the calibration curve. Acceptability of calibrations utilizing calibration response factors is based on calculation of the relative standard deviation (RSD). Acceptance limits for RSDs are listed in each analytical method.

23.3.2.5 When initial calibration criteria are not met, one or more of the following actions are taken until acceptable calibration data are obtained. Corrective actions include, but are not limited to: a) mechanical or electronic adjustment of the instrument followed by reanalysis of the initial calibration standards; b) instrument maintenance followed by reanalysis of the initial calibration standards; c) preparation of new standards and a new initial calibration curve; d) evaluation of one or more components of the standard for abnormally high response, indicating contamination, followed by corrective action to eliminate the contamination and reanalysis of the initial calibration standards; or e) removal of the instrument from service for subsequent repair. Additional corrective actions may be described in each analytical method.

23.3.3 Continuing Instrument Calibration

23.3.3.1 Continuing calibration verification standards (CCV) are analyzed at the frequency specified by the analytical methods or regulatory program and when calibration is not performed on the day of analysis.

23.3.3.2 Continuing calibration verification standards have defined acceptance criteria and are listed in each specific standard operating procedure.

23.3.3.3 If the continuing instrument calibration verification results obtained are outside the established acceptance criteria and analysis of an immediate second consecutive calibration verification fails to produce results within acceptance criteria, corrective actions are performed. Corrective actions include, but are not limited to, instrument maintenance and evaluation of chromatographic performance, software integration and mathematical calculations, and standard stability. Following corrective action, calibration verification is demonstrated by analyzing two consecutive passing calibration verifications. Alternatively, a new initial instrument calibration can be performed. Sample analyses are not initiated until the analytical system is calibrated and the calibration is verified.

23.3.3.4 When samples are analyzed using a system on which calibration has not been verified, the following rules apply:

a. When the acceptance criteria for the CCV are exceeded high (i.e., high bias) and there are associated samples that are non-detects, then those non-detects may be reported with a qualifying comment.

b. When the acceptance criteria for the CCV are exceeded low (i.e., low bias) and there are associated samples that have values exceeding a regulatory limit, those results may be reported with a qualifying comment.

c. In all other cases, the samples affected by the unacceptable calibration verification are re-analyzed after a new calibration curve has been established, evaluated, and accepted.

d. PA-regulated drinking water samples with qualified results must receive pre-approval from the state prior to reporting.

23.3.4 Other Method- or Instrument-Specific Calibration Requirements

Additional method- or instrument-specific procedures may be required and are specified in individual method SOPs. These include, but are not limited to, tuning of mass spectrometers and minimum RRF criteria (GC/MS and ICP/MS), PEM breakdown and retention time verification (pesticides), wavelength calibration of spectrophotometers (colorimetric determinations), and inter-element correction factor and linear dynamic range verification (ICP-OES and ICP/MS).

24.0 MEASUREMENT TRACEABILITY

24.1 Reference Standards and Reagents

24.1.1 EQC purchases analytical standards and reagents from established vendors. Suppliers are approved according to procedures described in EQC SOP QC0478 (Purchasing of Services and Supplies). Standards are prepared and analyzed according to the requirements of the analytical methods. Initial calibration standards are verified by analysis of second source standard prepared independently of the initial calibration standard.

24.1.2 Handling and documentation of standard materials and reagents is described in SOP QC0486 (Reagent/Reference Material Receipt, Labeling, Expiration, Storage and Disposal). Records document the traceability of working standards or reagents to the stock materials. Documentation also includes certificates of analysis or purity, receipt date, and information specific to the standard or reagent preparation (e.g. date of preparation, method of preparation, expiration date and preparer's initials). All prepared standards and reagents bear a unique identifier with expiration date and are traceable back to stock standards or reagents.

24.1.3 The sources of deionized water within the laboratory are tested periodically for the parameters listed in Table 24.1.3 (Deionized Water Monitoring Criteria). Additional parameters may be added as required by individual regulatory authorities or specific clients. Samples that are routinely monitored are

scheduled in the company LIMS for the following locations: EQC-Southampton, 2nd floor; EQC-Southampton, 1st Floor; and EQC-Delaware.

Samples of deionized water are collected from the discharge port of each DI water system after allowing water to run for at least one minute. Samples are collected according to procedures described in Section 10.11 of SOP QC0548 (General Field Sampling Procedures).

Samples are analyzed for the scheduled tests according to the appropriate SOP. Deionized water must meet all test requirements indicated in Table 24.1.3 to be suitable for use. Deionized water that does not meet these requirements must be re-sampled and re-tested. Management is notified if repeat analyses do not give acceptable results.

Table 24.1.3
Deionized Water Monitoring Criteria

Parameter	Requirements	Frequency
TOC NH3	<1 mg/L <0.1 mg/L	Monthly
Organic Nitrogen	<0.1 mg/L	Monthly
Conductivity	< 2.0 micromhos/cm or >0.5 MΩ resistance at 25 °C	Monthly
Residual Chlorine	<0.1 mg/L	Monthly
Heterotrophic Plate count	< 500 CFU/mL	Monthly
Suitability/Bacteriological Water Quality	Ratio: 0.8 - 3.0	Annually
Heavy and Trace Metals	≤ 0.05 mg/L per metal, ≤ 0.1 mg/L collectively	Annually
SiO_2	<0.1 mg/L	Annually

24.2 Reference Materials

24.2.1 Materials used for method validation or instrument calibration are, wherever possible, traceable to certified reference materials. See additional information in SOP QC0478 (Purchasing of Services and Supplies).

24. 3 Transport and Storage of Reference Standards and Materials

24.3.1 Handling and documentation of reference materials is described in SOP QC0486 (Reagent/Reference Material Receipt, Labeling, Expiration, Storage and Disposal).

24.3.2 Reference standards and materials are handled in a safe manner to protect their integrity and to prevent contamination or deterioration.

25.0 SAMPLE COLLECTION AND MANAGEMENT

25.1 Sample Collection

25.1.1 Sample collection by EQC personnel is performed in accordance with EQC SOPs or client-specified procedures. Sample collection procedures comply with applicable EPA and state regulations. Applicable field sampling SOPs are listed in Table 3.

25.2 Sample Containers

25.2.1 Selection of sample containers is based on the requirements specific to the analyte, matrix and analytical method. Acceptable sampling containers are described in SOP QC0346 (Policy for the Acceptance and Rejection of Environmental Samples).

25.3 Preservation and Holding Time

25.3.1 Samples preservation is verified and documented upon receipt in the laboratory. Each sample is evaluated to ensure that the holding time is met for all analytes. Preservation and holding time requirements are described in SOP QC0346.

25.4 Sample Receipt and Acceptance

25.4.1 Samples are checked in according to SOP QC0303 (Sample Log-in Procedure)

25.4.2 Policies and procedures for accepting samples at the laboratory are described in SOP QC0346 (Policy for the Acceptance and Rejection of Environmental Samples).The samples are checked for tampering, closure integrity, proper collection procedures, and proper preservation, including use of approved containers, temperature, pH, chlorine residual, or presence of other required chemical preservatives as described in SOP QC0346.

25.4.3 The COC form is reviewed for all relevant information. When required, EQC personnel follow established procedures to contact the client and obtain complete and accurate information for the sample submittal (see SOP QC0346). All COC issues are documented in the LIMS and the client is notified.

25.5 Chain of Custody

25.5.1 All samples received by the laboratory must be accompanied by a completed COC form available from the client services at EQC. The COC provides a record of sample handling history beginning with the date and time of sample collection and continuing through laboratory receipt and distribution to individual departments for analysis. EQC has the ability to provide a complete internal chain of custody record including handling by individual analysts through final analysis and disposition of the samples upon request. These procedures are described in SOP QC0302 and SOP QC0468 (Electronic Chain of Custody and Sample Transfer). Key elements of these procedures are summarized in the following sections.

25.5.2 Documentation of a sample chain of custody begins with proper completion of a COC which is initiated by the sampler at the time of sample collection. The field identification of each sample is recorded on the COC, and a durable label including the unique field identification is affixed to each sample container providing traceability of each sample to the COC record.

25.5.3 In addition to sample identification information and other project information associated with the terms of each individual contract, the COC also includes

specifics regarding required analyses, numbers of containers for each sample, field measurements, sample preservation and other client notes.

25.5.4 Each sample container is labeled in accordance with relevant health and safety requirements when preservation chemicals are added. This label also provides additional traceability to ensure the container and preservation are those specified for the analytical requirements indicated on the COC.

25.5.5 The sampler, project coordinator, or courier maintains custody prior to, during, and after sampling until the samples are relinquished to EQC laboratory personnel.

25.5.6 In the event that the laboratory receives an incomplete or incorrect chain of custody form, EQC personnel follow established procedures to contact the client and obtain accurate information for the samples. These procedures are described in SOP QC0346 (Policy for the Acceptance and Rejection of Environmental Samples).

25.6 Sample Identification and Login

25.6.1 All samples are assigned a unique identification number and are logged into the LIMS according to procedures described in SOP QC0303. When there are more than one bottle per sample, each sample container will be uniquely identified.

25.6.2 The sample number is printed on a permanent label which is attached to each sample container. Each label includes a sample/project number traceable to the LIMS as well as a second container identifier code unique to that individual container, also tracked in the LIMS. Sample identification information, the unique container identification, and preservatives added to the container are all encoded onto the sample container using bar code labels.

25.6.3 EQC prepares pre-printed forms ("pick sheets") for field service staff to use in order to identify samples requiring pickup. Pick sheets contain the unique sample identification that is used during sample login. Pick sheets use the letter "P" as a prefix to the sample identification. Upon sample login, the "P" is changed to an "L" which indicates the sample is available for analysis, and this designation, along with the unique sample identification, is maintained thereafter.

25.7 Sample Storage, Handling, and Transfer

25.7.1 Sample storage and handling procedures are described in SOP QC0308 (Sample Storage Procedure) and SOP QC0468. All samples are tracked and transferred using the unique identification number assigned by LIMS. All analysts responsible for department sample custody and sample custodians at EQC's main laboratory in Southampton are assigned a unique identification number and badge. Information including analyst's name and department is encoded onto the bar code included on the identification badge. The LIMS uses this information to maintain a record of all sample transfers. Additional safeguards have been encoded into the electronic system to prevent unauthorized personnel from receiving or relinquishing laboratory samples.

For EQC-Delaware, other satellite locations, or where electronic documentation is not possible, sample transfers are documented manually.

25.7.2 In cases where holding time or other constraints require sample transfer prior to bar coding, the transfer is tracked manually using a rush sample custody log. With the rush sample custody log, all signatures are obtained manually. Then, following analysis, the samples are returned to the sample custodian for entry into the LIMS and attachment of bar code labels.

25.7.3 Individual sample containers are relinquished to the appropriate departments for storage. During analysis, the samples are stored, tracked, and transferred thereafter by each department as required by applicable methods.

25.7.4 It is the responsibility of the Sample Custodian or designee to assure that all samples are logged into LIMS. Laboratory personnel are responsible for receiving and processing samples as described in Section 25.7.1.

25.7.5 Custody of samples and sample extracts/digestates transferred between various laboratory departments is maintained either electronically or manually through a transfer logbook.

25.7.6 Each sample digestate or extract is assigned a unique identifier that is traceable to the original sample container. Whenever possible, a bar code label is printed and affixed to the extract or digestate container and custody is tracked electronically as above. When it is not possible to affix a bar code label (i.e., due to the small size of an injection vial), custody of these samples is tracked using manual signatures in a department-specific sample transfer logbook. The sample digests or extract vial labels (e.g. for GC and GC/MS analyses) contain sample batch identification, unique sample identification, client name, and the analysis required or a cross-reference to this information.

25.8 Sample Disposal

25.8.1 Samples and sample preparation products, e.g. extracts, leachates, and digestates, are stored in the laboratory under required storage conditions. Procedures for disposal of these materials are described in SOP QC0479 (Laboratory Waste Disposal).

25.8.2 Original samples and sample preparation products are retained for a minimum 10 days following report generation, but not fewer than 15 days from sample receipt. The samples may be retained for a longer time if previously agreed with the clients.

26.0 QUALITY ASSURANCE FOR ANALYTICAL TESTING

26.1 Essential Quality Control Elements and Internal Procedures

The following quality control procedures or indicators are incorporated into applicable laboratory SOPs and the QSM. Specific procedures for data evaluation, corrective actions and data qualification are described in individual method SOPs and SOP QC0913 (Laboratory Data Review and Reporting).

26.1.1 **Demonstrations of Capability.** Each analyst is required to complete an Initial Demonstration of Capability (IDOC) and also perform an annual On-Going Demonstration of Capability (DOC). Additional details regarding the IDOC and the on-going DOC are contained in Sections 22.3 and 22.4 respectively.

26.1.2 **Method Detection Limit (MDL) Determinations.** MDL studies are performed at annually according to procedures in SOP QC0495.

26.1.3 **Blank Analysis**

26.1.3.1 **Laboratory Reagent Blanks**. The purpose is to evaluate contamination resulting from laboratory processes, reagents, or glassware. Laboratory reagent blanks are performed at a frequency of one per analytical batch of 20 or less.

26.1.3.2 **Method blanks.** EQC systematically prepares and analyzes method blanks with each batch of samples, to continuously evaluate analytical system interferences and background contamination. An aliquot of deionized (DI) water or other appropriate analyte-free matrix is submitted to the entire testing procedure. The presence of the analyte (s) of interest in the method blank render associated data suspect and requires corrective action. Method blanks are performed at a frequency of one per analytical batch of 20 or less.

26.1.3.3 **Field Blanks.** Field blanks are equipment rinsate blanks prepared in the field or samples of clean water sent to the sample site for transfer by the client into clean sample containers with subsequent shipment back to the laboratory with the field samples. Field blanks are analyzed according to client requests for all required analytes. Results provide valuable information regarding contamination introduced by the field sampling procedures which could affect sample data.

26.1.3.4 **Trip Blanks.** Trip blanks accompany associated samples requiring volatile organic analyses from the time of sample container preparation, shipment to and from the sampling site, and analysis by the laboratory. Trip blanks are analyzed to detect accidental or incidental contamination. Organic-free water is provided to the client by the laboratory in closed 40-mL vials or other appropriate containers. These containers are taken onsite, but not opened, and are subsequently shipped to the laboratory with associated field samples. The holding time for trip blanks begins at the time actual field samples are collected.

26.1.4 **Laboratory Fortified Blank (LFB) or Laboratory Control Sample (LCS)**

LFBs or LCSs are analyzed routinely to confirm proper method performance and to evaluate method accuracy. The LCS serves as the primary batch quality control check, and sample results may not be reported unless the LCS or LFB meet method-specified criteria. Laboratory control samples may be purchased as pre-prepared, whole-volume samples or in concentrate or dry reagent form

to be prepared by the laboratory for analysis. Laboratory control samples are obtained from a source different from that used to prepare the calibration standards. Analysis of laboratory control samples, in conjunction with matrix spikes and duplicates, allow delineation between matrix effects that may affect analysis of individual samples and overall method performance affecting analysis of all samples. Unless otherwise specified within the SOP, a LCS or LFB is analyzed with each batch of up to 20 samples per matrix per day.

26.1.5 Laboratory Spikes, Spike Duplicates, and Serial Dilutions

26.1.5.1 Matrix Spikes/Matrix Spike Duplicates (MS/MSD). These are also described as Laboratory Fortified Matrix (LFM) and LFM Duplicate. These samples are analyzed to assess matrix interference problems and method precision. At a minimum, an MS and MSD (or LFM and LFM Duplicate) are analyzed with each batch of 20 samples. The frequency of analysis of the MS/MSD could be greater if required by the analytical method or request for a specific project. The MS/MSD data are used to document the effect of matrix on analyte recovery and method precision. MS/MSD recoveries are evaluated based on quality control limits established by the method, or, if recovery criteria are not specified, using control limits established by the laboratory.

26.1.5.2 Post-Digestion Spikes

When MS/MSD recoveries for metals analyses (e.g. hexavalent chromium in solids, ICP-OES, and ICP-MS) do not meet acceptance criteria, post-digestion spikes may be required to evaluate whether recovery deviations are caused by instrumental interferences or problems with sample preparation. The sample digest is spiked at the level specified by the individual method SOP, and post-digestion spike recoveries are evaluated according to method acceptance criteria. Possible matrix interferences that are identified from evaluation of MS/MSD and post-digestion recovery data are documented.

26.1.5.3 Serial Dilution

Serial dilution is performed for ICP-OES and ICP-MS analyses to determine if significant chemical or physical interferences are caused by the sample matrix. Matrix interferences may be present if the diluted sample does not agree with the undiluted sample within the range specified by the method. Data not meeting the serial dilution criterion are reported with appropriate qualifiers.

26.1.6 Duplicates

26.1.6.1 Field Duplicates

Duplicates of field samples are collected at the time of sample collection. Field duplicate analyses are used to assess precision of

sampling processes. Field duplicates are collected as required by field sampling plans.

26.1.6.2 Laboratory Duplicates

The laboratory, or matrix, duplicate is a second aliquot of sample that is processed through the entire analytical procedure. Results of duplicate analyses are used to evaluate the precision of the analysis for that specific sample. However, usable precision data are produced only when the target analytes are present in the samples. Matrix spike duplicates (Section 26.1.5.1) are used in these cases to provide detectable levels of analytes to aid in evaluation of precision. Duplicates are analyzed at a minimum of one per analytical batch of 20 samples, or as required by method SOPs. The precision is evaluated by calculation of Relative Percent Difference (RPD) and comparison with acceptance criteria in the individual method SOP.

26.1.7 Internal Standards and Surrogate Spikes

Internal standards are used for GC and GC/MS analysis, when required by the methods, to compensate for chromatographic drift, establish relative retention time windows, and determine quantitation response factors for target analytes. Surrogate spikes, consisting of non-targeted compounds exhibiting responses similar to the targeted compounds, are added to each GC and GC/MS sample, extract, and standard. Surrogate spikes provide continuous evaluation of method performance and measurement of matrix effects on the recoveries of target analytes. Poor recoveries of surrogate spikes render associated sample data suspect. Corrective action is required and it may be necessary to reanalyze samples or qualify associated analytical results if it is not possible to obtain acceptable surrogate spike recoveries. Corrective actions are specified in individual method SOPs.

26.1.8 Initial and Continuing Calibration

Initial and continuing calibration of analytical instruments is performed as required by the applicable methods. Requirements for initial and continuing calibration are described in Section 23.3.2 and 23.3.3.

26.1.9 Control Charts

Control charts are used as described in Section 26.2.

26.1.10 Corrective and preventive action and root cause analysis

Policies and procedures for corrective and preventive action are described in Sections 13.0, 14.0, and 15.0.

26.1.11 Quality control acceptance criteria

EQC analytical SOPs contain acceptance criteria required by the approved analytical methods.

26.1.12 Definition of preparation and analytical batches

The frequency of analysis of quality control samples generally is dictated by the size of the analytical batch. Unless otherwise specified by the method or specific project, an analytical batch is a batch of 20 samples or less prepared within 48 hours from the beginning of the sample preparation process. Other requirements may be specified in the individual method SOPs.

26.1.13 Minimum frequency for conducting all quality control elements

Quality control elements are performed at defined frequencies according to procedures described in the individual analytical method SOPs.

26.1.14 Inhibitory Residue Test

Microbiological laboratories must perform the inhibitory residue test upon the first use of a dishwashing detergent or when the brand or type of detergent is changed. This test ensures that the glassware is free of toxic material. This test is not required if the certificate of analysis includes results of the inhibitory residue test.

26.2 Quality Control Limits

26.2.1 Quality control measures are assessed and evaluated on an on-going basis, and quality control acceptance criteria are established as specified in the approved methods. In the absence of method-specified limits, internally-generated or lab-defined control limits are used.

26.2.2 Control charts are prepared to create internally-generated control limits for both accuracy and precision as required by each analytical method or company standard operating procedure. Procedures for preparation of control charts are described in SOP QC0916.

26.2.3 Trend analysis: EQC uses control charts for monitoring data quality for specific contaminants of concern, based on data obtained from multiple instruments.

26.3 Marginal Exceedances

26.3.1 If a large number of analytes are in the LCS, it becomes statistically likely that a few will be outside control limits. This does not necessarily mean that the system is out of control, and therefore corrective action may not be required. Upper and lower marginal exceedance (ME) limits can be established to determine when corrective action is necessary.

26.3.2 A marginal exceedance (ME) is defined as being beyond the LCS control limit (three standard deviations), but within the ME limits. ME limits are between three and four standard deviations around the mean. The number of allowable marginal exceedances is based on the number of analytes in the LCS. If more analytes exceed the LCS control limits than are permitted by the method, or if any one analyte exceeds the ME limits, the LCS fails and corrective action is necessary.

26.3.3 This marginal exceedance approach is relevant for methods with numerous analytes. It does not apply to target analyte lists with fewer than eleven

analytes. The number of allowable marginal exceedances is determined using Table 26.3.3.

Table 26.3.3
Determination of Allowable Marginal Exceedances

Number of analytes in LCS	Number allowed as marginal exceedance
> 90	5
71-90	4
51-70	3
31-50	2
11-30	1
<11	0

26.3.4 If the same analyte exceeds the LCS control limit on consecutive analyses, it is an indication of a systemic problem requiring corrective action and the ME allowance does not apply.

26.4 Proficiency Test (PT) Samples or Inter-laboratory Comparisons

26.4.1 Analytes and methods for which EQC is certified are evaluated through the analysis of certified Performance Evaluation (PE) samples obtained from NELAC- accredited Proficiency Test (PT) sample providers.

26.4.2 EQC participates annually in two single-blind, single-concentration PT studies for each analyte on the NELAP designated Field of Proficiency Testing. A minimum of one PT is analyzed per year for non-NELAP parameters. Additional PT samples are analyzed as required by specific projects or other programs for which EQC holds accreditation.

26.4.3 Additionally, EQC conducts three internal blind PT Studies each year. These studies are conducted by the Quality Assurance Department to evaluate on-going proficiency in the analysis of potable water (Water Supply-WS) and non-potable water (Water Pollution-WP).

26.4.4 Each PT sample is integrated into the normal workload and tracked through LIMS. PT samples are diluted according to instructions provided by PT provider, and the diluted PT sample is then considered to be the actual sample. All PT samples are managed, analyzed, and reported in the same manner as normal environmental samples utilizing the same staff, methods, and quality control practices dictated by EQC SOPs.

26.4.5 All associated quality assurance data is reviewed for compliance with applicable criteria as specified in EQC SOPs.

26.4.6 EQC has established the following practices regarding analysis and reporting of PT samples:

26.4.6.1 EQC does not send any PT sample, or a portion of a PT sample, to another laboratory for analysis, nor will EQC knowingly receive any PT sample, or a portion of a PT sample, from another laboratory for analysis.

26.4.6.2 All EQC personnel, including laboratory management, are prohibited from communicating with any individual at another laboratory concerning the PT sample. All EQC personnel, including laboratory management, are prohibited from attempting to obtain the assigned value of any PT sample from a PT provider.

26.4.6.3 Final reporting of PT results is coordinated by the Quality Assurance Director who assures that all results are reported to the proper accrediting authorities and PT sample providers.

26.4.6.4 The laboratory maintains copies of all written, printed, and electronic records resulting from the analysis of PT samples according to policies described in Section 16.0 of the QSM. The laboratory records are available to auditors during on site audits of the laboratory.

26.4.7 PT samples for the State of Delaware shall be completed during the first quarter of the calendar year.

26.5 Data Reduction and Review

26.5.1 Data reduction and review procedures are described in SOP QC0913 (Laboratory Data Review and Reporting of Analytical Results). Permanent records of essential information pertinent to the analysis are maintained as described in Section 16.0 (Control of Records).

26.6 Expanded Data Packages

26.6.1 EQC provides expanded data packages required by various state and federal regulatory programs or site-specific project plans. Several routine options are available to clients ranging from a basic quality control summary to a complete data package with raw data that is suitable for validation. Procedures for preparation of expanded data packages are described in SOP QC0913 (Laboratory Data Review and Reporting of Analytical Results).

27.0 REPORTING OF RESULTS

27.1 Result Entry to LIMS

27.1.1 Data from most laboratory instruments are automatically entered into LIMS by interfacing the instrument workstations directly to LIMS. The automated data entry system is used at Southampton for most organic, metals, and wet chemistry instruments. Analysts review all results for conformance with applicable quality control criteria prior to initiation of data transfer. Department managers or peer review analysts then verify the accuracy of the data transfer. Data entry procedures are described in SOP QC0913 (Laboratory Data Review and Reporting of Analytical Results).

27.1.2 Manual data entry to LIMS is required for non-instrumental methods or procedures for which automated data transfer is not available. In these cases, a dual data entry system is used in LIMS whereby results (e.g. numerical value, date of analysis, analyst, dilution factor) are entered twice by the same person. LIMS monitors agreement between the two entries and provides a hardcopy report of the verification. Any discrepancies are evaluated and resolved before

a result is accepted by LIMS. Analysts review all results for conformance with applicable quality control criteria prior to initiation of data entry. Data entry procedures are described in SOP QC0913 (Laboratory Data Review and Reporting of Analytical Results).

27.2 Release and Reporting of Results

27.2.1 Following entry of results into LIMS, all chemistry results are reviewed prior to release to clients by the Laboratory Director, Manager of Environmental Laboratory Administration, Quality Assurance Director, or their designee. Microbiology results are reviewed by the Department Manager, Technical Director, or their designee. Results are reviewed for compliance with applicable regulatory limits, relationship to historical data if available, permit exceedances, MCL exceedances for compliance samples which are reported as required to the applicable regulatory authority, and other general criteria. Procedures for review, approval, and release of results are described in SOP QC0913 (Laboratory Data Review and Reporting of Analytical Results). Reports are issued with serial numbers in the format specified by the client.

27.3 Environmental Testing Obtained from Subcontractors

27.3.1 Subcontracted analyses are reported either by entry into LIMS or by attaching a copy of report from the subcontract laboratory to the EQC final report. The report clearly indicates the name and the laboratory identification number of the laboratory performing the analysis.

27.4 Electronic Transmission of Results

27.4.1 Clients have the option to access analytical results online using a secure access code.

27.4.2 Online analytical reports cannot be modified by the client.

27.5 Amendments to Test Reports

27.5.1 Amended test reports are identified with a new serial number as described in Section 27.2.1. Amended reports indicate the serialized report that it replaces and the reason for issuance of the revised report.

28.0 HEALTH AND SAFETY

EQC has established a formal health and safety program, which is detailed in its Safety Procedure Manual. The program includes policies and procedures that are essential for the safe operation of the laboratory. Training is provided to all employees on the key elements of this program.

28.1 **Policy:** EQC provides a safe and healthy working environment for all its staff. The Company's safety program complies with the requirements of Occupational Health and Safety Administration (OSHA) and other applicable regulatory agencies. EQC's objective of the health and safety program is to promote safe work practices that prevents or minimizes injuries and accidents, by raising awareness, and through safety training.

28.2 Elements of Health and Safety Program:

28.2.1 New Employee Safety Orientation: Training is provided to all new employees upon hiring. This training includes hazard communication, safe handling of laboratory equipment, chemicals and reagents, and Right Know Training. Policies adhere to OSHA's Hazard Communication Standard, Title 29, Code of Federal Regulations 1910.1200. Safety Data Sheets (SDS), previously, Material Safety Data Sheets (MSDS) are available for employees to access at each laboratory location, or via EQC's Intranet site for SDS.

28.2.2 Chemical Hygiene Plan: This plan includes identification and operating procedures of safety equipment and personal protective equipment (PPE). Potential health hazards of hazardous chemicals and reagents, and safe handling procedures are covered in this plan. EQC maintains a hazardous Chemicals Inventory at every laboratory location, and this list is updated annually.

28.2.3 Chemical Spill Response Plan: This plan includes steps to prevent spills, and minimize exposure risks from chemical spill or accidental release of chemicals or gases in the laboratory.

28.2.4 Blood borne Pathogen Plan: Blood borne pathogens are infectious microorganisms present in blood that can cause disease in humans. These pathogens include, but are not limited to, hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV), the virus that causes AIDS. EQC has implemented a plan to prevent workers' exposure to blood borne pathogens that are at risk for serious or life-threatening illnesses.

28.2.5 Respiratory Protection Plan: This plan includes steps for protection from exposure to respiratory hazards, when engineering controls and safe practices are inadequate to control the hazards.

28.2.6 Permit-Required Confined Space Program: Identifies confines spaces in the building. It instructs who can, and how to enter the confined spaces.

28.2.7 Radiation Protection Program: Identifies radiation devices, storage, handling and leak-checking requirements and responsibilities.

28.2.8 Fire Prevention Program: Identifies storage location of flammables, potential ignition sources and handling.

28.2.9 Emergency Response and Evacuation Plan: Procedures to protect staff and visitors during emergencies are detailed in this plan. These emergencies could include accidental fire, explosion, gas leaks, hazardous material spills, natural disasters etc. The plan identifies emergency response team that should coordinate the response in times of emergencies.

28.2.10 Lockout/Tagout Plan: When repair or maintenance is required on laboratory equipment, it is critical to ensure that the equipment is safe/inoperable before any work is done by EQC staff or outside contractors. The Lockout/Tagout plan

details procedures to do maintenance on equipment that has the potential to start, energize, or release energy, and cause injury to personnel.

28.3 All employees must wear appropriate personal protective equipment and adhere to the safety guidelines specified in the Safety Procedure Manual of EQC.

28.4 Food, drinks and plants are prohibited in the laboratory work areas.

28.5 Employees should not report to work when their health conditions might negatively affect other personnel or laboratory analysis.

28.6 Safety Committee: The Safety Committee comprises representatives from different laboratories, administrative personnel and Management, and conforms to guidelines of the State of Pennsylvania. The Committee coordinates periodic safety inspections, addresses safety concerns, makes improvements, and tracks facility accidents. The Committee meets monthly to discuss safety issues.

29.0 SUPERSESSION

29.1 This QSM supersedes the previous versions of the EQC QSM. Name references and logos were revised to reflect Eurofins QC, Inc. (EQC). Minor editorial changes were made throughout the document.

The following changes were made to Figures and Tables:

Figure 1	Updated for a new EQC Organization Chart
Figure 2	Updated to reflect the Eurofins' Ethics Policy Statement
Figure 3	Updated to reflect the Eurofins' Confidentiality Agreement
Figure 4	Added to reflect the Eurofins' Quality Policy Statement

Removed floor plans (Figure 2)

Other revisions were as follows:

Section 6.4.7	Added reference to additional reference Methods.
Section 9.0	Updated section with purchasing guidelines
Section 20.1.8	Added Manager of Environmental Laboratory Administration
Section 22.2.2.4	Defined LOQ for tests with no calibration curve
Section 22.5	Deleted to avoid redundancy.
Section 22.5.1	Manual integration policy summary added.
Section 23.3.2.4	Removed term "correlation coefficient" to indicate more general statistical criteria for calibration curves
Section 23.3.3.4.d	Section added to describe reporting of drinking water compliance samples to the state of Pennsylvania
Section 25.6.3	Section added to describe use of "pick sheets"
Section 25.8.2	Updated policy for sample disposal
Section 26.4.7	Added DE state requirement for PTs.
Section 26.1.5.2	Added hexavalent chromium in solids to for post-digest spikes
Section 26.2.3	Trend analysis added.
Section 27.2.1	Added Microbiology Department Manager and Technical Director for approval of microbiology data
Section 28.0	Updated Section 28.0 with detailed information on Health and Safety.

APPENDICES

Figure 1. Eurofins QC, Inc. Organization Chart

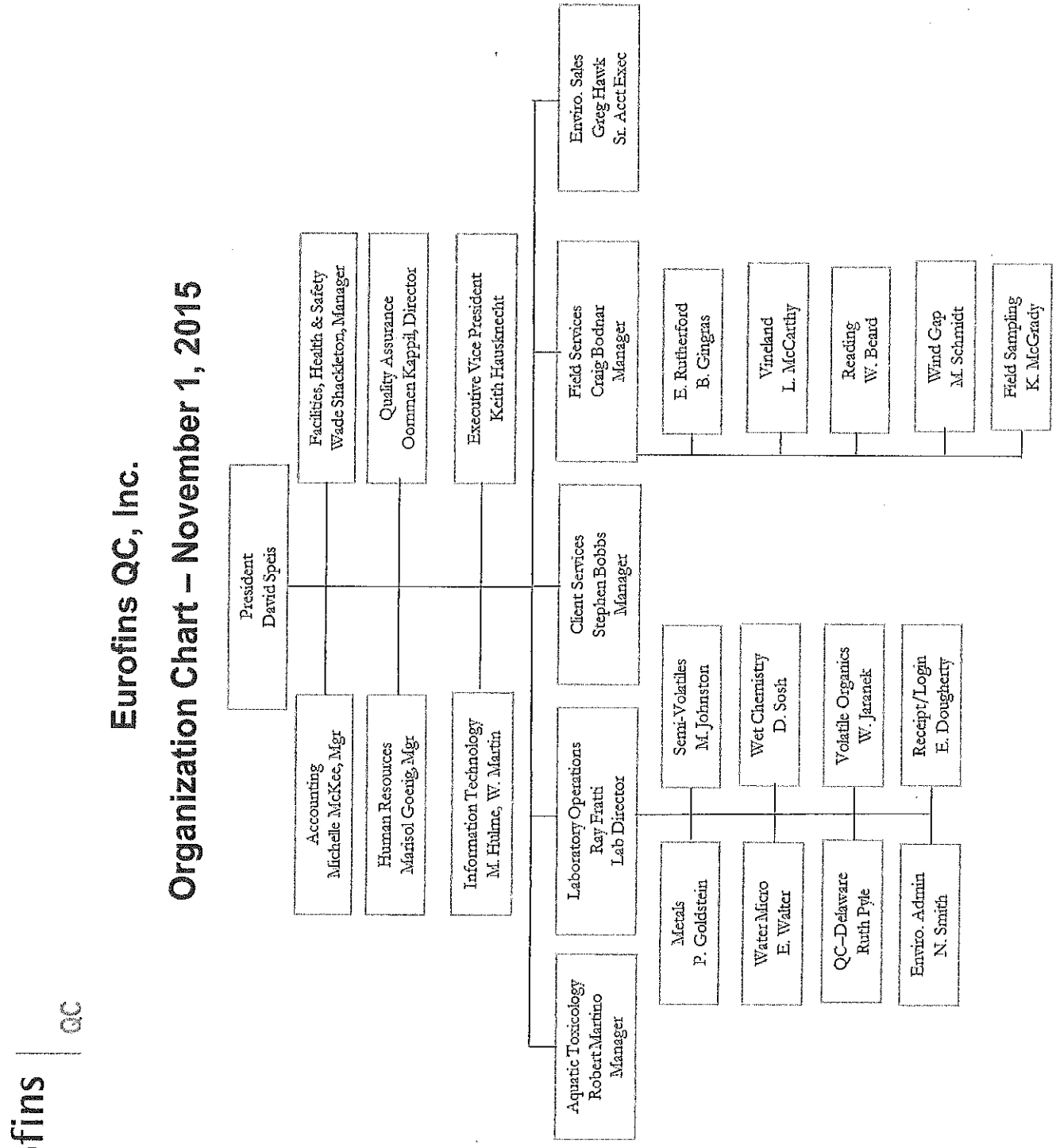

Figure 2

eurofins	Document Title: Eurofins Ethics Policy Statement		
	Eurofins Document Reference: N/A	Revision : 2	Historical Reference: N/A
	Effective date : 05/01/2015	Status: Effective	

Our Company was built on the foundation of high integrity and ethical laboratory practices. To preserve this standard we have a clear expectation that each of us take personal responsibility to do the right thing and uphold the highest level of ethics and quality in all of our dealings.

Here are the ethical responsibilities required of us:

Each and every one of us is expected to adhere to the highest professional and ethical standards. Each employee commits to honest and ethical practices in all daily actions.

- No one will intentionally improperly manipulate or falsify activities in <u>any</u> way.
- Ethical performance and data integrity MUST supersede any other objective of laboratory operations.
- Each employee bears ultimate responsibility for the validation and accuracy of his or her documentation. The analyst's signature signifies that the action taken to generate the data and the documentation are accurate and authentic, and confirm that all proper procedures were followed in the generation of the data in real time.
- Eurofins takes a zero tolerance stance for illegal, unethical, and improper practices affecting the testing process. Each employee is responsible for safeguarding the Lab's ethical practices. For this reason, each employee is responsible to report any situation that may be adversely affecting the quality and integrity of the data produced.
- It is vital that all employees take responsibility to preserve our ethical business practices. Employees who know of, or witness any violation of business, quality, or data integrity policy are required to report the activity to an Ethics Officer, Quality Director, or member of Senior Management. A timely and thorough investigation will occur to remedy any situation regarding these allegations.
- Any employee who knows of or witnesses any violation of business, quality, or data integrity policy, but fails to report it will be subject to disciplinary action.
- During a thorough investigation, the Ethics Officer, and/or Senior Management, will assess the situation and resolve the matter. Since data integrity is so vital to our business practices, any employee found willfully falsifying or manipulating data will be released from employment.
- The Ethics Officer, or Senior Management, in collaboration with appropriate staff, will complete a corrective action plan addressing the root causes. The action plan will be put in place and may include additional training or changes in policies and procedures. All those involved will receive confidential communication regarding corrective action steps taken to remedy the situation.

I understand and commit to these responsibilities. I understand the critical importance of data and business integrity compliance. I realize that any infractions of laboratory integrity procedures could lead to serious consequences including employment separation, debarment, or civil/criminal prosecution. I take personal responsibility to uphold the highest ethical business practices and report any concerns to help preserve Eurofins' integrity.

Name (Print)	Employee Number	Company Name
Signature	Date	

Figure 3

Eurofins QC, Inc.
CONFIDENTIALITY AGREEMENT

THIS AGREEMENT, made this _____ day of _____, 20__, between Eurofins QC, Inc.., a Pennsylvania corporation, hereinafter called "EQC" and _____, hereinafter called "Employee".

WHEREAS, EQC is engaged in the business of a professional testing laboratory, and

WHEREAS, EQC employs the Employee and the Employee desires to enter or continue in the employ of EQC on the terms, provisions and conditions specified herein as to confidentiality; and

WHEREAS, the employee in the course of his/her employment and as a necessary consequence thereof will receive information and acquire knowledge of the business and affairs of EQC and more particularly technical information which in character is private, peculiar and confidential in nature to EQC, and/or EQC's customers in their business; and,

WHEREAS, the business, success and profits of EQC depend in large part upon the maintenance of confidentiality as to such information and knowledge;

NOW, THEREFORE, in consideration of the mutual undertakings of the parties and the employment or continued employment of the Employee by EQC, incorporating the premises, intending to be legally bound, the parties agree as follows:

1. All technical information of a confidential nature encompassed within this agreement shall be made available to Employee on the basis that such technical information is necessary to Employee's proper performance of the work for which the Employee is responsible.
2. Employee agrees that he/she will not, while in the employ of EQC , or at any time thereafter, communicate or divulge either orally or in writing or otherwise, to anyone any knowledge or information that he/she may acquire or which may be imparted to him/her in the course of his/her employment, regarding the business or affairs of EQC or its customers and particularly, but not in limitation of the generality of the forgoing, knowledge or information regarding technical information of EQC or EQC's customers.
3. Other than as set forth herein, all terms and conditions of the employment of the Employee are as set forth from time to time in the Employee Handbook and any other document relevant to Employee or employees of EQC in general and this agreement shall not be constructed as granting to Employee any special rights or privileges not specifically granted in the said Handbook or other documents.

Staff Signature	Printed Name	Date
Corporate Signature	Printed Name	Date

Figure 4

QUALITY POLICY STATEMENT

eurofins	Document Title: Eurofins US Quality Policy Statement		
	Eurofins Document Reference: 1-P-QM-FOR-9007879	Revision: 6	Historical Reference: Form 2787
	Effective date: July 7, 2014	Status: Effective	

As an organization, all personnel are committed to high quality professional practice, testing and data, and service to our clients.

We strive to provide the highest quality data achievable by:

- Following all documentation requirements; describing clearly and accurately all activities performed; documenting "real time" as the task is carried out; understanding that it is never acceptable to "back date" entries and should additional information be required at a later date, the actual date and by whom the notation is made must be documented.
- Providing accountability and traceability for each sample analyzed through proper sample handling, labeling, preparation, instrument calibration/qualification/validation, analysis, and reporting; establishing an audit trail that identifies date, time, analyst, instrument used, instrument conditions, quality control samples (where appropriate and/or required by the method), and associated standard material.
- Emphasizing a total quality management process which provides accuracy, and strict compliance with agency regulations and client requirements, giving the highest degree of confidence; understanding that meeting the requirements of the next employee in the work flow process is just as important as meeting the needs of the external client.
- Providing thorough documentation and explanation to qualify reported data that may not meet all requirements and specifications, but is still of use to the client; understanding this occurs only after discussion with the client on the data limitations and acceptability of this approach.
- Responding immediately to indications of questionable data, out-of-specification occurrences, equipment malfunctions, and other types of laboratory problems, with investigation and applicable corrective action; documenting these activities completely, including the reasons for the decisions made.
- Providing a work environment that ensures accessibility to all levels of management and encourages questions and expression of concerns on quality issues to management.

We each take personal responsibility to provide this quality product while meeting the company's high standards of integrity and ethics, understanding that improprieties, such as failure to conduct the required test, manipulation of test procedures or data, or inaccurate documentation will not be tolerated. Intentional misrepresentation of the activities performed is considered fraud and is grounds for termination.

I understand the expectations and commit to implementation of all applicable policies and procedures and to providing quality data.

Name (printed) _____ Employee Number _____

Signature _____ Date _____

Table 1. List of Accreditations

Laboratory testing accreditations held by EQC are summarized below. Certified analyte lists are available upon request

State	EQC Department and Facility	Regulatory Authority	Programs	Certificate
International	Food Microbiology/Horsham PA	A-Class	ISO/IEC: 17025	72701
National	Pharmaceutical/Horsham PA	FDA	Pharmaceuticals/Personal Care Products	2515238
National	Food Chemistry/Horsham PA	USDA	Moisture, Protein, Salt, and Fat Contents	4260
Pennsylvania	Dairy/Horsham PA	Pennsylvania DOA	Raw Milk and Dairy Products	Approved
Pennsylvania	Food Chemistry/Horsham PA	Pennsylvania DOA	Meat and Poultry Products	NA
Delaware	Environmental/New Castle DE	Delaware DHSS/ODW	Microbiology/Potable Water	M13DE01102
Delaware	Environmental/New Castle DE	Delaware DHSS/ODW	Chemistry/Potable Water	C13DE01102
Connecticut	Environmental/Southampton PA	Connecticut DOH	Potable/Non-Potable Water Solid/Hazardous Waste	PH-0768
Maryland	Environmental/New Castle DE	Maryland DOE (MDE)	Potable Water	138
Maryland	Environmental/Southampton PA	Maryland DOE (MDE)	Potable Water	206
New Jersey	Environmental/East Rutherford NJ	New Jersey DEP	Potable/Non-Potable Water	2015
New Jersey	Environmental/Southampton PA	New Jersey DEP	Potable/Non-Potable Water Solid/Hazardous Waste	PA166
New Jersey	Environmental/Vineland NJ	New Jersey DEP	Potable/Non-Potable Water	06005
New Jersey	Environmental/Wind Gap PA	New Jersey DEP	Potable/Non-Potable Water	PA001
New York	Environmental/Southampton PA	New York DOH	Potable/Non-Potable Water Solid/Hazardous Waste	11223
Pennsylvania	Environmental/Reading PA	Pennsylvania DEP	Potable/Non-Potable Water	06-03543
Pennsylvania	Environmental/Southampton PA	Pennsylvania DEP	Potable/Non-Potable Water Solid/Hazardous Waste	09-00131
Pennsylvania	Environmental/Wind Gap PA	Pennsylvania DEP	Potable/Non-Potable Water	48-01334

Table 2. Equipment List

Department	Quantity	Equipment Description	Manufacturer/Model
EQC-Southampton			
Bioassay	2	pH Meter	Fisher Accumet Model 1002
Bioassay	1	pH Meter	Beckman Model 350
Bioassay	1	pH Meter	Fisher Accumet Model APS
Bioassay	2	Oxygen Meter	YSI Model 5000
Bioassay	2	Conductivity Meter	YSI Model 3100
Bioassay	9	Thermometer	Onset Model 2K Hobo
Bioassay	4	Thermometer	Onset Model HB
Bioassay	4	Mercury Thermometer	Fisher
Bioassay	1	Compound Microscope	Fisher Micromaster Model CK4
Bioassay	1	Dissecting Microscope	Cambridge
Bioassay	1	Analytical Balance	Mettler Model AE100
Bioassay	1	Analytical Balance	Mettler Model AE163
Bioassay	1	Drying Oven	Gallenkamp Model 300
Bioassay	3	Autoclave	Amsco Model 15
Bioassay	1	Sample Refrigerator	Bush 8 x 8 Walk-in
Bioassay	1	Sample Refrigerator	Magic Chef Model MCBR44W
Bioassay	1	Freezer	Gibson Chest
Bioassay	1	Environmental Chamber	VWR Model 2020
Bioassay	1	Environmental Chamber	VWR Model 2015
Bioassay	1	Mechanical Shaker	Lab Manufactured
Bioassay	1	Centrifuge	Fisher Model Marathon 10K
Bioassay	2	Water Bath	Precision Model 1100
Bioassay	1	Spectrophotometer	Hach Model DR100
Bioassay	1	Spectrophotometer	Milton Roy Model Spec 601
Bioassay	1	Fluorometer	Turner Model 450
Bioassay	1	Fume Hood	Fisher
Bioassay	4	Dessicator	Fisher
Bioassay	4	Light Box	Hall Productions
Bioassay	1	Photometer	SPER Model 840020
Bioassay	1	Water Purification System	U.S. Filter
Bioassay	36	15-gallon Breeder Tanks	Aquarium Supplier
Bioassay	9	5-gallon Batch Out Tanks	Aquarium Supplier
Bioassay	8	25-gallon Tanks	Fridgid
Bioassay	2	Chiller	Fridgid
Bioassay	1	150-gallon Tank for Reconstituted Water	Aquarium Supplier
Bioassay	1	350-gallon Polyethylene Tank For Saltwater	Aquarium Supplier
Bioassay	1	100-gallon Polyethylene Tank For Natural Fresh Water	Aquarium Supplier

Table 2. Equipment List (continued)

Department	Quantity	Equipment Description	Manufacturer/Model
EQC-Southampton			
Bioassay	3	Filter Systems	Rainbow
Bioassay	3	300-gallon Head Tanks	Aquarium Supplier
Bioassay	2	Dilutor	Specialized Environmental Equipment
Bioassay	2	Dilutor	ACE Glass
Bioassay	6	Peristaltic Pumps	Cole-Parmer
Bioassay	22	Water Baths	Various
Bioassay	1	Air Delivery System	Gas Regenerative Blower (1/2 HP)
Field Services	30	Compositor	ISCO Model 2910
Field Services	7	Submersible Pump	Grundfos Redi-Flow
Field Services	1	Low Flow Submersible Pump	ISCO
Field Services	6	Centrifugal Pump	Teel, 30 Ft. Capacity
Metals	1	ICAP with Autosampler	PE Optima 7300 DV/PE S10
Metals	1	ICAP with Autosampler	PE Optima 4300 DV/PE AS93 Plus
Metals	1	Graphite Furnace/Flame with	PE AANALYST 800/PE AS800
Metals	1	Mercury Analyzer	Leeman Hydra AA
Metals	1	Flame AA	PE AANALYST 300
Metals	1	ICP/MS with Autosampler	PE ELAN 9000/PE AS93 Plus
Metals	1	ICAP with Autosampler	Thermo 6500/CETAC ASX 500-Series
Metals	2	Digestion Block	Environmental Express SC100
Metals	1	Digestion Block	Environmental Express SC150
Metals	2	Digestion Block	Environmental Express SC154
Metals	1	Controller	Environmental Express/Hot Block Pro SC180
Metals	2	Digestion Block	Environmental Express/Hot Block Pro SC181
Metals	1	ICP/MS with Autosampler	Agilent 7500CX/CETAC ASX 500-Series
Metals	1	Microwave digestion system	CEM MARS5
Metals	1	DI water system	Thermo Nano Pure Water system
Metals	1	Turbidity Meter	Orbeco Hellige 965-10A
Organic Chemistry	2	GC (ECD/ECD)	HP5890 with injector and autosampler
Organic Chemistry	1	GC (FID)	HP5890 with purge and trap
Organic Chemistry	3	GC (ECD/ECD)	Agilent 6890 with injector and autosampler
Organic Chemistry	4	GC (FID/FID)	Agilent 6890 with injector and autosampler
Organic Chemistry	3	GC (ECD/ECD)	Agilent 7890 with injector and autosampler
Organic Chemistry	2	GC (FID/FID)	Agilent 7890 with injector and autosampler
Organic Chemistry	1	GC (FID)	Agilent 6890 with auotsampler (EST LGX50)
Organic Extractions	1	Concentrator	Zymark Turbovap II
Organic Extractions	2	ASE	Dionex ASE 200
Organic Extractions	2	Sonicator	Fisher 550
Organic Extractions	2	Sonicator	Fisher 500

Table 2. Equipment List (continued)

Department	Quantity	Equipment Description	Manufacturer/Model
EQC-Southampton			
Organic Extractions	1	Sonicator	Fisher 505
Organic Extractions	8	Automated Solid Phase Extraction Unit	Horizon Technology SPE-DEX 4790
Organic Extractions	1	Nitrogen Evaporator	Organomation Associates, Inc N-EVAP 112
Organic Extractions	2	Water bath	Organomation Associates, Inc S-EVAP-KD
Organic Extractions	1	TurboVap	Caliper Life Science
Sample Custody	1	Walk-in Cooler	Penn Refrigeration Service
Sample Custody	3	Walk-in Cooler	Bally Engineered Structures/Thermo Balance
Sample Custody	1	Walk-in Freezer	Bally Engineered Structures
Semivolatile Organics	2	GC/MS	Agilent 6890 GC/5973 MSD w/EPC
Semivolatile Organics	2	GC/MS	Agilent 7890 GC/5975 MSD w/EPC
Semivolatile Organics	2	Autosampler	Agilent 7683
Semivolatile Organics	2	Autosampler	Agilent 7693
Semivolatile Organics	4	Data Systems	HP Enviroquant Software
Volatile Organics	5	GC/MS	HP5890 GC/5971MSD w/EPC
Volatile Organics	4	GC/MS	HP5890 GC/5972 MSD w/EPC
Volatile Organics	1	GC/MS	HP6890/5973 MSD w/EPC
Volatile Organics	3	Purge and Trap	Evolution Dual Purge & Trap/Centurian
Volatile Organics	1	Purge and Trap	Encon Dual Purge & Trap/Centurian
Volatile Organics	1	Purge and Trap	Encon Dual Purge & Trap/Archon 2000
Volatile Organics	1	Purge and Trap	Encon Purge & Trap/Archon 2000
Volatile Organics	1	Purge and Trap	Tekmar 3000/Archon 2000
Volatile Organics	1	Purge and Trap	Tekmar LSC2000/ALS2016
Volatile Organics	8	Data Systems	HP Enviroquant Software
Water Microbiology	2	Autoclave	Consolidated – SR24C
Water Microbiology	1	Dishwasher National	Model NLW 441S
Water Microbiology	1	Dishwasher Fisher Jet Clean	Model 628
Water Microbiology	1	Dispenser	Filamatic
Water Microbiology	1	Incubator	Thermo-Fisher Model 815
Water Microbiology	1	Incubator	Thermo-Fisher Model 3721
Water Microbiology	1	Incubator	Thermo-Fisher Model 3720
Water Microbiology	1	Incubator	VWR Model 1545
Water Microbiology	1	Incubator	Precision Scientific
Water Microbiology	1	Incubator	Quincy Labs Model 10-180
Water Microbiology	1	Incubator	Fisher Model 525D
Water Microbiology	1	Walk-in Incubator	Hot Pack Model 462
Water Microbiology	1	Refrigerator/Freezer Combination	RCA Model MTX154CYXKRWH
Water Microbiology	1	Refrigerator	Woods Model RFA17NAD

Table 2. Equipment List (continued)

Department	Quantity	Equipment Description	Manufacturer/Model
EQC-Southampton			
Water Microbiology	1	Walk-in Refrigerator	Bally
Water Microbiology	1	Metal Bath	Thermo Scientific Model 2332
Water Microbiology	1	Water Bath	Precision Scientific Model 2868
Water Microbiology	1	Water Bath	Thermo Scientific Model 2862
Water Microbiology	1	Water Bath	Baxter W2975-22
Water Microbiology	1	Dark Field Colony Counter	Leica Model 3325
Wet Chemistry	2	TOC Analyzer	OI 1030 with 1088 auto sampler
Wet Chemistry	1	TOC Analyzer	Tekmar-Brinkman DC-190 with 183 solid sample
Wet Chemistry	1	Ion Chromatograph	Dionex ICS 1600 with AS-DV50 auto sampler
Wet Chemistry	1	Ion Chromatograph	Dionex DX-120 with AS50 auto sampler
Wet Chemistry	1	Ion Chromatograph	Dionex ICS 2000 with AS40 auto sampler
Wet Chemistry	1	Segmented Flow Analyzer	TrAAcs 800 with linear sampler
Wet Chemistry	1	Segmented Flow Analyzer	Alpkem RFA/2 with 301 auto sampler
Wet Chemistry	1	Discrete Auto-analyzer	Seal AQ2
Wet Chemistry	1	Infra-red Spectrophotometer	PE 710B
Wet Chemistry	1	Automated Titration / ISE with Conductivity Meter & xyz Sampler	Man-Tech, PC-Titrate Jenway, 4510 Conductivity meter Gilson 221 Liquid Handler
Wet Chemistry	1	Hexane Evaporation System	Horizon Technology Speed Vap II 9000
Wet Chemistry	1	Spectrophotometer	Hach DR/2400
Wet Chemistry	1	Spectrophotometer	Genesys 20
Wet Chemistry	3	pH Meter	Accumet AB-15
Wet Chemistry	1	pH/mV Meter	Orion EA920
Wet Chemistry	1	Conductivity Meter	YSI 3100
Wet Chemistry	1	Conductivity Meter	Mettler Toledo S230
Wet Chemistry	3	Automated BOD system	Man-Tech BOD Assay Plus
Wet Chemistry	2	Dissolved Oxygen Meter	YSI Model 52
Wet Chemistry	1	Dissolved Oxygen Meter	YSI Model 59
Wet Chemistry	2	Analytical Balance	Mettler AE240
Wet Chemistry	1	Analytical Balance	Mettler AE 160
Wet Chemistry	2	Cyanide Distillation System	Glastron Enviro Midi-Dist
Wet Chemistry	1	Phenol Distillation System	Midi-Dist 2210
Wet Chemistry	2	Ammonia Distillation System	Midi-Dist
Wet Chemistry	1	Incubator, 20^{0}C	Fisher 307C
Wet Chemistry	1	Walk-In Incubator, 20 ^{0}C	8' x 10' QC Manufactured
Wet Chemistry	3	Multi-position (6place) heating units with extraction glassware.	Lab-Line
Wet Chemistry	5	Top Load Balance	Various

Table 2. Equipment List (continued)

Department	Quantity	Equipment Description	Manufacturer/Model
EQC-Southampton			
Wet Chemistry	4	Drying Ovens	Various
Wet Chemistry	1	Muffle Furnace	Fisher Iso-Temp
Wet Chemistry	3	COD Reactors	HACH, 25-place
Wet Chemistry	2	Block Digesters	Technicon, BD40
Wet Chemistry	1	Pensky-Martens Flashpoint Tester	Boekel 152800
Wet Chemistry	1	Centrifuge	Whisperfuge, 12-place
Wet Chemistry	1	Sonicator	Branson 2510
Wet Chemistry	1	Ammonia Meter	Orion EA920
EQC-Delaware			
Field Services	12	Autosamplers	ISCO
Field Services	1	5-Station Battery Charger	ISCO
Field Services	1	M-Scope	Sample Pro 6000
Field Services	1	Conductivity Meter	Thermo Orion Model 135A
Field Services	3	Chlorine Meter	Hach DR-100
Water Microbiology	1	Autoclave	Market Forge Sterilmatic Model STM-E
Water Microbiology	1	Autoclave	Market Forge Sterilmatic Model STM-E
Water Microbiology	1	Colony Counter Denominator	Fisher Multiple Tally
Water Microbiology	1	pH Meter	Oakton Model 1100
Water Microbiology	1	Stirring Hot Plate	Thermo Fisher
Water Microbiology	1	Incubator	VWR Precision Model 1550 (#ACL-2D)
Water Microbiology	1	Incubator	VWR Precision Model 6M (#DEINC001)
Water Microbiology	1	Incubator	Quincy Labs Model 10-1450 (#L03602)
Water Microbiology		Membrane Filtration Equipment	Gelman , Millipore 3-place
Water Microbiology	1	Microscope	Fisher
Water Microbiology	1	Refrigerator	Danby DCR34W
Water Microbiology	1	UV Lamp 366nm, 6 W	Spectroline EA-160 (#1557885)
Water Microbiology	1	Water Bath (Coliform)	Precision (#66850)
Water Microbiology	1	Water Batch (Colilert)	Precision (#9308-426)
Water Microbiology	2	Quanti-Tray Sealer	IDEXX Model 2X
Wet Chemistry	1	Walk-in Cold Storage Box	Kysor/Needham
Wet Chemistry	2	Oxygen Meters	YSI Model 58/5906 BOD probe
Wet Chemistry	1	pH Meter	Cole-Parmer Mode 6209
Wet Chemistry	1	Analytical Balance	Denver Instruments TL-204
Wet Chemistry	1	Drying Oven #1	VWR Model 1320
Wet Chemistry	1	Drying Oven #2	Thelco Model 17
Wet Chemistry	1	Drying Oven #3	Fisher IsoTemp Model 6916
Wet Chemistry	1	Drying Oven #4	Thermo Precision Model 6958

Table 2. Equipment List (continued)

Department	Quantity	Equipment Description	Manufacturer/Model
EQC-Delaware			
Wet Chemistry	5	BOD Incubators	Fisher Model 507C
Wet Chemistry	1	Muffle Furnace	Lindberg Blue BF51766A
Wet Chemistry	1	Hot Water Bath	Fisher Scientific IsoTemp 120
Wet Chemistry	1	Heating Block	Fisher Scientific IsoTemp 145D
Wet Chemistry	1	Stir Plate	Cimarec 2 Thermolyne Model S46725
Wet Chemistry	1	Stir Plate	Fisher Vuemix Model 116
Wet Chemistry	1	Stir Plate	Fisher Scientific 11-06000-7S
Wet Chemistry	1	Stir Plate	Fisher Thermix Model 120S
Wet Chemistry	1	Stir Plate	Cimarec 3 Thermolyne Model S47035
Wet Chemistry	8	Dessicators	Boekel
Wet Chemistry	1	Dishwasher	Labconco Flask Scrubber
Wet Chemistry	1	Vacuum Pump	Marathon 5KH36KNA510X
Wet Chemistry	1	Turbidimeter	Hach Model 2100N
Wet Chemistry	1	Lachat Flow Injection Analyzer	QuikChem 8000, Lachate Omnion 2.0 Software Block Digestor Lachat Model BD-46
Wet Chemistry	1	Ion Chromatograph	Dionex ICS-1000, Autosampler Dionex AS-40 Software Dionex Chromeleon
Wet Chemistry	1	Ion Chromatograph	Dionex ICS-1600, Autosampler Dionex AS-40 Software Dionex Chromeleon
Wet Chemistry	2	COD Digestion Blocks	Hach 45600-00
Wet Chemistry	1	COD Temperature Probe	Hach 15-077-14
Wet Chemistry	1	Conductivity Meter	Orion (#9098)
Wet Chemistry	3	Stir Plates	VWR Mini-Stirrer Model 200
Wet Chemistry	1	UV-Vis Spectrophotometer	Hach DR-2500
Wet Chemistry	1	UV-Vis Spectrophotometer	Spectronic 20 Genesys
Wet Chemistry	1	Balance	Mettler Model PM-4600
Wet Chemistry	1	Hot Block	Environmental Express Model SC10
Wet Chemistry	1	Hot Block	Environmental Express Model SC100
Wet Chemistry	1	Refrigerator	Kenmore
Wet Chemistry	1	Refrigerator	Magic Chef
Wet Chemistry	1	TOC Analyzer	Teledyne Tekmar Phoenix 8000 Teledyne Tekmar Autosampler and Software
Wet Chemistry	1	Automatic Titrator	Metrohm Model 719S Titrino Autosampler Metrohm Model 730 Software Beckman Titrino Workcell V4.0

Table 3. List of Standard Operating Procedures

Department	Standard Operating Procedure Title	SOP Number
Bioassay	Quality Systems Manual for the Aquatic Toxicology Laboratory	QC0452
Bioassay	Dissolved Oxygen Measurement by Probe-Membrane Method (EPA 360.1)	QC0489
Bioassay	Test Methods and Protocols for Acute Testing Under the NPDES Program	QC0491
Bioassay	In Vitro Determination of Chlorophylls, a, b, $C_1 + C_2$ and Pheopigments in Marine and Freshwater Phytoplankton by Visible Spectrophotometry	QC0492
Bioassay	Sampling, Preparation and Handling of Dilution Waters and Effluent for Use in NPDES Testing	QC0493
Bioassay	Procedure for Cleaning Labware used in Aquatic Toxicity Testing	QC0496
Bioassay	Fathead Minnow, Pimehales Promelas, Larval Survival and Growth Test, EPA Method 1000.0	QC0503
Bioassay	Daphnid, Ceriodaphnia Dubia, Three Brood Survival and Reproduction Test, EPA Method 1002.0	QC0504
Bioassay	Mysid, Mysidopsis Bahia, Survival, Growth and Fecundity Test, EPA Test Method 1007.0	QC0507
Bioassay	Sheepshead Minnow, Cyprinodon Variegatus, Larval Survival and Growth Test, EPA Test Method 1004.0	QC0632
Bioassay	Atlantic Silverside, Menida Beryllina, Larval Survival, and Growth Test EPA Method 1006.0	QC0634
Bioassay	Standard Operating Procedure for Culturing the Green Algae Selenastrum for Testing and Use as Cladoceran Food	QC0635
Bioassay	Green Alga, Selenastrum Capricornutum, Growth Test Method 1003.0	QC0636
Bottle Preparation	Preparing a Bottle Order	QC0429
Bottle Preparation	Preparation and Storage of Pre-preserved Sample Bottles	QC0458
Bottle Preparation	Preparation of Containers for Soil Samples with Methanol	QC0842
Environmental Administration	Review of Routine Laboratory Results	QC0436
Environmental Administration	Review of Permitted Results	QC0436
Environmental Administration	Preparation of PADEP SDWA-Pb,Cu Forms	QC0451
Environmental Administration	Preparation of PADEP SDWA-1, TTHM, HAA, TOC, Alkalinity, PBCU, Bromide, Bromate, Coliform Check Samples, Chlorine Residual and HPC Forms	QC0453
Environmental Administration	Preparation of PADEP SDWA-4, Inorganic/Organic Chemical and Radiological Analysis Forms	QC0462
Environmental Administration	XMIT Program for Exxon	QC0517
Environmental Administration	Laboratory Information Management System (LIMS) Result Rollback Procedure	QC0571
Field Services	Groundwater Monitoring Well Sampling Procedures	QC0305
Field Services	Trip and Field Blank Preparation	QC0309
Field Services	DPD Chlorine and DPD Bromine Using a Taylor Slide Comparator	QC0317
Field Services	Field Measurement of Conductivity, Standard methods 2510B	QC0331

Table 3. List of Standard Operating Procedures (continued)

Department	Standard Operating Procedure Title	SOP Number
Field Services	Field Temperature Measurement	QC0332
Field Services	Field pH Measurement	QC0333
Field Services	Procedure for Collection & Submittal of VOC Field Reagent Blanks for Drinking Water Samples	QC0374
Field Services	Field Sampling Procedure for Swimming Pools, Wading Pools, Hot Tubs, Spas and Bathing Beaches	QC0538
Field Services	Field pH using a Taylor Slide Comparator	QC0547
Field Services	General Field Sampling Procedures	QC0548
Field Services	NJ Private Well Testing Act (PWTA) Sampling Procedures – General Requirements	QC0591
Field Services	NJ Private Well Testing Act (PWTA)– Microbiological Sampling	QC0591A
Field Services	NJ Private Well Testing Act (PWTA) Sampling Procedures – Volatile Organics	QC0591B
Field Services	NJ Private Well Testing Act (PWTA) Sampling Procedures – Nutrients	QC0591C
Field Services	NJ Private Well Testing Act (PWTA) Sampling Procedures – Metals	QC0591D
Field Services	NJ Private Well Testing Act (PWTA) Sampling Procedures – Field pH Measurement	QC0591E
Field Services	NJ Private Well Testing Act (PWTA) Sampling Procedures – GPS Readings	QC0591F
Field Services	NJ PWTA Sampling Procedures – 24 Hour Gross Alpha	QC0591G
Field Services	Sampling of Ice Cream and Frozen Desserts	QC0620
Field Services	Documentation of Field Measurements	QC0637
Field Services	Measurement of Free & Total Chlorine using the Hach® Pocket Colorimeter II	QC0661
Field Services	Low Flow Groundwater Monitoring Well Sampling Procedure	QC0663
Field Services	Grab and Composite Sampling Procedure	QC0664
Field Services	Sampling Procedure for the DRBC PCB Project	QC0711
General	Thermometer Calibration, Maintenance, and Record keeping	QC0339
General	Documentation of Laboratory Data	QC0343
General	Routine and Non-routine Instrument Maintenance	QC0417
General	Laboratory Balance Calibration	QC0470
General	Calibration Verification of Air Displacement Pipetters and non-Class A Disposable or Reusable Pipets	QC0472
General	Calibration of Reagent Delivery Pumps	QC0473
General	Purchasing of Services and Supplies	QC0478
General	Waste Disposal in the Laboratory	QC0479
General	Reagent/Reference Material Receipt, Labeling, Expiration, Storage and Disposal	QC0486
General	Proper Manual Integration Techniques for GC and GC/MS Chromatography	QC0559
General	Review Guidance for Data Deliverables Generated by EISC Software	QC0640

Table 3. List of Standard Operating Procedures (continued)

Department	Standard Operating Procedure Title	SOP Number
General	Culture Transfers between EQC Satellite Offices and the Southampton Laboratory	QC0760
General	Media Transfers between Southampton Laboratory and the EQC Satellite Offices	QC0761
General	Pest Management	QC0797
General	Change Control	QC0838
Metals	Mercury-Manual Cold Vapor Technique, EPA 245.1	QC0263
Metals	Determination of Trace Metals by Graphite Furnace Atomic Absorption, SM 3113B-2011	QC0265
Metals	Glassware Cleaning Procedure for Metals Analyses	QC0272
Metals	Metals and Trace Metals by Inductively Coupled Plasma (ICP) in Aqueous samples by EPA 200.7	QC0280
Metals	Mercury-Manual Cold Vapor Technique Method 7470A	QC0354
Metals	Mercury-Manual Cold Vapor Technique, SW846 Method 7471A & 7471B	QC0355
Metals	Acid Digestion of Aqueous Samples and Extracts for Analysis by SW846 Method 6010 (ICP)	QC0356
Metals	Acid Digestion of Sediments, Sludges, and Soils by Method EPA 3050B for ICP-AES Metals Analysis by Method 6010	QC0371
Metals	Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by SW846 Method 6010 (ICP)	QC0373
Metals	Turbidity Testing for Metals Digestion (Nephelometric) EPA Method 180.1	QC0430
Metals	Nitric Acid Digestion of Aqueous Samples by SM3030 E- 2004	QC0589
Metals	Calibration Validation of Digestion Vials	QC0592
Metals	Metals and Trace Elements by Inductively Coupled-Plasma Mass Spectroscopy (ICP-MS) by EPA 200.8	QC0599
Metals	Sample Preparation Procedure for the Digestion of Aqueous Samples for Total Recoverable Elements by EPA Method 200.2 for Analysis by EPA Methods 200.7, 200.8 and 200.9	QC0618
Metals	Metals and Trace Elements in Environmental Samples By Inductively Coupled Plasma (ICP) SW-846 Method 6010C	QC0757
Metals	Microwave Assisted Acid Digestion of Sediments, Sludges and Oils Method 3051A	QC0810
Metals	Metals and Trace Elements in Environmental Samples by Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS) by SW-846 Method 6020A	QC0829
Metals	Metals and Trace Elements in Food and Nutritional Samples by Inductively Coupled Plasma (ICP) AOAC Method 990.08	QC0910
Organic Extractions	Pressurized Fluid Extraction (PFE) EPA method 3545A	QC0415
Organic Extractions	Labware Washing Procedure for the Organic Extraction Laboratory	QC0469
Organic Extractions	Solid Phase Extraction-Herbicides by Method EPA 3535A	QC0674
Organic Extractions	Florisil Cleanup EPA 3620C	QC0677

Table 3. List of Standard Operating Procedures (continued)

Department	Standard Operating Procedure Title	SOP Number
Organic Chemistry	Diesel and Gasoline Range Organics by Gas Chromatography Based on USEPA SW-846 Method 8015B	QC0358
Organic Chemistry	Chlorinated Herbicides by Gas Chromatography based on EPA Method 8151A	QC0360
Organic Chemistry	1,2-Dibromomethane (EDB), 1,2-Dibromo-3-Chloropropane (DBCP), 1,2,3-Trichloropropane (1,2,3TCP) by Gas Chromatography based on EPA Methods 504.1 and 8011	QC0368
Organic Chemistry	Chlorinated Phenoxy Acid Herbicides by Gas Chromatography Based on Standard Methods 6640B	QC0412
Organic Chemistry	Organochlorine Pesticides and Polychlorinated Biphenyls by Gas Chromatography based on USEPA Method 608	QC0425
Organic Chemistry	Determination of Haloacetic acids in Drinking Water based on EPA Method 552.2	QC0555
Organic Chemistry	Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs) by Gas Chromatography based on SW846 Methods 8081 and 8082	QC0641
Organic Chemistry	Total Semivolatile Petroleum Hydrocarbons by Gas Chromatography Based on Method NJDEP OQA-QAM-025	QC0680
Organic Chemistry	The Determination of Extractable Petroleum Hydrocarbon Compounds by Flame Ionization Gas Chromatography Method NJ EPH 10/08	QC0756
Organic Chemistry	Determination of Chlorinated Pesticides in Drinking Water By Gas Chromatography with Electron Capture Detector (Method EPA 508 Revision 3.1)	QC0823
Organic Chemistry	Determination of Chlorinated Acids in Drinking Water by Liquid-Liquid Extraction, Derivatization and Gas Chromatography with Electron Capture Detection (EPA Method 515.3 Revision 1.0)	QC0824
Organic Chemistry	Determination of Ethylene Glycol, Propylene Glycol and Diethylene Glycol by Direct Aqueous Injection Using Gas Chromatography-Flame Ionization Detector	QC0825
Organic Chemistry	Analysis of Dissolved Gases in Water Using Headspace Autosampler and Flame Ionization Based on Method PA-DEOP 3686	QC0834
Quality Assurance	Content, Format, Preparation, Review, Approval, Distribution, Revision and Control of Standard Operating Procedures	QC0310
Quality Assurance	Content, Format, Preparation, Review, Approval, Distribution, Revision and Control of Administrative Standard Operating Procedures	QC0418
Quality Assurance	Archiving and Storage of Data Files and Computer Media	QC0460
Quality Assurance	Acceptance Criteria for Unspecified Methods	QC0485
Quality Assurance	Annual Review of Operations and Internal Quality Assurance Assessments	QC0488
Quality Assurance	Method Detection Limit Determination	QC0495
Quality Assurance	General Preparation and Evaluation of Demonstrations of Capability	QC0499
Quality Assurance	Customer Complaints	QC0510
Quality Assurance	Data Variance Requests	QC0515
Quality Assurance	Good Laboratory Practice	QC0673
Quality Assurance	Determination of LOD and LOQ	QC0684
Quality Assurance	Measurement of Uncertainty	QC0831
Sample Custody	Completing a Chain of Custody Form	QC0302
Sample Custody	Sample Log-in Procedure	QC0303
Sample Custody	Sample Storage Procedure	QC0308

Table 3. List of Standard Operating Procedures (continued)

Department	Standard Operating Procedure Title	SOP Number
Sample Custody	Sample Compositing and Sub-sampling	QC0338
Sample Custody	Policy for the Acceptance and Rejection of Environmental Samples	QC0346
Sample Custody	Sample Transfers Between EQC, Satellite Offices and the Southampton Laboratory	QC0432
Sample Custody	Electronic Chain of Custody and Sample Transfer	QC0468
Sample Custody	Preparation of ID Cards for Electronic Sample Custody Transfer	QC0511
Sample Custody	Sample Handling: Details Addressing Sample Movement from the Field or Deliveries to the Satellite and Testing Labs	QC0889
Semivolatile Organics	Semivolatile Organic Compounds Analyzed by GC/MS: SW846-8270C	QC0321
Semivolatile Organics	Semivolatiles Analyzed by EPA Method 625	QC0322
Semivolatile Organics	Reporting of Tentatively Identified Compounds Determined from Mass Spectral Analysis	QC0583
Semivolatile Organics	Semivolatile Organic Compounds Analyzed by GC/MS: EPA 525.2	QC0676
Semivolatile Organics	Semivolatile Organic Compounds Analyzed by GC/MS: SW846-8270D	QC0682
Volatile Organics	Determination of Volatile Organic Compounds by GC/MS: EPA Method 8260B	QC0320
Volatile Organics	Determination of Volatile Organic Compounds by GC/MS: EPA Method 624	QC0329
Volatile Organics	Determination of Volatile Organic Compounds in Drinking Water by GC/MS-EPA Method 524.2	QC0340
Volatile Organics	Determination of Volatile Organic Compounds by EPA 8260C	QC0681
Water Microbiology	Heterotrophic Plate Count by Standard Methods, 9215B (2000)	QC0439
Water Microbiology	Membrane Filter Technique for Members of the Coliform Group (SM9222B-1997, SM21st Ed.)	QC0440
Water Microbiology	Membrane Filter (MF) Technique for Members of the Fecal Coliform Group (SM21st Ed. 9222D)	QC0441
Water Microbiology	Multiple Tube Fermentation (MPN) Technique for Members of the Coliform Group SM9221B,C,E,F-2006)	QC0442
Water Microbiology	Membrane Filter (MF) Technique for Members of the Fecal Streptococcus and Enterococcus Groups SM9230C-2007	QC0444
Water Microbiology	Chromogenic Substrate Technique for Total Coliform and E. Coli (Colilert®) SM9223B 21st Ed.	QC0446
Water Microbiology	Media and Broth Preparation (SM20th Ed., 9050)	QC0448
Water Microbiology	Environmental Monitoring of the Laboratory (Standard Methods 9020B-2005)	QC0477
Water Microbiology	Preparation of Bottles Used for Environmental Microbiological Testing (SM 20th Ed., 9030B, 9040)	QC0480
Water Microbiology	Entering and Verifying Environmental Microbiology Results	QC0481
Water Microbiology	Operation and Maintenance of the Consolidated SR-24C Autoclaves	QC0482
Water Microbiology	Preparation of Phosphate-Buffered Dilution and Rinse Water (Standard Methods, 21st Ed., 9050C)	QC0500
Water Microbiology	Salmonella (SM 9260D)-1997	QC0512

Table 3. List of Standard Operating Procedures (continued)

Department	Standard Operating Procedure Title	SOP Number
Water Microbiology	Water, Waste water, Sludge and Compost Sampling for Microbiological Testing (SM 20th Ed., Methods 9060, 9213)	QC0519
Water Microbiology	Repeat Monitoring for Samples that are in Violation of the National Primary Drinking Water Regulations	QC0586
Water Microbiology	Membrane Filter (MF) Technique for Enterococci (EPA 1600)	QC0613
Water Microbiology	Membrane Filter (MF) Technique for E. Coli in Natural Bathing Beach Waters (SM 20th Ed., 9213D)	QC0617
Water Microbiology	Membrane Filter (MF) Technique for Pseudomonas aeruginosa (SM 20th Ed., 9213E)	QC0624
Water Microbiology	E. Coli in Water by Membrane Filtration using membrane-Thermotolerant Escherichia Coli, (mTEC) EPA1103.1	QC0642
Water Microbiology	*E. coli* in Water by Membrane Filtration using modified Membrane-Thermotolerant *Escherichia coli* Agar (Modified mTEC) (EPA 1603)	QC0665
Water Microbiology	Multiple Tube Fermentation (MPN) Technique for Members Fecal Coliform Group for Sewage Sludge (Biosolids)	QC0759
Water Microbiology	Water Microbiology Sample Receipt and Prioritization	QC0800
Water Microbiology	Documentation of Water Micro data in Logbooks	QC0811
Water Microbiology	Cleaning and Sanitizing Environmental Microbiology Laboratory	QC0818
Water Microbiology	Detection of Pseudomonas Aeruginosa in Recreation Waters (IDEXX Pseudalert Test Method)	QC0839
Water Microbiology	Chromogenic Substrate Technique for Total Coliform and Escherichia Coli by SM9223B (Colilert-18) 2004	QC0888
Water Microbiology	LIMS Report Comments: Water Microbiology Department	QC0901
Wet Chemistry	Specific Conductance Standard Methods 2510B and EPA SW-846 Method 9050	QC0094
Wet Chemistry	Determination of Dissolved Solids by Gravimetric Oven Drying Standard Methods 2540C-2011	QC0123
Wet Chemistry	EPA Method 1664B, n-Hexane Extractable Material and Silica Gel Treated n-Hexane Extractable Material by Solid Phase Extraction	QC0319
Wet Chemistry	Nitrite-Nitrogen: Colorimetric Standard Methods 4500NO_2-B	QC0347
Wet Chemistry	Paint Filter Liquids Test (SW846 9095B)	QC0379
Wet Chemistry	Soil and waste pH EPA 9045	QC0380
Wet Chemistry	pH, Electrometric Measurement (Method 9040)	QC0381
Wet Chemistry	Toxicity Characteristic Leaching Procedure (TCLP): SW846 Method 1311	QC0382
Wet Chemistry	Determination of Inorganic Ion by Ion Chromatography, SW846 Method 9056	QC0385
Wet Chemistry	Total Organic Halides by EPA 9020B and Standard Methods 5320B	QC0386
Wet Chemistry	Ignitability of Solids, SW-846 Method 1030	QC0387
Wet Chemistry	Pensky-Martens Closed-Cup Method for Flashpoint SW846 1010A and ASTM D93-80	QC0389
Wet Chemistry	Synthetic Procedure Leaching Procedure, Method 1312	QC0391

Table 3. List of Standard Operating Procedures (continued)

Department	Standard Operating Procedure Title	SOP Number
Wet Chemistry	Chromium Hexavalent by EPA Method 7196A	QC0392
Wet Chemistry	Total and Amenable Cyanide Distillation, SW846 Method 9010C	QC0393
Wet Chemistry	Manual Spectrophotometric and Titrimetric Determinative Method for Cyanide Using SW846 Method 9014	QC0394
Wet Chemistry	Determination of Reactive Cyanide and Reactive Sulfide, SW846 Chapter 7	QC0396
Wet Chemistry	Titrimetric Procedure for Sulfide, SW-846 Method 9034	QC0397
Wet Chemistry	Alkalinity: All forms. Titration to a pre-determined pH Standard Methods 20th 2320B	QC0408
Wet Chemistry	Labware Washing Procedure For the General Chemistry and Water Microbiology Departments	QC0409
Wet Chemistry	Turbidity, (Nephelometric)	QC0410
Wet Chemistry	Determination of Inorganic Ions by Ion Chromatography, EPA Method 300.0	QC0411
Wet Chemistry	Total Recoverable Phenols: Method 420.1 and Method 9065 (Spectrophotometric, Manual 4-AAP with Distillation)	QC0422
Wet Chemistry	Chromium Hexavalent Standard Methods: Colorimetric Method 3500Cr-B, 2011	QC0424
Wet Chemistry	Nitrogen, Ammonia-Potentiometric, Ion Selective Electrode by Method SM4500NH3-D	QC0456
Wet Chemistry	n-Hexane Extractable Material (HEM) for Sludge, Sediment and Solid Samples, SW846 Method 9071B	QC0457
Wet Chemistry	Chemical Oxygen Demand, Reactor Digestion Method-Hach Procedure 8000	QC0464
Wet Chemistry	Nitrate plus Nitrite and Nitrite alone, Automated Cadmium Reduction, SM4500 NO3-F	QC0466
Wet Chemistry	pH, Electrometric Measurement	QC0467
Wet Chemistry	Alkaline Digestion for Hexavalent Chromium, SW846 Method 3060A	QC0471
Wet Chemistry	Total Cyanide and Cyanide Amenable to Chlorination Manual Distillation, Colorimetric, SM4500 CN-C, E and G	QC0475
Wet Chemistry	Total Carbon and Total Organic Carbon by Combustion SW846-9060	QC0487
Wet Chemistry	Color by Visual Comparison Method, Platinum-Cobalt, SM2120B Rev. 2011	QC0494
Wet Chemistry	Salinity-Electrical Conductivity Method Standard Methods 20th 2520B	QC0514
Wet Chemistry	Phosphorous, Colorimetric, Single Reagent, All forms of Phosphorous Standard Methods 4500-P,B.5, E	QC0535
Wet Chemistry	Total Solids, Dried at 103-105 °C Standard Method 2540B 2011	QC0536
Wet Chemistry	Total Suspended Solids (TSS), (Non-Filterable Residue), and Total Suspended Volatile Solids (TSSVS) Method SM2540D and 2540E APPROVED 1997, Editorial Revisions 2011	QC0537
Wet Chemistry	Total Solids in Solids and Semi-Solid Samples, Dried at 103-105 °C, Standard Methods 2540G	QC0542
Wet Chemistry	Volatile and Fixed Solids and Semi-Solid Samples, Ignited at 550 degree C, SM2540G	QC0543
Wet Chemistry	Volatile Residue (Solids) Following ignition at 550 °C Method: EPA 600, 160.4	QC0544
Wet Chemistry	Acidity, Titration to pH 8.3-Standard Methods 2310B	QC0545
Wet Chemistry	Nitrogen Ammonia-Preliminary Distillation Step SM 4500 NH3-B	QC0546

Table 3. List of Standard Operating Procedures (continued)

Department	Standard Operating Procedure Title	SOP Number
Wet Chemistry	Nitrogen-Total Kjeldahl, Semi-Automated Colorimetry, EPA 351.2	QC0549
Wet Chemistry	Biochemical Oxygen Demand (BOD) and Carbonaceous BOD (cBOD) Standard Methods 5210B 2011	QC0550
Wet Chemistry	Dissolved Oxygen-Azide Modification Standard Methods, 22nd Ed 4500 O-C	QC0551
Wet Chemistry	Oxidation -Reduction Potential of Water, Method 2580B	QC0554
Wet Chemistry	Free and Total Chlorine Measurement in the Laboratory DPD Colorimetric Method SM4500 Cl-G	QC0556
Wet Chemistry	Ammonia as N, Distillation/Titration, Standard Methods 4500 NH3-B, C	QC0558
Wet Chemistry	Dissolved Oxygen-Modified Winkler Azide Method, HACH-Dissolved Oxygen Test Kit for Field Measurements	QC0567
Wet Chemistry	Sulfide: Colorimetric Methylene Blue Method:SM4500 S^2-D-2011	QC0569
Wet Chemistry	Chlorine: Free or Combined Forms DPD-FAS Titrimetric, Standard Methods: 4500-Cl2-F	QC0578
Wet Chemistry	Sulfite-Iodometric Titration	QC0580
Wet Chemistry	Settleable Solids-Imhoff Cone	QC0584
Wet Chemistry	Methylene Blue Active Substances-Anionic Surfactants as MBAS, Standard Methods 5540C	QC0585
Wet Chemistry	Total Organic Carbon Heated Persulfate Oxidation Method Standard Methods 5310C	QC0590
Wet Chemistry	Total Organic Carbon Method: USP 643 for Purified Water	QC0594
Wet Chemistry	UV Absorbing Organic Constituents, UV254	QC0595
Wet Chemistry	Chlorine Demand/Requirement Standard Methods 2350B	QC0598
Wet Chemistry	Threshold Odor Test Standard Methods: 2150B	QC0615
Wet Chemistry	Extractable Organic Halides (EOX) in Solids EPA Method: SW846- 9023	QC0616
Wet Chemistry	Multiple Extraction Procedure: Method 1320 (modified)	QC0621
Wet Chemistry	Organic and Volatile Acids, Distillation Method, Standard Methods 20th 5560C	QC0622
Wet Chemistry	Carbon Dioxide-Titrimetric Method, Standard Methods 4500CO2-C	QC0625
Wet Chemistry	Reserve Alkalinity for Solid Wastes	QC0626
Wet Chemistry	Total Organic Content by ASTM D2974	QC0628
Wet Chemistry	Total Chlorine (TX) in New and Used Petroleum Products EPA Method SW846 9076	QC0629
Wet Chemistry	Dissolved Oxygen-Membrane Electrode Method Standard Methods, 22nd Edition, 4500 O-G	QC0644
Wet Chemistry	Elutriate Preparation: Modified Elutriate Test	QC0649
Wet Chemistry	Shake Extraction of Solid Waste with Water by Method ASTM D3987-85	QC0686
Wet Chemistry	Perchlorate in Water via Ion Chromatography	QC0700
Wet Chemistry	Saturation Index (SI) Using SM2330B	QC0701
Wet Chemistry	Nitrite: Colorimetric Analysis Discrete Colorimetric Analyzer, Standard Methods 4500NO2 B Equivalent	QC0702

Table 3. List of Standard Operating Procedures (continued)

Department	Standard Operating Procedure Title	SOP Number
Wet Chemistry	Acid Producing Soil: pH and Qualitative Sulfate Test	QC0713
Wet Chemistry	Specific Gravity and Density Standard Methods SM2710F	QC0772
Wet Chemistry	Bulk Density	QC0773
Wet Chemistry	Determination of Moisture Content in Cocoa Beans by Method ISO-2291	QC0774
Wet Chemistry	Moisture Content in Food AOAC Official Method 950.46, Modified	QC0781
Wet Chemistry	Ortho Phosphorous Automated Ascorbic Acid Reduction Standard Methods 4500 P-F Discrete Auto Analyzer	QC0783
Wet Chemistry	Sieve Analysis with Hydrometer ASTM D 422-85 and ASTM D 422-43	QC0784
EQC-Delaware*		
General	Determination of Temperature by Standard Methods-SM2550B (For use EQC-Delaware)	QC0862
General	Calibration of Eppendorf and Mechanical Volumetric Pipets (For use at EQC-Delaware)	QC0866
Water Microbiology	Total Coliform and Fecal Coliform by Membrane Filtration by SM9222B-1997 (For Use at EQC-Delaware)	QC0843
Water Microbiology	Heterotrophic Plate Count by SM9215B-2004 (For use at EQC-Delaware)	QC0844
Water Microbiology	E. Coli by Most Probable Number (MPN), 9221F (For EQC-Delaware)	QC0853
Water Microbiology	Glassware Washing and Testing in Microbiological Laboratory (For use at EQC-Delaware)	QC0856
Water Microbiology	Operation of Autoclaves in the Microbiology Laboratory (For use at EQC-Delaware)	QC0857
Water Microbiology	Testing of Sample Containers used for Collection of Microbiological Samples (For use at EQC-Delaware)	QC0858
Water Microbiology	Total Coliform by Most Probable Number (MPN) Standard Methods SM 9221B-2006 (For use at EQC-Delaware)	QC0859
Water Microbiology	Fecal Coliform by Membrane Filtration Standard Methods:9222D-2006 (For use at EQC-Delaware)	QC0860
Water Microbiology	Total Coliform and E. Coli by Chromogenic Substrate by Standard Methods; SM9223B-2004 (For use at EQC-Delaware)	QC0861
Water Microbiology	Fecal Streptococcus and Enterococcus by Most Probable Number (MPN) Standard Methods 9230B-2007 (For use at EQC-Delaware)	QC0863
Water Microbiology	Fecal Coliform by Most Probable Number (MPN) Standard Methods: 9221E-2006 (For use at EQC-Delaware)	QC0864
Wet Chemistry	Determination of Dissolved Solids by Gravimetric Oven Drying by Standard Methods 2540C-2011, (For use at EQC-Delaware)	QC0850
Wet Chemistry	Specific Conductance Standard Methods 2510B and SW-846 9050 (For Use at EQC-Delaware)	QC0852
Wet Chemistry	Methylene Blue Active Substances-Anionic Surfactants as MBAS Standard Methods 5540C (For EQC-Delaware)	QC0854

Table 3. List of Standard Operating Procedures (continued)

Department	Standard Operating Procedure Title	SOP Number
Wet Chemistry	Calibration of Eppendorf and Mechanical Volumetric Pipets (For use at EQC-Delaware)	QC0866
Wet Chemistry	pH and Alkalinity: All Forms by Titration to a Pre-Determined pH, SM 4500-H^+ and SM 2320B (For use at EQC-Delaware)	QC0867
Wet Chemistry	Threshold Odor Test by Standard Methods 2150B (For use at EQC-Delaware)	QC0868
Wet Chemistry	Ammonia, Flow injection Analysis Colorimetry Standard Methods 4500-NH3-G (For use at EQC-Delaware)	QC0869
Wet Chemistry	Biochemical Oxygen Demand (BOD) and Carbonaceous Biochemical Oxygen Demand (cBOD) by Standard Methods 5210B (For use at EQC-Delaware)	QC0870
Wet Chemistry	Hexavalent Chromium, Colorimetric, Diphenylcarbazide Standard Methods: SM3500 Cr-B (For use at EQC-Delaware)	QC0871
Wet Chemistry	Determination of Total Volatile Solids (TVS) EPA 160.4 (For use at EQC-Delaware)	QC0874
Wet Chemistry	Determination of Total Solids Standard Methods 2540B (For use at EQC-Delaware)	QC0875
Wet Chemistry	Determination of Settleable Solids Standard Methods: SM2540F (For use at EQC-Delaware)	QC0877
Wet Chemistry	Determination of Total Suspended Solids (TSS) and Total Suspended Volatile Solids Standard Methods: SM2540D and SM2540E (For use at EQC-Delaware)	QC0878
Wet Chemistry	Color by Visual Comparison Method, Platinum-Cobalt, SM 2120B Rev. 2011 (For use at EQC-Delaware)	QC0879
Wet Chemistry	Determination of Inorganic Ions by Ion Chromatography EPA 300.0 Rev. 2.1 (For use at EQC-Delaware)	QC0882
Wet Chemistry	Turbidity, (Nephelometric)-SM2130B (For use at EQC-Delaware)	QC0883
Wet Chemistry	Determination of ortho-Phosphorous in Aqueous Matrices Standard Methods 4500-P E (For use at EQC-Delaware)	QC0884
Wet Chemistry	Total Organic Carbon-Heated Persulfate Oxidation Method Standard Methods: 5310C (For use at EQC-Delaware)	QC0885

EQC-Delaware: These SOPs are applicable to EQC-Delaware only. Please contact the QA Department of EQC For a listing of General SOPs applicable to each department.*

During the period of Q1 through Q3 2016, transitions are underway affecting the Eurofins QC, Inc. (EQC) operations of the Southampton PA laboratory location at 1205 Industrial Blvd and the Horsham PA location at 702 Electronic Drive. The laboratory operations currently performed at the Southampton lab are being moved and the location will ultimately be closed. Chemistry testing is being moved to Eurofins Lancaster Laboratories Environmental (ELLE) in Lancaster PA at 2425 New Holland Pike. Aquatic Toxicology and Microbiology testing currently performed in Southampton is being moved to Horsham. In addition, in February 2016, Oommen Kappil (QA Director of record in the manual) left Eurofins. QA responsibilities are being addressed through Eurofins Environment Testing US by ELLE QA Director, Dorothy Love, effective February 13, 2016.

As a result of the above listed transitions, the current EQC Quality Systems Manual (revision 26, effective 11/30/2015) contains some obsolete information. The manual will not be updated until after all transitions are complete and the Southampton operations cease. In the interim, this amendment serves to identify the sections of the manual that will need to be revised and what the changes will cover.

Section	Change
Cover	Change address to Horsham location
Approvers	List David Speis, Raphael Fratti, Erich Walter, Dorothy Love
Throughout	Change scope of service to be Aquatic Toxicology, Microbiology, and Pharmaceutical Product Testing
3.1.3	Remove Horsham as a satellite location as it will be the main laboratory location
Throughout	Remove all references to Southampton and simply make reference to the laboratory
4.1.1; 23.1.1; 24.1.3	Floor plans – note that these are available for review onsite but, due to security reasons, are not published in the quality manual or provided externally.
Throughout	Remove any sections detailing chemistry specific QC and calibration practices.
10.1.6; 16.3; 16.4	Refers to archives and server at Southampton – update location for these
Multiple	Discussions for client account history files and data review requests will need to be evaluated with the use of eLIMS-EP
12.1-9; 13.1.5; 17.1.2	Specifies CAPA and DVR reviews by the QA director. These may be handled by other QA staff. Add "or designee".
21.5	Describes building security access for Southampton. Revise to address Horsham.
24.1.3	DI water test plan, evaluate any changes that may be in place for Horsham.
25.7.1	Describe electronic sample tracking used at Southampton. Address with what will be used at Horsham.
Figure 1	Replace Oommen Kappil with Dorothy Love as the QA Director; update other positions when the transitions are complete.
Table 1 through 3	All will be revised for reduced scope of work at Horsham.

Interim Amendment Approvals:

David Speis, President
Technical Director, Organics

25 Mar 2016
Date

Raphael Fratti, Lab Director
Technical Director, Inorganics

3/28/2016
Date

Erich Walter
Technical Director, Microbiology

3/28/2016
Date

Dorothy Love
Quality Assurance Director

3/25/2016
Date

APPENDIX B

EuroFins QC Laboratory Standard Operating Procedures

Eurofins QC, Inc. UNCONTROLLED DOCUMENT
This document is valid only to the date shown below. Updates may be issued after this date which you will not receive. Use at your own discretion. This document is not for Eurofins QC, Inc. laboratory use.
PH / 10/13/16 — Initials / Issue Date
Next Rev — Valid Thru

eurofins | QC

SOP Number QC0441
Membrane Filter (MF) Technique for Members of the Fecal Coliform Group (SM 9222D-2006, Standard Methods, 22nd Ed.)

CONFIDENTIAL

Revision: 00	Date: 02/01/00
Revision: 01	Date: 01/16/01
Revision: 02	Date: 01/07/03
Revision: 03	Date: 12/16/04
Revision: 04	Date: 01/05/05
Revision: 05	Date: 11/21/05
Revision: 06	Date: 03/03/06
Revision: 07	Date: 11/17/08
Revision: 08	Date: 04/01/10
Revision: 09	Date: 07/20/10
Revision: 10	Date: 10/27/11
Revision: 11	Date: 12/15/14
Revision: 12	Date: 07/29/15
Revision: 13	Date: 01/08/16
Revision: 14	Date: 05/31/16
Revision: 15	Date: 09/30/16

Prepared/Revised By	: Tamara Charnauski	Date:	09/30/2016
Reviewed By	: Raphael Fratti	Date:	10/04/2016
QA Approval	: [signature]	Date:	10/11/16
Management Approval	: [signature]	Date:	10/12/16
Effective Date	: 10/13/16		

1.0 Scope and Application

1.1 This Standard Operating Procedure (SOP) is used to determine the density of fecal coliform bacteria by the membrane filtration (MF) technique. The MF technique is highly reproducible, can be used to test relatively large sample volumes and yields results more rapidly than the multiple-tube procedure. The MF technique is extremely useful in monitoring the quality of a variety of natural and recreational waters (lakes, streams, pools, etc.) as well as wastewaters (chlorinated effluents) and may be used in the examination of saline waters.

1.2 This SOP is for use at all Eurofins QC, Inc. (EQC) microbiology departments. Note: the Delaware laboratory in New Castle DE, maintains a separate SOP for fecal coliform by membrane filtration.

2.0 Summary and Discussion of Procedure

2.1 The MF procedure uses an enriched lactose medium and incubation temperature of 44.5 ± 0.2 °C for selectivity and gives 93% accuracy in differentiating between coliforms found in the feces of warm-blooded animals and those from other environmental sources. The sample volume will be dependent on the site from which the sample was taken. Small sample volumes may be necessary for waters in which high turbidity and/or historically elevated levels of fecal coliforms have been

observed. Samples are filtered through a sterile 47 mm, 0.45 micron membrane filter and incubated on M-FC agar for 24 ± 2 hours in a water bath at 44.5 ± 0.2 °C. Colonies produced by fecal coliform on M-FC medium are various shades of blue. Non-fecal coliform colonies are gray to cream-colored.

3.0 Definitions

3.1 *Fecal coliform*: A subgroup of the total coliform group found in the intestinal tract of warm blooded animals distinguished by its ability to grow at elevated temperatures. The occurrence of these bacteria is considered a specific indicator of fecal contamination.

3.2 *Holding Time*. The maximum time a sample may be held prior to analysis. For Microbiology testing the holding time for a sample is determined from the time a sample is collected to the time the sample incubation begins.

4.0 Health and Safety Warnings

4.1 Personnel engaged in laboratory analyses at EQC must be familiar with and adhere to the policies set forth in the current version of the EQC Safety Procedure Manual.

5.0 Cautions

5.1 Start microbiological examination of a water sample promptly after collection to avoid unpredictable changes.

5.1.1 Any deviances in transport or analyzing holding times, missing sampling information, sample volume, or test performed must be communicated to the client representative and notes made in the sample login and history log.

6.0 Interferences

6.1 High levels of background (non-coliform) bacteria, (i.e. 10^4 or greater), may lead to false negative results.

6.2 The MF procedure has limitations, particularly when testing waters with high turbidity or non-coliform (background) bacteria. It cannot be used to assess the quality of wastewaters that have received only primary treatment followed by chlorination because of turbidity in high volume samples or wastewaters containing toxic metals or toxic organic compounds such as phenols.

7.0 Personnel Qualifications

7.1 Before performing this test independent of secondary supervision and review, each analyst must have an approved Demonstration of Capability Certification Statement (DOC) form (see SOP QC0499) on file in the Quality Assurance office.

8.0 Equipment, Apparatus and Materials

8.1 Erlenmeyer flask-clean borosilicate, pre-sterilized for mixing media.

8.2 Petri dishes-60x15 mm pre-sterilized, plastic petri dishes.

8.3 95% ethanol.

8.4 Water bath capable of maintaining a temperature of 44.5 ± 0.2 °C.

8.5 Incubator capable of maintaining a temperature of 35 ± 0.5 °C.

8.6 Dissecting microscope 10-15x with fluorescent light source.

8.7 Filter funnels-47 mm magnetic (Gelman or equivalent).

8.8 Membrane filters-47 mm/0.45 micron sterile membrane filters (Millipore or equivalent).

8.9 Forceps.

8.10 Water-proof plastic bags.

8.11 Rosolic acid. Mix 0.5g of Rosolic Acid with 50 mL of sterile water and 10 mL of 1 N NaOH. Store Rosolic solution in refrigerator until use. Expiration date is two weeks. Record all media preparation data in the Electronic Media Prep Validation logbook as directed in SOP QC0448.

8.12 Vacuum manifold and pump.

8.13 M-FC agar (Acumedia or equivalent): Used for the enumeration of fecal coliform by the MF method. Rehydrate 52 gm of product per 1 L of purified water. Mix with agitation and heat to near boiling to dissolve medium and then remove from hotplate. Do not boil. Add 10 mL of 1% of Rosolic acid dissolved in 0.2 N NaOH. Allow for cooling to below 50 °C. Do not sterilize in autoclave. Dispense 5-7 mL in each 15 x 60 mm petri dishes and let solidify. Final pH should be 7.4 ± 0.2. The amount of media prepared can be adjusted accordingly to the work load. Label each batch and container with the date prepared, batch ID, date EXP, Lot #, temperature for storage and method name. Refrigerate finished media in tightly sealed containers and give a two-week expiration date. Store all prepared plates at 2-8 °C. Test for sterility and growth promotion properties as directed in SOP QC0448. The positive control for M-FC is *E. coli* and the negative is *E. aeruginosa*. Each new lot of medium must be tested against an acceptable previous lot. Let the water micro manager know when a new lot of media is being made.

8.14 EC broth (Acumedia or equivalent): Used for confirmation of fecal coliform at 44.5 °C. Add 37 grams of medium to 1 liter of purified water. Mix thoroughly. Dispense 10 mL portions into autoclavable, borosilicate glass tubes (with fermentation vials in them) of sufficient size to contain both the culture media and the sample without being three quarters full. Autoclave prepared media at 121 °C for 15 minutes. Final pH must be 6.9 ± 0.2. The amount of media prepared can be adjusted accordingly to the work load. Label each batch with the date prepared, batch ID, date of expiration, lot number, storage temp, method number and media name. Give media a two-week expiration date from prepared date for tubes with "pop" tops and three months for tubes with "screw" tops. Store in a cool, dry, location out of the way of direct light. Test for sterility and growth promotion properties as directed in SOP QC0448.

8.15 Lauryl Tryptose Broth (LTB) (Acumedia or equivalent): Used for the detection of coliform bacteria. Add 35.6 g of powder to 1 L of purified water. Mix thoroughly. Warm slightly to completely dissolve the powder. Dispense 10 mL portions into autoclavable, borosilicate glass tubes (with fermentation vials in them) of sufficient size to contain both the culture media and the sample without being three quarters full. Autoclave prepared media at 121 °C for 15 minutes. Cool the broth as quickly as

possible. Final pH after autoclaving must be 6.8 ± 0.2. The amount of media prepared can be adjusted accordingly to the work load. Label each batch with the date prepared, batch ID, date of expiration, media lot number, storage temp, method number and media name. Store in a cool, dry location out of the way of direct light. Give media a two-week expiration date from prepared date for tubes with "pop" tops and three months for tubes with "screw" tops. Test for sterility and growth promotion properties as directed in SOP QC0448.

8.16 Phosphate Buffered Dilution water: Prepare as directed in SOP QC0500. The amount of media prepared can be adjusted accordingly to the work load. Record prepared dilution water in the Electronic Media Prep Validation logbook as directed in SOP QC0448.

8.17 Sodium Thiosulfate – 100 mg/10 mg active tablets (Cargille Corp. or equivalent) or 10% solution.

8.18 Bottles-125 mL, polypropylene, autoclavable (Single use, sterilized coliform containers from a reputable manufacturer may be used).

8.19 Autoclave indicator tape.

8.20 Weights to keep samples submerged during incubation.

8.21 Computer capable of running live analysis time via the WM electronic logbook.

8.22 Positive control culture, *E. coli* ATTC 11775 or equivalent (BioBalls).

8.23 Negative control culture, *E. aeruginosa* ATTC 13048 or equivalent (BioBalls).

8.24 Autoclave bags for funnel sterilization.

8.25 Syringes- plastic, sterile (10 mL)

9.0 Calibration

9.1 Calibrate thermometers used to monitor the temperature of incubators and water baths against a NIST thermometer annually according to SOP QC0339.

9.2 Schedule annual calibration and maintenance of balances through the manufacturer or other qualified, contracted personnel.

9.3 Calibrate pH meters according to manufacturer's recommendations and SOP QC0467. Record daily calibrations in the Media Prep pH logbook.

9.4 Check incubator temperatures twice daily to ensure temperature requirements are being met. Record readings in the temperature logbooks.

10.0 Sample Preparation and Analysis

10.1 Collect samples as directed in SOP QC0519 Water, Wastewater, Sludge and Compost Sampling for Microbiological Testing. Maintain sample temperatures following collection and transport to the laboratory, on ice between 0 and 10 °C (do not freeze). When samples are stored at the testing laboratory, prior to analysis, store refrigerated between 0.5 °C and 6 °C.

10.2 The maximum holding time for fecal coliform testing is eight (8) hours from sample collection.

10.3 Sample size

10.3.1 Size of sample will be governed by the expected bacterial density and/or the degree of sample turbidity. An ideal sample volume will yield 20 to 60 fecal coliform colonies on a membrane filter surface. Where the bacterial density is expected to be high and/or turbidity situations exist, filter appropriate dilutions (i.e. 1:10, 1:100, etc.) prepared in phosphate buffered dilution water through a membrane. When analyzing a new site or the density of fecal coliform is unknown test using three dilutions (example: 100 mL, 10 mL, 1.0 mL) to obtain the best-expected density and reportable count.

10.4 Sterile filtration units

10.4.1 Begin each filtration series with a sterilized filter funnel. If more than 30 minutes elapses between sample filtrations during a filtration series, open and use a second sterilized filter funnel.

10.5 Filtration of sample

10.5.1 Using sterile forceps, place a sterile membrane filter (grid side up) over the porous plate of the filtration unit. Pour sample into filtration unit and filter under partial vacuum. With the membrane still in place, rinse the interior surface of the funnel 3 times with a 20-30 mL portion of sterile dilution water from a squeeze bottle to prevent carryover contamination. Upon completion of final rinse, and the filtration process, disengage vacuum, unlock and remove funnel, and immediately remove the membrane filter with sterile forceps, and place it on a M-FC agar dish which has been allowed to warm to room temperature with a rolling motion to avoid entrapment of air.

10.5.2 The first sample filtered on any sterile funnel is a "Sterility Blank". This serves as the 'Initial Sterility Blank'. Refer to section 11.3.

10.5.3 When more than one sample is processed on an individual funnel, the last sample filtered on a funnel is a "Final Sterility Blank". Refer to Section 11.3.

10.5.4 Analyze a Rinse Water check as a sample, one time, for each new bottle of sterile rinse water bottle opened. Rinse water counts as a sample in the filtration series. Refer to Section 11.3.

10.6 Filtration series

10.6.1 A filtration series is considered to be interrupted when an interval of 30 minutes or longer elapses between sample filtrations. After such interruption, treat any further sample filtration as a new filtration series and replace the filter funnels with new sterile filter funnels.

10.6.2 Do not process more than ten (10) filtrations on any funnel. That is, after ten filtrations, including samples, rinse water or sample dilutions, change-out the filter funnel to a second, sterile funnel.

10.6.3 During testing in the laboratory, multiple funnels may be used for less than 10 field sample filtrations in order to meet holding times or when, in the judgment of the analyst, a new funnel should be used following a sample with

a suspected high level of bacteria. Always complete any funnel use with a filter blank.

10.7 Place prepared samples in waterproof plastic bags, seal, invert and submerge in a water bath at 44.5 ± 0.2 °C for 24 ± 2 hours. Anchor dishes below water surface to maintain critical temperature requirements. Place all samples in the water bath within 30 minutes after filtration.

10.8 Counting fecal coliform colonies

10.8.1 Use a low power (10-15x) binocular wide-field dissecting microscope with a cool white fluorescent light source directed to provide optimal viewing.

10.8.2 Colonies produced by fecal coliform on M-FC medium are various shades of blue. Count colonies of any size including pinpoint blue colonies. Non-fecal coliform colonies are gray to cream-colored. Normally, few non-fecal coliform colonies will be observed on M-FC medium because of the selective action of the elevated temperature and addition of rosolic acid salt reagent.

10.8.3 Count and record in the Water Microbiology (WM) electronic logbook the number of fecal coliform colonies found on the membrane. Note: the ideal colony count for this test is a count or 20 to 60 CFU. Refer to section 12.0 for details.

10.9 Confirming fecal coliform colonies

10.9.1 Inoculate a tube of Lauryl Tryptose Broth (LTB) and EC Broth with a suspect fecal coliform colony directly from the membrane with an inoculating loop.

10.9.2 Incubate the LTB for 24 ± 2 hours in an incubator set at 35 ± 0.5 °C and examine for gas production with growth (turbidity). Incubate the EC Broth for 24 ± 2 hours in a circulating water bath at 44.5 ± 0.2 °C and examine for gas production with growth. If the confirmation does not verify the initial response, notify your supervisor. Test results will be qualified.

10.9.3 Gas production with growth in an EC broth culture within 24 ± 2 hours or less is considered a positive fecal coliform reaction. Failure to produce gas (with little or no growth) constitutes a negative reaction. If heavy growth occurs with no gas production, subject the culture to a fecal coliform or *E. coli* test using a different medium. Check with your supervisor if a different medium may be required.

11.0 Quality Control

11.1 Test all microbiological broth after preparation as directed in SOP QC0448 and record in the Water Microbiology Validation logbook.

11.2 Check each lot # of membrane filters for sterility by incubating in tryptic soy broth for 24 hours at 35 ± 0.5 °C and looking for growth. Reject any lot that is found to be non-sterile. Record results in the Water Microbiology Quality Control Logbook.

11.3 Perform the following checks when using autoclavable (multi-use) funnels.

11.3.1 Analyze an initial sterility blank, as the first sample for each sterile funnel used. Rinse each funnel with 20-30 mL of sterile water as performed in the

rinse step for a sample. Do not use additional rinses. Complete the analysis of the sterility blank as a regular sample.

11.3.2 Analyze a final sterility blank following all samples analyzed with any funnel, WHEN more than one sample is analyzed on a funnel. If only one sample is processed per funnel, a final sterility blank is not required.

11.3.3 For each autoclavable funnel, up to a maximum of ten (10) filtrations may be performed. A filtration include any: sample, sample dilution or rinse water check.

11.3.4 Results from the sterility blank or the rinse water check are reviewed for contamination. The data represent colonies per funnel or colonies per rinse. The criteria for these check is <1 cfu / funnel or < 1 cfu / rinse.

11.4 Disposable sterile funnels.

11.4.1 When using disposable sterile funnels, an initial sterility check or end procedural check is not required.

11.4.2 Disposable sterile funnels are lot checked for sterility when received at the laboratory.

11.5 Check each **batch** of rinse water for sterility by adding 50-mL water to 50- mL double strength tryptic soy broth, incubating at 35 ± 0.5 °C for 24 ± 2 hours and checking for growth. Reject any batch of rinse water that is found to be non-sterile. Record results in the electronic Media Prep logbook.

11.6 Check each newly opened rinse water bottle for sterility. Use 50 mL from the newly opened rinse water bottle and process by filtration as a sample.

11.7 Each lot of sample containers must be tested for sterility before use by adding approximately 100 mL of a non-selective broth (i.e. Tryptic Soy Broth), incubating for 24 ± 2 hours at 35 ± 0.5 °C and checking for growth (turbidity).

11.8 On a monthly basis, verify a minimum of 10 fecal coliform colonies (10 typical and 10 atypical) as directed in Section 10.9. Record results in the Water Microbiology Fecal Coliform Verification Logbook. The adjusted count may be REDUCED if the confirmation for any typical colony is negative. The adjusted count may be increased if the confirmation for any atypical colony is positive.

Example:

45 TOTAL Colonies

30 Typical Colonies, and 15 atypical colonies.

Reported Result = 30 colonies / 100 mL presumptive

Confirmation Phase: use percentage of colonies confirmed as below:

8 out of 10 typical show positive: adjust count DOWN to [(8/10) x 30] = 24

2 out of 10 atypical colonies show positive: adjust count UP by [(2/10) x 15] = 3

Actual count = 24 + 3 = 27 colonies / 100 mL

Edit and send the client a revised test report.

11.9 Compare old and new lots of MFC using dilution blanks inoculated with the appropriate ATC culture (Bio-Balls) to produce colony counts ranging from 20 - 60 CFU. Record results in the Electronic Water Microbiology log book.

11.10 Corrective actions are taken when nonconforming work or departures from policies and procedures in the management system or technical operations have been identified. Preventive action is a proactive process to identify opportunities for rather than a reaction to the identification of problems or complaints.

11.10.1 Analytical work may be stopped if necessary during the investigation, and analyses may resume after it is verified that the corrective actions taken have been effective.

11.10.2 Corrective actions may include, but not limited to instrument repair or maintenance, re-prep of media, resampling, reanalysis of samples, etc.

11.10.3 Preventive actions may include, but not limited to preventive maintenance, retraining of analysts, change in procedures etc.

11.10.4 Refer to EQC's Quality Systems Manual for more information.

12.0 Calculations and Record Keeping

12.1 Compute the count, using membrane filters with 20 to 60 fecal coliform colonies per membrane, by the following equation:

$$\text{Fecal coliform colonies/100 mL} = \frac{\text{Fecal coliform colonies counted} \times 100}{\text{mL sample filtered}}$$

(The 20 to 60 colony restriction is due to the larger colony size on M-FC medium.)

12.2 With water of good quality, the occurrence of fecal coliforms will be low. Therefore, count all fecal coliform colonies (disregarding the lower limit of 20 colonies cited in Section 12.1) and use the above formula given above to obtain fecal coliform density.

12.3 If the total number of fecal coliform colonies exceeds 60 per membrane, with one (1) dilution or if the colonies are not distinct enough for accurate counting, record the results as **>60** and compute and report the actual result by using the equation in the above equation.

12.4 For water other than drinking water quality

12.4.1 As with potable water samples, if no filter has a fecal count falling in the ideal range (20 to 60 CFU), total the fecal counts on all filters and report as the total number per 100 mL.

12.4.1.1 For example, if **duplicate 50-mL portions** were examined and the two membranes had 5 and 3 fecal coliforms, respectively, report the count as 8 fecal coliform colonies per 100 mL.

$$[(5 + 3) \times 100] / (50 + 50) = 8 \text{ CFU/100 mL}$$

12.4.2 Similarly, if 50-, 25-, and 10-mL **portions** were examined and the counts were 15, 6, and <1 fecal coliform colonies, respectively, then calculate **on the basis of the most nearly acceptable value** and report the fecal coliform count with a qualifying comment as "**estimated** 30 CFU/100mL":

[(15) X 100] / (50) = estimated 30 CFU/100 mL

12.4.3 On the other hand, if 10, 1.0, and 0.1-mL portions were examined with counts of **40**, 9, and <1 fecal coliform colonies, respectively, then select the 10-mL portion only for calculating the fecal coliform density because the filter had a fecal coliform count falling **in the acceptable range**, and report result as 400 CFU/100 mL:

(40 X 100) / 10 = 400 CFU/100 mL

12.4.4 If colony counts are **greater than the upper limit** then calculate on the basis of the most nearly acceptable value and report, with a qualifying comment.

An example: If 10, 1.0, and 0.1-mL portions were examined with counts of TNTC, 110, and 62 fecal coliform colonies, respectively, then calculate on the basis of the most nearly acceptable value and report, with a qualifying comment, as **estimated** 62,000 CFU/100 mL:

(62 X 100) / 0.1 = estimated 62,000 CFU/100 mL

12.4.5 If there is **more than one dilution having an acceptable range** of counts then sum the total coliform counts on the two filters and divide by the sum of their volume to obtain the final reported value:

An example: If 1.0, 0.3, 0.1, and 0.03 mL portions were examined with counts of TNTC, TNTC, 58, and 21 coliform colonies, respectively, then sum the total coliform counts on the two filters and divide by the sum of their volume to obtain the final reported value of 61 000 CFU/100 mL:

[(78 + 21) X 100] / (0.1 + 0.03) = 61 000 CFU/100 mL

12.4.6 If counts from all membranes are zero, calculate final result using the largest volume filtered.

12.4.7 If colony counts are both **above and below the upper and lower limits**, select the most nearly acceptable count.

12.4.8 For the sample in question (12.4.1.4) an error at the bench may have occurred investigate the issue, and report results with a qualifying comment or re-sample when possible.

12.5 Report confluent growth with or without discrete fecal coliform colonies as confluent growth per 100 mL with (or without) fecal coliforms and request a new sample via the field services department.

12.6 All results are required to be adjusted as per 11.8 if the sample was selected for colony confirmation.

12.7 If any sterility control sample, such as initial sterility blank, final sterility blank, or rinse water check, contains fecal coliform colonies, inform the supervisor

immediately. Qualify sample results on the test report and if possible, obtain a re-sample.

12.8 If a Laboratory accident, or cross-contamination is suspected, inform the supervisor immediately. For the sample(s) in question, investigate the issue and report with a qualifying comment and if possible, obtain a re-sample when possible.

12.9 Documentation of Laboratory work

12.9.1 Enter and initial the date and time sample was taken, received, run, and completed in designated areas on the EQC Chain of Custody form.

12.9.2 Document all laboratory data as outlined in SOP QC0343 Documentation of Laboratory Data.

12.9.3 Record all media preparation data in the Electronic Media Prep Validation logbook as directed in SOP QC0448.

13.0 Method Performance

13.1 Method performance is evaluated by the analysis of method blanks, positive and negative controls.

14.0 Pollution Prevention/Waste Management

14.1 Keep storage of chemicals in individual departments to a minimum, in order to minimize the potential for large spills and exposure to hazardous substances. Each laboratory manager or designee is required to inspect their department on a semi-annual basis for expired reagents and chemicals. Notify the Safety Director for disposal of expired reagents and chemicals.

14.2 Minimize the amount of waste generated by preparing only the minimum required amount of a reagent.

14.3 Expired hazardous chemicals, reagents, and samples requiring lab packing or other outside disposal/treatment are stored in a designated waste storage facility (such as the chemical shed) until final disposal. This is under the direction and supervision of the Safety Director. Individual analysts may not transfer chemicals or other substances to a waste storage facility without obtaining authorization from the Safety Director. All microbiological waste generated during the performance of this procedure (including used petri dishes) must be disposed of in accordance to the Laboratory Waste Disposal SOP, QC0479 and SOP QC0482 Operation and Maintenance of SR-24C Autoclaves. Additional details regarding specific disposal of chemical waste at EQC are given in the EQC Safety Procedure Manual, which is incorporated herein by reference.

15.0 References and Supplemental Documents

15.1 Standard Methods for the Examination of Water and Wastewater, SM 9222D-2006, Standard Methods, 22nd Edition.

15.2 EQC Quality Systems Manual, latest.

15.3 EQC Safety Procedure Manual, latest.

15.4 EQC SOP QC0339, Thermometer Calibration, Maintenance, and Record Keeping, latest.

15.5 EQC SOP QC0343, Documentation of Laboratory Data, latest.

15.6 EQC SOP QC0448, Media and Broth Preparation, latest.

15.7 EQC SOP QC0467, pH, Electronic measurement, latest.

15.8 EQC SOP QC0479, Waste Disposal in Laboratory.

15.9 EQC SOP QC0499, General Preparation and Evaluation of Demonstrations of Capability, latest.

15.10 EQC SOP QC0500, Preparation of Phosphate-Buffered Dilution and Rinse Water, latest.

15.11 EQC SOP QC0519, Water and Wastewater Sampling for Microbiological Testing, latest.

15.12 EQC SOP QC0848, Operation and Maintenance of Autoclaves Getinge Models 533LS and 733LS.

15.13 Microbiological Methods for Monitoring the Environment, EPA-600/8-78-017.

16.0 Supersession

16.1 Changes in this revision of QC0441 supersedes all previous revisions of SOP QC0441.

16.2 Revision 15: Details on color and size of CFU for counting added to Section 10.8.2; Section 10.9.2, added details when confirmation does not verify. Section 10.9.3; Verification by LTB and EC broth removed from Section 11.9; Section 12.4 revised and calculation examples added; Section 12.7 and 12.8 added; Reference to SOP QC0516 removed from SOP.

17.0 Tables and Figures

17.1 None.

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SOP Number QC0613
Membrane Filter (MF) Technique for Enterococci (EPA 1600)

Revision: 00	Date: 05/02/03
Revision: 01	Date: 08/03/04
Revision: 02	Date: 03/15/06
Revision: 03	Date: 04/05/07
Revision: 04	Date: 12/06/07
Revision: 05	Date: 01/13/08
Revision: 06	Date: 01/26/11
Revision: 07	Date: 10/27/11
Revision: 08	Date: 04/09/14
Revision: 09	Date: 09/18/15
Revision: 10	Date: 05/24/16
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CONFIDENTIAL

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QA Approval:	Pam Heller	Date: 12/1/16
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1.0 Scope and Application

1.1 The EPA has been increasingly concerned with the public health risks of infectious diseases caused by microbial organisms in a variety of waters including recreational fresh and marine waters. One such group of organisms under scrutiny is the Enterococci. Studies have indicated a direct relationship between the density of enterococci in recreational fresh and marine waters and the risk of gastrointestinal illness associated with swimming in the water.

1.2 This Standard Operating Procedure (SOP) applies to determination of microbial organisms in a variety of non-potable waters including recreational fresh and marine waters. The method outlined in this SOP describes a membrane filter (MF) procedure for the detection and enumeration of enterococci in water. Unlike the ME methods of 9213D and 1106.1 the enterococci 1600 method is a single step method which does not require a transfer of the filter to another medium. The modified medium of MEI has a reduced amount of triphenyltetrazolium chloride (TTC) and also includes indoxyl β-D-glucoside, a chromogenic cellbiose analog that is used in the place of esculin. The β-glucosidase, where positive enterococcus produces an indigo blue complex, diffuses into the MEI forming a blue halo around the colony. Enterococci are commonly found in the feces of humans and other warm-blooded animals. Although some strains are ubiquitous and not related to fecal pollution, the presence of enterococci in water is an indication of fecal pollution and the possible presence of enteric pathogens.

1.3 This SOP is to be performed by trained laboratory personnel anytime the enumeration of enterococci by membrane filtration in a water sample is required.

2.0 Summary and Discussion of Procedure

2.1 The MF method provides a direct count of bacteria in water based on the development of colonies on the surface of the membrane filter. A water sample is filtered through the membrane, which retains the bacteria. Following filtration, the membrane containing the bacterial cells is placed on mEI agar and incubated at 41 ± 0.5 °C for 24 ± 2 hours. All colonies greater than or equal to (≥) 0.5 mm in diameter (regardless of color) with a blue halo are recorded as enterococci colonies.

3.0 Definitions

3.1 Enterococcus – a subgroup of the fecal streptococci that includes *S. faecalis, S. faecium, S. gallinarum,* and *S. avium* differentiated from the fecal streptococci by their ability to grow in 6.5% sodium chloride, at pH 9.6 and at 10 and 45 °C. They are a valuable bacterial indicator for determining the extent of fecal contamination of recreational surface waters.

In Method 1600, enterococci are those bacteria, which produce colonies greater than or equal to (≥) 0.5 mm in diameter with a blue halo after incubation on mEI agar. The blue halo should not be included in the colony diameter measurement.

3.2 Serial dilutions: This procedure is used to identify the number of viable micro-organisms in a fixed amount of a liquid. Serial dilution involves repeatedly mixing known amounts of sample with sterilized liquid. 1 mL added to 9 mL gives a 10-fold dilution; 1 mL added to 99 mL gives a 100-fold dilution. The first 10-fold dilution is termed the 10^{-1} dilution. The first 100-fold dilution is termed the 10^{-2} dilution. An undiluted sample is termed the 10^{0} dilution. The buffer used for dilution depends on the substance being diluted. When fixed amounts of this dilution series are plated and incubated, then different numbers of colonies will be obtained. By working back from an easily counted plate and using the appropriate dilution factor, the number of micro-organisms in the original source can be calculated.

3.3 Holding Time: The maximum time a sample may be held after collection until analysis. Results reporting for regulatory purposes must be from an analysis within the established holding time. For microbiology samples holding time is determined from the sample collection time to the time the sample is placed into incubation.

4.0 Health and Safety Warnings

4.1 Personnel engaged in laboratory analyses at Eurofins QC, Inc. (EQC) must be familiar with and adhere to the policies set forth in the current version of the EQC Safety Procedure Manual.

5.0 Cautions

5.1 Start microbiological examination of a water sample promptly after collection to avoid unpredictable changes.

5.2 Notify a client service representative when any chain of custody record is not clear such as missing sample time or sample ID information or requested test. Document the notification and reason in the company LIMS History Log.

6.0 Interferences

6.1 Water samples containing colloidal or suspended particulate materials can clog the membrane filter and prevent filtration, or cause spreading of bacterial colonies, which could interfere with the enumeration and identification of target colonies.

7.0 Personnel Qualifications

7.1 Before performing this test independent of secondary supervision and review, each analyst in a NELAC facility must have an approved Demonstration of Capability Certification Statement (DOC) form (see SOP QC0499) on file in the Quality Assurance Department.

8.0 Equipment, Apparatus and Materials

Equipment:

8.1 Autoclave capable to maintain a high pressure saturated steam at 121 C (249 F) for around 15-30 minutes depending on the size of the load and the contents.

8.2 Flame Burner, for flame-sterilizing forceps.

8.3 Carboy capable of holding 20 L.

8.4 Erlenmeyer flask, clean borosilicate, for mixing media.

8.5 Filtration funnel units: filter funnels 47-mm magnetic (Gelman or equivalent), graduated at 50 and 100 mL, in assembly with base, sterile, re-usable.

Note: As an alternative, disposable, sterile filtration funnel units can be used (Fisher, Catalog # 09-740-30D or equivalent).

8.6 A filter manifold to hold a filter bases. A vacuum filter manifold.

8.7 Forceps.

8.8 Hand tally.

8.9 Incubators, capable of maintaining temperatures of 41 ± 0.5 °C, 35 ± 0.5 °C and 45 ± 0.5 °C.

8.10 Refrigerators capable of maintaining a temperature of 0 - 6 °C and 2 - 8 °C.

8.11 Stereo microscope with fluorescent light source.

8.12 Test tubes, screw-cap, 20 x 125 mm, borosilicate glass or plastic.

8.13 UV light (6 watt, 365 nm).

8.14 Water bath capable of maintaining a temperature of 44.5 ± 0.2 °C.

Supplies:

8.15 Autoclave funnel wrap: aluminum foil or kraft paper.

8.16 Autoclave Indicator tape.

8.17 Alcohol: Reagent alcohol, purchased reagent grade chemical for forceps sterilization. Store in a flammable cabinet at room temperature.

8.18 Inoculating loops, plastic, sterile.

8.19 Membrane filters 47-mm/0.45 micron pore-size, sterile (Millipore or equivalent).

8.20 Petri dishes, 60 x 15 mm plastic, presterilized.

8.21 Sample containers, 125 mL, polypropylene, containing Sodium Thiosulfate tablet for chlorine neutralization.

Media and Reagents:

8.22 mEI agar (Difco or equivalent)

8.22.1 Suspend 72 g of the powder into 1 L of purified water. Mix thoroughly. Heat with frequent agitation and boil for 1 minute to completely dissolve the powder. Autoclave prepared media at 121 °C for 15 minutes and then cool media in a 50 °C water bath. Add nalidixic acid and TTC solutions to the medium as outlined in the Sections 8.22.2.1 and 8.22.2.2 below, and mix. Read pH. Final pH must be 7.1 ± 0.2.

8.22.1.1 Mix 0.24 g nalidixic acid in 5-mL reagent grade water. Add a few drops of 0.1N NaOH to dissolve. Add this solution to 1 L of the mEI medium.

8.22.1.2 Add 2 mL (0.02 g) of 1% solution triphenyl tetrazolium chloride (TTC) separately to 1 L the mEI medium and mix.

Note: If larger volume of mEI prepared, the amount of nalidixic acid and TTC solutions must be adjusted accordingly to the work load.

8.22.2 Dispense mEI agar in 4 to 6 mL quantities into 60 x 15 mm disposable petri dishes and allow to solidify. The amount of media prepared can be adjusted accordingly to the work load. Label each batch and container of media with date prepared, batch ID, date expired, lot #, temperature for storage and method name. The positive control for mEI is *E. faecalis* and the negative control is *E coli*. Test for sterility and growth promotion properties using positive and negative controls as directed in SOP QC0448. Store all prepared plates at 2 - 8 °C for up to 2 weeks. Record all media preparation data in the Media Electronic Logbook (Media Logbook) as directed in SOP QC0448.

8.23 Brain-heart infusion agar (BHIA) (BD BBL or equivalent).

Used in the verification of fecal streptococcus and enterococcus colonies.

8.23.1 Suspend 52 g of the powder in 1 L of purified water. Mix thoroughly. Heat with frequent agitation and boil for 1 to completely dissolve the powder. Autoclave at 121 °C for 15 minutes. Before use agitate gently to distribute the precipitate uniformly throughout the medium. Final pH must be 7.4 ± 0.2 after autoclaving.

8.23.2 Dispense 10 mL of agar into tubes for slants, or 15 – 20 mL into petri dishes, and allow to solidify. Prepared media will be slightly hazy and amber color. The amount of media prepared can be adjusted accordingly to the work load. Label each batch and container of media with date prepared, batch ID, date expired, lot #, temperature for storage and method name. The positive control for brain heart infusion agar is *E. faecalis* and the negative control is not needed. Test for sterility and growth promotion properties as directed in SOP QC0448. Store all prepared plates at 2 - 8 °C for up to 2 weeks and

tubes for up to 3 month. Store unprepared medium in a cool, dry, location out of the way of direct light. Record all media preparation data in the Media Logbook as directed in SOP QC0448.

8.24 Brain-heart infusion broth (BHIB) (Acumedia or equivalent)

8.24.1 Dissolve 37 g of medium into 1 L of purified water. Heat with frequent agitation to completely dissolve the medium. Autoclave for 15 minutes at 121 °C. Final pH must be 7.4 ± 0.2 after autoclaving.

8.24.2 Dispense 10 mL into autoclavable, borosilicate glass tubes of sufficient size to contain both the culture media and the sample without being three-quarters full. No inserts are needed in the culture tubes. Prepared media may have precipitate, will be a clear light to medium amber color. The amount of media prepared can be adjusted accordingly to the work load. Label each batch and container of media with date prepared, batch ID, date expired, lot #, temperature for storage and method name. The positive control for brain heart infusion broth is *E. faecalis* and the negative control is not needed. Test for sterility and growth promotion properties as directed in SOP QC0448. Store all prepared tubes at 2 - 8 °C for up to 3 month. Store unprepared medium in a cool, dry, location out of the way of direct light. Record all media preparation data in the Water Media Logbook as directed in SOP QC0448.

8.25 Brain-heart infusion broth with 6.5% NaCl (BHIB with 6.5% NaCl) (Acumedia or equivalent)

8.25.1 Dissolve 37 g of medium into 1 L of purified water. Heat with frequent agitation to completely dissolve the medium. Add 60 g of NaCl for every liter of broth made.

Note: BHIB with 6.5% NaCl is the same as BHIB above (Section 8.24), but with additional NaCl.

Add 60 g of NaCl to formula provided in Section 8.24 above and follow all preparation steps in Section 8.24.

8.25.2 The positive control for brain heart infusion broth with NaCl is *E. faecalis* and the negative control is not needed.

8.26 Bile esculin agar (Remel or equivalent)

8.26.1 Suspend 64 g of medium into 1 L of purified water. Heat to boiling with agitation to completely dissolve. Autoclave for 15 minutes at 121 °C. Final pH must be 6.8 ± 0.2 after autoclaving.

8.26.2 Dispense 10 mL into autoclavable, borosilicate glass tubes of sufficient size to contain both the culture media and the sample without being three-quarters full. The amount of media prepared can be adjusted accordingly to the work load. Label each batch and container of media with date prepared, batch ID, date expired, lot #, temperature for storage and method name. The positive control for esculin agar is *E. faecalis* and the negative control is *E. coli*. Test for sterility and growth promotion properties as directed in SOP QC0448. Store unprepared medium in a cool, dry location out of the way of

direct light. Store prepared medium at 2 - 8 °C. Record all media preparation data in the Media Logbook as directed in SOP QC0448.

8.27 Tryptic soy agar (BD BBL or equivalent)

8.27.1 Suspend 45.7 g of the powder into 1 L of purified water. Mix thoroughly. Heat with frequent agitation. Boil for 1 minute to completely dissolve the powder. Autoclave at 121 °C for 15 minutes. Final pH must be 7.3 ± 0.2 after autoclaving.

8.27.2 Dispense 15 to 20 mL into 15 x 100 mm sterile petri dishes and allow to solidify. The amount of media prepared can be adjusted accordingly to the work load. Label each batch and container of media with date prepared, batch ID, date expired, lot #, temperature for storage and method name. The positive control for TSA is *E. coli* and a negative control is not needed. Test for sterility and growth promotion properties as directed in SOP QC0448. Store in a cool, dry, location out of the way of direct light. Record all media preparation data in the Media Logbook as directed in SOP QC0448.

8.28 Nalidixic acid.

8.29 0.1N NaOH.

8.30 Phosphate Buffered Dilution water

8.30.1 Prepare as directed in SOP QC0500. The amount of media prepared can be adjusted accordingly to the work load. Record all media preparation data in the Media Logbook as directed in SOP QC0448.

8.31 Phosphate Buffered Saline (PBS)

8.31.1 Composition:

Sodium dihydrogen phosphate (NaH_2PO_4)	0.58 g
Disodium hydrogen phosphate (Na_2HPO_4)	2.5 g
Sodium Chloride (NaCl)	8.5 g
Reagent-grade water	1.0 L

8.31.2 Dissolve the reagents in 1 L of reagent-grade water and dispense in appropriate amounts for dilutions in screw cap bottles and/or into containers for use as rinse water. Autoclave at 121 °C for 15 minutes. Final pH must be 7.4 ± 0.2. Record all media preparation data in the Water Microbiology Validation book as directed in SOP QC0448.

8.32 Sodium chloride.

8.33 Triphenyl Tetrazolium Chloride dye (TTC), 1% solution.

Cultures:

8.34 Positive control culture *Enterococcus faecalis*, ATCC 19433 or equivalent (BioBalls, *Enterococcus faecalis,* NCTC 775).

8.35 Negative control culture *E. coli*, ATCC 11775 or equivalent (BioBalls, *E. coli,* NCTC 9001).

9.0 Calibration

9.1 Calibrate glass thermometers used to monitor the temperature of incubators and water baths against a NIST thermometer annually according to SOP QC0339. Calibrate all others (digital, infrared, etc.) quarterly.

9.2 Schedule annual calibration and maintenance of balances through the manufacturer or other contracted personnel. See SOP QC0470, Laboratory Balance Calibration.

9.3 Calibrate pH meters according to manufacturer's recommendations and SOP QC0467, pH Electrometric Measurement.

9.4 Check incubator temperatures twice daily, four hours apart to ensure temperature requirements are being met. Record readings in the temperature logbooks.

10.0 Sample Preparation and Analysis

10.1 Collect samples as directed in SOP QC0519 Water, Wastewater, Sludge and Compost Sampling for Microbiological Testing. Store collected samples from the field to the laboratory on ice at a temperature between 0 and 10 °C (do not freeze). When samples are stored at the testing laboratory, prior to analysis, store refrigerated between 0.5 and 5 °C (do not freeze). At no time shall the sample be frozen.

10.2 The maximum holding time for samples analyzed by this procedure is eight (8) hours.

10.3 Sample size

10.3.1 The size of the sample will be governed by the expected bacterial density based on the previous historical enterococci levels of the source. An ideal sample volume will yield 20 to 60 enterococcus colonies on a membrane filter surface. **A minimum of 3 dilutions must be used for any new sample source.** In instances where the bacterial density is expected to be high, turbidity situations exist, no known history of bacterial density or for legal cases, filter at least three appropriate dilutions from 1 to 100 mL using log interval (e.g. 100, 10, 1, 0.1, etc.) or half log intervals (e.g. 100, 30, 10, 3, 1 mL) prepared in phosphate buffered dilution water through a membrane.

10.3.2 For special projects, such as river project samples, where the bacterial density is expected to be high, use 10-fold or 100-fold dilution technique. Certain samples may require a 10^{-6} dilution.

10.4 Sterile filtration units

10.4.1 Use for filtration series

10.4.1.1 A filtration series is considered to be interrupted when an interval of 30 minutes or longer elapses between sample filtrations. After such interruption, treat any further sample filtration as a new filtration series and replace the filter funnels with new sterile filter funnels.

10.4.1.2 Do not process more than ten (10) filtrations on any funnel. That is, after ten filtrations, including samples, rinse water or sample dilutions, change-out the filter funnel to a second, sterile funnel.

10.4.1.3 During testing in the laboratory, multiple funnels may be used for less than 10 field sample filtrations in order to meet holding times or

when, in the judgment of the analyst, a new funnel should be used following a sample with a suspected high level of bacteria. Always complete any funnel use with a filter blank.

10.4.2 Use for serial diluted single sample (i.e., river samples, etc.)

10.4.2.1 Use separate sterile filtration unit for each sample to be tested. Start filtration from the highest dilution to lowest. Rinse the interior surface of the funnel 3 times with a 20-30 mL of the sterile dilution water after each filtration. Place filtration unit into the autoclave container when sample filtration is done, and place a new sterile funnel onto manifold for new sample use.

10.5 Enterococci procedure

10.5.1 Using sterile forceps, place a sterile membrane filter (grid side up) over the porous plate on the filter base and attach the funnel to the base so that the membrane filter is now held between the funnel and the base.

10.5.2 Shake the sample in an up and down motion for a minimum of 25 times. Measure the desired volume of sample or dilution into the funnel. Select sample volumes based on previous knowledge of the enterococci level, to produce 20 - 60 enterococci colonies on filter.

10.5.3 Smaller sample size or sample dilutions can be used to minimize the interference of turbidity or for high bacterial densities. Multiple volumes of the same sample or sample dilutions may be filtered.

Note: When analyzing smaller sample volumes (e.g., <20 mL), 20 – 30 mL of PBS or phosphate-buffered dilution water should be added to the funnel or an aliquot of sample should be dispensed into a dilution blank prior to filtration. This will allow even distribution of the sample on the membrane.

10.5.4 Filter the sample under partial vacuum. With the membrane still in place, rinse the interior surface of the funnel 3 times with a 20 - 30 mL portion of sterile dilution water from a squeeze bottle to prevent carryover contamination. Upon completion of final rinse, and the filtration process, disengage vacuum, unlock and remove funnel, and immediately remove the membrane filter with sterile forceps, and place it on a mEI agar dish which has been allowed to warm to room temperature with a rolling motion to avoid entrapment of air.

10.5.5 Invert culture plates and incubate at 41 ± 0.5 °C for 24 ± 2 hours.

10.5.6 After incubation, count and record colonies on those membrane filters containing, if practical, 20 - 60 colonies with any blue halo that are 0.5 mm or larger (not including blue halo) regardless of colony color as an enterococci colony (see Figure 1). Count enterococcus colonies using a measuring magnifier and a low power binocular wide-field, stereo microscope with a cool white fluorescent light source to give maximum visibility of colonies.

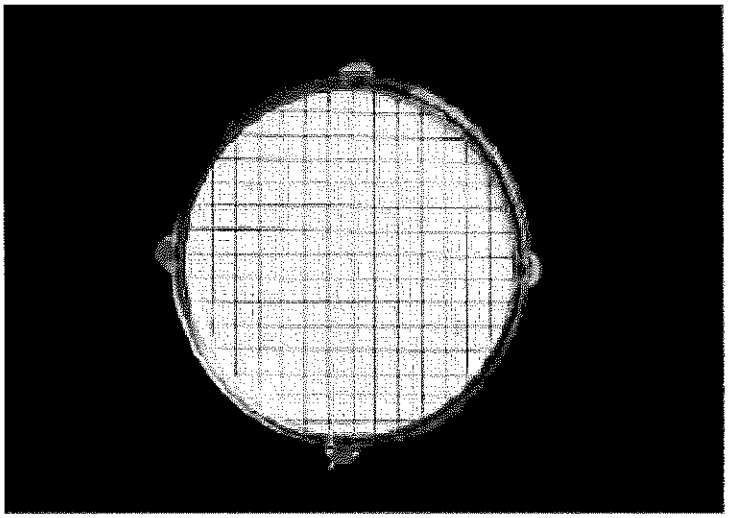

Figure 1. Enterococci colonies on mEI produce blue halos.

10.6 Verification Procedures

10.6.1 Frequency Tracking

The main lab and satellites offices must track the number of samples that contain typical and atypical colonies. Verification tests are performed at the main lab.

10.6.1.1 Following plate counting, use the Sample Tracking file for this method (EPA 1600) and bar-code each sample that has either typical or atypical colonies into the file for tracking frequency.

10.6.1.2 For satellites offices, take a picture of the plate. Send the plate and photo to the main lab for verification. Notify the main lab staff when plates are being sent.

Note: The main lab will use the picture as a reference for confirmation of original count of typical and atypical colonies.

10.6.1.3 After receiving plates from a Satellite office, initiate the verification the same day or at a minimum by the following day to ensure the quality of data.

10.6.1.4 Verification must be performed each month based on the following frequency: Verify a minimum of 10 typical (positive) and 10 atypical (negative) enterococci colonies or 1 typical and 1 atypical colony from 10% of all plates showing growth, whichever is more frequent.

10.6.1.5 When routine samples do not provide at least 10 typical and at least 10 atypical colonies, a source known to satisfy this requirement must be analyzed and verified. Such sources can include samples from local pounds or streams.

10.6.1.5.1 Collect a sample from local pound or stream and analyzed as a regular sample.

10.6.2 Verification tests performing

10.6.2.1 Using a sterile inoculating loop, transfer cells from the centers of at least 10 typical and 10 atypical colonies into BHI broth (BHIB) tubes and onto BHI agar (BHIA) plate. Incubate the broth tubes for 24 ± 2 hours at 35 ± 0.5 °C and the agar plates for 48 ± 3 hours at 35 ± 0.5 °C.

10.6.2.2 After 24 hours of incubation (10.6.2.1), transfer a loopful of growth from the BHIB tubes to the following:

10.6.2.2.1 Bile Esculin agar (BEA) and incubate at 35 ± 0.5 °C for 48 ± 3 hours.

10.6.2.2.2 BHI broth with 6.5% NaCl and incubate at 35 ± 0.5 °C for 48 ± 3 hours.

10.6.2.2.3 BHI broth and incubate at 45 ± 0.5 °C for 48 ± 3 hours.

10.6.2.3 After 48 hours of incubation, observe for turbidity (growth) and record any growth in each of the above tubes/plates.

10.6.2.4 After 48 hours of incubation, perform a gram stain on any growth found on each BHI agar plate/slant (10.6.2.1).

10.6.2.5 Gram positive cocci which grow and hydrolyze esculin on BEA (i.e. produce a black or brown precipitate) and grow in BHI broth at 45°C, and BHI broth with 6.5% NaCl at 35 °C, are verified as enterococci.

10.6.2.6 Alternately, commercially available multi-test identification systems (e.g. Vitek®) may be used to verify colonies. Such multi-test identification systems should include Esculin hydrolysis and growth in 6.5% NaCl.

10.6.2.7 Record all information (Typical or Atypical colonies, media batch number, incubation times, etc.) into Enterococci Verification logbook Form #3031. The laboratory manager or his designee must review the Logbook for accuracy.

10.6.3 Adjust results based upon percentage of Enterococcus colonies confirmed. The adjusted count may be REDUCED if the confirmation for any typical colony is negative. The adjusted count may be increased if the confirmation for any atypical colony is positive.

Example:

45 TOTAL Colonies
30 Typical Colonies, and 15 atypical colonies.
Reported Result = 30 colonies / 100 mL presumptive

Confirmation Phase: use percentage of colonies confirmed as below:

8 out of 10 typical show positive: adjust count DOWN to [(8/10) x 30] = 24
2 out of 10 atypical colonies show positive: adjust count UP by [(2/10) x 15] = 3
Actual count = 24 + 3 = 27 colonies / 100 mL

Edit the original data entered in to the company LIMS and send the client a revised report with comment.

11.0 Quality Control

11.1 Test all microbiological media after preparation as directed in SOP QC0448.

11.2 Check each lot # of membrane filters for sterility by placing a membrane on a tryptic soy agar plate for 24 ± 2 hours at 35 ± 0.5 °C. Absence of growth indicates sterility of the filter. Reject any lot that is found to be non-sterile. Record results in the Water Microbiology quality control book.

11.3 Duplicate analyses. Perform duplicate analyses at a minimum of a 5% (1 out of every 20 samples) frequency or 1 per week, whichever is more frequent. Refer to SOP QC0952 for further information.

11.4 Check each batch of PBS and phosphate-buffered rinse water for sterility by adding 50 mL water to 50 mL double strength trypticase soy broth, incubating at 35 ± 0.5°C for 24 ± 2 hours and checking for growth. Record results in the Water Microbiology quality control book.

11.5 On a monthly basis, verify a minimum of 10 typical and 10 atypical enterococci colonies (can be from a single membrane) or 1 typical and 1 atypical colony from 10% of all samples with growth, whichever is more frequent as directed in Section 10.6. Record results in the Method Verification Logbook.

11.6 Initial precision and recovery (IPR)

The IPR analysis is used to demonstrate acceptable method performance (recovery and precision) by each laboratory before the method is used for monitoring field samples. IPR samples must be accompanied by an acceptable method blank (sterile Phosphate-buffered saline (PBS)) and appropriate media sterility checks. The IPR procedure is as follows:

11.6.1 Prepare four, 100-mL samples of **PBS** (Section 8.31) and spike each sample with *Enterococcus faecalis* ATCC 19433 by aseptically adding one BioBall to each container and mixing by vigorously shaking the sample bottle a minimum of 25 times.

11.6.2 Filter and process each IPR sample according to the procedure outlined in Section 10.0 and calculate the number of Enterococci per 100 mL according to Section 12.0.

11.6.3 Calculate the percent recovery (R) for each IPR sample using the following equation:

$$R = 100 \times \frac{(Ns - Nu)}{(T)}$$

R = percent recovery

Ns = Enterococci (CFU/100 mL) in the spiked sample

Nu = Enterococci (CFU/100 mL) in the unspiked sample

(Even if no colonies are found, the minimum value is 1)

T = true spiked Enterococci (CFU/100 mL) manufacturer's lot mean

11.6.4 Using the percent recoveries of the four analyses, calculate the mean percent recovery and the relative standard deviation (RSD) of the recoveries. The RSD is the standard deviation divided by the mean, multiplied by 100.

11.6.5 Compare the mean recovery and the RSD with the corresponding IPR criteria below:

Recovery (mean percent)	**85% - 106%**
Precision (as maximum RSD)	**14%**

If the mean and the RSD for recovery of Enterococci meet acceptance criteria, system performance is acceptable and analysis of field samples may begin. If the mean or the RSD fall outside of the required range for recovery, system performance is unacceptable. In this event, identify the problem by evaluating each step of the analytical process, media, reagents, and controls, correct the problem and repeat the IPR analysis.

11.7 Ongoing precision and recovery (OPR)

To demonstrate ongoing control of the analytical system, the laboratory must routinely process and analyze spiked **PBS** (Section 8.31) samples. The laboratory must analyze one OPR sample after every 20 field and matrix spike samples or one per week that samples are analyzed, whichever occurs more frequently. OPR samples must be accompanied by an acceptable method blank (sterile phosphate-buffered saline (PBS)) and appropriate media sterility checks. The OPR procedure is as follows:

11.7.1 Spike a 100-mL sample of PBS with *Enterococcus faecalis* ATCC 19433 by aseptically adding one BioBall to the container and mixing by vigorously shaking the sample bottle a minimum of 25 times.

11.7.2 Filter and process each OPR sample according to the procedure outlined in Section 10.5 and calculate the number of Enterococci per 100 mL according to Section 12.0.

11.7.3 Calculate the percent recovery (R) for each OPR sample using the equation in section 11.6.3.

11.7.4 Compare the OPR results (percent recovery) with the corresponding recovery criteria below:

OPR (as percent recovery) 78%-113%

If the OPR result for recovery of Enterococci meets acceptance criteria, method performance is acceptable and analysis of field samples may continue. If the OPR result falls outside of the acceptance criteria for recovery, system performance is unacceptable. In this event, identify the problem by evaluating each step of the analytical process, media, reagents, and controls, correct the problem and repeat the OPR analysis.

11.8 Matrix spikes (MS)

MS analysis is performed to determine the effect of a particular matrix on enterococci recoveries. The laboratory must analyze one MS sample when **disinfected** wastewater samples are first received from a new source. Subsequently, 1 per 20 samples received from a disinfected wastewater must include a MS sample. MS samples must be accompanied by the analysis of an unspiked field sample (duplicate) subsequently collected from the same sampling site. Additionally, an OPR sample must be run along side the field samples. MS samples are performed as follows:

11.8.1 Prepare two 100 mL field samples that were subsequently collected from the same site. One sample will remain unspiked and the other will serve as the spiked sample. If 100 mL volume is not available, use two 10-mL volumes from a single field bottle sample.

11.8.2 Select sample sizes that will yield an enterococci value of 20 - 60 colonies on a membrane.

11.8.3 Spike the MS sample with an *E. faecalis* BioBall (Section 8.34).

11.8.4 Filter the spiked field sample and the unspiked field sample as directed in Section 10.5.

11.8.5 After incubation, count all enterococci colonies on both plates. Adjust the colony count of the spiked sample by subtracting any enterococci colonies found on the membrane of the unspiked sample.

11.8.6 Calculate the percent recovery (R) for the MS sample using the equation in section 11.6.3.

11.8.7 Compare the MS result (percent recovery) with the corresponding recovery criteria below:

MS (as percent recovery) 63%-110%

If the MS result for recovery of Enterococci meets acceptance criteria, system performance is acceptable and analysis of field samples from this disinfected wastewater source may continue. If the MS result is unacceptable and the OPR sample result associated with this batch of samples is acceptable, a matrix interference may be causing the poor results. If the MS recovery is unacceptable, all associated field data must be flagged.

11.9 Laboratories with two or more analysts must compare each analyst's colony counts from one positive field sample per month. Colony counts must be within 10% between analysts. Facilities with a single analyst must have that analyst perform duplicate colony counts of a single membrane filter each month. Duplicate colony counts must be within 5% for a single analyst. If no positive field samples are available, an OPR sample may be substituted for these determinations.

11.10 For additional details of OPR, MS, Duplicate and quality control samples analyses refer to SOP QC0952.

11.11 Immediately bring to the attention of the supervisor or his designee any deviations in expected quality control testing results and refer to SOP QC0516 Deviations in Expected Quality Control Data to institute corrective action procedures.

11.12 As part of the laboratory QA program, method recovery results for OPR and IPR samples should be charted and updated records maintained in order to monitor ongoing method performance. Refer to SOP QC0952 for further information.

11.13 A Demonstration of Capability (DOC) must be completed initially, and each time there is a significant change in instrument type, personnel, or test method. Demonstration must be documented using the form "Demonstration of Capability Certification Statement" as described in SOP QC0499.

11.13.1 DOC may be established with the use of IPR and OPR Study. Document the successful completion of the Initial Demonstration of Capability for each analyst using the "Demonstration of Capability Certification Statement".

11.13.2 Submit all raw data, a spreadsheet summarizing the recoveries and standard deviations, and a completed "Initial Demonstration of Capability Certification Statement" to the QA Director for review, via LIMS immediately upon completion.

11.13.3 Following review and approval by the QA Director, the original Certification Statement and spreadsheet will be maintained in the analyst training files, which are kept in the QA office.

11.14 Corrective actions are taken when nonconforming work or departures from policies and procedures in the management system or technical operations have been identified. Preventive action is a proactive process to identify opportunities for improvement rather than a reaction to the identification of problems or complaints.

- Analytical work may be stopped if necessary during the investigation, and analyses may resume after it is verified that the corrective actions taken have been effective.
- Corrective actions may include, but not limited to instrument repair or maintenance, recalibration of the instrument, resampling, reanalysis of samples, etc.

11.15 Preventive actions may include, but not limited to preventive maintenance, retraining of analysts, change in procedures etc.

12.0 Calculations and Record Keeping

12.1 Compute the count, using membrane filters with 20 to 60 enterococcus colonies or those closest to that, by the following equation:

enterococcus colonies/100 mL=

(enterococcus colonies counted / mL of sample filtered) x 100

Report results as x CFU/100 mL where X represents the number of colonies.

Note: Refer to Section 12.7 for guidance when colony counts are both above and below the upper and lower limits.

12.2 If all MF counts for a given sample are **below the lower acceptable limit** of 20, select the most nearly acceptable count and use the equation in Section 12.1 to obtain enterococcus density.

For example, sample volumes of 100, 10 and 1 mL produced colony counts of 17, 1 and 0, respectively. Calculate on the basis of the most nearly acceptable plate count, 17, and report as 17 CFU/100 mL.

12.3 If the total number of enterococcus colonies are **not distinct enough** for accurate counting (TNTC), use > 60 in the calculation and report the result by using the equation in 12.1. If all membrane counts are above the upper acceptable limit of 60 but countable, calculate the count using the smallest volume filtered.

For example, volumes 1, 0.5, and 0.01 mL all produced plate counts of TNTC. Use the upper range of 60 colonies as the basis of calculation with the smallest filtration volume and estimate the count:

60 / 0.01 X 100 = 600,000 CFU/100 mL

Report this as > 600,000 CFU/100 mL

12.4 If there are counts in the **acceptable range on replicate plates**, carry the counts independently to final reporting units, then calculate the arithmetic mean of those counts to obtain the final reporting value.

Example, if the counts are 24 and 36 for replicate plates of 100 mL each, then the arithmetic mean is calculated as follows:

(24 CFU/100 mL + 36 CFU/100 mL) / 2 = 30 CFU/100 mL

12.5 If there is **more than one dilution having an acceptable range** of counts, carry the counts independently to final reporting units, then average for final reporting value.

For example, volumes 100, 10 and 1 mL produce colony counts of TNTC (too numerous to count), 55, 30, and 1 respectively. Independently carry each MF count to a count of per 100 mL:

55/10 x 100 = 550 CFU/100 mL
30/1 x 100 = 3000 CFU/100 mL

Calculate the arithmetic mean:

(550 CFU/100 mL+ 3000 CFU/100 mL) / 2 = 1775 CFU/100 mL

Report 1775 CFU/10 mL

12.6 If counts from **all membranes are zero**, calculate final result using the largest volume filtered.

For example, sample volumes of 25, 10 and 2 mL produced colony counts of 0, 0 and 0 respectively. Calculate the number of colonies per 100 mL that would have been reported if there had been one colony on the filter representing the largest filtration volume. In this example the largest volume is 25 mL, calculation would be:

1/25 X 100 = 4 CFU/100 mL

Report as <4 CFU/100 mL.

12.7 If colony counts are **both above and below the upper and lower limits**, select the most nearly acceptable count.

For example, colony counts of 64, 6 and 0 from volumes of 100, 10 and 1 mL respectively. Calculate on the basis of the most nearly acceptable plate count, 64, and report 64 CFU/100 mL.

If sample volumes of 100, 10 and 1 mL produced colony counts of 98, 18 and 0 respectively calculate using 18 colonies. This must be reported as an estimated count.

12.8 If there is no result because of confluent growth, >200 atypical colonies (TNTC), lab accident, etc., the data must be reviewed by the Department Manager or his/her designee for any laboratory errors. A result may not be reported; the client must be notified with specific reason for lack of reportable result.

12.9 Documentation of Laboratory work

12.9.1 Enter and initial the date and time sample was taken, received, run, and completed in designated areas on the EQC Chain of Custody form.

12.9.2 Document all laboratory data as outlined in SOP QC0343, Documentation of Laboratory Data.

12.9.3 Immediately bring to the attention of the supervisor or his designee any deviations in expected quality control testing results and refer to SOP QC0516 Deviations in Expected Quality Control Data to institute corrective action procedures.

13.0 Method Performance

13.1 Specificity – The specificity of the medium used in this method is 6.0% false positive and 6.5% false negative for various environmental water samples. The false positive rate was calculated as the percent of colonies, which react typically, but did not verify as members of the enterococcus group. The false negative rate was calculated as the percent of all verified enterococcus colonies not reacting typically.

13.2 Bias – The persistent positive or negative deviation of the results from the assumed or accepted true value is not significant.

13.3 Precision – The precision among laboratories for marine water was 2.2% and for surface water was 18.9%.

14.0 Pollution Prevention/Waste Management

14.1 Keep storage of chemicals in individual departments to a minimum, in order to minimize the potential for large spills and exposure to hazardous substances. Each laboratory manager or designee is required to inspect their department on a semi-annual basis for expired reagents and chemicals. Notify the Safety Director for disposal of expired reagents and chemicals.

14.2 Minimize the amount of waste generated by preparing only the <u>minimum</u> required amount of a reagent.

14.3 Expired hazardous chemicals, reagents, and samples requiring lab packing or other outside disposal/treatment are stored in a designated waste storage facility (such as the chemical shed) until final disposal. This is under the direction and supervision of the Safety Director. Individual analysts may not transfer chemicals or other substances to a waste storage facility without obtaining authorization from the Safety

Director. All microbiological waste generated during the performance of this procedure (including used petri dishes) must be disposed of in accordance to the Laboratory Waste Disposal SOP, QC0479. Additional details regarding specific disposal of chemical waste at EQC are given in the EQC Safety Procedure Manual, which is incorporated herein by reference.

15.0 References and Supplemental Documents

15.1 EPA Method 1600: Enterococci In Water by Membrane Filtration Using membrane-Enterococcus Indoxyl-β-D Glucoside Agar (mEI) July, 2009.

15.2 EPA 600/8-78-017, Part II, Section C 3.5.

15.3 EQC Quality Systems Manual, latest.

15.4 EQC Safety Procedure Manual, latest.

15.5 EQC SOP QC0339, Thermometer Calibration, Maintenance, and Record Keeping, latest.

15.6 EQC SOP QC0343, Documentation of Laboratory Data, latest.

15.7 EQC SOP QC0448, Media and Broth Preparation, latest.

15.8 EQC SOP QC0467, pH Electrometric Measurement, latest.

15.9 EQC SOP QC0470, Laboratory Balance Calibration, latest.

15.10 EQC SOP QC0479, Laboratory Waste Disposal, latest.

15.11 EQC SOP QC0499, General Preparation and Evaluation of Demonstrations of Capability, latest.

15.12 EQC SOP QC0500, Preparation of Phosphate-Buffered Dilution and Rinse Water, latest.

15.13 EQC SOP QC0516, Corrective Action Procedures for Deviations from Expected Microbiological Quality Control Results, latest.

15.14 EQC SOP QC0519, Water and Wastewater Sampling for Microbiological Testing, latest.

15.15 EQC SOP QC0952, General Internal Quality Control Requirements for Analytical Methods in the Water Microbiology Laboratory, latest.

16.0 Supersession

16.1 EQC Southampton address removed from the SOP header; *E.coli* negative control removed from Section 8.24.

16.2 Section 3.2, updated; Section 8.0, restructured and updated; Section 10.1, non-significant addition made; Section 10.3.1, log interval dilutions added; Section 10.4.1.1 through 10.4.1.3 added; Section 10.6.1, 10.6.2.2, and 10.6.2.7 added; Section 11.3 and 11.10 refer to SOP QC0952.

17.0 Tables and Figures

17.1 Figure 1 (Section 10.5.6)

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SOP Number QC0665
E. coli in Water by Membrane Filtration Using Modified Membrane- Thermotolerant *Escherichia coli* Agar (Modified mTEC) by EPA 1603

CONFIDENTIAL

Revision: 00	Date: 02/20/08
Revision: 01	Date: 07/08/08
Revision: 02	Date: 12/23/08
Revision: 03	Date: 01/08/11
Revision: 04	Date: 10/27/11
Revision: 05	Date: 05/23/12
Revision: 06	Date: 10/01/14
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Prepared/Revised By	: Tamara Charnauski	Date: 11/23/2016
Reviewed By	: Raphael Fratti	Date: 11/30/2016
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Management Approval	: Raphael Fratti	Date: 12/1/16
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1.0 Scope and Application

1.1 This procedure is used when the number of *E. coli* in water needs to be determined by the membrane filtration (MF) method using modified membrane-thermotolerant *E. coli* agar (modified mTEC). It is to be performed by trained personnel anytime the enumeration of *E. coli* bacteria using this method is required.

1.2 The MF technique provides a direct count of bacteria in water based on the development of colonies on the surface of a membrane filter. It is highly reproducible, can be used to test relatively large sample volumes, and yields results more rapidly than the multiple-tube procedure. However, the MF procedure has limitations, particularly when testing waters with high turbidity or elevated background bacteria.

2.0 Summary and Discussion of Procedure

2.1 Method 1603 is approved for the detection and enumeration of *E. coli* in both disinfected wastewaters and ambient waters. With respect to the latter, a wide variety of pathogenic microorganisms can be transmitted to humans when bathing in such waters. Historically, fecal coliforms have been recommended as the indicator of choice for evaluating the microbiological quality of recreational waters. Recent studies, however, have demonstrated that *E. coli* and enterococci show a stronger correlation with swimming-associated gastroenteritis than do fecal coliforms, and that both indicators were equally acceptable for monitoring fresh water quality.

2.2 The MF procedure for *E. coli* uses a modified mTEC medium and an incubation temperature of 44.5 ± 0.2 °C for selectivity. Samples up to 100 mL are filtered through a sterile, 47 mm, 0.45 micron membrane filter and incubated on modified mTEC agar, first for 2 ± 0.5 hours at 35 ± 0.5 °C, and then for 22 ± 2 hours in a water bath at 44.5 ± 0.2 °C. All red or magenta colonies are counted as *E. coli.*

Typical and atypical *E. coli* colonies may be confirmed using a verification procedure.

3.0 Definitions

3.1 *E. coli* are those bacteria which produce red or magenta colonies on modified mTEC agar.

4.0 Health and Safety Warnings

4.1 Personnel engaged in laboratory analyses at Eurofins QC, Inc. (EQC) must be familiar with and adhere to the policies set forth in the current version of the EQCL Safety Procedure Manual.

5.0 Cautions

5.1 Start microbiological examination of a water sample promptly after collection to avoid unpredictable changes. Hold temperature of all samples at 0 to <10 °C (do not allow to freeze) during transit to the laboratory and prior to testing. The maximum hold time from time of collection to incubation start time must not exceed 8 hours, with the exception of drinking waters for LT2 (The Long Term 2 Enhanced Surface Water Treatment Rule) projects, which have a maximum hold time of 30 hours. Any deviations in transport or analyzing holding times, missing sampling information, sample volume, or test preformed must be communicated to the client representative and notes made in the sample login and history log.

6.0 Interferences

6.1 Water samples containing colloidal or suspended particulate material can clog the membrane filter and prevent filtration, or cause spreading of bacterial colonies that could interfere with enumeration and identification of target colonies.

7.0 Personnel Qualifications

7.1 Before performing this test independent of secondary supervision and review, each analyst must have an approved Demonstration of Capability Certification Statement (DOC) form (see SOP QC0499) on file in the Quality Assurance office.

8.0 Equipment, Apparatus and Materials

8.1 Erlenmeyer flask for mixing media, clean borosilicate

8.2 Forceps with smooth tips.

8.3 Incubator capable of maintaining a temperature of 35 ± 0.5 °C.

8.4 Petri dishes 60 x 15 mm, plastic, presterilized.

8.5 Stereoscopic microscope with fluorescent light source.

8.6 Filtration funnel units: filter funnels 47-mm magnetic (Gelman or equivalent), graduated at 50 and 100 mL, in assembly with base, sterile, re-usable.

Note: As an alternative, disposable, sterile filtration funnel units can be used (Fisher, Catalog # 09-740-30D or equivalent).

8.7 Membrane filters, 47 mm/0.45 micron, sterile (Millipore or equivalent).

8.8 Water-proof plastic bags.

8.9 Water bath capable of maintaining a temperature of 44.5 ± 0.2 °C.

8.10 Vacuum manifold and pump or laboratory house vacuum system.

8.11 Modified mTEC Agar (Difco or equivalent). Used for the detection and enumeration of *E. coli* in water by the MF method.

8.11.1 Suspend 45.6 g of the powder in 1 L of purified water. Mix thoroughly. Heat with frequent agitation and boil for 1 minute to completely dissolve the powder. Autoclave at 121 °C for 15 minutes.

8.11.2 Cool to 45 - 50 °C in a waterbath and aseptically add sterile 1N NaOH to achieve the pH of 7.3 ± 0.2.

8.11.3 Dispense agar in 4 to 6-mL quantities into 60 x 15 mm disposable petri dishes and allow to solidify.

8.11.4 Label each batch with the date prepared, batch ID, date of expiration, lot number, storage temp, method number and media name. Test for sterility and growth promotion properties as directed in SOP QC0448. Store all prepared plates at 2 - 8 °C for up to 2 weeks. The amount of media prepared can be adjusted accordingly to the work load. The positive control for modified mTEC is *E. coli*, negative control is *E. aerogenes*. Media lot comparisons are required for this method. Notify Water Microbiology Manager when a new manufacturer's lot is being used. Record all media preparation data in the Water Microbiology electronic media logbook as directed in SOP QC0448.

8.12 Tryptic soy agar (TSA) (BD BBL or equivalent). This medium is used for the cultivation and identification of bacteria.

8.12.1 Suspend 45.7 g of the powder into 1 L of purified water. Mix thoroughly. Heat with frequent agitation and boil for 1 minute to completely dissolve the powder. Autoclave at 121 °C for 15 minutes. Final pH must be 7.3 ± 0.2.

8.12.2 Dispense 15 to 20 mL into 15x100 mm, sterile petri dishes and allow to solidify. Prepared media will be light amber in color. The amount of media prepared can be adjusted accordingly to the work load. Label each batch with the date prepared, batch ID, date of expiration, lot number, storage temp, method number and media name. Test for sterility and growth promotion properties as directed in SOP QC0448. The positive control for TSA is *E. coli*; a negative control is not needed. Store all prepared plates at 2 - 8 °C for up to 2 weeks. Record all media preparation data in the Water Microbiology electronic media book as directed in SOP QC0448.

8.13 Trypticase soy broth (TSB) (BD BBL or equivalent). This medium is used as a general purpose media for cultivation of microorganisms.

8.13.1 Dissolve 30 g of the powder in 1 L of purified water. Mix thoroughly. Warm gently until solution is complete. Dispense 10-mL portions into suitable screw-cap tubes. Autoclave prepared media at 121 °C for 15 minutes. Final

pH must be 7.3 ± 0.2. Prepared media will be clear, yellow to amber in color and free from precipitates. The amount of media prepared can be adjusted accordingly to the work load.

8.13.2 Label each batch with the date prepared, batch ID, date of expiration, lot number, storage temp, method number and media name. Test for sterility and growth promotion properties as directed in SOP QC0448. The positive control for TSB is *E. coli*. No negative control is needed. Store all prepared tubes at 2 - 8 °C for up to 3 months. Record all media preparation data in the Water Microbiology electronic media logbook as directed in SOP QC0448.

8.14 Nutrient Agar (Remel or equivalent). Used for the cultivation and enumeration of microorganisms in water.

8.14.1 Suspend 23 g of the medium into 1 L of purified water. Heat to boiling with agitation to completely dissolve the powder. Autoclave prepared media at 121 °C for 15 minutes. Final pH must be 6.8 ± 0.2.

8.14.2 After sterilization, place 12-15 mL into 15 x 100 mm-sterile petri dishes and allow to solidify. Prepared media will be light amber in color and slightly opalescent. The amount of media prepared can be adjusted accordingly to the work load. Label each batch with the date prepared, batch ID, date of expiration, lot number, storage temp, method number and media name. Test for sterility and growth promotion properties as directed in SOP QC0448. The positive control for Nutrient Agar is *E. coli*; a negative control is not needed. Store all prepared plates at 2 - 8 °C for up to 2 weeks. Record all media preparation data in the Water Microbiology electronic media logbook as directed in SOP QC0448.

8.15 Lauryl Tryptose Broth (LTB) (Difco or equivalent). Used for detecting coliform bacteria in water and wastewater.

8.15.1 Suspend 35.6 g of the powder in 1 L of purified water. Mix thoroughly. Warm slightly to completely dissolve the powder. Prepare tubes with inverted 10 by 75 mm culture tubes before dispensing media. Dispense 10-mL portions into autoclavable, borosilicate glass tubes of sufficient size to contain both the culture media and the sample without being three quarters full. Autoclave prepared media at 121 °C for 15 minutes. Final pH must be 6.8 ± 0.2. Prepared media will be yellow to gold in color with some haziness. The amount of media prepared can be adjusted accordingly to the work load.

8.15.2 Label each batch with the date prepared, batch ID, date of expiration, lot number, storage temp, method number and media name. Test for sterility and growth promotion properties as directed in SOP QC0448. The positive control for LTB is *E. coli* and the negative control is *P. aeruginosa*. Store all prepared tubes at 2 - 8 °C for up to 3 months. Record all media preparation data in the Water Microbiology electronic media logbook as directed in SOP QC0448.

8.16 Simmons Citrate Agar (Acumedia or equivalent). Simmons Citrate will differentiate microorganisms based upon their ability to utilization of citrate.

8.16.1 Suspend 24.2 g of the medium in 1 L of purified water. Heat with frequent agitation and boil for one minute to completely dissolve the medium. Dispense agar into suitable screw cap tubes and autoclave at 121 °C for 15 minutes. Final pH must be 6.9 ± 0.2. After sterilization, slant tubes until media is solid. Prepared media will be forest green in color and slightly hazy. The amount of media prepared can be adjusted accordingly to the work load. Test for sterility and growth promotion properties as directed in SOP QC0448. The positive control for Simmons citrate is *E. areogenes* and the negative control is *E. coli*. Store all prepared tubes at 2 - 8 °C for up to 3 months. Record all media preparation data in the Water Microbiology electronic media logbook as directed in SOP QC0448.

8.17 EC Medium (EC Broth) (Acumedia or equivalent). Used in this method for the detection of *E. coli* at 44.5 °C.

8.17.1 Dissolve 37 g of the medium to 1 L of purified water. Mix thoroughly. Place 10 x 75 mm culture tubes (inverted) into autoclavable, borosilicate glass tubes. Dispense 10 mL of EC broth into the autoclavable, borosilicate glass tubes of sufficient size to contain both the culture media and the sample without being three quarters full. Autoclave prepared media at 121 °C for 15 minutes. Final pH must be 6.9 ± 0.2. The amount of media prepared can be adjusted accordingly to the work load. Label each batch with the date prepared, batch ID, date of expiration, lot number, storage temp, method number and media name. Test for sterility and growth promotion properties as directed in SOP QC0448. The positive control for EC broth is *E. coli* and the negative control is *E. aerogenes*. Store prepared media at 2 - 8 °C for two weeks in tubes with "pop" tops and three months for screw tops. Record all media preparation data in the Water Microbiology electronic media logbook as directed in SOP QC0448.

Note: Do not use tubes if the inverted tubes (durham tubes) are not completely filled with medium after sterilization.

8.18 Cytochrome oxidase reagent (Difco or equivalent).

N,N,N',N'-tetramethyl-*p*-phenylenediamine dihydrochloride, 1% aqueous solution (1 g per 100 mL reagent-grade water).

8.19 Kovacs indole reagent (Difco or equivalent).

p-dimethylaminobenzaldehyde (10 g), amyl or isoamyl alcohol (150 mL) and concentrated (12 M) hydrochloric acid.

8.20 Inoculating loops, sterile, plastic.

8.21 Tryptone Water – Bacto Tryptone (BD or equivalent). Tryptone Water is used to detect *E. coli* based on indole production.

8.21.1 Composition:

Bacto Tryptone	10.0 g
Sodium chloride	5.0 g
Reagent-grade water	1.0 L

8.21.2 Add reagents to 1 L of purified water and mix thoroughly to dissolve. Dispense 5 mL portions into autoclavable, borosilicate glass tubes of sufficient size. Autoclave prepared media for 15 minutes at 121 °C. Final pH must be 7.3 ± 0.2. Prepared media will be light to medium amber and slightly opalescent. The amount of media prepared can be adjusted accordingly to the work load. Label each batch with the date prepared, batch ID, date of expiration, lot number, storage temp, method number and media name. Test for sterility and growth promotion properties as directed in SOP QC0448. The positive control for Tryptone Water is *E. coli* and the negative control is *E. aerogenes*. Store prepared media at 2 - 8 °C for up to 3 months. Record all media preparation data in the Water Microbiology electronic media logbook as directed in SOP QC0448.

8.22 Phosphate Buffered Saline (PBS)

8.22.1 Composition:

Sodium dihydrogen phosphate (NaH_2PO_4)	0.58 g
Disodium hydrogen phosphate (Na_2HPO_4)	2.5 g
Sodium Chloride	8.5 g
Reagent-grade water	1.0 L

8.22.2 Dissolve the reagents in 1 L of reagent-grade water and dispense in appropriate amounts for dilutions in screw cap bottles. Autoclave at 121 °C for 15 minutes. Final pH must be 7.4 ± 0.2. Store prepared PBS at room temperature. Record in the Water Microbiology electronic media logbook as directed in SOP QC0448.

8.22.3 Ingredients can be modified to prepare larger or smaller amounts of PBS. The following is an example of how to make 10 L of PBS.

8.22.3.1 Measure out the total amount of reagents needed for 10 L. Pour these ingredients into 3 L of reagent-grade water. Boil the mixture to dissolve the salts. Add the solution to 7 L of reagent-grade water contained in a carboy. Dispense into screw cap bottles and/or into containers. Autoclave at 121 °C for 15 minutes. Final pH must be 7.4 ± 0.2.

Note: Use PBS when performing IPR and OPR sample analyses.

8.23 Phosphate Buffered Dilution water

8.23.1 Prepare as directed in SOP QC0500. The amount of dilution water prepared can be adjusted accordingly to the work load. Record media in the Water Microbiology electronic media logbook as directed in SOP QC0448.

8.24 Sample containers, 125 mL, polypropylene, containing Sodium Thiosulfate tablet for chlorine neutralization.

8.25 Positive control culture *Escherichia coli*, ATCC 11775 or equivalent (BioBalls).

8.26 Negative control culture *Enterococcus faecalis*, ATCC 19433 or equivalent (BioBalls), or *Enterobacter aerogenes* (*E. aerogenes*) ATCC 13048.

8.27 White Filter Paper (Whatman or equivalent).

8.28 60 x 15 mm presterilized, plastic petri dishes.

8.29 Carboy capable of holding 20 L.

8.30 Hotplate.

8.31 Water bath capable of maintaining 50 °C to temper agar.

8.32 A computer capable of real time sample analysis via the WM logbook.

8.33 Autoclave indicator tape.

8.34 Autoclave funnel wrap: aluminum foil or kraft paper.

9.0 Calibration

9.1 Calibrate thermometers used to monitor the temperature of incubators and water baths against a NIST thermometer annually according to SOP QC0339. Calibrate all others (digital, infrared, etc.) quarterly.

9.2 Schedule annual calibration and maintenance of balances through the manufacturer or other qualified, contracted personnel.

9.3 Calibrate pH meters according to manufacturer's recommendations and SOP QC0467.

9.4 Check incubator temperatures twice daily, at least four hours apart to ensure temperature requirements are being met. Record readings in the temperature logbooks.

10.0 Sample Preparation and Analysis

10.1 Collect samples as directed in SOP QC0519 Water and Wastewater Sampling for Microbiological Testing. Store collected samples from the field to the laboratory on ice at a temperature between 0 and 10 °C (do not freeze). When samples are stored at the testing laboratory, prior to analysis, store refrigerated between 0.5 and 5 °C (do not freeze). At no time shall the sample be frozen.

10.2 Initiate analysis as soon as possible after collection to minimize changes in bacterial population. The maximum time allowed between collection and analysis of a water sample is 8 hours, with the exception of waters for LT2 projects, which have a maximum holding time of 30 hours from time of collection to analysis.

10.3 Sample size

10.3.1 The size of the sample will be governed by the expected bacterial density based on the previous historical *E. coli* levels of the source. An ideal sample volume will yield 20 to 80 *E. coli* colonies on a membrane filter surface.

10.3.2 **A minimum of 3 dilutions must be used for any new sample source.**

10.3.3 In instances where the bacterial density is expected to be high, turbidity situations exist, no known history of bacterial density or for legal cases, filter at least three appropriate dilutions from 1 to 100 mL using log interval (e.g. 100, 10, 1, 0.1, etc.) or half log intervals (e.g. 100, 30, 10, 3, 1 mL) prepared in phosphate buffered dilution water through a membrane.

Note: When analyzing smaller sample volume (e.g., <20 mL), add 20-30 mL of phosphate buffered dilution water to the funnel prior to filtration. This will allow even distribution of the sample on the membrane.

10.3.4 If a sample is too turbid to filter, use a different technique for analysis, such as an MPN method.

10.4 Sterile filtration units

10.4.1 Use for filtration series

10.4.1.1 Use sterile filtration units to begin each filtration series. A filtration series is considered to be interrupted when an interval of 30 minutes or longer elapses between sample filtrations. After such interruption, treat any further sample filtration as a new filtration series and replace the filter funnels with new sterile filter funnels.

10.4.1.2 Do not process more than ten (10) filtrations on any funnel. That is, after ten filtrations, including samples, rinse water or sample dilutions, change-out the filter funnel to a second, sterile funnel.

10.4.1.3 During testing in the laboratory, multiple funnels may be used for less than 10 field sample filtrations in order to meet holding times or when, in the judgment of the analyst, a new funnel should be used following a sample with a suspected high level of bacteria. **Always complete any funnel use with a filter blank.**

10.4.2 Use for serial diluted single sample (i.e., river samples, etc.)

10.4.2.1 Use separate sterile filtration unit for each sample to be tested. Start filtration from the highest dilution to lowest. Rinse the interior surface of the funnel 3 times with a 20-30 mL of the sterile dilution water after each filtration. Following the third (final) rinse, remove the filter funnel and replace with a new, sterile disposable funnel.

10.5 Sample Filtration

10.5.1 Using sterile forceps, place a sterile membrane filter (grid side up) over the porous plate of the filtration unit. Pour sample into filtration unit and filter under partial vacuum.

10.5.2 With the membrane still in place, rinse the interior surface of the funnel 3 times with a 20-30 mL portion of sterile dilution water from a squeeze bottle. Thorough rinsing is required to prevent cross-contamination.

10.5.2.1 Where the bacterial density is expected to be high and/or turbidity situations exist additional rinses should be employed.

10.5.2.2 Perform at least one additional rinse to prevent cross-contamination to the following sample in the filtration series.

10.5.3 Upon completion of the final rinse, and the filtration process, disengage vacuum, unlock and remove funnel, and immediately remove the membrane filter with sterile forceps. Place the filter on a modified mTEC agar dish which has been allowed to warm to room temperature with a rolling motion to avoid entrapment of air.

10.5.4 The first two samples filtered on any sterile funnel is a "Sterility Blanks". These serves as the 'Initial Sterility Blank', and is a check on the efficiency of the autoclave sterilization for re-usuable funnels. Refer to Section 11.3.

10.5.5 When more than one sample is processed on an individual funnel, the last sample filtered on a funnel is a "Final Sterility Blank". Refer to Section 11.3.

10.5.6 Analyze a Rinse Water check as a sample, one time, for each new bottle of sterile rinse water bottle opened. Rinse water counts as a sample in the filtration series. Refer to Section 11.3.

10.6 Incubate samples at 35 ± 0.5 °C for 2 ± 0.5 hours to rejuvenate injured or stressed bacteria.

10.7 Transfer samples to waterproof plastic bags, seal, and submerge in a water bath at 44.5 ± 0.2 °C for 22 ± 2 hours. Anchor dishes below water surface to maintain critical temperature requirements.

10.8 Counting *E. coli* colonies

10.8.1 Use a colony counter or a low power stereoscopic microscope with a cool white fluorescent light source directed to provide optimal viewing.

10.8.2 Colonies produced by *E. coli* on modified mTEC are red or magenta in color. Red or magenta colonies are considered "typical" *E. coli*.

10.8.3 For samples with multiple volumes tested refer to Section 12.0 for further instructions.

10.9 *E. coli* Verification Procedure

10.9.1 Using sterile, plastic, inoculating loops, transfer growth from the centers of 10 well-isolated typical (red /magenta) colonies and 10 well-isolated atypical colonies to nutrient agar plates or slants and to trypticase soy broth.

10.9.2 Incubate the nutrient agar plates and trypticase soy broth cultures for 24 ± 2 hours at 35 ± 0.5 °C.

10.9.3 After the incubation outlined in 10.9.2, transfer growth from the nutrient agar and perform a cytochrome oxidase test. This test uses a sterile plastic loop to transfer a loop full of growth to a piece of white filter paper. Holding the cytochrome oxidase dropper, gently crush the ampule one time. After tapping the dropper bottle a few times on the bench top turn the dropper upside down and put a few drops of oxidase reagent onto the bacteria already on the filter paper. A positive reaction will take place within 15 seconds. If the area where the bacteria smear is applied turns deep purple within 15 seconds after applying cytochrome oxidase, the test is positive. Disregard any color change after 15 seconds. No color change is a negative reaction. Since *E. coli* is oxidase negative there should be no color change.

10.9.4 Transfer growth from the trypticase soy broth tube (after incubation in Section 10.9.2) to a Simmons citrate agar slant, tryptone water and an EC broth tube as outlined below.

10.9.4.1 Simmons Citrate: Take a loop full of growth from tryptic soy broth and transfer it to Simmons Citrate. To do this; stab the Citrate

with a loop full of bacteria, pushing the loop to the bottom of the tube. While pulling the loop out of the media streak the loop across the slant of the Citrate in a left to right motion. Incubate the Simmons Citrate agar for 4 days at 35 ± 0.5 °C in an aerobic atmosphere. A positive reaction is indicated by growth with an intense blue color on the slant. Since *E. coli* is citrate negative, there should be little or no growth and no change in agar color (i.e., medium remains dark green).

10.9.4.2 EC broth: From the trypticase soy broth tube, take a loop full of growth and inoculate it into EC medium (with an inverted culture tube). Incubate the EC broth tube at 44.5 ± 0.2 °C in a water bath for 24 ± 2 hours. The water level must be above the level of the EC broth in the tube. A positive *E. coli* test is indicated by turbidity and production of gas in the inverted 10 x 75 mm culture tube. No gas in the inverted culture tube is *E. coli* negative. *E coli* is EC positive for growth and gas.

10.9.4.3 Tryptone Water: From the trypticase soy broth, take a loop full of growth and transfer it to Tryptone water. Incubate the tryptone water (broth) for 18-24 hours at 35 ± 0.5 °C with loosened caps. After incubation gently crush the indole ampule one time. After tapping the dropper bottle a few times on the bench top turn the dropper upside down and put 0.5 mL of Kovacs indole reagent into the typtone water tube. Shake the tube gently. Allow the tube(s) to stand for 5-10 minutes at room temperature. A positive *E. coli* test is indicated by a deep red color, which develops in the alcohol layer on top of the broth. *E coli* is indole positive.

10.9.4.4 *E. coli* are oxidase negative, citrate negative, EC growth and gas positive, and indole positive.

10.9.4.5 Adjust results based upon percentage of *E. coli* colonies confirmed. For example, if only a few suspect colonies are verified to be *E. coli* the reported value needs to be adjusted as follows:

Total # of colonies counted = 60

# of colonies selected for verification = 10

# of colonies confirmed = 5

Adjusted final *E. Coli* result = 60 x 5/10 = 30

Note: Alternately, commercially available multi-test identification systems may be used to verify colonies. Refer to Section 12.0 of EPA 1603, July 2006.

10.9.4.6 Record all information (Typical or Atypical colonies, media batch number, incubation times, etc.) into *E.coli* Verification logbook Form #2084. The laboratory manager or his designee must review the Logbook for accuracy.

10.9.5 Frequency Tracking

The main lab and satellites offices must track the number of samples that contain typical and atypical colonies. Verification tests are performed at the main lab.

10.9.5.1 Following plate counting, use the Sample Tracking file for this method (EPA 1603) and bar-code each sample that has either typical or atypical colonies into the file for tracking frequency.

10.9.5.2 For satellites offices, take a picture of the plate. Send the plate and photo to the main lab for verification. Notify the main lab staff when plates are being sent.

Note: The main lab will use the picture as a reference for confirmation of original count of typical and atypical colonies.

10.9.5.3 After receiving plates from a Satellite office, initiate the verification the same day or at a minimum by the following day to ensure the quality of data.

10.9.5.4 Verification must be performed each month based on the following frequency: Verify a minimum of 10 typical (positive) and 10 atypical (negative) *E. coli* colonies or 1 typical and 1 atypical *E. coli* colony from 10% of all plates showing growth, whichever is more frequent.

10.9.5.5 When routine samples do not provide at least 10 typical and at least 10 atypical colonies, a source known to satisfy this requirement must be analyzed and verified. Such sources can include samples from local pounds or streams.

10.9.5.5.1 Collect a sample from local pound or stream and analyzed as a regular sample.

11.0 Quality Control

11.1 Test all microbiological media after preparation as directed in SOP QC0448.

11.2 Check each lot # of membrane filters for sterility by placing a membrane on a tryptic soy agar plate for 24 ± 2 hours at 35 ± 0.5 °C. Absence of growth indicates sterility of the filter. Reject any lot that is found to be non-sterile. Record results in the Water Microbiology quality control book.

11.3 Perform the following checks when using autoclavable (multi-use) funnels.

11.3.1 Analyze an initial sterility blank on TSA, as the first sample for each sterile funnel used as follows:

11.3.1.1 Rinse each funnel with 20-30 mL of phosphate-buffered dilution water as is done during the rinse step for a sample. Do not use additional rinses. Place the filters on TSA plates and incubate for 24 ± 2 hours at 35 ± 0.5 °C. Absence of growth indicates sterility of the phosphate-buffered dilution water and the filtration assembly. Record results in the Water Microbiology Logbook in LIMS.

11.3.2 Analyze an initial sterility blank on modified mTEC, as the second sample for each sterile funnel used as follows:

11.3.2.1 Rinse each funnel with 20-30 mL of phosphate-buffered dilution water as is done during the rinse step for a sample. Do not use additional rinses. Place the filter on a modified mTEC plate and complete the analysis of the sterility blank as a regular sample. Absence of growth indicates sterility of the phosphate-buffered dilution water and the filtration assembly for *E.coli*. Record results in the Water Microbiology Logbook in LIMS.

11.3.3 Analyze a final sterility blank following all samples analyzed with any funnel, WHEN more than one sample is analyzed on a funnel. If only one sample is processed per funnel, a final sterility blank is not required.

11.3.4 Analyze a Rinse Water check as a sample, one time, for each new bottle of sterile rinse water bottle opened. Pour 50 mL of sterile water into filtration unit and filter. Rinsing the interior surface of the funnel 3 times is not required. Complete the analysis of the sterility blank as a regular sample.

11.3.5 For each autoclavable funnel, up to a maximum of ten (10) filtrations may be performed before being replaced with an un-used sterile funnel. A filtration includes any: sample, sample dilution or rinse water check.

11.4 Disposable sterile funnels

11.4.1 When using disposable sterile funnels, an initial sterility check or final sterility blank is not required.

11.4.2 Disposable sterile funnels are lot checked for sterility when received at the laboratory.

11.5 Duplicate analyses. Perform duplicate analyses at a minimum of a 5% (1 out of every 20 samples) frequency or 1 per week, whichever is more frequent. Refer to SOP QC0952 for further information.

11.6 Check each batch of PBS and phosphate-buffered rinse water for sterility by adding 50 mL of PBS or rinse water to 50-mL double strength trypticase soy broth, incubating at 35 ± 0.5 °C for 24 hours and checking for growth. Record results in the Water Microbiology quality control logbook in LIMS.

11.7 On a monthly basis, verify a minimum of 10 typical and 10 atypical *E. coli* colonies (can be from a single membrane) or 1 typical and 1 atypical colony from 10% of all samples with growth, whichever is more frequent. Record results in the Water Microbiology Verification Book.

11.8 Initial precision and recovery (IPR)

The IPR analysis is used to demonstrate acceptable method performance (recovery and precision) by each laboratory before the method is used for monitoring field samples. IPR samples should be accompanied by an acceptable method blank (sterile Phosphate-buffered saline (PBS)) and appropriate media sterility checks. The IPR procedure is as follows:

11.8.1 Prepare four, 100-mL samples of **PBS** (Phosphate Buffered Saline, Section 8.22 above) and spike each sample with *E. coli* ATCC 11775 by aseptically adding 1 BioBall or known density of the laboratory prepared culture spike to each container and mixing by vigorously shaking the sample bottle a minimum of 25 times.

11.8.2 Filter and process each IPR sample according to the procedure outlined in Section 10.0 and calculate the number of *E. coli* per 100 mL according to Section 12.0.

11.8.3 Calculate the percent recovery (R) for each IPR sample using the following equation:

$$R = 100 \times \frac{(Ns - Nu)}{(T)}$$

R = percent recovery

Ns = *E. coli* (CFU/100 mL) in the spiked sample

Nu = *E. coli* (CFU/100 mL) in the unspiked sample (minimum value is 1 even if no colonies are found)

T = true spiked *E. coli* (CFU/100 mL) manufacturer's lot or lab culture spike mean

11.8.4 Using the percent recoveries of the four analyses, calculate the mean percent recovery and the relative standard deviation (RSD) of the recoveries. The RSD is the standard deviation divided by the mean, multiplied by 100.

11.8.5 Compare the mean recovery and the RSD with the corresponding IPR criteria below:

Recovery (mean percent): detect - 144%
Precision (as maximum RSD): 61%

If the mean and the RSD for recovery of *E. coli* meet acceptance criteria, system performance is acceptable and analysis of field samples may begin. If the mean or the RSD falls outside of the required range for recovery, system performance is unacceptable. In this event, identify the problem by evaluating each step of the analytical process, media, reagents, and controls, correct the problem and repeat the IPR analysis.

11.9 Ongoing Precision and Recovery (OPR)

To demonstrate ongoing control of the analytical system, the laboratory shall routinely process and analyze spiked PBS samples. The laboratory shall analyze one OPR sample after every 20 field and matrix spike samples or one per week that samples are analyzed, whichever occurs more frequently. OPR samples shall be accompanied by an acceptable method blank (sterile Phosphate-buffered saline) and appropriate media sterility checks. The OPR procedure is as follows:

11.9.1 Spike a 100-mL sample of **PBS** (Phosphate Buffered Saline, Section 8.22 above) with *E. coli* ATCC 11775 by aseptically adding 1 BioBall to the container and mixing by vigorously shaking the sample bottle a minimum of 25 times.

11.9.2 Filter and process each OPR sample according to the procedure outlined in Section 10.0 and calculate the number of *E. coli* per 100 mL according to Section 12.0.

11.9.3 Calculate the percent recovery (R) for each OPR sample using the equation in Section 11.8.3.

11.9.4 Compare the OPR results (percent recovery) with the corresponding recovery criteria below:

OPR (as percent recovery) detected - 144%

If the OPR result for recovery of *E. coli* meets acceptance criteria, method performance is acceptable and analysis of field samples may continue. If the OPR result falls outside of the acceptance criteria for recovery, system performance is unacceptable. In this event, identify the problem by evaluating each step of the analytical process, media, reagents, and controls, correct the problem and repeat the OPR analysis.

11.10 Matrix spikes (MS)

MS analysis are performed to determine the effect of a particular matrix on *E. coli* recoveries. The laboratory must analyze one MS sample when disinfected wastewater samples are first received from a new source. Subsequently, 1 per 20 samples received from a disinfected wastewater must include a MS sample. MS samples must be accompanied by the analysis of an unspiked field sample (duplicate) subsequently collected from the same sampling site. Additionally, an OPR sample must be run along side the field samples. MS samples are performed as follows:

11.10.1 Prepare two 100-mL field samples that were subsequently collected from the same site. One sample will remain unspiked and the other will serve as the spiked sample. If 100 mL volume is not available, use two 10-mL volumes from a single field bottle sample.

11.10.2 Select sample sizes that will yield an *E. coli* value of 20-80 colonies on a membrane.

11.10.3 Spike the MS sample with an *E. coli* BioBall (Section 8.26).

11.10.4 Filter the spiked field sample and the unspiked field sample as directed in Section 10.5.

11.11 Laboratories with two or more analysts must compare each analyst's colony counts from one positive field sample per month. Colony counts must agree within 10% between analysts. Facilities with a single analyst must have that analyst perform duplicate colony counts of a single membrane filter each month. Duplicate colony counts must be within 5% for a single analyst. If no positive field samples are available an OPR sample may be substituted for these determinations.

11.12 For additional details of OPR, MS, Duplicate and quality control samples analyses refer to SOP QC0952.

11.13 Immediately bring to the attention of the Director of Microbiology or his designee any deviations in expected quality control testing results and refer to SOP QC0516 Deviations in Expected Quality Control Data to institute corrective action procedures.

11.14 As part of the laboratory QA program, method recovery results for OPR and IPR samples should be charted and updated records maintained in order to monitor ongoing method performance. Refer to SOP QC0952 for further information.

11.15 A Demonstration of Capability (DOC) must be completed initially, and each time there is a significant change in instrument type, personnel, or test method. Demonstration must be documented using the form "Demonstration of Capability Certification Statement" as described in SOP QC0499.

11.15.1 DOC may be established with the use of IPR and OPR Study. Document the successful completion of the Initial Demonstration of Capability for each analyst using the "Demonstration of Capability Certification Statement".

11.15.2 Submit all raw data, a spreadsheet summarizing the recoveries and standard deviations, and a completed "Initial Demonstration of Capability Certification Statement" to the QA Director for review, via LIMS immediately upon completion.

11.15.3 Following review and approval by the QA Director, the original Certification Statement and spreadsheet will be maintained in the analyst training files, which are kept in the QA office.

11.16 Corrective actions are taken when nonconforming work or departures from policies and procedures in the management system or technical operations have been identified. Preventive action is a proactive process to identify opportunities for improvement rather than a reaction to the identification of problems or complaints.

- Analytical work may be stopped if necessary during the investigation, and analyses may resume after it is verified that the corrective actions taken have been effective.
- Corrective actions may include, but not limited to instrument repair or maintenance, recalibration of the instrument, resampling, reanalysis of samples, etc.

11.17 Preventive actions may include, but not limited to preventive maintenance, retraining of analysts, change in procedures etc.

12.0 Calculations and Record Keeping

12.1 Compute the count, using membrane filters with 20 to 80 *E. coli* colonies or those closest to that as described below, by the following equation:

$$\textit{E. coli}\ \text{colonies/100 mL} = \frac{\textit{E. coli}\ \text{colonies counted}}{\text{mL sample filtered}} \times 100$$

12.2 If all MF counts for a given sample are **below the lower acceptable limit** of 20, select the most nearly acceptable count and use the equation in 12.1 to obtain *E. coli* density.

12.2.1 For example, sample volumes of 100, 10 and 1 mL produced colony counts of 17, 1 and 0, respectively.

12.2.1.1 Calculate on the basis of the most nearly acceptable plate count, 17, and report as 17 colonies/100 mL.

In this case, because no calculations were done (i.e. this is the count for 100 mL), the count is reported as 17 CFU/100 mL rather than an "estimated count of 17 CFU/100 mL".

12.2.2 As a second example, sample volumes of 10 and 1 mL produced colony counts of 18 and 0, respectively.

12.2.2.1 Calculate on the basis of the most nearly acceptable plate count, 18, and calculate as in Section 12.1 above.

$$\frac{18}{10} X100 = 180 \text{ colonies /100 mL}$$

Report this as estimated count 180 CFU/100 mL. Use the "E" qualifier code.

12.3 If the total number of *E. coli* colonies are not distinct enough for accurate counting or too numerous to count (TNTC), record the results as > 80 and report the actual result by using the equation in 12.1.

12.4 If all membrane counts are **above the upper acceptable limit of 80 but countable**, calculate the count using the smallest volume filtered.

12.4.1 For example, sample volumes 1, 0.1, and 0.01 mL, produced colony counts of TNTC, 150, and 110 colonies, respectively, use the colony count from the smallest sample volume filtered.

$$\frac{110}{0.01} X100 = 1{,}100{,}000 \text{ colonies /100 mL}$$

Report this as estimated count 1,100,000 CFU/100 mL. Use the "E" qualifier code.

12.5 If there are counts in the **acceptable range on replicate plates**, carry the counts independently to final reporting units, then calculate the arithmetic mean of those counts to obtain the final reporting value.

12.5.1 Example, if the counts are 24 and 36 for **replicate plates** of 100 mL each, then the arithmetic mean is calculated as follows:

$$\frac{(24\text{col}/100\text{mL} + 36\text{col}/100\text{mL})}{2} = 30 \text{ colonies/100 mL}$$

12.6 If there is **more than one dilution having an acceptable range** of counts, carry the counts independently to final reporting units, then average for final reported value.

12.6.1 For example, sample volumes 100, 10, 1 and 0.1 mL, produced colony counts of TNTC, 75, 30, and 1, respectively, then two volumes, 10 mL and 1 mL, produced colonies in the acceptable counting range.

12.6.2 Independently carry each MF count to a count per 100 mL:

$$\frac{75}{10}X100 = 750 \text{ colonies/100 mL}$$

and

$$\frac{30}{1}X100 = 3000 \text{ colonies/100 mL}$$

12.6.3 Calculate the arithmetic mean as in Section 12.1.

$$\frac{(750\,\text{CFU/100mL} + 3000\,\text{CFU/100mL})}{2} = 1875 \text{ Colonies/100 mL}$$

12.7 If counts from **all membranes are zero**, calculate final result using the largest volume filtered.

12.7.1 For example, sample volumes of 25, 10, and 2 mL, produced colony counts of 0, 0, and 0, respectively. The largest volume filtered was 25 mL, so the calculation would be:

$$\frac{1}{25}X100 = 4 \text{ Colonies/100 mL}$$

Report this as < (less than) 4 colonies/100 mL.

12.8 If colony counts are **both above and below the upper and lower limits**, select the most nearly acceptable count.

12.8.1 For example, sample volumes of 100, 10, and 1 mL, produced colony counts of 84, 8, and 0, respectively. Calculate on the basis of the most nearly acceptable plate count, 84, and report as 84 colonies/100 mL:

84 colonies/100 mL

In this case, because no calculations were done (i.e. this is the count for 100 mL), the count is reported as 84 CFU/100 mL rather than an "estimated count of 84 CFU/100 mL".

12.8.2 As a second example, sample volumes of 100, 10, and 1 mL, produced colony counts of 98, 18, and 0, respectively. Calculate on the basis of the most nearly acceptable plate count, 18, and calculate as in section 12.1 above.

$$\frac{18}{10}X100 = 180 \text{ Colonies/100 mL}$$

Report this as estimated count 180 CFU/100 mL. Use the "E" qualifier code.

12.9 If there is **no result** because of confluent growth, >200 atypical colonies, lab accident, etc. **report as No Data** and specify the reason.

12.10 Documentation of Laboratory work

12.10.1 Enter and initial the date and time sample was taken, received, run, and completed in designated areas on the EQCL Chain of Custody form.

12.10.2 Document all laboratory data as outlined in SOP QC0343 Documentation of Laboratory Data.

12.10.3 Immediately bring to the attention of the Director of Microbiology or his designee any deviations in expected quality control testing results and refer to SOP QC0516 Deviations in Expected Quality Control Data to institute corrective action procedures.

12.10.4 Use the Water Micro Electronic Notebook to document all sample, sample duplicate and QC check samples.

12.10.5 Verification documentation is maintained in manual logbooks.

13.0 Method Performance

13.1 Method performance is evaluated by the review of blanks, OPR and MS/MSD. Refer to Section 15.0 of EPA method 1603 for additional information.

14.0 Pollution Prevention/Waste Management

14.1 Keep storage of chemicals in individual departments to a minimum, in order to minimize the potential for large spills and exposure to hazardous substances. Each laboratory manager or designee is required to inspect their department on a semi-annual basis for expired reagents and chemicals. Notify the Safety Director for disposal of expired reagents and chemicals.

14.2 Minimize the amount of waste generated by preparing only the minimum required amount of a reagent.

14.3 Expired hazardous chemicals, reagents, and samples requiring lab packing or other outside disposal/treatment are stored in a designated waste storage facility (such as the chemical shed) until final disposal. This is under the direction and supervision of the Safety Director. Individual analysts may not transfer chemicals or other substances to a waste storage facility without obtaining authorization from the Safety Director. All microbiological waste generated during the performance of this procedure (including used petri dishes) must be disposed of in appropriately labeled biohazardous waste bags and must be autoclaved prior to final disposal. Additional details regarding specific disposal of chemical waste at EQC are given in the EQC Safety Procedure Manual, which is incorporated herein by reference.

15.0 References and Supplemental Documents

15.1 EPA Method 1603 - *E. coli* in Water by Membrane Filtration Using Modified Membrane-Thermotolerant *Escherichia coli* Agar (modified mTEC), Dec. 2009

15.2 EQC Quality Systems Manual, latest.

15.3 EQC Safety Procedure Manual, latest.

15.4 EQC SOP QC0339, "Thermometer Calibration, Maintenance, and Record Keeping", latest.

15.5 EQC SOP QC0343, "Documentation of Laboratory Data", latest.

15.6 EQC SOP QC0448, "Media and Broth Preparation", latest.

15.7 EQC SOP QC0449, 'Reporting of Positive Microbiology Results', latest.

15.8 EQC SOP QC0499, "General Preparation and Evaluation of Demonstrations of Capability", latest.

15.9 EQC SOP QC0500, "Preparation of Phosphate-Buffered Dilution and Rinse Water", latest.

15.10 EQC SOP QC0516, "Corrective Action Procedures for Deviations from Expected Microbiological Quality Control Results", latest.

15.11 EQC SOP QC0519, "Water and Wastewater Sampling for Microbiological Testing", latest.

15.12 EQC SOP QC0952, General Internal Quality Control Requirements for Analytical Methods in the Water Microbiology Laboratory, latest.

16.0 Supersession

16.1 This SOP supersedes the previous versions of SOP QC0665.

16.2 The following changes were made: Section 5.1: "analysis" changed to "incubation start time"; "Validation" logbook replaced by "electronic media" logbook through SOP; Section 10.9.3: "30 seconds" changed to "15 seconds"; Section 11.8.1 and 11.8.3 "laboratory prepared culture spike" added; Section 15 updated company abbreviation

16.3 Section 8.0, 10.1, 10.3.3, 10.3.4, 10.8, 10.9.4.2 updated; Section 10.4 extended; Section 10.9.5 added; Section 11.3 and 11.4 deleted; Reference SOP QC0952 added.

APPENDIX C

Weston Field Sampling Analysis Plan and Standard Operating Procedures

SAMPLING ANALYSIS PLAN

DELAWARE COUNTY REGIONAL WATER QUALITY CONTROL AUTHORITY

CHESTER, DELAWARE COUNTY PENNSYLVANIA

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March 2017

SAMPLING ANALYSIS PLAN
DELAWARE COUNTY REGIONAL WATER QUALITY CONTROL AUTHORITY
CHESTER, DELAWARE COUNTY, PENNSYLVANIA

Approved by: _____ 3/20/2017
WESTON – Project Manager Date
Roger W. Lehman, P.E.

Approved by: _____ _____
Date

Aproved by: _____ _____
Date

Aproved by: _____ _____
Date

Approved by: _____ _____
Date

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1.0 BACKGROUND

Delaware County Regional Water Quality Control Authority (DELCORA) is responsible for the collection, transmission, treatment and disposal of approximately 65 million gallons per day (MGD) of wastewater generated in southeastern Pennsylvania. DELCORA's facilities serve residential, commercial, institutional, and industrial customers in Delaware County. DELCORA owns and operates an extensive system of pump stations, force mains, and sewers that provide the core infrastructure for the transmission of wastewater to treatment facilities in Delaware County and the City of Philadelphia as shown diagrammatically in Figure 1-1 (DELCORA, 2017b). The total service area served by DELCORA, as shown on Figure 1-2 (DELCORA, 2017b), is approximately 82,977 acres which illustrates that DELCORA serves a significant and widespread portion of Delaware County.

The combined sewer area simulated in DELCORA's existing Hydrologic and Hydraulic model is located within the City of Chester and consists of a drainage area of approximately 1,510 acres. It comprises approximately half of Chester City's serviced area. To support the service area, DELCORA owns and operates over 129 miles of separate and combined sewers. Included in the 129 miles of sewers are: 11.7 miles of an interceptor system; 3,209 manholes; and twenty-five (25) combined sewer outfall regulators controlling storm overflows. The location of Chester City's service area is illustrated on Figure 1-2 (DELCORA, 2017b).

Historically, DELCORA has characterized its service areas as "Eastern" and "Western." The Western service area discharges to DELCORA's Western Regional Treatment Plant (WRTP). The Eastern service area discharges to the Philadelphia Water Department's Southwest Water Pollution Control Plant (PWDSWPCP). In 2002, DELCORA completed the installation of a force main that connects the Eastern Service Area's Central Delaware Pump Station (CDPS) to the Chester Force Main. This connection allows DELCORA to send flow from the CDPS to the WRTP. Flows above 20 MGD are directed to the PWDSWPCP. As such, dry weather flows and a portion of the wet weather flows (total flow less than 20 MGD) from the Central Delaware County Authority in the Eastern Service Area are discharged to the WRTP.

There are a total of 26 combined sewer overflow outfalls listed with 25 discharge points (Outfall #009 and #010 both discharge at Outfall #009) in DELCORA's existing National Pollutant

Discharge Elimination System (NPDES) Permit. Under its NPDES Permit No. PA0027103, issued and administered by the Pennsylvania Department of Environmental Protection (PADEP), DELCORA is authorized to discharge from the Western Regional Treatment Plant (Outfall #001), four storm water outfalls at the WRTP (028-031) and from 26 combined sewer overflow outfalls (#002-#026, #032, #033) that ultimately discharge to the Delaware River, Chester Creek and/or Ridley Creek.

2.0 SAMPLING AND ANALYSIS PLAN OVERVIEW

The Sampling and Analysis Plan (SAP) is designed to collect data that will be used to develop and calibrate watershed and receiving water quality models which will be used to assess water quality concerns for the POCs identified in the Identification of Sensitive Areas and Pollutants of Concern Report (DELCORA, 2016a). These POCs are fecal coliform, *E. coli*, and *Enterococcus*. Additional *in situ* parameters, such as salinity, temperature, and conductivity will also be collected to inform the development of the Water Quality Model.

Water quality monitoring will be undertaken at up to thirteen (13) in-stream locations (seven of which are Delaware River sampling locations), four (4) CSO locations in the DELCORA combined sewer system area, and two (2) storm water locations in the City of Chester municipal separate storm sewer system, as shown in Figure 1. Maps of each sample location are also provided in DELCORA, 2017b. Water quality monitoring and sampling will be conducted as follows:

- Eleven (11) in-stream locations in the vicinity of the DELCORA CSO area will be sampled for water quality for (3) dry weather events; one of which will be targeted for collection during a tributary low-flow period (less than 25th percentile flow). The mid-stream and far-shore Delaware River locations will not be sampled during the dry weather surveys because it is expected that water quality in the river will be relatively uniform laterally due to the lack of active sources during dry weather. These dry weather events would preferably be distributed across the sampling season, which is assumed to be March through June of 2017. Grab samples and *in situ* measurements will be collected at each location during each event.
- Thirteen (13) in-stream locations will be sampled for water quality using grab samples and *in situ* monitoring for three (3) discrete wet weather events, according to the surface water quality monitoring program protocols described in this SAP;

- Up to four (4) CSO and two (2) stormwater outfall locations will be sampled for water quality for the same three (3) discrete wet weather events according to the outfall monitoring program protocols described in this SAP. Samples for all outfalls will be collected as grab samples.
- Standard operating procedures (SOPs) referenced in the following sections of this SAP.

The sampling events are planned to be distributed across the sampling season, which is assumed to be March through June 2017. Additionally, bathymetry surveys in the lower portion of the tributaries may be required to inform the development of the Water Quality Model, pending delivery of HEC models with transect information for these portions of the receiving waters.

2.1 SAMPLE LOCATIONS

Monitoring locations have been selected to characterize the watershed at a sub-watershed level, recognizing various political and hydrologic features, land uses and potential pollutant sources. Site selection and analytical parameters are designed to characterize stormwater outfalls, CSOs, tributaries upstream and within the Chester CSO discharge area, and the main stem of the Delaware River in the project area. The sampling locations are shown in Figure 1 and listed in Table 1, Table 2, and Table 3.

The tables include summaries of the rationales for each sampling location selected. The Chester Creek and Ridley Creek locations were selected to distinguish, to the extent possible, between upstream, stormwater and Chester CSO pollutant loads. The Delaware River sampling locations will provide a characterization of water quality entering the Chester CSO area from either tidal direction as well as water quality within the CSO discharge area. During wet weather, three samples will be collected across the transect corresponding to the DR-04 sampling location during each sampling round, when sampling across the river is feasible, to characterize lateral variability in the Delaware River during storm events. Delaware River conditions may be too hazardous for safe collection of one or more samples and/or sampling rounds (e.g. during periods of heavy barge traffic, small craft advisories, lightning, etc.). When these conditions occur, sampling will not be conducted in the river for safety reasons.

The CSO sampling locations were selected based on their outfall discharge location, relatively high frequency of overflow, their overflow volume, and their accessibility. The stormwater

sampling locations were selected to characterize the water quality associated with the predominant land uses (residential and commercial/industrial) in the study area. Each stormwater sampling location is in an area that is representative of the land use elsewhere in the City's stormwater area.

Figure 1: Proposed Receiving Water (RW), Combined Sewer (CSO), and Stormwater (SW) Monitoring Locations

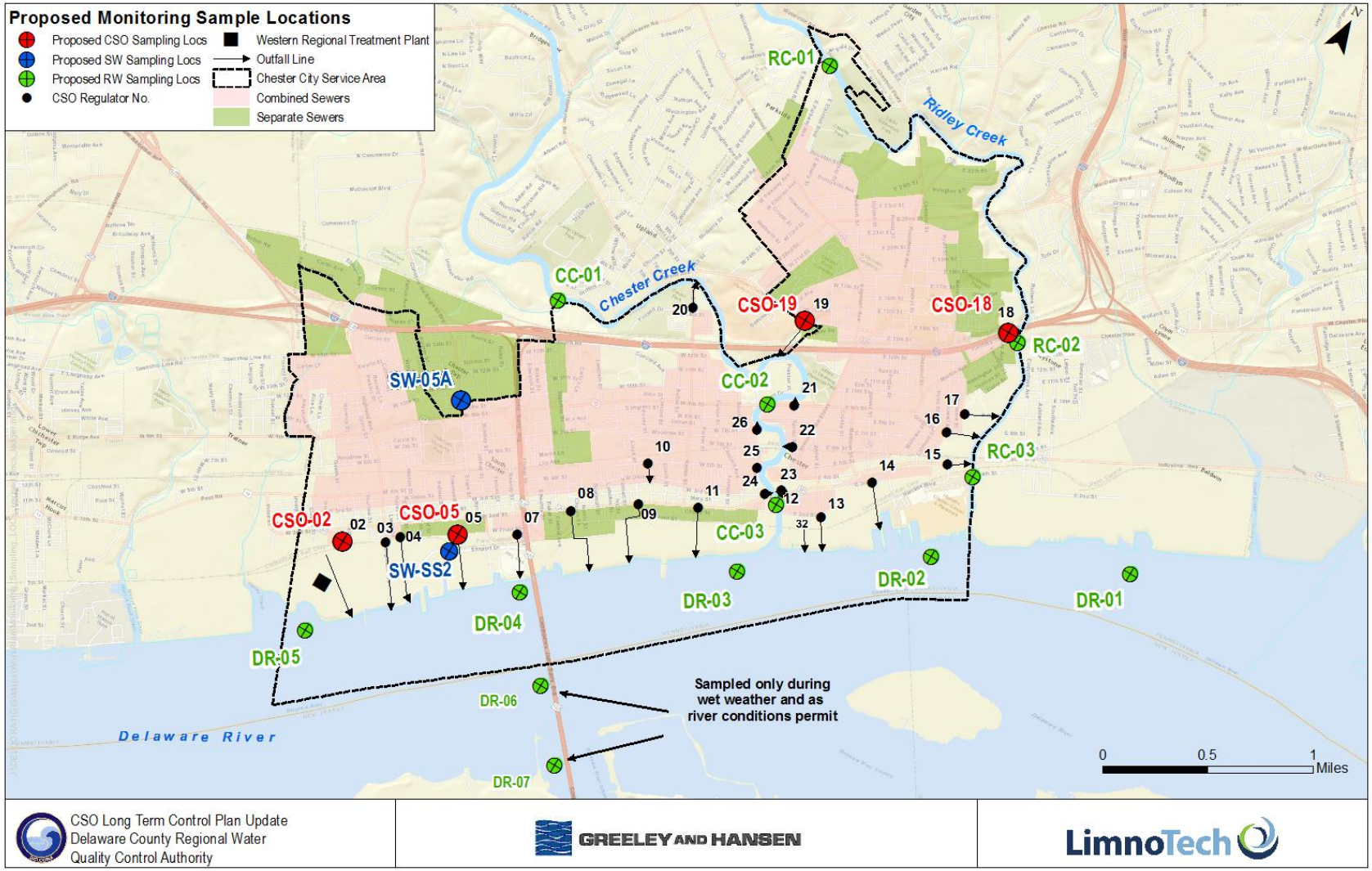

Table 1: Tributary Receiving Water Sampling Locations

Station ID	Sampling Location	Receiving Water	Type	Activity/Notes	Accessibility
CC-01	Upland Rd. / Incinerator Rd. Bridge. **39.850122, -75.386348**	Chester Creek	Tributary	20 ft. from rail to water. Upstream of CSO outfall. Creek is non-tidal.	Upland road access gated from both ends, may need to contact police for access or walk in from gate. Minimal traffic.
CC-02	9th St Bridge (54 W 9th St) **39.850709, -75.365530**	Chester Creek	Tributary	23 ft. from rail to water. Bridge is located next to Chester High School.	Accessible from 9th Street. Can pull vehicle on shoulder or pull into school. Light traffic.
CC-03	Intersection of Edgmont and 2nd street. William Penn's Landing Park (126 E 2nd St) **39.845227, -75.360284**	Chester Creek	Tributary	Site is in William Penn's Landing Park. Sample off of Concrete plaza that overhangs Chester Creek. Tidal influence. Grab samples upstream of bridge.	Can pull vehicle off of 2nd Street and walk into park. Light traffic.
RC-01	Chester Park Drive Bridge (298 East Elkington Blvd) **39.873264, -75.375183**	Ridley Creek	Tributary	19 ft. rail to water. Sample upstream of CSO outfall. Upstream of CSO-33. Creek is non-tidal here.	Can park in lot adjacent to Chester Park Drive Bridge. Minimal traffic.
RC-02	Morton Ave. Bridge (1300 Sun Drive) **39.863016, -75.348686**	Ridley Creek	Tributary	22 ft. rail to water (low tide), with 2 ft. water depth. Site is in same area as CSO-18.	Can park on Sun Drive and use sidewalk when sampling off of bridge. Medium traffic.
RC-03	4th Street (Harrah's) Bridge. Bridge No. 157 (Chester-Eddystone Bridge) (1050 East 4th St Eddystone) **39.853435, -75.346350**	Ridley Creek	Tributary	25 ft. rail to water (low tide) shallow during low tide. Creek is tidal. Lower bottle from bridge using a rope or other means.	Can park on shoulder north of bridge use sidewalk when sampling off of bridge. Medium traffic.

Table 2: Main Stream Receiving Water Sampling Locations

Station ID	Longitude	Latitude	Receiving Water	Type	Description	Rationale
DR-01	39.85282	-75.3299	Delaware River	Main stem	Delaware River between Ridley Creek and Crum Creek	"Upstream" of DELCORA's CSO discharges[1]
DR-02	39.84715	-75.3462	Delaware River	Main stem	Delaware River between CSO-14 and Ridley Creek	Characterize Ridley Creek impacts on Delaware River, in the upper Delaware River (Secondary contact area)
DR-03	39.8398	-75.3606	Delaware River	Main stem	Delaware River between CSO-11 and Chester Creek	Characterize Chester Creek impacts on Delaware River, in the upper Delaware River (Secondary contact area)
DR-04	39.83132	-75.3766	Delaware River	Main stem	Delaware River at the boat launch off Highway 322	Priority area, in the lower Delaware River (Primary contact area)
DR-05	39.82182	-75.3917	Delaware River	Main stem	Delaware River between CSO- 002 and Stoney Creek	"Downstream" of DELCORA's CSO discharges[1], in the Atlantic sturgeon sensitive area
DR-06[2]	39.82636	-75.371	Delaware River	Main stem	Delaware River mid-stream along the transect of DR-04	Characterize lateral variability in the Delaware River during storm events
DR-07[2]	39.82203	-75.3665	Delaware River	Main stem	Delaware River far shore (left descending bank) along the transect of DR-04	Characterize lateral variability in the Delaware River during storm events

Notes:
[1] "Upstream" and "downstream" subject to tidal conditions at time of sampling
[2] These locations will be sampled during the wet weather events only, when river conditions permit. POC concentrations are assumed to be laterally well-mixed during dry weather due to the absence of significant pollutant sources.

Table 3: CSO and Stormwater Sampling Locations

Station ID	Sampling Location	Receiving Water	Type	Activity/Notes	Accessibility
CSO-02	Front and Booth St (100 Booth St) **39.828334, -75.392570**	Delaware River	CSO	SCADA level sensor installed. Concrete dam diverts flow to right side MH flow to WRTP (has an orifice plate). Overflow over the dam will flow to CSO outfall at Delaware River.	Can park at the end of Booth St. prior to rail tracks. Minimal traffic. MH cover is marked with white dot.
CSO-05	Front and Townsend (101 Townsend St) **39.832598, -75.383958**	Delaware River	CSO	SCADA level sensor and Hach flow meter installed. Concrete dam diverts flow to right side MH flow to WRTP. Overflow over the dam will flow to CSO outfall at Delaware River.	Can park at the end of Townsend St. Minimal traffic. MH cover is marked with white dot.
CSO-18	Hancock St. and Sun Dr. (1310 Sun Dr) **39.863501, -75.349203**	Ridley Creek	CSO	SCADA level sensor and Hach flow meter installed. Concrete dam diverts flow to right side MH flow to WRTP. Overflow over the dam will flow to CSO outfall at Ridley Creek.	Can park at the end of Hancock St. Minimal traffic. MH cover is marked with white dot.
CSO-19	14th and Crozer Hospital (1 Medical Center Blvd) **39.857132, -75.366105**	Chester Creek	CSO	SCADA level sensor and Hach flow meter installed. Concrete dam diverts flow to interceptor MH flow to WRTP. Overflow over the dam will flow to CSO outfall at Chester Creek.	Can park in the cul-de-sac off of 14th St. High traffic. MH cover is on lawn area marked with white dot.
SW-SS2	105 Townsend St **39.832853, -75.384193**	Delaware River	SW	Industrial storm water MH. MH is clear and on gravel area near CSO-05.	Can park at the end of Townsend St. Minimal traffic. MH cover is marked “storm” with white dot.
SW-05A	7th and Engle Street (by tennis courts) **39.838501, -75.387708**	Chester Creek	SW	Residential storm water MH. MH is clear and on grass area off of road.	Can park on 7th St. shoulder and access MH on lawn next to traffic light. Medium traffic. MH cover is on lawn area marked with white dot.

2.2 SAMPLING SCHEDULE

2.2.1 DRY WEATHER SAMPLING

Collection of water quality samples will be performed for three (3) dry weather events; with one dry weather sampling event planned to be collected during a low-flow period (less than 25th percentile flow) in Chester Creek and Ridley Creek (if possible). Two rounds of sampling will be conducted for each dry weather survey: one round to be completed during ebb (outgoing) tide and the second round to be completed during flood (incoming) tide.

Dry weather event samples will be taken at up to eleven (11) locations:

- **Three (3) locations on Chester Creek** that will characterize water quality upstream of DELCORA's service area as well as in the portion of the creek adjacent to DELCORA's CSO discharges and the area adjacent to the City of Chester outside the combined sewer service area. Additionally, because DELCORA's CSO discharges are within the tidal extent of the Delaware Bay, the downstream sampling locations will also reflect these tidal influences on water quality.
- **Three (3) locations on Ridley Creek** that will characterize water quality upstream of DELCORA's service area as well as in the portion of the creek adjacent to DELCORA's CSO discharges and the area adjacent to the City of Chester outside the combined sewer service area. Additionally, because DELCORA's CSO discharges are within the tidal extent of the Delaware Bay, the downstream sampling locations will also reflect these tidal influences on water quality.
- **Five (5) locations on the Delaware River** that will characterize water quality in the vicinity of DELCORA's CSO discharges. Sampling locations have been selected to separate to the extent possible the effect of DELCORA's CSOs on water quality from other sources contributing pollutants to the waterways. Sampling will be conducted near the shoreline adjacent to the City of Chester.

The locations of these stations are shown in Figure 1. Details for these stations are provided in Table 1, Table 2, and Table 3. The set of parameters for which the samples will be analyzed is provided in Table 5. In-situ measurements of physical parameters, such as salinity, temperature, and conductivity will be collected at each sampling location with a sonde. In the Delaware River, *in situ* measurements will be made at three depths at each sampling location during each round of sampling.

2.2.2 WET WEATHER SAMPLING

Collection of water quality samples will be performed for three (3) wet weather events. The purpose of the wet weather sampling is to characterize the impact of CSO discharges and non-CSO source runoff on in-stream water quality. The wet weather events will span a range of precipitation, flow and seasonal conditions. Wet weather event samples will be taken at all 13 in-stream locations as well as at up to six source locations in the intervals described below:

- **Six (6) In-Stream Tributary Sampling Locations:** Three (3) locations will be on Chester Creek and three (3) locations on Ridley Creek. The locations will be the same locations used for the dry weather surveys. Tributary locations will be sampled up to five times per event at the following approximate intervals: Hour 0.5-2.5, Hour 4.5-6.5, Hour 8.5-10.5, Hour 14.5-16.5, and Hour 22-24. Sampling intervals will be defined by the start of rainfall rather than CSO or SSO activation. A total of 30 samples will be collected during each wet weather sampling event from in-stream locations. One field blank and one field duplicate will be collected during each event to be used as field quality control (QC).
- **Up to Seven (7) In-Stream Delaware River Locations:** Up to seven locations will be on the Delaware River and will be sampled up to ten times per event at the following approximate intervals: Hour 0, Hour 2, Hour 4, Hour 6, Hour 9, Hour 12, Hour 15, Hour 18, Hour 21, and Hour 24. Sampling intervals will be defined by the start of rainfall rather than CSO or SSO activation. The frequency of sampling is intended to capture in-stream impacts in the vicinity of DELCORA's service area from both DELCORA's CSOs as well as upstream sources. Two additional locations on the Delaware River, one at mid-stream and one near the far shore, have been added to characterize lateral variability in water quality during storm event conditions, when sampling across the river is feasible. The sampling regimen is also designed to allow a semi-quantitative mass balance to be computed over a complete tidal cycle. A total of 70 samples may be collected during each wet weather sampling event. If river conditions are unsafe for sampling (e.g. small craft advisories, heavy barge traffic, etc.), sampling may be suspended for one or more locations and/or sampling rounds. One field blank and one field duplicate will be collected during each event to be used as field QC. Final selection of sampling locations and sampling intervals will be determined prior to the start of the sampling program and will be based on logistic considerations (e.g. can seven locations be sampled and dropped off to a courier within the 3 hour sampling window), safety and accessibility to the Delaware River, and available resources.
- **Up to Six (6) Outfall Locations:** Sampling will be conducted at up to two (2) stormwater outfalls and up to four (4) combined sewer overflow outfalls. The CSO and stormwater sampling locations will be finalized prior to the initiation of the sampling program based on accessibility of sampling, safety of sampling personnel, equipment risk, and available resources. It is assumed that each of the outfall locations will have up to eight sets of samples collected for each event at the following intervals: 1st flush, 30 minutes, and 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, 24 hours. If a location is not flowing, no sample will be collected. As many as 48 samples may be collected during each wet weather sampling event, depending on the number of monitored outfalls and if all monitored

outfalls discharge for 24 hours. However, the actual number of samples is likely to be less than the amount indicated since it is unlikely that all of the monitored outfalls will discharge for the full 24 hour monitoring period. One field blank and one field duplicate will be collected during each event to be used as field QC.

The locations of these stations are shown in Figure 1. Details for these stations are provided in Table 1, Table 2, and Table 3. The set of parameters for which the samples will be analyzed are summarized in Table 5. *In-situ* measurements will not be collected at the outfall locations.

Sampling crews will conduct all wet weather event sampling using the protocols described in the Quality Assurance Project Plan (DELCORA, 2017a). Samples will be delivered to the laboratory where the samples will be analyzed for the laboratory parameters identified in Table 5.

Determination to mobilize for a Wet Weather Event will be a collaborative effort between Greeley and Hansen, LimnoTech, the field sampling contractor and the laboratory contractor personnel. The intent is to identify a 4 to 6 hour window in which a wet weather event may commence 24 hours in advance to assist in mobilization of the sampling crews.

2.3 FIELD SAMPLING METHODS AND PROCEDURES

2.3.1 RECEIVING WATER AND SOURCE SAMPLE COLLECTION METHODS

The physical, microbiological and chemical data that will be collected from the waterbodies are obtained either through direct (*in situ*) measurements or through analysis of a water sample. The microbiological and chemical data collected from the outfall discharges will be obtained through laboratory analysis of the water samples. The general collection procedures for receiving water and outfall sampling are as follows:

1. Clean and decontaminate all sampling equipment prior to and after sample collection according to the procedures in the SOP No. 301.
2. Don appropriate personal protective equipment as required by the Health and Safety Plan (HASP).
3. Collect samples by dipping a container on a pole, into the water. The water is then poured into the clean sample containers pre filled with preservative. The collection container will then be disposed of. Care should be taken to avoid capturing bottom sediment or surface foam/scum during sample collection.
4. Creek water samples collected from bridges higher than 25 ft above the water surface will be collected by bailer, or from a new wide mouth glass jar, connected to new string. The water is then poured into the clean sample containers pre filled with preservative. The

collection container will then be disposed of. Care should be taken to avoid capturing bottom sediment or surface foam/scum during sample collection.

5. CSO samples will be collected using a "clean hands, dirty hands" technique. In accordance with the HASP, atmospheric conditions, such as lower explosive limit, and hydrogen sulfide, will be monitored inside the manhole prior to sample collection, or any other invasive activity. CSO sample collection from CSO-19 (wet weather only), will be screened for radioactivity as there may be the potential for medical treatment waste to be present.
6. Label all sample containers with the date, time, site location, sampling personnel, and other requested information.
7. Record sample collection information on the field logs and then store the samples in a cooler with ice as described in the SOP No. 103.
8. Handle, pack, and ship samples according to the procedures in the SOP No. 103, including the completion of a Chain-of-Custody (COC) form for each cooler shipped to the laboratory for analyses

2.3.2 IN SITU MEASUREMENTS (RECEIVING WATER ONLY)

Instantaneous water quality measurements (such as salinity, temperature, and conductivity) using field instruments will be collected at the receiving water locations as specified in DELCORA, 2017b. These measurements, along with calibration and maintenance, will be conducted following manufacturer's instructions (YSI, 2009)

Field instruments will be calibrated before initiating monitoring activities for each event and a post-monitoring calibration check will be conducted at the end of the event. All calibration and maintenance activities will be documented on the Instrument Calibration Sheet. The field instrument calibration must be conducted in accordance with the manufactures instructions.

Salinity, temperature, and conductivity will be measured at all in-stream sampling locations using a YSI 6920 or similar instrument during both wet and dry sampling events, prior to sample collection. Measurements will be made mid-channel at mid-depth in the tributaries, whenever possible. In the Delaware River, measurements will be made at the surface, mid-depth and near the bottom, whenever possible. Measurements will be documented in the field logs. Documentation will include: date/time, location, type of measurement, personnel, equipment identification, and general site observations (e.g. weather, stream conditions).

2.3.3 SAMPLING EQUIPMENT

The sampling equipment required for the DELCORA monitoring program is included in Table 4.

Table 4: Sampling Equipment list

Sampling Activity	Required Equipment	
General Equipment (Required for all sampling activities)	Field log book with weather-proof paper and pen ("Rite- in-the-Rain") or field data sheets Pens/pencils and Maps Sample bottles and labels Swing sampler/dipper Chain-of-custody Zip lock bag Coolers with ice Amber glass bottles Bailer twine Intrinsically safe headlamps Intrinsically safe flashlight Extra batteries Hydrolab/YSI multi-parameter First Aid Kit and BBP Kit	12" Nitrile gloves Hand spray bottles with Liquinox solution Scrub brush and bucket Distilled water (10 gallons) Sun screen PPE as specified in HASP Phone Emergency Contact List Field Safety Instruction Eye Wash Cell phone Calibration materials and solutions/gases Sonde and instrument (sonde) calibration sheet Sonde instrument manual Sonde service kit Extra batteries for instruments (sondes)
Wet Weather In-Stream Sampling	General Equipment Rain Gear Submersible Marine Radio 16' Jon Boat with motor Tide Charts and Navigation Charts Float Plan Depth Finder Boat Gear (Personal and throwable PFD's, whistle, oars, anchor, line, nav lights, bailer, air horn) Mustang Suits	
Wet Weather CSO & Outfall Sampling	General Equipment Rain Gear RAD meter with pancake probe Multi RAE for LEL and H2S screening	
Dry Weather Sampling	General Equipment	

2.4 SAMPLE IDENTIFICATION

Sample packaging and shipping procedures are designed to ensure that the samples and the chain- of-custody forms will arrive at the laboratory intact and together.

1. All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. The laboratory will pre-label each bottle with all information except for the date and time of sample collection using the method described below. The person collecting the sample will complete the label with date and time. No bottle sets will be distributed without the pre-labeling unless specifically agreed upon among Greeley and Hansen, LimnoTech, the field sampling and laboratory contractors prior to the sampling event.

   Use indelible waterproof marking pen and include:

   - ***Sample identification code (ID)***– will include*:*
     - Site designation number - sampling round number, as follows:

       __ __ - __ __ __ - __ - __
       1 2 3 4 5 6 7

       Where,

       Characters 1-5: Sample Site ID (column 1 in Table 1, Table 2 and Table 3)

       Character 6: Sampling round number

       Character 7: B - Blank sample qualifier (if required)

     - Duplicate samples will be labeled with a sample ID of:

       "DUP __ __ __ - __ __".
       1 2 3 4 5

       Where

       Characters 1-3: Duplicate ID number (numbers will be assigned to each sampling crew)

       Characters 4-6: Designation of RW for receiving water sample duplicate or OF for outfall sample duplicate. A blank line will be placed in the location, date and time boxes of the sample label so the laboratory does not know where the sample was collected. The duplicate number in the duplicate sample ID will be assigned in the field and recorded in the field log book.

     - Blank samples will be given a normal sample ID, with a B qualifier at the end of the ID.

       - *Sample type (water);*
       - *Analysis required;*
       - *Date sampled;*

- *Time sampled;*
- *Name or initials of person who collected the sample;*
- *Mode of collection (composite or grab);*
- *Preservation added, if applicable.*

2. Check the caps on the sample containers so that they are tightly sealed.
3. Cover the label with clear packing tape to secure the label onto the container and prevent the label from being illegible if wet.
4. Store samples in coolers with ice to maintain the samples at ≤4 degrees Celsius until they are received in the laboratory.
5. Complete the information needed on the field log book and the chain-of-custody, primarily sample date and time and any notes regarding deviations from the planned sampling protocol (e.g. limited volume precluded collecting the full volume required).

2.5 SAMPLE MANAGEMENT

Samples will be properly packaged for transport to the laboratory as summarized below.

1. Using packaging tape, secure the outside and inside of the drain plug at the bottom of the cooler that is used for sample transport.
2. Place the sealed container upright in the cooler.
3. Place additional cushioning material around the sides of each sample container as needed.
4. Place ice on top of sample containers. Do not pack ice so tightly that it may prevent the addition of sufficient cushioning material. Ensure that bottle caps will not be submerged in water if ice melts.
5. Fill the remaining space in the cooler with vermiculite or other cushioning material if the coolers are being shipped.
6. Place the chain-of-custody forms in a large Ziploc© type bag and tape the forms to the inside of the cooler lid.
7. Close the cooler lid and fasten with packaging tape. Wrap strapping or packaging tape around both ends of the cooler at least twice, if coolers are being shipped.

All shipments will be accompanied by the chain-of-custody form identifying the contents. It is preferred that a separate chain-of-custody form be completed for and placed in each shipping container/cooler. The original form will accompany the shipment and copies will be retained by the sampler for the project records.

During the dry weather and wet weather sampling events, representatives from the laboratory will be responsible for collecting and delivering the samples to the laboratory quickly enough so that

hold times can be achieved for the bacteria parameters (8 hours from the time of sample collection). The Field Manager will manage the coordination of field crews and couriers during the sampling event.

2.5.1 SAMPLE DOCUMENTATION

2.5.2 FIELD DATA COLLECTION FORMS

The field log book will serve as a daily record of events, observations and measurements during all field activities. All information pertinent to sampling activities will be recorded in the field logs and will include:

- Names of field crew and specifically the author of the field log
- Date and time of the sample round beginning and ending
- Location of sampling activity
- Date and time of collection
- Sample identification numbers
- Field measurements

Field observations and details related to analysis or integrity of samples (e.g., weather conditions, noticeable odors, colors, stream flow description, etc.)

The field log book may also include:

- Sampling method
- Sampling equipment used
- Number and volume of samples collected
- Type of sample
- Summary of any meetings or discussions with the public, state agency, etc.
- Levels of safety protection

Field meters will be calibrated daily in accordance with the manufacturer's recommendations. Standards, solutions used, concentrations and readings taken will be recorded daily in Instrument Calibration Sheet.

2.5.3 SAMPLE CHAIN-OF-CUSTODY FORMS

A chain-of-custody is a legally-binding record of the date and time periods that samples were in the possession (e.g. custody) of the parties indicated. Transfers between parties are documented by the custodial party signing over custody to the receiving party and the receiving party signing

for receipt of the samples. Completed chain-of-custody forms will be required for all samples to be analyzed.

Chain-of-custody forms will be prepared in advance by the laboratory for each sampling location and round of sampling. Chain-of-custody forms will be initiated by the sampling crews in the field during the sampling events and must remain with the samples at all times. The samples and signed chain-of-custody form will remain in the possession of the sampling crew until samples are either delivered to the lab or placed in the custody of the personnel responsible for their delivery to the laboratory.

The chain-of-custody form will contain the sample's unique identification number, sample date and time, sample description, sample type and analyses required. Copies will be made prior to shipment for field documentation. The original chain-of-custody form will accompany the samples to the laboratory.

2.5.4 DATA SUBMITTAL

Instrument Calibration Sheets and copies of the field log book will be turned over to the LimnoTech Water Quality Monitoring Program Task Manager following each monitoring event. Following review by the LimnoTech Water Quality Monitoring Program Task Manager, all field logs, photographs and chain-of-custody forms will be included in the project database.

2.5.5 QUALITY CONTROL

The purpose of any quality assurance/quality control (QA/QC) program is to ensure that all sampling protocols and procedures are followed such that samples are representative of the water quality to which they are associated. The monitoring data that will be collected is intended to meet the quality assurance objectives described in the QAPP. Data quality will be measured in terms of accuracy and precision, completeness, representativeness, comparability, and the required detection limits for the analytical methods. Each of these data quality indicators is defined in the QAPP. QC samples will be collected in the field to support the assessment of data quality. The QA/QC program includes the following elements:

- Training of all field staff;
- Field quality control procedures;

- QA/QC samples; and,
- Equipment calibration.

2.6 DECONTAMINATION AND INVESTIGATION-DERIVED WASTE

If sampling equipment, such as buckets, etc., are to be reused at more than one location in the field, they must be cleaned prior to collecting the next sample. Prior to leaving a site, the equipment will be washed with a mild disinfectant solution (1:25 ratio household bleach to tap water), followed by a detergent solution (Alconox, or equivalent) wash, and must be rinsed at least three (3) times with distilled water. A brush may be used to remove deposits of material or sediment if necessary. At the next sampling site, the equipment must be rinsed at least one time at each location with creek water prior to sampling.

Equipment and instruments used for sample collection or monitoring at CSO locations (wet weather only) will be wiped down using a disinfectant wipe, followed by a distilled water rinse.

Decontamination water generated during the sampling events will be collected in 5 gallon buckets and disposed of at the DELCORA treatment facility at the end of the sampling shift.

3.0 ANALYTICAL PARAMETERS AND METHODS

Samples will be analyzed by Eurofins, in their network of accredited laboratories for fecal coliform, E coli, and enterococcus through laboratory analysis by the following methods, or in accordance with 40CFR136.

- Fecal coliform, Membrane Filters Technique for Members of the Fecal Coliform Group, Standard Methods 9222-D, 2006, 22nd Edition
- E. coli, Membrane Filtration Using Modified Membrane- Thermotolerant Escherichia coli Agar by EPA 1603
- Enterococci, EPA Method 1600, Membrane Filter Technique.

Table 5 summarizes the analytical parameters, the matrices, analyses, analytical methods, containers, preservatives, QA/QC samples, and technical holding times for the samples proposed for collection during the sampling event.

Table 5: Guidelines for Water Sample Container and Preparation and Preservation

Parameter	Sample Container	Sample Volume	Storage Requirement	Preservative	Sample Holding Time	Analytical Method	Detection Limit
Fecal coliform	Plastic- Sterile	250 ml	Place on ice, or refrigerate to ≤6°C	None	8 Hours	Standard Methods 9222-D	10 no./100 ml
E coli	Plastic- Sterile	250 ml	Place on ice, or refrigerate to ≤6°C	None	8 Hours	EPA 1603	10 no./100 ml
Enterococcus	Plastic- Sterile	250 ml	Place on ice, or refrigerate to ≤6°C	None	8 Hours	EPA 1600	10 no./100 ml

4.0 QUALITY ASSURANCE AND QUALITY CONTROL PROCEDURES

This section describes the QA and QC procedures for personnel during the site sampling event, including responsibilities, field QC, laboratory QC, data evaluation, and data management.

4.1 FIELD QUALITY CONTROL

The quality of data generated in a laboratory depends primarily on the integrity of the samples that arrive at the laboratory. Consequently, necessary precautions must be taken to protect samples from contamination and deterioration. Procedures detailed in SOP No. 203 for Collection of Discrete Water Samples and instrument manufacturer's instructions (YSI, 2009) will be followed to ensure field quality control.

Field accuracy will be assessed through the use of field or equipment blanks. In order for the accuracy assessment to be relevant, all appropriate protocols concerning sample collection, handling, preservation, and hold times must be maintained. Equipment that is used to collect samples for analysis may become cross-contaminated through the normal course of monitoring. If not properly cleaned and rinsed, samples may be contaminated during sampling from previous locations.

4.1.1 FIELD BLANKS

Field blanks will consist of a reagent grade blank water transferred into separate sample collection containers, transferred into the sample bottle ware, and submitted to the laboratory for

quality control. The laboratory will provide the sampling crews with the water to be used to prepare the field blanks.

Field blanks will be collected at a frequency of one blank during each sampling event per sampling crew.

4.1.2 FIELD DUPLICATES

Precision is a measure of the agreement between two or more measurements. Duplicate or replicate samples will be taken for a portion of the samples to assess field precision. A field duplicate is defined as a sample produced when a single sample is split into two or more aliquots immediately after the sample is collected. Each aliquot is placed into a separate container and analyzed separately.

Field duplicates will be collected at a frequency at least one field duplicate per sampling crew.

4.1.3 CALIBRATION OF FIELD EQUIPMENT

Instantaneous water quality measurements (such as salinity, temperature, and conductivity) using field instruments will be collected as specified in DELCORA, 2017b. Salinity, temperature, and conductivity will be measured at the specified sampling locations using an YSI 6920 or similar instrument, prior to sample collection. All field instruments will be calibrated at the beginning of the day of sampling and checked again at the end of each day, as required by the QAPP. Field instrument calibration and sample measurement data will be recorded on the Instrument Calibration Sheet and in the field log book, respectively.

4.1.4 DATA REPRESENTATIVENESS AND COMPLETENESS

The intent of this SAP is to obtain a complete data set which is representative of site conditions. Data will be reviewed for completeness. If not all samples were collected, resulting in less than 100% completeness, the reason for the data gaps will be identified in the Trip Report. If any data are rejected, the reason for the data rejection will be discussed in the Trip Report. If sampling activities or procedures vary significantly from this SAP due to unexpected conditions in the field or other unforeseeable factors, WESTON will discuss these deviations from the SAP and whether the changes affect data representativeness in the Trip Report.

5.0 REFERENCES

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ATTACHMENTS

STANDARD OPERATING PROCEDURES

WESTON SOLUTIONS, INC.
STANDARD OPERATING PROCEDURE

SOP 101 LOGBOOK DOCUMENTATION

Revision 2 December 2015

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to provide Weston Solutions, Inc. (WESTON®) members with a step-by-step guide for logbook documentation.

2.0 LOGBOOKS

2.1 Personal Logbooks

All WESTON members are required to document daily office activities in personal logbooks. Information in these logbooks shall be factual and objective and must be kept current at all times. Entries should include daily events, such as specific work order numbers, activities, task numbers, phone calls and meetings. It is important to note that all personal logbooks are property of WESTON® and may be reviewed by management at any time. A copy of Attachment A "Logbook Operating Practices" must be affixed to the inside cover of the personal logbook. Personal logbooks must be obtained through WESTON® Administrative support staff and must include a WESTON® logbook tracking number.

2.2 Site Logbooks

All WESTON members are required to document site activities in site logbooks. Information in these logbooks shall be factual and objective and must be kept current at all times. Entries should include daily events, such as site activities, safety meetings, names of personnel entering/exiting site, sampling data, etc. A copy of Attachment A "Logbook Operating Practices" must be affixed to the inside cover of the site logbook. All site logbooks are the property of client and must remain with the site file. Site logbooks will be maintained by the WESTON® Project Team Leader. Information may be entered into the site logbook by any appropriate team member. Entries will be made in waterproof ink. Site logbooks must be obtained through WESTON® Administrative support staff and must include a WESTON® logbook tracking number.

3.0 SPECIFIC PROTOCOL

Adhere to the following protocol for both personal and site logbooks (see Attachment A for additional information):

1. Logbooks are permanently bound, all pages numbered.
2. Entries begin on page 1.
3. Use only blue or black ink (waterproof).
4. Write Weston Solutions, Inc., as well as the mailing address and phone number on the inside covers of both the site and personal logbooks.

5. Print the site name, volume number, and coverage dates on the site logbook cover and inside cover.
6. Do not write in the margins or between written lines, and do not leave blank pages to fill in later.
7. Fill in all pages in all logbooks.
8. Place a single line through mistakes and initial each one.
9. At the end of any partial page, draw a single diagonal line across the page and initial the line to indicate the end of that pages notes.
10. If a line on the page is not completely filled, draw a horizontal line through the blank portion of the line and initial it.
11. Write late notes/entries as soon as possible and identify this entry as such (use "Late Note:" on a new line to begin a late note and "End Late Note" on a new line to finish a late note).
12. Be objective for all logbook entries
13. Ensure that the logbook clearly shows the sequence of the day's events.
14. If an error is made, draw a single line through the error and initial it.
15. Sign or initial all completed pages (typically in the lower right corner) as they are completed.
16. Sign entries at the end of the day, or before someone else writes in the logbook.
17. Maintain control of the logbook and keep in a secure location.

Personal logbooks will contain (see Attachment A for additional information) the following information:

1. Employee's name, work address, and telephone number.
2. Full names and affiliations for all persons cited in the logbook. Be sure to check the spelling of names and affiliations for accuracy.
3. Sequence of daily events.
4. Task numbers, full dates (i.e. 12 January 2012), and military time (i.e. 0800).
5. Initialed daily entries.

Site logbooks will contain (see Attachment A for additional information) the following information:

1. The name and location of the site.

2. Names of Site Leader and Assistant Site Leaders.
3. Site sketches if appropriate. Draw a box around the sketch to separate the sketch from the text in the logbook.
4. Dates of sample collection or event.
5. Time of sample collection or event.
6. Weather conditions on a daily basis.
7. Field observations.
8. Numbers and types of samples collected and sample identification numbers.
9. Description of sampling methodology by referenced Standard Operating Procedures or FSP.
10. Type(s) of laboratory analyses requested.
11. Phone calls and/or contacts with people at the site on a daily basis.
12. Name of subcontractor and excavation equipment.
13. Any modifications in work activities from approved work plans, FSPs, etc. (i.e., sampling locations, deviations from procedures with reasons, etc.).
14. Visual description of samples and test pits, as required. Includes color, texture, moisture, and other physical soil characteristics.
15. Levels of personal protective equipment worn for tasks performed.
16. Significant changes during the day (i.e., stoppage of work during a lightning storm).

3.1 Audits

Personal and Site logbooks are subject to audit by WESTON® Quality Assurance personnel at any time. Logbook audits will be documented and maintained in the site project file and/or personnel file. Attachment B Logbook Auditing Check sheet or another method of documentation will be used to document all logbook audits.

4.0 REFERENCES

WESTON® (Roy F. Weston, Inc.). 1993. Standard Operating Practices (SP) Manual. SP No. 16-11-016, “Test Pit Excavation and Sampling”. West Chester, PA.

ATTACHMENT A: LOGBOOK OPERATING PRACTICES

Logbook Operating Practices

Procedure

- Logbooks are permanently bound, all pages numbered and entries begin on page 1.
- Use only blue or black ink (waterproof).
- Written Legibly.
- Write Weston Solutions, Inc., as well as the mailing address and phone number on the inside covers of both the site and personal logbooks.
- Print the site name, volume number, and coverage dates on the site logbook cover and inside cover.
- Do not write in the margins or between written lines; do not leave blank pages to fill in later.
- Fill in all pages in all logbooks.
- Include the date on every page.
- At the end of any partial page, draw a single diagonal line across the page and initial the line to indicate the end of that pages notes.
- If a line on the page is not completely filled, draw a horizontal line through the blank portion of the line and initial it.
- Write late notes/entries as soon as possible and identify this entry as such (use "Late Note:" to begin a late note and "End Late Note" to finish a late note).
- Be objective for all logbook entries.
- Ensure that the logbook clearly shows the sequence of the day's events.
- If an error is made, draw a single line through the error and initial it.
- Sign or initial all completed pages (typically in the lower right corner).
- Sign entries at the end of the day, or before someone else writes in the logbook.
- Maintain control of the logbook and keep in a secure location.
- End of Logbook noted on last page ("End of Logbook").

General Information

- Team members listed at beginning of day.
- Other Personnel & Affiliation (e.g. OSC-Smith, OSC-Jones) identified.
- Signatures when change of recorder.
- Team Members' Site Entries and Exits are documented.
- Late Entries Noted Appropriately.

Field Logbooks

- General Information.
- Name, location of site, and work order number.
- Name of the Site Manager or Field Team Leader.
- Names and responsibilities of all field team members using the logbook (or involved with activities for which entries are being made).
- Weather conditions.
- Objective narratives written.
- Field observations.
- Names of any site visitors including entities that they represent.

Sampling (a table in the logbook can be used for sample information)

- Time Collected.
- Grab/Composite.
- Sample Location.
- Type of Analysis.
- CLP Case Number(s)
- Shipping Information.
- Number and types of collected samples.
- Sample identification numbers, including any applicable cross-references to split samples or samples collected by another entity.
- A description of sampling methodology, or reference to any governing document (i.e. Work Plan, QAPP). Any deviations from governing document(s) are identified with reasons for deviations specified.
- Summary of equipment preparation and decontamination procedures.
- Sample description including depth, color, texture, moisture content, and evidence of waste material or staining.
- Air monitoring (field screening) results.
- Types of laboratory analyses requested.

Photo Logs

- Camera and PDA (IDs).
- Date of pictures.
- Time of pictures.
- Directions of photos.
- Description of photos.
- Photographer/Witness.

Safety

- All safety, accident, and/or incident reports.
- Real-time personnel air monitoring results, if applicable.
- Heat/cold stress monitoring data, if applicable.
- Level of protection for tasks.
- Reasons for upgrades or downgrades in personal protective equipment.
- Health and safety inspections, checklists (drilling safety guide), meetings/briefings.
- Equipment make, model, and serial number for monitoring instruments.
- Calibration records for monitoring instruments.
- Site Safety Meeting (time/topics).
- Site Objectives/ Plan of Activities.
- Chemical/Physical Hazards.
- Personnel Attending.

Equipment

- Equipment Type (make, model, a serial numbers).
- Calibration records.
- Background Readings & Locations.
- Monitoring Readings & Locations.
- Sampler(s) initials

Contractor Oversight Activities

- Progress and activities performed by contractors including operating times.
- Deviations of contractor activities with respect to project governing documents (i.e., specifications).
- Contractor sampling results and disposition of contingent soil materials/stockpiles.
- Excavation specifications and locations of contractor confirmation samples.
- General site housekeeping and safety issues by site contractors.
- Equipment and personnel on-site.
- Duration of equipment use vs. standby.
- Inventory of shipments received (or verification of items on packing slip).
- Document inspection of disposal trucks arriving at site (e.g., visual observation of clean tankers or truck trailers, etc.).

Logbook OP_Rev3 December 2015

ATTACHMENT B: SITE LOGBOOK AUDITING CHECKSHEET

Site Name:_____

Work Assignment/TDD No. _____

Site Name:_____ Site Location:_____

Logbook Recorder:_____ Logbook Reviewer:_____

As a part of WESTON's quality assurance program, the following checklist should be used as a guide for items, at a minimum, to include in your logbook. In the future, please make your best effort to thoroughly document all field activities.

LOGBOOK AUDITING CHECKSHEET				
INFORMATION:	***YES***	***NO***	***N/A***	***COMMENTS***
Logbook is permanently bound, all pages numbered and entries begin on page 1.				
Only blue or black ink used.				
Written Legibly.				
"Weston Solutions, Inc." as well as the mailing address and phone number are included on the inside cover.				
The site name, volume number, and coverage dates (if the logbook is completed) are included on the site logbook cover and inside cover.				
No writing in the margins or between written lines.				
No blank pages; all pages are filled in.				
Date is included on every page.				
At the end of any partial page, a single diagonal line is drawn across the page and initialed.				
Where a line on the page is not completely filled, a horizontal line is drawn through the blank portion of the line and initialed.				
Any late notes/entries are identified as such (i.e., "Late Note:" to begin a late note and "End Late Note" to finish a late note).				
Logbook entries are objective.				
The logbook clearly shows the sequence of events.				
If an error was made, a single line was drawn through the error and it was initialed.				
All completed pages are signed or initialed (typically in the lower right corner).				
Signature of author at the end of the day				
Signature of author at change of recorder.				

ATTACHMENT B: SITE LOGBOOK AUDITING CHECKSHEET

LOGBOOK AUDITING CHECKSHEET				
INFORMATION:	***YES***	***NO***	***N/A***	***COMMENTS***
End of Logbook noted on last page ("End of Logbook") for completed logbooks.				
General Information				
Team members are listed at beginning of day.				
Other Personnel & Affiliation (e.g. OSC-Smith, OSC-Jones) are identified.				
Team Members' Site Entries and Exits are documented.				
Name, location of site, and work order number is identified.				
Name of the Site Manager or Field Team Leader is identified.				
Weather conditions are noted.				
Field observations are sufficiently detailed.				
Sampling (a table in the logbook can be used for sample information)				
Sample identification numbers, are noted.				
Time Collected is identified.				
Grab/Composite is identified (or FSP/SAP is referenced).				
Sample Locations are identified (or FSP/SAP is referenced).				
Type of Analysis is identified (or FSP/SAP is referenced).				
CLP Case Number(s) is noted.				
Number and types of collected samples are identified (or FSP/SAP is referenced).				
A description of sampling methodology is included (or FSP/SAP is referenced).				
Any deviations from the FSP/SAP or other governing document(s) are noted, including specified reasons for deviations.				
Summary of equipment preparation and decontamination procedures are noted (or FSP/SAP is referenced).				
Sample description including depth, color, texture, moisture content, and evidence of waste material or staining are noted.				
Air monitoring (field screening) results are included.				
Types of laboratory analyses requested are identified (or FSP/SAP is referenced).				
Logbook is permanently bound, all pages numbered and entries begin on page 1.				

ATTACHMENT B: SITE LOGBOOK AUDITING CHECKSHEET

LOGBOOK AUDITING CHECKSHEET				
INFORMATION:	***YES***	***NO***	***N/A***	***COMMENTS***
Only blue or black ink used.				
Written Legibly.				
"Weston Solutions, Inc." as well as the mailing address and phone number are included on the inside cover.				
The site name, volume number, and coverage dates (if the logbook is completed) on the site logbook cover and inside cover.				
No writing in the margins or between written lines				
No blank pages; all pages are filled in.				
Date is included on every page.				
At the end of any partial page, a single diagonal line is drawn across the page and initialed.				
Where a line on the page is not completely filled, a horizontal line is drawn through the blank portion of the line and initialed.				
Any late notes/entries are identified as such (i.e., "Late Note:" to begin a late note and "End Late Note" to finish a late note).				

_____ _____

Signature of Reviewer Date

WESTON SOLUTIONS, INC.
STANDARD OPERATING PROCEDURE

SOP 103 CHAIN-OF-CUSTODY DOCUMENTATION

August 2011

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to provide Weston Solutions, Inc. (WESTON®) team members with a step-by-step guide for chain-of-custody documentation.

2.0 SCOPE

This SOP describes the minimum requirements for sample chain-of-custody procedures. These procedures permit traceability from the time of sample collection to generation of the analytical data report.

These procedures are intended to document sample possession from the time of sample collection to sample disposal (i.e., sample shipment, sample storage, sample analysis).

3.0 GENERAL PROTOCOL

A chain-of-custody record will be maintained from the time of sample collection until final disposition.

For the case of the chain-of-custody forms and the traffic report chain-of-custody forms, every transfer of custody will be noted and signed. The distribution of the chain-of-custody forms will be done in accordance with the distribution list at the bottom of each form. The chain-of-custody record shall contain, at a minimum, the following information:

- Project identification
- Project identification number
- Sample number
- Sample type and description
- Sample location
- Time and date of sample collection (military time)
- Requested analyses
- Sample information (e.g., no. of bottles, preservatives, etc.)
- Names and signatures of samplers
- Signatures of individuals who have had sample custody
- The name of the carrier and the airbill number, if the sample is shipped

4.0 PROTOCOL FOR SHIPMENTS

All pertinent data must be recorded legibly in black or blue ink. Mistakes can only be corrected by drawing a single line through the mistake and then initialing and dating the correction.

Listed below are the information needed in each section of the chain-of-custody record:

- The PROJ. NO. section of the form will always contain the site Project Control System (PCS) number.
- The PROJECT NAME section of the form will contain the Site name only if the samples are being analyzed by the EPA Region III Laboratory, otherwise it will contain the START Analytical Technical Directive Document (TDD) number or the DAS project number.
- The SAMPLERS (Signature) section should contain the printed name and signature of samplers.
- The TIME section should be in military time.
- The LOCATION section should give a description of the sample location (note: never put resident's names or full addresses in this section).
- The diagonal lines on the top of the form should contain the analyses to be performed for each sample. An X should be placed in the block beneath the analyses to be performed for each sample.
- The airbill number and shipper should be identified in the REMARKS section at the bottom of the form.

Every time the samples are relinquished to a different individual the current sample custodian is required to relinquish the custody to the new individual.

5.0 SAMPLE LABELS AND CUSTODY SEALS

In addition to chain-of-custody forms, sample labels and custody seals are needed to ensure sample custody has been maintained. Sample labels should contain the same information contained on the chain-of-custody record to ensure the proper analyses are being performed on the samples. Custody seals ensure that the samples have not been tampered with during sample shipment. Below is a description of the information needed for the labels and custody seals.

5.1 Sample Labels

The following information will be recorded on the sample labels affixed to each container:

- Project identification number
- Sample number
- Time and date of sample collection
- Sample type (composite/grab)

- Sample location
- Analyses requested
- Preservatives used

5.2 Custody Seals

Custody seals confirm that samples have not been tampered with. The individual who has custody of the samples will sign, date, and affix the seals to the cooler or shipping box which contains the samples so that it cannot be opened without breaking the seal. A wide clear tape will be placed over the seals to ensure that the seals are not accidentally broken during transportation.

6.0 REFERENCES

American Standards for Testing and Materials (ASTM). 1993. Standard Practices for Sampling Chain-of-custody Procedures. Designation D 4840-88 (Reapproved 1993). Philadelphia, PA. May. (Replaced with ASTM D4840 - 99(2010) Standard Guide for Sampling Chain-of-Custody Procedures)

WESTON SOLUTIONS, INC.
STANDARD OPERATING PROCEDURE

SOP 103 CHAIN-OF-CUSTODY DOCUMENTATION

August 2011

ATTACHMENT 1: CHAIN-OF-CUSTODY RECORD

CHAIN OF CUSTODY RECORD

Philadelphia, Pennsylvania 19107

PROJ. NO. | PROJECT NAME

SAMPLERS: *(Signature)*

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS	REMARKS

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

3 16092

WESTON SOLUTIONS, INC
STANDARD OPERATING PROCEDURE

SOP 104 PHOTOGRAPHIC AND VIDEO DOCUMENTATION

Revised November 2015

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to provide Weston Solutions, Inc. (WESTON®) team members with a step-by-step guide for photographic and video documentation. Photographs/videos should be used to document field activities including initial site conditions during assessments and emergencies prior to, during and after removal and remedial actions, during enforcement actions, and at special events and outreach programs.

2.0 PHOTOGRAPHIC AND VIDEO DOCUMENTATION

2.1 Photographs

Unless specifically requested otherwise, WESTON will document all site, sampling and special events using digital photographs.

Date and time should be accurately set for all digital cameras to document the date of the photography. Descriptions of the photograph subject, date, time, site name and location should be documented in the site logbook for all photographs. This information can also be documented in the digital camera or other electronic data collection device; however, written logbook descriptions should be maintained.

2.2 Video

If requested WESTON team members will document site activities using hand-held digital video cameras. Film video will only be taken if specifically requested, and such documentation, as well as High-definition digital video or other specialized video services, may require subcontractor support.

Date and time should be accurately set for all digital video cameras to document the date of the video. Descriptions of the video subject, date, time, site name and location should be documented in the site logbook for all video. This information can also be documented in the digital camera or other electronic data collection device; however, written logbook descriptions should be maintained.

3.0 SPECIFIC PROTOCOL

Adhere to the following protocol for both photographic and video documentation:

- Enter description of filming activities in the site logbook documenting type of camera, time (military time) and date, filming individual, and orientation angle of the viewing angle.

- Print the site name, the project number, and coverage dates on each storage media that has been used.
- Prepare a photographic log and label all photographs with the following information: the project number, site name, site location, date and time, description of photograph, orientation, and photographer.
- Store all storage media (SandDisk [SD] or other memory card, MicroSD, Digital tape, Universal Serial Bus [USB] flash drive, site negatives, original videos or other media) in the official site file.
- Be objective for all photographs/video. Ensure the purpose of the photograph is entered into the site log (e.g., documenting labels for enforcement, or condition of neighboring properties prior to the initiation of a removal action, or documenting an exposure pathway).

4.0 REFERENCES

NEIC Policies and Procedures. EPA-330/9-78-001-R, May 1978 (Revised 1983)

WESTON SOLUTIONS, INC
STANDARD OPERATING PROCEDURE

SOP 104 PHOTOGRAPHIC AND VIDEO DOCUMENTATION

Revised November 2015

ATTACHMENT A: EXAMPLE PHOTOGRAPHIC DOCUMENTATION LOG

PHOTOGRAPHIC DOCUMENTATION LOG

Client:		**Prepared by:**	Weston Solutions, Inc.
Site Name:	Site	**Photographer(s):**	C. Body; D. Person
Location:	Somewhere, PA	**TDD Number:**	WS01-10-07-002
Phase:	Creek Reconstruction	**Date:**	May 30, 2014

Date: 9/9/2011

Time: 09:00

Orientation: SW

Description: Damage assessment of after Tropical Storm Lee.

Date: 9/14/2011

Time: 13:50

Orientation: E

Description: Collection and staging of flood debris for disposal.

WESTON SOLUTIONS, INC.
STANDARD OPERATING PROCEDURE

SOP 203 SURFACE WATER SAMPLING

Revised November 2015

1.0 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative liquid samples from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface.

2.0 METHOD SUMMARY

Sampling situations vary widely and therefore no universal sampling procedure can be recommended.

However, sampling of liquids from the above mentioned sources is generally accomplished through the use of one of the following samplers or sampling techniques:

- Kemmerer bottle
- Van dorn sampler
- bacon bomb sampler
- dip sampler
- direct method

These sampling techniques will allow for the collection of representative samples from the majority of surface waters and impoundments encountered.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Once samples have been collected, follow these procedures:

1. Transfer the sample(s) into suitable labeled sample containers.
2. Preserve the sample if appropriate, or use pre-preserved sample bottles.
3. Cap the container, put it in a resealable plastic bag and place it on ice in a cooler.
4. Record all pertinent data in the site logbook and on a field data sheet.
5. Complete the chain-of-custody form.
6. Attach custody seals to the cooler prior to shipment.
7. Decontaminate all sampling equipment prior to the collection of additional samples.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems with surface water sampling. These include cross-contamination of samples and improper sample collection.

- Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary.

- Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area.

Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems.

5.0 EQUIPMENT/APPARATUS

Equipment needed for collection of surface water samples includes:

- Kemmerer bottles
- Van Dorn sampler
- Bacon bomb sampler
- Dip sampler
- Line and messengers
- Sample bottles and preservatives
- pH paper
- Resealable plastic bags
- Ice for sample preservation
- Coolers
- Ball-point pen, permanent marker, grease pencil, marking spray paint
- Chain of custody forms, EPA custody seals, field data sheets
- Sample bottle labels/tags
- Decontamination equipment (brushes, buckets, garden sprayer, alconox or liquinox, water, etc.)
- Paper towels
- Plastic sheeting
- Map/plot plan/sketches
- Personal protective equipment and monitoring equipment (as specified in the Health and Safety Plan)
- Field data measurement equipment as specified in the FSP (such as YSI)
- Compass
- Tape measure (up to 300 ft)
- Survey stakes, flags, or buoys and anchors
- Global positioning system (GPS) unit with sub-meter accuracy or better
- Digital camera with adequate storage media
- Logbook/waterproof pen and field data sheets
- Plastic garbage bags
- Scissors

- Nitrile or latex sample gloves
- Shipping documents (Federal Express forms/shipping labels/etc.)
- Strapping/packing tape

6.0 REAGENTS

Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed. Decontamination solutions are specified in SOP No. 301, Decontamination Procedures.

7.0 PROCEDURES

7.1 Preparation

- Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.
- Obtain necessary sampling and monitoring equipment.
- Decontaminate or pre-clean equipment, and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey prior to site entry in accordance with the site specific health and safety plan.
- Use stakes, flags, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

7.2 Sampling Considerations

7.2.1 Representative Samples

In order to collect a representative sample, the hydrology and morphometrics (e.g., measurements of volume, depth, etc.) of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths.

Water quality data should be collected in impoundments to determine if stratification is present. Measurements of dissolved oxygen, pH, and temperature can indicate if strata exist that would affect analytical results. Measurements should be collected at one-meter intervals from the substrate to the surface using an appropriate instrument, such as a YSI (or equivalent).

Water quality measurements such as dissolved oxygen, pH, temperature, conductivity, and oxidation-reduction potential can assist in the interpretation of analytical data and the selection of sampling sites and depths anytime surface water samples are collected.

Generally, the deciding factors in the selection of a sampling device for sampling liquids in streams, rivers, lakes, ponds, lagoons, and surface impoundments are:

- Will the sample be collected from the shore or from a boat on the impoundment?
- What is the desired depth at which the sample is to be collected?
- What is the overall depth and flow direction/flow rate of river or stream?

7.2.2 Sampler Composition

The appropriate sampling device must be of a proper composition. Samplers constructed of glass, stainless steel, polyvinyl chloride (PVC) or Polytetrafluoroethylene (PFTE such as Teflon®) should be used based upon the analyses to be performed.

7.3 Sample Collection

Photograph sample locations with landmarks in view. Keep in mind that sample locations may need to be referenced in the future, often years after your sampling event.

7.3.1 Kemmerer Bottle

Kemmerer bottle may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Using a properly decontaminated Kemmerer bottle, set the sampling device so that the sampling end pieces are pulled away from the sampling tube, allowing the substance to be sampled to pass through the tube.
2. Lower the pre-set sampling device to the predetermined depth. Avoid bottom disturbance.
3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.
4. Retrieve the sampler and discharge the first 10 to 20 mL to clear any potential contamination on the valve. Transfer the sample to the appropriate sample container.

7.3.2 Van Dorn Sampler

A Van Dorn sampler is used to collect surface water from a very specific sampling depth or from a shallow water body. Since the sampler is suspended horizontally, the depth interval sampled is the diameter of the sampling tube. The sampling procedure is as follows:

1. Use a properly decontaminated Van Dorn sampler. Set the device so that the end stoppers are pulled away from the body allowing surface water to enter the tube.
2. Lower the pre-set sampling device to the predetermined depth. Avoid disturbance of the bottom.
3. When the Van Dorn is at the required depth, send the weighted messenger down the suspension line, closing the sampling device.
4. Retrieve the sampler and discharge the first 10-20 milliliters (mL) from the drain to clear potential contamination from the valve. This procedure may be repeated if additional sample volume is needed to fulfill analytical requirements. Subsequent grabs may be composited or transferred directly to appropriate sample containers.

7.3.3 Bacon Bomb Sampler

A bacon bomb sampler may be used in similar situations to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

1. Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut.
2. Release the trigger line and retrieve the sampler.
3. Transfer the sample to the appropriate sample container by pulling the trigger.

7.3.4 Dip or Swing Sampler

A dip sampler and/or a swing sampler are useful for situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.
2. Extend the device to the sample location and collect the sample.
3. Retrieve the sampler and transfer the sample to the appropriate sample container.

7.3.5 Direct Method

For streams, rivers, lakes and other surface waters, the direct method may be utilized to collect water samples from the surface. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants are a concern.

Using adequate protective clothing, access the sampling station by appropriate means. For shallow stream stations, collect the sample under the water surface, pointing the sample container upstream. The container must be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and the boat wake.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

8.0 QUALITY ASSURANCE/QUALITY CONTROL

The following general QA/QC procedures apply:

- Field QA/QC samples (e.g., field blanks, equipment rinsate blanks, trip blanks, duplicate samples, MS/MSD, etc.) must be collected in accordance with the FSP and QAPP
- All data must be documented in site logbooks.
- All sample locations should be recorded using a GPS unit.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout must occur prior to sampling/operation and should be documented.

9.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

More specifically, when sampling lagoons or surface impoundments containing known or suspected hazardous substances, take adequate precautions. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause him or her to lose their balance. The person performing the sampling should be on a lifeline and be wearing adequate protective equipment, including a Type II PFD.

Sampling over and around water can be dangerous, be sure to follow all HAS procedures and have an approved HASP. Whenever boats are to be used to collect samples, a Float Plan must be prepared and included as part of the approved HASP. When working around and over cold water, appropriate survival suits are required (such as Mustang suits), as specified in the approved HASP.

10.0 REFERENCE

EPA. 1991. Compendium of Emergency Response Team (ERT) Surface Water and Sediment Sampling Procedures. Office of Solid Waste and Emergency Response, Washington, DC. EPA/540/P-91/005.

WESTON SOLUTIONS, INC.
STANDARD OPERATING PROCEDURE

SOP 203 SURFACE WATER SAMPLING

Revised November 2015

ATTACHMENT 1: FIGURES

Figure 1: Kemmerer Bottle

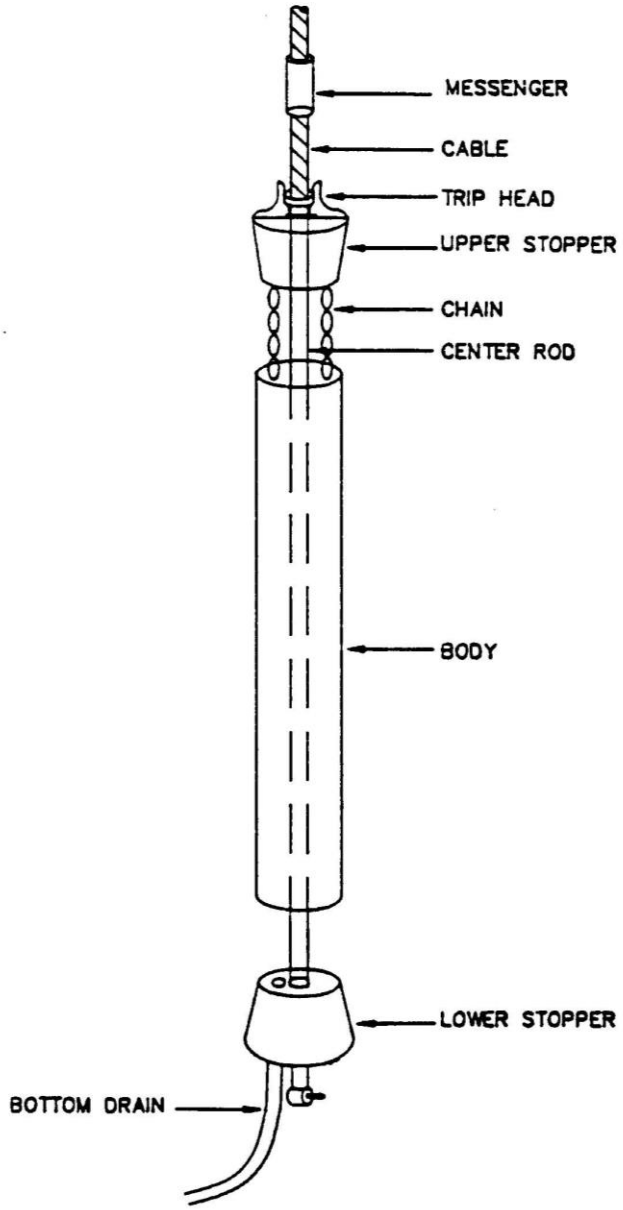


Figure 2: Van Dorn Sampler

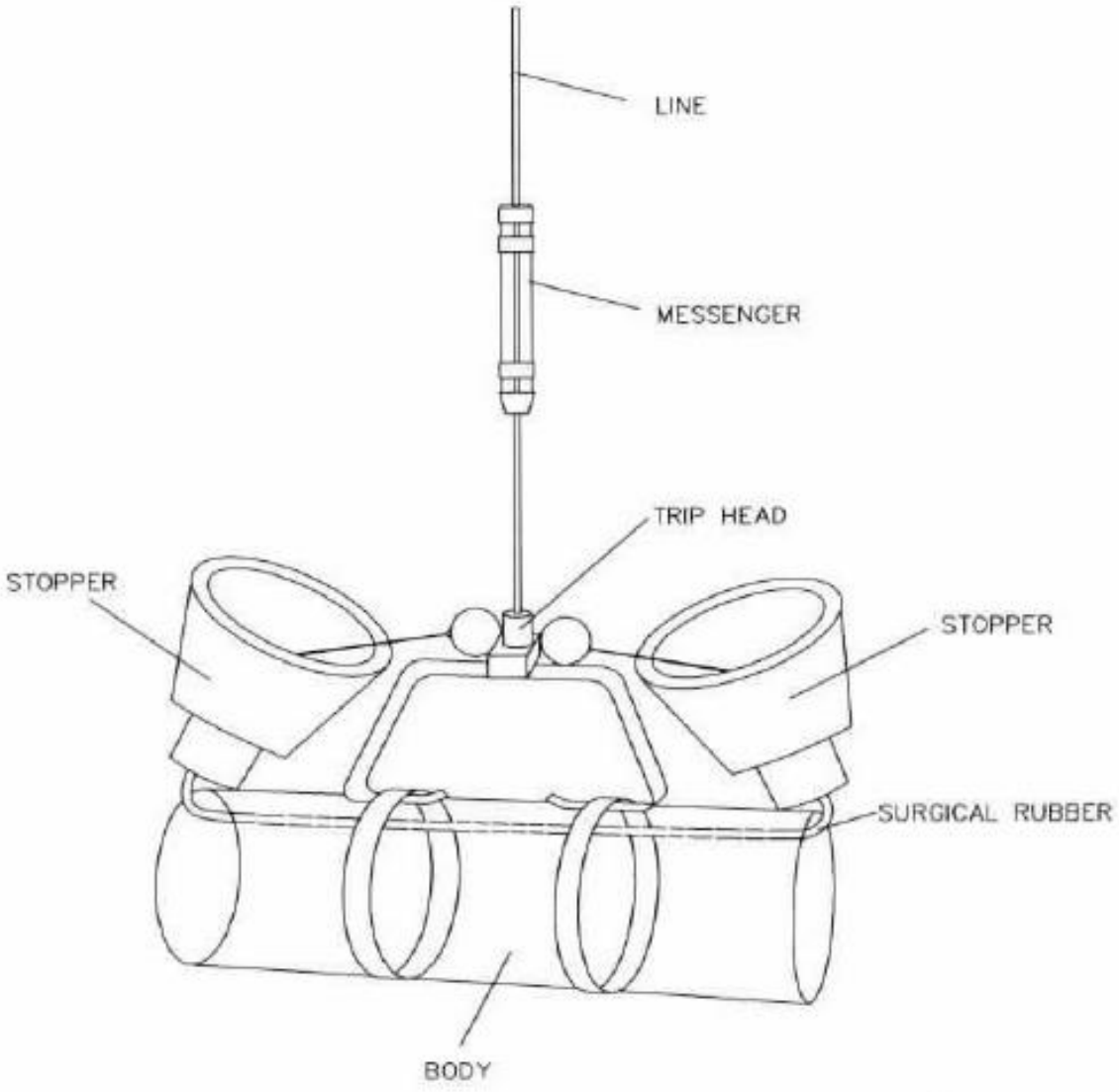


Figure 3: Bacon Bomb Sampler

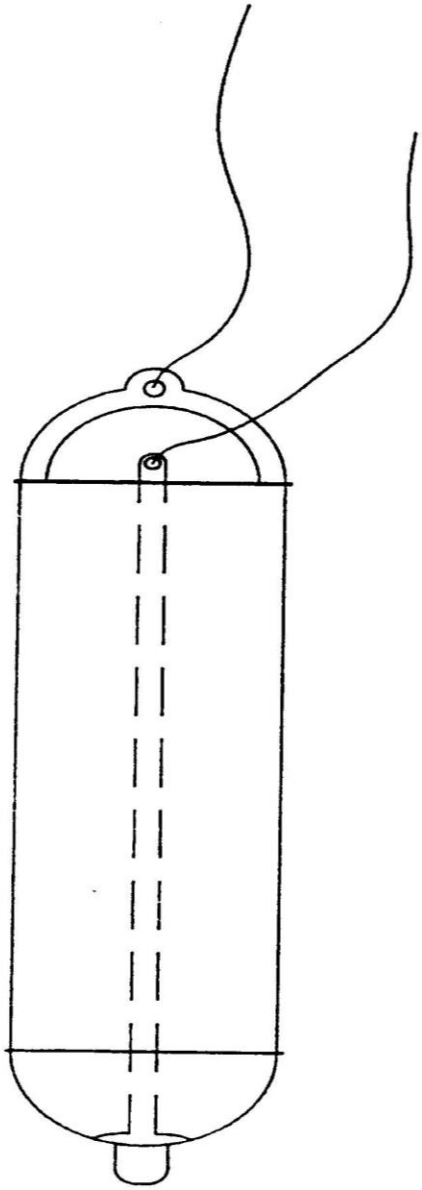
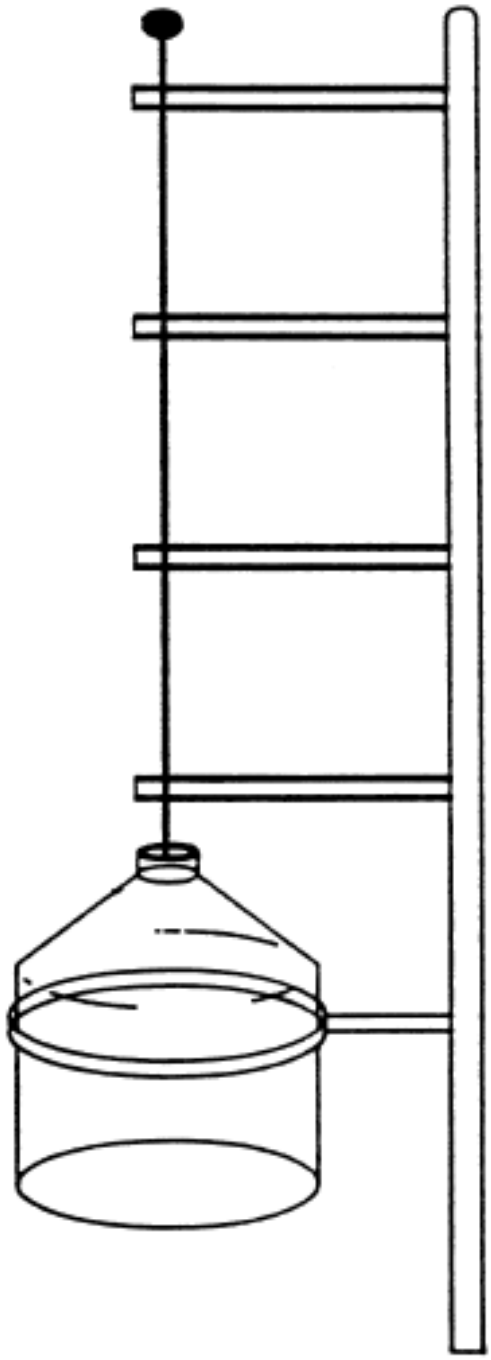


Figure 4: Dip Sampler



WESTON SOLUTIONS, INC.
STANDARD OPERATING PROCEDURE

SOP 301 DECONTAMINATION PROCEDURES

Revised November 2015

1.0 PURPOSE

To provide guidance for the decontamination of equipment used to sample, install sample points (monitor wells, soil borings and test pits), and make field measurements. This operating practice is not intended to be site specific or equipment specific, but to provide guidance in place of non-existent state or federal guidelines or in cases where the site-specific work plan or Field Sampling Plan does not provide additional detail on decontamination procedures.

2.0 DISCUSSION

2.1 Introduction

The objective of decontamination procedures is to provide clean equipment for the retrieval of representative environmental samples. Decontamination procedures differ depending on the nature of the equipment used. The three categories of decontamination procedures are discussed below:

- Intrusive equipment used to install sample points including drilling (tools, augers, rods, etc.) and excavation equipment (backhoes, excavators, etc.).
- Equipment used to measure the characteristics of the media to be sampled including water level, pH, specific conductivity, and temperature probes. This category also includes pumps to purge water.
- Equipment that has contact with the sample to be submitted for laboratory analysis including bailer, split-spoons, hand auger, stainless steel bowls and scoops.

Because items from the first two categories do not contact the sample media that is sent to a laboratory for analysis, the decontamination procedures are less stringent. Dedicated and disposable equipment will be used whenever feasible to limit decontamination and the possibility of cross-contamination. This includes rope, tubing, filterware and, in some cases, soil scoops, pans, and bailers.

3.0 PROCEDURES

3.1 Intrusive Equipment

Drilling tools, including augers, rods, drill bits, hand tools, etc. will be steam cleaned prior to use and after each location. Split spoons will also be steam cleaned if not used for sample collection. Backhoe buckets and arms will also be steam cleaned prior to use and between each sample location.

3.2 Field Measurement Equipment

Water level probes will be cleaned using the following procedures:

- Wipe the probe with a paper towel.
- Alconox®, Liquinox®, or other appropriate cleaning solution and potable water wash.
- Deionized water rinse.

Other measurement equipment should be rinsed with deionized water between readings. Pumps used for well purging shall be decontaminated using the following procedures:

- Alconox®, Liquinox®, or other appropriate cleaning solution and potable water scrub and pump through.
- Potable water rinse and pump through.

Rope and tubing used with the pump will be made of polyethylene and be dedicated (and disposable) to one sample location.

3.3 Sampling Equipment

Equipment used for sample collection include but are not limited to:

- Teflon bailers
- Stainless steel scoops and bowls
- Hand augers
- Split spoons

This equipment will be cleaned using the following procedures:

- Alconox®, Liquinox®, or other appropriate cleaning solution and potable water scrub.
- Thorough potable water rinse.
- Deionized water rinse.
- Specialized decontamination fluid rinse, if necessary for the type of sampling and level of analyses.
- Deionized water rinse, if a specialized decontamination fluid rinse is used.
- Total air dry (only if sample is to be analyzed for organics).

Sampling instruments should be wrapped in aluminum foil after decontamination to keep clean before sampling. Note that this may be eliminated if low level metals analyses are being

conducted and aluminum is a potential contaminant of concern. Also note that aluminum foil should not be used if sampling for Perfluorinated Compounds.

4.0 DOCUMENTATION

Decontamination efforts should be documented in the field logbook. Decontamination fluids should be disposed of properly. Depending on site conditions, it may be appropriate to contain spent decontamination fluids. In that case, the appropriate vessel (i.e., drum) should be used depending on the ultimate disposition of the material. See *SOP 019 Investigative Derived Waste Compliance Plan* for more detailed information on handling and disposal of these wastes.

5.0 INTERPRETATION

If there are questions on the interpretation or applicability of items in this operating practice, the Project Manager, Technical Manager or Quality Manger should be consulted.

6.0 REFERENCES

New Jersey Department of Environmental Protection and energy Field Sampling Procedures Manual, May 1992. {Updated 2011, See NJDEP website. Specific changes listed}

"Standard Practice for Decontamination of Field Equipment Used at Non-radioactive Waste Sites", ASTM Designation D5088-90.

WATER QUALITY SAMPLING SITE VISIT NOTES

Water Quality Sampling Site Visit Notes

March 7, 2017

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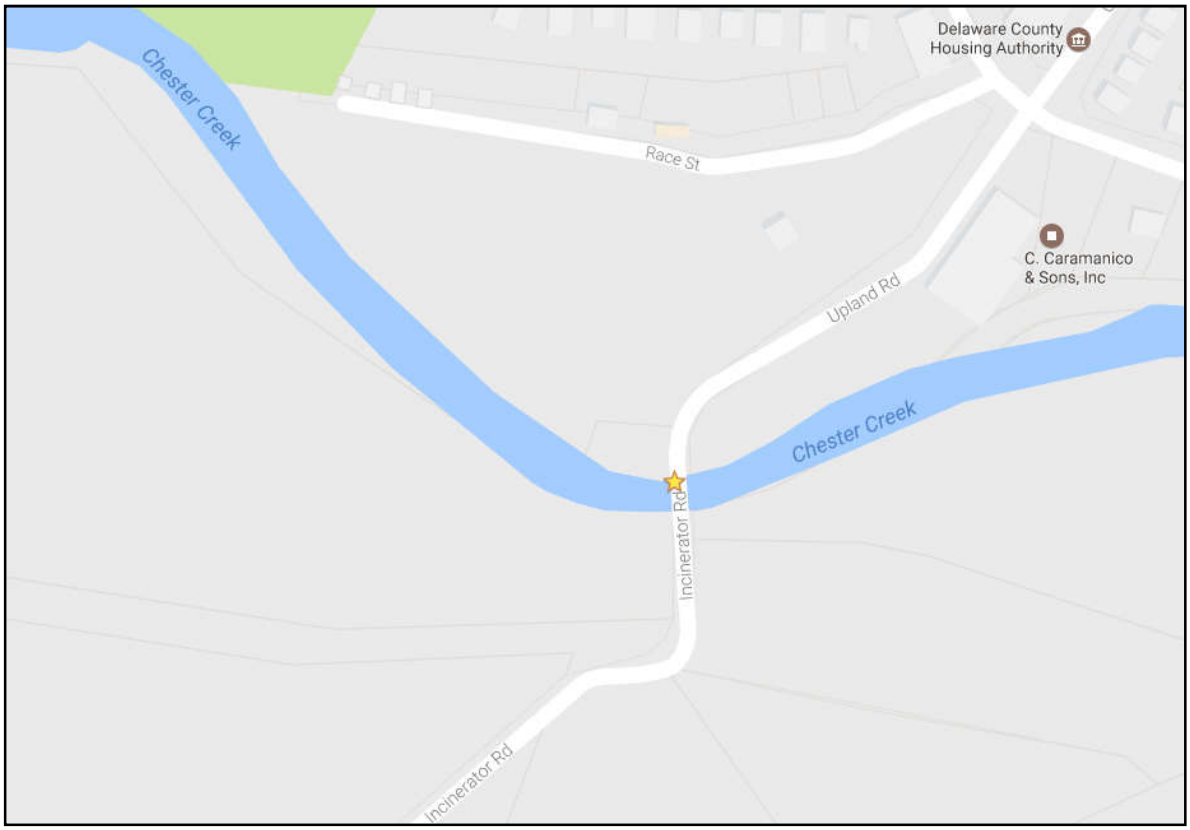
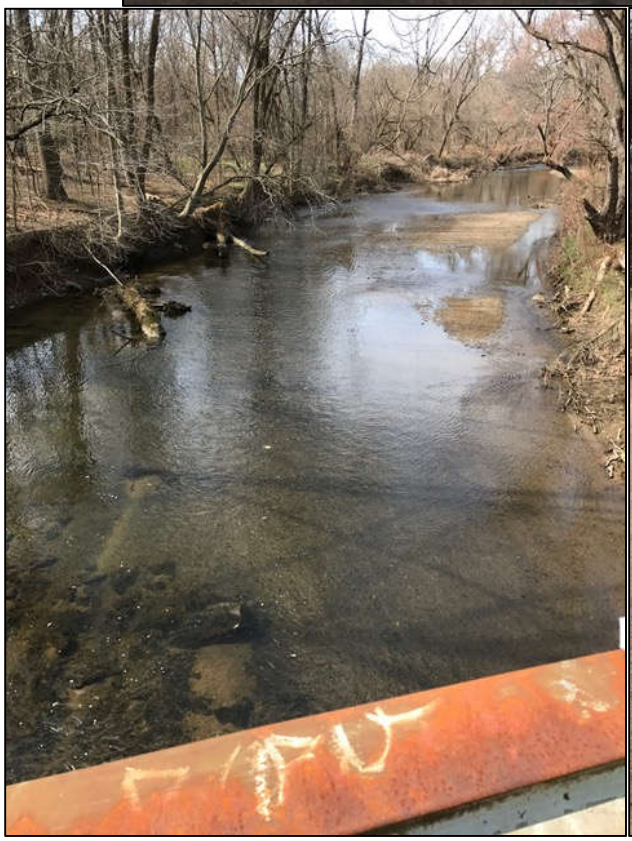
SITE VISIT NOTES

Sampling ID	Sampling Location	Activity / Notes	Accessibility
CC-01	Upland Rd. / Incinerator Rd. Bridge. **39.850122, -75.386348**	20 ft. from rail to water. Upstream of CSO outfall. Creek is non-tidal. Lower bottle with rope or other means	Upland road access gated from both ends, may need to contact police for access. Minimal traffic.

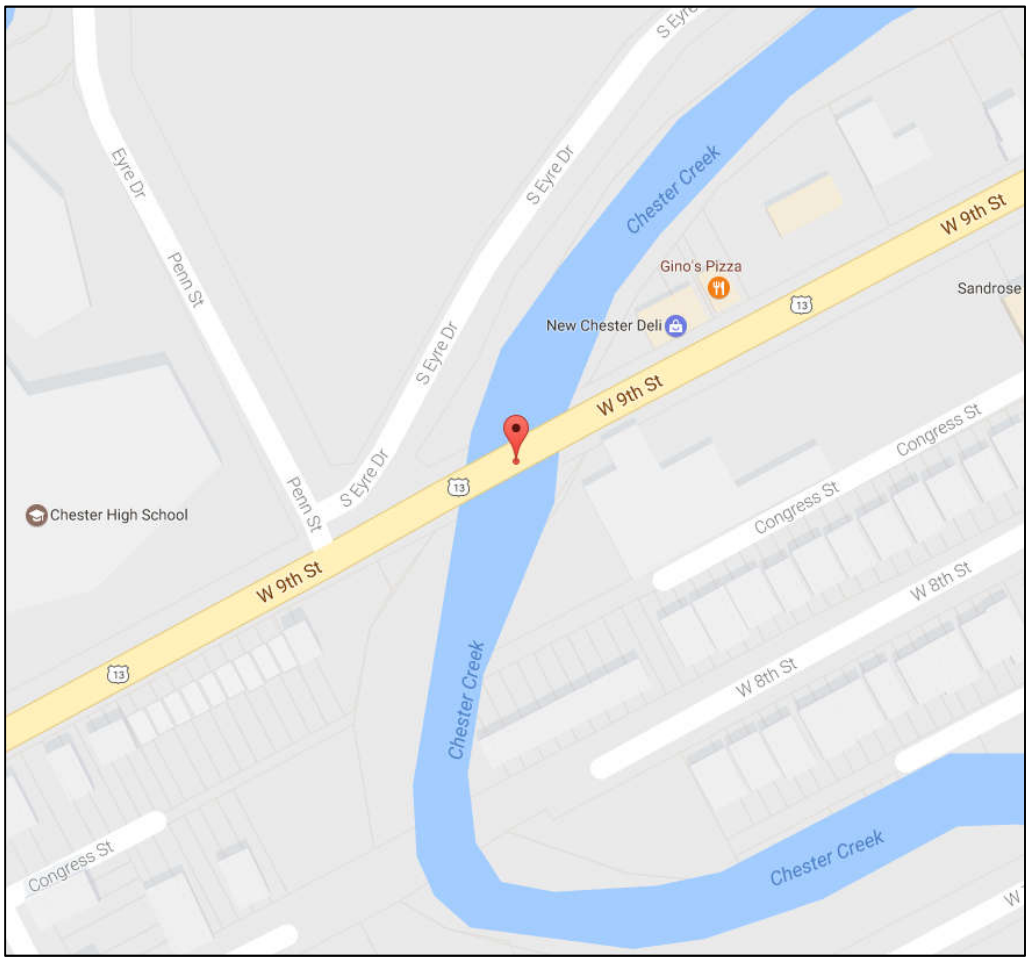


CC-01 Location Plan Map

CC-01 - Photos

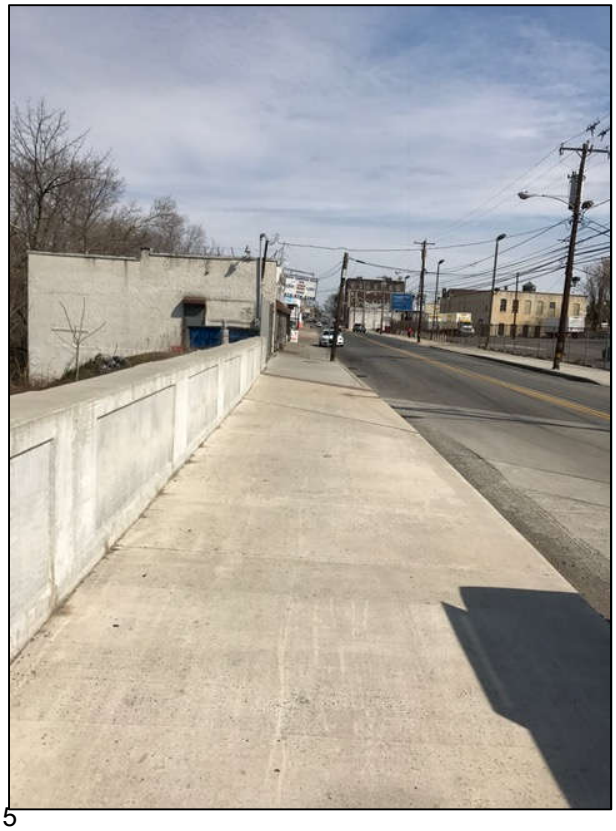


Sampling ID	Sampling Location	Activity / Notes	Accessibility
CC-02	9th and Penn St. Bridge **39.850709, -75.365530**	23 ft. from rail to water. Bridge is located next to Chester High School.	Accessible from 9th Street. Can pull vehicle on shoulder. Light traffic.

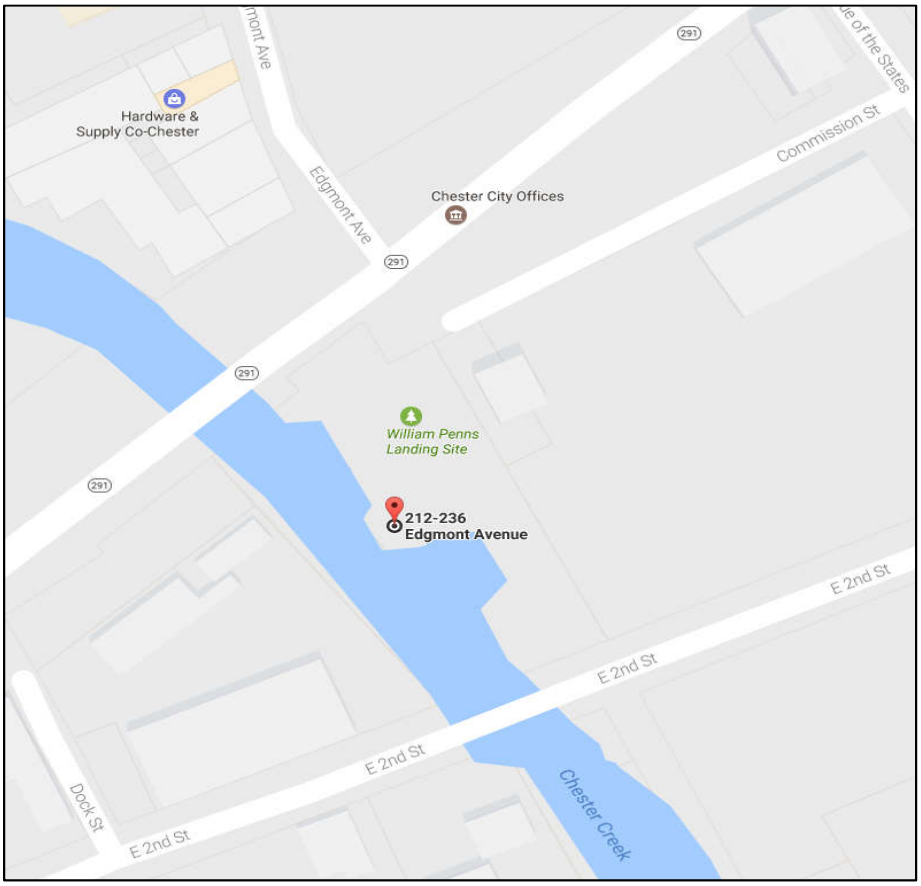


CC-02 Location Plan Map

CC-02 - Photos

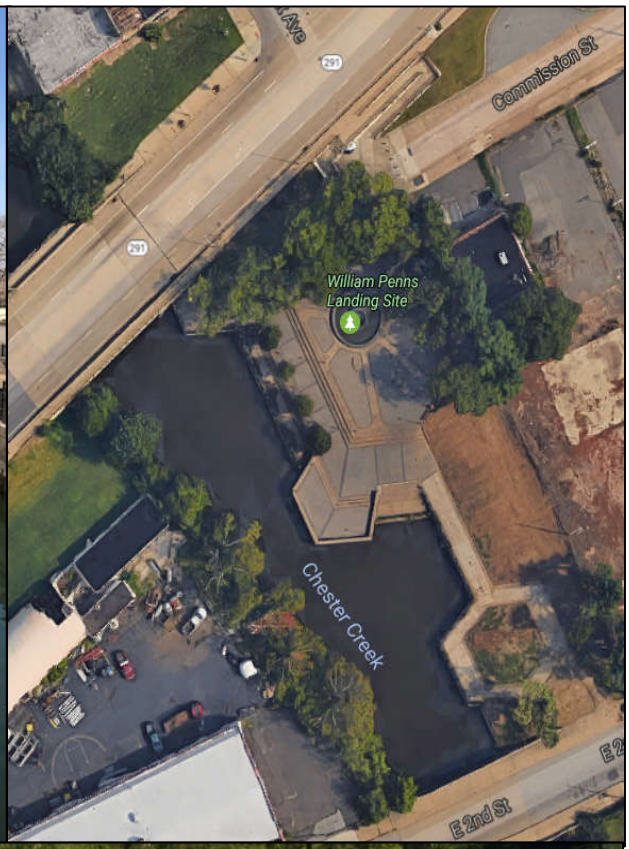


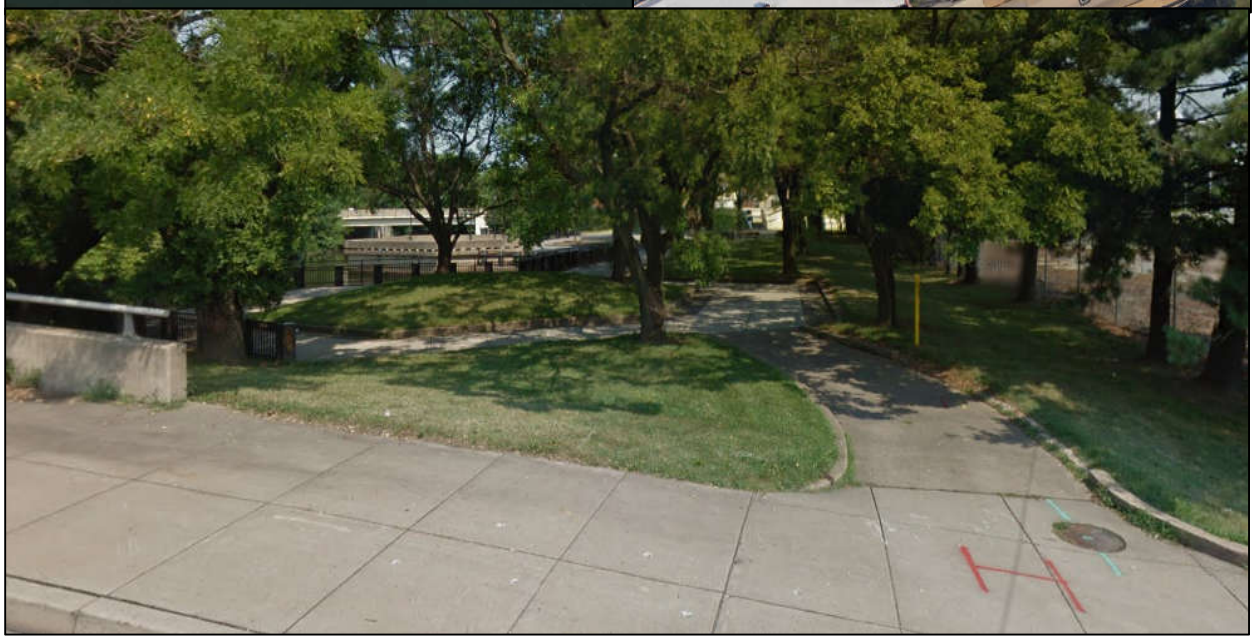
Sampling ID	Sampling Location	Activity / Notes	Accessibility
CC-03	Intersection of Edgmont and 2nd street. William Penn's Landing Park **39.845227, -75.360284**	Site is in William Penn's Landing Park. Sample off of Concrete plaza that overhangs Chester Creek. Tidal influence. Grab samples upstream of bridge.	Can pull vehicle off of 2nd Street and walk into park. Light traffic.



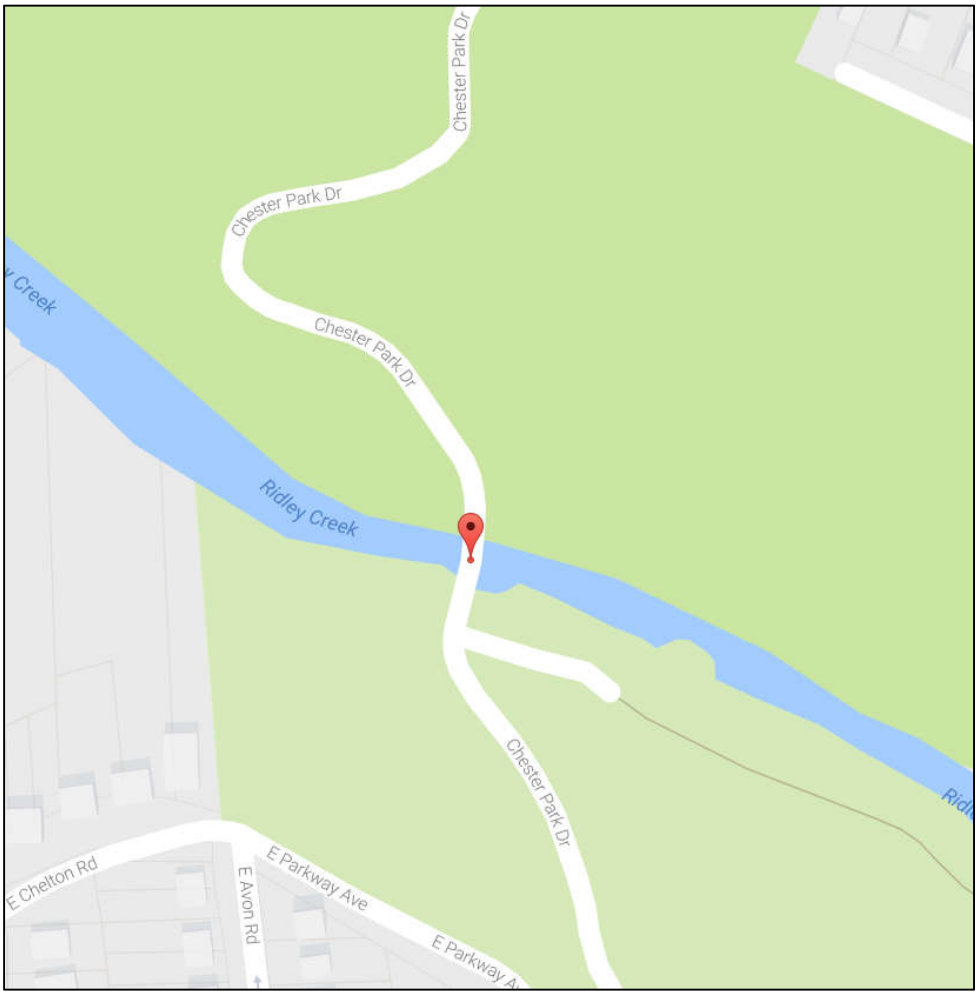
CC-03 Location Plan Map

CC-03 – Photos


Commission St
291
291
William Penns
Landing Site
Chester Creek
E 2nd St



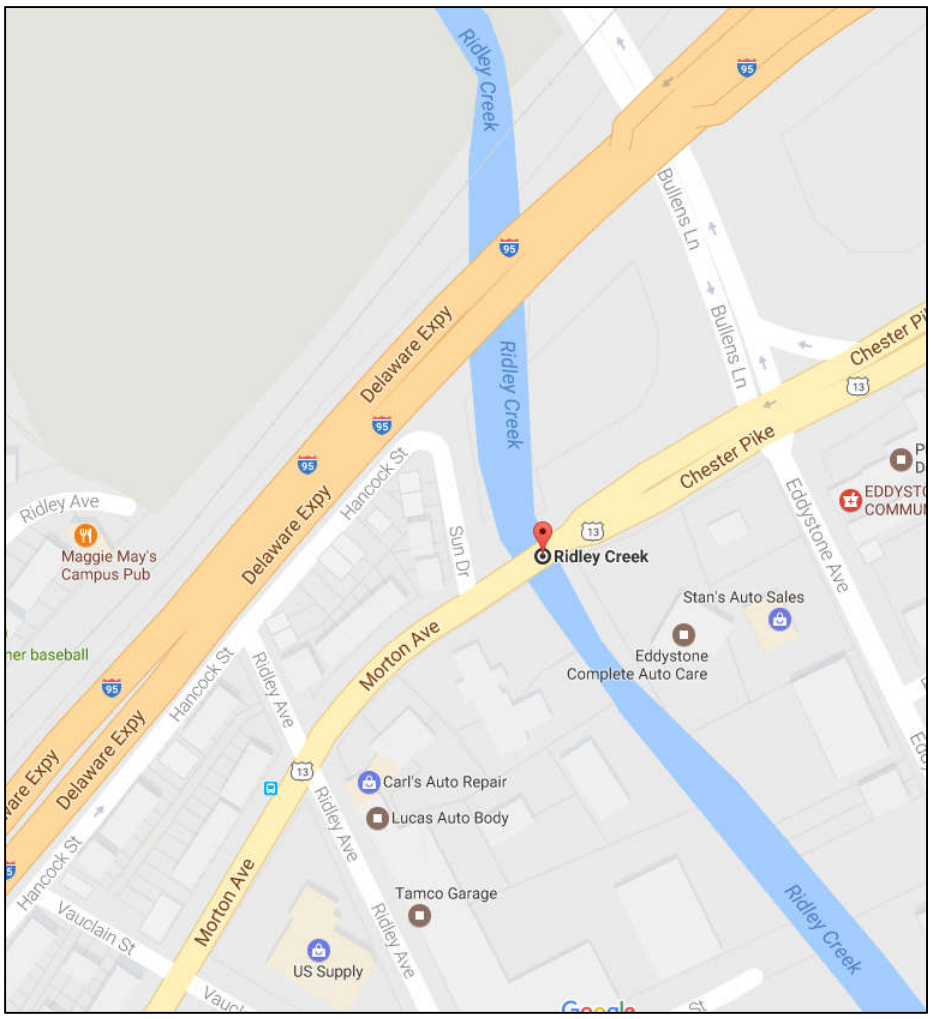
Sampling ID	Sampling Location	Activity / Notes	Accessibility
RC-01	Chester Park Drive Bridge **39.873264, -75.375183**	19 ft. rail to water. Sample upstream of CSO outfall. Upstream of CSO-33. Creek is non-tidal here. Lower bottle with rope or other means.	Can park in lot adjacent to Chester Park Drive Bridge. Minimal traffic.



RC-01 Location Plan Map

RC-01 – Photos

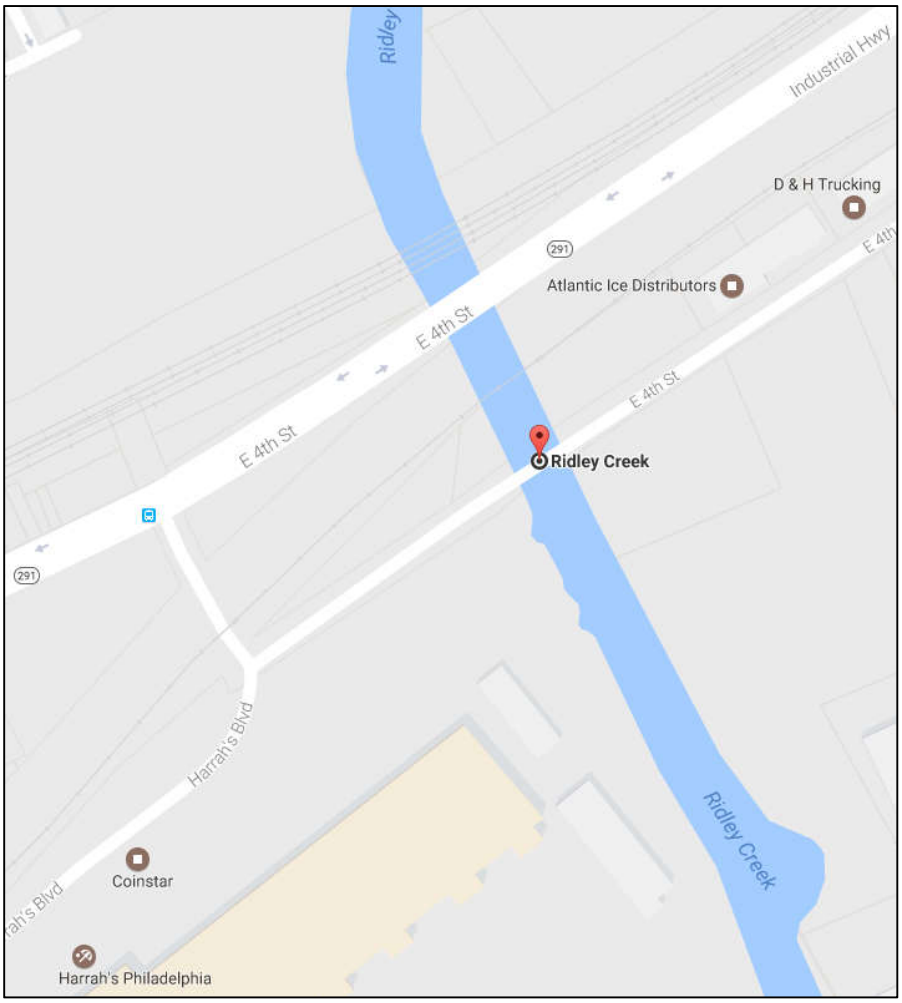
Sampling ID	Sampling Location	Activity / Notes	Accessibility
RC-02	Morton Ave. Bridge **39.863016, -75.348686**	22 ft. rail to water (low tide), with 2 ft. water depth. Site is in same area as CSO-18.	Can park on Sun Drive and use sidewalk when sampling off of bridge. Medium traffic.



RC-02 Location Plan Map

RC-02 – Photos

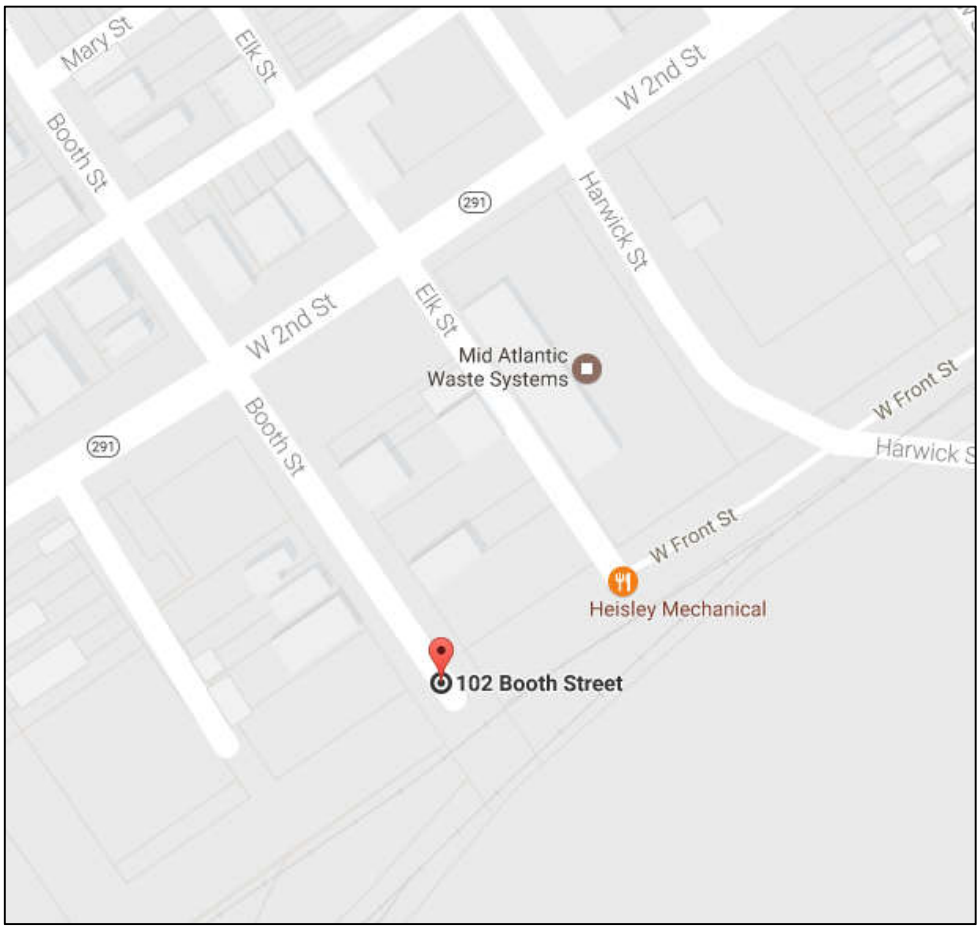
Sampling ID	Sampling Location	Activity / Notes	Accessibility
RC-03	4th Street (Harrah's) Bridge. Bridge No. 157 (Chester-Eddystone Bridge) **39.853435, -75.346350**	25 ft. rail to water (low tide), shallow during low tide. Creek is tidal. Lower bottle from bridge using a rope or other means.	Can park on shoulder north of bridge use sidewalk when sampling off of bridge. Medium traffic.



RC-03 Location Plan Map

RC-03 – Photos

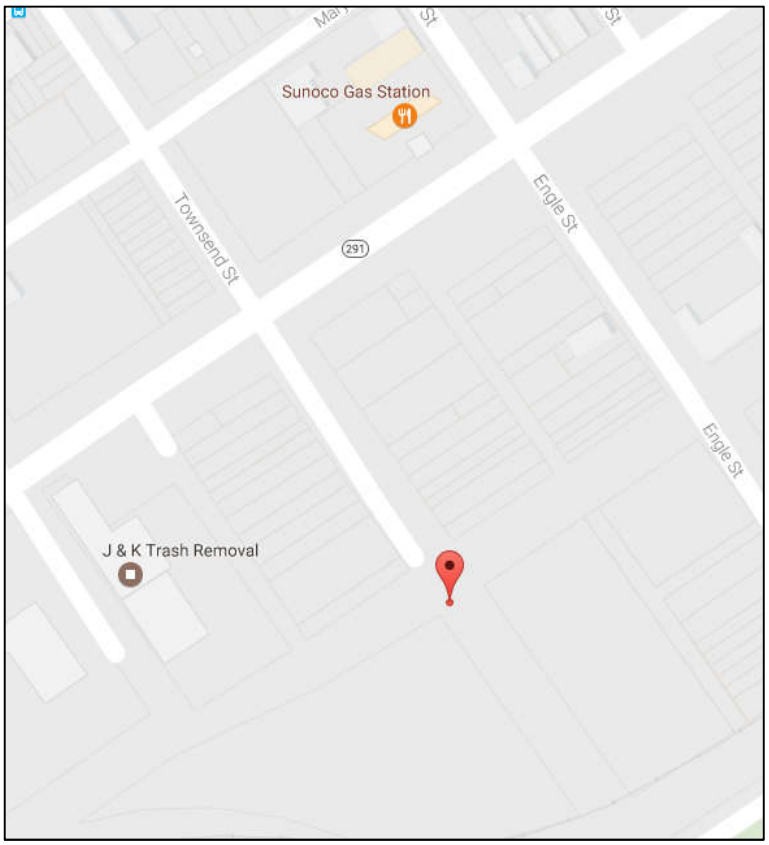
Sampling ID	Sampling Location	Activity / Notes	Accessibility
CSO-02	Front and Booth St. **39.828334, -75.392570**	SCADA level sensor installed. Concrete dam diverts flow to right side MH flow to WRTP (has an orifice plate). Overflow over the dam will flow to CSO outfall at Delaware River.	Can park at the end of Booth St. prior to rail tracks. Minimal traffic. MH cover is marked with white dot.



CSO-02 Location Plan Map

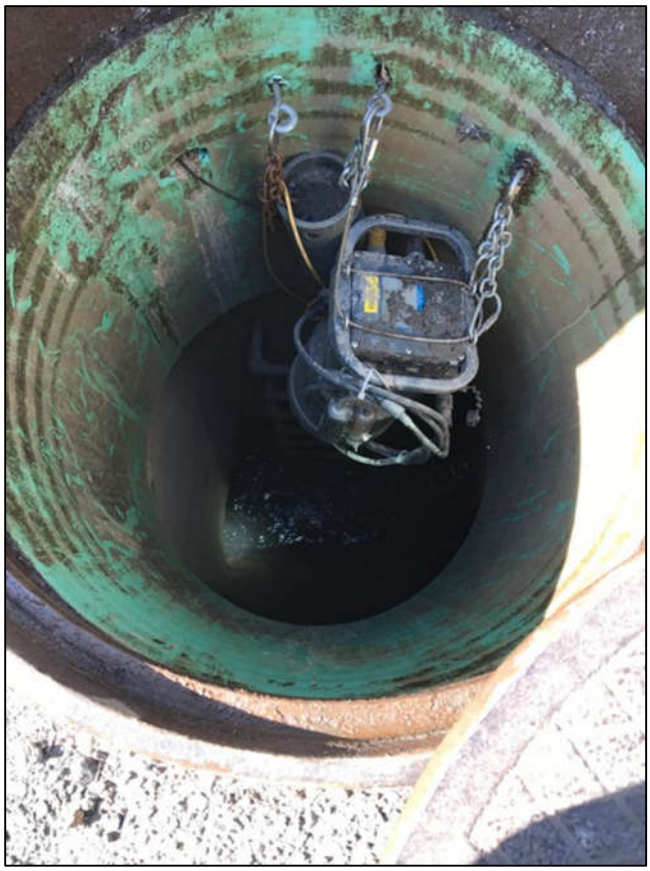
CSO-02 Photos

Sampling ID	Sampling Location	Activity / Notes	Accessibility
CSO-05	Front and Townsend **39.832598, -75.383958**	SCADA level sensor and Hach flow meter installed. Concrete dam diverts flow to right side MH flow to WRTP. Overflow over the dam will flow to CSO outfall at Delaware River.	Can park at the end of Townsend St. Minimal traffic. MH cover is marked with white dot.

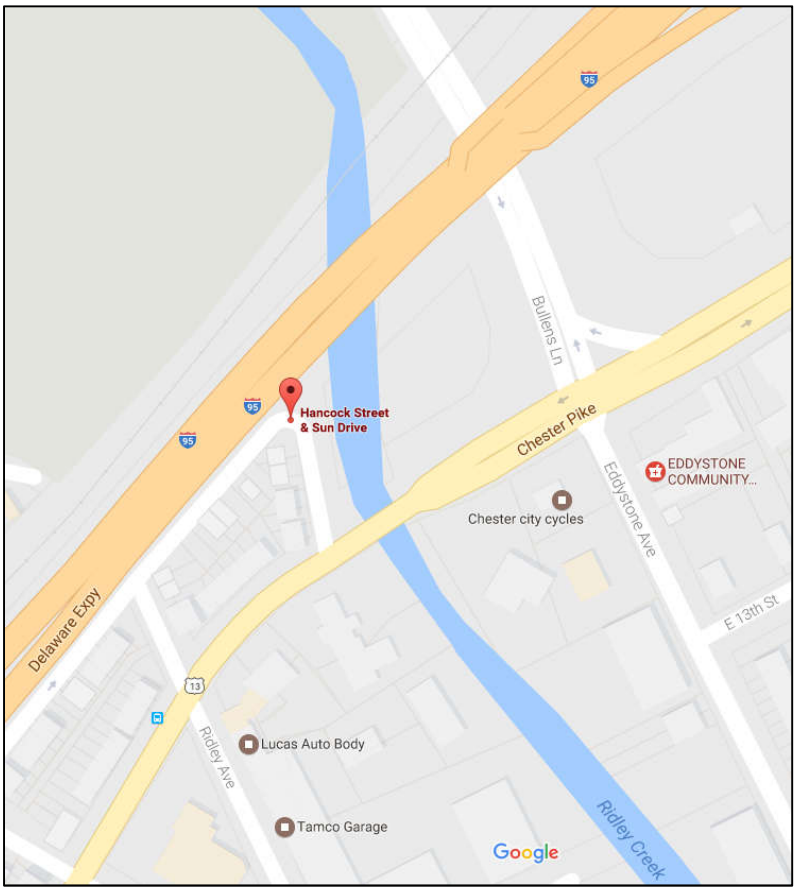


CSO-05 Location Plan Map

CSO-05 Photos

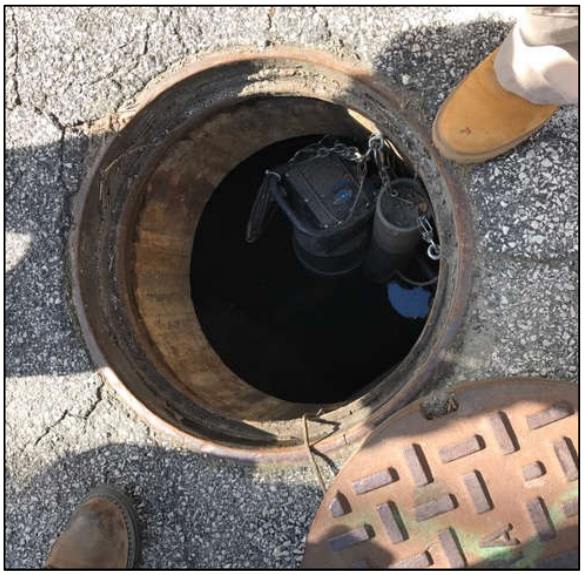


Sampling ID	Sampling Location	Activity / Notes	Accessibility
CSO-18	Hancock St. and Sun Dr. **39.863501, -75.349203**	SCADA level sensor and Hach flow meter installed. Concrete dam diverts flow to right side MH flow to WRTP. Overflow over the dam will flow to CSO outfall at Ridley Creek.	Can park at the end of Hancock St. Minimal traffic. MH cover is marked with white dot.

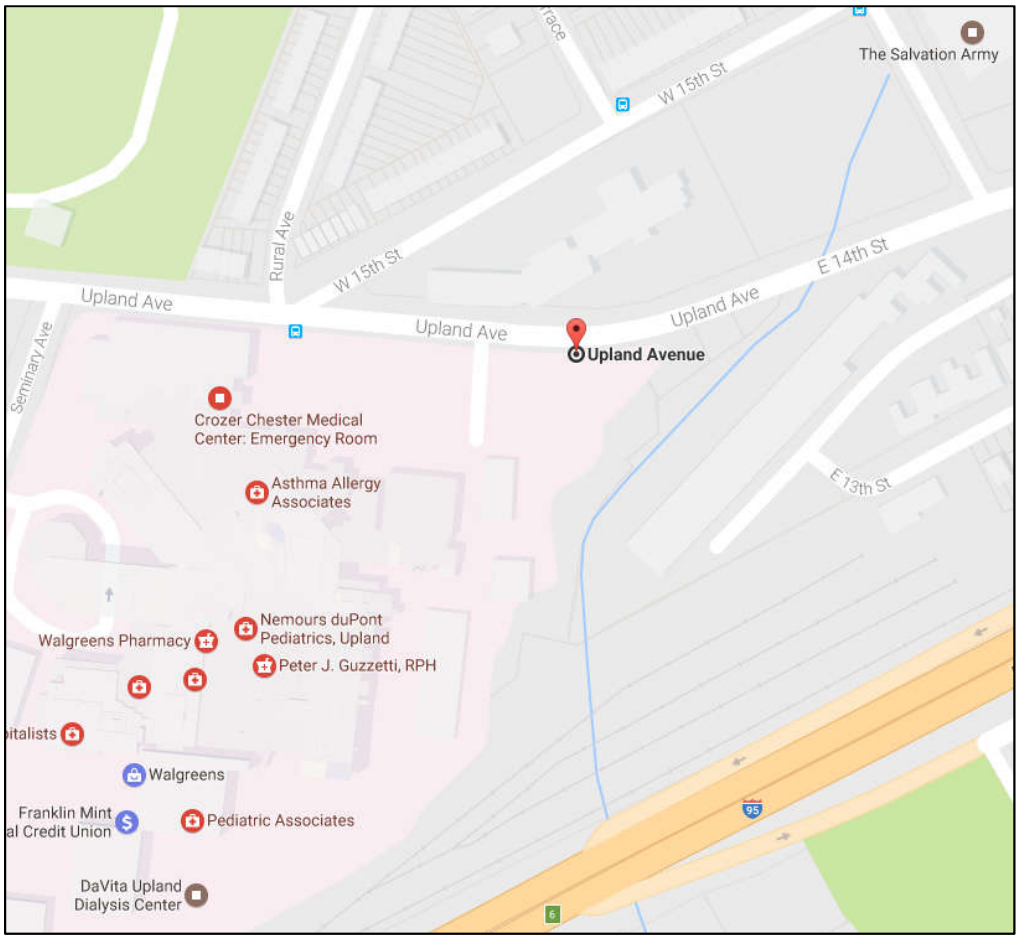


CSO-18 Location Plan Map

CSO-18- Photos

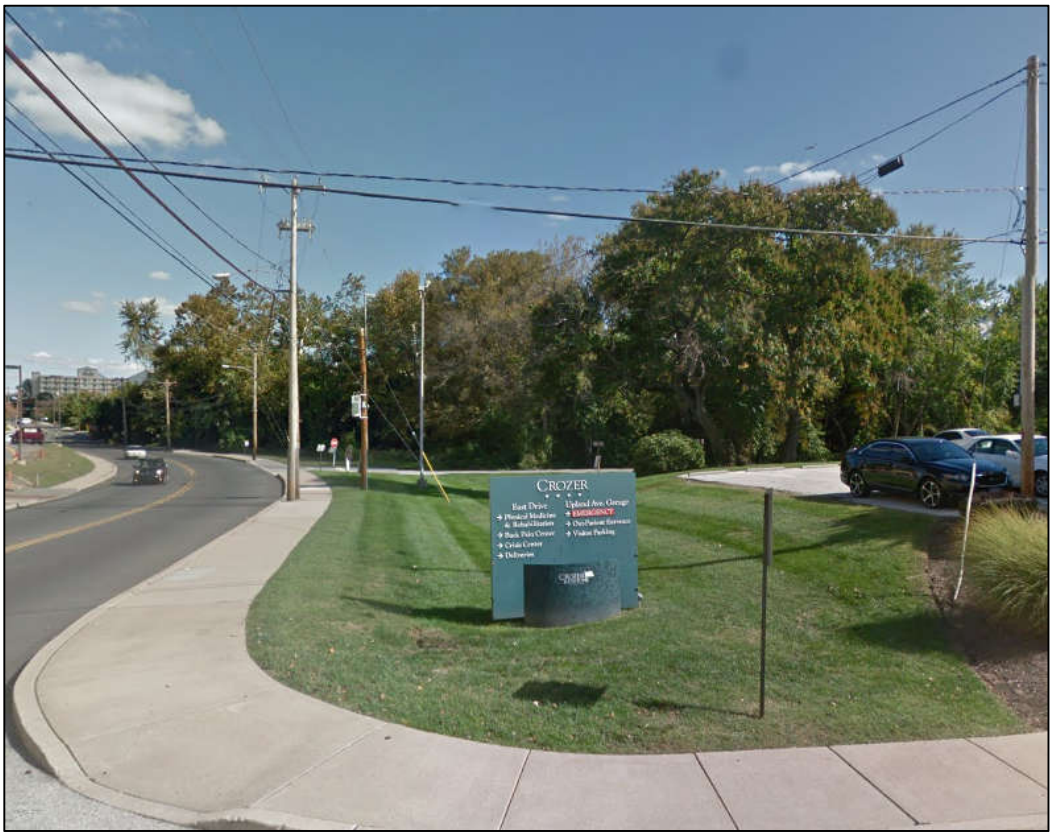


Sampling ID	Sampling Location	Activity / Notes	Accessibility
CSO-19	14th and Crozer Hospital **39.857132, -75.366105**	SCADA level sensor and Hach flow meter installed. Concrete dam diverts flow to interceptor MH flow to WRTP. Overflow over the dam will flow to CSO outfall at Chester Creek.	Can park in the cul-de-sac off of 14th St. High traffic. MH cover is on lawn area marked with white dot.

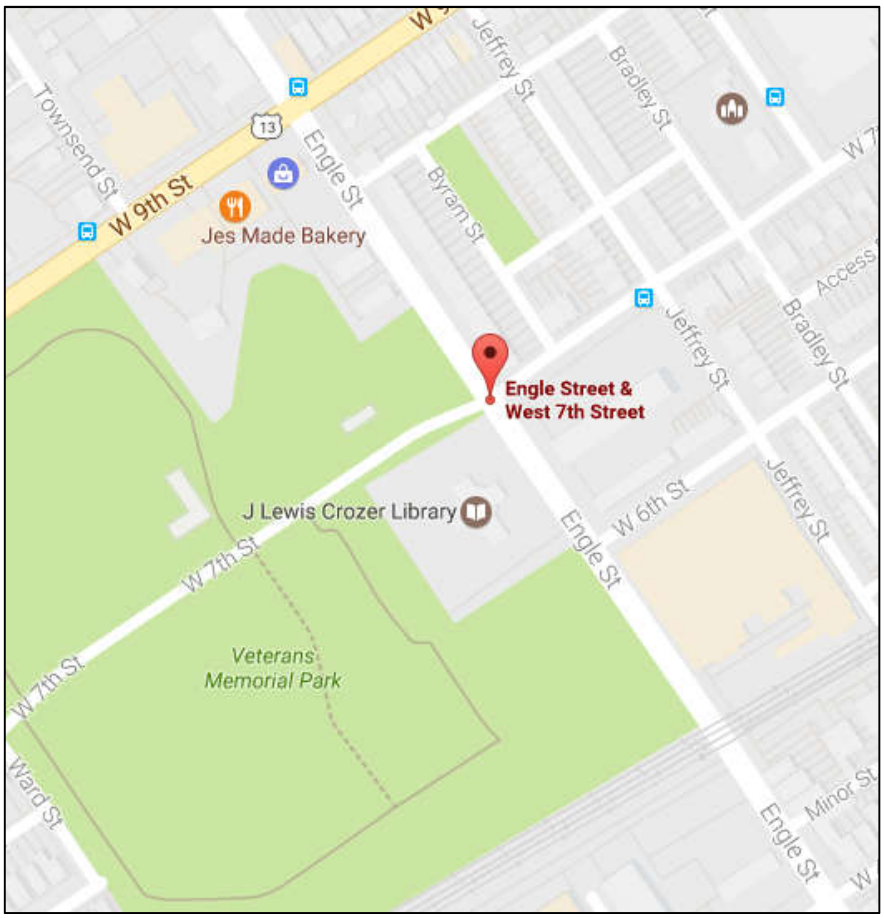


CSO-19 Location Plan Map

CSO-19- Photos



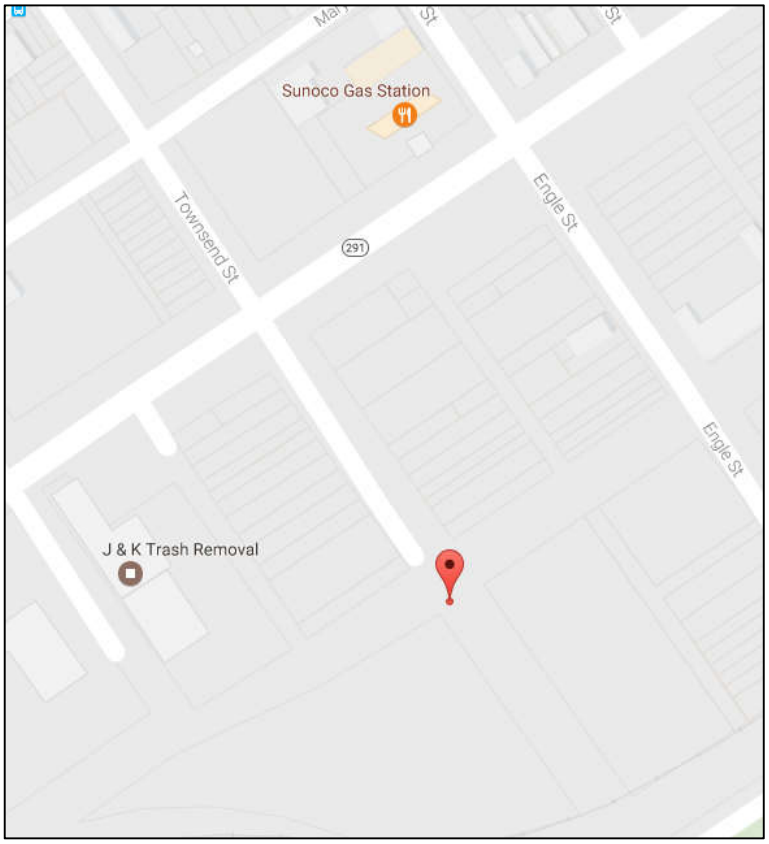
Sampling ID	Sampling Location	Activity / Notes	Accessibility
SW-05A	7th and Engle Street **39.838658, -75.387550**	Residential storm water MH. MH is clear and on grass area off of road.	Can park on 7th St. shoulder and access MH on lawn next to traffic light. Medium traffic. MH cover is on lawn area marked with white dot.



SW-05A Location Plan Map

SW-05A-Photos

Sampling ID	Sampling Location	Activity / Notes	Accessibility
SW-SS2	105 Townsend Street **39.832687, -75.384032**	Industrial storm water MH. MH is clear and on gravel area near CSO-05.	Can park at the end of Townsend St. Minimal traffic. MH cover is marked "storm" with white dot.



SW-SS2 Location Plan Map

SW-SS2-Photos

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www.greeley-hansen.com

LimnoTech
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Washington, DC 20003
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REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Doug Billillent

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By 2018-0503

APR 16 2018

Mr. Robert Willert, Executive Director
Delaware County Regional Quality Control Authority
100 East Fifth Street
Chester, PA 19013

RE: Civil Action 2:15-cv-04652-RB

Dear Mr. Willert:

The United States Environmental Protection Agency (EPA) has received the Delaware County Regional Quality Control Authority (DELCORA) Water Quality Modeling and Monitoring Work Plan Update WQMMWP dated July 31, 2017. EPA has consulted with the Pennsylvania Department of the Environment (PaDEP). This letter served to iterate the original approval and formally notify you that EPA accepted the updated WQMMWP and is approved.

Sincerely,

Andrew F. Seligman, Environmental Scientist
Water Enforcement Branch

cc: P. Yeany, EPA
M. DeSantis, DELCORA
Tom Magee, PaDEP, SERO
C. Hurst, DELCORA

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APPENDIX J

WATER QUALITY MODELING REPORT

- DELCORA Water Quality Model Report - Final dated February 2018
- USEPA Approval of the Water Quality Water Quality Model Report dated April 17, 2018

Note: This Appendix includes a report by Greeley & Hansen which rebranded to TYLin in 2023.

Delaware County Regional Water Quality Control Authority
CSO Long Term Control Plan Update

Water Quality Model Report

Final

Submitted: February 2018

GREELEY AND HANSEN

LimnoTech

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Report Signature Cover Sheet

Signature of this cover signifies agreement with the content of the DELCORA Water Quality Model Report.

I certify under penalty of law that the document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

DELCORA MANAGEMENT		
Executive Director	*Signature*	*Date*
DELCORA ENGINEERING		
Director of Engineering	*Signature*	2/27/18 *Date*
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	*Signature*	2/27/18 *Date*

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES

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Appendices

Appendix A: Bathymetry Survey of Ridley and Chester Creeks

Appendix B: DELCORA Water Quality Sampling Report

Appendix C: Water Quality Model Calibration Results

Glossary

CDPS: Central Delaware Pump Station
CSO: Combined sewer overflow
CSS: Combined sewer system
CWA: Clean Water Act
DCIA: Directly connected impervious area
DEM: Digital elevation model
EFDC: Environmental Fluid Dynamic Code
EMC: Event mean concentration
HSG: Hydrologic soil group
LiDAR: Light detection and ranging
LTCP: Long Term Control Plan
MRLC: Multi-Resolution Land Characteristics
MS4: Municipal separate storm sewer system
NCDC: National Climatic Data Center
NLCD: National Land Cover Database
NMC: Nine Minimum Controls
NOAA: National Oceanic and Atmospheric Administration
NPDES : National Pollutant Discharge Elimination System
NRCS: National Resources Conservation Service
PADEP: Pennsylvania Department of Environmental Protection
PWD-SWPCP: Philadelphia Water Department's Southwest Water Pollution Control Plant
SSO: Sanitary sewer overflow
SSURGO: Soil Survey Geographic database
SWMM: Stormwater Management Model
USGS: United States Geological Survey
WRTP: Western Regional Treatment Plant

Executive Summary

Introduction

The DELCORA Consent Decree requires that a Water Quality Model be developed to support the Long Term Control Plan Update. This report describes DELCORA's receiving water quality model, including the development and calibration of the model, and the initial application of the model to quantify baseline pollutant of concern (POC) water quality conditions in the receiving waters for the typical period. The POCs include Fecal coliform, *E.coli*, and *Enterococcus*. The objective of the water quality modeling was to compute POC concentrations in the tidal portions of Chester Creek and Ridley Creek, and in the Delaware River, by accounting for all major POC sources within the model domain. The intended use of the water quality modeling framework is to evaluate the water quality under typical year conditions and to evaluate CSO control alternatives.

Model Development

Three types of models, which comprise the modeling framework, were jointly applied to compute POC concentrations in Chester and Ridley Creeks and the Delaware River:

- A watershed model which simulates flows and POC loads from the Chester and Ridley Creeks watersheds;
- CSO models to simulate flows and POC loads from the DELCORA and Philadelphia Water Department (PWD) combined sewer systems (CSS) to the streams; and,
- A receiving water quality model that computes POC concentrations in Chester and Ridley Creeks and the Delaware River resulting from the various sources of POCs to the streams.

The watershed and CSS models were developed using the EPA Stormwater Management Model (SWMM) and the receiving water quality model was developed using the EPA Environmental Fluid Dynamics Code (EFDC) model.

Model Calibration

Site specific data was used for calibrating the various models, including USGS flow data, NOAA tide data, wet and dry weather water quality data obtained by DELCORA, and ambient water quality data obtained from the Delaware River Basin Commission (DRBC). The water quality data obtained by DELCORA proved particularly useful in calibration the water quality model, as it contained both wet and dry weather data at various locations within the study area, including both upstream and downstream of the DELCORA CSO discharges.

Calibration of the various models was evaluated using metrics such as total runoff volume, peak flow rates, timing of the flow response, frequency of discharge, water levels, water velocities, and

in-stream water quality concentration. The calibration approach was to adjust model parameters and evaluate changes in model results against the entire calibration dataset, and identify the model values that were most consistent with the central tendencies of the dataset by stream. Each model within the framework was developed and calibrated using the best available data, and found to be reasonably consistent with observed data and therefore reliable to be applied for the Long Term Control Plan Update.

Model Application

The water quality model was applied for the typical year hydrologic period of 1994-1996, which includes one relatively dry year, a relatively wet year, and an average year (DELCORA, 2016b). Modeled POC concentrations were compared to the currently applicable and potential future water quality standards, as described in the table below. The Upper Delaware River and the tidal zones of Chester and Ridley Creek currently have secondary contact water quality standards whereas the Lower Delaware River currently has primary contact water quality standards for bacteria. The boundary between the Upper and Lower Delaware River occurs at river mile 81.8, which is just downstream of Chester Creek and CSO-11.

Table ES-1: Water Quality Standards for Comparisons with Model Results

Segment	*Enterococcus* (#/100 mL)	Fecal Coliform (#/100 mL)	*E.coli*[1] (#/100 mL)
Upper Delaware River and Tidal Zones of Creeks	Monthly Geomean: 88 #/100 mL	Monthly Geomean: 770 #/100 mL	n/a
Lower Delaware River	Monthly Geomean: 33 #/100 mL	Monthly Geomean: 200 #/100 mL	Monthly Geomean: 126 #/100 mL Statistical Threshold Value: 410 #/100 mL

1. *E.coli* (EC) standards likely to be codified by PADEP 12-24 months from July 2017. These criteria would apply to the non-tidal tributaries and Delaware River below R.M. 81.8, during recreational months only (May 1 - September 30).

Model results were summarized over the stream reaches that receive CSO discharges, and that occur within Pennsylvania water. Generally, the modeling indicated that the *Enterococcus* standards are the most stringent (relative to current concentrations) among the three POCs. Excursions above the WQS are frequent in the two Creeks and infrequent in the Delaware River. The excursions are almost always due to background sources coming from upstream of the DELCORA CSO area. DELCORA CSOs have a relatively smaller (less than 10%, on average) impact on monthly geometric mean concentrations than background sources.

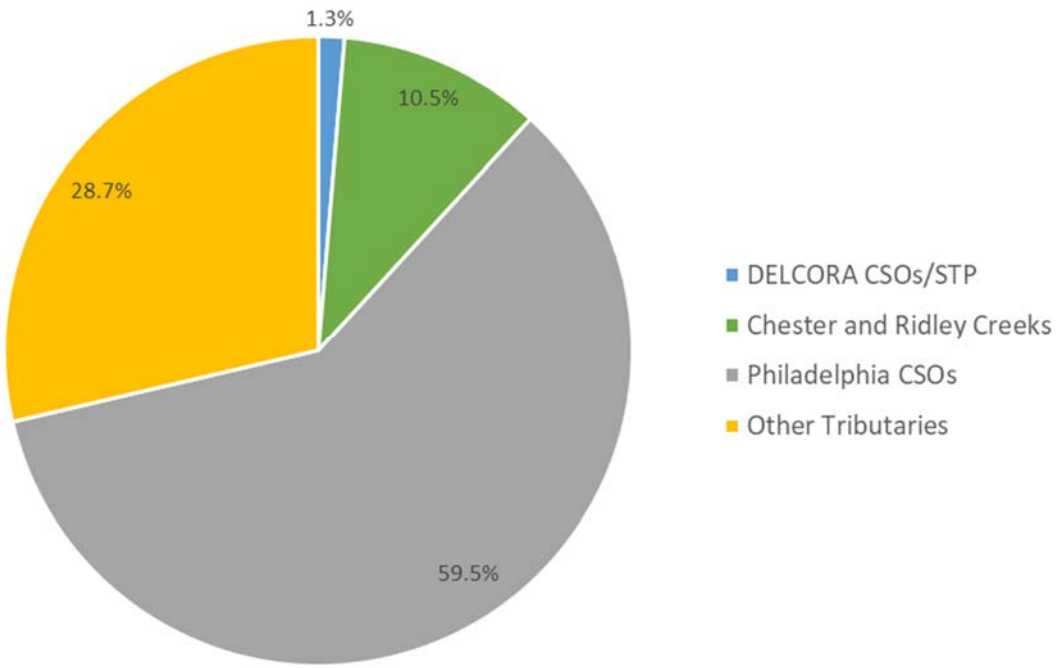
Findings and Implications

A water quality model was developed to compute POC concentrations in the tidal sections of Chester Creek and Ridley Creek, as well as in the Delaware River. Major findings of the modeling are as follows:

- The model is deemed adequate to assess the local water quality conditions in the DELCORA project area, including in the tidal portions of Chester and Ridley Creek, and in the Delaware River from roughly river mile 80 near Marcus Hook Creek, to river mile 85 near Crum Creek.
- Outputs of the hydrologic and hydraulic model relative to volumes and loadings were adequate for utilization as inputs for the development of the water quality model.
- The monitoring data shows that wet weather concentration at the most upstream monitoring locations (located upstream of CSO influence) in Chester Creek and Ridley Creek often exceed the monthly geometric mean WQS concentration for the three POCs. Wet weather exceedances are also observed in the most upstream monitoring location for the Delaware River, but less frequently as compared to the creeks. The *E.coli* statistical threshold value WQS[1] concentration (410 #/100 mL) was exceeded once under wet weather conditions during the sampling periods in the Delaware River.
- The modeling results show that when water quality standards are exceeded during wet weather events, upstream and background sources typically prevent the attainment of both the monthly geometric mean and STV water quality standards.
- The modeling results show that CSOs by themselves do not cause water quality violations in any of the stream segments.
- The DELCORA CSO loads are small compared to upstream and background loads entering the DELCORA project area (Figure ES-1).

[1] E.coli (EC) standards likely to be codified by PADEP 12-24 months from July 2017. These criteria would apply to the non-tidal tributaries and Delaware River below R.M. 81.8, during recreational months only (May 1 - September 30).

Figure ES-1: Percent of Bacteria Load by Source



Further, each model within the framework was developed and calibrated using the best available data, and found to be reasonably consistent with observed data and therefore reliable to be applied for the LTCPU. Two major observations can be made from the water quality modeling application results. One is that background sources dominate the modeled POC concentrations (and by extension, DELCORA CSO loads are small compared to background loads, as shown in the figure above), and the second is that the DELCORA CSOs by themselves do not cause non-attainment, or preclude the attainment, of WQS. Moreover, the modeling results show that regardless of additional CSO controls, even complete separation, water quality standards would still be exceeded under current conditions because background sources typically prevent compliance with WQS. While the Consent Decree addresses the issue of background sources by requiring CSO controls to also be assessed assuming that background sources are reduced to 75% of the applicable WQS, it is not clear that imposing CSO controls under these conditions is reasonable given that there is no current plan for reducing background loads in Chester and Ridley Creeks. The CSO Policy states that "where WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a wasteload allocation and a load allocation, or other means should be used to apportion pollutant loads". Such apportionment of loads does not currently exist for Ridley and Chester Creeks for bacteria.

The intended use of the water quality modeling framework is to evaluate CSO control alternatives with respect to applicable water quality standards and demonstrate that alternatives selected for the LTCPU program will meet the water quality-based requirements of the Clean Water Act and Consent Decree. The water quality model is adequate to assess presumption levels of control to show that the CSOs after controls are in place do or do not preclude the attainment of water quality standards. The model framework could also be used to assess the demonstration approach, however, as explained in this report, the modeling shows that CSOs alone do not cause WQS violation and do not preclude the attainment of WQS, and background loads are currently causing WQS violations upstream of the CSOs and the CSO influence. Without a State plan for estimating the cost and practicality for controlling the background load upstream of DELCORA's CSO area, it is difficult to justify the demonstration approach.

As such, DELCORA will utilize the presumption approach, which is shown in this report to be reasonable in light of the data and analysis as called for in the National CSO Policy.

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Section 1 Introduction

1.1 Background of DELCORA's Facilities

Delaware County Regional Water Quality Control Authority (DELCORA) is responsible for the collection, transmission, treatment and disposal of approximately 65 million gallons per day (MGD) of wastewater generated in southeastern Pennsylvania. DELCORA's facilities serve residential, commercial, institutional, and industrial customers in Delaware County. DELCORA owns and operates an extensive system of pump stations, force mains, and sewers that provide the core infrastructure for the transmission of wastewater to treatment facilities in Delaware County and the City of Philadelphia as shown diagrammatically in Figure 1-1. The total service area served by DELCORA, as shown on Figure 1-2, is approximately 82,977 acres which illustrates that DELCORA serves a significant and widespread portion of Delaware County.

The combined sewer area simulated in DELCORA's existing Hydrologic and Hydraulic model is located within the City of Chester and consists of a drainage area of approximately 1,510 acres. It comprises approximately half of Chester City's serviced area. To support the service area, DELCORA owns and operates over 129 miles of separate and combined sewers. Included in the 129 miles of sewers are: 11.7 miles of an interceptor system; 3,209 manholes; and twenty-five (25) combined sewer outfall regulators controlling storm overflows. The location of Chester City's service area is illustrated on Figure 1-2.

Historically, DELCORA has characterized its service areas as "Eastern" and "Western." The Western service area discharges to DELCORA's Western Regional Treatment Plant (WRTP). The Eastern service area discharges to the Philadelphia Water Department's Southwest Water Pollution Control Plant (PWD-SWPCP). In 2002, DELCORA completed the installation of a force main that connects the Eastern Service Area's Central Delaware Pump Station (CDPS) to the Chester Force Main. This connection allows DELCORA to send flow from the CDPS to the WRTP. Flows above 20 MGD are directed to the PWDSWPCP. As such, dry weather flows and a portion of the wet weather flows (total flow less than 20 MGD) from the Central Delaware County Authority in the Eastern Service Area are discharged to the WRTP.

There are a total of 26 combined sewer overflow outfalls listed with 25 discharge points (Outfall #009 and #010 both discharge at Outfall #009) in DELCORA's existing National Pollutant Discharge Elimination System (NPDES) Permit. Under its NPDES Permit No. PA0027103, issued and administered by the Pennsylvania Department of Environmental Protection (PADEP), DELCORA is authorized to discharge from the Western Regional Treatment Plant (Outfall #001), four stormwater outfalls at the WRTP (028-031) and from 26 combined sewer overflow outfalls (#002-#026, #032, #033) that ultimately discharge to the Delaware River, Chester Creek and/or Ridley Creek.

Figure 1-1: DELCORA's Conveyance System

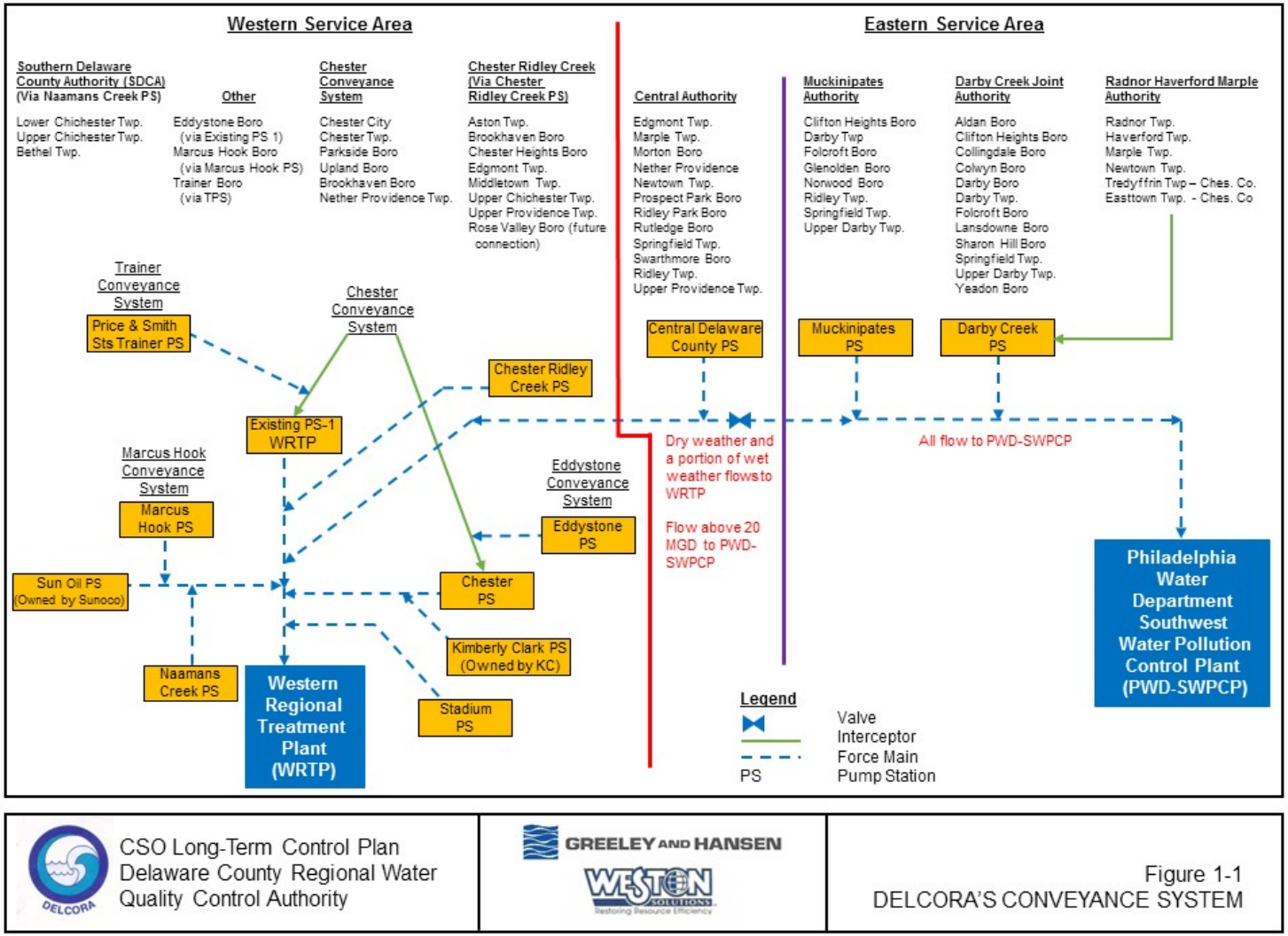
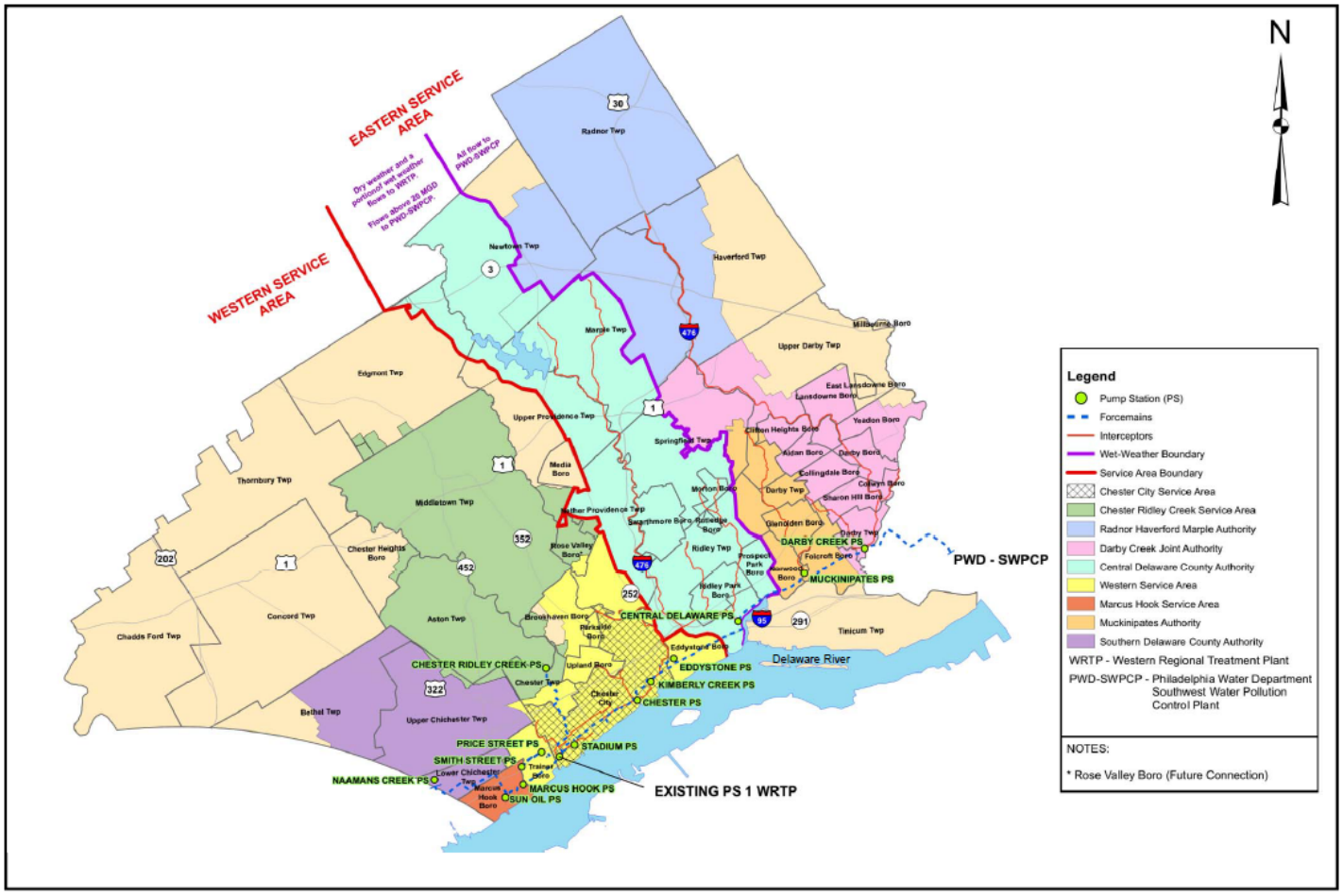


Figure 1-2: DELCORA's Service Area



CSO Long-Term Control Plan
Delaware County Regional Water Quality Control Authority

GREELEY AND HANSEN

Figure 1-2
DELCORA'S SERVICE AREA

Part C – Other Requirements, Section V – Combined Sewer Overflows of the NPDES Permit details DELCORA's responsibilities with respect to the CSO system including reporting, continued implementation of and continued compliance with the Nine Minimum Controls (NMC), and implementation of the existing Long-Term Control Plan (LTCP) dated April 1999 and the July 2008 addendum to the LTCP until the updated LTCP is approved.

1.2 Consent Decree Requirements

On August 17, 2015, a Consent Decree was lodged in the United States District Court for the Eastern District of Pennsylvania that requires DELCORA to complete and submit a revised and updated LTCP to the United States Environmental Protection Agency (USEPA or EPA) and the Pennsylvania Department of Environmental Protection (PADEP or DEP) for review and approval. The Consent Decree specifies that within sixty (60) days after the approved Water Quality Model Plan is fully implemented according to the schedule included in the Modeling Work Plan, DELCORA shall submit to EPA and PADEP a Water Quality Model Report for review and approval pursuant to Section VI (Review and Approval of Submittals) which shall specifically address each item set forth in Paragraph 15(a)(i)-(vi).

The work plan was first submitted in January 11, 2017 and a revision was submitted in July 31, 2017.

1.3 CSO and Receiving Water System Description

The combined portion of DELCORA's sewer system is located within the City of Chester (City), and it comprises approximately half of the City's serviced area. The combined wastewater/stormwater system in the City of Chester is complicated by the fact that parts of the system are owned, operated and maintained by two governmental entities, the City and DELCORA. DELCORA owns, operates and maintains the parts of the system that convey wastewater, such as the street sewers, collectors, interceptors, and CSO regulators and CSO outfalls. The City owns, operates and maintains the inlets, stormwater-only sewers that connect to the combined sewer system and any stormwater-only outfalls. The City is also responsible for the maintenance and cleaning of the streets, planning, zoning, and development controls. The Chester CSO system contains 26 permitted outfalls and they discharge to three receiving water bodies: the Delaware River, Chester Creek, and Ridley Creek. However, there are only 25 CSO discharge locations, as CSO #010 discharges to the Delaware River through CSO #009. Figure 1-3 depicts the locations of CSO regulators and outfalls that are DELCORA's responsibility. Figure 1-3 also provides a sewer system characterization and illustrate the breakdown of each outfall and how each drainage area has combined sewers and separate sewers. Figure 1-4 is a schematic of the Chester CSO system and shows the outfalls and the interceptors that are connected to each CSO. Note that CSO #033 does not appear to overflow during the typical year period. This CSO will be evaluated in the LTCP but, as a practical matter, it does not cause or contribute to WQS being exceeded.

Figure 1-3: Location of Regulators and Combined Sewer Outfalls with Drainage Areas

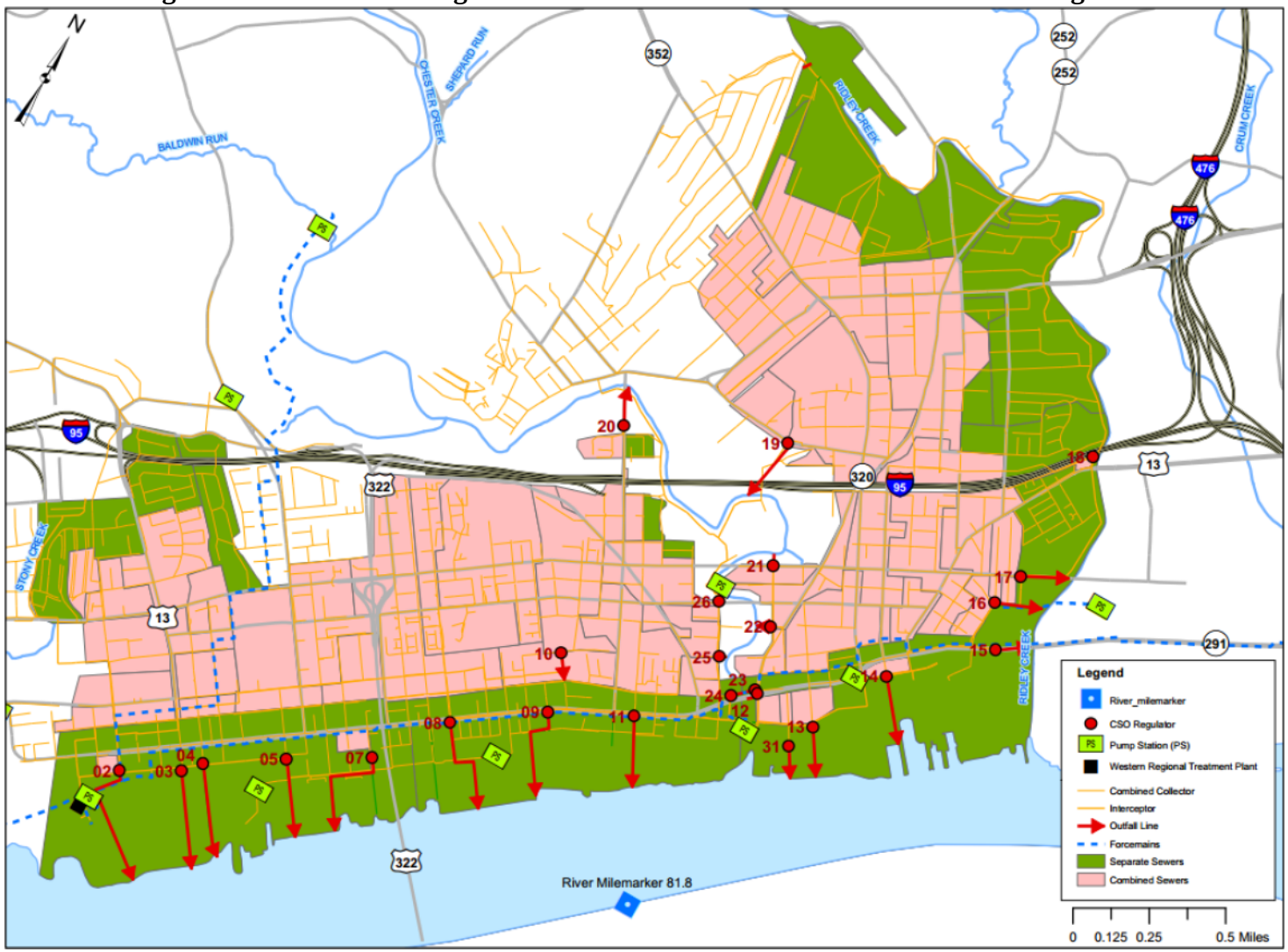
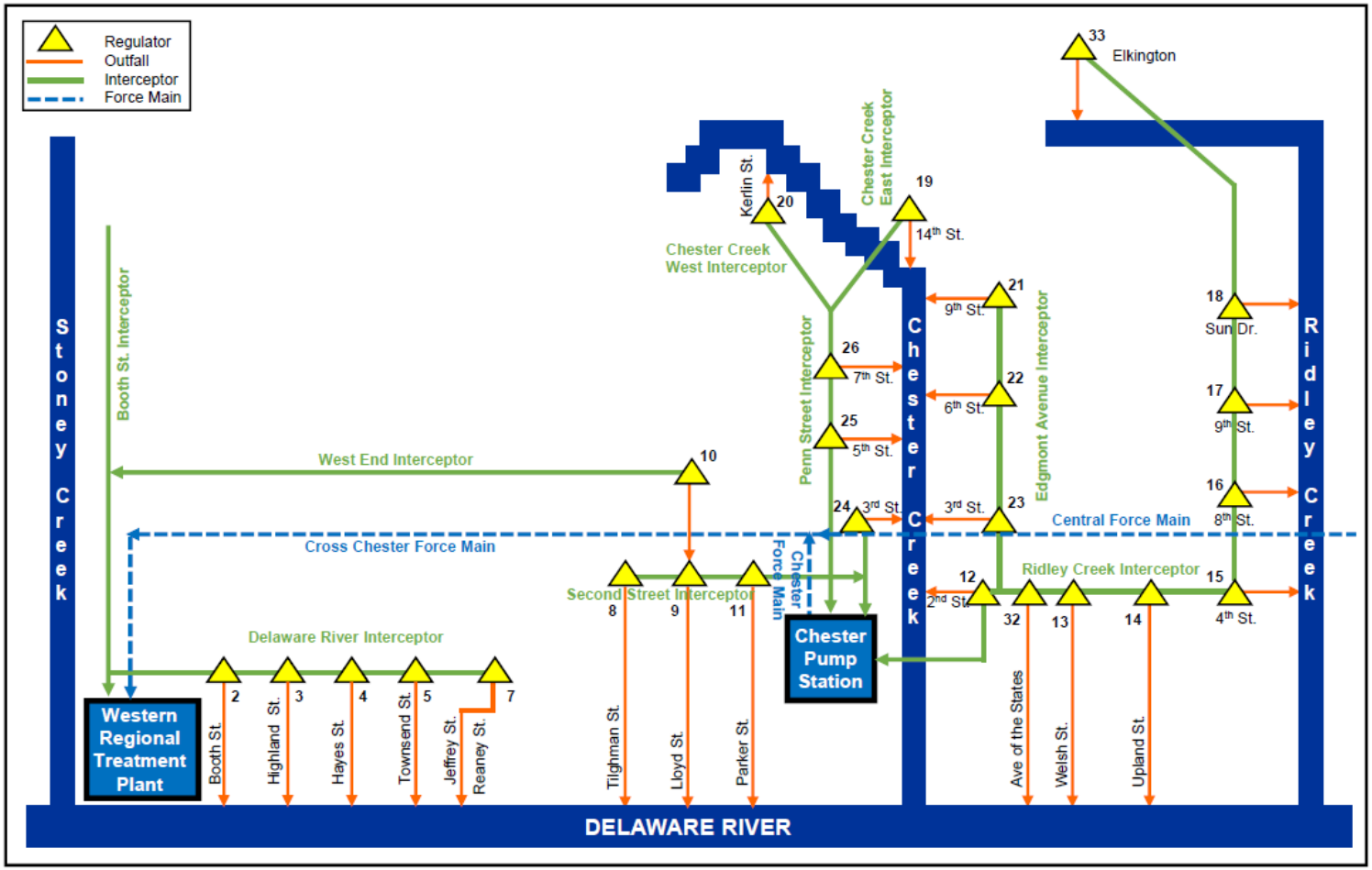


Figure 1-4: Schematic of Chester CSO System



CSO Long-Term Control Plan
Delaware County Regional Water Quality Control Authority

GREELEY AND HANSEN

Figure 1-4
SCHEMATIC OF CHESTER CSO SYSTEM

The pollutants of concern (POC) in the receiving waters are described in the "Identification of Sensitive Areas and Pollutants of Concern Report" (DELCORA, 2016a), and include Fecal coliform, *E.coli*, and *Enterococcus*.

DELCORA conducted an extensive wet and dry weather monitoring program between March and June 2017 to better characterize the POC loads within the project area. Site selection and analytical parameters were designed to characterize stormwater outfalls, CSOs, tributaries upstream and within the Chester CSO discharge area, and the main stem of the Delaware River in the project area. More information on the DELCORA Water Quality Monitoring Program can be found in Section 4.1.3 as well as in Appendix B.

1.4 Report Purpose and Objectives

This report describes DELCORA's receiving water quality model, which will support the Long Term Control Plan update (LTCPU). Specifically, the report describes the development and calibration of the model, and the initial application of the model to quantify baseline POC water quality conditions in the receiving waters for the typical period. The objective of the water quality modeling was to compute POC concentrations in Chester Creek, Ridley Creek, and the Delaware River, by accounting for all major POC sources within the model domain. Furthermore, the objective of the water quality model is to produce results for the typical period that will serve as the basis for evaluating CSO control alternatives. The primary focus of the water quality model is on the local water conditions, including the tidal zones of Chester and Ridley Creeks, and the Delaware River from roughly river mile 80 near Marcus Hook Creek to river mile 85 near Crum Creek. The intended use of the water quality modeling framework is to evaluate the water quality under typical year conditions and for the LTCP CSO control alternatives.

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Section 2 Water Quality Modeling Software

Three types of models, which comprise the modeling framework, were jointly applied to compute pollutant of concern (POC) concentrations in Chester and Ridley Creeks and the Delaware River:

- A watershed model which simulates flows and POC loads from the Chester and Ridley Creeks watersheds;
- CSO models to simulate flows and POC loads from the DELCORA and Philadelphia Water Department (PWD) combined sewer systems (CSS) to the streams; and,
- A receiving water quality model that computes POC concentrations in Chester and Ridley Creeks and the Delaware River resulting from the various sources of POCs to the streams.

The watershed model framework for this project is the EPA Stormwater Management Model (SWMM), which is supported by the USEPA. SWMM is a dynamic rainfall-runoff simulation model used for single event or continuous simulation of runoff quantity and quality from primarily urban areas (USEPA, 2014). The watershed model is based upon the EPA SWMM, Version 5.1.010, which is consistent with the version used for the CSS model. A variety of enhanced SWMM platforms are available that integrate the EPA SWMM software with user friendly interfaces and GIS capabilities. For this project, PCSWMM, developed by Computational Hydraulics International (CHI), was used.

The DELCORA combined sewer system hydrologic and hydraulic (H&H) model used for this study was developed by Greeley and Hansen (GH) to support DELCORA's Long Term Control Plan Update (LTCPU). The CSS model is based upon the EPA SWMM, Version 5.1, Build 5.1.012 and was applied through the proprietary software InfoSWMM Version 14.5 Update 4, developed by Innovyze (DELCORA, 2017).

A simplified Philadelphia combined sewer system model was developed by LimnoTech to estimate Philadelphia CSO flow and POC load contributions. The reason for including these loads is because large contributions of POCs occur upstream of DELCORA that impact the water quality in the DELCORA project area. The Philadelphia CSS model is also based on the EPA SWMM, Version 5.1.010 model using PCSWMM. Unlike the DELCORA CSS model, it does not represent hydraulics of the Philadelphia combined sewer system; instead it represents the storage capacity of the system and the frequency and magnitude of combined sewer overflows.

The receiving water quality model was developed based on USEPA's EFDC (Environmental Fluid Dynamics Code) modeling framework. This model has been applied to support numerous CSO water quality projects (Lynchburg, VA; Northern Kentucky; Evansville, IN; Cincinnati, OH) and is suitable for representing hydrodynamic and water quality conditions occurring in the Delaware River and its tributaries. EFDC is a state-of-the-art finite difference model that can be used to simulate hydrodynamic and water quality behavior in one, two, or three dimensions in riverine, lacustrine, and estuarine environments (TetraTech, 2007). The model has been applied to hundreds of water bodies across the United States, including in the Delaware Bay and Chesapeake Bay.

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Section 3 Model Configuration and Development

Model configuration and development is the process of configuring a model to represent certain conditions of interest (e.g. combined sewer overflows, or bacteria concentrations) at a particular site. The model development process for DELCORA's water quality modeling framework included definition of 1) important physical and chemical processes, 2) model inputs and assumptions influencing the modeled processes, 3) the spatial extent of model calculations, and 4) the time span of model calculations. This process is described below for each of the components of the modeling framework.

3.1 Watershed Model

3.1.1 Purpose and Description

The purpose of the Chester and Ridley Creek watershed model is to estimate flow conditions in the creeks for periods when USGS flow data for the two creeks are unavailable for the application period. Gage data are available through much of the typical period, except for a long data gap in Ridley Creek (9/22/1995 through 12/31/1996) and some shorter periods at both gages. The watershed model is used to fill in those data gaps, as well as to estimate the flow contribution of the separate storm sewer areas within the DELCORA project area as represented in Figure 1-3.

The watershed model consists of a set of subcatchments representing the hydrology of the system. The subcatchments are connected to a network of stream segments representing the hydraulics of the system. During wet weather events, runoff and associated pollutants are transported from the subcatchments to the stream network, and ultimately discharge to Chester Creek, Ridley Creek, or the Delaware River.

To set up the watershed model in SWMM, processes influencing the system's hydrology and hydraulics were characterized. Several different types of data were used for this characterization. The processes that were modeled and the relevant data that were collected and analyzed for setting up the watershed model are further described below.

3.1.2 Model Processes

The first step in model development is determining what hydraulic and water quality processes should be included. SWMM is capable of modeling six processes: rainfall/runoff, infiltration, snow melt, groundwater, flow routing, and water quality. To meet the objectives of this model three of these processes were used: rainfall/runoff, infiltration, and flow routing. The other three processes were not used or were modified as follows:

- Snow melt: it was assumed that snow melt typically does not generate significant runoff in the DELCORA area, so this process was not included.

- Groundwater: the contribution of groundwater to stream flow was approximated using a base flow time pattern for select model nodes as well as the RTK model for faster interflow response (See Section 3.1.2.3), so explicitly modeling groundwater was not necessary.
- Water quality: water quality was modeled by assigning wet weather and dry weather flow bacteria concentration to the modeled flows. These concentrations were calculated based on the results from the dry and wet weather monitoring program. Explicitly modeling pollutant loads through build-up/wash-off functions was therefore not necessary.

Site-specific watershed data were used to define key inputs and to represent the local relationship between precipitation, runoff, and in-stream flow conditions. These data include area, slope, percent impervious, soil type (infiltration), depression storage, base flow, and Manning's roughness coefficient. General watershed model characteristics for each watershed and the source of information are provided in Table 3-1, and are further explained in the subsections following the table. The modeled hydraulic and runoff response was further refined through the calibration process.

Table 3-1: Watershed Model Characteristics

	Chester Creek	Ridley Creek	Data Source
Annual Precipitation (in)	41.6	41.6	NOAA NCDC (Philadelphia International Airport)[2]
Drainage Area (sq. miles)	65.6	38.2	USGS Streamstats[3]
Imperviousness (%)	13.2	8.5	USGS Streamstats[2]
Average Overland Slope (%)	7.5	7.5	USGS Streamstats[2]
Top Three Land Uses (%)	Residential (45%)	Residential (44%)	Delaware Valley Regional Planning Commission[4]
	Wooded (24%)	Wooded (29%)	
	Agriculture (7%)	Agriculture (13%)	
Dominant Hydrologic Soil Group	HSG B	HSG B	USDA NRCS SSURGO 2016[5]
Average Watershed Yield (MG/mi^2)	10.4	9.2	USGS Gage Data[6]

[2] https://www.ncdc.noaa.gov/cdo-web/
[3] https://streamstats.usgs.gov/ss/
[4] https://www.dvrpc.org/Mapping/Data/
[5] https://websoilsurvey.nrcs.usda.gov/
[6] https://waterdata.usgs.gov

3.1.2.1 Subwatershed Delineations

The watershed model consists of a set of subcatchments representing the drainage area of the Chester Creek and Ridley Creek watershed. For modeling purposes, each tributary's watershed was subdivided into smaller subwatersheds using the hydrologic unit code (HUC) delineations developed by the USGS[7] as the initial basis for the delineation. These HUC 10 subwatersheds were then divided into smaller subcatchments through interpretation of a digital elevation model (DEM) in ArcGIS, and consideration of tributary confluences, flow metering stations, water quality monitoring stations, road planimetric data, and the delineation of the Chester City separate sewer area as well as the combined sewer area. The separate sewer area and combined sewer area were previously delineated by the City of Chester and Greeley & Hansen respectively. Overall, the drainage areas downstream of the USGS gages were divided into smaller subcatchments compared to the upstream areas because more information was available to facilitate the delineations at the subcatchment level. Additionally, the majority of drainage area downstream of the USGS gages also coincides with the focus area of the modeling. The delineation of the two watersheds are shown in Figure 3-1.

3.1.2.2 Meteorology

SWMM requires two meteorological inputs: a precipitation time series to generate runoff, and temperature data to calculate evaporation. Several meteorological stations are located in or near the Ridley and Chester Creek Watershed, as shown in Figure 3-2.

Complete time series for precipitation (hourly and daily), daily minimum and maximum temperatures were available at Philadelphia International Airport from 1948 through current conditions, including the watershed calibration time period of 2006 through 2016. All meteorological data at this station was obtained from NCDC, which is operated by the National Oceanic and Atmospheric Administration (NOAA). The other stations either have incomplete data sets, recordings that do not overlap with the complete calibration period, or the recorded time steps are too coarse (larger time step than hourly). These stations are therefore not suitable for the watershed hydrology calibration.

[7] https://water.usgs.gov/GIS/huc.html

Figure 3-1: Extent of Watershed Model

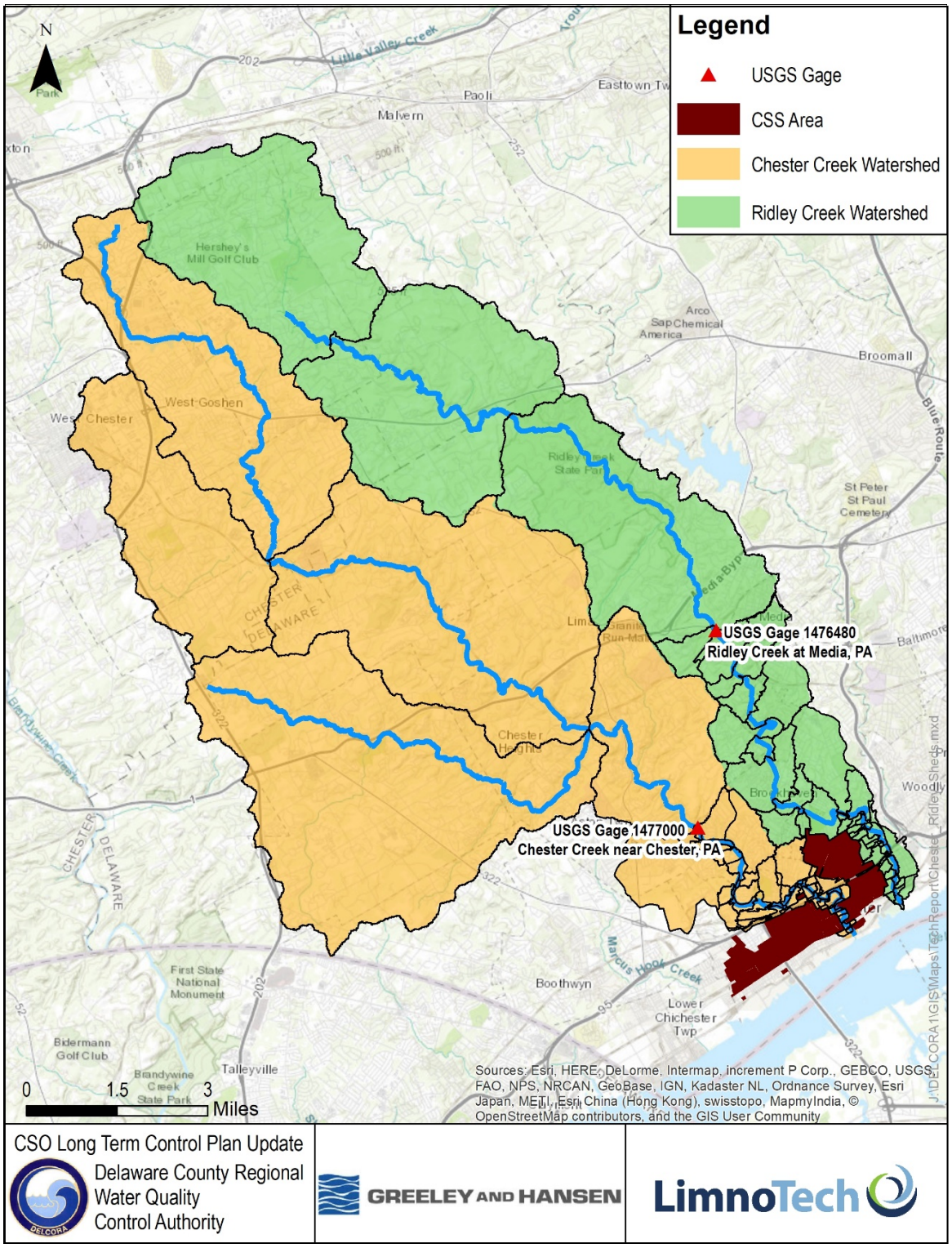
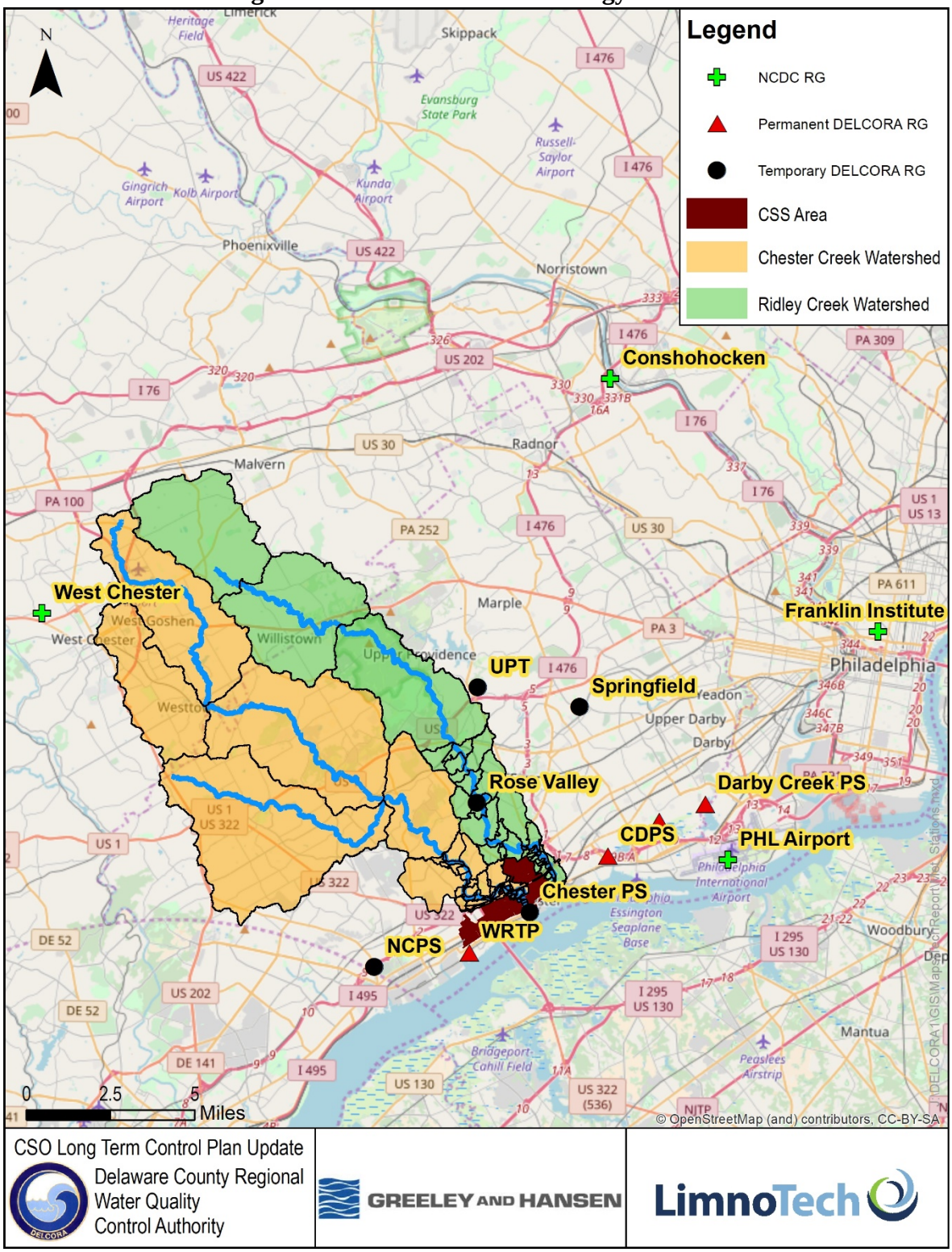
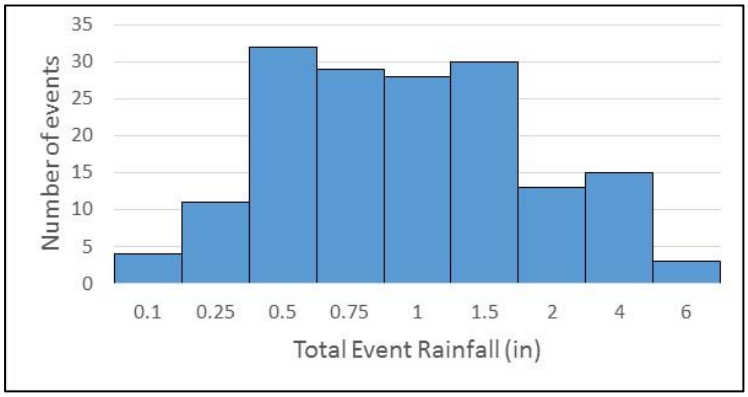


Figure 3-2: Location of Meteorology Stations



The availability of only one gage for the watershed calibration means that the model may be less accurate for rainfall patterns that vary across the watershed. In order to minimize the effect of this spatial variability on the calibration, a set of 165 rainfall events were chosen from the 10-year calibration period when there was consistency between the total rainfall depth at Philadelphia International Airport and the observed flow runoff depth at the Ridley and Chester Creek USGS gages. Two criteria were used to evaluate "consistency" between observed precipitation and flow: (1) precipitation events must increase baseflow by at least 3 times, and (2) the observed flow response occurs within 4 hours of the precipitation event. The selected rainfall events vary in intensity, duration, and overall rainfall depth, as shown in Figure 3-3 below.

Figure 3-3: Watershed Calibration Events: Rainfall Depths



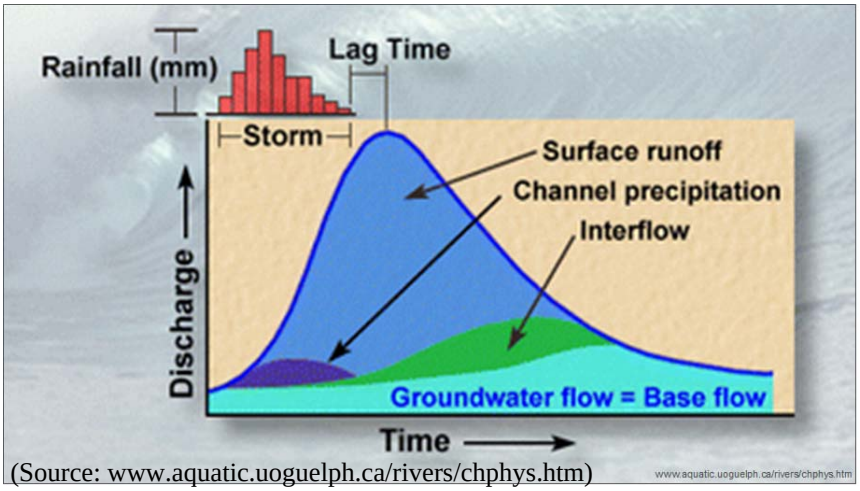
3.1.2.3 Hydrology

The total observed stream discharge relative to a rain event can be separated into different categories of flow, including:

- Channel precipitation: This is flow from rain that falls directly on streams. It represents a very small portion of the total stream flow, but produces an almost instantaneous increase in flow relative to the beginning of a rain event.
- Direct surface runoff: This represents the portion of rain that lands on the ground surface and becomes stormwater runoff. This flow builds up quickly (i.e.: short lag time) relative to the beginning of a rain event, especially in urban areas. Direct runoff can enter streams through overland flow (flow moving over the top of the ground surface) or through a sewer pipe conveyance system.
- Interflow: This is the flow from the portion of rain that infiltrates into the ground and moves laterally through the shallow unsaturated soils towards streams. This flow has a more delayed response compared to surface runoff.
- Groundwater or base flow: This is flow entering the creek from the groundwater table. This flow has a much slower response time to rainfall compared to direct surface runoff and interflow.

A generalized streamflow response to a rainfall event is shown in Figure 3-4 below.

Figure 3-4: Generic Streamflow Hydrograph



(Source: www.aquatic.uoguelph.ca/rivers/chphys.htm)

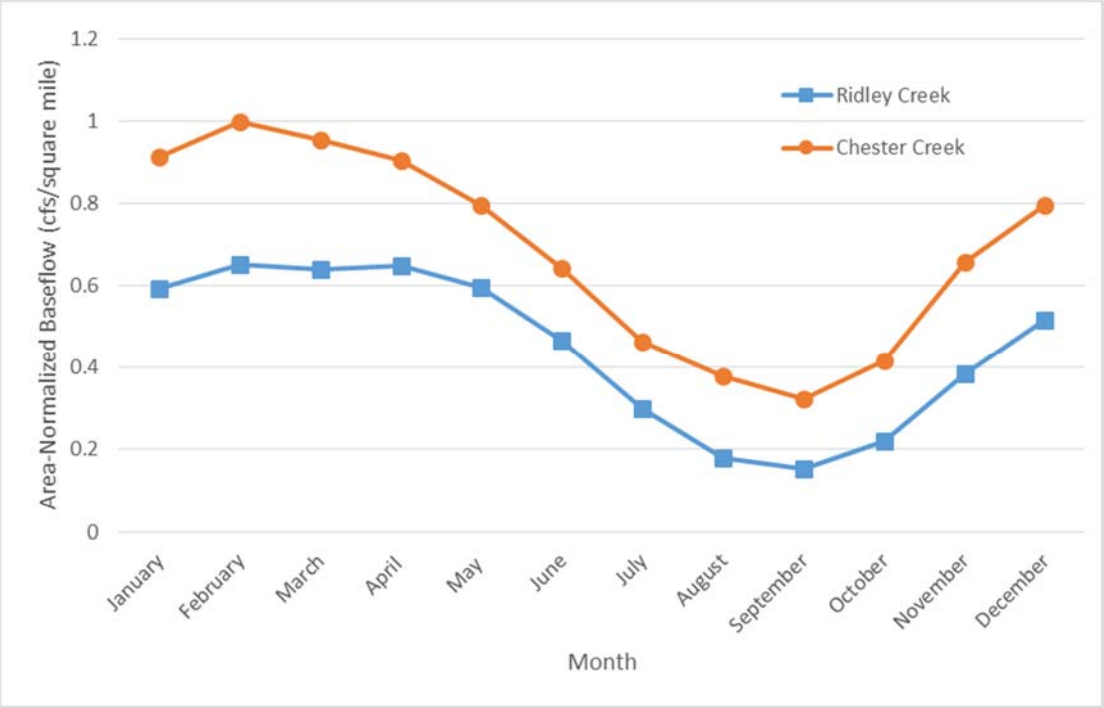
The watershed model simulates the direct surface runoff via the SWMM runoff block using a nonlinear reservoir method. Parameters that influence the surface runoff are explained in the subsections below.

Initial model results and comparisons with observed stream flows at the USGS gages indicated a significant interflow response during wet weather. Interflow was therefore simulated using the RTK approach in the SWMM model since sufficient data for explicit groundwater modeling within SWMM was not available. RTK is an application of the synthetic unit hydrograph method and is based on fitting up to three triangular unit hydrographs to an observed hydrograph to estimate the fast, medium, and slow stream responses (EPA 2008; Lai, 2017).

Surface Runoff and Channel precipitation are represented by one of the three RTK hydrographs that is generally used to represent inflow to sewers. Interflow is represented by the RTK hydrograph that is used to represent short term infiltration. Base flow is represented by the RTK hydrograph that is used to estimate groundwater flow.

Base flow comprises the majority of stream flow during extended periods of dry weather, and can be estimated from measured flow data time series. The flow records from the two USGS gages at Ridley and Chester Creek were used to approximate base flow within each creek. Using 10 years of flow data, monthly 7Q10 flows were calculated using methods from Risley et al (2008). The 7Q10 flows represent flows in a stream during dry periods and can be estimated on a monthly basis to capture the seasonal variability in these dry flows. These values were then normalized to watershed area (in mi^2) and applied to subcatchments that contribute to the streams and creeks that are included in the watershed model (Figure 3-5). Base flow was added to the watershed model as a constant inflow with monthly variations based on the area of the contributing subwatershed.

Figure 3-5: Area-Normalized Base Flow Values for Ridley and Chester Creek



3.1.2.4 Soil infiltration

SWMM offers several methods for soil infiltration (listed in order of increasing complexity): Curve Number, Horton's, and Green-Ampt. The curve number methodology is a fairly coarse representation of soil infiltration and does not allow for time-and-rain variable soil infiltration variations. The Green-Ampt method requires very site-specific knowledge to characterize infiltration parameters, which were not readily available for this project. Therefore, the Horton method was selected as most appropriate for the watershed model. Horton's method uses a set of parameters that defines the maximum infiltration rate, the minimum infiltration rate, the decay rate for transitioning from maximum to minimum infiltration rates, a recovery rate for transitioning from minimum to maximum infiltration rates, and an overall maximum infiltration volume. These parameters are determined based on the hydrologic soil groups that are present in the watershed model extent.

The hydrologic properties of soils influence how quickly and how much precipitation is converted to runoff. In general, soils can be classified by hydrologic soil group (HSG). There are four basic HSGs, called HSG A, HSG B, HSG C, and HSG D. Soils in group A have the lowest runoff potential, while soils in group D have the greatest runoff potential (Mockus et al., 2004). These four basic classifications can then be broken down into dual classifications such as A/D or B/D. Dual classifications represent soils that are classified as group D because of a high water table, causing them to have a high runoff potential. However, if the water table were lowered, these soils would have a lower runoff potential (such as group A or B).

To characterize the soils within the model extent, data were downloaded from the 2016 Soil Survey Geographic (SSURGO) database provided by the National Resources Conservation Service (NRCS). A wide range of HSGs are represented within the SWMM model extent (Table 3-2). In addition to the four standard categories (HSG A through D), several dual classifications are also

represented. These dual classifications were assumed to be undrained, and were therefore assigned the same soil properties as HSG D. Any soil types with no official hydrologic soil group classification were also assumed to be mainly poorly drained and would have a high potential for runoff. Therefore, they were assigned the same soil properties as HSG D.

The soil infiltration parameters associated with each HSG were estimated from tables provided in the *User's Guide to SWMM 5* (James et al., 2010). An average minimum and average maximum value from the suggested range was used for the infiltration rate. In the absence of detailed soil data, the decay constant and drying time were assumed to be the same for all soil types within the model extent, and a maximum infiltration volume was not specified.

Table 3-2: Description of Hydrologic Soil Groups within Watershed Model Extent

Hydrologic Soil Group	Description	Ridley Creek		Chester Creek	
		Area (acres)	% of Total	Area (acres)	% of Total
A	Soils with low runoff potential	7.3	19%	7.0	11%
A/D	Soils with high runoff potential unless drained. Otherwise classified as HSG A.	0.0	0%	0.0	0%
B	Soils with moderately low runoff potential	12.6	33%	27.8	42%
B/D	Soils with high runoff potential unless drained. Otherwise classified as HSG B.	2.0	5%	4.1	6%
C	Soils with moderately high runoff potential	12.0	32%	18.8	29%
C/D	Soils with high runoff potential unless drained. Otherwise classified as HSG C.	3.2	8%	6.8	10%
D	Soils with high runoff potential	1.1	3%	1.1	2%
	TOTAL	38.2	100.0%	65.6	100.0%

3.1.2.5 Impervious Area and Slope

Percent impervious area and percent slope strongly influence the amount of precipitation that runs off to the streams. Large amounts of impervious area and/or high slopes can lead to high-volume and "flashy" runoff. To estimate median percent impervious area for each subcatchment, a high-

resolution land cover raster was downloaded from the Chesapeake Conservancy[8]. Percent slope for each subcatchment was estimated using the National Elevation Dataset (NED) (Gesch et al., 2002). The average percent imperviousness for Chester and Ridley creek are 10% and 8.5% respectively.

3.1.2.6 Other Subcatchment Parameters

In addition to the major subcatchment parameters listed in the sections above, there are five additional parameters that were characterized for each subcatchment: Manning's n coefficient for overland flow over pervious and impervious areas, depression storage for pervious and impervious areas, and percent of impervious area with zero depression storage (Table 3-3). These parameters can be used to adjust the shape and the timing of the hydrograph. For simplicity, these parameters were set to constant values for all subcatchments. The values were selected based on literature values from the SWMM5 manual (James et al., 2010).

Table 3-3: Additional SWMM Subcatchment Parameters

Parameter	Value	Description	Source
Manning's n for overland flow over impervious area	0.018	Average value	Mc Cuen et al. (1996)
Manning's n for overland flow over pervious area	0.25	Dense grass	Mc Cuen et al. (1996)
Depression storage for impervious area	0.075	Average value for impervious surfaces	ASCE (1992)
Depression storage for pervious areas	0.15	Average value for lawns	ASCE (1992)
Percent of impervious area with no depression storage	25%	Default value in SWMM	-

3.1.2.7 Hydraulics and Routing

SWMM offers three methods for routing water through the stream network (listed in order of increasing complexity): steady flow, kinematic wave, and dynamic wave. Dynamic wave was selected for the routing portion of the model. The dynamic wave model can account for channel storage, backwater, entrance/exit losses, flow reversal, and pressurized flow. The dynamic wave model allows for more complex flow conditions than the other routing methods, but requires the use of smaller computational time steps, so choosing this method generally increases the model run times. This method was selected because it has the potential to produce more accurate results.

[8] https://chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/land-cover-data-project/.

3.1.2.8 Stream Network

The stream network that makes up Chester and Ridley Creek upstream of Chester City were developed using two sources. Hydrography data were acquired from the National Hydrography Dataset (NHD Plus), which is developed by USEPA Office of Water and the US Geological Survey (USGS)[9]. This dataset includes nationwide spatial information about a variety of waterbodies, including streams, rivers, lakes, and ponds. NHD Plus was modified using a digital elevation model developed from LiDAR mass points. Modifications of the NHD Plus flow lines were made to align with the lowest nearby digital elevation model (DEM) elevation and with aerial photographs. No bathymetric data was available for the stream network upstream of Chester City, so the channels were assumed to be trapezoidal channels with a connected floodplain. The geometry of the channels were first estimated using the available DEM data, and then modified during the hydrology calibration process. In the tidal regions of the two Creeks, bathymetric data was collected through a field survey and was used to specify the channel geometry in the receiving water model. The bathymetric field survey of Chester and Ridley Creek was conducted in March of 2017, and the results are described in Appendix A.

3.1.2.9 Water Quality

To estimate tributary water quality concentrations, modeled tributary flows were separated into base flow and runoff components. Event mean concentrations for each component were then estimated based on sampling data (see Section 4.1), then later refined during the water quality model calibration process, which is described in Section 4.2. These event mean concentrations were then associated with each flow component (i.e. runoff and base flow) to estimate POC loads in the tributaries. This method allowed for time-variable POC concentrations that are consistent with the timing of the wet weather flow response.

3.1.2.10 Linkage to the EFDC Water Quality Model

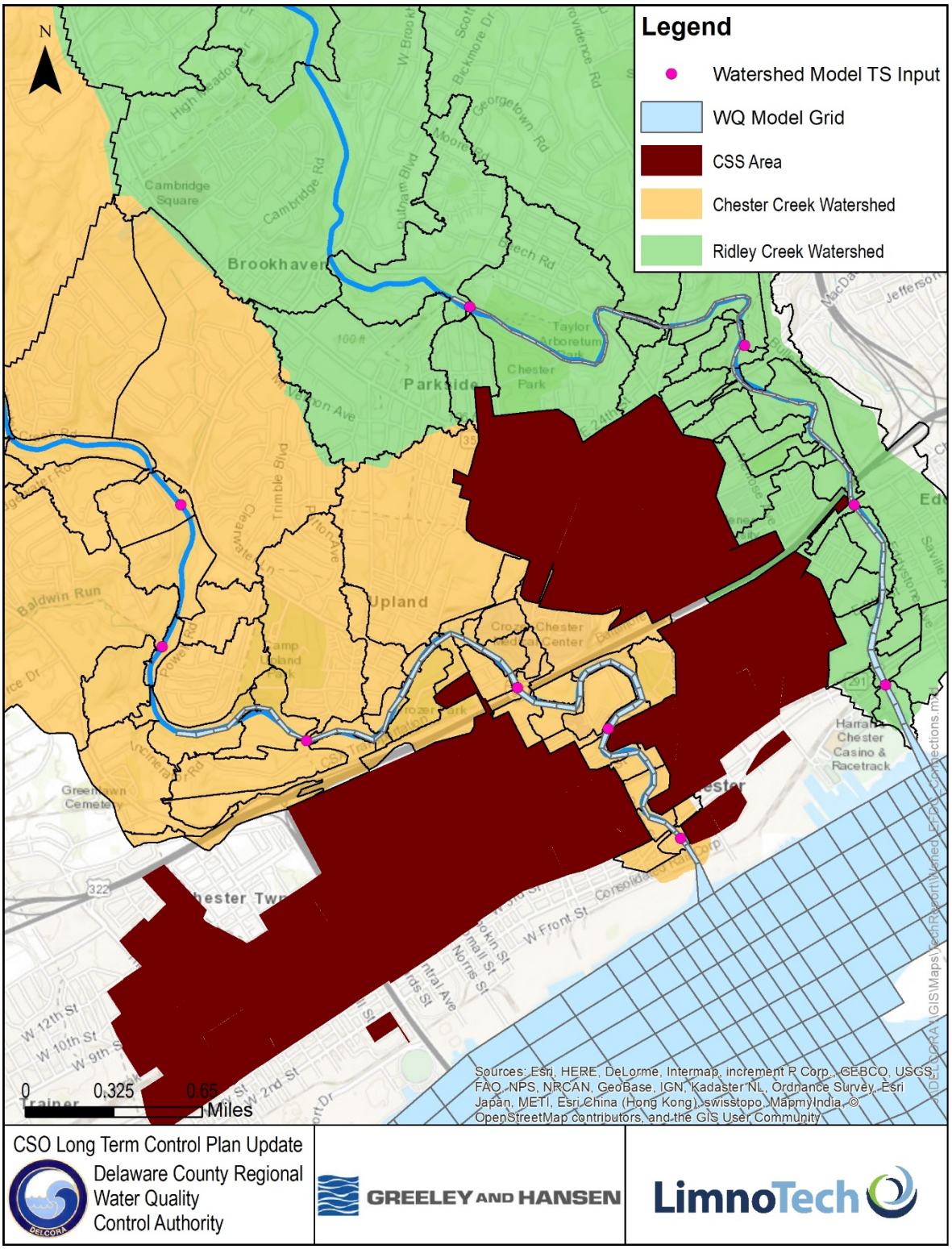
The hydrograph time series (TS) produced by the watershed model were tied into the EFDC at the most appropriate geographic location. These linkages are shown in Figure 3-6.

3.2 DELCORA Combined Sewer System Model Development

The DELCORA combined sewer system (CSS) hydrologic and hydraulic (H&H) model used for this study was developed by Greeley and Hansen (GH) to support the DELCORA Long Term Control Plan Update (LTCPU). This model has been documented in detail in the Sewer System Hydrologic and Hydraulic Model Report (DELCORA, 2017).

[9] https://nhd.usgs.gov/

Figure 3-6: Watershed-Receiving Water Model Connections



3.3 Philadelphia Simplified CSO Model

3.3.1 Purpose and Description

The Philadelphia CSO system is a complex sewer system network managed by the Philadelphia Water Department. It has CSO outfalls located along the Western shore of the Delaware River, the Schuylkill River, Frankford Creek, Pennypack Creek, Tacony Creek, and Cobbs Creek. The bacteria loads from these outfalls contribute to the overall bacteria concentrations in the Delaware River upstream of the DELCORA project area. The Philadelphia CSO model developed for the purpose of this project is a simplified model that approximates the storage volume within the CSO network and magnitude and frequency of Philadelphia CSO discharges and associated POC loads, thereby accounting for Philadelphia CSO POC water quality impacts on the downstream DELCORA service area.

3.3.2 Model Processes

Due to the limited amount of publically available information related to the Philadelphia sewer network, and no publically available calibration data such as metered flows, the Philadelphia CSO model constructed for the purposes of this project is a simplified hydrologic model. It does not explicitly represent the hydraulics of the Philadelphia combined sewer network but rather uses hydrologic functions and parameters available in the SWMM software to approximate the storage volume and flow characteristics within the CSO sewer network, thereby simulating the magnitude (volume) and frequency (timing) of Philadelphia CSO discharges.

Development and calibration of this model relied principally on information from the 2015 and 2016 annual reports of Philadelphia CSO model overflows (PWD, 2015-2016). A summary of information available from these this reports are is shown in Table 3-4. Data from the 2015 annual report was then used to verify the developed model.

Table 3-4: Information Available from the 2016 Philadelphia CSO Model Annual Reports

Receiving Stream	Number of Outfalls (#)	Total Annual Overflow Events (#)	Total Annual Overflow Duration (hours)	Total Annual Overflow Volume (MG)
Cobbs Creek	34	21	46	667
Delaware River	54	33	135	5,025
Frankford Creek	16	39	111	1,000
Pennypack Creek	5	30	165	617
Schuylkill River	41	42	117	2,811
Tacony Creek	15	42	122	2,314

The information presented in the reports helped to constrain model inputs related to the CSS sewersheds, including the total subwatershed area, depression storage, average surface slope, and subwatershed width and length. These parameters were defined for each combined sewer outfall.

Section 4.3 describes how these model inputs were calibrated so that the model accurately computes the volume and frequency of Philadelphia CSOs.

3.4 Receiving Water Model Development

3.4.1 Purpose and Description

The receiving water quality model simulates POC concentrations in the tidal reaches of Chester and Ridley Creeks, as well as in the Delaware River near the DELCORA service area. These modeled POC concentrations will be compared to water quality standards to assess the influence of DELCORA CSO loads on present day water quality compliance. CSO control scenarios will then be simulated within the modeling framework to describe the associated improvements to water quality.

3.4.2 Model Processes

To compute POC concentrations in the receiving waters, the receiving water quality model integrates different known flow and POC contributions, the subsequent transport and mixing of these sources, and the decay of the POCs. Key features represented in the model include upstream Delaware River flows; tributary dry and wet weather flows, tidal conditions, and POC loads from the tributaries, the DELCORA CSOs, and the Philadelphia CSOs. The processes that were modeled and the relevant data that were collected and analyzed for setting up the receiving water quality model are further described below.

Figure 3-7 and Figure 3-8 illustrate the elements related to the development and calibration of the receiving water quality model. These are also further explained in the following subsections.

Figure 3-7: Water Quality Model Extent and Related Features

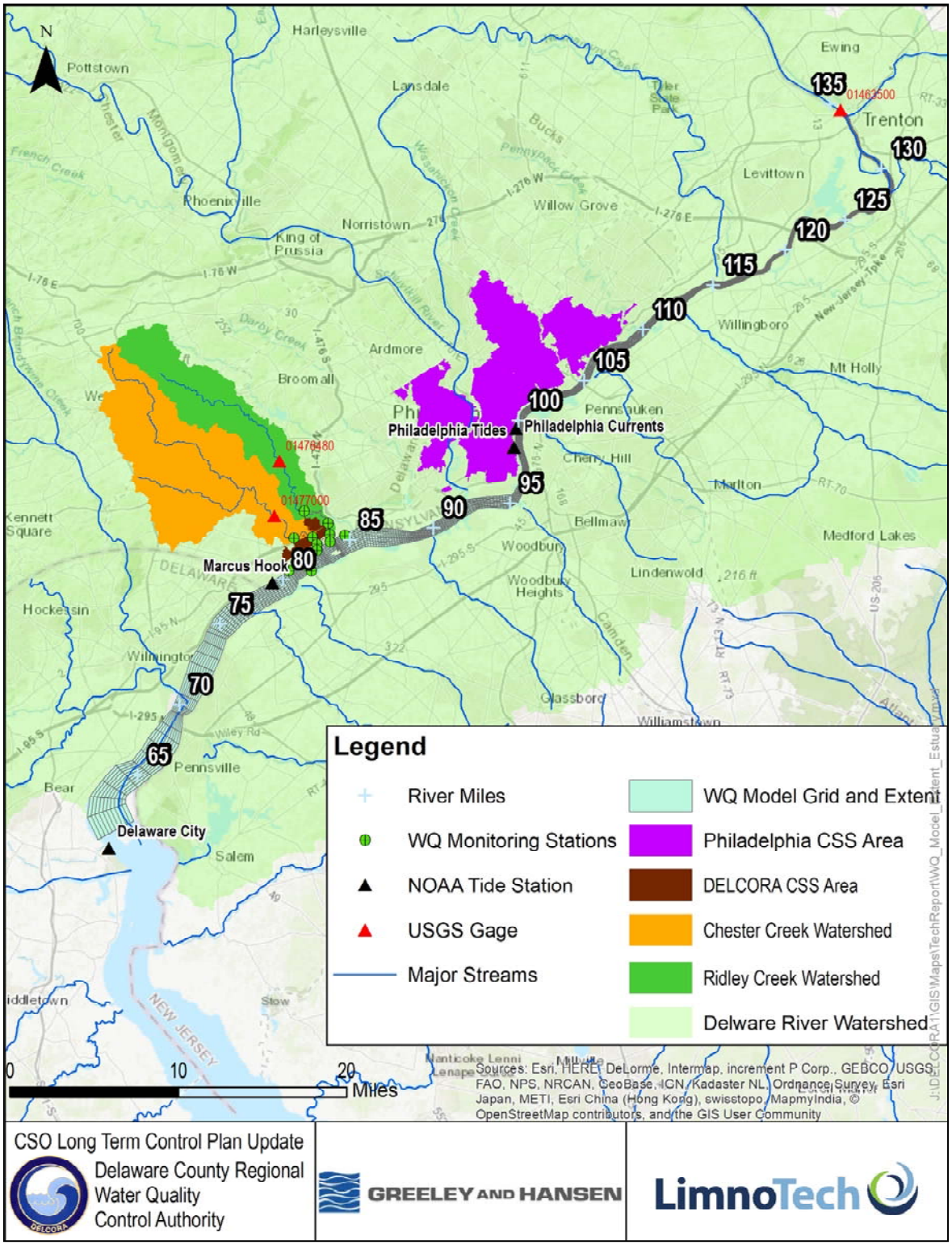
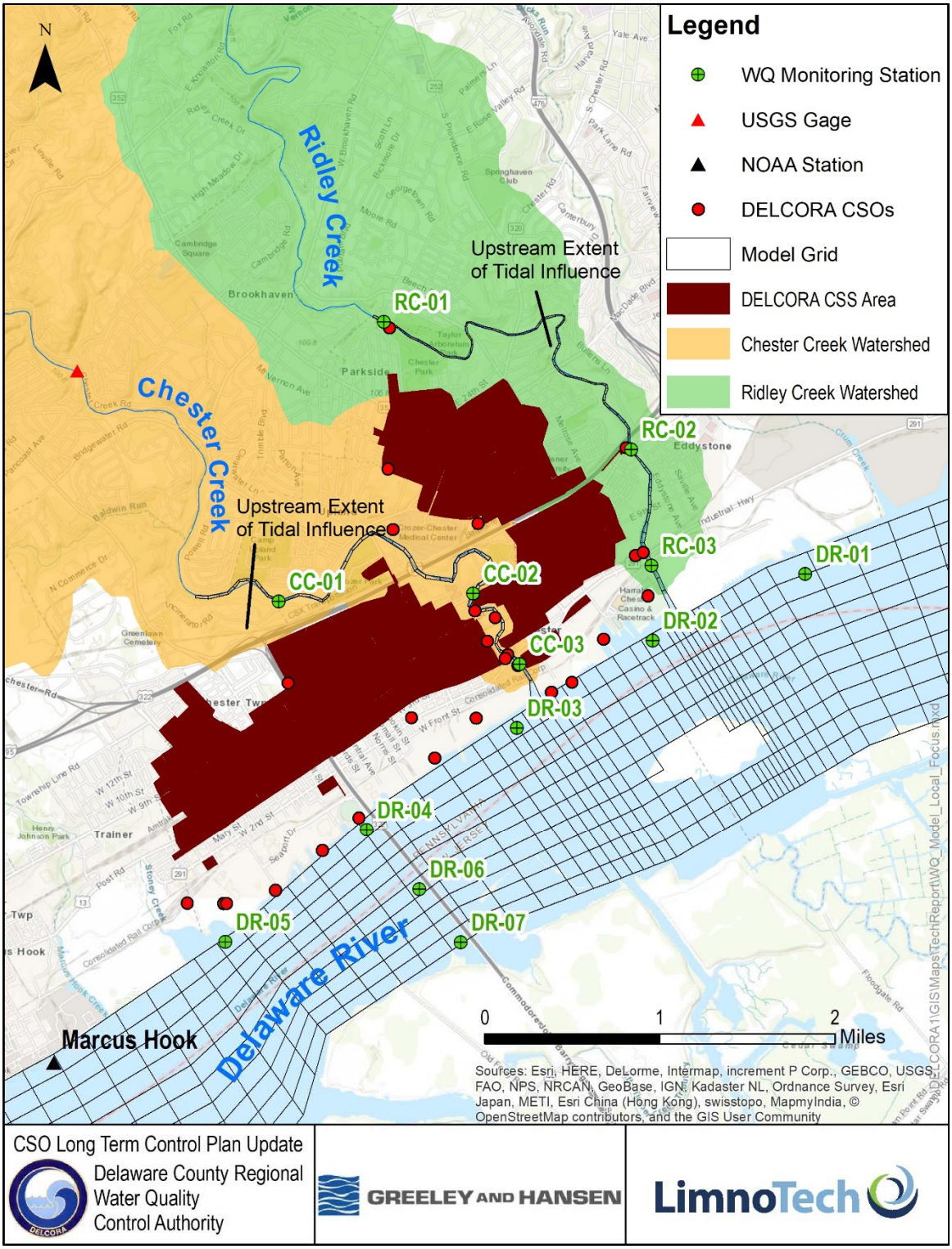


Figure 3-8: Water Quality Model and Related Features near DELCORA System



3.4.2.1 Model Extent and Grid Development

The intended use of the water quality model is to predict the local water quality near the DELCORA combined sewer outfalls. However, the extent of the model is much greater than this localized area in order to appropriately represent the mixing of DELCORA POC sources with background POC sources, and the back-and-forth tidal movement that occurs in the Delaware River. The DELCORA water quality model extends from the head of tide in Trenton, NJ to Delaware City, DE. The upstream limit was chosen because that is the limit of the tidal influence and because there is a USGS flow gage present. The downstream limit was chosen because it is well below the DELCORA CSO discharges and because there is a NOAA tidal station present. Both the USGS flow gage and the NOAA tidal station are used as boundary conditions to the model, as further described in Section 3.4.2.1.

The stream lengths that are represented in the model, along with the average grid cell dimensions are shown in Table 3-5. The model grid has the greatest detail near DELCORA CSOs to describe near-field concentration patterns during periods of CSO discharge, and less detail farther from DELCORA CSOs. Grid cell dimensions in Chester and Ridley Creeks were chosen to be long enough that they would not overly constrain the model time step and short enough that they would follow the sinuous paths of the creeks.

Table 3-5: EFDC Water Quality Model Grid Summary

	Miles of Stream Represented	Average Grid Cell Dimensions (LxWxD)*	Total Number of Cells Used	Average Number of Cells Across Stream Width	Average Number of Layers Through Stream Depth
Delaware River	73	1,000ft x 300ft x 23ft	3,766	10	4
Chester Creek	3.5	320ft x 90ft x 4ft	55	1	1
Ridley Creek	3.5	230ft x 60ft x 2ft	80	1	1

* Cell dimensions vary greatly across the model extent depending on the physical properties of the river.

3.4.2.2 Flow and POC Contributions

The EFDC water quality model includes flows and POC loads from a variety of sources, including:

- DELCORA CSOs, represented by the DELCORA H&H model and entered as flow and bacteria concentration time series at each location where DELCORA CSOs discharge into Ridley Creek, Chester Creek, and the Delaware River.
- Philadelphia CSOs, represented by the simplified Philadelphia CSO model, and entered as flow and bacteria concentration time series at the mouth of the tributaries where CSO discharges occur, or directly to the CSO discharge location along the Delaware River.

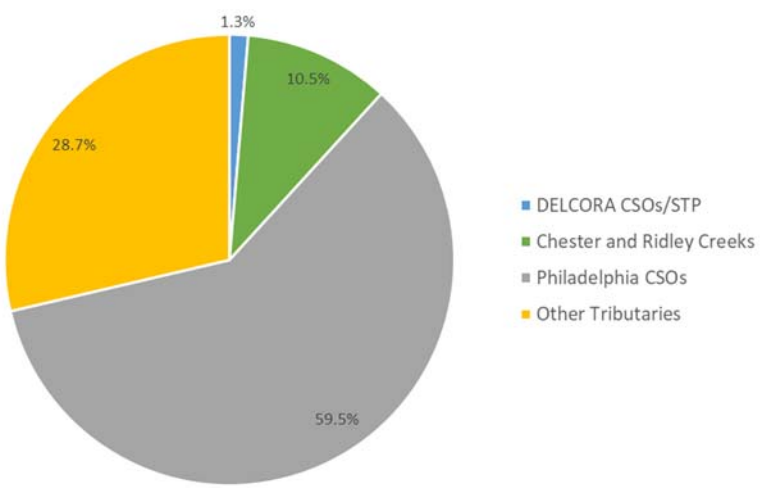
- Ridley and Chester Creek watershed sources, represented by the watershed model or USGS gage data, and entered as flow and bacteria time series at various locations along the two creeks, as explained in Section 3.1.2.9.
- Tributaries along the Delaware River but outside of the DELCORA project area, including, for examples, the Schuylkill River and Darby Creek. These are entered as flow and bacteria time series at the confluence of the tributaries and the Delaware River. The contributions from these tributaries were based on available USGS flow data. Average drainage area ratios were used for the ungaged portions of tributaries, including some tributaries which are entirely ungaged. Bacteria concentrations were estimated as they were for Ridley and Chester Creeks; by separating base flow and runoff and associating EMCs with each flow component, as explained in Section 3.1.2.9.

The respective percent contribution of modeled bacteria load from the different sources are shown in the figure below. The principle loads include the following:

- DELCORA CSO/STP: 1.3% of total load
- Chester and Ridley Creek above the CSO area: 10.5% of total load
- Philadelphia CSO: 59.5% of total load
- Other tributary loads: 28.7% of total load

These modeled bacteria loads were calculated by summing up the total flow contributions from each of the four major sources during both wet and dry weather conditions for the 3-year "Typical Year" application period. These volumes were multiplied by the respective EMC values to calculate the 3-year modeled load and relative percent contribution from each source. It should be noted that the relative contribution from the "Other Tributaries" source is the least constrained by actual monitoring data and is likely much higher in reality than what is shown in the figure. This load has little impact on the water quality and the calibration results near the DELCORA focus area.

Figure 3-9: Percent of Bacteria Load by Source



3.4.2.3 Hydrodynamic Processes

To quantify rates of transport and mixing, the receiving water model represents tidal hydrodynamics in the lower reaches of the creeks and in the Delaware River estuary. The main processes that effect river hydrodynamics include tidal phasing and amplitude, river velocities, flow contributions from tributaries along the Delaware River, and sediment bed resistance (roughness). To simulate the loss of POCs within the receiving water, a first-order, in-stream net decay rate was applied within the model.

Two boundary conditions are used to specify the hydrodynamic and water quality conditions at the upstream and downstream ends of the water quality model. At the upstream end of the model, near Trenton, NJ, flow from USGS gage #01463500 was used to specify the flow coming into the system. At the downstream end of the model, near Delaware City, DE, the Reedy Point NOAA gage #8551910 was used to specify the tidal water surface elevation. Constant bacteria concentrations of 10 #/100 mL were assumed at the upstream and downstream model boundaries, and model tests showed that the boundary conditions had a negligible influence on concentrations near the project area due to the long distances between the boundaries and the project area, and due to bacterial decay. Table 3-6 below summarizes the primary water quality model inputs and supporting data sources.

Table 3-6: Receiving Water Quality Model Inputs and Data Sources

Model Input	Data Source	Notes
Delaware River Bathymetry	NOAA bathymetric soundings	Used most contemporary data available for each reach of the Delaware River
Chester and Ridley Creek Bathymetry	LimnoTech bathymetric soundings	Survey conducted in 2017 (See appendix A)
Tributary Flow Rates	USGS gaged flow data	Used drainage area ratios to estimate flows in ungaged areas
Water Surface Elevations	NOAA 6-minute tidal water level data	Used NOAA gages within the model extent
Water Temperature	USGS daily water temperature data	Delaware River at Chester station (#01477050) Delaware River at Reedy Island Jetty (#1482800)
Meteorological Inputs (e.g. atmospheric pressure)	NOAA hourly meteorological data	Philadelphia International Airport
Upstream Boundary Condition	USGS gaged flow data	Delaware River at Trenton (#01463500)
Downstream Boundary Condition	NOAA 6-minute tidal water level data	Reedy Point station (#8551910)

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Section 4 Model Calibration

Model calibration is described in USEPA guidance (USEPA, 1994) as the "process of adjusting model parameters within physically defensible ranges until the resulting predictions give the best possible fit to the observed data." Model parameters and assumptions were initially defined to the extent possible based on site specific data. However, if site-specific data were not available, model parameters and assumptions were initially defined based on literature values. The calibration process fine-tuned these parameters, within reasonable bounds, to improve model calculations.

4.1 Site Specific Calibration Data

Site specific data used for calibrating the various models include USGS flow data, NOAA tide data, wet and dry weather monitoring within the DELCORA project area, and Delaware River Basin Commission (DRBC) monitoring data. These datasets are explained in further detail in the sections below. Water quality data was organized in a Microsoft (MS) Access database system to ensure consistency in naming and unit conventions, and for ease of extracting information for calibration purposes.

4.1.1 USGS Data

USGS flow data were used to calibrate the watershed model. The information is available through the USGS[10]. Two stations were used for calibration: Ridley Creek gage (#01476480) and Chester Creek gage (#01477000). The time period of 2006 to 2016 was used for watershed calibration, flow data from 2017 was used for the receiving water quality modeling calibration, and the time period of 1994-1996 was used for the typical period application. Availability of gage data during the typical period is variable, with a long period of data missing in Ridley Creek (9/22/1995 through 12/31/1996) and a few multi-day periods missing at both gages during the three year period. A third station at Trenton, NJ (#01463500) was used to specify the upstream boundary condition for the Delaware River portion of the water quality model. The locations of the USGS gages are shown in Figure 3-7.

4.1.2 NOAA Tide Data

Tide data representing tidal phasing (timing), amplitude (variations in water surface elevation), and current velocity (water speed and direction) were used to calibrate the hydrodynamic component of the water quality model. This information is available through NOAA[11]. Two tidal stations were used for calibration: the Philadelphia station (#8545240) and the Marcus Hook (#8540433) station. A third station at Reedy Point (#8551910) was used to specify the downstream boundary condition for the Delaware River portion of the water quality model. NOAA data from

[10] https://waterdata.usgs.gov/nwis
[11] https://tidesandcurrents.noaa.gov/

2017 was used to calibrate the hydrodynamics of the water quality model. The locations of the NOAA gages are shown in Figure 3-7.

4.1.3 DELCORA Wet and Dry Weather Monitoring Program

DELCORA conducted an extensive wet and dry weather monitoring program between March and June of 2017. Water quality data from this monitoring program was used to calibrate the water quality component of the water quality model and to set initial values for the dry weather, stormwater, and CSO POC event mean concentrations (EMCs). Monitoring was undertaken at thirteen (13) in-stream locations (seven on the Delaware River, three on Ridley Creek, and three on Chester Creek), four (4) CSO locations in the DELCORA combined sewer system area, and two (2) stormwater locations in the City of Chester municipal separate storm sewer system, as shown in Figure 3-7 and in more detail in Figure 4-1.

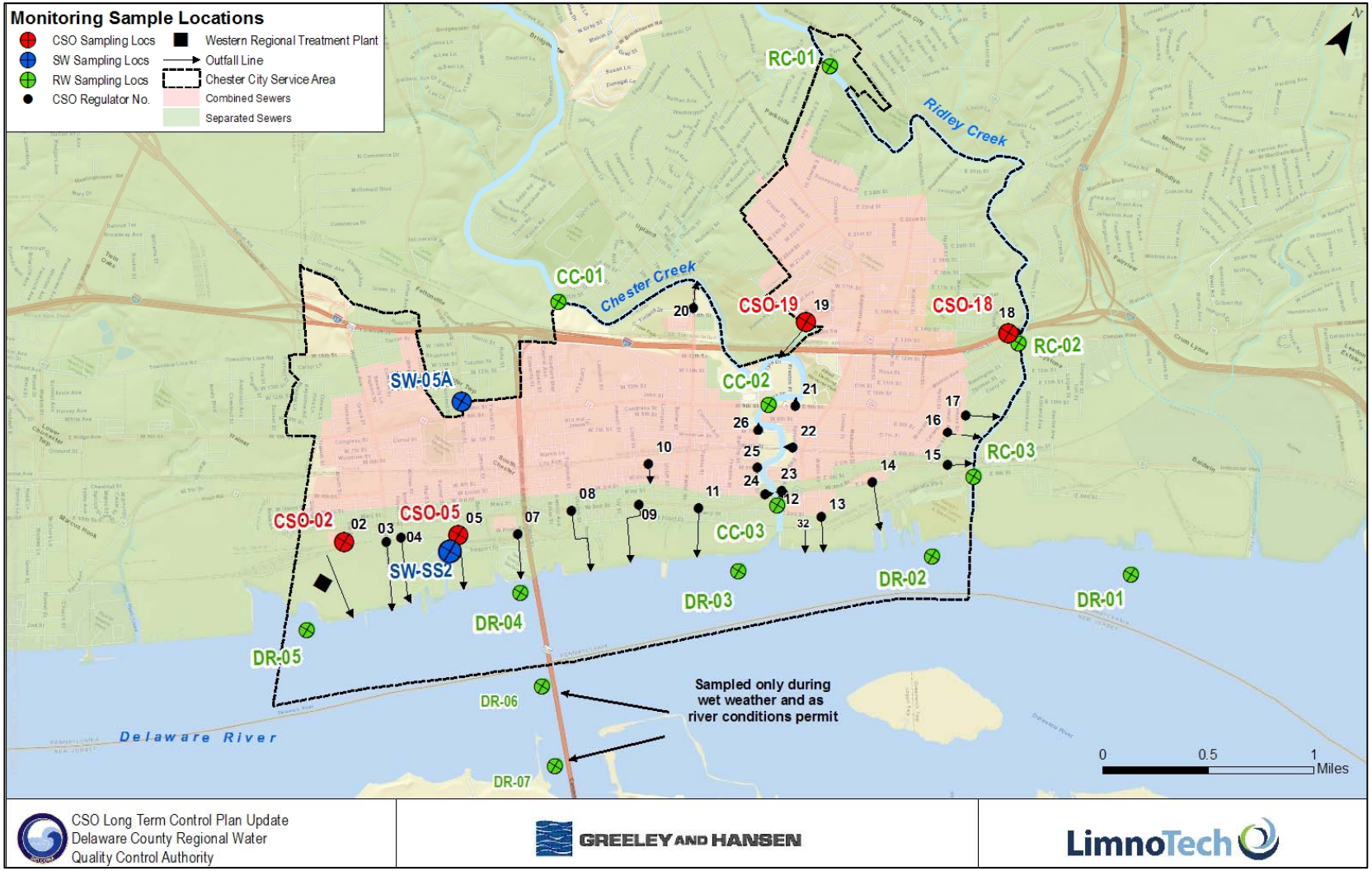
Monitoring locations were selected to characterize the watershed at a sub-watershed level, recognizing various political and hydrologic features, land uses and potential pollutant sources. Site selection and analytical parameters are designed to characterize stormwater outfalls, CSOs, tributaries upstream and within the Chester CSO discharge area, and the main stem of the Delaware River in the project area. The POCs sampled were Fecal coliform, *E.coli*, and *Enterococcus*.

Water quality monitoring and sampling was conducted as follows:

- Eleven (11) in-stream locations in the vicinity of the DELCORA CSO area were sampled for water quality for (3) dry weather events. The mid-stream and far-shore Delaware River locations were not sampled during the dry weather surveys because the water quality in the river is found to be relatively uniform laterally due to the lack of active sources during dry weather. These dry weather events were distributed across the sampling season, which was from March through June of 2017. Grab samples and *in situ* measurements were collected at each location during each event.
- All thirteen (13) in-stream locations were sampled for water quality using grab samples and *in situ* monitoring for three (3) discrete wet weather events.
- Up to four (4) CSO and two (2) stormwater outfall locations were sampled for water quality for the same three (3) discrete wet weather. Samples for all outfalls were collected as grab samples.

The sampling events were planned and distributed across the sampling season, which was from March through June 2017.

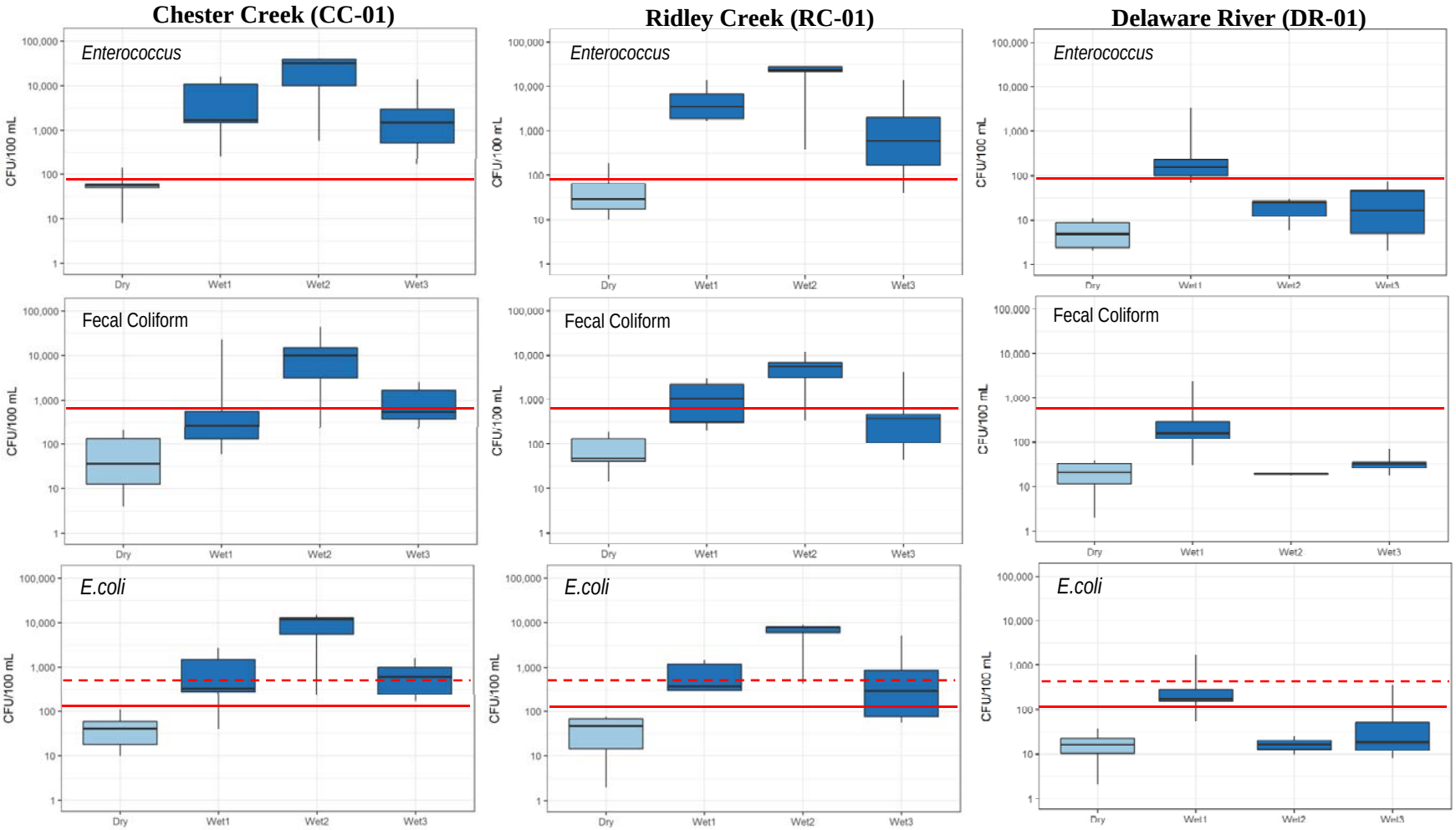
Figure 4-1: Receiving Water, Combined Sewer (CSO), and Stormwater (SW) Monitoring Locations



Detailed information on the results and observations from the DELCORA Water Quality Monitoring Program can be found in Appendix B. Some general observations are summarized below and shown in Figure 4-2.

- Dry weather POC concentrations at the most upstream locations (RC-01, CC-01, DR-01) in the creeks tended to be similar to each other;
- Dry weather concentrations at the most upstream locations (RC-01, CC-01) were mostly, but not always, below numeric thresholds used for water quality standard (WQS) criteria in the tributaries, and were well below WQS numeric thresholds in the Delaware River (DR-01);
- An increase in dry weather POC concentration from upstream to downstream was observed in each of the tributaries, suggesting there may be significant but currently unknown bacteria sources impacting these tributaries during dry weather. This occurs between sampling stations RC-01 and RC-02 in Ridley Creek and between CC-01 and CC-02 in Chester Creek, and is most pronounced for Fecal Coliform and *E.coli*;
- Wet weather concentrations at the most upstream monitoring locations in Chester Creek (CC-01) and Ridley Creek (RC-01) often exceed the monthly geometric mean WQS criteria for the three POCs. These stations are located upstream of the tidal influence, and the exceedances indicate that upstream areas of Ridley and Chester Creeks do not currently meet WQS (Figure 4-2). These data furthermore indicate the practical impossibility of meeting WQS through downstream CSO control.
- Wet weather concentrations at the most upstream monitoring location in the Delaware River sometimes also exceed numeric thresholds used for the monthly geometric mean water quality standard criteria, but less frequently as compared to the creeks. The E.coli statistical threshold value WQS was exceeded once under wet weather conditions during the sampling periods.
- The time series profiles in the Chester Creek and Ridley Creek waterbodies indicate that DELCORA's CSO discharges and Chester's stormwater discharges are not the only sources impacting these tributaries during wet weather. Upstream sources also contribute to high bacteria concentrations during wet weather events.

Figure 4-2: Sampling Results at Most Upstream Sampling Locations in the Creeks and the Delaware River



STV WQS (E.coli: 410 CFU/100ml (proposed); Fecal Coliform and Enterococcus: no STV standard)
Monthly Geometric Mean WQS (E.coli: 126#/100ml (proposed); Fecal Coliform: 770#/100ml; Enterococcus: 88#/100ml)

4.1.4 DRBC Monitoring Data

The Delaware River Basin Commission conducts regular monitoring of bacteria through its "Delaware Estuary Boat Run" program[12]. Ambient samples are collected monthly along the navigational channel from the head of tide at Trenton, N.J. to the mouth of the Delaware Bay. Samples are collected at 22 stations, once monthly from April to October. Data collected in 2012 were used to validate the water quality component of the water quality model, especially outside of the DELCORA project area, to evaluate the accuracy of modeled POC loads from the Philadelphia CSOs and the Schuylkill River, which are estimated to be the largest POC loads to the estuary. The locations of the DRBC monitoring locations are shown in Figure 3-7.

4.2 Watershed Model Calibration

The modeled hydraulic and runoff response was refined through the calibration process. In this process, the percent impervious, Manning's roughness, RTK interflow and base flow parameters were adjusted within defensible (literature) ranges so that modeled runoff volumes and peak flows were consistent with the observed flow data. Runoff response was calibrated using 165 wet weather events from 2006 to 2016. The rainfall events were chosen to represent a range of different intensities, duration, and rainfall depth. Moreover, these events were chosen when there was consistency between the total rainfall depth at Philadelphia International Airport and observed flow at the Ridley and Chester Creek USGS gages. Two criteria were used to evaluate "consistency" between observed precipitation and flow: (1) precipitation events must increase baseflow by at least 3 times, and (2) the observed flow response occurs within 4 hours of the precipitation event. Calibrating to this subset of events helps minimize the effect of issues with spatial variability of rainfall.

Calibration was evaluated both on total runoff volume, peak flow rates, and timing of the flow response. Various types of plots were used to help assess the calibration, including 1-to-1 plots, event-based time-series hydrographs, and bar charts. To evaluate the overall reasonableness of the watershed calibration, a weight of evidence approach (USEPA, 2015b; Donigian, 2002) was applied using several evaluation metrics, including:

1. Goodness of fit based on correlation coefficients for a wide range of calibration events;
2. Visual checks on continuous time series hydrograph data; and
3. Long term annual performance.

The performance of the model was first evaluated using 1-to-1 plots for comparisons of wet weather event flow volume and peak flows. This is illustrated in Figure 4-3. Both the correlation coefficient (R^2) and the Integral Square Error (ISE) can be used as measures of goodness-of-fit between observed and modeled hydrographs (Sarma, 1969). Overall, the watershed model performed satisfactorily for the total event volume and for the peak flow rates, as shown in the

[12] http://www.state.nj.us/drbc/quality/datum/boat-run.html#3

table below. The slope of each trend line is nearly 1, indicating that the modeled runoff response is unbiased.

Table 4-1: Watershed Model Performance Metrics

	Ridley Creek		Chester Creek	
	R^2	ISE	R^2	ISE
Total Event Volume	0.778 (Good)	5.6 (Very Good)	0.778 (Good)	4.61 (Very Good)
Peak Flow Rate	0.61 (Fair)	8.84 (Good)	0.605 (Fair)	7.2 (Good)

In addition to 1-to-1 plots, a visual check of flow time series (hydrographs) was conducted for the time period of March through May of 2017, when wet weather water quality sampling was conducted. Figure 4-4 and Figure 4-5 compare the observed and modeled flow hydrographs for Chester and Ridley Creeks respectively. The modeled response to the rainfall at the Philadelphia Airport closely tracks the gaged response observed at the two USGS gages. The timing of the peaks occur as expected relative to the occurrence of the rainfall event and to the observed data, providing confidence that the routing parameters used were adequately calibrated. The hydrograph figures also support the previous conclusion that overall, the model predicts volume well, but slightly over predicts peak flow rates. The hydrographs show that the model tends to under predict the effect of baseflow and interflow, despite using the SWMM RTK function.

The hydrograph figures show that there was a notable discrepancy between the observed data and modeled results for the event labeled as “Wet Weather Event 3”. This event and other specific wet weather events like this where the modeled runoff volume differed significantly from the observed runoff volume were reviewed more closely. Based upon this review, it was concluded that notable deviation between modeled and observed runoff volumes can occur when rainfall is not uniform over the watershed (e.g. when rainfall is concentrated in a small portion of the watershed) due to the fact that a single rain gage (Philadelphia Airport) is used in the watershed model to represent rainfall conditions over the entire watershed.

In the case of Wet Weather Event 3, the rainfall was concentrated in the vicinity of the City of Chester and areas east of the Delaware River (Figure 4-6). So while the observed rain at the Philadelphia Airport is significant (0.51 inches), very little rainfall fell in the upstream areas of the Ridley and Chester watersheds (less than 0.1 inches), and consequently, very little wet weather flow was observed at the two USGS flow gages (consistent with what would be expected from a small (<0.1-inch) rainfall event) whereas the model predicted more flow (consistent with what would be expected from a 0.5-inch storm).

While the limited number of rainfall gages is a constraint on the accuracy of the watershed model for a single wet weather event, on a long term basis (such as the three year typical hydrologic period) the model provides reasonably accurate estimates of creek flow, as demonstrated in Figure 4-3 on the previous page. In other words, even if an individual event was modeled too high or too low, on a long term basis, the model produces a typical response to rainfall conditions and yearly modeled creek flows during dry weather and wet weather are consistent with the observed data.

Figure 4-3: 1 to 1 Watershed Model Wet Weather Calibration Plots

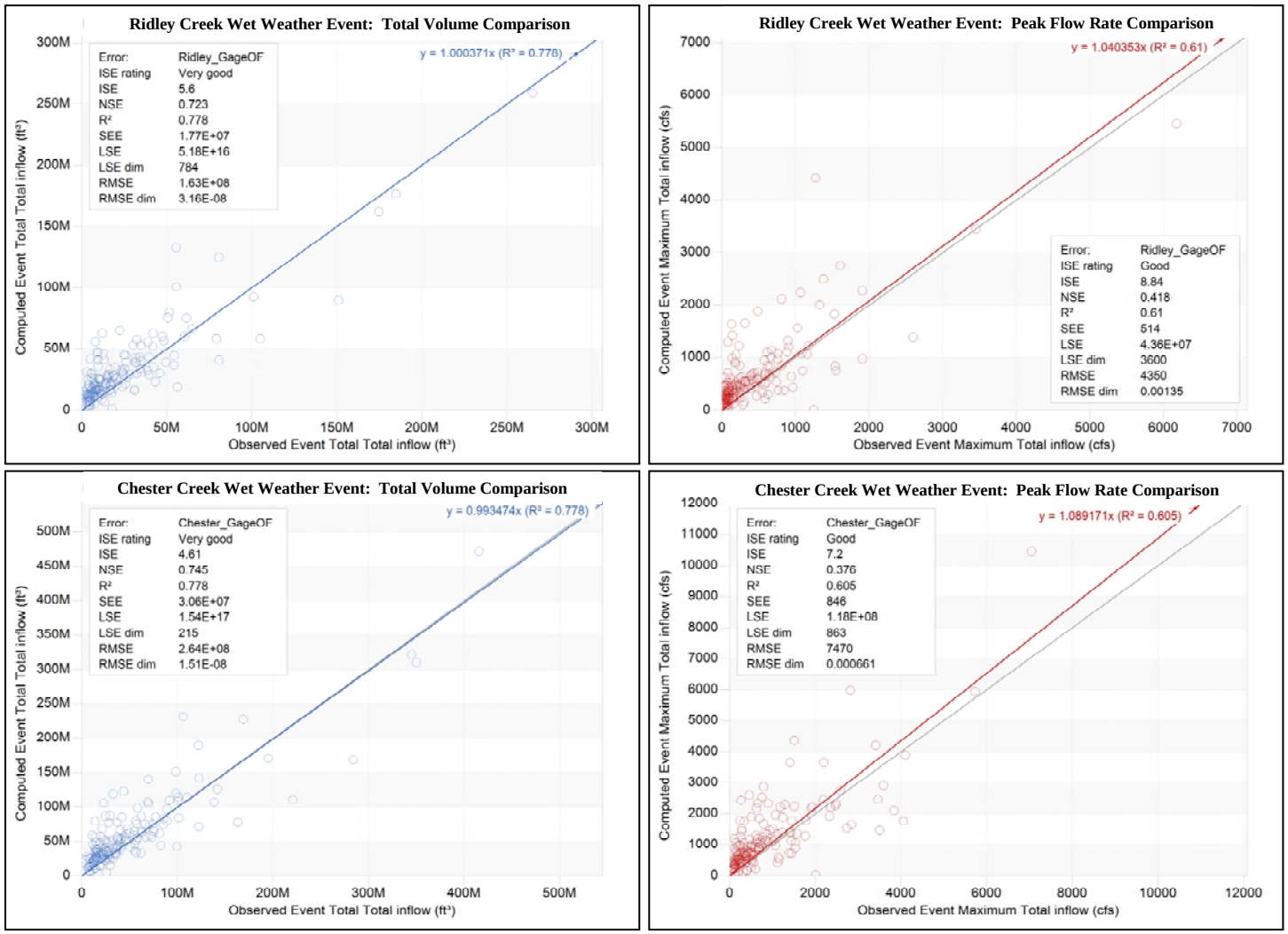


Figure 4-4: Chester Creek - Comparison of Modeled vs. Observed Flow Hydrograph

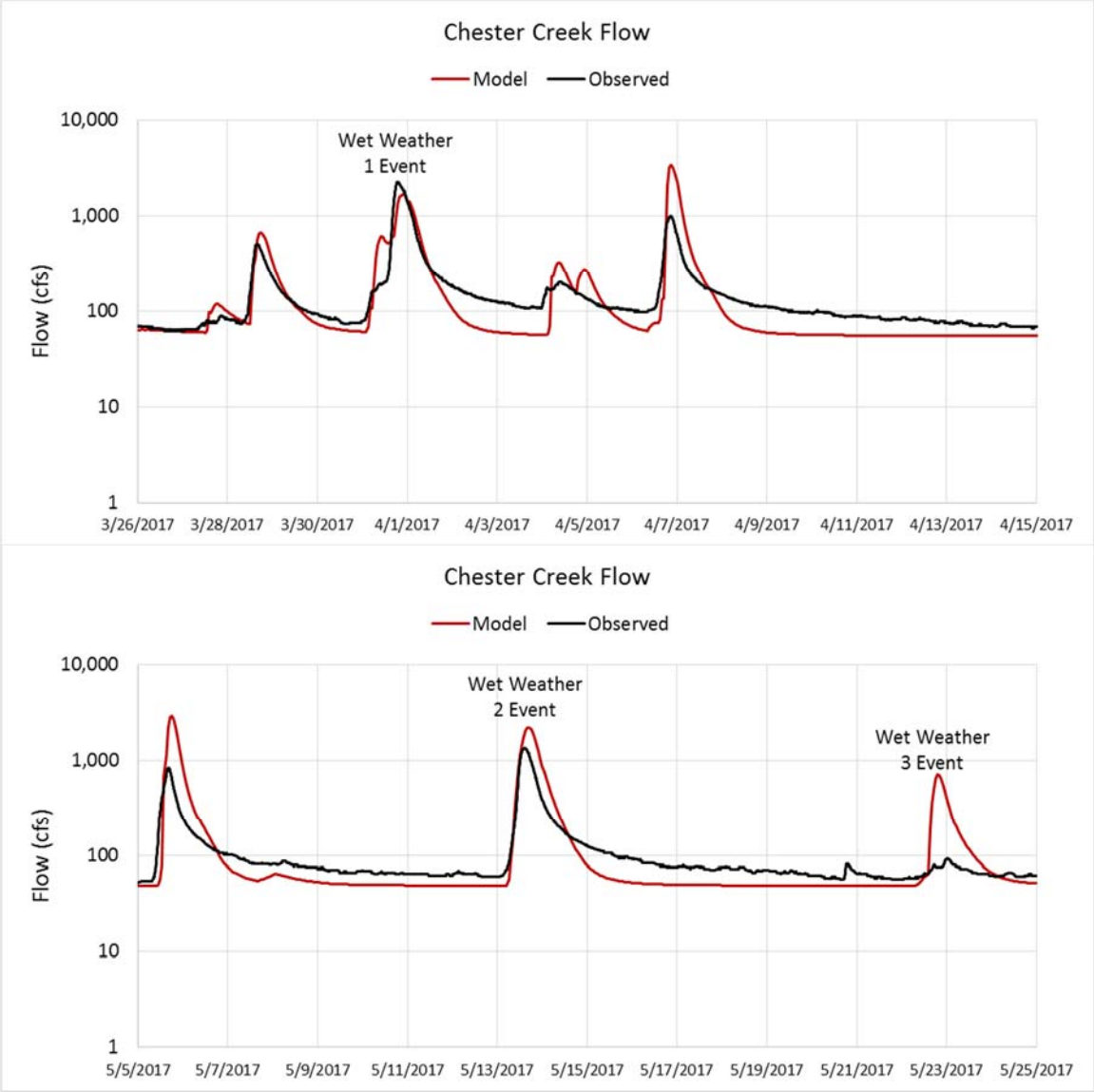


Figure 4-5: Ridley Creek - Comparison of Modeled vs. Observed Flow Hydrograph

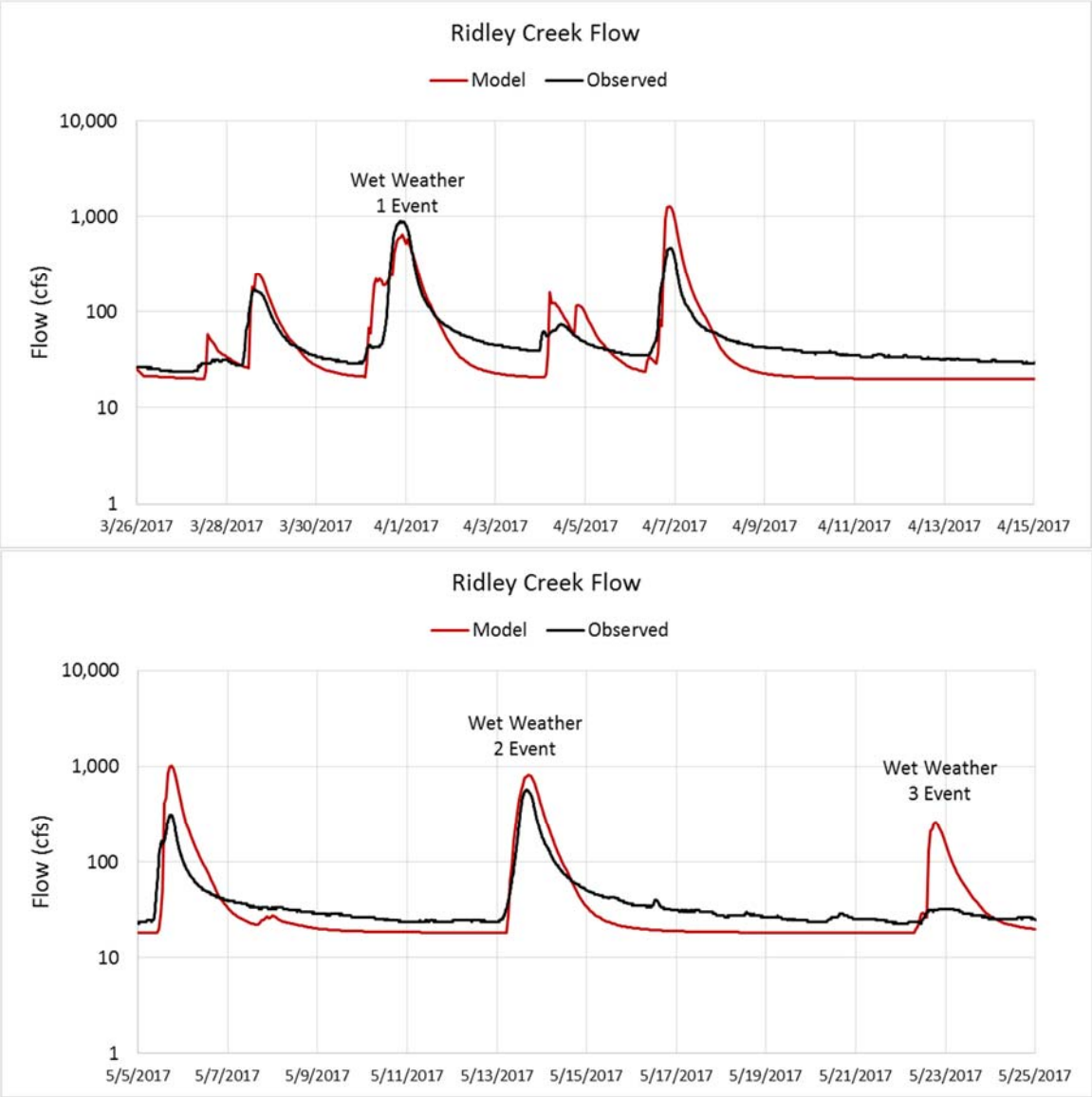
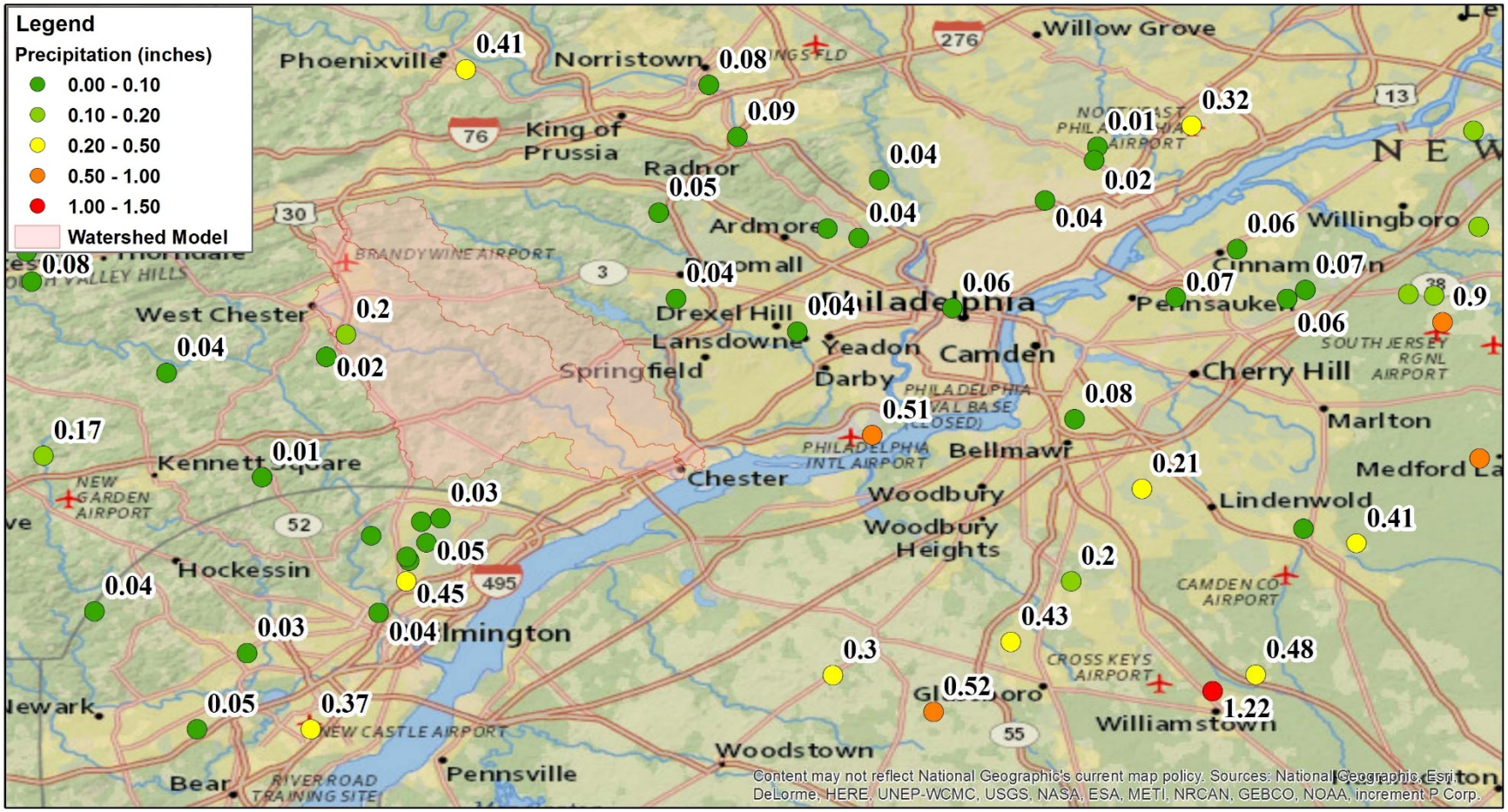


Figure 4-6: Rainfall Distribution for Wet Weather Event 3 (May 22, 2017)



In addition to evaluating the performance of the watershed model on an event basis, the overall annual performance was evaluated. This analysis accounts for contributions from base flow, interflow, and runoff, and compares the model performance against observed flow volume at the USGS gages. The results are shown in the table below and in Figure 4-7.

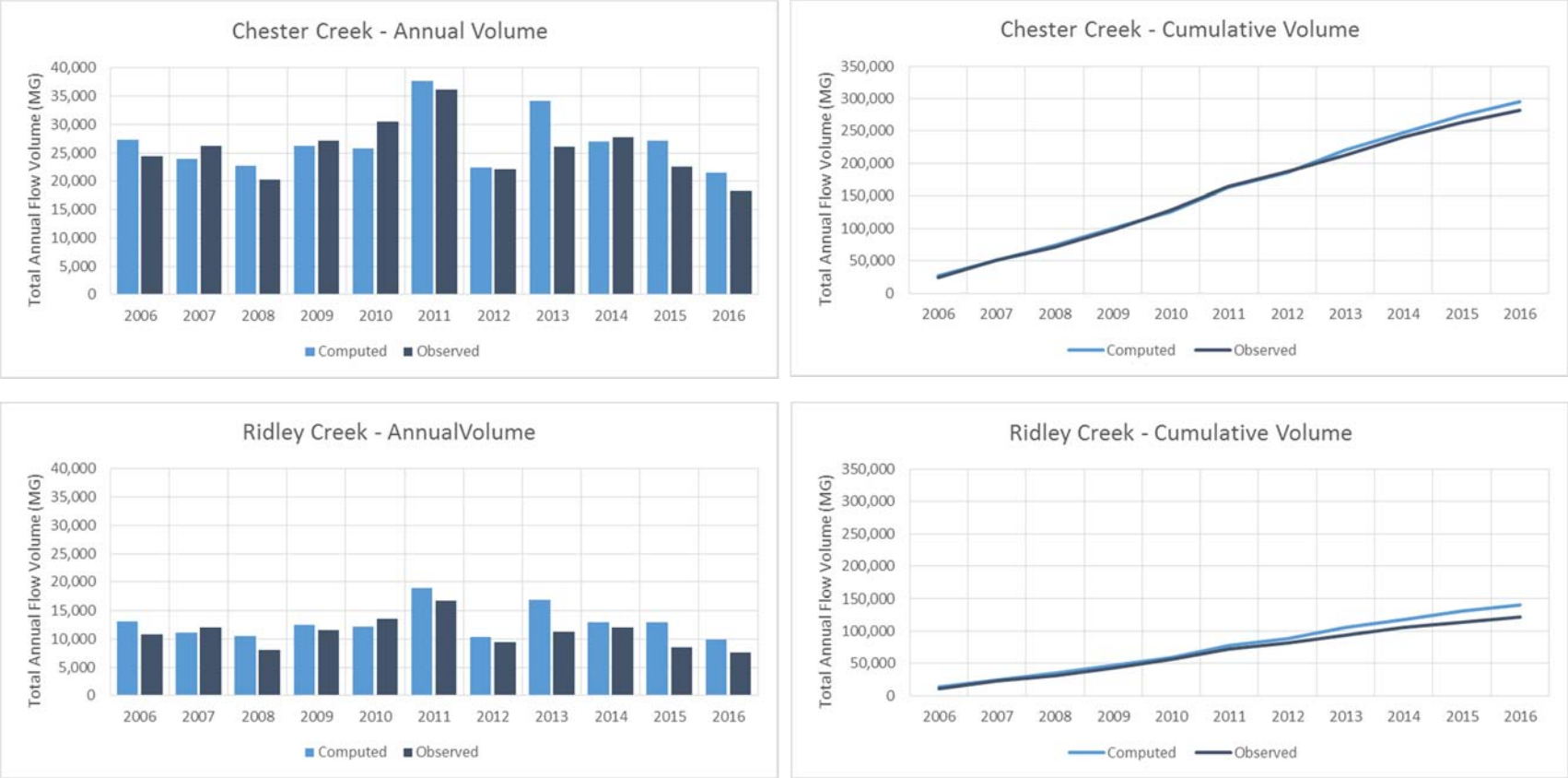
Table 4-2: Watershed Model Overall Annual Performance

	Chester Creek			Ridley Creek		
Year	Modeled Volume (MG)	Observed* Volume (MG)	Percent Difference	Modeled Volume (MG)	Observed* Volume (MG)	Percent Difference
2006	27,324	24,340	12%	13,093	10,865	21%
2007	23,999	26,172	-8%	11,086	12,005	-8%
2008	22,674	20,278	12%	10,460	8,101	29%
2009	26,255	27,175	-3%	12,486	11,540	8%
2010	25,762	30,512	-16%	12,234	13,539	-10%
2011	37,727	36,184	4%	18,844	16,794	12%
2012	22,375	22,068	1%	10,297	9,390	10%
2013	34,210	26,094	31%	16,981	11,234	51%
2014	26,980	27,722	-3%	12,890	12,093	7%
2015	27,108	22,639	20%	12,948	8,513	52%
2016	21,487	18,226	18%	9,845	7,555	30%

*Missing gage data periods were interpolated using the average flow over the whole time series.

This table shows that the model response is variable from year to year, sometimes over predicting and sometimes under predicting total volume. Our understanding is that these over- and under-predictions are largely driven by rainfall variations over the watershed that are not represented in the watershed model because of lack of limited precipitation data over the entire watersheds. In other words, if the total rainfall observed at the Philadelphia Airport is larger than what was observed in the upper portions of the watershed, then the model would likely over predict total flow volume compared to the observed total flow volume. Conversely, if the total rainfall observed at the Philadelphia Airport is smaller than what was observed in the upper portions of the watershed, then the model would likely under predict total volume compared to the observed total volume. For example, in 2010, less rain was recorded at the Philly Airport than at the West Chester Rain Gage, which is located north of the Chester Creek Watershed, and the model accordingly under predicted total volume in that year. And in 2013, more rain was recorded at the Philly Airport than at the West Chester Rain gage, and the model over predicted volume in that year.

Figure 4-7: Comparison of Modeled vs. Observed Annual Flow Volume and Cumulative Flow Volume



This pattern was observed for some but not all of the years, suggesting that other factors may contribute too. One of those factors may be that there was missing flow data at the two USGS gages during the calibration period. The missing data was replaced by the average flow for the purpose of this specific evaluation, but that may have also led to some over or under prediction in the observed flow volumes. Due to the uncertainty related to rainfall and flow data, this evaluation was not used to fine-tune the calibration because it would compromise the calibration of the individual calibration events and hydrographs.

Taking into account the results from the 1-to-1 plots that showed satisfactory correlation coefficients (see Table 4-1 and Figure 4-3) and the visual checks of the flow time series that confirmed satisfactory responsiveness of the model to rainfall data, the watershed model was deemed sufficiently calibrated, consistent with observed data, and reliable to be applied for the purpose of predicting flows when observed data are not available during the typical year period. As explained in Section 4.1.1, availability of gage data during the typical period is variable, with a long period of data missing in Ridley Creek (9/22/1995 through 12/31/1996) and a few shorter periods (of a few days at a time) missing at both gages during the three year period.

To estimate tributary water quality concentrations, modeled tributary flows were separated into dry and wet weather flow components based on the methodology described in Section 3.1.2.3. Dry weather is the sum of base flow and interflow, while wet weather is represented by the direct runoff and channel precipitation. Statistical reference concentrations for the POC event mean concentrations were initially estimated based on the sampling data obtained from the DELCORA Wet and Dry Weather Monitoring Program (See section 4.1.3). These reference concentrations are shown in Table 4-3. It was somewhat surprising that the *enterococcus* results tended to be higher than the fecal coliform and *E.coli* data. However, there is very little data in the literature for *enterococcus* so it was difficult to assess whether these results are unusual. The fecal coliform concentrations however, are within the range of urban storm water bacteria concentrations reported in the literature (EPA 2004). It should also be noted that, as previously shown in Section 4.1.3, the monitoring data shows that wet weather concentration at the most upstream monitoring locations (located upstream of CSO influence) in Chester Creek and Ridley Creek often exceed the applicable monthly geometric mean or STV WQS concentration for all three POCs.

Table 4-3: Reference POC Concentrations Used to Develop EMCs for Modeled Flows

	Enterococcus (#/100 mL)			Fecal Coliform (#/100 mL)			*E.coli* (#/100 mL)		
	25th %ile	75th %ile	Geo-mean	25th %ile	75th %ile	Geo-mean	25th %ile	75th %ile	Geo-mean
Dry Weather Flow	19	65	39	22	180	40	13	69	28
Wet Weather Flow	8,500	59,500	31,784	799	22,750	4,516	668	18,750	3,042

The POC concentration assumptions were further refined during the water quality model calibration process, which is described in Section 4.5.2. Event mean concentrations were applied to each dry and wet weather flow component to estimate POC loads in the tributaries. This method allows for time-variable POC concentrations that are consistent with the timing of the wet weather flow responses. The final EMCs were determined based on the results of the receiving water model calibration, as explained in Section 4.5. The selected dry weather EMC (30 #/100 mL) is consistent with the geometric mean of the observed data. It was also not varied by POC because the dry weather sampling data were variable but had similar central tendencies. The final calibrated EMC values used in the watershed model are shown in the table below.

Table 4-4: Calibrated POC EMC values for Ridley and Chester Creek

Model Input	*Enterococcus* (#/100 mL)	Fecal Coliform (#/100 mL)	*E.coli* (#/100 mL)
Dry Weather Flow	30	30	30
Wet Weather Flow	20,000	8,000	4,000

4.3 DELCORA Combined Sewer System Model

DELCORA CSO flows were obtained from the calibrated DELCORA CSS H&H Model. The calibration and application of the CSS H&H model is discussed in detail in the H&H model report (DELCORA, 2016).

To model the POC loads from the CSO system, Statistical reference concentrations for the POC event mean concentrations were initially estimated based on the sampling data obtained from the DELCORA Wet and Dry Weather Monitoring Program (See section 4.1.3). These reference concentrations are shown in Table 4-5. Measured concentrations were within the range of CSO bacteria concentrations reported in the literature (EPA, 2004) but tended to be lower than the median concentrations measured in other communities. Several potential explanations for this include: 1) the highly industrialized nature of the DELCORA service area may result in a smaller bacteria load via runoff to the combined system than communities with less industrial land; 2) DELCORA may have a relatively high percentage of stormwater in the combined system.

The data presented a challenge in that the *E.coli* values are generally higher than the fecal coliform values, which is not physically possible since *E.coli* is a subset of fecal coliform. These data were therefore used as initial estimates, but then further refined and adjusted during the water quality model calibration process so as to reflect both the physical constraints (i.e.: *E.coli* EMCs that are smaller than Fecal Coliform EMCs) and the observed ranges.

Table 4-5: Reference POC Concentrations Used to Develop EMCs for the Modeled DELCORA CSOs

	Enterococcus (#/100 mL)			Fecal Coliform (#/100 mL)			*E.coli* (#/100 mL)		
	25th %ile	75th %ile	Geo-mean	25th %ile	75th %ile	Geo-mean	25th %ile	75th %ile	Geo-mean
CSO Concen-tration	42,250	191,750	81,510	53,000	157,000	95,310	66,000	265,500	129,920

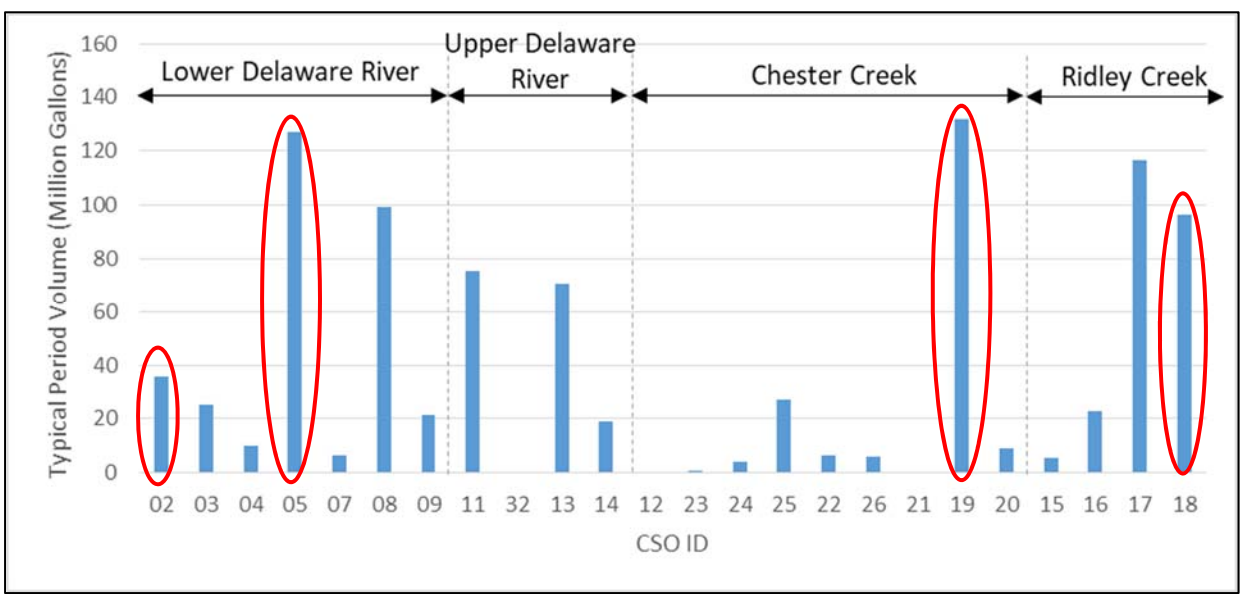
The water quality model was ultimately calibrated using the CSO EMCs shown in Table 4-6 below.

Table 4-6: Calibrated POC EMC Values for the DELCORA CSOs

Model Input	*Enterococcus* (#/100 mL)	Fecal Coliform (#/100 mL)	*E.coli* (#/100 mL)
CSO EMC	125,000	150,000	125,000

Figure 4-8 illustrates the distribution of CSO volumes among the various outfalls by receiving water. The CSOs that were part of the wet weather monitoring program are circled in red.

Figure 4-8: CSO Volumes for Typical Period (1994-1996)



POC loads associated with DELCORA CSOs are estimated by multiplying modeled CSO flow rates by POC EMC concentrations.

4.4 Philadelphia Simplified CSO Model

Calibration of this SWMM model relied principally on information from annual reports of Philadelphia CSO model overflows (PWD, 2017). Tables from these reports, which describe the annual overflow volume, number of overflow events, and total overflow duration per CSO, helped to constrain model inputs related to the combined sewersheds, including the total impervious area, depression storage, average surface slope, and sewershed width and length.

Model parameters described above were first calibrated to reported overflow volumes and frequencies from the 2016 annual CSO reports, then validated using the 2015 annual CSO reports. Modeled and reported overflow volumes and frequencies were in close agreement for the 165 CSO locations in both 2015 and 2016, as shown in Figure 4-9 and Figure 4-10. However, at one overflow location, identified as "F_FRFG," the reported overflow changed significantly between 2015 (1,250 million gallons) and 2016 (<1 million gallons), indicating that some change occurred in the Philadelphia sewer system that eliminated overflows at that discharge location. The SWMM model was configured for the 2016 condition for the water quality calibration. Overall, the model provides reliable estimates of Philadelphia CSO overflow volume and frequency of discharge.

The process for calibration of the model was as follows:

1. Gather CSO information from the Philadelphia CSO Annual Reports[13], including total annual overflow volumes, number of overflow events, and overflow event durations.
2. Develop annual rainfall event statistics, including total rainfall depth and duration for Philadelphia Airport rain gage.
3. Rank the developed rainfall events by total depth and distribute the reported overflow volume over the reported number of overflow events for each CSO. This method assumes that overflows occur during the highest volume rainfall events and that the overflow volume is proportional to the total rainfall depth.
4. Parameterize the SWMM runoff model relying principally on the total assumed rainfall depth which cause overflows, and the reported overflow characteristics (volume, number of overflows and duration).
5. Use the SWMM runoff model to compute the hourly CSO response for each rainfall event and CSO location.
    a. Assume 100% impervious sewersheds and calculate necessary sewershed area for each CSO by dividing the reported annual overflow volume by the assumed total rainfall depth causing overflow.
    b. Set depression storage input equivalent to largest rainfall depth that does not result in an overflow. Further, a constant evaporation rate was used to deplete the depression storage between rainfall events.

[13] http://www.phillywatersheds.org/what_were_doing/documents_and_data/CSO_SW_AnnualReports

c. Adjust sewershed width-to-length ratio, which influences runoff dynamics, for consistency with reported number of overflow events and reported overflow duration.

4.5 Receiving Water Model Calibration

The receiving water model calibration was comprised of two components: calibration of the hydrodynamic calculations (water movement), and calibration of the water quality calculations. These are explained in the following sections.

4.5.1 Hydrodynamic Model Calibration

Calibration of tidal hydrodynamics occurred first. Modeled tidal propagation is principally influenced by sediment bed resistance which varies due to changes in sediment grain size and bed forms. Model inputs related to bed resistance (roughness) were calibrated for consistency with NOAA tidal data at multiple stations near DELCORA CSOs, including the Marcus Hook Station (only water level measured) and Philadelphia Station (water level and currents measured). Modeled and observed water levels were compared for the 2017 water quality sampling period (March through June 2017). The model's representation of changes in tidal phasing and amplitude along the Delaware River estuary, which influence rates of pollutant transport and mixing, were refined during the calibration process.

Figure 4-11 and Figure 4-12 illustrate the hydrodynamic model performance relative to observations. These figures show good agreement between modeled and observed water levels and sufficient agreement between modeled and observed current velocities. Modeled current velocities tend to be low relative to observed current velocities, which is likely due to differences in scale between the observations and the model output. Model output represent average velocities over approximately a 200 foot width and 1,400 foot length, while the observations represent velocities at a much smaller scale (i.e. tens of feet laterally and vertically). Consistency between modeled and observed water levels is a strong indication that at larger spatial scales (i.e. the scale of the model grid and larger scales), the model accurately computes tidal current velocities.

Figure 4-9: Philadelphia CSOs – Comparison of Modeled and Reported Overflow Volumes

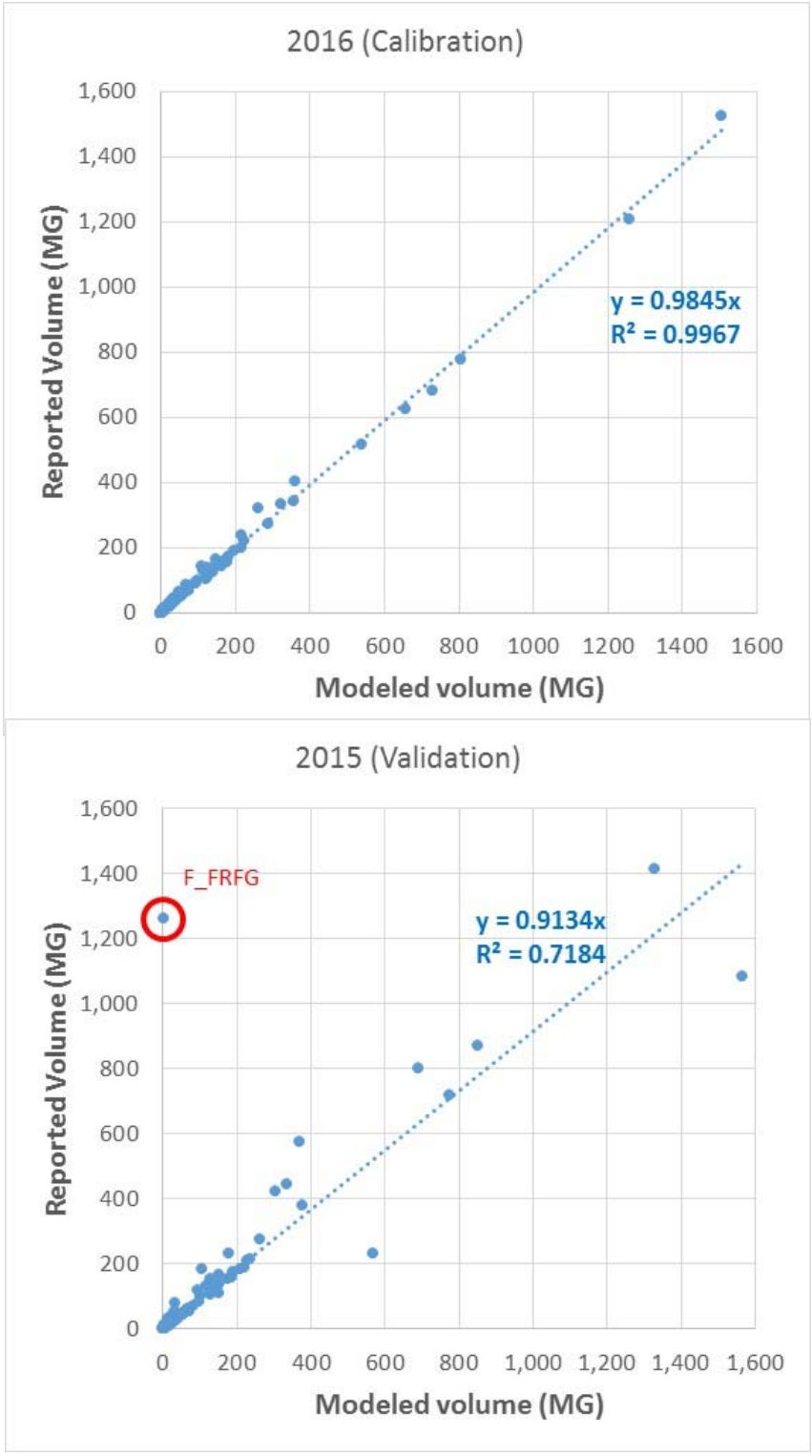


Figure 4-10: Philadelphia CSOs – Comparison of Modeled and Reported Overflow Events

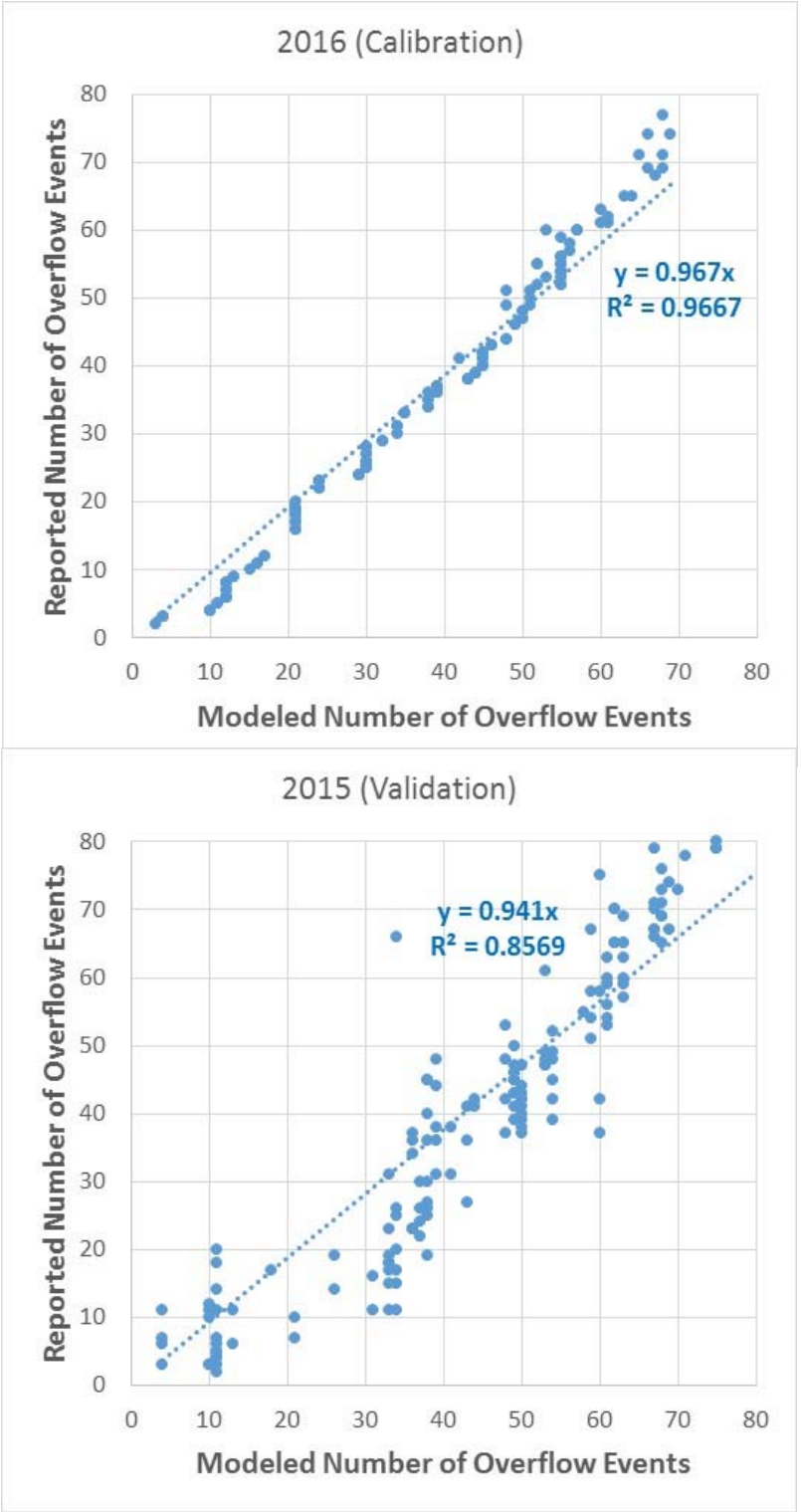


Figure 4-11: Delaware River – Comparison of Modeled and Observed Water Levels

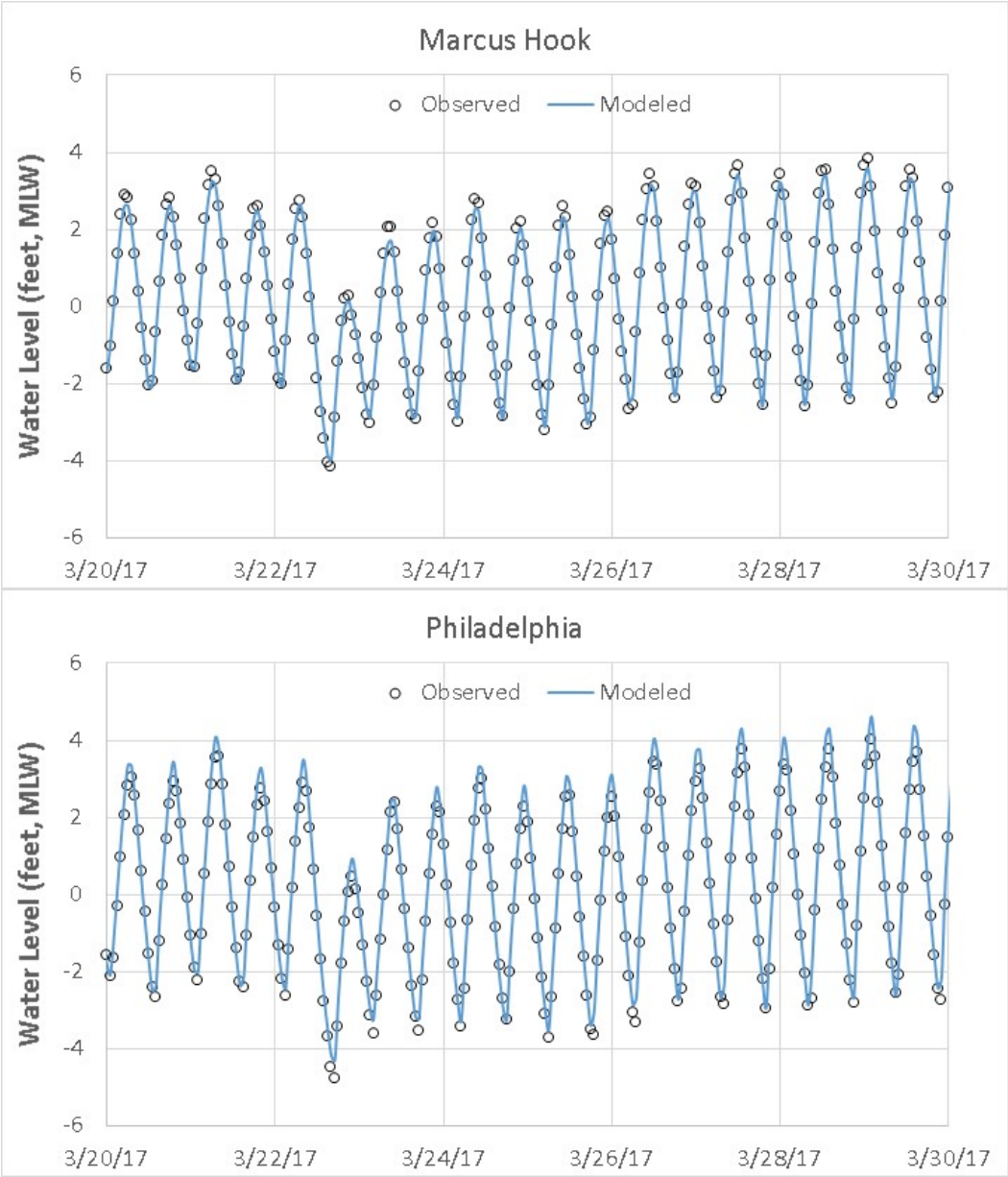
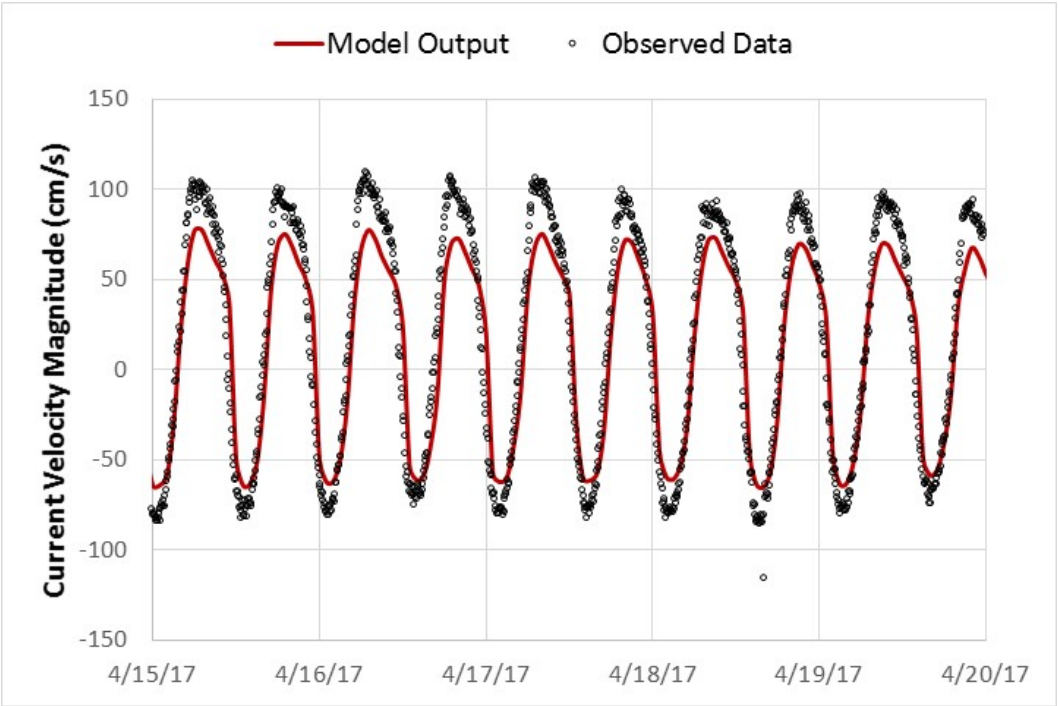


Figure 4-12: Delaware River – Comparison of Modeled and Observed Velocities at NOAA Philadelphia Currents Station



4.5.2 Water Quality Calibration and Validation

4.5.2.1 Approach

The water quality model component was calibrated to sampling data collected in 2017 by DELCORA (see section 4.1.3) and validated to water quality data collected in 2012 by the Delaware River Basin Commission (DRBC). The intent of the calibration is to refine initial POC load (EMC and flow) estimates and the assumed first-order, in-stream POC net decay rate. The POC loads control the amount, the timing, and the intensity of the bacteria loads from the various sources to the receiving water. The decay rate then controls how quickly bacteria decays (decreases in concentration due to the net effects of multiple bacterial processes) over time. The calibration approach was to adjust POC load and decay rate values, evaluate changes in model results against the entire calibration dataset, and identify the model values that were most consistent with the central tendencies of the dataset by stream.

The central tendencies are evaluated through the use of event-based pollutographs and 1-to-1 plots. The pollutographs were evaluated using visual checks for individual events at relevant water quality stations. These visual checks include an evaluation for goodness of fit with respect to the modeled vs observed concentrations, and the time-response of the POC concentrations. The 1-to-1 plots were evaluated with respect to how closely the modeled data could replicate the observed

data within a certain range to account for the typical variability observed with bacteria data. The intent of the water quality calibration was to find the overall best fit across all of the different sampling events and all the relevant monitoring stations, with more emphasis placed on the water quality stations within the DELCORA CSO area. This approach invariably leads to calibration results that are better at some locations or for some events than others. Using different POC load assumptions may improve results for some stations and events, but may diminish results for other stations and events. Model assumptions were refined to obtain the best fit across all of the stations.

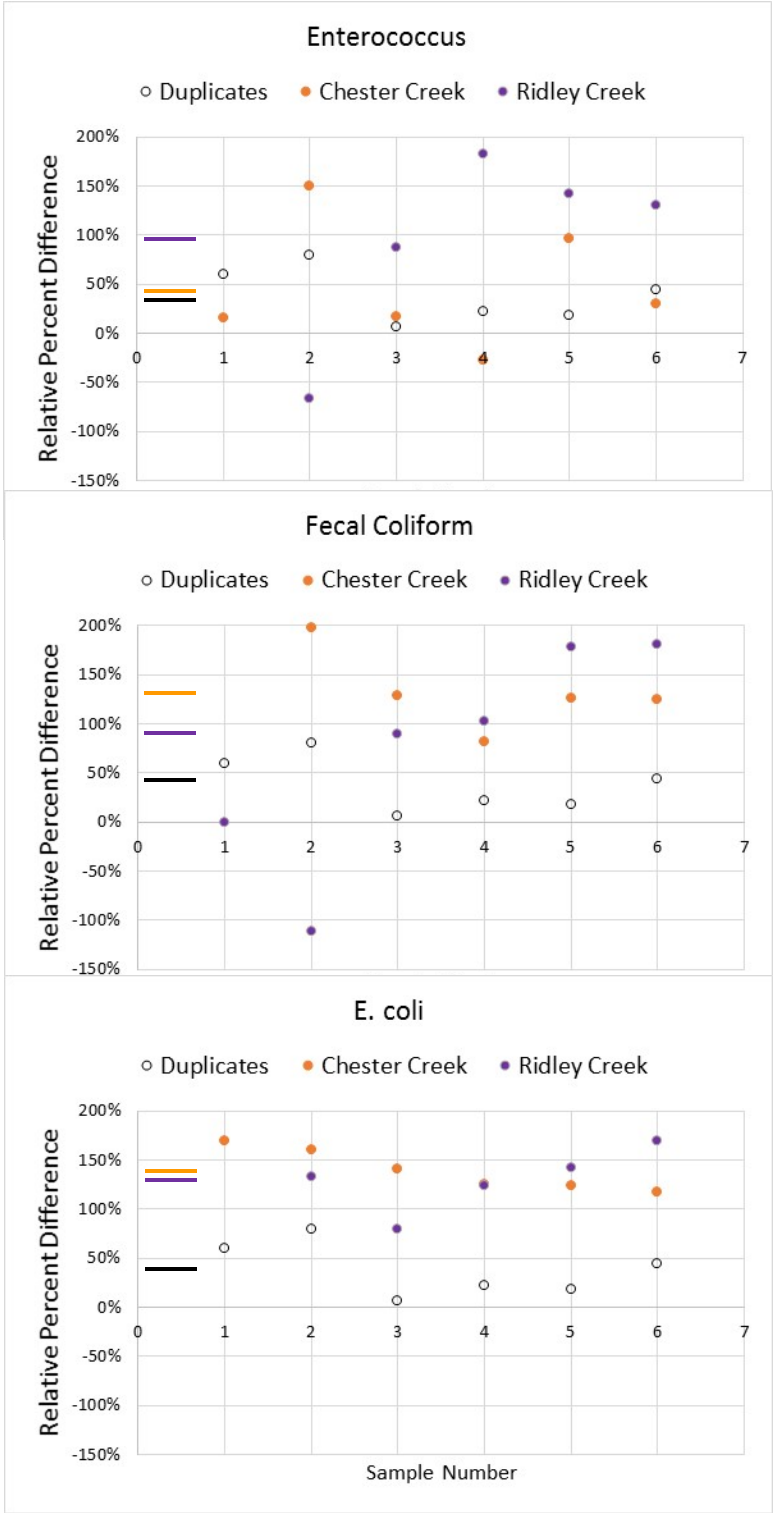
The approach focused first on establishing the appropriate dry weather model values, followed by the wet weather model values. Based on this approach, the decay rate was calibrated to 1.0 per day (1/day), dry weather flow POC concentrations were set to 30 #/100 mL, and wet weather POC EMCs for the tributaries and CSOs were calibrated to the values listed in the table below.

Table 4-7: Model Inputs for POC EMC Concentrations

Model Input	*Enterococcus* (#/100 mL)	Fecal Coliform (#/100 mL)	*E.coli* (#/100 mL)
Background Tributary Runoff POC Concentration	20,000	8,000	4,000
DELCORA and Philadelphia CSOs POC Concentration	125,000	150,000	125,000

As discussed in Section 4.1.3, the results from DELCORA's monitoring program showed an increase in POC concentration from upstream to downstream in each of the tributaries, indicating there may be bacteria sources entering these tributaries during dry weather. Dry weather POC concentrations generally appreciably increase from the most upstream sampling stations (RC-01 and CC-01) to the next downstream sampling stations (RC-02 and CC-02), as illustrated in the figure on the next page. This figure shows the relative percent difference in concentrations from the upstream to downstream sampling locations. When the relative difference is positive, it indicates an increase in concentration from upstream to downstream. While small (+/- 50%) changes could be due to the typical variability observed in sampling data, larger increases (>50%) could be indicative of a bacteria source entering the tributary somewhere between CC-01 and CC-02, and between RC-01 and RC-02. These unknown sources were included in the water quality model and were calibrated for consistency with the central tendency of the dry weather POC data at stations RC-02 and CC-02. The final calibrated loads of the unknown sources ranged from 1.1e6 to 9.1e6 cfu/s depending on POC and stream. Such a source was not included in the model of *Enterococcus* in Chester Creek because no consistent *Enterococcus* concentration increase was observed in the sampling data.

Figure 4-13. Difference in POC Concentration in Upstream vs Downstream Station



Horizontal bars represent mean relative percent difference of paired observations

4.5.2.2 Calibration and Validation Results

The results from the dry weather calibration is shown in Figure 4-14 and Figure 4-15 for Fecal Coliform for dry weather event 2. Model results are shown with the red line and observed data are shown using the gray squares. The figure also shows how the model performs for 50% higher and 50% lower POC load assumptions. Showing the +/- 50% results helps demonstrate that the model represents the central tendencies of the observed water quality data. Generally speaking, the model reasonably predicts dry weather Fecal Coliform concentrations for dry weather event 2, over predicts for dry weather event 1 and under predicts for dry weather event 3. Performance for the other POCS is shown in the table below. A complete set of figures for model calibration for all dry weather events and all POCs can be found in Appendix C.

Table 4-8: Assessment of Dry Weather Events Water Quality Calibration

		Enterococcus	Fecal Coliform	*E.coli*
Dry Weather Event 1	Ridley	Biased High	Biased High	Biased High
	Chester	Biased High	Biased Low	Reasonable fit
	Delaware	Biased High	Biased High	Biased High
Dry Weather Event 2	Ridley	Reasonable fit	Reasonable fit	Reasonable fit
	Chester	Reasonable fit	Reasonable fit	Reasonable fit
	Delaware	Biased High	Reasonable fit	Reasonable fit
Dry Weather Event 3	Ridley	Reasonable fit	Biased Low	Reasonable fit
	Chester	Reasonable fit	Biased Low	Reasonable fit
	Delaware	Reasonable fit	Reasonable fit	Reasonable fit

After calibrating the model to the dry weather events, attention turned to calibrating the wet weather events. Figure 4-16 illustrates the water quality model calibration for fecal coliform during the first wet weather event at select stations in the tributaries and the Delaware River, along with sensitivity tests that show how the model performs for 50% higher and 50% lower POC load assumptions. The objective of the in-stream calibration is to provide the overall best fit across all stations, thus providing consistency with the central tendency along the length of the modeled river. Modeled POC concentrations are consistent with the range of observed concentrations from the DELCORA monitoring program and the model performance is reasonable compared to the observed data. Performance for the other POCS is shown in the table below. A complete set of figures for model calibration for all wet weather events and all POCs can be found in Appendix C.

Table 4-9: Assessment of Wet Weather Events Water Quality Calibration

		Enterococcus	Fecal Coliform	*E.coli*
Wet Weather Event 1	Ridley	Reasonable fit	Biased High	Biased High
	Chester	Reasonable fit	Reasonable fit	Reasonable fit
	Delaware	Biased High	Biased High	Reasonable fit
Wet Weather Event 2	Ridley	Biased Low	Biased Low	Reasonable fit
	Chester	Biased Low	Biased Low	Reasonable fit
	Delaware	Reasonable fit	Reasonable fit	Reasonable fit
Wet Weather Event 3	Ridley	Reasonable fit	Reasonable fit	Reasonable fit
	Chester	Reasonable fit	Biased Low	Biased Low
	Delaware	Reasonable fit	Biased High	Reasonable fit

Following calibration of the dry and wet weather events using the data from the DELCORA Monitoring Program, the water quality model was subsequently validated to water quality data collected in 2012 by the Delaware River Basin Commission (DRBC). Seven samples per location were taken between April and November of 2012 in the Delaware River from Trenton to the mouth of the Delaware River. These data are primarily useful for evaluating accuracy of modeled POC loads from the Philadelphia CSOs and the Schuylkill River, which are estimated to be the largest POC loads to the estuary. Figure 4-17 illustrates the water quality model validation for fecal coliform at stations near Delaware County, starting at river mile 87.9 which is upstream of the DELCORA CSO area. Modeled POC concentrations are consistent with the range and timing of observed concentrations in the DRBC data, and the model performance is reasonable compared to the observed data. Modeled results are also consistent with the observed pattern of higher concentrations near Philadelphia and lower concentrations near DELCORA. A complete set of figures for all POCs and stations used for model validation can be found in Appendix C.

Figure 4-14. Fecal Coliform Dry Weather Calibration at Ridley and Chester Creek (Dry Weather Event #2, 5/10/17)

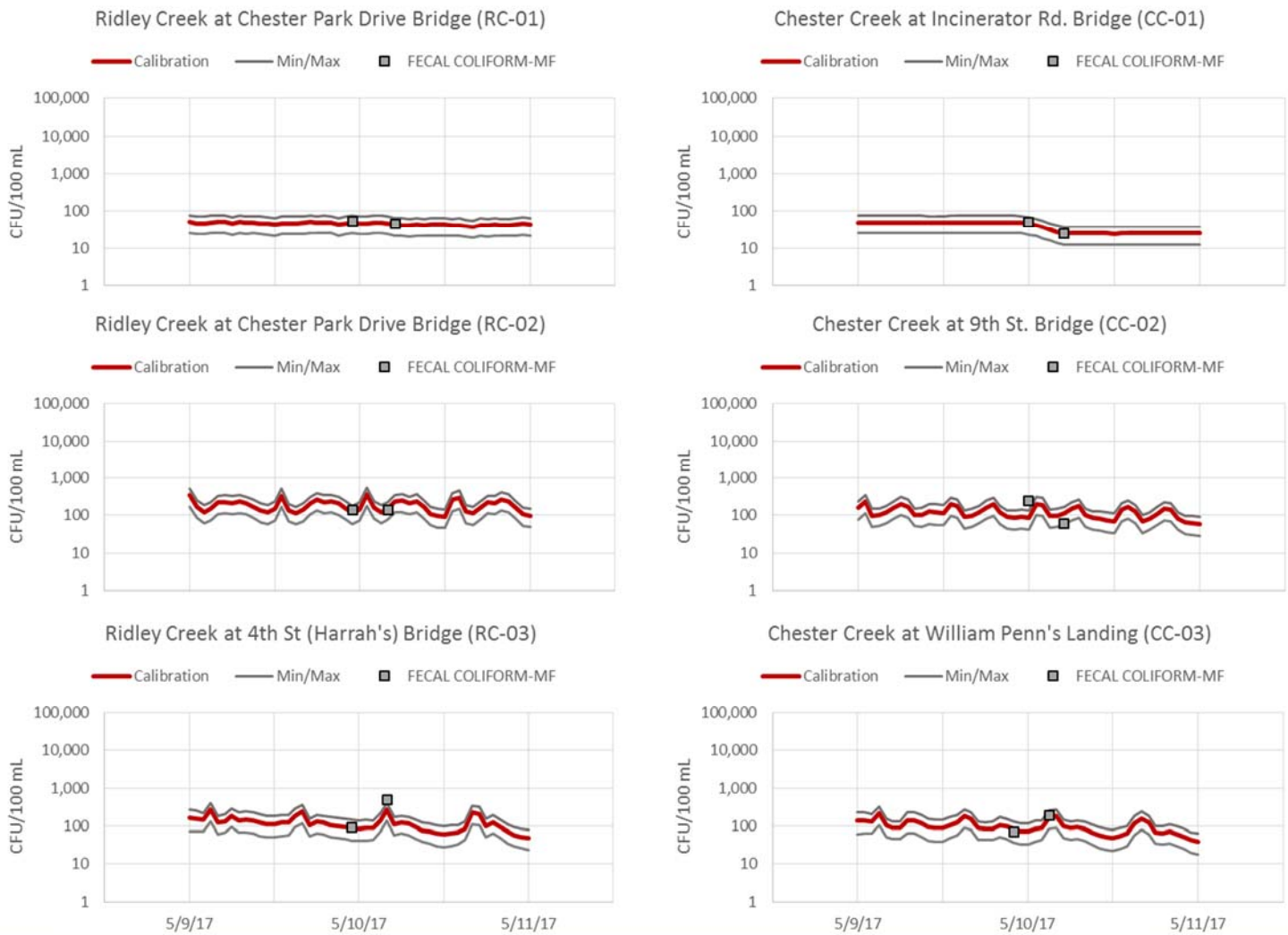


Figure 4-15. Fecal Coliform Dry Weather Calibration at Delaware River Stations (Dry Weather Event #2, 5/10/17)

Figure 4-16. Fecal Coliform Calibration at Ridley Creek, Chester Creek, and Delaware River Stations (Wet Weather Event #1, 3/30/17-4/1/17)

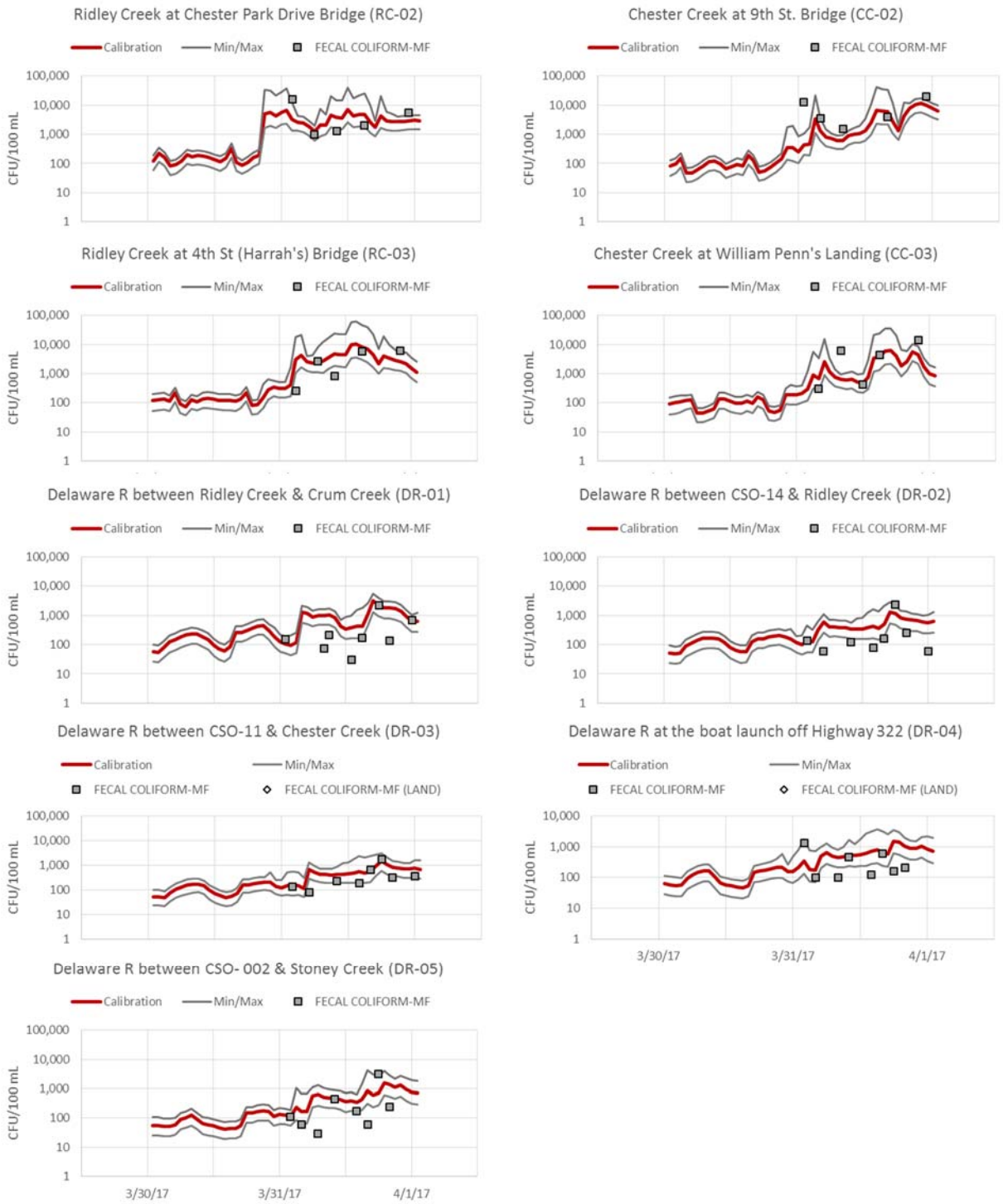
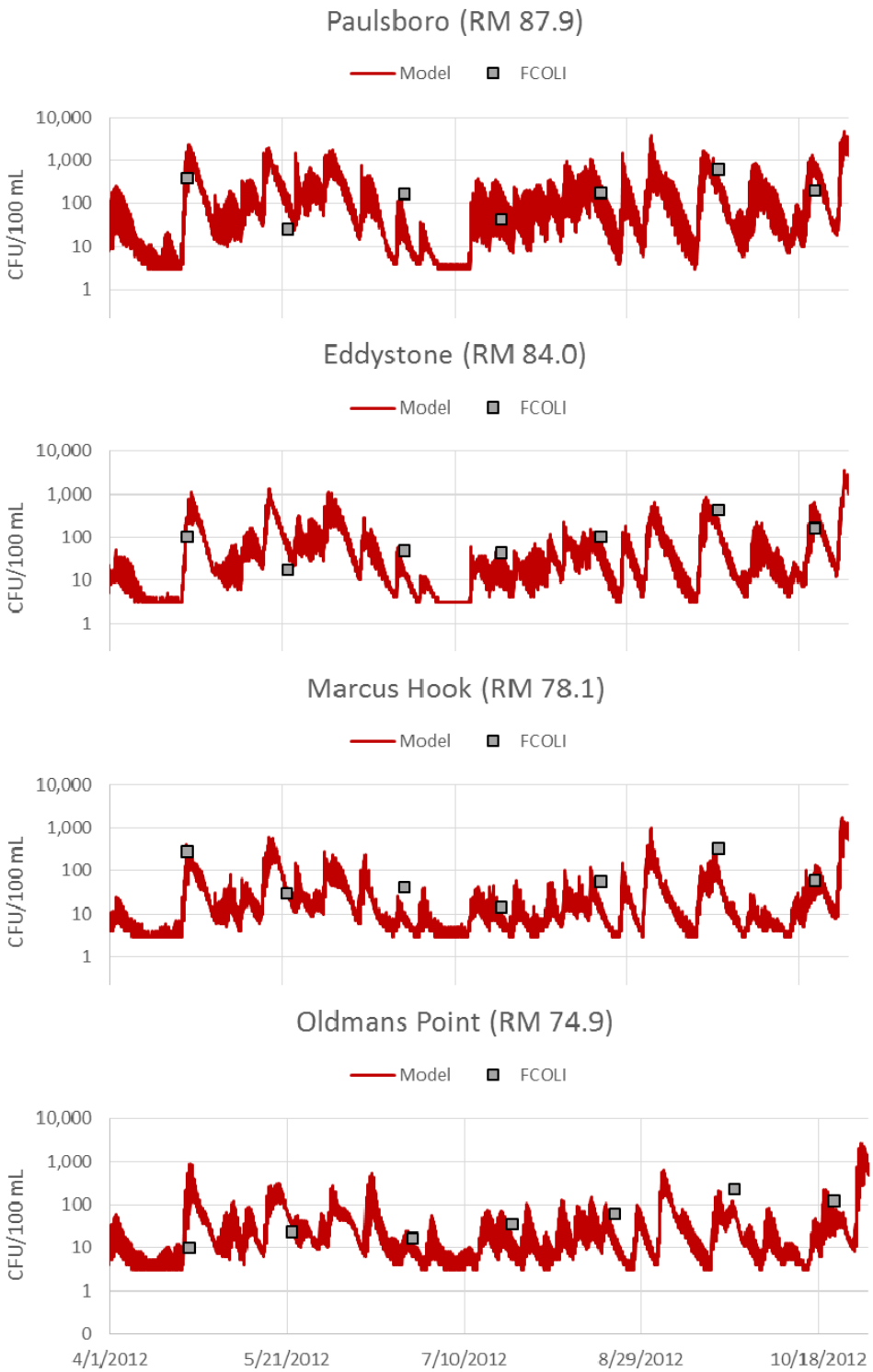


Figure 4-17: Fecal Coliform Model Validation Results near Delaware County



One-to-one plots were also used to assess model performance relative to all observed data at all stations. This is shown in Figure 4-18, Figure 4-19, and Figure 4-20 for the three POCs. These figures pair observed POC concentrations with their associated modeled concentrations for both wet and dry weather events. To account for the natural variability that can occur when sampling POCs, two additional sets of lines were added to the 1-to-1 plot to represent confidence intervals. The first set of dashed lines represent a two times (2x) confidence interval representing the variability in monitoring data results associated with field-collection efforts. The second set of dotted lines represents a ten-time (10x) confidence interval which represents the possible variability in monitoring data results associated with the combination of field and laboratory factors. This confidence interval is based on best professional judgement and variability with field and analytical duplicate results. The majority of points on the one-to-one plots fall within the 10x confidence interval for all stations, however the creek predictions are biased slightly low whereas the Delaware River has an overall reasonable fit, as shown in the table below. Overall, even if an individual event was modeled too high or too low, on a long term basis, the model produces a fairly typical response to POC loads that follow the central tendencies observed.

Table 4-10: Assessment of Overall Water Quality Calibration and Validation

	Enterococcus	Fecal Coliform	*E.coli*
Creeks Calibration	Biased Slightly Low	Biased Slightly Low	Biased Slightly Low
Delaware Calibration	Reasonable fit	Biased Slightly High	Biased Slightly High
Delaware Validation	Reasonable fit	Reasonable fit	Reasonable fit

4.6 Overall Calibration Observations

A water quality modeling framework has been developed and calibrated, and is ready for application to compute POC concentrations in the tidal portions of Chester and Ridley Creeks and in the Delaware River adjacent to DELCORA, for the typical year period. Each model within the framework was developed and calibrated using the best available data, and found to be reasonably consistent with the central tendencies of the observed data and therefore reliable to be applied for the Long Term Control Plan Update.

Figure 4-18: *Enterococcus* Model Calibration and Validation Summary

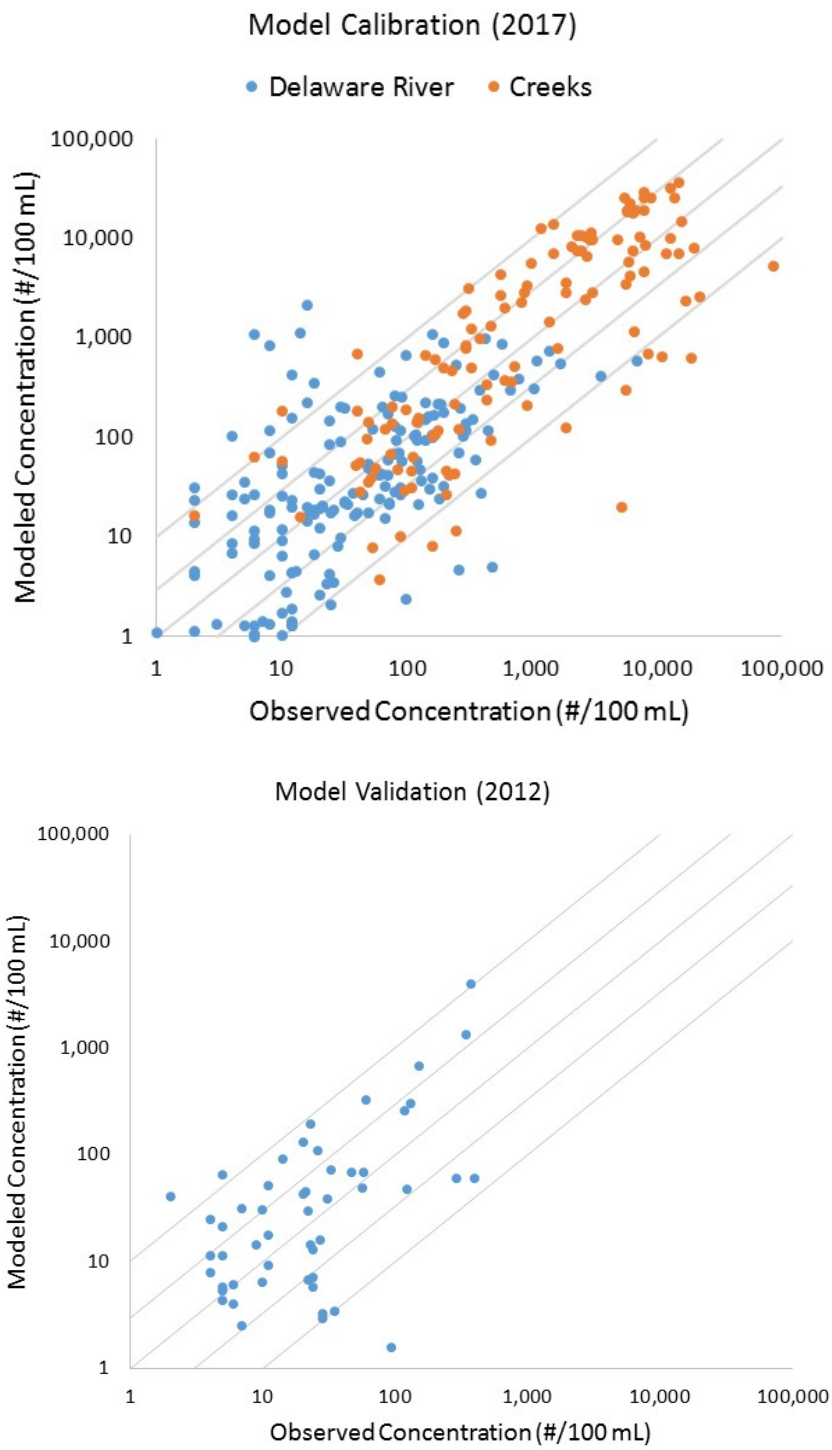


Figure 4-19: Fecal Coliform Model Calibration and Validation Summary

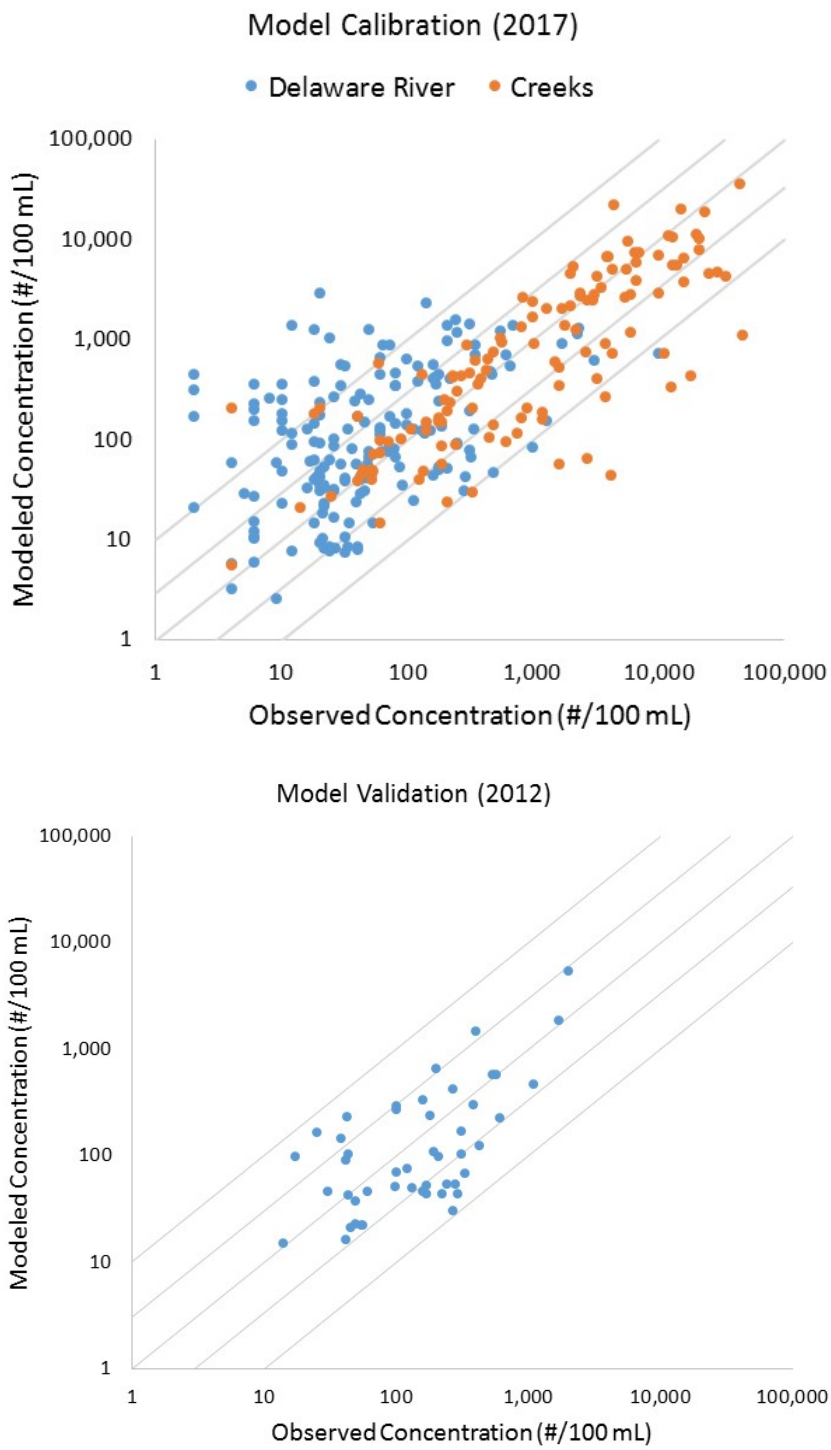
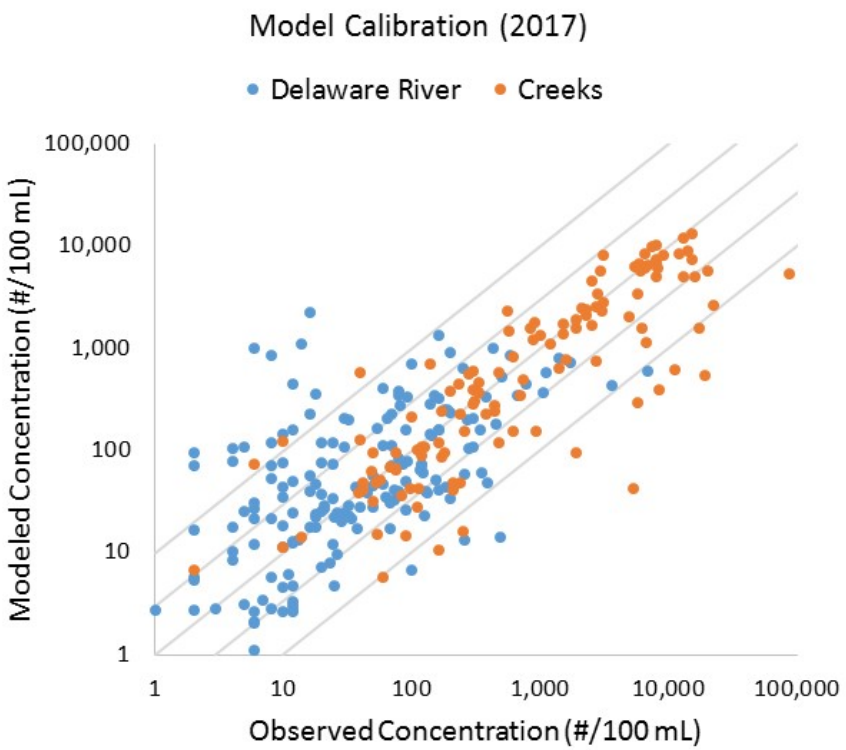
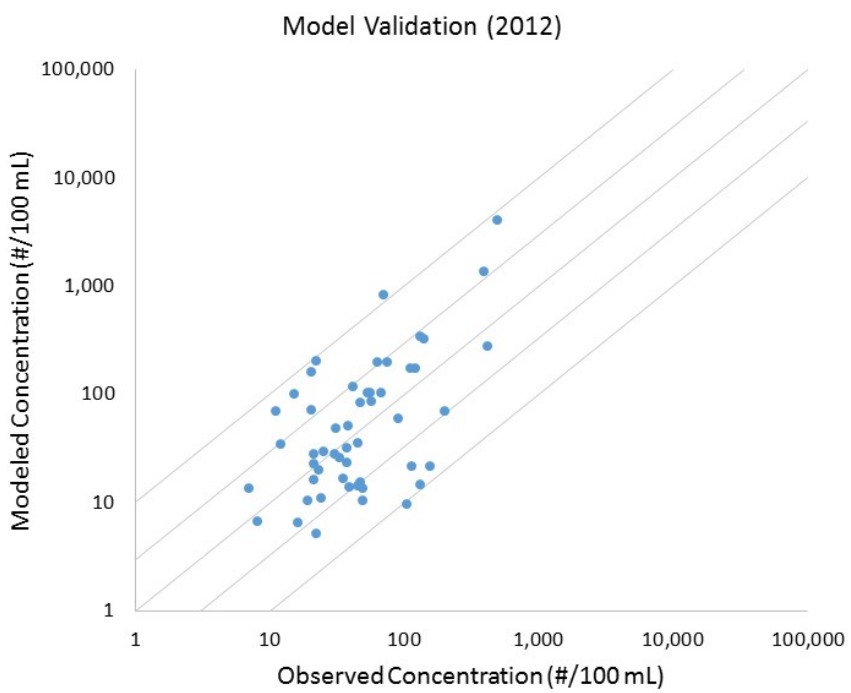


Figure 4-20: *E.coli* Model Calibration and Validation Summary





Section 5 Water Quality Model Application to Evaluate Typical Year Condition

5.1 Typical year simulation description

The purpose of the DELCORA water quality model is to compute water quality concentrations for a baseline scenario and potential future control scenarios, and to quantify the water quality benefits of potential future infrastructure projects. The baseline conditions represent the in-stream water quality conditions using the most recent and appropriate data to represent current watershed, tributary, and CSO loads, including the existing DELCORA combined sewer system configuration and operation. The water quality model was applied for the typical year hydrologic period of 1994-1996. This period was identified as being representative of longer-term hydrologic conditions, and includes one relatively dry year, a relatively wet year, and an average year (DELCORA, 2016b).

5.2 Relevant Water Quality Standards

Modeled POC concentrations were compared to the currently applicable and potential future water quality standards. The standards vary by POC and by stream segment, and are summarized in the table below (Table 5-1). The Upper Delaware River and the tidal zones of Chester and Ridley Creek currently have secondary contact WQS whereas the Lower Delaware River currently has primary contact WQS for bacteria. The boundary between the Upper and Lower Delaware River occurs at river mile 81.8, which is just downstream of Chester Creek and CSO-11 (Figure 5-1). Generally, the modeling work indicated that the *enterococcus* standards are the most stringent (relative to current concentrations) among the three POCs.

Table 5-1: Water Quality Thresholds for Comparisons with Model Results

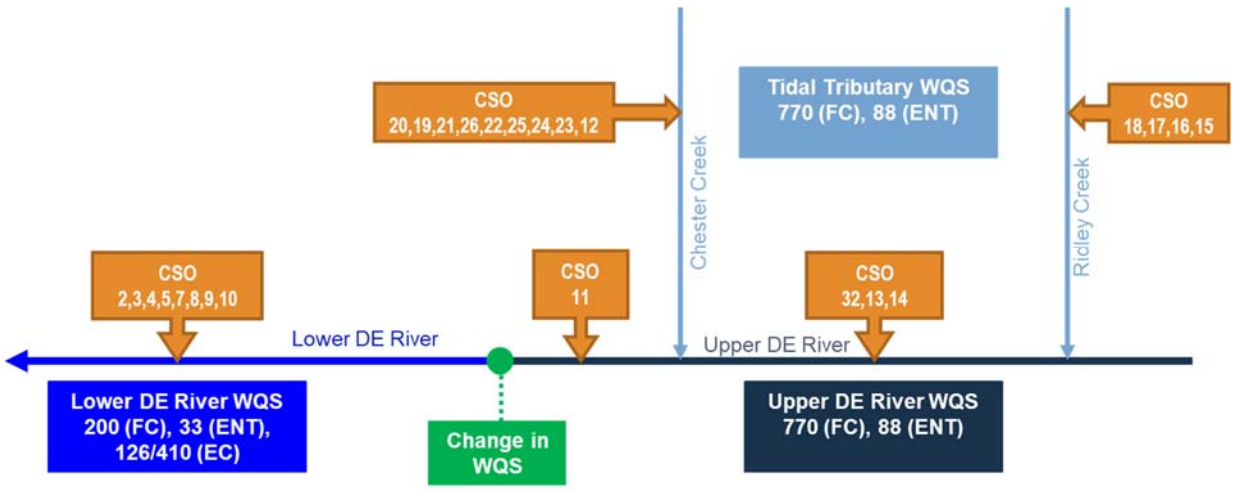
Segment	*Enterococcus* (#/100 mL)	Fecal Coliform (#/100 mL)	*E.coli*[1] (#/100 mL)
Upper Delaware River and Tidal Zones of Creeks	Monthly Geomean: 88 #/100 mL	Monthly Geomean: 770 #/100 mL	n/a
Lower Delaware River	Monthly Geomean: 33 #/100 mL	Monthly Geomean: 200 #/100 mL	Monthly Geomean: 126 #/100 mL Statistical Threshold Value: 410 #/100 mL

1. *E.coli* (EC) standards likely to be codified by PADEP 12-24 months from July 2017. These criteria would apply to the non-tidal tributaries and Delaware River below R.M. 81.8, during recreational months only (May 1 - September 30).

E.coli standards similar to the Lower Delaware River are also proposed for the non-tidal tributaries, which are located upstream of DELCORA's CSO discharges. Outfall CSO-033 is located in the non-tidal portion of Ridley Creek, but this outfall does not appear to overflow during

the typical year period. CSO-033 will be evaluated in the LTCP but, as a practical matter, it does not cause or contribute to WQS being exceeded.

Figure 5-1: Schematic of Applicable POC Water Quality Standards

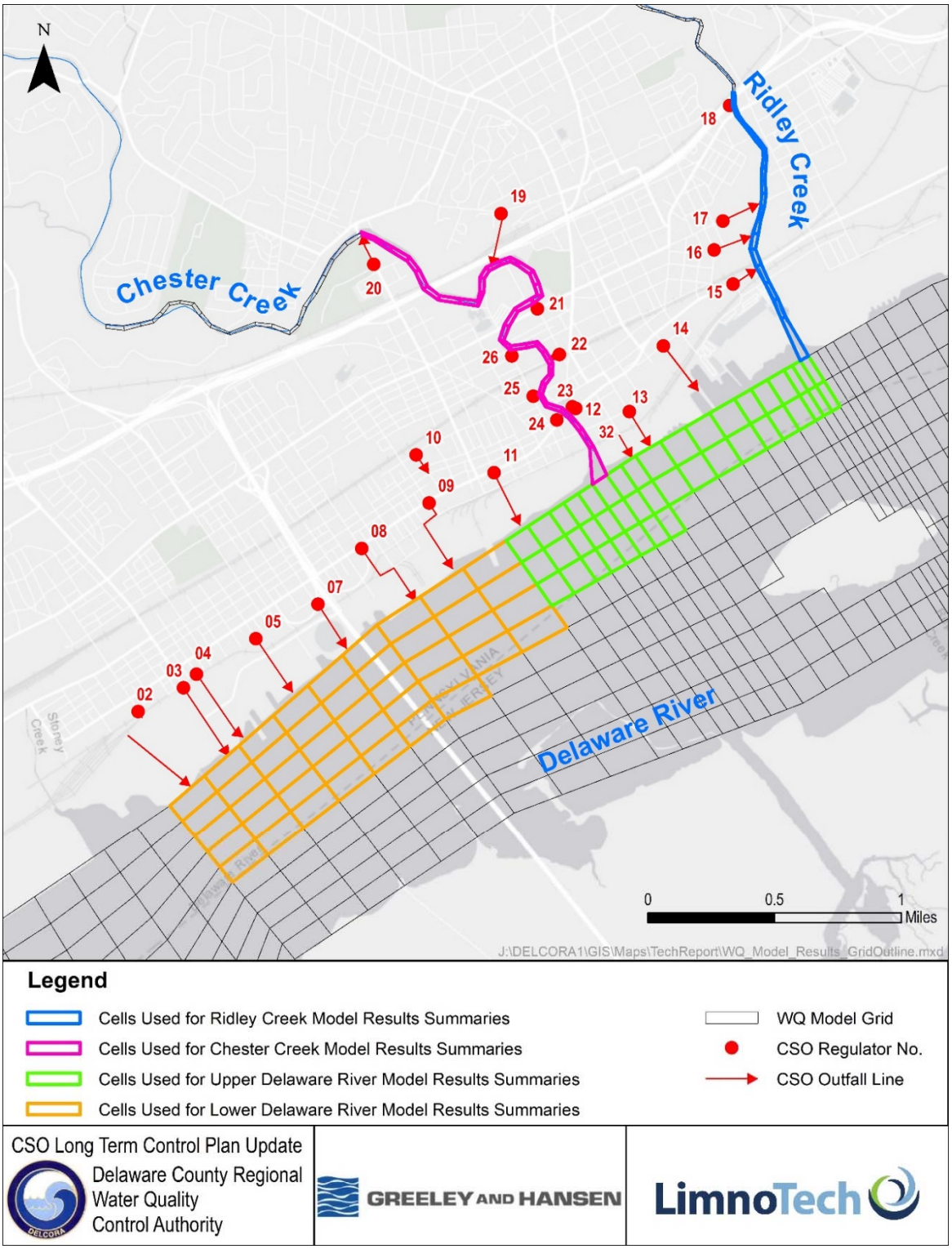


The model has been configured to separately track the in-stream concentration associated with background sources from the in-stream concentration associated with DELCORA sources (CSO and WWTP). This separate accounting will allow for background and non-background sources to be reduced independently from each other. Non-background sources include the DELCORA CSOs and DELCORA STP.

5.3 Typical year simulation results

Model results were summarized for comparison with the applicable water quality standards, which include monthly geometric mean (GM) and statistical threshold value (STV) standards. Model results were summarized over the stream reaches that receive CSO discharges, and that occur within Pennsylvania water as shown in Figure 5-2 below. Monthly geometric mean concentrations and exceedances of the STV standard are computed from hourly model output within each of the selected model grid cells. Model results for the typical year are presented in the sections below.

Figure 5-2: Model Grid Cells Used for Presenting Model Results



5.3.1 Ridley and Chester Creek Observations

Excursions above the *Enterococcus* monthly geomean water quality standards occur in the tidal zone of Ridley Creek almost every single month of the simulation period, and about one third of the time in Chester Creek. No excursions above the Fecal Coliform monthly geomean WQS are observed in either creek. The tidal zone of these creeks do not have a current or proposed *E.coli* WQS.

The excursions are largely due to background sources. As shown in Section 4.1.3, the water quality monitoring data shows that wet weather concentration at the most upstream monitoring locations (located upstream of CSO influence) in Chester Creek and Ridley Creek often exceed the monthly geometric mean and STV WQS concentration for the three POCs. DELCORA CSOs have a relatively smaller impact (less than 10%, on average) on monthly geometric mean concentrations than background sources, because they are intermittent discharges that are only active for short time periods within a monthly geometric mean evaluation period. The assimilative capacity of Ridley Creek is less than in Chester Creek due to its smaller stream flows, so DELCORA CSOs have a larger relative impact on in-stream water quality in Ridley Creek versus Chester Creek. Table 5-2 below shows the number of months where water quality standards are exceeded for each of the three POCs in the creeks. Results are shown for all sources (background and CSOs) and for CSO-only sources. This table shows that CSOs by themselves do not cause water quality violations in the Creeks and are not precluding the attainment of WQS.

5.3.2 Delaware River Observations

Occasional (less than 10%) excursions above the *Enterococcus* monthly geomean water quality standards occur in the Upper Delaware River within the DELCORA LTCPU focus area. No excursions above the Fecal Coliform monthly geomean WQS are observed for the Upper Delaware River. The Upper Delaware River does not have a current or proposed *E.coli* WQS.

Occasional (less than 10%) excursions above all three POC monthly geomean and STV water quality standards occur in the Lower Delaware River within the DELCORA LTCPU focus area. Excursions are somewhat more frequent in the Lower Delaware River than in the Upper Delaware due to the significantly lower water quality standard in the Lower Delaware. Background concentrations near DELCORA are similar in both zones because upstream background sources have a large influence on concentrations in both the upper and lower segments. DELCORA CSOs have a greater impact on the Lower Delaware zone than the Upper Delaware zone because more CSO volume discharges to the Lower Delaware. However, the DELCORA contribution to monthly geometric mean concentrations is generally low (less than 7%, on average) relative to background sources. As shown in Section 4.1.3, the water quality monitoring data shows that wet weather exceedances are observed in the most upstream monitoring location for the Delaware River (DR-01).

Table 5-2 shows the number of months where water quality standards are exceeded for each of the three POCs in the Upper and Lower Delaware River. Results are shown for all sources (background and CSOs) and for CSO-only sources. This tables shows that CSOs by themselves do not cause

water quality violations in the upper or lower Delaware River and are not precluding the attainment of WQS.

Table 5-2: Number of Months Exceeding the Monthly Geomean Water Quality Standard

	Enterococcus Monthly Geomean	Fecal Coliform *Monthly Geomean*	*E.coli*[1] *Monthly Geomean*	*E.coli*[1] *STV*
Ridley Creek				
All Sources	35/36	27/36	n/a	n/a
CSO only	0/36	0/36	n/a	n/a
Chester Creek				
All Sources	14/36	0/36	n/a	n/a
CSO only	0/36	0/36	n/a	n/a
Upper Delaware				
All Sources	2/36	0/36	n/a	n/a
CSO only	0/36	0/36	n/a	n/a
Lower Delaware				
All Sources	5/36	2/36	2/36	12/36
CSO only	0/36	0/36	0/36	0/36

1. No *E.coli* standard currently exists or has been proposed for the tidal portions of Ridley and Chester Creeks or for the upper Delaware River, therefore results for these segments are marked as "n/a" in this table.

5.4 Intended Application of the Water Quality Model

The water quality model is deemed adequate to evaluate compliance with the WQS and the degree to which DELCORA CSOs contribute to non-attainment of WQS. The water quality model will be used to help assess the water quality benefits of potential infrastructure projects considered for the LTCPU (i.e.: CSO alternative scenarios). These CSO alternatives will be simulated by the DELCORA hydrologic and hydraulic (H&H) model (i.e. CSS model) and then evaluated with the receiving water quality model. Resulting changes to in-stream POC concentrations will be compared to the applicable water quality standards as well as to the concentrations observed under the baseline conditions. Water quality model output will be used to summarize the predicted reduction to in-stream POC concentrations.

Two major observations can be made from the water quality modeling application results. One is that background sources dominate the modeled POC concentrations (and by extension, DELCORA CSO loads are small compared to background loads), and the second is that the

DELCORA CSOs by themselves do not cause non-attainment, or preclude the attainment, of WQS. Moreover, the modeling results show that regardless of additional CSO controls, even complete separation, water quality standards would still be exceeded under current conditions because background sources typically prevent compliance with WQS. The modeling results are supported by the water quality data results from the wet weather sampling program, which shows that wet weather concentrations at the most upstream monitoring locations (located upstream of CSO influence) in Chester Creek and Ridley Creek (and to a lesser extent in the Delaware River) often exceed the monthly geometric mean and STV WQS concentration for the three POCs. These monitoring and modeling data taken together indicate the upstream bacteria loads result in a practical impossibility of meeting Water Quality standards in the tidal waters through CSO control. While the Consent Decree addresses the issue of background sources by requiring CSO controls to also be assessed assuming that background sources are reduced to 75% of the applicable WQS, it is not clear that imposing CSO controls under these conditions is reasonable given that there is no current plan for reducing background loads in Chester and Ridley Creeks. The CSO Policy states that "*where WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs, a total maximum daily load, including a wasteload allocation and a load allocation, or other means should be used to apportion pollutant loads*". Such apportionment of loads does not currently exist for Ridley and Chester Creeks for bacteria.

As stated previously, the intended use of the water quality modeling framework is to evaluate CSO control alternatives with respect to applicable water quality standards and demonstrate that alternatives selected for the LTCPU program will meet the water quality-based requirements of the Clean Water Act and Consent Decree. The water quality model is adequate to assess presumption levels of control to show that the CSOs after controls are in place do or do not preclude the attainment of water quality standards. The model framework could also be used to assess the demonstration approach, however, as explained in this report, the modeling shows that CSOs alone do not cause WQS violation and do not preclude the attainment of WQS, and background loads are currently causing WQS violations upstream of the CSOs and the CSO influence. Without a State plan for estimating the cost and practicality for controlling the background load upstream of DELCORA's CSO area, it is difficult to justify the demonstration approach.

As such, DELCORA will utilize the presumption approach, which is shown in this report to be reasonable in light of the data and analysis as called for in the National CSO Policy.

5.4.1 Interpretation of Section 19.b.iv of the Consent Decree

The typical year simulation results show that background sources prevent compliance with the applicable water quality results during some months, and the CSOs are not precluding the attainment of WQS. DELCORA's consent decree requires that if DELCORA uses the demonstration approach and background sources prevent compliance with water quality standards, then DELCORA must also run its water quality model assuming that background sources have

been controlled to 75% of the applicable water quality standards (EPA, 2015). More specifically, section 19.b.iv of the DELCORA Consent Decree states that "*If background sources currently prevent compliance with the water quality standards, DELCORA shall also assess the impact of each size of the CSO controls assuming background pollutant levels are reduced such that in-stream concentrations upstream of the CSO Outfalls are no more than seventy-five (75) percent of the applicable water quality standard*."

"*Background sources*" are generally understood to be the sources that would not be controlled through the LTCPU, and includes watershed sources of intermittent POCs (e.g. from washoff of POCs from wildlife and pets due to rainfall) as well as continuous sources (e.g. failing septic tanks, etc.), and CSOs from other communities. In other words, background sources are all sources accounted for in the model except for DELCORA CSOs and the DELCORA WWTP. Based on our interpretation of this consent decree language, we could reduce background sources to 75% of the water quality standard during months when there is an excursion above the water quality standard and background sources exceed 75% of the water quality standard.

The Consent Decree states that simulations be conducted with background sources set to seventy-five percent of the water quality standards "*upstream of the CSO outfalls*". However the water quality standard upstream of the outfalls (i.e. in the Upper Delaware) is higher than the standard in the Lower Delaware. So if background sources are reduced to seventy-five percent of the Upper Delaware standard, then the Lower Delaware background concentration would still exceed the Lower Delaware standard (i.e. 75% of the *Enterococcus* Upper Delaware River WQS is 66 #/100ml, which is higher than the Lower Delaware River WQS of 33#/100ml).

The assumed intent of this Consent Decree requirement is to provide some assimilative capacity in the river such that the water quality benefits of potential DELCORA LTCPU infrastructure projects can be more readily identified. With that understanding, the proposed approach to reducing background sources is to separately evaluate CSO controls in the Lower and Upper Delaware zones. First, background sources would be controlled to 75% of the Upper Delaware and Tidal Tributary standard, and control scenarios would be evaluated for CSOs discharging directly to the Upper Delaware and to Chester and Ridley Creeks (which discharge to the Upper Delaware). Second, background sources would be controlled to 75% of the Lower Delaware standard, which would require a larger reduction in background sources, and control scenarios would be evaluated for CSOs discharging directly to the Lower Delaware.

The model has been configured to separately track the in-stream concentration associated with background sources from the in-stream concentration associated with DELCORA sources (CSO and WWTP). This separate accounting will allow for background sources to be reduced independently from non-background sources. Using the time series output from the model, the background sources will be scaled back in the tributaries and in the Upper Delaware River to 75% of the Tidal Tributaries & Upper Delaware River WQS using scaling factors that are specific to each water segment and each month such that background sources are at 75% of the applicable water quality standard for months when non-compliance can be demonstrated.

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APPENDIX A
Bathymetry Survey of Ridley and Chester Creeks

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Memorandum

From:	Cullen O'Brien, LimnoTech	**Date:**	4/30/2017
		Project:	DELCORA
To:	Carrie Turner, LimnoTech Anouk Savineau, Limnotech	**CC:**	Click here to enter text.

SUBJECT: Bathymetric Survey of Chester and Ridley Creeks

This memo summaries field work activities conducted by LimnoTech the week of March 27, 2017. An elevation (bathymetric) survey was completed in support of water quality model development on the lower portions of Chester and Ridley Creeks. The creeks are located in the city of Chester, Pennsylvania and are tidally influenced tributaries to the Delaware River. The field crew was made up of LimnoTech employees Cullen O'Brien and Robert Betz.

Survey methods consisted of acquiring cross sectional bank and bed elevation data. Reaches surveyed included the lower 2.75 miles of Chester Creek and 3.25 miles of Ridley Creek to their discharge into the Delaware River. The most upstream transect location corresponds to the most upstream water quality sampling location included in the 2017 wet and dry weather monitoring program conducted by Weston, Greeley and Hansen, and LimnoTech. Transects were collected on ¼-mile interval spacing. Access to the creeks on the upper portions, generally greater than 1 mile upstream, was by wading where the bottom was shallow and firm. The portions below 1 mile were too deep and soft to be accessed on foot and a john boat with tagline was utilized.

Survey position and elevation was collected using Real Time Kinematic-Global Positioning System RTK-GPS techniques. This technique utilizes satellite positioning with real-time corrections for accurate georeferencing spatial locations and reference information to convert measured depths to elevations. GPS equipment consisted of a Trimble GeoXH centimeter edition with external Hurricane antenna. Real-time position corrections were accessed through cellular connection with the Pennsylvania Virtual Reference Station (VRS) network, ensuring high accuracy position data. Each creek cross section was surveyed at approximately five locations across the bed, water surface, bank toe, and bank top. Access to the entire upland bank at transect locations was not always possible; so the closest points safely accessed to the bank toe were surveyed. Elevation measurements collected from the boat were completed by marking the location at the water surface and subsequently measuring the water depth.

Quality control for horizontal and vertical position was verified with a local National Geodetic Survey (NGS) benchmark. A benchmark is an established survey monument with a known lateral and longitudinal (X, Y) position and elevation (Z) position that is stable. An approximate error estimate of +/- 0.5 feet in the vertical and less than 0.5 feet for horizontal position was observed at some transects, but the majority of locations surveyed were considerably more accurate. The observed errors are due to applying GPS technology in a challenging environment with overhead obstructions such as tree cover, buildings, and local thunderstorms that can dilute or interfere with the GPS signal.

The map below (Figure 1) shows the transect locations where elevation measurements were collected.

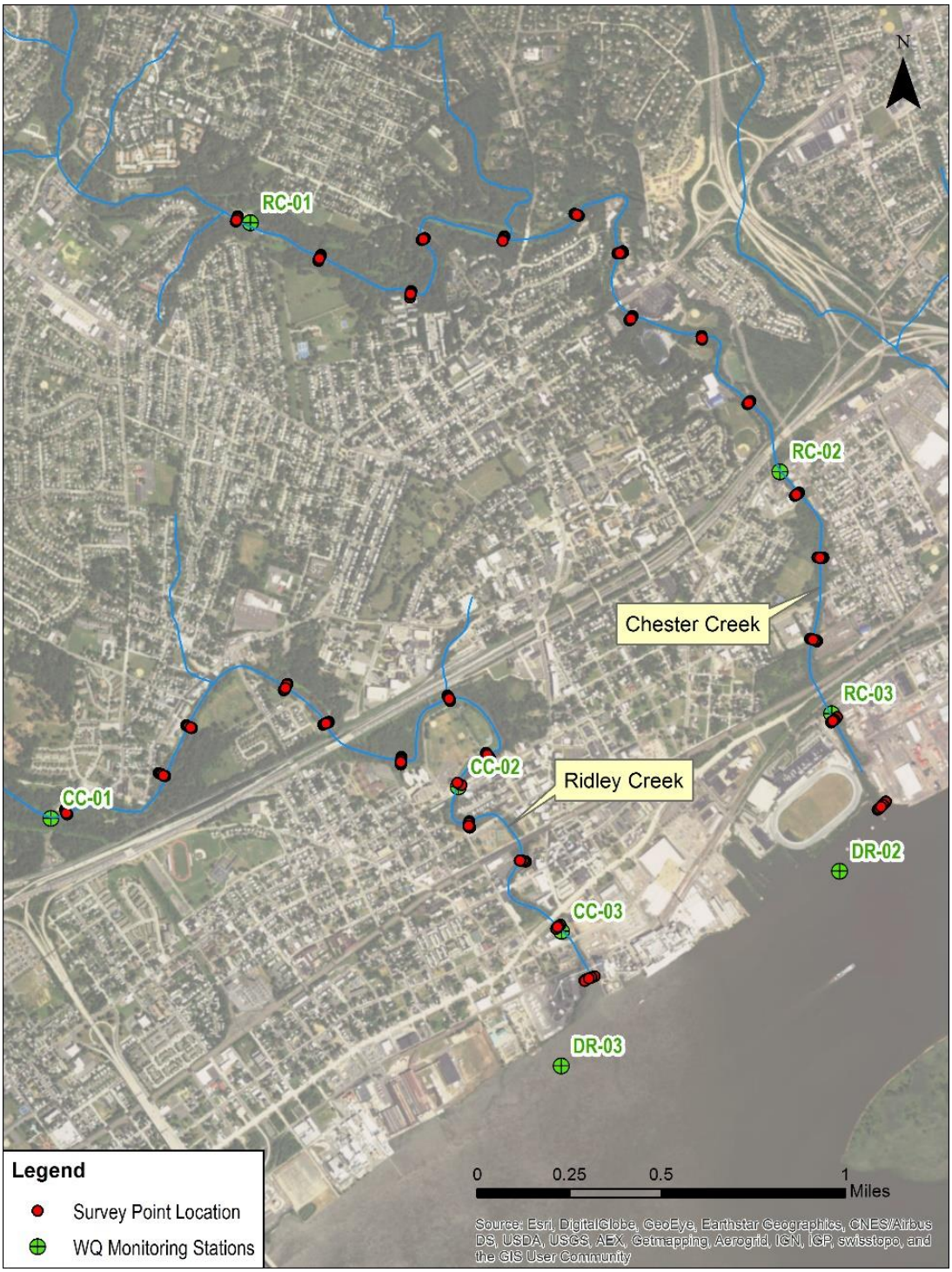

Figure 1: Locations of Creek Elevation Measurements in Chester and Ridley Creeks

Elevation measurements from this survey were compared with similar elevation data from a 1977 Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) of the creeks (FEMA, 2015). Though the FEMA study was completed several decades ago, it serves as a useful check on the accuracy and sufficiency of the bathymetric survey data. Figures 1 and 2 compare the LimnoTech survey data with the FEMA data.

A few characteristics of these figures are relevant to the water quality modeling of the creeks. In Chester Creek, the LimnoTech bed elevations are substantially higher (about five to ten feet) than FEMA elevations. Higher contemporary creek elevations influence both the degree of tidal exchange in the lower reaches of the creeks, and travel times of upland runoff and base flow to the Delaware River.

To check for potential bias in the LimnoTech measurements, the LimnoTech measurements of water surface elevation were compared to similar data maintained by NOAA at a nearby tide gage (Philadelphia gage, #8545240). These measurements of water surface elevation agreed well (within two inches) which is a strong indication that the LimnoTech creek bed elevations are not biased high.

Higher creek bed elevations near the Chester Creek mouth are an indication that soft sediments have accumulated there since the 1970s. The highest observed peak flow in Chester Creek occurred a few years before the FEMA survey (in 1971, peak flow of 21,000 cfs) while recent peak flows have been significantly lower (average peak flow of 4,000 cfs in the last ten years) (USGS, 2017). Lower contemporary peak flows may have allowed for the accumulation of soft sediments in the lower reaches of Chester Creek.

Another significant observation from the LimnoTech data is that a pipe crossing near river mile 1.0 in Chester Creek created a high point in the creek bed profile. This high point acts to slightly reduce upstream water currents during lower flow conditions. This would tend to lengthen travel times of bacteria.

In Ridley Creek the LimnoTech data show a more constant bed slope between river miles 2.0 and 3.5 than the FEMA data. This is because low head dams existed in the 1970s near river miles 2.0 and 3.0, but are no longer in place. These dams previously acted to accumulate sediments in their shallow upstream pools, but when the dams were no longer present these accumulated sediments were likely washed away downstream.

These comparisons between the LimnoTech survey data, the historical FEMA data, and the NOAA tide gage, show consistency and provide confidence in the data collected. These comparison also help to identify locations where the creek bed has changed in the last several decades in ways that would influence creek hydraulics and pollutant transport.

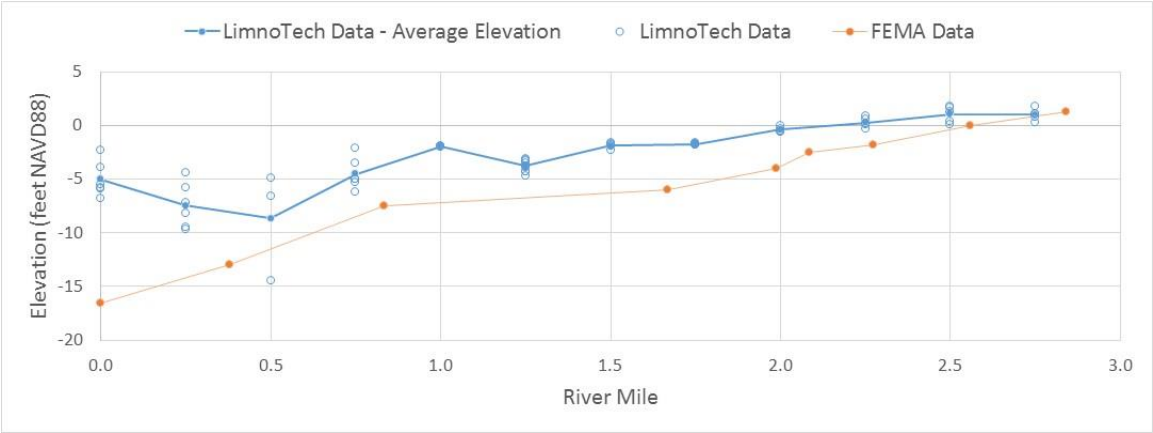

Figure 2: Comparison of Chester Creek bed elevation measurements

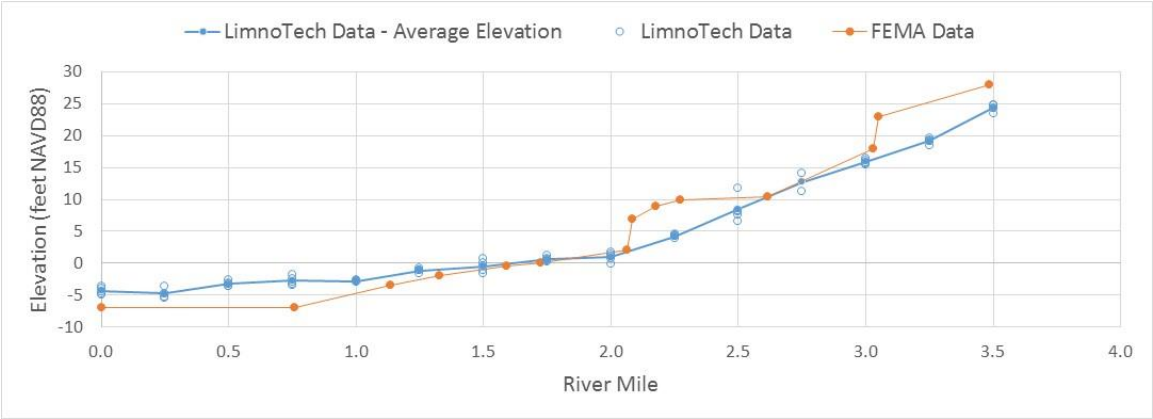

Figure 3: Comparison of Ridley Creek bed elevation measurements

References

FEMA, 2015. Flood Insurance Study: Delaware County, Pennsylvania. Volume 1 of 2. Revised September 2, 2015. Flood Insurance Study Number 42045CV001B.

USGS, 2017. Peak Streamflow for Pennsylvania: USGS 01477000 Chester Creek near Chester, PA. Website accessed on April 25, 2017 at: https://nwis.waterdata.usgs.gov/pa/nwis/peak/?site_no=01477000&agency_cd=USGS

APPENDIX B
DELCORA Water Quality Sampling Report

Delaware County Regional Water Quality Control Authority (DELCORA)
CSO Long Term Control Plan Update

Water Quality Sampling Report

October 2017

GREELEY AND HANSEN

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES

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Section 1 Introduction

1.1 Background of DELCORA's Facilities

Delaware County Regional Water Quality Control Authority (DELCORA) is responsible for the collection, transmission, treatment and disposal of approximately 65 million gallons per day (MGD) of wastewater generated in southeastern Pennsylvania. DELCORA's facilities serve residential, commercial, institutional, and industrial customers in Delaware County. DELCORA owns and operates an extensive system of pump stations, force mains, and sewers that provide the core infrastructure for the transmission of wastewater to treatment facilities in Delaware County and the City of Philadelphia as shown diagrammatically in Figure 1-1. The total service area served by DELCORA, as shown on Figure 1-2, is approximately 82,977 acres which illustrates that DELCORA serves a significant and widespread portion of Delaware County.

The combined sewer area simulated in DELCORA's existing Hydrologic and Hydraulic model is located within the City of Chester and consists of a drainage area of approximately 1,510 acres. It comprises approximately half of Chester City's serviced area. To support the service area, DELCORA owns and operates over 129 miles of separate and combined sewers. Included in the 129 miles of sewers are 11.7 miles of an interceptor system; 3,209 manholes; and twenty-five (25) combined sewer regulated outfalls controlling storm overflows. The location of Chester City's service area is illustrated on Figure 1-2.

Historically, DELCORA has characterized its service areas as "Eastern" and "Western." The Western Service Area discharges to DELCORA's Western Regional Treatment Plant (WRTP). The Eastern Service Area discharges to the Philadelphia Water Department's Southwest Water Pollution Control Plant (PWDSWPCP). In 2002, DELCORA completed the installation of a force main that connects the Eastern Service Area's Central Delaware Pump Station (CDPS) to the Chester Force Main. This connection allows DELCORA to send flow from the CDPS to the WRTP. As such, dry weather flows and a portion of the wet weather flows (total flow less than 20 MGD) from the Central Delaware County Authority in the Eastern Service Area are discharged to the WRTP. Flows above 20 MGD are directed to the PWDSWPCP.

1.2 CSO and Receiving Water System Description

The Chester Combined Sewer Overflow (CSO) system contains 26 permitted outfalls and they discharge to three receiving water bodies: the Delaware River, Chester Creek, and Ridley Creek. However, there are only 25 CSO discharge locations, as CSO #010 discharges to the Delaware River through CSO #009. Figure 1-3 depicts the locations of CSO regulators and outfalls that are DELCORA's responsibility. Figure 1-3 also provides a sewer characterization and illustrates the breakdown of each outfall and how each drainage area has combined sewers and separate sewers. Figure 1-4 is a schematic of the Chester CSO system and shows the outfalls and the interceptors that are connected to each CSO.

1.3 NPDES Permit Requirements

There are a total of 26 combined sewer overflow outfalls listed with 25 discharge points (Outfall #009 and #010 both discharge at Outfall #009) in DELCORA's existing National Pollutant Discharge Elimination System (NPDES) Permit. Under its NPDES Permit No. PA0027103, issued and administered by the Pennsylvania Department of Environmental Protection (PADEP), DELCORA is authorized to discharge from the Western Regional Treatment Plant (Outfall #001), four storm water outfalls at the WRTP (028-031) and from 26 combined sewer overflow outfalls (#002-#026, #032, #033) that ultimately discharge to the Delaware River, Chester Creek and/or Ridley Creek.

Part C - Other Requirements, Section V - Combined Sewer Overflows of the NPDES Permit details DELCORA's responsibilities with respect to the CSO system including reporting, continued implementation of and continued compliance with the Nine Minimum Controls (NMC), and implementation of the existing Long-Term Control Plan (LTCP) dated April 1999 and the July 2008 addendum to the LTCP until the updated LTCP is approved.

1.4 Consent Decree Requirements

On August 17, 2015, a Consent Decree was lodged in the United States District Court for the Eastern District of Pennsylvania that requires DELCORA to complete and submit a revised and updated LTCP to the United States Environmental Protection Agency (USEPA or EPA) and the Pennsylvania Department of Environmental Protection (PADEP or DEP) for review and approval. Consent Decree Paragraph V.A.15 (Water Quality Model Plan) requires that within ninety (90) days after EPA reviews and approves the Alternatives Evaluation Approach, DELCORA shall submit to EPA and PADEP a Water Quality Model Plan for review and approval.

The Alternatives Evaluation Approach Report was approved by US EPA on October 13, 2016. The "Demonstration Approach" was selected for each CSO, receiving streams based on the methodology outlined in the Alternatives Evaluation Report.

1.5 Water Quality Sampling Program Purpose and Objectives

The "Demonstration Approach" requires that a Water Quality Model be developed for each receiving stream. The Water Quality Modeling effort will require calibration and validation of the model and therefore Water Quality Sampling is required. The Water Quality Sampling Program will gather data required for this effort. The three water bodies that receive overflows from DELCORA's CSS include the Delaware River, Chester Creek and Ridley Creek.

1.6 Water Quality Sampling Report Purpose and Objectives

The purpose and objective of the Water Quality Sampling Report is to provide a detailed description of the water quality sampling task undertaken to gather field data as required to build and calibrate the Water Quality Model in accordance with the Water Quality Monitoring and Modeling Work plan (Greeley and Hansen / Limnotech, Revised July 2017). The data gathered through sampling efforts on the Creeks, River, Combined Sewer Outfalls (CSO) and Stormwater (SW) locations has been analyzed and is discussed at length in this report. The report also provides a summary of the sampling activities for each

Dry and Wet weather sampling event along with laboratory testing results and in-situ field data collected on-site for each sampling event.

Figure 1-1: DELCORA'S Conveyance Systems

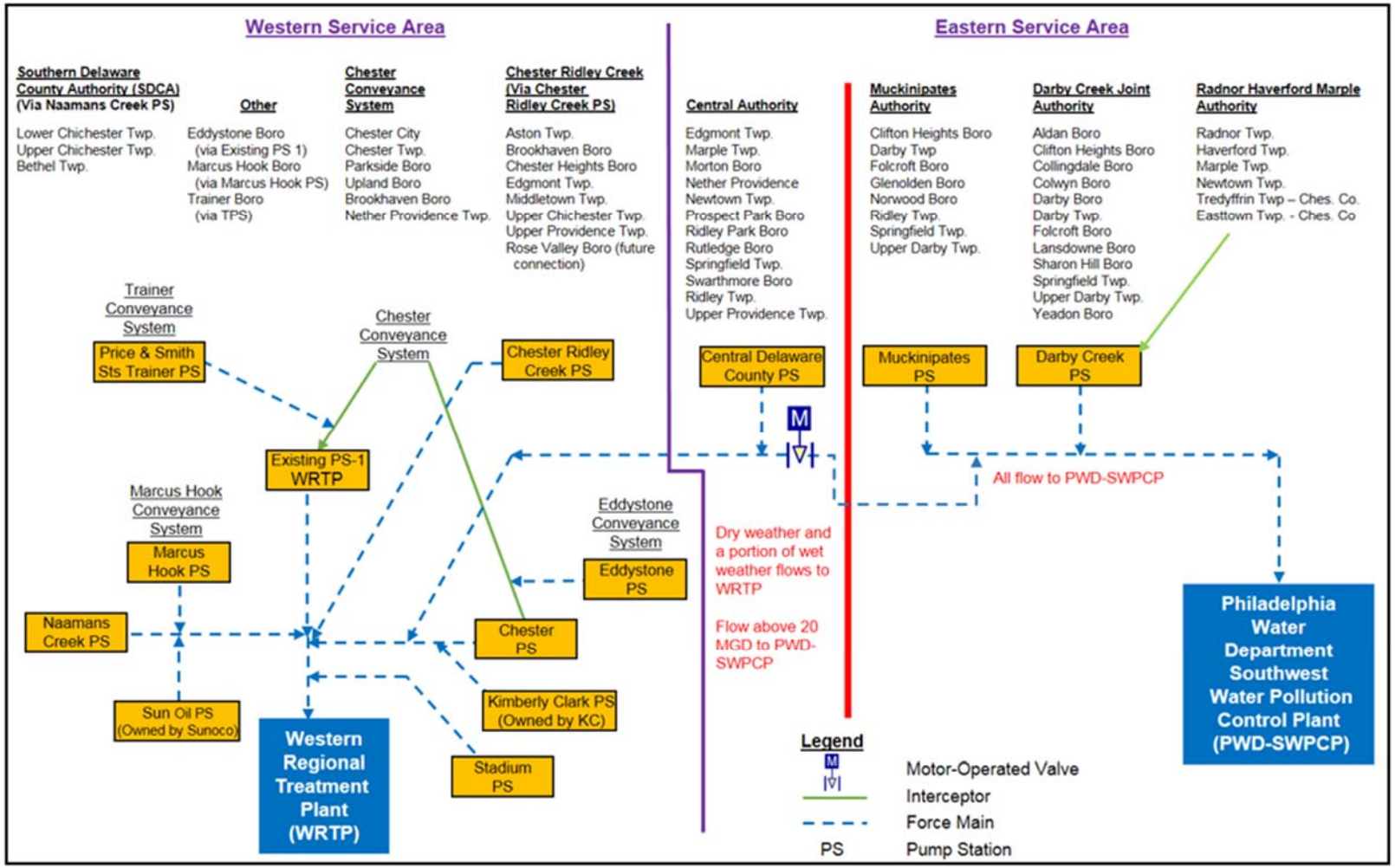


Figure 1-2: DELCORA's Service Area

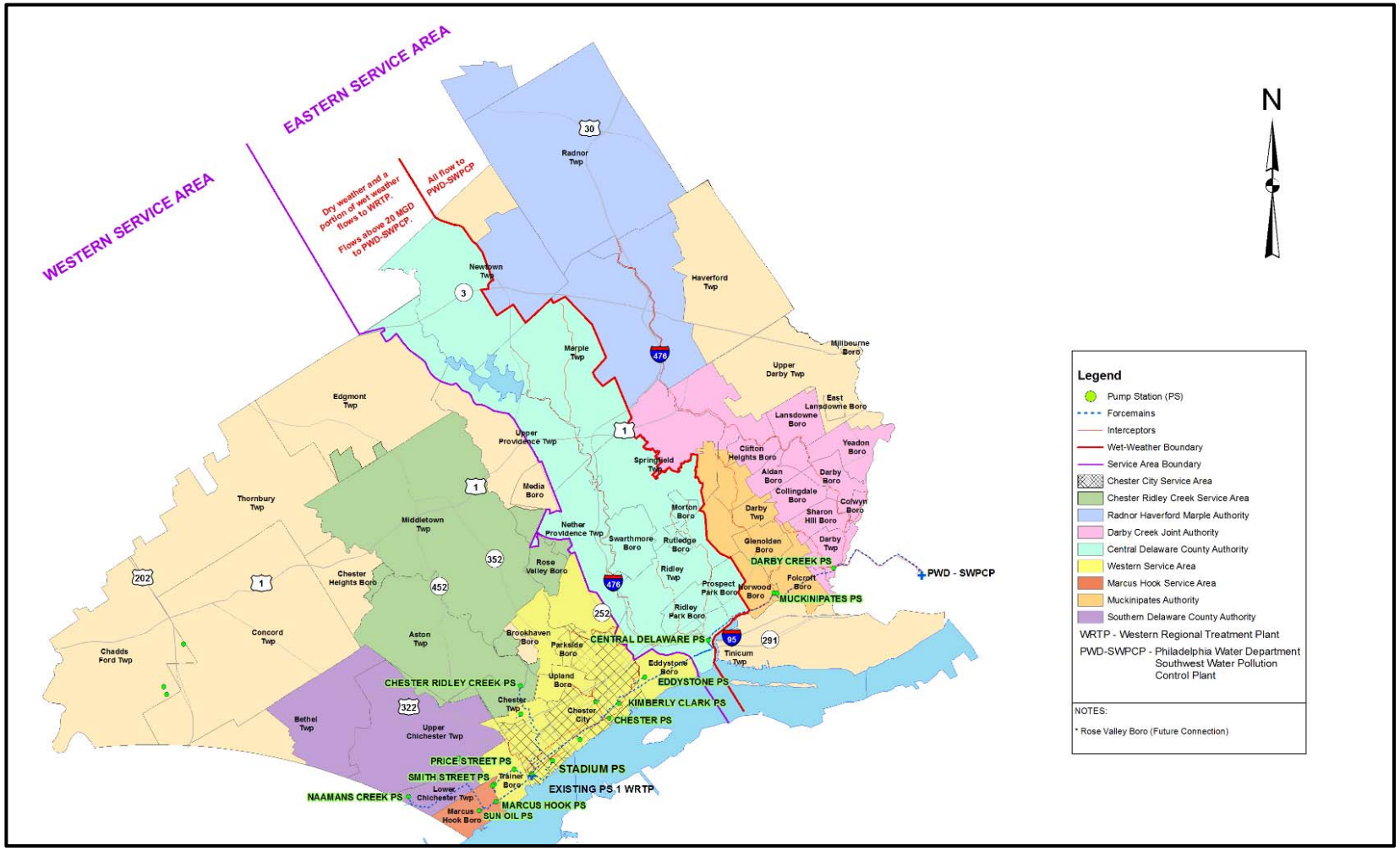


Figure 1-3: Location of Regulators and Combined Sewer Outfalls with Drainage Areas

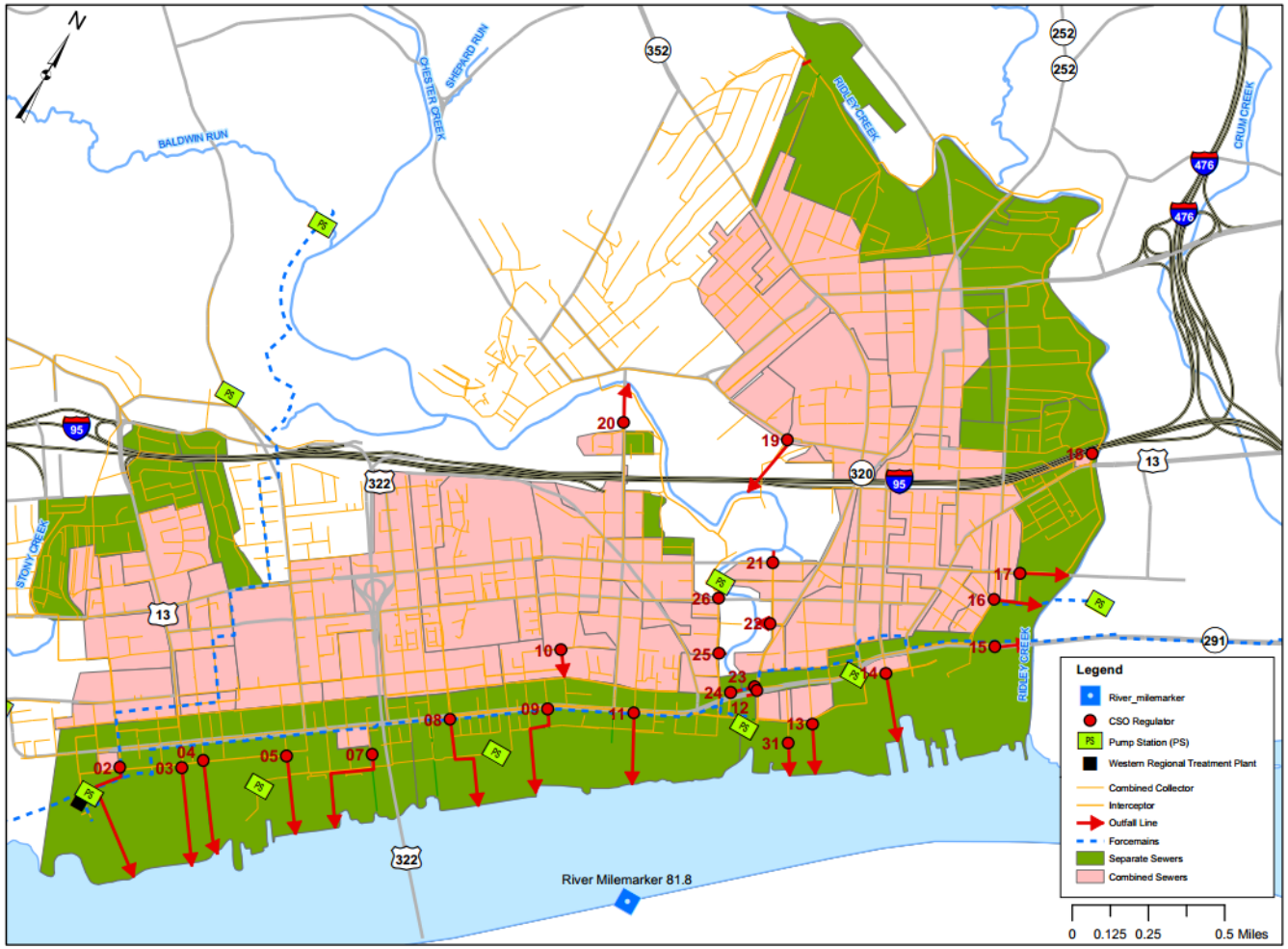
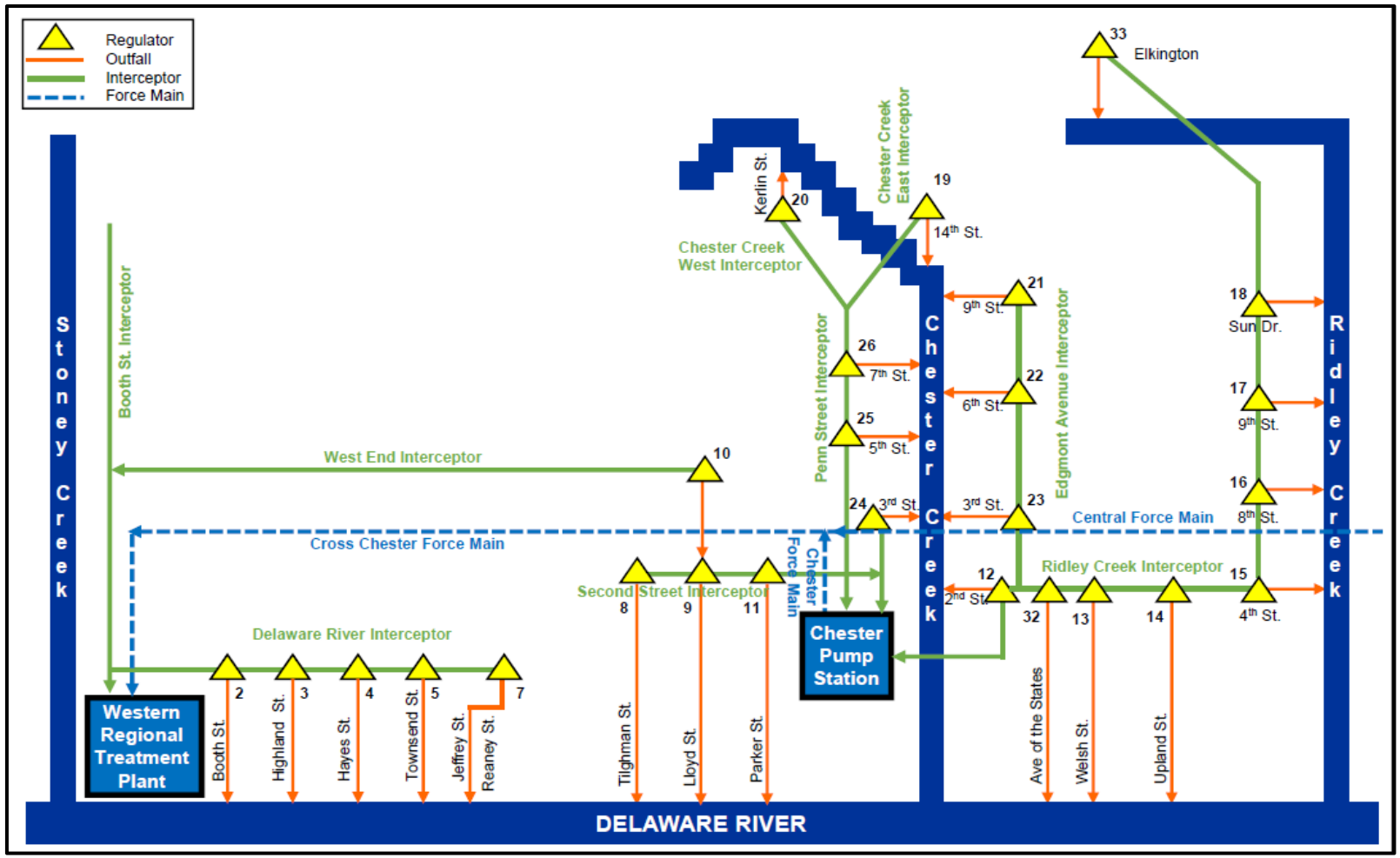


Figure 1-4: Schematic of Chester CSO System



Section 2 Sampling and Analysis Plan Overview

2.1 Existing Water Quality Monitoring Overview

The Water Quality Monitoring Program (WQMP) was designed to collect data that will be used to assess water quality concerns identified in the Delaware River watershed and its tributaries, Chester Creek and Ridley Creek, in the vicinity of Chester, PA. Pollutants of concern (POCs) are identified in the Identification of Sensitive Areas and Pollutants of Concern Report (Greeley and Hansen, 2016c) which was approved by US EPA on October 13, 2016. Table 2-1 below lists the POCs that were identified which exceeded the maximum water quality standards (WQS) in the receiving streams and were approved for further investigation through water quality monitoring and modelling. The POCs are Fecal coliform, *E. coli*, and *Enterococcus* and are the primary focus of the WQMP. Figure 2-1 shows the water quality standards in the receiving streams.

Table 2-1: List of Pollutants of Concern (POC)

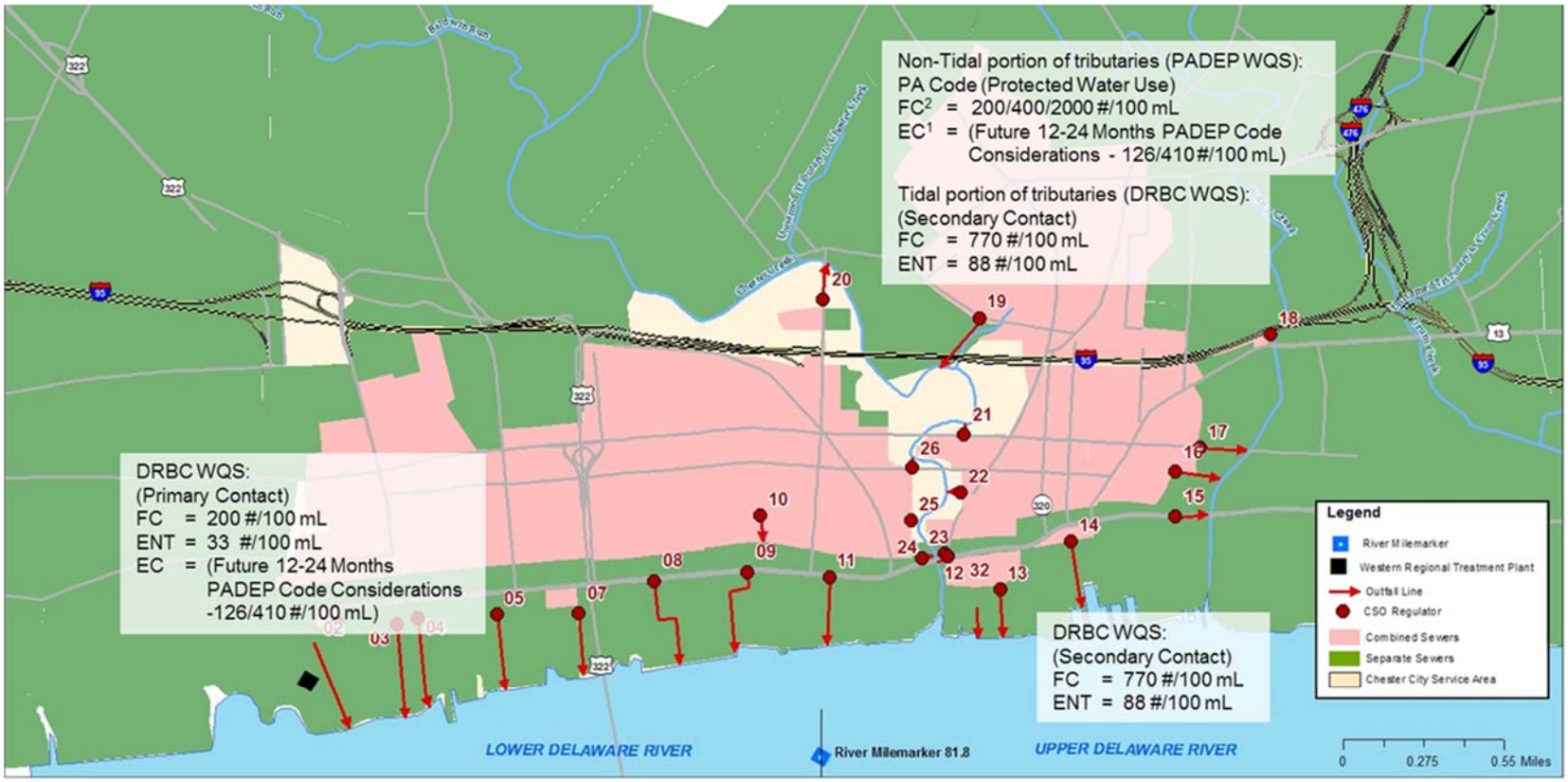
No.	Upper Delaware River		Lower Delaware River		Chester Creek		Ridley Creek	
Pollutants of Concern (>10% of observed samples exceed WQS)								
1	Fecal Coliform[b]	100%	Fecal Coliform[b]	100%	Fecal Coliform[a],[b]	100%	Fecal Coliform[a],[b]	100%
2	Enterococcus [b],[c]	100%	Enterococcus [b],[c]	100%	Enterococcus [b],[c]	100%	Enterococcus [b],[c]	100%
3	E. coli[c]	100%	E. coli[c]	100%	E. coli[c]	100%	E. coli[c]	100%

[a] Based on historical sampling conducted in 2010 upstream and downstream of CSO outfalls only on Chester and Ridley Creeks.

[b] Fecal Coliform and Enterococcus are listed as POCs due to both being parameters typically associated with CSOs.

[c] DRBC regulations are available for Enterococcus and it is typically associated with CSOs and therefore it is included as a POC. However, in consultation with PADEP Enterococcus could be replaced with E. coli bacteria in the future (based on the anticipation that national standards on E. coli will be adopted in Pennsylvania) and therefore E.coli is also included as a POC.

Figure 2-1: Water Quality Standards in the Receiving Streams



[1] E.coli (EC) standards likely to be codified by PADEP 12-24 months from July 2017. These criteria would apply to the non-tidal tributaries and Delaware River below R.H. 81.8, during recreational months only (May 1 - September 30). First value is a geometric mean standard, second is a statistical threshold value (STV) standard (no more than 10% of concentrations can be above this value).

[2] First value is a geometric mean standard, second is a statistical threshold value (STV) standard (no more than 10% of concentrations can be above this value), third value is a non-recreational season standard (October 1 - April 31).

2.2 Sampling and Analysis Plan Overview

Water quality sampling was undertaken at thirteen (13) in-stream locations (seven of which are Delaware River sampling locations), four (4) CSO locations in the DELCORA combined sewer system area, and two (2) stormwater locations in the City of Chester municipal separate storm sewer system, as shown in Figure 2-1. Water quality sampling was conducted as follows:

- Eleven (11) in-stream locations in the vicinity of the DELCORA CSO area were sampled for water quality for (3) dry weather events; one of which was targeted for collection during a tributary low-flow period (less than 25th percentile flow). The mid-stream and far-shore Delaware River locations were not sampled during the dry weather surveys because the water quality in the river is found to be relatively uniform laterally due to the lack of active sources during dry weather. These dry weather events were distributed across the sampling season, which was from March through June of 2017. Grab samples and *in situ* measurements were collected at each location during each event.
- All thirteen (13) in-stream locations were sampled for water quality using grab samples and *in situ* monitoring for three (3) discrete wet weather events, according to the surface water quality monitoring program protocols described in the Water Quality Monitoring and Modeling Work Plan (Greeley and Hansen / Limnotech, Revised July 2017);
- Up to four (4) CSO and two (2) stormwater outfall locations were sampled for water quality for the same three (3) discrete wet weather events according to the outfall monitoring program protocols described in the Water Quality Monitoring and Modeling Work Plan (Greeley and Hansen / Limnotech, Revised July 2017). Samples for all outfalls were collected as grab samples.

The sampling events were planned and distributed across the sampling season, which was from March through June 2017.

2.3 Sampling Locations

Sampling locations were selected to characterize the watershed at a sub-watershed level, recognizing various political and hydrologic features, land uses and potential pollutant sources. Site selection and analytical parameters are designed to characterize stormwater outfalls, CSOs, tributaries upstream and within the Chester CSO discharge area, and the main stem of the Delaware River in the project area. The sampling locations are shown in Figure 2-2.

Tables 2-2, 2-3 and 2-4 include summaries of the rationales for each sampling location selected. The Chester Creek and Ridley Creek locations were selected to distinguish, to the extent possible, between upstream, stormwater and Chester CSO pollutant loads. The Delaware River sampling locations provided a characterization of water quality entering the Chester CSO area from either tidal direction as well as water quality within the CSO discharge area. During wet weather, three samples were collected across the transect corresponding to the DR-03 sampling location during each sampling round, when sampling across the river was feasible, to characterize lateral variability in the Delaware River during storm events.

The CSO sampling locations were selected based on their outfall discharge location, relatively high frequency of overflow, their overflow volume, and their accessibility. The stormwater sampling locations

Figure 2-2: Receiving Water, Combined Sewer (CSO), and Stormwater (SW) Sampling Locations

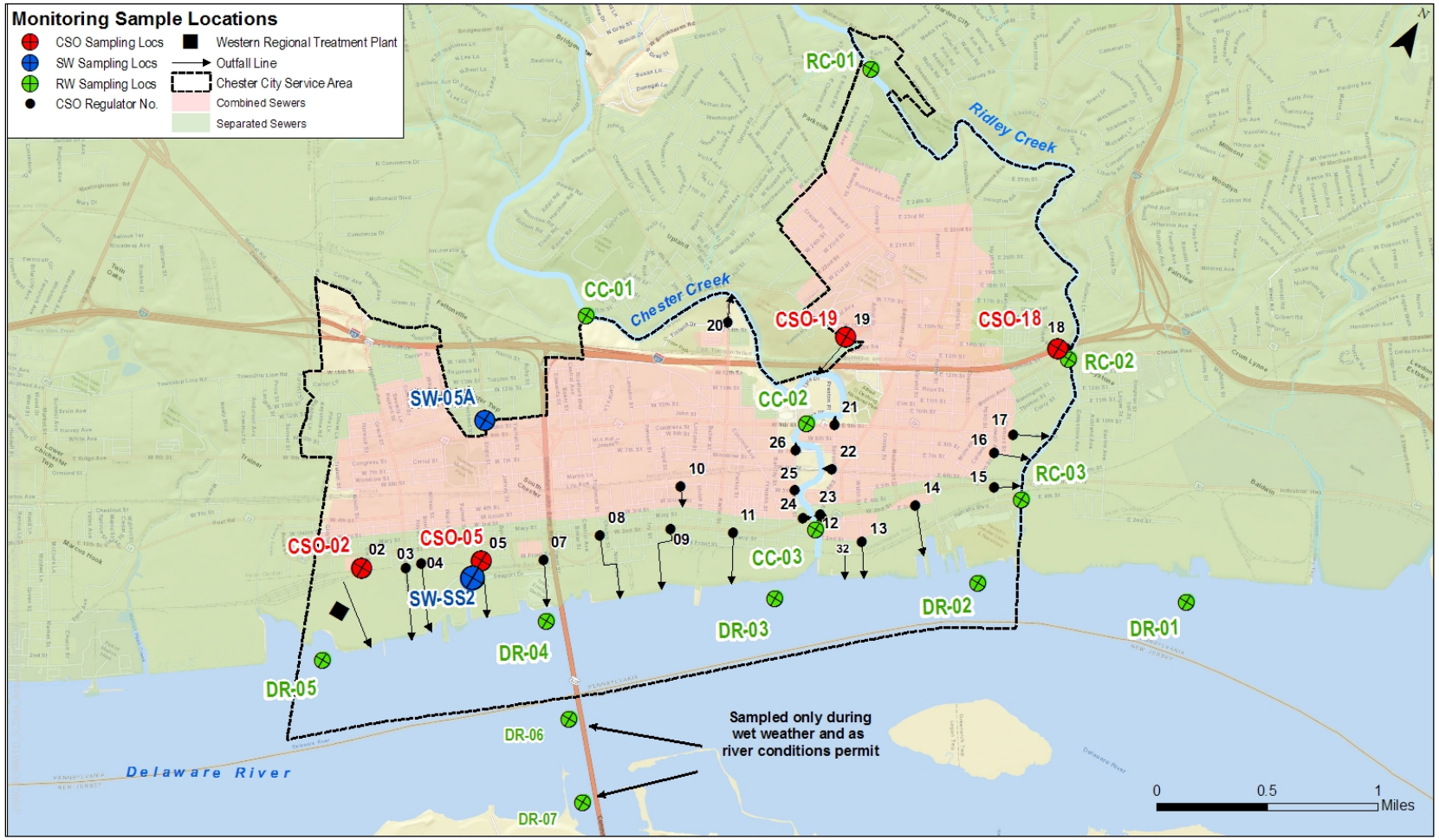


Table 2-2: Tributary Receiving Water Sampling Locations

Station ID	Latitude[1]	Longitude[1]	Receiving Water	Type	Description	Rationale
CC-01	39.850122	-75.386348	Chester Creek	Tributary	Chester Creek at Upland-Incinerator Rd.	Upstream of all City sources and upstream of tidal influence
CC-02	39.850709	-75.365530	Chester Creek	Tributary	Chester Creek at the 9th St Bridge; 54 W 9th St	Characterize impacts from non-CSO urban runoff sources
CC-03	39.845227	-75.360284	Chester Creek	Tributary	Chester Creek at E 2nd St., William Penn's Landing Park	Characterize impacts from all CSOs discharging to Chester Creek
RC-01	39.873264	-75.375183	Ridley Creek	Tributary	Ridley Creek at Chester Park Drive Bridge; 298 East Elkington Blvd	Upstream of all City sources and upstream of tidal influence
RC-02	39.863016	-75.348686	Ridley Creek	Tributary	Ridley Creek at Morton Ave. Bridge; 1300 Sun Drive	Characterize impacts from non-CSO urban runoff sources
RC-03	39.853435	-75.346350	Ridley Creek	Tributary	Ridley Creek at East 4th St. (Harrah's) Bridge	Characterize impacts from all CSOs discharging to Ridley Creek

Notes:
[1] GPS Coordinates, WGS 1984

Table 2-3: Main Stem Receiving Water Sampling Locations

Station ID	Latitude[1]	Longitude[1]	Receiving Water	Type	Description	Rationale
DR-01	39.85282	-75.3299	Delaware River	Main stem	Delaware River between Ridley Creek and Crum Creek	"Upstream" of DELCORA's CSO discharges[2]
DR-02	39.84715	-75.3462	Delaware River	Main stem	Delaware River between CSO-14 and Ridley Creek	Characterize Ridley Creek impacts on Delaware River, in the upper Delaware River (Secondary contact area)
DR-03	39.8398	-75.3606	Delaware River	Main stem	Delaware River between CSO-11 and Chester Creek	Characterize Chester Creek impacts on Delaware River, in the upper Delaware River (Secondary contact area)
DR-04	39.83132	-75.3766	Delaware River	Main stem	Delaware River at the boat launch off Highway 322	Priority area, in the lower Delaware River (Primary contact area)
DR-05	39.82182	-75.3917	Delaware River	Main stem	Delaware River between CSO-002 and Stony Creek	"Downstream" of DELCORA's CSO discharges[2], in the Atlantic sturgeon sensitive area
DR-06[3]	39.82636	-75.371	Delaware River	Main stem	Delaware River mid-stream along the transect of DR-04	Characterize lateral variability in the Delaware River during storm events
DR-07[3]	39.82203	-75.3665	Delaware River	Main stem	Delaware River far shore (left descending bank) along the transect of DR-04	Characterize lateral variability in the Delaware River during storm events

Notes:
[1] GPS Coordinates, WGS 1984
[2] "Upstream" and "downstream" subject to tidal conditions at time of sampling
[3] These locations will be sampled during the wet weather events only, when river conditions permit. POC concentrations are assumed to be laterally well-mixed during dry weather due to the absence of significant pollutant sources.

Table 2-4: CSO and Stormwater Sampling Locations

Station ID	Latitude[1]	Longitude[1]	Receiving Water	Type	Description	Rationale
CSO-19	39.857132	-75.366105	Chester Creek	CSO	14th and Crozer Hospital; 1 Medical Center Blvd	Discharges to Chester Creek, one of the largest volume CSOs in DELCORA system
CSO-05	39.832598	-75.383958	Delaware River	CSO	Front and Townsend; 101 Townsend St	Discharges to Delaware River, one of the largest volume CSOs in DELCORA system
CSO-02	39.828334	-75.392570	Delaware River	CSO	Front and Booth; 100 Booth St	Aggregates cumulative effect of CS conditions, one of the largest volume CSOs in DELCORA system
CSO-18	39.863501	-75.349203	Ridley Creek	CSO	Sun Drive and Hancock St.; 1310 Sun Dr	Discharges to Ridley Creek
SW-05A	39.838501	-75.387708	Chester Creek	SW	7th and Engle Street; by tennis courts	Characterize runoff quality from predominantly residential area representative of the residential portion of the study area
SW-SS2	39.832853	-75.384193	Delaware River	SW	Front and Townsend; 105 Townsend St	Characterize runoff quality from predominantly commercial/industrial area representative of the commercial/industrial portion of the study area

Notes:
[1] GPS Coordinates, WGS 1984

were selected to characterize the water quality associated with the predominant land uses (residential and commercial/industrial) in the study area. Each stormwater sampling location is in an area that is representative of the land use elsewhere in the City's stormwater area.

2.4 Analytical Parameters

All of the in-stream dry and wet weather samples was analyzed for the parameters shown in Table 2-5. The outfall samples was analyzed for *E. coli*, *Enterococcus* and Fecal coliform.

Table 2-5: Analytical and Field Parameters

Parameter	Description	Sampling Program	Type of Measurement
E. coli	Escherichia coli	Dry, Wet	Grab
Enterococcus	Enterococcus sp.	Dry, Wet	Grab
Fecal coliform	Fecal coliform	Dry, Wet	Grab
Temp	Water temperature	Dry, Wet, Receiving Water Only	In-situ
Cond	Conductivity	Dry, Wet, Receiving Water Only	In-situ
Salinity	Salinity	Dry, Wet, Receiving Water Only	In-situ

2.5 Sampling Schedule

2.5.1 Dry Weather Sampling

Collection of water quality samples was performed for three (3) dry weather events; with one dry weather sampling event collected during a low-flow period (less than 25th percentile flow) in Chester Creek and Ridley Creek.

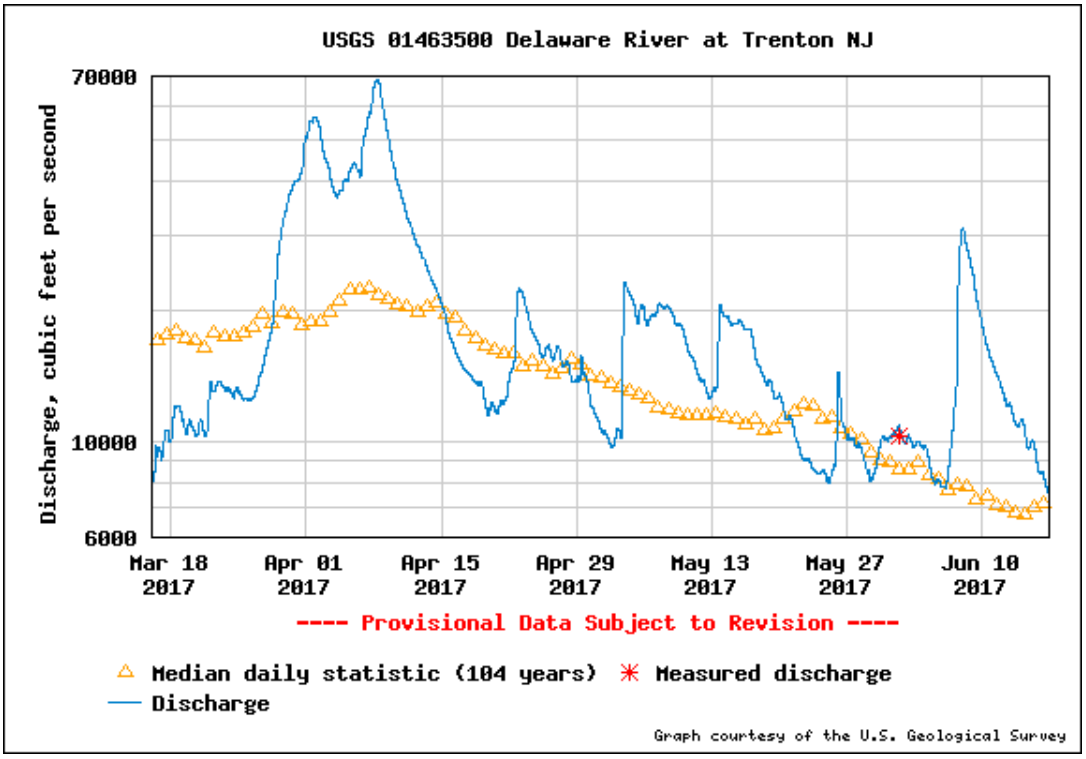
The values and statistics in Tables 2-6 and 2-7 were obtained from the United States Geological Survey (USGS). The USGS StreamStats (https://streamstats.usgs.gov/ss/) website provided the 25th percentile for the period of record for each water body and the National Water Information System (NWIS) provided current flow data. For each Dry Weather Event, the flow listed was reported as the average for the time of the sampling event calculated from 15-minute recorded observations not the average daily flow.

Table 2-6: Gage Information

Water Body	Gage Identification	Gage Description	Latitude	Longitude	Period of Record	StreamStats Weblink	NWIS Weblink
Delaware River	USGS 01463500	Delaware River at Trenton, NJ	40°13'18"	-74°46'41"	1912-2015	https://streamstatsags.cr.usgs.gov/gagepages/html/01463500.htm	https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=01463500
Chester Creek	USGS 01477000	Chester Creek near Chester, PA	39°52'08"	-75°24'31"	1931-2015	https://streamstatsags.cr.usgs.gov/gagepages/html/01477000.htm	https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=01477000
Ridley Creek	USGS 01476480	Ridley Creek at Media, PA	39°54'58"	-75°24'13"	1986-2015	https://streamstatsags.cr.usgs.gov/gagepages/html/01476480.htm	https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=01476480

A graph of the stream flow for each gage over the duration of the sampling program is shown below in Figures 2.3 - 2.5. The percentile for the streamflow during each event was interpolated from the statistical data provided on the StreamStats page.

Figure 2-3: Delaware River Flow, USGS Gage at Trenton, NJ



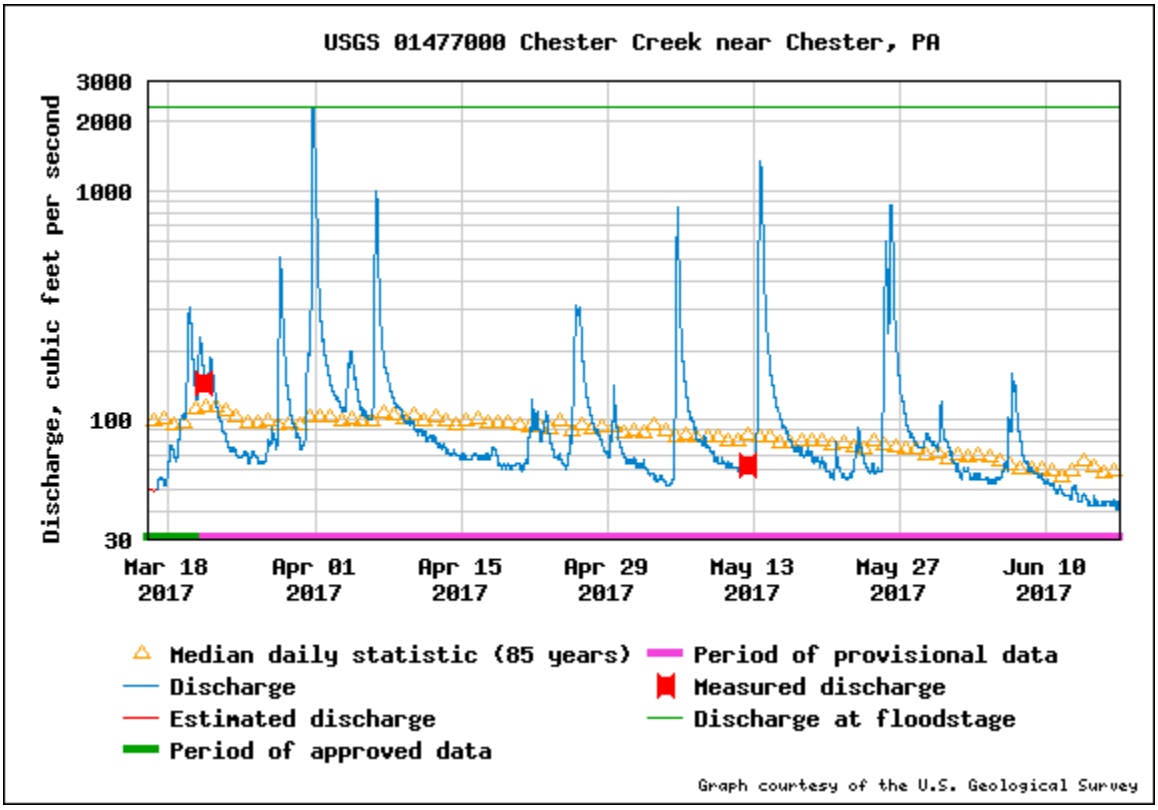
https://nwis.waterdata.usgs.gov/nwisweb/graph?agency_cd=USGS&site_no=01463500&parm_cd=00060&begin_date=2017-03-16&end_date=2017-06-16

Table 2-7: Receiving Waters 25th Percentile Flow

Water Body	Gage Identification	Gage Description	25th Percentile Flow	Dry Weather Event 1 Average Flow		Dry Weather Event 2 Average Flow		Dry Weather Event 3 Average Flow	
			(cfs)	(cfs)	Percentile	(cfs)	Percentile	(cfs)	Percentile
Delaware River	USGS 01463500	Delaware River at Trenton, NJ	4,600	13,323	70.1	16,306	78.1	10,862	62.1
Chester Creek	USGS 01477000	Chester Creek near Chester, PA	41	75.7	60.5	63.9	50.7	46.8	32.2
Ridley Creek	USGS 01476480	Ridley Creek at Media, PA	18	29.4	49	25.0	41.7	19.0	27.5

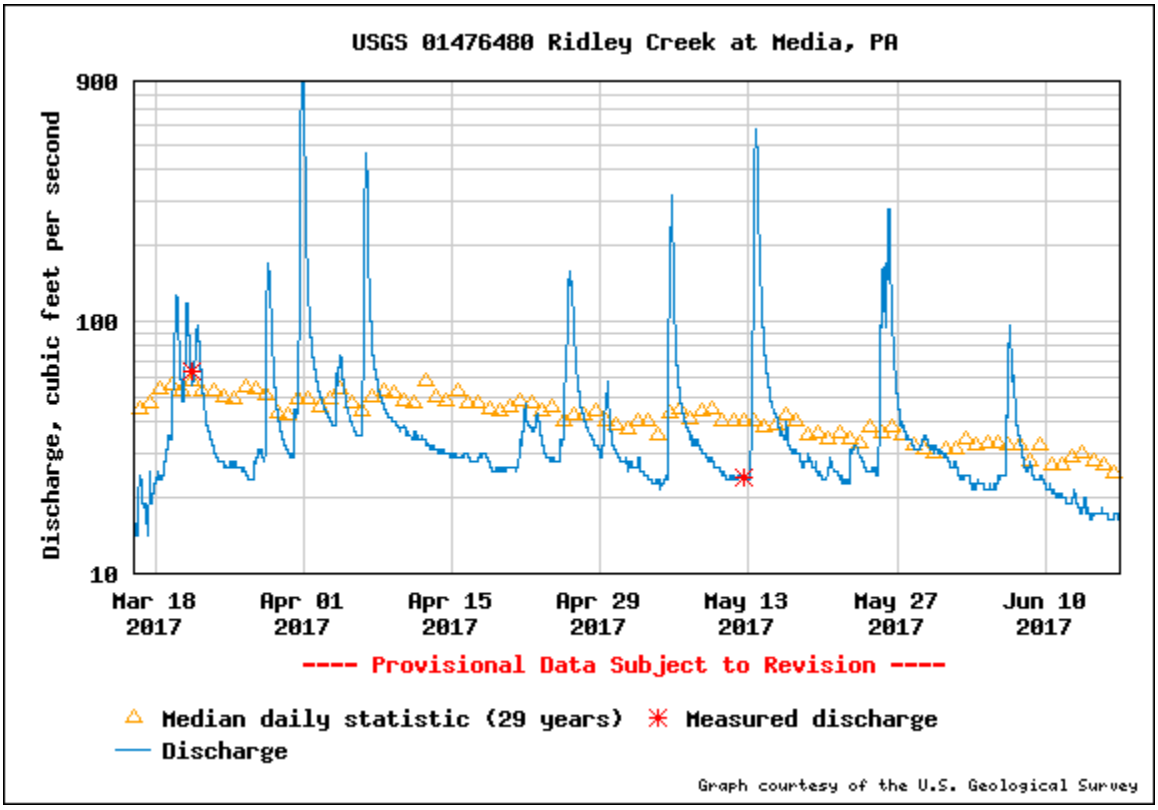
Source:
-25th percentile flow (cfs) and percentile for each water body is courtesy of the U.S. Geological Survey (USGS) StreamStats (https://streamstats.usgs.gov/ss/)
-Observed flow data (cfs) for each Dry Weather Event is courtesy of the following current/historical observations link on the National Water Information System (NWIS) webpage:
Delaware River: https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=01463500
Chester Creek: https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=01477000
Ridley Creek: https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=01476480

Figure 2-4: Chester Creek Flow, USGS Gage near Chester, PA



https://nwis.waterdata.usgs.gov/nwisweb/graph?agency_cd=USGS&site_no=01477000&parm_cd=00060&begin_date=2017-03-16&end_date=2017-06-16

Figure 2-5: Ridley Creek Flow, USGS Gage at Media, PA



https://nwis.waterdata.usgs.gov/nwisweb/graph?agency_cd=USGS&site_no=01476480&parm_cd=00060&begin_date=2017-03-16&end_date=2017-06-16

Two rounds of sampling were conducted for each dry weather survey: one round was completed during ebb (outgoing) tide and the second round was completed during flood (incoming) tide.

Dry weather event samples were taken at eleven (11) locations:

- **Three (3) locations on Chester Creek** that characterizes water quality upstream of DELCORA's service area as well as in the portion of the creek adjacent to DELCORA's CSO discharges and the area adjacent to the City of Chester outside the combined sewer service area. Additionally, because DELCORA's CSO discharges are within the tidal extent of the Delaware Bay, the downstream sampling locations used reflect these tidal influences on water quality.
- **Three (3) locations on Ridley Creek** that characterizes water quality upstream of DELCORA's service area as well as in the portion of the creek adjacent to DELCORA's CSO discharges and the area adjacent to the City of Chester outside the combined sewer service area. Additionally, because DELCORA's CSO discharges are within the tidal extent of the Delaware Bay, the downstream sampling locations used reflect these tidal influences on water quality.
- **Five (5) locations on the Delaware River** that characterizes water quality in the vicinity of DELCORA's CSO discharges. Sampling locations used are selected to separate to the extent possible the effect of DELCORA's CSOs on water quality from other sources contributing pollutants to the waterways. Sampling was conducted near the shoreline adjacent to the City of Chester

The locations of these stations are shown in Figure 2-1. Details for the parameters for which the samples were analyzed is provided in Table 2-5. In-situ measurements of physical parameters, such as salinity, temperature, and conductivity were collected at each sampling location with a YSI sonde. In the Delaware River, *in situ* measurements were collected at three depths at each sampling location during each round of sampling.

2.5.2 Wet Weather Sampling

Collection of water quality samples were performed for three (3) wet weather events. The purpose of the wet weather sampling was to characterize the impact of CSO discharges and non-CSO source runoff on in-stream water quality. The wet weather events spanned a range of precipitation, flow and seasonal conditions.

Wet weather event samples were taken at all 13 in-stream locations as well as at up to six source locations in the intervals described below:

- **Six (6) In-Stream Tributary Sampling Locations:** Three (3) locations were on Chester Creek and three (3) locations on Ridley Creek. The locations were the same locations used for the dry weather surveys. Tributary locations were sampled up to five times per event at the following approximate intervals: Hour 0.5-2.5, Hour 4.5-6.5, Hour 8.5-10.5, Hour 14.5-16.5, and Hour 22-24. Sampling intervals were defined by the start of rainfall rather than CSO or SSO activation. A total of 30 samples were collected during each wet weather sampling event from in-stream locations. One field blank and one field duplicate were collected during each event to be used as field quality control (QC).

- **Up to Seven (7) In-Stream Delaware River Locations:** Up to seven locations were on the Delaware River and were sampled up to ten times per event at the following approximate intervals: Hour 0, Hour 2, Hour 4, Hour 6, Hour 9, Hour 12, Hour 15, Hour 18, Hour 21, and Hour 24. Sampling intervals were defined by the start of rainfall rather than CSO or SSO activation. The frequency of sampling was intended to capture in-stream impacts in the vicinity of DELCORA's service area from both DELCORA's CSOs as well as upstream sources. Two additional locations on the Delaware River, one at mid-stream and one near the far shore, were added to characterize lateral variability in water quality during storm event conditions, when sampling across the river is feasible. The sampling regimen was also designed to allow a semi-quantitative mass balance to be computed over a complete tidal cycle. When the river conditions were unsafe for sampling (e.g. small craft advisories, heavy barge traffic, etc.), sampling was suspended for one or more locations and/or sampling rounds. One field blank and one field duplicate were collected during each event to be used as field QC. Final selection of sampling locations and sampling intervals were determined prior to the start of the sampling program and were based on logistic considerations (e.g. can seven locations be sampled and dropped off to a courier within the 3 hour sampling window), safety and accessibility to the Delaware River, and available resources.
- **Up to Six (6) Outfall Locations:** Sampling was be conducted at up to two (2) stormwater outfalls and up to four (4) combined sewer overflow outfalls. The CSO and stormwater sampling locations were finalized prior to the initiation of the sampling program based on accessibility of sampling, safety of sampling personnel, equipment risk, and available resources. It was assumed that each of the outfall locations will have up to eight sets of samples collected for each event at the following intervals: 1st flush, 30 minutes, and 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, 24 hours. If a location was found to be not flowing, no sample was collected. One field blank and one field duplicate were collected during each event to be used as field QC.

The locations of these stations are shown in Figure 2-2. The set of parameters for which the samples will be analyzed are summarized in Table 2-4. *In-situ* measurements was not collected at the outfall locations.

Sampling crews conducted all wet weather event sampling using the protocols described in the Water Quality Monitoring and Modeling Quality Assurance Project Plan (Greeley and Hansen / Limnotech, Revised July 2017). Crews were required to keep a City of Chester Map with sampling locations clearly marked as well as a letter from DELCORA permitting the crews access to manholes, shorelines, outfalls, and surface waters (see Appendix J). Samples were delivered to the laboratory where the samples were analyzed for the laboratory parameters identified in Table 2-5.

Determination to mobilize for a Wet Weather Event was a collaborative effort between Greeley and Hansen, LimnoTech, the field sampling contractor and the laboratory contractor personnel. The intent was to identify a 4 to 6 hour window in which a wet weather event that commenced 24 hours in advance to assist in mobilization of the sampling crews.

Section 3 Dry and Wet Weather Sampling Activities

3.1 Dry Weather Sampling Event 1

Dry Weather Sampling Event-1 occurred on March 23, 2017. See Table 2-7 for receiving water flows and percentiles based on USGS gages.

3.1.1 Activity on Creeks

Sampling was conducted on Chester Creek (CC) and Ridley Creek (RC). On this date, the observed daily average flows for Chester Creek and Ridley Creek were 75.7 cfs and 29.4 cfs, respectively, at the locations indicated in Table 2-7.

3.1.1.1 Sample Type and Locations

Grab samples were collected from the following locations on the Creeks:

- Three (3) on Chester Creek - CC-01, CC-02, CC-03
- Three (3) on Ridley Creek - RC-01, RC-02, RC-03

A single in-situ measurement was collected at every location and sampling round.

See Figure 2-2 for map of sampling locations. See Appendix K for sampling photos.

3.1.1.2 Sampling Round and Sampling Time

An incoming tide and outgoing tide sample was collected at each of the three Chester Creek and three Ridley Creek locations described above along with the required Field Blanks and Duplicates. Field Blanks were collected at the first sampling location for each event regardless of tide condition. Samples from the downstream end of the creeks were collected first to capture the outgoing tide at the earliest. The samples on creeks were collected in the following order for each sampling round - CC-03, RC-03, RC-02, RC-01, CC-02 and CC-01. The number and type of samples collected from the Creeks for Dry Event 1 are shown in Appendix A - Dry Weather Event 1 - Field Logs and Lab Results Summary.

The sampling event started on March 23, 2017 at 1:00 PM and ended at 7:30 PM. The sampling times were selected so that they were in between the high tide and low tide time data. The outgoing tide samples were collected first followed by the incoming tide later in the evening. The tide data for that date showed a range of high tide to low tide from 9:15 AM to 4:22 PM and a range of low tide to high tide from 4:22 PM to 9: 54 PM. The sample collection times from the Creeks for Dry Weather Event 1 are shown in Appendix A - Dry Weather Event 1 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.1.1.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) (Weston Solutions, Inc., March 2017) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Dry Weather Event 1 samples on the creeks was held within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site, and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix A - Dry Weather Event 1 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of Dry Weather Event 1 Chain of Custody Forms are shown in Appendix A - Dry Weather Event 1 - Field Logs and Lab Results Summary.

3.1.2 Activity on Delaware River

Sampling was conducted on Delaware River (DR) with 5 locations on the Pennsylvania side of the river. On this date, the observed daily average flow for the Delaware River was 13,323 cfs at the location indicated in Table 2-7.

3.1.2.1 Sample Type and Locations

Grab samples were collected from the following locations on the Delaware River:

- Five (5) on Delaware River – DR-01, DR-02, DR-03, DR-04, DR-05

A single in-situ measurement was collected at every location at surface, mid and near bottom depths.

See Figure 2-2 for map of sampling locations.

3.1.2.2 Sampling Round and Sampling Time

There was an incoming tide and outgoing tide sample collected at each of the five Delaware River locations along with the required Field Blanks and Duplicates. The samples on the river were collected in the following order for each sampling round - DR-01, DR-02, DR-03, DR-04 and DR-05. The number and type of samples collected from the river for Dry Weather Event 1 are shown in Appendix A - Dry Weather Event 1 - Field Logs and Lab Results Summary.

The sampling event started on March 23, 2017 at 12:55 PM and ended at around 6:30 PM. The sampling times were selected so that they were in between the high tide and low tide time data. The outgoing tide samples were collected first followed by the incoming tide later in the afternoon/evening. The tide data for that date showed a range of high tide to low tide from 9:15 AM to 4:22 PM and a range of low tide to high tide from 4:22 PM to 9:54 PM. The sample collection times from the Creeks for Dry Weather Event 1 are shown in Appendix A - Dry Weather Event 1 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.1.2.3 Field Observation and Sample Management

The grab sample was collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Dry Weather Event 1 samples on the creeks was held within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde at surface, mid and near bottom depths of the river. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix A - Dry Weather Event 1- Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of Dry Weather Event 1 Chain of Custody Forms are shown in Appendix A - Dry Weather Event 1 - Field Logs and Lab Results Summary.

3.2 Dry Weather Sampling Event 2

Dry Weather Sampling Event-2 occurred on 5/10/2017. See Table 2-7 for receiving water flows and percentiles based on USGS gages.

3.2.1 Activity on Creeks

Sampling was conducted on Chester Creek (CC) and Ridley Creek (RC). On this date, the observed daily average flows for Chester Creek and Ridley Creek were 63.9 cfs and 25.0 cfs respectively at the locations indicated in Table 2-7.

3.2.1.1 Sample Type and Locations

Grab samples were collected from the following locations on the Creeks:

- Three (3) on Chester Creek – CC-01, CC-02, CC-03
- Three (3) on Ridley Creek – RC-01, RC-02, RC-03

A single in-situ measurement was collected at every location and sampling round.

See Figure 2-2 for map of sampling locations.

3.2.1.2 Sampling Round and Sampling Time

An incoming tide and outgoing tide sample was collected at each of the three Chester Creek and three Ridley Creek locations described above along with the required Field Blanks and Duplicates. Field Blanks were collected at the first sampling location for each event regardless of tide condition. Samples

from the downstream end of the creeks were collected first to capture the outgoing tide at the earliest. The samples on creeks were collected in the following order for each sampling round – CC-03, RC-03, RC-02, RC-01, CC-01 and CC-02. The number and type of samples collected from the Creeks for Dry Weather Event 2 are shown in Appendix B - Dry Weather Event 2 - Field Logs and Lab Results Summary.

The sampling event started on May 10, 2017 at 10:00 AM and ended at 5:45 PM. The sampling times were selected so that they were in between the high tide and low tide time data. The incoming tide samples were collected first followed by the outgoing tide later in the afternoon. The tide data for that date showed a range of low tide to high tide from 7:35 AM to 12:56 PM and a range of high tide to low tide from 12:56 PM to 7: 45 PM. The sample collection times from the Creeks for Dry Weather Event 2 are shown in Appendix B - Dry Weather Event 2 - Field Logs and Lab Results Summary.

See Appendix G for Sample Collection Matrix.

3.2.1.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Dry Weather Event 2 samples on the creeks was held within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix B - Dry Weather Event 2 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of Dry Weather Event 2 Chain of Custody Forms are shown in Appendix B - Dry Weather Event 2 - Field Logs and Lab Results Summary.

3.2.2 Activity on Delaware River

Sampling was conducted on Delaware River (DR) with 5 locations on the Pennsylvania side of the river. On this date, the observed daily average flow for the Delaware River was 16,306 cfs at the location indicated in Table 2-7.

3.2.2.1 Sample Type and Locations

Grab samples were collected from the following locations on the Delaware River:

- Five (5) on Delaware River – DR-01, DR-02, DR-03, DR-04, DR-05

A single in-situ measurement was collected at every location at surface, mid and near bottom depths.

See Figure 2-2 for map of sampling locations.

3.2.2.2 Sampling Round and Sampling Time

There was an incoming tide and outgoing tide sample collected at each of the five Delaware River locations along with the required Field Blanks and Duplicates. The samples on river were collected in the following order for each sampling round - DR-01, DR-02, DR-03, DR-04 and DR-05. The number and type of samples collected from the river for Dry Weather Event 2 are shown in Appendix B - Dry Weather Event 2 - Field Logs and Lab Results Summary.

The sampling event started on May 10, 2017 at 10:00 AM and ended at 5:45 PM. The sampling times were selected so that they were in between the high tide and low tide time data. The incoming tide samples were collected first followed by the outgoing tide later in the afternoon. The tide data for that date showed a range of low tide to high tide from 7:35 AM to 12:56 PM and a range of high tide to low tide from 12:56 PM to 7: 45 PM. The sample collection times from the Creeks for Dry Weather Event 2 are shown in Appendix B - Dry Weather Event 2 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.2.2.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Dry Weather Event 2 samples on the creeks was held within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde at surface, mid and near bottom depths of the river. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix B - Dry Weather Event 2 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Dry Weather Event 2 Chain of Custody Forms are shown in Appendix B - Dry Weather Event 2 - Field Logs and Lab Results Summary.

3.3 Dry Weather Sampling Event 3

Dry Weather Sampling Event-3 occurred on 6/13/2017. See Table 2-7 for receiving water flows and percentiles based on USGS gages.

3.3.1 Activity on Creeks

Sampling was conducted on Chester Creek (CC) and Ridley Creek (RC). On this date, the observed flows for Chester Creek and Ridley Creek were 46.8 cfs and 19.0 cfs, respectively, at the locations indicated in Table 2-7.

3.3.1.1 Sample Type and Locations

Grab samples were collected from the following locations on the Creeks:

- Three (3) on Chester Creek – CC-01, CC-02, CC-03
- Three (3) on Ridley Creek – RC-01, RC-02, RC-03

A single in-situ measurement was collected at every location and sampling round.

See Figure 2-2 for map of sampling locations.

3.3.1.2 Sampling Round and Sampling Time

An incoming tide and outgoing tide sample was collected at each of the three Chester Creek and three Ridley Creek locations described above along with the required Field Blanks and Duplicates. Field Blanks were collected at the first sampling location for each event regardless of tide condition. Samples from the downstream end of the creeks were collected first to capture the outgoing tide at the earliest. The samples on creeks were collected in the following order for each sampling round - CC-03, RC-03, RC-02, RC-01, CC-01 and CC-02. The number and type of samples collected from the Creeks for Dry Weather Event -3 are shown in Appendix C - Dry Weather Event 3 - Field Logs and Lab Results Summary.

The sampling event started on June 13, 2017 at 12:50 AM and ended at 20:06 PM. The sampling times were selected so that they were in between the high tide and low tide time data. The incoming tide samples were collected first followed by the outgoing tide later in the evening. The tide data for that date showed a range of low tide to high tide from 10:33 AM to 3:42 PM and a range of high tide to low tide from 3:42 PM to 10:24 PM. The sample collection times from the Creeks for Dry Weather Event 3 are shown in Appendix C - Dry Weather Event 3 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.3.1.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Dry Weather Event-3 samples on the creeks was held within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix C - Dry Weather Event 3 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Dry Weather Event 3 Chain of Custody Forms are shown in Appendix C - Dry Weather Event 3 - Field Logs and Lab Results Summary.

3.3.2 Activity on Delaware River

Sampling was conducted on Delaware River (DR) with 5 locations on the Pennsylvania side of the river. On this date, the observed flow for the Delaware River was 10,862 cfs at the location indicated in Table 2-7.

3.3.2.1 Sample Type and Locations

Grab samples were collected from the following locations on the Delaware River:

- Five (5) on Delaware River – DR-01, DR-02, DR-03, DR-04, DR-05

A single in-situ measurement was collected at every location at surface, mid and near bottom depths.

See Figure 2-2 for map of sampling locations.

3.3.2.2 Sampling Round and Sampling Time

There was an incoming tide and outgoing tide sample collected at each of the five Delaware River locations along with the required Field Blanks and Duplicates. The samples on river were collected in the following order for each sampling round - DR-01, DR-02, DR-03, DR-04 and DR-05. The number and type of samples collected from the river for Dry Weather Event 3 are shown in Appendix C - Dry Weather Event 3 - Field Logs and Lab Results Summary.

The sampling event started on June 13, 2017 at 12:50 PM and ended at 20:06 PM. The sampling times were selected so that they were in between the high tide and low tide time data. The incoming tide samples were collected first followed by the outgoing tide later in the evening. The tide data for that date showed a range of low tide to high tide from 10:33 AM to 3:42 PM and a range of high tide to low tide from 3:42 PM to 10:24 PM. The sample collection times from the Creeks for Dry Weather Event 3 are shown in Appendix C - Dry Weather Event 3 - Field Logs and Lab Results Summary.

3.3.2.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Dry Weather Event-3 samples on the creeks was held within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde at surface, mid and near bottom depths of the river. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix C - Dry Weather Event 3 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Dry Weather Event 3 Chain of Custody Forms are shown in Appendix C - Dry Weather Event 3 - Field Logs and Lab Results Summary.

3.4 Wet Weather Sampling Event 1

Wet Weather Sampling Event 1 occurred on 3/31/2017. See Table 2-7 and Figures 2-2 thru 2-4 for receiving water flows based on USGS gages.

3.4.1 Activity on Creeks

Sampling was conducted on Chester Creek (CC) and Ridley Creek (RC). The observed flows for Chester Creek were 79.1 cfs at the beginning of the sampling event, reached a peak flow of 2,260 cfs at 6:45PM, and was 1,330 cfs when the sampling event concluded. For Ridley Creek, flow was 28.8 cfs at the beginning of the sampling event, reached a peak flow of 898 cfs at 9:30PM, and was 790 cfs when the sampling event concluded. The flow gauge locations are shown on Figure 3-1 - Flow Gauge Locations.

3.4.1.1 Sample Type and Locations

Grab samples were collected from the following locations on the Creeks:

- Three (3) on Chester Creek – CC-01, CC-02, CC-03
- Three (3) on Ridley Creek – RC-01, RC-02, RC-03

A first grab sample collected on creek was during T=0 at the beginning for the rainfall event. Time T=0 for collection of the in-stream sample was initiated approximately 0.5 hours after the start of rainfall, or when 0.1 inches of rain had fallen or when CSO discharges start occurring (whichever occurs first). Significant rainfall began at 11:45 PM and sampling personnel were already in place to begin sampling within the first half hour. Accordingly, the first storm water sample was taken at location SW-SS2 at 11:50 PM and the first creek sample was collected on Chester Creek at CC-03 at midnight 0:00 hours. The sampling round intervals for all sampling locations are shown in the sampling collection matrix in Appendix G. See Figure 2-2 for map of sampling locations.

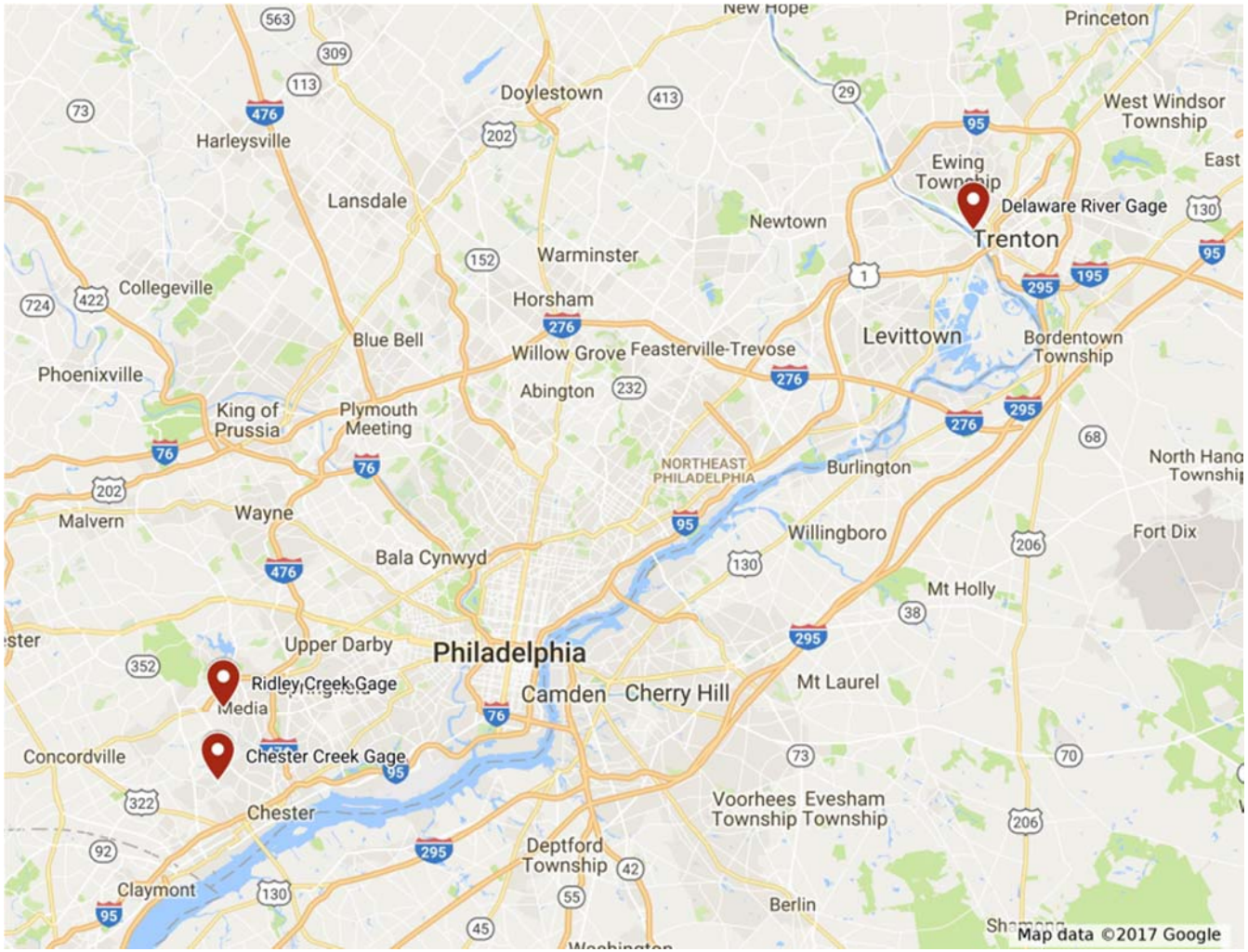
A single in-situ measurement was collected at every location and sampling round.

3.4.1.2 Sampling Round and Sampling Time

The grab samples collected on the Creeks as shown above were collected in intervals. The sampling intervals spanned over a 24 hour rain event. The intervals for sampling on creeks were at hour 0.5-2.5, hour 4.5-6.5, hour 8.5-10.5, hour 14.5-16.5, and hour 22-24. The samples also included the required Field Blanks and Duplicates as indicated in the Sampling collection matrix shown in Appendix G. Field Blanks were collected at the first sampling location. Samples from the downstream end of the creeks were collected first to capture the outgoing tide at the earliest. The samples on creeks were collected in the following order for each sampling round - CC-03, RC-03, RC-02, RC-01, CC-02 and CC-01. The number and type of samples collected from the Creeks for Wet Weather Event 1 are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

The sampling event started on March 31, 2017 at 12:30 AM and ended on April 1, 2017 at 12:30 AM. There were a total of five (5) rounds of sampling conducted on the creeks. The sampling intervals were selected to capture the earlier part of the rainfall event and any impact of CSOs and Storm water runoff on the Creeks water quality. All samples from each location and from each sampling round were collected

Figure 3-1: Flow Gauge Locations



for analysis. The sample collection times from the Creeks for Wet Weather Event 1 are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.4.1.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Dry Weather Event 1 samples on the creeks was held within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix D – Wet Weather Event 1 – Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 1 Chain of Custody Forms are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

3.4.2 Activity on Delaware River

Sampling was conducted on Delaware River (DR) with 5 locations on the Pennsylvania side of the river and 2 locations, mid-channel and New Jersey side, on a transect near the Commodore Barry Bridge. On this date, the observed flow for the Delaware River was 44,100 cfs at the location shown on Figure 3-1.

3.4.2.1 Sample Type and Locations

Grab samples were collected from the following locations on the Delaware River:

- Seven (7) on Delaware River – DR-01, DR-02, DR-03, DR-04, DR-05, DR-06, DR-07

A first grab sample collected on river was during T=0 at the beginning for the rainfall event. Time T=0 for collection of the in-stream sample was initiated approximately 0.5 hours after the start of rainfall, or when 0.1 inches of rain had fallen or when CSO discharges start occurring (whichever occurs first). The sampling round intervals for all sampling locations are shown in the sampling collection matrix in Appendix G. See Figure 2-2 for map of sampling locations.

A single in-situ measurement was collected at every location at surface, mid and near bottom depths.

3.4.2.2 Sampling Round and Sampling Time

The grab samples collected on the Creeks as shown above were collected in intervals. The sampling intervals spanned over a 24 hour rain event. The intervals for sampling on creeks were at hour 0, hour 2, hour 4, hour 6, hour 9, hour 12, hour 15, hour 18, hour 21, and hour 24. The samples also included the required Field Blanks and Duplicates as indicated in the Sampling collection matrix shown in Appendix G. The samples on river were collected in the by two boat crews. One of the boat crews were assigned to sample the northern sampling locations DR-01, DR-02, DR-03 and the other boat crew was assigned to sample the southern sampling locations and points across the river at DR-04, DR-05, DR-06 and DR-07. The two boat crews were used to collect samples during the first five (5) sampling rounds to provide enough time to return the samples to the lab and complete the entire sampling loop on the river within the decided sampling intervals. After the first five (5) rounds only one boat crew was required to sample at all locations due to the availability of more time between sampling intervals after completing the entire loop. The number and type of samples collected from the river for Wet Weather Event 1 are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

Boat activities became too hazardous as determined by the boat captain and all on-water activities were halted at 4:45 AM. A couple of shore grabs were collected at near locations DR-04, DR-05 between 7:00 AM and 7:30 AM. Conditions improved allowing for the resumption of boat activities after a period of approximately 4 hours. Delaware River loop was behind by one (1) entire set due to skipped locations because of boat motor issues, ship docking on river near sampling location and hazardous conditions on river.

See Appendix G for Sample collection matrix.

3.4.2.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Dry Weather Event-1 samples on the creeks was held within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site, and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde at surface, mid and near bottom depths of the river. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 1 Chain of Custody Forms are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

3.4.3 Activity at Combined Sewer Overflow (CSO) Locations

3.4.3.1 Sample Type and Locations

Grab samples were collected from the following CSO locations:

- Four (4) locations – CSO-02, CSO-05, CSO-18, CSO-19

See Figure 2-2 for map of sampling locations.

3.4.3.2 Sampling Round and Sampling Time

The samples were collected at each of the CSO locations along with the required Field Blanks and Duplicates. The samples at the CSOs were collected in the following order for each sampling round - first flush, 30 minutes, 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, and 24 hours. The samples were collected only if there was any active overflow occurring over the weir at the CSO location. The number and type of samples collected from the river for Wet Weather Event 1 are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

The sampling event started on March 30, 2017 at 12:30 AM and ended on April 1, 2017 at around 12:30 AM. The sampling was started at time T=0 at the start of rain fall event to collect the first flush sample. The sampling intervals were distributed over a 24 hour sampling period. If it was found that a CSO was not active then no samples were collected at those locations during those sampling rounds. It was observed that CSO-02 activated very fast whereas CSO-05 took longer to activate compared to CSO-18 and CSO-19. Any samples that were not collected in the previous round were recaptured in the next round so as to have the desired number of samples for analysis. The sample collection times from the CSO locations for Wet Weather Event 1 are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.4.3.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 1 samples at the CSO locations was held within the recommended time for lab analysis. While collecting the samples the sample was collected on the downstream side of the overflow for an active overflow at the CSO locations. The sampling equipment was used and then decontaminated using DI water at every sampling location. The field observations and Field Blanks and Duplicate information is provided in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 1 Chain of Custody Forms are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

3.4.4 Activity at Storm Water (SW) Locations

3.4.4.1 Sample Type and Locations

Grab samples were collected from the following storm water locations:

- Two (2) locations – SW-05A, SW-SS2

See Figure 2-2 for map of sampling locations.

3.4.4.2 Sampling Round and Sampling Time

Samples were collected at both of the storm water locations along with the required Field Blanks and Duplicates. The samples on were collected in the following order for each sampling round - SW-SS2 and SW-05A. The number and type of samples collected for Wet Weather Event 1 are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

The sampling event started on March 30, 2017 at 12:30 AM and ended on March 31 at 12:30 PM. The sampling times were distributed to cover the storm over 24 hour period and samples were collected whenever there was active storm flow occurring. The sample collection times from the Storm water locations for Wet Weather Event 1 are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.4.4.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate equipment and protective gear. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 1 samples at the Storm water locations was held within the recommended time for lab analysis. The sampling equipment was used and decontaminated using DI water at every sampling location. The number of samples, Field Blanks and Duplicates are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 1 Chain of Custody Forms are shown in Appendix D - Wet Weather Event 1 - Field Logs and Lab Results Summary.

3.5 Wet Weather Sampling Event 2

Wet Weather Sampling Event 2 occurred on 5/5/2017. See Table 2-7 and Figures 2-2 through 2-4 for receiving water flows based on USGS gages.

3.5.1 Activity on Creeks

Sampling was conducted on Chester Creek (CC) and Ridley Creek (RC). The observed flows for Chester Creek were 54.8 cfs at the beginning of the sampling event, reached a peak flow of 841 cfs at 4:15PM, and was 160 cfs when the sampling event concluded. For Ridley Creek, flow was 24.5 cfs at the beginning of the sampling event, reached a peak flow of 315 cfs at 5:30PM, and was 60.8 cfs when the sampling event concluded. The flow gauge locations are shown on Figure 3-1.

3.5.1.1 Sample Type and Locations

Grab samples were collected from the following locations on the Creeks:

- Three (3) on Chester Creek – CC-01, CC-02, CC-03
- Three (3) on Ridley Creek – RC-01, RC-02, RC-03

A first grab sample collected on creek was during T=0 at the beginning for the rainfall event. Time T=0 for collection of the in-stream sample was initiated approximately 0.5 hours after the start of rainfall, or when 0.1 inches of rain had fallen or when CSO discharges start occurring (whichever occurs first). Significant rainfall began at 7:00 AM and sampling personnel were already in place to begin sampling within the first half hour. Accordingly, the first creek sample was taken at 7:20 AM. The sampling round intervals for all sampling locations are shown in the sampling collection matrix in Appendix G. See Figure 2-2 for map of sampling locations.

A single in-situ measurement was collected at every location and sampling round.

3.5.1.2 Sampling Round and Sampling Time

The grab samples collected on the Creeks as shown above were collected in intervals. The sampling intervals spanned over a 24-hour period. The intervals for sampling on creeks were at hour 0.5-2.5, hour 4.5-6.5, hour 8.5-10.5, hour 14.5-16.5, and hour 22-24. The samples also included the required Field Blanks and Duplicates as indicated in the sampling collection matrix shown in Appendix G. Field Blanks were collected at the first sampling location. Samples from the downstream end of the creeks were collected first to capture the outgoing tide at the earliest. The samples on creeks were collected in the following order for each sampling round - CC-03, RC-03, RC-02, RC-01, CC-02 and CC-01. The number and type of samples collected from the Creeks for Wet Weather Event 2 are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

The sampling event started on May 5, 2017 at 7:00 AM and ended on May 6, 2017 at 7:00 AM. There were a total of five (5) rounds of sampling conducted on the creeks. The sampling intervals were selected to capture the earlier part of the rainfall event and any impact of CSOs and Storm water runoff on the Creeks water quality. All samples from each location and from each sampling round were collected for analysis. The sample collection times from the Creeks for Wet Weather Event 2 are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

See Appendix G for sample collection matrix.

3.5.1.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate sampling and personal protection equipment. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 2 samples on the creeks was within the recommended time for lab analysis. While collecting the samples, field observations were noted to indicate any specific weather, water body, site, and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 2 Chain of Custody Forms are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

3.5.2 Activity on Delaware River

Sampling was conducted on Delaware River (DR) with 5 locations on the Pennsylvania side of the river and 2 locations, mid-channel and New Jersey side, on a transect near the Commodore Barry Bridge. On this date, the observed flow for the Delaware River was 19,900 cfs at the location shown on Figure 3-1.

3.5.2.1 Sample Type and Locations

Grab samples were collected from the following locations on the Delaware River:

- Seven (7) on Delaware River – DR-01, DR-02, DR-03, DR-04, DR-05, DR-06, DR-07

A first grab sample collected on river was during T=0 at the beginning for the rainfall event. Time T=0 for collection of the in-stream sample was initiated approximately 0.5 hours after the start of rainfall, or when 0.1 inches of rain had fallen or when CSO discharges start occurring (whichever occurs first). The sampling round intervals for all sampling locations are shown in the sampling collection matrix in Appendix G. See Figure 2-2 for map of sampling locations.

A single in-situ measurement was collected at every location at surface, mid and near bottom depths.

3.5.2.2 Sampling Round and Sampling Time

The grab samples collected on the Creeks as shown above were collected in intervals. The sampling intervals spanned over a 24-hour period. The intervals for sampling on the Delaware River were at hour 0, hour 2, hour 4, hour 6, hour 9, hour 12, hour 15, hour 18, hour 21, and hour 24. The samples also included the required Field Blanks and Duplicates as indicated in the sampling collection matrix shown in Appendix G. The samples on the river were collected by two boat crews. One of the boat crews was assigned to sample the northern sampling locations DR-01, DR-02, DR-03 and the other boat crew was assigned to sample the southern sampling locations and points across the river at DR-04, DR-05, DR-06 and DR-07. The two boat crews were planned for sample collection during the first five (5) sampling rounds, to provide enough time to return the samples to the lab and complete the entire sampling loop on

the river within the decided sampling intervals. After the first three (3) rounds, only one boat crew would be required to sample at all locations because of the availability of more time between sampling intervals after completing the entire loop.

As Round 2 was being completed, lightning was observed in the area. Safety protocols required that both boats be removed from the water and that 30 minutes elapse with no lightning before resumption of boat activities. This resulted in a 35-minute delay in the start of Round 3. After the third round of sampling, several punctures were discovered in one of the boat's hull causing water to inundate the boat see Appendix K - Sampling Photos). For safety and maneuverability concerns, this boat was pulled from the river. As the second boat began Round 4, it also encountered mechanical issues when its engine could not propel the boat forward. After inspection, a problem with the transmission was identified and this boat was also removed from the river. It was suggested to switch out the engine so that sampling on the Delaware River could continue, but was unsuccessful due to the incompatibility of the steering systems between the two boats. At this point two (2) rounds were missed, hour 6 and hour 9. As an alternative option (to get as much data as possible) the remainder of sampling on the Delaware River for rounds six through ten were taken from shore locations close to DR-03 and DR- 04. There were no accessible points along Chester City shoreline to collect grab samples for DR-01, DR-02 and DR-05. Grab sample for DR-03 was collected from shore on Norris Street and that for DR-04 was collected from the boat launch ramp near the stadium. Grab samples were collected using bailer and rope along with insitu readings for both locations. For reference, the number and type of samples collected from the river for Wet Weather Event 2 are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

The sampling event started on May 5, 2017 at 7:00 AM and ended on May 6, 2017 at 7:00 AM. There were a total of eight (8) rounds of sampling conducted on the Delaware. The sampling intervals were selected to capture the earlier part of the rainfall event and any impact the CSOs and storm water runoff had on river water quality. The sample collection times from the Creeks for Wet Weather Event 2 are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

See Appendix G for sample collection matrix.

3.5.2.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate sampling and personal protective equipment. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 2 samples on the Delaware River was within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site, and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde at surface, mid and near bottom depths of the river. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples.

Copies of the Wet Weather Event 2 Chain of Custody Forms are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

3.5.3 Activity at Combined Sewer Overflow (CSO) Locations

3.5.3.1 Sample Type and Locations

Grab samples were collected from the following CSO locations:

- Four (4) locations – CSO-02, CSO-05, CSO-18, CSO-19

See Figure 2-2 for map of sampling locations.

3.5.3.2 Sampling Round and Sampling Time

Grab samples were collected at each of the CSO locations along with the required Field Blanks and Duplicates. The samples at the CSOs were collected in the following order for each sampling round - first flush, 30 minutes, 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, and 24 hours. The samples were collected only for the first five (5) rounds for all CSO locations because there was not any active overflow occurring over the weir after 6 hours. The number and type of samples collected from the river for Wet Weather Event 2 are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

The sampling event started on May 5, 2017 at 7:00 AM and ended on May 6, 2017 at around 7:00 AM. The sampling was started at time T=0, the beginning of an active overflow, to collect the first flush sample. The sampling intervals were distributed over a 24 hour sampling period, but before sampling rounds six through eight, it was found that no CSOs were actively discharging, therefore no samples were collected at those locations during those sampling rounds. Because of the precipitation intensity for this particular round of sampling, all CSOs discharged within minutes of each other. The sample collection times from the CSO locations for Wet Weather Event 2 are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.5.3.3 Field Observation and Sample Management

The samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate sampling and personal protective equipment. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 2 samples at the CSO locations was within the recommended time for lab analysis. Samples were collected on the downstream side of the overflow for an active overflow at the CSO locations. The sampling equipment was used and then decontaminated using DI water at every sampling location. The field observations, Field Blanks, and Duplicate information is provided in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples.

Copies of the Wet Weather Event 2 Chain of Custody Forms are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

3.5.4 Activity at Storm Water (SW) Locations

3.5.4.1 Sample Type and Locations

Grab samples were collected from the following storm water locations:

- Two (2) locations – SW-05A, SW-SS2

See Figure 2-2 for map of sampling locations.

3.5.4.2 Sampling Round and Sampling Time

Samples were collected at both of the storm water locations along with the required Field Blanks and Duplicates. The samples at SW-05A and SW-SS2 were collected in the following order for each sampling round - first flush, 30 minutes, 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, and 24 hours. The samples were collected only for the first five (5) rounds for both storm water locations because there was not any flow occurring in the storm sewers after 6 hours. The number and type of samples collected from the river for Wet Weather Event 2 are shown in Appendix E - Wet Weather Event 2 - Field Logs, Chain of Custody Forms, and Lab Results.

The sampling event started on May 5, 2017 at 7:00 AM and ended on May 6, 2017 at around 7:00 AM. The sampling was started at time T=0, the beginning of an active flow, to collect the first flush sample. The sampling intervals were distributed over a 24 hour sampling period, but before sampling rounds six through eight, it was found that neither storm sewer had active flow occurring, therefore no samples were collected at those locations during those sampling rounds. The sample collection times from the CSO locations for Wet Weather Event 2 are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.5.4.3 Field Observation and Sample Management

The samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate sampling and personal protective equipment. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 2 samples at the storm water locations was within the recommended time for lab analysis. The sampling equipment was used and decontaminated using DI water at every sampling location. The number of samples, Field Blanks and Duplicates are shown in Appendix E – Wet Weather Event 2 – Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 2 Chain of Custody Forms are shown in Appendix E - Wet Weather Event 2 - Field Logs and Lab Results Summary.

3.6 Wet Weather Sampling Event 3

Wet Weather Sampling Event 3 occurred on 5/22/2017

3.6.1 Activity on Creeks

Sampling was conducted on Chester Creek (CC) and Ridley Creek (RC). The observed flows for Chester Creek were 58.1 cfs at the beginning of the sampling event, reached a peak flow of 92.1 cfs at 12:15AM, and was 70.4 cfs when the sampling event concluded. For Ridley Creek, flow was 23.6 cfs at the beginning of the sampling event, reached a peak flow of 32.5 cfs at 8:15PM, and was 28.8 cfs when the sampling event concluded. The flow gauge locations are shown on Figure 3-1.

3.6.1.1 Sample Type and Locations

Grab samples were collected from the following locations on the Creeks:

- Three (3) on Chester Creek – CC-01, CC-02, CC-03
- Three (3) on Ridley Creek – RC-01, RC-02, RC-03

A first grab sample collected on creek was during T=0 at the beginning for the rainfall event. Time T=0 for collection of the in-stream sample was initiated approximately 0.5 hours after the start of rainfall, or when 0.1 inches of rain had fallen or when CSO discharges started occurring (whichever occurs first). Significant rainfall began at 10:20 AM and sampling personnel were already in place to begin sampling within the first half hour. Accordingly, the first creek sample was taken at 10:42 AM. The sampling round intervals for all sampling locations are shown in the sampling collection matrix in Appendix G. See Figure 2-2 for map of sampling locations.

A single in-situ measurement was collected at every location and sampling round.

3.6.1.2 Sampling Round and Sampling Time

The grab samples collected on the Creeks as shown above were collected in intervals. The sampling intervals spanned over a 24 hour period. The intervals for sampling on creeks were at hour 0.5-2.5, hour 4.5-6.5, hour 8.5-10.5, hour 14.5-16.5, and hour 22-24. The samples also included the required Field Blanks and Duplicates as indicated in the sampling collection matrix shown in Appendix G. Field Blanks were collected at the first sampling location. Samples from the downstream end of the creeks were collected first to capture the outgoing tide at the earliest. The samples on creeks were collected in the following order for each sampling round - CC-03, RC-03, RC-02, RC-01, CC-02 and CC-01. The number and type of samples collected from the Creeks for Wet Weather Event 3 are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

The sampling event started on May 22, 2017 at 9:00 AM and ended on May 23, 2017 at 10:30 AM. There were a total of five (5) rounds of sampling conducted on the creeks. The sampling intervals were selected to capture the earlier part of the rainfall event and any impact of CSOs and Storm water runoff on the Creeks water quality. All samples from each location and from each sampling round were collected for analysis. The sample collection times from the Creeks for Wet Weather Event 3 are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

See Appendix G for sample collection matrix.

3.6.1.3 Field Observation and Sample Management

The samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate sampling and personal protection equipment. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 3 samples on the creeks was within the recommended time for lab analysis. While collecting the samples, field observations were noted to indicate any specific weather, water body, site, and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde. The sonde was used and decontaminated using DI water at every sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 3 Chain of Custody Forms are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

3.6.2 Activity on Delaware River

Sampling was conducted on Delaware River (DR) with 5 locations on the Pennsylvania side of the river and 2 locations, mid-channel and New Jersey side, on a transect near the Commodore Barry Bridge. On this date, the observed flow for the Delaware River was 9,180 cfs at the location shown on Figure 3-1 - Flow Gauge Locations.

3.6.2.1 Sample Type and Locations

Grab samples were collected from the following locations on the Delaware River:

- Seven (7) on Delaware River – DR-01, DR-02, DR-03, DR-04, DR-05, DR-06, DR-07

A first grab sample collected on river was during T=0 at the beginning for the rainfall event. Time T=0 for collection of the in-stream sample was initiated approximately 0.5 hours after the start of rainfall, or when 0.1 inches of rain had fallen or when CSO discharges started occurring (whichever occurs first). Very light precipitation had occurred intermittently throughout the early morning hours (2:00 AM to 9:00 AM). Steady rainfall began after 9:00 AM, by which time 0.05 inches of rain had fallen, according to the WRTP rain gauge. Sampling personnel were already in place to begin sampling immediately. Accordingly, the first river sample was taken at 9:05 AM. The sampling round intervals for all sampling locations are shown in the sampling collection matrix in Appendix G. See Figure 2-2 for map of sampling locations.

A single in-situ measurement was collected at every location at surface, mid and near bottom depths.

3.6.2.2 Sampling Round and Sampling Time

The grab samples collected on the Creeks as shown above were collected in intervals. The sampling intervals spanned over a 24 hour period. The intervals for sampling on the Delaware River were at hour 0, hour 2, hour 4, hour 6, hour 9, hour 12, hour 15, hour 18, hour 21, and hour 24. The samples also included the required Field Blanks and Duplicates as indicated in the sampling collection matrix shown in Appendix G. The samples on the river were collected by two boat crews. One of the boat crews was assigned to sample the northern sampling locations DR-01, DR-02, DR-03 and the other boat crew was assigned to sample the southern sampling locations and points across the river at DR-04, DR-05, DR-06 and DR-07. The two boat crews were planned for sample collection during the first five (5) sampling rounds, to provide enough time to return the samples to the lab and complete the entire sampling loop on the river within the decided sampling intervals. After the first five (5) rounds, only one boat crew would be required to sample at all locations because of the availability of more time between sampling intervals after completing the entire loop.

In actuality, two boat crews were used for 3 rounds, due to mechanical issues with the boats. After the third round of sampling, several small punctures were discovered in one of the boat's hull causing water to inundate the boat. For safety and maneuverability concerns, the boat was pulled from the river. The second boat also encountered issues at this time when its engine could not propel the boat forward. After inspection, a problem with the transmission was identified and this boat was also removed from the river. An attempt to switch out the engine was made so that sampling on the Delaware River could continue, but was unsuccessful. At this point two (2) rounds were missed, hour 6 and hour 9. As an alternative option (to get as much data as possible) the remainder of sampling on the Delaware River for rounds six through ten were taken from shore locations close to DR-03 and DR- 04. There were no accessible points along Chester City shoreline to collect grab samples for DR-01, DR-02 and DR-05. Grab sample for DR-03 was collected from shore on Norris Street and that for DR-04 was collected from the boat launch ramp near the stadium. Grab samples were collected using bailer and rope along with in-situ readings for both locations. For reference, the number and type of samples collected from the river for Wet Weather Event 3 are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

The sampling event started on May 22, 2017 at 9:00 AM and ended on May 23, 2017 at 10:30 AM. There were a total of ten (10) rounds of sampling conducted on the Delaware. The sampling intervals were selected to capture the earlier part of the rainfall event and any impact the CSOs and storm water runoff had on river water quality. The sample collection times from the Creeks for Wet Weather Event 3 are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

See Appendix G for sample collection matrix.

3.6.2.3 Field Observation and Sampling Management

The samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate sampling and personal protective equipment. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 3 samples on the Delaware River was within the recommended time for lab analysis. While collecting the samples the field observations were noted to indicate any specific weather, water body, site, and sample conditions. In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde at surface, mid and near bottom depths of the river. The sonde was used and decontaminated using DI water at every

sampling location. The field observations and in-situ field measurements including water salinity readings, temperature and conductivity are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 3 Chain of Custody Forms are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

3.6.3 Activity at Combined Sewer Overflow (CSO) Locations

3.6.3.1 Sample Type and Locations

Grab samples were collected from the following CSO locations:

- Four (4) locations – CSO-02, CSO-05, CSO-18, CSO-19

See Figure 2-2 for map of sampling locations.

3.6.3.2 Sampling Round and Sampling Time

Samples were collected at each of the CSO locations along with the required Field Blanks and Duplicates. The samples at the CSOs were collected in the following order for each sampling round - first flush, 30 minutes, 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, and 24 hours. The samples were collected only for the first five (5) rounds for all CSO locations because there was not any active overflow occurring over the weir after 6 hours. The number and type of samples collected from the river for Wet Weather Event 3 are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

The sampling event started on May 22, 2017 at 9:00 AM and ended on May 23, 2017 at around 10:30 AM. The CSO sampling was started at time T=0, the beginning of an active overflow, to collect the first flush sample. Significant rainfall began at 10:20 AM and sampling personnel were already in place to begin CSO sampling at first flush, which occurred at 10:25 AM. Because of the precipitation intensity for this particular round of sampling, all CSOs discharged within minutes of each other. The sampling intervals were distributed over a 24-hour sampling period, but before sampling rounds six through eight, it was found that no CSOs were actively discharging, therefore no samples were collected at those locations during those sampling rounds. The sample collection times from the CSO locations for Wet Weather Event 3 are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.6.3.3 Field Observation and Sample Management

The grab samples were collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate sampling and personal protective equipment. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 3 samples at the CSO locations was within the recommended time for lab analysis. Samples were collected on the

downstream side of the overflow for an active overflow at the CSO locations. The sampling equipment was used and then decontaminated using DI water at every sampling location. The field observations, Field Blanks, and Duplicate information is provided in Appendix F - Wet Weather Event 3 - Field Logs, Chain of Custody Forms, and Lab Results.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 3 Chain of Custody forms are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

3.6.4 Activity at Storm Water (SW) Locations

3.6.4.1 Sample Type and Locations

Grab samples were collected from the following storm water locations:

- Two (2) locations – SW-05A, SW-SS2

See Figure 2-2 for map of sampling locations.

3.6.4.2 Sampling Round and Sampling Time

Samples were collected at both of the storm water locations along with the required Field Blanks and Duplicates. The samples at SW-05A and SW-SS2 were collected in the following order for each sampling round - first flush, 30 minutes, 60 minutes, 2 hours, 4 hours, 8 hours, 12 hours, and 24 hours. The samples were collected only for the first five (5) rounds for both storm water locations because there was not any flow occurring in the storm sewers after 6 hours. The number and type of samples collected from the river for Wet Weather Event 3 are shown in Appendix F - Wet Weather Event 3 - Field Logs, Chain of Custody Forms, and Lab Results.

The sampling event started on May 5, 2017 at 7:00 AM and ended on May 6, 2017 at around 7:00 AM. The sampling was started at time T=0, the beginning of active flow, to collect the first flush sample. Significant rainfall began at 10:20 AM and sampling personnel were already in place to begin SW sampling at first flush, which occurred at 10:30 AM. The sampling intervals were distributed over a 24-hour sampling period, but before sampling rounds six through eight, it was found that neither storm sewer had active flow occurring, therefore no samples were collected at those locations during those sampling rounds. The sample collection times from the CSO locations for Wet Weather Event 3 are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

See Appendix G for Sample collection matrix.

3.6.4.3 Field Observation and Sample Management

The sample was collected as per the requirements of the Sampling and Analysis Plan (SAP) using appropriate sampling and personal protective equipment. The samples were preserved immediately on ice for transfer to laboratory for further analysis. The hold time for all the Wet Weather Event 3 samples at the storm water locations was within the recommended time for lab analysis. The sampling equipment

was used and decontaminated using DI water at every sampling location. The number of samples, Field Blanks and Duplicates are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

The samples were handed over the laboratory for analysis with their respective Chain of Custody Forms. The Chain of Custody Forms included details on the sample IDs, type of sample and release of samples. Copies of the Wet Weather Event 3 Chain of Custody Forms are shown in Appendix F - Wet Weather Event 3 - Field Logs and Lab Results Summary.

Section 4 Laboratory Results

The Sampling Program succeeded in acquiring the volume and range of pollutant data needed to construct, calibrate and validate the water quality model. Table 4-1 provides a summary of the number of samples collected for each of the sampling events at each sampling station. Table 4-2 provides a summary of the range of observed pollutant concentrations collected during the dry and wet weather sampling events.

The pollutants of concern (POCs) analyzed in the samples collected in the Sampling Program include fecal coliform, *Escherichia coliform (E. coli)*, and enterococcus. The coliform group has been used to assess sanitary quality in recreational waterways for decades (Standard Methods, 1980). Fecal coliform is a member of the coliform group present in the gut and feces of warm-blooded animals and is used as an indicator of fecal contamination and associated pathogens. The fecal coliform group includes many genera, including *Enterobacter, Klebsiella, Citrobacter, and Escherichia* (Standard Methods, 1998). E. coli is a one member of the fecal coliform group that provides more specificity than fecal coliform as a potential indicator of pathogenic organisms (USEPA, 1986), particularly in freshwater systems (USEPA, 2012). Enterococcus is a subgroup of the fecal streptococcus group, another type of bacteria found in the gastrointestinal tract of warm-blooded animals (Standard Methods, 1998). Enterococci have been found to be the best pathogenic indicator of fecal contamination in marine waters (USEPA, 2012). Because the DELCORA service area includes both freshwater and tidal/marine waterways, all of these indicators are pertinent to assessing water quality conditions in the local waterways and comparing to corresponding water quality standards.

This section describes the laboratory results for each of the individual sampling events. The environmental conditions of each of these sampling events were described in Section 3. Plots of concentrations over time are presented in this section for a subset of locations, and plots for all locations are included in Appendix H. For the tributaries, the flow at the upstream USGS gage is also included in the figures. However, for the Delaware River, no flow values are shown because the nearest flow gage is in Trenton, NJ, which is too far away (~80 miles upstream) to be indicative of local conditions.

The quality of the data with respect to the QAPP objectives are described in additional detail in Section 5. Additional analysis of the data, such as developing Event Mean Concentrations (EMCs) for the CSOs and stormwater locations are described in Section 6.

Table 4-1: Number of Samples Collected During the Sampling Program

Sample Summary	Dry1	Dry2	Dry3	Wet1	Wet2	Wet3	Total
Chester Creek							
CC-01	2	2	2	5	5	5	**21**
CC-02	2	2	2	5	5	5	**21**
CC-03	2	2	2	5	5	5	**21**
Ridley Creek							
RC-01	2	2	2	5	5	5	**21**
RC-02	2	2	2	5	5	5	**21**
RC-03	2	2	2	5	5	5	**21**
Delaware River							
DR-01	2	2	2	8	3	9	**26**
DR-02	2	2	2	8	3	10	**27**
DR-03	2	2	2	8	3	10	**27**
DR-03 (Shore)					5		**5**
DR-04	2	2	2	9	3	10	**28**
DR-04 (Shore)					5		**5**
DR-05	2	2	2	9	3	10	**28**
DR-06				7	3	10	**20**
DR-07				7	3	10	**20**
CSO							
CSO-02				9	5	4	**18**
CSO-05				8	5	5	**18**
CSO-18				7	5	4	**16**
CSO-19				8	5	2	**15**
SW							
SW-05A				8	6	5	**19**
SW-SS2				8	6	5	**19**
Field Blanks and Duplicates							
Blanks	3	2	2	5	4	5	**21**
Duplicates	3	3	3	5	4	5	**23**

Notes: At DR-06 and DR-07, the CSOs and SW locations were only sampled during wet weather. Due to challenges described in Section 3, DR-03 (Shore) and DR-04 (Shore) were added to collect samples from the bank of the river.

Table 4-2: Range of Observed Pollutant Concentrations during Dry and Wet Weather Events

Parameter	Event Type	Location	Minimum	Maximum	Average	Count
E. COLI	DRY	Chester Creek	10	470	130	18
		Delaware River	1	45	17	27
		Ridley Creek	2	1,900	265	16
	WET	Chester Creek	40	22,000	4,937	45
		Delaware River	2	6,900	207	143
		Ridley Creek	56	87,000	5,690	45
		CSO	25,000	1,780,000	254,403	67
		Stormwater	36	156,000	16,248	38
ENTERO-COCCUS	DRY	Chester Creek	8	190	70	18
		Delaware River	1	320	21	22
		Ridley Creek	6	900	167	16
	WET	Chester Creek	40	41,000	9,584	44
		Delaware River	2	40,000	476	141
		Ridley Creek	20	31,000	8,112	45
		CSO	4,800	3,220,000	193,961	67
		Stormwater	1,091	505,000	72,206	38
FECAL COLIFORM	DRY	Chester Creek	4	1,200	361	17
		Delaware River	2	54	27	30
		Ridley Creek	4	3,800	709	18
	WET	Chester Creek	52	44,000	7,134	45
		Delaware River	2	10,000	250	145
		Ridley Creek	44	103,000	7,646	45
		CSO	15,300	1,630,000	165,486	67
		Stormwater	20	1,480,000	54,081	38

4.1 Dry Weather Sampling – Event 1 Results

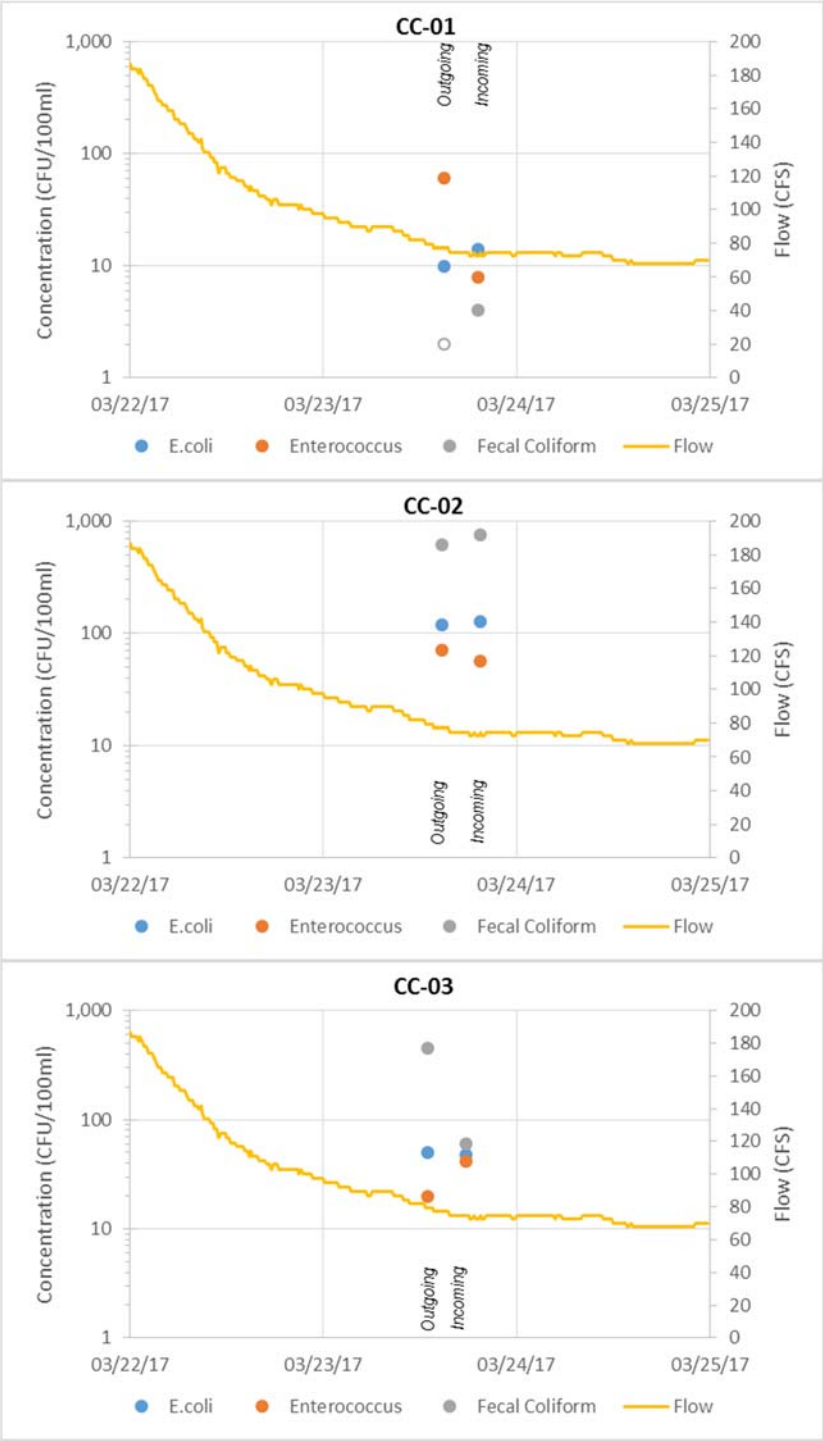
The first dry weather event (Dry 1), on March 23, 2017, had the highest tributary (i.e. Chester Creek, Ridley Creek) flows of all of the dry weather sampling events (as shown in Table 2-7). This was expected as the Spring (mid-March) season tends to have higher base flow due to snow melt infiltration and higher frequency of rainfall that typically occurs. Laboratory results are presented by waterbody below.

4.1.1 Chester Creek Results

Samples collected on incoming and outgoing tides were fairly similar in concentrations of each pollutant and the majority of concentrations were within values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-1 shows the concentrations at each station. Note that in this figure, solid dots are measured results while open dots are non-detect results plotted at the detection limit. Additional plots are provided in Appendix H.

Fecal coliform levels tended to have the highest concentrations of the three pollutants of concern (POC) while enterococcus tended to have the lowest concentrations. However, the fecal coliform results at CC-01 appear to be anomalous, as they are the lowest concentrations of the POCs and lower than corresponding E. coli levels, which is physically impossible because E. coli is a subgroup within the fecal coliform group. These anomalies are likely mostly due to the difficulty in measuring low levels of bacteria concentrations (see Section 5 for additional discussion). These figures also illustrate an increase in each POC levels from the upstream location (CC-01) to the downstream locations (CC-02 &CC-03) during both incoming and outgoing tidal conditions. This may be indicative of dry weather sources of bacteria entering Chester Creek, such as illicit discharges and connections or wildlife and pet contributions. Additional analysis and interpretation of the data will be conducted as part of the water quality model development and calibration process.

Figure 4-1: Dry Weather 1 Concentrations in Chester Creek

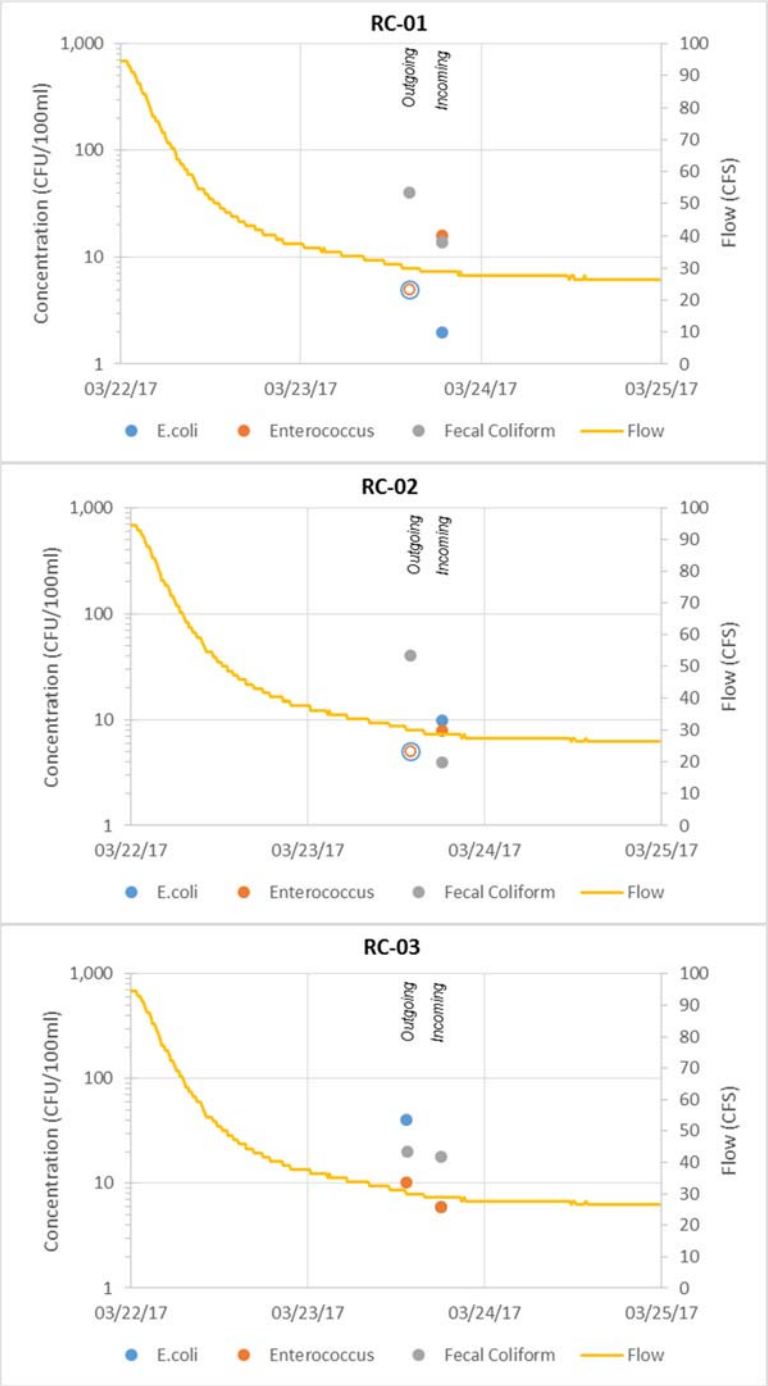


4.1.2 Ridley Creek Results

Samples collected on incoming and outgoing tides were fairly similar in concentrations of each pollutant and the majority of concentrations were within values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-2 shows the concentrations at each station. Note that in this figure, solid dots are measured results while open dots are non-detect results plotted at the detection limit. Additional plots are provided in Appendix H.

With few exceptions, fecal coliform tended to have the highest concentrations of the three pollutants of concern (POC) while enterococcus tended to have the lowest concentrations. These figures also illustrate an increase in E. coli levels from the upstream (RC-01) locations to the downstream locations (RC-02 and RC-03). However, the spatial trend for fecal coliform show a decrease in concentrations from upstream to downstream, while enterococcus levels were similar at all locations. Additional analysis and interpretation of the data will be conducted as part of the water quality model development and calibration process.

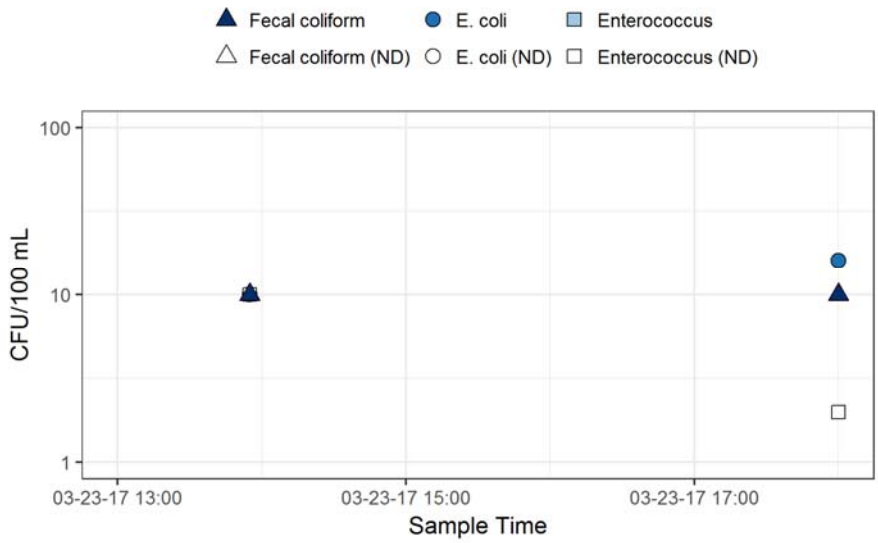
Figure 4-2: Dry Weather 1 Concentrations in Ridley Creek



4.1.3 Delaware River Results

Samples collected on incoming and outgoing tides were fairly similar in concentrations of each pollutant and all of concentrations were within values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-3 shows the concentrations at DR-03, the mid-point station on the river. Additional plots are provided in Appendix H.

Figure 4-3: Dry Weather 1 Concentrations in Delaware River at DR-03



Fecal coliform levels tended to have the highest of the three pollutants of concern (POC) while enterococcus levels tended to be the lowest. Concentrations for all POCs were all fairly low, with twelve (12) of the 33 results reported as less than the reporting limit (shown as open symbols in the Appendix figures). In addition, nineteen (19) of the 33 results were flagged as based on counts outside the ideal counting range, which is often applied when the concentrations are very low. Results are similar to historical data collected previously by the Delaware River Basin Commission (DRBC).

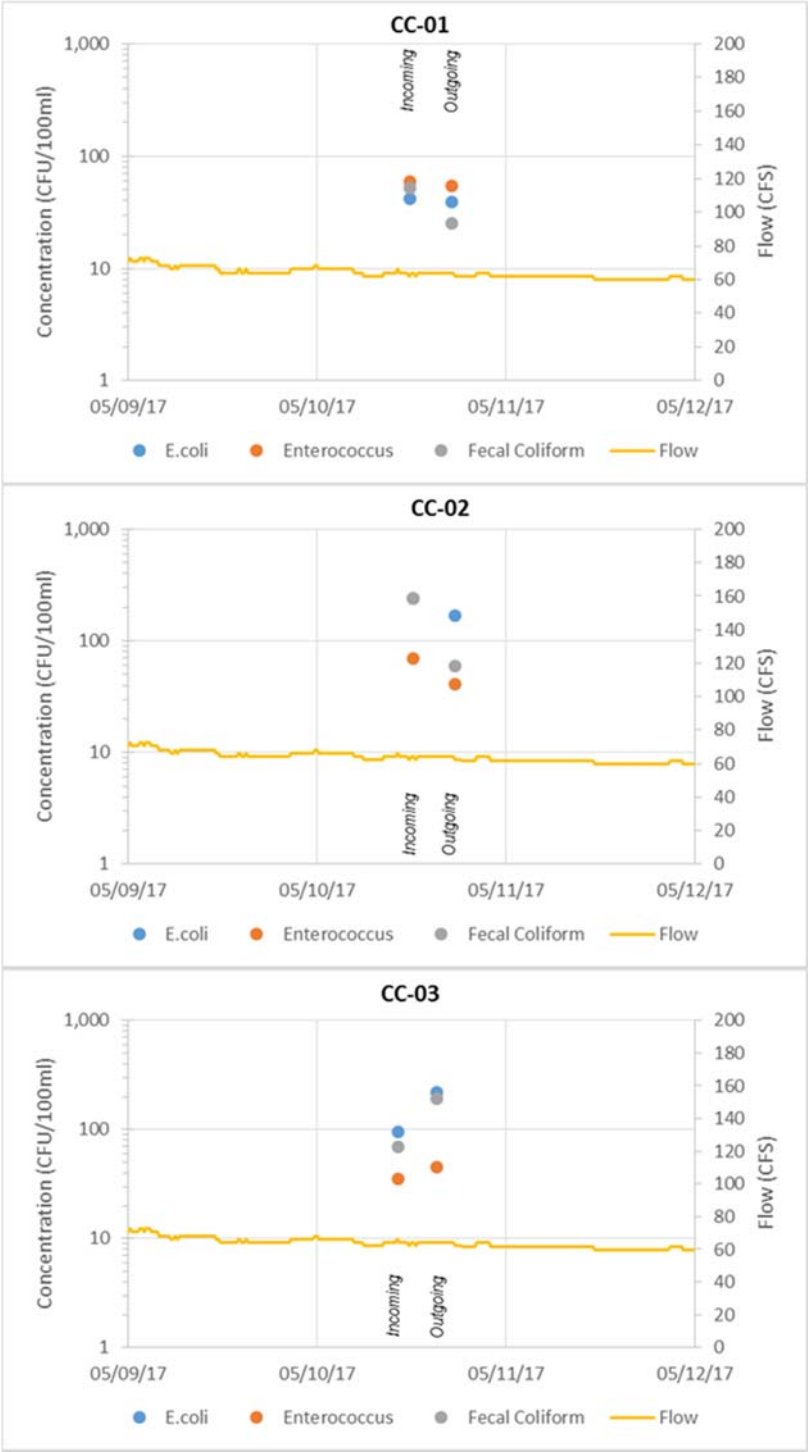
4.2 Dry Weather Sampling – Event 2 Results

The second dry weather event (Dry 2), on May 10, 2017, had fairly typical dry weather flows in each waterbody (as shown in Table 2-7). Laboratory results are presented by waterbody below.

4.2.1 Chester Creek Results

Samples collected on incoming and outgoing tides were fairly similar in concentrations of each pollutant and the majority of concentrations were within values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-4 shows the concentrations at each station. Additional plots are provided in Appendix H.

Figure 4-4: Dry Weather 2 Concentrations in Chester Creek



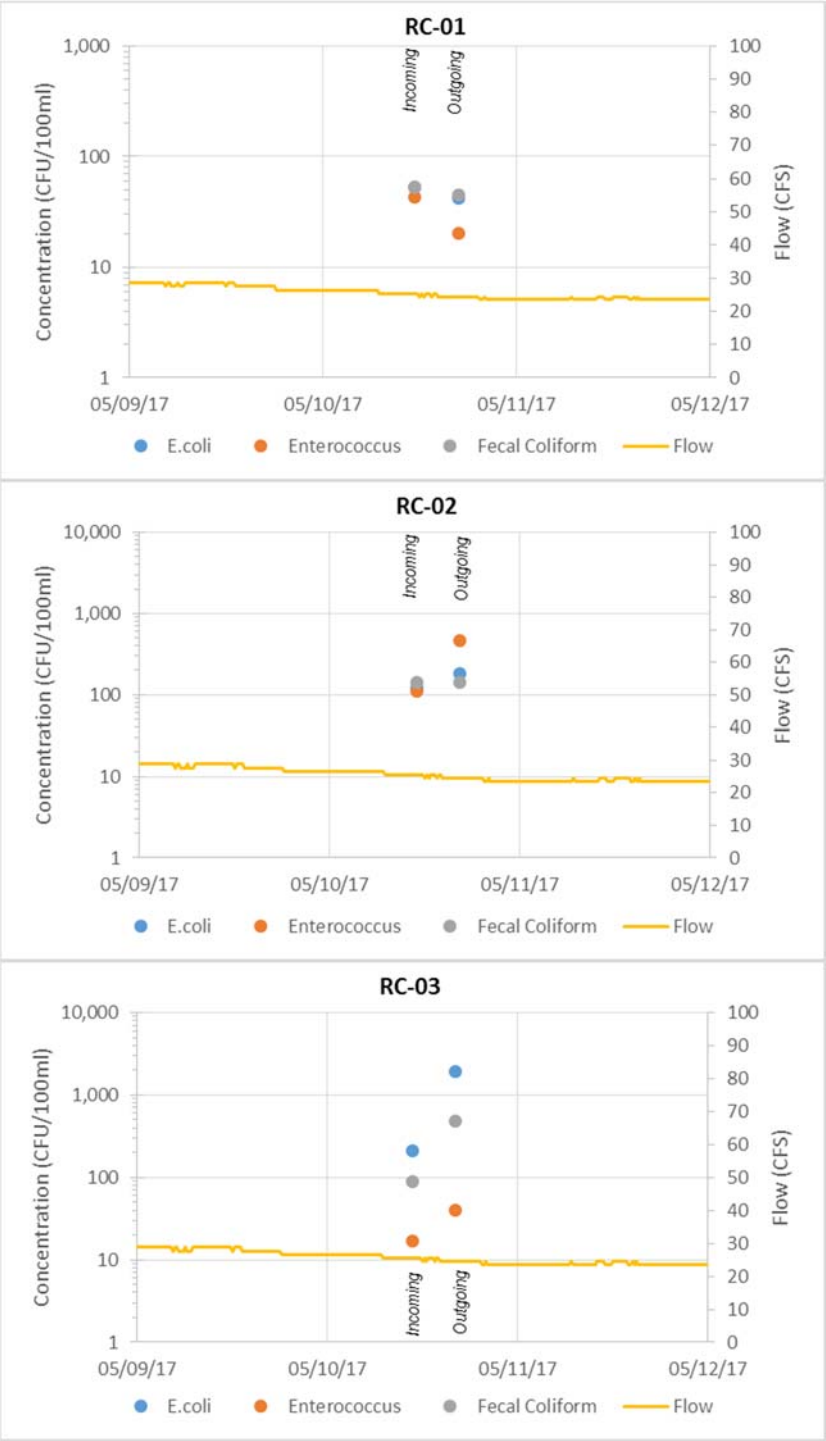
E. coli levels tended to have the highest of the three pollutants of concern (POC) while enterococcus levels tended to be the lowest. As noted in the introduction to Section 4, E. coli is a subgroup of fecal coliform and should have lower concentrations than fecal coliform. It is, however, fairly common for E. coli to be reported with higher concentrations than corresponding fecal coliform results, due to differences in the analytical methodology, the challenge of obtaining a homogenous sample, and the difficulty in measuring low levels of bacteria concentrations (see Section 5 for additional discussion). These figures also illustrate an increase in fecal coliform and E. coli POC levels from upstream (CC-01) to downstream to the mouth (CC-03) during both incoming and outgoing tidal conditions while enterococcus levels tended to be similar from upstream to downstream. Additional analysis and interpretation of the data will be conducted as part of the water quality model development and calibration process.

4.2.2 Ridley Creek Results

Samples collected on incoming and outgoing tides were fairly similar in concentrations of each pollutant and the majority of concentrations were within values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-5 shows the concentrations at each station. Additional plots are provided in Appendix H.

At RC-01 and RC-02, fecal coliform levels tended to have the highest of the three pollutants of concern (POC) while enterococcus levels tended to be the lowest. At RC-03, E. coli concentrations were higher than corresponding fecal coliform concentrations. As noted in the introduction to Section 4, E. coli is a subgroup of fecal coliform and should have lower concentrations than fecal coliform. It is, however, fairly common for E. coli to be reported with higher concentrations than corresponding fecal coliform results, due to differences in the analytical methodology, the challenge of obtaining a homogenous sample, and the difficulty in measuring low levels of bacteria concentrations. These figures also illustrate an increase in fecal coliform and E. coli levels from upstream (RC-01) to downstream to the mouth (RC-03), while enterococcus levels were similar at all locations. Additional analysis and interpretation of the data will be conducted as part of the water quality model development and calibration process.

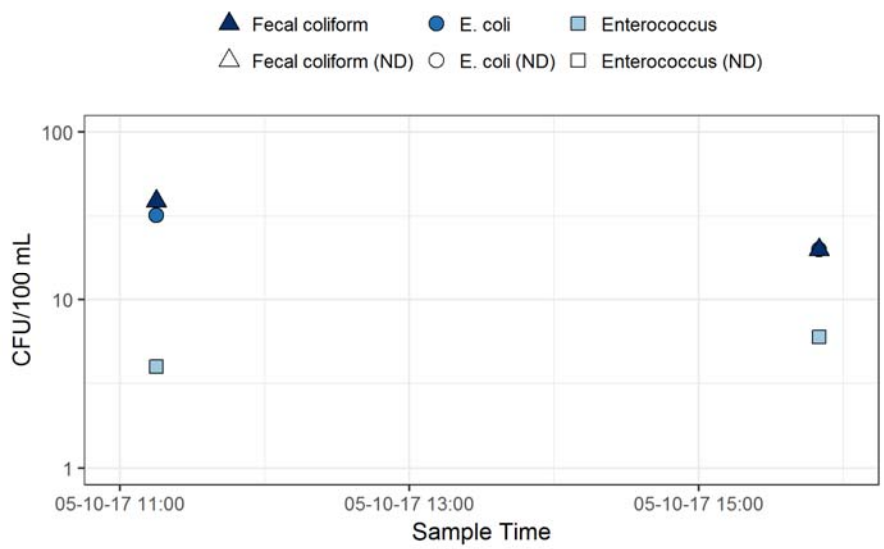
Figure 4-5: Dry Weather 2 Concentrations in Ridley Creek



4.2.3 Delaware River Results

Samples collected on incoming and outgoing tides were fairly similar in concentrations of each pollutant and all of concentrations were within values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-6 shows the concentrations at DR-03, the mid-point station on the river. Additional plots are provided in Appendix H.

Figure 4-6: Dry Weather 2 Concentrations in Delaware River at DR-03



Concentrations for all POCs were higher than Dry 1 but were still fairly low, well below maximum water quality standard criteria. Results were similar to historical data collected previously by the Delaware River Basin Commission (DRBC).

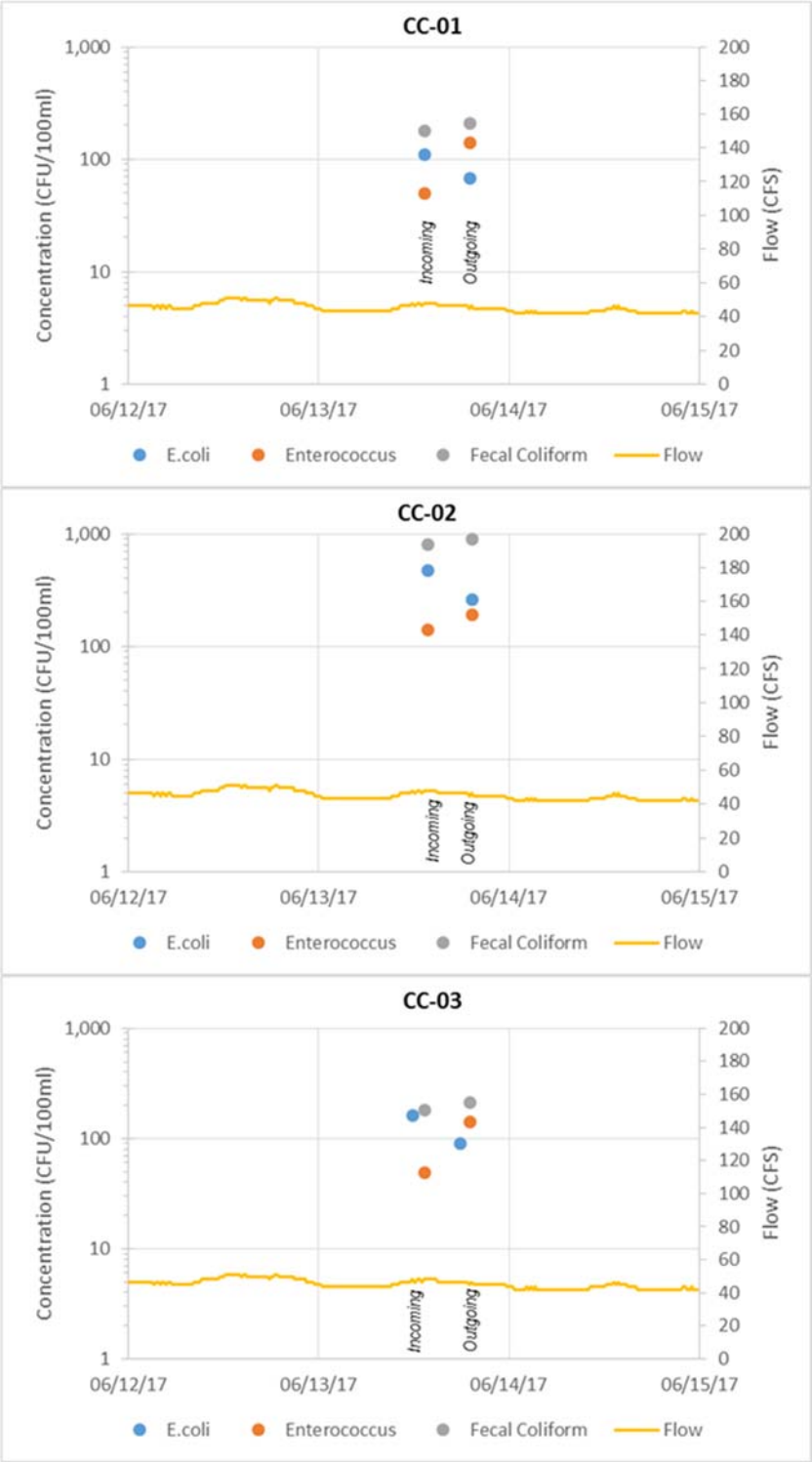
4.3 Dry Weather Sampling – Event 3 Results

The third dry weather event (Dry 3), on June 13, 2017, had the lowest dry weather flows in each waterbody (as shown in Table 2-7), approaching the 25th percentile flow. Laboratory results are presented by waterbody below.

4.3.1 Chester Creek Results

Samples collected on incoming and outgoing tides were fairly similar in concentrations of each pollutant. Enterococcus concentrations at each location tended to be higher on outgoing tide samples than incoming tide samples while the reverse was observed for E. coli. The majority of concentrations were higher than values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-7 shows the concentrations at each station. Additional plots are provided in Appendix H.

Figure 4-7: Dry Weather 3 Concentrations in Chester Creek



Fecal coliform levels tended to have the highest of the three pollutants of concern (POC) while enterococcus levels tended to be the lowest. These figures also illustrate an increase in POC levels from upstream (CC-01) to downstream to the mid-point (CC-02) during both incoming and outgoing tidal conditions, followed by a decline in POC levels near the mouth (CC-03). Additional analysis and interpretation of the data will be conducted as part of the water quality model development and calibration process.

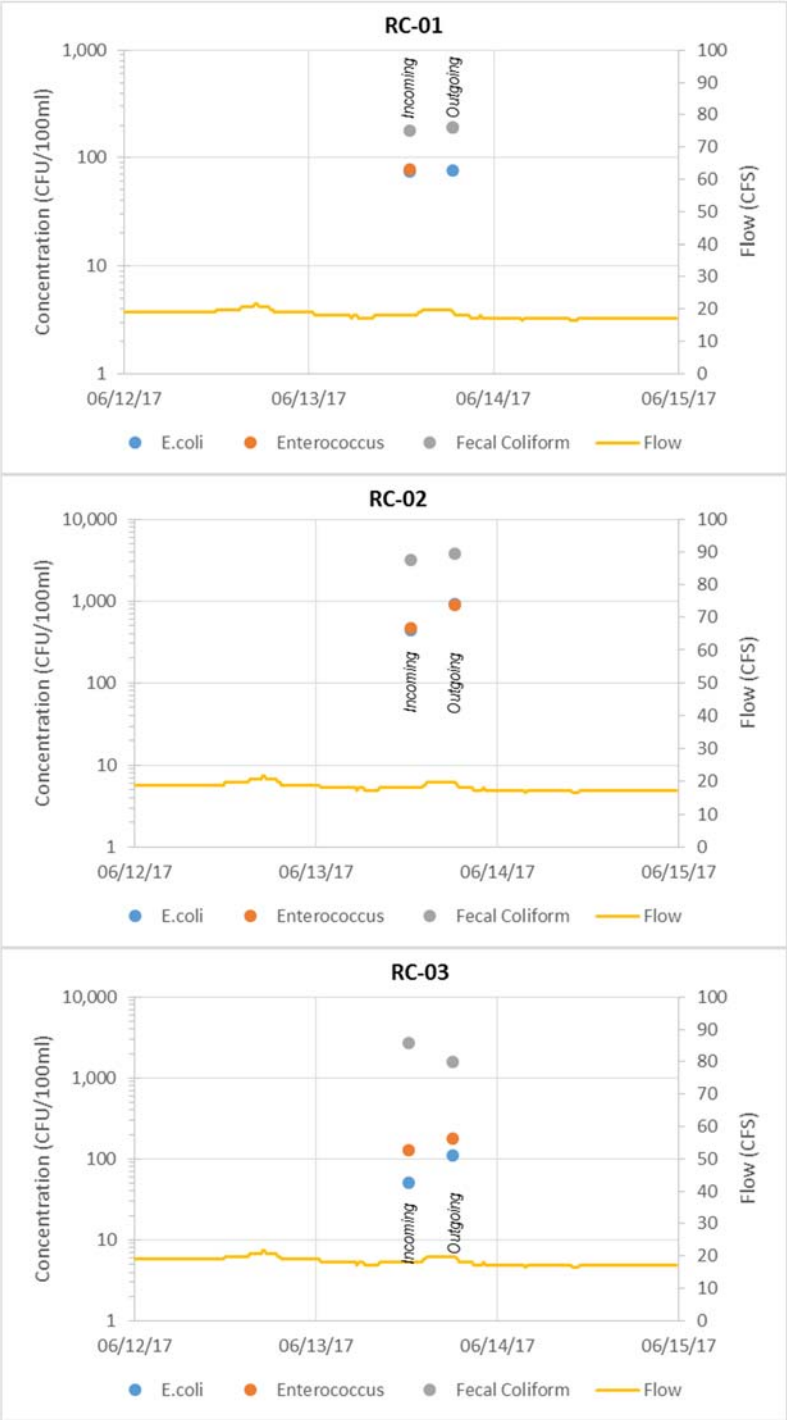
4.3.2 Ridley Creek Results

Samples collected on incoming and outgoing tides were fairly similar in concentrations of each pollutant. However, concentrations of enterococcus tended to be about two times higher in the outgoing samples than incoming sample levels.

Fecal coliform and enterococcus concentrations tended to be higher than the other dry weather events and maximum water quality standard criteria. The majority of E. coli concentrations were within values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-8 shows the concentrations at each station. Additional plots are provided in Appendix H.

Fecal coliform levels tended to have the highest of the three pollutants of concern (POC) while enterococcus levels tended to be the lowest, except at RC-03. As with the other dry weather events, the laboratory encountered difficulties in analyzing the samples at the best dilution and quantifying results for samples with low concentrations. These figures also illustrate an increase in POC levels from upstream (RC-01) to downstream to the mid-point (RC-02) during both incoming and outgoing tidal conditions, followed by a decline in POC levels near the mouth (RC-03).

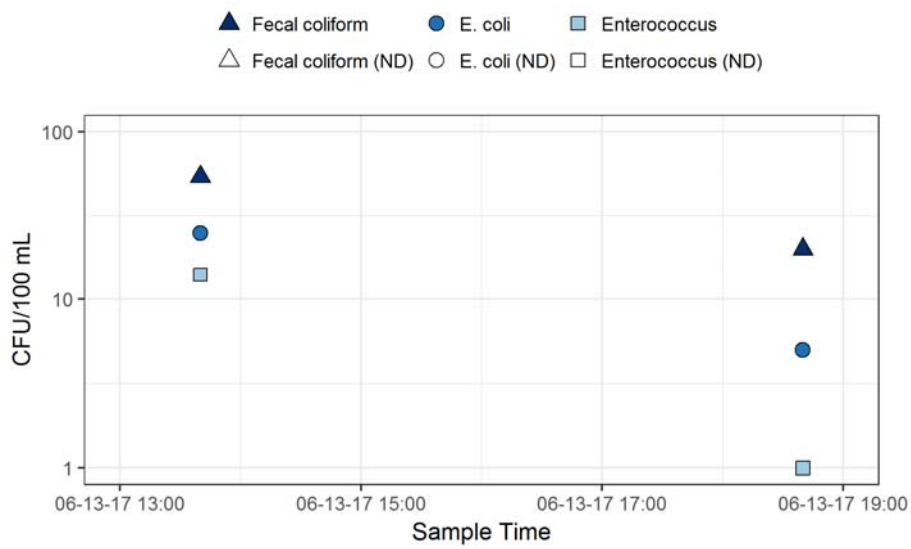
Figure 4-8: Dry Weather 3 Concentrations in Ridley Creek



4.3.3 Delaware River Results

Samples collected on incoming and outgoing tides were fairly similar in concentrations of each pollutant and all of concentrations were within values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-9 shows the concentrations at DR-03, the mid-point station on the river. Additional sampling plots are provided in Appendix H.

Figure 4-9: Dry Weather 3 Concentrations in Delaware River at DR-03



Concentrations for all POCs were fairly low, well below maximum water quality standard criteria. Results were similar to historical data collected previously by the Delaware River Basin Commission (DRBC).

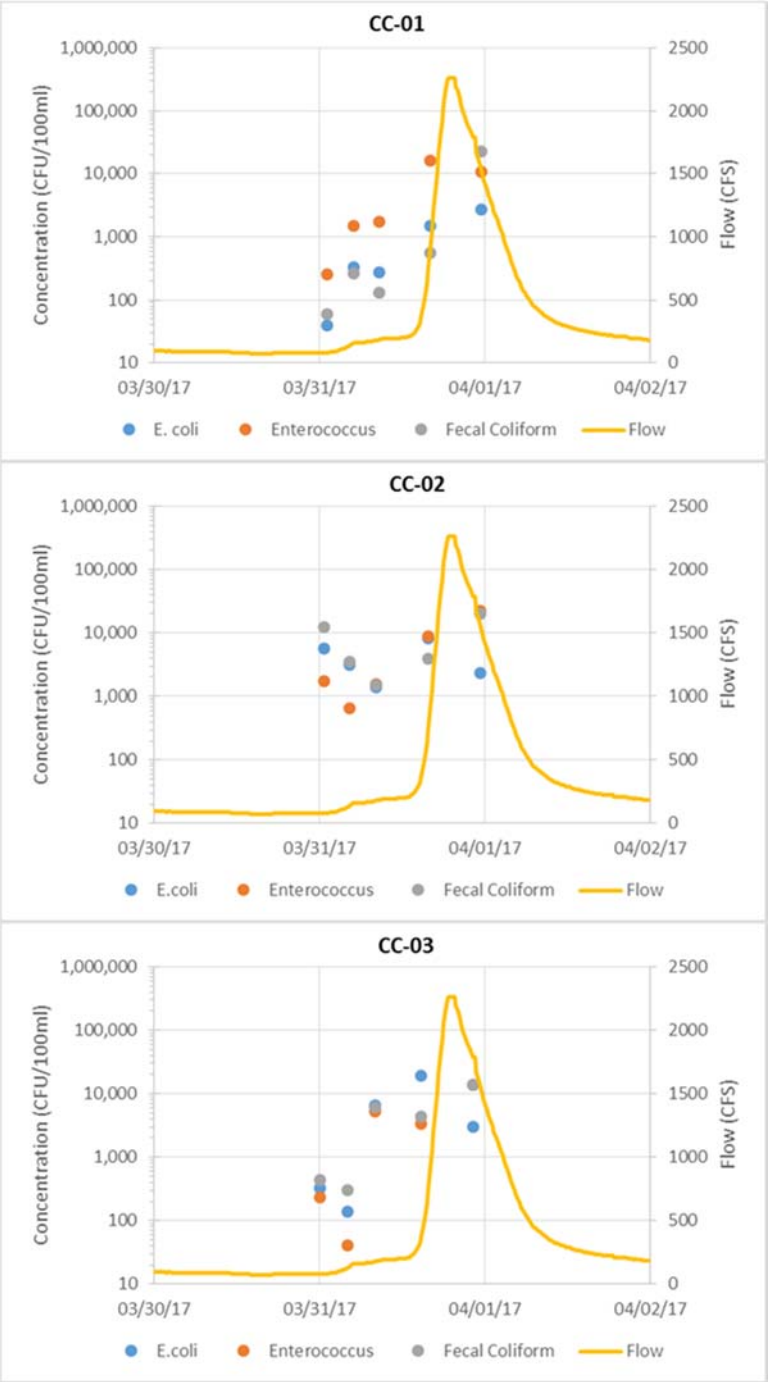
4.4 Wet Weather Sampling – Event 1 Results

Wet weather event 1 (Wet 1), was conducted on March 31-April 1, 2017. This event was the largest of the three events, with just over 1.5" recorded at the Philadelphia Airport. Rainfall was also mostly uniform across the watershed. This event also had the highest flows in the tributaries of the three sampled wet weather events. Laboratory results are presented by waterbody and source type below.

4.4.1 Chester Creek Results

Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. The majority of concentrations for all of the POCs were higher than values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-10 shows the concentrations at each station in the creek and the flow measured at the USGS gage just upstream of the DELCORA study area. Additional sampling plots are provided in Appendix H.

Figure 4-10: Wet Weather Event 1 Concentrations in Chester Creek



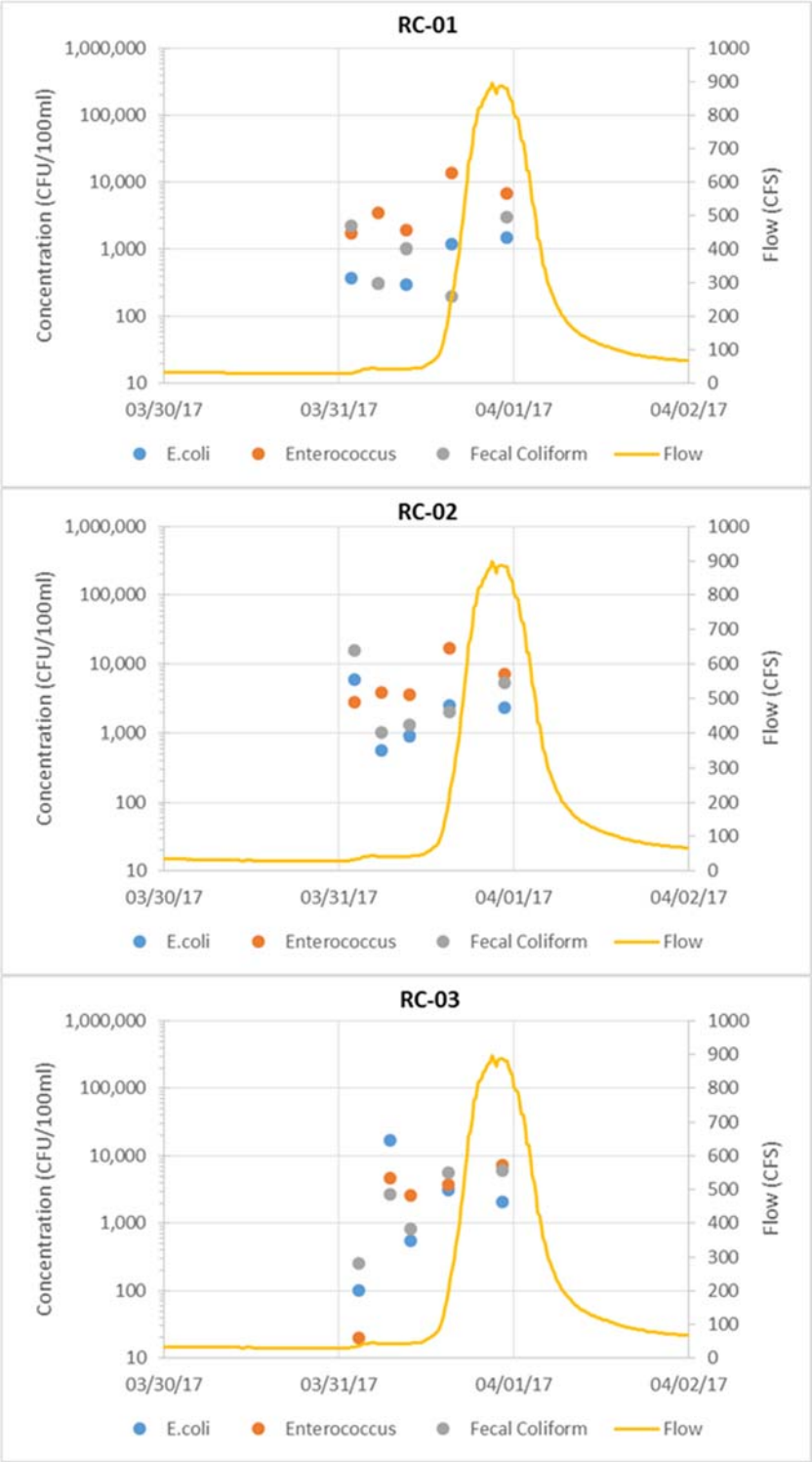
The impact of DELCORA's CSOs and Chester stormwater POC loads are most evident in the data at CC-02 for first two rounds of sampling, which correspond to roughly the first six hours of the event. Similar concentrations were measured further downstream at CC-03 during the third and fourth rounds of sampling, which corresponds to approximately hours 8 through 16 of the event. The data at CC-01 suggest that loads from upstream sources reached the study area in the fourth and fifth rounds of sampling, approximately 16 to 24 hours of the event. POC concentrations peak at 23,000 cfu/100 ml (fecal coliform).

4.4.2 Ridley Creek Results

Samples were collected at the intervals specified in the Sampling and Analysis Plan and Section 2.5.2. The majority of concentrations for all of the POCs were higher than values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-11 shows the concentrations at each station in the creek and the flow measured at the USGS gage just upstream of the DELCORA study area. Additional sampling plots are provided in Appendix H.

The impact of DELCORA's CSOs and Chester stormwater POC loads are most evident in the data at RC-02 for first two rounds of sampling. Similar concentrations were measured further downstream at RC-03 during the third and fourth rounds of sampling. The data at RC-01 suggest that loads from upstream sources reached the study area in the fourth and fifth rounds of sampling. POC concentrations peak at 17,000 cfu/100 ml (enterococcus).

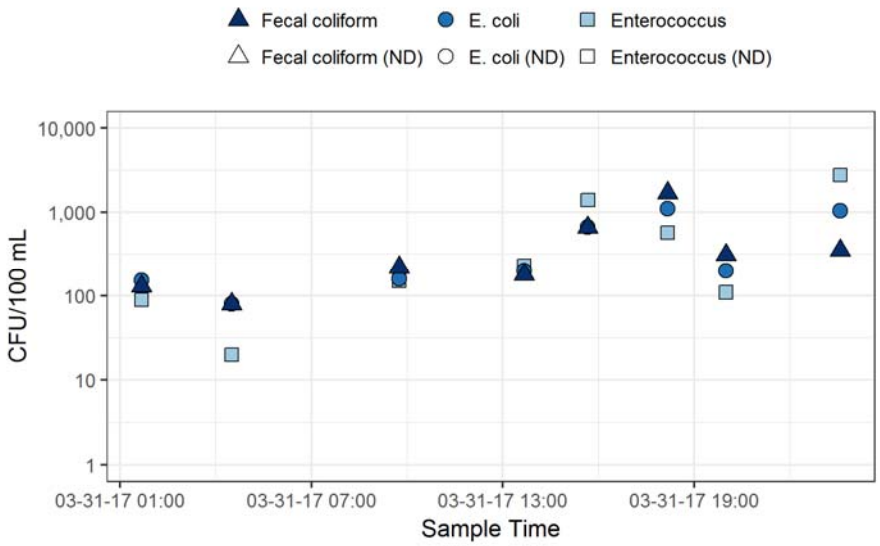
Figure 4-11: Wet Weather Event 1 Concentrations in Ridley Creek



4.4.3 Delaware River Results

Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. Samples were collected more frequently in the Delaware River than in the tributaries to ensure that wet weather impacts were characterized under an entire tidal cycle. Figure 4-12 shows the concentrations at DR-03, the mid-point station on the river. CSOs impacts would be captured at this station under all tidal conditions. Similar levels were observed at the other near shore Delaware River locations. These time series plots are provided in Appendix H.

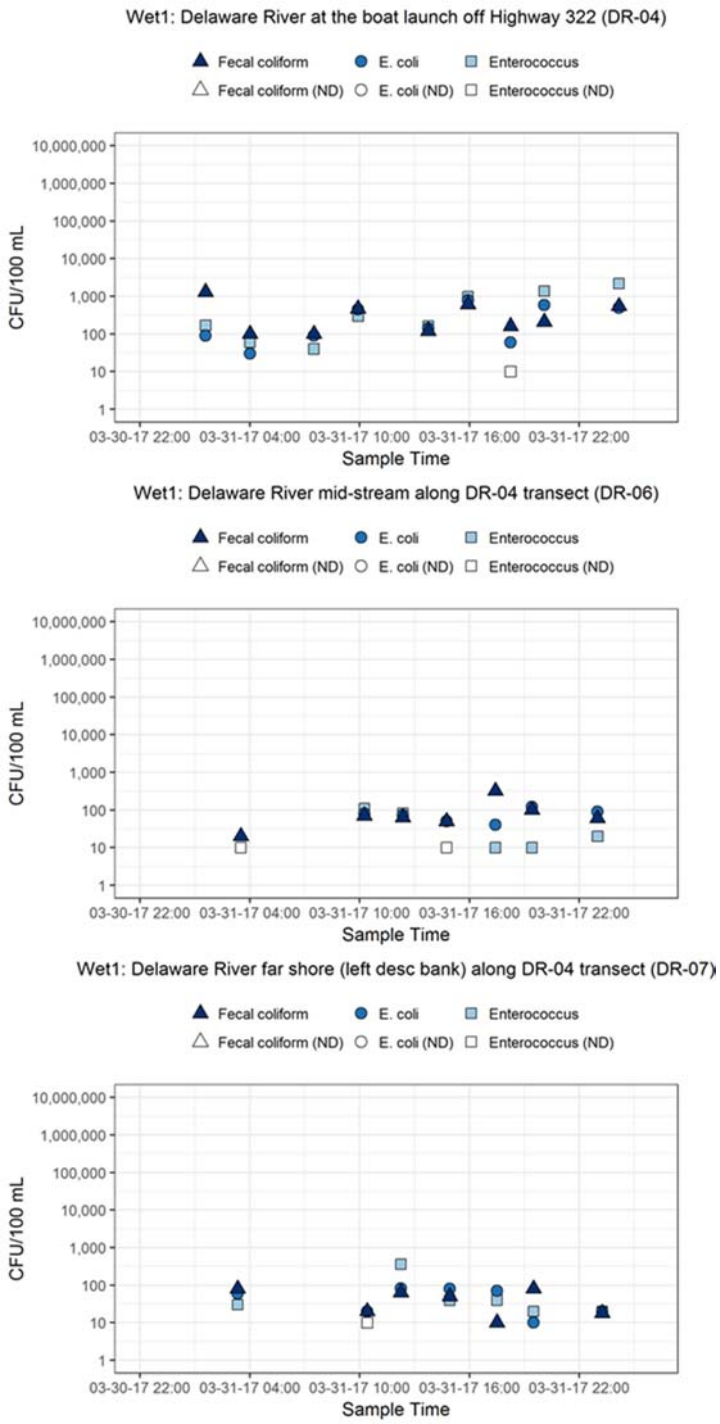
Figure 4-12: Wet Weather Event 1 Concentrations in Delaware River at DR-03



POC concentrations in the Delaware River tend to be approximately an order of magnitude lower than the levels observed in the tributaries, though there are several measurements that are higher than values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2.

Near shore impacts of DELCORA's CSOs were assessed by collecting samples across the transect corresponding to near shore station DR-04 (see Figure 2-2). Results are shown for DR-04, DR-06 (mid-stream) and DR-07 (far shore) in Figure 4-13. This figure indicates that there is a small lateral gradient during the period when DELCORA's CSOs were discharging. The near shore concentrations are typically an order of magnitude larger than the mid or far shore concentrations, indicating that the influence of the DELCORA CSOs is limited to the near shore area. A better understanding of lateral mixing will be obtained through the model calibration process.

Figure 4-13: Wet Weather Event 1 Concentrations Across the Delaware River



4.4.4 Combined Sewer Overflow (CSO) Location Results

All of the CSOs were sampled during this event. Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. A full set of samples (i.e. 8 rounds) were collected at each CSO, except CSO-018, which had 7 rounds of sampling conducted before it stopped discharging. Concentrations for each POC for each CSO are presented in Figures 4-14 through 4-16. Concentration time series figures are presented in Appendix H.

Figure 4-14: CSO Fecal coliform Concentrations in Wet 1 Event

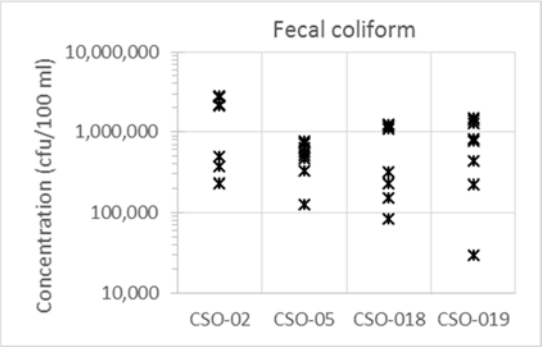


Figure 4-15: CSO E. coli Concentrations in Wet 1 Event

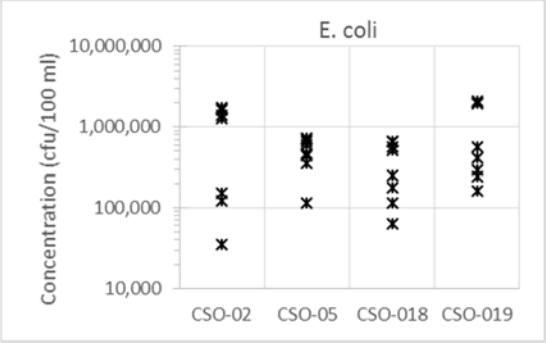
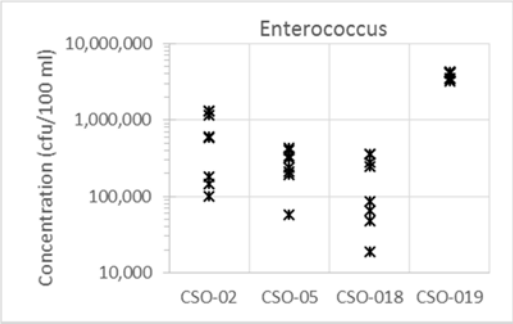


Figure 4-16: CSO Enterococcus Concentrations in Wet 1 Event



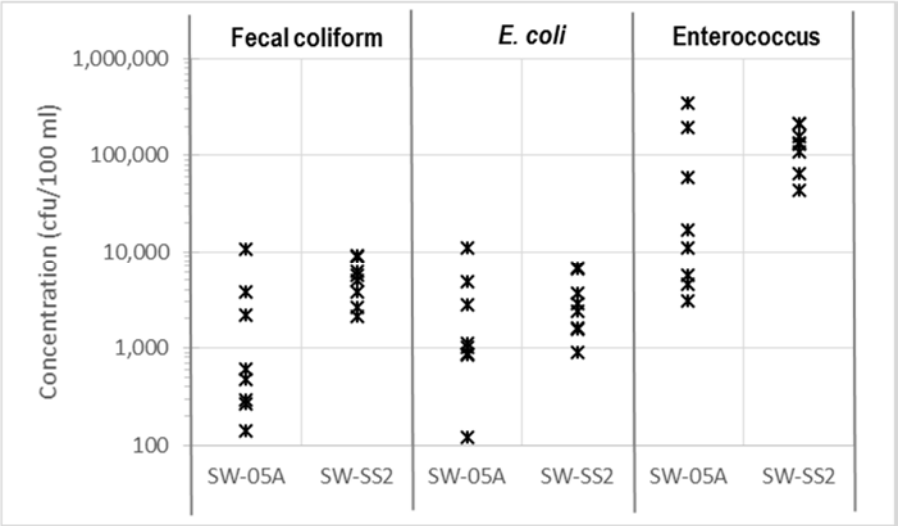
One potential outlier result was identified: the enterococcus result in round 1 at CSO-019 was 3,220,000 cfu/100 ml, and flagged as quantified with a count outside the ideal counting range. The next highest quantified result was 500,000 cfu/100 ml, nearly an order of magnitude lower. However, in round 4 at CSO-019, the result was reported as >600,000 cfu/100 ml (ie. actual concentration is greater than 600,000 cfu/100 ml), which provides some supporting evidence that enterococcus results in CSO-019 were higher than in the other CSOs and the potential outlier may be a legitimate reflection of conditions. The effect of this potential outlier will be further evaluated through the model calibration process.

Measured concentrations were within the range of CSO bacteria concentrations reported in the literature (EPA 2002) but tended to be lower than concentrations measured in other communities. Several potential explanations for this include: 1) the highly industrialized nature of the DELCORA service area may result in a smaller bacteria load to the combined system than communities with less industrial land; 2) DELCORA may have a relatively high percentage of stormwater in the combined system.

4.4.5 Stormwater Location Results

Both stormwater outfalls were sampled during this event. Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. A full set of samples (e.g. 8 rounds) were collected at each stormwater location. Concentrations for each POC are presented in Figure 4-17. Concentration time series figures are provided in Appendix H.

Figure 4-17: Stormwater POC Concentrations in Wet 1 Event



Most of the measured concentrations were within the range of stormwater bacteria concentrations reported in the literature (NSQD, 2015). It was somewhat surprising that the enterococcus results tended to be higher than the fecal coliform and E. coli data at both locations. However, there is very little data in the literature for enterococcus so it is difficult to assess whether these results are unusual. Additional evaluation of POC loads will be conducted as part of the watershed and water quality model calibrations.

4.5 Wet Weather Sampling – Event 2 Results

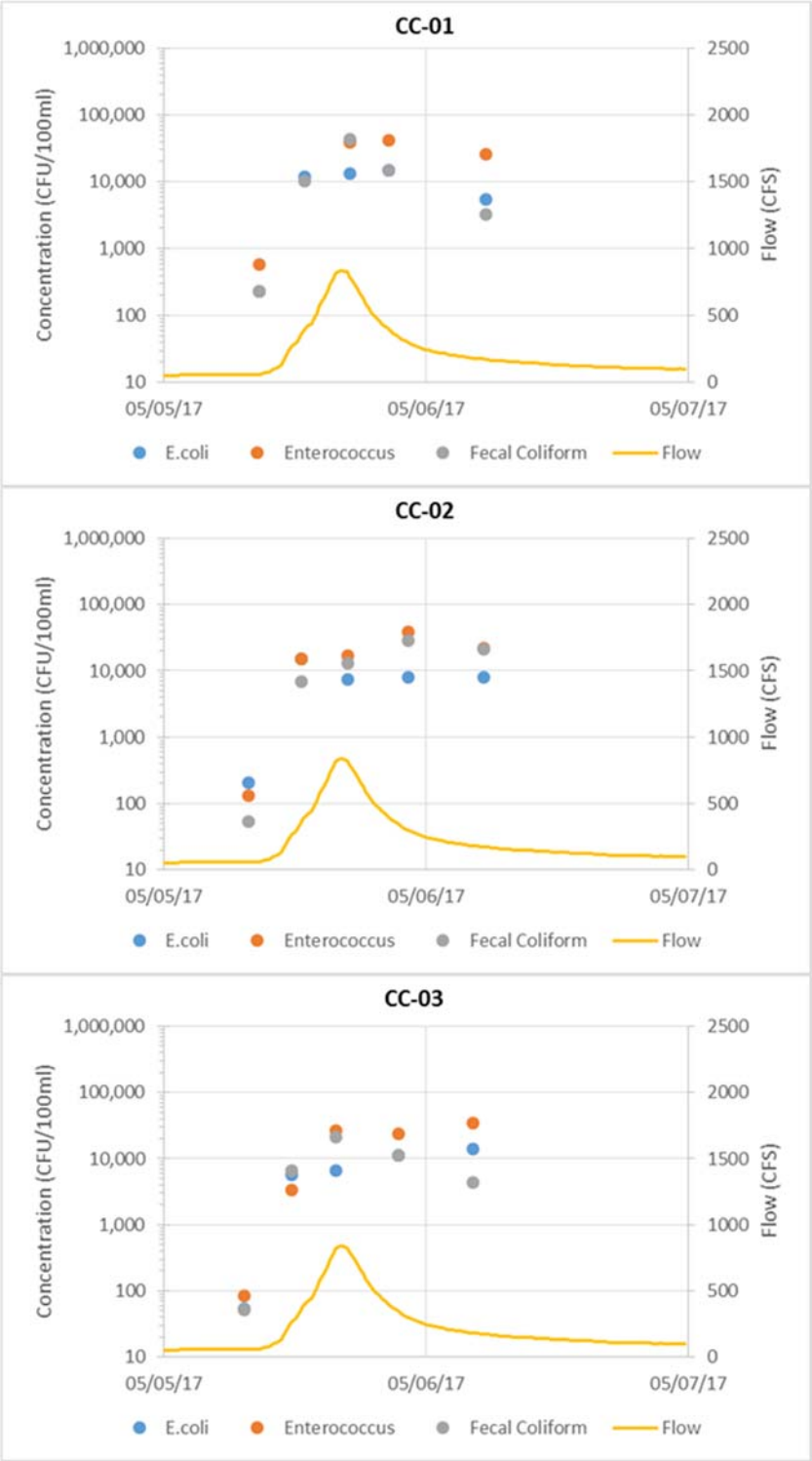
Wet weather event 2 (Wet 2), was conducted on May 5, 2017. This event was slightly smaller than the first wet weather event, with 1.47" recorded at the Philadelphia Airport. Rainfall varied somewhat across the watershed, with less rain falling in the DELCORA area and the upstream Chester and Ridley Creek watersheds, than in the Philadelphia area and areas bordering the Delaware River. Laboratory results are presented by waterbody and source type below.

4.5.1 Chester Creek Results

Samples were collected at the intervals specified in the Sampling and Analysis Plan (SAP). The majority of concentrations for all of the POCs were higher than values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-18 shows the concentrations at each station in the creek and the flow measured at the USGS gage just upstream of the DELCORA study area. Additional sampling plots are provided in Appendix H.

The impact of DELCORA's CSOs and Chester stormwater POC loads appear to begin in the second round of sampling. Concentrations remain elevated throughout the rest of the event at all three locations, despite the fact that DELCORA CSOs stopped discharging within 8 hours. This suggests that upstream and/or other bacteria sources are likely also impacting the creek. POC concentrations peak at 44,000 cfu/100 ml (fecal coliform).

Figure 4-18: Wet Weather Event 2 Concentrations in Chester Creek

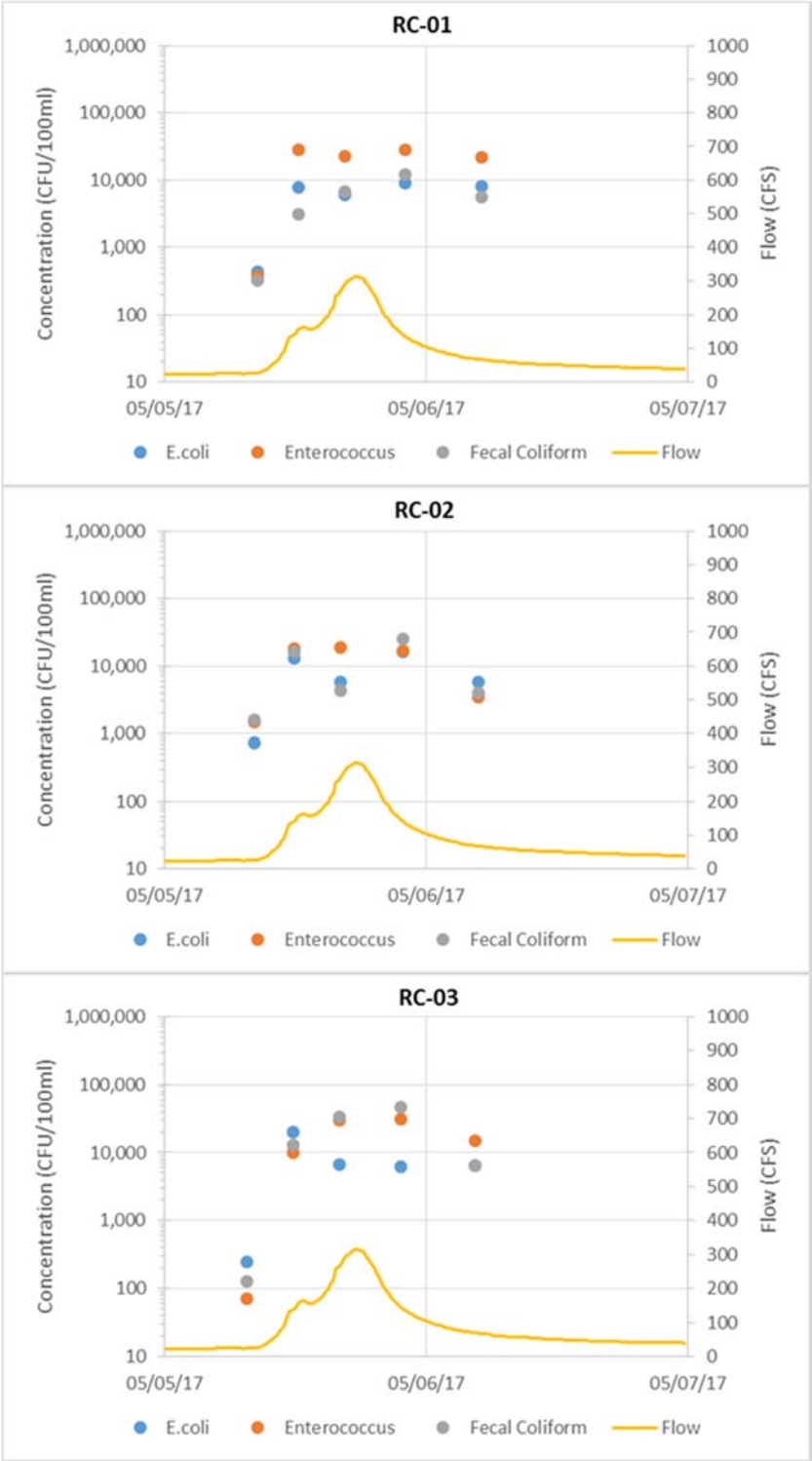


4.5.2 Ridley Creek Results

Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. The majority of concentrations for all of the POCs were higher than values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-19 shows the concentrations at each station in the creek and the flow measured at the USGS gage just upstream of the DELCORA study area. Additional sampling plots are provided in Appendix H.

The impact of DELCORA's CSOs and Chester stormwater POC loads appear to begin in the second round of sampling. Concentrations remain elevated throughout the rest of the event at all three locations, despite the fact that DELCORA CSOs stopped discharging within 8 hours (based on sampling intervals where samples could be collected in the CSOs). This suggests that upstream and/or other bacteria sources are likely also impacting the creek. POC concentrations peak at 47,000 cfu/100 ml (fecal coliform).

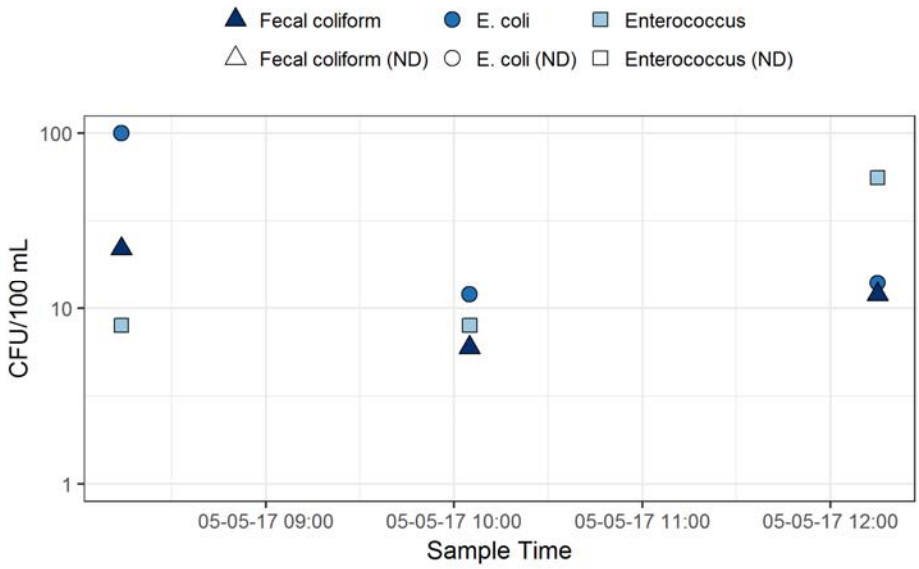
Figure 4-19: Wet Weather Event 2 Concentrations in Ridley Creek



4.5.3 Delaware River Results

Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. Samples were collected more frequently in the Delaware River than in the tributaries to ensure that wet weather impacts were characterized under an entire tidal cycle. Figure 4-20 shows the concentrations at DR-03, the mid-point station on the river. CSOs impacts would be captured at this station under all tidal conditions. Similar levels were observed at the other near shore Delaware River locations. All concentration time series figures are provided in Appendix H.

Figure 4-20: Wet Weather Event 2 Concentrations in Delaware River at DR-03



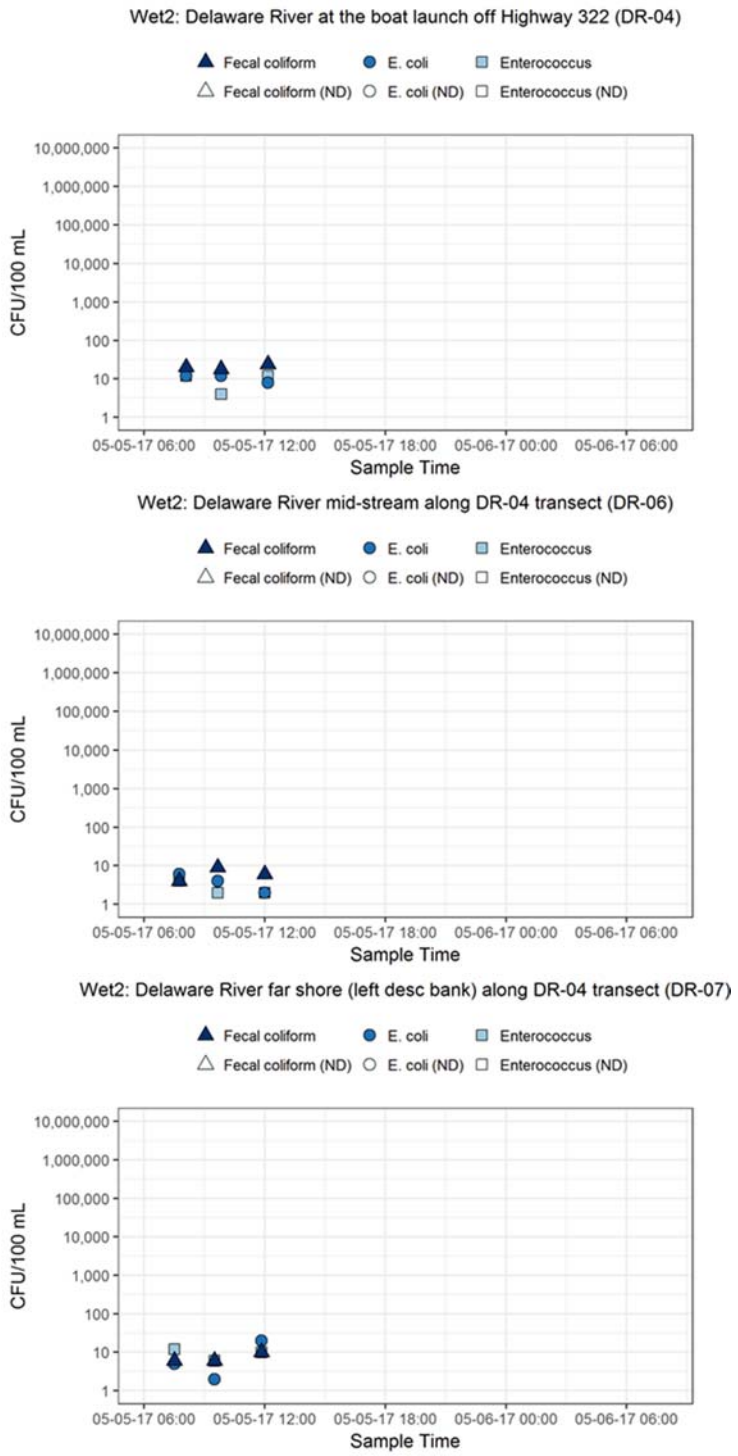
Note that sample collection in the Delaware River had to be stopped midway through the event, as described in Section 3 so the time series includes the three rounds of sampling that were completed as per the Sampling and Analysis Plan. Additional samples were collected from the bank during this event. The data from these locations are higher than the samples collected with the boat and likely reflect localized conditions rather than conditions at the scale of the water quality model.

POC concentrations in the Delaware River tend to be approximately 1-2 orders of magnitude lower than the levels observed in the tributaries. Only the last round of sampling at DR-05 had any POC concentrations greater than 100 cfu/100 ml (the maximum value shown on the y-axis). Because DELCORA's CSOs had stopped discharging well before this round, the concentrations are likely due to loads from other sources. All of the other measurements in the Delaware River are lower than values used as values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2.

Near shore impacts of DELCORA's CSOs were assessed by collecting samples across the transect corresponding to near shore station DR-04. Results are shown for DR-04, DR-06 (mid-stream) and DR-07 (far shore) in Figure 4-21. This figure indicates that a lateral gradient is very slight for the sampling rounds that could be collected. POC concentrations on the near shore and far shore are slightly higher

(~2x) than the mid-stream concentrations. A better understanding of lateral mixing will be obtained through the model calibration process.

Figure 4-21: Wet Weather Event 2 Concentrations Across the Delaware River



4.5.4 Combined Sewer Overflow (CSO) Location Results

All of the CSOs were sampled during this event. Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. Five rounds of samples were collected at each CSO before discharges ended. Concentrations for each POC for each CSO are presented in Figures 4-22 through 4-24. Time series plots are presented in Appendix H.

Figure 4-22: CSO Fecal coliform Concentrations in Wet 2 Event

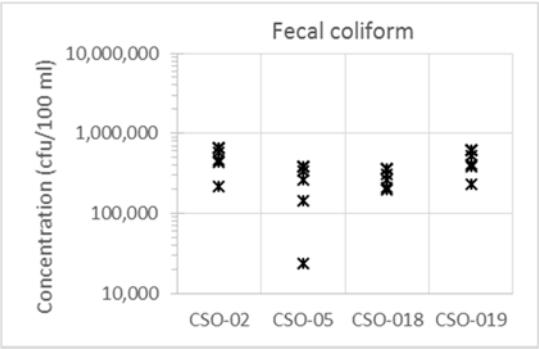


Figure 4-23: CSO E. coli Concentrations in Wet 2 Event

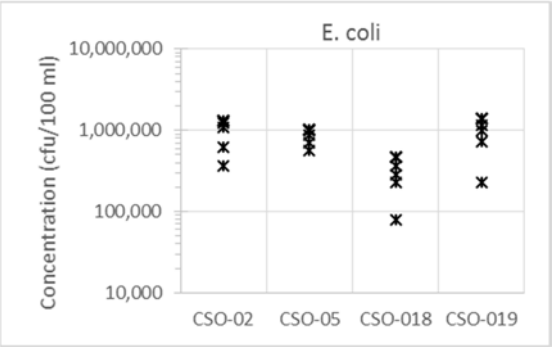
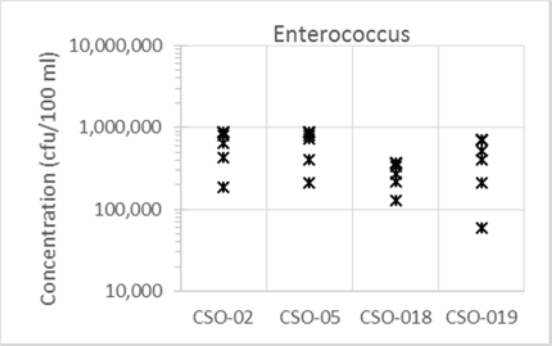


Figure 4-24: CSO Enterococcus Concentrations in Wet 2 Event

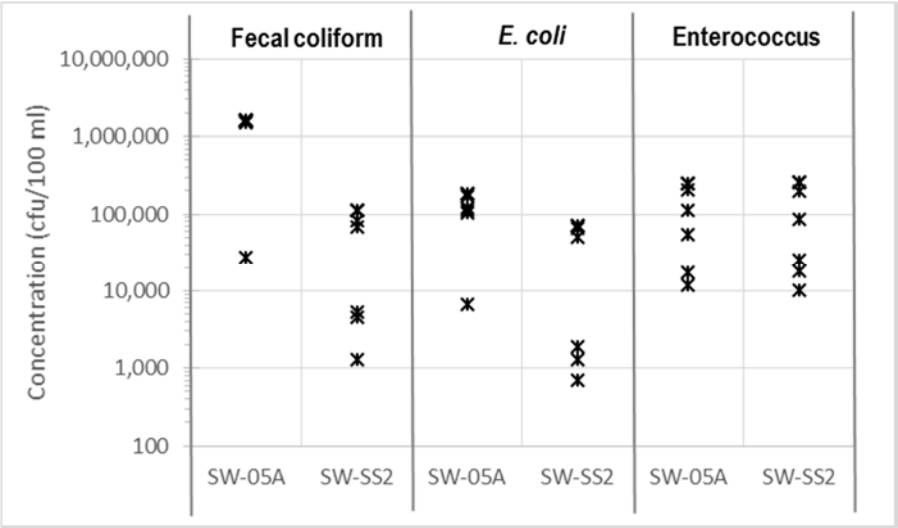


Measured concentrations were within the range of CSO bacteria concentrations reported in the literature (EPA 2002) and were similar to concentrations measured in other communities. Because this event had less rain than Wet Weather Event 1, CSO discharges likely had a smaller fraction of stormwater than in Wet Weather Event 1, resulting in slightly higher concentrations throughout the discharge period.

4.5.5 Stormwater Location Results

Both stormwater outfalls were sampled during this event. Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. Six rounds of samples were collected at each stormwater location before the runoff ended. Concentrations for each POC are presented in Figure 4-25. Time series plots are provided in Appendix H.

Figure 4-25: Stormwater POC Concentrations in Wet 2 Event



Most of the measured concentrations were within the range of stormwater bacteria concentrations reported in the literature. The enterococcus results were similar in magnitude to, though still higher on average than, the fecal coliform and E. coli data. Additional evaluation of POC loads will be conducted as part of the watershed and water quality model calibrations.

4.6 Wet Weather Sampling – Event 3 Results

Wet weather event 3 (Wet 3), was conducted on May 22, 2017. This event was the smallest storm, with 0.51" recorded at the Philadelphia Airport. Rainfall varied across the watershed, with the upper tributary watersheds receiving much less rain than the areas closer to the Delaware River. Less rain fell in the DELCORA area than Philadelphia. Laboratory results are presented by waterbody and source type below.

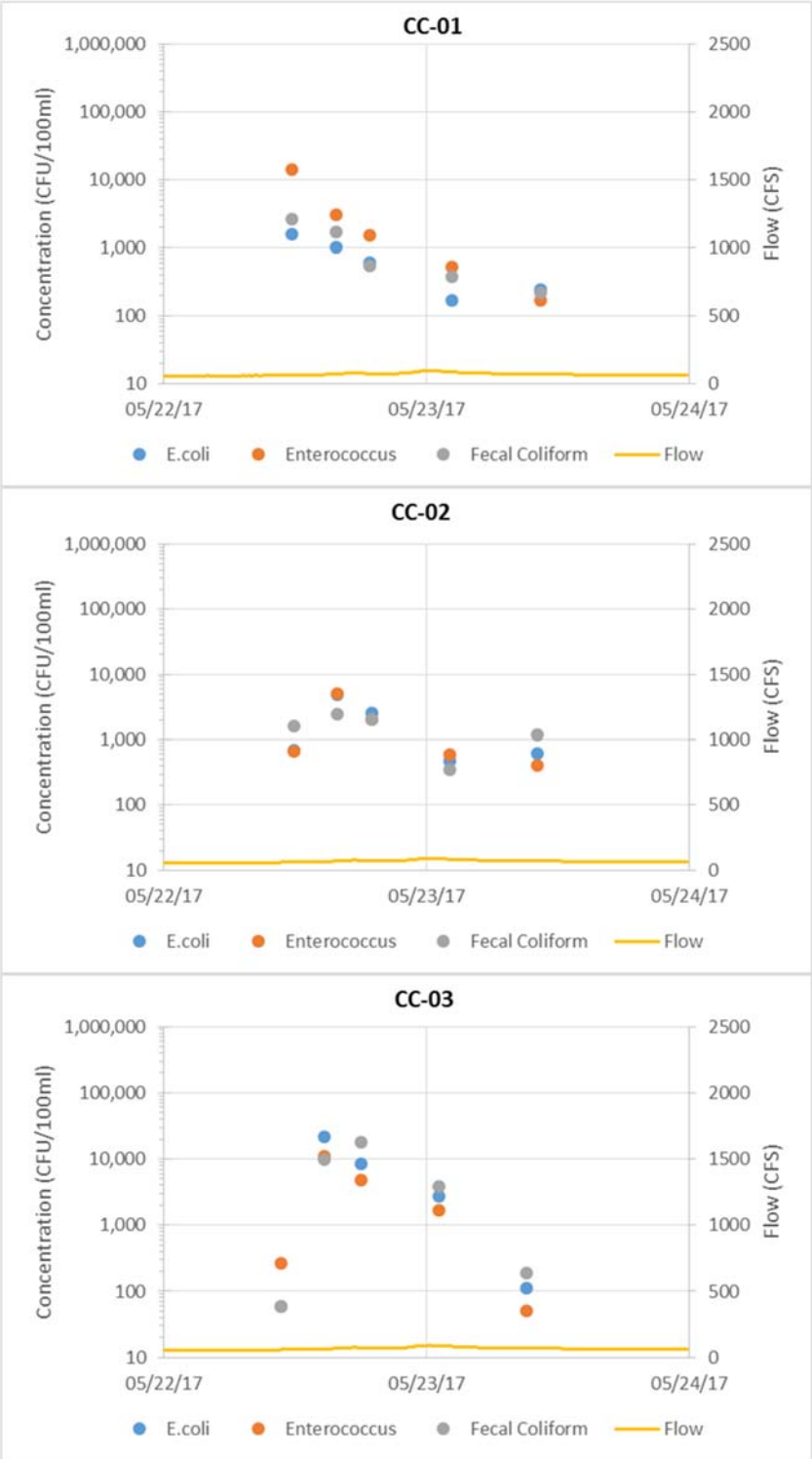
4.6.1 Chester Creek Results

Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. The majority of concentrations for all of the POCs were higher than values used as

maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-26 shows the concentrations at each station in the creek and the flow measured at the USGS gage just upstream of the DELCORA study area. Additional sampling plots are provided in Appendix H.

The impact of DELCORA's CSOs and Chester stormwater POC loads are most evident in the data at CC-03 for second and third rounds of sampling. The data at CC-01 suggest that loads from upstream sources reached the study area at the beginning of the event, which likely reflects the spatial variability in the rainfall. POC concentrations peak at 22,000 cfu/100 ml (E. coli).

Figure 4-26: Wet Weather Event 3 Concentrations in Chester Creek

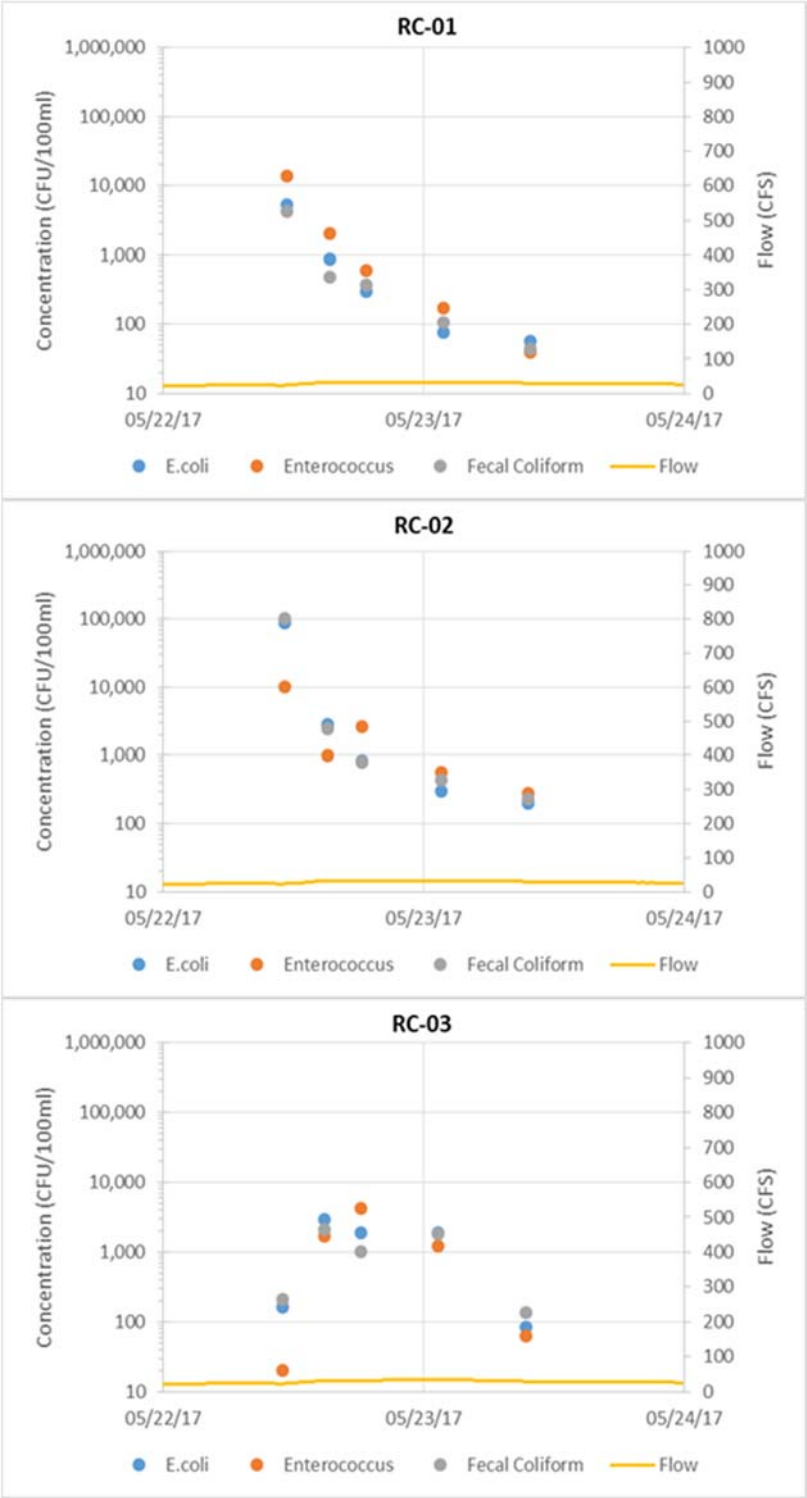


4.6.2 Ridley Creek Results

Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. The majority of concentrations for all of the POCs were higher than values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2. Figure 4-27 shows the concentrations at each station in the creek and the flow measured at the USGS gage just upstream of the DELCORA study area. Additional sampling plots are provided in Appendix H.

The impact of DELCORA's CSOs and Chester stormwater POC loads are most evident in the data at RC-02 in the second round and RC-03 in the second and third rounds of sampling. The data at RC-01 suggest that loads from upstream sources reached the study area at the beginning of the event, which likely reflects the spatial variability in the rainfall. POC concentrations peak at 103,000 cfu/100 ml (fecal coliform).

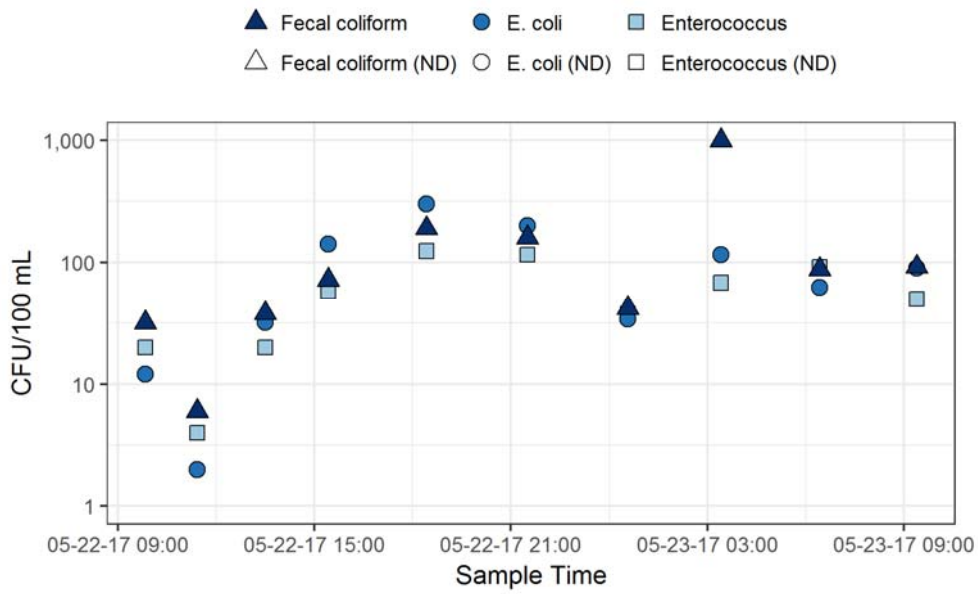
Figure 4-27: Wet Weather Event 3 Concentrations in Ridley Creek



4.6.3 Delaware River Results

Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. Samples were collected more frequently in the Delaware River than in the tributaries to ensure that wet weather impacts were characterized under an entire tidal cycle. Figure 4-28 shows the concentrations at DR-03, the mid-point station on the river. CSOs impacts would be captured at this station under all tidal conditions. Similar levels were observed at the other near shore Delaware River locations. All concentration time series figures are provided in Appendix H.

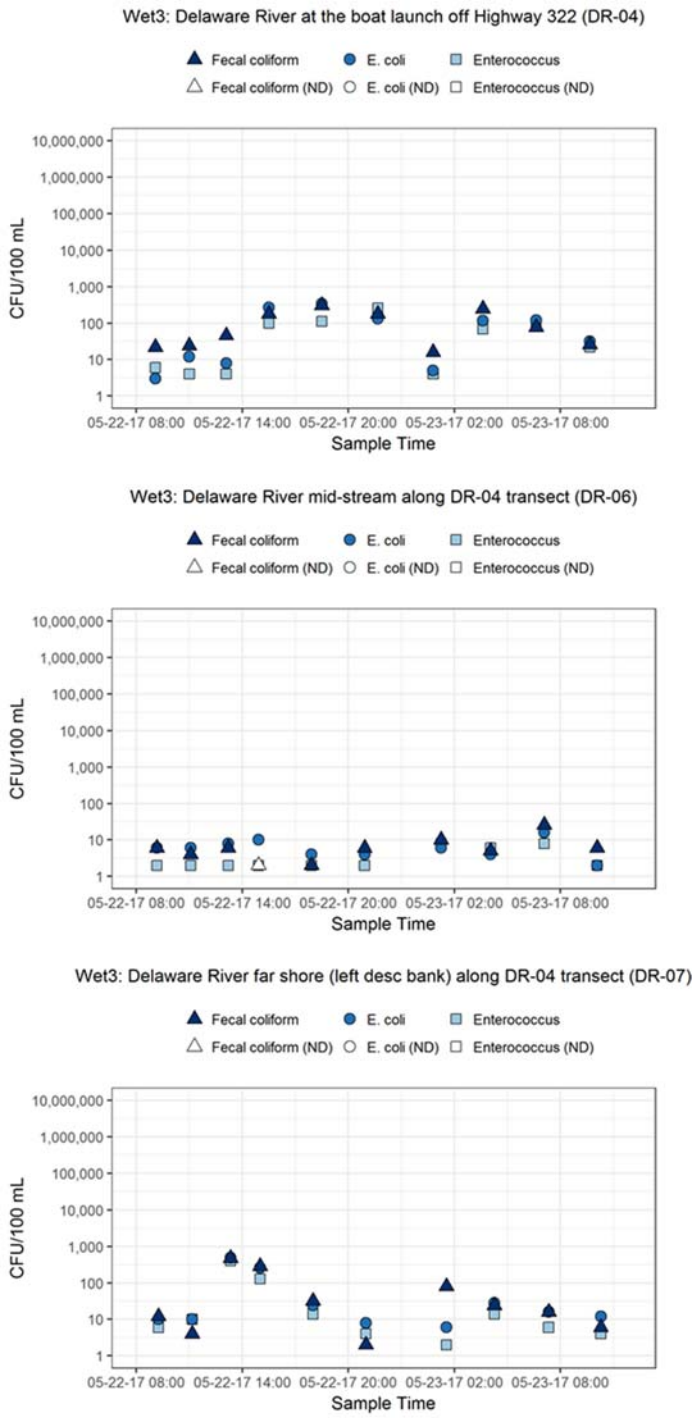
Figure 4-28: Wet Weather Event 3 Concentrations in Delaware River at DR-03



POC concentrations in the Delaware River tend to be approximately 1-2 orders of magnitude lower than the levels observed in the tributaries. The highest concentrations were observed in Rounds 5 and 8 (Hours 9 and 18) at this location. Most of the other measurements in the Delaware River are lower than values used as maximum water quality standard criteria. Maximum water quality standard criteria are shown in Figure 2.1 in Section 2.

Near shore impacts of DELCORA's CSOs were assessed by collecting samples across the transect corresponding to near shore station DR-04. Results are shown for DR-04, DR-06 (mid-stream) and DR-07 (far shore) in Figure 4-29. This figure indicates that a lateral gradient exists with both shores. POC concentrations on the near shore and far shore are approximately 1-2 orders of magnitude higher than the mid-stream concentrations. A better understanding of lateral mixing will be obtained through the model calibration process.

Figure 4-29: Wet Weather Event 3 Concentrations Across the Delaware River



4.6.4 Combined Sewer Overflow (CSO) Location Results

All of the CSOs were sampled during this event. Samples were collected at the intervals specified in the Sampling and Analysis Plan (SAP). Four rounds of samples were collected at each CSO before discharges ended. Concentrations for each POC for each CSO are presented in Figures 4-30 through 4-32. Figures of concentrations over time are presented in Appendix H.

Figure 4-30: CSO Fecal coliform Concentrations in Wet 3 Event

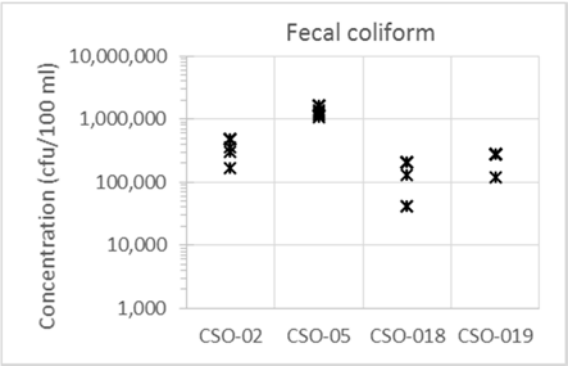


Figure 4-31: CSO E. coli Concentrations in Wet 3 Event

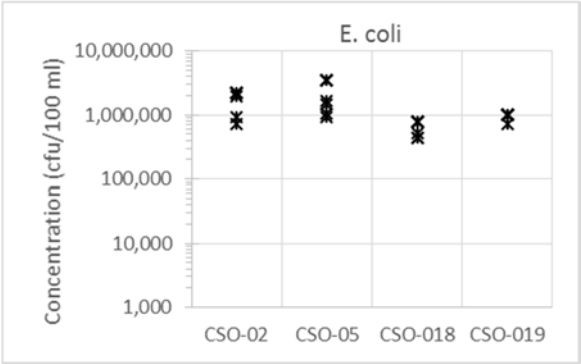
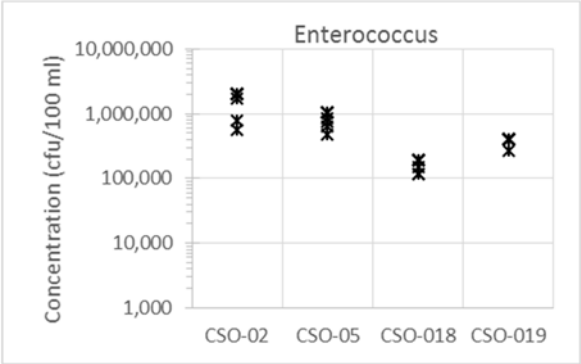


Figure 4-32: CSO Enterococcus Concentrations in Wet 3 Event

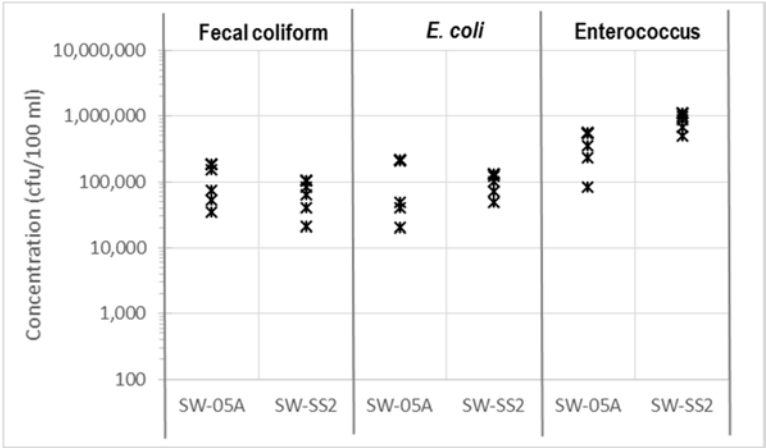


Measured concentrations were within the range of CSO bacteria concentrations reported in the literature (EPA 2002) and tended to be somewhat higher overall than concentrations measured in other communities. Because this event had much less rain than the first two wet weather events, the CSO discharges likely contained a much higher percentage of sanitary sewage than the other events.

4.6.5 Stormwater Location Results

Both stormwater outfalls were sampled during this event. Samples were collected at the intervals specified in the Sampling and Analysis Plan and summarized in Section 2.5.2. Five rounds of samples were collected at each stormwater location before the runoff ended. Concentrations for each POC are presented in Figure 4-33. Figures of concentration over time are provided in Appendix H.

Figure 4-33: Stormwater POC Concentrations in Wet 3 Event



Most of the measured concentrations were within the range of stormwater bacteria concentrations reported in the literature (NSQD 2015). It was somewhat surprising that the enterococcus results tended to be higher than the fecal coliform and E. coli data at both locations. However, there is very little stormwater data in the literature for enterococcus so it is difficult to assess whether these results are unusual. Additional evaluation of POC loads will be conducted as part of the watershed and water quality model calibrations.

Section 5 Comparison of Laboratory Results to QAPP

The Sampling Program execution was consistent with the QAPP objectives. This section presents a summary of the quality of the data relative to the QAPP objectives. Out of a total of 1,195 analysis, 1,104 (92%) did not require data qualifications as a result of poor QA/QC. The remaining 91 analysis were conducted outside the specified 8 hour hold time. However, of these 91 analyses, 84 were completed within 10 hours. These results have been qualified but minimal impact on the use of the data is anticipated due to the similarity in concentrations between results measured within and outside the analytical hold time. Much more uncertainty exists within the analytical methodology and field practices (e.g. obtaining a homogenous, representative sample, etc.). The most common qualifier applied to the data was due to bacteria counts outside ideal ranges. Most of these were the result of low ambient concentrations and the uncertainty associated with their quantification reflects the limitations of the analytical methodology.

Complete Laboratory QA Program Manuals and SOPs for each laboratory procedure are found in Appendix I.

5.1 QAPP Requirements

Section 2.4 of the QAPP provided data quality objectives for the following areas:

- Accuracy
- Precision
- Completeness
- Representativeness
- Comparability
- Required detection limits

Accuracy, precision and detection limits requirements for field and laboratory activities are summarized in Table 5-1. Completeness objectives for the field measurements and sample collection was 90%. The completeness objective was 95% for the laboratory (see Section 2.1.4.3 of the QAPP). Representativeness and comparability objectives were qualitative and will be presented in the context of the sample program comparison in Section 5.2.

Table 5-1: Data Quality Objectives

Parameter	Data Accuracy Objectives (% R)		Data Precision Objectives				Required Detection Limits	
			Field Precision (RPD)		Analytical Precision (RPD)			
	Estimated By	Objective	Estimated By	Objective	Estimated By	Objective	Reference Method	RL*
Fecal coliform	Presence/ Absence Control	P/A	Field Duplicates	50%	Lab Replicates	40%	SM 9222D	10 No./ 100 ml
Escherichia coliform (E. coli)	Presence/ Absence Control	P/A	Field Duplicates	50%	Lab Replicates	40%	EPA 1603	10 No./ 100 ml
Enterococcus	Presence/ Absence Control	P/A	Field Duplicates	50%	Lab Replicates	40%	EPA 1600	10 No./ 100 ml

P/A - method detects presence when bacteria is present in control (P) and method does not detect bacteria when absent in control (A).
RL - Reporting Limit
SM - Standard Methods of the Examination of Water and Wastewater, 22nd Edition

5.2 Comparison of Results to QAPP

This section presents a high level summary of the comparison of the QAPP objectives to the results from the Sampling Program.

5.2.1 Accuracy

Accuracy cannot be directly measured for bacterial samples. Accuracy was assessed by the laboratory through the analysis of positive and negative controls and matrix spikes and with field blanks in the field. Field blanks are used to determine if samples collected were contaminated. Dilution blank samples and method blank samples were generated by the contract laboratory and used to assess contamination resulting from laboratory procedures. Overall, the accuracy of the Sampling Program was excellent.

A total of 21 field blanks were collected during the Sampling Program with at least one field blank collected per sampling event. Each field blank was analyzed for all three POCs, providing up to 63 measures of field accuracy. Only two of the 63 field blank results had a measurement higher than the analytical reporting limit. The field blank concentrations for these two results were inspected for potential evidence of contamination in the associated sample. The comparison indicated that the field blank concentration was much lower than the corresponding sample concentration, so the apparent field contamination impact on the sample result was nominal.

Eurofins, the laboratory that conducted the bacteria analyses for the sampling program, conducted positive/negative controls for E.Coli and Enterococci. Fecal coliform does not require analysis of this QA/QC measure. A positive control is a sample known to have bacteria while a negative control is a

sample known to be bacteria-free. The test is intended to confirm that the laboratory can grow bacteria for the positive controls and does not grow any measurable bacteria for the negative controls. For both E. coli and Enterococcus, six positive and six negative controls were analyzed. All measures met the requirements except one E. coli positive control, which did not have sufficient bacteria growth. Overall, this corresponds to a 96% success rate.

Matrix spikes are analyzed at a frequency of approximately one every 20 samples, depending on available sample volume, sufficient hold time and laboratory capacity. Matrix spikes are prepared by adding a known quantity of bacteria to a sample and measuring the amount recovered. Although this QA/QC measure was not included in the Sample Program QAPP, it provides another measure of laboratory accuracy. Matrix spikes were performed for all three parameters of interest using DELCORA samples.

Results are summarized in the table below. A percent recovery range of 50% - 150% recovery was used for acceptance windows. Note that percent recovery cannot be calculated under the following circumstances:

1. If the unspiked sample has a very high concentration relative to the amount spiked
2. If the matrix spike sample concentration exceeds the quantitation range (e.g. “>”)

Both of these situations occurred with each parameter, as shown in the table below.

Table 5-2: Laboratory Matrix Spike Summary

Parameter	Number of MS samples analyzed	Number of MS samples without calculable percent recovery	Number of MS samples with measurable percent recovery	Number of MS samples with acceptable percent recovery
E. coli	13	4	9	6 (67%)
Enterococcus	12	4	8	8 (100%)
Fecal Coliform	10	5	5	3 (60%)

Overall, 77% of the matrix spikes where a percent recovery could be calculated were within the 50% - 150% windows.

5.2.2 Precision

Precision is a measure of agreement between two or more measurements. The precision test objective is shown in Table 5-1. Field duplicates and laboratory replicates samples were taken for a portion of the samples. As noted in the QAPP (Section 2.4.1.2), the precision test (i.e.: comparison between two or more samples) is applied if the average result of the duplicate/replicate samples is greater than five times the analysis detection limit. If the average result of the duplicate/replicate samples is less than five times the analysis detection limit, the precision test was not utilized. Overall, the precision of the Sampling Program was mostly successful at meeting the QAPP objectives. The issues impacting field precision were largely due to factors outside the control of sampling personnel as well as by the well-established difficulty in generating reproducible results analytically for these parameters.

A total of 23 field duplicates were collected during the Sampling Program, with at least one field duplicate collected per sampling event. Each field duplicate was analyzed for all three POCs, providing up to 69 measures of field precision. Table 5-2 provides a summary of the field duplicate precision, calculated as the relative percent difference (% RPD).

Table 5-3: Field Precision % RPD Summary

Event	Location	E. coli % RPD	Fecal % RPD	Entero % RPD
Dry1	CC-01	<5x RL	<5x RL	<5x RL
Dry1	DR-02	<5x RL	<5x RL	<5x RL
Dry1	RC-03	91%	<5x RL	<5x RL
Dry2	CC-02	60%	59%	11%
Dry2	DR-04	80%	7%	<5x RL
Dry2	RC-02	7%	49%	42%
Dry3	CC-03	22%	9%	55%
Dry3	DR-03	18%	5%	<5x RL
Dry3	RC-01	44%	10%	0%
Wet1	CC-03	44%	36%	56%
Wet1	CSO-02	45%	107%	20%
Wet1	DR-02	55%	41%	<5x RL
Wet1	DR-04	133%	0%	52%
Wet1	RC-01	34%	67%	1%
Wet2	CC-01	27%	35%	3%
Wet2	CSO-018	2%	19%	18%
Wet2	DR-03 (LAND)	75%	147%	15%
Wet2	RC-02	34%	6%	18%
Wet3	CC-02	2%	50%	18%
Wet3	CSO-019	22%	1%	36%
Wet3	DR-01	50%	58%	<5x RL
Wet3	DR-02	6%	40%	34%
Wet3	RC-03	41%	21%	26%

Twelve (12) of the 69 RPDs could not be calculated because of the low pollutant concentrations in the samples and the field duplicates. For E. coli, 15 of the 21 calculable field duplicates met the 50% precision objective. For fecal coliform, 15 of the 20 calculable field duplicates met the 50% precision objective. For enterococcus, 13 of the 16 calculable field duplicates met the 50% precision objective.

Laboratory replicates are analyzed at a frequency of approximately one every 20 samples, depending on available sample volume, sufficient hold time and laboratory capacity. Replicates are prepared by analyzing a second aliquot of a sample and measuring the agreement between the two analyses as the

relative % difference (% RPD). Replicates provide an assessment of laboratory precision. Replicates were performed for all three parameters of interest using DELCORA samples.

Results are summarized in the table below. A % RPD target of 40% was specified in the QAPP for acceptance windows. Note that % RPD cannot be calculated under the following circumstances:

1. If the sample or replicate concentration exceeds the quantitation range (e.g. “>”)
2. If the sample or replicate concentration is less than the reporting limit (e.g. “<”)

Both of these situations occurred with each parameter, as shown in the table below. In addition, the sample id for one of the replicates for each parameter was inadvertently not recorded so it was not possible to compare its concentration to the first aliquot.

Table 5-4: Relative Percent Difference Summary

Parameter	Number of replicate samples analyzed	Number of replicate samples without calculable % RPD	Number of replicate samples with measurable % RPD	Number of replicate samples with acceptable % RPD
E. coli	13	6	7	7 (100%)
Enterococcus	12	7	5	3 (40%)
Fecal Coliform	10	7	3	1 (40%)

Overall, 73% of the replicates where a % RPD could be calculated were within the 40% window.

5.2.3 Completeness

Completeness is a measure of the amount of valid data obtained from the monitoring program compared to the amount of data that were expected. Events that may contribute to reduction in measurement completeness include sample container breakage, inaccessibility to desired sampling locations, automatic sampler failure, and laboratory equipment failures.

Field completeness is determined by the number of measurements collected versus the number of measurements planned for collection. As noted in the QAPP, The completeness criterion for all measurements and sample collection is 90 percent, but will be influenced by environmental situations that may alter monitoring schedules. These environmental situations were presented in Section 3 of this report for each event. Laboratory completeness is a measure of the amount of valid measurements obtained from all samples submitted for each sampling activity. The completeness criterion for all measurements is 95 percent.

All analyses were completed on the samples that were collected so the laboratory completeness measure is 100%. The overall field completeness was 87%. Field completeness was impacted by the sampling challenges described in Section 3, including weather-related safety issues and mechanical problems with the boat that resulted in several rounds of sampling that could not be conducted as planned. These issues only impacted the wet weather sampling in the Delaware River. When possible, samples were collected from the bank but access was limited to only two stations. For the tributaries, CSOs and stormwater

locations, the field completeness was 100%. Depending on the location in the Delaware River, the field completeness ranged from 67% to 78%. Overall, the completeness objective was successfully achieved as most of the problems affecting the ability to collect the planned samples in the Delaware River were unavoidable.

5.2.4 Representativeness

Representativeness is the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representative data of dry weather and wet weather conditions are required to support the evaluation and modeling efforts.

For sample collection, representativeness will be assured by following the Water Quality Monitoring and Modeling Work Plan (Greeley and Hansen / Limnotech, Revised July 2017) and applying proper collection techniques including the proper sample sizes and volumes, sampling times, and sampling locations. The volumes of the samples depend on the analytical methods and should allow for QC sample analysis and reanalysis, if required. In the laboratory, representativeness will be ensured by using the appropriate sample preparation techniques, by following appropriate analytical procedures, and by meeting the recommended sample holding times.

Representativeness was achieved in the Sampling Program by sampling three dry weather events under a range of flow conditions and during both the spring and summer season, and by sampling three wet weather events under a range of environmental conditions, with rainfall ranging from 0.5 inches to more than 1.5 inches. Figures 5-1 and 5-2 shows the sampling intervals in each of the waterways for the three dry weather and three wet weather events, respectively. There were no instances where samples lacked sufficient volume for analysis. In the laboratory, representativeness was generally good.

All samples were analyzed for all POCs using accepted methods. However, of the 459 samples collected in the Sampling Program, 61 had at least one parameter analyzed outside the specified hold time of 8 hours. Most of these samples were associated with the wet weather events, reflecting the logistical challenges associated with this type of sampling. A total of 91 analyses were conducted after the hold time had expired. However, 84 of these analyses were completed within 10 hours, so the hold time was missed by less than 2 hours for the vast majority of samples. These results have been qualified but minimal impact on the use of the data is anticipated due to the similarity in concentrations between results measured within and outside the analytical hold time. Much more uncertainty exists within the analytical methodology and field practices (e.g. obtaining a homogenous, representative sample, etc.).

Overall, the representativeness objectives of the QAPP was achieved through the selection of sampling events that collectively, capture the river and tributary characteristics over a range of environmental conditions.

Figure 5-1: Representativeness of Dry Weather Sampling Events and Sampling Intervals in Each Waterway

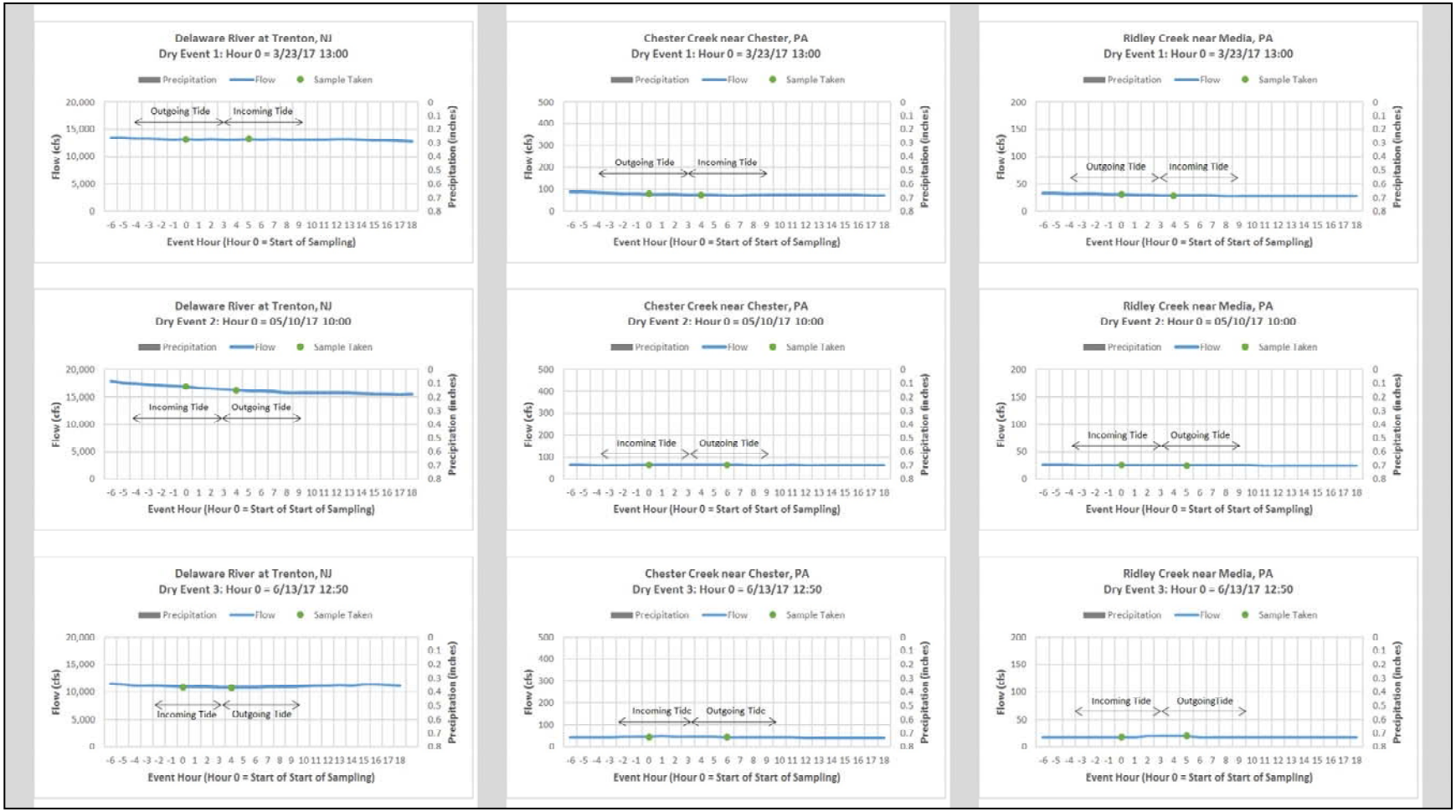
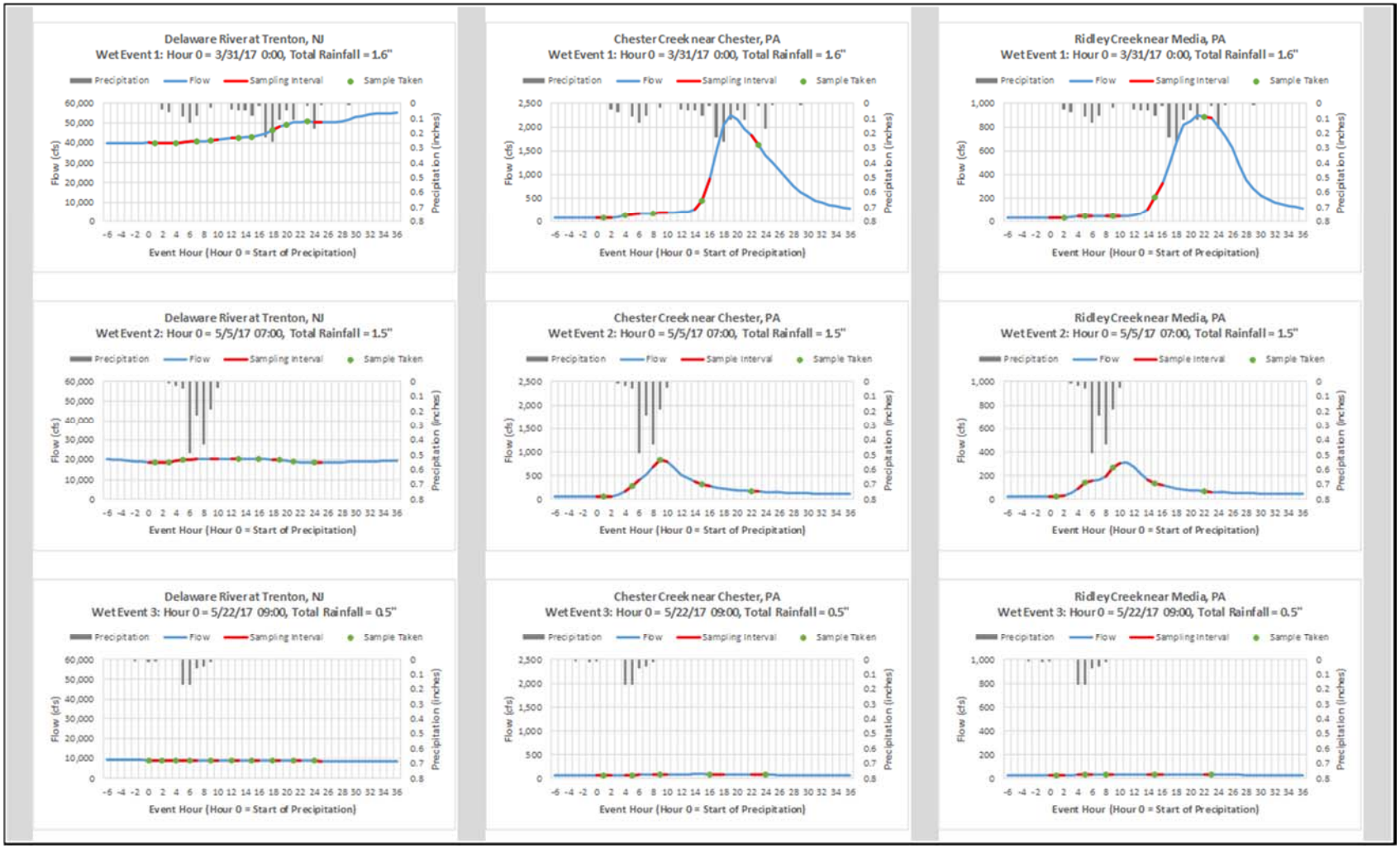


Figure 5-2: Representativeness of Wet Weather Sampling Events and Sampling Intervals in Each Waterway



5.2.5 Comparability

The objective for data comparability is to generate data for each parameter that related water quality conditions between sampling locations and over time. Data comparability will be promoted by:

1. Using standard U.S. EPA approved methods, where possible.
2. Consistently following the sampling methods detailed in the SAP.
3. Consistently following the analytical methods detailed in the QAPP.
4. Achieving the required detection limits detailed in the QAPP.

All sample collection and analytical methods will be specified, and any deviations from the methods will be documented. All results will be reported in the standard units as shown in QAPP. All field and laboratory calibrations will be performed using standards traceable to National Institute of Science and Technology (NIST) or other U.S. EPA approved sources.

The field crews and laboratory were consistent in collecting and analyzing the samples from the Sampling Program in a manner that allows the data to be compared between events. In the laboratory, the same EPA-approved analytical method was used for each parameter across all sampling events and samples were consistently analyzed at the dilutions specified in the QAPP and Work Plan. The Sampling Program successfully met this objective of the QAPP.

5.2.6 Required Detection Limits

All required detection limits were met in the Sampling Program.

Section 6 Water Quality Sampling Results Summary

This section presents additional analysis of the water quality sampling program results, particularly with respect to their use in the development and calibration of the water quality model.

6.1 Data Analysis

Section 4 presented an overview of the dry and wet weather datasets by individual event. The following observations were presented with respect to the data:

- Bacteria concentrations tended to be similar in all of the waterbodies during dry weather for both incoming and outgoing tidal conditions;
- Dry weather concentrations in the tributaries were mostly below numeric thresholds used for water quality standard criteria;
- Dry weather concentrations in the Delaware River tended to be well below numeric thresholds used for water quality standard criteria;
- An increase in POC concentration from upstream to downstream was observed in each of the tributaries, suggesting there may be significant bacteria sources impacting these tributaries during dry weather;
- Wet weather concentrations in all of the waterbodies tended to exceed numeric thresholds used for water quality standard criteria;
- Lateral POC gradients in the Delaware River were present but not at a significant level (e.g. orders of magnitude); and,
- The time series profiles in the Chester Creek and Ridley Creek waterbodies suggest that DELCORA's CSO discharges and Chester's stormwater discharges are not the only sources impacting these tributaries during wet weather. Upstream or other wet-weather sources also contribute to high bacteria concentrations during wet weather events.

In addition to the insights gleaned from the time series figures described in Section 4 and presented in Appendix H, this section presents data analyses that considered the results for the events more holistically than the individual event summaries presented in Section 4. Additional data analyses presented in this section include 1) an evaluation of the waterway response to the various environmental conditions during the sampled events and 2) an evaluation of whether a first flush could be discerned for any of the POCs in the source (e.g. CSO and stormwater) data.

6.1.1 Evaluation of Waterway Response to Environmental Conditions

Because multiple storm events were sampled, along with several dry weather events, a comparison of the response at each stream location across the sampling events may yield insight into how sensitive a given stream reach is to the amount and distribution of rainfall. This may be an important factor to consider in developing CSO control strategies. For example, a control strategy may target reductions of CSOs in non-tidal areas if those portions of the streams show a stronger response to rainfall than tidal areas.

Figure 6-1 presents box-and-whisker plots of the tributary sampling locations in Chester Creek and Ridley Creek. The figures are ordered such that the top figure is the most upstream sampling location and the bottom figure is the most downstream sampling location. The boxes in the figure correspond to the 25th and 75th percentiles of the data. The line in the center of the box is the median concentration. The end of the whiskers correspond to the minimum and maximum concentrations. The data for each wet and dry weather events were grouped separately into subsets for the purpose of the plot. Similar figures are presented in Appendix H for the other POCs and sampling locations.

The following insights can be gleaned from these figures:

- Dry weather concentrations of the analyzed bacteria are lower than each of the wet weather event concentrations;
- The stream response was most pronounced for the second wet weather event. This event was slightly less depth than the first wet weather event (1.47 inches vs. 1.5 inches) but the rainfall occurred over a shorter duration and with higher intensity in the second wet weather event, resulting in a stronger in-stream response.
- Downstream locations show more spread in the distribution of concentrations within each event as compared to the most upstream locations. This is likely the result of higher mixing with the Delaware River and the tidal influence on water quality at the more downstream locations.

Figure 6-2 presents box-and-whisker plots of three Delaware River locations: DR-01, which is the most upstream (e.g. least tidally impacted) station, DR-03, which is approximately midway along the reach of the river adjacent to the DELCORA service area, and DR-05, which is the most downstream station.

This figure shows some of the same characteristics as Figure 6-1 as well as some differences. Like the tributaries, the most downstream location shows the largest spread in concentrations, likely the result of higher mixing associated with the tidal influence on water quality at this station compared to the others located further upstream. Unlike the tributaries, which had the largest response to the second wet weather event, the Delaware River had the highest concentrations in the first wet weather event, though at DR-05, the peak concentration occurred during the second wet weather event. Another difference between the characteristics of the Delaware River and the tributaries' water quality is that the dry and wet weather concentrations in the Delaware River tended to be more similar than in the tributaries. Additional analysis and interpretation of the data will be conducted as part of the water quality model development and calibration process.

Figure 6-1: Comparison of Fecal Coliform Concentrations for the Sampling Events in Chester and Ridley Creeks

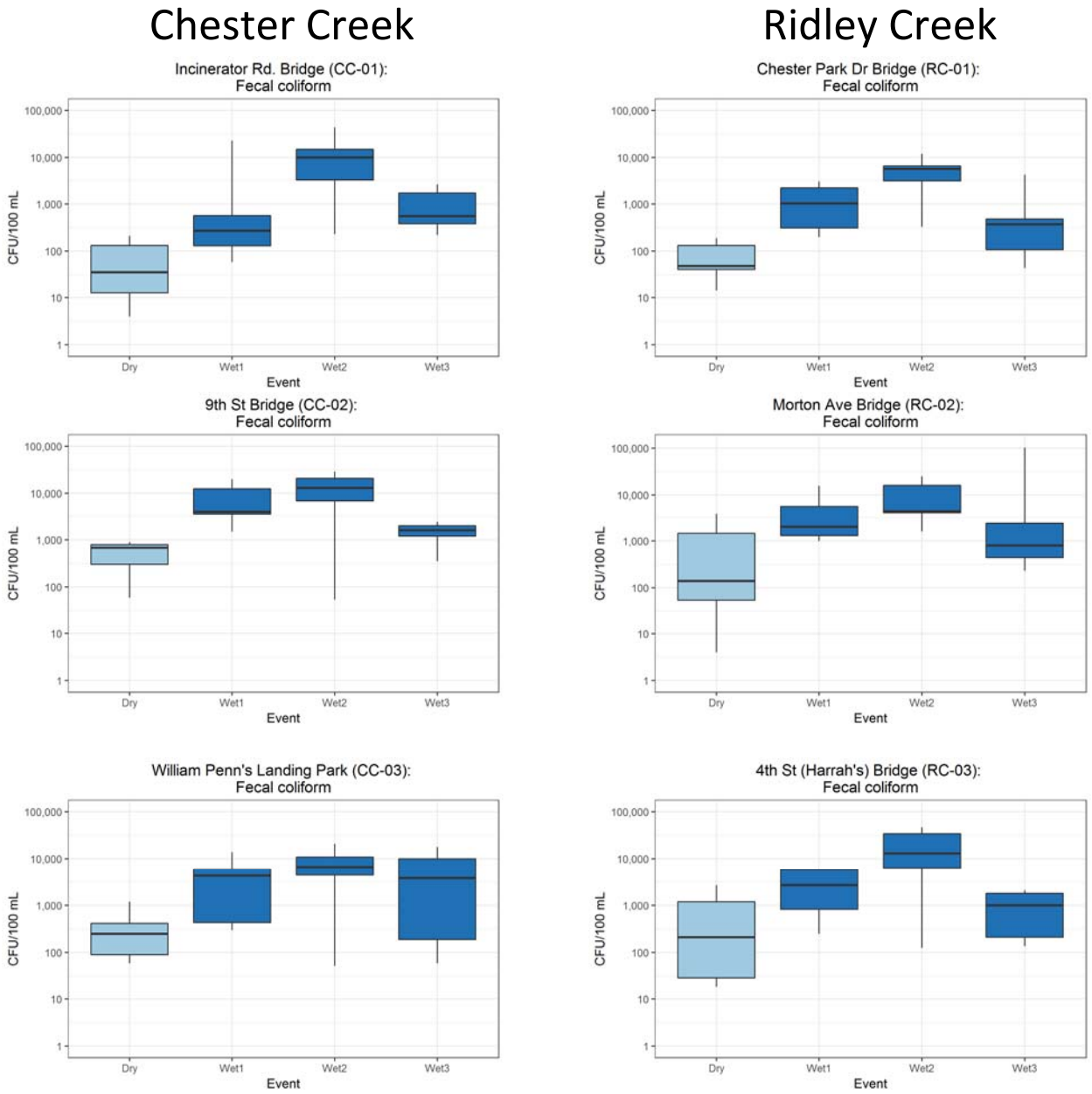
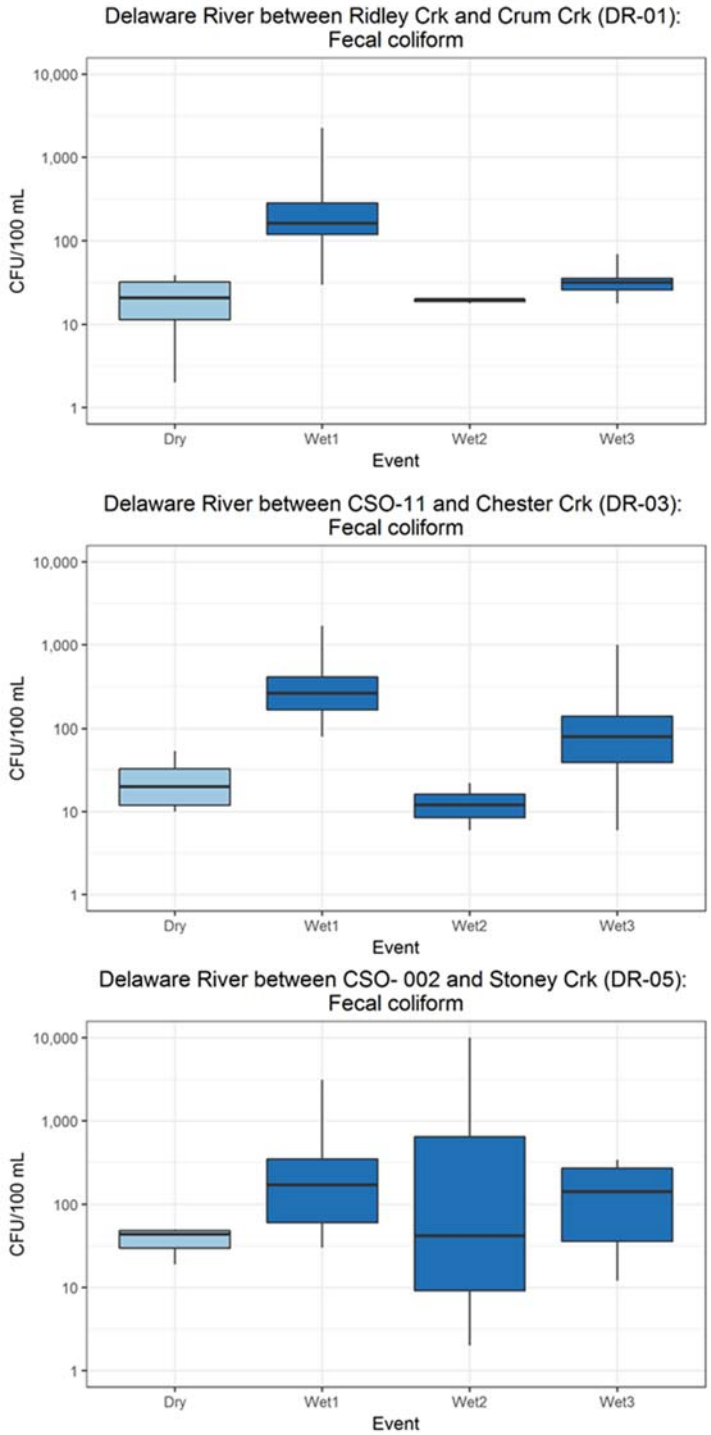


Figure 6-2: Comparison of Fecal Coliform Concentrations for the Sampling Events in the Delaware River



6.1.2 CSO and Stormwater First Flush Effect Analysis

A second analysis that was conducted across all of the event datasets was an evaluation of the CSO and stormwater data for first flush effects. A first flush effect means that pollutant concentrations that build up on the land surface between rainfall events are quickly washed off and flushed through the collection system, resulting in higher pollutant concentrations during the beginning of the discharge period compared to concentrations during the later portion of the discharge event.

Figure 6-3 presents a comparison of fecal coliform data in each of the CSOs for each of the wet weather events by sampling round. Note that the first three rounds are sampled within the first hour of discharge, with the fourth round representing the 2nd hour of discharge. If a first flush effect existed, concentrations during one or more of these rounds of sampling would be consistently higher than the later rounds. As this figure illustrates, there are combinations of events and rounds where the concentration is significantly higher than other events and/or other rounds, but no consistent pattern is discernible. Similar results were obtained for the other POCs (see Appendix H). Bacteria concentrations can be highly variable and it is typically very difficult to identify a consistent first flush for these parameters.

Figure 6-4 presents a similar analysis and result for the two stormwater outfalls for fecal coliform. Plots for the other POCs are presented in Appendix H.

This figure also shows a significant outlier data point during Wet 2 (1,500,000 cfu/100 ml) that is not believed to be representative of the quality of the stormwater runoff. The field notes, chain of custodies and laboratory analytical reports were inspected for potential explanation for the high value but none could be determined from the record set. This data point was not used in any statistical calculations or other data analyses.

6.1.3 CSO and Stormwater Event Mean Concentrations

Based on the first flush effect analysis presented in the previous section, the CSO and stormwater data were further analyzed to develop an initial estimate of representative concentration for each source type to calculate pollutant loads. These representative concentrations are referred to as event mean concentrations (EMCs) and represent the average water quality in the CSO and storm sewer systems.

Figure 6-3: CSO Fecal Coliform Concentrations by Sampling Round

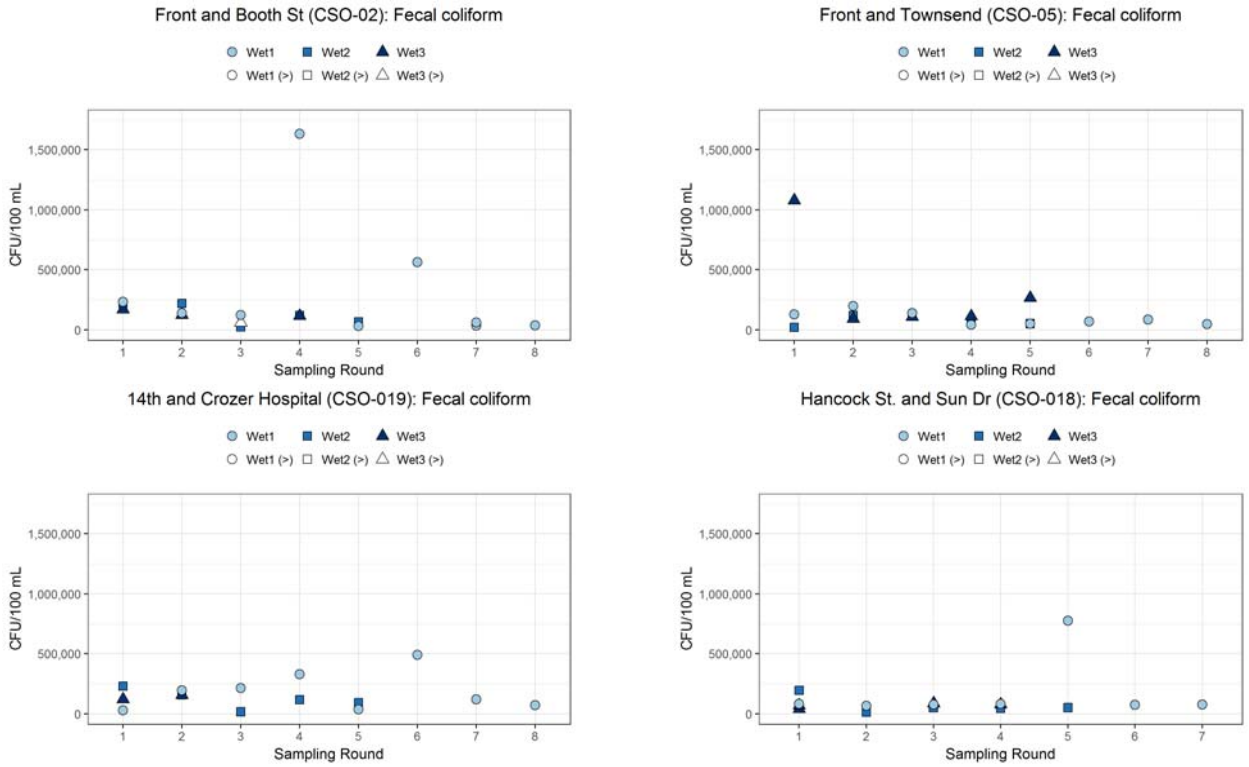
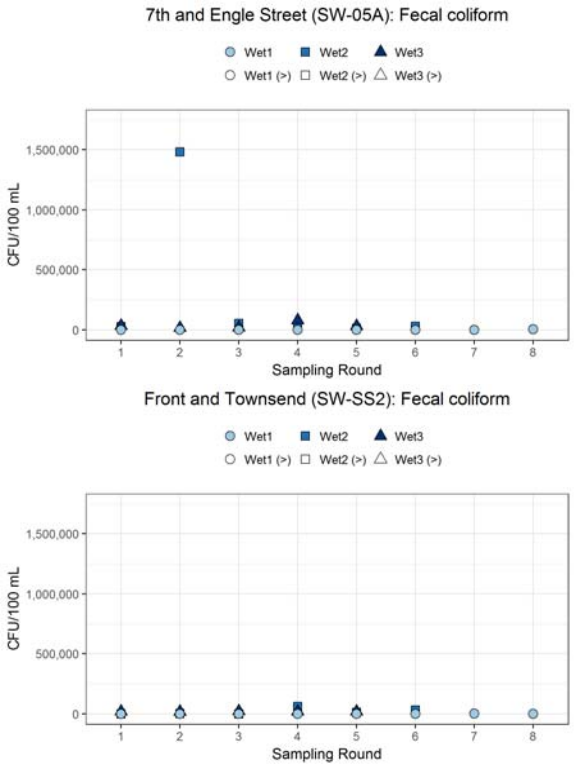


Figure 6-4: Stormwater Fecal Coliform Concentrations by Sampling Round



Flow-weighted EMCs were calculated for CSO-02, CSO-05, and CSO-019 using the metered flow data at the CSO diversion structure and the measured concentration data. Since CSO-018 was not metered, this method could not be applied for this CSO. A summary is presented in Table 6-1 for each event and POC.

Table 6-1: Flow-weighted CSO Event Mean Concentrations

	CSO-019	CSO-02	CSO-05
Fecal coliform			
Wet 1	175,264	160,758	75,948
Wet 2	97,421	95,158	72,093
Wet 3	125,183	124,408	126,934
Average	128,814	123,924	88,578
E. coli			
Wet 1	233,830	112,097	42,575
Wet 2	232,809	176,018	107,485
Wet 3	689,748	304,759	370,265
Average	334,860	181,845	119,216
Enterococcus			
Wet 1	167,891	110,237	52,790
Wet 2	149,515	141,616	119,217
Wet 3	254,176	305,311	142,677
Average	185,474	168,291	96,475

It should be noted that these calculations are a starting point for determining EMCs for use in the water quality model. The calculations shown in Table 1 present a challenge in that the E. coli values are higher than the fecal coliform values, which is not physically possible.

A statistical analysis was conducted on the CSO and stormwater data directly with results shown in Table 6-2. This analysis allows the data from locations without flow data, such as CSO-018 and the two stormwater locations, to be included for consideration. All of the data for a given location were evaluated together in developing the statistics presented in Table 6-2.

Table 6-2: Distribution of CSO and Stormwater Pollutant Concentrations

	Sample Count	Geomean	25th Percentile	75th Percentile
Fecal coliform				
CSO-02	18	116,611	60,750	205,250
CSO-05	18	99,861	56,750	126,750
CSO-018	17	74,335	53,000	85,000
CSO-019	15	116,754	83,773	206,000
SW-05A	19	5,522	883	31,000
SW-SS2	19	3,693	913	21,000
E. coli				
CSO-02	18	158,546	60,500	345,500
CSO-05	18	144,369	66,000	231,250
CSO-018	17	95,812	63,000	104,000
CSO-019	15	189,860	100,000	286,000
SW-05A	19	3,843	1,180	16,500
SW-SS2	19	2,407	625	18,000
Enterococcus				
CSO-02	18	123,582	73,250	288,750
CSO-05	18	90,052	61,250	180,000
CSO-018	17	48,669	29,000	83,000
CSO-019	15	131,911	56,500	197,000
SW-05A	19	25,118	5,700	112,000
SW-SS2	19	40,217	19,250	119,250

Results in this table for each location are slightly lower than the results using the flow-weighted method average results presented in Table 6-1. The results also show that the CSO E. coli values are higher than the CSO fecal coliform values, which is not physically possible since E. coli is a subset of fecal coliform. The 25th and 75th percentile values will be used as a basis for adjusting the EMC value used in estimating the loads from each source type. Additional analysis and interpretation of the data will be conducted as part of the water quality model development and calibration process.

6.2 Conclusion

The DELCORA Sampling Program was designed to fill data gaps necessary to characterize sources and surface waters during dry and wet weather events to support the development of water quality models for use in the development of the CSO Long Term Control Plan Update. It provides the first co-located, coordinated sampling of Chester Creek, Ridley Creek and the Delaware River for the three bacteria parameters most often used to protect recreational water quality and identified as Pollutants of Concern. This was also the first Sampling Program to capture both dry and wet weather in-stream conditions, conduct time-intensive wet weather sampling, and concurrently characterize CSO and stormwater

sources. The data are sufficient to characterize DELCORA's CSO and stormwater source loads for the water quality model. The data also span a range of environmental conditions and provide an extensive dataset for demonstrating the robustness of the water quality model. The Sampling Program fully achieved the objectives of collecting comprehensive and complete datasets needed to characterize pollutant sources, produce an appropriately calibrated watershed and water quality model, and successfully meet the quality objectives of the QAPP. No further data collection is required at this time to develop or calibrate the models for use in the development of DELCORA's Long Term Control Plan Update.

Section 7 References

Greeley and Hansen / Limnotech. (Revised July 2017). *Water Quality Monitoring and Modeling Quality Assurance Project Plan.* Originally submitted January 2017, Revised March 2017: Report prepared for Delaware County Regional Water Quality Control Authority (DELCORA).

Greeley and Hansen / Limnotech. (Revised July 2017). *Water Quality Monitoring and Modeling Work Plan.* Report prepared for Delaware County Regional Water Quality Control Authority (DELCORA).

Greeley and Hansen. (2016c). *Identification of Sensitive Areas and Pollutants of Concern Report.* Report prepared for Delaware County Regional Water Quality Control Authority (DELCORA). This report was approved by USEPA and PADEP on October 13, 2016. See approval letters in this section.

USEPA. (1999). *Combined Sewer Overflows: Guidance for Monitoring and Modeling.* Washington, DC: United States Environmental Protection Agency.

Weston Solutions, Inc. (March 2017). *Sampling Analysis Plan.* Prepared for Greeley and Hansen for submittal to Delaware County Regional Water Quality Control Authority (DELCORA).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Mr. Robert Willert, Executive Director
Delaware County Regional Quality Control Authority
100 East Fifth Street
Chester, PA 19013

OCT 13 2016

RE: Civil Action 2:15-cv-04652-RB

Dear Mr. Willert:

The United States Environmental Protection Agency (EPA) has received the Delaware County Regional Quality Control Authority (DELCORA) Revised Identification of Sensitive Area Analysis (RISAA) dated May 13, 2016. EPA has consulted with the Pennsylvania Department of the Environment (PaDEP). EPA hereby approves the RISAA.

Sincerely,

Andrew F. Seligman, Environmental Scientist
Water Enforcement Branch

cc: R. Smolski, EPA
P. Yeany, EPA
M. DeSantis, DELCORA

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Section 8 Abbreviations

CSO:	Combined Sewer Overflow
CSS:	Combined Sewer System
CWA:	Clean Water Act
DELCORA:	Delaware County Municipal Utilities Authority
DEP:	Pennsylvania Department of Environmental Protection
DRBC:	Delaware River Basin Commission
e-DMR:	electronic Discharge Monitoring Report
EMC:	Event Mean Concentration
GIS:	Geographic Information System
H&H:	Hydrologic and Hydraulic
KCPS:	Kimberly Clark Pump Station
LTCP:	Long Term Control Plan
LTCPU:	Long-Term Control Plan Update
MDL:	Method Detection Limit
MGD:	Million Gallons per Day
NPDES	National Pollutant Discharge Elimination System
NRCS:	Natural Resources Conservation Service
PA Integrated Report:	PA Integrated Water Quality Monitoring and Assessment Report
PADEP:	Pennsylvania Department of Environmental Protection
POC:	Pollutant of Concern
PSWPCP:	Philadelphia Water Department's Southwest Water Pollution Control Plant
QA/QC:	Quality Assurance/Quality Control
QAPP:	Quality Assurance Project Plan
R.M.:	River Mile
RHM:	Radnor Haverford Marple Authority
STORET:	Storage and Retrieval for Water Quality Data
TMDL:	Total Maximum Daily Load
UH:	Unit Hydrograph
USEPA or EPA:	United States Environmental Protection Agency
WQMP:	Water Quality Monitoring Program
WQR:	Water Quality Regulations
WQS:	Water Quality Standards
WRTP:	Western Regional Treatment Plant
WWF:	Warm Water Fishes
EMC:	Event Mean Concentration

APPENDIX A

DRY WEATHER EVENT 1 – FIELD LOGS AND LAB RESULTS SUMMARY

(Chain of Custody Forms and Complete Lab Results provided in digital form only on CD attached to this report)

DRY WEATHER EVENT: 1

DATE: 3/23/2017 — **Note Temperature of Receiving Stream if below 10 °C threshhold**

EVENT START TIME: 12:55

Sampling Station	Sampling Round	Estimated Target Sample Collection (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? [1] (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? [1] (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab (hh:mm)	Water Salinity Reading (%)	Water Temperature Reading (°C)	Conductivity Reading (umhos/cm)	Field Observations[2] (see notes, below)
CC-01	Incoming tide	19:30	19:34	N	-	N	-	Y	19:55	0.55	6.52	718	Dusk, clear, little debris, foam
	Outgoing tide	15:05	15:09	Y	15:10	N	-	Y	15:30	0.55	5.87	698	Sunny & clear, no debris, little foam
CC-02	Incoming tide	19:10	19:12	N	-	N	-	Y	19:55	0.55	5.37	695	Dusk, clear, no debris, little foam
	Outgoing tide	14:45	14:48	N	-	N	-	Y	15:30	0.55	5.77	698	Sunny & clear, no debris, no foam, tree branches, bark
CC-03	Incoming tide	17:45	17:44	N	-	N	-	Y	19:55	0.55	5.82	701	Sunny & clear, no debris, no foam, some scum
	Outgoing tide	13:00	13:00	N	-	Y	13:03	Y	15:30	0.55	3.36	659	Sunny & clear, mild debris, clear water, no turbidity
RC-01	Incoming tide	18:40	18:47	N	-	N	-	Y	19:55	0.41	5.66	523	Dusk, clear, no debris, foam
	Outgoing tide	14:22	14:25	N	-	N	-	Y	15:30	0.39	5.72	503	Sunny & clear, no debris, little foam, (non-tidal)
RC-02	Incoming tide	18:15	18:20	N	-	N	-	Y	19:55	0.4	6.54	532	Dusk, clear, no debris, little foam
	Outgoing tide	13:55	14:00	N	-	N	-	Y	15:30	0.41	5.34	518	Flushing hydrant, sunny clear, very mild foam
RC-03	Incoming tide	17:55	18:00	Y	18:00	N	-	Y	19:55	0.41	6.60	536	Sunny & clear, no debris, clear water
	Outgoing tide	13:30	13:35	N	-	Y	13:35	Y	15:30	0.41	3.26	496	Sunny & clear, no debris, clear water
DR-01	Incoming tide	17:30	17:25	N	-	N	-	Y	19:55	0.28/ 0.29/ 0.29	5.49/ 5.32/ 5.38	362/ 373/ 376	Total depth = 20.6 ft.
	Outgoing tide	12:55	12:55	N	-	Y	12:55	Y	15:30	0.26/ 0.27/ 0.28	5.50/ 5.40/ 5.30	345/ 349/ 357	Total depth = 25.0 ft.
DR-02	Incoming tide	17:45	17:45	N	-	N	-	Y	19:55	0.28/ 0.29/ 0.29	5.48/ 5.54/ 5.56	366/ 372/ 374	Total depth = 33.0 ft.
	Outgoing tide	13:15	13:30	Y	13:30	N	-	Y	15:30	0.27/ 0.27/ 0.27	5.5/ 5.4/ 5.4	345/ 346/ 349	Total depth = 35.0 ft.
DR-03	Incoming tide	18:00	18:00	N	-	N	-	Y	19:55	0.29/ 0.29/ 0.29	5.58/ 5.59/ 5.59	375/ 374/ 374	Total depth = 33 ft.
	Outgoing tide	13:30	13:55	N	-	N	-	Y	15:30	0.26/ 0.27/ 0.27	5.5/ 5.5/ 5.5	342/ 350/ 349	Total depth = 34 ft.
DR-04	Incoming tide	18:15	18:15	N	-	N	-	Y	19:55	0.29/ 0.28/ 0.28	6.22/ 6.21/ 6.22	363/ 364/ 365	Total depth = 25.0 ft.
	Outgoing tide	13:50	14:10	N	-	N	-	Y	15:30	0.27/ 0.28/ 0.28	5.6/ 5.6/ 5.6	357/ 358/ 359	Total depth = 19.4 ft.
DR-05	Incoming tide	18:30	18:30	N	-	N	-	Y	19:55	0.28/ 0.28/ 0.28	6.22/ 6.21/ 6.22	363/ 364/ 365	Total depth = 7.0 ft.
	Outgoing tide	14:15	14:30	N	-	N	-	Y	15:30	0.42/ 0.42/ 0.40	9.5/ 9.6/ 9.2	603/ 600/ 571	Total depth = 4.8 ft.

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6724475-1	RC-01-1	03/23/17 02:30pm	E. COLI-MF (1603)	EPA 1603	<10	03/23/17 06:26PM	BHS
L6724475-1	RC-01-1	03/23/17 02:30pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/23/17 06:33PM	BHS
L6724475-1	RC-01-1	03/23/17 02:30pm	FECAL COLIFORM-MF	SM 9222D	40 E	03/23/17 06:43PM	BHS
L6724476-1	CL-02-8	03/23/17 01:00pm	E. COLI-MF (1603)	EPA 1603	<10	03/23/17 06:26PM	BHS
L6724476-1	CL-02-8	03/23/17 01:00pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/23/17 06:33PM	BHS
L6724476-1	CL-02-8	03/23/17 01:00pm	FECAL COLIFORM-MF	SM 9222D	<10	03/23/17 06:43PM	BHS
L6729205-1	DR-05-1	03/23/17 02:30pm	E. COLI-MF (1603)	EPA 1603	30 E	03/23/17 06:26PM	BHS
L6729205-1	DR-05-1	03/23/17 02:30pm	ENTEROCOCCUS-MF 24	EPA 1600	320	03/23/17 06:33PM	BHS
L6729205-1	DR-05-1	03/23/17 02:30pm	FECAL COLIFORM-MF	SM 9222D	50 E	03/23/17 06:43PM	BHS
L6729206-1	DUP DR-02-2	03/23/17 01:30pm	E. COLI-MF (1603)	EPA 1603	10 E	03/23/17 06:26PM	BHS
L6729206-1	DUP DR-02-2	03/23/17 01:30pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/23/17 06:33PM	BHS
L6729206-1	DUP DR-02-2	03/23/17 01:30pm	FECAL COLIFORM-MF	SM 9222D	50 E	03/23/17 06:43PM	BHS
L6729207-1	DR-01-1	03/23/17 01:00pm	E. COLI-MF (1603)	EPA 1603	10 E	03/23/17 06:26PM	BHS
L6729207-1	DR-01-1	03/23/17 01:00pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/23/17 06:33PM	BHS
L6729207-1	DR-01-1	03/23/17 01:00pm	FECAL COLIFORM-MF	SM 9222D	10 E	03/23/17 06:43PM	BHS
L6729208-1	DR-02-1	03/23/17 01:30pm	E. COLI-MF (1603)	EPA 1603	<10	03/23/17 06:26PM	BHS
L6729208-1	DR-02-1	03/23/17 01:30pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/23/17 06:33PM	BHS
L6729208-1	DR-02-1	03/23/17 01:30pm	FECAL COLIFORM-MF	SM 9222D	40 E	03/23/17 06:43PM	BHS
L6729209-1	DR-03-01	03/23/17 01:55pm	E. COLI-MF (1603)	EPA 1603	<10	03/23/17 06:26PM	BHS
L6729209-1	DR-03-01	03/23/17 01:55pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/23/17 06:33PM	BHS
L6729209-1	DR-03-01	03/23/17 01:55pm	FECAL COLIFORM-MF	SM 9222D	10 E	03/23/17 06:43PM	BHS
L6729210-1	DR-04-1	03/23/17 02:10pm	E. COLI-MF (1603)	EPA 1603	<10	03/23/17 06:26PM	BHS
L6729210-1	DR-04-1	03/23/17 02:10pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/23/17 06:33PM	BHS
L6729210-1	DR-04-1	03/23/17 02:10pm	FECAL COLIFORM-MF	SM 9222D	20 E	03/23/17 06:43PM	BHS
L6729211-1	BLANK	03/23/17 12:55pm	E. COLI-MF (1603)	EPA 1603	<2	03/23/17 06:26PM	BHS
L6729211-1	BLANK	03/23/17 12:55pm	ENTEROCOCCUS-MF 24	EPA 1600	<2	03/23/17 06:33PM	BHS
L6729211-1	BLANK	03/23/17 12:55pm	FECAL COLIFORM-MF	SM 9222D	<2	03/23/17 06:43PM	BHS
L6729212-1	DUP CC-01-D	03/23/17 03:00pm	E. COLI-MF (1603)	EPA 1603	<10	03/23/17 06:26PM	BHS
L6729212-1	DUP CC-01-D	03/23/17 03:00pm	ENTEROCOCCUS-MF 24	EPA 1600	40 E	03/23/17 06:33PM	BHS
L6729212-1	DUP CC-01-D	03/23/17 03:00pm	FECAL COLIFORM-MF	SM 9222D	<10	03/23/17 06:43PM	BHS
L6729213-1	CC-01-1	03/23/17 03:00pm	E. COLI-MF (1603)	EPA 1603	10 E	03/23/17 06:26PM	BHS
L6729213-1	CC-01-1	03/23/17 03:00pm	ENTEROCOCCUS-MF 24	EPA 1600	60 E	03/23/17 06:33PM	BHS
L6729213-1	CC-01-1	03/23/17 03:00pm	FECAL COLIFORM-MF	SM 9222D	<10	03/23/17 06:43PM	BHS
L6729214-1	CC-02-1	03/23/17 02:45pm	E. COLI-MF (1603)	EPA 1603	120 E	03/23/17 06:26PM	BHS
L6729214-1	CC-02-1	03/23/17 02:45pm	ENTEROCOCCUS-MF 24	EPA 1600	70 E	03/23/17 06:33PM	BHS
L6729214-1	CC-02-1	03/23/17 02:45pm	FECAL COLIFORM-MF	SM 9222D	610 E	03/23/17 06:43PM	BHS
L6729215-1	CC-03-1	03/23/17 01:00pm	E. COLI-MF (1603)	EPA 1603	50 E	03/23/17 06:26PM	BHS
L6729215-1	CC-03-1	03/23/17 01:00pm	ENTEROCOCCUS-MF 24	EPA 1600	20 E	03/23/17 06:33PM	BHS
L6729215-1	CC-03-1	03/23/17 01:00pm	FECAL COLIFORM-MF	SM 9222D	450	03/23/17 06:43PM	BHS
L6729216-1	RC-03-B	03/23/17 01:30pm	E. COLI-MF (1603)	EPA 1603	<10	03/23/17 06:26PM	BHS
L6729216-1	RC-03-B	03/23/17 01:30pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/23/17 06:33PM	BHS
L6729216-1	RC-03-B	03/23/17 01:30pm	FECAL COLIFORM-MF	SM 9222D	<10	03/23/17 06:43PM	BHS

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6729217-1	RC-03-1	03/23/17 01:30pm	E. COLI-MF (1603)	EPA 1603	40 E	03/23/17 06:26PM	BHS
L6729217-1	RC-03-1	03/23/17 01:30pm	ENTEROCOCCUS-MF 24	EPA 1600	10 E	03/23/17 06:33PM	BHS
L6729217-1	RC-03-1	03/23/17 01:30pm	FECAL COLIFORM-MF	SM 9222D	20 E	03/23/17 06:43PM	BHS
L6729218-1	RC-02-1	03/23/17 02:00pm	E. COLI-MF (1603)	EPA 1603	<10	03/23/17 06:26PM	BHS
L6729218-1	RC-02-1	03/23/17 02:00pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/23/17 06:33PM	BHS
L6729218-1	RC-02-1	03/23/17 02:00pm	FECAL COLIFORM-MF	SM 9222D	40 E	03/23/17 06:43PM	BHS
L6729227-1	DR-05-2	03/23/17 06:30pm	ENTEROCOCCUS-MF 24	EPA 1600	10 E	03/23/17 10:04PM	BHS
L6729227-1	DR-05-2	03/23/17 06:30pm	E. COLI-MF (1603)	EPA 1603	18 E	03/23/17 09:57PM	BHS
L6729227-1	DR-05-2	03/23/17 06:30pm	FECAL COLIFORM-MF	SM 9222D	48	03/23/17 10:09PM	BHS
L6729227-2	DR-04-2	03/23/17 06:15pm	ENTEROCOCCUS-MF 24	EPA 1600	<2	03/23/17 10:04PM	BHS
L6729227-2	DR-04-2	03/23/17 06:15pm	E. COLI-MF (1603)	EPA 1603	6 E	03/23/17 09:57PM	BHS
L6729227-2	DR-04-2	03/23/17 06:15pm	FECAL COLIFORM-MF	SM 9222D	18 E	03/23/17 10:09PM	BHS
L6729227-3	DR-03-2	03/23/17 06:00pm	ENTEROCOCCUS-MF 24	EPA 1600	<2	03/23/17 10:04PM	BHS
L6729227-3	DR-03-2	03/23/17 06:00pm	E. COLI-MF (1603)	EPA 1603	16 E	03/23/17 09:57PM	BHS
L6729227-3	DR-03-2	03/23/17 06:00pm	FECAL COLIFORM-MF	SM 9222D	10 E	03/23/17 10:09PM	BHS
L6729227-4	DR-01-2	03/23/17 05:25pm	ENTEROCOCCUS-MF 24	EPA 1600	<2	03/23/17 10:04PM	BHS
L6729227-4	DR-01-2	03/23/17 05:25pm	E. COLI-MF (1603)	EPA 1603	2 E	03/23/17 09:57PM	BHS
L6729227-4	DR-01-2	03/23/17 05:25pm	FECAL COLIFORM-MF	SM 9222D	2 E	03/23/17 10:09PM	BHS
L6729227-5	DR-02-2	03/23/17 05:45pm	ENTEROCOCCUS-MF 24	EPA 1600	<2	03/23/17 10:04PM	BHS
L6729227-5	DR-02-2	03/23/17 05:45pm	E. COLI-MF (1603)	EPA 1603	4 E	03/23/17 09:57PM	BHS
L6729227-5	DR-02-2	03/23/17 05:45pm	FECAL COLIFORM-MF	SM 9222D	8 E	03/23/17 10:09PM	BHS
L6729227-6	CC-03-2	03/23/17 05:40pm	ENTEROCOCCUS-MF 24	EPA 1600	42	03/23/17 10:04PM	BHS
L6729227-6	CC-03-2	03/23/17 05:40pm	E. COLI-MF (1603)	EPA 1603	48	03/23/17 09:57PM	BHS
L6729227-6	CC-03-2	03/23/17 05:40pm	FECAL COLIFORM-MF	SM 9222D	60 E	03/23/17 10:09PM	BHS
L6729227-7	CC-01-2	03/23/17 07:10pm	ENTEROCOCCUS-MF 24	EPA 1600	8 E	03/23/17 10:04PM	BHS
L6729227-7	CC-01-2	03/23/17 07:10pm	E. COLI-MF (1603)	EPA 1603	14 E	03/23/17 09:57PM	BHS
L6729227-7	CC-01-2	03/23/17 07:10pm	FECAL COLIFORM-MF	SM 9222D	4 E	03/23/17 10:09PM	BHS
L6729227-8	RC-03-2	03/23/17 06:10pm	ENTEROCOCCUS-MF 24	EPA 1600	6 E	03/23/17 10:04PM	BHS
L6729227-8	RC-03-2	03/23/17 06:10pm	E. COLI-MF (1603)	EPA 1603	6 E	03/23/17 09:57PM	BHS
L6729227-8	RC-03-2	03/23/17 06:10pm	FECAL COLIFORM-MF	SM 9222D	18 E	03/23/17 10:09PM	BHS
L6729227-9	CC-02-2	03/23/17 07:30pm	ENTEROCOCCUS-MF 24	EPA 1600	56	03/23/17 10:04PM	BHS
L6729227-9	CC-02-2	03/23/17 07:30pm	E. COLI-MF (1603)	EPA 1603	126	03/23/17 09:57PM	BHS
L6729227-9	CC-02-2	03/23/17 07:30pm	FECAL COLIFORM-MF	SM 9222D	750 E	03/23/17 10:09PM	BHS
L6729227-10	RC-01-2	03/23/17 06:45pm	ENTEROCOCCUS-MF 24	EPA 1600	16 E	03/23/17 10:04PM	BHS
L6729227-10	RC-01-2	03/23/17 06:45pm	E. COLI-MF (1603)	EPA 1603	2 E	03/23/17 09:57PM	BHS
L6729227-10	RC-01-2	03/23/17 06:45pm	FECAL COLIFORM-MF	SM 9222D	14 E	03/23/17 10:09PM	BHS
L6729227-11	RC-02-2	03/23/17 06:20pm	ENTEROCOCCUS-MF 24	EPA 1600	8 E	03/23/17 10:04PM	BHS
L6729227-11	RC-02-2	03/23/17 06:20pm	E. COLI-MF (1603)	EPA 1603	10 E	03/23/17 09:57PM	BHS
L6729227-11	RC-02-2	03/23/17 06:20pm	FECAL COLIFORM-MF	SM 9222D	4 E	03/23/17 10:09PM	BHS
L6729227-12	DUP RC-02-2-X	03/23/17 06:00pm	ENTEROCOCCUS-MF 24	EPA 1600	14 E	03/23/17 10:04PM	BHS
L6729227-12	DUP RC-02-2-X	03/23/17 06:00pm	E. COLI-MF (1603)	EPA 1603	16 E	03/23/17 09:57PM	BHS
L6729227-12	DUP RC-02-2-X	03/23/17 06:00pm	FECAL COLIFORM-MF	SM 9222D	16 E	03/23/17 10:09PM	BHS

APPENDIX B

DRY WEATHER EVENT 2 – FIELD LOGS AND LAB RESULTS SUMMARY

(Chain of Custody Forms and Complete Lab Results provided in digital form only on CD attached to this report)

DRY WEATHER EVENT: 2

DATE: 5/10/2017 **Note Temperature of Receiving Stream if below 10 °C threshhold**

EVENT START TIME: 10:00

Sampling Station	Sampling Round	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? [1] (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? [1] (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Water Salinity Reading (%)	Water Temperature Reading (°C)	Conductivity Reading (umhos/cm)	Field Observations[2] (see notes, below)
CC-01	Incoming tide	11:00	11:46	N	N/A	N	N/A	Y	12:07	0.02	11.33	0.330	Clear sky, 61 °F, water very clear, no debris
	Outgoing tide	17:00	17:07	N	N/A	N	N/A	Y	18:00	0.33	12.54	0.511	Clear sky 71 °F, water clear, no debris
CC-02	Incoming tide	12:00	12:07	N	N/A	N	N/A	Y	12:07	0.23	13.86	0.378	Clear sky 61 °F, water mostly clear, minimal debris
	Outgoing tide	17:25	17:30	Y	17:31	N	N/A	Y	18:00	0.30	11.69	0.464	Clear sky 71 °F, water little cloudy, no debris
CC-03	Incoming tide	10:00	10:16	N	N/A	Y	10:09	Y	12:07	0.32	10.56	0.467	Clear sky, 59 °F, water mostly clear, no debris
	Outgoing tide	15:40	15:44	N	N/A	N	N/A	Y	18:00	0.21	14.44	0.339	Clear sky 71 °F, water mostly clear, minimal debris
RC-01	Incoming tide	11:20	11:26	N	N/A	N	N/A	Y	12:07	0.34	16.73	0.590	Clear sky 60 °F, water very clear, small amount of foam
	Outgoing tide	16:40	16:45	N	N/A	N	N/A	Y	18:00	0.35	16.47	0.590	Clear sky 70 °F, water clear, some foam
RC-02	Incoming tide	11:00	11:02	Y	11:02	N	N/A	Y	12:07	0.26	16.00	0.439	Clear sky 60 °F, water clear, small amount of floating debris
	Outgoing tide	16:20	16:21	N	N/A	N	N/A	Y	18:00	0.25	16.69	0.440	Clear sky 70 °F, water clear, some floating debris
RC-03	Incoming tide	10:30	10:43	N	N/A	N	N/A	Y	12:07	0.27	16.49	0.458	Clear sky 59 °F, water mostly clear, no debris
	Outgoing tide	16:00	16:04	N	N/A	N	N/A	Y	18:00	0.22	15.93	0.378	Clear sky 71 °F, water clear, no debris
DR-01	Incoming tide	10:25	10:25	N	N/A	N	N/A	Y	12:42	0.15 /0.15/ 0.15	16.70 / 16.67/ 16.68	269/ 286/ 267	Total depth = 28 ft ; calm water
	Outgoing tide	15:30	15:30	N	N/A	N	N/A	Y	18:00	0.23/ 0.22/ 0.22	14.55/ 14.38/ 14.37	374/ 368/ 362	Total depth = 28 ft ; calm water
DR-02	Incoming tide	10:50	10:50	N	N/A	N	N/A	Y	12:42	0.16/ 0.16/ 0.16	16.78/ 16.72/ 16.71	280/ 280/ 277	Total Depth = 25 ft; calm water
	Outgoing tide	15:40	15:40	N	N/A	N	N/A	Y	18:00	0.23/ 0.22/ 0.22	14.43/ 14.42/ 14.42	371/ 370/ 366	Total Depth = 28 ft; calm water
DR-03	Incoming tide	11:15	11:15	N	N/A	N	N/A	Y	12:42	0.16/ 01.6/ 0.16	16.91/ 16.88/ 16.88	285/ 285/ 285	Total Depth = 17 ft; calm water
	Outgoing tide	15:50	15:50	N	N/A	N	N/A	Y	18:00	0.22/ 0.22/ 0.22	14.39/ 14.38/ 14.39	369/ 368/ 364	Total Depth = 19 ft; calm water
DR-04	Incoming tide	12:00	12:00	Y	12:05	N	N/A	Y	12:42	0.16/ 0.16/ 0.16	17.03/ 16.94/ 16.95	289/ 286/ 286	Total Depth = 12 ft; calm water
	Outgoing tide	16:00	16:00	N	N/A	N	N/A	Y	18:00	0.23/ 0.23/ 0.23	14.53/ 14.53/ 14.53	380/ 380/ 378	Total Depth = 9 ft; calm water
DR-05	Incoming tide	12:20	12:20	N	N/A	Y	12:25	Y	12:42	0.16/ 0.16/ 0.16	17.34/ 17.24/ 17.25	287/ 286/ 286	Total Depth = 6 ft; calm water
	Outgoing tide	16:10	16:10	N	N/A	N	N/A	Y	18:00	0.23/ 0.22/ 0.22	14.51/ 14.48/ 14.48	372/ 370/ 368	Total Depth = 7 ft; calm water

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6778952-1	CC-03-1	05/10/17 10:16am	FECAL COLIFORM-MF	SM 9222D	70 E	05/10/17 03:04PM	DYS
L6778952-1	CC-03-1	05/10/17 10:16am	ENTEROCOCCUS-MF 24	EPA 1600	35	05/10/17 03:09PM	SYM
L6778952-1	CC-03-1	05/10/17 10:16am	E. COLI-MF (1603)	EPA 1603	96 E	05/10/17 03:19PM	BHS
L6778952-2	RC-03-1	05/10/17 10:43am	FECAL COLIFORM-MF	SM 9222D	90 E	05/10/17 03:04PM	DYS
L6778952-2	RC-03-1	05/10/17 10:43am	ENTEROCOCCUS-MF 24	EPA 1600	17	05/10/17 03:09PM	SYM
L6778952-2	RC-03-1	05/10/17 10:43am	E. COLI-MF (1603)	EPA 1603	210	05/10/17 03:19PM	BHS
L6778952-3	RC-02-1	05/10/17 11:02am	FECAL COLIFORM-MF	SM 9222D	140 E	05/10/17 03:04PM	DYS
L6778952-3	RC-02-1	05/10/17 11:02am	ENTEROCOCCUS-MF 24	EPA 1600	110 E	05/10/17 03:09PM	SYM
L6778952-3	RC-02-1	05/10/17 11:02am	E. COLI-MF (1603)	EPA 1603	120 E	05/10/17 03:19PM	BHS
L6778952-4	RC-01-1	05/10/17 11:26am	FECAL COLIFORM-MF	SM 9222D	53	05/10/17 03:04PM	DYS
L6778952-4	RC-01-1	05/10/17 11:26am	ENTEROCOCCUS-MF 24	EPA 1600	43	05/10/17 03:09PM	SYM
L6778952-4	RC-01-1	05/10/17 11:26am	E. COLI-MF (1603)	EPA 1603	52	05/10/17 03:19PM	BHS
L6778952-5	CC-01-1	05/10/17 11:47am	FECAL COLIFORM-MF	SM 9222D	52	05/10/17 03:04PM	DYS
L6778952-5	CC-01-1	05/10/17 11:47am	ENTEROCOCCUS-MF 24	EPA 1600	59	05/10/17 03:09PM	SYM
L6778952-5	CC-01-1	05/10/17 11:47am	E. COLI-MF (1603)	EPA 1603	42	05/10/17 03:19PM	BHS
L6778952-6	CC-02-1	05/10/17 12:08pm	FECAL COLIFORM-MF	SM 9222D	240	05/10/17 03:04PM	DYS
L6778952-6	CC-02-1	05/10/17 12:08pm	ENTEROCOCCUS-MF 24	EPA 1600	70 E	05/10/17 03:09PM	SYM
L6778952-6	CC-02-1	05/10/17 12:08pm	E. COLI-MF (1603)	EPA 1603	240	05/10/17 03:19PM	BHS
L6778952-7	DR-01-1	05/10/17 10:25am	FECAL COLIFORM-MF	SM 9222D	26	05/10/17 03:04PM	DYS
L6778952-7	DR-01-1	05/10/17 10:25am	ENTEROCOCCUS-MF 24	EPA 1600	4	05/10/17 03:09PM	SYM
L6778952-7	DR-01-1	05/10/17 10:25am	E. COLI-MF (1603)	EPA 1603	37	05/10/17 03:19PM	BHS
L6778952-8	DR-02-1	05/10/17 10:50am	FECAL COLIFORM-MF	SM 9222D	26	05/10/17 03:04PM	DYS
L6778952-8	DR-02-1	05/10/17 10:50am	ENTEROCOCCUS-MF 24	EPA 1600	13	05/10/17 03:09PM	SYM
L6778952-8	DR-02-1	05/10/17 10:50am	E. COLI-MF (1603)	EPA 1603	45	05/10/17 03:19PM	BHS
L6778952-9	DR-03-1	05/10/17 11:15am	FECAL COLIFORM-MF	SM 9222D	39	05/10/17 03:04PM	DYS
L6778952-9	DR-03-1	05/10/17 11:15am	ENTEROCOCCUS-MF 24	EPA 1600	4	05/10/17 03:09PM	SYM
L6778952-9	DR-03-1	05/10/17 11:15am	E. COLI-MF (1603)	EPA 1603	32	05/10/17 03:19PM	BHS
L6778952-10	DR-04-1	05/10/17 12:00pm	FECAL COLIFORM-MF	SM 9222D	52	05/10/17 03:04PM	DYS
L6778952-10	DR-04-1	05/10/17 12:00pm	ENTEROCOCCUS-MF 24	EPA 1600	6	05/10/17 03:09PM	SYM
L6778952-10	DR-04-1	05/10/17 12:00pm	E. COLI-MF (1603)	EPA 1603	18	05/10/17 03:19PM	BHS
L6778952-11	DR-05-1	05/10/17 12:20pm	FECAL COLIFORM-MF	SM 9222D	48	05/10/17 03:04PM	DYS
L6778952-11	DR-05-1	05/10/17 12:20pm	ENTEROCOCCUS-MF 24	EPA 1600	2	05/10/17 03:09PM	SYM
L6778952-11	DR-05-1	05/10/17 12:20pm	E. COLI-MF (1603)	EPA 1603	25	05/10/17 03:19PM	BHS
L6778952-12	DUP-DR-04-1	05/10/17 12:00pm	FECAL COLIFORM-MF	SM 9222D	56	05/10/17 03:04PM	DYS
L6778952-12	DUP-DR-04-1	05/10/17 12:00pm	ENTEROCOCCUS-MF 24	EPA 1600	10 E	05/10/17 03:09PM	SYM
L6778952-12	DUP-DR-04-1	05/10/17 12:00pm	E. COLI-MF (1603)	EPA 1603	42	05/10/17 03:19PM	BHS
L6778952-13	DUP-RC-02-1	05/10/17 11:02am	FECAL COLIFORM-MF	SM 9222D	230	05/10/17 03:04PM	DYS
L6778952-13	DUP-RC-02-1	05/10/17 11:02am	ENTEROCOCCUS-MF 24	EPA 1600	72	05/10/17 03:09PM	SYM
L6778952-13	DUP-RC-02-1	05/10/17 11:02am	E. COLI-MF (1603)	EPA 1603	112	05/10/17 03:19PM	BHS
L6778952-14	BLANK-01	05/10/17 00:00am	FECAL COLIFORM-MF	SM 9222D	<2 Q	05/10/17 03:04PM	DYS
L6778952-14	BLANK-01	05/10/17 00:00am	ENTEROCOCCUS-MF 24	EPA 1600	<2 Q	05/10/17 03:09PM	SYM
L6778952-14	BLANK-01	05/10/17 00:00am	E. COLI-MF (1603)	EPA 1603	<2 Q	05/10/17 03:19PM	BHS

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6778952-15	BLANK-02	05/10/17 12:25pm	FECAL COLIFORM-MF	SM 9222D	<2	05/10/17 03:04PM	DYS
L6778952-15	BLANK-02	05/10/17 12:25pm	ENTEROCOCCUS-MF 24	EPA 1600	<2	05/10/17 03:09PM	SYM
L6778952-15	BLANK-02	05/10/17 12:25pm	E. COLI-MF (1603)	EPA 1603	<2	05/10/17 03:19PM	BHS
L6778952-16	CC-03-2	05/10/17 03:14pm	ENTEROCOCCUS-MF 24	EPA 1600	45	05/10/17 08:47PM	BHS
L6778952-16	CC-03-2	05/10/17 03:14pm	FECAL COLIFORM-MF	SM 9222D	190 E	05/10/17 08:37PM	BHS
L6778952-16	CC-03-2	05/10/17 03:14pm	E. COLI-MF (1603)	EPA 1603	220	05/10/17 08:30PM	BHS
L6778952-17	RC-03-2	05/10/17 04:04pm	ENTEROCOCCUS-MF 24	EPA 1600	40 E	05/10/17 08:47PM	BHS
L6778952-17	RC-03-2	05/10/17 04:04pm	FECAL COLIFORM-MF	SM 9222D	490	05/10/17 08:37PM	BHS
L6778952-17	RC-03-2	05/10/17 04:04pm	E. COLI-MF (1603)	EPA 1603	1900 E	05/10/17 08:30PM	BHS
L6778952-18	RC-02-2	05/10/17 04:20pm	ENTEROCOCCUS-MF 24	EPA 1600	460	05/10/17 08:47PM	BHS
L6778952-18	RC-02-2	05/10/17 04:20pm	FECAL COLIFORM-MF	SM 9222D	140 E	05/10/17 08:37PM	BHS
L6778952-18	RC-02-2	05/10/17 04:20pm	E. COLI-MF (1603)	EPA 1603	180 E	05/10/17 08:30PM	BHS
L6778952-19	RC-01-2	05/10/17 04:45pm	ENTEROCOCCUS-MF 24	EPA 1600	20 E	05/10/17 08:47PM	BHS
L6778952-19	RC-01-2	05/10/17 04:45pm	FECAL COLIFORM-MF	SM 9222D	45	05/10/17 08:37PM	BHS
L6778952-19	RC-01-2	05/10/17 04:45pm	E. COLI-MF (1603)	EPA 1603	42	05/10/17 08:30PM	BHS
L6778952-20	CC-01-2	05/10/17 05:07pm	ENTEROCOCCUS-MF 24	EPA 1600	54	05/10/17 08:47PM	BHS
L6778952-20	CC-01-2	05/10/17 05:07pm	FECAL COLIFORM-MF	SM 9222D	25	05/10/17 08:37PM	BHS
L6778952-20	CC-01-2	05/10/17 05:07pm	E. COLI-MF (1603)	EPA 1603	39	05/10/17 08:30PM	BHS
L6778952-21	CC-02-2	05/10/17 05:28pm	ENTEROCOCCUS-MF 24	EPA 1600	41	05/10/17 08:47PM	BHS
L6778952-21	CC-02-2	05/10/17 05:28pm	FECAL COLIFORM-MF	SM 9222D	60 E	05/10/17 08:37PM	BHS
L6778952-21	CC-02-2	05/10/17 05:28pm	E. COLI-MF (1603)	EPA 1603	170 E	05/10/17 08:30PM	BHS

APPENDIX C

DRY WEATHER EVENT 3 – FIELD LOGS AND LAB RESULTS SUMMARY

(Chain of Custody Forms and Complete Lab Results provided in digital form only on CD attached to this report)

DRY WEATHER EVENT: 3

DATE: 6/13/2017 **Note Temperature of Receiving Stream if below 10 °C threshhold**

EVENT START TIME: 11:40

Sampling Station	Sampling Round	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Water Salinity Reading (%)	Water Temperature Reading (°C)	Conductivity Reading (umhos/cm)	Field Observations (see notes, below)
CC-01	Incoming tide	13:19	13:23	N	N/A	N	N/A	Y	14:17	0.38	23.17	748	Clear sky, very little foam, no debris
	Outgoing tide	19:05	19:07	N	N/A	N	N/A	Y	20:06	0.38	25.02	786	Clear sky, little foam, no debris
CC-02	Incoming tide	13:36	13:41	N	N/A	N	N/A	Y	14:17	0.39	21.98	749	Clear sky, some debris, no foam
	Outgoing tide	19:25	19:24	N	N/A	N	N/A	Y	20:06	0.39	23.79	776	Clear sky, little debris, no foam little turbidity
CC-03	Incoming tide	11:57	12:00	Y	12:00	Y	11:59	Y	14:17	0.38	22.30	733	Clear sky, little debris, no foam little turbidity
	Outgoing tide	17:48	17:48	N	N/A	N	N/A	Y	20:06	0.24	21.37	455	Clear sky, 95 F, some floating debris
RC-01	Incoming tide	12:59	13:02	N	N/A	N	N/A	Y	14:17	0.32	22.08	624	Clear sky, little foam, little debris
	Outgoing tide	18:40	18:43	Y	18:43	N	N/A	Y	20:06	0.32	23.38	637	Clear sky, little foam, 94 F
RC-02	Incoming tide	12:34	12:37	N	N/A	N	N/A	Y	14:17	0.33	20.91	617	Clear sky, little debris, very little foam
	Outgoing tide	18:25	18:20	N	N/A	N	N/A	Y	20:06	0.34	23.35	675	Clear sky, 94 F, little debris, no turbidity
RC-03	Incoming tide	12:14	12:20	N	N/A	N	N/A	Y	14:17	0.32	22.08	609	Clear sky, no foam, no debris, little turbidity
	Outgoing tide	18:05	18:04	N	N/A	N	N/A	Y	20:06	0.26	22.86	512	Clear sky, 94 F, debris, little turbidity
DR-01	Incoming tide	13:00	13:00	N	N/A	Y	13:05	Y	14:17	0.14/0.14/0.14	21.82/21.8/21.7	275/274/273	Total Depth = 24 ft
	Outgoing tide	18:15	18:15	N	N/A	N	N/A	Y	20:06	0.14/0.14/0.14	22.5/22.2/22.2	287/283/282	Total Depth = 27 ft
DR-02	Incoming tide	13:25	13:25	N	N/A	N	N/A	Y	14:17	0.14/0.14/0.14	21.9/21.8/21.8	274/273/272	Total Depth = 36 ft
	Outgoing tide	18:30	18:30	N	N/A	N	N/A	Y	20:06	0.14/0.14/0.14	22.4/22.3/22.3	286/286/286	Total Depth = 33 ft
DR-03	Incoming tide	13:40	13:40	N	N/A	N	N/A	Y	14:17	0.15/0.15/0.15	22.3/22.3/22.3	291/291/289	Total Depth = 18 ft
	Outgoing tide	18:40	18:40	N	N/A	N	N/A	Y	20:06	0.14/0.14/0.14	22.4/22.4/22.3	286/286/286	Total Depth = 16 ft
DR-04	Incoming tide	13:50	13:50	N	N/A	N	N/A	Y	14:17	0.15/0.15/0.15	22.4/22.3/22.4	291/291/291	Total Depth = 17 ft
	Outgoing tide	18:50	18:50	N	N/A	N	N/A	Y	20:06	0.15/0.15/0.15	22.5/22.5/22.5	294/294/293	Total Depth = 15 ft
DR-05	Incoming tide	14:05	14:05	N	N/A	N	N/A	Y	14:17	0.14/0.14/0.14	22.5/22.3/22.3	290/289/288	Total Depth = 8 ft
	Outgoing tide	19:00	19:00	N	N/A	N	N/A	Y	20:06	0.19/0.15/0.15	23.0/22.5/22.4	376/304/291	Total Depth = 12 ft

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6851627-1	BLANK 01	06/13/17 11:48am	ENTEROCOCCUS-MF 24	EPA 1600	<1	06/13/17 05:28PM	SYM
L6851627-1	BLANK 01	06/13/17 11:48am	E. COLI-MF (1603)	EPA 1603	<1	06/13/17 05:29PM	SYM
L6851627-1	BLANK 01	06/13/17 11:48am	FECAL COLIFORM-MF	SM 9222D	<1	06/13/17 05:24PM	BHS
L6851627-2	CC-03-01	06/13/17 11:48am	ENTEROCOCCUS-MF 24	EPA 1600	85	06/13/17 05:28PM	SYM
L6851627-2	CC-03-01	06/13/17 11:48am	E. COLI-MF (1603)	EPA 1603	160 E	06/13/17 05:29PM	SYM
L6851627-2	CC-03-01	06/13/17 11:48am	FECAL COLIFORM-MF	SM 9222D	1200 E	06/13/17 05:24PM	BHS
L6851627-3	RC-03-01	06/13/17 12:19pm	ENTEROCOCCUS-MF 24	EPA 1600	130 E	06/13/17 05:28PM	SYM
L6851627-3	RC-03-01	06/13/17 12:19pm	E. COLI-MF (1603)	EPA 1603	50 E	06/13/17 05:29PM	SYM
L6851627-3	RC-03-01	06/13/17 12:19pm	FECAL COLIFORM-MF	SM 9222D	2700	06/13/17 05:24PM	BHS
L6851627-4	DUP-CC	06/13/17 00:00am	ENTEROCOCCUS-MF 24	EPA 1600	150 Q	06/13/17 05:28PM	SYM
L6851627-4	DUP-CC	06/13/17 00:00am	E. COLI-MF (1603)	EPA 1603	200 Q	06/13/17 05:29PM	SYM
L6851627-4	DUP-CC	06/13/17 00:00am	FECAL COLIFORM-MF	SM 9222D	1100 E, Q	06/13/17 05:24PM	BHS
L6851627-5	RC-02-01	06/13/17 12:37pm	ENTEROCOCCUS-MF 24	EPA 1600	460	06/13/17 05:28PM	SYM
L6851627-5	RC-02-01	06/13/17 12:37pm	E. COLI-MF (1603)	EPA 1603	440	06/13/17 05:29PM	SYM
L6851627-5	RC-02-01	06/13/17 12:37pm	FECAL COLIFORM-MF	SM 9222D	3200	06/13/17 05:24PM	BHS
L6851627-6	RC-01-01	06/13/17 01:02pm	ENTEROCOCCUS-MF 24	EPA 1600	78	06/13/17 05:28PM	SYM
L6851627-6	RC-01-01	06/13/17 01:02pm	E. COLI-MF (1603)	EPA 1603	75	06/13/17 05:29PM	SYM
L6851627-6	RC-01-01	06/13/17 01:02pm	FECAL COLIFORM-MF	SM 9222D	180 E	06/13/17 05:24PM	BHS
L6851627-7	CC-01-01	06/13/17 01:23pm	ENTEROCOCCUS-MF 24	EPA 1600	49	06/13/17 05:28PM	SYM
L6851627-7	CC-01-01	06/13/17 01:23pm	E. COLI-MF (1603)	EPA 1603	110 E	06/13/17 05:29PM	SYM
L6851627-7	CC-01-01	06/13/17 01:23pm	FECAL COLIFORM-MF	SM 9222D	180 E	06/13/17 05:24PM	BHS
L6851627-8	CC-02-01	06/13/17 01:42pm	ENTEROCOCCUS-MF 24	EPA 1600	140 E	06/13/17 05:28PM	SYM
L6851627-8	CC-02-01	06/13/17 01:42pm	E. COLI-MF (1603)	EPA 1603	470	06/13/17 05:29PM	SYM
L6851627-8	CC-02-01	06/13/17 01:42pm	FECAL COLIFORM-MF	SM 9222D	800 E	06/13/17 05:24PM	BHS
L6851627-9	DR-01-1	06/13/17 01:00pm	ENTEROCOCCUS-MF 24	EPA 1600	11	06/13/17 05:28PM	SYM
L6851627-9	DR-01-1	06/13/17 01:00pm	E. COLI-MF (1603)	EPA 1603	23	06/13/17 05:29PM	SYM
L6851627-9	DR-01-1	06/13/17 01:00pm	FECAL COLIFORM-MF	SM 9222D	39	06/13/17 05:24PM	BHS
L6851627-10	BLANK-02	06/13/17 01:05pm	ENTEROCOCCUS-MF 24	EPA 1600	<1	06/13/17 05:28PM	SYM
L6851627-10	BLANK-02	06/13/17 01:05pm	E. COLI-MF (1603)	EPA 1603	<1	06/13/17 05:29PM	SYM
L6851627-10	BLANK-02	06/13/17 01:05pm	FECAL COLIFORM-MF	SM 9222D	<1	06/13/17 05:24PM	BHS
L6851627-11	DR-02-1	06/13/17 01:25pm	ENTEROCOCCUS-MF 24	EPA 1600	9	06/13/17 05:28PM	SYM
L6851627-11	DR-02-1	06/13/17 01:25pm	E. COLI-MF (1603)	EPA 1603	11	06/13/17 05:29PM	SYM
L6851627-11	DR-02-1	06/13/17 01:25pm	FECAL COLIFORM-MF	SM 9222D	21	06/13/17 05:24PM	BHS
L6851627-12	DR-03-1	06/13/17 01:40pm	ENTEROCOCCUS-MF 24	EPA 1600	14	06/13/17 05:28PM	SYM
L6851627-12	DR-03-1	06/13/17 01:40pm	E. COLI-MF (1603)	EPA 1603	25	06/13/17 05:29PM	SYM
L6851627-12	DR-03-1	06/13/17 01:40pm	FECAL COLIFORM-MF	SM 9222D	54	06/13/17 05:24PM	BHS
L6851627-13	DR-04-1	06/13/17 01:50pm	ENTEROCOCCUS-MF 24	EPA 1600	4	06/13/17 05:28PM	SYM
L6851627-13	DR-04-1	06/13/17 01:50pm	E. COLI-MF (1603)	EPA 1603	12	06/13/17 05:29PM	SYM
L6851627-13	DR-04-1	06/13/17 01:50pm	FECAL COLIFORM-MF	SM 9222D	21	06/13/17 05:24PM	BHS
L6851627-14	DR-05-1	06/13/17 02:05pm	ENTEROCOCCUS-MF 24	EPA 1600	6	06/13/17 05:28PM	SYM
L6851627-14	DR-05-1	06/13/17 02:05pm	E. COLI-MF (1603)	EPA 1603	10	06/13/17 05:29PM	SYM
L6851627-14	DR-05-1	06/13/17 02:05pm	FECAL COLIFORM-MF	SM 9222D	40	06/13/17 05:24PM	BHS

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6851627-15	DR-01-2	06/13/17 06:15pm	ENTEROCOCCUS-MF 24	EPA 1600	6	06/13/17 10:17PM	BHS
L6851627-15	DR-01-2	06/13/17 06:15pm	E. COLI-MF (1603)	EPA 1603	12	06/13/17 10:13PM	BHS
L6851627-15	DR-01-2	06/13/17 06:15pm	FECAL COLIFORM-MF	SM 9222D	35	06/13/17 10:34PM	BHS
L6851627-16	DR-02-2	06/13/17 06:30pm	ENTEROCOCCUS-MF 24	EPA 1600	2	06/13/17 10:17PM	BHS
L6851627-16	DR-02-2	06/13/17 06:30pm	E. COLI-MF (1603)	EPA 1603	7	06/13/17 10:13PM	BHS
L6851627-16	DR-02-2	06/13/17 06:30pm	FECAL COLIFORM-MF	SM 9222D	32	06/13/17 10:34PM	BHS
L6851627-17	DR-03-2	06/13/17 06:40pm	ENTEROCOCCUS-MF 24	EPA 1600	1	06/13/17 10:17PM	BHS
L6851627-17	DR-03-2	06/13/17 06:40pm	E. COLI-MF (1603)	EPA 1603	5	06/13/17 10:13PM	BHS
L6851627-17	DR-03-2	06/13/17 06:40pm	FECAL COLIFORM-MF	SM 9222D	20	06/13/17 10:34PM	BHS
L6851627-18	DR-04-2	06/13/17 06:50pm	ENTEROCOCCUS-MF 24	EPA 1600	2	06/13/17 10:17PM	BHS
L6851627-18	DR-04-2	06/13/17 06:50pm	E. COLI-MF (1603)	EPA 1603	2	06/13/17 10:13PM	BHS
L6851627-18	DR-04-2	06/13/17 06:50pm	FECAL COLIFORM-MF	SM 9222D	34	06/13/17 10:34PM	BHS
L6851627-19	DR-05-2	06/13/17 07:00pm	ENTEROCOCCUS-MF 24	EPA 1600	2	06/13/17 10:17PM	BHS
L6851627-19	DR-05-2	06/13/17 07:00pm	E. COLI-MF (1603)	EPA 1603	1	06/13/17 10:13PM	BHS
L6851627-19	DR-05-2	06/13/17 07:00pm	FECAL COLIFORM-MF	SM 9222D	27	06/13/17 10:34PM	BHS
L6851627-20	DUP-DR	06/13/17 00:00am	ENTEROCOCCUS-MF 24	EPA 1600	5 Q	06/13/17 10:17PM	BHS
L6851627-20	DUP-DR	06/13/17 00:00am	E. COLI-MF (1603)	EPA 1603	6 Q	06/13/17 10:13PM	BHS
L6851627-20	DUP-DR	06/13/17 00:00am	FECAL COLIFORM-MF	SM 9222D	21 Q	06/13/17 10:34PM	BHS
L6851627-21	CC-03-02	06/13/17 05:48pm	ENTEROCOCCUS-MF 24	EPA 1600	87	06/13/17 10:17PM	BHS
L6851627-21	CC-03-02	06/13/17 05:48pm	E. COLI-MF (1603)	EPA 1603	90 E	06/13/17 10:13PM	BHS
L6851627-21	CC-03-02	06/13/17 05:48pm	FECAL COLIFORM-MF	SM 9222D	330	06/13/17 10:34PM	BHS
L6851627-22	RC-03-02	06/13/17 06:04pm	ENTEROCOCCUS-MF 24	EPA 1600	180 E	06/13/17 10:17PM	BHS
L6851627-22	RC-03-02	06/13/17 06:04pm	E. COLI-MF (1603)	EPA 1603	110 E	06/13/17 10:13PM	BHS
L6851627-22	RC-03-02	06/13/17 06:04pm	FECAL COLIFORM-MF	SM 9222D	1600 E	06/13/17 10:34PM	BHS
L6851627-23	RC-02-02	06/13/17 06:23pm	ENTEROCOCCUS-MF 24	EPA 1600	900 E	06/13/17 10:17PM	BHS
L6851627-23	RC-02-02	06/13/17 06:23pm	E. COLI-MF (1603)	EPA 1603	920 E	06/13/17 10:13PM	BHS
L6851627-23	RC-02-02	06/13/17 06:23pm	FECAL COLIFORM-MF	SM 9222D	3800	06/13/17 10:34PM	BHS
L6851627-24	RC-01-02	06/13/17 06:43pm	ENTEROCOCCUS-MF 24	EPA 1600	190 E	06/13/17 10:17PM	BHS
L6851627-24	RC-01-02	06/13/17 06:43pm	E. COLI-MF (1603)	EPA 1603	76	06/13/17 10:13PM	BHS
L6851627-24	RC-01-02	06/13/17 06:43pm	FECAL COLIFORM-MF	SM 9222D	190 E	06/13/17 10:34PM	BHS
L6851627-25	CC-01-02	06/13/17 07:06pm	ENTEROCOCCUS-MF 24	EPA 1600	140 E	06/13/17 10:17PM	BHS
L6851627-25	CC-01-02	06/13/17 07:06pm	E. COLI-MF (1603)	EPA 1603	67	06/13/17 10:13PM	BHS
L6851627-25	CC-01-02	06/13/17 07:06pm	FECAL COLIFORM-MF	SM 9222D	210	06/13/17 10:34PM	BHS
L6851627-26	CC-02-02	06/13/17 07:24pm	ENTEROCOCCUS-MF 24	EPA 1600	190 E	06/13/17 10:17PM	BHS
L6851627-26	CC-02-02	06/13/17 07:24pm	E. COLI-MF (1603)	EPA 1603	260	06/13/17 10:13PM	BHS
L6851627-26	CC-02-02	06/13/17 07:24pm	FECAL COLIFORM-MF	SM 9222D	900 E	06/13/17 10:34PM	BHS
L6851627-27	DUP-RC	06/13/17 00:00am	ENTEROCOCCUS-MF 24	EPA 1600	190 E, Q	06/13/17 10:17PM	BHS
L6851627-27	DUP-RC	06/13/17 00:00am	E. COLI-MF (1603)	EPA 1603	119 Q	06/13/17 10:13PM	BHS
L6851627-27	DUP-RC	06/13/17 00:00am	FECAL COLIFORM-MF	SM 9222D	210 Q	06/13/17 10:34PM	BHS

APPENDIX D

WET WEATHER EVENT 1 – FIELD LOGS AND LAB RESULTS SUMMARY

(Chain of Custody Forms and Complete Lab Results provided in digital form only on CD attached to this report)

WET WEATHER EVENT: 1

DATE: *3/31/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *23:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Water Salinity Reading (%)	Water Temperature Reading (°C)	Conductivity Reading (umhos/cm)	Field Observations (see notes, below)
IN-STREAM TRIBUTARY STATION: CC-01													
1	0.5-2.5	1:00	1:03	N	N/A	N	N/A	Y	3:04	0.30	9.00	431.9	Raining
2	4.5-6.5	6:00	4:54	N	N/A	N	N/A	Y	6:55	0.20	8.90	515	Raining
3	8.5-10.5	10:00	8:37	N	N/A	N	N/A	Y	10:15	0.28	8.16	567	Raining
4	14.5-16.5	16:00	16:05	N	N/A	N	N/A	Y	16:40	0.17	8.04	349	Raining
5	22-24	23:00	23:25	N	N/A	N	N/A	Y	23:45	0.11	8.01	233	Raining
IN-STREAM TRIBUTARY STATION: CC-02													
1	0.5-2.5	0:40	0:43	N	N/A	N	N/A	Y	3:04	0.3	10.30	433.4	Raining
2	4.5-6.5	5:40	4:16	N	N/A	N	N/A	Y	6:55	0.3	9.80	548	Raining
3	8.5-10.5	9:40	8:18	N	N/A	N	N/A	Y	10:15	0.26	8.59	527	Raining
4	14.5-16.5	15:40	15:40	N	N/A	N	N/A	Y	16:40	0.19	8.13	403	Raining
5	22-24	22:40	23:15	N	N/A	N	N/A	Y	23:45	0.11	8.00	228	Raining
IN-STREAM TRIBUTARY STATION: CC-03													
1	0.5-2.5	0:00	0:00	Y	0:01	Y	0:05	Y	3:04	0.20	9.00	479.3	Raining
2	4.5-6.5	5:00	4:05	N	N/A	N	N/A	Y	6:55	0.20	7.40	384.6	Raining
3	8.5-10.5	9:00	8:18	N	N/A	N	N/A	Y	10:15	0.28	9.26	574.0	Raining
4	14.5-16.5	15:00	14:40	N	N/A	N	N/A	Y	16:40	0.25	8.20	520.0	Raining
5	22-24	22:00	22:15	N	N/A	N	N/A	Y	23:45	0.12	8.01	120.0	Raining
IN-STREAM TRIBUTARY STATION: RC-01													
1	0.5-2.5	1:30	1:30	N	N/A	N	N/A	Y	3:04	0.20	8.80	419.4	Raining
2	4.5-6.5	6:30	5:22	N	N/A	N	N/A	Y	6:55	0.20	8.40	404.2	Raining
3	8.5-10.5	10:30	9:15	N	N/A	N	N/A	Y	10:15	0.19	7.94	399.0	Raining
4	14.5-16.5	16:30	15:25	Y	15:26	N	N/A	Y	16:40	0.13	8.09	270.0	Raining
5	22-24	23:30	22:55	N	N/A	N	N/A	Y	23:45	0.10	7.65	216.0	Raining
IN-STREAM TRIBUTARY STATION: RC-02													
1	0.5-2.5	2:00	2:10	N	N/A	N	N/A	Y	3:04	0.20	9.60	474.8	Raining
2	4.5-6.5	7:00	6:43	N	N/A	N	N/A	Y	6:55	0.17	8.17	353.0	Raining
3	8.5-10.5	11:00	9:36	N	N/A	N	N/A	Y	10:15	0.20	7.97	421.0	Raining
4	14.5-16.5	17:00	15:10	N	N/A	N	N/A	Y	16:40	0.13	8.06	273.0	Raining
5	22-24	0:00	22:40	N	N/A	N	N/A	Y	23:45	0.11	7.75	224.0	Raining
IN-STREAM TRIBUTARY STATION: RC-03													
1	0.5-2.5	2:30	2:39	N	N/A	N	N/A	Y	3:04	0.10	7.40	373.6	Raining
2	4.5-6.5	7:30	7:00	N	N/A	N	N/A	Y	6:55	0.20	8.33	423.0	Raining
3	8.5-10.5	11:30	9:56	N	N/A	N	N/A	Y	10:15	0.19	8.01	391.0	Raining
4	14.5-16.5	17:30	14:55	N	N/A	N	N/A	Y	16:40	0.19	8.00	395.0	Raining
5	22-24	0:30	22:25	N	N/A	N	N/A	Y	23:45	0.00	7.40	228.0	Raining

WET WEATHER EVENT: 1
DELAWARE RIVER STATION: DR-01

DATE: *3/31/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *23:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Surface, Mid-depth & Bottom Water Salinity Reading(s) (%)	Surface, Mid-depth & Bottom Water Temperature Reading(s) (°C)	Surface, Mid-depth & Bottom Water Conductivity Reading(s) (umhos/cm)	Field Observations (see notes, below)
1	0	1:00	1:10	N	N/A	N	N/A	Y	2:54	0.18/ 0.18/	3.33/ 3.32/	0.376/ 0.372/	Mid depth = 12 ft
2	2	3:00		N	N/A	N	N/A	N		/ /	/ /	/ /	Weather delay
3	4	5:00	7:45	N	N/A	N	N/A	Y	9:56	/ /	/ /	/ /	No logs
4	6	7:00	9:20	N	N/A	N	N/A	Y	10:40	0.18/ 0.17/ 0.17	3.39/ 3.38/ 3.37	0.366/ 0.361/ 0.359	Mid depth = 13 ft, Bottom depth = 26 ft
5	9	10:00	13:03	N	N/A	N	N/A	Y	14:35	0.17/ 0.17/ 0.17	3.44/ 3.50/ 3.50	0.363/ 0.363/ 0.364	Mid depth = 10 ft, Bottom depth = 25 ft
6	12	13:00	15:20	N	N/A	N	N/A	Y	17:07	0.17/ 0.17/ 0.17	3.37/ 3.38/ 3.38	0.362/ 0.362/ 0.362	Mid depth = 15 ft, Bottom depth = 27 ft
7	15	16:00	17:55	N	N/A	N	N/A	Y	18:00	0.17/ 0.17/ 0.17	3.36/ 3.36/ 3.37	0.363/ 0.363/ 0.363	Mid depth = 15 ft, Bottom depth = 26 ft
8	18	19:00	19:50	N	N/A	N	N/A	Y	21:20	0.17/ 0.17/ 0.17	3.44/ 3.45/ 3.46	0.354/ 0.355/ 0.355	Mid depth = 13 ft, Bottom depth = 25 ft
9	21	22:00	23:35	N	N/A	N	N/A	Y	0:52	0.16/ 0.16/ 0.16	3.58/ 3.59/ 3.59	0.333/ 0.334/ 0.335	Mid depth = 11 ft, Bottom depth = 10 ft
10	24	1:00		N	N/A	N	N/A	Y		/ /	/ /	/ /	

DELAWARE RIVER STATION: DR-02

1	0	1:30	1:31	N	N/A	N	N/A	Y	2:54	0.18/ 0.18/	3.23/ 3.22/	0.371/ 0.370/	Mid depth = 12 ft
2	2	3:30	4:50	Y	4:50	N	N/A	Y	6:34	0.18/ 0.18/ 0.18	3.05/ 3.12/ 3.12	0.380/ 0.381/ 0.381	Mid depth = 16 ft, Bottom depth = 28.65 ft
3	4	5:30		N	N/A	N	N/A	Y		/ /	/ /	/ /	Weather delay
4	6	7:30	9:35	N	N/A	N	N/A	Y	10:40	0.17/ 0.17/ 0.17	3.31/ 3.32/ 3.34	0.361/ 0.362/ 0.363	Mid depth = 18 ft, Bottom depth = 35 ft
5	9	10:30	13:20	N	N/A	N	N/A	Y	14:35	0.17/ 0.17/ 0.17	3.33/ 3.33/ 3.34	0.351/ 0.357/ 0.351	Mid depth = 15 ft, Bottom depth = 34 ft
6	12	13:30	15:30	N	N/A	N	N/A	Y	17:07	0.17/ 0.17/ 0.17	3.31/ 3.31/ 3.31	0.362/ 0.363/ 0.363	Mid depth = 15 ft, Bottom depth = 30 ft
7	15	16:30	18:05	N	N/A	N	N/A	Y	18:00	0.17/ 0.17/ 0.17	3.39/ 3.39/ 3.40	0.350/ 0.350/ 0.352	Mid depth = 20 ft, Bottom depth = 35 ft
8	18	19:30	19:55	N	N/A	N	N/A	Y	21:20	0.16/ 0.17/ 0.16	3.36/ 3.37/ 3.38	0.343/ 0.343/ 0.344	Mid depth = 17 ft., Bottom depth = 35 ft
9	21	22:30	23:45	N	N/A	N	N/A	Y	0:52	0.15/ 0.15/ 0.15	3.35/ 3.35/ 3.36	0.317/ 0.317/ 0.316	Mid depth = 15 ft, Bottom depth = 30 ft
10	24	1:30		N	N/A	N	N/A	Y		/ /	/ /	/ /	

DELAWARE RIVER STATION: DR-03

1	0	1:40	1:40	N	N/A	N	N/A	Y	2:54	0.19/ 0.19/	3.41/ 3.44/	0.390/ 0.391/	Mid depth = 7.6 ft
2	2	3:40	4:30	N	N/A	Y	4:33	Y	6:34	0.19/ 0.18/ 0.18	3.05/ 3.06/ 3.04	0.388/ 0.386/ 0.386	Mide depth = 10 ft, Bottom depth = 18 ft
3	4	5:40		N	N/A	N	N/A	Y		/ /	/ /	/ /	Weather delay
4	6	7:40	9:45	N	N/A	N	N/A	Y	10:40	0.18/ 0.18/ 0.18	3.32/ 3.33/ 3.34	0.367/ 0.365/ 0.362	Mid depth = 13 ft, Bottom depth = 24 ft
5	9	10:40	13:35	N	N/A	N	N/A	Y	14:35	0.18/ 0.18/ 0.18	3.42/ 3.42/ 3.44	0.371/ 0.371/ 0.372	Mid depth = 7.5 ft, Bottom depth = 13 ft
6	12	13:40	15:40	N	N/A	N	N/A	Y	17:07	0.18/ 0.18/ 0.18	3.33/ 3.34/ 3.34	0.370/ 0.370/ 0.370	Mid depth = 8 ft, Botto depth = 16 ft
7	15	16:40	18:10	N	N/A	N	N/A	Y	18:00	0.18/ 0.18/ 0.18	3.36/ 3.37/ 3.37	0.377/ 0.377/ 0.378	Mid depth = 15, Bottom depth = 30 ft
8	18	19:40	20:00	N	N/A	N	N/A	Y	21:20	0.17/ 0.17/ 0.17	3.37/ 3.38/ 3.38	0.353/ 0.353/ 0.353	Mid depth = 15 ft, Bottom depth = 29 ft
9	21	22:40	23:55	N	N/A	N	N/A	Y	0:52	0.16/ 0.16/ 0.16	3.59/ 3.60/ 3.60	0.341/ 0.341/ 0.341	Mid depth = 12 ft, Bottom depth = 22 ft
10	24	1:40		N	N/A	N	N/A	Y		/ /	/ /	/ /	

DELAWARE RIVER STATION: DR-04

1	0	1:35	1:35	Y	1:35	N	N/A	Y	2:54	0.19/ 0.19/ 0.19	7.52/7.53/ 7.54	0.386/ 0.387/ 0.388	Mid depth = 16.12 ft, Bottom depth = 32.5 ft
2	2	3:35	4:00	N	N/A	N	N/A	Y	6:35	0.19/ 0.19/ 0.18	3.12/ 3.10/ 3.08	0.389/ 0.386/ 0.385	Mid depth = 11 ft, Bottom depth = 22 ft
3	4	5:35	7:30	N	N/A	N	N/A	Y	9:56	0.18	3.71	0.385	Only one reading recorded
4	6	7:35	9:55	N	N/A	N	N/A	Y	10:40	0.18/ 0.18/ 0.18	3.33/ 3.35/ 3.35	0.381/ 0.382/ 0.383	Mid depth = 13 ft, Bottom depth = 25 ft
5	9	10:35	13:15	N	N/A	N	N/A	Y	14:35	0.17/ 0.17/ 0.17	3.39/ 3.40/ 3.40	0.363/ 0.364/ 0.363	Mid depth = 10 ft, Bottom depth = 16 ft
6	12	13:35	15:55	N	N/A	N	N/A	Y	17:07	0.18/ 0.18/ 0.18	3.15/ 3.15/ 3.11	0.368/ 0.369/ 0.368	Mid depth = 11 ft, Bottom depth = 20 ft
7	15	16:35	18:15	N	N/A	N	N/A	Y	18:00	0.17/ 0.17/ 0.17	3.01/ 3.02/ 3.02	0.365/ 0.365/ 0.365	Mid depth = 15 ft , Bottom depth = 29 ft
8	18	19:35	20:05	N	N/A	N	N/A	Y	21:20	0.17/ 0.17/ 0.17	3.49/ 3.49/ 3.49	0.354/ 0.355/ 0.355	Mid dpeth = 15 ft, Bottom depth = 27 ft
9	21	22:35	0:10	N	N/A	N	N/A	Y	0:52	0.17/ 0.16/ 0.16	3.59/ 3.59/ 3.60	0.344/ 0.344/ 0.345	Mid dpeth = 12 ft, Bottom depth = 22 ft
10	24	1:35		N	N/A	N	N/A	Y		/ /	/ /	/ /	

WET WEATHER EVENT: 1
DELAWARE RIVER STATION: DR-05

DATE: *3/31/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *23:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Surface, Mid-depth & Bottom Water Salinity Reading(s) (%)	Surface, Mid-depth & Bottom Water Temperature Reading(s) (°C)	Surface, Mid-depth & Bottom Water Conductivity Reading(s) (umhos/cm)	Field Observations (see notes, below)
1	0	2:10	2:10	N	N/A	N	N/A	Y	2:54	0.18/ 0.18/ 0.18	3.11/ 3.14/ 3.14	0.383/ 0.383/ 0.383	Mid depth = 4 ft, Bottom depth = 7.5 ft
2	2	4:10	3:45	N	N/A	N	N/A	Y	6:35	0.18/ 0.18/ 0.18	3.06/ 3.06/ 3.06	0.384/ 0.384/ 0.384	Mid depth = 4 ft, Bottom depth = 8 ft
3	4	6:10	7:00	N	N/A	N	N/A	Y	9:56	0.29	5.88	0.596	Only one reading recorded
4	6	8:10	10:05	N	N/A	N	N/A	Y	10:40	0.18/ 0.18/ 0.18	3.36/ 3.36/ 3.37	0.382/ 0.383/ 0.383	Mid depth = 5 ft, Mid depth = 11 ft
5	9	11:10	13:50	N	N/A	N	N/A	Y	14:35	0.17/ 0.17/ 0.17	3.41/ 3.41/ 3.42	0.372/ 0.372/ 0.372	Mid depth = 4 ft, Bottom depth = 7 ft
6	12	14:10	16:05	N	N/A	N	N/A	Y	17:07	0.18/ 0.18/ 0.18	3.17/ 3.17/ 3.17	0.380/ 0.380/ 0.380	Mid depth = 7 ft, Bottom depth = 13 ft
7	15	17:10	18:25	N	N/A	N	N/A	Y	18:00	0.17/ 0.17/ 0.17	3.19/ 3.18/ 3.19	0.378/ 0.378/ 0.378	Mid depth = 10 ft, Bottom depth = 15 ft
8	18	20:10	20:15	N	N/A	N	N/A	Y	21:20	0.17/ 0.17/ 0.17	3.30/ 3.31/ 3.32	0.360/ 0.360/ 0.360	Mid depth = 9 ft, Bottom depth = 15 ft
9	21	23:10	0:20	N	N/A	N	N/A	Y	0:52	0.16/ .016/ 0.16	3.47/ 3.48/ 3.48	0.336/ 0.337/ 0.337	Mid dpeth = 9 ft, Bottom depth = 15 ft
10	24	2:10		N	N/A	N	N/A	Y		/ /	/ /	/ /	
DELAWARE RIVER STATION: DR-06													
1	0	2:00								/ /	/ /	/ /	Missed station / time delay
2	2	4:00	3:45	N	N/A	N	N/A	Y	6:35	0.18/ 0.18/ 0.18	2.92/ 2.91/ 2.91	0.375/ 0.375/ 0.375	Mid depth = 15 ft, Bottom Depth = 30 ft
3	4	6:00		N	N/A	N	N/A	Y		/ /	/ /	/ /	Weather delay
4	6	8:00	10:15	N	N/A	N	N/A	Y	10:40	0.17/ 0.17/ 0.17	2.90/ 2.91/ 2.91	0.354/ 0.355/ 0.356	Mid depth = 11 ft, Bottom depth = 21 ft
5	9	11:00	12:22	N	N/A	N	N/A	Y	14:35	0.16/ 0.16/ 0.15	3.0/ 2.9/ 2.9	0.349/ 0.350/ 0.351	Mid depth = 10 ft, Bottom depth = 24 ft
6	12	14:00	14:45	N	N/A	N	N/A	Y	17:07	0.17/ 0.17/ 0.17	3.00/ 3.01/ 3.01	0.357/ 0.357/ 0.358	Mid depth = 15 ft, Bottom depth = 25 ft
7	15	17:00	17:25	N	N/A	N	N/A	Y	18:00	0.17/ 0.17/ 0.17	2.93/ 2.93/ 2.93	0.365/ 0.366/ 0.366	Mid depth = 15 ft, Bottom depth = 28 ft
8	18	20:00	19:25	N	N/A	N	N/A	Y	21:20	0.17/ 0.17/ 0.17	3.04/ 3.05/ 3.08	0.354/ 0.355/ 0.355	Mid depth - 15 ft, Bottom depth = 25 ft
9	21	23:00	23:00	N	N/A	N	N/A	Y	0:52	0.16/ 0.16/ 0.16	3.21/ 3.21/ 3.21	0.335/ 0.335/ 0.335	Mid depth = 10 ft, Bottom depth = 19 ft
10	24	2:00		N	N/A	N	N/A	Y		/ /	/ /	/ /	
DELAWARE RIVER STATION: DR-07													
1	0	1:50								/ /	/ /	/ /	Missed station / time delay
2	2	3:50	3:20	N	N/A	N	N/A	Y	6:35	0.17/ 0.17/ 0.17	3.05/ 3.05/ 3.05	0.364/ 0.364/ 0.364	Mid depth = 3.5 ft, Bottom depth = 7.2 ft
3	4	5:50		N	N/A	N	N/A	Y		/ /	/ /	/ /	Weather delay
4	6	7:50	10:25	N	N/A	N	N/A	Y	10:40	0.18/ 0.18	3.15/ 3.16	0.370/ 0.370	Bottom depth = 2.5 ft, Mid too shallow
5	9	10:50	12:15	N	N/A	N	N/A	Y	14:35	0.17/ 0.17	2.94/ 2.94	0.353/ 0.354	Bottom depth = 4.05 ft, Mid too shallow
6	12	13:50	14:55	N	N/A	N	N/A	Y	17:07	0.17	3.04	0.352	Total depth = ft, too shallow fro multiple readings
7	15	16:50	17:30	N	N/A	N	N/A	Y	18:00	0.17/ 0.17/ 0.17	3.08/ 3.08/ 3.09	0.354/ 0.354/ 0.355	Mid depth = 7 ft, Bottom depth = 13 ft
8	18	19:50	19:30	N	N/A	N	N/A	Y	21:20	0.17/ 0.17/ 0.17	3.18/ 3.18/ 3.18	0.361/ 0.360/ 0.362	Mid depth = 6 ft, Bottom depth = 10 ft
9	21	22:50	23:15	N	N/A	N	N/A	Y	0:52	0.16/ 0.16/ 0.16	3.24/ 3.24/ 3.24	0.343/ 0.343/ 0.344	Mid depth = 3 ft, Bottom depth = 6 ft
10	24	1:50		N	N/A	N	N/A	Y		/ /	/ /	/ /	

WET WEATHER EVENT: 1
CSO STATION: CSO-02

DATE: *3/31/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *23:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Filed Observations (see notes, below)
1	T=0 (First Flush)	23:54	23:54	N	N/A	Y	23:48	Y	2:20	
2	30 Min	0:24	1:35	N	N/A	N	N/A	Y	3:42	NO OVERFLOW UNTIL 01:30
3	60 Min	0:54	2:08	N	N/A	N	N/A	Y	3:42	
4	2 Hours	1:54	3:09	N	N/A	N	N/A	Y	3:42	
5	4 Hours	3:54	5:15	N	N/A	N	N/A	Y	7:10	
6	8 Hours	7:54	9:25	Y	N/A	N	N/A	Y	10:12	
7	12 Hours	11:54	12:30	N	N/A	N	N/A	Y	13:37	
7-X	16 Hours		16:55	N	N/A	N	N/A	Y	18:00	
8	24 Hours	23:54	0:00	N	N/A	N	N/A	Y	1:10	
CSO STATION: CSO-05										
1	T=0 (First Flush)	0:17	0:17	N	N/A	Y	12:08	Y	2:20	
2	30 Min	0:47	1:45	N	N/A	N	N/A	Y	3:42	NO OVERFLOW UNTIL 01:45
3	60 Min	1:17	2:20	N	N/A	N	N/A	Y	3:42	
4	2 Hours	2:17	3:20	N	N/A	N	N/A	Y	3:42	
5	4 Hours	4:17	9:55	N	N/A	N	N/A	Y	10:12	NO OVERFLOW UNTIL 09:55
6	8 Hours	8:17	12:45	N	N/A	N	N/A	Y	13:37	
7	12 Hours	12:17	17:15	N	N/A	N	N/A	Y	18:00	
8	24 Hours	0:17	0:15	N	N/A	N	N/A	Y	1:10	
CSO STATION: CSO-18										
1	T=0 (First Flush)	0:07	0:07	N	N/A	Y	0:03	Y	3:29	
2	30 Min	0:37	1:45	N	N/A	N	N\A	Y	3:29	NO OVERFLOW UNTIL 01:45
3	60 Min	1:07	2:10	N	N/A	N	N\A	Y	3:29	
4	2 Hours	2:07	3:10	N	N/A	N	N\A	Y	3:29	
5	4 Hours	4:07	9:40	N	N/A	N	N\A	Y	9:52	NO OVERFLOW UNTIL 09:40
6	8 Hours	8:07	13:00	N	N/A	N	N\A	Y	13:37	
7	12 Hours	12:07	17:25	N	N/A	N	N\A	Y	18:00	
8	24 Hours	0:07	0:35	N	N/A	N	N\A	-	-	NO OVERFLOW
CSO STATION: CSO-19										
1	T=0 (First Flush)	0:25	0:25	N	N/A	Y		Y	3:29	
2	30 Min	0:55	1:35	N	N/A	N	N/A	Y	3:29	NO OVERFLOW UNTIL 01:35
3	60 Min	1:25	1:58	N	N/A	N	N/A	Y	3:29	
4	2 Hours	2:25	2:55	N	N/A	N	N/A	Y	3:29	
5	4 Hours	4:25	4:55	N	N/A	N	N/A	Y	6:35	
6	8 Hours	8:25	8:50	N	N/A	N	N/A	Y	9:52	
7	12 Hours	12:25	17:40	N	N/A	N	N/A	Y	18:00	NO OVERFLOW UNTIL 17:40
8	24 Hours	0:25	0:40	N	N/A	N	N/A	Y	1:10	

WET WEATHER EVENT: 1

STORM WATER STATION: SW-05A

DATE: *3/31/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *23:30*

Sampling	Sample Interval (Hours)	Target Sample (hh:mm)	Actual Sample (hh:mm)	Duplicate (Y/N)	Duplicate (hh:mm)	Field Blank (Y/N)	Field Blank (hh:mm)	Chain of (Y/N)	Time Sample (hh:mm)	Filed Observations (see notes, below)
1	T=0 (First Flush)	0:00	0:00					Y	2:19	43°F, Rain
2	30 Min	0:30	0:30					Y	2:19	
3	60 Min	1:00	1:00					Y	2:19	
4	2 Hours	2:00	2:00					Y	2:18	
5	4 Hours	4:00	4:00					Y	6:20	
6	8 Hours	8:00	8:00					Y	8:07	
7	12 Hours	12:00	12:00					Y	13:37	
8	24 Hours	0:00	0:15					Y	1:10	

STORM WATER STATION: SW-SS2

1	T=0 (First Flush)	23:50	23:50					Y	2:19	43°F, Rain
2	30 Min	0:20	0:20					Y	2:19	
3	60 Min	0:50	0:50					Y	2:19	
4	2 Hours	1:50	1:50					Y	2:18	
5	4 Hours	3:50	3:50					Y	6:20	
6	8 Hours	7:50	7:50					Y	8:07	
7	12 Hours	11:50	11:50					Y	13:37	
8	24 Hours	23:50	0:20					Y	1:10	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6732900-1	SW-SS2-4	03/31/17 01:50am	ENTEROCOCCUS-MF 24	EPA 1600	19000 E	03/31/17 09:25AM	ARD
L6732900-1	SW-SS2-4	03/31/17 01:50am	FECAL COLIFORM-MF	SM 9222D	1280 E	03/31/17 09:09AM	ARD
L6732900-1	SW-SS2-4	03/31/17 01:50am	E. COLI-MF (1603)	EPA 1603	790 E, Q	03/31/17 10:34AM	ARD
L6732900-2	SW-05A-4	03/31/17 02:00am	ENTEROCOCCUS-MF 24	EPA 1600	5300	03/31/17 09:25AM	ARD
L6732900-2	SW-05A-4	03/31/17 02:00am	FECAL COLIFORM-MF	SM 9222D	180 E	03/31/17 09:09AM	ARD
L6732900-2	SW-05A-4	03/31/17 02:00am	E. COLI-MF (1603)	EPA 1603	144 E, Q	03/31/17 10:34AM	ARD
L6732900-3	SW-SS2-1	03/30/17 11:50pm	ENTEROCOCCUS-MF 24	EPA 1600	44000	03/31/17 07:36AM	ARD
L6732900-3	SW-SS2-1	03/30/17 11:50pm	FECAL COLIFORM-MF	SM 9222D	2100	03/31/17 07:43AM	ARD
L6732900-3	SW-SS2-1	03/30/17 11:50pm	E. COLI-MF (1603)	EPA 1603	900 E, Q	03/31/17 10:34AM	ARD
L6732900-4	SW-05A-1	03/31/17 12:00am	FECAL COLIFORM-MF	SM 9222D	140 E	03/31/17 07:43AM	ARD
L6732900-4	SW-05A-1	03/31/17 12:00am	E. COLI-MF (1603)	EPA 1603	120 E,Q	03/31/17 08:04AM	BHS
L6732900-4	SW-05A-1	03/31/17 12:00am	ENTEROCOCCUS-MF 24	EPA 1600	3100 Q	03/31/17 09:25AM	ARD
L6732900-5	SW-S52-2	03/31/17 12:20am	E. COLI-MF (1603)	EPA 1603	660 E	03/31/17 08:04AM	BHS
L6732900-5	SW-S52-2	03/31/17 12:20am	ENTEROCOCCUS-MF 24	EPA 1600	20000 Q	03/31/17 09:25AM	ARD
L6732900-5	SW-S52-2	03/31/17 12:20am	FECAL COLIFORM-MF	SM 9222D	503 E, Q	03/31/17 08:59AM	ARD
L6732900-6	SW-05A-2	03/31/17 12:30am	ENTEROCOCCUS-MF 24	EPA 1600	1455 E, Q	03/31/17 09:25AM	ARD
L6732900-6	SW-05A-2	03/31/17 12:30am	FECAL COLIFORM-MF	SM 9222D	130 E, Q	03/31/17 09:09AM	ARD
L6732900-6	SW-05A-2	03/31/17 12:30am	E. COLI-MF (1603)	EPA 1603	720 E, Q	03/31/17 10:34AM	ARD
L6732900-7	SW-SS2-3	03/31/17 12:50am	ENTEROCOCCUS-MF 24	EPA 1600	46000 Q	03/31/17 09:25AM	ARD
L6732900-7	SW-SS2-3	03/31/17 12:50am	FECAL COLIFORM-MF	SM 9222D	1140 E, Q	03/31/17 09:09AM	ARD
L6732900-7	SW-SS2-3	03/31/17 12:50am	E. COLI-MF (1603)	EPA 1603	50 E, Q	03/31/17 10:34AM	ARD
L6732900-8	SW-SSA-3	03/31/17 01:00am	FECAL COLIFORM-MF	SM 9222D	20	03/31/17 08:02AM	ARD
L6732900-8	SW-SSA-3	03/31/17 01:00am	ENTEROCOCCUS-MF 24	EPA 1600	1091 E,Q	03/31/17 09:25AM	ARD
L6732900-8	SW-SSA-3	03/31/17 01:00am	E. COLI-MF (1603)	EPA 1603	36 E, Q	03/31/17 10:34AM	ARD
L6732900-9	CS0-02-B	03/30/17 11:48pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/31/17 07:36AM	ARD
L6732900-9	CS0-02-B	03/30/17 11:48pm	FECAL COLIFORM-MF	SM 9222D	<10	03/31/17 07:43AM	ARD
L6732900-9	CS0-02-B	03/30/17 11:48pm	E. COLI-MF (1603)	EPA 1603	81 E, Q	03/31/17 10:34AM	ARD
L6732904-1	SW-SS2-5	03/31/17 03:50am	ENTEROCOCCUS-MF 24	EPA 1600	6600 E	03/31/17 11:26AM	GNM
L6732904-1	SW-SS2-5	03/31/17 03:50am	E. COLI-MF (1603)	EPA 1603	490	03/31/17 11:46AM	BHS
L6732904-1	SW-SS2-5	03/31/17 03:50am	FECAL COLIFORM-MF	SM 9222D	550	03/31/17 11:36AM	ARD
L6732904-2	SW-05A-5	03/31/17 04:00am	ENTEROCOCCUS-MF 24	EPA 1600	6100 E	03/31/17 11:26AM	GNM
L6732904-2	SW-05A-5	03/31/17 04:00am	E. COLI-MF (1603)	EPA 1603	100 E	03/31/17 11:46AM	BHS
L6732904-2	SW-05A-5	03/31/17 04:00am	FECAL COLIFORM-MF	SM 9222D	146 E	03/31/17 11:36AM	ARD
L6732904-3	DR-03-2	03/31/17 04:30am	ENTEROCOCCUS-MF 24	EPA 1600	20 E	03/31/17 11:26AM	GNM
L6732904-3	DR-03-2	03/31/17 04:30am	E. COLI-MF (1603)	EPA 1603	80 E	03/31/17 11:46AM	BHS
L6732904-3	DR-03-2	03/31/17 04:30am	FECAL COLIFORM-MF	SM 9222D	80 E	03/31/17 11:50AM	GNM
L6732904-4	DR-02-2-D	03/31/17 04:50am	ENTEROCOCCUS-MF 24	EPA 1600	20 E	03/31/17 11:26AM	GNM
L6732904-4	DR-02-2-D	03/31/17 04:50am	E. COLI-MF (1603)	EPA 1603	40 E	03/31/17 11:46AM	BHS
L6732904-4	DR-02-2-D	03/31/17 04:50am	FECAL COLIFORM-MF	SM 9222D	91 E	03/31/17 11:36AM	ARD
L6732904-5	DR-02-2	03/31/17 04:50am	ENTEROCOCCUS-MF 24	EPA 1600	10 E	03/31/17 11:26AM	GNM
L6732904-5	DR-02-2	03/31/17 04:50am	E. COLI-MF (1603)	EPA 1603	70 E	03/31/17 11:46AM	BHS
L6732904-5	DR-02-2	03/31/17 04:50am	FECAL COLIFORM-MF	SM 9222D	60 E	03/31/17 11:11AM	ARD
L6732904-6	BLANK-DR	03/31/17 04:33am	ENTEROCOCCUS-MF 24	EPA 1600	<2	03/31/17 11:26AM	GNM
L6732904-6	BLANK-DR	03/31/17 04:33am	E. COLI-MF (1603)	EPA 1603	<2	03/31/17 11:46AM	BHS
L6732904-6	BLANK-DR	03/31/17 04:33am	FECAL COLIFORM-MF	SM 9222D	<2	03/31/17 11:36AM	ARD
L6732904-7	DR-04-2	03/31/17 04:00am	ENTEROCOCCUS-MF 24	EPA 1600	60 E	03/31/17 11:26AM	GNM
L6732904-7	DR-04-2	03/31/17 04:00am	E. COLI-MF (1603)	EPA 1603	30 E	03/31/17 11:46AM	BHS
L6732904-7	DR-04-2	03/31/17 04:00am	FECAL COLIFORM-MF	SM 9222D	100 E	03/31/17 11:11AM	ARD

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6732904-8	DR-05-2	03/31/17 03:45am	ENTEROCOCCUS-MF 24	EPA 1600	40 E	03/31/17 11:26AM	GNM
L6732904-8	DR-05-2	03/31/17 03:45am	FECAL COLIFORM-MF	SM 9222D	60 E	03/31/17 11:11AM	ARD
L6732904-8	DR-05-2	03/31/17 03:45am	E. COLI-MF (1603)	EPA 1603	73 E, Q	03/31/17 11:46AM	BHS
L6732904-9	DR-06-2	03/31/17 03:30am	ENTEROCOCCUS-MF 24	EPA 1600	<10	03/31/17 11:26AM	GNM
L6732904-9	DR-06-2	03/31/17 03:30am	FECAL COLIFORM-MF	SM 9222D	20 E	03/31/17 11:11AM	ARD
L6732904-9	DR-06-2	03/31/17 03:30am	E. COLI-MF (1603)	EPA 1603	E, Q	03/31/17 11:46AM	BHS
L6732905-1	DR-05-3	03/31/17 07:00am	E. COLI-MF (1603)	EPA 1603	<10 Q	03/31/17 04:29PM	BHS
L6732905-1	DR-05-3	03/31/17 07:00am	FECAL COLIFORM-MF	SM 9222D	30 E, Q	03/31/17 04:36PM	BHS
L6732905-1	DR-05-3	03/31/17 07:00am	ENTEROCOCCUS-MF 24	EPA 1600	<10 Q	03/31/17 04:37PM	BHS
L6732905-2	DR-04-3	03/31/17 07:30am	E. COLI-MF (1603)	EPA 1603	91 E, Q	03/31/17 04:29PM	BHS
L6732905-2	DR-04-3	03/31/17 07:30am	FECAL COLIFORM-MF	SM 9222D	100 E, Q	03/31/17 04:36PM	BHS
L6732905-2	DR-04-3	03/31/17 07:30am	ENTEROCOCCUS-MF 24	EPA 1600	40 E, Q	03/31/17 04:37PM	BHS
L6732905-3	SW-SS2-6	03/31/17 07:00am	E. COLI-MF (1603)	EPA 1603	838 E, Q	03/31/17 04:29PM	BHS
L6732905-3	SW-SS2-6	03/31/17 07:00am	FECAL COLIFORM-MF	SM 9222D	685 E, Q	03/31/17 04:36PM	BHS
L6732905-3	SW-SS2-6	03/31/17 07:00am	ENTEROCOCCUS-MF 24	EPA 1600	20000 Q	03/31/17 04:37PM	BHS
L6732905-4	SW-05A-6	03/31/17 08:00am	E. COLI-MF (1603)	EPA 1603	1640 E, Q	03/31/17 04:29PM	BHS
L6732905-4	SW-05A-6	03/31/17 08:00am	FECAL COLIFORM-MF	SM 9222D	1586 E, Q	03/31/17 04:36PM	BHS
L6732905-4	SW-05A-6	03/31/17 08:00am	ENTEROCOCCUS-MF 24	EPA 1600	42000 Q	03/31/17 04:37PM	BHS
L6732905-5	DR-01-3	03/31/17 07:45am	E. COLI-MF (1603)	EPA 1603	164 E, Q	03/31/17 08:39PM	BHS
L6732905-5	DR-01-3	03/31/17 07:45am	ENTEROCOCCUS-MF 24	EPA 1600	200 Q	03/31/17 08:51PM	BHS
L6732905-5	DR-01-3	03/31/17 07:45am	FECAL COLIFORM-MF	SM 9222D	73 E, Q	03/31/17 09:05PM	BHS
L6732905-6	CS0-19-6	03/31/17 08:50am	E. COLI-MF (1603)	EPA 1603	1380000 E	03/31/17 04:29PM	BHS
L6732905-6	CS0-19-6	03/31/17 08:50am	FECAL COLIFORM-MF	SM 9222D	490000	03/31/17 04:36PM	BHS
L6732905-6	CS0-19-6	03/31/17 08:50am	ENTEROCOCCUS-MF 24	EPA 1600	132000 E	03/31/17 04:37PM	BHS
L6732905-7	CS0-18-5	03/31/17 09:40am	E. COLI-MF (1603)	EPA 1603	267000 E	03/31/17 04:29PM	BHS
L6732905-7	CS0-18-5	03/31/17 09:40am	FECAL COLIFORM-MF	SM 9222D	780000 E	03/31/17 04:36PM	BHS
L6732905-7	CS0-18-5	03/31/17 09:40am	ENTEROCOCCUS-MF 24	EPA 1600	160000 E	03/31/17 04:37PM	BHS
L6732905-8	CS0-02-6	03/31/17 09:25am	E. COLI-MF (1603)	EPA 1603	265000 E	03/31/17 04:29PM	BHS
L6732905-8	CS0-02-6	03/31/17 09:25am	FECAL COLIFORM-MF	SM 9222D	560000	03/31/17 04:36PM	BHS
L6732905-8	CS0-02-6	03/31/17 09:25am	ENTEROCOCCUS-MF 24	EPA 1600	550000	03/31/17 04:37PM	BHS
L6732905-9	DUPCS0-02	03/31/17 09:25am	E. COLI-MF (1603)	EPA 1603	168000 E	03/31/17 04:29PM	BHS
L6732905-9	DUPCS0-02	03/31/17 09:25am	FECAL COLIFORM-MF	SM 9222D	170000 E	03/31/17 04:36PM	BHS
L6732905-9	DUPCS0-02	03/31/17 09:25am	ENTEROCOCCUS-MF 24	EPA 1600	450000	03/31/17 04:37PM	BHS
L6735514-1	CS0-02-8	04/01/17 12:00am	FECAL COLIFORM-MF	SM 9222D	39000 Q	04/01/17 08:18AM	ARD
L6735514-1	CS0-02-8	04/01/17 12:00am	E. COLI-MF (1603)	EPA 1603	25000	04/01/17 07:44AM	ARD
L6735514-1	CS0-02-8	04/01/17 12:00am	ENTEROCOCCUS-MF 24	EPA 1600	5600	04/01/17 07:00AM	ARD
L6735514-2	CS0-02-8	04/01/17 12:15am	FECAL COLIFORM-MF	SM 9222D	50000	04/01/17 07:23AM	ARD
L6735514-2	CS0-02-8	04/01/17 12:15am	E. COLI-MF (1603)	EPA 1603	33000	04/01/17 07:44AM	ARD
L6735514-2	CS0-02-8	04/01/17 12:15am	ENTEROCOCCUS-MF 24	EPA 1600	28000	04/01/17 07:00AM	ARD
L6735514-3	CS0-05-8	04/01/17 12:20am	FECAL COLIFORM-MF	SM 9222D	126 E	04/01/17 08:18AM	ARD
L6735514-3	CS0-05-8	04/01/17 12:20am	E. COLI-MF (1603)	EPA 1603	100 E	04/01/17 06:55AM	ARD
L6735514-3	CS0-05-8	04/01/17 12:20am	ENTEROCOCCUS-MF 24	EPA 1600	2300	04/01/17 07:00AM	ARD
L6735514-4	150-19-8	04/01/17 12:40am	FECAL COLIFORM-MF	SM 9222D	74546 E	04/01/17 08:18AM	ARD
L6735514-4	150-19-8	04/01/17 12:40am	E. COLI-MF (1603)	EPA 1603	80000 E	04/01/17 07:44AM	ARD
L6735514-4	150-19-8	04/01/17 12:40am	ENTEROCOCCUS-MF 24	EPA 1600	46000	04/01/17 07:00AM	ARD
L6735514-5	SW-05A-8	04/01/17 12:55am	FECAL COLIFORM-MF	SM 9222D	6937 E	04/01/17 08:18AM	ARD
L6735514-5	SW-05A-8	04/01/17 12:55am	E. COLI-MF (1603)	EPA 1603	6100	04/01/17 07:44AM	ARD
L6735514-5	SW-05A-8	04/01/17 12:55am	ENTEROCOCCUS-MF 24	EPA 1600	150000 E	04/01/17 07:00AM	ARD
L6735514-6	DR-06-09	03/31/17 11:00pm	E. COLI-MF (1603)	EPA 1603	90 E	04/01/17 06:55AM	ARD
L6735514-6	DR-06-09	03/31/17 11:00pm	FECAL COLIFORM-MF	SM 9222D	60 Q,E	04/01/17 07:23AM	ARD
L6735514-6	DR-06-09	03/31/17 11:00pm	ENTEROCOCCUS-MF 24	EPA 1600	20 E	04/01/17 07:00AM	ARD

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6735514-7	DR-07-09	03/31/17 11:15pm	E. COLI-MF (1603)	EPA 1603	20 E	04/01/17 06:55AM	ARD
L6735514-7	DR-07-09	03/31/17 11:15pm	FECAL COLIFORM-MF	SM 9222D	18 Q, E	04/01/17 07:23AM	ARD
L6735514-7	DR-07-09	03/31/17 11:15pm	ENTEROCOCCUS-MF 24	EPA 1600	20 E	04/01/17 07:00AM	ARD
L6735514-8	DR-01-09	03/31/17 11:35pm	E. COLI-MF (1603)	EPA 1603	1700 E	04/01/17 06:55AM	ARD
L6735514-8	DR-01-09	03/31/17 11:35pm	FECAL COLIFORM-MF	SM 9222D	700 E	04/01/17 07:23AM	ARD
L6735514-8	DR-01-09	03/31/17 11:35pm	ENTEROCOCCUS-MF 24	EPA 1600	3300	04/01/17 07:00AM	ARD
L6735514-9	DR-02-09	03/31/17 11:45pm	E. COLI-MF (1603)	EPA 1603	80 E	04/01/17 06:55AM	ARD
L6735514-9	DR-02-09	03/31/17 11:45pm	FECAL COLIFORM-MF	SM 9222D	60 E	04/01/17 07:23AM	ARD
L6735514-9	DR-02-09	03/31/17 11:45pm	ENTEROCOCCUS-MF 24	EPA 1600	90 E	04/01/17 07:00AM	ARD
L6732900-10	CS0-02-1	03/30/17 11:54pm	ENTEROCOCCUS-MF 24	EPA 1600	100000 E	03/31/17 07:36AM	ARD
L6732900-10	CS0-02-1	03/30/17 11:54pm	FECAL COLIFORM-MF	SM 9222D	234000 E	03/31/17 07:43AM	ARD
L6732900-10	CS0-02-1	03/30/17 11:54pm	E. COLI-MF (1603)	EPA 1603	35000 Q	03/31/17 10:34AM	ARD
L6732900-11	CS0-05-1	03/31/17 12:17am	E. COLI-MF (1603)	EPA 1603	115000 E	03/31/17 08:04AM	BHS
L6732900-11	CS0-05-1	03/31/17 12:17am	ENTEROCOCCUS-MF 24	EPA 1600	57000 Q	03/31/17 09:25AM	ARD
L6732900-11	CS0-05-1	03/31/17 12:17am	FECAL COLIFORM-MF	SM 9222D	128000 E, Q	03/31/17 09:09AM	ARD
L6732900-12	DR-01-1	03/31/17 01:10am	FECAL COLIFORM-MF	SM 9222D	153 E	03/31/17 08:02AM	ARD
L6732900-12	DR-01-1	03/31/17 01:10am	ENTEROCOCCUS-MF 24	EPA 1600	72 E, Q	03/31/17 09:25AM	ARD
L6732900-12	DR-01-1	03/31/17 01:10am	E. COLI-MF (1603)	EPA 1603	390 Q	03/31/17 10:34AM	ARD
L6732900-13	DR-02-1	03/31/17 01:31am	FECAL COLIFORM-MF	SM 9222D	137 E	03/31/17 08:02AM	ARD
L6732900-13	DR-02-1	03/31/17 01:31am	ENTEROCOCCUS-MF 24	EPA 1600	40 E	03/31/17 09:25AM	ARD
L6732900-13	DR-02-1	03/31/17 01:31am	E. COLI-MF (1603)	EPA 1603	182 E, Q	03/31/17 10:34AM	ARD
L6732900-14	DR-03-1	03/31/17 01:40am	ENTEROCOCCUS-MF 24	EPA 1600	90 E	03/31/17 07:36AM	ARD
L6732900-14	DR-03-1	03/31/17 01:40am	FECAL COLIFORM-MF	SM 9222D	130 E	03/31/17 08:02AM	ARD
L6732900-14	DR-03-1	03/31/17 01:40am	E. COLI-MF (1603)	EPA 1603	153 E, Q	03/31/17 10:34AM	ARD
L6732900-15	DR-04-1	03/31/17 01:35am	ENTEROCOCCUS-MF 24	EPA 1600	170 E	03/31/17 07:36AM	ARD
L6732900-15	DR-04-1	03/31/17 01:35am	FECAL COLIFORM-MF	SM 9222D	1300 E	03/31/17 08:02AM	ARD
L6732900-15	DR-04-1	03/31/17 01:35am	E. COLI-MF (1603)	EPA 1603	91 E, Q	03/31/17 10:34AM	ARD
L6732900-16	DR-05-1	03/31/17 02:10am	ENTEROCOCCUS-MF 24	EPA 1600	30 E	03/31/17 07:36AM	ARD
L6732900-16	DR-05-1	03/31/17 02:10am	E. COLI-MF (1603)	EPA 1603	60 E	03/31/17 08:04AM	BHS
L6732900-16	DR-05-1	03/31/17 02:10am	FECAL COLIFORM-MF	SM 9222D	112 E	03/31/17 08:02AM	ARD
L6732900-17	DUP DR-04-HR15	03/31/17 01:35am	ENTEROCOCCUS-MF 24	EPA 1600	100 E	03/31/17 07:36AM	ARD
L6732900-17	DUP DR-04-HR15	03/31/17 01:35am	E. COLI-MF (1603)	EPA 1603	450	03/31/17 08:04AM	BHS
L6732900-17	DUP DR-04-HR15	03/31/17 01:35am	FECAL COLIFORM-MF	SM 9222D	1300 E	03/31/17 08:02AM	ARD
L6732900-18	CC-03-01	03/31/17 12:00am	ENTEROCOCCUS-MF 24	EPA 1600	230	03/31/17 07:36AM	ARD
L6732900-18	CC-03-01	03/31/17 12:00am	FECAL COLIFORM-MF	SM 9222D	430	03/31/17 07:43AM	ARD
L6732900-18	CC-03-01	03/31/17 12:00am	E. COLI-MF (1603)	EPA 1603	330 Q	03/31/17 08:04AM	BHS
L6732900-19	CC-03-DUP	03/31/17 12:00am	ENTEROCOCCUS-MF 24	EPA 1600	130 E	03/31/17 07:36AM	ARD
L6732900-19	CC-03-DUP	03/31/17 12:00am	FECAL COLIFORM-MF	SM 9222D	300	03/31/17 07:43AM	ARD
L6732900-19	CC-03-DUP	03/31/17 12:00am	E. COLI-MF (1603)	EPA 1603	210 Q	03/31/17 08:04AM	BHS
L6732900-20	CC-02-01	03/31/17 12:40am	ENTEROCOCCUS-MF 24	EPA 1600	1700 E	03/31/17 07:36AM	ARD
L6732900-20	CC-02-01	03/31/17 12:40am	E. COLI-MF (1603)	EPA 1603	5700	03/31/17 08:04AM	BHS
L6732900-20	CC-02-01	03/31/17 12:40am	FECAL COLIFORM-MF	SM 9222D	12500 E	03/31/17 08:02AM	ARD
L6732900-21	BLANK CC	03/31/17 12:05am	ENTEROCOCCUS-MF 24	EPA 1600	<2	03/31/17 07:36AM	ARD
L6732900-21	BLANK CC	03/31/17 12:05am	E. COLI-MF (1603)	EPA 1603	<2	03/31/17 08:04AM	BHS
L6732900-21	BLANK CC	03/31/17 12:05am	FECAL COLIFORM-MF	SM 9222D	<2 Q	03/31/17 09:09AM	ARD
L6732900-22	CC-01-01	03/31/17 01:00am	E. COLI-MF (1603)	EPA 1603	40 E	03/31/17 08:04AM	BHS
L6732900-22	CC-01-01	03/31/17 01:00am	FECAL COLIFORM-MF	SM 9222D	59	03/31/17 08:59AM	ARD
L6732900-22	CC-01-01	03/31/17 01:00am	ENTEROCOCCUS-MF 24	EPA 1600	260 Q	03/31/17 09:25AM	ARD
L6732900-23	RC-01-01	03/31/17 01:35am	E. COLI-MF (1603)	EPA 1603	380	03/31/17 08:04AM	BHS
L6732900-23	RC-01-01	03/31/17 01:35am	FECAL COLIFORM-MF	SM 9222D	2200	03/31/17 08:02AM	ARD
L6732900-23	RC-01-01	03/31/17 01:35am	ENTEROCOCCUS-MF 24	EPA 1600	1700 E	03/31/17 09:25AM	ARD

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6732900-24	RC-02-01	03/31/17 02:06am	FECAL COLIFORM-MF	SM 9222D	15700 E	03/31/17 08:02AM	ARD
L6732900-24	RC-02-01	03/31/17 02:06am	ENTEROCOCCUS-MF 24	EPA 1600	2800	03/31/17 09:25AM	ARD
L6732900-24	RC-02-01	03/31/17 02:06am	E. COLI-MF (1603)	EPA 1603	6000 Q	03/31/17 10:34AM	ARD
L6732900-25	RC-03-01	03/31/17 02:37am	ENTEROCOCCUS-MF 24	EPA 1600	20 E	03/31/17 09:25AM	ARD
L6732900-25	RC-03-01	03/31/17 02:37am	FECAL COLIFORM-MF	SM 9222D	250	03/31/17 09:09AM	ARD
L6732900-25	RC-03-01	03/31/17 02:37am	E. COLI-MF (1603)	EPA 1603	100 E	03/31/17 10:34AM	ARD
L6732900-26	CS0-18-1	03/31/17 12:07am	ENTEROCOCCUS-MF 24	EPA 1600	19000 E	03/31/17 07:36AM	ARD
L6732900-26	CS0-18-1	03/31/17 12:07am	E. COLI-MF (1603)	EPA 1603	63000 E	03/31/17 08:04AM	BHS
L6732900-26	CS0-18-1	03/31/17 12:07am	FECAL COLIFORM-MF	SM 9222D	85000 E, Q	03/31/17 09:34AM	ARD
L6732900-27	CS0-19-1	03/31/17 12:25am	ENTEROCOCCUS-MF 24	EPA 1600	3220000 E	03/31/17 07:36AM	ARD
L6732900-27	CS0-19-1	03/31/17 12:25am	E. COLI-MF (1603)	EPA 1603	160000 E	03/31/17 08:04AM	BHS
L6732900-27	CS0-19-1	03/31/17 12:25am	FECAL COLIFORM-MF	SM 9222D	30100 E, Q	03/31/17 09:09AM	ARD
L6732900-28	CS0-19-2	03/31/17 01:55am	ENTEROCOCCUS-MF 24	EPA 1600	200000	03/31/17 09:25AM	ARD
L6732900-28	CS0-19-2	03/31/17 01:55am	FECAL COLIFORM-MF	SM 9222D	197000 E	03/31/17 09:09AM	ARD
L6732900-28	CS0-19-2	03/31/17 01:55am	E. COLI-MF (1603)	EPA 1603	80000 Q	03/31/17 10:34AM	ARD
L6732900-29	CS0-18-2	03/31/17 01:45am	ENTEROCOCCUS-MF 24	EPA 1600	29000	03/31/17 09:25AM	ARD
L6732900-29	CS0-18-2	03/31/17 01:45am	FECAL COLIFORM-MF	SM 9222D	69000 E	03/31/17 09:34AM	ARD
L6732900-29	CS0-18-2	03/31/17 01:45am	E. COLI-MF (1603)	EPA 1603	51000 Q	03/31/17 10:34AM	ARD
L6732900-30	CS0-19-3	03/31/17 01:58am	ENTEROCOCCUS-MF 24	EPA 1600	53000	03/31/17 09:25AM	ARD
L6732900-30	CS0-19-3	03/31/17 01:58am	FECAL COLIFORM-MF	SM 9222D	215000 E	03/31/17 09:09AM	ARD
L6732900-30	CS0-19-3	03/31/17 01:58am	E. COLI-MF (1603)	EPA 1603	52000 Q	03/31/17 10:34AM	ARD
L6732900-31	CS0-18-3	03/31/17 02:10am	ENTEROCOCCUS-MF 24	EPA 1600	17000 E	03/31/17 09:25AM	ARD
L6732900-31	CS0-18-3	03/31/17 02:10am	FECAL COLIFORM-MF	SM 9222D	78000 E	03/31/17 09:34AM	ARD
L6732900-31	CS0-18-3	03/31/17 02:10am	E. COLI-MF (1603)	EPA 1603	67000 Q	03/31/17 10:34AM	ARD
L6732900-32	CS0-19-4	03/31/17 02:55am	ENTEROCOCCUS-MF 24	EPA 1600	>600000	03/31/17 09:25AM	ARD
L6732900-32	CS0-19-4	03/31/17 02:55am	E. COLI-MF (1603)	EPA 1603	120000 E	03/31/17 10:34AM	ARD
L6732900-32	CS0-19-4	03/31/17 02:55am	FECAL COLIFORM-MF	SM 9222D	330000	03/31/17 09:34AM	ARD
L6732900-33	CS0-18-4	03/31/17 03:10am	ENTEROCOCCUS-MF 24	EPA 1600	20000	03/31/17 09:25AM	ARD
L6732900-33	CS0-18-4	03/31/17 03:10am	E. COLI-MF (1603)	EPA 1603	69000	03/31/17 10:34AM	ARD
L6732900-33	CS0-18-4	03/31/17 03:10am	FECAL COLIFORM-MF	SM 9222D	85000 E	03/31/17 09:34AM	ARD
L6732900-34	BLANK CS0-18	03/31/17 12:03am	ENTEROCOCCUS-MF 24	EPA 1600	<2	03/31/17 07:36AM	ARD
L6732900-34	BLANK CS0-18	03/31/17 12:03am	E. COLI-MF (1603)	EPA 1603	<2 Q	03/31/17 08:04AM	BHS
L6732900-34	BLANK CS0-18	03/31/17 12:03am	FECAL COLIFORM-MF	SM 9222D	<2 Q	03/31/17 09:09AM	ARD
L6732900-35	CS0-02-2	03/31/17 01:35am	ENTEROCOCCUS-MF 24	EPA 1600	43000	03/31/17 09:25AM	ARD
L6732900-35	CS0-02-2	03/31/17 01:35am	FECAL COLIFORM-MF	SM 9222D	140000 E	03/31/17 09:09AM	ARD
L6732900-35	CS0-02-2	03/31/17 01:35am	E. COLI-MF (1603)	EPA 1603	89000 E, Q	03/31/17 10:34AM	ARD
L6732900-36	CS0-05-02	03/31/17 01:45am	ENTEROCOCCUS-MF 24	EPA 1600	135000 E	03/31/17 09:25AM	ARD
L6732900-36	CS0-05-02	03/31/17 01:45am	FECAL COLIFORM-MF	SM 9222D	199000 E	03/31/17 09:09AM	ARD
L6732900-36	CS0-05-02	03/31/17 01:45am	E. COLI-MF (1603)	EPA 1603	240000 Q	03/31/17 10:34AM	ARD
L6732900-37	CS0-02-3	03/31/17 02:08am	ENTEROCOCCUS-MF 24	EPA 1600	37000	03/31/17 09:25AM	ARD
L6732900-37	CS0-02-3	03/31/17 02:08am	FECAL COLIFORM-MF	SM 9222D	123000 E	03/31/17 09:09AM	ARD
L6732900-37	CS0-02-3	03/31/17 02:08am	E. COLI-MF (1603)	EPA 1603	30000 E, Q	03/31/17 10:34AM	ARD
L6732900-38	CS0-05-3	03/31/17 02:20am	ENTEROCOCCUS-MF 24	EPA 1600	19000 E	03/31/17 09:25AM	ARD
L6732900-38	CS0-05-3	03/31/17 02:20am	FECAL COLIFORM-MF	SM 9222D	140000 E	03/31/17 08:59AM	ARD
L6732900-38	CS0-05-3	03/31/17 02:20am	E. COLI-MF (1603)	EPA 1603	90000 E, Q	03/31/17 10:34AM	ARD
L6732900-39	CS0-02-4	03/31/17 03:09am	ENTEROCOCCUS-MF 24	EPA 1600	410000	03/31/17 09:25AM	ARD
L6732900-39	CS0-02-4	03/31/17 03:09am	FECAL COLIFORM-MF	SM 9222D	1630000 E	03/31/17 08:59AM	ARD
L6732900-39	CS0-02-4	03/31/17 03:09am	E. COLI-MF (1603)	EPA 1603	1130000 E	03/31/17 10:34AM	ARD
L6732900-40	CS0-05-4	03/31/17 03:20am	ENTEROCOCCUS-MF 24	EPA 1600	27000	03/31/17 09:25AM	ARD
L6732900-40	CS0-05-4	03/31/17 03:20am	FECAL COLIFORM-MF	SM 9222D	43000	03/31/17 08:59AM	ARD
L6732900-40	CS0-05-4	03/31/17 03:20am	E. COLI-MF (1603)	EPA 1603	29000	03/31/17 10:34AM	ARD

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6732900-41	CS0-05-B	03/31/17 12:08am	ENTEROCOCCUS-MF 24	EPA 1600	<2	03/31/17 07:36AM	ARD
L6732900-41	CS0-05-B	03/31/17 12:08am	E. COLI-MF (1603)	EPA 1603	<2	03/31/17 08:04AM	BHS
L6732900-41	CS0-05-B	03/31/17 12:08am	FECAL COLIFORM-MF	SM 9222D	<2 Q	03/31/17 09:09AM	ARD
L6732904-10	DR-07-2	03/31/17 03:20am	FECAL COLIFORM-MF	SM 9222D	80 E	03/31/17 11:11AM	ARD
L6732904-10	DR-07-2	03/31/17 03:20am	ENTEROCOCCUS-MF 24	EPA 1600	30 E, Q	03/31/17 11:26AM	GNM
L6732904-10	DR-07-2	03/31/17 03:20am	E. COLI-MF (1603)	EPA 1603	60 E, Q	03/31/17 11:46AM	BHS
L6732904-11	CS0-19-5	03/31/17 04:55am	ENTEROCOCCUS-MF 24	EPA 1600	15000 E	03/31/17 11:26AM	GNM
L6732904-11	CS0-19-5	03/31/17 04:55am	E. COLI-MF (1603)	EPA 1603	151000 E	03/31/17 11:46AM	BHS
L6732904-11	CS0-19-5	03/31/17 04:55am	FECAL COLIFORM-MF	SM 9222D	38000	03/31/17 11:36AM	ARD
L6732904-12	CC-03-2	03/31/17 04:00am	ENTEROCOCCUS-MF 24	EPA 1600	40 E	03/31/17 11:26AM	GNM
L6732904-12	CC-03-2	03/31/17 04:00am	E. COLI-MF (1603)	EPA 1603	140 E	03/31/17 11:46AM	BHS
L6732904-12	CC-03-2	03/31/17 04:00am	FECAL COLIFORM-MF	SM 9222D	300 E	03/31/17 11:50AM	GNM
L6732904-13	CC-02-2	03/31/17 04:15am	ENTEROCOCCUS-MF 24	EPA 1600	660 E	03/31/17 11:26AM	GNM
L6732904-13	CC-02-2	03/31/17 04:15am	E. COLI-MF (1603)	EPA 1603	3100	03/31/17 11:46AM	BHS
L6732904-13	CC-02-2	03/31/17 04:15am	FECAL COLIFORM-MF	SM 9222D	3500	03/31/17 11:36AM	ARD
L6732904-14	CC-01-2	03/31/17 04:52am	ENTEROCOCCUS-MF 24	EPA 1600	1500 E	03/31/17 11:26AM	GNM
L6732904-14	CC-01-2	03/31/17 04:52am	E. COLI-MF (1603)	EPA 1603	330	03/31/17 11:46AM	BHS
L6732904-14	CC-01-2	03/31/17 04:52am	FECAL COLIFORM-MF	SM 9222D	270	03/31/17 11:36AM	ARD
L6732904-15	RC-01-2	03/31/17 05:19am	ENTEROCOCCUS-MF 24	EPA 1600	3500	03/31/17 11:26AM	GNM
L6732904-15	RC-01-2	03/31/17 05:19am	E. COLI-MF (1603)	EPA 1603	310	03/31/17 11:46AM	BHS
L6732904-15	RC-01-2	03/31/17 05:19am	FECAL COLIFORM-MF	SM 9222D	310	03/31/17 11:50AM	GNM

APPENDIX E

WET WEATHER EVENT 2 – FIELD LOGS AND LAB RESULTS SUMMARY

(Chain of Custody Forms and Complete Lab Results provided in digital form only on CD attached to this report)

WET WEATHER EVENT: 2

DATE: *5/5/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *7:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Water Salinity Reading (%)	Water Temperature Reading (°C)	Conductivity Reading (umhos/cm)	Field Observations (see notes, below)
IN-STREAM TRIBUTARY STATION: CC-01													
1	0.5-2.5	8:42	8:45	N	N/A	Y	8:35	Y	9:15	0.30	15.50	512	Raining
2	4.5-6.5	12:49	12:55	N	N/A	N	N/A	Y	13:15	0.10	25.80	222.5	Raining
3	8.5-10.5	16:58	17:05	N	N/A	N	N/A	Y	17:30	0.10	24.90	203.5	Raining
4	14.5-16.5	22:35	22:40	N	N/A	N	N/A	Y	23:15	0.18	12.98	291	Raining
5	22-24	5:30	5:35	N	N/A	N	N/A	Y	5:55	0.24	13.24	377	Raining
IN-STREAM TRIBUTARY STATION: CC-02													
1	0.5-2.5	7:44	7:45	Y	7:45	N	N/A	Y	8:15	0.2	16.60	415.3	Raining
2	4.5-6.5	12:33	12:35	N	N/A	N	N/A	Y	13:15	0.2	23.80	353.7	Raining
3	8.5-10.5	16:43	16:48	N	N/A	N	N/A	Y	17:30	0.1	25.80	228.6	Raining
4	14.5-16.5	22:20	22:25	N	N/A	N	N/A	Y	23:15	0.24	12.66	375	Raining
5	22-24	5:15	5:20	N	N/A	N	N/A	Y	5:55	0.24	13.25	381	Raining
IN-STREAM TRIBUTARY STATION: CC-03													
1	0.5-2.5	7:10	7:20	N	N/A	N	N/A	Y	7:55	0.20	16.70	321.4	Raining
2	4.5-6.5	11:37	11:40	N	N/A	N	N/A	Y	13:15	0.20	20.30	351.5	Raining
3	8.5-10.5	15:40	15:45	N	N/A	N	N/A	Y	17:30	0.10	25.40	255.2	Raining
4	14.5-16.5	21:15	21:20	N	N/A	N	N/A	Y	23:15	0.33	27.10	597.0	Raining
5	22-24	4:20	4:25	N	N/A	N	N/A	Y	5:55	0.20	13.15	316.0	Raining
IN-STREAM TRIBUTARY STATION: RC-01													
1	0.5-2.5	1:30	1:30	N	N/A	N	N/A	Y	3:04	0.20	8.80	419.4	Raining
2	4.5-6.5	6:30	5:22	N	N/A	N	N/A	Y	6:55	0.20	8.40	404.2	Raining
3	8.5-10.5	10:30	9:15	N	N/A	N	N/A	Y	10:15	0.19	7.94	399.0	Raining
4	14.5-16.5	16:30	15:25	Y	15:26	N	N/A	Y	16:40	0.13	8.09	270.0	Raining
5	22-24	23:30	22:55	N	N/A	N	N/A	Y	23:45	0.10	7.65	216.0	Raining
IN-STREAM TRIBUTARY STATION: RC-02													
1	0.5-2.5	8:26	8:30	N	N/A	N	N/A	Y	9:15	0.20	14.70	495.5	Raining
2	4.5-6.5	12:12	12:15	N	N/A	N	N/A	Y	13:15	0.10	23.60	188.8	Raining
3	8.5-10.5	16:25	16:30	N	N/A	N	N/A	Y	17:30	0.10	25.30	185.2	Raining
4	14.5-16.5	22:05	22:10	N	N/A	N	N/A	Y	23:15	0.27	34.90	433.0	Raining
5	22-24	5:05	5:10	N	N/A	N	N/A	Y	5:55	0.19	12.73	308.0	Raining
IN-STREAM TRIBUTARY STATION: RC-03													
1	0.5-2.5	7:30	7:35	N	N/A	N	N/A	Y	7:55	0.10	16.70	308.7	Used Bailer to collect sample
2	4.5-6.5	11:44	11:47	N	N/A	N	N/A	Y	13:15	0.20	20.30	351.5	Used Bailer to collect sample
3	8.5-10.5	15:53	16:00	N	N/A	N	N/A	Y	17:30	0.10	23.50	188.0	Used Bailer to collect sample
4	14.5-16.5	21:35	21:40	N	N/A	N	N/A	Y	23:15	0.48	31.30	846.0	Used Bailer to collect sample
5	22-24	4:30	4:35	N	N/A	N	N/A	Y	5:55	0.21	12.79	327.0	Used Bailer to collect sample

WET WEATHER EVENT: 2
DELAWARE RIVER STATION: DR-01

DATE: *5/5/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *7:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Surface, Mid-depth & Bottom Water Salinity Reading(s) (%)	Surface, Mid-depth & Bottom Water Temperature Reading(s) (°C)	Surface, Mid-depth & Bottom Water Conductivity Reading(s) (umhos/cm)	Field Observations (see notes, below)
1	0	7:36	7:36	N	N/A	Y	7:34	Y		0.19/ 0.19/ 0.19	14.36/ 14.35/ 14.36	322/ 321/ 320	
2	2	9:36	9:50	N	N/A	N	N/A	Y		0.15/ 0.15/ 0.15	16.89/ 16.81/ 16.80	271/ 271/ 271	Total Depth = 20.1 ft
3	4	11:36	12:00	N	N/A	N	N/A	Y		0.15/ 0.15/ 0.15	16.82/ 16.82/ 16.83	270/ 270/ 271	Total Depth = 20.4 ft
4	6												Round skipped due to boat issues
5	9												Round skipped due to boat issues
6	12												Round skipped due to boat issues
7	15												Round skipped due to boat issues
8	18												Round skipped due to boat issues
9	21												Round skipped due to boat issues
10	24												Round skipped due to boat issues
DELAWARE RIVER STATION: DR-02													
1	0	8:00	8:00	N	N/A	N	N/A	Y		0.20/ 0.20/ 0.20	14.50/ 14.47/ 14.45	328/ 326/ 324	
2	2	10:00	10:00	N	N/A	N	N/A	Y		0.15/ 0.15/ 0.15	16.96/ 16.96/ 16.96	264/ 263/ 262	Total Depth = 28 ft
3	4	12:00	12:10	N	N/A	N	N/A	Y		0.15/0.15/0.15	16.92/16.92/16.89	264/264/265	Total Depth = 28.2 ft
4	6												Round skipped due to boat issues
5	9												Round skipped due to boat issues
6	12												Round skipped due to boat issues
7	15												Round skipped due to boat issues
8	18												Round skipped due to boat issues
9	21												Round skipped due to boat issues
10	24												Round skipped due to boat issues
DELAWARE RIVER STATION: DR-03													
1	0	8:14	8:14	N	N/A	N	N/A	Y		0.20/ 0.20/ 0.20	14.51/ 14.51/ 14.52	334/ 333/333	
2	2	10:05	10:05	N	N/A	N	N/A	Y		0.16/ 0.16/ 0.16	17.00/ 17.00/ 16.49	276/ 276/ 275	Total Depth = 30.1
3	4	12:15	12:15	N	N/A	N	N/A	Y		0.15/0.15/0.15	16.95/16.95/16.94	265/264/264	Total Depth = 30.0
4	6	-											Round skipped due to boat issues
5	9	-											Round skipped due to boat issues
6	12	20:30	20:35	N	N/A	N	N/A	Y	23:30	0.1	23.9	246.2	Sample collected from shore near Norris Street due to boat issues
7	15	23:00	23:05	N	N/A	N	N/A	Y	23:30	0.22	14.88	363	Sample collected from shore near Norris Street due to boat issues
8	18	2:00	2:05	N	N/A	N	N/A	Y	5:55	0.2	14.4	339	Sample collected from shore near Norris Street due to boat issues
9	21	4:00	4:05	Y	4:05	N	N/A	Y	5:55	0.19	14.34	321	Sample collected from shore near Norris Street due to boat issues
10	24	6:00	6:05	N	N/A	N	N/A	Y	5:55	0.2	14.29	323	Sample collected from shore near Norris Street due to boat issues
DELAWARE RIVER STATION: DR-04													
1	0	8:05	8:05	N	N/A	N	N/A	Y		0.16/ 0.16/ 0.16	16.98/ 17.00/ 17.00	278/ 280/ 284	Total Depth = 22.5 ft
2	2	9:50	9:50	N	N/A	N	N/A	Y		0.20/ 0.20/ 0.20	14.69/ 14.67/ 14.69	327/ 332/ 335	Total Depth = 15 ft
3	4	12:10	12:10	N	N/A	N	N/A	Y		0.19/ 0.19/ 0.19	14.60/ 14.61/ 14.60	323/ 321/ 322	Total Depth = 14 ft
4	6	-											Round skipped due to boat issues
5	9	-											Round skipped due to boat issues
6	12	20:50	20:50	N	N/A	N	N/A	Y	23:30	0.1	23.6	256.1	Sample collected from shore near boat launch ramp due to boat issues
7	15	23:10	23:15	N	N/A	N	N/A	Y	23:30	0.22	14.92	371	Sample collected from shore near boat launch ramp due to boat issues
8	18	2:15	2:20	N	N/A	N	N/A	Y	5:55	0.21	14.51	340	Sample collected from shore near boat launch ramp due to boat issues
9	21	4:10	4:15	N	N/A	N	N/A	Y	5:55	0.2	14.37	331	Sample collected from shore near boat launch ramp due to boat issues
10	24	6:10	6:15	N	N/A	N	N/A	Y	5:55	0.2	14.27	324	Sample collected from shore near boat launch ramp due to boat issues

WET WEATHER EVENT: 2
DELAWARE RIVER STATION: DR-05

DATE: *5/5/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *7:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Surface, Mid-depth & Bottom Water Salinity Reading(s) (%)	Surface, Mid-depth & Bottom Water Temperature Reading(s) (°C)	Surface, Mid-depth & Bottom Water Conductivity Reading(s) (umhos/cm)	Field Observations (see notes, below)
1	0	7:55	7:55	N	N/A	N	N/A	Y		0.17/ 0.17/ 0.17	17.02/ 17.02/ 17.02	293/ 295/ 295	
2	2	10:05	10:05	N	N/A	N	N/A	Y		0.19/ 0.19/ 0.19	14.65/ 14.65/ 14.65	320/ 320/ 320	
3	4	12:17	12:17	N	N/A	N	N/A	Y		0.24/ 0.21/ 0.20	15.37/ 14.82/ 14.69	415/ 350/ 331	Total Depth = 10 ft
4	6												Round skipped due to boat issues
5	9												Round skipped due to boat issues
6	12												Round skipped due to boat issues
7	15												Round skipped due to boat issues
8	18												Round skipped due to boat issues
9	21												Round skipped due to boat issues
10	24												Round skipped due to boat issues

DELAWARE RIVER STATION: DR-06

1	0	7:45	7:45	N	N/A	N	N/A	Y		0.14/ 0.14/ 0.14	16.88/ 16.89/ 16.89	255/ 255/ 255	Total Depth = 16 ft
2	2	9:40	9:40	N	N/A	N	N/A	Y		0.19/ 0.19/ 0.19	14.62/ 14.61/ 14.60	309/ 309/ 310	Total Depth = 27 ft
3	4	12:00	12:00	N	N/A	N	N/A	Y		0.18/ 0.18/ 0.18	14.48/ 14.48/ 14.47	306/ 306/ 307	Total Depth = 27 ft
4	6												Round skipped due to boat issues
5	9												Round skipped due to boat issues
6	12												Round skipped due to boat issues
7	15												Round skipped due to boat issues
8	18												Round skipped due to boat issues
9	21												Round skipped due to boat issues
10	24												Round skipped due to boat issues

DELAWARE RIVER STATION: DR-07

1	0	7:30	7:30	N	N/A	N	N/A	Y		0.14/ 0.14/ 0.14	16.58/ 16.59/ 16.59	253/ 253/ 253	Total Depth = 15 ft
2	2	9:30	9:30	N	N/A	N	N/A	Y		0.19/ 0.19/ 0.18	14.33/ 14.33/ 14.33	306/ 306/ 305	Total Depth = 9.5 ft
3	4	11:50	11:50	N	N/A	N	N/A	Y		0.18/ 0.18/ 0.18	14.15/ 14.14/ 14.15	301/ 301/ 301	Total Depth = 4 ft
4	6												Round skipped due to boat issues
5	9												Round skipped due to boat issues
6	12												Round skipped due to boat issues
7	15												Round skipped due to boat issues
8	18												Round skipped due to boat issues
9	21												Round skipped due to boat issues
10	24												Round skipped due to boat issues

WET WEATHER EVENT: 2
CSO STATION: CSO-02

DATE: *5/5/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *7:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Filed Observations (see notes, below)
1	T=0 (First Flush)	8:20	8:20	N	N/A	N	N/A	Y	9:20	
2	30 Min	8:50	8:50	N	N/A	N	N/A	Y	9:20	
3	60 Min	9:30	9:30	N	N/A	N	N/A	Y	9:50	
4	2 Hours	10:30	10:30	N	N/A	N	N/A	Y	10:55	
5	4 Hours	12:30	12:30	N	N/A	N	N/A	Y	12:55	
6	8 Hours	16:20	-	-	-	-	-	-	-	No overflow over weir
7	12 Hours	20:20	-	-	-	-	-	-	-	No overflow over weir
8	24 Hours	8:20	-	-	-	-	-	-	-	No overflow over weir
CSO STATION: CSO-05										
1	T=0 (First Flush)	8:40	8:40	N	N/A	N	N/A	Y	9:20	
2	30 Min	9:05	9:05	N	N/A	N	N/A	Y	9:20	
3	60 Min	9:40	9:40	N	N/A	N	N/A	Y	9:50	
4	2 Hours	10:40	10:40	N	N/A	N	N/A	Y	10:55	
5	4 Hours	12:40	12:40	N	N/A	N	N/A	Y	12:55	
6	8 Hours	16:40	-	-	-	-	-	-	-	No overflow over weir
7	12 Hours	20:40	-	-	-	-	-	-	-	No overflow over weir
8	24 Hours	8:40	-	-	-	-	-	-	-	No overflow over weir
CSO STATION: CSO-18										
1	T=0 (First Flush)	8:40	8:42	N	N/A	N	N/A	Y	8:54	Overflowing to Creek
2	30 Min	9:17	9:19	N	N/A	N	N/A	Y	9:35	
3	60 Min	9:42	9:47	Y	9:47	Y	9:45	Y	9:55	
4	2 Hours	10:40	10:45	N	N/A	N	N/A	Y	10:55	
5	4 Hours	12:40	12:47	N	N/A	N	N/A	Y	12:57	
6	8 Hours	16:40	-	-	-	-	-	-	-	No overflow over weir
7	12 Hours	20:40	-	-	-	-	-	-	-	No overflow over weir
8	24 Hours	8:40	-	-	-	-	-	-	-	No overflow over weir
CSO STATION: CSO-19										
1	T=0 (First Flush)	8:35	8:27	N	N/A	N	N/A	Y	8:54	Weir not overflowing until 8:27; Water level just at top of weir wall
2	30 Min	9:05	9:07	N	N/A	N	N/A	Y	9:35	
3	60 Min	9:35	9:37	N	N/A	N	N/A	Y	9:35	
4	2 Hours	10:35	10:34	N	N/A	N	N/A	Y	10:55	
5	4 Hours	12:35	12:35	N	N/A	N	N/A	Y	12:57	
6	8 Hours	16:35	-	-	-	-	-	-	-	No overflow over weir.
7	12 Hours	20:35	-	-	-	-	-	-	-	No overflow over weir
8	24 Hours	8:35	-	-	-	-	-	-	-	No overflow over weir

WET WEATHER EVENT: 2
STORM WATER STATION: SW-05A

DATE: *5/5/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *7:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Filed Observations (see notes, below)
1	T=0 (First Flush)	6:45	6:45					Y	7:00	
2	30 Min	7:20	7:20					Y	8:00	
3	60 Min	7:45	7:50					Y	8:00	
4	2 Hours	8:45	8:50					Y	9:00	
5	4 Hours	10:45	10:50					Y	11:00	
6	8 Hours	14:45	14:45					Y	15:00	
7	12 Hours	18:45	-					-	-	No flow to collect sample
8	24 Hours	6:45	-					-	-	No flow to collect sample

STORM WATER STATION: SW-SS2

1	T=0 (First Flush)	6:40	6:40					Y	7:00	
2	30 Min	7:10	7:10					Y	8:00	
3	60 Min	7:40	7:40					Y	8:00	
4	2 Hours	8:40	8:40					Y	9:00	
5	4 Hours	10:40	10:40					Y	11:00	
6	8 Hours	14:40	14:35					Y	15:00	
7	12 Hours	18:40	-					-	-	No flow to collect sample
8	24 Hours	6:40	-					-	-	No flow to collect sample

Login Number	Sample ID	Sample Date/Time	Parameter Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6794156-1	SW-SS2-1	05/05/17 06:40am	ENTEROCOCCUS-MF 24	EPA 1600	10000 E	05/05/17 12:31PM	
L6794156-1	SW-SS2-1	05/05/17 06:40am	E. COLI-MF (1603)	EPA 1603	690	05/05/17 12:26PM	
L6794156-1	SW-SS2-1	05/05/17 06:40am	FECAL COLIFORM-MF	SM 9222D	1300 E	05/05/17 12:44PM	
L6794156-2	SW-05A-1	05/05/17 06:45am	ENTEROCOCCUS-MF 24	EPA 1600	12000 E	05/05/17 12:31PM	
L6794156-2	SW-05A-1	05/05/17 06:45am	E. COLI-MF (1603)	EPA 1603	6600	05/05/17 12:26PM	
L6794156-2	SW-05A-1	05/05/17 06:45am	FECAL COLIFORM-MF	SM 9222D	27000	05/05/17 12:44PM	
L6794156-3	SW-SS2-2	05/05/17 07:10am	ENTEROCOCCUS-MF 24	EPA 1600	8000 E	05/05/17 12:31PM	
L6794156-3	SW-SS2-2	05/05/17 07:10am	E. COLI-MF (1603)	EPA 1603	580	05/05/17 12:26PM	
L6794156-3	SW-SS2-2	05/05/17 07:10am	FECAL COLIFORM-MF	SM 9222D	3300	05/05/17 12:44PM	
L6794156-4	SW-05A-2	05/05/17 07:20am	ENTEROCOCCUS-MF 24	EPA 1600	5000 E	05/05/17 12:31PM	
L6794156-4	SW-05A-2	05/05/17 07:20am	E. COLI-MF (1603)	EPA 1603	96000 E	05/05/17 12:26PM	
L6794156-4	SW-05A-2	05/05/17 07:20am	FECAL COLIFORM-MF	SM 9222D	1480000 E	05/05/17 12:44PM	
L6794156-5	SW-SS2-3	05/05/17 07:40am	ENTEROCOCCUS-MF 24	EPA 1600	6900 E	05/05/17 12:31PM	
L6794156-5	SW-SS2-3	05/05/17 07:40am	E. COLI-MF (1603)	EPA 1603	590	05/05/17 12:26PM	
L6794156-5	SW-SS2-3	05/05/17 07:40am	FECAL COLIFORM-MF	SM 9222D	650 E	05/05/17 12:44PM	
L6794156-6	SW-05A-3	05/05/17 07:50am	ENTEROCOCCUS-MF 24	EPA 1600	38000	05/05/17 12:31PM	
L6794156-6	SW-05A-3	05/05/17 07:50am	E. COLI-MF (1603)	EPA 1603	9600 E	05/05/17 12:26PM	
L6794156-6	SW-05A-3	05/05/17 07:50am	FECAL COLIFORM-MF	SM 9222D	55000	05/05/17 12:44PM	
L6794156-7	CC-02-1	05/05/17 07:45am	ENTEROCOCCUS-MF 24	EPA 1600	132 E	05/05/17 12:31PM	
L6794156-7	CC-02-1	05/05/17 07:45am	E. COLI-MF (1603)	EPA 1603	210	05/05/17 12:26PM	
L6794156-7	CC-02-1	05/05/17 07:45am	FECAL COLIFORM-MF	SM 9222D	54	05/05/17 12:44PM	
L6794156-8	CC-03-1	05/05/17 07:20am	ENTEROCOCCUS-MF 24	EPA 1600	84	05/05/17 12:31PM	
L6794156-8	CC-03-1	05/05/17 07:20am	E. COLI-MF (1603)	EPA 1603	54	05/05/17 12:26PM	
L6794156-8	CC-03-1	05/05/17 07:20am	FECAL COLIFORM-MF	SM 9222D	52	05/05/17 12:44PM	
L6794156-9	RC-03-1	05/05/17 07:35am	ENTEROCOCCUS-MF 24	EPA 1600	72	05/05/17 12:31PM	
L6794156-9	RC-03-1	05/05/17 07:35am	E. COLI-MF (1603)	EPA 1603	250	05/05/17 01:06PM	
L6794156-9	RC-03-1	05/05/17 07:35am	FECAL COLIFORM-MF	SM 9222D	126 E	05/05/17 12:44PM	
L6794156-10	DR-01-1	05/05/17 07:36am	ENTEROCOCCUS-MF 24	EPA 1600	25 E	05/05/17 12:31PM	
L6794156-10	DR-01-1	05/05/17 07:36am	E. COLI-MF (1603)	EPA 1603	26 E	05/05/17 01:06PM	
L6794156-10	DR-01-1	05/05/17 07:36am	FECAL COLIFORM-MF	SM 9222D	20 E	05/05/17 12:44PM	
L6794156-11	DR-02-1	05/05/17 08:00am	ENTEROCOCCUS-MF 24	EPA 1600	18 E	05/05/17 12:31PM	
L6794156-11	DR-02-1	05/05/17 08:00am	E. COLI-MF (1603)	EPA 1603	20 E	05/05/17 01:06PM	
L6794156-11	DR-02-1	05/05/17 08:00am	FECAL COLIFORM-MF	SM 9222D	22 E	05/05/17 12:44PM	
L6794156-12	DR-03-1	05/05/17 08:14am	ENTEROCOCCUS-MF 24	EPA 1600	8 E	05/05/17 12:31PM	
L6794156-12	DR-03-1	05/05/17 08:14am	E. COLI-MF (1603)	EPA 1603	100	05/05/17 01:06PM	
L6794156-12	DR-03-1	05/05/17 08:14am	FECAL COLIFORM-MF	SM 9222D	22 E	05/05/17 12:44PM	
L6794156-13	BLANK-DR-2	05/05/17 07:24am	ENTEROCOCCUS-MF 24	EPA 1600	<2	05/05/17 12:31PM	
L6794156-13	BLANK-DR-2	05/05/17 07:24am	E. COLI-MF (1603)	EPA 1603	<2	05/05/17 01:06PM	
L6794156-13	BLANK-DR-2	05/05/17 07:24am	FECAL COLIFORM-MF	SM 9222D	2 E	05/05/17 12:44PM	
L6794156-14	DR-04-1	05/05/17 08:05am	ENTEROCOCCUS-MF 24	EPA 1600	12 E	05/05/17 12:31PM	
L6794156-14	DR-04-1	05/05/17 08:05am	E. COLI-MF (1603)	EPA 1603	12 E	05/05/17 01:06PM	
L6794156-14	DR-04-1	05/05/17 08:05am	FECAL COLIFORM-MF	SM 9222D	20 E	05/05/17 12:44PM	
L6794156-15	DR-05-1	05/05/17 07:55am	ENTEROCOCCUS-MF 24	EPA 1600	6 E	05/05/17 12:31PM	
L6794156-15	DR-05-1	05/05/17 07:55am	E. COLI-MF (1603)	EPA 1603	13 E	05/05/17 01:06PM	
L6794156-15	DR-05-1	05/05/17 07:55am	FECAL COLIFORM-MF	SM 9222D	42	05/05/17 12:44PM	
L6794156-16	DR-06-1	05/05/17 07:45am	ENTEROCOCCUS-MF 24	EPA 1600	4 E	05/05/17 12:31PM	
L6794156-16	DR-06-1	05/05/17 07:45am	E. COLI-MF (1603)	EPA 1603	6	05/05/17 12:26PM	
L6794156-16	DR-06-1	05/05/17 07:45am	FECAL COLIFORM-MF	SM 9222D	4 E	05/05/17 12:44PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6794156-17	DR-07-1	05/05/17 07:30am	ENTEROCOCCUS-MF 24	EPA 1600	12 E	05/05/17 12:31PM	
L6794156-17	DR-07-1	05/05/17 07:30am	E. COLI-MF (1603)	EPA 1603	5 E	05/05/17 01:06PM	
L6794156-17	DR-07-1	05/05/17 07:30am	FECAL COLIFORM-MF	SM 9222D	6 E	05/05/17 12:44PM	
L6794156-18	RC-02-01	05/05/17 08:15am	ENTEROCOCCUS-MF 24	EPA 1600	1500 E	05/05/17 12:31PM	
L6794156-18	RC-02-01	05/05/17 08:15am	E. COLI-MF (1603)	EPA 1603	730	05/05/17 12:26PM	
L6794156-18	RC-02-01	05/05/17 08:15am	FECAL COLIFORM-MF	SM 9222D	1600 E	05/05/17 12:44PM	
L6794156-19	RC-01-01	05/05/17 08:30am	ENTEROCOCCUS-MF 24	EPA 1600	380	05/05/17 12:31PM	
L6794156-19	RC-01-01	05/05/17 08:30am	E. COLI-MF (1603)	EPA 1603	440	05/05/17 01:06PM	
L6794156-19	RC-01-01	05/05/17 08:30am	FECAL COLIFORM-MF	SM 9222D	330	05/05/17 12:44PM	
L6794156-20	CC-01-01	05/05/17 08:45am	ENTEROCOCCUS-MF 24	EPA 1600	580	05/05/17 12:31PM	
L6794156-20	CC-01-01	05/05/17 08:45am	E. COLI-MF (1603)	EPA 1603	230	05/05/17 01:06PM	
L6794156-20	CC-01-01	05/05/17 08:45am	FECAL COLIFORM-MF	SM 9222D	230	05/05/17 12:44PM	
L6794156-21	BLANK-CREEK-1	05/05/17 08:35am	ENTEROCOCCUS-MF 24	EPA 1600	<2	05/05/17 12:31PM	
L6794156-21	BLANK-CREEK-1	05/05/17 08:35am	E. COLI-MF (1603)	EPA 1603	<1	05/05/17 01:06PM	
L6794156-21	BLANK-CREEK-1	05/05/17 08:35am	FECAL COLIFORM-MF	SM 9222D	<2	05/05/17 12:44PM	
L6794156-22	DUP-RC1	05/05/17 08:15am	ENTEROCOCCUS-MF 24	EPA 1600	1800 E	05/05/17 12:31PM	
L6794156-22	DUP-RC1	05/05/17 08:15am	E. COLI-MF (1603)	EPA 1603	520	05/05/17 01:06PM	
L6794156-22	DUP-RC1	05/05/17 08:15am	FECAL COLIFORM-MF	SM 9222D	1500 E	05/05/17 12:44PM	
L6794156-23	CSO-19-1	05/05/17 08:27am	ENTEROCOCCUS-MF 24	EPA 1600	>60000	05/05/17 12:31PM	
L6794156-23	CSO-19-1	05/05/17 08:27am	E. COLI-MF (1603)	EPA 1603	229000 E	05/05/17 01:06PM	
L6794156-23	CSO-19-1	05/05/17 08:27am	FECAL COLIFORM-MF	SM 9222D	230000 E	05/05/17 12:44PM	
L6794156-24	CSO-18-1	05/05/17 08:42am	ENTEROCOCCUS-MF 24	EPA 1600	127000 E	05/05/17 12:31PM	
L6794156-24	CSO-18-1	05/05/17 08:42am	E. COLI-MF (1603)	EPA 1603	>80000	05/05/17 12:26PM	
L6794156-24	CSO-18-1	05/05/17 08:42am	FECAL COLIFORM-MF	SM 9222D	196000 E	05/05/17 12:44PM	
L6794156-25	SW-SS2-4	05/05/17 08:40am	ENTEROCOCCUS-MF 24	EPA 1600	>60000	05/05/17 12:31PM	
L6794156-25	SW-SS2-4	05/05/17 08:40am	E. COLI-MF (1603)	EPA 1603	49000	05/05/17 01:06PM	
L6794156-25	SW-SS2-4	05/05/17 08:40am	FECAL COLIFORM-MF	SM 9222D	63000 E	05/05/17 12:44PM	
L6794156-26	SW-05A-4	05/05/17 08:50am	ENTEROCOCCUS-MF 24	EPA 1600	59000	05/05/17 12:31PM	
L6794156-26	SW-05A-4	05/05/17 08:50am	E. COLI-MF (1603)	EPA 1603	8000	05/05/17 01:06PM	
L6794156-26	SW-05A-4	05/05/17 08:50am	FECAL COLIFORM-MF	SM 9222D	22000	05/05/17 12:44PM	
L6794156-27	CSO-19-2	05/05/17 09:07am	ENTEROCOCCUS-MF 24	EPA 1600	152000 E	05/05/17 02:21PM	
L6794156-27	CSO-19-2	05/05/17 09:07am	E. COLI-MF (1603)	EPA 1603	504000 E	05/05/17 02:51PM	
L6794156-27	CSO-19-2	05/05/17 09:07am	FECAL COLIFORM-MF	SM 9222D	160000 E	05/05/17 01:05PM	
L6794156-28	CSO-18-2	05/05/17 09:19am	ENTEROCOCCUS-MF 24	EPA 1600	90000 E	05/05/17 02:21PM	
L6794156-28	CSO-18-2	05/05/17 09:19am	E. COLI-MF (1603)	EPA 1603	150000 E	05/05/17 02:51PM	
L6794156-28	CSO-18-2	05/05/17 09:19am	FECAL COLIFORM-MF	SM 9222D	15300 E	05/05/17 02:50PM	
L6794156-29	CSO-19-3	05/05/17 09:34am	ENTEROCOCCUS-MF 24	EPA 1600	189000 E	05/05/17 02:21PM	
L6794156-29	CSO-19-3	05/05/17 09:34am	E. COLI-MF (1603)	EPA 1603	272000 E	05/05/17 02:51PM	
L6794156-29	CSO-19-3	05/05/17 09:34am	FECAL COLIFORM-MF	SM 9222D	18800 E	05/05/17 02:50PM	
L6794156-30	CSO-18-3	05/05/17 09:47am	ENTEROCOCCUS-MF 24	EPA 1600	54000	05/05/17 02:21PM	
L6794156-30	CSO-18-3	05/05/17 09:47am	E. COLI-MF (1603)	EPA 1603	53000	05/05/17 02:51PM	
L6794156-30	CSO-18-3	05/05/17 09:47am	FECAL COLIFORM-MF	SM 9222D	53000	05/05/17 01:05PM	
L6794156-31	DUP-CSO	05/05/17 09:47am	ENTEROCOCCUS-MF 24	EPA 1600	45000	05/05/17 02:21PM	
L6794156-31	DUP-CSO	05/05/17 09:47am	E. COLI-MF (1603)	EPA 1603	52000	05/05/17 02:51PM	
L6794156-31	DUP-CSO	05/05/17 09:47am	FECAL COLIFORM-MF	SM 9222D	44000	05/05/17 01:05PM	
L6794156-32	BLANK-04	05/05/17 09:45am	ENTEROCOCCUS-MF 24	EPA 1600	<2	05/05/17 02:21PM	
L6794156-32	BLANK-04	05/05/17 09:45am	E. COLI-MF (1603)	EPA 1603	2	05/05/17 02:51PM	
L6794156-32	BLANK-04	05/05/17 09:45am	FECAL COLIFORM-MF	SM 9222D	<2	05/05/17 01:05PM	
L6794156-33	CSO-02-03	05/05/17 09:30am	ENTEROCOCCUS-MF 24	EPA 1600	211000 E	05/05/17 02:21PM	
L6794156-33	CSO-02-03	05/05/17 09:30am	E. COLI-MF (1603)	EPA 1603	468000 E	05/05/17 02:51PM	
L6794156-33	CSO-02-03	05/05/17 09:30am	FECAL COLIFORM-MF	SM 9222D	24300 E	05/05/17 02:50PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6794156-34	CSO-05-03	05/05/17 09:40am	ENTEROCOCCUS-MF 24	EPA 1600	306000 E	05/05/17 02:21PM	
L6794156-34	CSO-05-03	05/05/17 09:40am	E. COLI-MF (1603)	EPA 1603	177000 E	05/05/17 02:51PM	
L6794156-34	CSO-05-03	05/05/17 09:40am	FECAL COLIFORM-MF	SM 9222D	123000 E	05/05/17 01:05PM	
L6794156-35	CSO-02-01	05/05/17 08:20am	ENTEROCOCCUS-MF 24	EPA 1600	187000 E	05/05/17 02:21PM	
L6794156-35	CSO-02-01	05/05/17 08:20am	E. COLI-MF (1603)	EPA 1603	364000 E	05/05/17 02:51PM	
L6794156-35	CSO-02-01	05/05/17 08:20am	FECAL COLIFORM-MF	SM 9222D	217000 E	05/05/17 01:05PM	
L6794156-36	CSO-05-01	05/05/17 08:40am	ENTEROCOCCUS-MF 24	EPA 1600	213000 E	05/05/17 02:21PM	
L6794156-36	CSO-05-01	05/05/17 08:40am	E. COLI-MF (1603)	EPA 1603	568000 E	05/05/17 02:51PM	
L6794156-36	CSO-05-01	05/05/17 08:40am	FECAL COLIFORM-MF	SM 9222D	23500 E	05/05/17 02:50PM	
L6794156-37	BLANK-S	05/05/17 08:20am	ENTEROCOCCUS-MF 24	EPA 1600	<2	05/05/17 02:21PM	
L6794156-37	BLANK-S	05/05/17 08:20am	E. COLI-MF (1603)	EPA 1603	7 E	05/05/17 02:51PM	
L6794156-37	BLANK-S	05/05/17 08:20am	FECAL COLIFORM-MF	SM 9222D	2 E	05/05/17 01:05PM	
L6794156-38	CSO-02-02	05/05/17 08:50am	ENTEROCOCCUS-MF 24	EPA 1600	243000 E	05/05/17 02:21PM	
L6794156-38	CSO-02-02	05/05/17 08:50am	E. COLI-MF (1603)	EPA 1603	253000 E	05/05/17 02:51PM	
L6794156-38	CSO-02-02	05/05/17 08:50am	FECAL COLIFORM-MF	SM 9222D	219000 E	05/05/17 01:05PM	
L6794156-39	CSO-05-02	05/05/17 09:05am	ENTEROCOCCUS-MF 24	EPA 1600	195000 E	05/05/17 02:21PM	
L6794156-39	CSO-05-02	05/05/17 09:05am	E. COLI-MF (1603)	EPA 1603	141000 E	05/05/17 02:51PM	
L6794156-39	CSO-05-02	05/05/17 09:05am	FECAL COLIFORM-MF	SM 9222D	120000 E	05/05/17 01:05PM	
L6794156-40	DR-01-2	05/05/17 09:50am	ENTEROCOCCUS-MF 24	EPA 1600	6 E	05/05/17 05:20PM	
L6794156-40	DR-01-2	05/05/17 09:50am	E. COLI-MF (1603)	EPA 1603	10 E	05/05/17 05:45PM	
L6794156-40	DR-01-2	05/05/17 09:50am	FECAL COLIFORM-MF	SM 9222D	18 E	05/05/17 05:30PM	
L6794156-41	DR-02-2	05/05/17 10:00am	ENTEROCOCCUS-MF 24	EPA 1600	3 E	05/05/17 05:20PM	
L6794156-41	DR-02-2	05/05/17 10:00am	E. COLI-MF (1603)	EPA 1603	8 E	05/05/17 05:20PM	
L6794156-41	DR-02-2	05/05/17 10:00am	FECAL COLIFORM-MF	SM 9222D	12 E	05/05/17 05:30PM	
L6794156-42	DR-03-2	05/05/17 10:05am	ENTEROCOCCUS-MF 24	EPA 1600	8 E	05/05/17 05:20PM	
L6794156-42	DR-03-2	05/05/17 10:05am	E. COLI-MF (1603)	EPA 1603	12 E	05/05/17 05:20PM	
L6794156-42	DR-03-2	05/05/17 10:05am	FECAL COLIFORM-MF	SM 9222D	6 E	05/05/17 05:30PM	
L6794156-43	DR-04-2	05/05/17 09:50am	ENTEROCOCCUS-MF 24	EPA 1600	4 E	05/05/17 05:20PM	
L6794156-43	DR-04-2	05/05/17 09:50am	E. COLI-MF (1603)	EPA 1603	12 E	05/05/17 05:45PM	
L6794156-43	DR-04-2	05/05/17 09:50am	FECAL COLIFORM-MF	SM 9222D	18 E	05/05/17 05:30PM	
L6794156-44	DR-05-2	05/05/17 10:05am	ENTEROCOCCUS-MF 24	EPA 1600	4 E	05/05/17 05:20PM	
L6794156-44	DR-05-2	05/05/17 10:05am	E. COLI-MF (1603)	EPA 1603	18 E	05/05/17 05:45PM	
L6794156-44	DR-05-2	05/05/17 10:05am	FECAL COLIFORM-MF	SM 9222D	2 E	05/05/17 05:30PM	
L6794156-45	DR-06-2	05/05/17 09:40am	ENTEROCOCCUS-MF 24	EPA 1600	2 E	05/05/17 05:20PM	
L6794156-45	DR-06-2	05/05/17 09:40am	E. COLI-MF (1603)	EPA 1603	4 E	05/05/17 05:20PM	
L6794156-45	DR-06-2	05/05/17 09:40am	FECAL COLIFORM-MF	SM 9222D	9 E	05/05/17 05:30PM	
L6794156-46	DR-07-2	05/05/17 09:30am	ENTEROCOCCUS-MF 24	EPA 1600	6 E	05/05/17 05:20PM	
L6794156-46	DR-07-2	05/05/17 09:30am	E. COLI-MF (1603)	EPA 1603	2 E	05/05/17 05:20PM	
L6794156-46	DR-07-2	05/05/17 09:30am	FECAL COLIFORM-MF	SM 9222D	6 E	05/05/17 05:30PM	
L6794156-47	CSO-02-04	05/05/17 10:30am	ENTEROCOCCUS-MF 24	EPA 1600	145000 E	05/05/17 05:20PM	
L6794156-47	CSO-02-04	05/05/17 10:30am	E. COLI-MF (1603)	EPA 1603	132000 E	05/05/17 05:20PM	
L6794156-47	CSO-02-04	05/05/17 10:30am	FECAL COLIFORM-MF	SM 9222D	122000 E	05/05/17 05:30PM	
L6794156-48	CSO-05-04	05/05/17 10:40am	ENTEROCOCCUS-MF 24	EPA 1600	77000 E	05/05/17 05:20PM	
L6794156-48	CSO-05-04	05/05/17 10:40am	E. COLI-MF (1603)	EPA 1603	95000 E	05/05/17 05:20PM	
L6794156-48	CSO-05-04	05/05/17 10:40am	FECAL COLIFORM-MF	SM 9222D	68000 E	05/05/17 05:30PM	
L6794156-49	CSO-18-4	05/05/17 10:34am	ENTEROCOCCUS-MF 24	EPA 1600	109000 E	05/05/17 05:20PM	
L6794156-49	CSO-18-4	05/05/17 10:34am	E. COLI-MF (1603)	EPA 1603	163000 E	05/05/17 05:20PM	
L6794156-49	CSO-18-4	05/05/17 10:34am	FECAL COLIFORM-MF	SM 9222D	119000 E	05/05/17 05:30PM	
L6794156-50	CSO-18-4	05/05/17 10:45am	ENTEROCOCCUS-MF 24	EPA 1600	59000	05/05/17 05:20PM	
L6794156-50	CSO-18-4	05/05/17 10:45am	E. COLI-MF (1603)	EPA 1603	80000	05/05/17 05:20PM	
L6794156-50	CSO-18-4	05/05/17 10:45am	FECAL COLIFORM-MF	SM 9222D	47000	05/05/17 05:30PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6794156-51	SW-SS2-5	05/05/17 10:40am	ENTEROCOCCUS-MF 24	EPA 1600	114000 E	05/05/17 05:20PM	
L6794156-51	SW-SS2-5	05/05/17 10:40am	E. COLI-MF (1603)	EPA 1603	15000 E	05/05/17 05:20PM	
L6794156-51	SW-SS2-5	05/05/17 10:40am	FECAL COLIFORM-MF	SM 9222D	13000 E	05/05/17 05:30PM	
L6794156-52	SW-05A-5	05/05/17 10:50am	ENTEROCOCCUS-MF 24	EPA 1600	95000 E	05/05/17 05:20PM	
L6794156-52	SW-05A-5	05/05/17 10:50am	E. COLI-MF (1603)	EPA 1603	50000	05/05/17 05:20PM	
L6794156-52	SW-05A-5	05/05/17 10:50am	FECAL COLIFORM-MF	SM 9222D	15000 E	05/05/17 05:30PM	
L6794156-53	DR-04-3	05/05/17 12:10pm	ENTEROCOCCUS-MF 24	EPA 1600	12 E	05/05/17 05:20PM	
L6794156-53	DR-04-3	05/05/17 12:10pm	E. COLI-MF (1603)	EPA 1603	8 E	05/05/17 05:45PM	
L6794156-53	DR-04-3	05/05/17 12:10pm	FECAL COLIFORM-MF	SM 9222D	24 E	05/05/17 05:30PM	
L6794156-54	DR-05-3	05/05/17 12:17pm	ENTEROCOCCUS-MF 24	EPA 1600	40000	05/05/17 05:20PM	
L6794156-54	DR-05-3	05/05/17 12:17pm	E. COLI-MF (1603)	EPA 1603	6900	05/05/17 06:11PM	
L6794156-54	DR-05-3	05/05/17 12:17pm	FECAL COLIFORM-MF	SM 9222D	10000 E	05/05/17 05:30PM	
L6794156-55	DR-06-3	05/05/17 12:00pm	ENTEROCOCCUS-MF 24	EPA 1600	2 E	05/05/17 05:20PM	
L6794156-55	DR-06-3	05/05/17 12:00pm	E. COLI-MF (1603)	EPA 1603	2 E	05/05/17 05:20PM	
L6794156-55	DR-06-3	05/05/17 12:00pm	FECAL COLIFORM-MF	SM 9222D	6 E	05/05/17 05:30PM	
L6794156-56	DR-07-3	05/05/17 11:50am	ENTEROCOCCUS-MF 24	EPA 1600	10 E	05/05/17 05:20PM	
L6794156-56	DR-07-3	05/05/17 11:50am	E. COLI-MF (1603)	EPA 1603	20 E	05/05/17 05:45PM	
L6794156-56	DR-07-3	05/05/17 11:50am	FECAL COLIFORM-MF	SM 9222D	10 E	05/05/17 05:30PM	
L6794156-57	DR-01-3	05/05/17 12:00pm	ENTEROCOCCUS-MF 24	EPA 1600	30 E	05/05/17 05:20PM	
L6794156-57	DR-01-3	05/05/17 12:00pm	E. COLI-MF (1603)	EPA 1603	16 E	05/05/17 05:20PM	
L6794156-57	DR-01-3	05/05/17 12:00pm	FECAL COLIFORM-MF	SM 9222D	20 E	05/05/17 05:30PM	
L6794156-58	DR-02-3	05/05/17 12:10pm	ENTEROCOCCUS-MF 24	EPA 1600	8 E	05/05/17 05:20PM	
L6794156-58	DR-02-3	05/05/17 12:10pm	E. COLI-MF (1603)	EPA 1603	6 E	05/05/17 05:20PM	
L6794156-58	DR-02-3	05/05/17 12:10pm	FECAL COLIFORM-MF	SM 9222D	18 E	05/05/17 05:30PM	
L6794156-59	DR-03-3	05/05/17 12:15pm	ENTEROCOCCUS-MF 24	EPA 1600	56	05/05/17 05:20PM	
L6794156-59	DR-03-3	05/05/17 12:15pm	E. COLI-MF (1603)	EPA 1603	14 E	05/05/17 05:20PM	
L6794156-59	DR-03-3	05/05/17 12:15pm	FECAL COLIFORM-MF	SM 9222D	12 E	05/05/17 05:30PM	
L6794156-60	CSO-02-05	05/05/17 12:15pm	ENTEROCOCCUS-MF 24	EPA 1600	89000 E	05/05/17 05:20PM	
L6794156-60	CSO-02-05	05/05/17 12:15pm	E. COLI-MF (1603)	EPA 1603	96000 E	05/05/17 05:45PM	
L6794156-60	CSO-02-05	05/05/17 12:15pm	FECAL COLIFORM-MF	SM 9222D	68000 E	05/05/17 05:30PM	
L6794156-61	CSO-05-05	05/05/17 12:40pm	ENTEROCOCCUS-MF 24	EPA 1600	75000 E	05/05/17 05:20PM	
L6794156-61	CSO-05-05	05/05/17 12:40pm	E. COLI-MF (1603)	EPA 1603	55000	05/05/17 06:11PM	
L6794156-61	CSO-05-05	05/05/17 12:40pm	FECAL COLIFORM-MF	SM 9222D	53000	05/05/17 05:30PM	
L6794156-62	CC-01-02	05/05/17 12:55pm	ENTEROCOCCUS-MF 24	EPA 1600	LA Q	05/05/17 05:20PM	
L6794156-62	CC-01-02	05/05/17 12:55pm	E. COLI-MF (1603)	EPA 1603	12000 E	05/05/17 05:20PM	
L6794156-62	CC-01-02	05/05/17 12:55pm	FECAL COLIFORM-MF	SM 9222D	10000 E	05/05/17 05:30PM	
L6794156-63	CC-02-2	05/05/17 12:35pm	ENTEROCOCCUS-MF 24	EPA 1600	15000 E	05/05/17 05:20PM	
L6794156-63	CC-02-2	05/05/17 12:35pm	E. COLI-MF (1603)	EPA 1603	15000 E	05/05/17 05:20PM	
L6794156-63	CC-02-2	05/05/17 12:35pm	FECAL COLIFORM-MF	SM 9222D	6900 E	05/05/17 05:30PM	
L6794156-64	CC-03-2	05/05/17 11:40am	ENTEROCOCCUS-MF 24	EPA 1600	3400	05/05/17 05:20PM	
L6794156-64	CC-03-2	05/05/17 11:40am	E. COLI-MF (1603)	EPA 1603	5700	05/05/17 06:11PM	
L6794156-64	CC-03-2	05/05/17 11:40am	FECAL COLIFORM-MF	SM 9222D	6700 E	05/05/17 05:30PM	
L6794156-65	RC-01-2	05/05/17 12:15pm	ENTEROCOCCUS-MF 24	EPA 1600	28000	05/05/17 05:20PM	
L6794156-65	RC-01-2	05/05/17 12:15pm	E. COLI-MF (1603)	EPA 1603	7900	05/05/17 05:20PM	
L6794156-65	RC-01-2	05/05/17 12:15pm	FECAL COLIFORM-MF	SM 9222D	3100	05/05/17 05:30PM	
L6794156-66	RC-02-2	05/05/17 11:55am	ENTEROCOCCUS-MF 24	EPA 1600	18000 E	05/05/17 05:20PM	
L6794156-66	RC-02-2	05/05/17 11:55am	E. COLI-MF (1603)	EPA 1603	13000 E	05/05/17 06:11PM	
L6794156-66	RC-02-2	05/05/17 11:55am	FECAL COLIFORM-MF	SM 9222D	16000 E	05/05/17 05:30PM	
L6794156-67	RC-03-2	05/05/17 11:47am	ENTEROCOCCUS-MF 24	EPA 1600	10000 E	05/05/17 05:20PM	
L6794156-67	RC-03-2	05/05/17 11:47am	E. COLI-MF (1603)	EPA 1603	20000	05/05/17 06:11PM	
L6794156-67	RC-03-2	05/05/17 11:47am	FECAL COLIFORM-MF	SM 9222D	13000 E	05/05/17 05:30PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6794156-68	CSO-19-5	05/05/17 12:35pm	ENTEROCOCCUS-MF 24	EPA 1600	194000 E	05/05/17 05:20PM	
L6794156-68	CSO-19-5	05/05/17 12:35pm	E. COLI-MF (1603)	EPA 1603	234000 E	05/05/17 06:11PM	
L6794156-68	CSO-19-5	05/05/17 12:35pm	FECAL COLIFORM-MF	SM 9222D	93000 E	05/05/17 05:30PM	
L6794156-69	CSO-18-5	05/05/17 12:47pm	ENTEROCOCCUS-MF 24	EPA 1600	37000	05/05/17 05:20PM	
L6794156-69	CSO-18-5	05/05/17 12:47pm	E. COLI-MF (1603)	EPA 1603	104000 E	05/05/17 05:20PM	
L6794156-69	CSO-18-5	05/05/17 12:47pm	FECAL COLIFORM-MF	SM 9222D	53000	05/05/17 05:30PM	
L6794156-70	CC-01-3	05/05/17 05:05pm	ENTEROCOCCUS-MF 24	EPA 1600	39000	05/05/17 07:49PM	
L6794156-70	CC-01-3	05/05/17 05:05pm	E. COLI-MF (1603)	EPA 1603	13000 E	05/05/17 07:41PM	
L6794156-70	CC-01-3	05/05/17 05:05pm	FECAL COLIFORM-MF	SM 9222D	44000	05/05/17 07:49PM	
L6794156-71	CC-02-3	05/05/17 04:48pm	ENTEROCOCCUS-MF 24	EPA 1600	17000 E	05/05/17 07:49PM	
L6794156-71	CC-02-3	05/05/17 04:48pm	E. COLI-MF (1603)	EPA 1603	7300	05/05/17 07:41PM	
L6794156-71	CC-02-3	05/05/17 04:48pm	FECAL COLIFORM-MF	SM 9222D	13000 E	05/05/17 07:49PM	
L6794156-72	CC-03-3	05/05/17 03:45pm	ENTEROCOCCUS-MF 24	EPA 1600	27000	05/05/17 07:49PM	
L6794156-72	CC-03-3	05/05/17 03:45pm	E. COLI-MF (1603)	EPA 1603	6500	05/05/17 07:41PM	
L6794156-72	CC-03-3	05/05/17 03:45pm	FECAL COLIFORM-MF	SM 9222D	21000	05/05/17 07:49PM	
L6794156-73	RC-01-3	05/05/17 04:30pm	ENTEROCOCCUS-MF 24	EPA 1600	23000	05/05/17 07:49PM	
L6794156-73	RC-01-3	05/05/17 04:30pm	E. COLI-MF (1603)	EPA 1603	6100	05/05/17 07:41PM	
L6794156-73	RC-01-3	05/05/17 04:30pm	FECAL COLIFORM-MF	SM 9222D	6700 E	05/05/17 07:49PM	
L6794156-74	RC-02-3	05/05/17 04:10pm	ENTEROCOCCUS-MF 24	EPA 1600	19000 E	05/05/17 07:49PM	
L6794156-74	RC-02-3	05/05/17 04:10pm	E. COLI-MF (1603)	EPA 1603	5900	05/05/17 07:41PM	
L6794156-74	RC-02-3	05/05/17 04:10pm	FECAL COLIFORM-MF	SM 9222D	4300	05/05/17 07:49PM	
L6794156-75	RC-03-3	05/05/17 04:00pm	ENTEROCOCCUS-MF 24	EPA 1600	30000	05/05/17 07:49PM	
L6794156-75	RC-03-3	05/05/17 04:00pm	E. COLI-MF (1603)	EPA 1603	6800	05/05/17 07:41PM	
L6794156-75	RC-03-3	05/05/17 04:00pm	FECAL COLIFORM-MF	SM 9222D	34000	05/05/17 07:49PM	
L6794156-76	SW-SS2-6	05/05/17 04:35pm	ENTEROCOCCUS-MF 24	EPA 1600	57000	05/05/17 07:49PM	
L6794156-76	SW-SS2-6	05/05/17 04:35pm	E. COLI-MF (1603)	EPA 1603	6200	05/05/17 07:41PM	
L6794156-76	SW-SS2-6	05/05/17 04:35pm	FECAL COLIFORM-MF	SM 9222D	33000	05/05/17 07:49PM	
L6794156-77	SW-05A-6	05/05/17 04:45pm	ENTEROCOCCUS-MF 24	EPA 1600	44000	05/05/17 07:49PM	
L6794156-77	SW-05A-6	05/05/17 04:45pm	E. COLI-MF (1603)	EPA 1603	13000 E	05/05/17 07:41PM	
L6794156-77	SW-05A-6	05/05/17 04:45pm	FECAL COLIFORM-MF	SM 9222D	30000	05/05/17 07:49PM	
L6794156-78	DUP-CC	05/05/17 00:00pm	ENTEROCOCCUS-MF 24	EPA 1600	40000 Q	05/05/17 07:49PM	
L6794156-78	DUP-CC	05/05/17 00:00pm	E. COLI-MF (1603)	EPA 1603	17000 E, Q	05/05/17 07:41PM	
L6794156-78	DUP-CC	05/05/17 00:00pm	FECAL COLIFORM-MF	SM 9222D	31000 Q	05/05/17 07:49PM	
L6794156-79	DR-03-07 (LAND)	05/05/17 11:00pm	ENTEROCOCCUS-MF 24	EPA 1600	15000 E	05/06/17 01:05AM	
L6794156-79	DR-03-07 (LAND)	05/05/17 11:00pm	E. COLI-MF (1603)	EPA 1603	5500	05/06/17 12:40AM	
L6794156-79	DR-03-07 (LAND)	05/05/17 11:00pm	FECAL COLIFORM-MF	SM 9222D	23000	05/06/17 12:50AM	
L6794156-80	DR-04-07 (LAND)	05/05/17 11:10pm	ENTEROCOCCUS-MF 24	EPA 1600	12000 E	05/06/17 01:05AM	
L6794156-80	DR-04-07 (LAND)	05/05/17 11:10pm	E. COLI-MF (1603)	EPA 1603	4500	05/06/17 12:40AM	
L6794156-80	DR-04-07 (LAND)	05/05/17 11:10pm	FECAL COLIFORM-MF	SM 9222D	3800	05/06/17 12:50AM	
L6794156-81	CC-01-04	05/05/17 10:35pm	ENTEROCOCCUS-MF 24	EPA 1600	41000	05/06/17 01:05AM	
L6794156-81	CC-01-04	05/05/17 10:35pm	E. COLI-MF (1603)	EPA 1603	15000 E	05/06/17 12:40AM	
L6794156-81	CC-01-04	05/05/17 10:35pm	FECAL COLIFORM-MF	SM 9222D	15000 E	05/06/17 12:50AM	
L6794156-82	CC-02-04	05/05/17 10:20pm	ENTEROCOCCUS-MF 24	EPA 1600	38000	05/06/17 01:05AM	
L6794156-82	CC-02-04	05/05/17 10:20pm	E. COLI-MF (1603)	EPA 1603	8000 E	05/06/17 12:40AM	
L6794156-82	CC-02-04	05/05/17 10:20pm	FECAL COLIFORM-MF	SM 9222D	29000	05/06/17 12:50AM	
L6794156-83	CC-03-04	05/05/17 09:30pm	ENTEROCOCCUS-MF 24	EPA 1600	24000	05/06/17 01:05AM	
L6794156-83	CC-03-04	05/05/17 09:30pm	E. COLI-MF (1603)	EPA 1603	11000 E	05/06/17 12:40AM	
L6794156-83	CC-03-04	05/05/17 09:30pm	FECAL COLIFORM-MF	SM 9222D	11000 E	05/06/17 12:50AM	
L6794156-84	RC-01-04	05/05/17 10:05pm	ENTEROCOCCUS-MF 24	EPA 1600	28000	05/06/17 01:05AM	
L6794156-84	RC-01-04	05/05/17 10:05pm	E. COLI-MF (1603)	EPA 1603	9000 E	05/06/17 12:40AM	
L6794156-84	RC-01-04	05/05/17 10:05pm	FECAL COLIFORM-MF	SM 9222D	12000 E	05/06/17 12:50AM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6794156-85	RC-02-04	05/05/17 09:50pm	ENTEROCOCCUS-MF 24	EPA 1600	17000 E	05/06/17 01:05AM	
L6794156-85	RC-02-04	05/05/17 09:50pm	E. COLI-MF (1603)	EPA 1603	16000 E	05/06/17 12:40AM	
L6794156-85	RC-02-04	05/05/17 09:50pm	FECAL COLIFORM-MF	SM 9222D	25000	05/06/17 12:50AM	
L6794156-86	RC-03-04	05/05/17 09:40pm	ENTEROCOCCUS-MF 24	EPA 1600	31000	05/06/17 01:05AM	
L6794156-86	RC-03-04	05/05/17 09:40pm	E. COLI-MF (1603)	EPA 1603	6100 E	05/06/17 12:40AM	
L6794156-86	RC-03-04	05/05/17 09:40pm	FECAL COLIFORM-MF	SM 9222D	47000	05/06/17 12:50AM	
L6794156-87	DR-03-06 (LAND)	05/05/17 08:35pm	ENTEROCOCCUS-MF 24	EPA 1600	28000	05/06/17 01:05AM	
L6794156-87	DR-03-06 (LAND)	05/05/17 08:35pm	E. COLI-MF (1603)	EPA 1603	6700 E	05/06/17 12:40AM	
L6794156-87	DR-03-06 (LAND)	05/05/17 08:35pm	FECAL COLIFORM-MF	SM 9222D	18000 E	05/06/17 12:50AM	
L6794156-88	DR-04-06 (LAND)	05/05/17 08:50pm	ENTEROCOCCUS-MF 24	EPA 1600	24000	05/06/17 01:05AM	
L6794156-88	DR-04-06 (LAND)	05/05/17 08:50pm	E. COLI-MF (1603)	EPA 1603	5700	05/06/17 12:40AM	
L6794156-88	DR-04-06 (LAND)	05/05/17 08:50pm	FECAL COLIFORM-MF	SM 9222D	32000	05/06/17 12:50AM	
L6794156-89	DR-03-08 (LAND)	05/06/17 02:00am	ENTEROCOCCUS-MF 24	EPA 1600	4700	05/06/17 09:18AM	
L6794156-89	DR-03-08 (LAND)	05/06/17 02:00am	E. COLI-MF (1603)	EPA 1603	2000	05/06/17 09:48AM	
L6794156-89	DR-03-08 (LAND)	05/06/17 02:00am	FECAL COLIFORM-MF	SM 9222D	2800	05/06/17 09:44AM	
L6794156-90	DR-04-08 (LAND)	05/06/17 02:15am	ENTEROCOCCUS-MF 24	EPA 1600	6100 E	05/06/17 09:18AM	
L6794156-90	DR-04-08 (LAND)	05/06/17 02:15am	E. COLI-MF (1603)	EPA 1603	2100	05/06/17 09:48AM	
L6794156-90	DR-04-08 (LAND)	05/06/17 02:15am	FECAL COLIFORM-MF	SM 9222D	3900	05/06/17 09:44AM	
L6794156-91	RC-01-05	05/06/17 05:05am	ENTEROCOCCUS-MF 24	EPA 1600	22000	05/06/17 09:18AM	
L6794156-91	RC-01-05	05/06/17 05:05am	E. COLI-MF (1603)	EPA 1603	8000	05/06/17 09:48AM	
L6794156-91	RC-01-05	05/06/17 05:05am	FECAL COLIFORM-MF	SM 9222D	5600	05/06/17 09:44AM	
L6794156-92	RC-02-05	05/06/17 04:50am	ENTEROCOCCUS-MF 24	EPA 1600	3400	05/06/17 09:18AM	
L6794156-92	RC-02-05	05/06/17 04:50am	E. COLI-MF (1603)	EPA 1603	5800	05/06/17 09:48AM	
L6794156-92	RC-02-05	05/06/17 04:50am	FECAL COLIFORM-MF	SM 9222D	4000	05/06/17 09:44AM	
L6794156-93	RC-03-05	05/06/17 04:30am	ENTEROCOCCUS-MF 24	EPA 1600	15000 E	05/06/17 09:18AM	
L6794156-93	RC-03-05	05/06/17 04:30am	E. COLI-MF (1603)	EPA 1603	6500	05/06/17 09:48AM	
L6794156-93	RC-03-05	05/06/17 04:30am	FECAL COLIFORM-MF	SM 9222D	6400	05/06/17 09:44AM	
L6794156-94	CC-01-05	05/06/17 05:30am	ENTEROCOCCUS-MF 24	EPA 1600	26000	05/06/17 09:18AM	
L6794156-94	CC-01-05	05/06/17 05:30am	E. COLI-MF (1603)	EPA 1603	5500	05/06/17 09:48AM	
L6794156-94	CC-01-05	05/06/17 05:30am	FECAL COLIFORM-MF	SM 9222D	3200	05/06/17 09:44AM	
L6794156-95	CC-02-05	05/06/17 05:15am	ENTEROCOCCUS-MF 24	EPA 1600	22000	05/06/17 09:18AM	
L6794156-95	CC-02-05	05/06/17 05:15am	E. COLI-MF (1603)	EPA 1603	7900	05/06/17 09:48AM	
L6794156-95	CC-02-05	05/06/17 05:15am	FECAL COLIFORM-MF	SM 9222D	21000	05/06/17 09:44AM	
L6794156-96	CC-03-05	05/06/17 04:20am	ENTEROCOCCUS-MF 24	EPA 1600	35000	05/06/17 09:18AM	
L6794156-96	CC-03-05	05/06/17 04:20am	E. COLI-MF (1603)	EPA 1603	14000 E	05/06/17 09:48AM	
L6794156-96	CC-03-05	05/06/17 04:20am	FECAL COLIFORM-MF	SM 9222D	4400	05/06/17 09:44AM	
L6794156-97	DR-03-09 (LAND)	05/06/17 04:00am	ENTEROCOCCUS-MF 24	EPA 1600	5000	05/06/17 09:18AM	
L6794156-97	DR-03-09 (LAND)	05/06/17 04:00am	E. COLI-MF (1603)	EPA 1603	1500 E	05/06/17 09:48AM	
L6794156-97	DR-03-09 (LAND)	05/06/17 04:00am	FECAL COLIFORM-MF	SM 9222D	2000	05/06/17 09:44AM	
L6794156-98	DR-04-09 (LAND)	05/06/17 04:10am	ENTEROCOCCUS-MF 24	EPA 1600	5000	05/06/17 09:18AM	
L6794156-98	DR-04-09 (LAND)	05/06/17 04:10am	E. COLI-MF (1603)	EPA 1603	1200 E	05/06/17 09:48AM	
L6794156-98	DR-04-09 (LAND)	05/06/17 04:10am	FECAL COLIFORM-MF	SM 9222D	2100	05/06/17 09:44AM	
L6794156-99	DUP-DR	05/06/17 00:00am	ENTEROCOCCUS-MF 24	EPA 1600	4300 Q	05/06/17 09:18AM	
L6794156-99	DUP-DR	05/06/17 00:00am	E. COLI-MF (1603)	EPA 1603	3300 Q	05/06/17 09:48AM	
L6794156-99	DUP-DR	05/06/17 00:00am	FECAL COLIFORM-MF	SM 9222D	13000 E, Q	05/06/17 09:44AM	
L6794156-100	DR-04-10 (LAND)	05/06/17 06:10am	ENTEROCOCCUS-MF 24	EPA 1600	5500	05/06/17 09:18AM	
L6794156-100	DR-04-10 (LAND)	05/06/17 06:10am	E. COLI-MF (1603)	EPA 1603	2300	05/06/17 09:48AM	
L6794156-100	DR-04-10 (LAND)	05/06/17 06:10am	FECAL COLIFORM-MF	SM 9222D	23000	05/06/17 09:44AM	
L6794156-101	DR-03-10 (LAND)	05/06/17 06:00am	ENTEROCOCCUS-MF 24	EPA 1600	3700	05/06/17 09:18AM	
L6794156-101	DR-03-10 (LAND)	05/06/17 06:00am	E. COLI-MF (1603)	EPA 1603	1700 E	05/06/17 09:48AM	
L6794156-101	DR-03-10 (LAND)	05/06/17 06:00am	FECAL COLIFORM-MF	SM 9222D	3300	05/06/17 09:44AM	

APPENDIX F

WET WEATHER EVENT 3 – FIELD LOGS AND LAB RESULTS SUMMARY

(Chain of Custody Forms and Complete Lab Results provided in digital form only on CD attached to this report)

WET WEATHER EVENT: 3

DATE: *5/22/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *10:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Water Salinity Reading (%)	Water Temperature Reading (°C)	Conductivity Reading (umhos/cm)	Field Observations (see notes, below)
IN-STREAM TRIBUTARY STATION: CC-01													
1	0.5-2.5	10:30	11:42	N	N/A	N	N/A	Y	12:28	0.27	16.18	465	Raining
2	4.5-6.5	14:30	15:40	N	N/A	N	N/A	Y	17:48	0.26	16.21	439	Raining
3	8.5-10.5	18:30	18:46	N	N/A	N	N/A	Y	19:50	0.27	16.36	462	Raining
4	14.5-16.5	0:30	2:17	N	N/A	N	N/A	Y	3:52	0.28	16.13	483	Raining
5	22-24	8:30	10:20	N	N/A	N	N/A	Y	10:45	0.28	15.88	479	Raining
IN-STREAM TRIBUTARY STATION: CC-02													
1	0.5-2.5	10:30	12:00	N	N/A	N	N/A	Y	12:28	0.3	16.85	520	Raining
2	4.5-6.5	14:30	15:50	Y	15:50	N	N/A	Y	17:48	0.126	16.67	450	Raining
3	8.5-10.5	18:30	19:00	N	N/A	N	N/A	Y	19:50	0.26	16.81	454	Raining
4	14.5-16.5	0:30	2:05	N	N/A	N	N/A	Y	3:52	0.27	16.36	467	Raining
5	22-24	8:30	10:05	N	N/A	N	N/A	Y	10:45	0.23	16.65	395	Raining
IN-STREAM TRIBUTARY STATION: CC-03													
1	0.5-2.5	10:30	10:42	N	N/A	N	N/A	Y	12:28	0.13	17.66	233.0	Raining
2	4.5-6.5	14:30	14:40	N	N/A	N	N/A	Y	17:48	0.29	16.69	497.0	Raining
3	8.5-10.5	18:30	18:00	N	N/A	N	N/A	Y	19:50	0.27	16.73	465.0	Raining
4	14.5-16.5	0:30	1:05	N	N/A	N	N/A	Y	3:52	0.20	17.33	352.0	Raining
5	22-24	8:30	9:05	N	N/A	N	N/A	Y	10:45	0.13	17.58	244.0	Raining
IN-STREAM TRIBUTARY STATION: RC-01													
1	0.5-2.5	10:30	11:26	N	N/A	N	N/A	Y	12:28	0.18	16.43	307.0	Raining
2	4.5-6.5	14:30	15:18	N	N/A	N	N/A	Y	17:48	0.19	16.46	336.0	Raining
3	8.5-10.5	18:30	18:40	N	N/A	N	N/A	Y	19:50	0.22	16.49	375.0	Raining
4	14.5-16.5	0:30	1:52	N	N/A	N	N/A	Y	3:52	0.22	16.13	373.0	Raining
5	22-24	8:30	9:50	N	N/A	N	N/A	Y	10:45	0.21	15.90	367.0	Raining
IN-STREAM TRIBUTARY STATION: RC-02													
1	0.5-2.5	10:30	11:10	N	N/A	N	N/A	Y	12:28	0.23	16.09	398.0	Raining
2	4.5-6.5	14:30	15:05	N	N/A	N	N/A	Y	17:48	0.20	16.35	353.0	Raining
3	8.5-10.5	18:30	18:18	N	N/A	N	N/A	Y	19:50	0.20	16.68	345.0	Raining
4	14.5-16.5	0:30	1:35	N	N/A	N	N/A	Y	3:52	0.23	16.38	393.0	Raining
5	22-24	8:30	9:35	N	N/A	N	N/A	Y	10:45	0.23	15.85	384.0	Raining
IN-STREAM TRIBUTARY STATION: RC-03													
1	0.5-2.5	10:30	11:00	N	N/A	N	N/A	Y	12:28	0.13	17.57	226.0	Used Bailer to collect sample
2	4.5-6.5	14:30	14:50	Y	14:50	N	N/A	Y	17:48	0.22	16.27	371.0	Used Bailer to collect sample
3	8.5-10.5	18:30	18:12	N	N/A	N	N/A	Y	19:50	0.20	16.72	357.0	Used Bailer to collect sample
4	14.5-16.5	0:30	1:20	N	N/A	N	N/A	Y	3:52	0.19	16.91	332.0	Used Bailer to collect sample
5	22-24	8:30	9:22	N	N/A	N	N/A	Y	10:45	0.13	17.61	229.0	Used Bailer to collect sample

WET WEATHER EVENT: 3
DELAWARE RIVER STATION: DR-01

DATE: *5/22/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *10:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Surface, Mid-depth & Bottom Water Salinity Reading(s) (%)	Surface, Mid-depth & Bottom Water Temperature Reading(s) (°C)	Surface, Mid-depth & Bottom Water Conductivity Reading(s) (umhos/cm)	Field Observations (see notes, below)
1	0	9:30	9:25	N	N/A	N	N/A	Y	10:38	-	17.8/17.8/17.8	205/205/205	TOTAL DEPTH = 27 FEET
2	2	11:30	11:10	N	N/A	Y	11:05	Y	12:28	-	17.83/17.83/17.84	205/204/205	TOTAL DEPTH = 25 FEET
3	4	13:30	13:15	Y	13:15	N	N/A	Y	15:35	-	17.82/17.81/17.81	207/207/206	TOTAL DEPTH = 25 FEET
4	6	15:30	15:15	N	N/A	N	N/A	Y	17:40	0.19/0.19/0.19	15.80/15.79/15.79	318/318/319	TOTAL DEPTH = 24.7 FEET
5	9	18:30	18:15	N	N/A	N	N/A	Y	19:30	0.19/0.19/0.19	15.82/15.81/15.81	327/326/326	TOTAL DEPTH = 23.26 FEET
6	12	21:30	21:15	N	N/A	N	N/A	Y	22:15	0.19/0.19/0.19	15.85/15.87/15.88	320/322/323	TOTAL DEPTH = 28 FEET
7	15	0:30	0:05	N	N/A	N	N/A	Y	3:52	0.18/0.18/0.18	15.90/15.90/15.90	309/310/310	TOTAL DEPTH = 27 FEET
8	18	3:30	3:00	N	N/A	N	N/A	Y	5:35	0.18/0.18/0.18	15.72/15.73/15.73	308/308/308	TOTAL DEPTH = 25 FEET
9	21	6:30	6:00	N	N/A	N	N/A	Y	10:45	0.18/0.18/0.18	15.68/15.68/15.68	299/303/307	TOTAL DEPTH = 23 FEET
10	24	9:30	9:00	N	N/A	N	N/A	Y	10:45	0.16/0.17/0.17	15.69/15.69/15.68	281/284/287	TOTAL DEPTH = 26 FEET
DELAWARE RIVER STATION: DR-02													
1	0	9:30	9:30	N	N/A	N	N/A	Y	10:38	-	17.85/17.85/17.85	209/206/206	TOTAL DEPTH = 37 FEET
2	2	11:30	11:15	N	N/A	N	N/A	Y	12:28	-	17.87/17.87/17.87	203/204/207	TOTAL DEPTH = 35 FEET
3	4	13:30	13:20	N	N/A	N	N/A	Y	15:35	-	17.79/17.80/17.80	210/210/210	TOTAL DEPTH = 30 FEET
4	6	15:30	15:20	N	N/A	N	N/A	Y	17:40	0.18/0.18/0.18	15.73/15.74/15.75	309/311/312	TOTAL DEPTH = 36 FEET
5	9	18:30	18:20	N	N/A	N	N/A	Y	19:30	0.18/0.18/0.18	15.74/15.76/15.76	314/314/314	TOTAL DEPTH = 33 FEET
6	12	21:30	21:25	Y	21:25	N	N/A	Y	22:15	0.19/0.19/0.19	15.92/15.92/15.93	322/322/322	TOTAL DEPTH = 28 FEET
7	15	0:30	0:20	N	N/A	N	N/A	Y	3:52	0.18/0.18/0.18	15.93/15.93/15.93	313/313/313	TOTAL DEPTH = 40 FEET
8	18	3:30	3:15	N	N/A	N	N/A	Y	5:35	0.18/0.18/0.18	15.77/15.78/15.78	310/312/315	TOTAL DEPTH = 31 FEET
9	21	6:30	6:13	N	N/A	N	N/A	Y	10:45	0.18/0.18/0.18	15.70/15.70/15.70	314/315/313	TOTAL DEPTH = 34 FEET
10	24	9:30	9:12	N	N/A	N	N/A	Y	10:45	0.17/0.17/0.17	15.79/15.79/15.79	295/297/300	TOTAL DEPTH = 38 FEET
DELAWARE RIVER STATION: DR-03													
1	0	9:30	9:35	N	N/A	N	N/A	Y	10:38	-	17.91/17.91/17.91	213/212/212	TOTAL DEPTH = 20 FEET
2	2	11:30	11:20	N	N/A	N	N/A	Y	12:28	-	17.86/17.91/17.91	206/207/207	TOTAL DEPTH = 20 FEET
3	4	13:30	13:30	N	N/A	N	N/A	Y	15:35	-	17.83/17.84/17.84	207/207/207	TOTAL DEPTH = 22 FEET
4	6	15:30	15:25	N	N/A	N	N/A	Y	17:40	0.19/0.19/0.19	15.75/15.80/15.82	319/328/320	TOTAL DEPTH = 13.3 FEET
5	9	18:30	18:25	N	N/A	N	N/A	Y	19:30	0.19/0.20/0.21	15.79/15.79/15.79	341/353/353	TOTAL DEPTH = 11.5 FEET
6	12	21:30	21:30	N	N/A	N	N/A	Y	22:15	0.19/0.19/0.19	15.97/15.98/15.98	325/323/323	TOTAL DEPTH = 19 FEET
7	15	0:30	0:34	N	N/A	N	N/A	Y	3:52	0.18/0.19/0.19	15.99/15.99/15.98	317/318/320	TOTAL DEPTH = 23 FEET
8	18	3:30	3:25	N	N/A	N	N/A	Y	5:35	0.18/0.19/0.19	15.78/15.78/15.78	316/317/318	TOTAL DEPTH = 22 FEET
9	21	6:30	6:26	N	N/A	N	N/A	Y	10:45	0.19/0.19/0.19	15.69/15.69/15.69	319/320/323	TOTAL DEPTH = 20 FEET
10	24	9:30	9:24	N	N/A	N	N/A	Y	10:45	0.18/0.19/0.19	15.75/15.75/15.73	314/316/319	TOTAL DEPTH = 21 FEET
DELAWARE RIVER STATION: DR-04													
1	0	9:30	9:05	N	N/A	N	N/A	Y	10:38	0.18/0.18/0.18	15.97/15.95/15.95	306/308/309	TOTAL DEPTH = 14 FEET
2	2	11:30	11:00	N	N/A	N	N/A	Y	12:28	0.19/0.19/0.19	16.08/16.09/16.10	320/322/324	TOTAL DEPTH = 11 FEET
3	4	13:30	13:05	N	N/A	N	N/A	Y	15:35	0.18/0.18/0.18	15.91/15.92/15.92	311/312/312	TOTAL DEPTH = 8.5 FEET
4	6	15:30	15:30	N	N/A	N	N/A	Y	17:40	0.19/0.19/0.19	15.78/15.88/15.85	328/328/328	TOTAL DEPTH = 10 FEET
5	9	18:30	18:30	N	N/A	N	N/A	Y	19:30	0.19/0.19/0.19	15.81/15.82/15.83	327/327/328	TOTAL DEPTH = 9.3 FEET
6	12	21:30	21:40	N	N/A	N	N/A	Y	22:15	0.19/0.19/0.19	16.17/16.17/16.18	327/329/329	TOTAL DEPTH = 11.4 FEET
7	15	0:30	0:48	N	N/A	N	N/A	Y	3:52	0.18/0.18/0.18	16.02/16.02/16.01	313/313/313	TOTAL DEPTH = 19 FEET
8	18	3:30	3:37	N	N/A	N	N/A	Y	5:35	0.19/0.19/0.19	15.80/15.82/15.82	320/322/322	TOTAL DEPTH = 26 FEET
9	21	6:30	6:38	N	N/A	N	N/A	Y	10:45	0.19/0.19/0.19	15.66/15.66/15.67	329/331/331	TOTAL DEPTH = 24 FEET
10	24	9:30	9:40	N	N/A	N	N/A	Y	10:45	0.18/0.18/0.18	15.87/15.86/15.86	301/302/303	TOTAL DEPTH = 22 FEET

WET WEATHER EVENT: 3
DELAWARE RIVER STATION: DR-05

DATE: *5/22/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *10:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Surface, Mid-depth & Bottom Water Salinity Reading(s) (%)	Surface, Mid-depth & Bottom Water Temperature Reading(s) (°C)	Surface, Mid-depth & Bottom Water Conductivity Reading(s) (umhos/cm)	Field Observations (see notes, below)
1	0	9:30	9:30	N	N/A	N	N/A	Y	10:38	0.18/0.18/0.18	16.15/16.15/16.10	312/317/318	TOTAL DEPTH = 9 FEET
2	2	11:30	11:20	N	N/A	N	N/A	Y	12:28	0.22/0.22/0.18	16.69/16.43/16.23	383/380/317	TOTAL DEPTH = 10 FEET
3	4	13:30	13:30	N	N/A	N	N/A	Y	15:35	0.18/0.18/0.18	15.94/15.94/15.94	307/308/310	TOTAL DEPTH = 11.6 FEET
4	6	15:30	15:35	N	N/A	N	N/A	Y	17:40	0.24/0.20/0.20	16.56/16.25/16.08	383/341/343	TOTAL DEPTH = 9.2 FEET
5	9	18:30	18:35	N	N/A	N	N/A	Y	19:30	0.19/0.19/0.19	16.84/16.40/16.39	334/340/343	TOTAL DEPTH = 11.3 FEET
6	12	21:30	21:45	N	N/A	N	N/A	Y	22:15	0.19/0.19/0.19	16.15/16.19/16.19	323/319/319	TOTAL DEPTH = 12.2 FEET
7	15	0:30	1:02	N	N/A	N	N/A	Y	3:52	0.18/0.18/0.18	16.04/16.04/16.03	313/313/313	TOTAL DEPTH = 16 FEET
8	18	3:30	3:50	N	N/A	N	N/A	Y	5:35	0.18/0.19/0.19	15.85/15.86/15.86	316/320/320	TOTAL DEPTH = 11 FEET
9	21	6:30	6:52	N	N/A	N	N/A	Y	10:45	0.20/0.20/0.19	16.33/15.88/15.75	345/335/325	TOTAL DEPTH = 10 FEET
10	24	9:30	9:53	N	N/A	N	N/A	Y	10:45	0.18/0.18/0.18	15.97/15.97/15.97	309/310/311	TOTAL DEPTH = 10 FEET
DELAWARE RIVER STATION: DR-06													
1	0	9:30	9:10	N	N/A	N	N/A	Y	10:38	0.17/0.17/0.18	15.81/15.84/15.85	295/300/300	TOTAL DEPTH = 28 FEET
2	2	11:30	11:05	N	N/A	N	N/A	Y	12:28	0.18/0.18/0.18	15.88/15.88/15.88	301/302/303	TOTAL DEPTH = 29 FEET
3	4	13:30	13:12	N	N/A	N	N/A	Y	15:35	0.17/0.17/0.17	15.82/15.84/15.85	298/299/299	TOTAL DEPTH = 25.1 FEET
4	6	15:30	14:55	N	N/A	N	N/A	Y	17:40	0.17/0.18/0.18	15.82/15.85/15.86	299/301/302	TOTAL DEPTH = 23.5 FEET
5	9	18:30	17:55	N	N/A	N	N/A	Y	19:30	0.17/0.17/0.17	15.73/15.71/15.70	293/294/294	TOTAL DEPTH = 24 FEET
6	12	21:30	20:55	N	N/A	N	N/A	Y	22:15	0.17/0.17/0.17	15.84/15.85/15.85	298/299/299	TOTAL DEPTH = 27 FEET
7	15	0:30	1:15	N	N/A	N	N/A	Y	3:52	0.18/0.18/0.18	15.92/15.91/15.91	303/303/303	TOTAL DEPTH = 24 FEET
8	18	3:30	4:03	N	N/A	N	N/A	Y	5:35	0.18/0.18/0.18	15.77/15.78/15.78	300/302/302	TOTAL DEPTH = 20 FEET
9	21	6:30	7:05	N	N/A	N	N/A	Y	10:45	0.18/0.18/0.18	15.72/15.72/15.72	299/300/301	TOTAL DEPTH = 24 FEET
10	24	9:30	10:05	N	N/A	N	N/A	Y	10:45	0.17/0.17/0.17	15.80/15.80/15.80	288/291/293	TOTAL DEPTH = 25 FEET
DELAWARE RIVER STATION: DR-07													
1	0	9:30	9:15	N	N/A	N	N/A	Y	10:38	0.18/0.18/0.18	15.77/15.77/15.77	300/300/300	TOTAL DEPTH = 5.5 FEET
2	2	11:30	11:10	N	N/A	N	N/A	Y	12:28	0.17/0.17/0.17	15.78/15.78/15.78	297/297/298	TOTAL DEPTH = 5 FEET
3	4	13:30	13:20	N	N/A	N	N/A	Y	15:35	0.17/0.17/0.17	15.77/15.77/15.77	299/299/299	TOTAL DEPTH = 4.1 FEET
4	6	15:30	15:00	N	N/A	N	N/A	Y	17:40	0.18/0.18/0.18	16.01/16.01/15.99	304/304/304	TOTAL DEPTH = 2.7 FEET
5	9	18:30	18:00	N	N/A	N	N/A	Y	19:30	0.18/0.18/0.18	15.89/15.89/15.89	300/300/300	TOTAL DEPTH = 1.5 FEET
6	12	21:30	21:00	N	N/A	N	N/A	Y	22:15	0.18/0.18/0.18	15.89/15.89/15.91	303/303/303	TOTAL DEPTH = 5 FEET
7	15	0:30	1:33	N	N/A	N	N/A	Y	3:52	0.18/0.18/0.18	15.94/15.93/15.93	303/303/303	TOTAL DEPTH = 6 FEET
8	18	3:30	4:16	N	N/A	N	N/A	Y	5:35	0.18/0.18/0.18	15.92/15.92/15.91	306/306/307	TOTAL DEPTH = 5 FEET
9	21	6:30	7:20	N	N/A	N	N/A	Y	10:45	0.18/0.18/0.18	15.68/15.67/15.67	301/301/302	TOTAL DEPTH = 5 FEET
10	24	9:30	10:17	N	N/A	N	N/A	Y	10:45	0.18/0.18/0.18	15.76/15.76/15.76	295/297/297	TOTAL DEPTH = 8 FEET

WET WEATHER EVENT: 3
CSO STATION: CSO-02

DATE: *5/22/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *10:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Filed Observations (see notes, below)
1	T=0 (First Flush)	10:25	10:30	N	N/A	Y	10:31	Y	12:28	
2	30 Min	10:55	11:00	N	N/A	N	N/A	Y	12:28	
3	60 Min	11:25	11:30	N	N/A	N	N/A	Y	12:28	
4	2 Hours	0:25	0:40	N	N/A	N	N/A	Y	15:35	
5	4 Hours	14:25	-	-	-	-	-	-		NO OVERFLOW
6	8 Hours	18:25	-	-	-	-	-	-		NO OVERFLOW
7	12 Hours	22:25	-	-	-	-	-	-		NO OVERFLOW
8	24 Hours	10:25	-	-	-	-	-	-		NO OVERFLOW
CSO STATION: CSO-05										
1	T=0 (First Flush)	10:25	10:25	N	N/A	N	N/A	Y	12:28	
2	30 Min	10:55	11:05	N	N/A	N	N/A	Y	12:28	
3	60 Min	11:25	11:35	N	N/A	N	N/A	Y	12:28	
4	2 Hours	0:25	0:35	N	N/A	N	N/A	Y	15:35	
5	4 Hours	14:25	14:35	N	N/A	N	N/A	Y	15:35	
6	8 Hours	18:25	-	-	-	-	-	-		NO OVERFLOW
7	12 Hours	22:25	-	-	-	-	-	-		NO OVERFLOW
8	24 Hours	10:25	-	-	-	-	-	-		NO OVERFLOW
CSO STATION: CSO-18										
1	T=0 (First Flush)	10:45	10:45	N	N/A	N	N/A	Y	12:28	
2	30 Min	11:15	11:15	N	N/A	N	N/A	Y	12:28	
3	60 Min	11:45	0:05	N	N/A	Y	0:00	Y	12:28	
4	2 Hours	0:45	0:45	N	N/A	N	N/A	Y	15:35	
5	4 Hours	14:45	-	-	-	-	-	-		NO OVERFLOW at 14:45
6	8 Hours	18:45	-	-	-	-	-	-		NO OVERFLOW at 18:45
7	12 Hours	22:45	-	-	-	-	-	-		NO OVERFLOW at 22:45
8	24 Hours	10:45	-	-	-	-	-	-		NO OVERFLOW at 10:45
CSO STATION: CSO-19										
1	T=0 (First Flush)	10:45	11:00	N	N/A	N	N/A	Y	12:28	
2	30 Min	11:15	-	-	-	-	-	-		NO OVERFLOW at 11:25
3	60 Min	11:45	-	-	-	-	-	-		NO OVERFLOW at 12:15
4	2 Hours	0:45	0:55	Y	0:55	N	N/A	Y	15:35	
5	4 Hours	14:45	-	-	-	-	-	-		NO OVERFLOW at 14:45
6	8 Hours	18:45	-	-	-	-	-	-		NO OVERFLOW at 18:45
7	12 Hours	22:45	-	-	-	-	-	-		NO OVERFLOW at 22:45
8	24 Hours	10:45	-	-	-	-	-	-		NO OVERFLOW at 10:45

WET WEATHER EVENT: 3
STORM WATER STATION: SW-05A

DATE: *5/22/2017* **Note Temperature of Receiving Stream if below 10 °C threshhold**

START OF RAINFALL TIME: *10:30*

Sampling Round	Sample Interval from Start of Rainfall (Hours)	Target Sample Collection Time (hh:mm)	Actual Sample Collection Time (hh:mm)	Duplicate Sample Collected? (Y/N)	Duplicate Collection Time (hh:mm)	Field Blank Sample Collected? (Y/N)	Field Blank Collection Time (hh:mm)	Chain of Custody Provided & Completed (Y/N)	Time Sample Transferred to Lab Courier (hh:mm)	Filed Observations (see notes, below)
1	T=0 (First Flush)	10:30	10:40					Y	12:28	
2	30 Min	11:00	11:10					Y	12:28	
3	60 Min	11:30	11:40					Y	12:28	
4	2 Hours	0:30	0:40					Y	15:35	
5	4 Hours	14:30	14:40					Y	15:35	
6	8 Hours	18:30	-					-	-	NO FLOW OR VERY LESS FLOW TO SAMPLE
7	12 Hours	22:30	-					-	-	NO FLOW OR VERY LESS FLOW TO SAMPLE
8	24 Hours	10:30	-					-	-	NO FLOW OR VERY LESS FLOW TO SAMPLE
STORM WATER STATION: SW-SS2										
1	T=0 (First Flush)	10:30	10:30					Y	12:28	
2	30 Min	11:00	11:00					Y	12:28	
3	60 Min	11:30	11:30					Y	12:28	
4	2 Hours	0:30	0:30					Y	15:35	
5	4 Hours	14:30	14:30					Y	15:35	
6	8 Hours	18:30	-					-	-	NO FLOW OR VERY LESS FLOW TO SAMPLE
7	12 Hours	22:30	-					-	-	NO FLOW OR VERY LESS FLOW TO SAMPLE
8	24 Hours	10:30	-					-	-	NO FLOW OR VERY LESS FLOW TO SAMPLE

Login Number	Sample ID	Sample Date/Time	Parameter Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	Tech Initials
L6810904-1	DR-01-1	05/22/17 09:20am	ENTEROCOCCUS-MF 24	EPA 1600	2 E	05/22/17 05:05PM	
L6810904-1	DR-01-1	05/22/17 09:20am	E. COLI-MF (1603)	EPA 1603	12E	05/22/17 05:04PM	
L6810904-1	DR-01-1	05/22/17 09:20am	FECAL COLIFORM-MF	SM 9222D	24E	05/22/17 05:04PM	
L6810904-2	DR-02-1	05/22/17 09:35am	ENTEROCOCCUS-MF 24	EPA 1600	14E	05/22/17 05:05PM	
L6810904-2	DR-02-1	05/22/17 09:35am	E. COLI-MF (1603)	EPA 1603	8E	05/22/17 05:04PM	
L6810904-2	DR-02-1	05/22/17 09:35am	FECAL COLIFORM-MF	SM 9222D	40	05/22/17 05:04PM	
L6810904-3	DR-03-1	05/22/17 09:50am	ENTEROCOCCUS-MF 24	EPA 1600	20E	05/22/17 05:05PM	
L6810904-3	DR-03-1	05/22/17 09:50am	E. COLI-MF (1603)	EPA 1603	12E	05/22/17 05:04PM	
L6810904-3	DR-03-1	05/22/17 09:50am	FECAL COLIFORM-MF	SM 9222D	32E	05/22/17 05:04PM	
L6810904-4	DR-04-1	05/22/17 09:05am	ENTEROCOCCUS-MF 24	EPA 1600	6E	05/22/17 05:05PM	
L6810904-4	DR-04-1	05/22/17 09:05am	E. COLI-MF (1603)	EPA 1603	3 E	05/22/17 05:04PM	
L6810904-4	DR-04-1	05/22/17 09:05am	FECAL COLIFORM-MF	SM 9222D	22	05/22/17 05:04PM	
L6810904-5	DR-05-1	05/22/17 09:30am	ENTEROCOCCUS-MF 24	EPA 1600	12E	05/22/17 05:05PM	
L6810904-5	DR-05-1	05/22/17 09:30am	E. COLI-MF (1603)	EPA 1603	6E	05/22/17 05:04PM	
L6810904-5	DR-05-1	05/22/17 09:30am	FECAL COLIFORM-MF	SM 9222D	12E	05/22/17 05:04PM	
L6810904-6	DR-06-1	05/22/17 09:10am	ENTEROCOCCUS-MF 24	EPA 1600	2 E	05/22/17 05:05PM	
L6810904-6	DR-06-1	05/22/17 09:10am	E. COLI-MF (1603)	EPA 1603	6E	05/22/17 05:04PM	
L6810904-6	DR-06-1	05/22/17 09:10am	FECAL COLIFORM-MF	SM 9222D	6E	05/22/17 05:04PM	
L6810904-7	DR-07-1	05/22/17 09:15am	ENTEROCOCCUS-MF 24	EPA 1600	6E	05/22/17 05:05PM	
L6810904-7	DR-07-1	05/22/17 09:15am	E. COLI-MF (1603)	EPA 1603	10E	05/22/17 05:04PM	
L6810904-7	DR-07-1	05/22/17 09:15am	FECAL COLIFORM-MF	SM 9222D	12E	05/22/17 05:04PM	
L6810904-8	BLANK 03	05/22/17 09:05am	ENTEROCOCCUS-MF 24	EPA 1600	<2	05/22/17 05:05PM	
L6810904-8	BLANK 03	05/22/17 09:05am	E. COLI-MF (1603)	EPA 1603	<2	05/22/17 05:04PM	
L6810904-8	BLANK 03	05/22/17 09:05am	FECAL COLIFORM-MF	SM 9222D	<2	05/22/17 05:04PM	
L6810904-9	CSO-05-1	05/22/17 10:25am	ENTEROCOCCUS-MF 24	EPA 1600	476000E	05/22/17 06:24PM	
L6810904-9	CSO-05-1	05/22/17 10:25am	E. COLI-MF (1603)	EPA 1603	920000E	05/22/17 06:21PM	
L6810904-9	CSO-05-1	05/22/17 10:25am	FECAL COLIFORM-MF	SM 9222D	1080000E	05/22/17 06:23PM	
L6810904-10	CSO-02-1	05/22/17 10:30am	ENTEROCOCCUS-MF 24	EPA 1600	558000E	05/22/17 06:24PM	
L6810904-10	CSO-02-1	05/22/17 10:30am	E. COLI-MF (1603)	EPA 1603	730000E	05/22/17 06:21PM	
L6810904-10	CSO-02-1	05/22/17 10:30am	FECAL COLIFORM-MF	SM 9222D	170000E	05/22/17 06:23PM	
L6810904-11	BLANK 04	05/22/17 10:31am	ENTEROCOCCUS-MF 24	EPA 1600	<10	05/22/17 06:24PM	
L6810904-11	BLANK 04	05/22/17 10:31am	E. COLI-MF (1603)	EPA 1603	<10	05/22/17 06:21PM	
L6810904-11	BLANK 04	05/22/17 10:31am	FECAL COLIFORM-MF	SM 9222D	<10	05/22/17 06:23PM	
L6810904-12	SW-SS2-1	05/22/17 10:31am	ENTEROCOCCUS-MF 24	EPA 1600	505000E	05/22/17 06:24PM	
L6810904-12	SW-SS2-1	05/22/17 10:31am	E. COLI-MF (1603)	EPA 1603	49000	05/22/17 06:21PM	
L6810904-12	SW-SS2-1	05/22/17 10:31am	FECAL COLIFORM-MF	SM 9222D	21000	05/22/17 06:23PM	
L6810904-13	SW-05A-1	05/22/17 10:40am	ENTEROCOCCUS-MF 24	EPA 1600	82000E	05/22/17 06:24PM	
L6810904-13	SW-05A-1	05/22/17 10:40am	E. COLI-MF (1603)	EPA 1603	20000	05/22/17 06:21PM	
L6810904-13	SW-05A-1	05/22/17 10:40am	FECAL COLIFORM-MF	SM 9222D	35000	05/22/17 06:23PM	
L6810904-14	SW-SS2-2	05/22/17 11:00am	ENTEROCOCCUS-MF 24	EPA 1600	177000E	05/22/17 06:24PM	
L6810904-14	SW-SS2-2	05/22/17 11:00am	E. COLI-MF (1603)	EPA 1603	21000	05/22/17 06:21PM	
L6810904-14	SW-SS2-2	05/22/17 11:00am	FECAL COLIFORM-MF	SM 9222D	19000E	05/22/17 06:23PM	
L6810904-15	SW-05A-2	05/22/17 11:10am	ENTEROCOCCUS-MF 24	EPA 1600	148000E	05/22/17 06:24PM	
L6810904-15	SW-05A-2	05/22/17 11:10am	E. COLI-MF (1603)	EPA 1603	20000	05/22/17 06:21PM	
L6810904-15	SW-05A-2	05/22/17 11:10am	FECAL COLIFORM-MF	SM 9222D	18000E	05/22/17 06:23PM	
L6810904-16	SW-05A-3	05/22/17 11:40am	ENTEROCOCCUS-MF 24	EPA 1600	129000E	05/22/17 06:24PM	
L6810904-16	SW-05A-3	05/22/17 11:40am	E. COLI-MF (1603)	EPA 1603	9000E	05/22/17 06:21PM	
L6810904-16	SW-05A-3	05/22/17 11:40am	FECAL COLIFORM-MF	SM 9222D	21000	05/22/17 06:23PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6810904-17	SW-SS2-3	05/22/17 11:30am	ENTEROCOCCUS-MF 24	EPA 1600	185000E	05/22/17 06:24PM	
L6810904-17	SW-SS2-3	05/22/17 11:30am	E. COLI-MF (1603)	EPA 1603	32000	05/22/17 06:21PM	
L6810904-17	SW-SS2-3	05/22/17 11:30am	FECAL COLIFORM-MF	SM 9222D	23000	05/22/17 06:23PM	
L6810904-18	CC-03	05/22/17 10:42am	ENTEROCOCCUS-MF 24	EPA 1600	270	05/22/17 06:24PM	
L6810904-18	CC-03	05/22/17 10:42am	E. COLI-MF (1603)	EPA 1603	60E	05/22/17 06:21PM	
L6810904-18	CC-03	05/22/17 10:42am	FECAL COLIFORM-MF	SM 9222D	60E	05/22/17 06:23PM	
L6810904-19	RC-03	05/22/17 10:56am	ENTEROCOCCUS-MF 24	EPA 1600	20E	05/22/17 06:24PM	
L6810904-19	RC-03	05/22/17 10:56am	E. COLI-MF (1603)	EPA 1603	160E	05/22/17 06:21PM	
L6810904-19	RC-03	05/22/17 10:56am	FECAL COLIFORM-MF	SM 9222D	210	05/22/17 06:23PM	
L6810904-20	RC-02	05/22/17 11:07am	ENTEROCOCCUS-MF 24	EPA 1600	10000E	05/22/17 06:24PM	
L6810904-20	RC-02	05/22/17 11:07am	E. COLI-MF (1603)	EPA 1603	87000 E	05/22/17 06:54PM	
L6810904-20	RC-02	05/22/17 11:07am	FECAL COLIFORM-MF	SM 9222D	103000E	05/22/17 06:23PM	
L6810904-21	RC-01	05/22/17 11:23am	ENTEROCOCCUS-MF 24	EPA 1600	14000E	05/22/17 06:24PM	
L6810904-21	RC-01	05/22/17 11:23am	E. COLI-MF (1603)	EPA 1603	5300	05/22/17 06:21PM	
L6810904-21	RC-01	05/22/17 11:23am	FECAL COLIFORM-MF	SM 9222D	4200	05/22/17 06:23PM	
L6810904-22	CC-01	05/22/17 11:42am	ENTEROCOCCUS-MF 24	EPA 1600	14000E	05/22/17 06:24PM	
L6810904-22	CC-01	05/22/17 11:42am	E. COLI-MF (1603)	EPA 1603	1600E	05/22/17 06:21PM	
L6810904-22	CC-01	05/22/17 11:42am	FECAL COLIFORM-MF	SM 9222D	2600	05/22/17 06:23PM	
L6810904-23	CC-02	05/22/17 11:54am	ENTEROCOCCUS-MF 24	EPA 1600	660E	05/22/17 06:24PM	
L6810904-23	CC-02	05/22/17 11:54am	E. COLI-MF (1603)	EPA 1603	700E	05/22/17 06:21PM	
L6810904-23	CC-02	05/22/17 11:54am	FECAL COLIFORM-MF	SM 9222D	1600E	05/22/17 06:23PM	
L6810904-24	BLANK 01	05/22/17 12:00pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	05/22/17 06:24PM	
L6810904-24	BLANK 01	05/22/17 12:00pm	E. COLI-MF (1603)	EPA 1603	<10	05/22/17 06:21PM	
L6810904-24	BLANK 01	05/22/17 12:00pm	FECAL COLIFORM-MF	SM 9222D	<10	05/22/17 06:23PM	
L6810904-25	CSO-18-1	05/22/17 10:45am	ENTEROCOCCUS-MF 24	EPA 1600	116000E	05/22/17 06:24PM	
L6810904-25	CSO-18-1	05/22/17 10:45am	E. COLI-MF (1603)	EPA 1603	441000E	05/22/17 06:21PM	
L6810904-25	CSO-18-1	05/22/17 10:45am	FECAL COLIFORM-MF	SM 9222D	42000	05/22/17 06:23PM	
L6810904-26	CSO-19-1	05/22/17 11:00am	ENTEROCOCCUS-MF 24	EPA 1600	267000E	05/22/17 06:24PM	
L6810904-26	CSO-19-1	05/22/17 11:00am	E. COLI-MF (1603)	EPA 1603	730000E	05/22/17 06:21PM	
L6810904-26	CSO-19-1	05/22/17 11:00am	FECAL COLIFORM-MF	SM 9222D	122000E	05/22/17 06:23PM	
L6810904-27	CSO-02-2	05/22/17 11:00am	ENTEROCOCCUS-MF 24	EPA 1600	238000E	05/22/17 06:24PM	
L6810904-27	CSO-02-2	05/22/17 11:00am	E. COLI-MF (1603)	EPA 1603	209000 E	05/22/17 06:54PM	
L6810904-27	CSO-02-2	05/22/17 11:00am	FECAL COLIFORM-MF	SM 9222D	126000E	05/22/17 06:23PM	
L6810904-28	CSO-05-2	05/22/17 11:05am	ENTEROCOCCUS-MF 24	EPA 1600	147000E	05/22/17 06:24PM	
L6810904-28	CSO-05-2	05/22/17 11:05am	E. COLI-MF (1603)	EPA 1603	135000 E	05/22/17 06:54PM	
L6810904-28	CSO-05-2	05/22/17 11:05am	FECAL COLIFORM-MF	SM 9222D	92000E	05/22/17 06:23PM	
L6810904-29	DR-01-2	05/22/17 11:10am	ENTEROCOCCUS-MF 24	EPA 1600	4E	05/22/17 06:24PM	
L6810904-29	DR-01-2	05/22/17 11:10am	E. COLI-MF (1603)	EPA 1603	10 E	05/22/17 06:54PM	
L6810904-29	DR-01-2	05/22/17 11:10am	FECAL COLIFORM-MF	SM 9222D	30E	05/22/17 06:23PM	
L6810904-30	DR-02-2	05/22/17 11:15am	ENTEROCOCCUS-MF 24	EPA 1600	4 Q, E	05/22/17 08:18PM	
L6810904-30	DR-02-2	05/22/17 11:15am	E. COLI-MF (1603)	EPA 1603	<2	05/22/17 06:54PM	
L6810904-30	DR-02-2	05/22/17 11:15am	FECAL COLIFORM-MF	SM 9222D	26E	05/22/17 06:23PM	
L6810904-31	DR-03-2	05/22/17 11:25am	ENTEROCOCCUS-MF 24	EPA 1600	4E	05/22/17 06:24PM	
L6810904-31	DR-03-2	05/22/17 11:25am	E. COLI-MF (1603)	EPA 1603	2 E, Q	05/22/17 07:40PM	
L6810904-31	DR-03-2	05/22/17 11:25am	FECAL COLIFORM-MF	SM 9222D	6E	05/22/17 06:23PM	
L6810904-32	DR-04-2	05/22/17 11:00am	ENTEROCOCCUS-MF 24	EPA 1600	4E	05/22/17 06:24PM	
L6810904-32	DR-04-2	05/22/17 11:00am	E. COLI-MF (1603)	EPA 1603	12 E, Q	05/22/17 07:40PM	
L6810904-32	DR-04-2	05/22/17 11:00am	FECAL COLIFORM-MF	SM 9222D	24E	05/22/17 06:23PM	
L6810904-33	DR-05-2	05/22/17 11:20am	ENTEROCOCCUS-MF 24	EPA 1600	32E	05/22/17 06:24PM	
L6810904-33	DR-05-2	05/22/17 11:20am	E. COLI-MF (1603)	EPA 1603	4E	05/22/17 06:54PM	
L6810904-33	DR-05-2	05/22/17 11:20am	FECAL COLIFORM-MF	SM 9222D	34E	05/22/17 06:23PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6810904-34	DR-06-2	05/22/17 11:05am	ENTEROCOCCUS-MF 24	EPA 1600	2 E, Q	05/22/17 08:18PM	
L6810904-34	DR-06-2	05/22/17 11:05am	E. COLI-MF (1603)	EPA 1603	6 E, Q	05/22/17 07:40PM	
L6810904-34	DR-06-2	05/22/17 11:05am	FECAL COLIFORM-MF	SM 9222D	4E	05/22/17 06:23PM	
L6810904-35	DR-07-2	05/22/17 11:10am	ENTEROCOCCUS-MF 24	EPA 1600	10E	05/22/17 06:24PM	
L6810904-35	DR-07-2	05/22/17 11:10am	E. COLI-MF (1603)	EPA 1603	10E	05/22/17 06:21PM	
L6810904-35	DR-07-2	05/22/17 11:10am	FECAL COLIFORM-MF	SM 9222D	4E	05/22/17 06:23PM	
L6810904-36	BLANK 02	05/22/17 11:05am	ENTEROCOCCUS-MF 24	EPA 1600	650E	05/22/17 06:24PM	
L6810904-36	BLANK 02	05/22/17 11:05am	E. COLI-MF (1603)	EPA 1603	<2 Q	05/22/17 07:40PM	
L6810904-36	BLANK 02	05/22/17 11:05am	FECAL COLIFORM-MF	SM 9222D	<2	05/22/17 06:23PM	
L6810904-37	CSO-18-1	05/22/17 11:15am	ENTEROCOCCUS-MF 24	EPA 1600	72000E	05/22/17 06:24PM	
L6810904-37	CSO-18-1	05/22/17 11:15am	E. COLI-MF (1603)	EPA 1603	101000 E, Q	05/22/17 07:40PM	
L6810904-37	CSO-18-1	05/22/17 11:15am	FECAL COLIFORM-MF	SM 9222D	71000E	05/22/17 06:23PM	
L6810904-38	CSO-02-3	05/22/17 11:30am	ENTEROCOCCUS-MF 24	EPA 1600	920000E	05/22/17 06:24PM	
L6810904-38	CSO-02-3	05/22/17 11:30am	E. COLI-MF (1603)	EPA 1603	1030000 E, Q	05/22/17 07:40PM	
L6810904-38	CSO-02-3	05/22/17 11:30am	FECAL COLIFORM-MF	SM 9222D	>60000	05/22/17 07:28PM	
L6810904-39	CSO-05-3	05/22/17 11:35am	ENTEROCOCCUS-MF 24	EPA 1600	141000 E, Q	05/22/17 08:18PM	
L6810904-39	CSO-05-3	05/22/17 11:35am	E. COLI-MF (1603)	EPA 1603	401000 Q,E	05/22/17 07:40PM	
L6810904-39	CSO-05-3	05/22/17 11:35am	FECAL COLIFORM-MF	SM 9222D	110000 E	05/22/17 07:28PM	
L6810904-40	BLANK-05	05/22/17 12:00pm	ENTEROCOCCUS-MF 24	EPA 1600	<10	05/22/17 06:24PM	
L6810904-40	BLANK-05	05/22/17 12:00pm	E. COLI-MF (1603)	EPA 1603	10 E, Q	05/22/17 07:40PM	
L6810904-40	BLANK-05	05/22/17 12:00pm	FECAL COLIFORM-MF	SM 9222D	<10	05/22/17 07:28PM	
L6810904-41	CSO-18-3	05/22/17 12:05pm	ENTEROCOCCUS-MF 24	EPA 1600	33000	05/22/17 06:24PM	
L6810904-41	CSO-18-3	05/22/17 12:05pm	E. COLI-MF (1603)	EPA 1603	76000 E, Q	05/22/17 07:40PM	
L6810904-41	CSO-18-3	05/22/17 12:05pm	FECAL COLIFORM-MF	SM 9222D	88000E	05/22/17 06:23PM	
L6810904-42	SW-SS2-4	05/22/17 12:30pm	ENTEROCOCCUS-MF 24	EPA 1600	137000E	05/22/17 08:18PM	
L6810904-42	SW-SS2-4	05/22/17 12:30pm	E. COLI-MF (1603)	EPA 1603	21000 Q	05/22/17 08:16PM	
L6810904-42	SW-SS2-4	05/22/17 12:30pm	FECAL COLIFORM-MF	SM 9222D	21000	05/22/17 07:28PM	
L6810904-43	SW-05A-4	05/22/17 12:40pm	ENTEROCOCCUS-MF 24	EPA 1600	172000E	05/22/17 08:18PM	
L6810904-43	SW-05A-4	05/22/17 12:40pm	E. COLI-MF (1603)	EPA 1603	156000 E, Q	05/22/17 08:16PM	
L6810904-43	SW-05A-4	05/22/17 12:40pm	FECAL COLIFORM-MF	SM 9222D	81000 E	05/22/17 07:28PM	
L6810904-44	CSO-05-4	05/22/17 12:35pm	ENTEROCOCCUS-MF 24	EPA 1600	98000E	05/22/17 08:18PM	
L6810904-44	CSO-05-4	05/22/17 12:35pm	E. COLI-MF (1603)	EPA 1603	205000 E, Q	05/22/17 08:16PM	
L6810904-44	CSO-05-4	05/22/17 12:35pm	FECAL COLIFORM-MF	SM 9222D	114000 E	05/22/17 07:28PM	
L6810904-45	CSO-02-4	05/22/17 12:40pm	ENTEROCOCCUS-MF 24	EPA 1600	304000E	05/22/17 08:18PM	
L6810904-45	CSO-02-4	05/22/17 12:40pm	E. COLI-MF (1603)	EPA 1603	290000 E, Q	05/22/17 08:16PM	
L6810904-45	CSO-02-4	05/22/17 12:40pm	FECAL COLIFORM-MF	SM 9222D	117000 E	05/22/17 07:28PM	
L6810904-46	CSO-18-4	05/22/17 12:45pm	ENTEROCOCCUS-MF 24	EPA 1600	40000	05/22/17 08:18PM	
L6810904-46	CSO-18-4	05/22/17 12:45pm	E. COLI-MF (1603)	EPA 1603	255000 E, Q	05/22/17 08:16PM	
L6810904-46	CSO-18-4	05/22/17 12:45pm	FECAL COLIFORM-MF	SM 9222D	79000 E	05/22/17 07:28PM	
L6810904-47	CSO-19-2	05/22/17 12:55pm	ENTEROCOCCUS-MF 24	EPA 1600	130000E	05/22/17 08:18PM	
L6810904-47	CSO-19-2	05/22/17 12:55pm	E. COLI-MF (1603)	EPA 1603	300000 E, Q	05/22/17 08:16PM	
L6810904-47	CSO-19-2	05/22/17 12:55pm	FECAL COLIFORM-MF	SM 9222D	156000 E	05/22/17 07:28PM	
L6810904-48	DUP-CSO	05/22/17 12:55pm	ENTEROCOCCUS-MF 24	EPA 1600	188000E	05/22/17 08:18PM	
L6810904-48	DUP-CSO	05/22/17 12:55pm	E. COLI-MF (1603)	EPA 1603	241000 Q, E	05/22/17 08:16PM	
L6810904-48	DUP-CSO	05/22/17 12:55pm	FECAL COLIFORM-MF	SM 9222D	155000 E	05/22/17 07:28PM	
L6810904-49	DR-01-3	05/22/17 01:15pm	ENTEROCOCCUS-MF 24	EPA 1600	5 E	05/22/17 08:18PM	
L6810904-49	DR-01-3	05/22/17 01:15pm	E. COLI-MF (1603)	EPA 1603	12 E, Q	05/22/17 08:16PM	
L6810904-49	DR-01-3	05/22/17 01:15pm	FECAL COLIFORM-MF	SM 9222D	32 E	05/22/17 07:28PM	
L6810904-50	DR-02-3	05/22/17 01:20pm	ENTEROCOCCUS-MF 24	EPA 1600	26E	05/22/17 08:18PM	
L6810904-50	DR-02-3	05/22/17 01:20pm	E. COLI-MF (1603)	EPA 1603	30 E, Q	05/22/17 08:16PM	
L6810904-50	DR-02-3	05/22/17 01:20pm	FECAL COLIFORM-MF	SM 9222D	50 E	05/22/17 07:28PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6810904-51	DR-03-3	05/22/17 01:30pm	ENTEROCOCCUS-MF 24	EPA 1600	20E	05/22/17 08:18PM	
L6810904-51	DR-03-3	05/22/17 01:30pm	E. COLI-MF (1603)	EPA 1603	32 E, Q	05/22/17 08:16PM	
L6810904-51	DR-03-3	05/22/17 01:30pm	FECAL COLIFORM-MF	SM 9222D	38 E	05/22/17 07:28PM	
L6810904-52	DUP-DR1	05/22/17 01:15pm	ENTEROCOCCUS-MF 24	EPA 1600	10E	05/22/17 08:18PM	
L6810904-52	DUP-DR1	05/22/17 01:15pm	E. COLI-MF (1603)	EPA 1603	20 E, Q	05/22/17 08:16PM	
L6810904-52	DUP-DR1	05/22/17 01:15pm	FECAL COLIFORM-MF	SM 9222D	58	05/22/17 07:28PM	
L6810904-53	DR-04-3	05/22/17 00:00pm	ENTEROCOCCUS-MF 24	EPA 1600	4 E, Q	05/22/17 08:18PM	
L6810904-53	DR-04-3	05/22/17 00:00pm	E. COLI-MF (1603)	EPA 1603	8 E, Q	05/22/17 08:16PM	
L6810904-53	DR-04-3	05/22/17 00:00pm	FECAL COLIFORM-MF	SM 9222D	46 Q	05/22/17 07:28PM	
L6810904-54	DR-05-3	05/22/17 00:00pm	ENTEROCOCCUS-MF 24	EPA 1600	58 Q	05/22/17 08:18PM	
L6810904-54	DR-05-3	05/22/17 00:00pm	E. COLI-MF (1603)	EPA 1603	86 Q	05/22/17 08:16PM	
L6810904-54	DR-05-3	05/22/17 00:00pm	FECAL COLIFORM-MF	SM 9222D	250 Q	05/22/17 07:28PM	
L6810904-55	DR-06-3	05/22/17 00:00pm	ENTEROCOCCUS-MF 24	EPA 1600	2 E	05/22/17 08:18PM	
L6810904-55	DR-06-3	05/22/17 00:00pm	E. COLI-MF (1603)	EPA 1603	8 Q, E	05/22/17 08:16PM	
L6810904-55	DR-06-3	05/22/17 00:00pm	FECAL COLIFORM-MF	SM 9222D	6 Q, E	05/22/17 07:28PM	
L6810904-56	DR-07-3	05/22/17 00:00pm	ENTEROCOCCUS-MF 24	EPA 1600	410 Q	05/22/17 08:18PM	
L6810904-56	DR-07-3	05/22/17 00:00pm	E. COLI-MF (1603)	EPA 1603	490 Q	05/22/17 08:16PM	
L6810904-56	DR-07-3	05/22/17 00:00pm	FECAL COLIFORM-MF	SM 9222D	480 Q	05/22/17 07:28PM	
L6810904-57	CSO-05-5	05/22/17 02:35pm	ENTEROCOCCUS-MF 24	EPA 1600	191000E	05/22/17 08:18PM	
L6810904-57	CSO-05-5	05/22/17 02:35pm	E. COLI-MF (1603)	EPA 1603	1780000 E, Q	05/22/17 08:16PM	
L6810904-57	CSO-05-5	05/22/17 02:35pm	FECAL COLIFORM-MF	SM 9222D	266000 E	05/22/17 07:28PM	
L6810904-58	SW-SS2-5	05/22/17 02:30pm	ENTEROCOCCUS-MF 24	EPA 1600	121000E	05/22/17 08:18PM	
L6810904-58	SW-SS2-5	05/22/17 02:30pm	E. COLI-MF (1603)	EPA 1603	8546 Q	05/22/17 08:16PM	
L6810904-58	SW-SS2-5	05/22/17 02:30pm	FECAL COLIFORM-MF	SM 9222D	21000	05/22/17 07:28PM	
L6810904-59	SW-05A-5	05/22/17 02:40pm	ENTEROCOCCUS-MF 24	EPA 1600	19000E	05/22/17 08:18PM	
L6810904-59	SW-05A-5	05/22/17 02:40pm	E. COLI-MF (1603)	EPA 1603	8000 Q	05/22/17 08:16PM	
L6810904-59	SW-05A-5	05/22/17 02:40pm	FECAL COLIFORM-MF	SM 9222D	32000	05/22/17 07:28PM	
L6810904-60	CC-03	05/22/17 02:40pm	ENTEROCOCCUS-MF 24	EPA 1600	11000E	05/22/17 10:17PM	
L6810904-60	CC-03	05/22/17 02:40pm	E. COLI-MF (1603)	EPA 1603	22000	05/22/17 10:26PM	
L6810904-60	CC-03	05/22/17 02:40pm	FECAL COLIFORM-MF	SM 9222D	10000E	05/22/17 10:39PM	
L6810904-61	RC-03	05/22/17 02:50pm	ENTEROCOCCUS-MF 24	EPA 1600	1700E	05/22/17 10:17PM	
L6810904-61	RC-03	05/22/17 02:50pm	E. COLI-MF (1603)	EPA 1603	2900	05/22/17 10:26PM	
L6810904-61	RC-03	05/22/17 02:50pm	FECAL COLIFORM-MF	SM 9222D	2100	05/22/17 10:39PM	
L6810904-62	RC-02	05/22/17 03:05pm	ENTEROCOCCUS-MF 24	EPA 1600	1000E	05/22/17 10:17PM	
L6810904-62	RC-02	05/22/17 03:05pm	E. COLI-MF (1603)	EPA 1603	2800	05/22/17 10:26PM	
L6810904-62	RC-02	05/22/17 03:05pm	FECAL COLIFORM-MF	SM 9222D	2400	05/22/17 10:39PM	
L6810904-63	RC-01	05/22/17 03:18pm	ENTEROCOCCUS-MF 24	EPA 1600	2000	05/22/17 10:17PM	
L6810904-63	RC-01	05/22/17 03:18pm	E. COLI-MF (1603)	EPA 1603	870E	05/22/17 10:26PM	
L6810904-63	RC-01	05/22/17 03:18pm	FECAL COLIFORM-MF	SM 9222D	480	05/22/17 10:39PM	
L6810904-64	CC-07	05/22/17 03:40pm	ENTEROCOCCUS-MF 24	EPA 1600	3000	05/22/17 10:17PM	
L6810904-64	CC-07	05/22/17 03:40pm	E. COLI-MF (1603)	EPA 1603	1000E	05/22/17 10:26PM	
L6810904-64	CC-07	05/22/17 03:40pm	FECAL COLIFORM-MF	SM 9222D	1700E	05/22/17 10:39PM	
L6810904-65	CC-02	05/22/17 03:50pm	ENTEROCOCCUS-MF 24	EPA 1600	5000	05/22/17 10:17PM	
L6810904-65	CC-02	05/22/17 03:50pm	E. COLI-MF (1603)	EPA 1603	4900	05/22/17 10:26PM	
L6810904-65	CC-02	05/22/17 03:50pm	FECAL COLIFORM-MF	SM 9222D	2400	05/22/17 10:39PM	
L6810904-66	DUPLICATE-CC	05/22/17 00:00pm	ENTEROCOCCUS-MF 24	EPA 1600	6000 Q	05/22/17 10:17PM	
L6810904-66	DUPLICATE-CC	05/22/17 00:00pm	E. COLI-MF (1603)	EPA 1603	4800 Q	05/22/17 10:26PM	
L6810904-66	DUPLICATE-CC	05/22/17 00:00pm	FECAL COLIFORM-MF	SM 9222D	4000 Q	05/22/17 10:39PM	
L6810904-67	DUPLICATE-RC	05/22/17 00:00pm	ENTEROCOCCUS-MF 24	EPA 1600	2200 Q	05/22/17 10:17PM	
L6810904-67	DUPLICATE-RC	05/22/17 00:00pm	E. COLI-MF (1603)	EPA 1603	4400 Q	05/22/17 10:26PM	
L6810904-67	DUPLICATE-RC	05/22/17 00:00pm	FECAL COLIFORM-MF	SM 9222D	2600 Q	05/22/17 10:39PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6810904-68	DR-01-4	05/22/17 03:15pm	ENTEROCOCCUS-MF 24	EPA 1600	46	05/22/17 10:17PM	
L6810904-68	DR-01-4	05/22/17 03:15pm	E. COLI-MF (1603)	EPA 1603	64	05/22/17 10:26PM	
L6810904-68	DR-01-4	05/22/17 03:15pm	FECAL COLIFORM-MF	SM 9222D	26E	05/22/17 10:39PM	
L6810904-69	DR-02-4	05/22/17 03:20pm	ENTEROCOCCUS-MF 24	EPA 1600	4E	05/22/17 10:17PM	
L6810904-69	DR-02-4	05/22/17 03:20pm	E. COLI-MF (1603)	EPA 1603	24E	05/22/17 10:26PM	
L6810904-69	DR-02-4	05/22/17 03:20pm	FECAL COLIFORM-MF	SM 9222D	18E	05/22/17 10:39PM	
L6810904-70	DR-03-4	05/22/17 03:25pm	ENTEROCOCCUS-MF 24	EPA 1600	58	05/22/17 10:17PM	
L6810904-70	DR-03-4	05/22/17 03:25pm	E. COLI-MF (1603)	EPA 1603	142	05/22/17 10:26PM	
L6810904-70	DR-03-4	05/22/17 03:25pm	FECAL COLIFORM-MF	SM 9222D	72	05/22/17 10:39PM	
L6810904-71	DR-04-4	05/22/17 03:30pm	ENTEROCOCCUS-MF 24	EPA 1600	100E	05/22/17 10:17PM	
L6810904-71	DR-04-4	05/22/17 03:30pm	E. COLI-MF (1603)	EPA 1603	270	05/22/17 10:26PM	
L6810904-71	DR-04-4	05/22/17 03:30pm	FECAL COLIFORM-MF	SM 9222D	180E	05/22/17 10:39PM	
L6810904-72	DR-05-4	05/22/17 03:35pm	ENTEROCOCCUS-MF 24	EPA 1600	1600E	05/22/17 10:17PM	
L6810904-72	DR-05-4	05/22/17 03:35pm	E. COLI-MF (1603)	EPA 1603	16E	05/22/17 10:26PM	
L6810904-72	DR-05-4	05/22/17 03:35pm	FECAL COLIFORM-MF	SM 9222D	42	05/22/17 10:39PM	
L6810904-73	DR-06-4	05/22/17 02:55pm	ENTEROCOCCUS-MF 24	EPA 1600	2 E	05/22/17 10:17PM	
L6810904-73	DR-06-4	05/22/17 02:55pm	E. COLI-MF (1603)	EPA 1603	10 E	05/22/17 10:26PM	
L6810904-73	DR-06-4	05/22/17 02:55pm	FECAL COLIFORM-MF	SM 9222D	<2	05/22/17 10:39PM	
L6810904-74	DR-07-4	05/22/17 03:00pm	ENTEROCOCCUS-MF 24	EPA 1600	130E	05/22/17 10:17PM	
L6810904-74	DR-07-4	05/22/17 03:00pm	E. COLI-MF (1603)	EPA 1603	260	05/22/17 10:26PM	
L6810904-74	DR-07-4	05/22/17 03:00pm	FECAL COLIFORM-MF	SM 9222D	290	05/22/17 10:39PM	
L6810904-75	DR-06-5	05/22/17 05:55pm	ENTEROCOCCUS-MF 24	EPA 1600	2E	05/22/17 11:55PM	
L6810904-75	DR-06-5	05/22/17 05:55pm	E. COLI-MF (1603)	EPA 1603	4E	05/22/17 10:26PM	
L6810904-75	DR-06-5	05/22/17 05:55pm	FECAL COLIFORM-MF	SM 9222D	2E	05/22/17 10:39PM	
L6810904-76	DR-07-5	05/22/17 06:00pm	ENTEROCOCCUS-MF 24	EPA 1600	14E	05/22/17 11:55PM	
L6810904-76	DR-07-5	05/22/17 06:00pm	E. COLI-MF (1603)	EPA 1603	24E	05/22/17 10:26PM	
L6810904-76	DR-07-5	05/22/17 06:00pm	FECAL COLIFORM-MF	SM 9222D	32E	05/22/17 10:39PM	
L6810904-77	DR-01-5	05/22/17 06:15pm	ENTEROCOCCUS-MF 24	EPA 1600	66	05/22/17 11:55PM	
L6810904-77	DR-01-5	05/22/17 06:15pm	E. COLI-MF (1603)	EPA 1603	50	05/22/17 10:26PM	
L6810904-77	DR-01-5	05/22/17 06:15pm	FECAL COLIFORM-MF	SM 9222D	36E	05/22/17 10:39PM	
L6810904-78	DR-02-5	05/22/17 06:20pm	ENTEROCOCCUS-MF 24	EPA 1600	30 E	05/22/17 11:55PM	
L6810904-78	DR-02-5	05/22/17 06:20pm	E. COLI-MF (1603)	EPA 1603	24E	05/22/17 10:26PM	
L6810904-78	DR-02-5	05/22/17 06:20pm	FECAL COLIFORM-MF	SM 9222D	20E	05/22/17 10:39PM	
L6810904-79	DR-03-5	05/22/17 06:25pm	ENTEROCOCCUS-MF 24	EPA 1600	124E	05/22/17 11:55PM	
L6810904-79	DR-03-5	05/22/17 06:25pm	E. COLI-MF (1603)	EPA 1603	300	05/22/17 10:26PM	
L6810904-79	DR-03-5	05/22/17 06:25pm	FECAL COLIFORM-MF	SM 9222D	190E	05/22/17 10:39PM	
L6810904-80	DR-04-5	05/22/17 06:30pm	ENTEROCOCCUS-MF 24	EPA 1600	112	05/22/17 11:55PM	
L6810904-80	DR-04-5	05/22/17 06:30pm	E. COLI-MF (1603)	EPA 1603	340	05/22/17 10:26PM	
L6810904-80	DR-04-5	05/22/17 06:30pm	FECAL COLIFORM-MF	SM 9222D	310	05/22/17 10:39PM	
L6810904-81	DR-05-5	05/22/17 06:35pm	ENTEROCOCCUS-MF 24	EPA 1600	280E	05/22/17 11:55PM	
L6810904-81	DR-05-5	05/22/17 06:35pm	E. COLI-MF (1603)	EPA 1603	280	05/22/17 10:26PM	
L6810904-81	DR-05-5	05/22/17 06:35pm	FECAL COLIFORM-MF	SM 9222D	340	05/22/17 10:39PM	
L6810904-82	RC-01-03	05/22/17 06:40pm	ENTEROCOCCUS-MF 24	EPA 1600	600	05/22/17 10:17PM	
L6810904-82	RC-01-03	05/22/17 06:40pm	E. COLI-MF (1603)	EPA 1603	300	05/22/17 10:26PM	
L6810904-82	RC-01-03	05/22/17 06:40pm	FECAL COLIFORM-MF	SM 9222D	370	05/22/17 10:39PM	
L6810904-83	RC-02-03	05/22/17 06:18pm	ENTEROCOCCUS-MF 24	EPA 1600	2600	05/22/17 11:55PM	
L6810904-83	RC-02-03	05/22/17 06:18pm	E. COLI-MF (1603)	EPA 1603	840E	05/22/17 10:26PM	
L6810904-83	RC-02-03	05/22/17 06:18pm	FECAL COLIFORM-MF	SM 9222D	800E	05/22/17 10:39PM	
L6810904-84	RC-03-03	05/22/17 06:12pm	ENTEROCOCCUS-MF 24	EPA 1600	4200	05/22/17 10:17PM	
L6810904-84	RC-03-03	05/22/17 06:12pm	E. COLI-MF (1603)	EPA 1603	1900E	05/22/17 10:26PM	
L6810904-84	RC-03-03	05/22/17 06:12pm	FECAL COLIFORM-MF	SM 9222D	1000E	05/22/17 10:39PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6810904-85	CC-01-03	05/22/17 06:46pm	ENTEROCOCCUS-MF 24	EPA 1600	1500E	05/22/17 11:55PM	
L6810904-85	CC-01-03	05/22/17 06:46pm	E. COLI-MF (1603)	EPA 1603	610	05/22/17 10:26PM	
L6810904-85	CC-01-03	05/22/17 06:46pm	FECAL COLIFORM-MF	SM 9222D	550	05/22/17 10:39PM	
L6810904-86	CC-02-03	05/22/17 07:00pm	ENTEROCOCCUS-MF 24	EPA 1600	2000	05/22/17 10:17PM	
L6810904-86	CC-02-03	05/22/17 07:00pm	E. COLI-MF (1603)	EPA 1603	2500	05/22/17 10:26PM	
L6810904-86	CC-02-03	05/22/17 07:00pm	FECAL COLIFORM-MF	SM 9222D	2000	05/22/17 10:39PM	
L6810904-87	CC-03-03	05/22/17 06:00pm	ENTEROCOCCUS-MF 24	EPA 1600	4800	05/22/17 11:55PM	
L6810904-87	CC-03-03	05/22/17 06:00pm	E. COLI-MF (1603)	EPA 1603	8500E	05/22/17 10:26PM	
L6810904-87	CC-03-03	05/22/17 06:00pm	FECAL COLIFORM-MF	SM 9222D	18000E	05/22/17 10:39PM	
L6810904-88	DR-01-06	05/22/17 09:15pm	ENTEROCOCCUS-MF 24	EPA 1600	76	05/22/17 11:55PM	
L6810904-88	DR-01-06	05/22/17 09:15pm	E. COLI-MF (1603)	EPA 1603	353	05/22/17 11:44PM	
L6810904-88	DR-01-06	05/22/17 09:15pm	FECAL COLIFORM-MF	SM 9222D	70	05/22/17 11:47PM	
L6810904-89	DR-02-06	05/22/17 09:25pm	ENTEROCOCCUS-MF 24	EPA 1600	72	05/22/17 11:55PM	
L6810904-89	DR-02-06	05/22/17 09:25pm	E. COLI-MF (1603)	EPA 1603	162E	05/22/17 11:44PM	
L6810904-89	DR-02-06	05/22/17 09:25pm	FECAL COLIFORM-MF	SM 9222D	210	05/22/17 11:47PM	
L6810904-90	DR-03-06	05/22/17 09:30pm	ENTEROCOCCUS-MF 24	EPA 1600	116	05/22/17 11:55PM	
L6810904-90	DR-03-06	05/22/17 09:30pm	E. COLI-MF (1603)	EPA 1603	200	05/22/17 11:44PM	
L6810904-90	DR-03-06	05/22/17 09:30pm	FECAL COLIFORM-MF	SM 9222D	160E	05/22/17 11:47PM	
L6810904-91	DR-04-06	05/22/17 09:40pm	ENTEROCOCCUS-MF 24	EPA 1600	260	05/22/17 11:55PM	
L6810904-91	DR-04-06	05/22/17 09:40pm	E. COLI-MF (1603)	EPA 1603	132	05/22/17 11:44PM	
L6810904-91	DR-04-06	05/22/17 09:40pm	FECAL COLIFORM-MF	SM 9222D	180E	05/22/17 11:47PM	
L6810904-92	DR-05-06	05/22/17 09:45pm	ENTEROCOCCUS-MF 24	EPA 1600	100	05/22/17 11:55PM	
L6810904-92	DR-05-06	05/22/17 09:45pm	E. COLI-MF (1603)	EPA 1603	124	05/22/17 11:44PM	
L6810904-92	DR-05-06	05/22/17 09:45pm	FECAL COLIFORM-MF	SM 9222D	280	05/22/17 11:47PM	
L6810904-93	DR-06-06	05/22/17 08:55pm	ENTEROCOCCUS-MF 24	EPA 1600	2E	05/22/17 11:55PM	
L6810904-93	DR-06-06	05/22/17 08:55pm	E. COLI-MF (1603)	EPA 1603	4E	05/22/17 11:44PM	
L6810904-93	DR-06-06	05/22/17 08:55pm	FECAL COLIFORM-MF	SM 9222D	6E	05/22/17 11:47PM	
L6810904-94	DR-07-06	05/22/17 09:00pm	ENTEROCOCCUS-MF 24	EPA 1600	4E	05/22/17 11:55PM	
L6810904-94	DR-07-06	05/22/17 09:00pm	E. COLI-MF (1603)	EPA 1603	8E	05/22/17 11:44PM	
L6810904-94	DR-07-06	05/22/17 09:00pm	FECAL COLIFORM-MF	SM 9222D	2E	05/22/17 11:47PM	
L6810904-95	DUP-DR	05/22/17 00:00pm	ENTEROCOCCUS-MF 24	EPA 1600	102 Q	05/22/17 11:55PM	
L6810904-95	DUP-DR	05/22/17 00:00pm	E. COLI-MF (1603)	EPA 1603	152 Q	05/22/17 11:44PM	
L6810904-95	DUP-DR	05/22/17 00:00pm	FECAL COLIFORM-MF	SM 9222D	140 E, Q	05/22/17 11:47PM	
L6810904-96	DR-01-07	05/23/17 12:05am	ENTEROCOCCUS-MF 24	EPA 1600	24E	05/23/17 07:33AM	
L6810904-96	DR-01-07	05/23/17 12:05am	E. COLI-MF (1603)	EPA 1603	18E	05/23/17 07:08AM	
L6810904-96	DR-01-07	05/23/17 12:05am	FECAL COLIFORM-MF	SM 9222D	18E	05/23/17 07:53AM	
L6810904-97	DR-02-07	05/23/17 12:20am	ENTEROCOCCUS-MF 24	EPA 1600	10E	05/23/17 07:33AM	
L6810904-97	DR-02-07	05/23/17 12:20am	E. COLI-MF (1603)	EPA 1603	6E	05/23/17 07:08AM	
L6810904-97	DR-02-07	05/23/17 12:20am	FECAL COLIFORM-MF	SM 9222D	22E	05/23/17 07:53AM	
L6810904-98	DR-03-07	05/23/17 12:34am	ENTEROCOCCUS-MF 24	EPA 1600	38E	05/23/17 07:33AM	
L6810904-98	DR-03-07	05/23/17 12:34am	E. COLI-MF (1603)	EPA 1603	34E	05/23/17 07:08AM	
L6810904-98	DR-03-07	05/23/17 12:34am	FECAL COLIFORM-MF	SM 9222D	42	05/23/17 07:53AM	
L6810904-99	DR-04-07	05/23/17 12:48am	ENTEROCOCCUS-MF 24	EPA 1600	4E	05/23/17 07:33AM	
L6810904-99	DR-04-07	05/23/17 12:48am	E. COLI-MF (1603)	EPA 1603	5 E	05/23/17 07:08AM	
L6810904-99	DR-04-07	05/23/17 12:48am	FECAL COLIFORM-MF	SM 9222D	16E	05/23/17 07:53AM	
L6810904-100	DR-05-07	05/23/17 01:02am	ENTEROCOCCUS-MF 24	EPA 1600	56	05/23/17 07:33AM	
L6810904-100	DR-05-07	05/23/17 01:02am	E. COLI-MF (1603)	EPA 1603	12E	05/23/17 07:08AM	
L6810904-100	DR-05-07	05/23/17 01:02am	FECAL COLIFORM-MF	SM 9222D	22E	05/23/17 07:53AM	
L6810904-101	DR-06-07	05/23/17 01:15am	ENTEROCOCCUS-MF 24	EPA 1600	8E	05/23/17 07:33AM	
L6810904-101	DR-06-07	05/23/17 01:15am	E. COLI-MF (1603)	EPA 1603	6E	05/23/17 07:08AM	
L6810904-101	DR-06-07	05/23/17 01:15am	FECAL COLIFORM-MF	SM 9222D	10E	05/23/17 07:53AM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6810904-102	DR-07-07	05/23/17 01:33am	ENTEROCOCCUS-MF 24	EPA 1600	2E	05/23/17 07:33AM	
L6810904-102	DR-07-07	05/23/17 01:33am	E. COLI-MF (1603)	EPA 1603	6E	05/23/17 07:08AM	
L6810904-102	DR-07-07	05/23/17 01:33am	FECAL COLIFORM-MF	SM 9222D	80	05/23/17 07:53AM	
L6810904-103	RC-01-04	05/23/17 01:50am	ENTEROCOCCUS-MF 24	EPA 1600	170E	05/23/17 07:33AM	
L6810904-103	RC-01-04	05/23/17 01:50am	E. COLI-MF (1603)	EPA 1603	76	05/23/17 07:08AM	
L6810904-103	RC-01-04	05/23/17 01:50am	FECAL COLIFORM-MF	SM 9222D	108	05/23/17 07:53AM	
L6810904-104	RC-02-04	05/23/17 01:35am	ENTEROCOCCUS-MF 24	EPA 1600	580	05/23/17 07:33AM	
L6810904-104	RC-02-04	05/23/17 01:35am	E. COLI-MF (1603)	EPA 1603	300	05/23/17 07:08AM	
L6810904-104	RC-02-04	05/23/17 01:35am	FECAL COLIFORM-MF	SM 9222D	440	05/23/17 07:53AM	
L6810904-105	RC-03-04	05/23/17 01:20am	ENTEROCOCCUS-MF 24	EPA 1600	1200E	05/23/17 07:33AM	
L6810904-105	RC-03-04	05/23/17 01:20am	E. COLI-MF (1603)	EPA 1603	1900E	05/23/17 07:08AM	
L6810904-105	RC-03-04	05/23/17 01:20am	FECAL COLIFORM-MF	SM 9222D	1800E	05/23/17 07:53AM	
L6810904-106	CC-01-04	05/23/17 02:17am	ENTEROCOCCUS-MF 24	EPA 1600	520	05/23/17 07:33AM	
L6810904-106	CC-01-04	05/23/17 02:17am	E. COLI-MF (1603)	EPA 1603	170E	05/23/17 07:08AM	
L6810904-106	CC-01-04	05/23/17 02:17am	FECAL COLIFORM-MF	SM 9222D	380	05/23/17 07:53AM	
L6810904-107	CC-02-04	05/23/17 02:05am	ENTEROCOCCUS-MF 24	EPA 1600	600	05/23/17 07:33AM	
L6810904-107	CC-02-04	05/23/17 02:05am	E. COLI-MF (1603)	EPA 1603	470	05/23/17 07:08AM	
L6810904-107	CC-02-04	05/23/17 02:05am	FECAL COLIFORM-MF	SM 9222D	350	05/23/17 07:53AM	
L6810904-108	CC-03-04	05/23/17 01:05am	ENTEROCOCCUS-MF 24	EPA 1600	1700E	05/23/17 07:33AM	
L6810904-108	CC-03-04	05/23/17 01:05am	E. COLI-MF (1603)	EPA 1603	2700E	05/23/17 07:08AM	
L6810904-108	CC-03-04	05/23/17 01:05am	FECAL COLIFORM-MF	SM 9222D	3800	05/23/17 07:53AM	
L6810904-109	DR-02-08	05/23/17 03:15am	ENTEROCOCCUS-MF 24	EPA 1600	70E	05/23/17 10:18AM	
L6810904-109	DR-02-08	05/23/17 03:15am	E. COLI-MF (1603)	EPA 1603	50E	05/23/17 10:32AM	
L6810904-109	DR-02-08	05/23/17 03:15am	FECAL COLIFORM-MF	SM 9222D	9 E	05/23/17 10:54AM	
L6810904-110	DR-03-08	05/23/17 03:25am	ENTEROCOCCUS-MF 24	EPA 1600	68	05/23/17 10:18AM	
L6810904-110	DR-03-08	05/23/17 03:25am	E. COLI-MF (1603)	EPA 1603	116	05/23/17 10:32AM	
L6810904-110	DR-03-08	05/23/17 03:25am	FECAL COLIFORM-MF	SM 9222D	1000 E	05/23/17 10:54AM	
L6810904-111	DR-04-08	05/23/17 03:37am	ENTEROCOCCUS-MF 24	EPA 1600	70	05/23/17 10:18AM	
L6810904-111	DR-04-08	05/23/17 03:37am	E. COLI-MF (1603)	EPA 1603	118	05/23/17 10:32AM	
L6810904-111	DR-04-08	05/23/17 03:37am	FECAL COLIFORM-MF	SM 9222D	250	05/23/17 10:54AM	
L6810904-112	DR-05-08	05/23/17 03:50am	ENTEROCOCCUS-MF 24	EPA 1600	110	05/23/17 10:18AM	
L6810904-112	DR-05-08	05/23/17 03:50am	E. COLI-MF (1603)	EPA 1603	260	05/23/17 10:32AM	
L6810904-112	DR-05-08	05/23/17 03:50am	FECAL COLIFORM-MF	SM 9222D	310	05/23/17 10:54AM	
L6810904-113	DR-06-08	05/23/17 04:03am	ENTEROCOCCUS-MF 24	EPA 1600	6E	05/23/17 10:18AM	
L6810904-113	DR-06-08	05/23/17 04:03am	E. COLI-MF (1603)	EPA 1603	4E	05/23/17 10:32AM	
L6810904-113	DR-06-08	05/23/17 04:03am	FECAL COLIFORM-MF	SM 9222D	5 E	05/23/17 10:54AM	
L6810904-114	DR-07-08	05/23/17 04:16am	ENTEROCOCCUS-MF 24	EPA 1600	14E	05/23/17 10:18AM	
L6810904-114	DR-07-08	05/23/17 04:16am	E. COLI-MF (1603)	EPA 1603	28E	05/23/17 10:32AM	
L6810904-114	DR-07-08	05/23/17 04:16am	FECAL COLIFORM-MF	SM 9222D	24E	05/23/17 10:54AM	
L6810904-115	DR-01-09	05/23/17 06:00am	ENTEROCOCCUS-MF 24	EPA 1600	10E	05/23/17 01:29PM	
L6810904-115	DR-01-09	05/23/17 06:00am	E. COLI-MF (1603)	EPA 1603	8E	05/23/17 01:26PM	
L6810904-115	DR-01-09	05/23/17 06:00am	FECAL COLIFORM-MF	SM 9222D	32 Q, E	05/23/17 02:22PM	
L6810904-116	DR-02-09	05/23/17 06:13am	ENTEROCOCCUS-MF 24	EPA 1600	40	05/23/17 01:29PM	
L6810904-116	DR-02-09	05/23/17 06:13am	E. COLI-MF (1603)	EPA 1603	68	05/23/17 01:26PM	
L6810904-116	DR-02-09	05/23/17 06:13am	FECAL COLIFORM-MF	SM 9222D	46	05/23/17 02:22PM	
L6810904-117	DR-03-09	05/23/17 06:26am	ENTEROCOCCUS-MF 24	EPA 1600	92	05/23/17 01:29PM	
L6810904-117	DR-03-09	05/23/17 06:26am	E. COLI-MF (1603)	EPA 1603	62	05/23/17 01:26PM	
L6810904-117	DR-03-09	05/23/17 06:26am	FECAL COLIFORM-MF	SM 9222D	88	05/23/17 02:22PM	
L6810904-118	DR-04-09	05/23/17 06:38am	ENTEROCOCCUS-MF 24	EPA 1600	86	05/23/17 01:29PM	
L6810904-118	DR-04-09	05/23/17 06:38am	E. COLI-MF (1603)	EPA 1603	122	05/23/17 01:26PM	
L6810904-118	DR-04-09	05/23/17 06:38am	FECAL COLIFORM-MF	SM 9222D	78	05/23/17 02:22PM	

Login Number	Sample ID	Sample Date/Time	Parm Stored	Method	Result (cfu/100 mL)	Analysis Date/Time	
L6810904-119	DR-05-09	05/23/17 06:52am	ENTEROCOCCUS-MF 24	EPA 1600	90	05/23/17 01:29PM	
L6810904-119	DR-05-09	05/23/17 06:52am	E. COLI-MF (1603)	EPA 1603	128	05/23/17 01:26PM	
L6810904-119	DR-05-09	05/23/17 06:52am	FECAL COLIFORM-MF	SM 9222D	180E	05/23/17 02:22PM	
L6810904-120	DR-06-09	05/23/17 07:05am	ENTEROCOCCUS-MF 24	EPA 1600	8E	05/23/17 01:29PM	
L6810904-120	DR-06-09	05/23/17 07:05am	E. COLI-MF (1603)	EPA 1603	16E	05/23/17 01:26PM	
L6810904-120	DR-06-09	05/23/17 07:05am	FECAL COLIFORM-MF	SM 9222D	26E	05/23/17 02:22PM	
L6810904-121	DR-07-09	05/23/17 07:20am	ENTEROCOCCUS-MF 24	EPA 1600	6E	05/23/17 01:29PM	
L6810904-121	DR-07-09	05/23/17 07:20am	E. COLI-MF (1603)	EPA 1603	16E	05/23/17 01:26PM	
L6810904-121	DR-07-09	05/23/17 07:20am	FECAL COLIFORM-MF	SM 9222D	16E	05/23/17 02:22PM	
L6810904-122	DR-01-10	05/23/17 09:00am	ENTEROCOCCUS-MF 24	EPA 1600	16E	05/23/17 01:29PM	
L6810904-122	DR-01-10	05/23/17 09:00am	E. COLI-MF (1603)	EPA 1603	24E	05/23/17 01:26PM	
L6810904-122	DR-01-10	05/23/17 09:00am	FECAL COLIFORM-MF	SM 9222D	44	05/23/17 02:22PM	
L6810904-123	DR-02-10	05/23/17 09:12am	ENTEROCOCCUS-MF 24	EPA 1600	42	05/23/17 01:29PM	
L6810904-123	DR-02-10	05/23/17 09:12am	E. COLI-MF (1603)	EPA 1603	68	05/23/17 01:26PM	
L6810904-123	DR-02-10	05/23/17 09:12am	FECAL COLIFORM-MF	SM 9222D	42	05/23/17 02:22PM	
L6810904-124	DR-03-10	05/23/17 09:24am	ENTEROCOCCUS-MF 24	EPA 1600	50	05/23/17 01:29PM	
L6810904-124	DR-03-10	05/23/17 09:24am	E. COLI-MF (1603)	EPA 1603	90	05/23/17 01:26PM	
L6810904-124	DR-03-10	05/23/17 09:24am	FECAL COLIFORM-MF	SM 9222D	92	05/23/17 02:22PM	
L6810904-125	DR-04-10	05/23/17 09:40am	ENTEROCOCCUS-MF 24	EPA 1600	22E	05/23/17 01:29PM	
L6810904-125	DR-04-10	05/23/17 09:40am	E. COLI-MF (1603)	EPA 1603	32E	05/23/17 01:26PM	
L6810904-125	DR-04-10	05/23/17 09:40am	FECAL COLIFORM-MF	SM 9222D	26E	05/23/17 02:22PM	
L6810904-126	DR-05-10	05/23/17 09:53am	ENTEROCOCCUS-MF 24	EPA 1600	16E	05/23/17 01:29PM	
L6810904-126	DR-05-10	05/23/17 09:53am	E. COLI-MF (1603)	EPA 1603	38E	05/23/17 01:26PM	
L6810904-126	DR-05-10	05/23/17 09:53am	FECAL COLIFORM-MF	SM 9222D	112	05/23/17 02:22PM	
L6810904-127	DR-06-10	05/23/17 10:05am	ENTEROCOCCUS-MF 24	EPA 1600	2E	05/23/17 01:29PM	
L6810904-127	DR-06-10	05/23/17 10:05am	E. COLI-MF (1603)	EPA 1603	2E	05/23/17 01:26PM	
L6810904-127	DR-06-10	05/23/17 10:05am	FECAL COLIFORM-MF	SM 9222D	6E	05/23/17 02:22PM	
L6810904-128	DR-07-10	05/23/17 10:17am	ENTEROCOCCUS-MF 24	EPA 1600	4E	05/23/17 01:29PM	
L6810904-128	DR-07-10	05/23/17 10:17am	E. COLI-MF (1603)	EPA 1603	12E	05/23/17 01:26PM	
L6810904-128	DR-07-10	05/23/17 10:17am	FECAL COLIFORM-MF	SM 9222D	6E	05/23/17 02:22PM	
L6810904-129	CC-01-05	05/23/17 10:20am	ENTEROCOCCUS-MF 24	EPA 1600	170E	05/23/17 01:29PM	
L6810904-129	CC-01-05	05/23/17 10:20am	E. COLI-MF (1603)	EPA 1603	240	05/23/17 01:26PM	
L6810904-129	CC-01-05	05/23/17 10:20am	FECAL COLIFORM-MF	SM 9222D	220	05/23/17 02:22PM	
L6810904-130	CC-02-05	05/23/17 10:05am	ENTEROCOCCUS-MF 24	EPA 1600	400	05/23/17 01:29PM	
L6810904-130	CC-02-05	05/23/17 10:05am	E. COLI-MF (1603)	EPA 1603	610	05/23/17 01:26PM	
L6810904-130	CC-02-05	05/23/17 10:05am	FECAL COLIFORM-MF	SM 9222D	1200E	05/23/17 02:22PM	
L6810904-131	CC-03-05	05/23/17 09:05am	ENTEROCOCCUS-MF 24	EPA 1600	50	05/23/17 01:29PM	
L6810904-131	CC-03-05	05/23/17 09:05am	E. COLI-MF (1603)	EPA 1603	112	05/23/17 01:26PM	
L6810904-131	CC-03-05	05/23/17 09:05am	FECAL COLIFORM-MF	SM 9222D	190E	05/23/17 02:22PM	
L6810904-132	RC-01-05	05/23/17 09:50am	ENTEROCOCCUS-MF 24	EPA 1600	40	05/23/17 01:29PM	
L6810904-132	RC-01-05	05/23/17 09:50am	E. COLI-MF (1603)	EPA 1603	56	05/23/17 01:26PM	
L6810904-132	RC-01-05	05/23/17 09:50am	FECAL COLIFORM-MF	SM 9222D	44	05/23/17 02:22PM	
L6810904-133	RC-02-05	05/23/17 09:35am	ENTEROCOCCUS-MF 24	EPA 1600	280	05/23/17 01:29PM	
L6810904-133	RC-02-05	05/23/17 09:35am	E. COLI-MF (1603)	EPA 1603	200	05/23/17 01:26PM	
L6810904-133	RC-02-05	05/23/17 09:35am	FECAL COLIFORM-MF	SM 9222D	230	05/23/17 02:22PM	
L6810904-134	RC-03-05	05/23/17 09:22am	ENTEROCOCCUS-MF 24	EPA 1600	64	05/23/17 01:29PM	
L6810904-134	RC-03-05	05/23/17 09:22am	E. COLI-MF (1603)	EPA 1603	84	05/23/17 01:26PM	
L6810904-134	RC-03-05	05/23/17 09:22am	FECAL COLIFORM-MF	SM 9222D	136E	05/23/17 02:22PM	

APPENDIX G

SAMPLE COLLECTION MATRIX

Dry Weather Event									Field Measurement Water Depth				Field Duplicate Locations			
Water Body	**Location**	**# Rounds**	**Round Notes**	**No. Samples/ Event**	**No. of Field Duplicates/ Event**	**No. of Field Blanks/ Event**	**Lab Analytes**	**Field Measurements**	**Surface**	**Mid-depth**	**Bottom**	**# Lab Samples/Event**	**Dry 1 Field Duplicate Locations**	**Dry 2 Field Duplicate Locations**	**Dry 3 Field Duplicate Locations**	**Notes**
Chester Creek	CC-01	2	Incoming & outgoing tide	2	1	1 See notes column	E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	X			8	CC-01 outgoing tide			Prepare field blank at first sampling location for each event, regardless of tide condition.
Chester Creek	CC-02	2	Incoming & outgoing tide	2			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	X					CC-02 outgoing tide		
Chester Creek	CC-03	2	Incoming & outgoing tide	2			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	X						CC-03 incoming tide	
Ridley Creek	RC-01	2	Incoming & outgoing tide	2	1	none	E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	X			7			RC-01 outgoing tide	
Ridley Creek	RC-02	2	Incoming & outgoing tide	2		none	E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	X					RC-02 incoming tide		
Ridley Creek	RC-03	2	Incoming & outgoing tide	2		none	E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	X				RC-03 incoming tide			
Delaware River	DR-01	2	Incoming & outgoing tide	2	1	1 See notes column	E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	X	X	X	12				
Delaware River	DR-02	2	Incoming & outgoing tide	2			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	X	X	X		DR-02 outgoing tide			
Delaware River	DR-03	2	Incoming & outgoing tide	2			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	X	X	X				DR-03 outgoing tide	
Delaware River	DR-04	2	Incoming & outgoing tide	2			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	X	X	X			DR-04 incoming tide		
Delaware River	DR-05	2	Incoming & outgoing tide	2			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	X	X	X					
Delaware River	DR-06	not sampled					none	none				none				
Delaware River	DR-07	not sampled					none	none				none				
Outfall (combined sewer)	CSO-02	not sampled					none	none				none				
Outfall (combined sewer)	CSO-05	not sampled					none	none				none				
Outfall (combined sewer)	CSO-18	not sampled					none	none				none				
Outfall (combined sewer)	CSO-19	not sampled					none	none				none				
Outfall (storm water)	SW-05A	not sampled					none	none				none				
Outfall (storm water)	SW-SS2	not sampled					none	none				none				

Wet Weather Event									Field Measurement Water Depth			Field Duplicate Locations				
Water Body	**Location**	**# Rounds**	**Sample Collection Times/Intervals from T=0 (hours)**	**No. Samples/ Event**	**No. of Field Duplicates/ Event**	**No. of Field Blanks/ Event**	**Lab Analytes**	**Field Measurements**	**Surface**	**Mid-depth**	**Bottom**	**per event**	**Wet 1 Field Duplicate Locations**	**Wet 2 Field Duplicate Locations**	**Wet 3 Field Duplicate Locations**	**Notes**
Chester Creek	CC-01	5	0.5-2.5, 4.5-6.5, 8.5-10.5, 14.5-16.5, 22-24	5	1	1 See notes column	E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	x			17		CC-01 HR 8.5-10.5		Prepare field blank at first sampling location for each event, regardless of tide condition.
Chester Creek	CC-02	5	0.5-2.5, 4.5-6.5, 8.5-10.5, 14.5-16.5, 22-24	5			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	x						CC-02 HR 4.5-6.5	
Chester Creek	CC-03	5	0.5-2.5, 4.5-6.5, 8.5-10.5, 14.5-16.5, 22-24	5			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	x				CC-03 HR0.5-2.5			
Ridley Creek	RC-01	5	0.5-2.5, 4.5-6.5, 8.5-10.5, 14.5-16.5, 22-24	5	1	1 See notes column	E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	x			17	RC-01 HR 14.5-16.5			
Ridley Creek	RC-02	5	0.5-2.5, 4.5-6.5, 8.5-10.5, 14.5-16.5, 22-24	5			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	x					RC-02 HR0.5-2.5		
Ridley Creek	RC-03	5	0.5-2.5, 4.5-6.5, 8.5-10.5, 14.5-16.5, 22-24	5			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (surface water depth)	x						RC-03 HR4.5-6.5	
Delaware River	DR-01	10	0, 2, 4, 6, 9, 12, 15, 18, 21, 24	10	2	1 See notes column	E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	x	x	x	73		DR-01 HR 9		
Delaware River	DR-02	10	0, 2, 4, 6, 9, 12, 15, 18, 21, 24	10			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	x	x	x		DR-02 HR 2			
Delaware River	DR-03	10	0, 2, 4, 6, 9, 12, 15, 18, 21, 24	10			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	x	x	x			DR-03 HR 21	DR-03 HR 4	
Delaware River	DR-04	10	0, 2, 4, 6, 9, 12, 15, 18, 21, 24	10			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	x	x	x		DR-04 HR 15			
Delaware River	DR-05	10	0, 2, 4, 6, 9, 12, 15, 18, 21, 24	10			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	x	x	x				DR-05 HR 12	
Delaware River	DR-06	10	0, 2, 4, 6, 9, 12, 15, 18, 21, 24	10			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	x	x	x					
Delaware River	DR-07	10	0, 2, 4, 6, 9, 12, 15, 18, 21, 24	10			E. coli, Enterococcus, Fecal coliform	Salinity, Temperature, Conductivity (at surface water, mid, near bottom depths)	x	x	x					
Outfall (combined sewer)	CSO-02	8	0, 0.5, 1, 2, 4, 8, 12, 24	8 max	1	1 Same location as field duplicate, See notes column	E. coli, Enterococcus, Fecal coliform	none				34	CSO-02 HR 1			Prepare field blank at same location as field duplicate. Prepare field blank once crew arrives at sampling location.
Outfall (combined sewer)	CSO-05	8	0, 0.5, 1, 2, 4, 8, 12, 24	8 max			E. coli, Enterococcus, Fecal coliform	none								
Outfall (combined sewer)	CSO-18	8	0, 0.5, 1, 2, 4, 8, 12, 24	8 max			E. coli, Enterococcus, Fecal coliform	none						CSO-18 HR 1		
Outfall (combined sewer)	CSO-19	8	0, 0.5, 1, 2, 4, 8, 12, 24	8 max			E. coli, Enterococcus, Fecal coliform	none							CSO-19 HR 1	
Outfall (storm water)	SW-05A	8	0, 0.5, 1, 2, 4, 8, 12, 24	8 max	0	0	E. coli, Enterococcus, Fecal coliform	none				16				
Outfall (storm water)	SW-SS2	8	0, 0.5, 1, 2, 4, 8, 12, 24	8 max	0	0	E. coli, Enterococcus, Fecal coliform	none								

APPENDIX H

WATER QUALITY SAMPLING PLOTS

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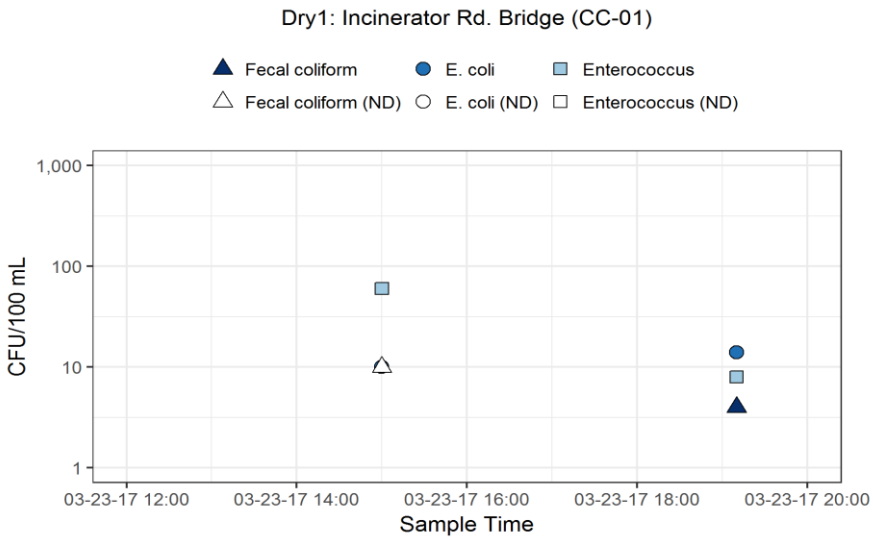
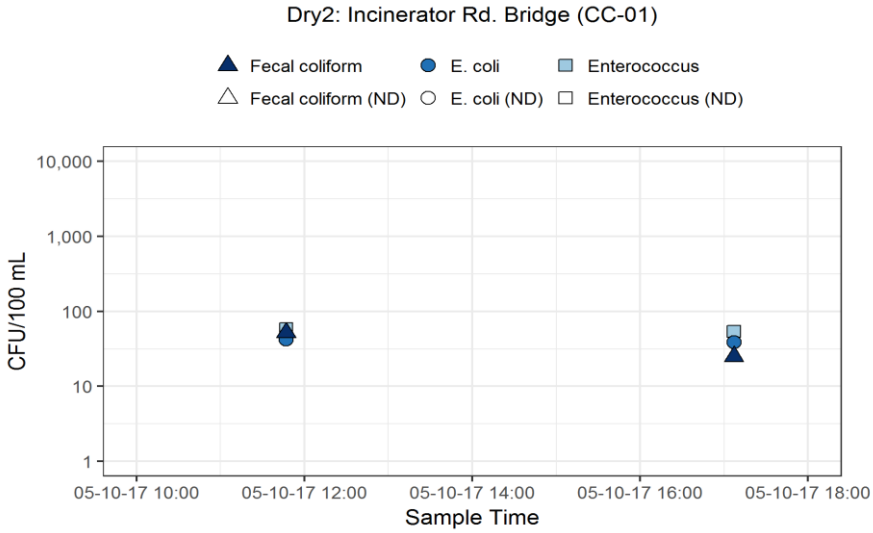
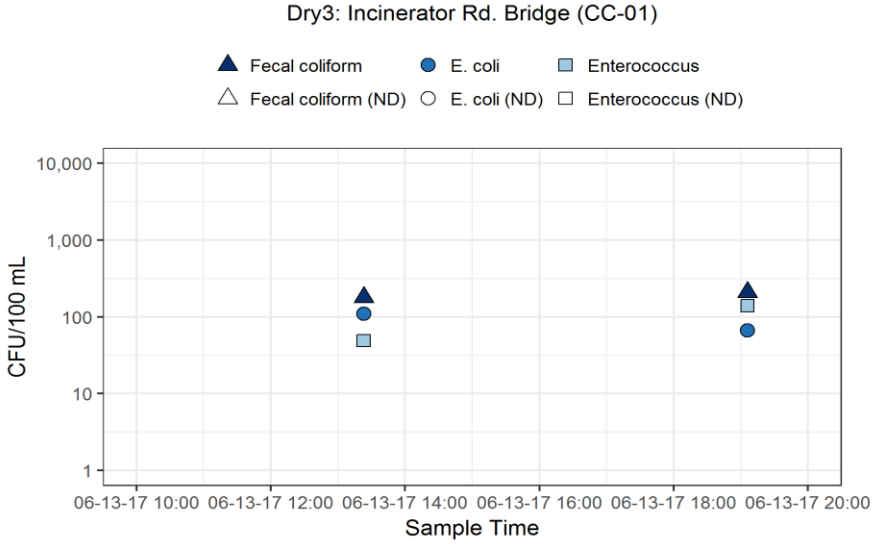
Section 1 Sampling Results by Station

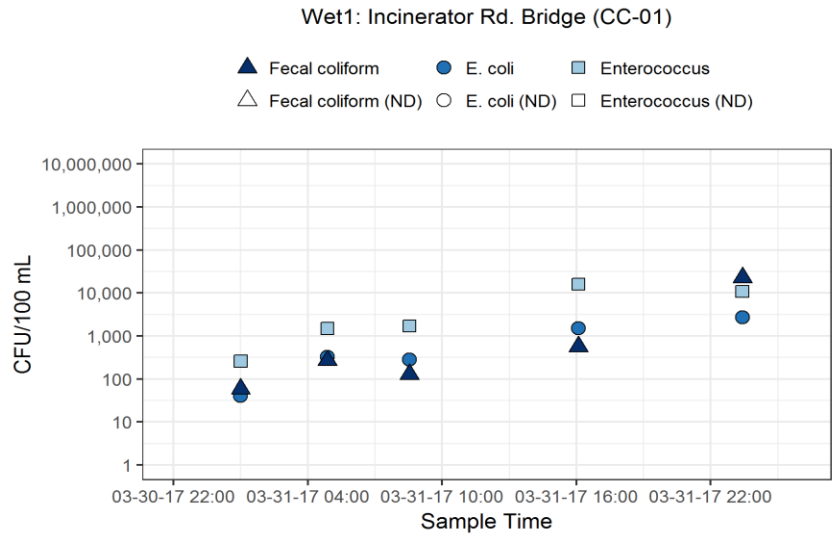
1.1 CC-01 Dry

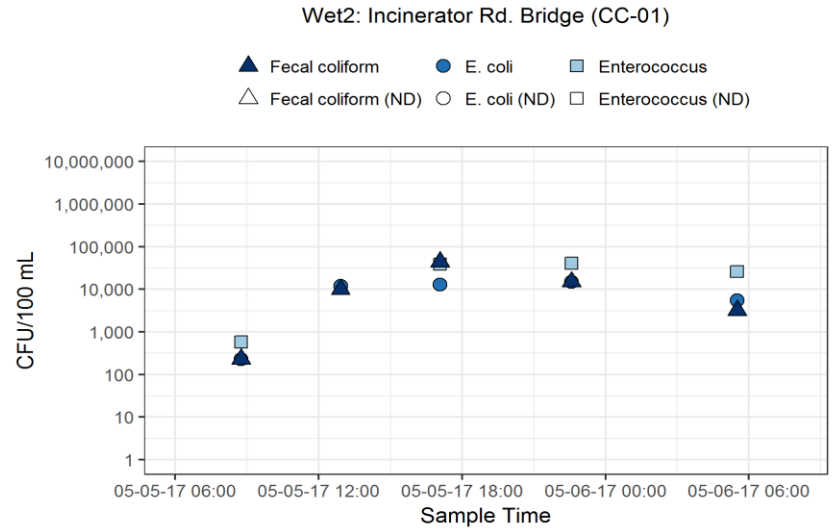

Dry1: Incinerator Rd. Bridge (CC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

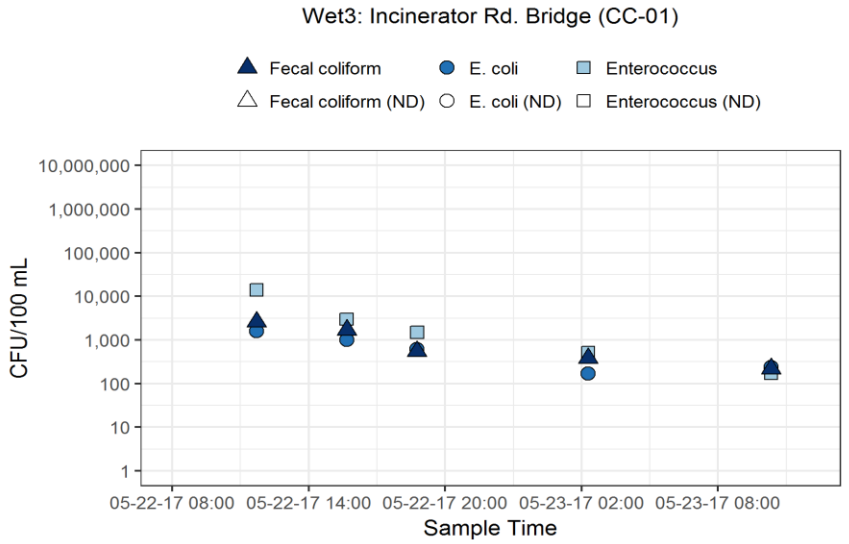

Dry2: Incinerator Rd. Bridge (CC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: Incinerator Rd. Bridge (CC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

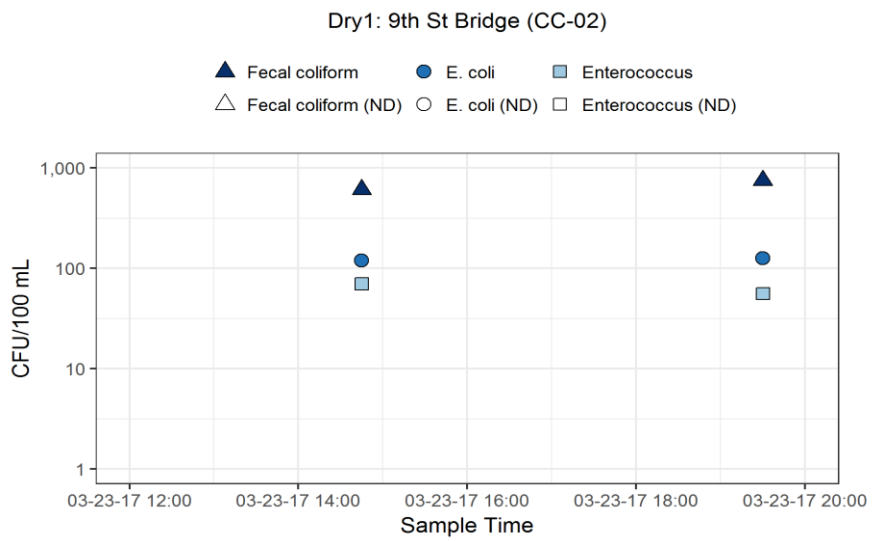
1.1 CC-01 Wet

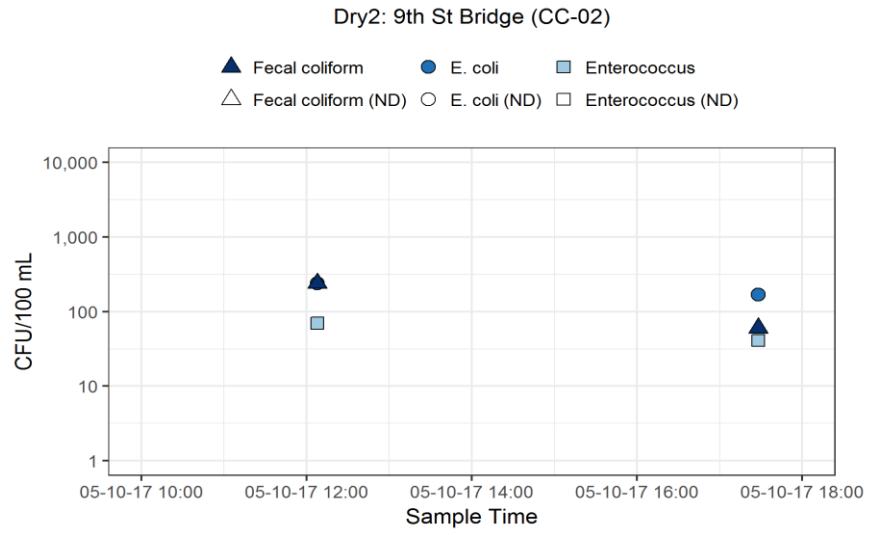

Wet1: Incinerator Rd. Bridge (CC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

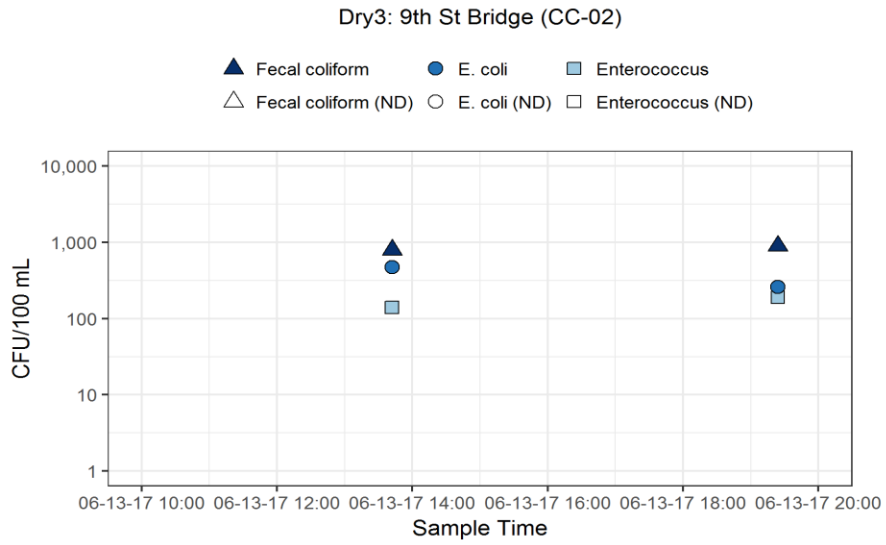

Wet2: Incinerator Rd. Bridge (CC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: Incinerator Rd. Bridge (CC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

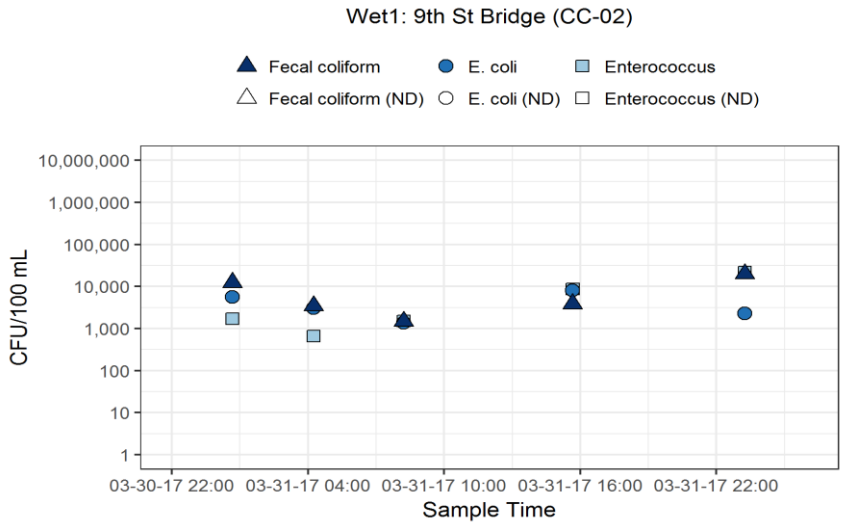
1.2 CC-02 Dry

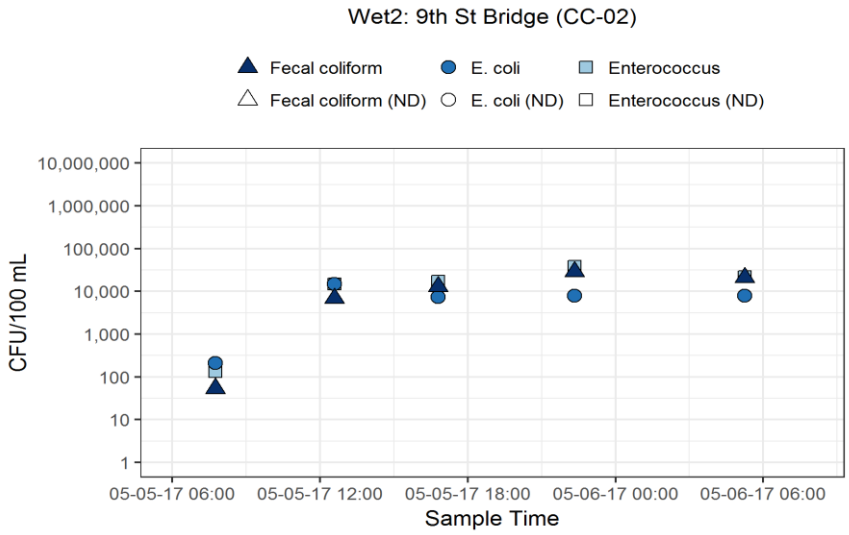

Dry1: 9th St Bridge (CC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

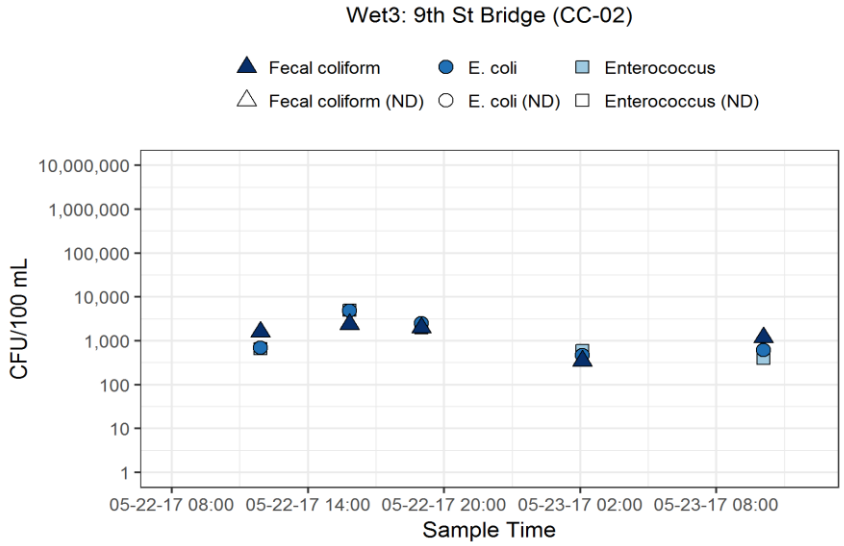

Dry2: 9th St Bridge (CC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: 9th St Bridge (CC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

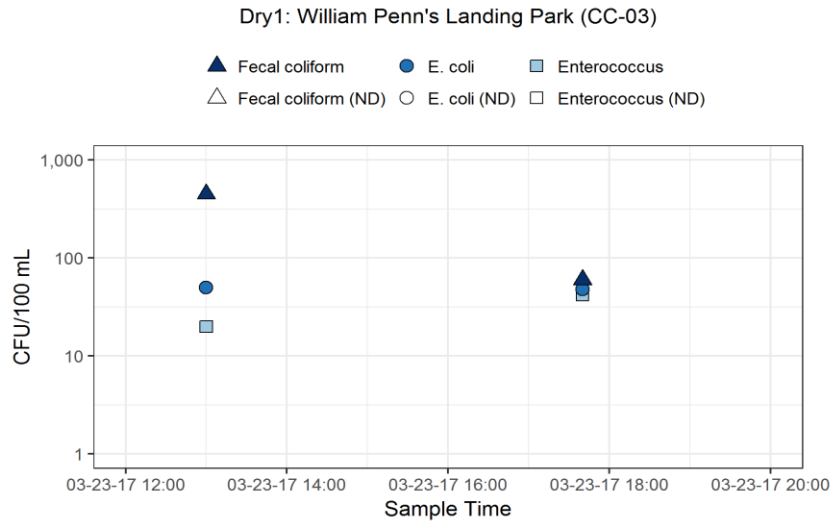
1.2 CC-02 Wet

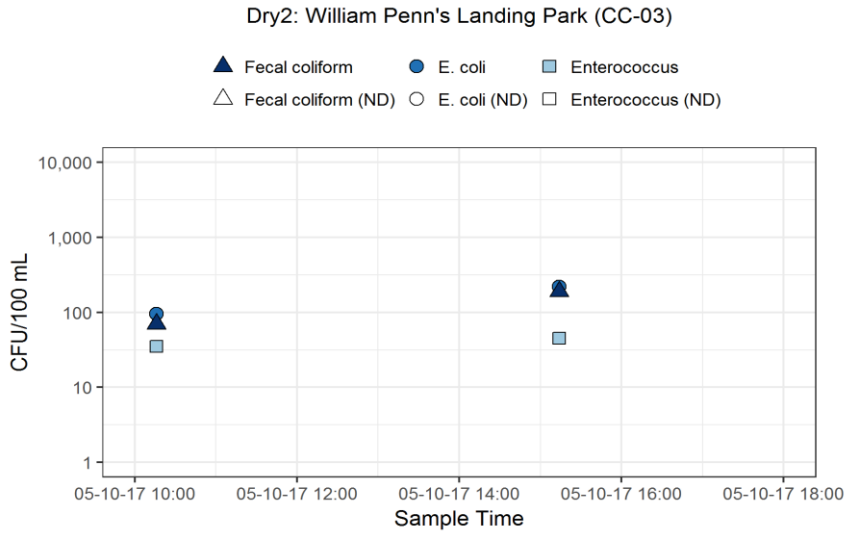

Wet1: 9th St Bridge (CC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

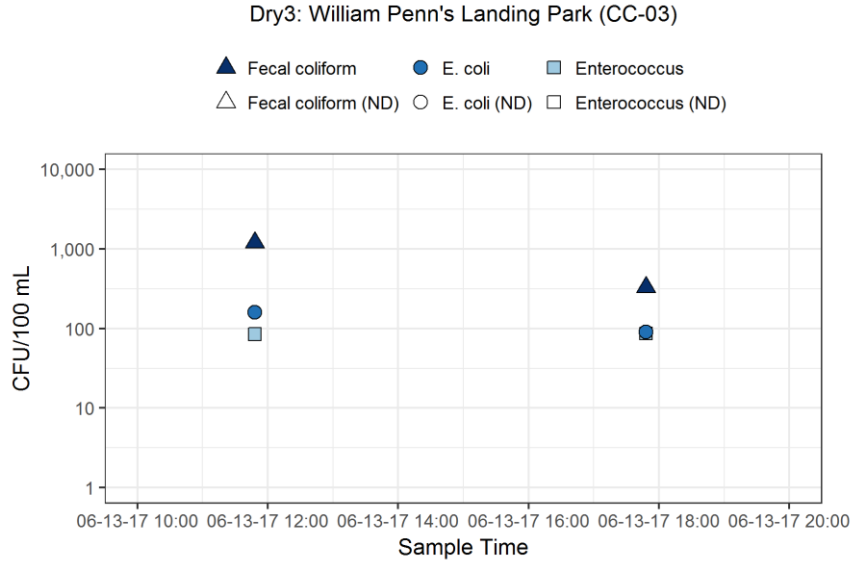

Wet2: 9th St Bridge (CC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: 9th St Bridge (CC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

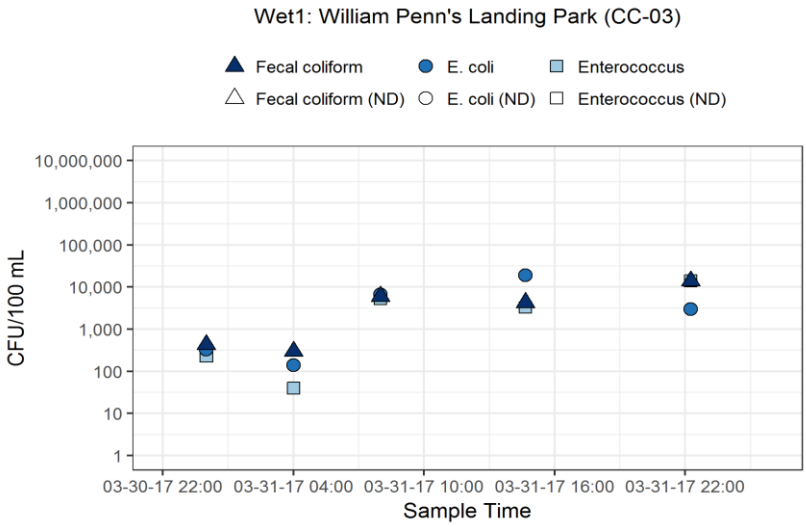
1.3 CC-03 Dry

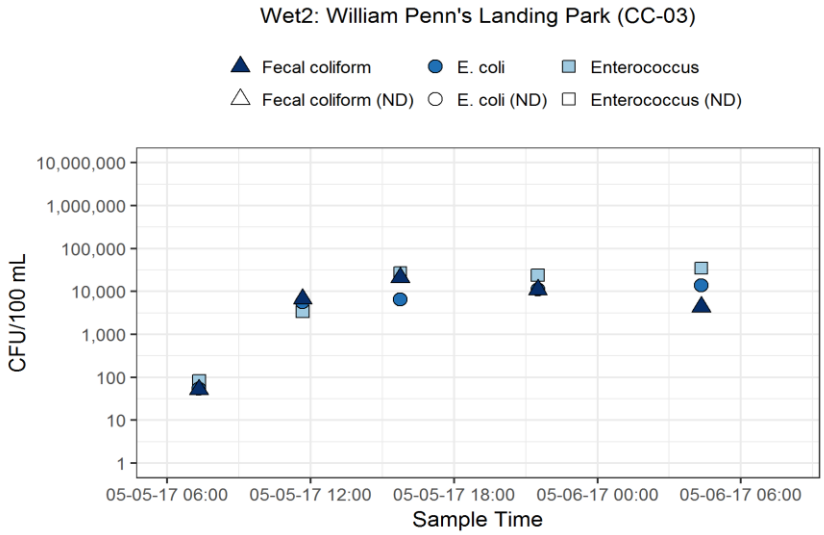

Dry1: William Penn's Landing Park (CC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

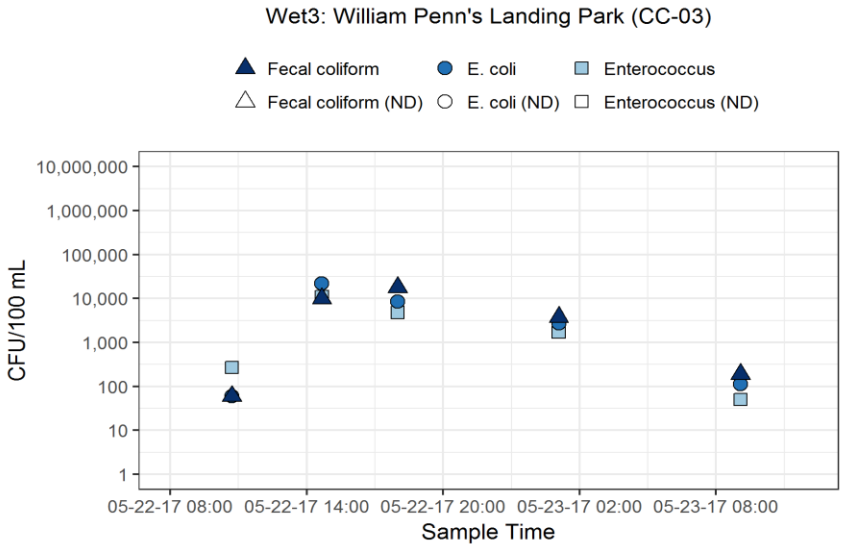

Dry2: William Penn's Landing Park (CC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: William Penn's Landing Park (CC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

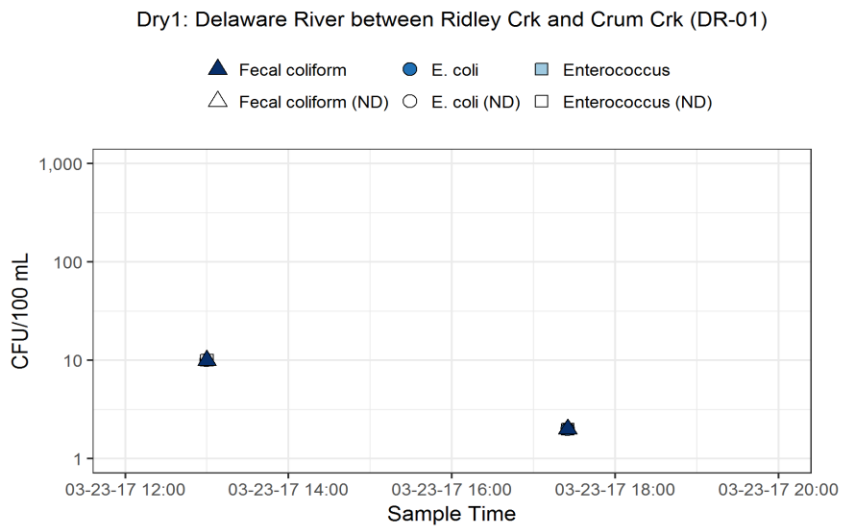
1.3 CC-03 Wet

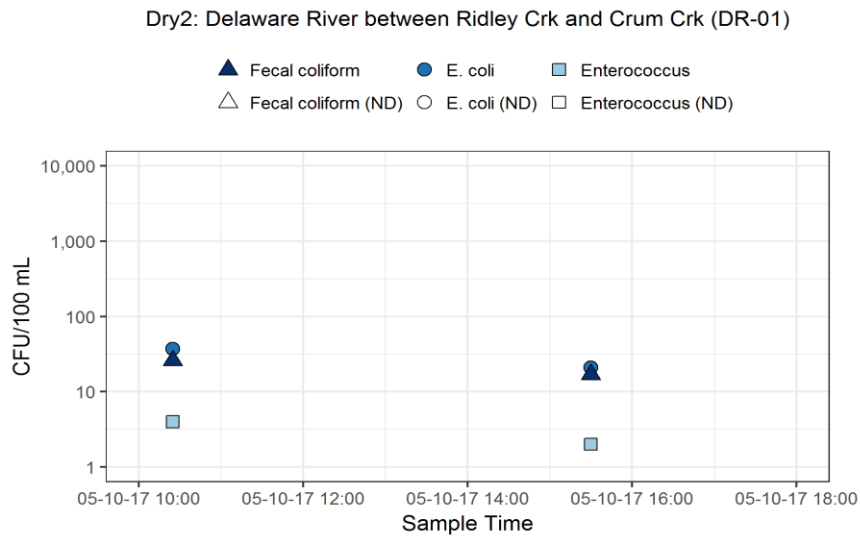

Wet1: William Penn's Landing Park (CC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

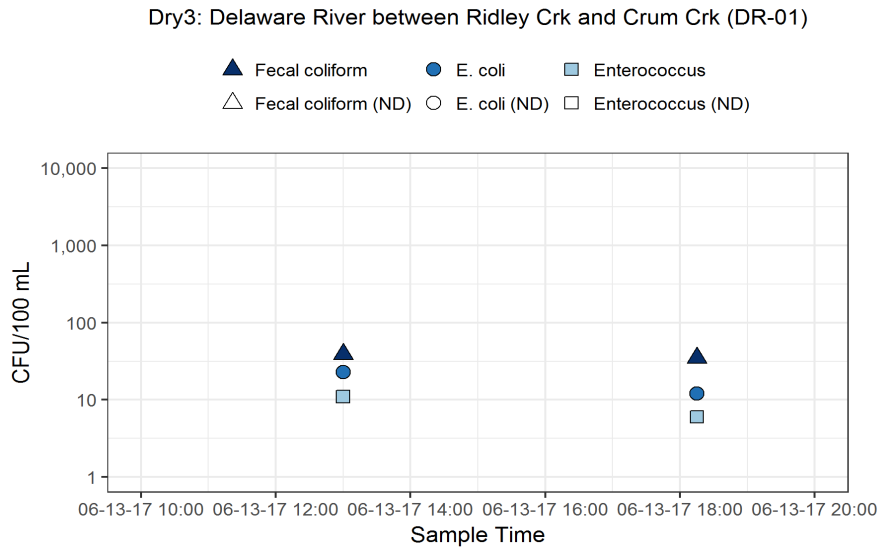

Wet2: William Penn's Landing Park (CC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: William Penn's Landing Park (CC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

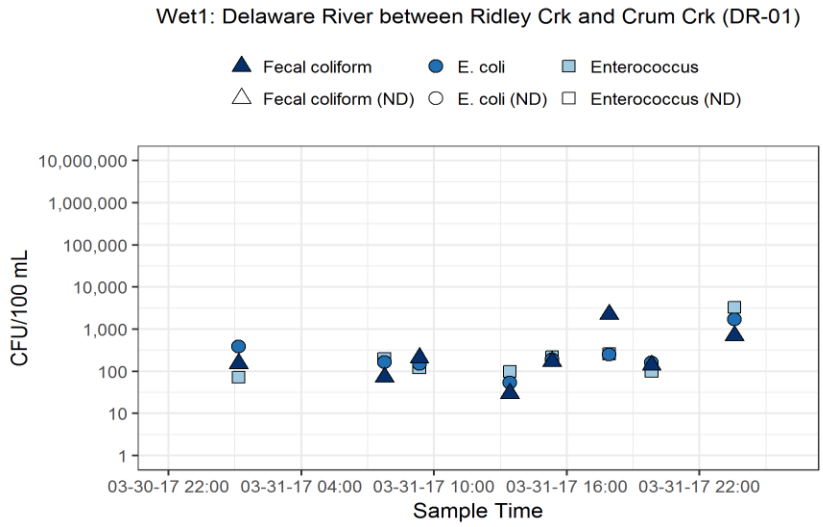
1.4 DR-01 Dry

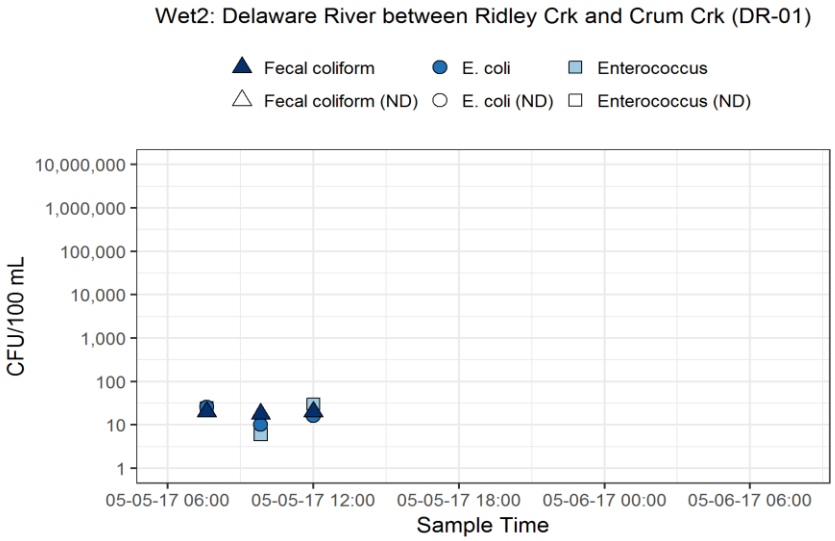

Dry1: Delaware River between Ridley Crk and Crum Crk (DR-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

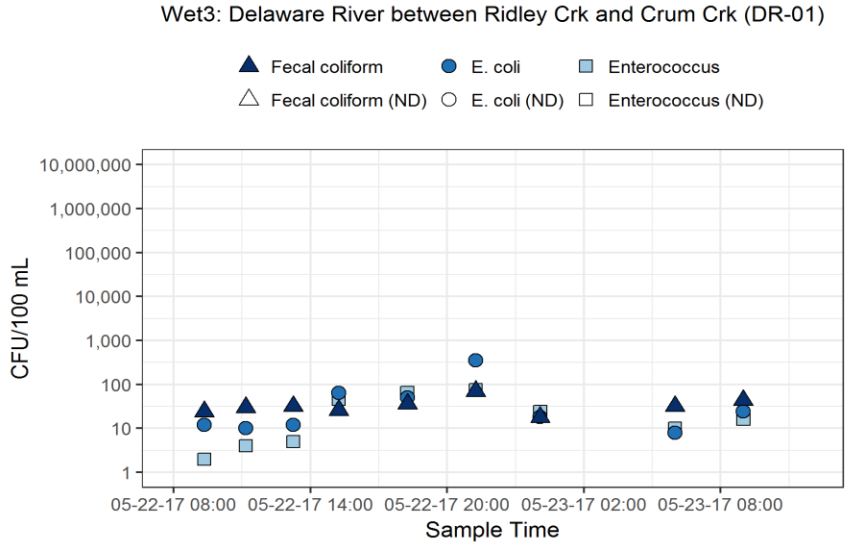

Dry2: Delaware River between Ridley Crk and Crum Crk (DR-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: Delaware River between Ridley Crk and Crum Crk (DR-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

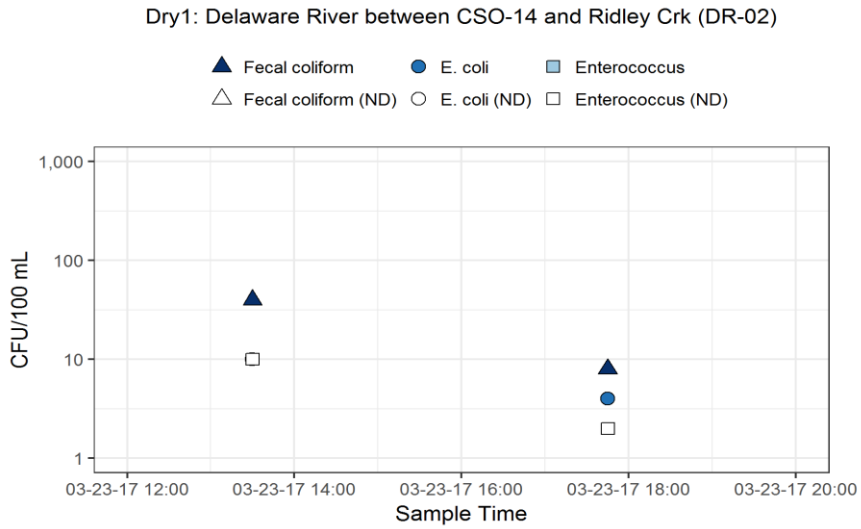
1.4 DR-01 Wet

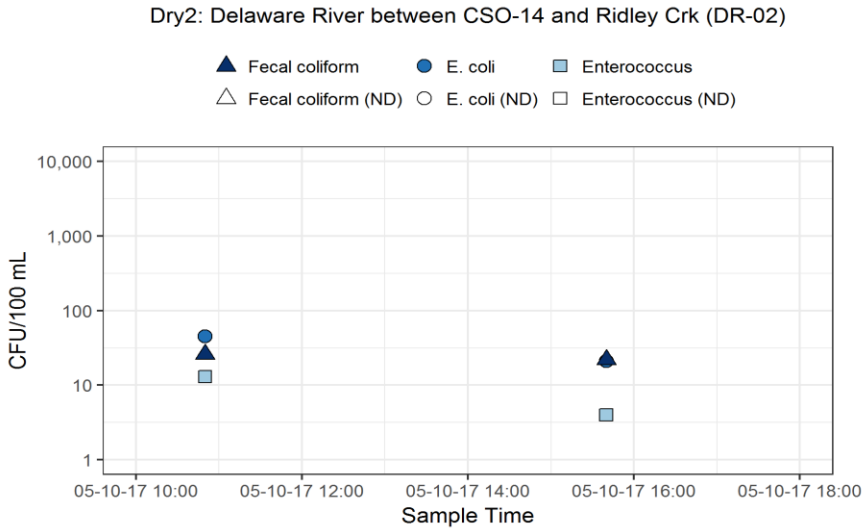

Wet1: Delaware River between Ridley Crk and Crum Crk (DR-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

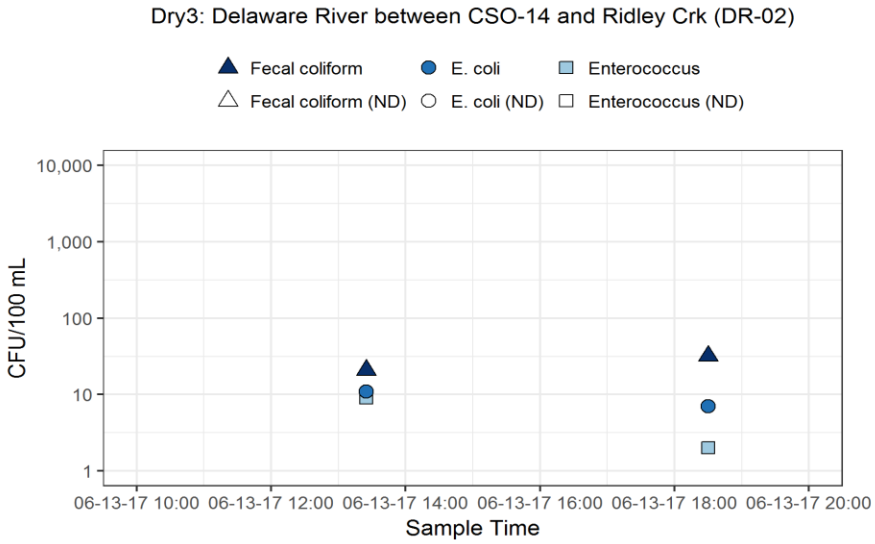

Wet2: Delaware River between Ridley Crk and Crum Crk (DR-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: Delaware River between Ridley Crk and Crum Crk (DR-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

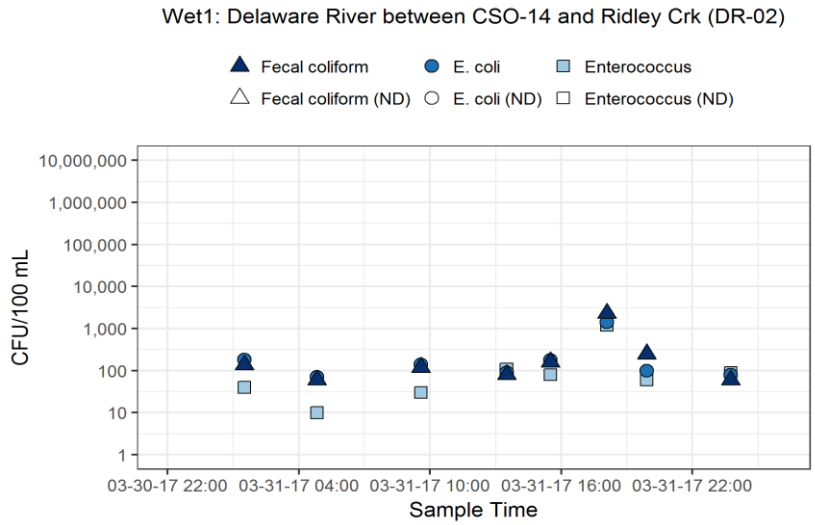
1.5 DR-02 Dry

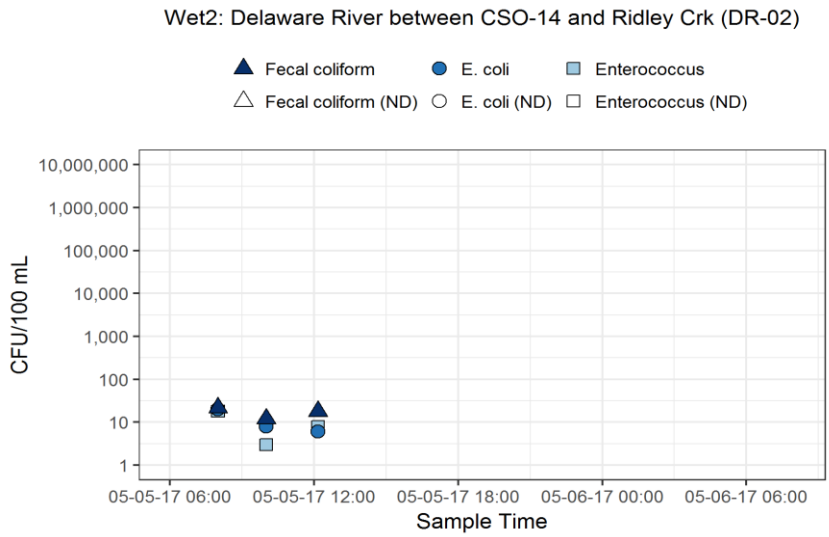

Dry1: Delaware River between CSO-14 and Ridley Crk (DR-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

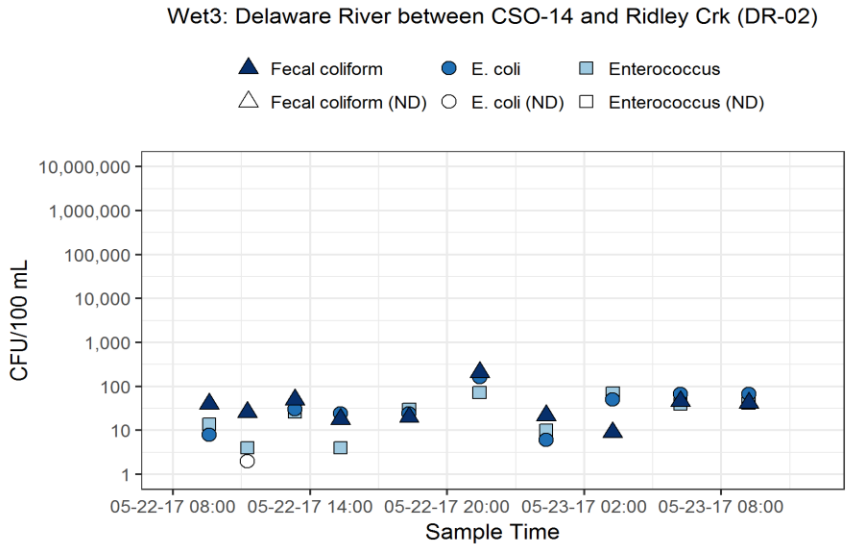

Dry2: Delaware River between CSO-14 and Ridley Crk (DR-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: Delaware River between CSO-14 and Ridley Crk (DR-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

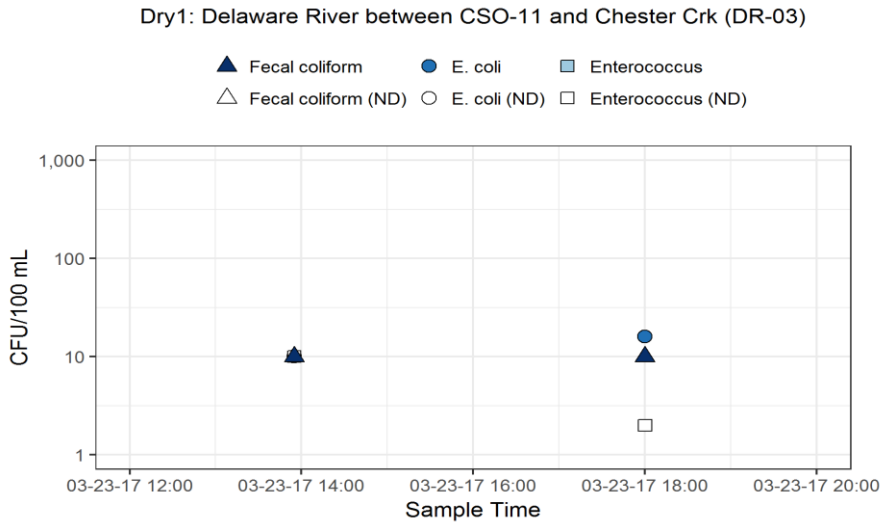
1.5 DR-02 Wet

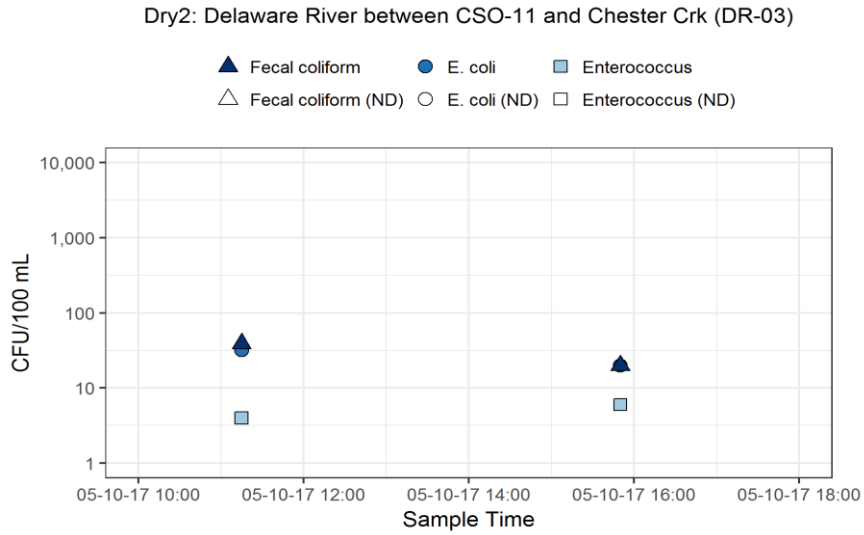

Wet1: Delaware River between CSO-14 and Ridley Crk (DR-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

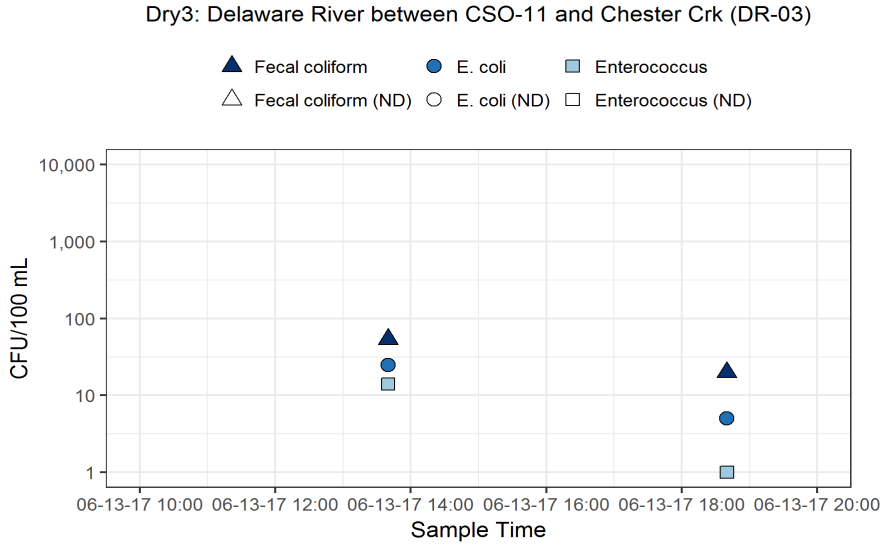

Wet2: Delaware River between CSO-14 and Ridley Crk (DR-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: Delaware River between CSO-14 and Ridley Crk (DR-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

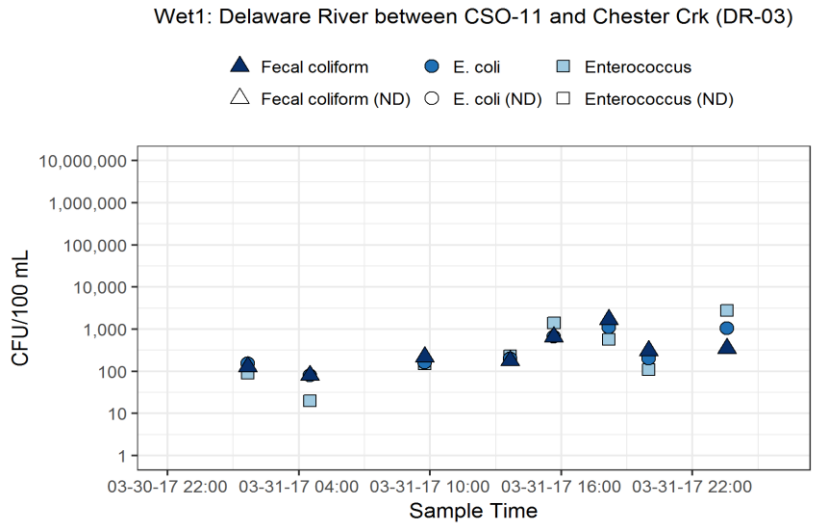
1.6 DR-03 Dry

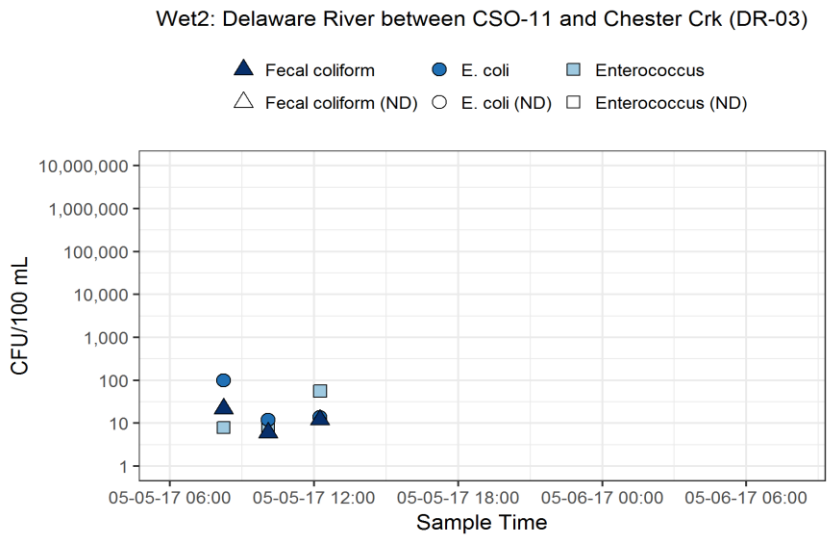

Dry1: Delaware River between CSO-11 and Chester Crk (DR-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

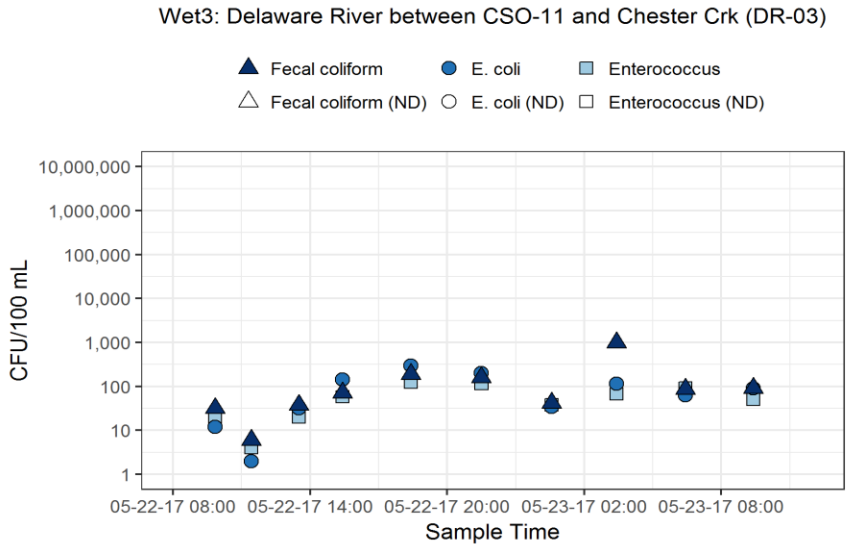

Dry2: Delaware River between CSO-11 and Chester Crk (DR-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: Delaware River between CSO-11 and Chester Crk (DR-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

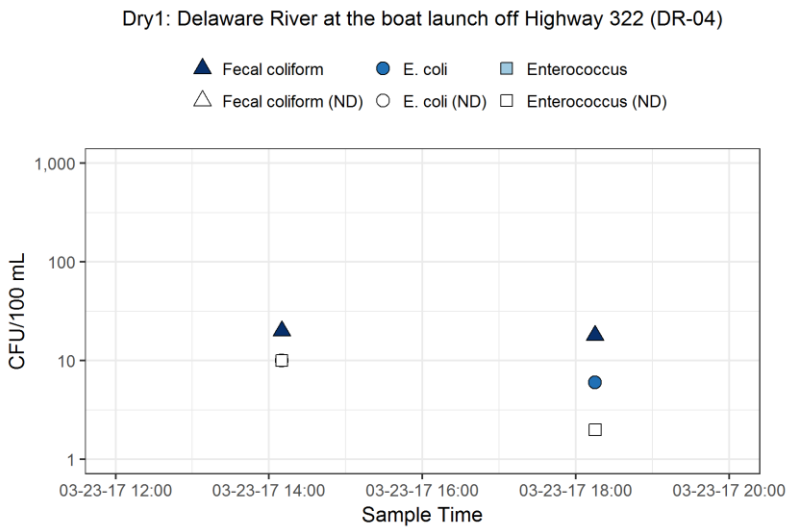
1.6 DR-03 Wet

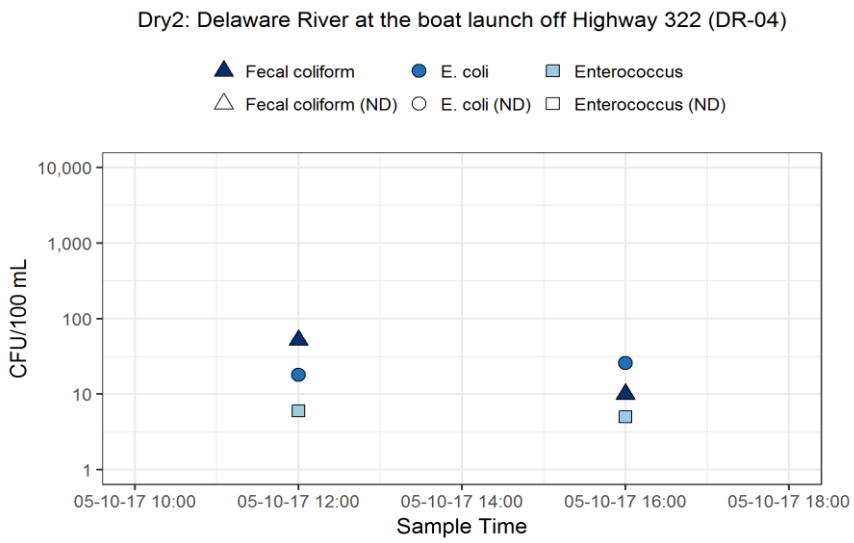

Wet1: Delaware River between CSO-11 and Chester Crk (DR-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

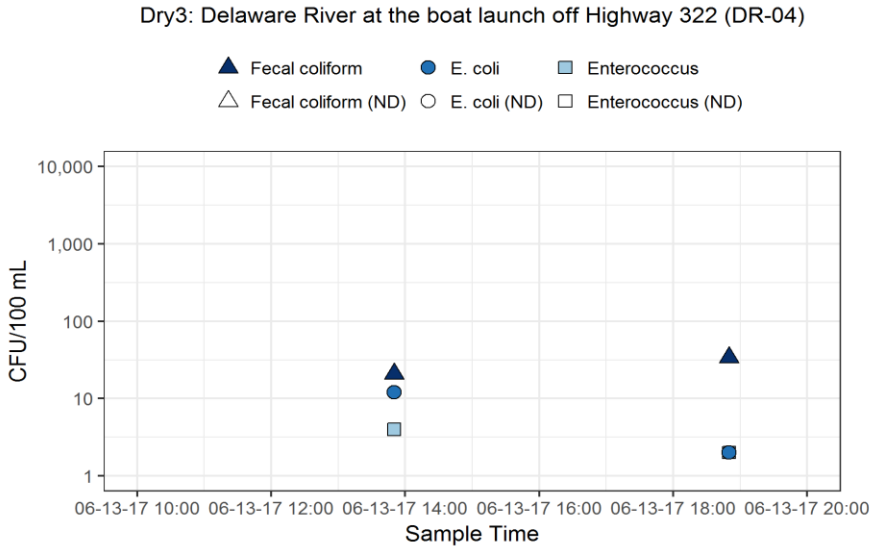

Wet2: Delaware River between CSO-11 and Chester Crk (DR-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: Delaware River between CSO-11 and Chester Crk (DR-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

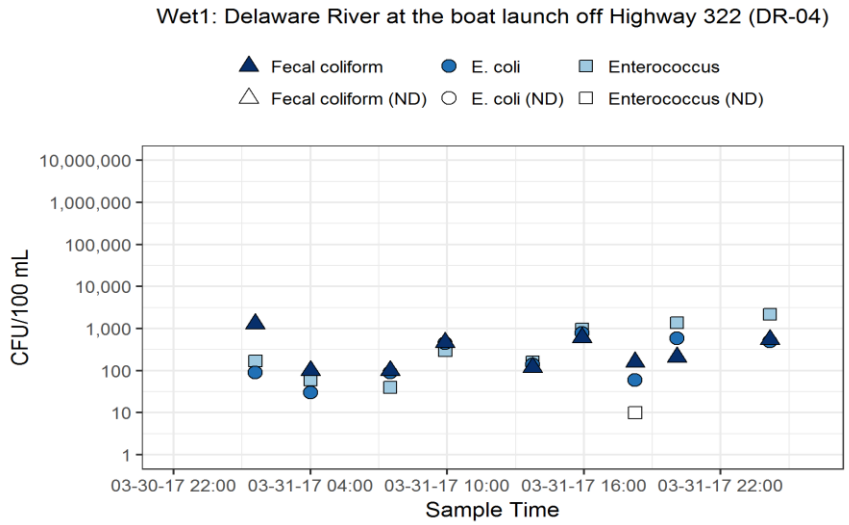
1.7 DR-04 Dry

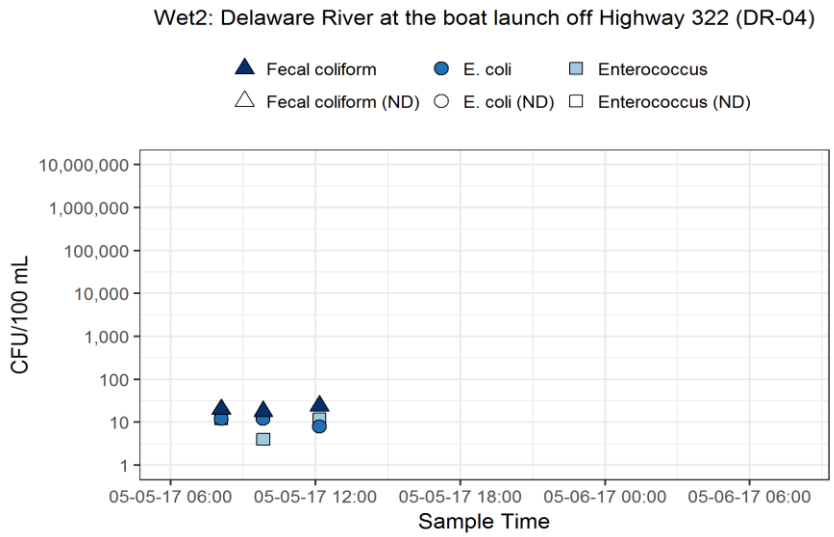

Dry1: Delaware River at the boat launch off Highway 322 (DR-04)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

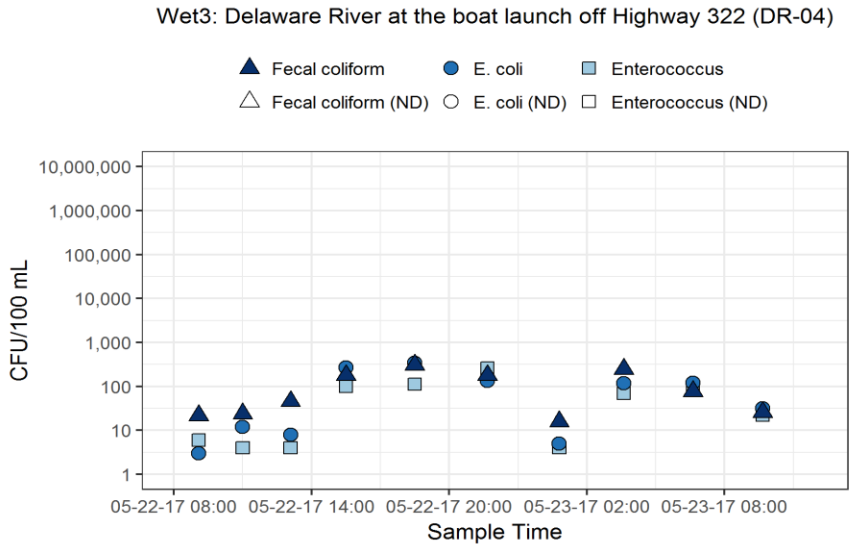

Dry2: Delaware River at the boat launch off Highway 322 (DR-04)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: Delaware River at the boat launch off Highway 322 (DR-04)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

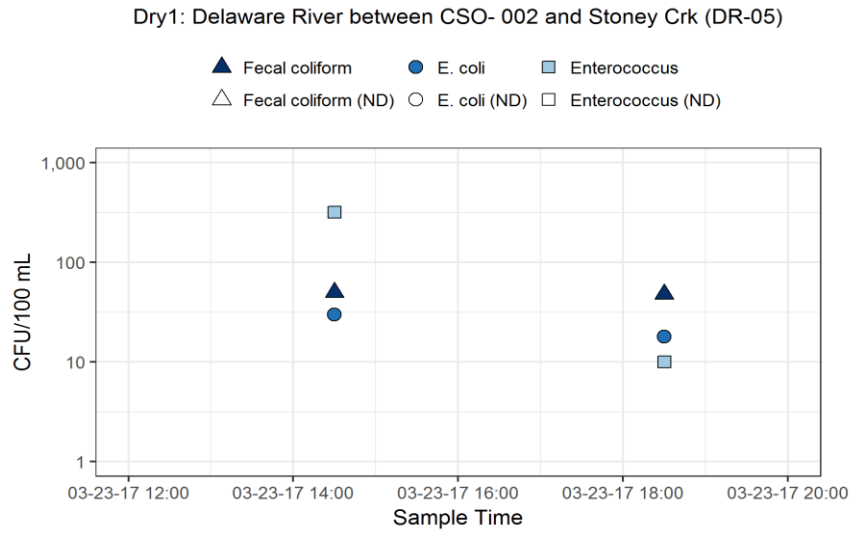
1.7 DR-04 Wet

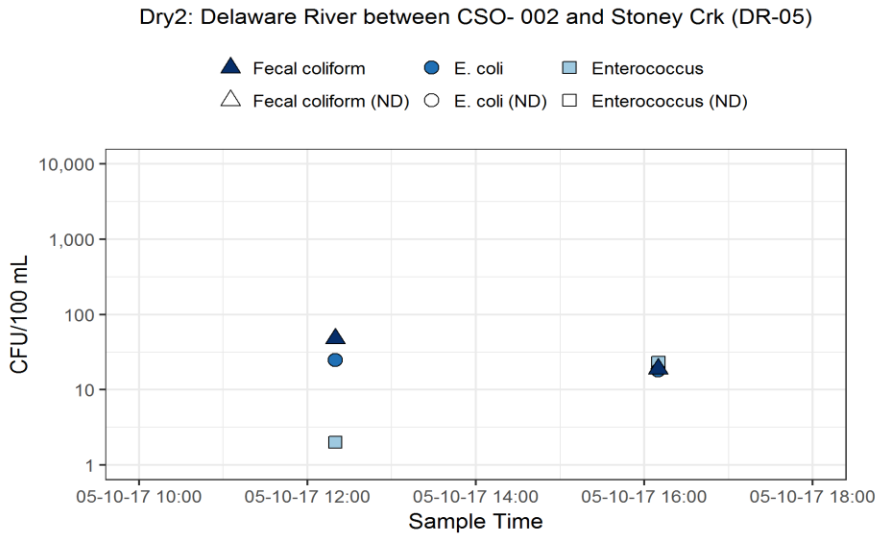

Wet1: Delaware River at the boat launch off Highway 322 (DR-04)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

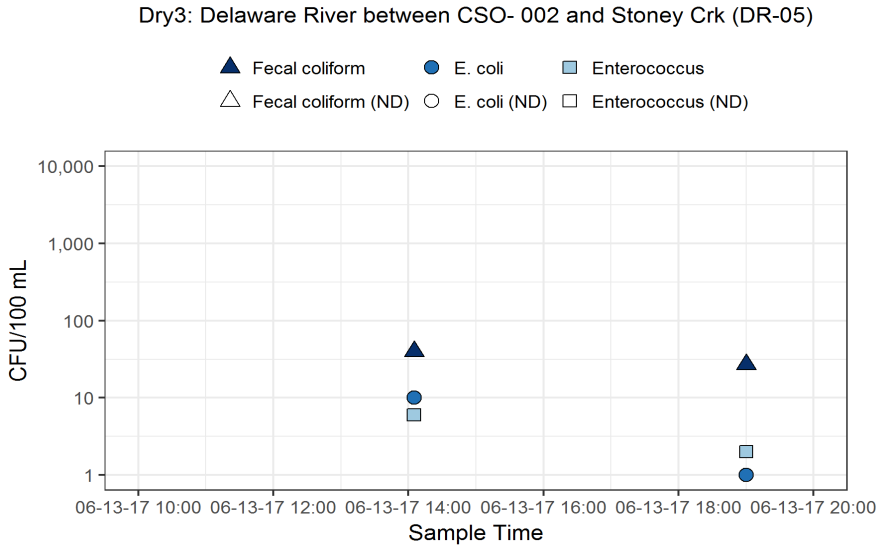

Wet2: Delaware River at the boat launch off Highway 322 (DR-04)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: Delaware River at the boat launch off Highway 322 (DR-04)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

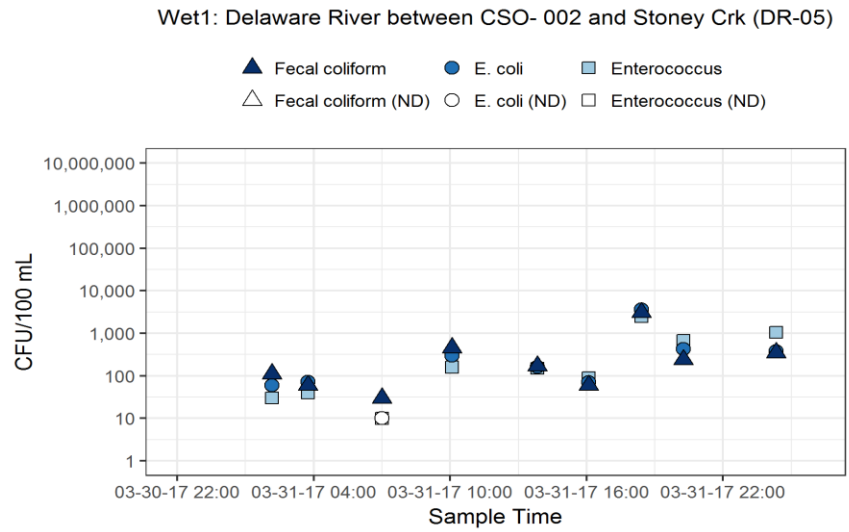
1.8 DR-05 Dry

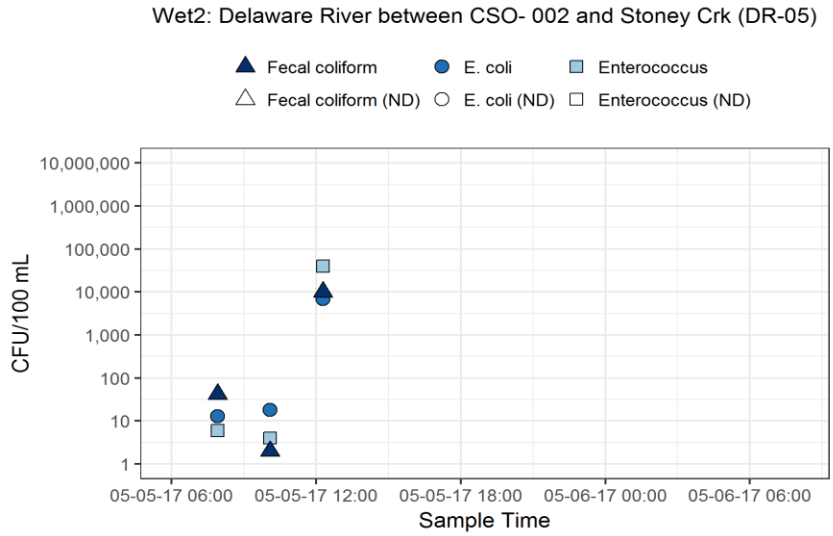

Dry1: Delaware River between CSO- 002 and Stoney Crk (DR-05)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

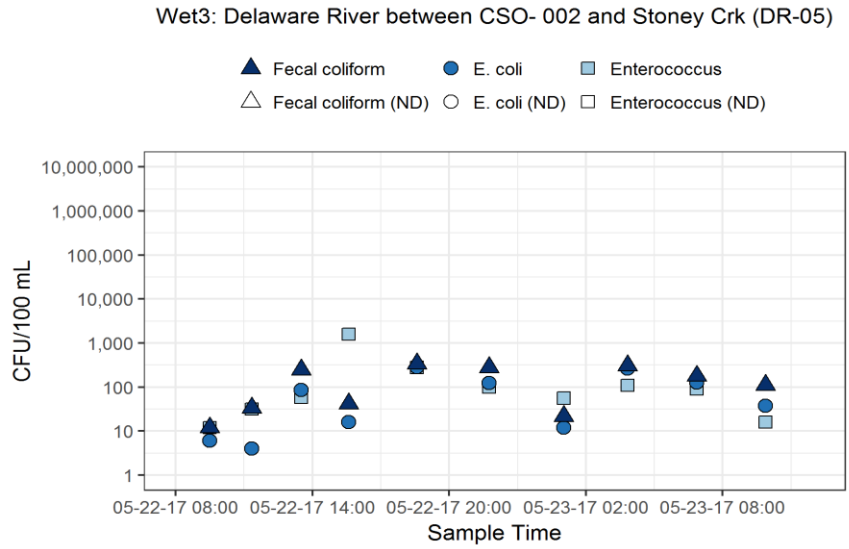

Dry2: Delaware River between CSO- 002 and Stoney Crk (DR-05)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: Delaware River between CSO- 002 and Stoney Crk (DR-05)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

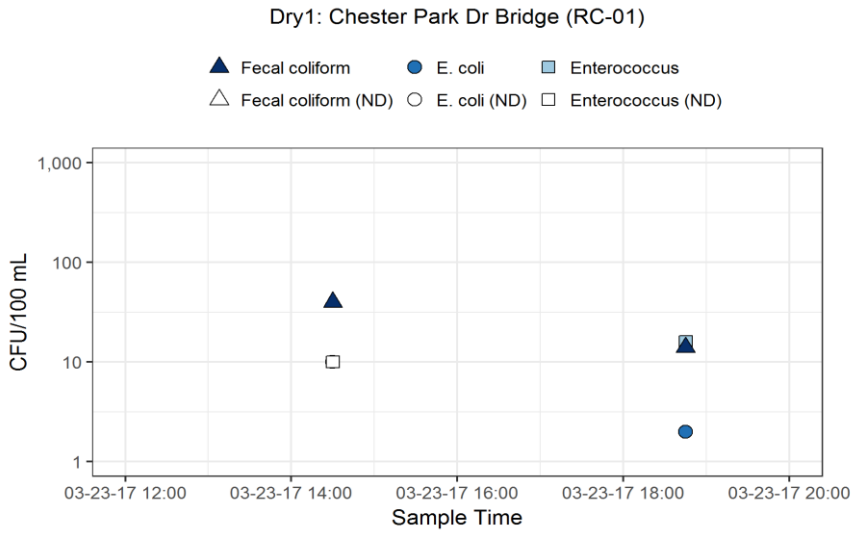
1.8 DR-05 Wet

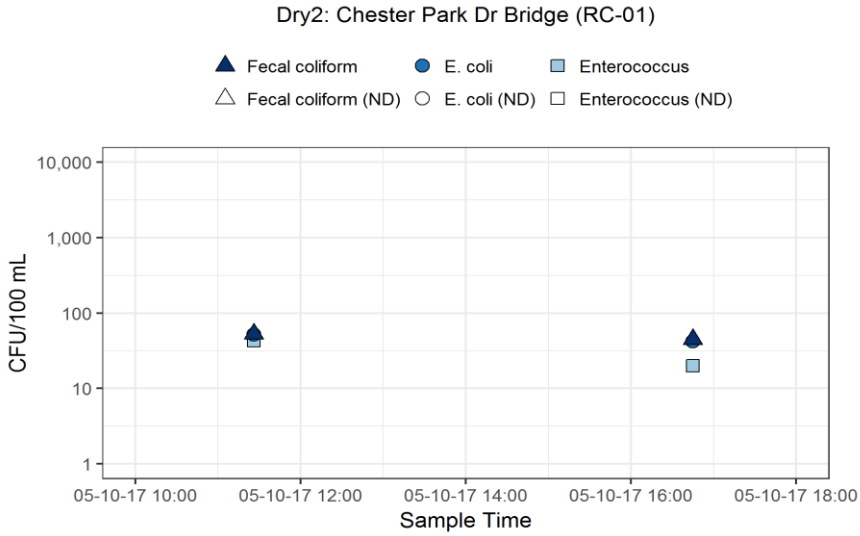

Wet1: Delaware River between CSO- 002 and Stoney Crk (DR-05)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

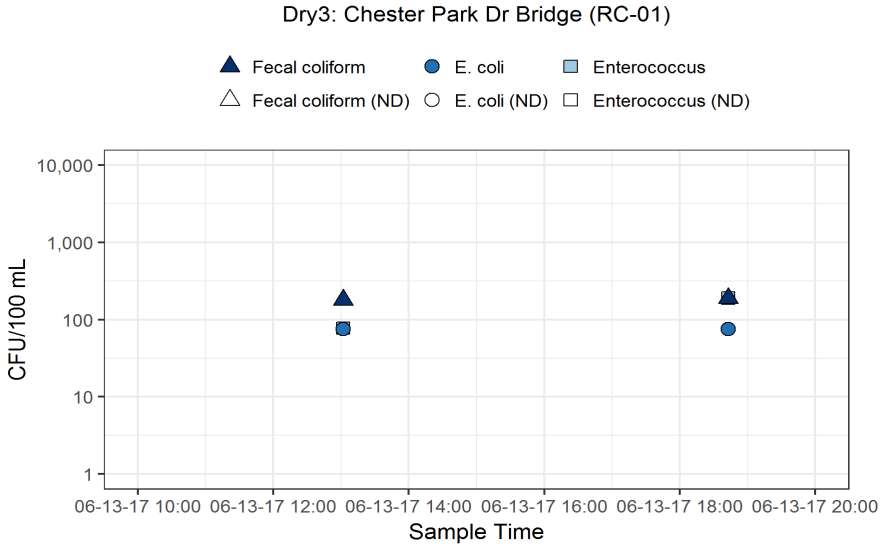

Wet2: Delaware River between CSO- 002 and Stoney Crk (DR-05)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: Delaware River between CSO- 002 and Stoney Crk (DR-05)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

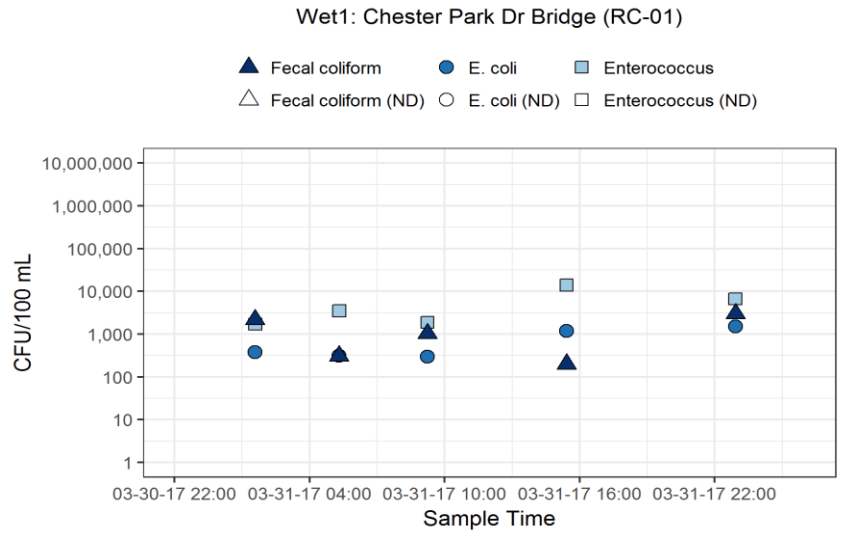
1.9 RC-01 Dry

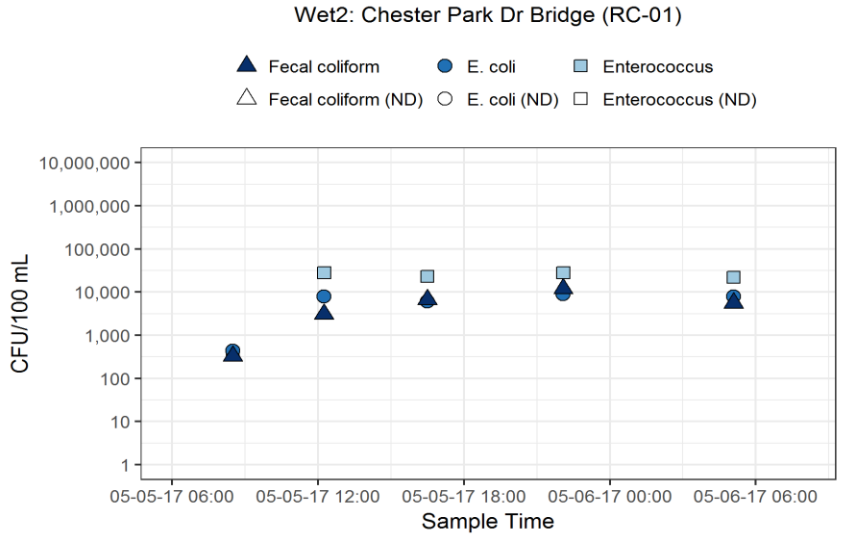

Dry1: Chester Park Dr Bridge (RC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

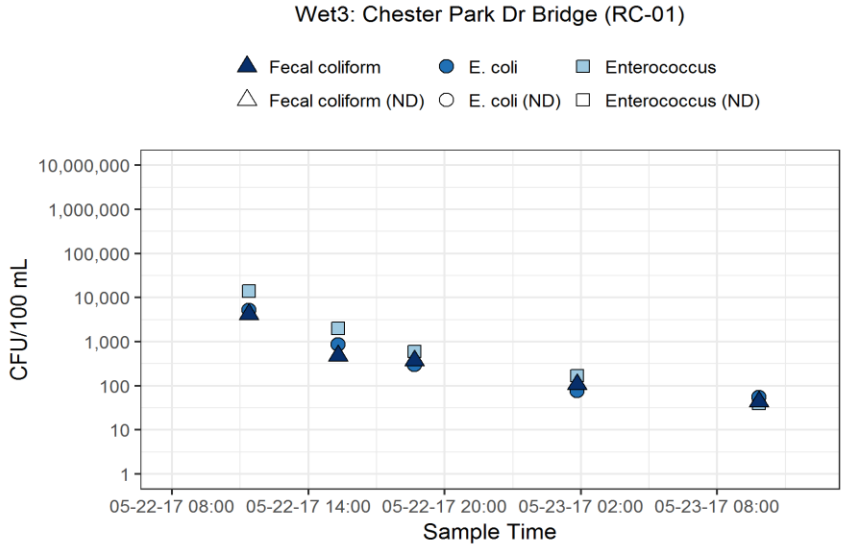

Dry2: Chester Park Dr Bridge (RC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: Chester Park Dr Bridge (RC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

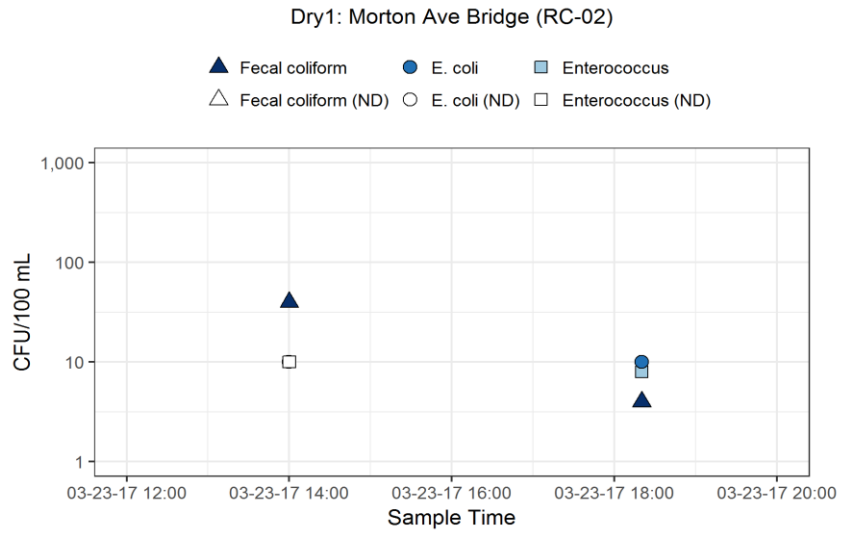
1.9 RC-01 Wet

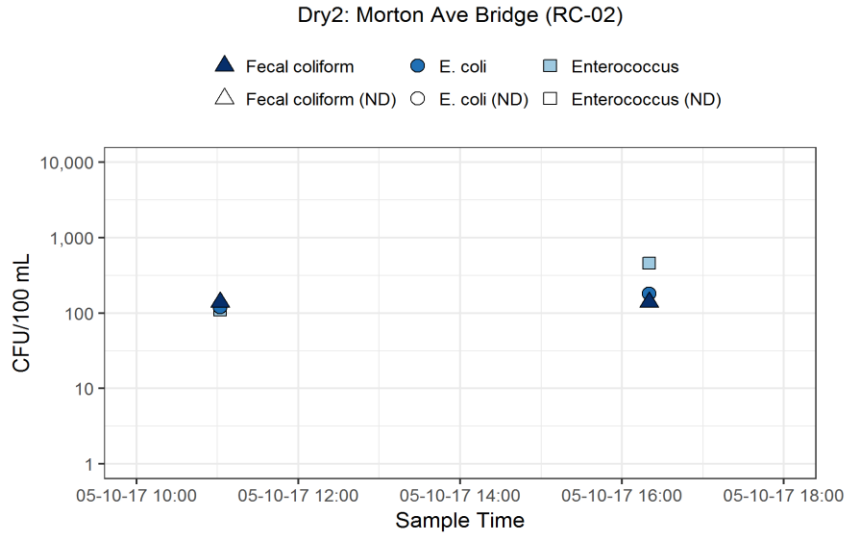

Wet1: Chester Park Dr Bridge (RC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

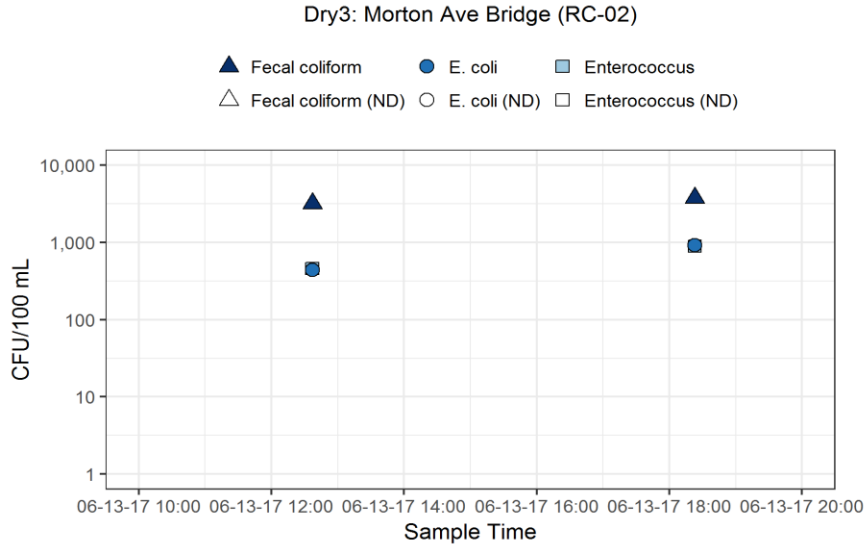

Wet2: Chester Park Dr Bridge (RC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: Chester Park Dr Bridge (RC-01)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

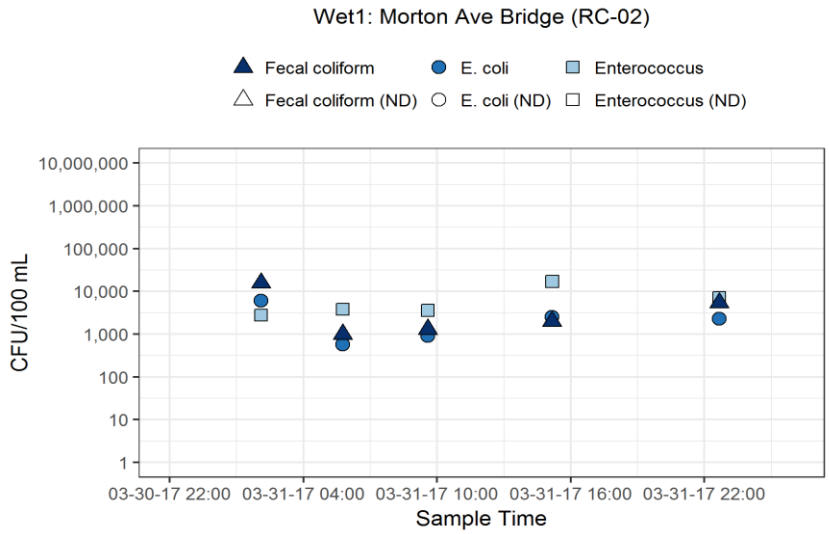
1.10 RC-02 Dry

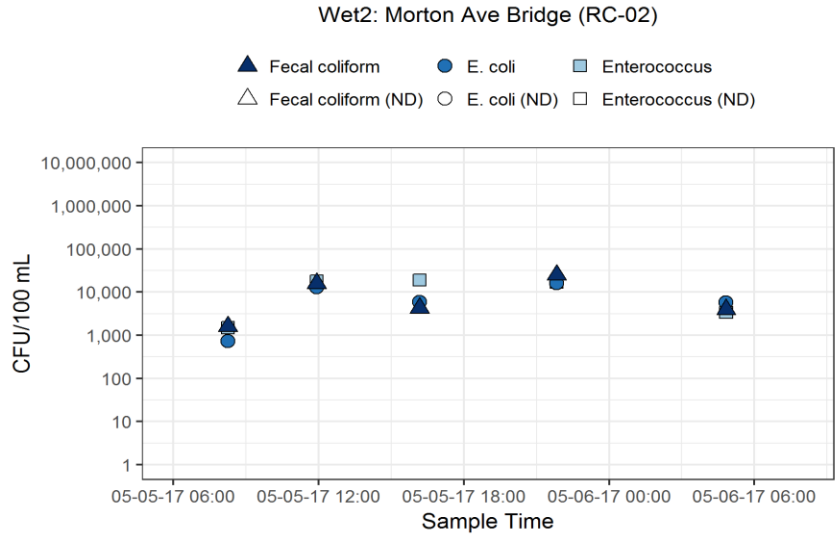

Dry1: Morton Ave Bridge (RC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

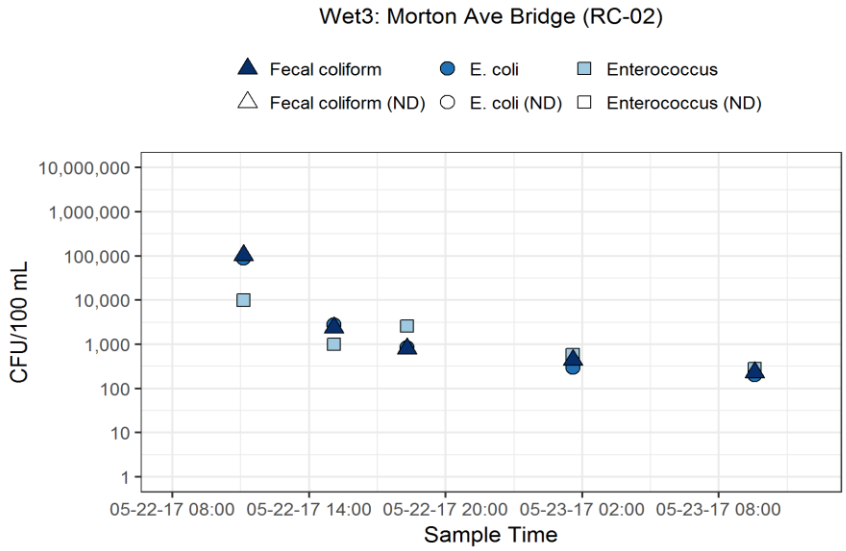

Dry2: Morton Ave Bridge (RC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: Morton Ave Bridge (RC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

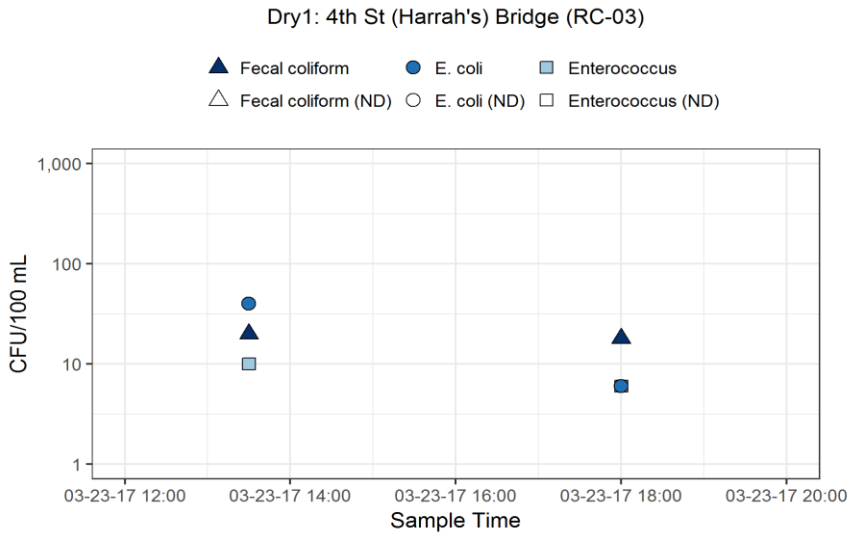
1.10 RC-02 Wet

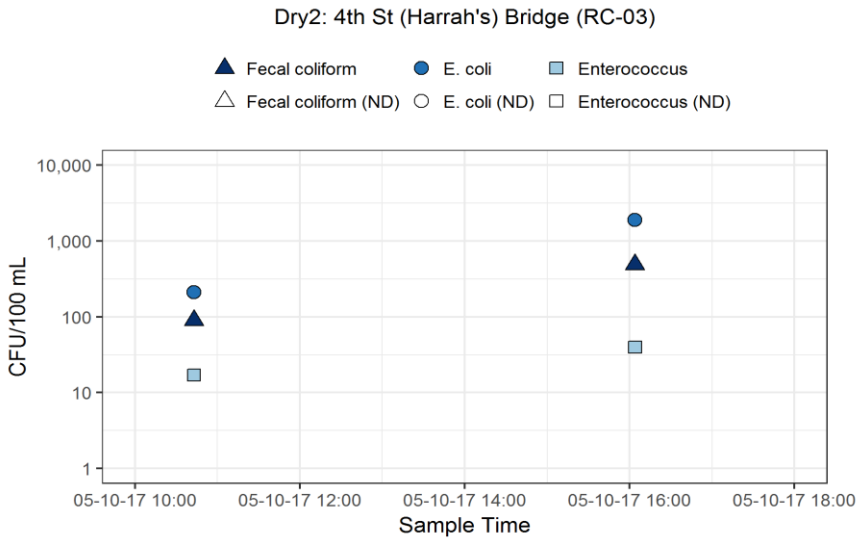

Wet1: Morton Ave Bridge (RC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

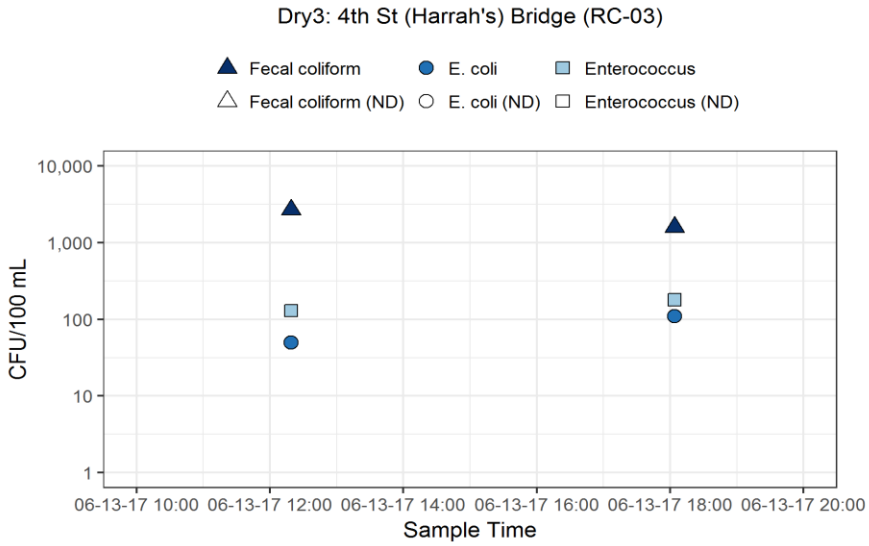

Wet2: Morton Ave Bridge (RC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: Morton Ave Bridge (RC-02)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

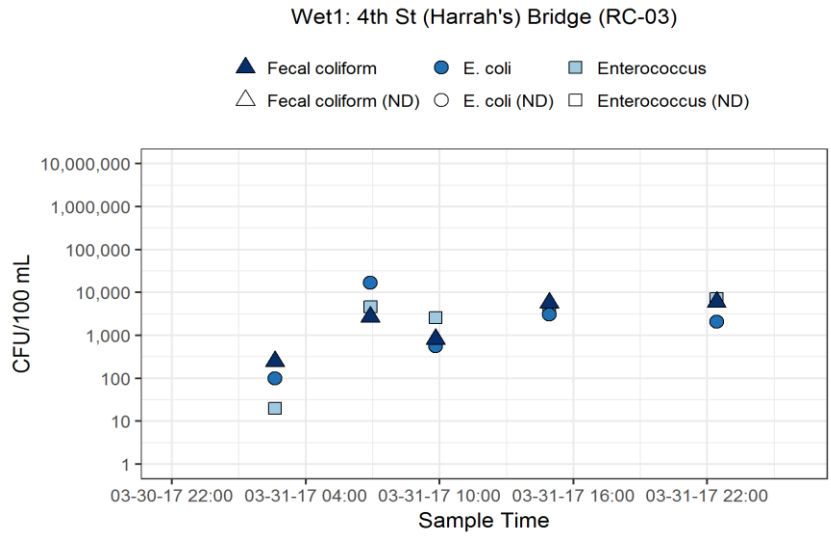
1.11 RC-03 Dry

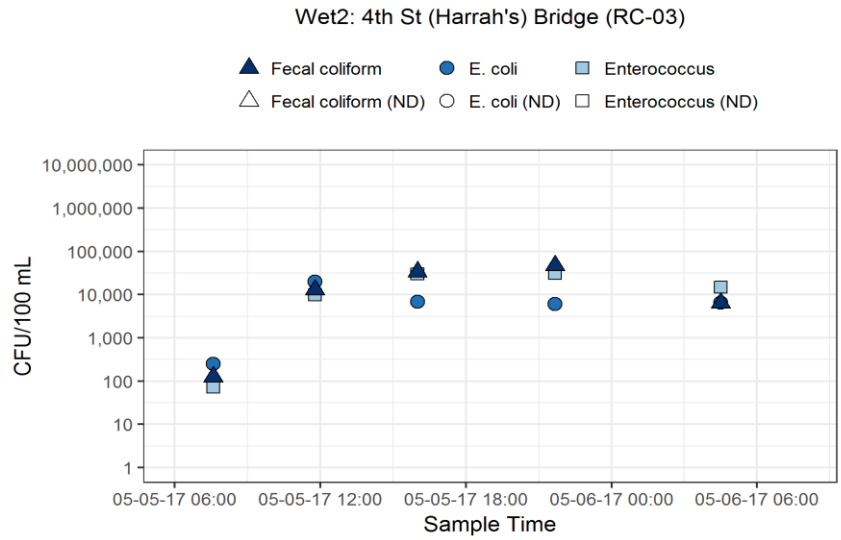

Dry1: 4th St (Harrah's) Bridge (RC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
1,000
100
10
1
03-23-17 12:00
03-23-17 14:00
03-23-17 16:00
03-23-17 18:00
03-23-17 20:00
Sample Time

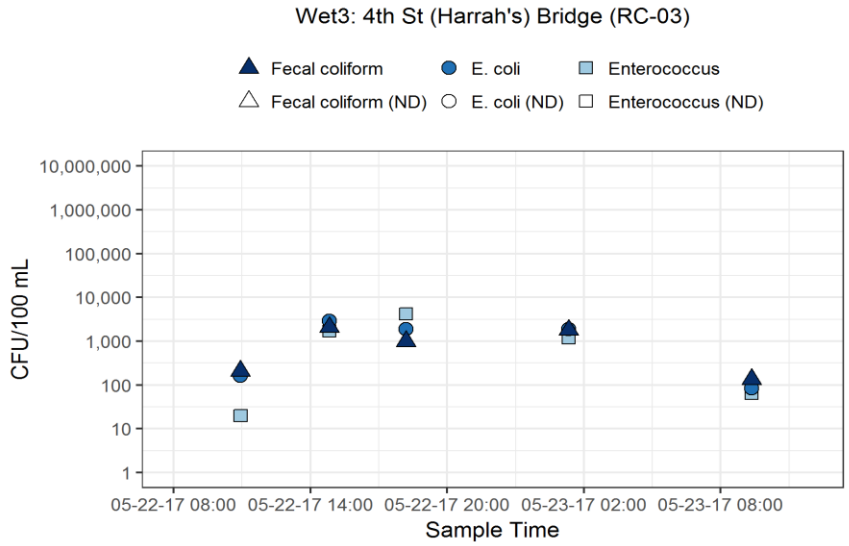

Dry2: 4th St (Harrah's) Bridge (RC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
05-10-17 10:00
05-10-17 12:00
05-10-17 14:00
05-10-17 16:00
05-10-17 18:00
Sample Time


Dry3: 4th St (Harrah's) Bridge (RC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000
1,000
100
10
1
06-13-17 10:00
06-13-17 12:00
06-13-17 14:00
06-13-17 16:00
06-13-17 18:00
06-13-17 20:00
Sample Time

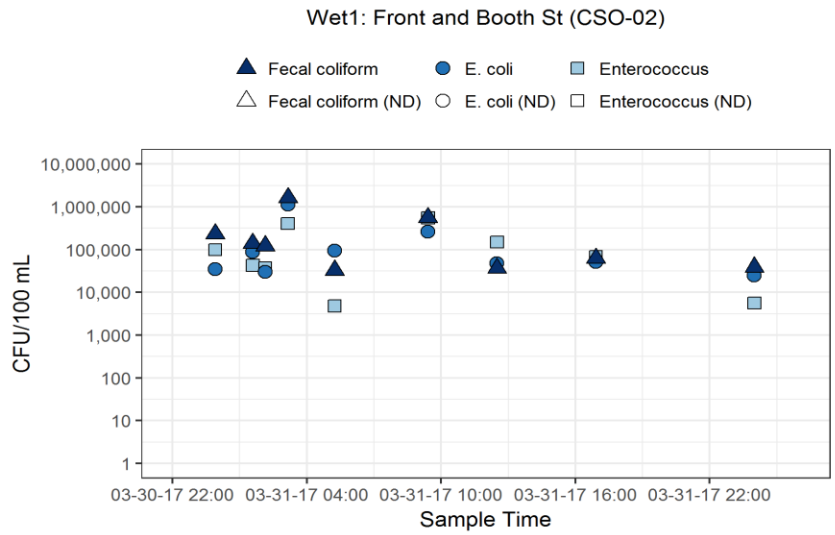
1.11 RC-03 Wet

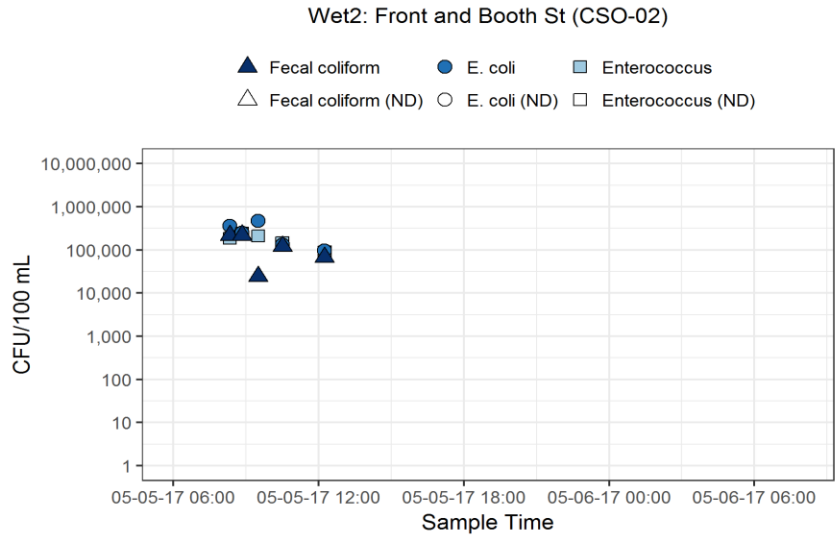

Wet1: 4th St (Harrah's) Bridge (RC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
03-30-17 22:00
03-31-17 04:00
03-31-17 10:00
03-31-17 16:00
03-31-17 22:00
Sample Time

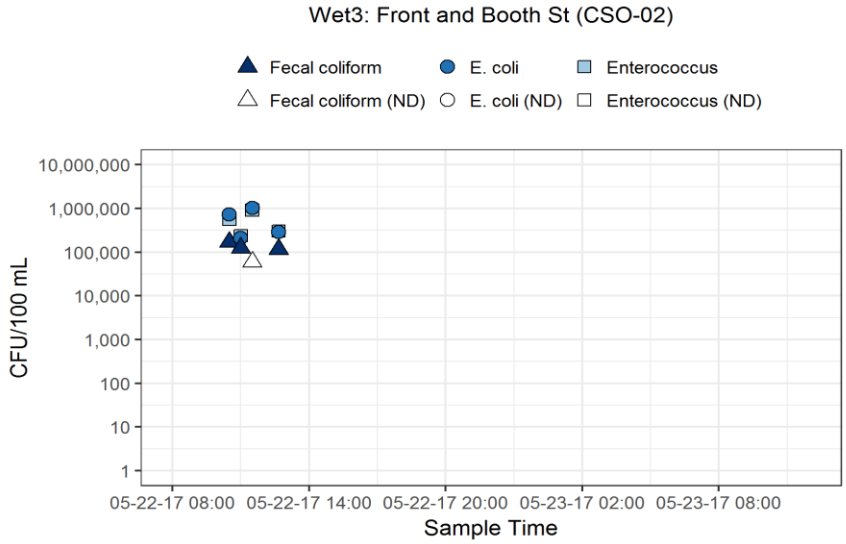

Wet2: 4th St (Harrah's) Bridge (RC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-05-17 06:00
05-05-17 12:00
05-05-17 18:00
05-06-17 00:00
05-06-17 06:00
Sample Time


Wet3: 4th St (Harrah's) Bridge (RC-03)
Fecal coliform
E. coli
Enterococcus
Fecal coliform (ND)
E. coli (ND)
Enterococcus (ND)
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
05-22-17 08:00
05-22-17 14:00
05-22-17 20:00
05-23-17 02:00
05-23-17 08:00
Sample Time

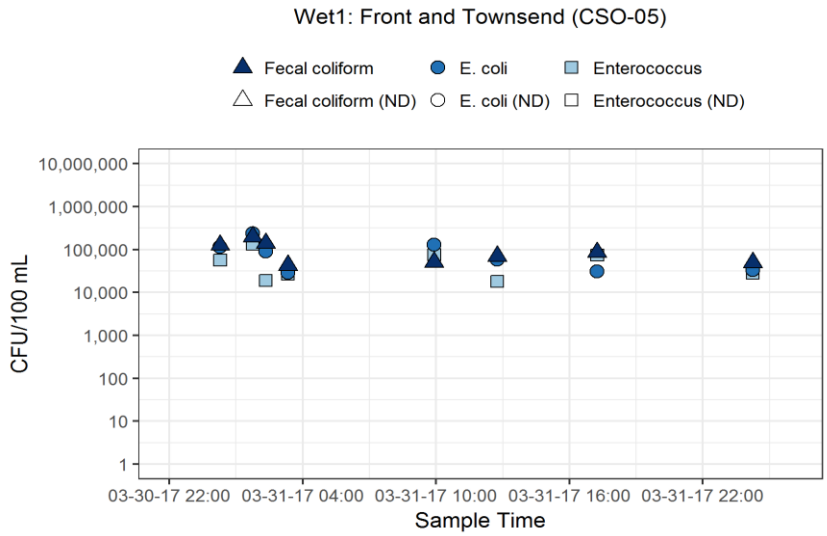
1.12 CSO-02 Wet

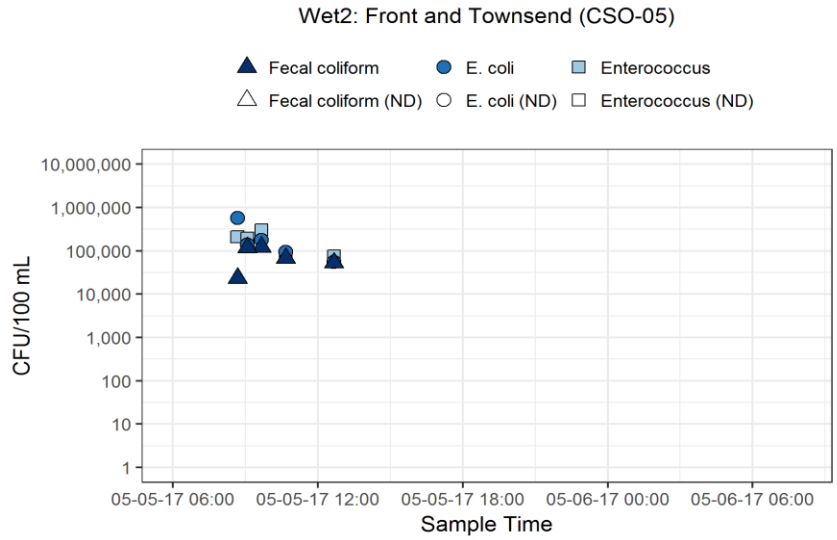


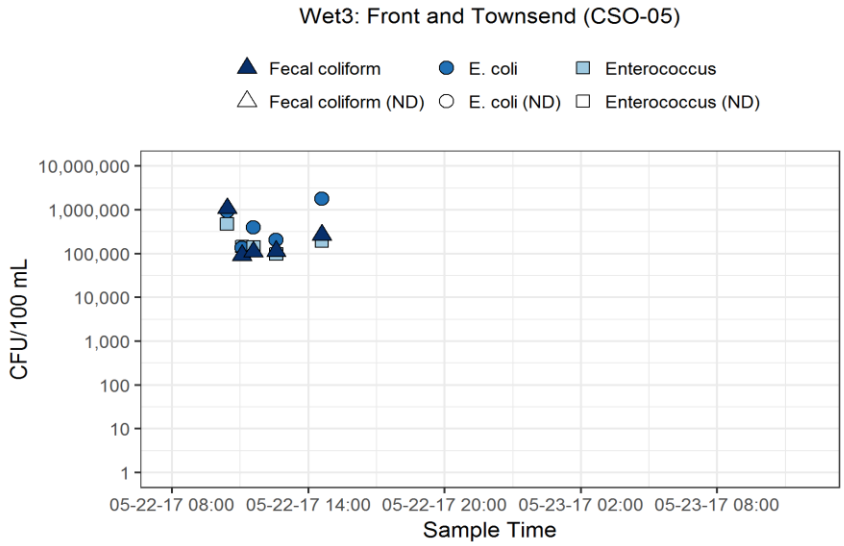




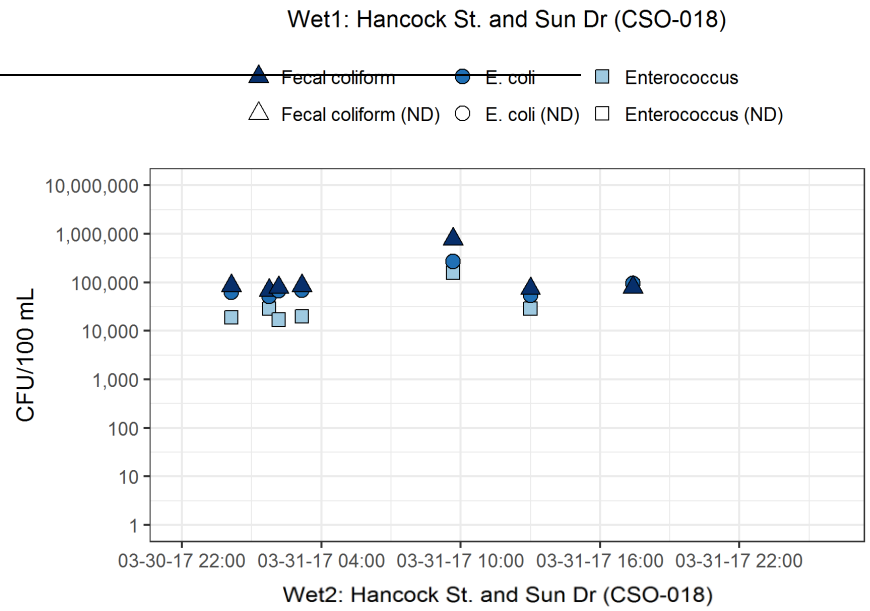
1.12 CSO-05 Wet

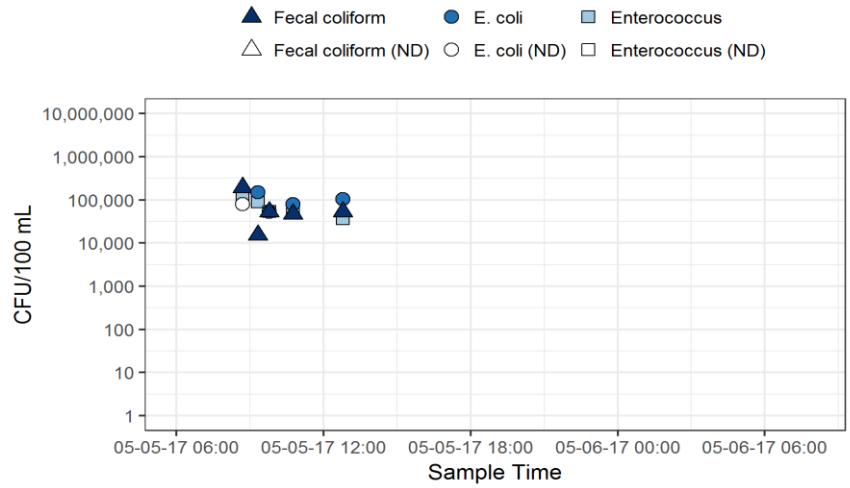


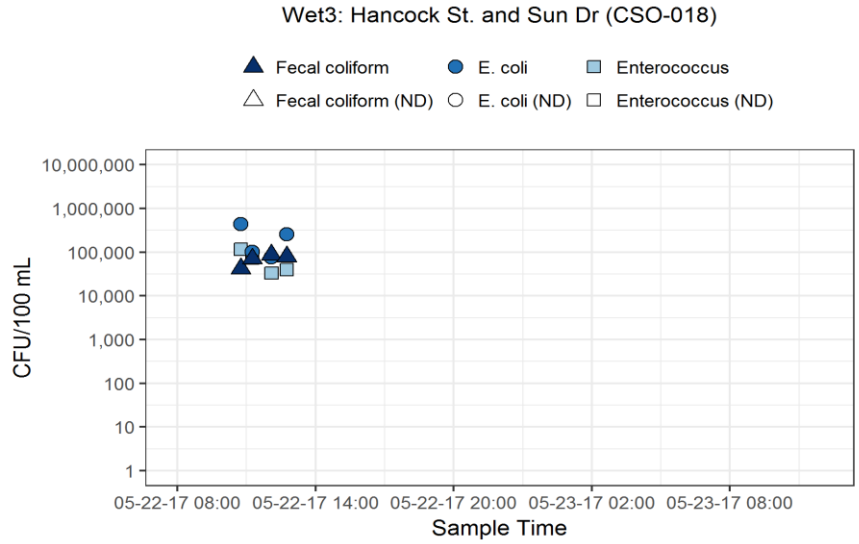




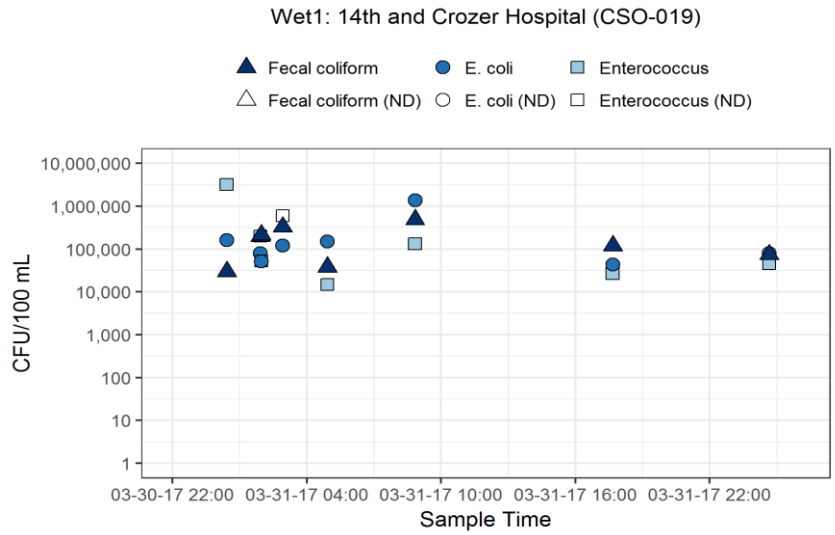
1.13 CSO-18 Wet

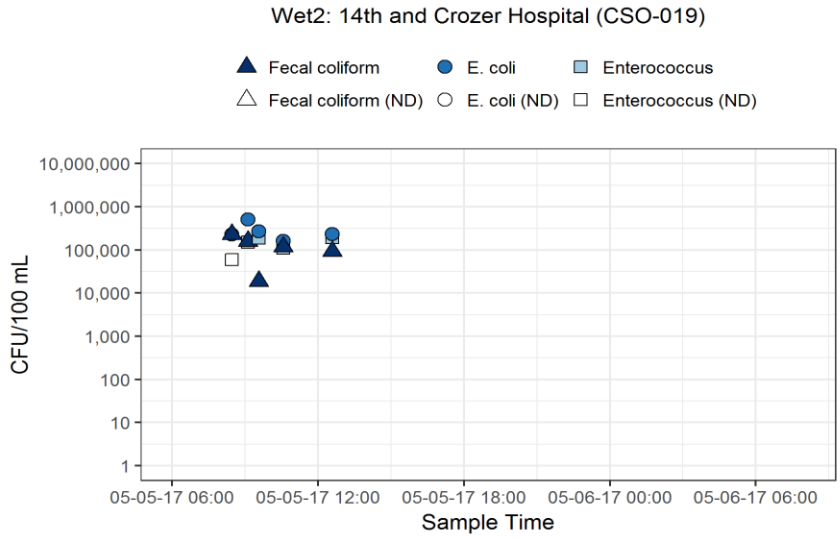


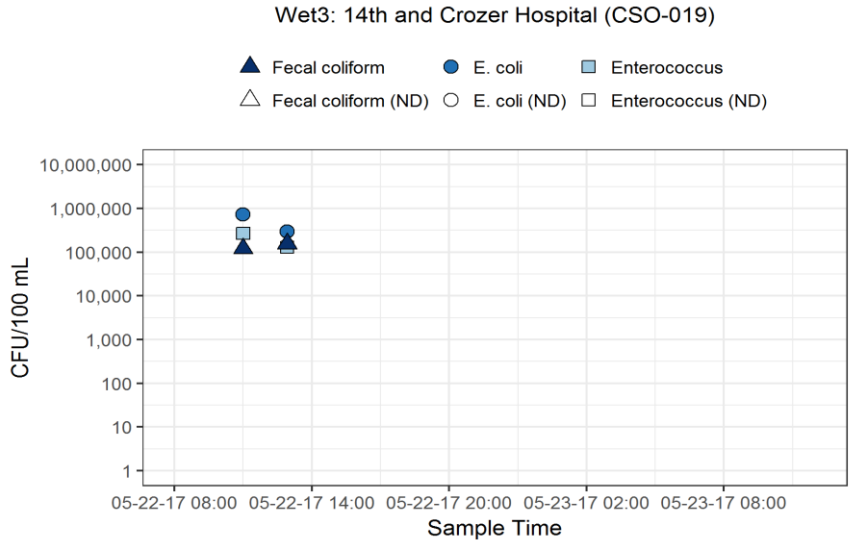




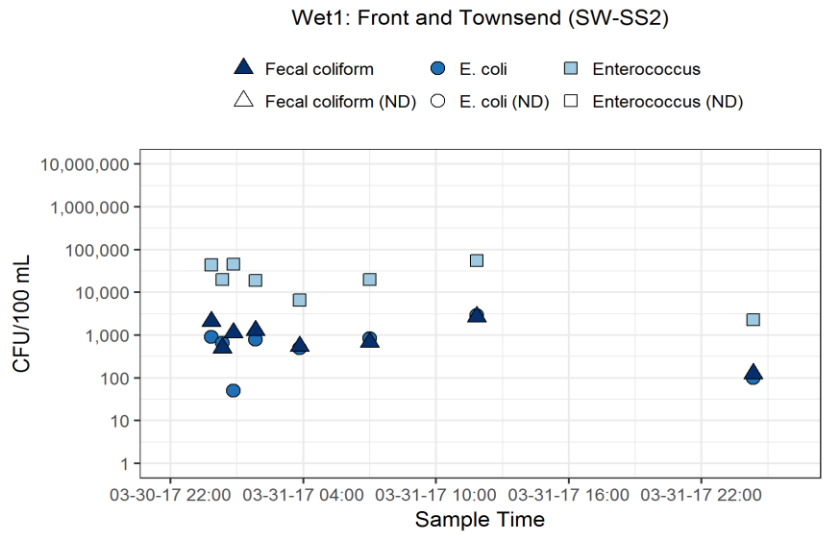
1.14 CSO-19 Wet

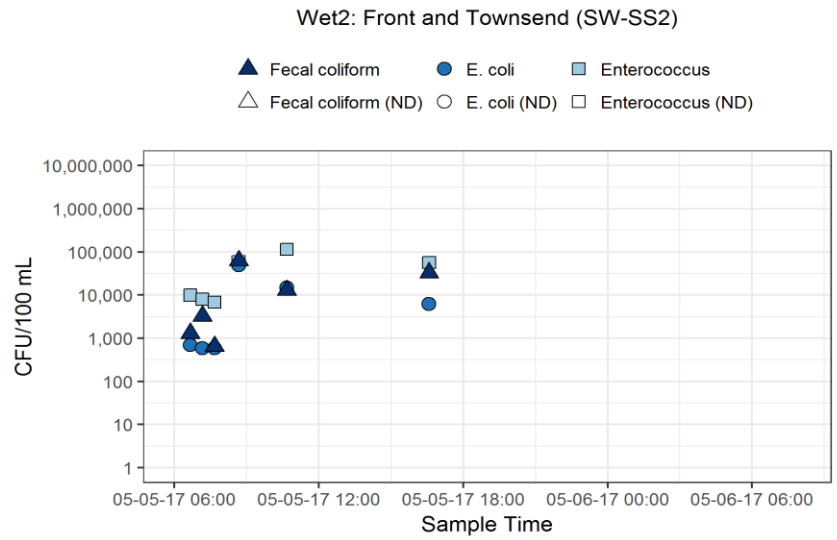


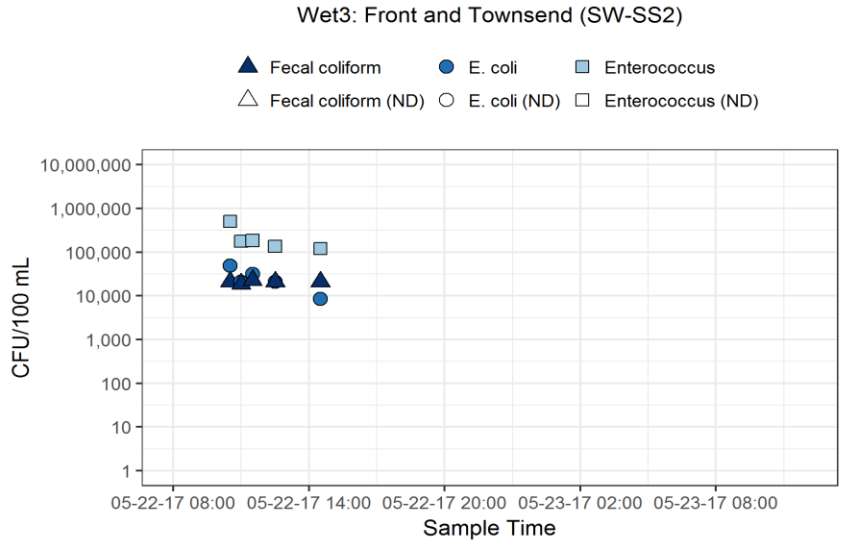




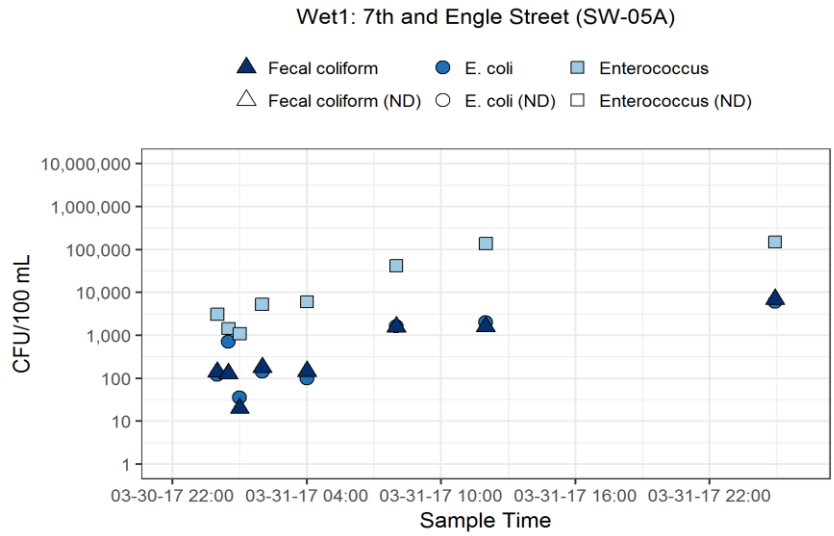
1.15 SW-SS2 Wet

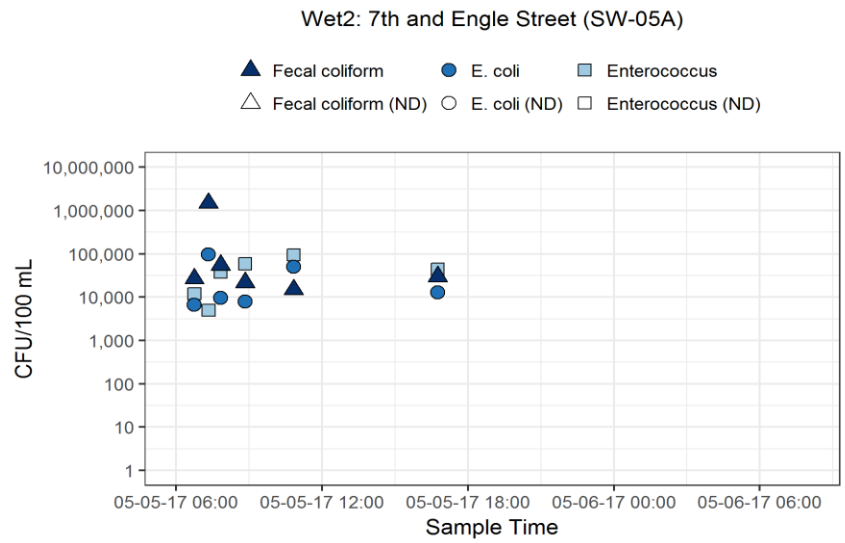


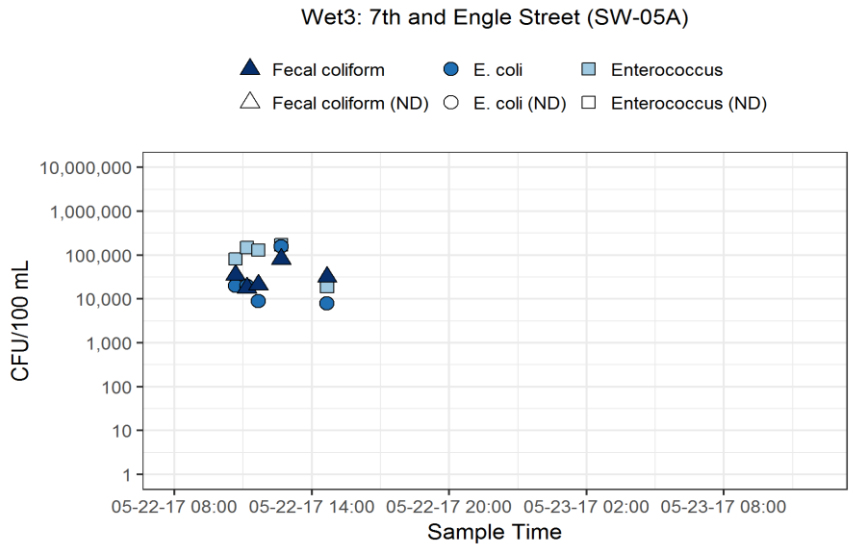




1.16 SW-O5A Wet

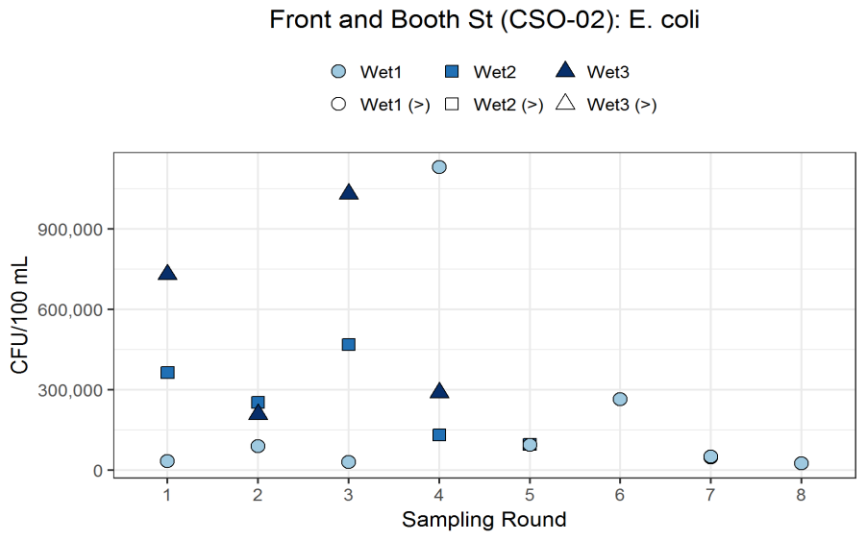


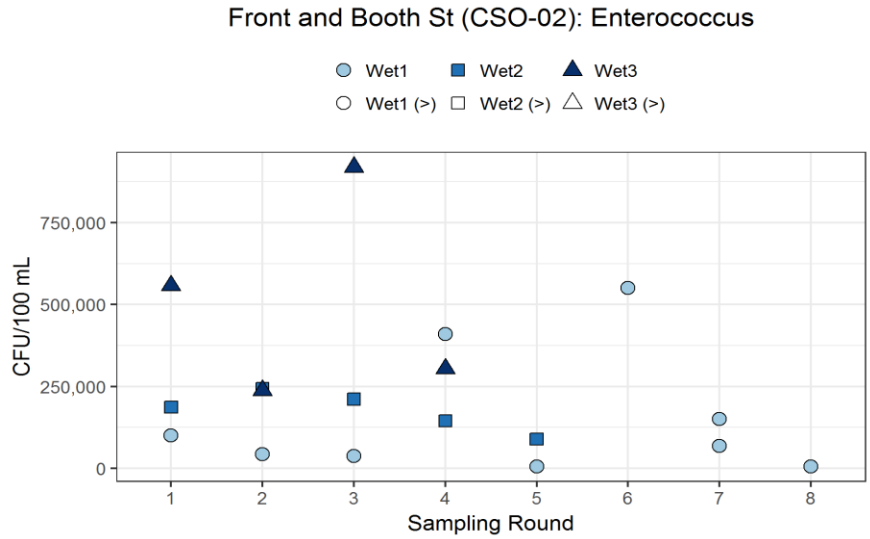


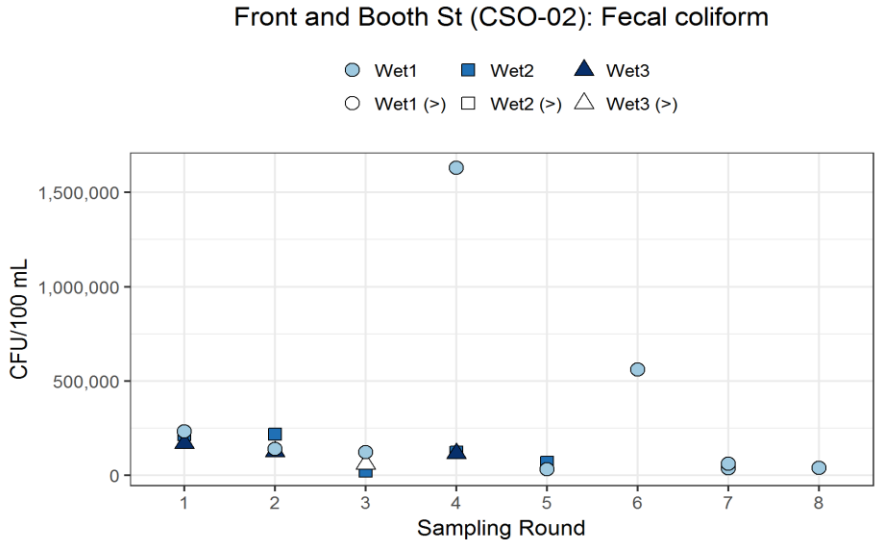


Section 2 First Flush Analysis

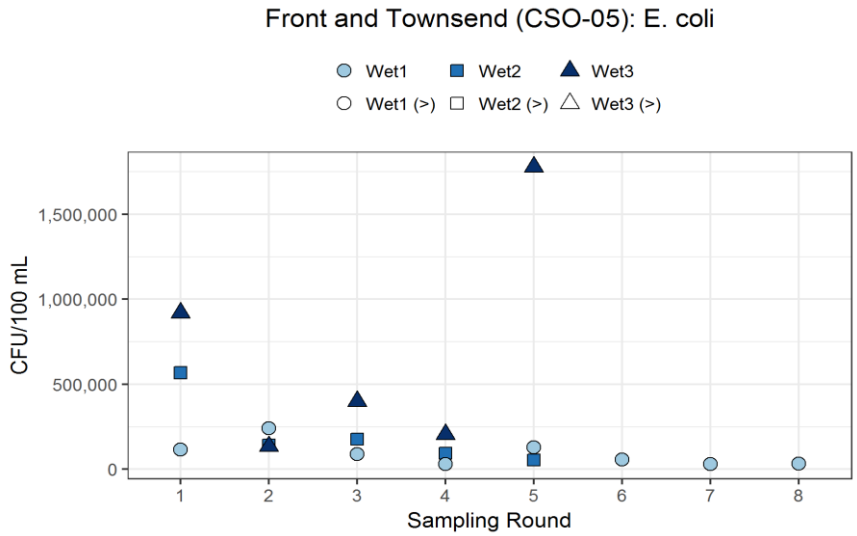
2.1 CSO-02

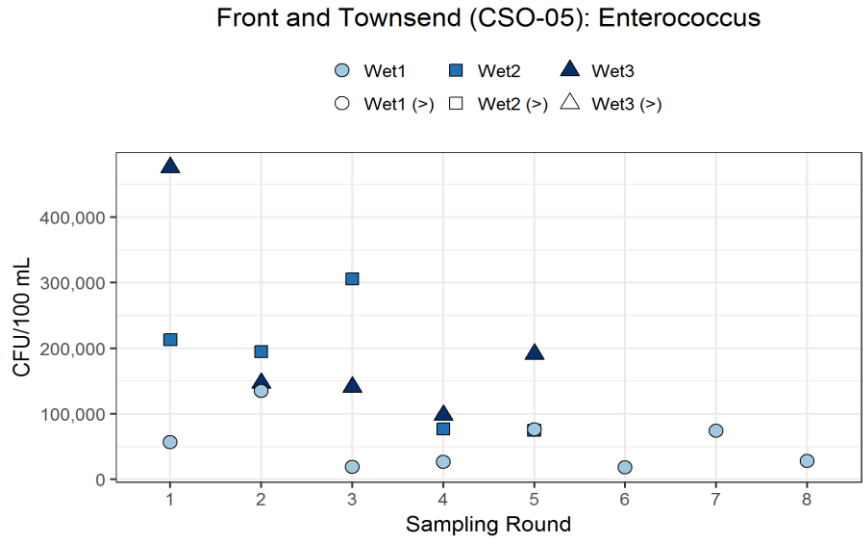

Front and Booth St (CSO-02): E. coli
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
900,000
600,000
300,000
0
1
2
3
4
5
6
7
8
Sampling Round

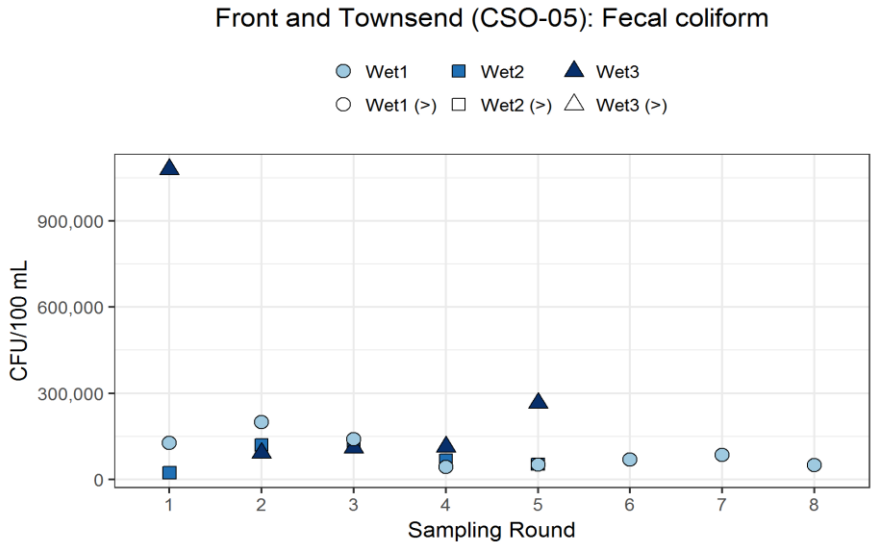

Front and Booth St (CSO-02): Enterococcus
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
750,000
500,000
250,000
0
1
2
3
4
5
6
7
8
Sampling Round


Front and Booth St (CSO-02): Fecal coliform
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
1,500,000
1,000,000
500,000
0
1
2
3
4
5
6
7
8
Sampling Round

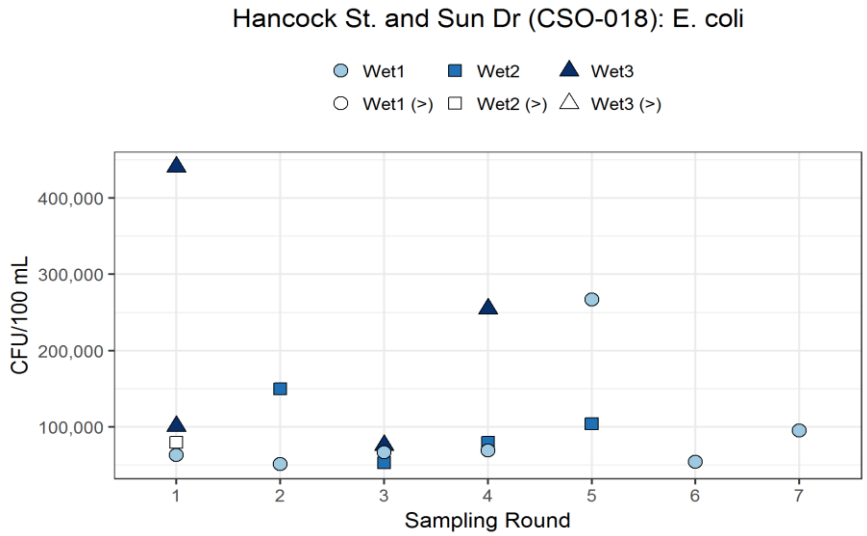
2.2 CSO-05

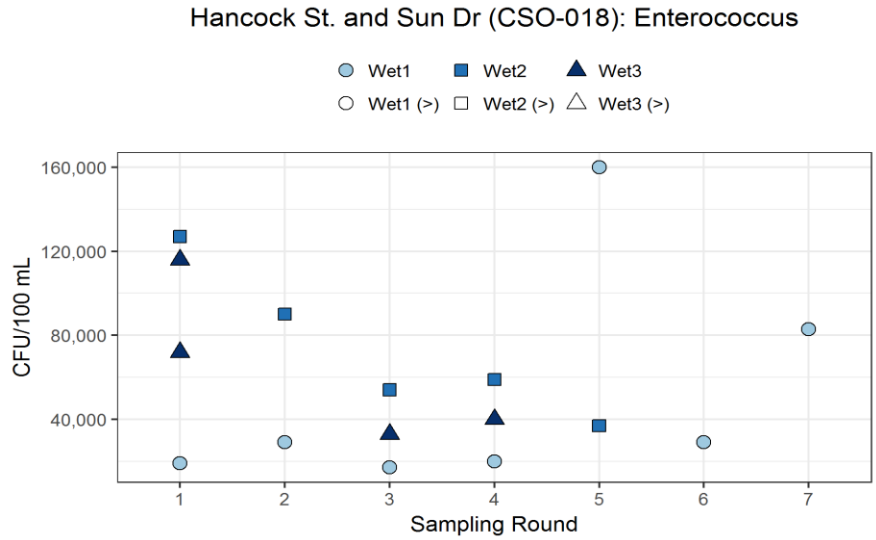

Front and Townsend (CSO-05): E. coli
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
1,500,000
1,000,000
500,000
0
1
2
3
4
5
6
7
8
Sampling Round

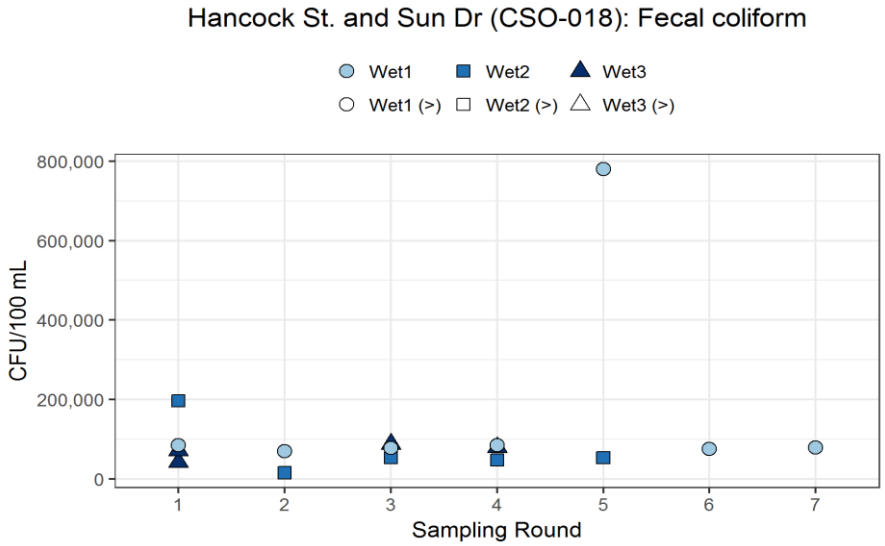

Front and Townsend (CSO-05): Enterococcus
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
400,000
300,000
200,000
100,000
0
1
2
3
4
5
6
7
8
Sampling Round


Front and Townsend (CSO-05): Fecal coliform
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
900,000
600,000
300,000
0
1
2
3
4
5
6
7
8
Sampling Round

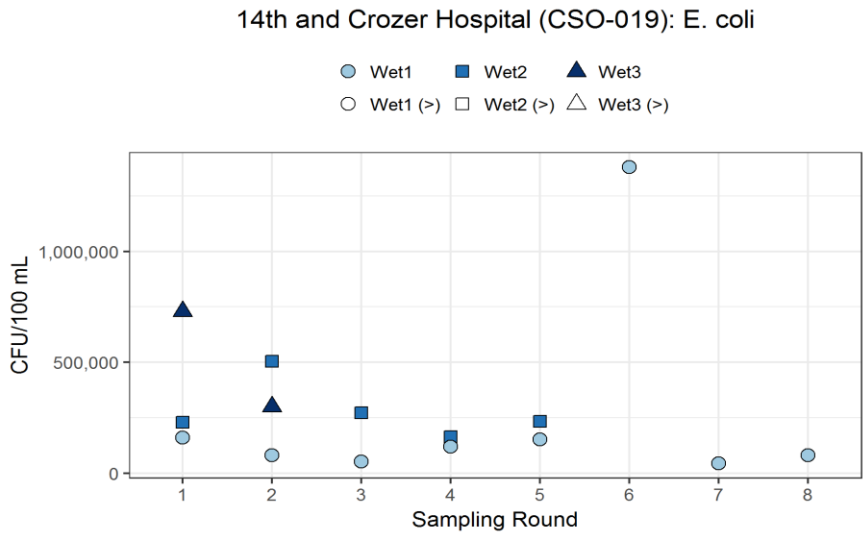
2.3 CSO-018

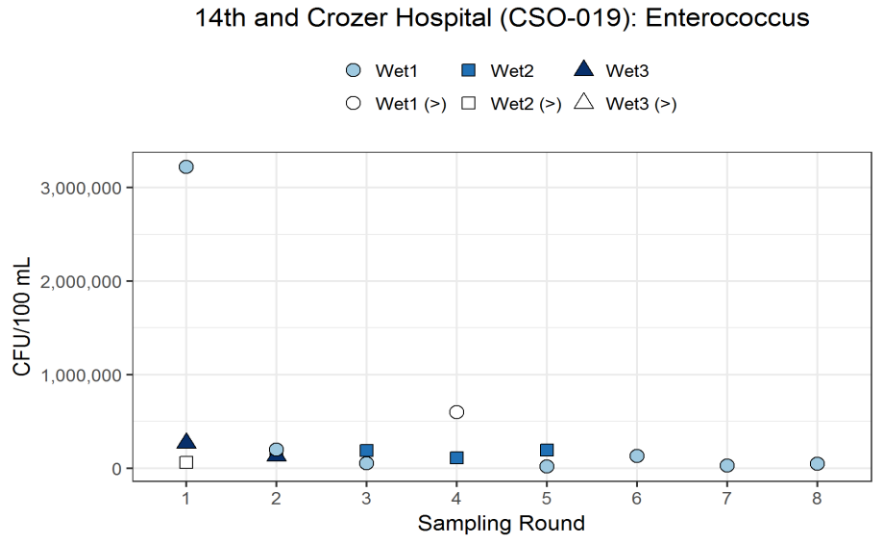

Hancock St. and Sun Dr (CSO-018): E. coli
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
400,000
300,000
200,000
100,000
1
2
3
4
5
6
7
Sampling Round

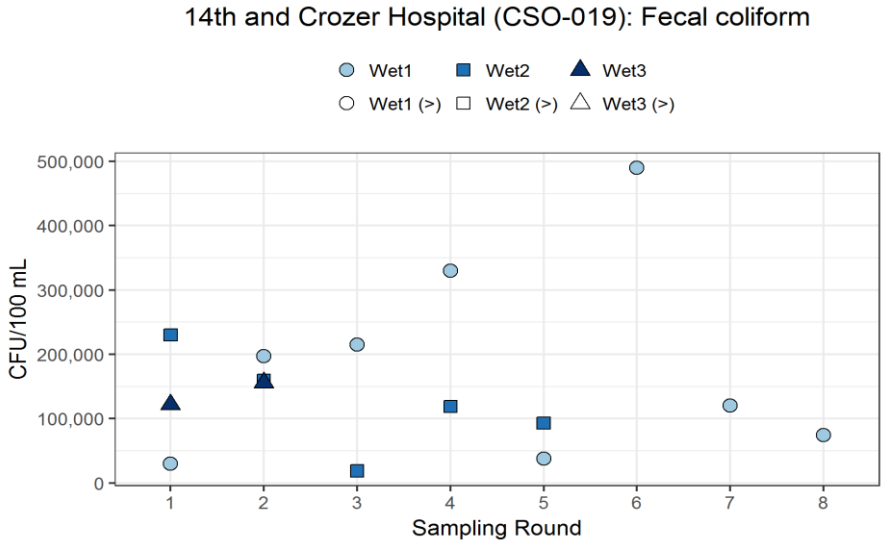

Hancock St. and Sun Dr (CSO-018): Enterococcus
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
160,000
120,000
80,000
40,000
1
2
3
4
5
6
7
Sampling Round


Hancock St. and Sun Dr (CSO-018): Fecal coliform
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
800,000
600,000
400,000
200,000
0
1
2
3
4
5
6
7
Sampling Round

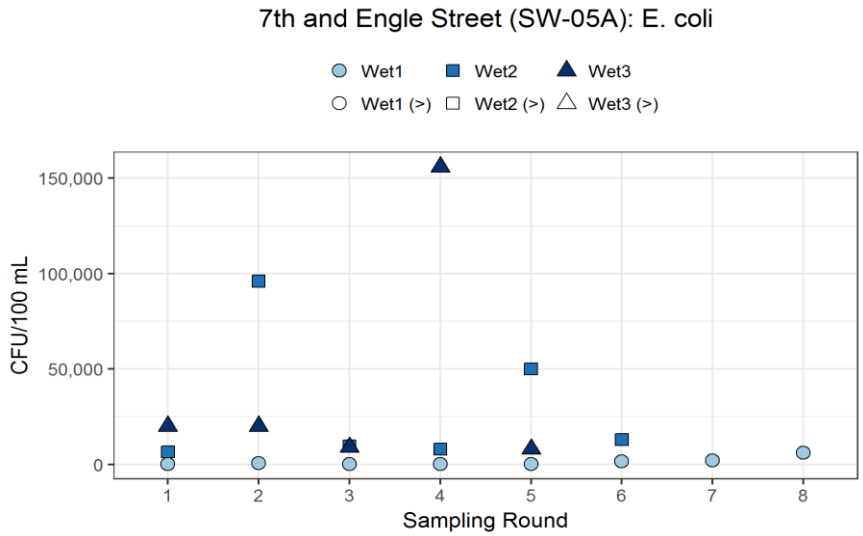
2.4 CSO-019

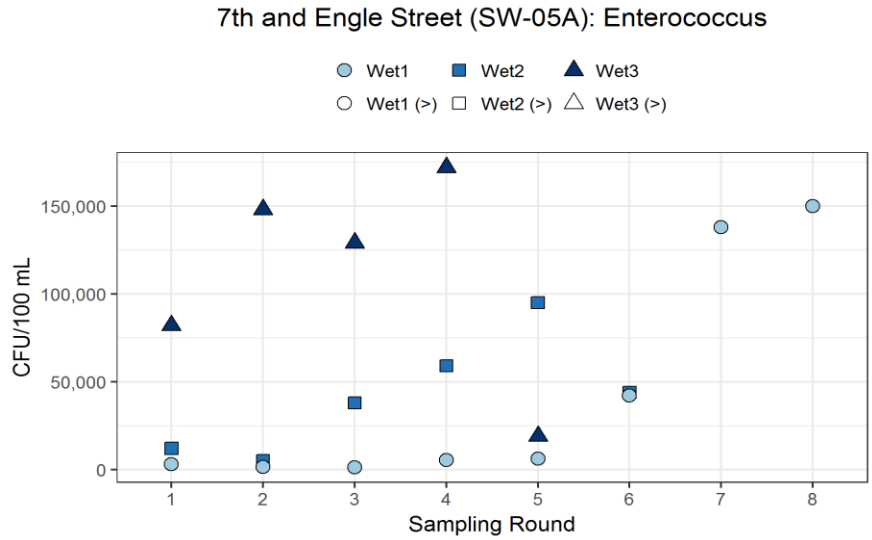

14th and Crozer Hospital (CSO-019): E. coli
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
1,000,000
500,000
0
1
2
3
4
5
6
7
8
Sampling Round

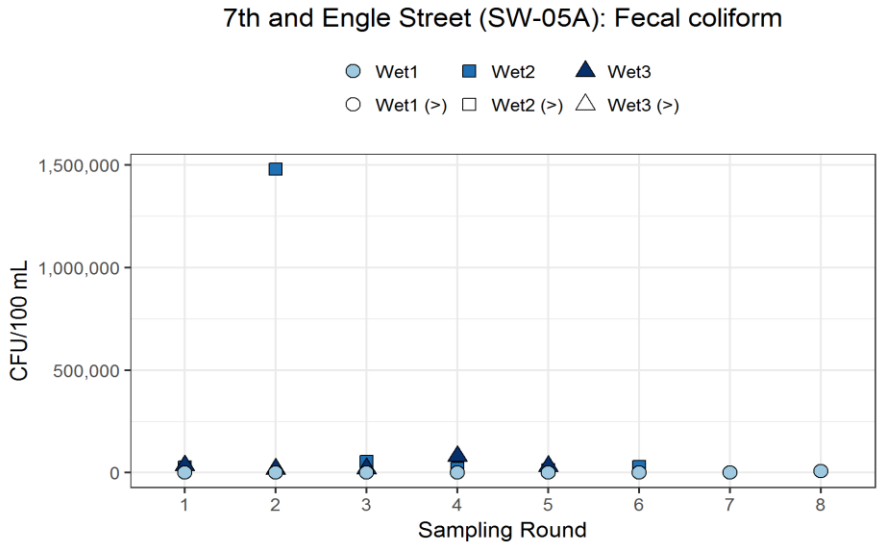

14th and Crozer Hospital (CSO-019): Enterococcus
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
3,000,000
2,000,000
1,000,000
0
1
2
3
4
5
6
7
8
Sampling Round


14th and Crozer Hospital (CSO-019): Fecal coliform
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
500,000
400,000
300,000
200,000
100,000
0
1
2
3
4
5
6
7
8
Sampling Round

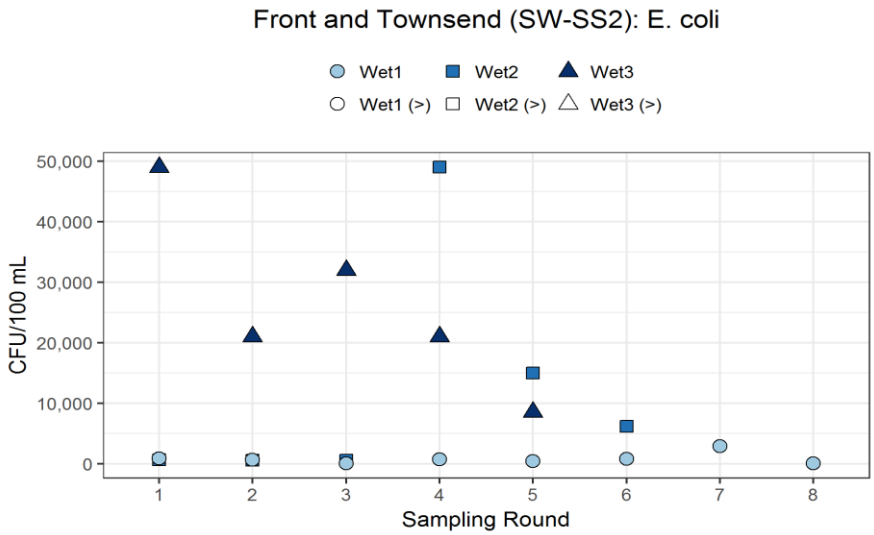
2.5 SW-05A

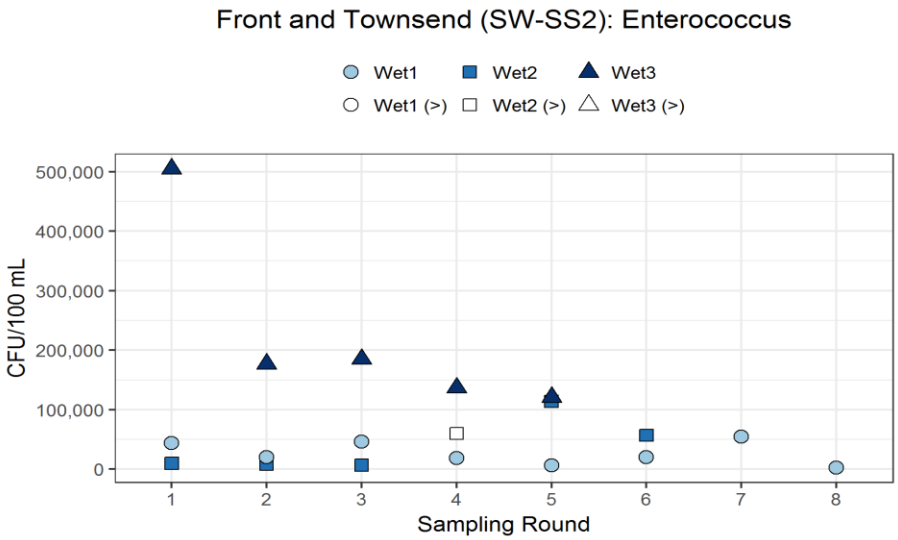

7th and Engle Street (SW-05A): E. coli
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
150,000
100,000
50,000
0
1
2
3
4
5
6
7
8
Sampling Round

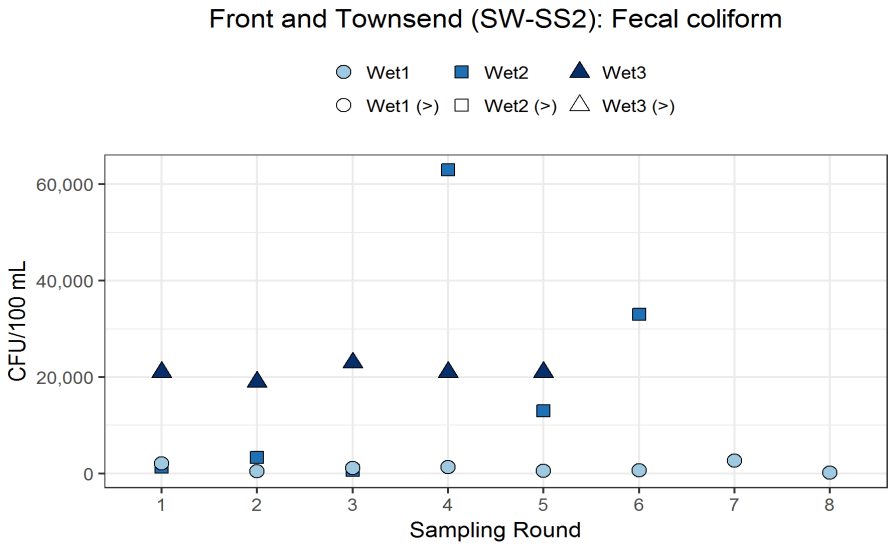

7th and Engle Street (SW-05A): Enterococcus
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
150,000
100,000
50,000
0
1
2
3
4
5
6
7
8
Sampling Round


7th and Engle Street (SW-05A): Fecal coliform
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
1,500,000
1,000,000
500,000
0
1
2
3
4
5
6
7
8
Sampling Round

2.6 SW-SS2

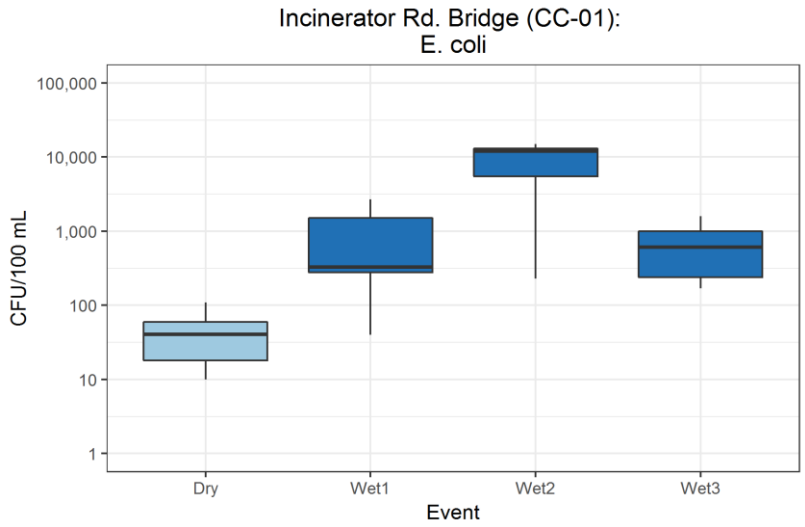

Front and Townsend (SW-SS2): E. coli
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
50,000
40,000
30,000
20,000
10,000
0
1
2
3
4
5
6
7
8
Sampling Round

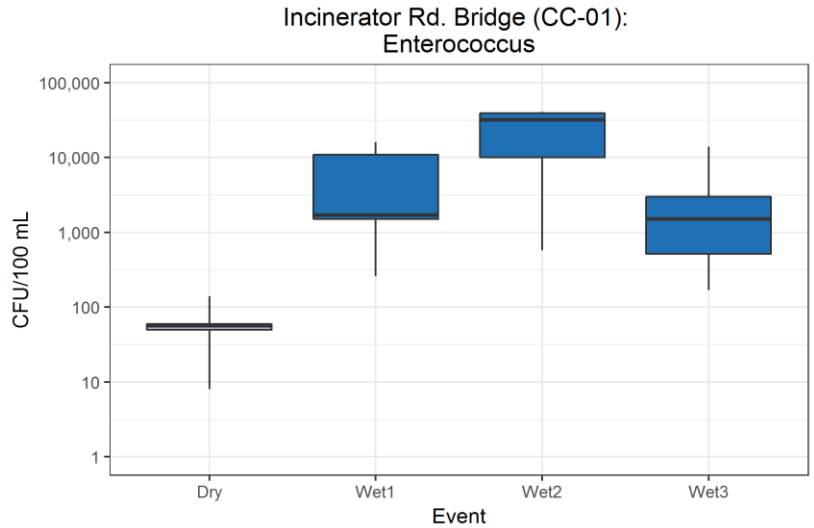

Front and Townsend (SW-SS2): Enterococcus
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
500,000
400,000
300,000
200,000
100,000
0
1
2
3
4
5
6
7
8
Sampling Round

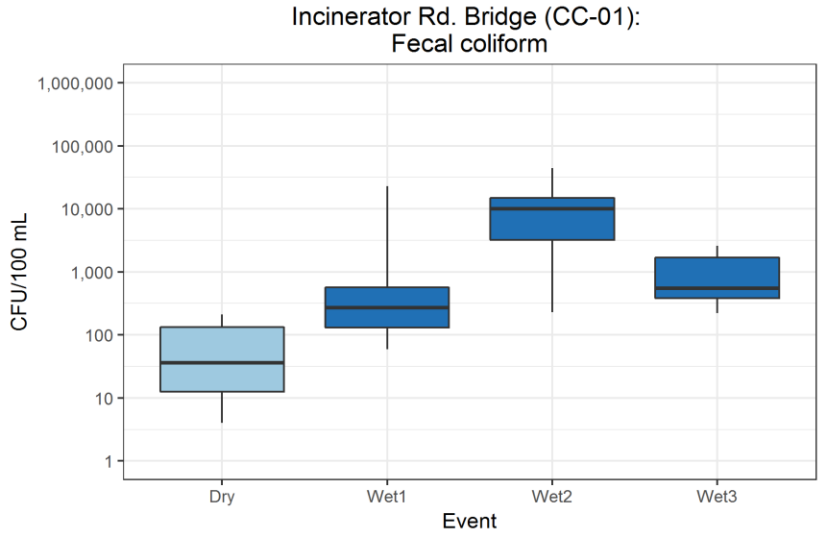

Front and Townsend (SW-SS2): Fecal coliform
Wet1
Wet2
Wet3
Wet1 (>)
Wet2 (>)
Wet3 (>)
CFU/100 mL
60,000
40,000
20,000
0
1
2
3
4
5
6
7
8
Sampling Round

Section 3 Receiving Water Wet Weather Sampling Results

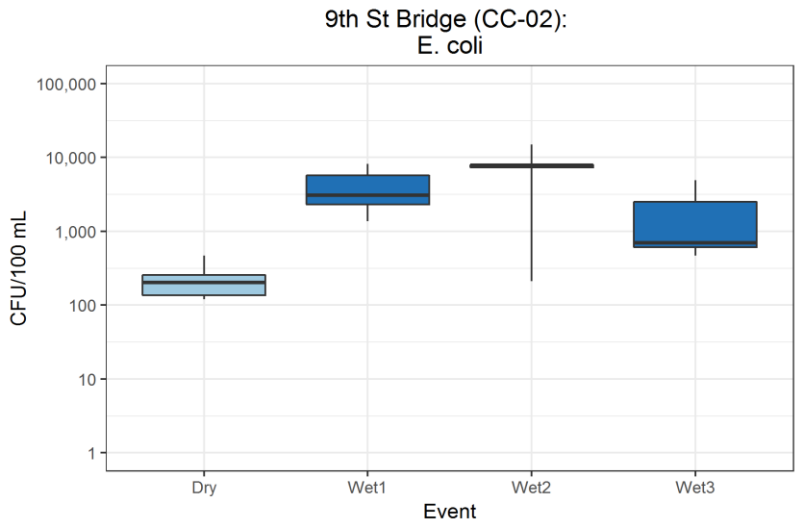
3.1 CC-01

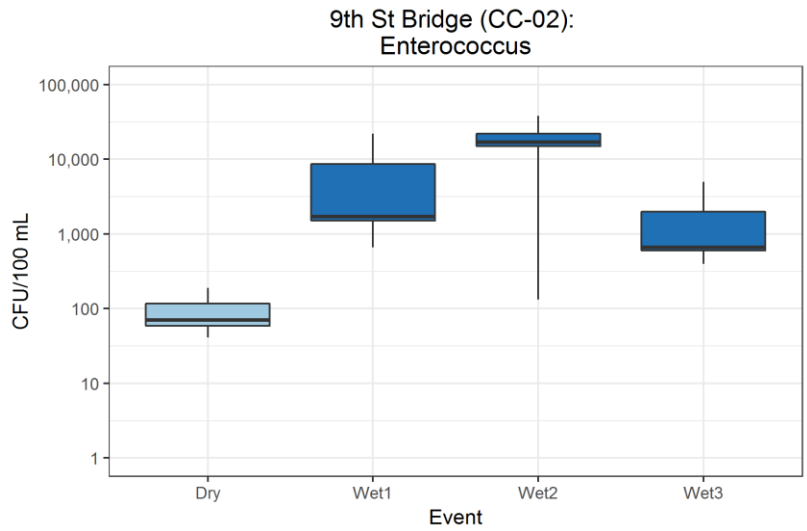

Incinerator Rd. Bridge (CC-01):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

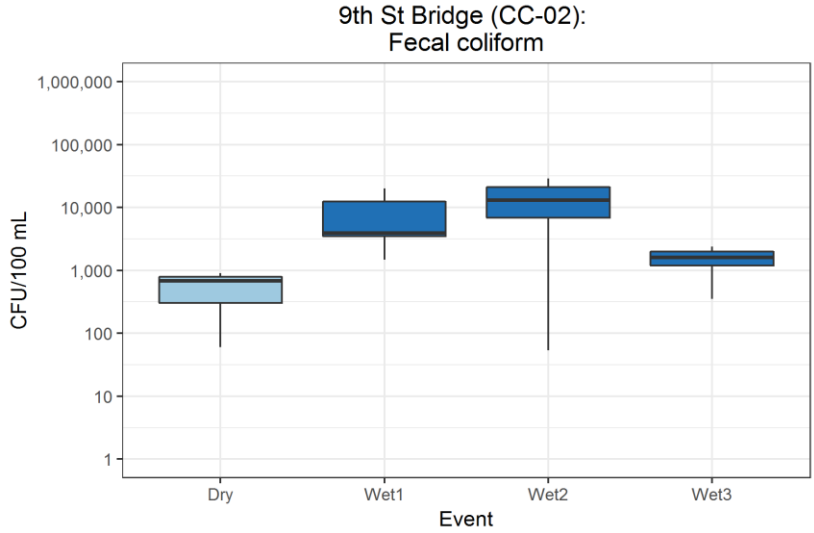

Incinerator Rd. Bridge (CC-01):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


Incinerator Rd. Bridge (CC-01):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

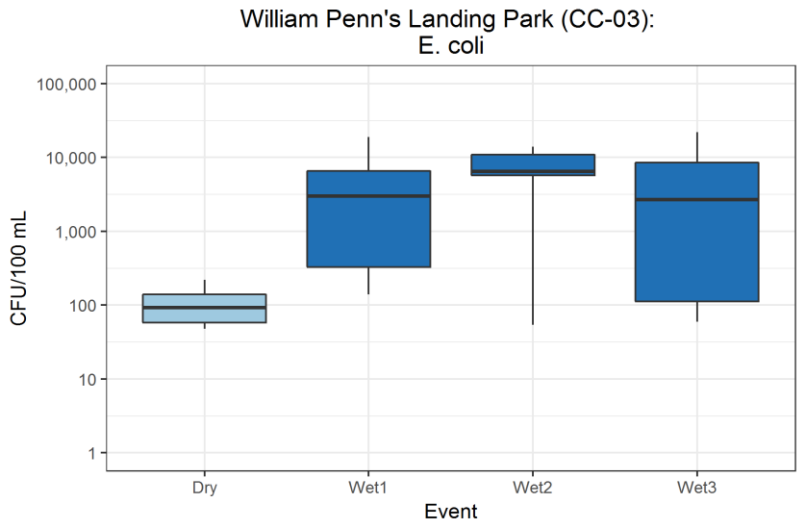
3.2 CC-02

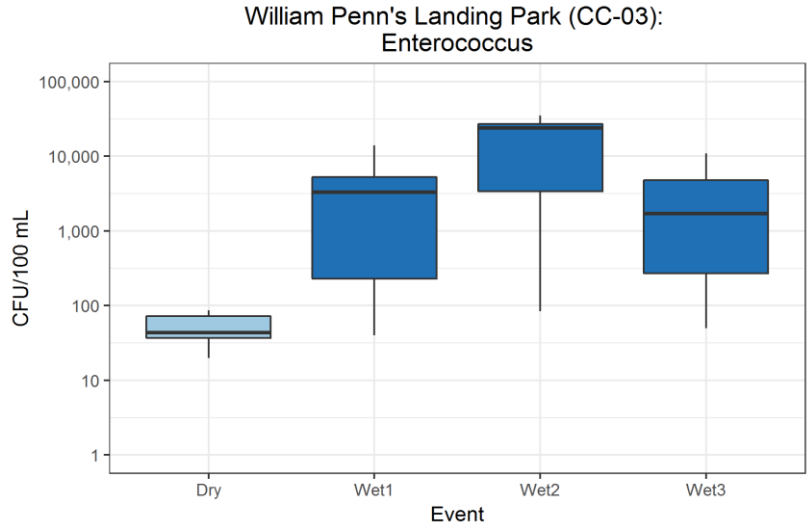

9th St Bridge (CC-02):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

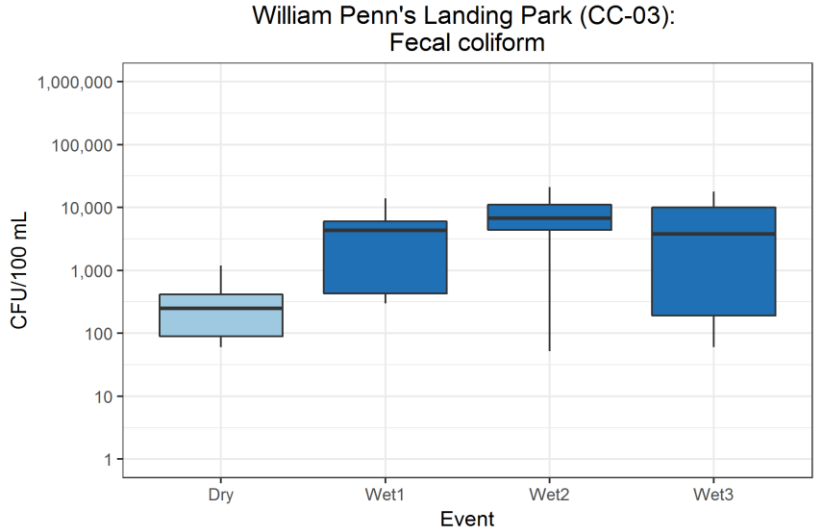

9th St Bridge (CC-02):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


9th St Bridge (CC-02):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

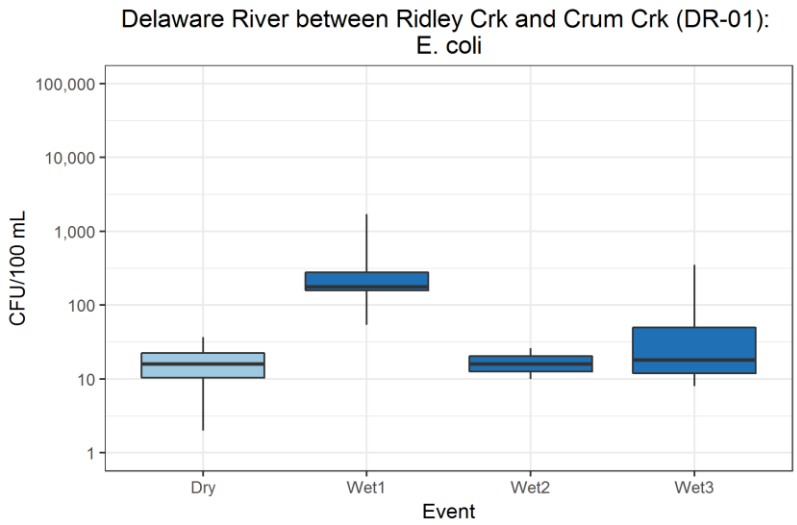
3.3 CC-03

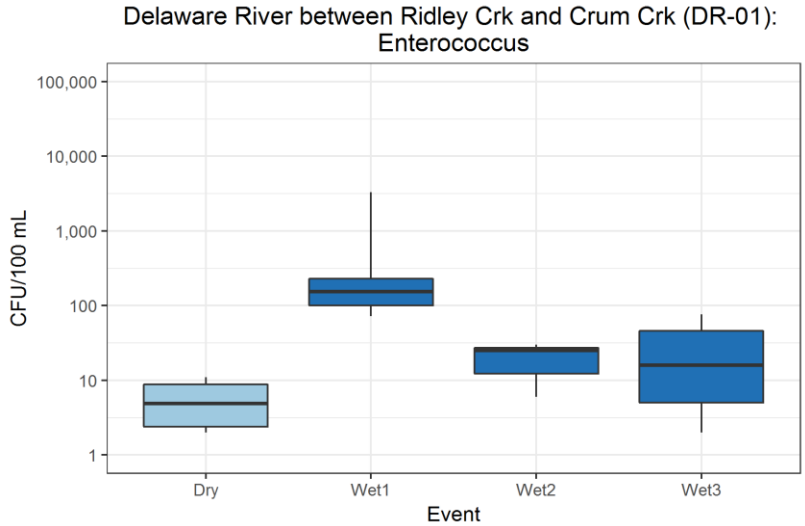

William Penn's Landing Park (CC-03):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

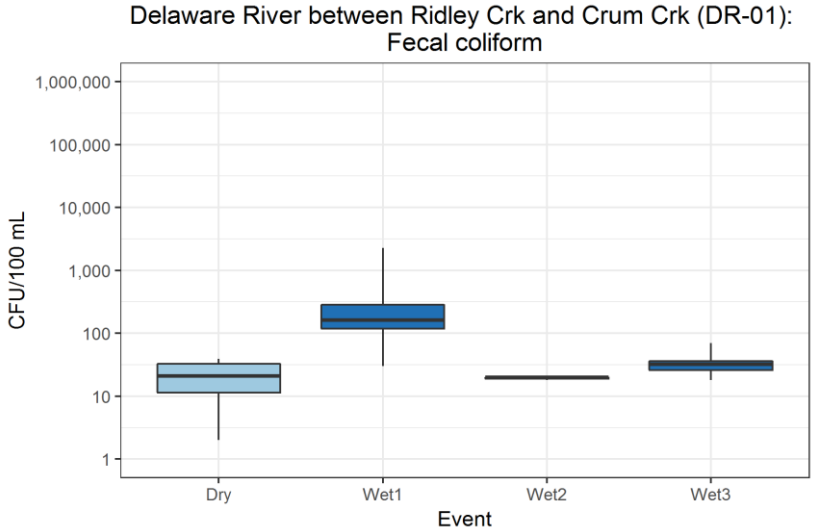

William Penn's Landing Park (CC-03):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


William Penn's Landing Park (CC-03):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

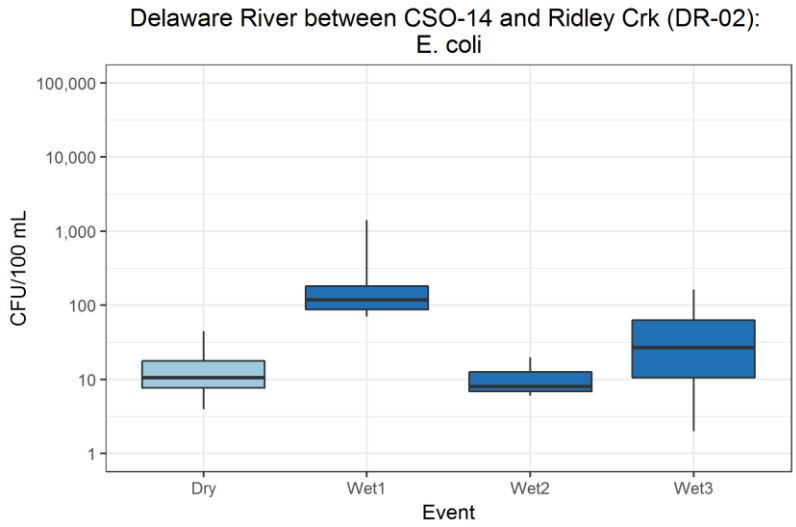
3.4 DR-01

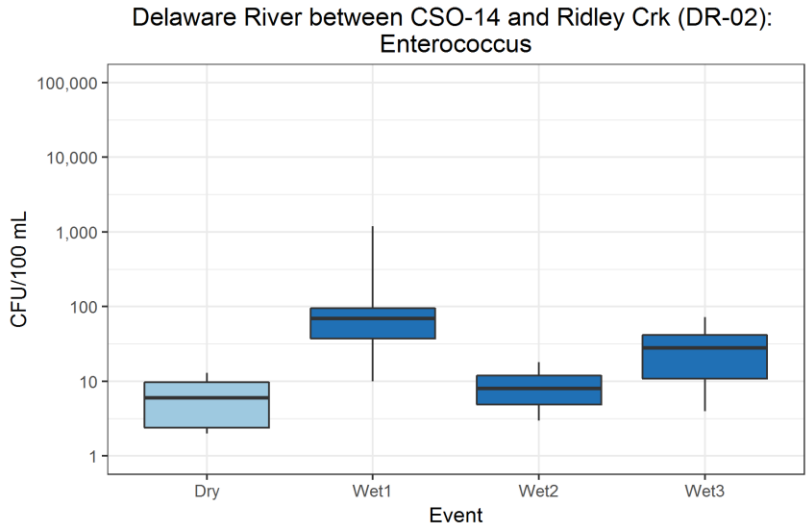

Delaware River between Ridley Crk and Crum Crk (DR-01):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

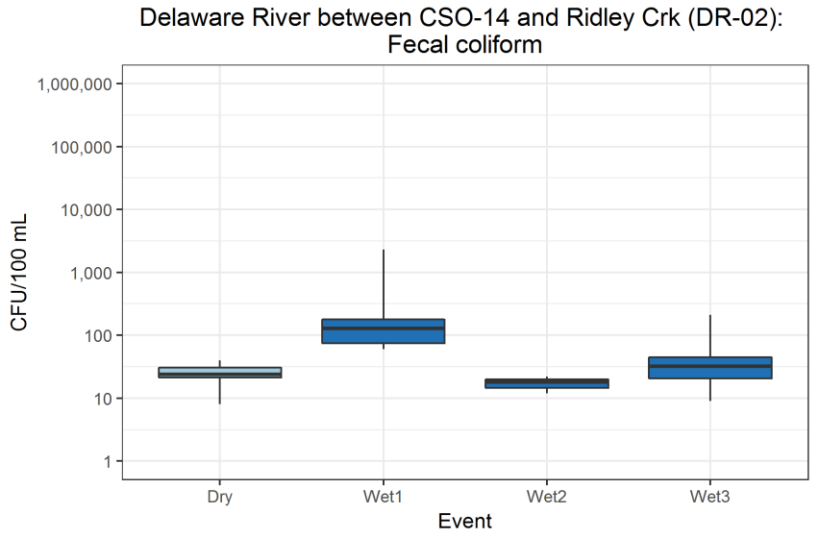

Delaware River between Ridley Crk and Crum Crk (DR-01):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


Delaware River between Ridley Crk and Crum Crk (DR-01):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

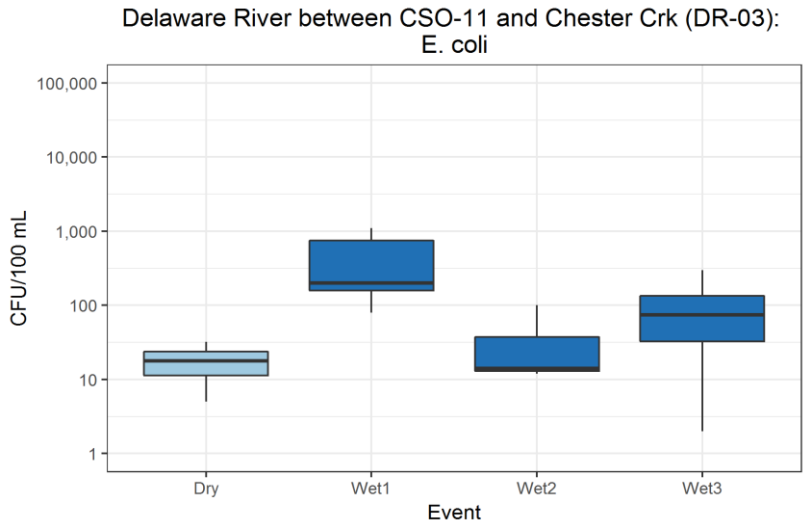
3.5 DR-02

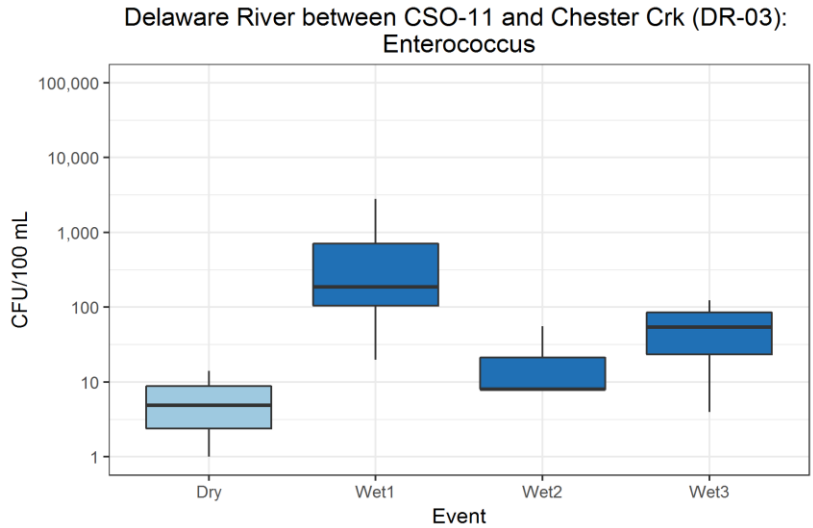

Delaware River between CSO-14 and Ridley Crk (DR-02):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

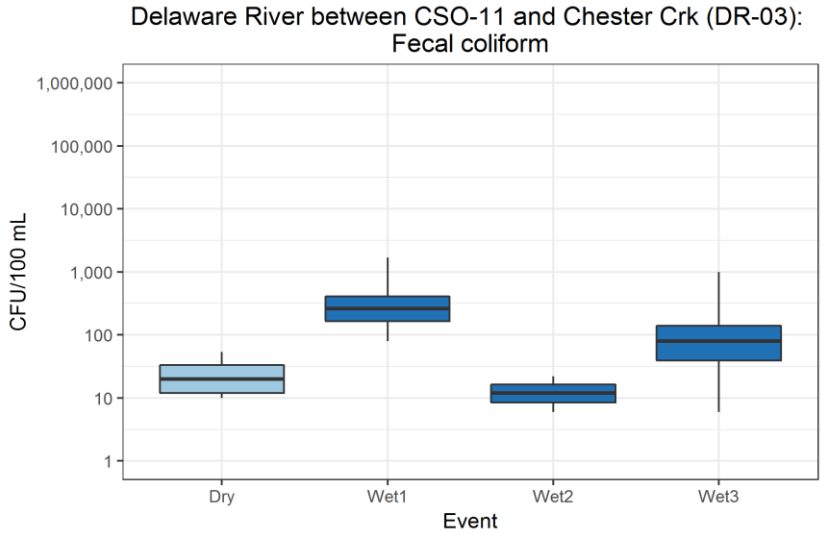

Delaware River between CSO-14 and Ridley Crk (DR-02):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


Delaware River between CSO-14 and Ridley Crk (DR-02):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

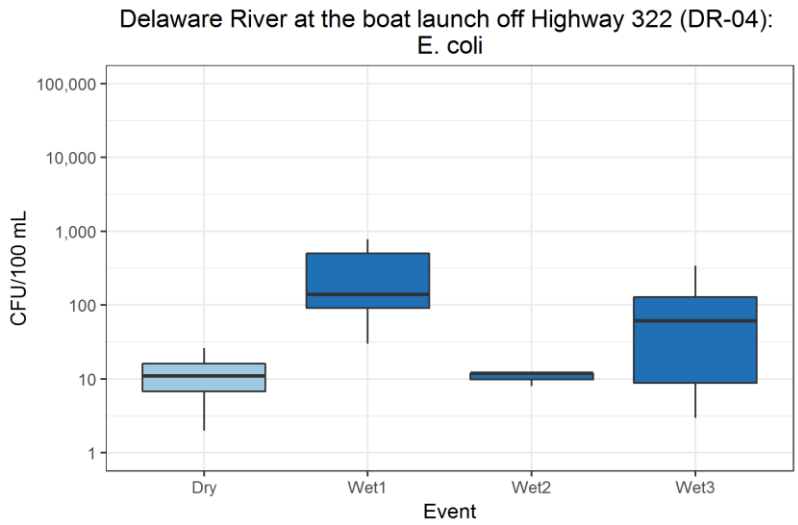
3.6 DR-03

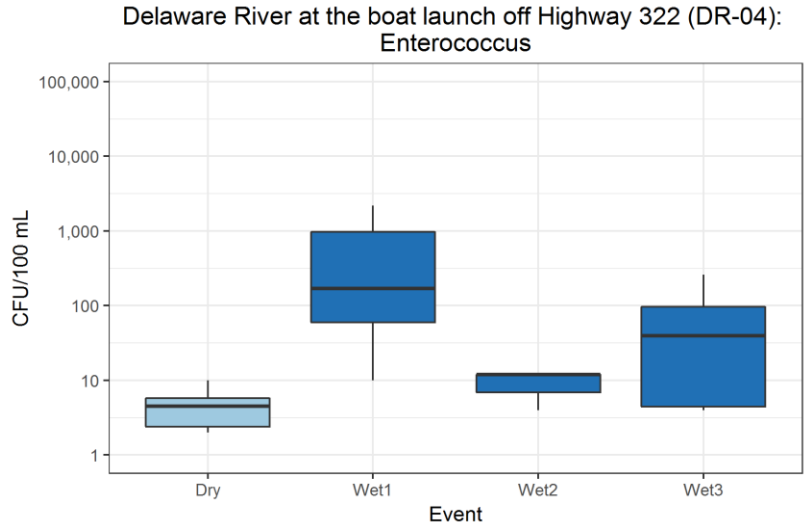

Delaware River between CSO-11 and Chester Crk (DR-03):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

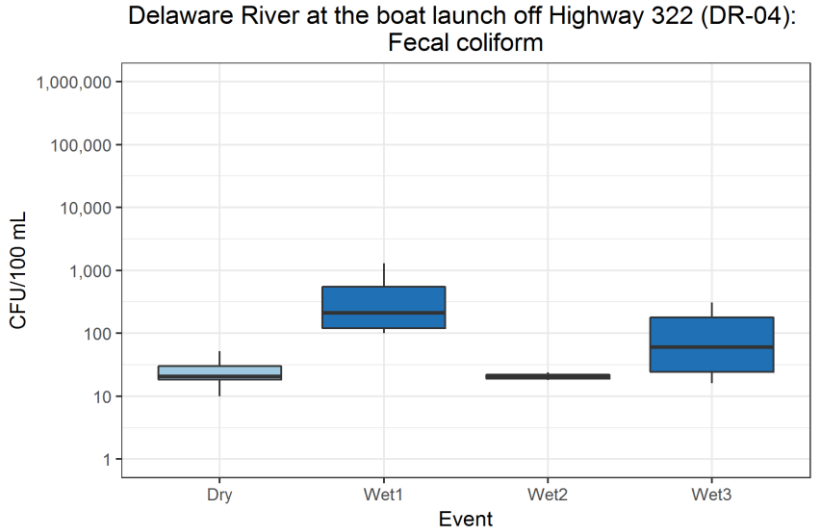

Delaware River between CSO-11 and Chester Crk (DR-03):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


Delaware River between CSO-11 and Chester Crk (DR-03):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

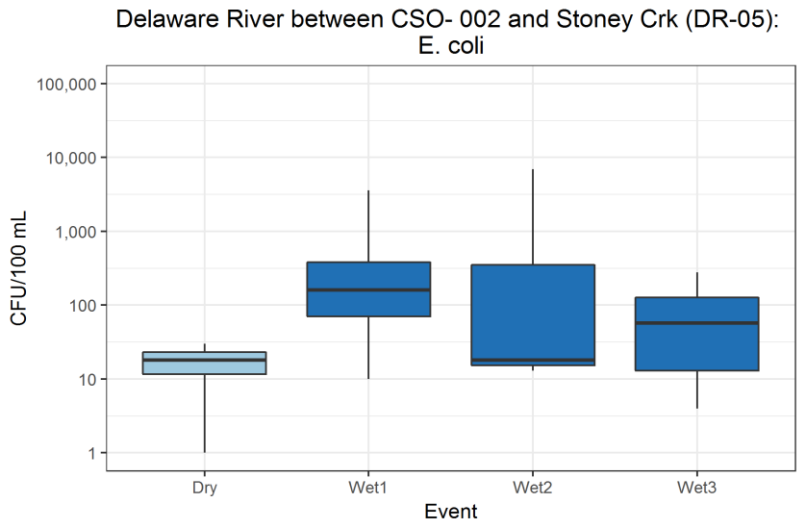
3.7 DR-04

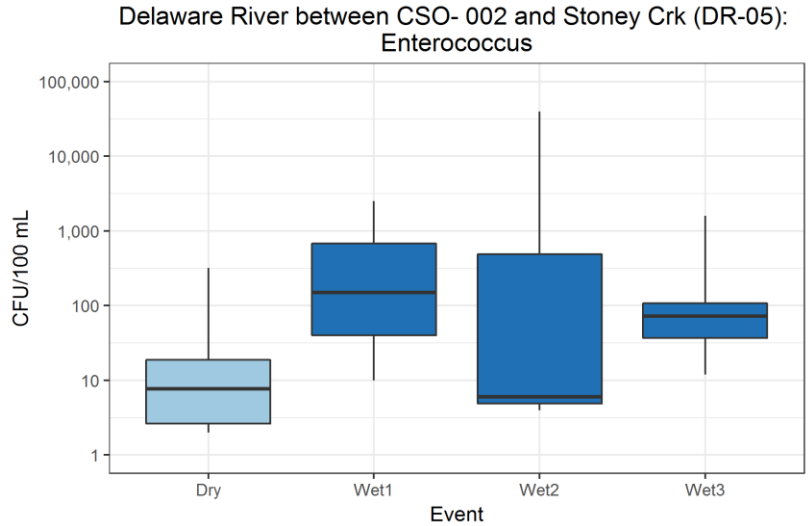

Delaware River at the boat launch off Highway 322 (DR-04):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

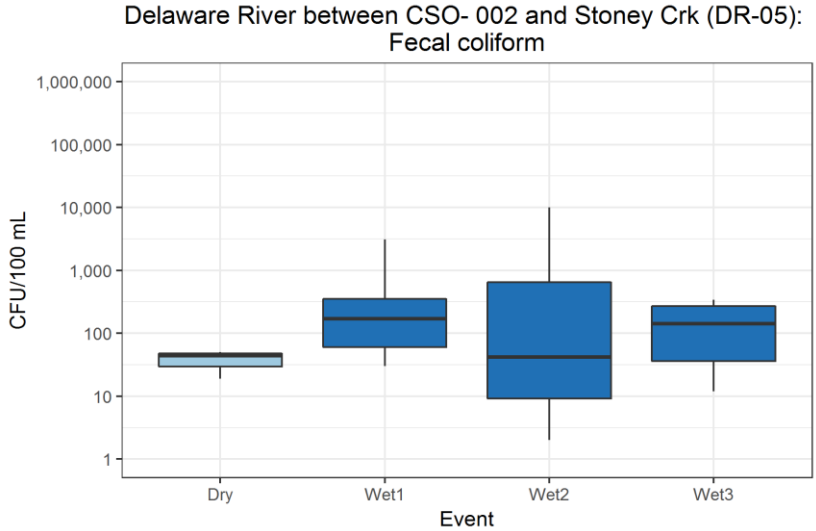

Delaware River at the boat launch off Highway 322 (DR-04):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


Delaware River at the boat launch off Highway 322 (DR-04):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

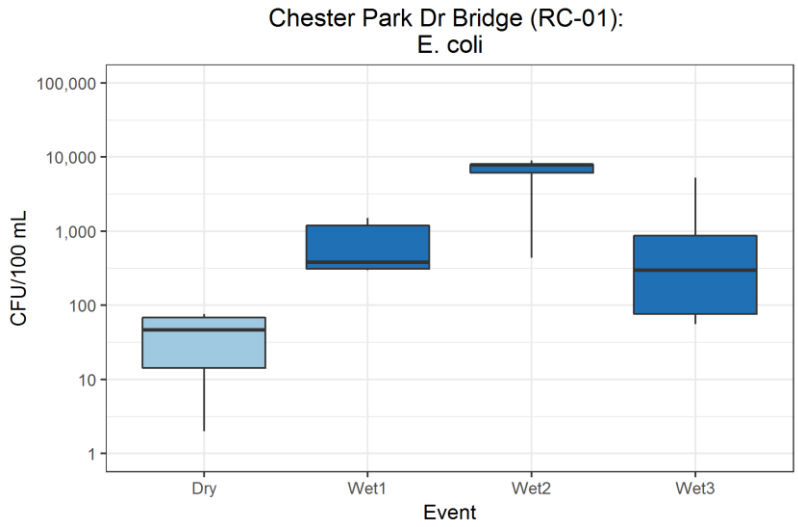
3.8 DR-05

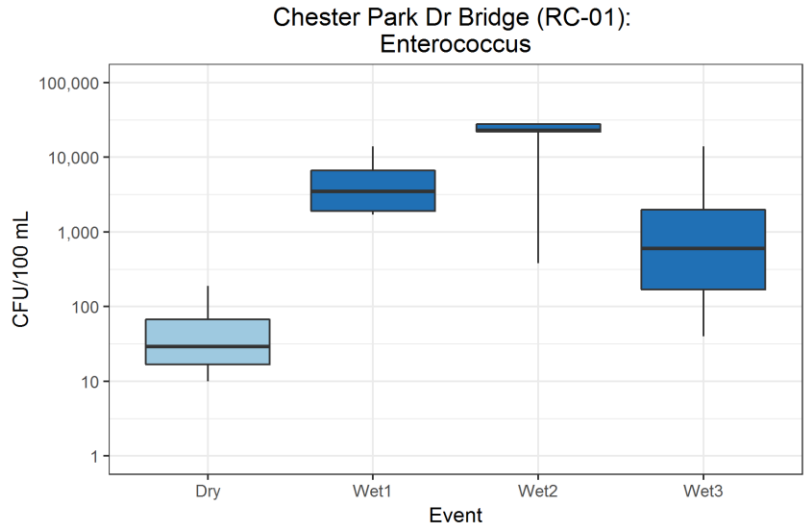

Delaware River between CSO- 002 and Stoney Crk (DR-05):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

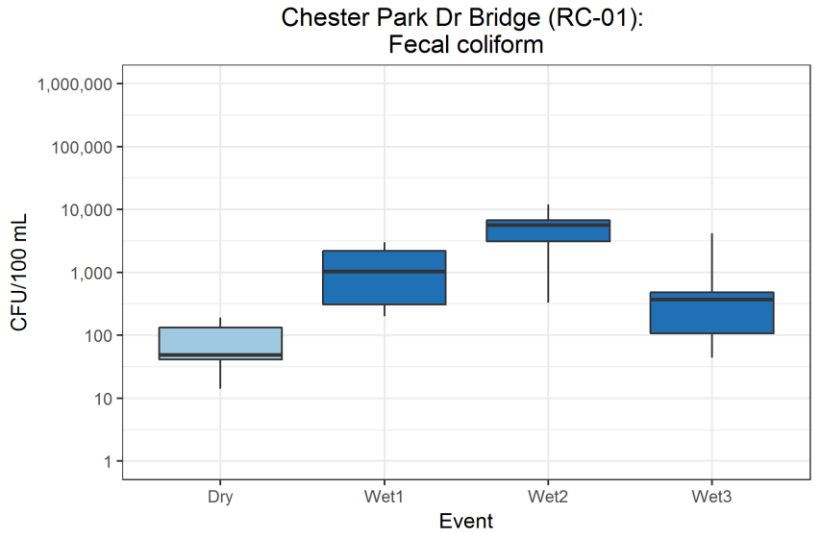

Delaware River between CSO- 002 and Stoney Crk (DR-05):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


Delaware River between CSO- 002 and Stoney Crk (DR-05):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

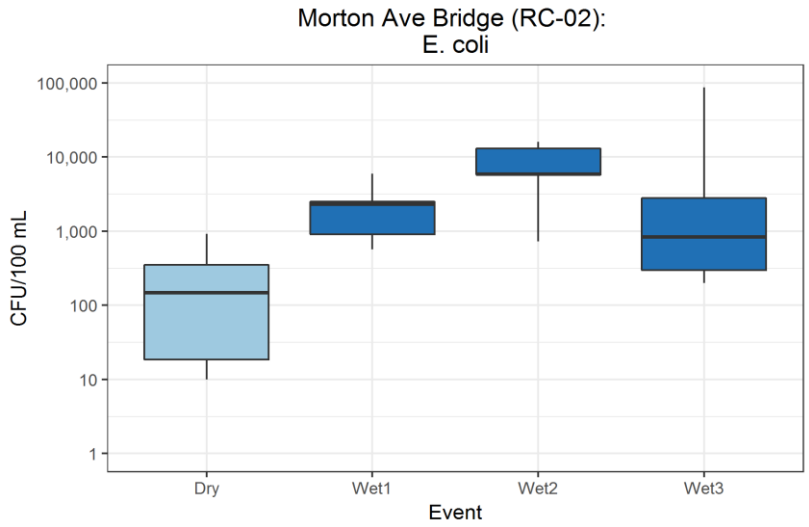
3.9 RC-01

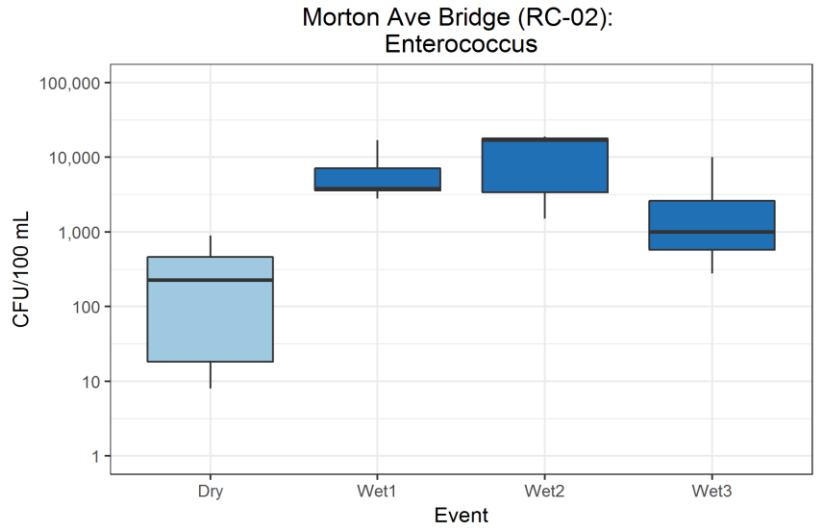

Chester Park Dr Bridge (RC-01):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

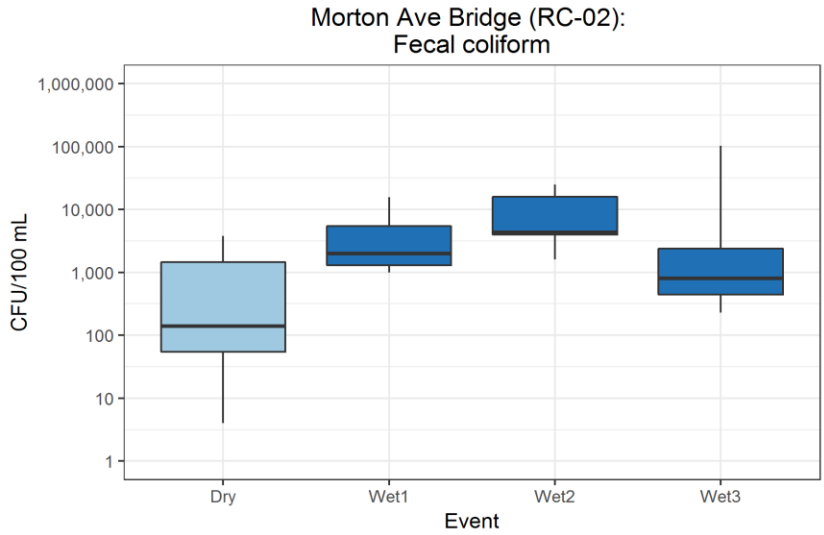

Chester Park Dr Bridge (RC-01):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


Chester Park Dr Bridge (RC-01):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

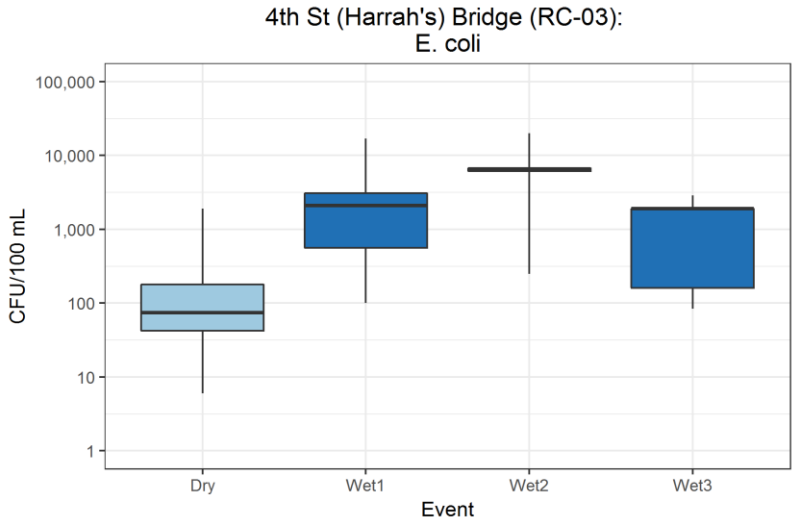
3.10 RC-02

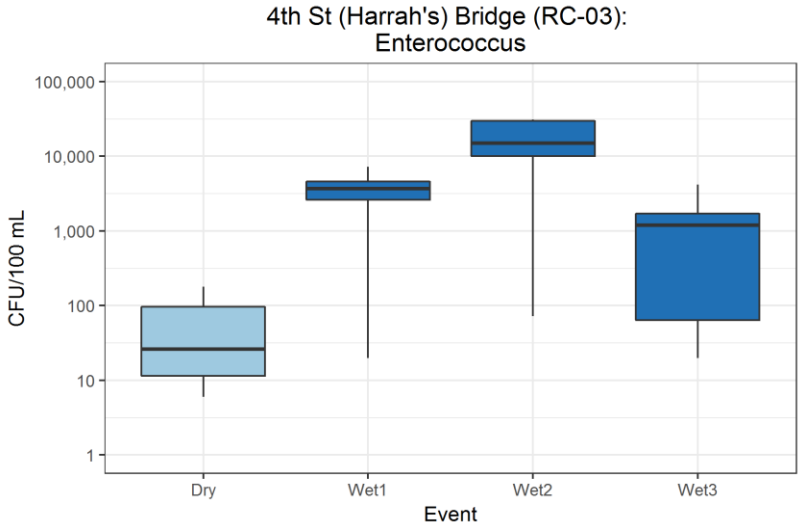

Morton Ave Bridge (RC-02):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

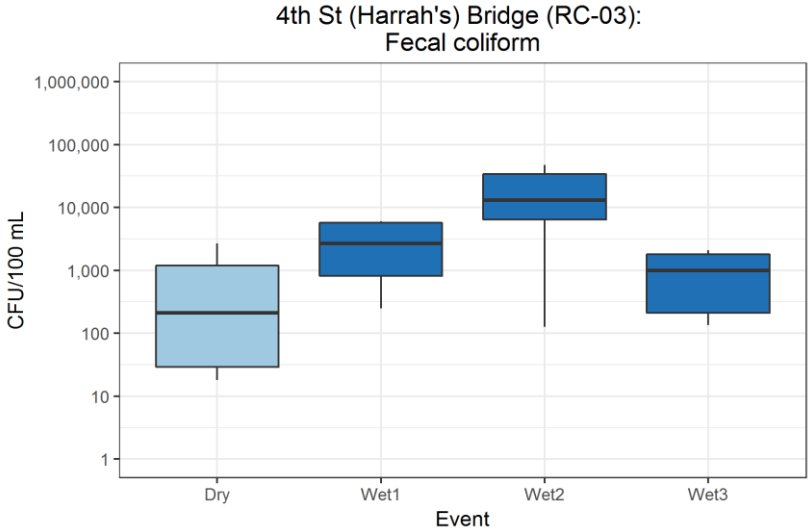

Morton Ave Bridge (RC-02):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event


Morton Ave Bridge (RC-02):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

3.11 RC-03

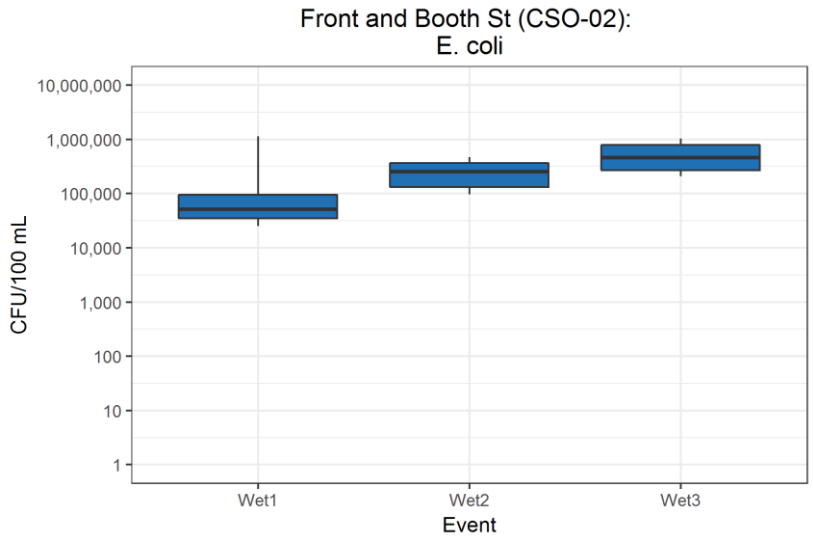

4th St (Harrah's) Bridge (RC-03):
E. coli
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

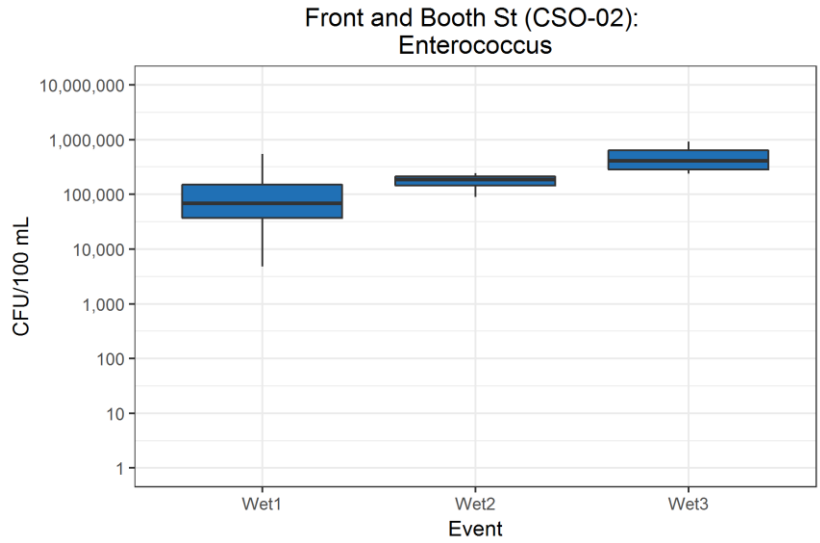

4th St (Harrah's) Bridge (RC-03):
Enterococcus
CFU/100 mL
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

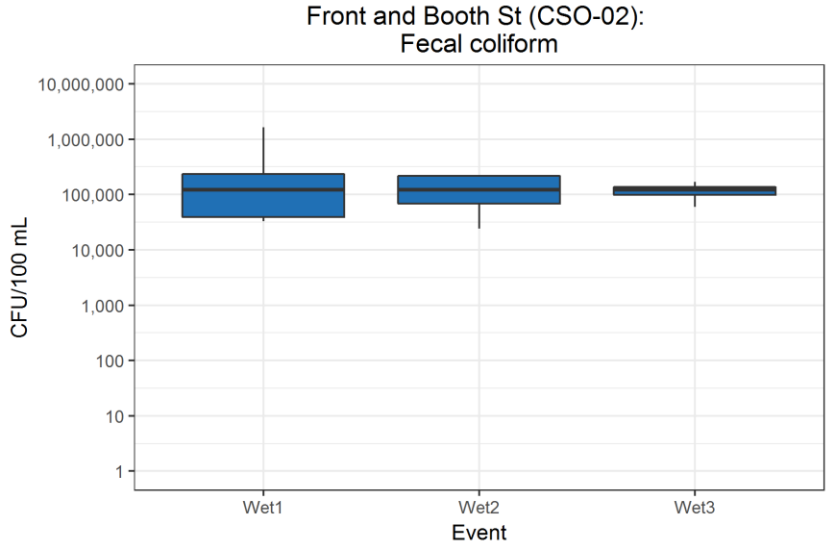

4th St (Harrah's) Bridge (RC-03):
Fecal coliform
CFU/100 mL
1,000,000
100,000
10,000
1,000
100
10
1
Dry
Wet1
Wet2
Wet3
Event

Section 4 Outfall Wet Weather Sampling Results

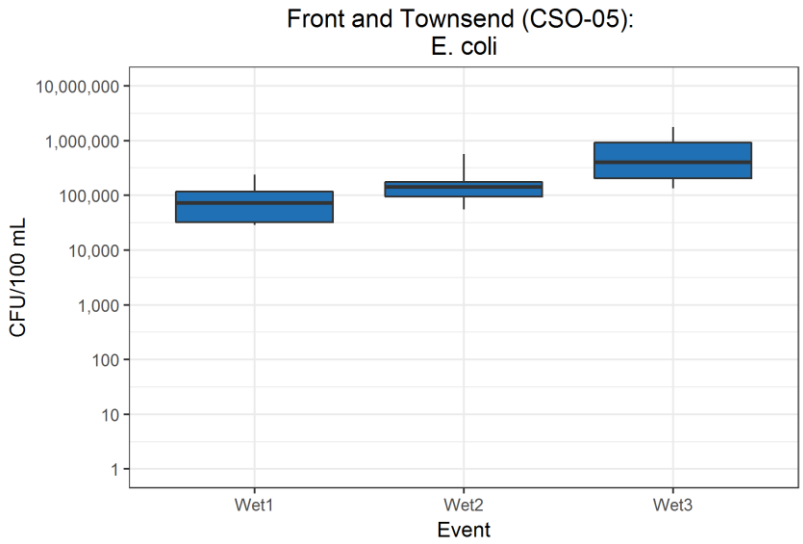
4.1 CSO-02

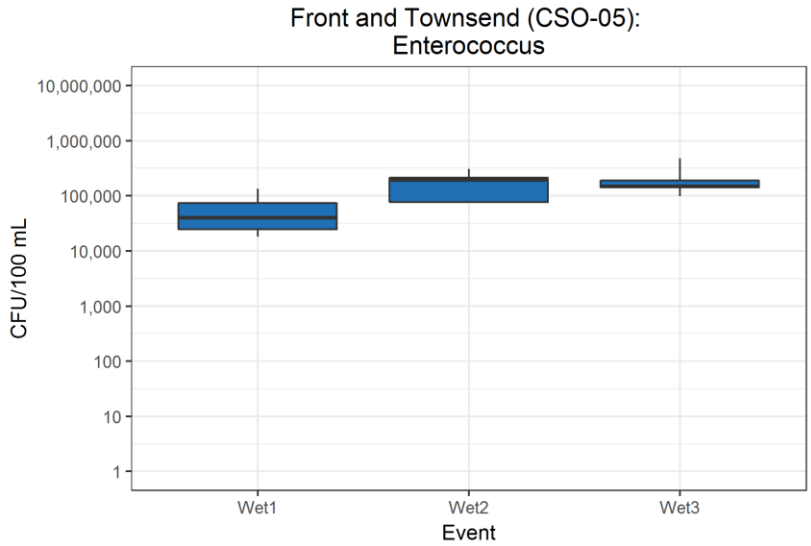

Front and Booth St (CSO-02):
E. coli
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
CFU/100 mL
Wet1
Wet2
Wet3
Event

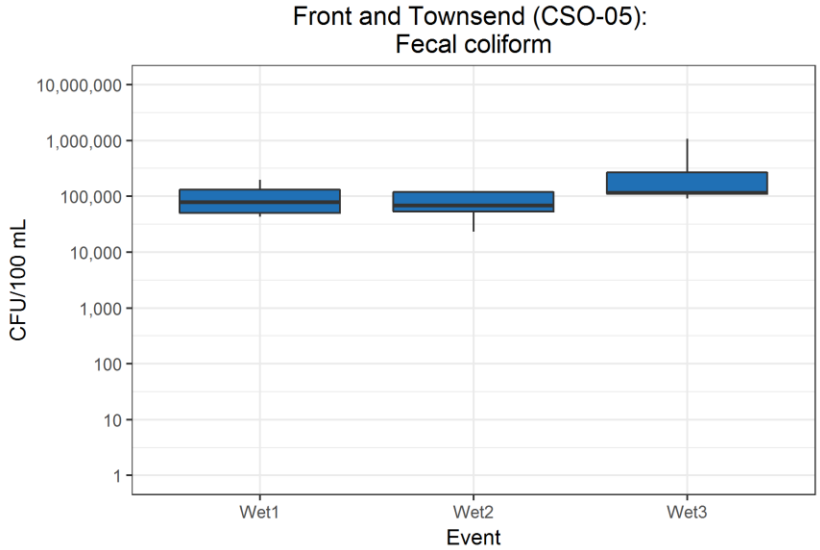

Front and Booth St (CSO-02):
Enterococcus
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
CFU/100 mL
Wet1
Wet2
Wet3
Event


Front and Booth St (CSO-02):
Fecal coliform
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
CFU/100 mL
Wet1
Wet2
Wet3
Event

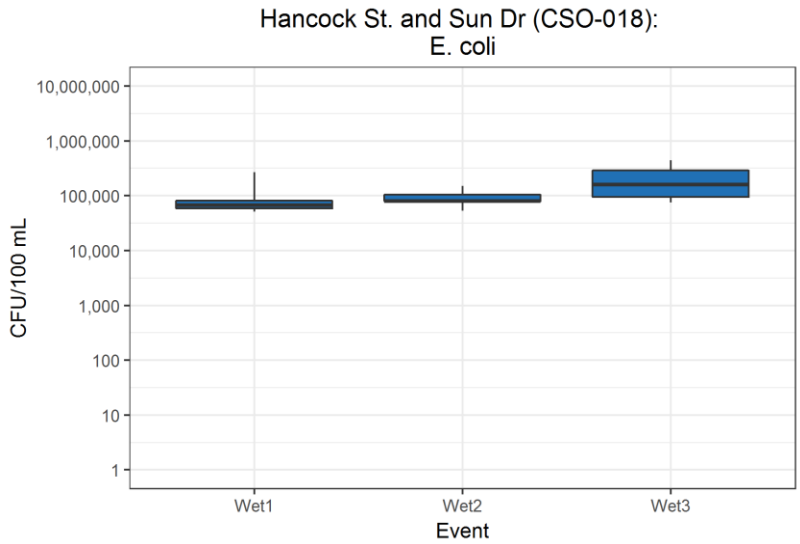
4.2 CSO-05

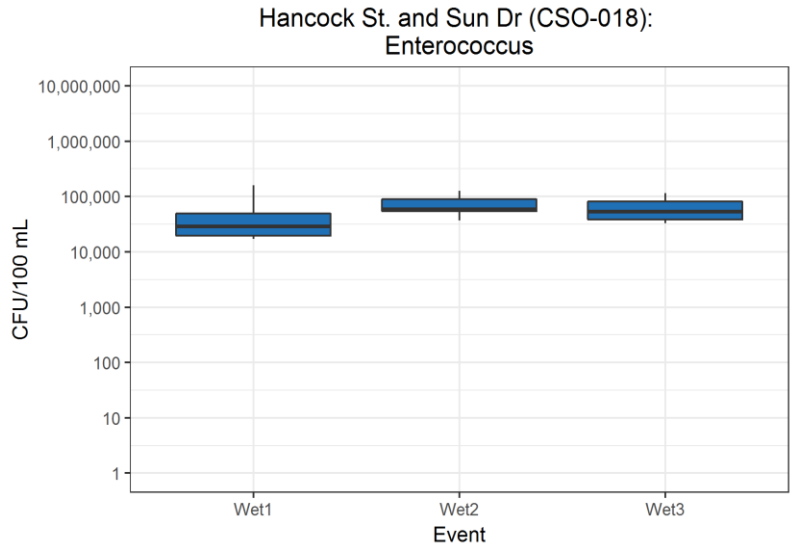

Front and Townsend (CSO-05):
E. coli
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event

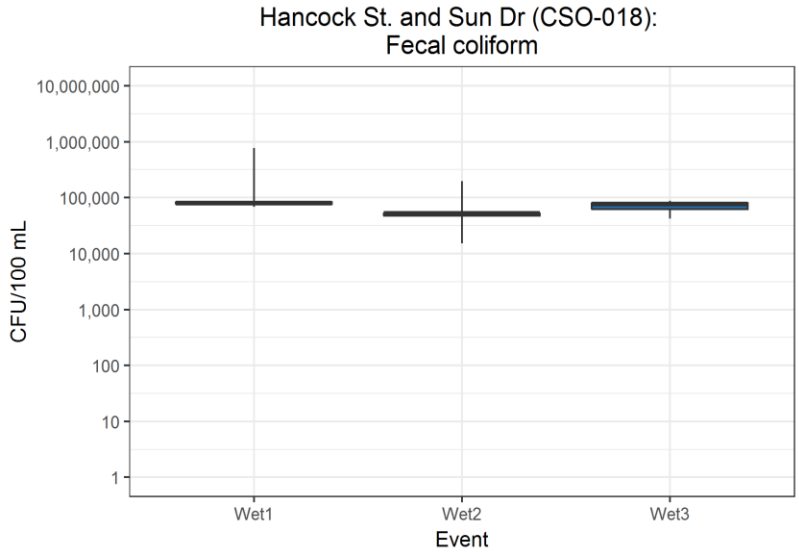

Front and Townsend (CSO-05):
Enterococcus
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event


Front and Townsend (CSO-05):
Fecal coliform
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event

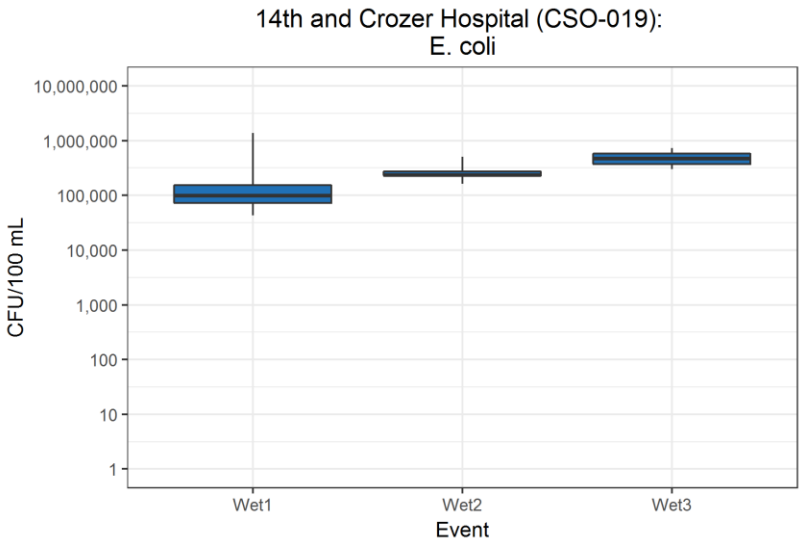
4.3 CSO-018

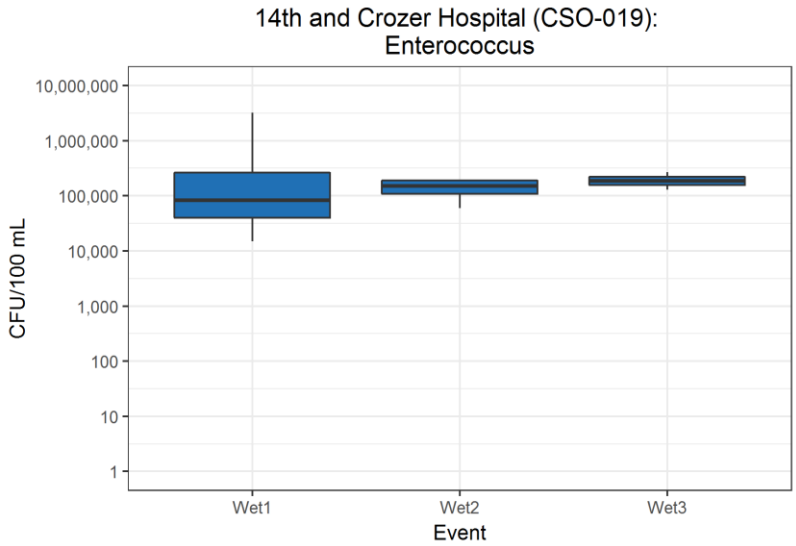

Hancock St. and Sun Dr (CSO-018):
E. coli
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event

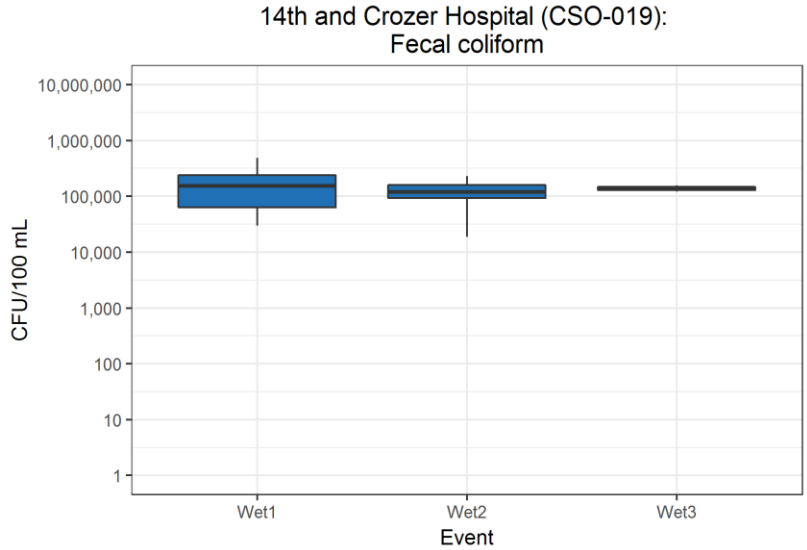

Hancock St. and Sun Dr (CSO-018):
Enterococcus
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event


Hancock St. and Sun Dr (CSO-018):
Fecal coliform
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event

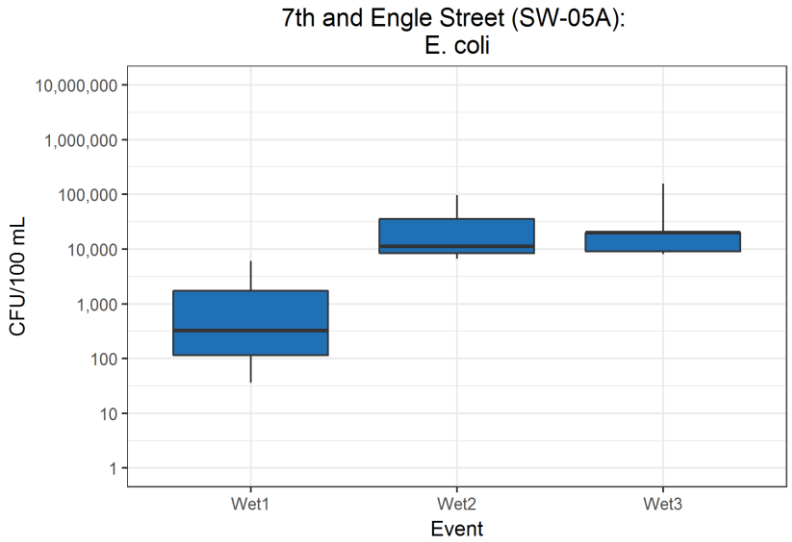
4.4 CSO-019

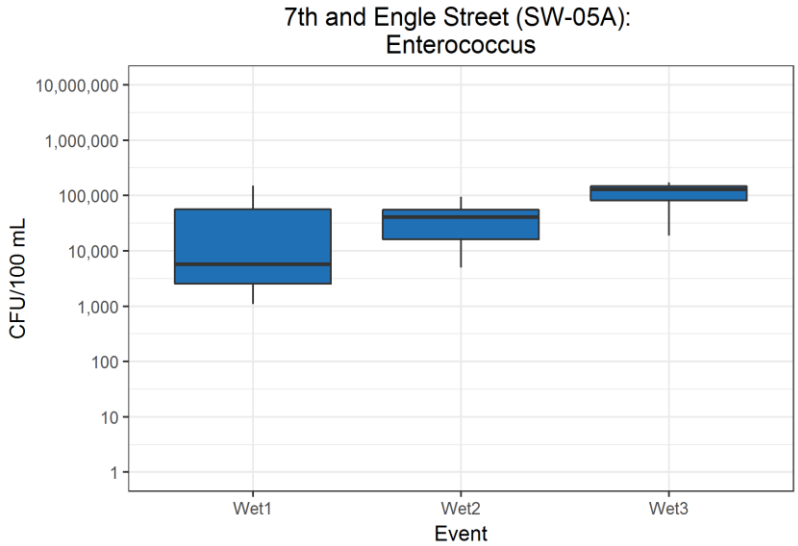

14th and Crozer Hospital (CSO-019):
E. coli
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
CFU/100 mL
Wet1
Wet2
Wet3
Event

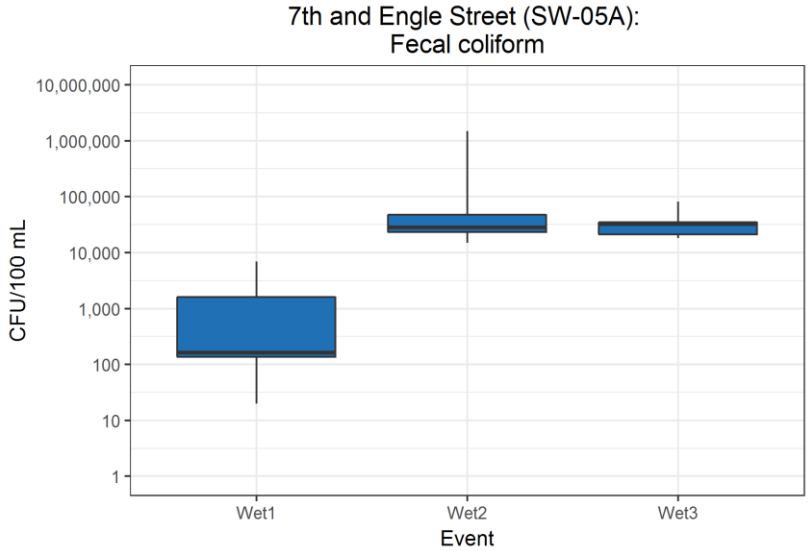

14th and Crozer Hospital (CSO-019):
Enterococcus
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
CFU/100 mL
Wet1
Wet2
Wet3
Event


14th and Crozer Hospital (CSO-019):
Fecal coliform
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
CFU/100 mL
Wet1
Wet2
Wet3
Event

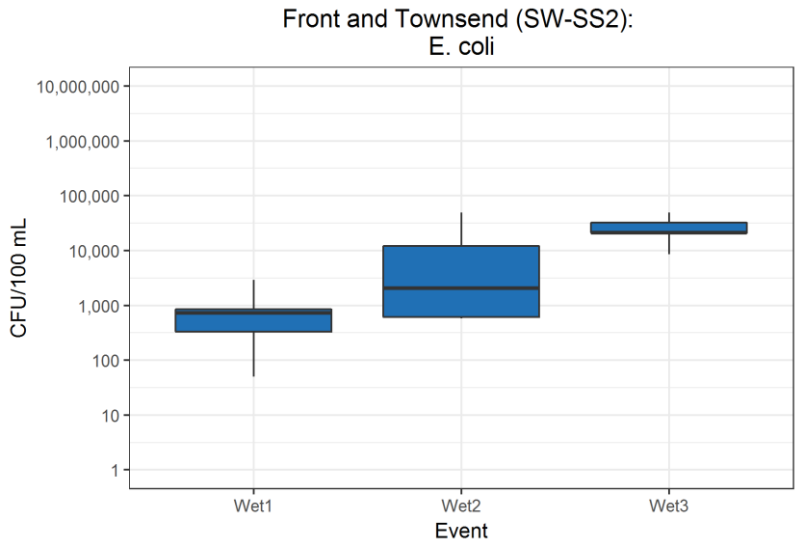
4.5 SW-05A

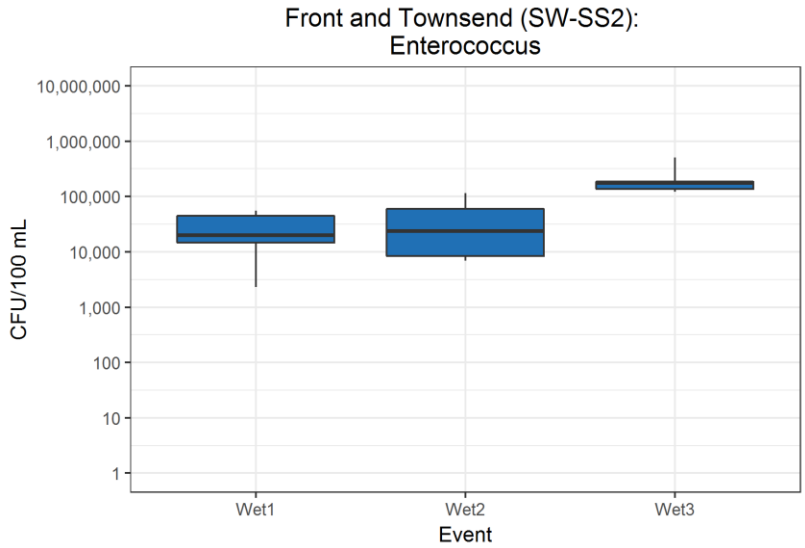

7th and Engle Street (SW-05A):
E. coli
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event

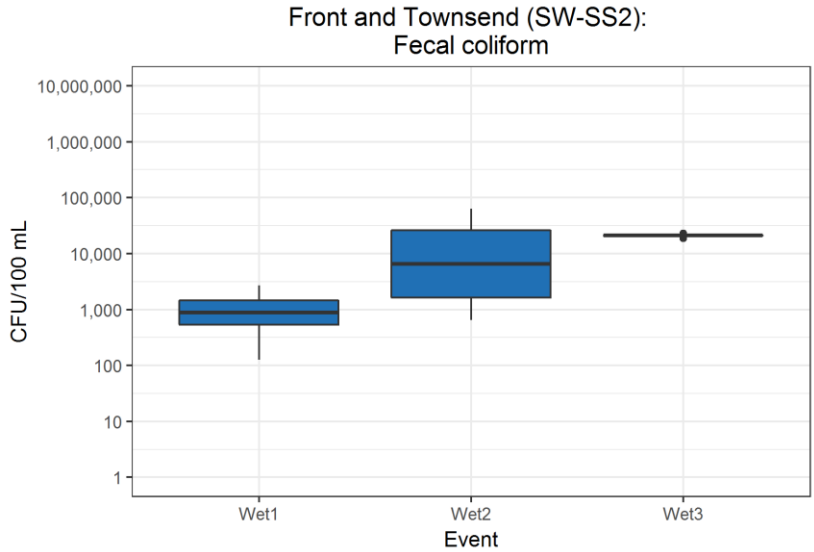

7th and Engle Street (SW-05A):
Enterococcus
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event


7th and Engle Street (SW-05A):
Fecal coliform
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event

4.6 SW-SS2


Front and Townsend (SW-SS2):
E. coli
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event


Front and Townsend (SW-SS2):
Enterococcus
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event


Front and Townsend (SW-SS2):
Fecal coliform
CFU/100 mL
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
Wet1
Wet2
Wet3
Event

APPENDIX I

LABORATORY QA/QC DATA

Positive / Negative Control Summary

Date Analyzed	Parameter	OPR POS LIMS #	OPR POS Result	Acceptable (Y/N)	OPR NEG LIMS #	OPR NEG Result	Acceptable (Y/N)
2/20/2017	E. coli 1603	L6645565-4	30	Y	L6645565-5	<1	Y
2/20/2017	Entero 1600	L6645565-1	28	Y	L6645565-2	<1	Y
3/27/2017	E. coli 1603	L6645566-4	30	Y	L6645566-5	<1	Y
3/27/2017	Entero 1600	L6645566-1	26	Y	L6645566-2	<1	Y
3/31/2017	E. coli 1603	L6645566-4	30	Y	L6645566-5	<1	Y
3/31/2017	Entero 1600	L6645566-1	26	Y	L6645566-2	<1	Y
4/24/2017	E. coli 1603	L6645568-4	33	Y	L6645568-5	<1	Y
4/24/2017	Entero 1600	L6645568-1	33	Y	L6645568-2	<1	Y
5/15/2017	E. coli 1603	L6645569-4	14	N	L6645569-5	<1	Y
5/15/2017	Entero 1600	L6645569-1	30	Y	L6645569-2	<1	Y
6/6/2017	E. coli 1603	L6839202-4	7	N	L6839202-5	<1	Y
6/6/2017	Entero 1600	L6839202-1	32	Y	L6839202-2	<1	Y

Matrix Spike Summary

Date Analyzed	Parameter	MS LIMS #	Amount Spiked	MS Result	Sample Result	Amount Recovered	Percent Recovery
5/22/17	E. coli 1603	L6687478-2	30.6	>80	>80	Unknown	Incalculable
5/23/17	Entero 1600	L6687479-2	30.6	25	4	21	68.63
5/22/17	E. coli 1603	L6687480-2	30.6	>80	>80	Unknown	Incalculable
5/22/17	Entero 1600	L6687481-2	30.7	46	2	44	143.32
5/22/17	E. coli 1603	L6687482-2	30.6	21	4	17	55.56
5/23/17	Entero 1600	L6687485-2	30.6	64	24	40	130.72
5/23/17	E. coli 1603	L6687483-2	31.3	45	12	33	105.43
3/31/17	Entero 1600	L6695428-2	29.2	30	<2	30	102.74
5/23/17	E. coli 1603	L6687486-2	31.3	45	8	37	118.21
3/23/17	Entero 1600	L6695441-2	29.2	25	<10	25	85.62
3/23/17	E. coli 1603	L6695439-2	29.6	26	<10	26	87.84
3/31/17	Entero 1600	L6695444-2	29.2	>60	>60	Unknown	Incalculable
3/31/17	E. coli 1603	L6695443-2	30.6	11	Blank	Blank	35.95
3/31/17	Entero 1600	L6695452-2	29.2	>60	>60	Unknown	Incalculable
5/22/17	E. coli 1603	L6695447-2	30.6	<1	2	<1	0
3/31/17	Entero 1600	L6695453-2	29.2	>60	>60	Unknown	Incalculable
3/31/17	E. coli 1603	L6695448-2	30.6	26	<2	26	84.97

5/5/17	Entero 1600	L6695467-2	30.7	25	6	19	61.89
3/31/17	E. coli 1603	L6695449-2	29.6	>60	>60	Unknown	Incalculable
5/22/17	Entero 1600	L6695469-2	30.7	31	12	19	61.89
3/31/17	E. coli 1603	L6695454-2	29.6	>60	>60	Unknown	Incalculable
5/5/17	Entero 1600	L6695475-2	30.7	>60	>60	Unknown	Incalculable
5/5/17	E. coli 1603	L6695468-2	29.6	47	26	21	70.95
6/13/17	Entero 1600	L6815251-2	30.6	23	<1	23	75.16
6/13/17	E. coli 1603	L6815247-2	30.6	14	<1	24	45.75

Lab Replicate Summary

Date Analyzed	Parameter	MS LIMS #	Replicate Result (cfu / 100 mL)	Original Result (cfu / 100 mL)	Relative Percent Difference (%)
5/22/17	E. coli 1603	L6687478-1	>800	401000	Incalculable
5/23/17	Entero 1600	L6687479-1	<10	2	Incalculable
5/22/17	E. coli 1603	L6687480-1	>800	241000	Incalculable
5/22/17	Entero 1600	L6687481-1	180	116	43.24
5/22/17	E. coli 1603	L6687482-1	150	152	1.32
5/23/17	Entero 1600	L6687485-1	550	580	5.31
5/23/17	E. coli 1603	L6687483-1	360	300	18.18
3/31/17	Entero 1600	L6695428-1	40	6600	197.59
5/23/17	E. coli 1603	L6687486-1	160	112	35.29
3/23/17	Entero 1600	L6695441-1	<10	<10	Incalculable
3/23/17	E. coli 1603	L6695439-1	<10	<10	Incalculable
3/31/17	Entero 1600	L6695444-1	>600	200000	Incalculable
3/31/17	E. coli 1603	L6695443-1	80	100	22.22
3/31/17	Entero 1600	L6695452-1	>600	550000	Incalculable
5/22/17	E. coli 1603	L6695447-1	<10	Blank	Incalculable
3/31/17	Entero 1600	L6695453-1	>600	3300	Incalculable
3/31/17	E. coli 1603	L6695448-1	50	40	22.22
5/5/17	Entero 1600	L6695467-1	<10	12	Incalculable
3/31/17	E. coli 1603	L6695449-1	>600	2020	Incalculable
5/22/17	Entero 1600	L6695469-1	20	12	50
3/31/17	E. coli 1603	L6695454-1	>600	19000	Incalculable
5/5/17	Entero 1600	L6695475-1	>600	37000	Incalculable
5/5/17	E. coli 1603	L6695468-1	240	230	4.26
6/13/17	Entero 1600	L6815251-1	180	150	18.18
6/13/17	E. coli 1603	L6815247-1	200	200	0

BioBall SingleShot

Certificate of Analysis

Lot Number: B3628

Reference Material Data

Organism:	*Escherichia coli*
Designation:	NCTC 9001
Reference:	413832 10 Vials
	56033 20 Vials
BTF Internal Reference:	B-EC9001-30-10
	B-EC9001-30-20
Date of Manufacture:	19 July 2016
Expiry Date:	19 July 2018
Extended Expiry Date*:	N/A

Quantification Data
(Method Ref: BB-001)

cfu Count per BioBall ®

Mean cfu	SD
29.6	2.6

95% Prediction Interval

Lower Limit	Upper Limit
24.3	34.8

For an explanation of the Prediction Interval see the BioBall Instructions For Use on the BioBall website - www.bioball.com

Culture Information

No. of Passages:	4
QC Media:	Nutrient agar
Plate Incubation Time (hrs):	14 - 24
Plate Incubation Temp °C:	37 Aerobic

Note: Number of passages are indicated from the original strain assuming original strain is zero.

Strain Confirmation

Bacteria strains are confirmed by genetic typing. Yeast and Mould strains are confirmed by Commonwealth Scientific and Industrial Research Organisation (CSIRO).

NATA
Accredited for compliance with ISO Guide 34
Accredited Reference Material Producer
Accreditation Number: 14293
Site Number: 15276

Strain sourced from NCTC (National Collection of Type Cultures)

*BTF occasionally extends the expiry dates on standard BioBall products. Please check the BioBall website http://bioball.com/bioball/certificate-of-analysis/ to determine whether or not the shelf life of your BioBall batch has been extended.

Quality Officer:

Fiona Pollock

15 August 2016

Manufactured by:
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BIOMÉRIEUX INDUSTRY

Page 1 of 1
Issue. 5 - June 2016

BioBall SingleShot

Certificate of Analysis

Lot Number: B3827

Reference Material Data

Organism:	*Escherichia coli*
Designation:	NCTC 12923
Reference:	413833 10 Vials
	56034 20 Vials
BTF Internal Reference:	B-EC12923-30-10
	B-EC12923-30-20
Date of Manufacture:	22 November 2016
Expiry Date:	22 November 2018
Extended Expiry Date*:	N/A

Quantification Data
(Method Ref: BB-001)

cfu Count per BioBall ©

Mean cfu	SD
30.6	2.3

95% Prediction Interval

Lower Limit	Upper Limit
25.9	35.3

For an explanation of the Prediction Interval see the BioBall Instructions For Use on the BioBall website - www.bioball.com

Culture Information

No. of Passages:	4
QC Media:	Nutrient agar
Plate Incubation Time (hrs):	14 - 24
Plate Incubation Temp °C:	37 Aerobic

Note: Number of passages are indicated from the original strain assuming original strain is zero.

Strain Confirmation

Bacteria strains are confirmed by genetic typing. Yeast and Mould strains are confirmed by Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Quality Officer:

Fiona Pollock

14 December 2016

NATA TECHNICAL COMPETENCE

Accredited for compliance with ISO Guide 34

Accredited Reference Material Producer
Accreditation Number: 14993
Site Number: 15276

Strain sourced from NCTC (National Collection of Type Cultures)

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BIOMÉRIEUX INDUSTRY

Page 1 of 1
Issue: 2 - June 2016

BioBall SingleShot

Certificate of Analysis

Lot Number: B3458

Reference Material Data

Organism:	*Escherichia coli*
Designation:	NCTC 9001
Reference:	413832 10 Vials
	56033 20 Vials
BTF Internal Reference:	B-EC9001-30-10
	B-EC9001-30-20
Date of Manufacture:	14 March 2016
Expiry Date:	14 March 2018
Extended Expiry Date*:	N/A

Quantification Data
(Method Ref: BB-001)

cfu Count per BioBall ©

Mean cfu	SD
31.3	2.1

95% Prediction Interval

Lower Limit	Upper Limit
27.1	35.5

For an explanation of the Prediction Interval see the BioBall Instructions For Use on the BioBall website - www.bioball.com

Culture Information

No. of Passages:	4
QC Media:	Nutrient agar
Plate Incubation Time (hrs):	14 - 24
Plate Incubation Temp °C:	37 Aerobic

Note: Number of passages are indicated from the original strain assuming original strain is zero.

Strain Confirmation

Bacteria strains are confirmed by genetic typing. Yeast and Mould strains are confirmed by Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Quality Officer:

Linh Le

6 April 2016

NATA
Accredited for compliance with ISO Guide 34
Accredited Reference Material Producer
Accreditation Number: 14993
Site Number: 15276

Strain sourced from NCTC (National Collection of Type Cultures)

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BIOMÉRIEUX INDUSTRY

Issue: 7 - May 2012

BioBall SingleShot

Certificate of Analysis

Lot Number: B3778

Reference Material Data

Organism:	*Enterococcus faecalis*
Designation:	NCTC 775
Reference:	413850 10 Vials
	56032 20 Vials
BTF Internal Reference:	B-EF775-30-10
	B-EF775-30-20
Date of Manufacture:	24 October 2016
Expiry Date:	24 October 2018
Extended Expiry Date*:	N/A

Quantification Data
(Method Ref: BB-001)

cfu Count per BioBall ®

Mean cfu	SD
29.2	2.6

95% Prediction Interval

Lower Limit	Upper Limit
23.9	34.6

For an explanation of the Prediction Interval see the BioBall Instructions For Use on the BioBall website - www.bioball.com

Culture Information

No. of Passages:	4
QC Media:	Horse Blood agar
Plate Incubation Time (hrs):	14 - 24
Plate Incubation Temp °C:	37 Aerobic

Note: Number of passages are indicated from the original strain assuming original strain is zero.

Strain Confirmation

Bacteria strains are confirmed by genetic typing. Yeast and Mould strains are confirmed by Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Quality Officer:

Fiona Pollock

28 November 2016

NATA TECHNICAL COMPETENCE

Accredited for compliance with ISO Guide 34

Accredited Reference Material Producer
Accreditation Number: 14993
Site Number: 15276

Strain sourced from NCTC (National Collection of Type Cultures)

*BTF occasionally extends the expiry dates on standard BioBall products. Please check the Bioball website http://bioball.com/bioball/certificate-of-analysis/ to determine whether or not the shelf life of your BioBall batch has been extended.

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BIOMÉRIEUX INDUSTRY

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Issue: 5 - June 2016

BioBall SingleShot

Certificate of Analysis

Lot Number: B3698

Reference Material Data

Organism:	*Enterococcus faecalis*
Designation:	NCTC 775
Reference:	413850 10 Vials
	56032 20 Vials
BTF Internal Reference:	B-EF775-30-10
	B-EF775-30-20
Date of Manufacture:	30 August 2016
Expiry Date:	30 August 2018
Extended Expiry Date*:	N/A

Quantification Data

(Method Ref: BB-001)

cfu Count per BioBall®

Mean cfu	SD
30.7	2.5

95% Prediction Interval

Lower Limit	Upper Limit
25.6	35.8

For an explanation of the Prediction Interval see the BioBall Instructions For Use on the BioBall website - www.bioball.com

Culture Information

No. of Passages:	4
QC Media:	Horse Blood agar
Plate Incubation Time (hrs):	14 - 24
Plate Incubation Temp °C:	37 Aerobic

Note: Number of passages are indicated from the original strain assuming original strain is zero.

Strain Confirmation

Bacteria strains are confirmed by genetic typing. Yeast and Mould strains are confirmed by Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Quality Officer:

Fiona Pollock

15 September 2016

NATA

Accredited for compliance with ISO Guide 34

Accredited Reference Material Producer
Accreditation Number: 14093
Site Number: 15276

Strain sourced from NCTC (National Collection of Type Cultures)

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BIOMÉRIEUX INDUSTRY

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Issue: 5 - June 2016

BioBall SingleShot

Certificate of Analysis

Lot Number: B3347

Reference Material Data

Organism:	*Enterococcus faecalis*
Designation:	NCTC 775
Reference:	413850 10 Vials
	56032 20 Vials
BTF Internal Reference:	B-EF775-30-10
	B-EF775-30-20
Date of Manufacture:	19 November 2015
Expiry Date:	18 November 2017
Extended Expiry Date*:	N/A

Quantification Data
(Method Ref: BB-001)

cfu Count per BioBall ©

Mean cfu	SD
30.6	2.2

95% Prediction Interval

Lower Limit	Upper Limit
26.2	34.9

For an explanation of the Prediction Interval see the BioBall Instructions For Use on the BioBall website - www.bioball.com

Culture Information

No. of Passages:	4
QC Media:	Horse Blood agar
Plate Incubation Time (hrs):	14 - 24
Plate Incubation Temp °C:	37 Aerobic

Note: Number of passages are indicated from the original strain assuming original strain is zero.

Strain Confirmation

Bacteria strains are confirmed by genetic typing. Yeast and Mould strains are confirmed by Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Quality Officer:

Fiona Pollock

9 December 2015

NATA
Accredited for compliance with ISO Guide 34
Accredited Reference Material Producer
Accreditation Number: 14993
Site Number: 15276

Strain sourced from NCTC (National Collection of Type Cultures)

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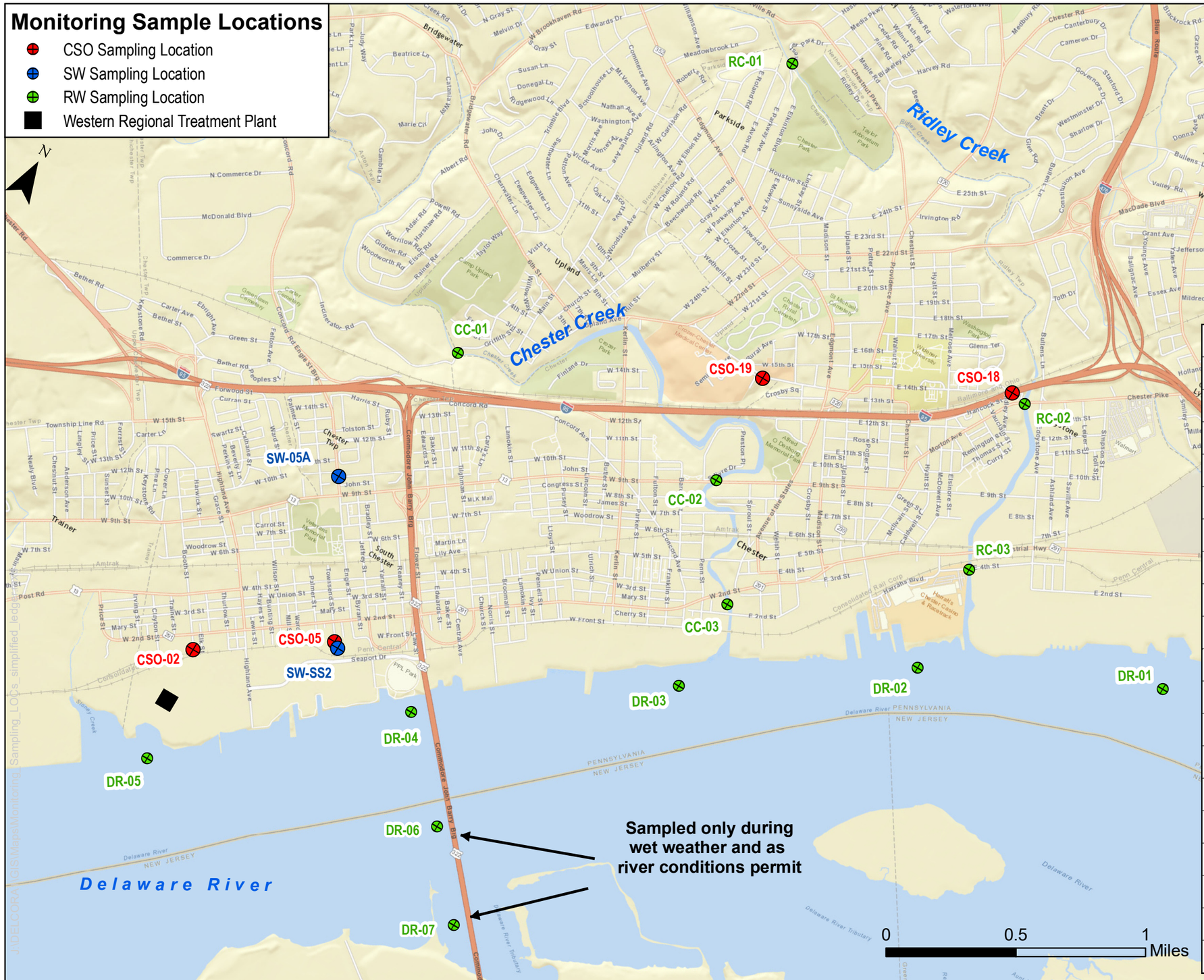
Issue. 7 - May 2012

APPENDIX J

CITY OF CHESTER MAP AND LETTER



Station ID	GPS Coordinates	Address/Location
CC-01	39.850122, -75.386348	Upland Rd., Incinerator Rd. Bridge
CC-02	39.850709, -75.365530	9th St Bridge; 54 W 9th St
CC-03	39.845227, -75.360284	Intersection of Edgmont and 2nd street; William Penn's Landing Park; 126 E 2nd St
RC-01	39.873264, -75.375183	Chester Park Drive Bridge; 298 East Elkington Blvd
RC-02	39.863016, -75.348686	Morton Ave. Bridge; 1300 Sun Drive
RC-03	39.853435, -75.346350	4th Street (Harrah's) Bridge; aka Bridge No. 157 (Chester-Eddystone Bridge); 1050 East 4th St Eddystone
DR-01	39.85282, -75.3299	Delaware River between Ridley Creek and Crum Creek
DR-02	39.84715, -75.3462	Delaware River between CSO-14 and Ridley Creek
DR-03	39.8398, -75.3606	Delaware River between CSO-11 and Chester Creek
DR-04	39.83132, -75.3766	Delaware River at the boat launch off Highway 322
DR-05	39.82182, -75.3917	Delaware River between CSO- 002 and Stoney Creek
DR-06	39.82636, -75.371	Delaware River mid-stream along the transect of DR-04
DR-07	39.82203, -75.3665	Delaware River far shore (left descending bank) along the transect of DR-04
CSO-02	39.828334, -75.392570	Front and Booth St; 100 Booth St
CSO-05	39.832598, -75.383958	Front and Townsend; 101 Townsend St
CSO-18	39.863501, -75.349203	Hancock St. and Sun Dr.; 1310 Sun Dr
CSO-19	39.857132, -75.366105	14th and Crozer Hospital; 1 Medical Center Blvd
SW-SS2	39.832853, -75.384193	Front and Townsend; 105 Townsend St
SW-05A	39.838501, -75.387708	7th and Engle Street; by tennis courts

CSO Long Term Control Plan Update
Delaware County Regional Water Quality Control Authority

GREELEY AND HANSEN

LimnoTech

DELAWARE COUNTY REGIONAL WATER QUALITY CONTROL AUTHORITY
P.O. BOX 999 • CHESTER, PA 19016-0999

March 17, 2017

To Whom It May Concern:

The Delaware County Water Quality Control Authority (DELCORA) is a municipal authority located in Chester, PA, established in 1970 with the acquisition and upgrade of the City of Chester's wastewater treatment plant to become DELCORA's Western Regional Treatment Plant (WRTP). DELCORA owns, operates and maintains collection systems that serve approximately a half million people in the Greater Philadelphia area, including 42 municipalities in Delaware and Chester Counties.

DELCORA entered into a Consent Decree (CD) with the United States Government to establish a schedule for implementation of Long Term Control Plan Update (LTCPU) to achieve full compliance with the Clean Water Act and the regulations and Clean Streams Law and regulations. As part of the DELCORA LTCPU, water quality monitoring is required.

Greeley and Hansen LLC currently serves as a consultant to DELCORA for the LTCPU Project in an effort to address combined sewer overflows (CSO) associated with the Consent Decree.

Greeley and Hansen's work incudes conducting receiving stream surveys and collecting samples from manholes, outfalls and surface waters. As such, Greeley and Hansen's employees, as well as employees from Greeley and Hansen's sub-consultants, will be working along shorelines and in boats and will be temporarily stopped in vans on local roadways to access sampling points from the spring of 2017 through the summer of 2017. Representatives of Greeley and Hansen LLC and their sub-consultants who are carrying out these responsibilities should not be deemed as trespassers as they are authorized to conduct these field surveys on behalf of DELCORA.

Should you have any questions, please do not hesitate to contact me by telephone at (610) 876-5523 or (267) 212-4559 or by e-mail at hurstc@delcora.org.

Thank you.

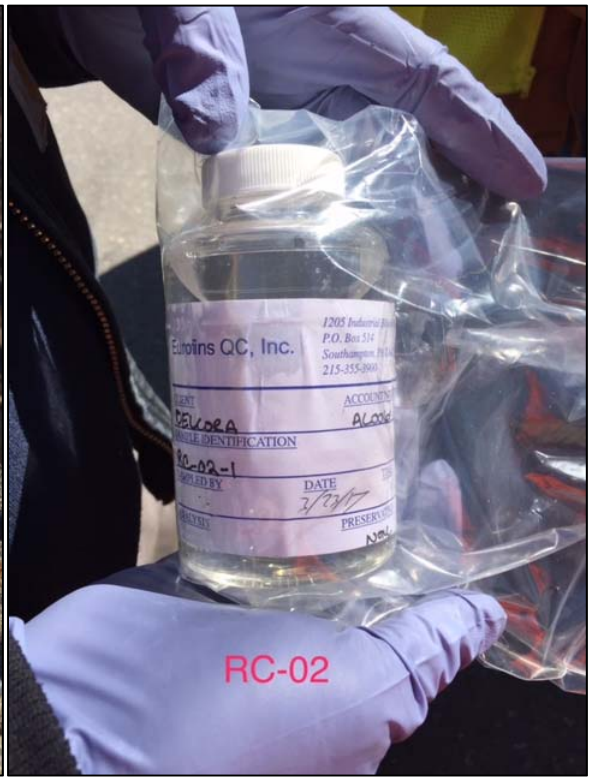
Sincerely,

Charles Hurst, P.E.

c: Robert Willert, DELCORA
Michael DiSantis, DELCORA
Edwin Bothwell, DELCORA
Margaret Hill, Blank Rome LLP

APPENDIX K

SAMPLING PHOTOS

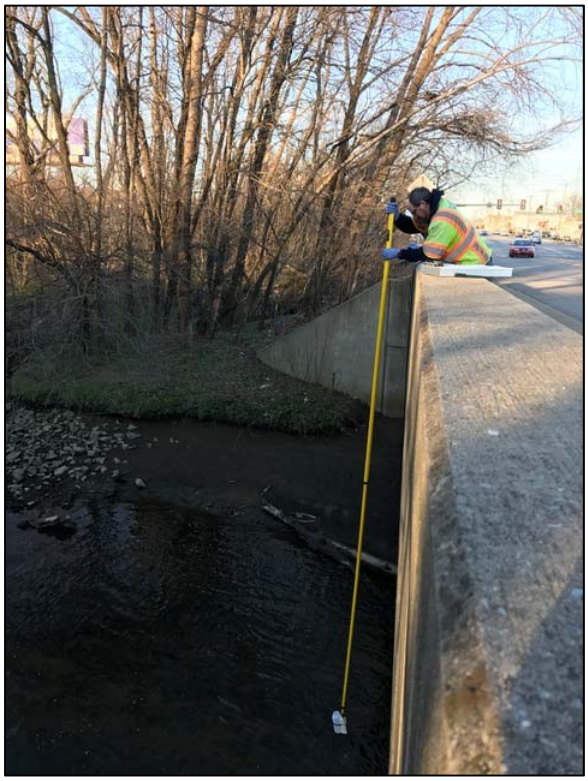


All water quality samples were collected and transeffered into 250 mL bottles provided by Eurofins QC, Inc. The samples were preserved immideatley on ice for transfer to the laboratory for further analysis.

A view of the Delaware River, looking out from the bulkhead wall at the WRTP toward sampling location DR-05.

Sampling off of overpass bridges at Chester Creek (CC-03) and Ridley Creek (RC-03) sampling locations.

Sampling off of the overpass bridge at Ridley Creek (RC-03) sampling location required use of a Bailer Bottle Sampler due to the increased height requirements at the site.



Sampling off of an overpass bridge at Ridley Creek (RC-02) sampling location.

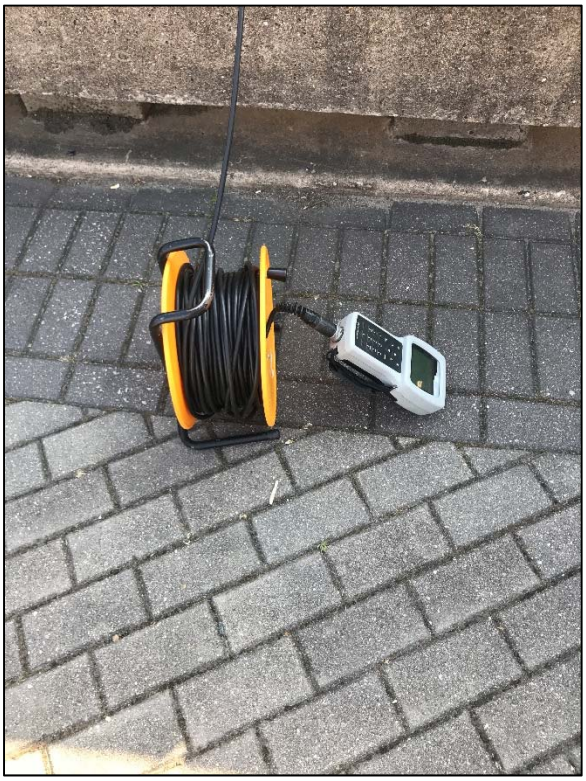
Sampling off of an overpass bridge at Ridley Creek (RC-01) sampling location.

Sampling off of an overpass bridge at Chester Creek (CC-01) sampling location.

Sampling off of an overpass bridge at Chester Creek (CC-02) sampling location.

During the third wet-weather sampling event, one of the two boats in the Delaware River had to be removed from the river due to punctures in its hull. Grab samples were collected at accessible points along the Delaware shore in proximity to DR-03 and DR-04.

During the second wet-weather sampling event, boat activities were halted in the Delaware due to hazardous conditions (lightning and visibility issues). Conditions eventually improved, allowing for the resumption of boat activities after approximately four hours.



In-situ field measurements were taken using a YSI Model 556 with a 6920 V2 sonde. These measurements included water temperature, salinity, and conductivity in the receiving waters.

Sampling off of an overpass bridges at Ridley Creek (RC-02) sampling location.

Water Quality Sampling Report

Appendix K

APPENDIX L

SAMPLING ANALYSIS PLAN (SAP)

(Sampling Analysis Plan (SAP) provided in digital form only on CD attached to this report)

Greeley and Hansen LLC
1700 Market Street, Suite 2130
Philadelphia, PA 19103
(215) 563-3460
www.greeley-hansen.com

GREELEY AND HANSEN

APPENDIX C
Water Quality Model Calibration Results

Notes:

1. The 2017 Dry Weather Event in-stream sampling typically has two results per POC, per event, and per location. One sample was taken on the incoming tide and one sample was taken on the outgoing tide. There was no dry weather sampling at DR-05 and DR-06.
2. The 2017 Wet Weather Event in-stream sampling typically has five or more results per POC, per event, and per location. These were taken at t=0 (onset of rain) and then at approximately every 2 hours after that.
3. More information on the 2017 in-stream sampling results can be found in DELCORA's "Water Quality Sampling Report" (DELCORA, 2017).
4. More information on the 2012 DRBC boat run program can be found online at http://www.state.nj.us/drbc/programs/quality/boat-run.html

Fecal Coliform

Fecal Coliform—2017 Dry Weather Calibration

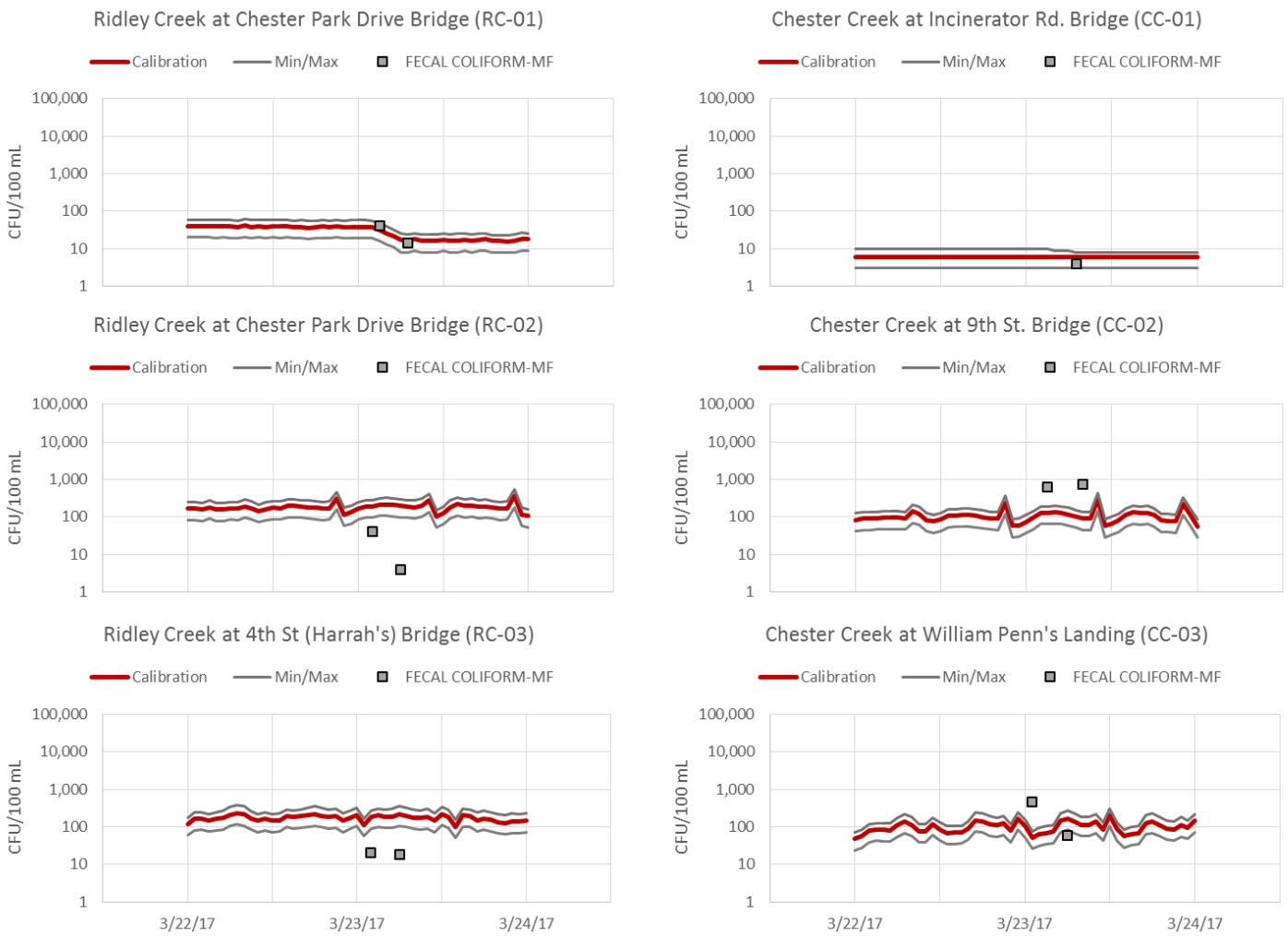


Figure 1. Fecal Coliform Calibration at Ridley Creek and Chester Creek Stations (Dry Weather Event #1, 3/23/17)

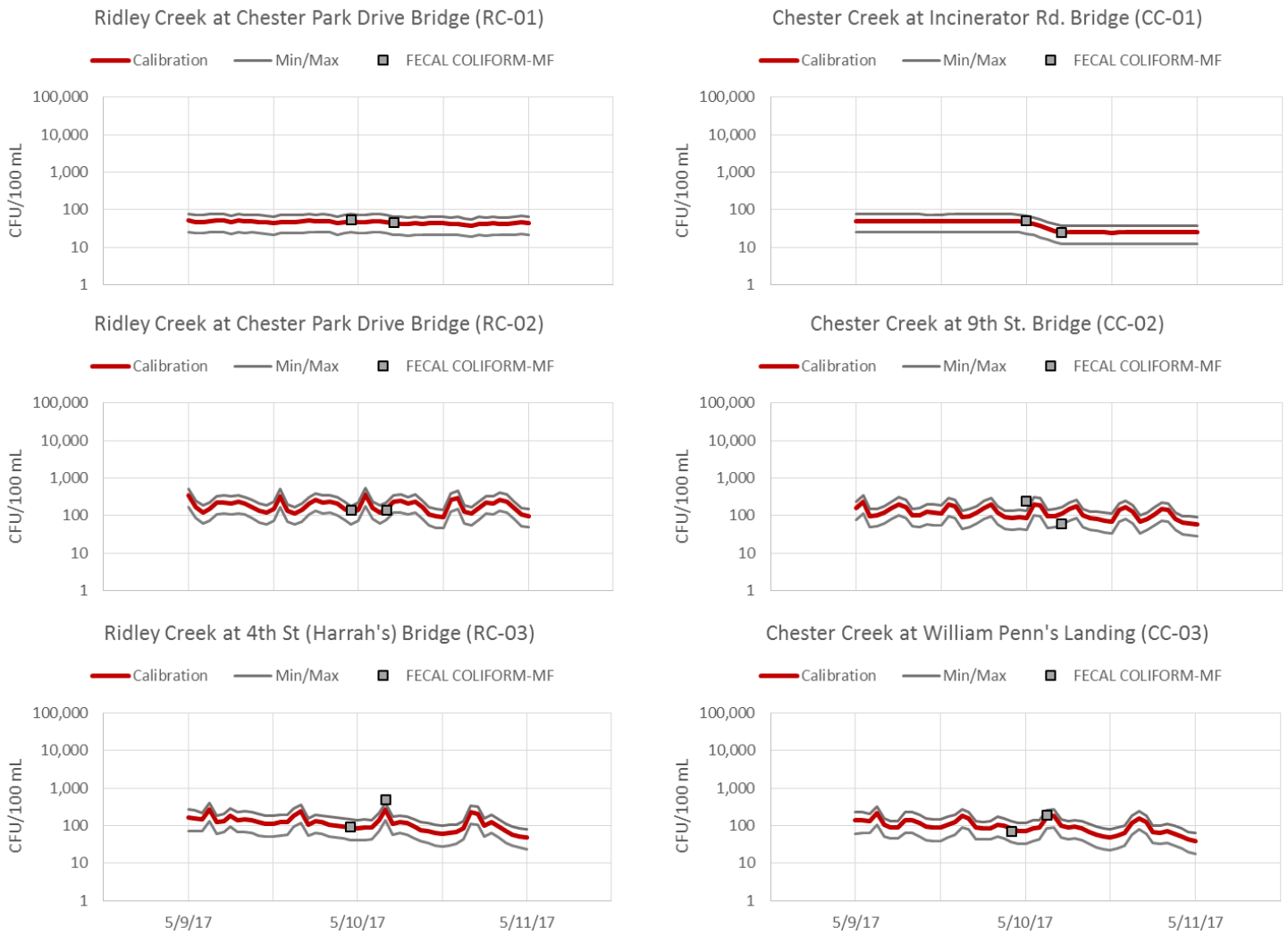


Figure 2. Fecal Coliform Calibration at Ridley Creek and Chester Creek Stations (Dry Weather Event #2, 5/10/17)

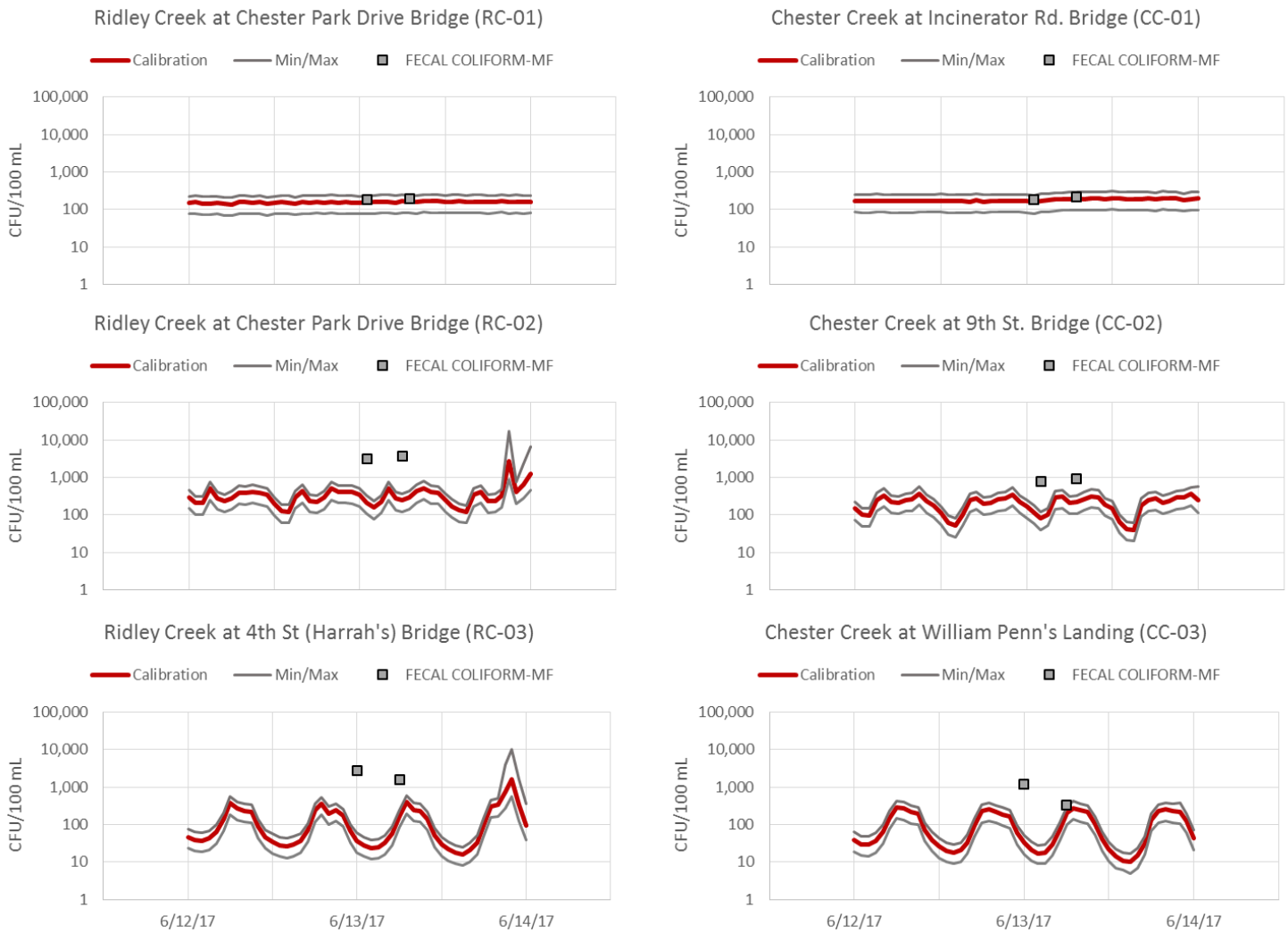


Figure 3. Fecal Coliform Calibration at Ridley Creek and Chester Creek Stations (Dry Weather Event #3, 6/13/17)

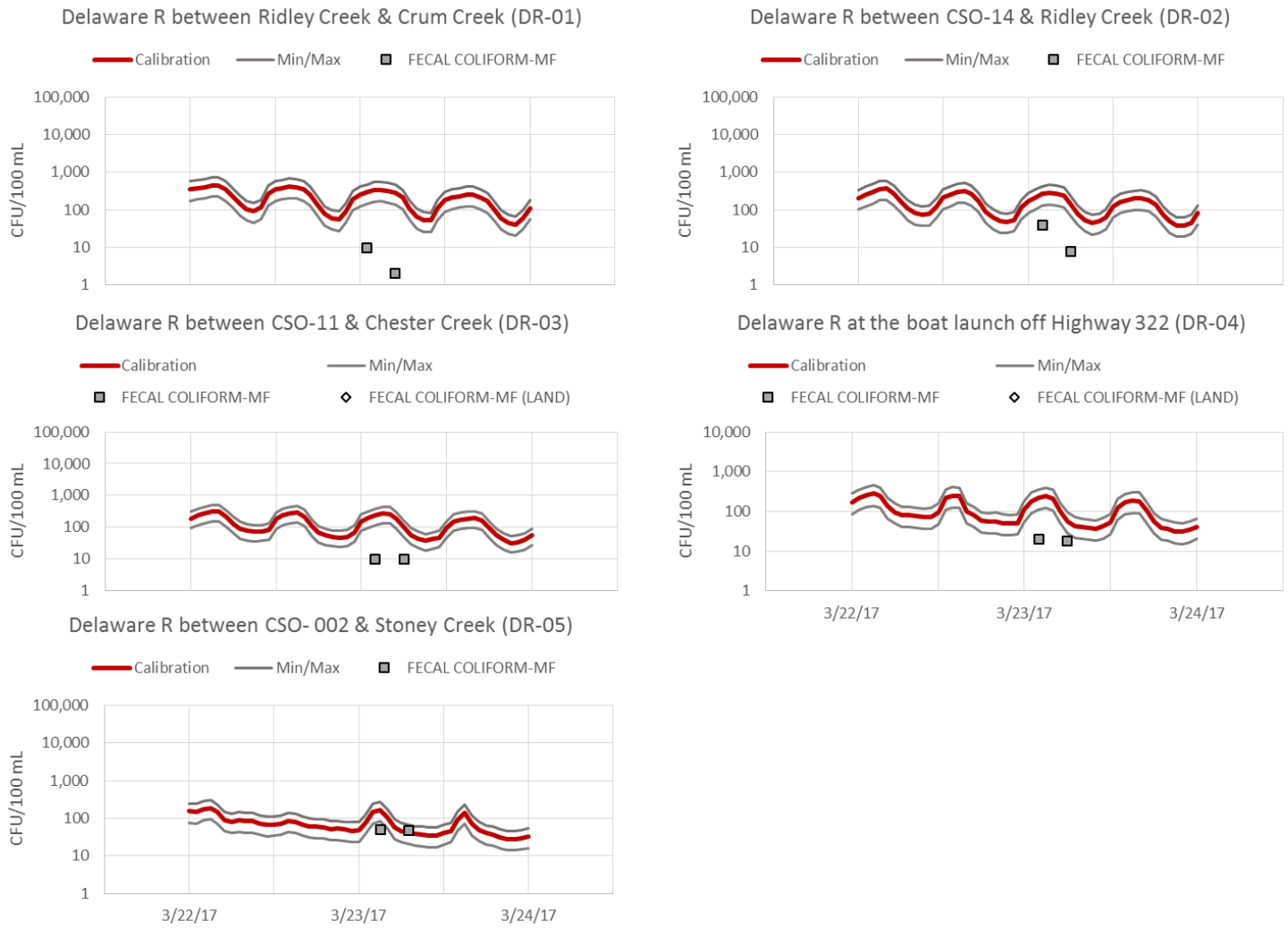


Figure 4. Fecal Coliform Calibration at Delaware River Stations (Dry Weather Event #1, 3/23/17)

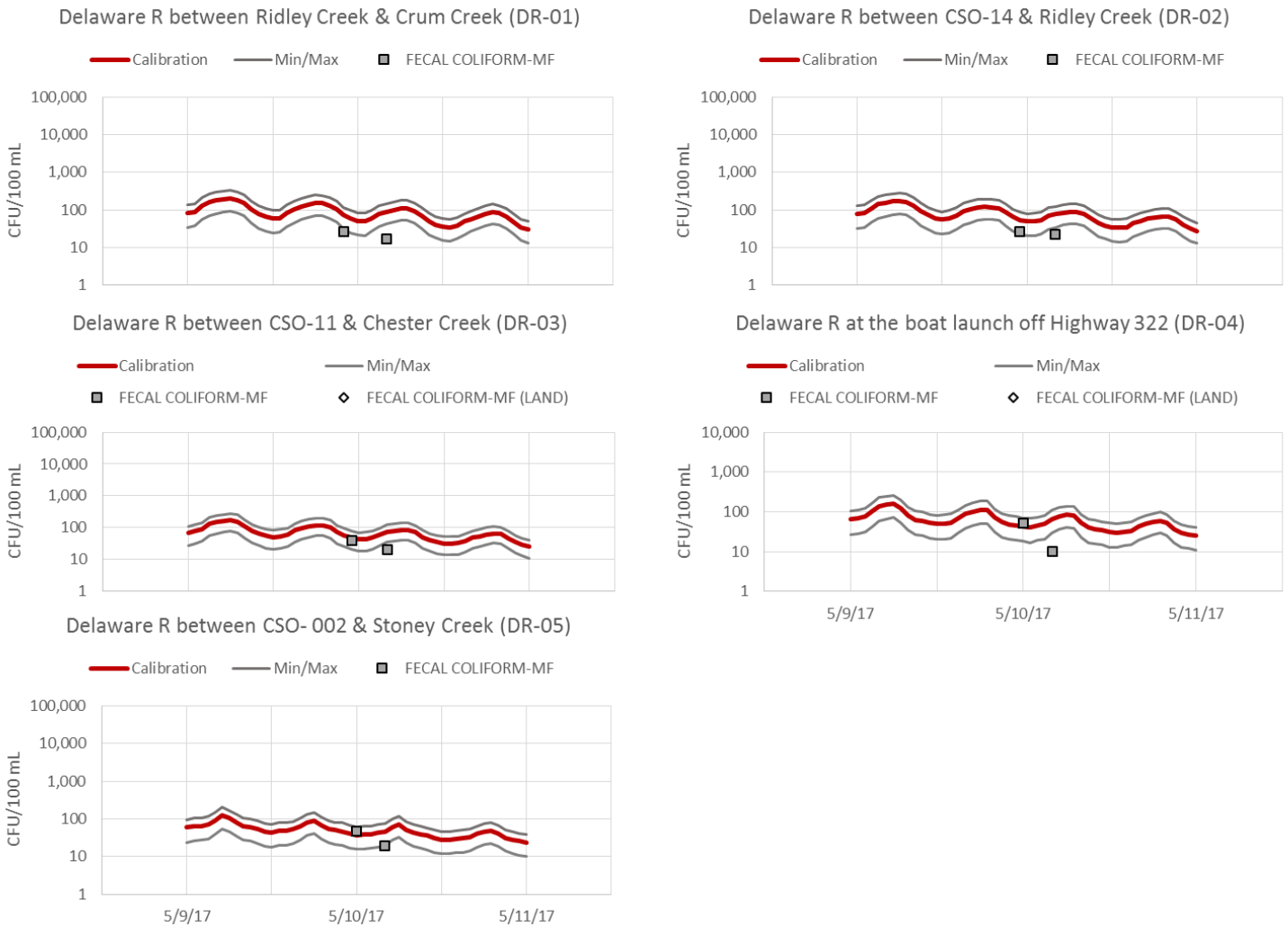


Figure 5. Fecal Coliform Calibration at Delaware River Stations (Dry Weather Event #2, 5/10/17)

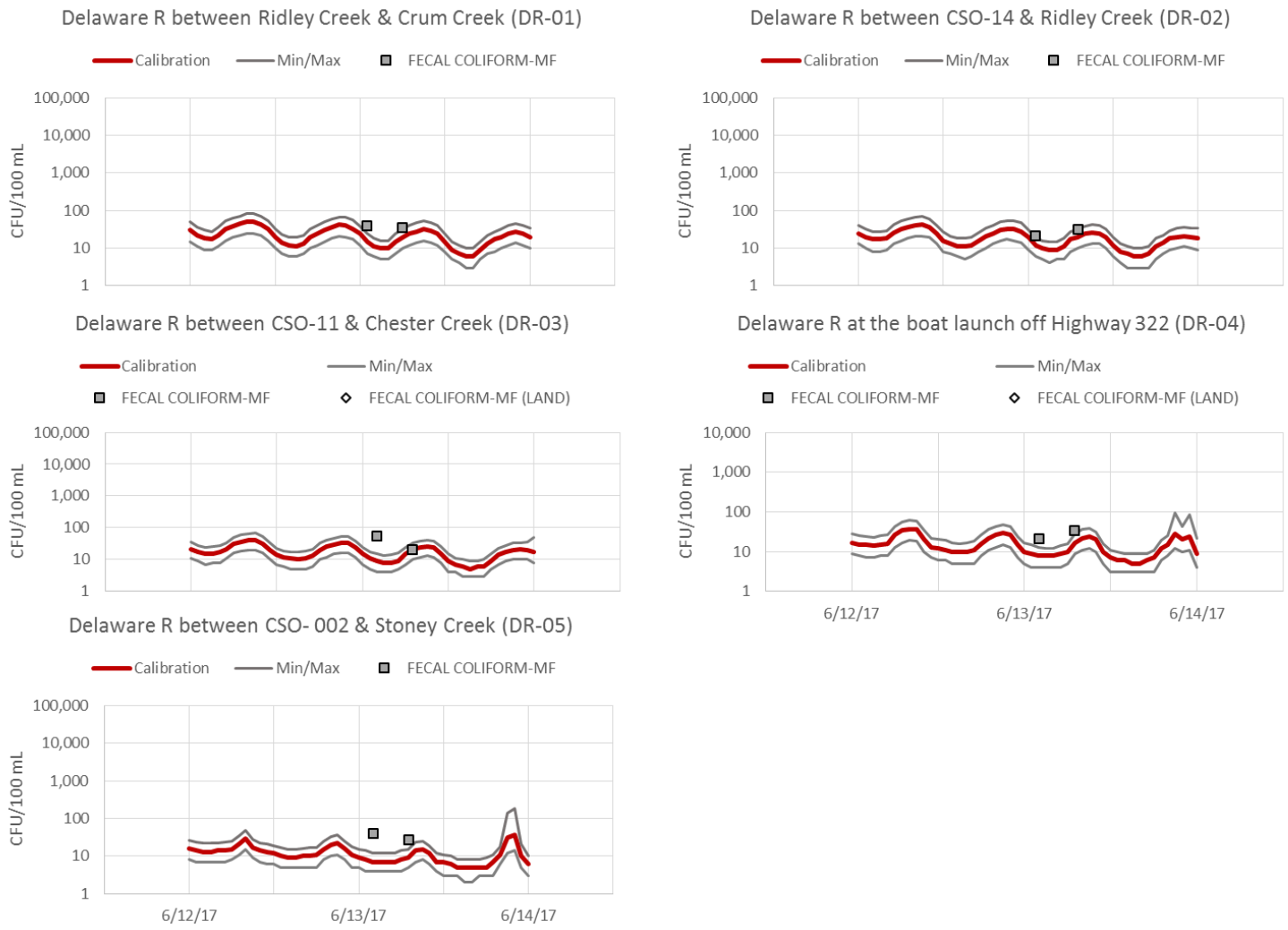


Figure 6. Fecal Coliform Calibration at Delaware River Stations (Dry Weather Event #3, 6/13/17)

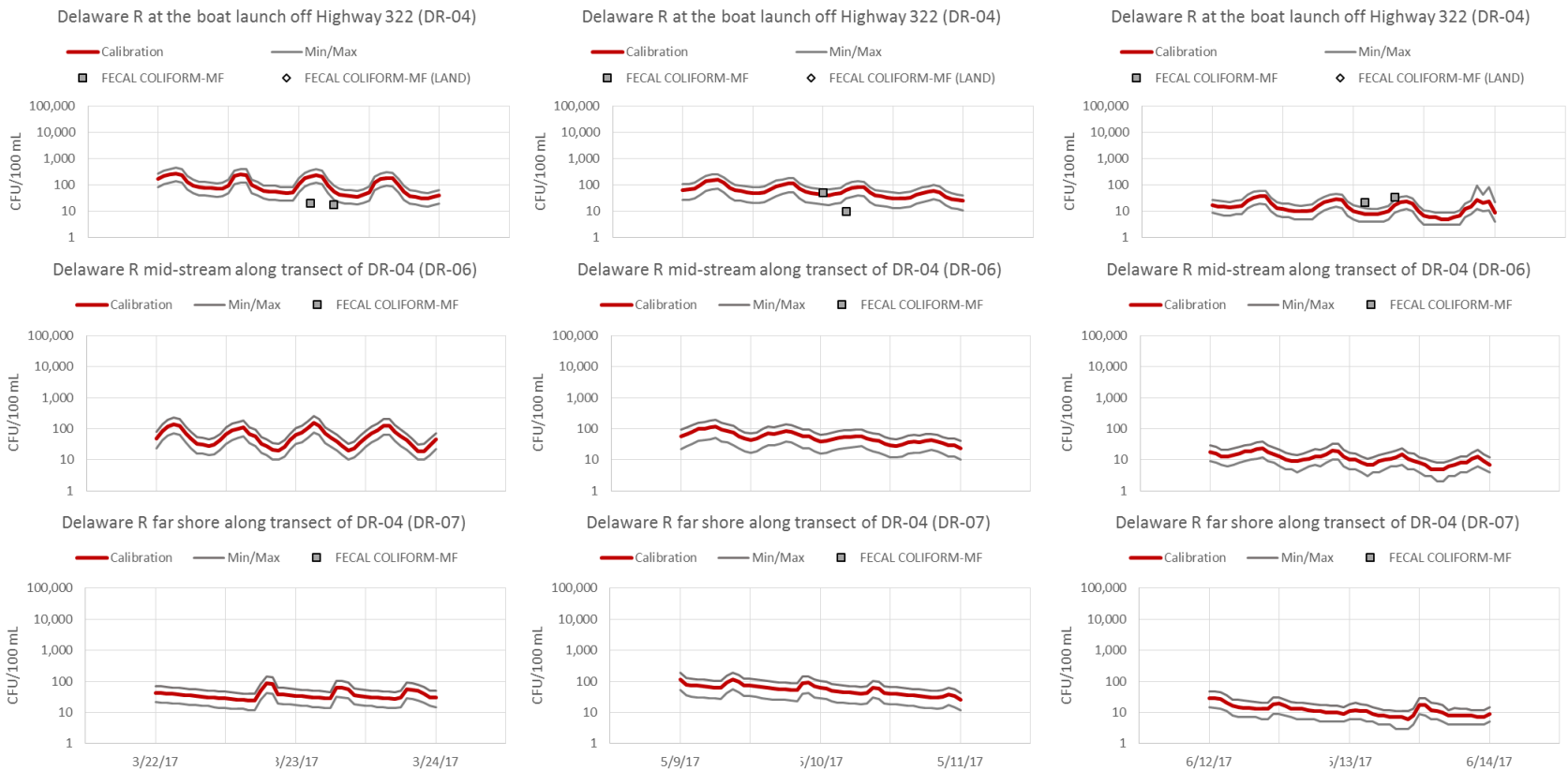


Figure 7. Fecal Coliform Calibration at Delaware River Cross Section (Dry Weather Events #1-3)

Fecal Coliform—2017 Wet Weather Calibration

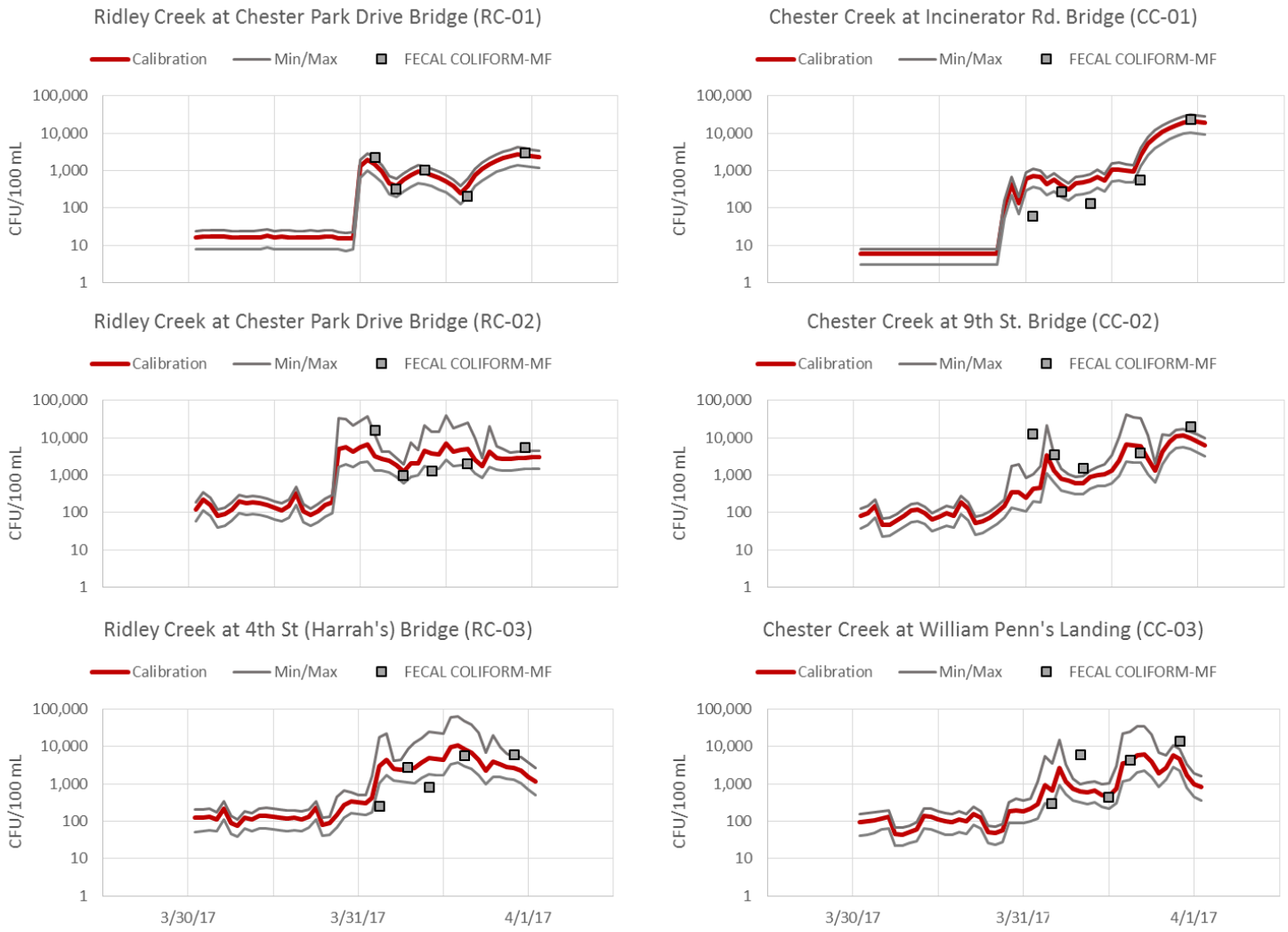


Figure 8. Fecal Coliform Calibration at Ridley Creek and Chester Creek Stations (Wet Weather Event #1, 3/30/17-4/1/17)

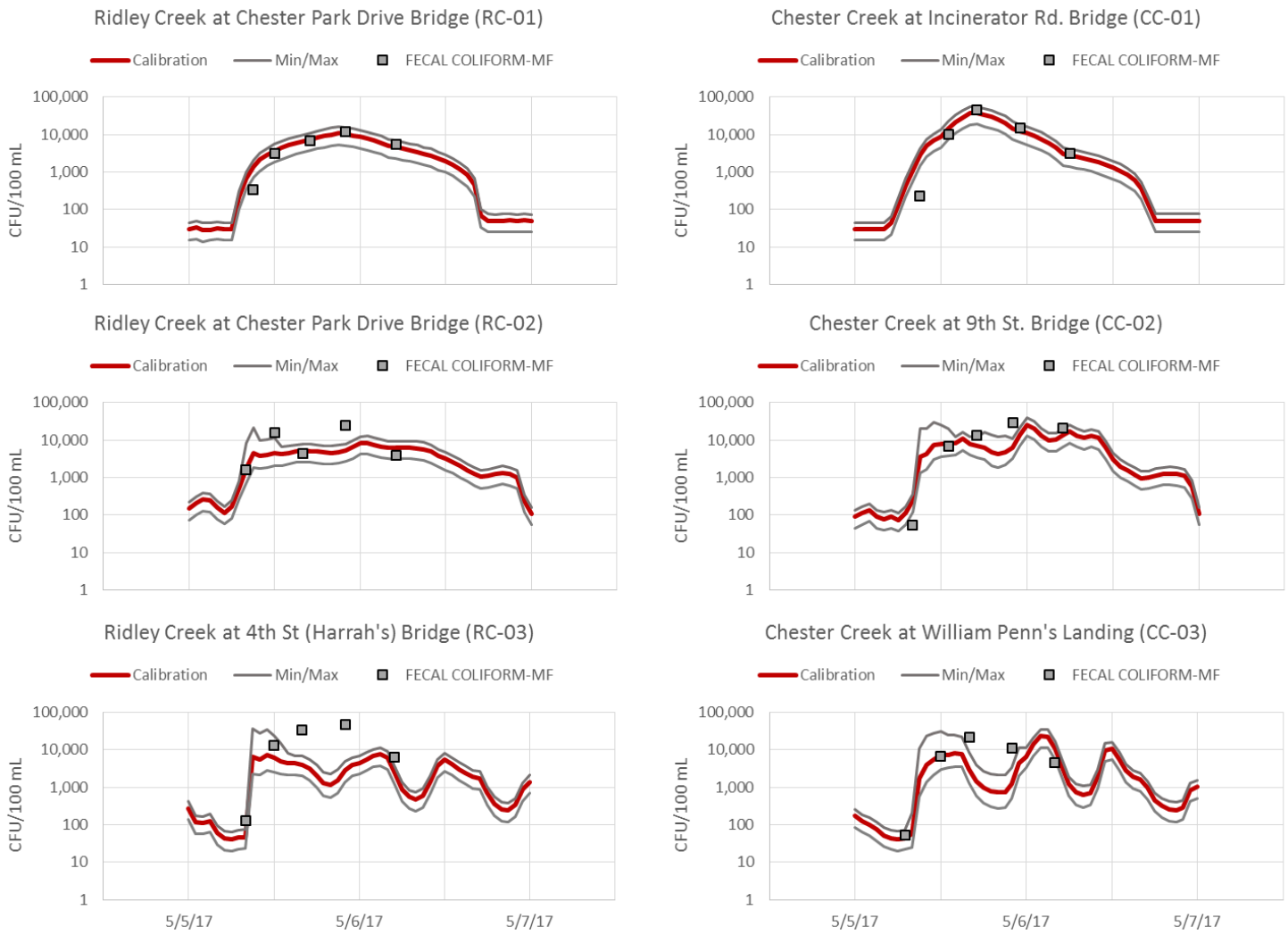


Figure 9. Fecal Coliform Calibration at Ridley Creek and Chester Creek Stations (Wet Weather Event #2, 5/5/17-5/6/17)

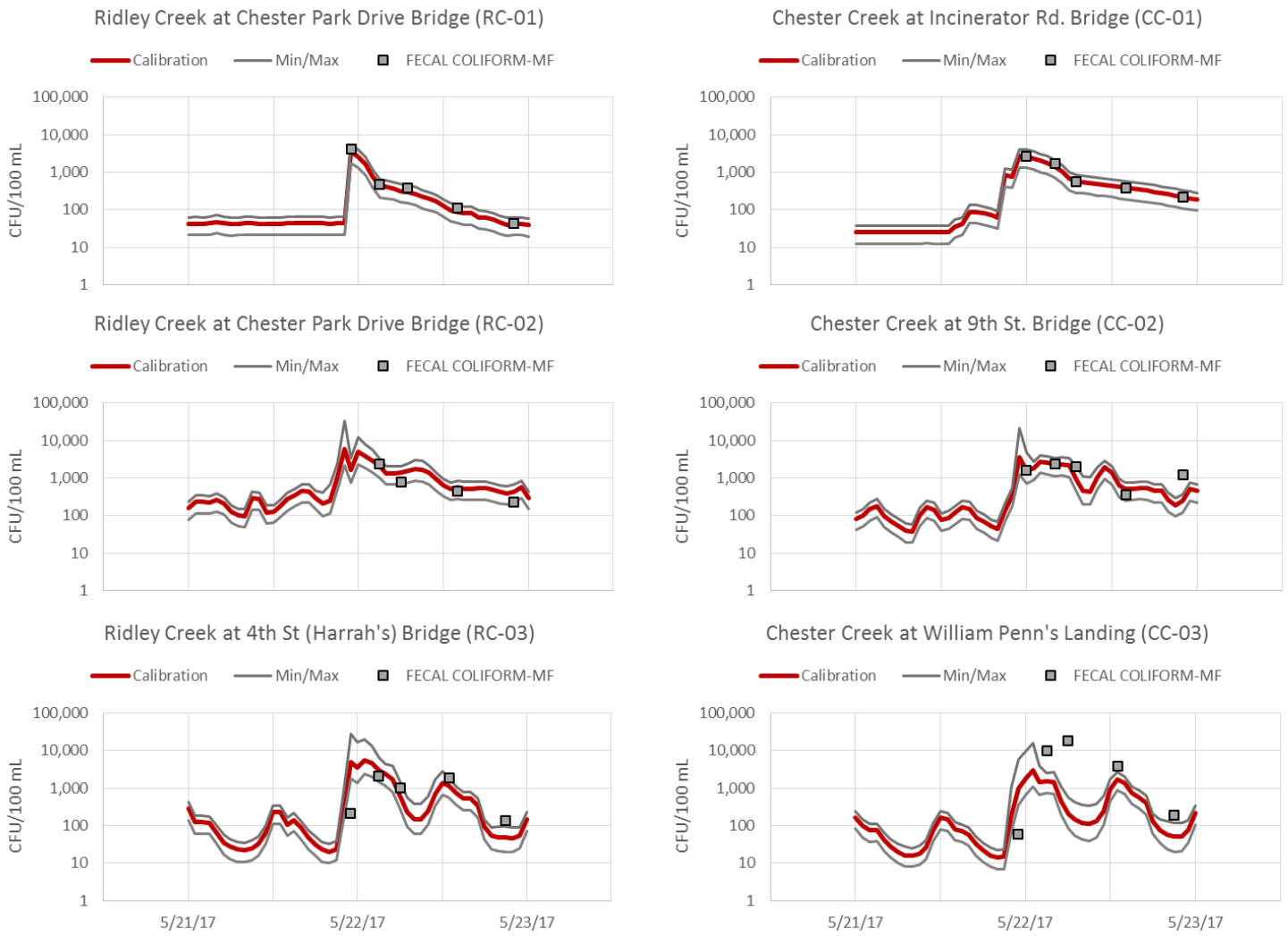


Figure 10. Fecal Coliform Calibration at Ridley Creek and Chester Creek Stations (Wet Weather Event #3, 5/22/17-5/23/17)

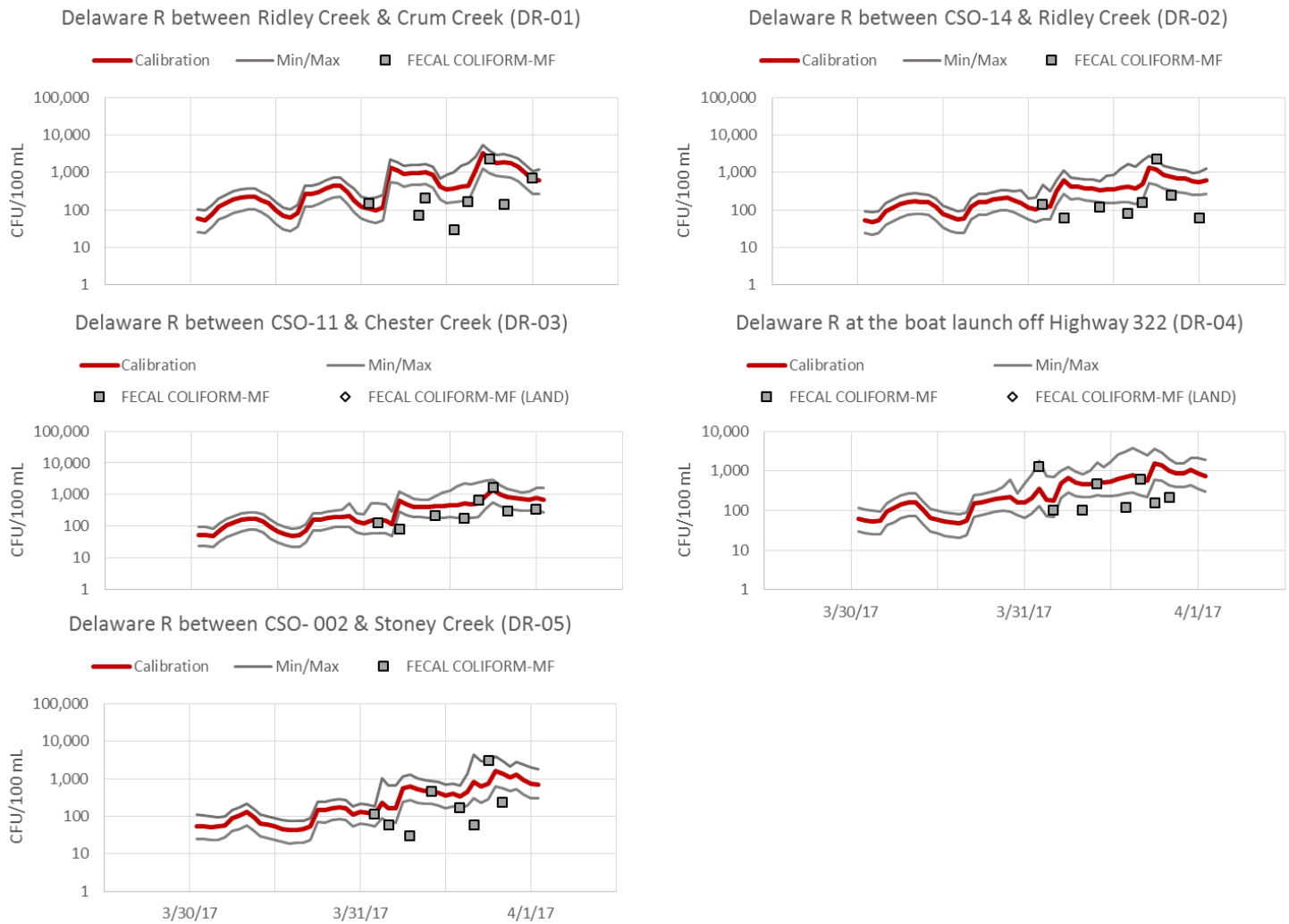


Figure 11. Fecal Coliform Calibration at Delaware River Stations (Wet Weather Event #1, 3/30/17-4/1/17)

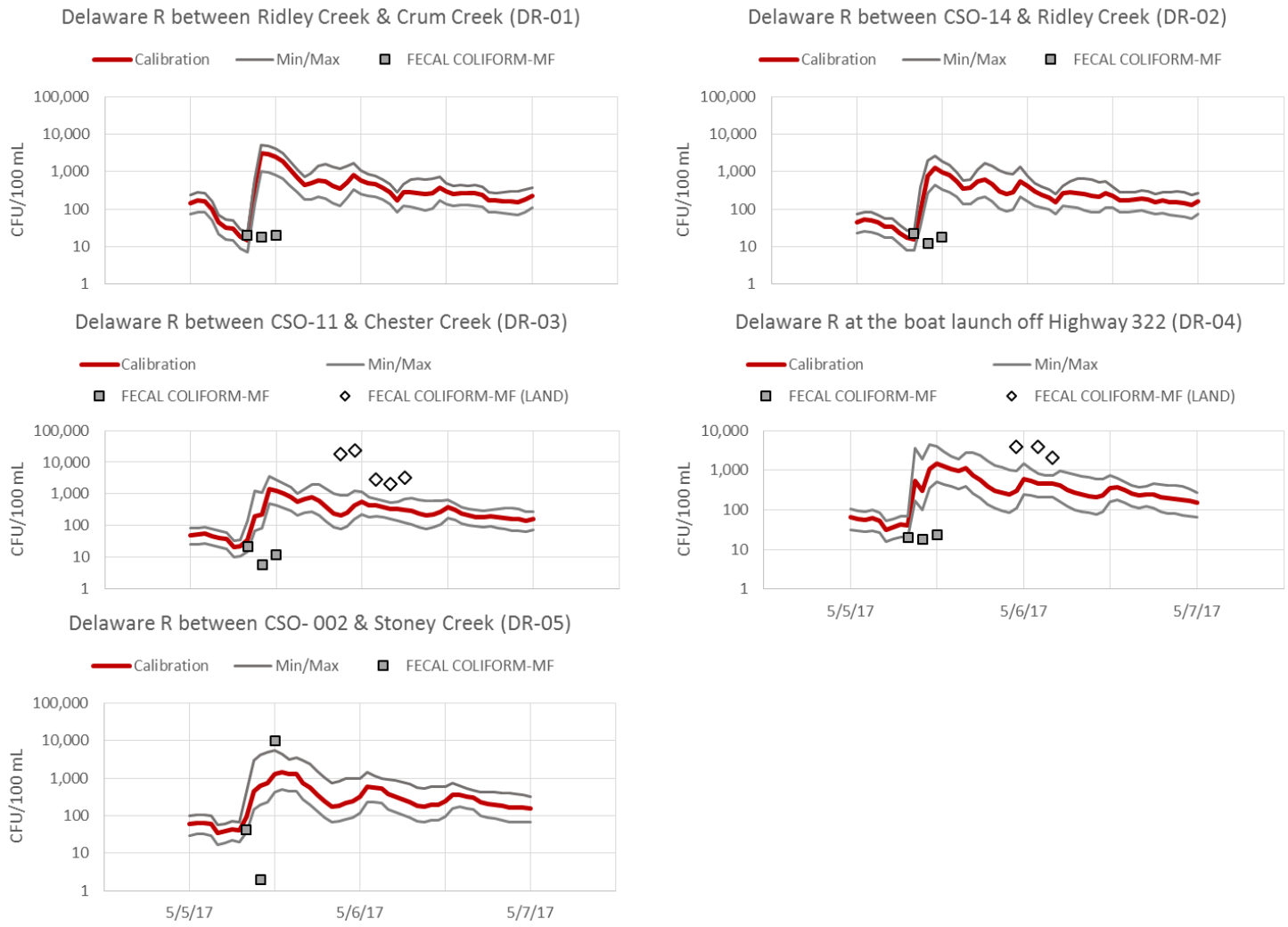


Figure 12. Fecal Coliform Calibration at Delaware River Stations (Wet Weather Event #2, 5/5/17-5/6/17)

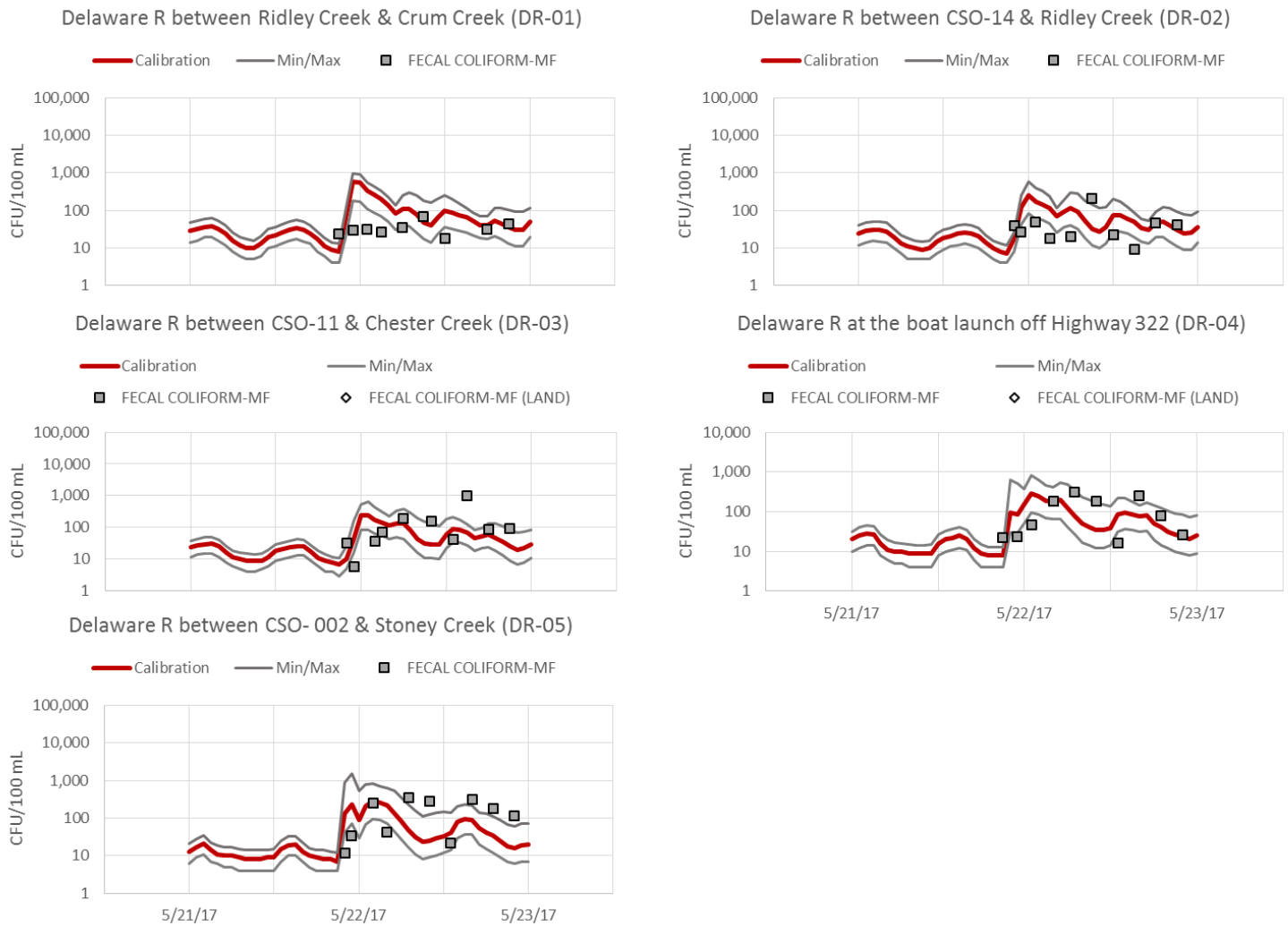


Figure 13. Fecal Coliform Calibration at Delaware River Stations (Wet Weather Event #3, 5/22/17-5/23/17)

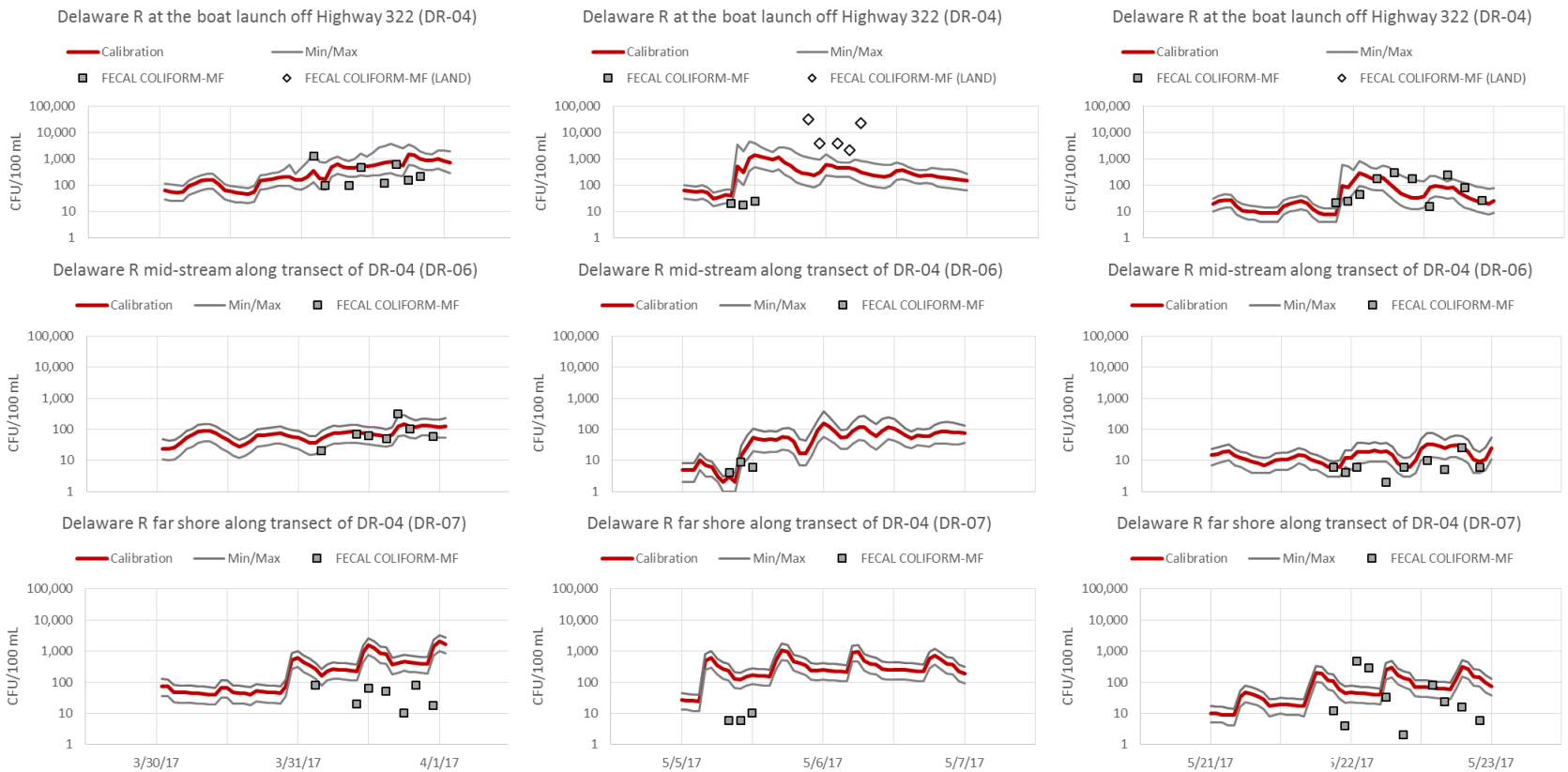


Figure 14. Fecal Coliform Calibration at Delaware River Cross Section (Wet Weather Events #1-3)

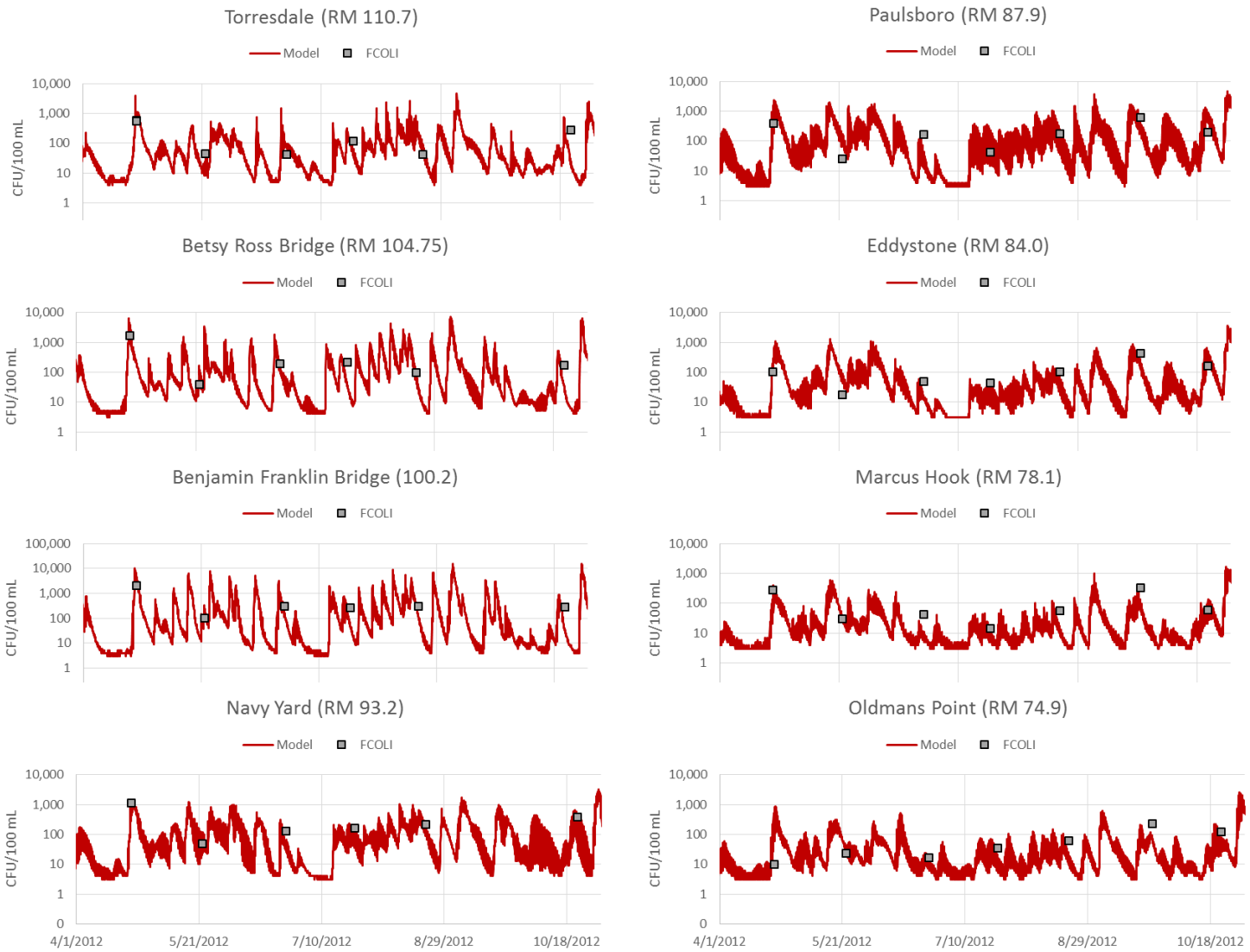


Figure 15. Fecal Coliform Model Validation at DRBC Delaware River Sampling Stations (2012)

E. coli

E. coli—2017 Dry Weather Calibration

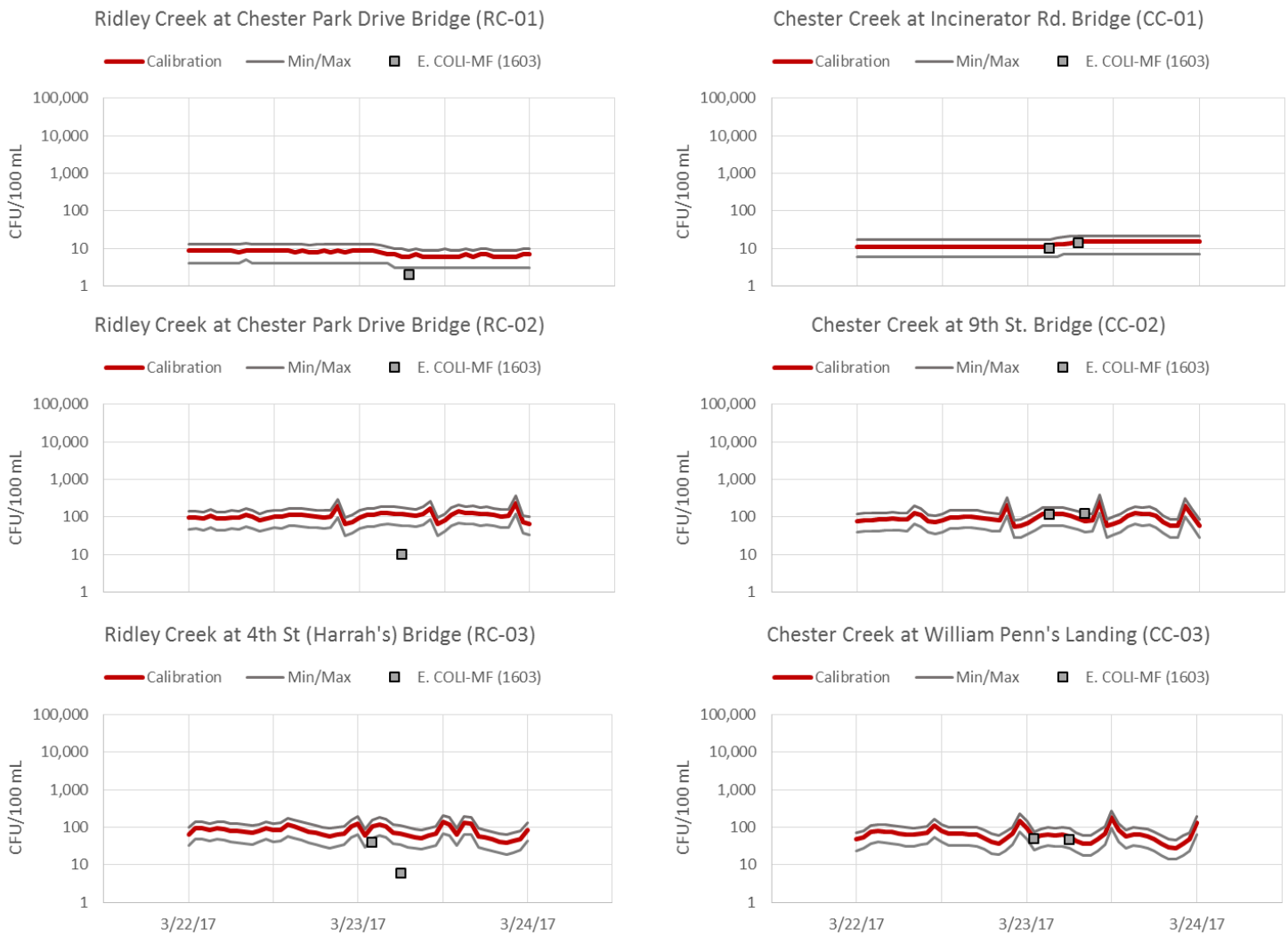


Figure 16. E. coli Calibration at Ridley Creek and Chester Creek Stations (Dry Weather Event #1, 3/23/17)

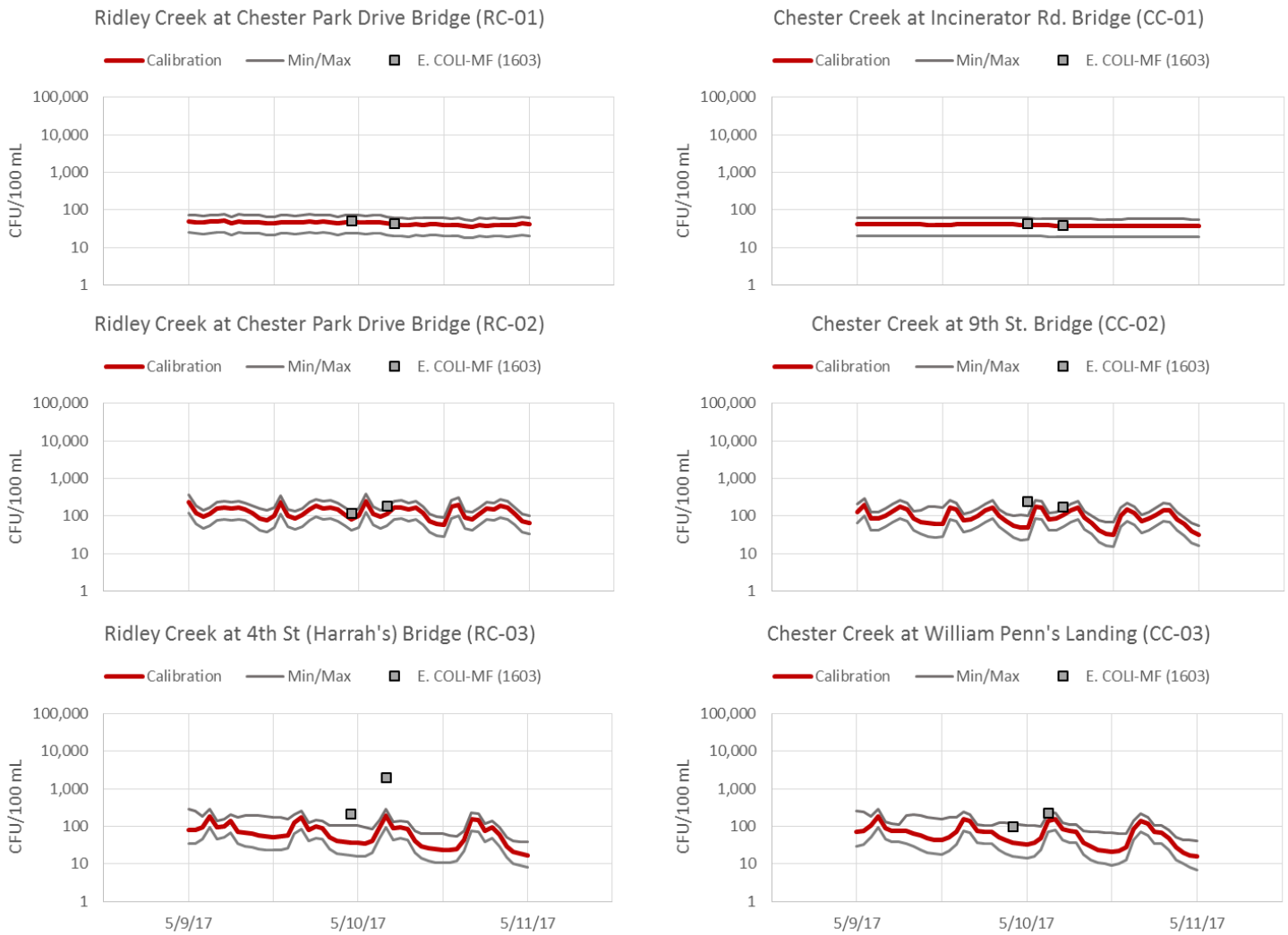


Figure 17. E. coli Calibration at Ridley Creek and Chester Creek Stations (Dry Weather Event #2, 5/10/17)

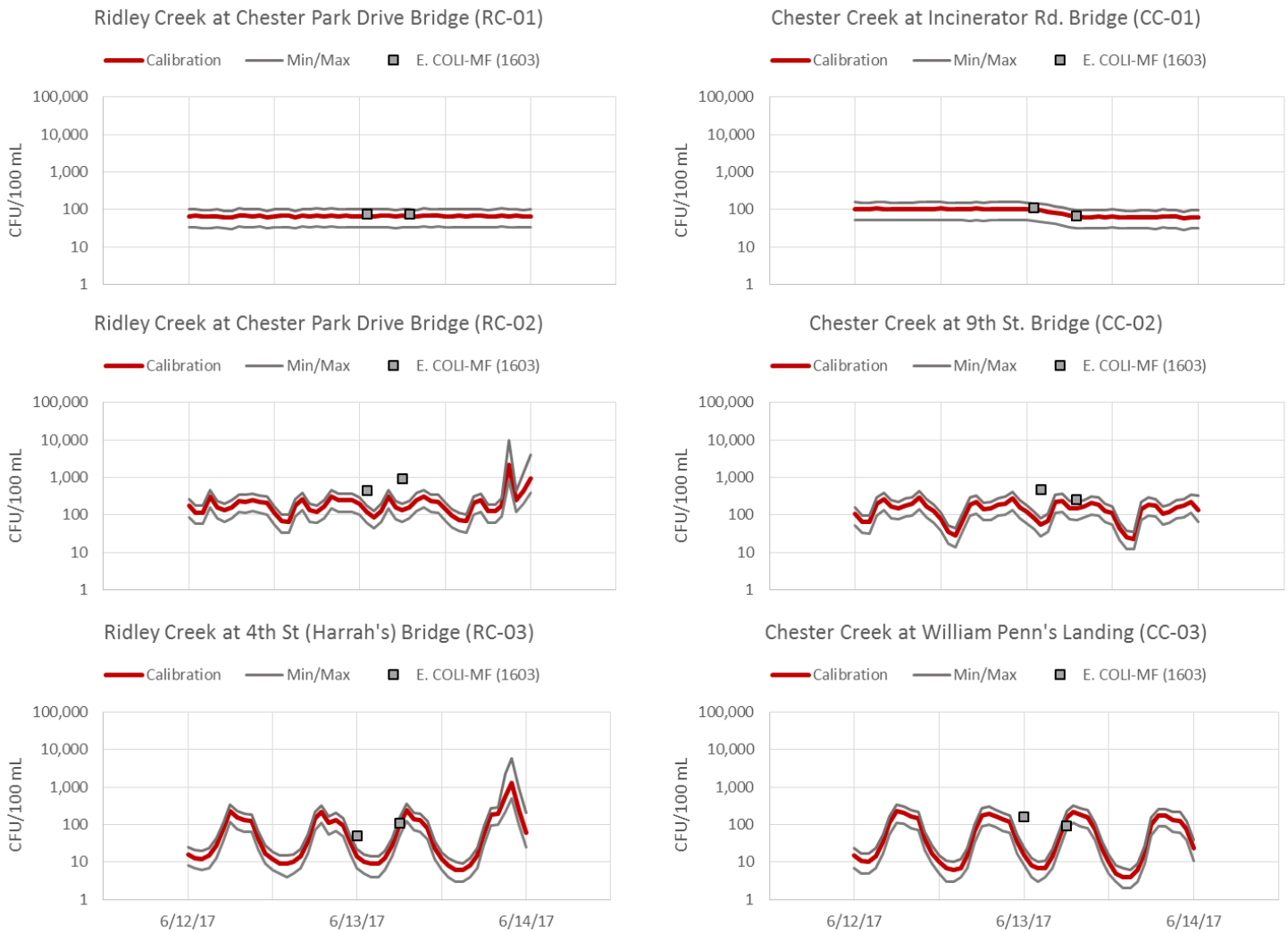


Figure 18. E. coli Calibration at Ridley Creek and Chester Creek Stations (Dry Weather Event #3, 6/13/17)

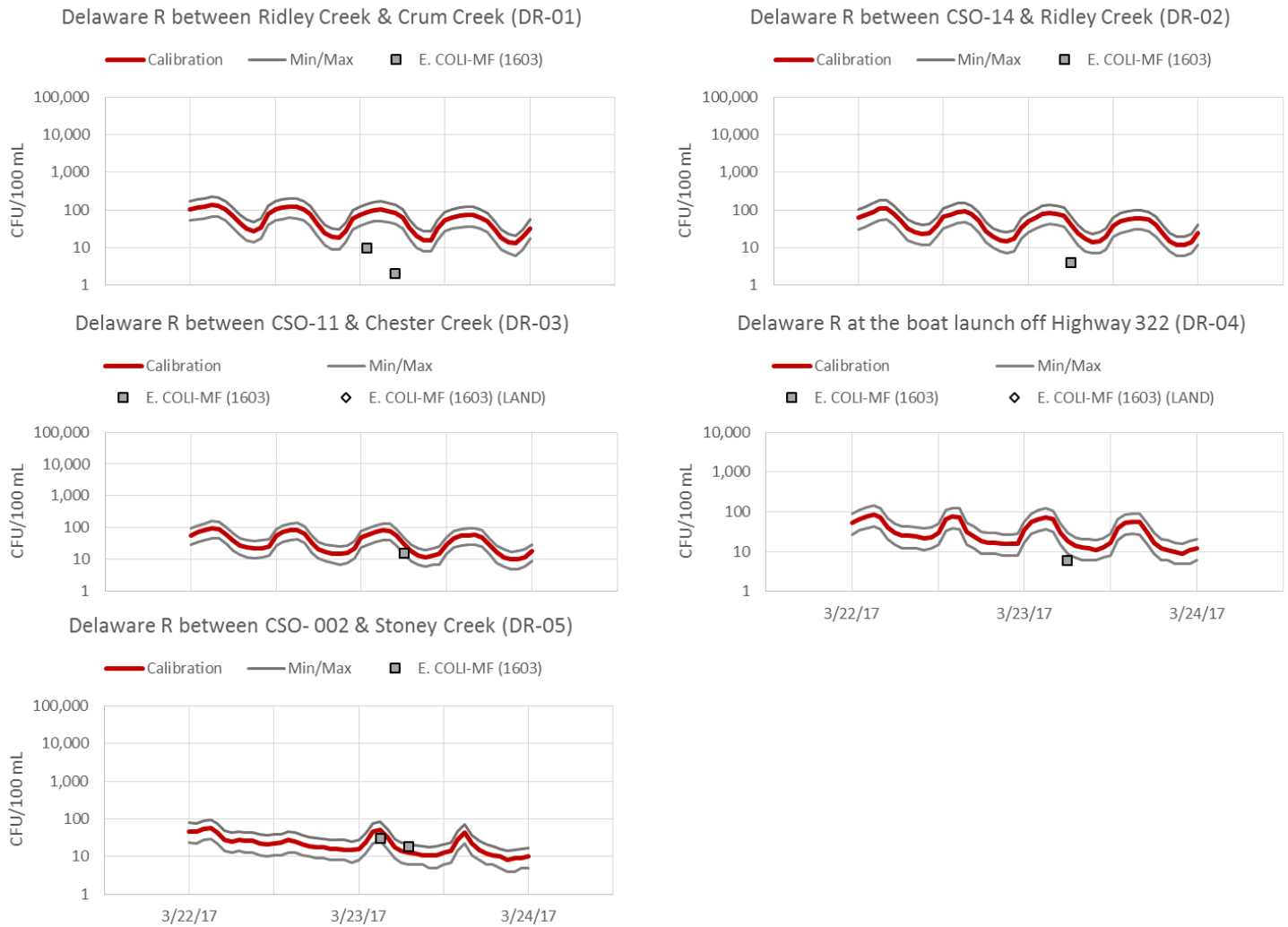


Figure 19. E. coli Calibration at Delaware River Stations (Dry Weather Event #1, 3/23/17)

Figure 20. E. coli Calibration at Delaware River Stations (Dry Weather Event #2, 5/10/17)

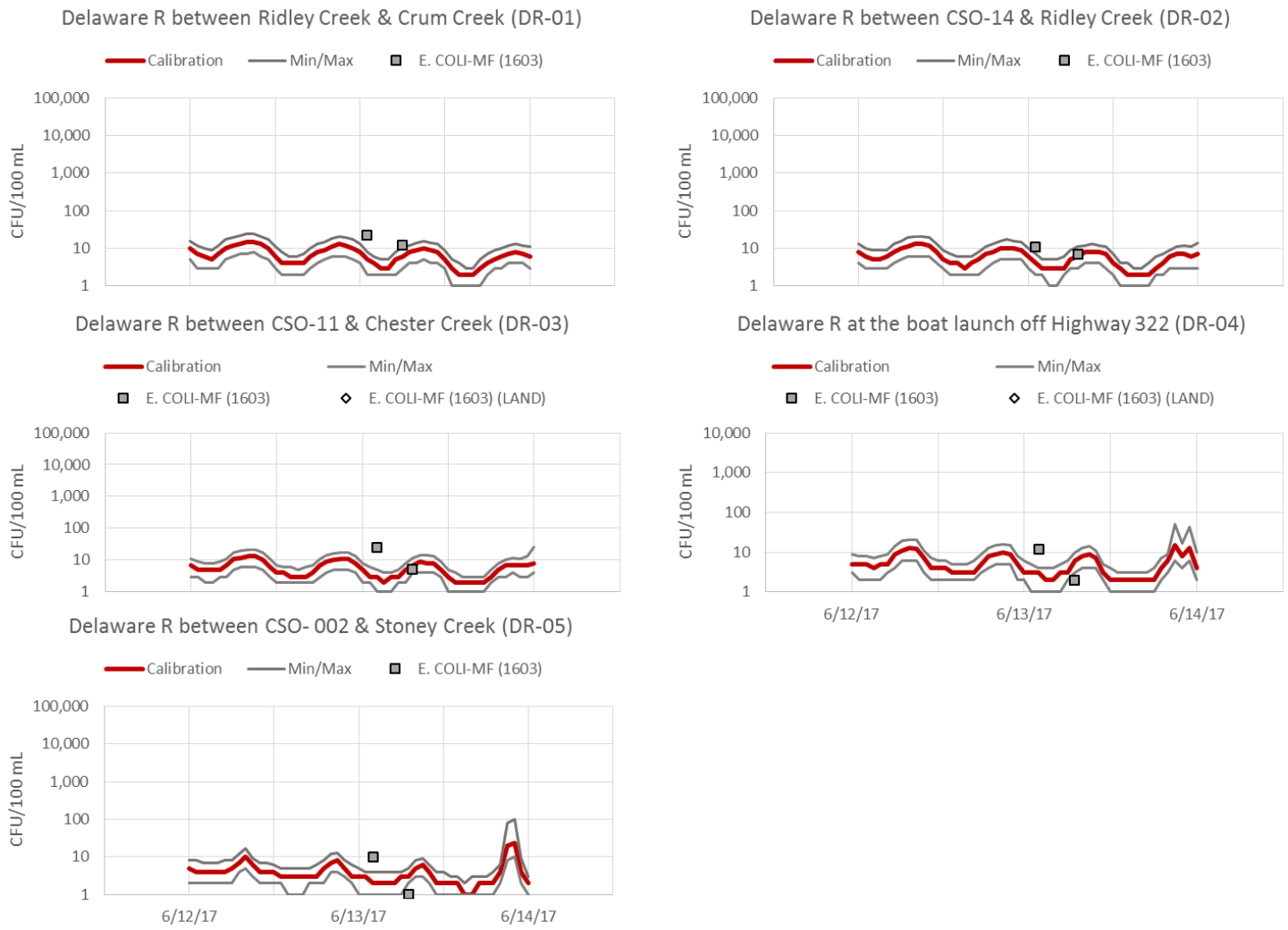


Figure 21. E. coli Calibration at Delaware River Stations (Dry Weather Event #3, 6/13/17)

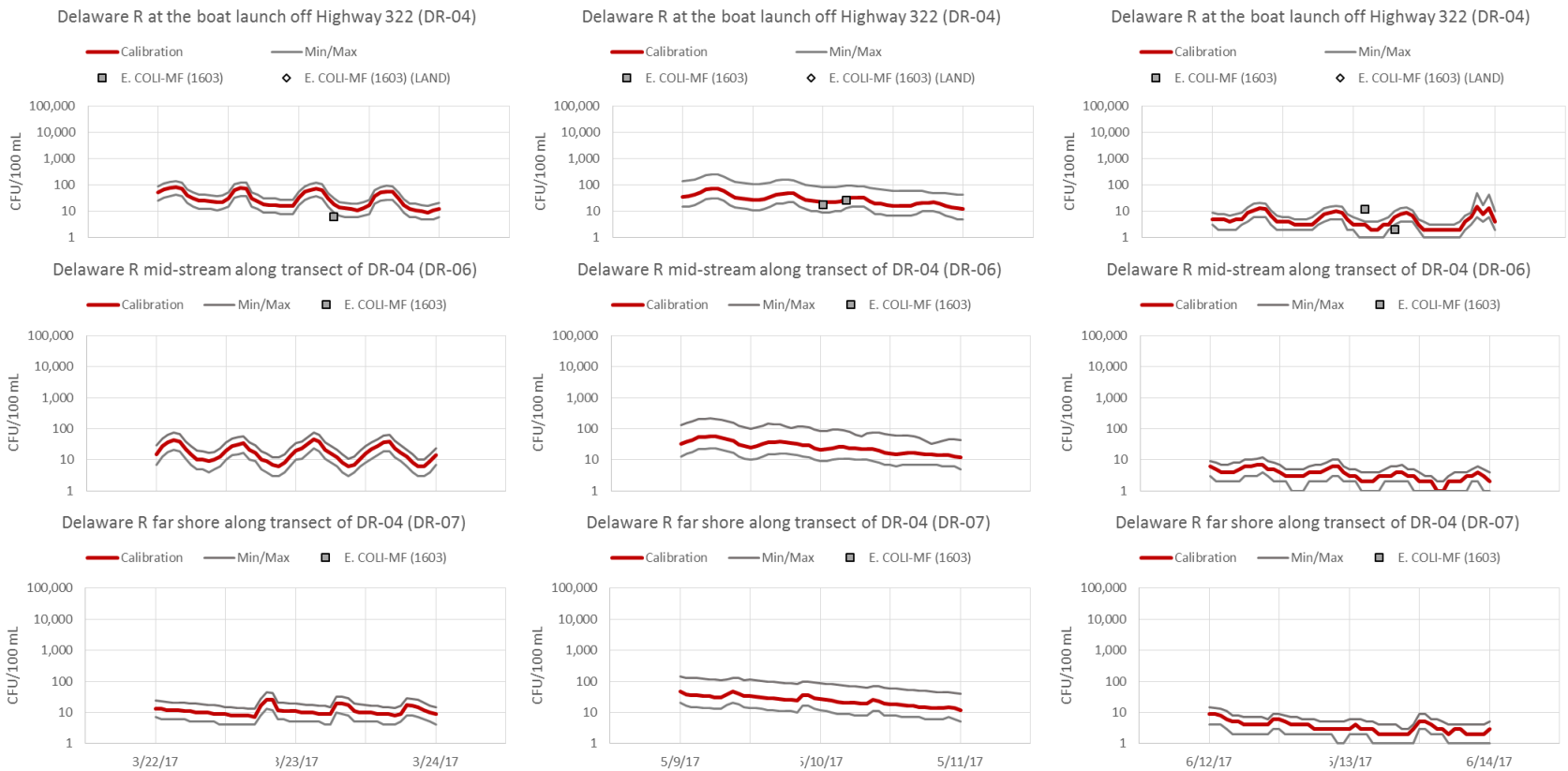


Figure 22. E. coli Calibration at Delaware River Cross Section (Dry Weather Events #1-3)

E. coli—2017 Wet Weather Calibration

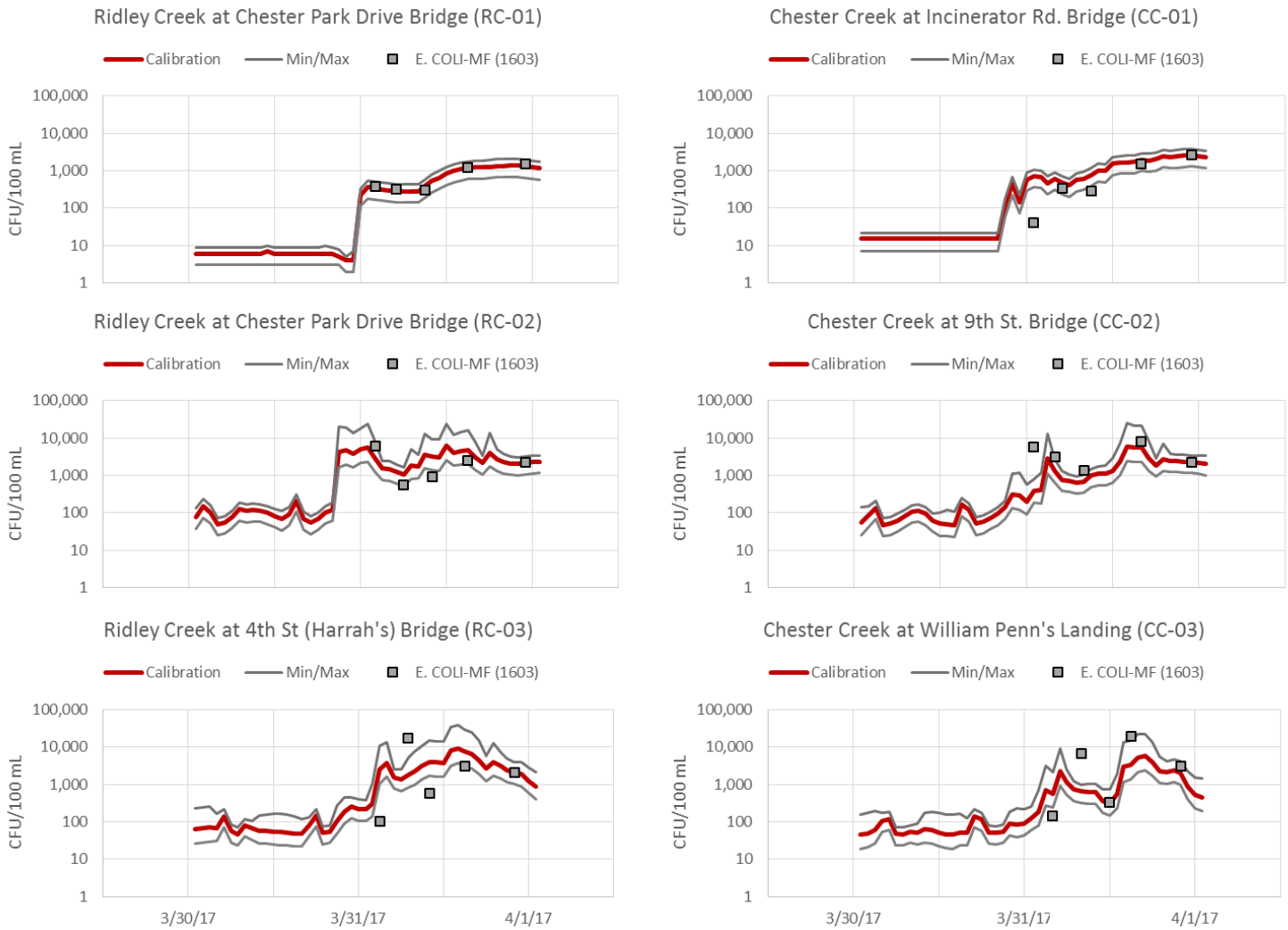


Figure 23. E. coli Calibration at Ridley Creek and Chester Creek Stations (Wet Weather Event #1, 3/30/17-4/1/17)

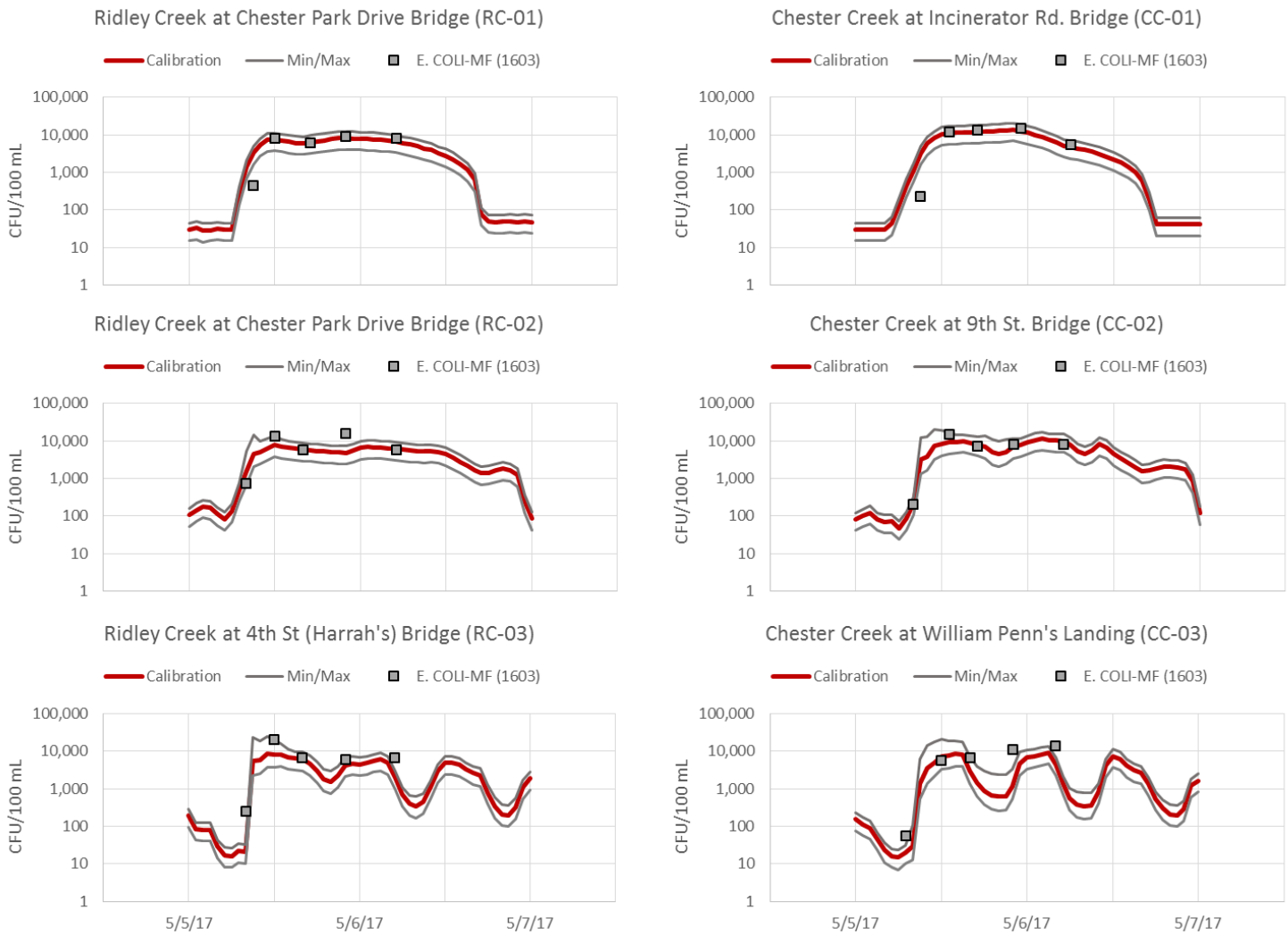


Figure 24. E. coli Calibration at Ridley Creek and Chester Creek Stations (Wet Weather Event #2, 5/5/17-5/6/17)

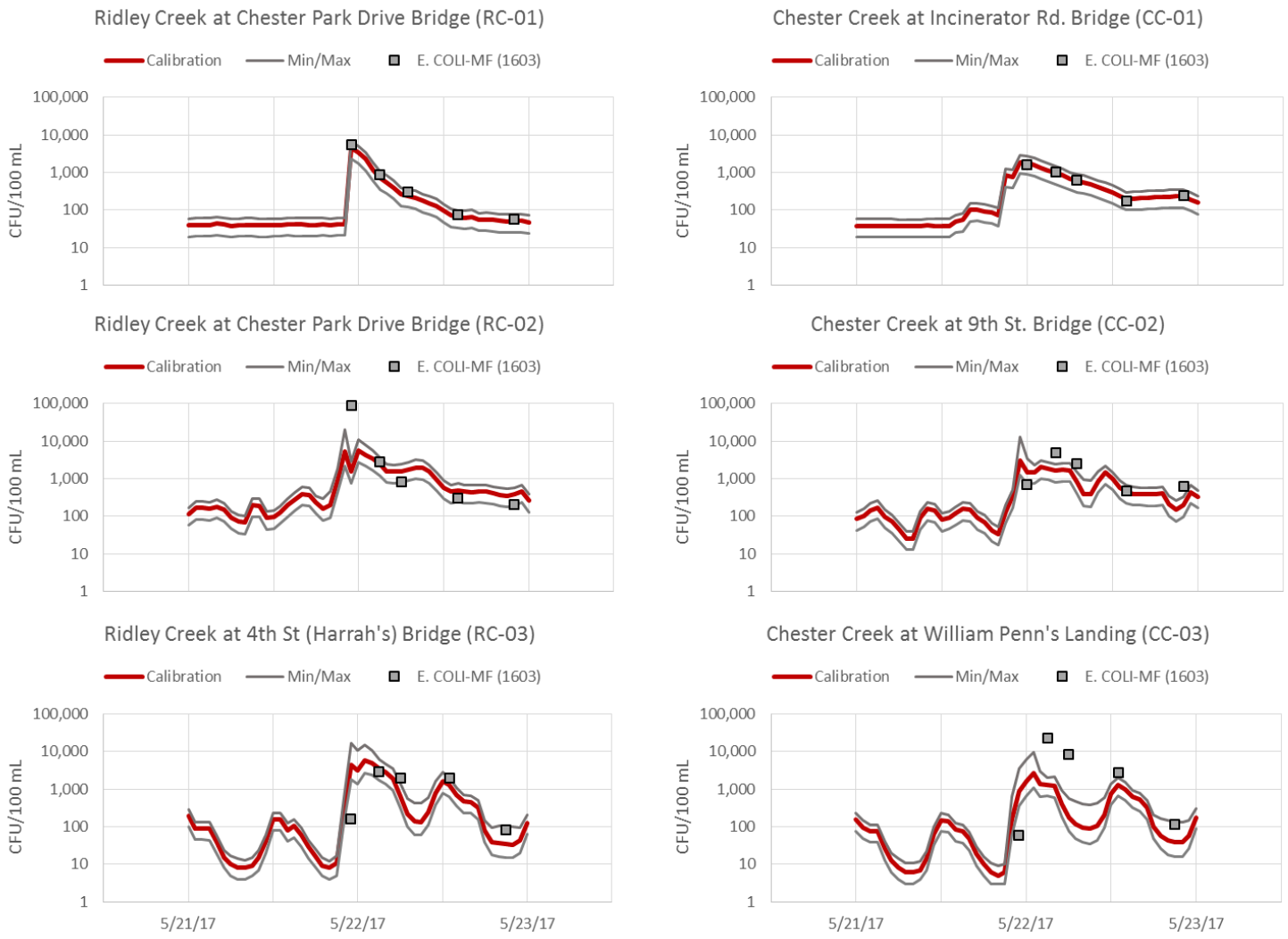


Figure 25. E. coli Calibration at Ridley Creek and Chester Creek Stations (Wet Weather Event #3, 5/22/17-5/23/17)

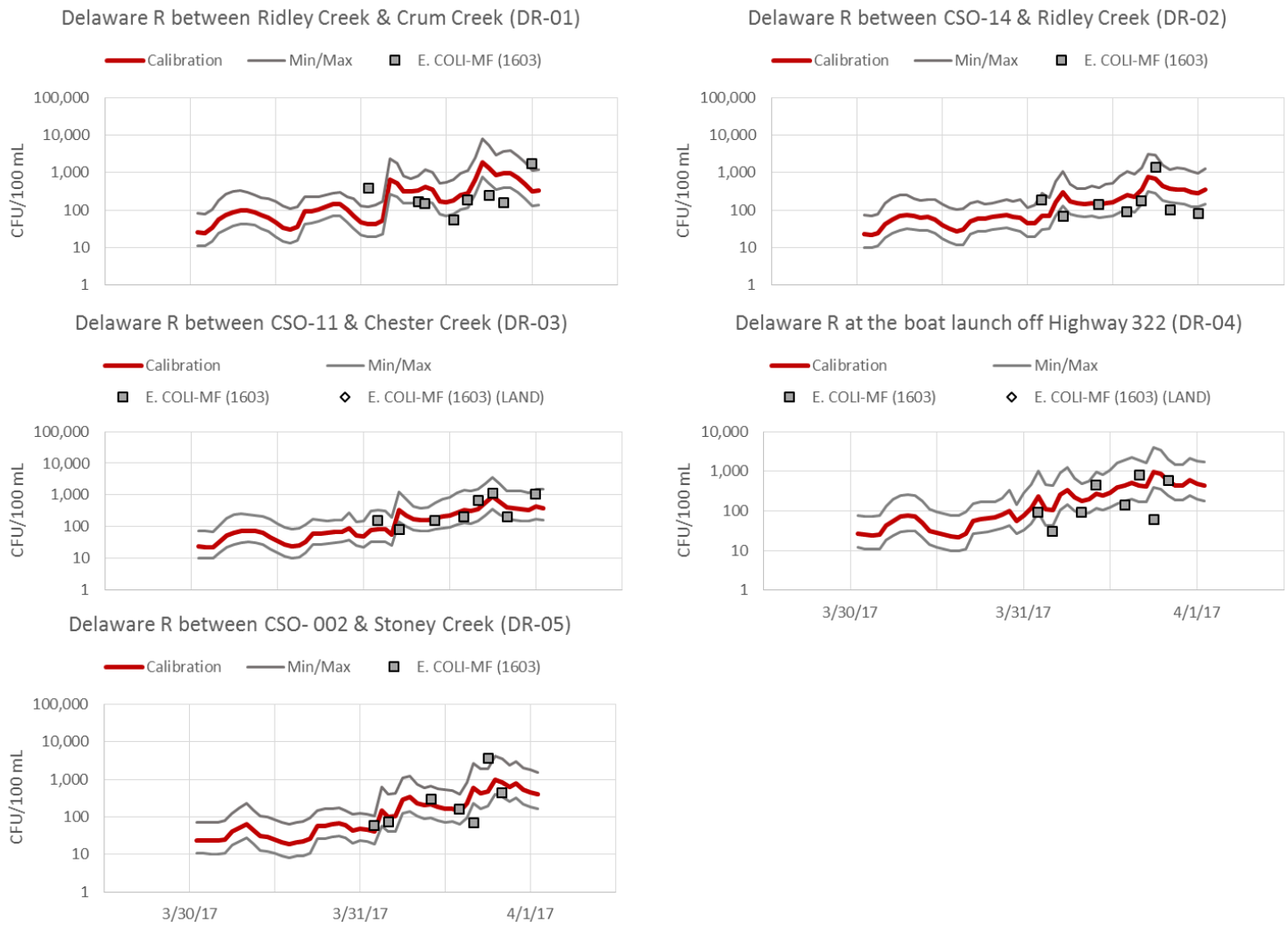


Figure 26. E. coli Calibration at Delaware River Stations (Wet Weather Event #1, 3/30/17-4/1/17)

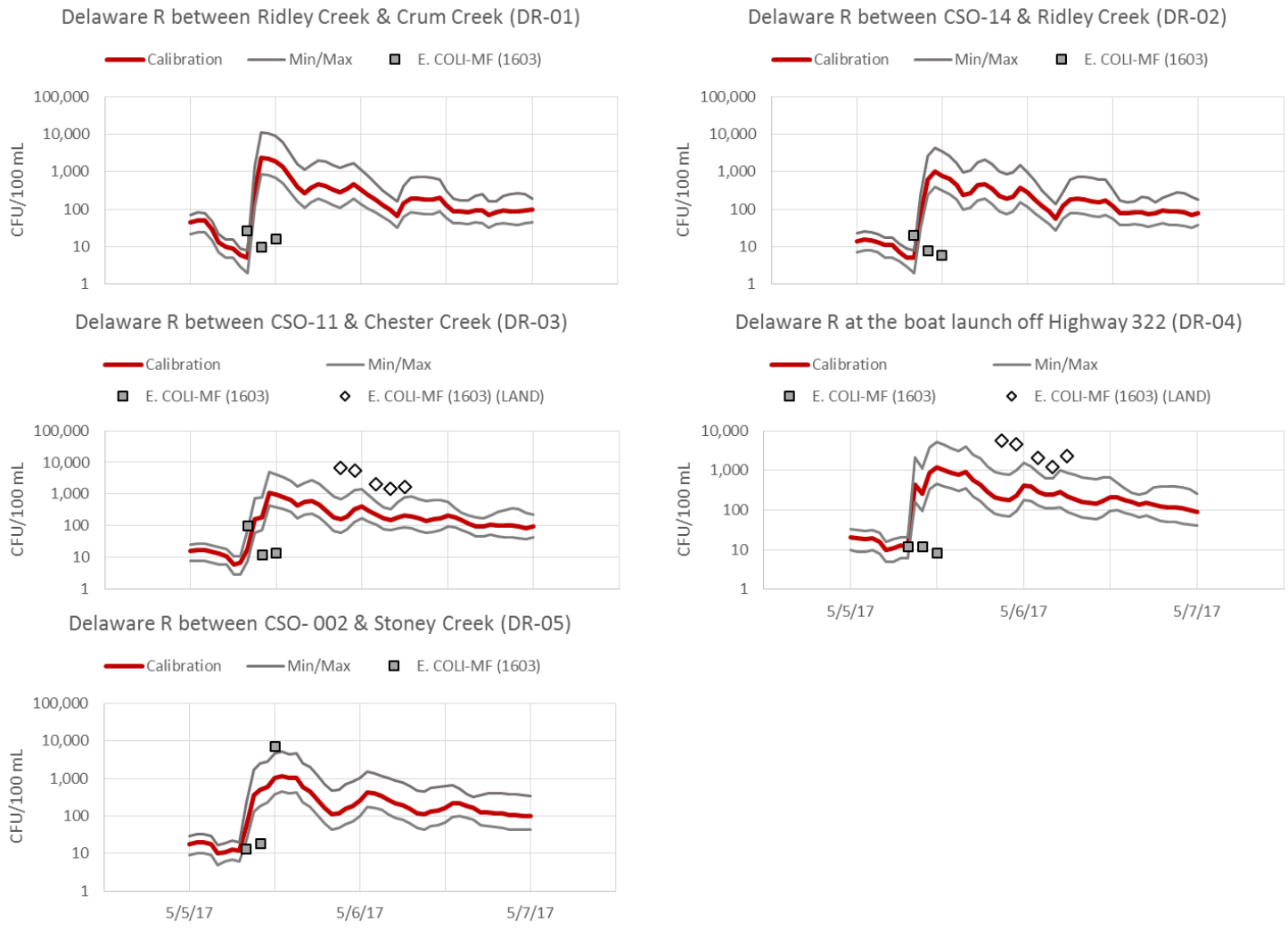


Figure 27. E. coli Calibration at Delaware River Stations (Wet Weather Event #2, 5/5/17-5/6/17)

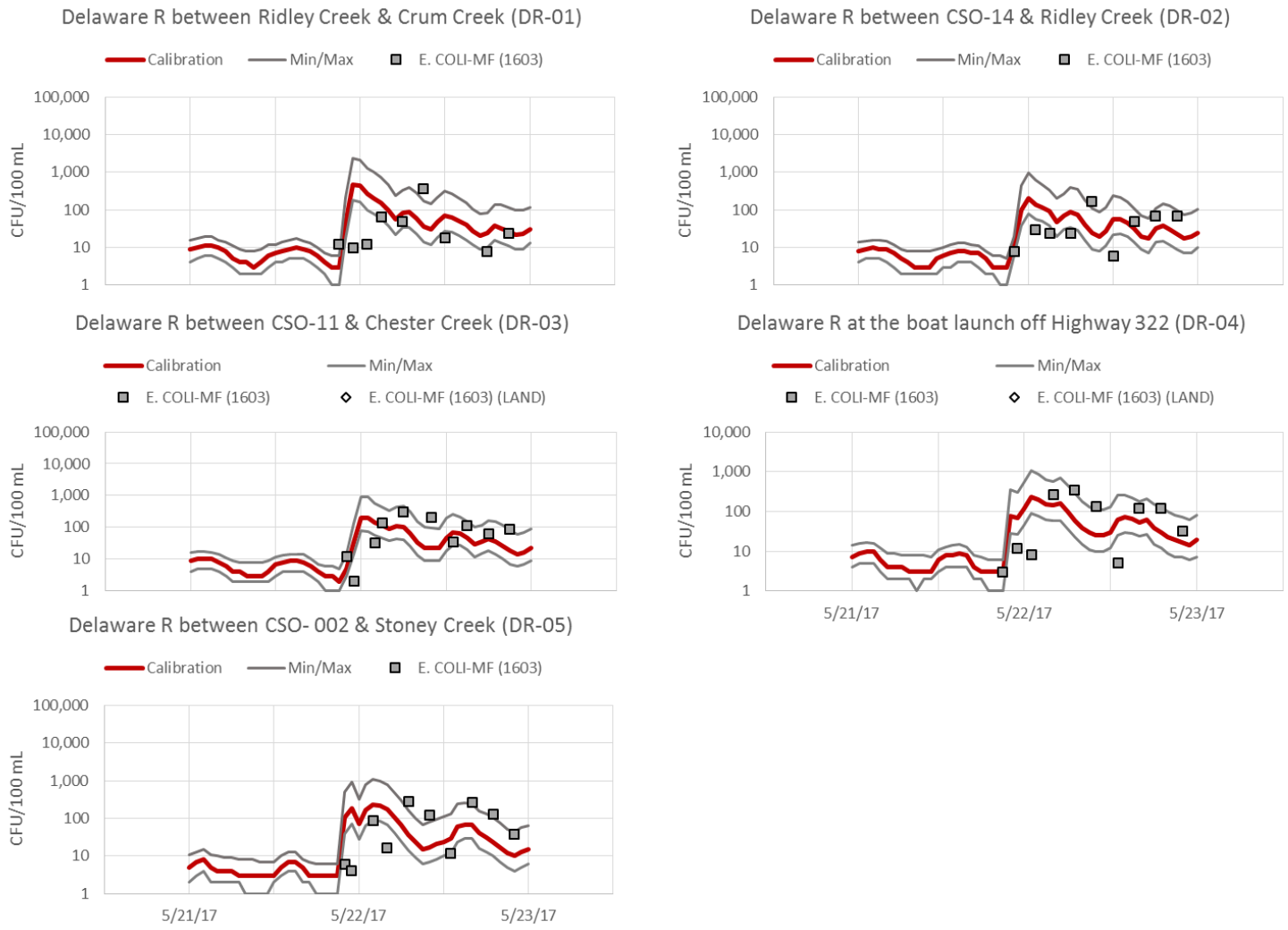


Figure 28. E. coli Calibration at Delaware River Stations (Wet Weather Event #3, 5/22/17-5/23/17)

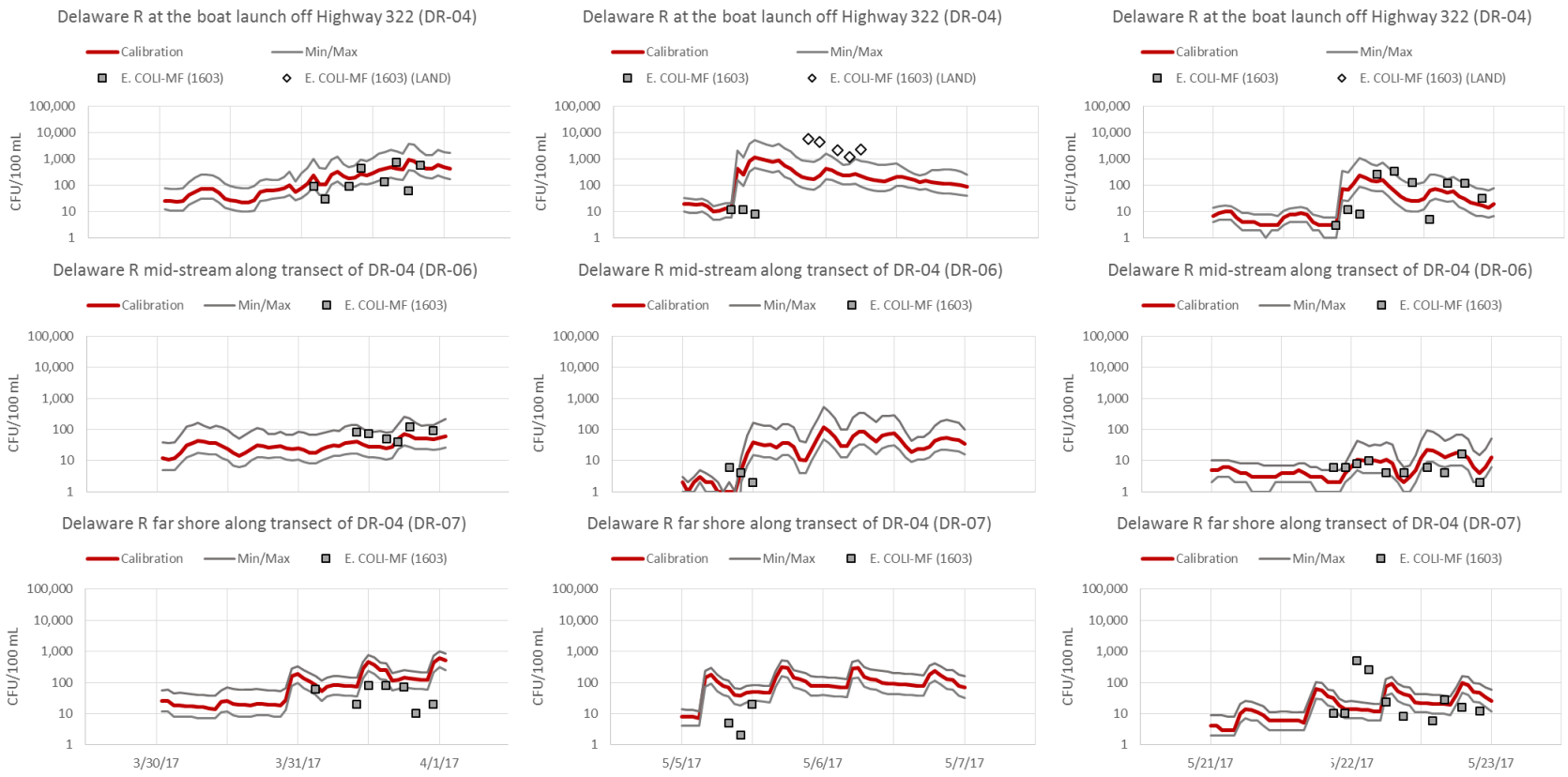


Figure 29. E. coli Calibration at Delaware River Cross Section (Wet Weather Events #1-3)

E. coli—2012 Model Validation

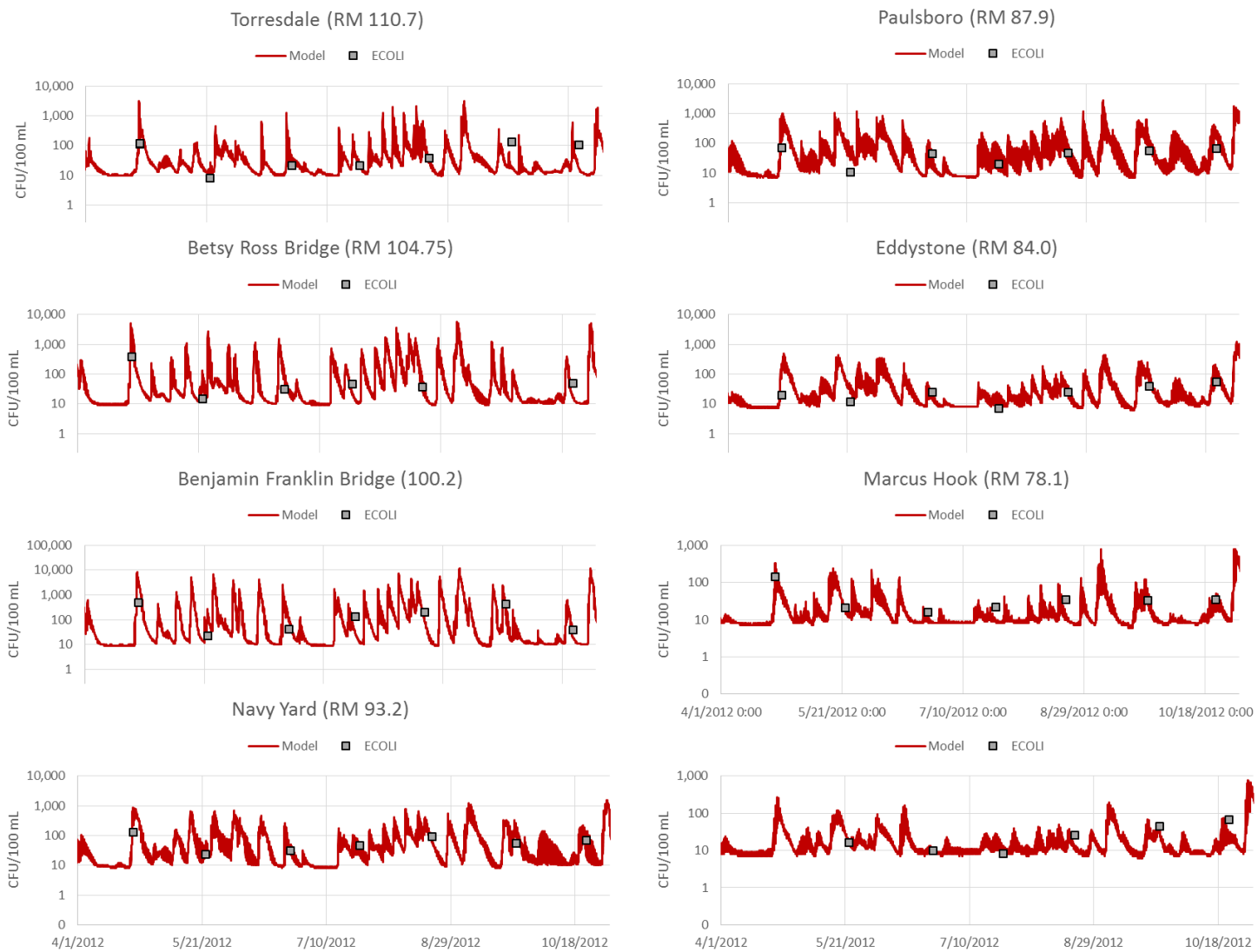


Figure 30. E. coli Model Validation at DRBC Delaware River Sampling Stations (2012)

Enterococcus

Enterococcus—2017 Dry Weather Calibration

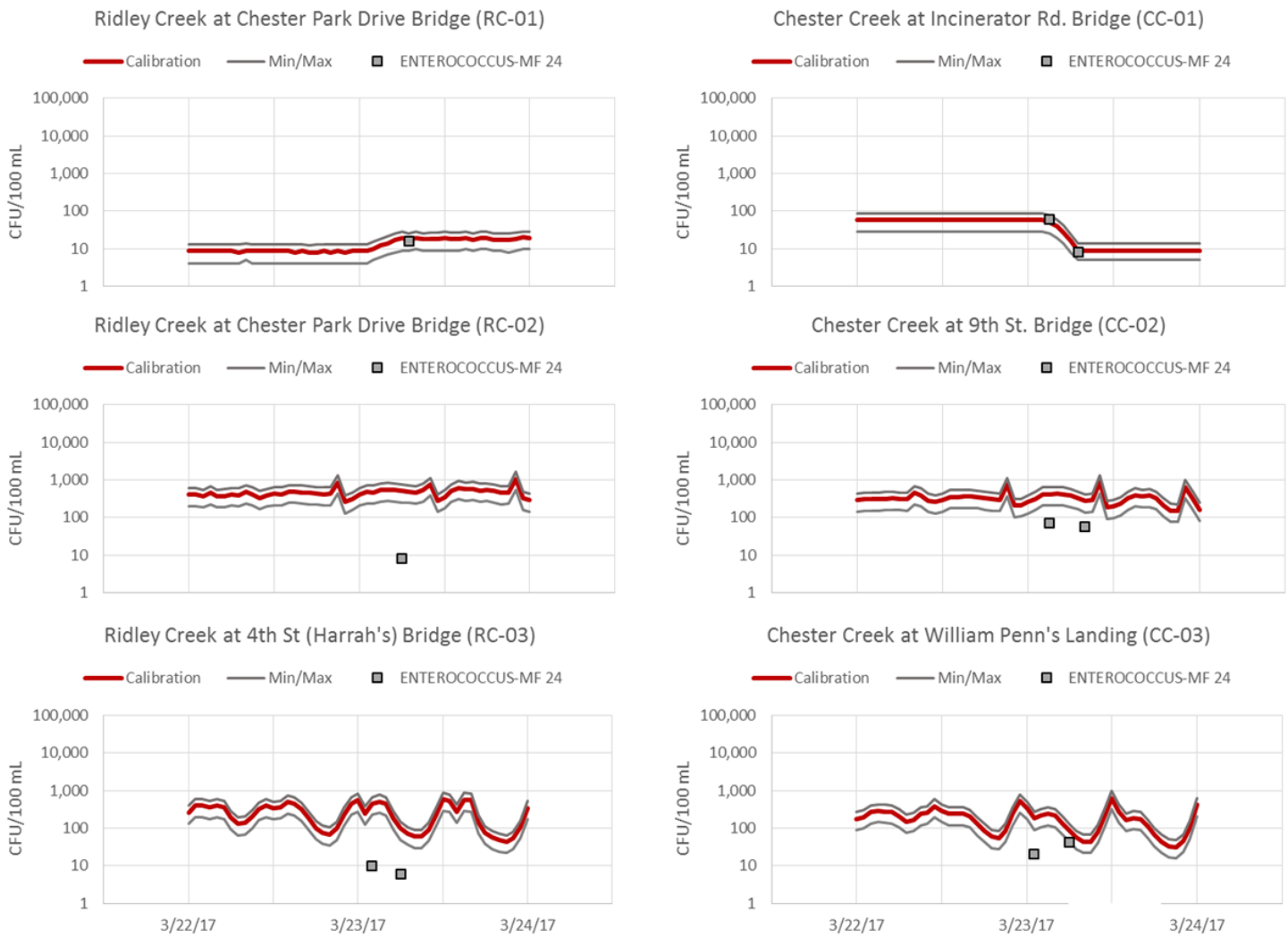


Figure 31. Enterococcus Calibration at Ridley Creek and Chester Creek Stations (Dry Weather Event #1, 3/23/17)

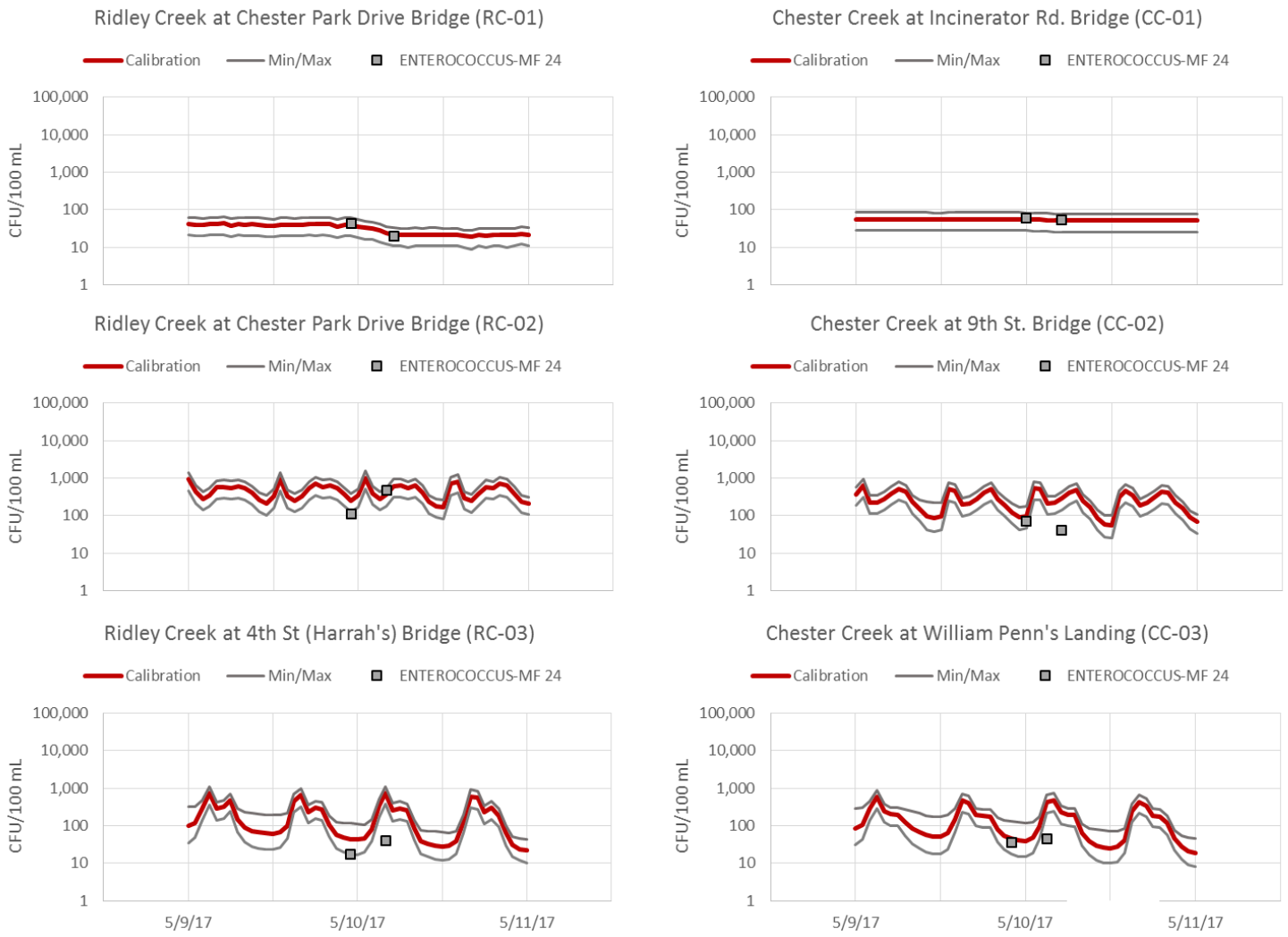


Figure 32. Enterococcus Calibration at Ridley Creek and Chester Creek Stations (Dry Weather Event #2, 5/10/17)

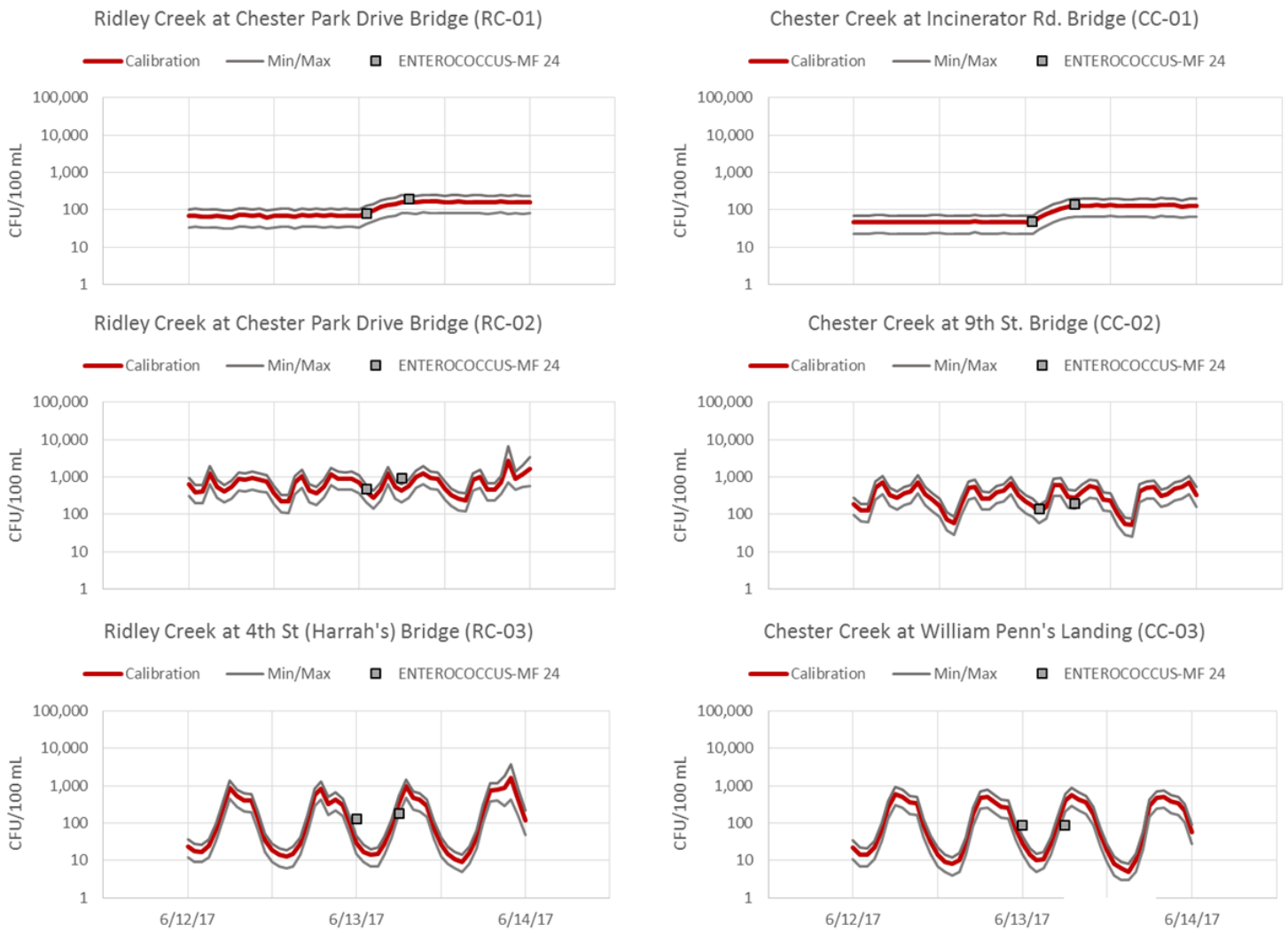


Figure 33. Enterococcus Calibration at Ridley Creek and Chester Creek Stations (Dry Weather Event #3, 6/13/17)

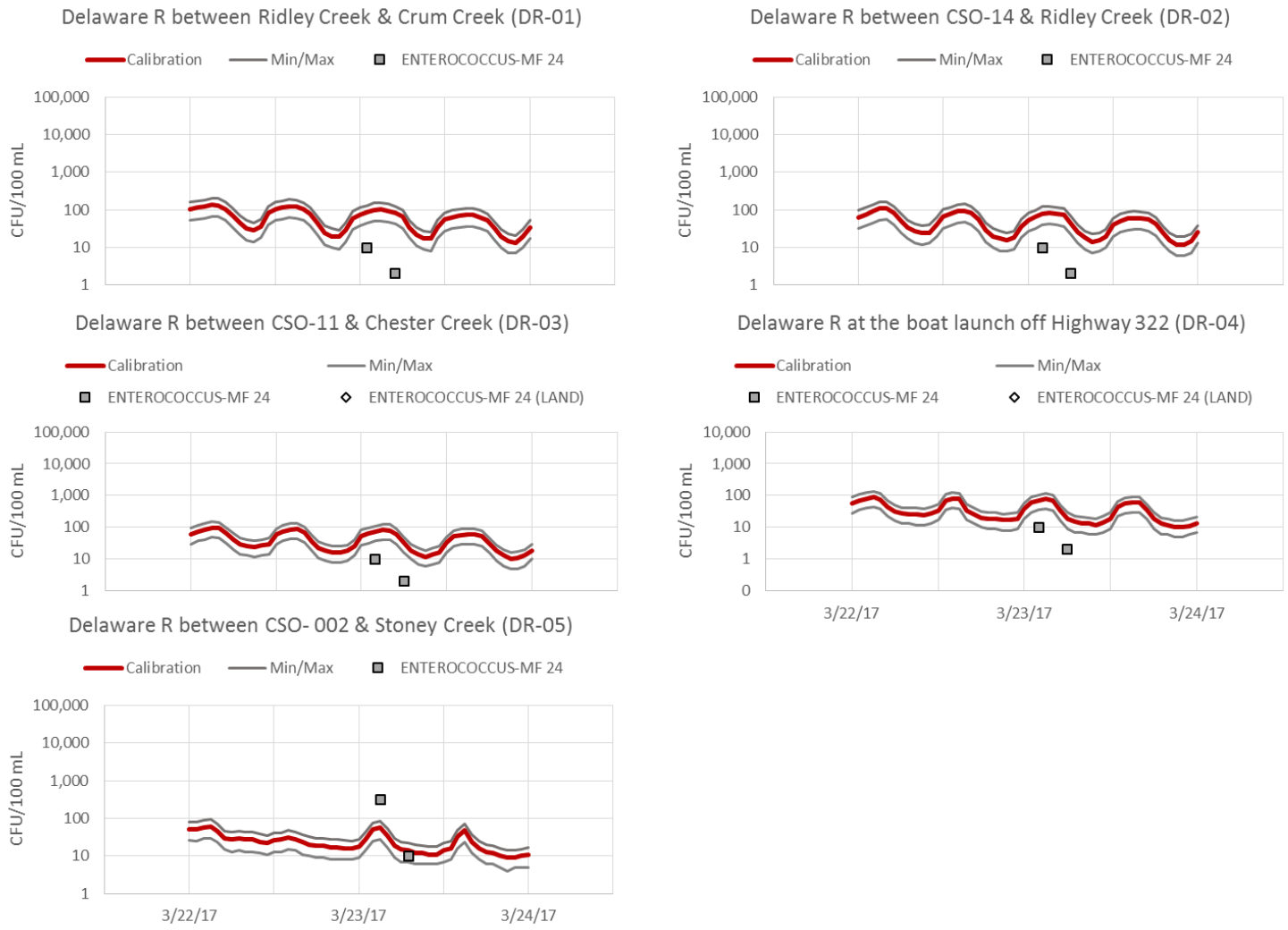


Figure 34. Enterococcus Calibration at Delaware River Stations (Dry Weather Event #1, 3/23/17)

Figure 35. Enterococcus Calibration at Delaware River Stations (Dry Weather Event #2, 5/10/17)

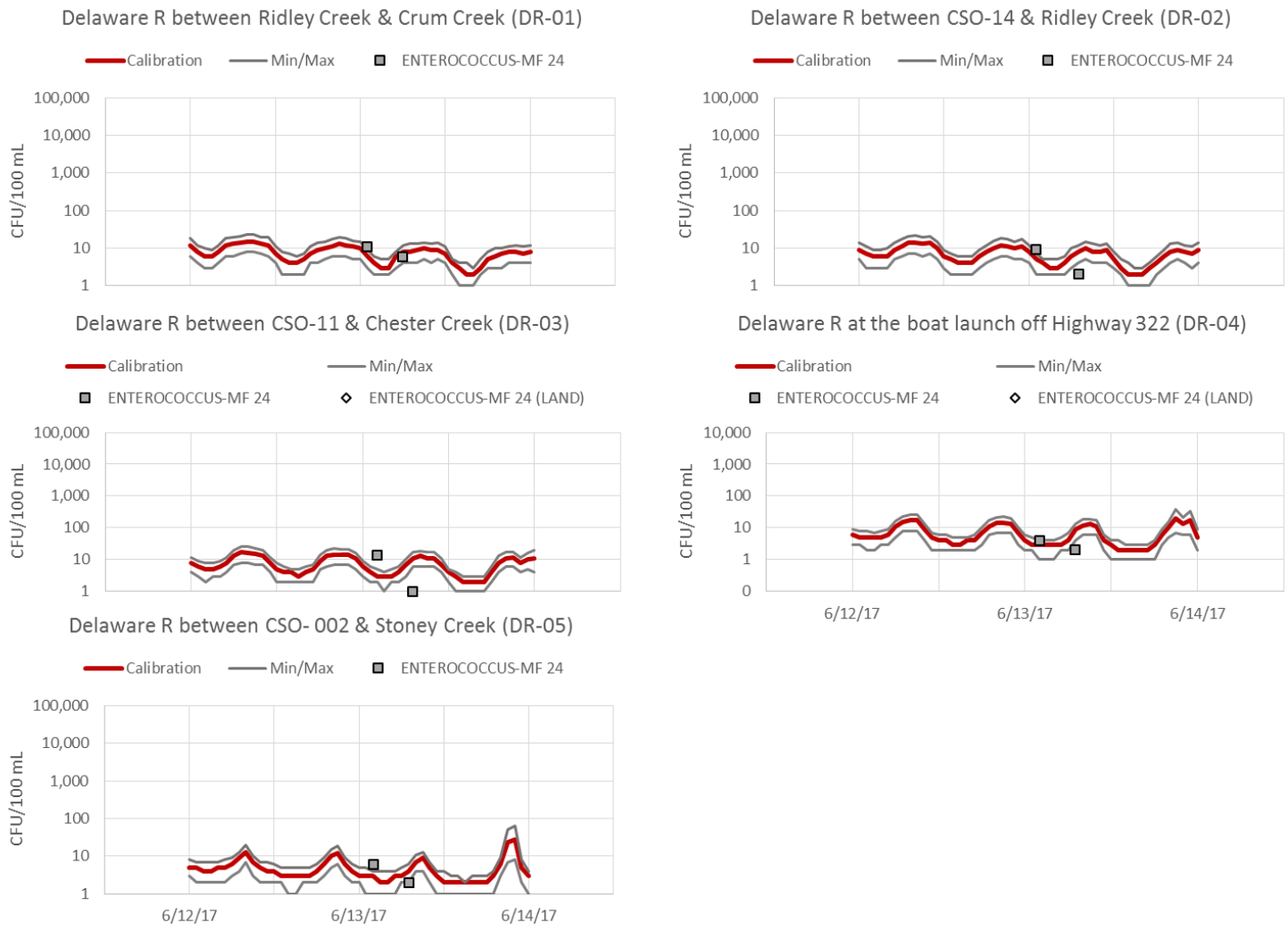


Figure 36. Enterococcus Calibration at Delaware River Stations (Dry Weather Event #3, 6/13/17)

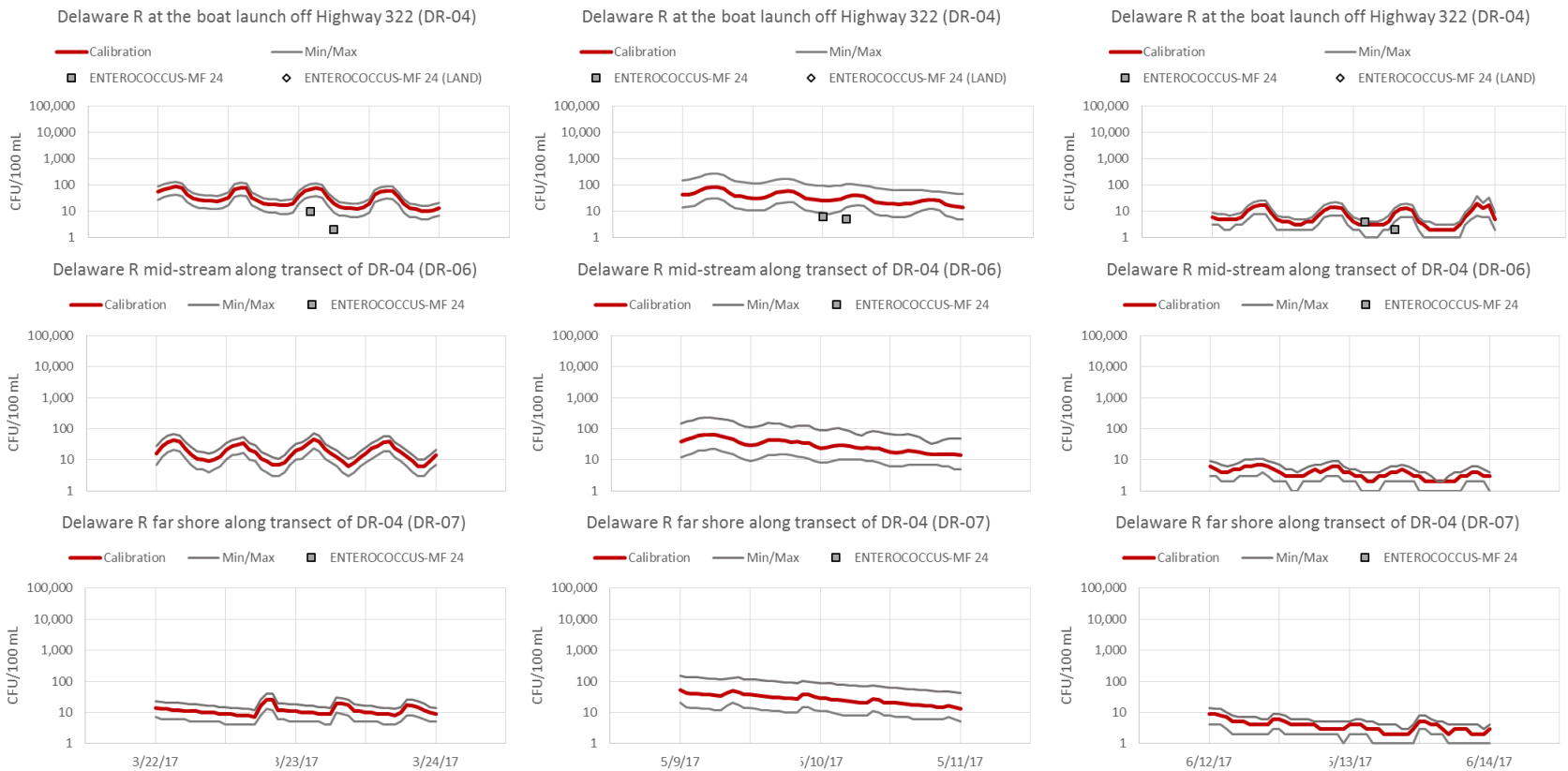


Figure 37. Enterococcus Calibration at Delaware River Cross Section (Dry Weather Events #1-3)

Enterococcus—2017 Wet Weather Calibration

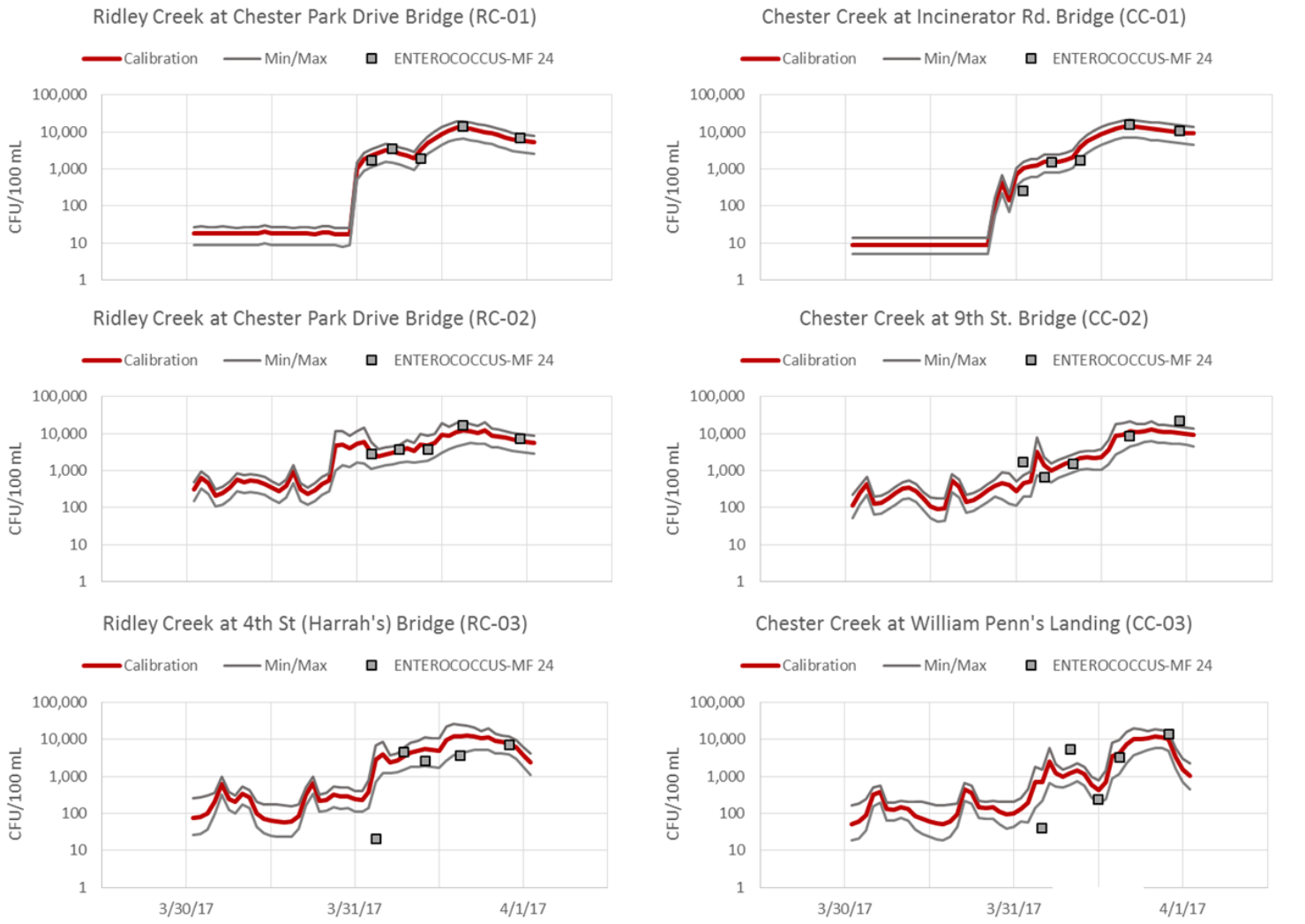


Figure 38. Enterococcus Calibration at Ridley Creek and Chester Creek Stations (Wet Weather Event #1, 3/30/17-4/1/17)

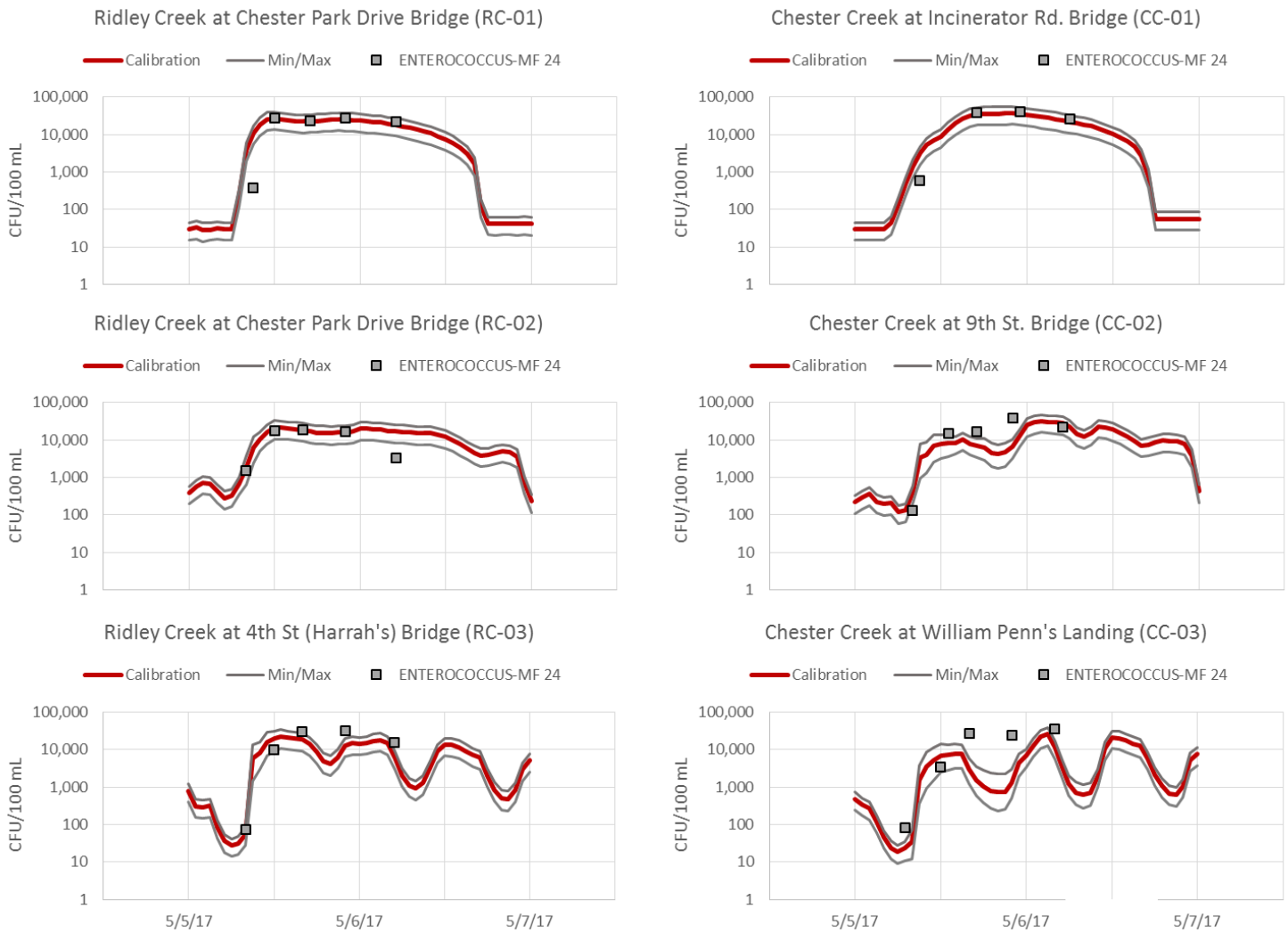


Figure 39. Enterococcus Calibration at Ridley Creek and Chester Creek Stations (Wet Weather Event #2, 5/5/17-5/6/17)

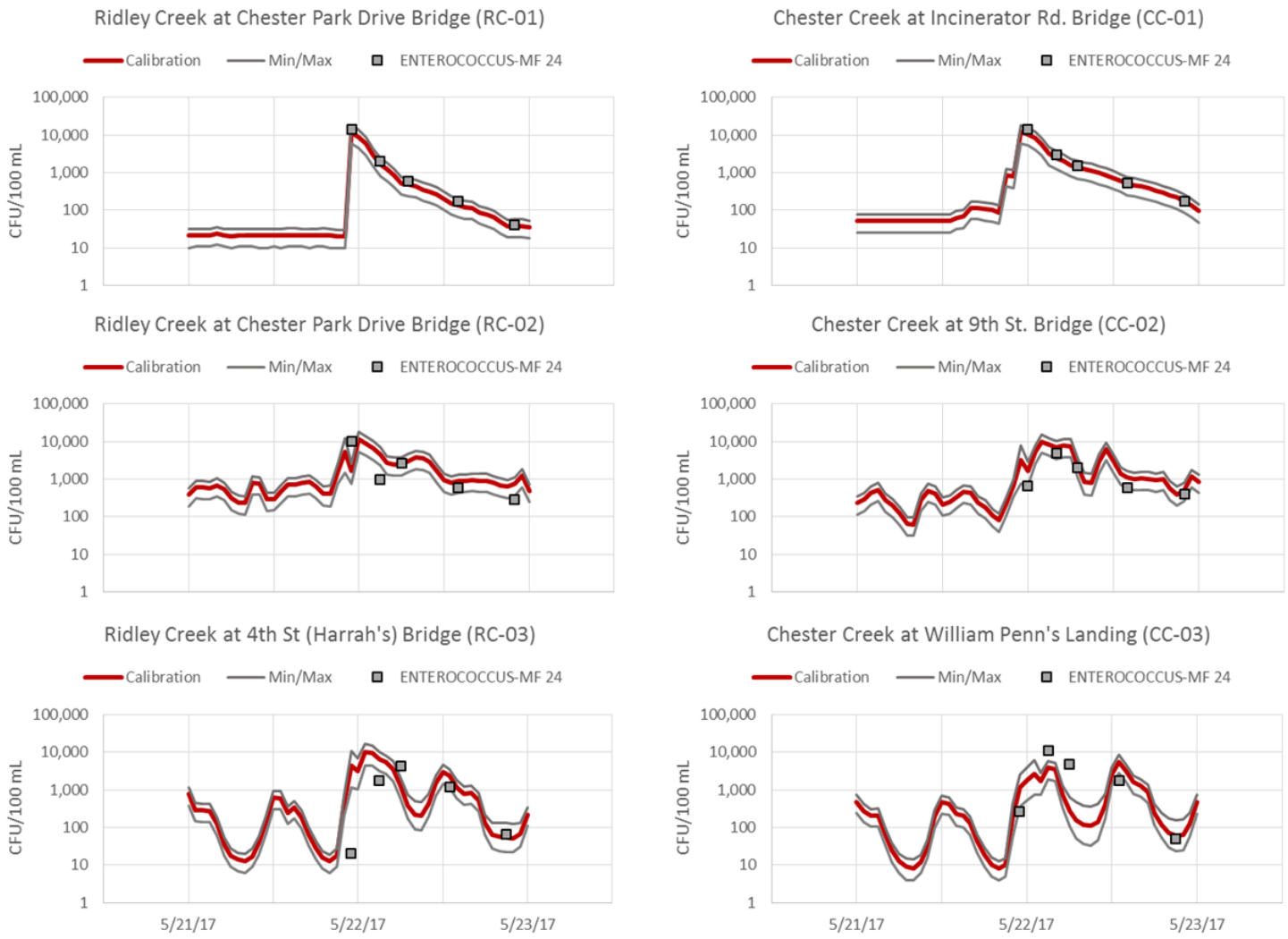


Figure 40. Enterococcus Calibration at Ridley Creek and Chester Creek Stations (Wet Weather Event #3, 5/22/17-5/23/17)

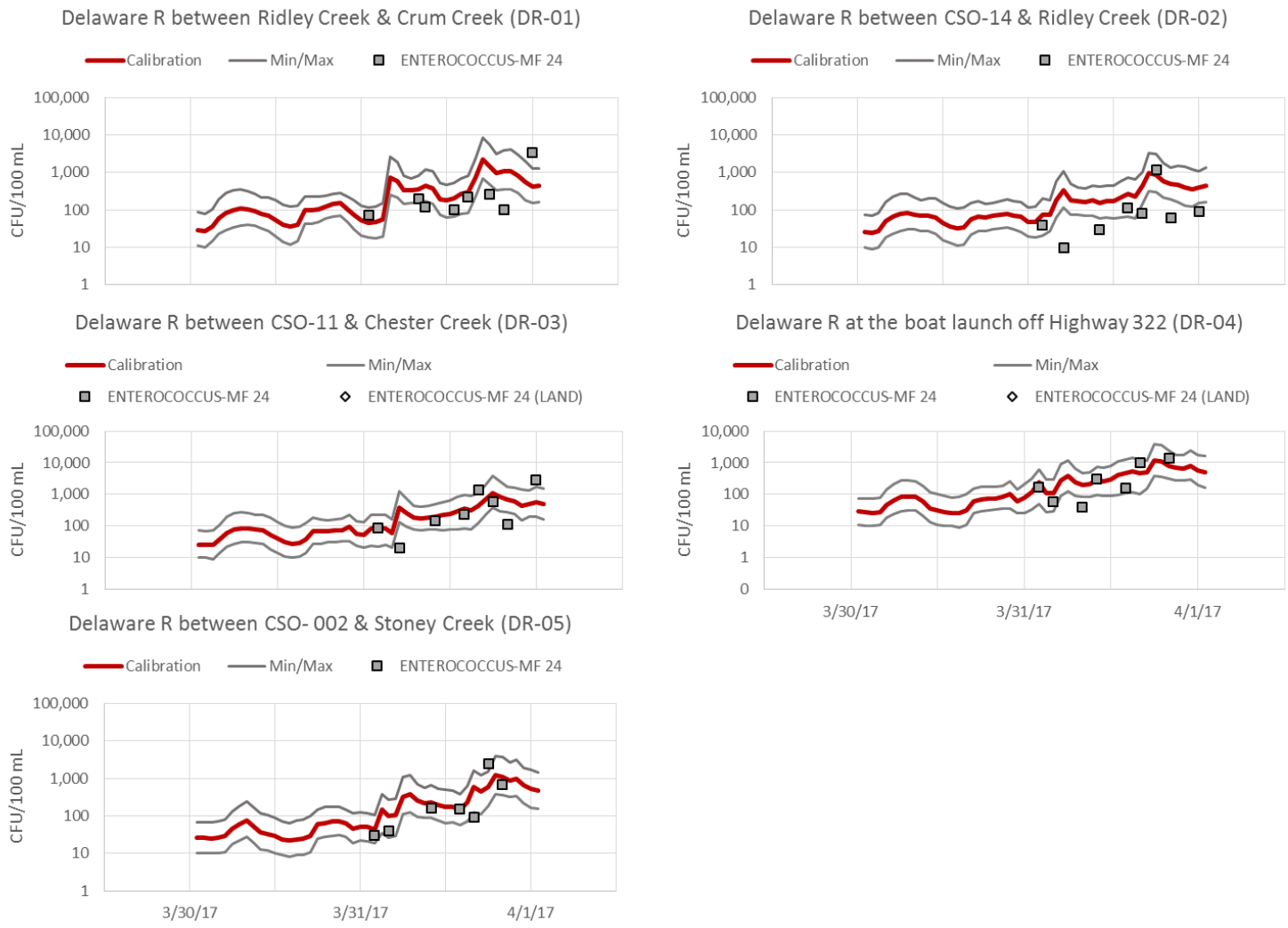


Figure 41. Enterococcus Calibration at Delaware River Stations (Wet Weather Event #1, 3/30/17-4/1/17)

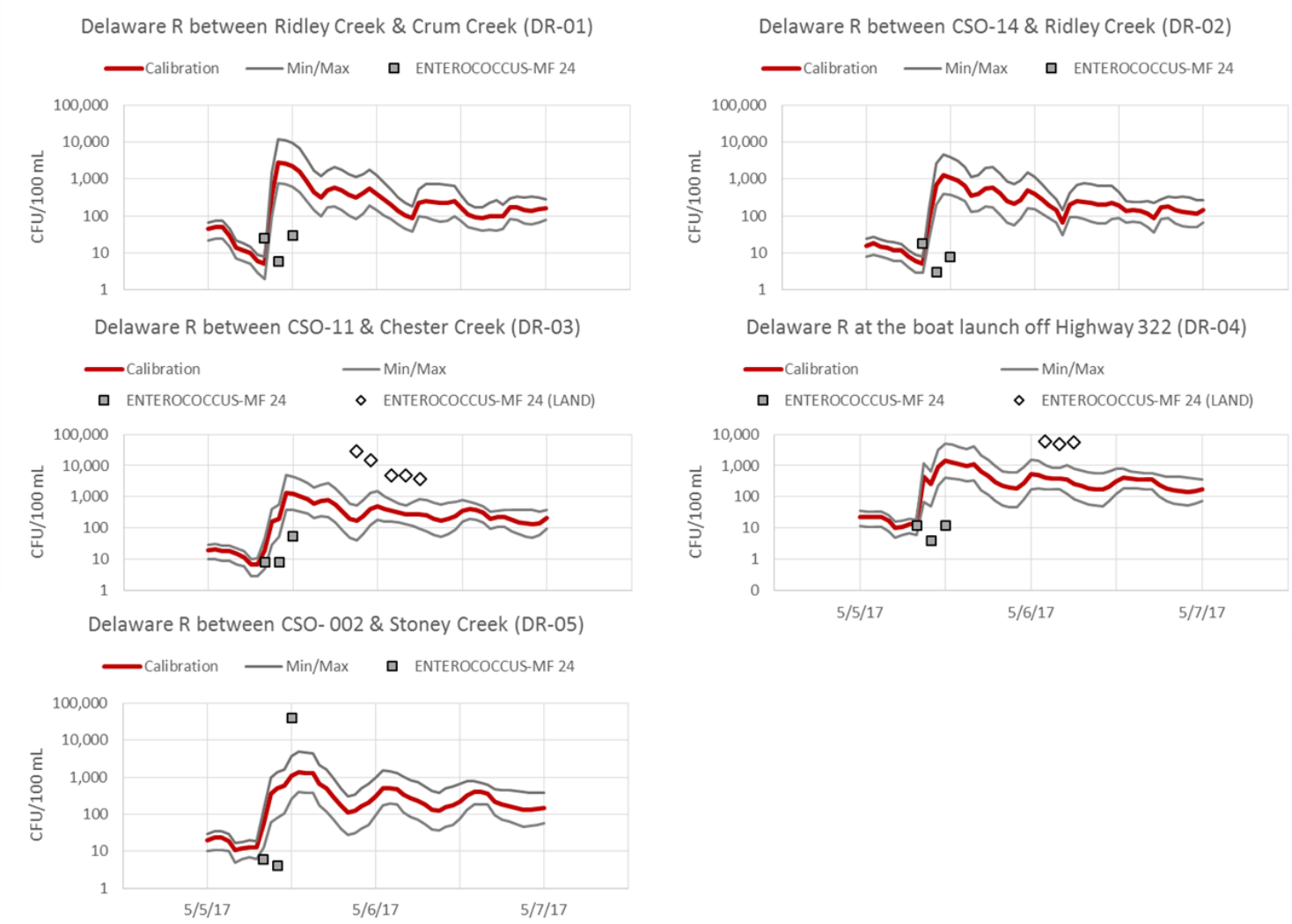


Figure 42. Enterococcus Calibration at Delaware River Stations (Wet Weather Event #2, 5/5/17-5/6/17)

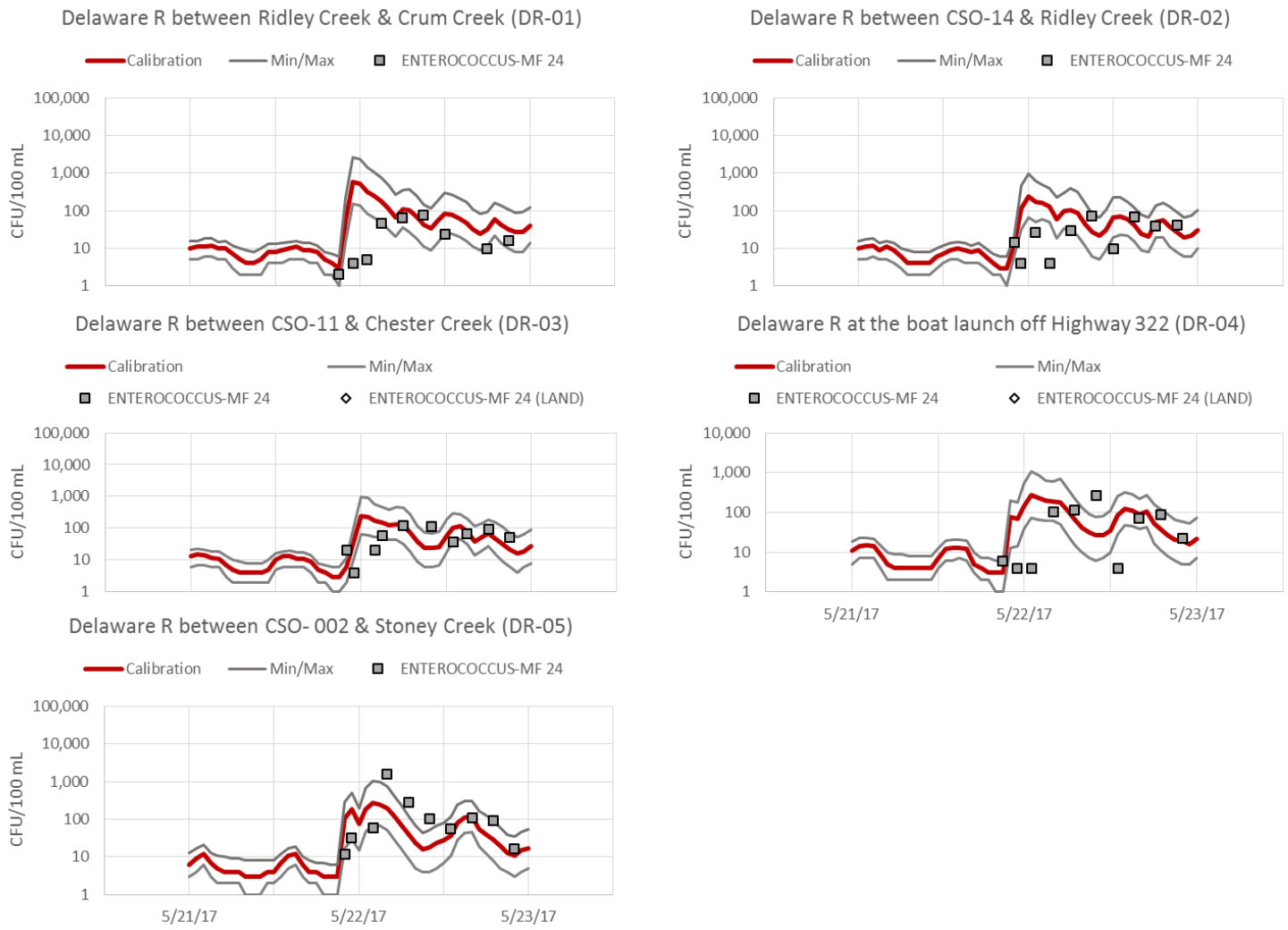


Figure 43. Enterococcus Calibration at Delaware River Stations (Wet Weather Event #3, 5/22/17-5/23/17)

Figure 44. Enterococcus Calibration at Delaware River Cross Section (Wet Weather Events #1-3)

Enterococcus—2012 Model Validation

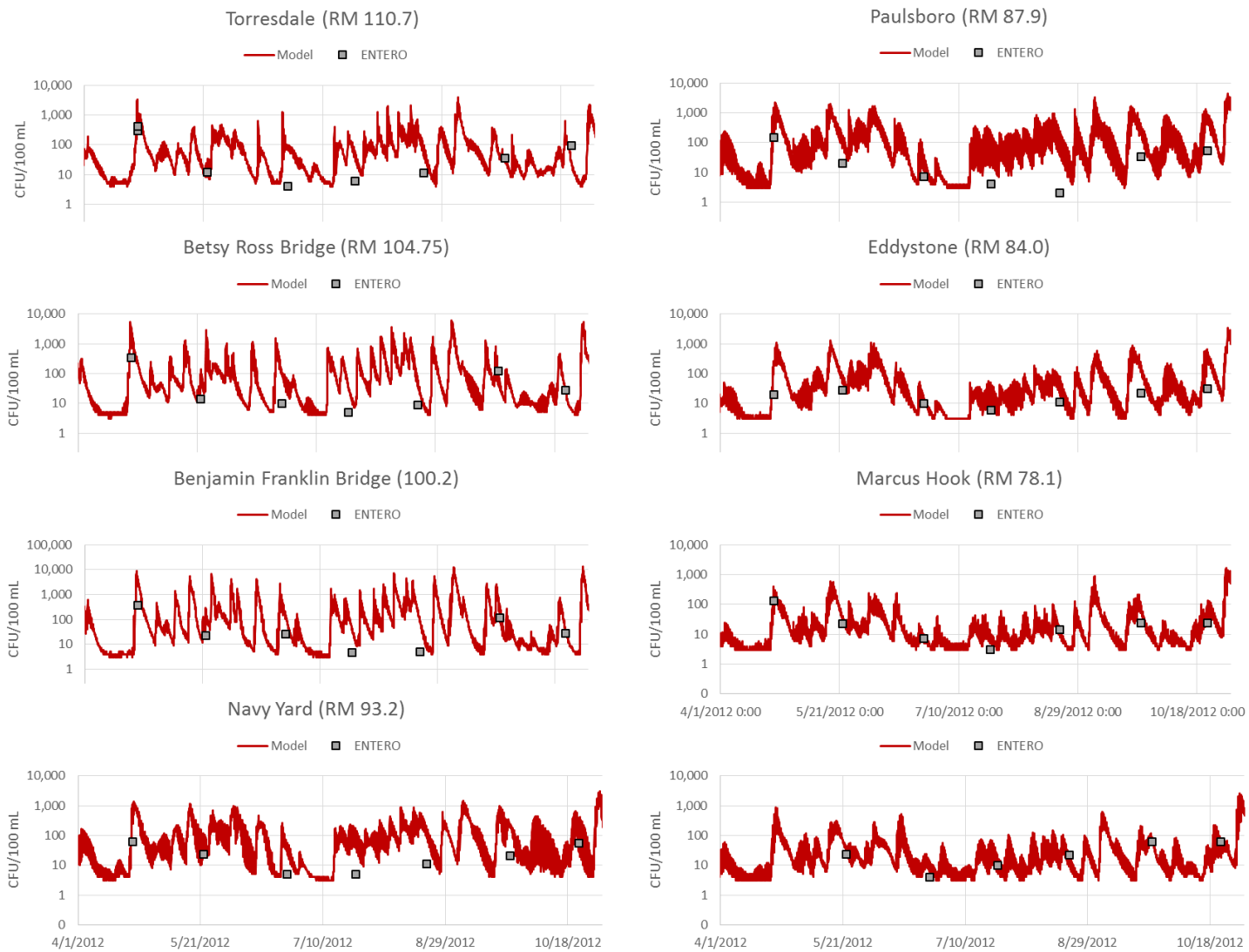


Figure 45. Enterococcus Model Validation at DRBC Delaware River Sampling Stations (2012)

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Orig. M. DiSantis

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4/17/2018

Mr. Michael DiSantis, Director of Operations & Maintenance
Delaware County Regional Water Quality Control Authority
100 East Fifth Street
Chester, PA 19013

RE: Civil Action 2:15-cv-04652-RB

Dear Mr. DeSantis:

The United States Environmental Protection Agency (EPA) has received the Delaware County Regional Quality Regional Water Quality Control Authority (DELCORA) Water Quality Model Report dated February 27, 2018. EPA has consulted with the Pennsylvania Department of the Environment (PaDEP). EPA accepts and approves the subject report.

Sincerely,

Andrew F. Seligman, Environmental Scientist
Water Enforcement Branch

cc: P. Yeany, EPA
Tom Magee, PaDEP, SERO
C. Hurst, DELCORA

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