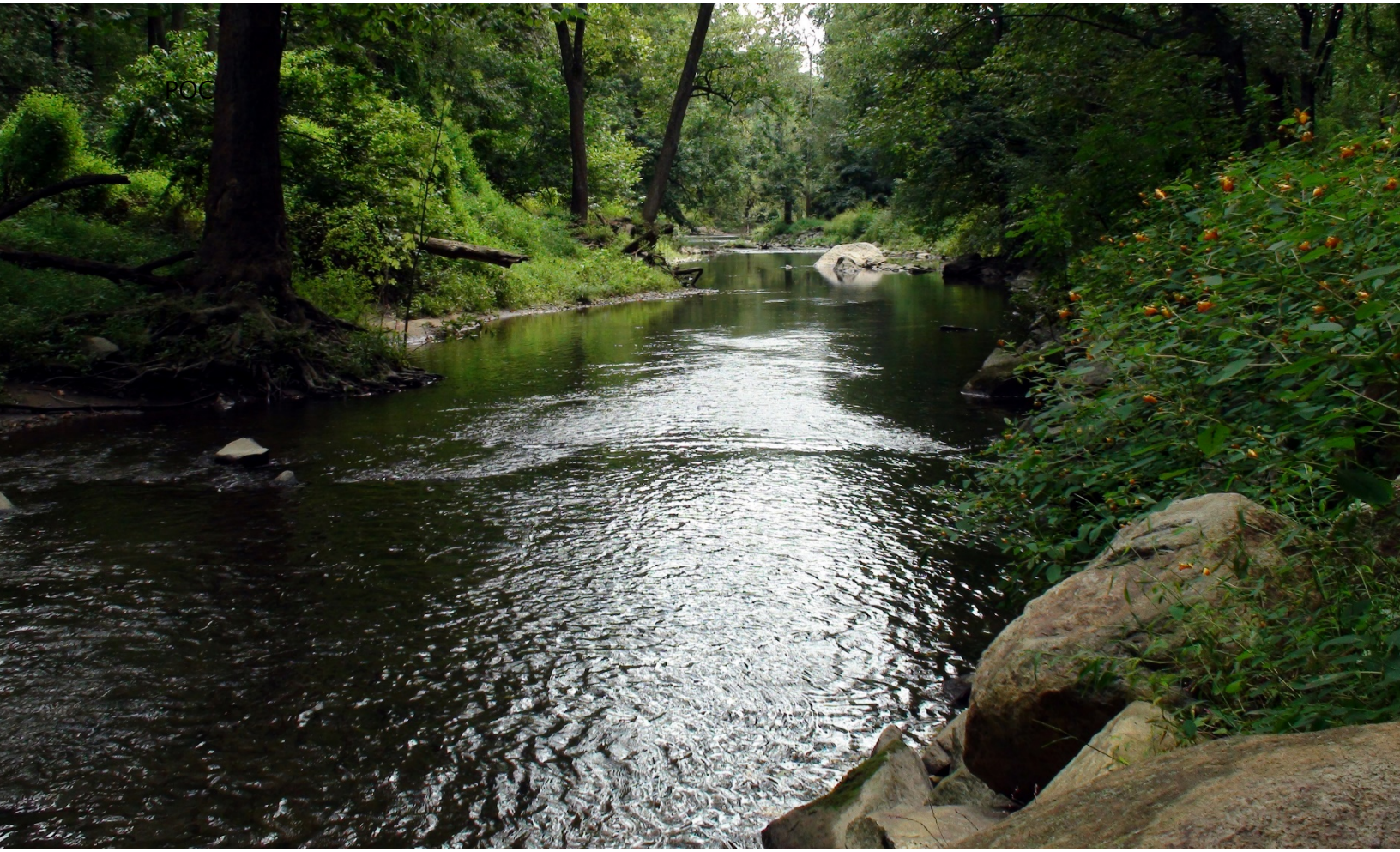

Delaware County Regional Water Quality Control Authority (DELCORA)

CSO Long-Term Control Plan Update

APPENDICES
VOLUME 2 of 4

December 11, 2025

DELCORA | TYLin

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APPENDICES

This Long Term Control Plan Update was developed as a series of technical reports submitted to the USEPA and/or PADEP for their review and comment. Although these documents served as the basis for the final LTCPU, specific aspects of the final LTCPU Report have changed since the original technical reports were written. As such, these reference documents included as appendices here can be used to gain a deeper understanding of the methodologies used in

developing the Final LTCPU Report. Appendix Z has been included as a reference for the reader to follow the history of the LTCPU.

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Appendix A - Alternatives Evaluation Approach Report (Final), April 2016

Appendix B - Applicable Water Quality Standards Master Table

Appendix C - Identification of Sensitive Areas and Pollutants of Concern Report, May 2016

Appendix D - Hydrologic and Hydraulic Model Update and Calibration Plan (Final), October 2015

Appendix E - Typical Hydrologic Period Report (Final), Updated April 2016

Appendix F - Sewer System Hydrologic and Hydraulic Model Report, June 2017 with revised Appendix C updated March 1, 2018 to address USEPA comments

Appendix G - Rainfall and Flow Monitoring Quarterly Reports:

Quarterly Report No. 1, July 2016

Quarterly Report No. 2, October 2016,

Quarterly Report No. 3, January 2017

Quarterly Report No. 4, April 2017

Appendix H - Water Quality Modeling and Monitoring Work Plan, Updated July 2017

Appendix I - Water Quality Monitoring and Modeling Quality Assurance Project Plan (QAPP), Updated July 2017

Appendix J - Water Quality Model Report (Includes Sampling and Monitoring Report), February 2018

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Appendix K - Existing Service Area Characterization Report (Final), August 2017

Appendix L - Public Participation Plan (Final), Updated April 2016

Appendix M - Public Meeting Notes, Presentations and Comments with Responses

Appendix N - Corvias Green Stormwater Infrastructure Evaluation, November 2017

Appendix O - DELCORA Alternatives Analysis Contingency Breakdown and DELCORA Alternatives Analysis Opinion of Probably Cost Methodology Memos

Appendix P - WRTP Process and Hydraulic Evaluation, April 2011

Appendix Q - Draft Feasibility Study for Pipe Repairs from M.H. 329 to M.H. 3070 and Combination Flow Mitigation for C.S.O. No. 18, December 2016

~~Appendix R - Draft Financial Capability Assessment Report (Final), Revised April 2017~~ No longer in use, see 2022 FCA document in Appendix Y

~~Appendix S - FCA Supplement, August 2017~~ No longer in use, see 2022 FCA document in Appendix Y

Appendix T - Updated Model Calibration and Validation Results for Sewer System Hydrologic and Hydraulic Model Report and Existing Service Area Characterization Report, dated July 2018

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Appendix U - Updated Model Calibration and Validation Results for Sewer System Hydrologic and Hydraulic Model Report and Existing Service Area Characterization Report, dated June 2020
Appendix V - Atlantic Sturgeon Status Review Team. 2007. Status Review of Atlantic sturgeon (Acipenser oxyrinchus oxyrinchus). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007, 174 pp.
Appendix W - Percent Capture Calculation Methodology and Percent Capture by Watershed Memorandum
Appendix X - Additional Communications with USEPA
Appendix Y - Financial Capabilities Assessment Report (Final), December 2022
Appendix Z - Chronological History of the DELCORA CSO LTCPU Program

APPENDIX A

ALTERNATIVES EVALUATION APPROACH REPORT

- DELCORA Alternatives Evaluation Approach Report dated April 2016
- USEPA Approval of the Alternatives Evaluation Approach Report dated October 13, 2016

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

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

Alternatives Evaluation Approach Report (Final)

April 2016

GREELEY AND HANSEN

REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Alternatives Evaluation 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	4/13/16 Date
DELCORA ENGINEERING		
Director of Engineering	Signature	4/12/16 Date
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	Signature	4/13/16 Date

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES

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Section 1 Introduction

1.1 Background

The Delaware County Regional Water Quality Control Authority (DELCORA) is a municipal wastewater authority that owns, operates and maintains collection systems that serve approximately a half-million people in southeastern Pennsylvania, including 42 municipalities in Delaware and Chester Counties. DELCORA operates a Combined Sewer System (CSS) that is comprised of sewer sections that accept both stormwater and sanitary wastewater, which is treated at DELCORA's Western Regional Treatment Plant (WRTP).

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 Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) to the United States Environmental Protection Agency (USEPA or EPA) and the Pennsylvania Department of Environmental Protection (PADEP or DEP).

1.2 Purpose

As part of the Long Term Control Plan Update (or "LTCPU"), the Consent Decree requires DELCORA (in coordination with the USEPA and PADEP) to propose what approach to the Long Term Control Plan Alternative Evaluation (i.e., the "Presumption Approach" or the "Demonstration Approach") is appropriate for the each of DELCORA's receiving waters, and to submit a written explanation to the USEPA and PADEP for review and approval. The three water bodies that receive overflows from DELCORA's CSS include the Delaware River, Chester Creek and Ridley Creek.

DELCORA is in the process of developing the LTCPU for its Combined Sewer System, and the purpose of this report is to meet the requirement in the Consent Decree for the submission of a written explanation of DELCORA's Alternatives Evaluation Approach to the USEPA and PADEP, while also addressing those requirements from USEPA's "Combined Sewer Overflow Control Policy," April 1994 and also considering the "Combined Sewer Overflows Guidance for Long-Term Control Plan," September 1995 (CSO Guidance Document). Determination of the use of the Presumption or Demonstration Approach is important because it can potentially affect the development of the CSO control alternatives.

Section 2 Regulatory Framework

There are various documents that discuss the Alternatives Evaluation Approach that may be taken for the development of a long term control plan. These documents are discussed in further detail in this Section.

2.1 Consent Decree Requirements

The Consent Decree requires DELCORA to complete and submit a LTCPU to the USEPA and PADEP for review and approval. Section V.A.13 of the Consent Decree ("Alternatives Evaluation Approach") specifically requires that:

> *"Within nine (9) months after the Date of Lodging, DELCORA shall propose, in coordination with the EPA and PADEP and in accordance with Section II.C.4 of the CSO Control Policy, what approach to LTCP Alternative Evaluation (i.e., Presumption or Demonstration) is appropriate for each of DELCORA's Receiving Waters, and to submit a written explanation of such determination to Plaintiffs for review and approval pursuant to Section VI (Review and Approval of Submittals)."*

The Consent Decree further states that:

> *"Use of the Presumption Approach will be allowed only where EPA and PADEP each agree that the specific presumption(s) to be used in a particular water body are reasonable pursuant to Section II.C.4.a of the CSO Control Policy".*

2.2 USEPA's CSO Control Policy Requirements

Section II.C.4 of the USEPA's CSO Control Policy states that the long term CSO control plan should adopt one of the following two approaches for CSO controls sufficient to meet CWA requirements: 1) the Presumption Approach, and 2) the Demonstration Approach.

2.2.1 Presumption Approach from USEPA's CSO Control Policy

Sub-section II.C.4.a of the USEPA's CSO Control Policy (Presumption Approach) states that:

> "*A program that meets any of the criteria listed below would be presumed to provide an adequate level of control to meet the water quality-based requirements of the CWA, provided the permitting authority determines that such presumption is reasonable in light of the data and analysis conducted in the characterization, monitoring, and modeling of the system and the consideration of sensitive areas... These criteria are provided because data and modeling of wet weather events*

often do not give a clear picture of the level of CSO controls necessary to protect WQS."

Under the Presumption Approach, CSO controls proposed in the LTCPU are presumed to protect water quality in the receiving water bodies if the Combined Sewer System achieves any of the following three criteria:

i. *"No more than an average of four overflow events per year, provided that the permitting authority may allow up to two additional overflow events per year. For the purpose of this criterion, an overflow event is one or more overflows from a CSS as the result of a precipitation event that does not receive the minimum treatment specified below; or*

ii. *The elimination or the capture for treatment of no less than 85% by volume of the combined sewage collected in the CSS during precipitation events on a system-wide annual average basis; or*

iii. *The elimination or removal of no less than the mass of the pollutants identified as causing water quality impairment through the sewer system characterization, monitoring, and modeling effort, for the volumes that would be eliminated or captured for treatment under the paragraph ii above."*

"Minimum treatment," as noted in Item "*i*" above, is defined in Sub-section II.C.4.a of the CSO Control Policy as:

- *"Primary Clarification (Removal of floatables and settleable solids may be achieved by any combination of treatment technologies or methods that are shown to be equivalent to primary clarification.);*
- *Solids and floatables disposal; and*
- *Disinfection of effluent, if necessary, to meet WQS, protect designated uses and protect human health, including removal of harmful disinfection chemical residuals, where necessary."*

2.2.2 Demonstration Approach from USEPA's CSO Control Policy

Sub-section II.C.4.b of the USEPA's CSO Control Policy (Demonstration Approach) states that:

"A permittee may demonstrate that a selected control program, though not meeting the criteria specified in II.C.4.a. above is adequate to meet the water quality-based requirements of the CWA."

Under the Demonstration Approach, the municipality would be required to successfully demonstrate compliance with each of the following criteria from the CSO Control Policy:

i. *"The planned control program is adequate to meet WQS and protect designated uses, unless WQS or uses cannot be met as a result of natural background conditions or pollution sources other than CSOs;*

ii. *The CSO discharges remaining after implementation of the proposed control program will not preclude the attainment of WQS or the receiving waters' designated uses or contribution to their impairment. Where WQS are not met in part because of natural background conditions or pollution sources other than CSO discharges, a total maximum daily load, including a waste load allocation and a load allocation or other means should be used to apportion pollutant loads;*

iii. *The planned control program will provide the maximum pollution reduction benefits reasonably attainable; and*

iv. *The planned control program is designed to allow cost effective expansion or cost effective retrofitting if additional controls are determined to be necessary to meet WQS or designated uses."*

2.3 USEPA's CSO Guidance for Long-Term Control Plan Requirements

The USEPA's CSO Guidance for Long-Term Control Plan (or "CSO Guidance Document") states that the Demonstration Approach and the Presumption Approach are the two general approaches to attainment of WQS, and that these two approaches provide municipalities with targets for CSO controls that achieve compliance with the Clean Water Act, particularly the protection of designated uses.

Section 1.3 of the CSO Guidance Document states:

> *"Permittees should develop long-term control plans (LTCPs) for controlling CSOs. A permittee may use one of two approaches: 1) demonstrate that its plan is adequate to meet the water quality-based requirements of the CWA ("demonstration approach"), or 2) implement a minimum level of treatment (e.g., primary clarification of at least 85 percent of the collected combined sewage flows) that is presumed to meet the water quality-based requirements of the CWA, unless data indicate otherwise ("presumption approach")."*

Section 2.6.2.1 states that:

> *"Under the CSO Control Policy, a municipality should develop an LTCP that adopts either the demonstration or the presumption approach to attainment of*

WQS. The demonstration approach is based on adequately demonstrating that the selected CSOs will provide for the attainment of WQS, including designated uses in the receiving water. The presumption approach does not explicitly call for analysis of receiving water impacts. The presumption approach usually involves at least screening-level models of receiving water impacts, however, because the approach will not apply if the NPDES permitting authority determines that the LTCP will not result in attainment of CWA requirements."

2.3.1 Presumption Approach from USEPA's CSO Guidance for LTCP

For the Presumption Approach, Section 3.2.1 of the USEPA's CSO Guidance Document states that:

"If the data collected by a community do not provide "...a clear picture of the level of CSO controls necessary to protect WQS", the presumption approach may be considered. Use of the presumption approach is contingent, however, on the municipality presenting sufficient data to the NPDES permitting authority to allow the agency to make a reasonable judgment that WQS will probably be met with a control plan that meets one of the three presumption criteria."

Furthermore, the CSO Guidance Document states:

"Use of the presumption approach does not release municipalities from the overall requirement that WQS be attained. If data collected during system characterization suggest that use of the presumption approach cannot be reasonably expected to result in attainment of WQS, the municipality should be required to use the demonstration approach instead. Furthermore, if implementation of the presumption approach does not result in attainment of WQS, additional controls beyond those already implemented might be required."

2.3.2 Demonstration Approach from USEPA's CSO Guidance for LTCP

For the Demonstration Approach, Section 3.2.1 of the USEPA's CSO Guidance Document states that:

"Generally, if sufficient data are available to demonstrate that the proposed plan would result in an appropriate level of CSO control, then the demonstration approach will be selected. The demonstration approach is particularly appropriate where attainment of WQS cannot be achieved through CSO control alone, due to the impacts of non-CSO sources of pollution. In such cases, an appropriate level of CSO control cannot be dictated directly by existing WQS but must be defined based on water quality data, system performance modeling, and economic factors."

The Demonstration Approach is consistent with the total maximum daily load (TMDL) development approach and may be used in the TMDL process where the WQS and designated uses are not met in part because of natural background conditions or pollution sources other than CSOs. Section 3.2.1.1 of the CSO Guidance Document states:

> *"the demonstration approach encourages the development of total maximum daily loads and/or the use of a watershed approach throughout the LTCP process. In conducting the existing baseline water quality assessments as part of the system characterization, for example, the specific pollutants causing nonattainment of WQS, including existing or designated uses, would be identified, and then the sources of these pollutants could be identified and loads apportioned and quantified."*

2.4 Comparison of the Two Approaches

The following table summarizes the major differences between the Presumption Approach and the Demonstration Approach.

Table 2-1: Comparison of the Two Approaches

Item	Presumption Approach	Demonstration Approach
Criteria	• Meet one of three criteria and compliance is presumed: 1) No more than an average of 4-6 overflow events per year; 2) 85% capture (by volume) 3) Elimination or removal of the mass of pollutants, identified as causing water quality impairment.	• Number of CSO events, flow or pollutant loading limited by a proposed CSO system Waste Load Allocation which will comply with Water Quality Standards (WQS). • Relies on data collection and model simulation to demonstrate that the proposed LTCP results in meeting the current WQS and designated uses.
Monitoring Data Collection	• Flow metering of the collection system and/or water quality sampling of CSOs.	• Flow metering of the collection system and water quality sampling of CSOs and receiving water bodies.
Modeling	• Combined sewer system (CSS) hydrologic and hydraulic (H&H) model.	• CSS H&H Model and Receiving Water Quality Model(s).
Pollutant Sources Evaluated	• Only CSOs.	• The contributing pollutant sources in the watershed including urban stormwater, agricultural (if any), wildlife, etc.

The Demonstration Approach takes a holistic watershed based approach to understand the pollutant sources and their relative contributions, so that appropriate level of controls can be cost-effectively applied to each pollutant source instead of focusing on just the CSOs. The

Demonstration Approach can help to understand where the current CSO program is in terms of meeting the WQS and demonstrate the impact of future WQS changes on the CSO controls. Under the Demonstration Approach, the permittee must document that their CSO control program is adequate to meet the water quality-based requirements of the CWA.

Use of the Presumption Approach for a particular water body is only allowed when approved by the USEPA and PADEP and each agree that the specific presumption(s) to be used in a particular water body are reasonable pursuant to Section II.C.4.a of the CSO Control Policy.

Certain tasks must be completed regardless if the Presumption or Demonstration Approach is used, such as system characterization, sewer and GIS mapping, and the evaluation of alternatives. However, it is to be noted that the study phase for the Demonstration Approach also requires water quality sampling and water quality modeling of the receiving waters.

Section 3 CSO System Description

3.1 Background of DELCORA's Facilities

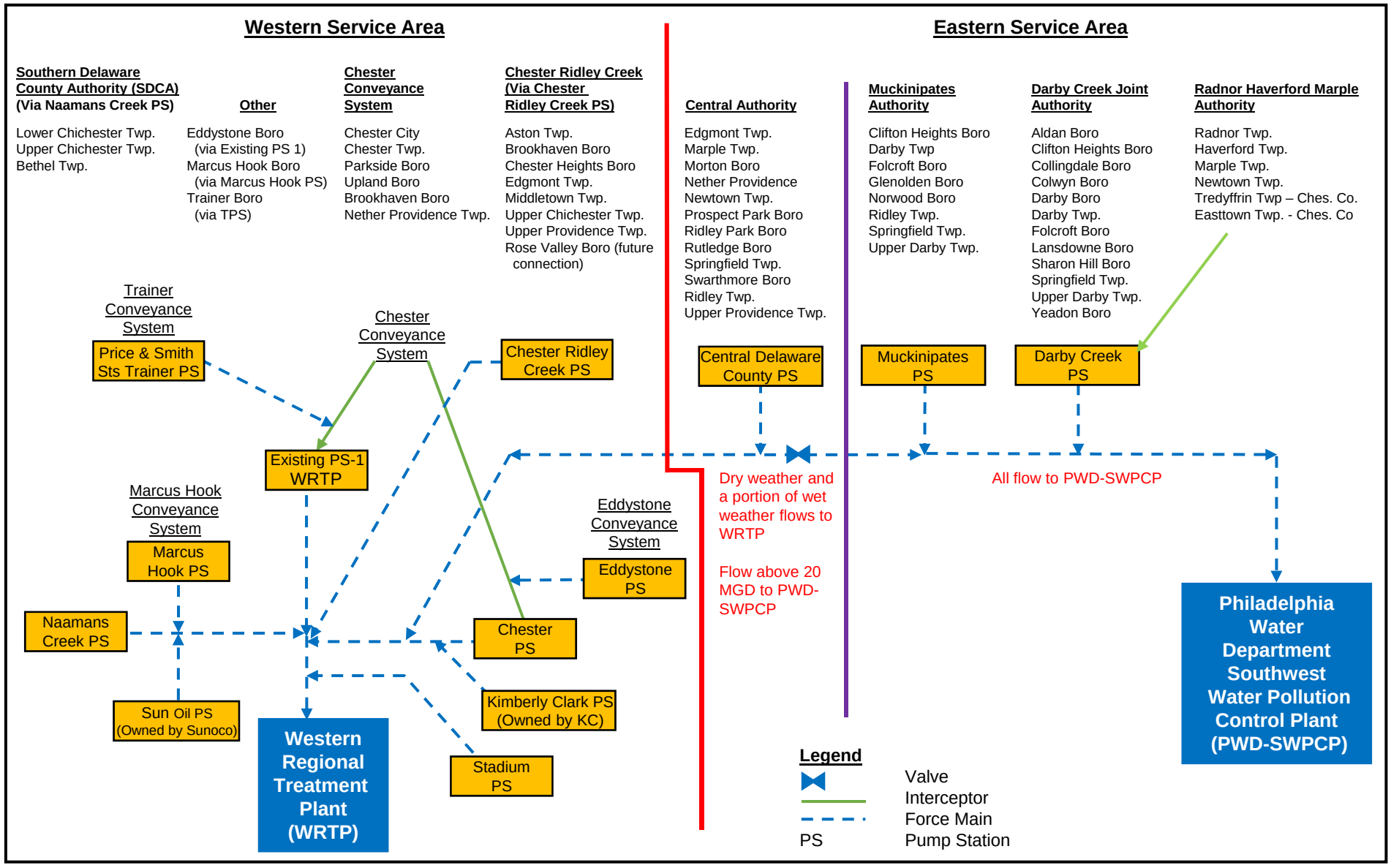
The Delaware County Regional Water Quality Control Authority is responsible for the safe collection, transmission, treatment and disposal of approximately 65 million gallons per day (MGD) of wastewater generated in southeastern Pennsylvania. DELCORA's facilities serve residential, commercial, institutional, 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 3-1. The total service area served by DELCORA, as shown on Figure 3-2, 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 (H&H) 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.

Historically, DELCORA has characterized its service areas as the "Eastern" and "Western." The Western Service Area wastewater is treated at DELCORA's Western Regional Treatment Plant, 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 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 overflows with 25 discharge points listed 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, DELCORA is authorized to discharge from the Western Regional Treatment Plant (#001), four storm water outfalls at the WRTP (#028-031),



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WESTON SOLUTIONS
Restoring Resource Efficiency

Figure 3-1
DELCORA'S CONVEYANCE SYSTEM

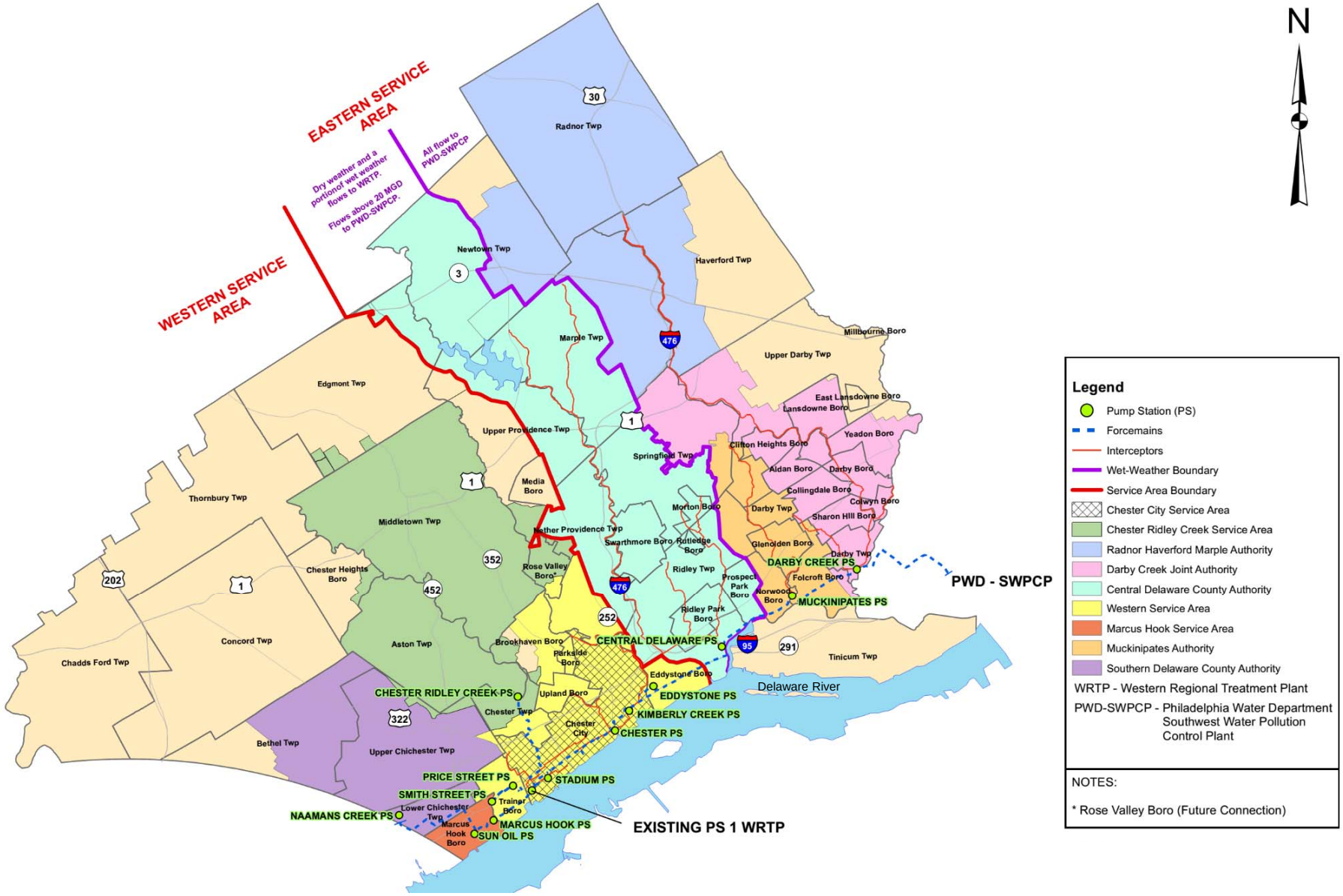

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Figure 3-2
DELCORA'S SERVICE AREA

and from 26 combined sewer overflow outfalls (#002-#026, #032, #033) that ultimately discharge to the Delaware River, Chester Creek and/or Ridley Creek. CSOs #009 and #010 both discharge at CSO #009.

3.2 City of Chester CSO System

As noted in Section 3.1, 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 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, 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 3-1 that discharge to three receiving water bodies; the Delaware River, Chester Creek and Ridley Creek. Figure 3-3 depicts the locations of CSO regulators and outfalls that are DELCORA's responsibility.

Table 3-1: 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	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

Name of Receiving Stream	CSO Outfall	Interceptor/CSO Regulator Location	Latitude	Longitude
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	033	Elkington Boulevard and Ridley Creek	39°52'22"N	75°22'29"W

Notes:

(1) CSO Outfall 010 discharges to the Delaware River through CSO Outfall 009.

Figure 3-3 and Table 3-2 also provide a sewer system characterization and illustrate the breakdown of each outfall and how each drainage area has combined sewers and separate sewers. Figure 3-4 is a schematic of the Chester CSO system and shows the outfalls and the interceptors that are connected to each CSO.

3.3 CSO System Modeling

Since 1997, DELCORA has conducted annual modeling of the CSO system using the USEPA's Storm Water Management Model (SWMM) to estimate overflows to its receiving waters. SWMM is a dynamic rainfall-runoff model for "single-event" or "continuous" simulations of runoff quantity and quality from primarily urban areas. The model simulates the time-varying process of rainfall onto land surfaces, the conversion of rainfall to infiltration, evaporation, or surface runoff, and the routing of mixed stormwater runoff and sanitary sewage through the collection system. DELCORA's SWMM is also referred to in this report as the Hydrologic and Hydraulic (H&H) model.

Section 2.6.1 (Combined Sewer System Modeling) of the USEPA's CSO Guidance for Long-Term Control Plan states that:

> *"The primary objective of CSS modeling is to understand the hydraulic response of the CSS to a variety of precipitation and drainage area inputs. CSS modeling can also be used to predict pollutant loadings to receiving waters. Once the model is calibrated and verified, it can be used for numerous applications that support CSO planning efforts, including (EPA, 1995d):*



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

Table 3-2: Subarea Type and Size

CSO Regulator/ Interceptor	Subarea	Collection System Type	Area (ac)
2	02A	CSS	20.7
	02B	CSS	31.7
	02C	CSS	0.3
			52.7
3	03A	Separate	12.8
	03B	CSS	21.9
	03C	CSS	46.5
	03D	CSS	18.5
	03E	CSS	2.9
			102.5
4	04A	CSS	10.8
	04B	CSS	22.6
	04C	CSS	2.5
	04D	Separate	1.0
			36.8
5	05A	Separate	97.4
	05B	Separate	26.4
	05C	CSS	32.0
	05D	CSS	29.1
		Unsewered	32.1
	05E	CSS	28.6
			245.7
6	Converted to Regulator 7 subareas		
7	07A	CSS	12.8
	07B	CSS	18.5
	07C	CSS	16.3
			47.6
8	08A	CSS	83.2
	08B	CSS	90.2
	08C	Separate	9.8
	08D	CSS	3.8
			187.0

CSO Regulator/ Interceptor	Subarea	Collection System Type	Area (ac)
9	09A	CSS	29.3
10	10A	CSS	46.6
11	11A	CSS	11.8
	11B	CSS	31.4
	11C	CSS	6.3
	11D	CSS	2.5
			52.0
12	12A	CSS	3.3
13	13A	CSS	25.3
	13B	CSS	19.7
	13C	CSS	7.2
			52.1
14	14A	CSS	41.4
	14B	CSS	11.8
	14C	CSS	10.5
	14D	CSS	2.4
			66.1
15	15A	CSS	8.6
	15B	Separate	4.1
			12.7
16	16A	CSS	6.9
16/17	16/17A	CSS	36.4
	16/17B	CSS	41.4
	16/17C	CSS	17.2
			95.0
17	17A	CSS	7.6
18	18A	CSS	27.2
	18B	CSS	4.8
			32.1

CSO Regulator/ Interceptor	Subarea	Collection System Type	Area (ac)
19	19A	Separate	30.7
	19B	CSS	73.5
	19C	CSS	138.2
	19D	CSS	71.5
	19E	CSS	36.3
	19F	CSS	38.7
	19G	CSS	6.1
			395.0
20	20A	CSS	12.8
21	21A	CSS	18.3
22	22A	CSS	17.3
23	23A	CSS	9.1
24	24A	CSS	6.1
25	25A	CSS	23.7
26	26A	CSS	18.3
	26B	CSS	8.6
			26.9
31	31A	CSS	5.9
Stoney Creek Collector	SC1	CSS	49.1
Booth Street Inteceptor	BS1	Separate	18.4
	BS2	CSS	22.2
	BS3	CSS	14.3
	BS4	Separate	63.2
	BS5	Separate	60.3
			178.4
West End Interceptor	WE1	Separate	39.7
Delaware River Interceptor	DR1	CSS	5.8

CSO Regulator/ Interceptor	Subarea	Collection System Type	Area (ac)
2nd Street Interceptor	SS1	Separate	7.1
	SS2	Separate	19.0
	SS3	Separate	30.4
			56.5
Penn Street Interceptor	PS1	CSS	2.9
	PS2	CSS	3.4
			6.3
Chester Creek West Interceptor	CCW1	CSS	18.9
	CCW2	CSS	6.2
			25.1
Chester Creek East Interceptor	CCE1	Separate	6.9
Edgmont Avenue Interceptor	EA1	CSS	3.8
Ridley Creek Interceptor	RC1	CSS	2.2
	RC2	Separate	24.7
	RC3	Separate	19.2
	RC4	Separate	27.7
	RC5	Separate	21.4
	RC6	Separate	27.2
	RC7	Separate	23.9
	RC8	Separate	25.1
	RC9	Separate	31.6
	RC10	CSS	7.7
			210.7
		CSS	**1,506.1**
		Separate	**632.4**
TOTAL			**2,138.5**

NOTE: CSS = Combined Sewer System

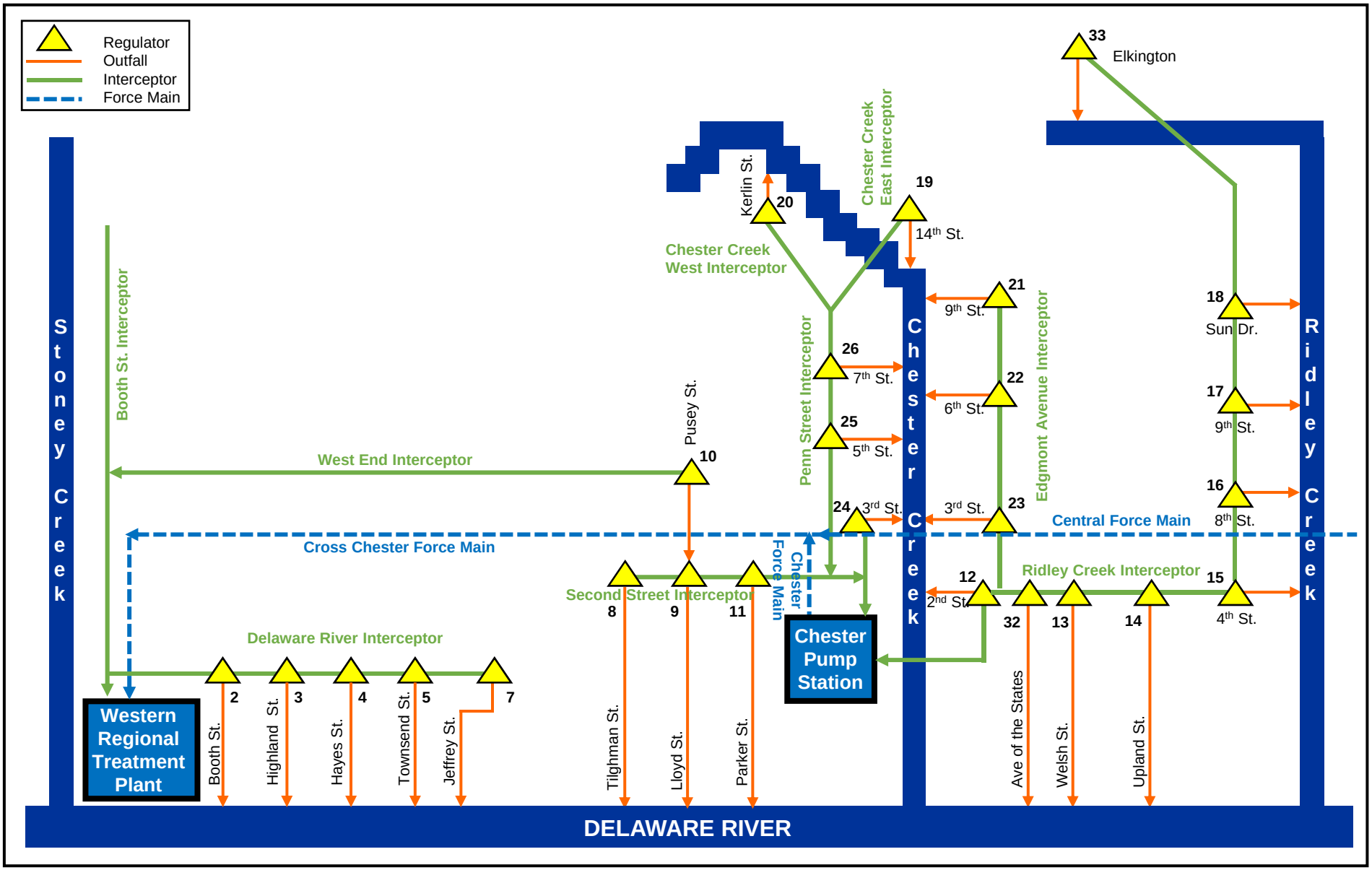

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Figure 3-4
SCHEMATIC OF CHESTER CSO SYSTEM

- *To predict overflow occurrence, volume, and, in some cases, quality for rain events other than those which occurred during the monitoring phase. These can include a storm event of large magnitude (long recurrence period) or numerous storm events over an extended period of time.*

- *To predict the performance of portions of the CSS that have not been extensively monitored.*

- *To develop CSO statistics, such as annual number of overflows and percent of combined sewage captured in response to the presumption approach of the CSO Control Policy.*

- *To optimize CSS performance as part of NMC implementation. In particular, modeling can assist in locating storage opportunities and hydraulic bottlenecks and demonstrate that system storage and flow to the POTW are maximized.*

- *To evaluate and optimize control alternatives, from simple controls described under the NMC to more complex controls proposed in a municipality's LTCP. An example of a simple control would be to raise weir heights to increase in-line storage. The model can be used to evaluate the resulting reductions in CSO volume and frequency."*

The original DELCORA H&H model was developed and calibrated for the 1999 LTCP. The model was set up to simulate monthly CSO discharges in EPA SWMM 5.0, and it is used to estimate the frequency and volume of CSO overflows in the City of Chester and to evaluate long-term strategies for minimizing CSO overflows. The model uses data from the rain gauge located at the WRTP and is supplemented with data from a gauge at the Central Delaware Pump Station. The current model has been updated and expanded over the years to account for changes in the CSO system, but it has not been re-calibrated. Updating and additional calibration and validation of the SWMM model will occur in a subsequent task as part of the requirements of DELCORA's Consent Decree.

Monthly Reports of CSO Modeling using the SWMM are provided to the PADEP as part of DELCORA's Annual Municipal Wasteload Management Report (Chapter 94 Report), and are also provided monthly with the PADEP electronic Discharge Monitoring Report (e-DMR). For the purposes of this report, a run of the existing H&H model was performed using the typical hydrologic period established for DELCORA's CSO LTCPU. The typical hydrologic period was previously determined to be the 3-year period from 1994 – 1996, as detailed in the "Typical Hydrologic Period Report" submitted to the USEPA in November 2015. The hydrologic period from 1994 – 1996 contains a wet year (1996 with 52.1 inches), a dry year (1995 with 31.6 inches) and a year close to average conditions (1994 with 44.9 inches).

A series of monthly simulations of the existing H&H model was executed to estimate the overflow frequency, duration and volume to each of the three receiving water bodies (the Delaware River, Chester Creek and Ridley Creek) as well as the percent volume captured for treatment. The model was run in continuous mode for each month for the 1994 – 1996 period. Evaporation was not included in the simulation since it does not affect the model in a meaningful way, and may cause underreporting of CSO discharges in some cases. It is also to be noted that the snowfall recorded at the rain gauges was simulated in SWMM as rainfall and since peak runoff from snowmelt is typically lower than from rainfall, the SWMM model simulates a conservative estimate of CSO overflows.

The outputs from the H&H model run for the typical hydrologic period are summarized in Table 3-3. Based on the model results for the 1994 – 1996 typical hydrologic period, Table 3-3 indicates that:

- Only four (4) of the 25 outfalls (i.e., #012, 024, 032 and 033) are currently estimated by the model to have had less than 4-6 annual overflow events, which is a prime requirement for use of the Presumption Approach. The next lowest number of overflow events is shown to occur at CSO #020, for which the model indicates an annual average of 21 overflow events. All of the remaining outfalls are shown to have to an annual average of 25 or more overflow events.

- The response of certain regulators (i.e., #002, 003, 004, 005, 007, 008, 009, 011, 013, 015, 017, 018, 019, 022 and 025) is sensitive to even the smallest amounts of precipitation. The model indicates that these outfalls had the highest frequency of discharges.

- The Delaware River received overflows from 11 of the 25 discharge points in the CSS, which was approximately 50% of the total annual average overflow volume and accounted for approximately 49% of the overall number of discharge events.

- The Ridley Creek received overflows from 5 of the 25 discharge points in the CSS, which was approximately 12% of the total annual average overflow volume and accounted for approximately 23% of the overall number of discharge events.

- The Chester Creek received overflows from 9 of the 25 discharge points in the CSS, which was approximately 38% of the total annual average overflow volume and accounted for approximately 28% of the overall number of discharge events.

- The existing H&H model estimates that the percentage of the combined flow treated at the wastewater treatment plant was approximately 61% for the 1994 - 1996 period, which is significantly less than the 85% capture rate for treatment required for use of the Presumption Approach.

A bar chart is also included below Table 3-3 that graphically illustrates the information in the table. The chart shows the large gap that exists between the modeled number of overflow events for the typical hydrologic period, and the limit prescribed for use of the Presumption Approach of only 4-6 overflow events per year.

Table 3-3: H&H Model Results for Typical Hydrologic Period (1994 - 1996)

		Western Chester City Service Area						Central Chester City Service Area												Eastern Chester City Service Area								
		DELAWARE RIVER						DELAWARE RIVER			CHESTER CREEK									DELAWARE RIVER			RIDLEY CREEK					

Annual Overflow Frequency (Occurrence)

	Rainfall	#002	#003	#004	#005	#006	#007	#008	#009	#011	#012	#019	#020	#021	#022	#023	#024	#025	#026	#013	#014	#032	#015	#016	#017	#018	#033	Max
1/1/1994	45	80	76	44	72	0	74	76	48	50	3	93	21	43	51	30	5	65	26	54	31	2	46	32	97	93	5	97
1/1/1995	31	62	60	37	58	0	60	61	39	39	1	80	13	31	40	23	4	53	17	44	24	1	37	26	83	80	2	83
1/1/1996	52	88	83	56	83	0	84	84	57	58	1	112	28	52	59	36	5	79	32	64	38	1	56	42	115	112	3	115
Average	43	77	73	46	71	0	73	74	48	49	2	95	21	42	50	30	5	66	25	54	31	1	46	33	98	95	3	98

Typical Year Overflow Volume (MG)

	Rainfall	#002	#003	#004	#005	#006	#007	#008	#009	#011	#012	#019	#020	#021	#022	#023	#024	#025	#026	#013	#014	#032	#015	#016	#017	#018	#033	Annual Total
1/1/1994	45.0	67.0	52.9	14.6	56.7	0.0	28.7	96.9	27.1	20.7	0.2	272.5	2.5	6.5	7.6	2.5	0.5	13.3	5.8	26.1	15.4	0.1	2.4	17.9	51.0	27.6	0.4	862
1/1/1995	31.4	44.3	34.1	8.3	36.9	0.0	18.7	61.9	16.6	12.1	0.0	182.1	0.8	3.5	4.5	1.1	0.1	8.5	2.0	16.2	7.0	0.0	1.2	7.6	36.5	18.6	0.0	554
1/1/1996	52.1	78.8	62.2	16.0	67.5	0.0	33.9	112.8	30.9	23.2	0.0	318.0	1.4	6.7	8.6	2.0	0.1	15.8	3.4	30.4	13.1	0.0	2.4	14.1	62.0	32.1	0.0	988
Average	42.8	63.4	49.7	13.0	53.7	0.0	27.1	90.6	24.9	18.7	0.1	257.5	1.6	5.6	6.9	1.9	0.2	12.6	3.7	24.2	11.8	0.0	2.0	13.2	49.8	26.1	0.1	801

WWTP Treated Wet Weather Volume (Assuming max WWTP flow at 105.54 MGD, and plant DWF at 7.01 MGD)

1994	634	MG
1995	481	MG
1996	743	MG
Average	620	MG

Total Overflow

1994	862	MG
1995	554	MG
1996	988	MG
Average	801	MG

Percent of Wet Weather Flow Treated by WWTP

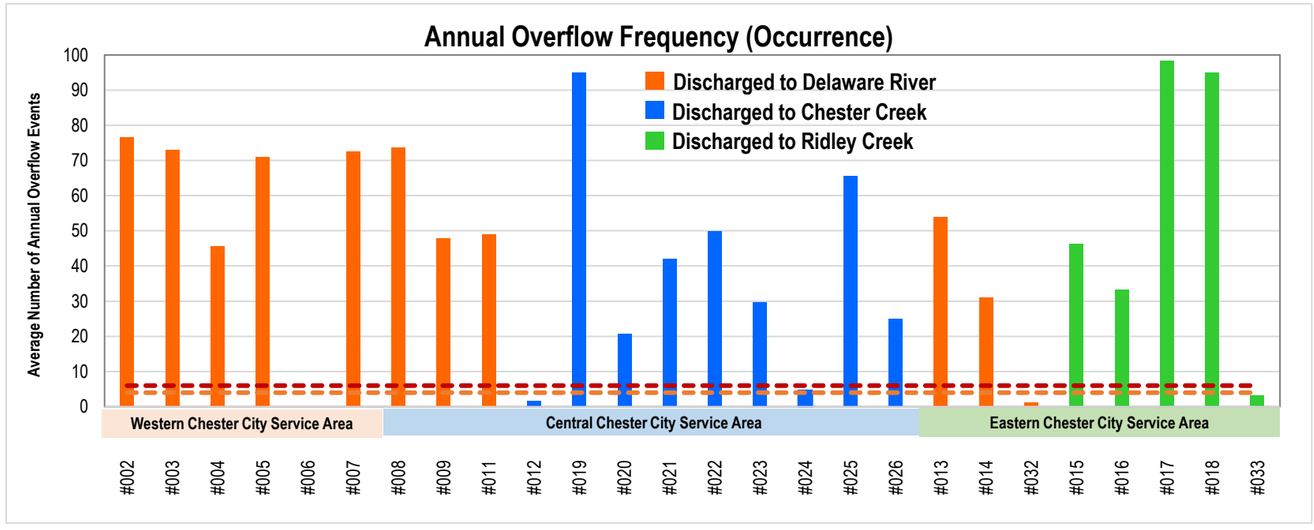
1994	42%
1995	47%
1996	43%
Average	44%

Percent of Combined Flow Treated by WWTP

1994	59%
1995	64%
1996	59%
Average	61%

Notes:

1. Modeled was test run for June, July and August, 2014, the results are in line with Weston's 2014 report.
2. The model only include the Chester City Service Area, it does not include flows from the other service areas and the Central Delaware PS.
3. Modeled max flow to the WWTP is only 86.64 MGD, less than the plant record of 105.54 MGD
4. We checked Regulator #08 set up in the model and the drawing, they are different.
5. The "Percent of Combined Flow Treated by WWTP" is estimated based on precipitation inter-event time (IET) of 12 hr.
6. CSO #006 has been separated and no longer discharges combined storm/wastewater flow.
7. CSO #010 discharges to the Delaware River through CSO #009.



Section 4 Characterization of Receiving Water Bodies

In order to select the Presumption Approach or the Demonstration Approach, it is necessary to understand the existing condition of the receiving water bodies. Use of the Presumption Approach is contingent on the municipality presenting sufficient data to make a reasonable judgment that the water quality standards in the receiving water body will presumably be met with a control plan that meets one of the three presumption criteria (see Section 2.2.1). The Demonstration Approach is appropriate where attainment of water quality standards cannot be achieved through CSO controls alone, due to the impacts of background conditions or pollution sources other than CSOs.

For the characterization of receiving water bodies, Section 2.6.2 (Receiving Water Modeling) of the USEPA's CSO Guidance Document states that:

> *"Under the CSO Control Policy, a municipality should develop an LTCP that adopts either the demonstration or the presumption approach to attainment of WQS. The demonstration approach is based on adequately demonstrating that the selected CSOs will provide for the attainment of WQS, including designated uses in the receiving water. The presumption approach does not explicitly call for analysis of receiving water impacts. The presumption approach usually involves at least screening-level models of receiving water impacts, however, because the approach will not apply if the NPDES permitting authority determines that the LTCP will not result in attainment of CWA requirements."*

In February 2016, DELCORA submitted to the USEPA its "Identification of Sensitive Areas and Pollutants of Concern Report" as a requirement of the Consent Decree. The report reviewed the impairment status of each of the three receiving water bodies and identified parameters associated with CSOs that are exceeding the water quality standards as "Pollutants of Concern".

Figure 4-1 (from the Identification of Sensitive Areas and Pollutants of Concern Report) shows the Non-Attaining and TMDL streams and river within the area impacted by DELCORA's CSO discharges, as determined from the 2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report. The location of each of DELCORA's CSOs for each of the water bodies is shown in the figure.



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

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Figure 4-1

Non-Attaining and TMDL Streams/River
Within DELCORA's Service Area

Section 5 Selection of the Presumption or Demonstration Approach for Each of DELCORA's Receiving Waters

The development of an LTCPU allows for either the Presumption Approach or the Demonstration Approach to be utilized. DELCORA's approach is to establish the most reliable CSO Program that meets the Consent Decree requirements, the USEPA's CSO Policy and Guidance Document, and the applicable water quality standards.

5.1 Methodology Used in this Study

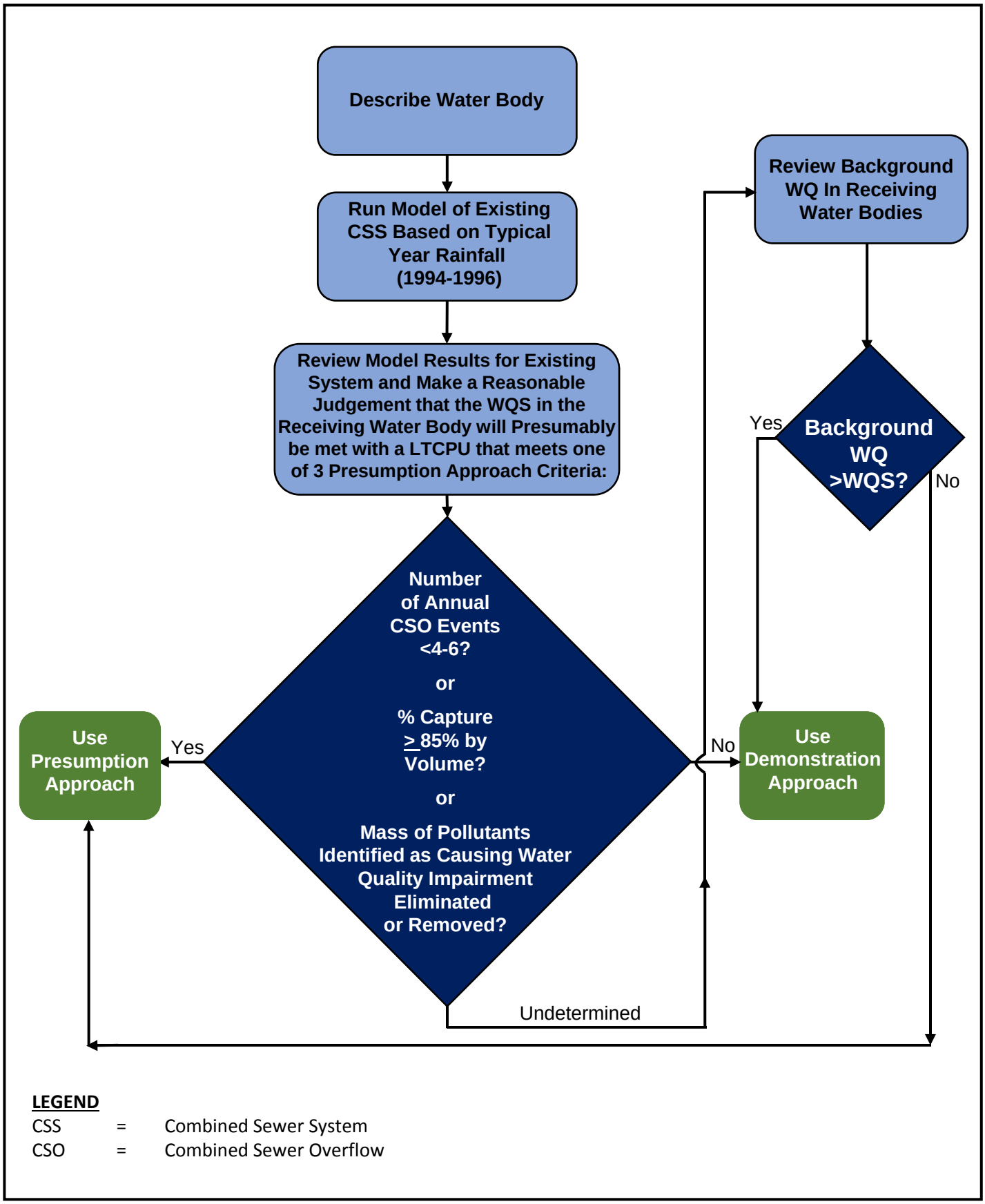
A flowchart was created to help illustrate the decision-making methodology used to assist in determining the recommended Alternatives Evaluation Approach for each of DELCORA's three receiving water bodies. This flowchart is presented in Figure 5-1.

The flowchart emphasizes two main decision making steps that lead to the recommendation of either the Demonstration or Presumption Approach, and these decision making steps are shown as dark blue diamonds. The primary decision step is to make a reasonable judgement that after all of the future CSO controls have been installed (1) will the annual average number of overflow events be less than 4 - 6 events, or (2) will the annual average percent capture for treatment of the combined wastewater be greater than or equal to 85%, or (3) for the volumes that would be eliminated or captured for treatment under item "(2)" will the mass of pollutants identified as causing water quality impairment be eliminated or removed? An answer of "Yes" to any one of these three questions is required for use of the Presumption Approach.

The results from the H&H model run for the typical hydrologic period of 1994 – 1996 were used to estimate the annual average number of overflow events per outfall, and the average percentage of the combined flow treated at the WWTP. The existing H&H model is not able to estimate if the mass of pollutants identified as causing water quality impairment will be eliminated or removed for the volumes that would be eliminated or captured for treatment, and therefore no determination can be made on that specific question at this time.

It was concluded that if the H&H model (Section 3.3) shows substantially more than 4 - 6 annual overflow events per outfall for the CSOs or if significantly less than 85% of the combined flow is shown to be captured for treatment, it will likely not be economically justifiable to install the full range of CSO control measures needed to meet the overflow frequency requirements of the Presumption Approach, and the Demonstration Approach will be favored. This determination is based on the use of Best Professional Judgement.

If it cannot be determined from the H&H model results as to whether the future CSO controls will likely be able to meet the annual number of overflow events or the percent capture rate for the Presumption Approach, then the flowchart indicates a secondary decision making step in



LEGEND

CSS = Combined Sewer System
CSO = Combined Sewer Overflow

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Delaware County Regional Water Quality Control Authority

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Figure 5-1
METHODOLOGY FLOWCHART FOR THE ALTERNATIVES EVALUATION APPROACH

which the existing water quality of the receiving water bodies is reviewed and compared to the applicable water quality standards. This determination is required since use of the Presumption Approach is contingent on the municipality presenting sufficient data to make a reasonable judgment that water quality standards will probably be met with a control plan that meets one of the three presumption criteria.

If the review of the background concentrations of those parameters typically associated with CSOs in the receiving water bodies are less than the applicable water quality standards, then the flow chart indicates that the Presumption Approach can be considered. However, if the background concentrations for those parameters are above the applicable water quality standards, then the Demonstration Approach should be used.

A review of the methodology flowchart was performed for each of the three receiving water bodies and is described in the following sub-sections.

5.1.1 Delaware River

Eleven (11) of DELCORA's 25 CSO outfalls discharge to the Delaware River. The H&H model run for the typical hydrologic period shown in Table 3-3 estimates that the Delaware River received discharges from these 11 outfalls accounting for approximately 50% of the total annual average overflow volume from the CSS, and approximately 49% of the overall number of discharge events.

Table 3-3 indicates that 10 of the 11 outfalls to the Delaware River had substantially more than the 4 – 6 annual overflow events that are the target for using the Presumption Approach. Only CSO #032 is shown to have had less than 4 – 6 annual overflows. Of the 10 CSOs that were modeled to overflow more than 4 - 6 times a year, the model estimates that all 10 of them had at least 31 annual overflow events and five of the outfalls are modeled as having had more than 71 overflow events.

Following the methodology described in the flowchart, the answers to the questions in the first decision making step indicate that the **Demonstration Approach** is the most appropriate to be used for the CSO discharges to the Delaware River.

5.1.2 Chester Creek

Nine (9) of DELCORA's 25 CSO outfalls discharge to the Chester Creek. The H&H model run for the typical hydrologic period of 1994 – 1996 shown in Table 3-3 estimates that the Chester Creek received discharges from these 9 outfalls accounting for approximately 38% of the total annual average overflow volume from the CSS, and approximately 28% of the overall number of discharge events.

Table 3-3 indicates that 7 of the 9 outfalls to the Chester Creek had substantially more than the 4 – 6 annual overflow events that are the target for using the Presumption Approach. Only CSOs #012 and #024 are shown to have had less than 4 – 6 overflows. Of the 7 CSOs that were modeled to overflow more than 4-6 times a year, the model estimates that all 7 of them had at least 21 or more annual overflow events and four of the outfalls are modeled as having had more than 42 overflow events.

Following the methodology described in the flowchart, the answers to the questions in the first decision making step indicate that the **Demonstration Approach** is the most appropriate to be used for the CSO discharges to the Chester Creek.

5.1.3 Ridley Creek

Five (5) of DELCORA's 25 CSO outfalls discharge to the Ridley Creek. The H&H model run for the typical hydrologic period of 1994 – 1996 shown in Table 3-3 estimates that the Chester Creek received discharges from these 5 outfalls accounting for approximately 12% of the total annual average overflow volume from the CSS, and approximately 23% of the overall number of discharge events.

Table 3-3 indicates that 4 of the 5 outfalls to the Ridley Creek had substantially more than the 4 – 6 annual overflow events that are the target for using the Presumption Approach. Only CSOs #033 is shown to have had less than 4 – 6 overflows. Of the four CSOs that were modeled to overflow more than 4- 6 times a year, the model estimates that all four of them had at least 33 or more annual overflow events and two of the outfalls are modeled as having had more than 95 overflow events.

Following the methodology described in the flowchart, the answers to the questions in the first decision making step indicate that the **Demonstration Approach** is the most appropriate for the CSO discharges to the Ridley Creek.

Section 6 Recommendations

It is recommended that the Demonstration Approach be utilized for the Delaware River, Chester Creek and Ridley Creek.

The Demonstration Approach relies on data collection and model simulation to demonstrate that the proposed LTCPU will meet applicable water quality standards and designated uses, and it provides a reliable tool to identify, evaluate and compare the selection and recommendation of the CSO control measures to be installed.

In addition to flow metering of the combined sewer system and water quality sampling of the CSOs to help refine and calibrate the H&H Model for the collection system, the Demonstration Approach requires a water quality model be developed for the Delaware River, Chester Creek and Ridley Creek. Water quality sampling of the receiving water bodies will be required to calibrate the water quality model and to identify and quantify the contributing pollutant sources in the watersheds other than CSOs.

The Demonstration Approach will be a better predictor than the Presumption Approach of actual resulting water quality at the end of the LTCPU program, and use of the Demonstration Approach will allow DELCORA to make more informed decisions regarding the long term control plan update investments that will result in compliance with the applicable water quality-based requirements.

Greeley and Hansen LLC
1700 Market Street, Suite 2130
Philadelphia, PA 19103
(215) 563-3460
www.greeley-hansen.com

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Consent ORDER

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

OCT 1 3 2016

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) Alternatives Evaluation Approach Report (AEAR) dated April 27, 2016. EPA understands DELCORA has chosen the "Demonstration Approach" and hereby approves the AEAR.

Sincerely,

Andrew F. Seligman, Environmental Scientist
Water Enforcement Branch

cc: R. Smolski, EPA
P. Yeany, EPA
M. DeSantis, DELCORA

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Customer Service Hotline: 1-800-438-2474

APPENDIX B

APPLICABLE WQS MASTER TABLE

- Applicable Water Quality Standards Master Table dated December 18, 2015

DELCORA CSO LTCPU - Applicable Water Quality Standards

Rev: 12-18-2015

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Alkalinity	DRBC WQRs - for Zone 4 / PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**Minimum**	**20**	**20**	**20**	---	---	---	---	---	---	---	---	---	---	**20**	mg/L as $CaCO_3$	Can eliminate from POCs since it is naturally occurring	Alkalinity
Alkalinity	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**120**	**120**		---	---	---	---	---	---	---	---	---	---	---	mg/L as $CaCO_3$	Can eliminate from POCs since it is naturally occurring	Alkalinity
Alkalinity	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**120**	**120**		---	---	---	---	---	---	---	---	---	---	---	mg/L as $CaCO_3$	Can eliminate from POCs since it is naturally occurring	Alkalinity
Aluminum	DRBC WQRs - Table 5 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**750**	---	---	**750**	87	---	---	---	---	---	**750**	---	**750**	87	µg/L	Total recoverable, restricted to pH 6.5 - 9	Aluminum
Aluminum	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**87**	---	---	750	**87**	---	---	---	---	---	750	---	750	**87**	µg/L	Total recoverable, restricted to pH 6.5 - 9	Aluminum
Aluminum	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**87**	---	---	750	**87**	---	---	---	---	---	750	---	750	**87**	µg/L	Total recoverable, restricted to pH 6.5 - 9	Aluminum
Ammonia	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**Maximum**	**$(NH_3 - N) \times (\log^{-1}[pK_T - pH] + 1)$**	---	**$(NH_3 - N) \times (\log^{-1}[pK_T - pH] + 1)$**	---	---	---	---	---	---	---	---	---	---	---	mg/L	pH dependent	Ammonia
Anthracene	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River**	**Maximum**	**8,300**	---	---	---	---	---	---	**8,300**	40,000	---	---	**8,300**	---	---	µg/L		Anthracene
Anthracene	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**8,300**	---	---	---	---	---	---	**8,300**	40,000	---	---	**8,300**	---	---	µg/L		Anthracene
Antimony	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**1,100**	---	---	---	---	---	---	5.6	640	220	**1,100**	5.6	---	---	µg/L		Antimony
Antimony	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**200**	---	---	---	---	---	---	5.6	640	**220**	1,100	5.6	---	---	µg/L		Antimony
Antimony	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River**	**Maximum**	**5.6**	---	---	---	---	---	---	**5.6**	640	220	1,100	**5.6**	---	---	µg/L		Antimony
Antimony	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**5.6**	---	---	---	---	---	---	**5.6**	640	220	1,100	**5.6**	---	---	µg/L		Antimony
Arsenic (trivalent) (As III)	DRBC WQRs - Table 5 / PA Code - Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Acute Maximum**	**340**	---	---	**340**	150	---	---	---	---	150	**340**	10	**340**	150	µg/L	Dissolved criteria	Arsenic (trivalent) (As III)
Arsenic (trivalent) (As III)	DRBC WQRs - Table 5 / PA Code - Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Chronic Maximum**	**150**	---	---	340	**150**	---	---	---	---	**150**	340	10	340	**150**	µg/L	Dissolved criteria	Arsenic (trivalent) (As III)
Arsenic (trivalent) (As III)	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**10**	---	---	340	150	---	---	---	---	150	340	**10**	340	150	µg/L	Dissolved criteria	Arsenic (trivalent) (As III)
Bacteria - Enterococcus (Above R.M. 81.8)	DRBC WQRs - for Zone 4	**Delaware River Upstream of RM 81.8**	**Maximum Geometric Average**	**88**	**88**	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Enterococcus (Above R.M. 81.8)
Bacteria - Enterococcus (Below R.M. 81.8)	DRBC WQRs - for Zone 4	**Delaware River Downstream of RM 81.8**	**Maximum Geometric Average**	**33**	**33**	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Enterococcus (Below R.M. 81.8)
Bacteria - Enterococcus	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum Geometric Average**	**88**	**88**	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Enterococcus (Above R.M. 81.8)
Bacteria - Fecal Coliform (Above R.M. 81.8)	DRBC WQRs - for Zone 4	**Delaware River Upstream of RM 81.8**	**Maximum Geometric Average**	**770**	**770**	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Fecal Coliform (Above R.M. 81.8)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Bacteria - Fecal Coliform (Below R.M. 81.8)	DRBC WQRs - for Zone 4	**Delaware River Downstream of RM 81.8**	**Maximum Geometric Average**	**200**	**200**	---	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL	DRBC WQRs and PA Code PA Code for WC Critical Use agree from May 1 - Sept 30, but PA Code of 2000 CFU/100 mL from Oct. 1 - April 30 for WC exceeds that allowed by DRBC Zone 4.	Bacteria - Fecal Coliform (Below R.M. 81.8)
Bacteria - Fecal Coliform	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum Geometric Average**	**770**	**770**	---	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Fecal Coliform (Above R.M. 81.8)
Barium	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Acute Maximum**	**21,000**			---	---	---	---	---	---	4,100	**21,000**	2,400			µg/L		Barium
Barium	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Chronic Maximum**	**4,100**			---	---	---	---	---	---	**4,100**	21,000	2,400			µg/L		Barium
Barium	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**2,400**			---	---	---	---	---	---	4,100	21,000	**2,400**			µg/L		Barium
Benzene	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**640**	---	---	---	---	0.61	14	---	3,100	130	**640**	1.2			µg/L		Benzene
Benzene	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**130**	---	---	---	---	0.61	14	---	3,100	**130**	640	1.2			µg/L		Benzene
Benzene	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**14**	---	---	---	---	0.61	**14**	---	3,100	130	640	1.2			µg/L		Benzene
Benzene	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**14**	---	---	---	---	0.61	**14**	---	3,100	130	640	1.2			µg/L		Benzene
Benzene	DRBC WQRs - Table 6	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.61**	---	---	---	---	**0.61**	14	---	3,100	130	640	1.2			µg/L		Benzene
benzo (a) anthracene	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Acute Maximum**	**0.5**	---	---	---	---	---	---	---	---	0.1	**0.5**	0.0038			µg/L		benzo (a) anthracene
benzo (a) anthracene	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Chronic Maximum**	**0.1**	---	---	---	---	---	---	---	---	**0.1**	0.5	0.0038			µg/L		benzo (a) anthracene
benzo (a) anthracene	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.0038**	---	---	---	---	---	---	---	---	0.1	0.5	**0.0038**			µg/L		benzo (a) anthracene
Beryllium	DRBC WQRs - Table 7	**Delaware River**	**Maximum**	**420**							---	**420**	---	---				µg/L		Beryllium
Beryllium	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**420**							---	**420**	---	---				µg/L		Beryllium
Biological Oxygen Demand (BOD)	No Standard						---	---	---	---	---	---	---	---	---					Biological Oxygen Demand (BOD)
Bis (2-ethylhexyl) phthalate	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**4,500**	---	---	---	---	1.2	2.2	---	620	910	**4,500**	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bis (2-ethylhexyl) phthalate	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**910**	---	---	---	---	1.2	2.2	---	620	**910**	4,500	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bis (2-ethylhexyl) phthalate	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**2.2**	---	---	---	---	1.2	**2.2**	---	620	910	4,500	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bis (2-ethylhexyl) phthalate	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**2.2**	---	---	---	---	1.2	**2.2**	---	620	910	4,500	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bis (2-ethylhexyl) phthalate	DRBC WQRs - Table 6	**Delaware River Downstream of RM 81.8**	**Maximum**	**1.2**	---	---	---	---	**1.2**	2.2	---	620	910	4,500	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bromodichloromethane (aka Dichlorobromomethane)	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**17**					0.55	**17**	680	---	---	---	0.55			µg/L		Bromodichloromethane (aka Dichlorobromomethane)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Bromodichloromethane (aka Dichlorobromomethane)	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**17**					0.55	**17**	680	---	---	---	0.55			µg/L		Bromodichloromethane (aka Dichlorobromomethane)
Bromodichloromethane (aka Dichlorobromomethane)	PA Code 25 - 93.8c, Table 5 / DRBC WQRs - Table 6	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.55**					**0.55**	17	680	---	---	---	**0.55**			µg/L		Bromodichloromethane (aka Dichlorobromomethane)
Butylbenzyl phthalate	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**140**	---	---	---	---			1,500	1,900	35	**140**	150			µg/L		Butylbenzyl phthalate
Butylbenzyl phthalate	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**35**	---	---	---	---			1,500	1,900	**35**	140	150			µg/L		Butylbenzyl phthalate
Cadmium	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**0.651*EXP(1.0166*LN(hardness)-3.924)**	---	---	**0.651*EXP(1.0166*LN(hardness)-3.924)**	0.651*EXP(0.7409*LN(hardness)-4.719)	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**0.651*EXP(0.7409*LN(hardness)-4.719)**	---	---	0.651*EXP(1.0166*LN(hardness)-3.924)	**0.651*EXP(0.7409*LN(hardness)-4.719)**	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.651*EXP(1.0166*LN(hardness)-3.924)**	---	---	**0.651*EXP(1.0166*LN(hardness)-3.924)**	0.651*EXP(0.7409*LN(hardness)-4.719)	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.651*EXP(0.7409*LN(hardness)-4.719)**	---	---	0.651*EXP(1.0166*LN(hardness)-3.924)	**0.651*EXP(0.7409*LN(hardness)-4.719)**	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	PA Code - Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)**	---	---	0.651*EXP(1.0166*LN(hardness)-3.924)	0.651*EXP(0.7409*LN(hardness)-4.719)	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	**(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)**	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	PA Code - Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)**	---	---	0.651*EXP(1.0166*LN(hardness)-3.924)	0.651*EXP(0.7409*LN(hardness)-4.719)	---	---	3.4	16	**(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)**	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
CBOD5	No Standard						---	---	---	---	---	---	---	---	---					CBOD5
CBOD20	No Standard						---	---	---	---	---	---	---	---	---					CBOD20
Chlorine (Total Residual Chlorine)	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**4-day Average (Chronic Maximum)**	**11**		**11**	---	---	---	---	---	---				19	**11**	µg/L		Chlorine (Total Residual Chlorine)
Chlorine (Total Residual Chlorine)	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**1-hour Average (Acute Maximum)**	**19**		**19**	---	---	---	---	---	---				**19**	11	µg/L		Chlorine (Total Residual Chlorine)
Chlorodibromomethane	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**13**	---	---	---	---	0.4	**13**			---	---	0.4			µg/L		Chlorodibromomethane
Chlorodibromomethane	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**13**	---	---	---	---	0.4	**13**			---	---	0.4			µg/L		Chlorodibromomethane
Chlorodibromomethane	DRBC WQRs - Table 6 / PA Code Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.4**	---	---	---	---	**0.4**	13			---	---	**0.4**			µg/L		Chlorodibromomethane
Chloroform	DRBC WQRs - Tables 6 & 7 / PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**1,900**	---	---	---	---	5.7	470	68	2,100	390	**1,900**	5.7			µg/L		Chloroform
Chloroform	DRBC WQRs - Tables 6 & 7 / PA Code Table 5	**Chester Creek, Ridley Creek, Delaware River Upstream of RM 81.8**	**Chronic Maximum**	**390**	---	---	---	---	5.7	470	68	2,100	**390**	1,900	5.7			µg/L		Chloroform
Chloroform	DRBC Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**470**	---	---	---	---	5.7	**470**	68	2,100	390	1,900	**5.7**			µg/L		Chloroform
Chloroform	DRBC Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**470**	---	---	---	---	5.7	**470**	68	2,100	390	1,900	**5.7**			µg/L		Chloroform

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Chloroform	PA Code 25 - 93.8c, Table 5 / DRBC Table 6	**Delaware River Downstream of RM 81.8**	**Maximum**	**5.7**	---	---	---	---	**5.7**	470	68	2,100	390	1,900	**5.7**			µg/L		Chloroform
COD	No Standard						---	---	---	---	---	---								COD
Chromium (trivalent) (Cr III)	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**0.277*EXP(0.819*LN(hardness)+3.7256)**	---	---	**0.277*EXP(0.819*LN(hardness)+3.7256)**	0.277*EXP(0.819*LN(hardness)+0.6848)	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**0.277*EXP(0.819*LN(hardness)+0.6848)**	---	---	0.277*EXP(0.819*LN(hardness)+3.7256)	**0.277*EXP(0.819*LN(hardness)+0.6848)**	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.277*EXP(0.819*LN(hardness)+3.7256)**	---	---	**0.277*EXP(0.819*LN(hardness)+3.7256)**	0.277*EXP(0.819*LN(hardness)+0.6848)	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.277*EXP(0.819*LN(hardness)+0.6848)**	---	---	0.277*EXP(0.819*LN(hardness)+3.7256)	**0.277*EXP(0.819*LN(hardness)+0.6848)**	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**(0.819 x LN(hardness)+3.7256)**	---	---	0.277*EXP(0.819*LN(hardness)+3.7256)	0.277*EXP(0.819*LN(hardness)+0.6848)	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	**(0.819 x LN(hardness)+3.7256)**	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**(0.819 x LN(hardness)+0.6848)**	---	---	0.277*EXP(0.819*LN(hardness)+3.7256)	0.277*EXP(0.819*LN(hardness)+0.6848)	---	---	---	380,000	**(0.819 x LN(hardness)+0.6848)**	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (hexavalent) (Cr VI)	DRBC WQRs - Tables 5 & 7 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**16**	---	---	**16**	11	---	---	92	---	10	**16**	---	16	11	µg/L	Dissolved criteria	Chromium (hexavalent) (Cr VI)
Chromium (hexavalent) (Cr VI)	PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**10**	---	---	16	11	---	---	92	---	**10**	16	---	16	11	µg/L	Dissolved criteria	Chromium (hexavalent) (Cr VI)
Chyrsene	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**18**	---	---	---	---	3.8	**18**	---	---	---	---	0.0038			µg/L		Chyrsene
Chyrsene	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**18**	---	---	---	---	3.8	**18**	---	---	---	---	0.0038			µg/L		Chyrsene
Chyrsene	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.0038**	---	---	---	---	3.8	18	---	---	---	---	**0.0038**			µg/L		Chyrsene
Copper	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**0.908*EXP(0.9422*LN(hardness)-1.7)**	---	---	**0.908*EXP(0.9422*LN(hardness)-1.7)**	0.908*EXP(0.8545*LN(hardness)-1.702)	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Copper	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**0.908*EXP(0.8545*LN(hardness)-1.702)**	---	---	0.908*EXP(0.9422*LN(hardness)-1.7)	**0.908*EXP(0.8545*LN(hardness)-1.702)**	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Copper	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.908*EXP(0.9422*LN(hardness)-1.7)**	---	---	**0.908*EXP(0.9422*LN(hardness)-1.7)**	0.908*EXP(0.8545*LN(hardness)-1.702)	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Copper	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.908*EXP(0.8545*LN(hardness)-1.702)**	---	---	0.908*EXP(0.9422*LN(hardness)-1.7)	**0.908*EXP(0.8545*LN(hardness)-1.702)**	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Copper	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**0.960 x Exp(0.9422*LN(hardness)-1.70)**	---	---	0.908*EXP(0.9422*LN(hardness)-1.7)	0.908*EXP(0.8545*LN(hardness)-1.702)	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	**0.960 x Exp(0.9422*LN(hardness)-1.70)**	---	---	---	µg/L	Dissolved criteria	Copper
Copper	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.960 x Exp(0.8545*LN(hardness)-1.702)**	---	---	0.908*EXP(0.9422*LN(hardness)-1.7)	0.908*EXP(0.8545*LN(hardness)-1.702)	---	---	---	---	**0.960 x Exp(0.8545*LN(hardness)-1.702)**	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Cyanide (free)	DRBC WQRs - Table 5 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**22**	---	---	**22**	5.2	---	---	140	140	5.2	**22**	140	**22**	5.2	µg/L		Cyanide (free)
Cyanide (free)	DRBC WQRs - Table 5 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**5.2**	---	---	22	**5.2**	---	---	140	140	**5.2**	22	140	22	**5.2**	µg/L		Cyanide (free)
Dieldrin	PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**0.24**	---	---	0.24	0.056	0.000052	0.000054	0.041	0.043	0.056	**0.24**	0.000052	**0.24**	0.056	µg/L		Dieldrin
Dieldrin	PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.056**	---	---	0.24	0.056	0.000052	0.000054	0.041	0.043	**0.056**	0.24	0.000052	0.24	**0.056**	µg/L		Dieldrin

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Dieldrin	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**0.000054**	---	---	0.24	0.056	0.000052	**0.000054**	0.041	0.043	0.056	0.24	0.000052	0.24	0.056	µg/L		Dieldrin
Dieldrin	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.000054**	---	---	0.24	0.056	0.000052	**0.000054**	0.041	0.043	0.056	0.24	0.000052	0.24	0.056	µg/L		Dieldrin
Dieldrin	DRBC WQRs - Table 6 / PA Code - Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.000052**	---	---	0.24	0.056	**0.000052**	0.000054	0.041	0.043	0.056	0.24	**0.000052**	0.24	0.056	µg/L		Dieldrin
Diethylphthalate	PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**4,000**	---	---	---	---			17,000	44,000	800	**4,000**	17,000			µg/L		Diethylphthalate
Diethylphthalate	PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**800**	---	---	---	---			17,000	44,000	**800**	4,000	17,000			µg/L		Diethylphthalate
Dissolved Oxygen (DO)$_1$	DRBC WQRs - for Zone 4	**Delaware River**	**24 hr. Average Minimum**	**3.5**	**3.5**		---	---	---	---	---	---						mg/L	**Year Round Minimum**	Dissolved Oxygen (DO)$_1$
Dissolved Oxygen (DO)$_1$	DRBC WQRs - for Zone 4	**Delaware River**	**24 hr. Average Minimum**	**6.5**	**6.5**		---	---	---	---	---	---						mg/L	**Minimum for April 1 to June 15 and Sept. 16 to Dec. 31**	Dissolved Oxygen (DO)$_1$
Dissolved Oxygen (DO)$_1$	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**24 hr. Average Minimum**	**3.5**	**3.5**		---	---	---	---	---	---						mg/L	**Year Round Minimum**	Dissolved Oxygen (DO)$_1$
Dissolved Oxygen (DO)$_1$	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**24 hr. Average Minimum**	**6.5**	**6.5**		---	---	---	---	---	---						mg/L	**Minimum for April 1 to June 15 and Sept. 16 to Dec. 31**	Dissolved Oxygen (DO)$_1$
Dissolved Oxygen (DO)$_2$	PA Code (WWF)	**Chester Creek upstream of OF#20, & Ridley Creek from OF#18 upstream to Rt. 320**	**7-day Average**	**5.5**		**5.5**	---	---	---	---	---	---						mg/L		Dissolved Oxygen (DO)$_2$
Dissolved Oxygen (DO)$_2$	PA Code (WWF)	**Chester Creek upstream of OF#20, & Ridley Creek from OF#18 upstream to Rt. 320**	**Minimum**	**5.0**		**5.0**	---	---	---	---	---	---						mg/L		Dissolved Oxygen (DO)$_2$
Dissolved Oxygen (DO)$_3$ (Feb. 15 - July 31)	PA Code (TSF)	**Ridley Creek from Rt. 320 upstream to Media Water Intake**	**7-day Average**	**6.0**		**6.0**	---	---	---	---	---	---						mg/L	TSF only applies to Ridley Creek for impacts by DELCORA CSOs	Dissolved Oxygen (DO)$_3$
Dissolved Oxygen (DO)$_3$ (Feb. 15 - July 31)	PA Code (TSF)	**Ridley Creek from Rt. 320 upstream to Media Water Intake**	**Minimum**	**5.0**		**5.0**	---	---	---	---	---	---						mg/L	TSF only applies to Ridley Creek for impacts by DELCORA CSOs	Dissolved Oxygen (DO)$_3$
Dissolved Oxygen (DO)$_3$ (Aug. 1 - Feb. 14)	PA Code (TSF)	**Ridley Creek from Rt. 320 upstream to Media Water Intake**	**7-day Average**	**5.5**		**5.5**												mg/L	TSF only applies to Ridley Creek for impacts by DELCORA CSOs	Dissolved Oxygen (DO)$_3$
Dissolved Oxygen (DO)$_3$ (Aug. 1 - Feb. 14)	PA Code (TSF)	**Ridley Creek from Rt. 320 upstream to Media Water Intake**	**Minimum**	**5.0**		**5.0**												mg/L	TSF only applies to Ridley Creek for impacts by DELCORA CSOs	Dissolved Oxygen (DO)$_3$
Ethylbenzene	PA Code - Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**2,900**	---	---	---	---			530	2,100	580	**2,900**	530			µg/L		Ethylbenzene
Ethylbenzene	PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**580**	---	---	---	---			530	2,100	**580**	2,900	530			µg/L		Ethylbenzene
Ethylbenzene	DRBC WQRs - Table 7	**Delaware River Upstream of RM 81.8**	**Maximum**	**2,100**	---	---	---	---			530	**2,100**	580	2,900	530			µg/L		Ethylbenzene
Ethylbenzene	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**2,100**	---	---	---	---			530	**2,100**	580	2,900	530			µg/L		Ethylbenzene

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Ethylbenzene	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**530**	---	---	---	---			**530**	2,100	580	2,900	**530**			µg/L		Ethylbenzene
Fluorene	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River Upstream of RM 81.8**	**Maximum**	**5,300**	---	---	---	---			1,100	**5,300**	---	---	1,100			µg/L		Fluorene
Fluorene	DRBC WQRs - Table 7 / PA Code - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**5,300**	---	---	---	---			1,100	**5,300**	---	---	1,100			µg/L		Fluorene
Fluorene	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**1,100**	---	---	---	---			**1,100**	5,300	---	---	**1,100**			µg/L		Fluorene
Hardness	No Standard	**Delaware River, Chester Creek, Ridley Creek**	--		--	--	---	---	---	---	---	---						$mg/L\ as\ CaCO_3$	Needed to calculate some of the metal concentrations	Hardness
Iron (Fe)	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**30-day Average**	**1.5**		**1.5**	---	---	---	---	---	---						mg/L as total recoverable	Iron as total recoverable	$Iron\ (Fe)_{(1)}$
Iron (Fe)	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**Maximum**	**0.3**		**0.3**	---	---	---	---	---	---				---	1.0	mg/L as dissolved	Iron as dissolved	$Iron\ (Fe)_{(2)}$
Lead	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**38**	---	---	**38**	5.4	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**5.4**	---	---	38	**5.4**	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**38**	---	---	**38**	5.4	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**5.4**	---	---	38	**5.4**	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)**	---	---	38	5.4	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	**(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)**	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)**	---	---	38	5.4	---	---	---	---	**(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)**	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Mercury (Hg)	PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**1.4**	---	---	1.4	0.77	---	---	0.05	0.051	0.77 (Hg2+)	**1.4 (Hg2+)**	0.05	**1.4**	0.77	µg/L	Dissolved criteria	Mercury (Hg)
Mercury (Hg)	PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.77**	---	---	1.4	0.77	---	---	0.05	0.051	**0.77 (Hg2+)**	1.4 (Hg2+)	0.05	1.4	**0.77**	µg/L	Dissolved criteria	Mercury (Hg)
Mercury (Hg)	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.051**	---	---	1.4	0.77	---	---	0.05	**0.051**	0.77 (Hg2+)	1.4 (Hg2+)	0.05	1.4	**0.77**	µg/L	Dissolved criteria	Mercury (Hg)
Mercury (Hg)	DRBC WQRs - Table 7	**Delaware River Upstream of RM 81.8**	**Maximum**	**0.051**	---	---	1.4	0.77	---	---	0.05	**0.051**	0.77 (Hg2+)	1.4 (Hg2+)	0.05	1.4	**0.77**	µg/L	Dissolved criteria	Mercury (Hg)
Mercury (Hg)	DRBC WQRs - Table 7 / PA Code Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.05**	---	---	1.4	0.77	---	---	**0.05**	0.051	0.77 (Hg2+)	1.4 (Hg2+)	**0.05**	1.4	0.77	µg/L	Dissolved criteria	Mercury (Hg)
Methylene chloride (Dichloromethane)	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**12,000**	---	---	---	---	---	590	---	260,000	2,400	**12,000**	4.6			µg/L		Methylene chloride (Dichloromethane)
Methylene chloride (Dichloromethane)	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**2,400**	---	---	---	---	---	590	---	260,000	**2,400**	12,000	4.6			µg/L		Methylene chloride (Dichloromethane)
Methylene chloride (Dichloromethane)	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**590**	---	---	---	---	---	**590**	---	260,000	2,400	12,000	4.6			µg/L		Methylene chloride (Dichloromethane)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Methylene chloride (Dichloromethane)	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**590**	---	---	---	---	---	**590**	---	260,000	2,400	12,000	4.6			µg/L		Methylene chloride (Dichloromethane)
Methylene chloride (Dichloromethane)	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**4.6**	---	---	---	---	---	590	---	260,000	2,400	12,000	**4.6**			µg/L		Methylene chloride (Dichloromethane)
Molybdenum	No Standard						---	---	---	---	---	---								Molybdenum
MTBE	No Standard						---	---	---	---	---	---								MTBE
Naphthalene	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**140**			---	---	---	---	---	---	43	**140**	---			µg/L		Naphthalene
Naphthalene	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**43**			---	---	---	---	---	---	**43**	140	---			µg/L		Naphthalene
Nickel	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**0.998 x Exp(0.846 x LN(hardness)+2.255)**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	**0.998 x Exp(0.846 x LN(hardness)+2.255)**	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.997 x Exp(0.846 x LN(hardness)+0.0584)**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	500	1,700	**0.997 x Exp(0.846 x LN(hardness)+0.0584)**	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.846*EXP(0.846*LN(hardness)+2.255)**	---	---	**0.846*EXP(0.846*LN(hardness)+2.255)**	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.846*EXP(0.846*LN(hardness)+0.0584)**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	**0.846*EXP(0.846*LN(hardness)+0.0584)**	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 5	**Delaware River Upstream of RM 81.8**	**Acute Maximum**	**0.846*EXP(0.846*LN(hardness)+2.255)**	---	---	**0.846*EXP(0.846*LN(hardness)+2.255)**	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 5	**Delaware River Upstream of RM 81.8**	**Chronic Maximum**	**0.846*EXP(0.846*LN(hardness)+0.0584)**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	**0.846*EXP(0.846*LN(hardness)+0.0584)**	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 7	**Delaware River Downstream of RM 81.8**	**Maximum**	**500**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	**500**	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nitrate	No Standard						---	---	---	---	---	---								Nitrate
Nitrite	No Standard						---	---	---	---	---	---								Nitrite
Nitrate + Nitrate	No Standard																			Nitrate + Nitrate
N-Nitroso-di-n-propylamine	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**0.51**	---	---	---	---	0.005	**0.51**					0.005			µg/L		N-Nitroso-di-n-propylamine
N-Nitroso-di-n-propylamine	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.51**	---	---	---	---	0.005	**0.51**					0.005			µg/L		N-Nitroso-di-n-propylamine
N-Nitroso-di-n-propylamine	DRBC WQRs - Table 6 / PA Code Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.005**	---	---	---	---	**0.005**	0.51					**0.005**			µg/L		N-Nitroso-di-n-propylamine
Oil and Grease	No Standard						---	---	---	---	---	---								Oil and Grease
Osmotic Pressure (OP)	**PA Code (WWF, MF, TSF)**	**Delaware River, Chester Creek, Ridley Creek**	**Maximum**	**50**		**50**	---	---	---	---	---	---						milliosmoles/kg		Osmotic Pressure (OP)
PCBs (Total)	DRBC WQRs - Table 5 / PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.014**	---	---	1.0	**0.014**	0.000016	0.000016	0.008390	0.008490	**0.014**	---	0.000064	---	**0.014**	µg/L		PCBs (Total)
PCBs (Total)	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.000016**	---	---	1.0	0.014	**0.000016**	**0.000016**	0.008390	0.008490	0.014	---	0.000064	---	0.014	µg/L		PCBs (Total)
PCBs (Total)	DRBC WQRs - Table 6	**Delaware River**	**Maximum**	**0.000016**	---	---	1.0	0.014	**0.000016**	**0.000016**	0.008390	0.008490	0.014	---	0.000064	---	0.014	µg/L		PCBs (Total)
pH$_{(1)}$	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**8.5**	**8.5**		---	---	---	---	---	---				---	6.5 - 9	--	Exceeds criteria from PA Code for WWF, MF, & TSF of pH 6 - 9	pH$_{(1)}$
pH$_{(1)}$	DRBC WQRs - for Zone 4	**Delaware River**	**Minimum**	**6.5**	**6.5**		---	---	---	---	---	---						--	Exceeds criteria from PA Code for WWF, MF, & TSF of pH 6 - 9	pH$_{(1)}$

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
pH(1)	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**8.5**	**8.5**		---	---	---	---	---	---				---	6.5 - 9	--	Exceeds criteria from PA Code for WWF, MF, & TSF of pH 6 - 9	pH(1)
pH(1)	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Minimum**	**6.5**	**6.5**		---	---	---	---	---	---						--	Exceeds criteria from PA Code for WWF, MF, & TSF of pH 6 - 9	pH(1)
pH(2)	PA Code (WWF, MF, TSF)	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Maximum**	**9.0**		**9.0**	---	---	---	---	---	---						--	Use the more stringent standard above from DRBC Zone 4 for the Delaware River	pH(2)
pH(2)	PA Code (WWF, MF, TSF)	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Minimum**	**6.0**		**6.0**	---	---	---	---	---	---						--	Use the more stringent standard above from DRBC Zone 4 for the Delaware River	pH(2)
Phenanthrene	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**5**			---	---	---	---	---	---	1	**5**	---			µg/L		Phenanthrene
Phenanthrene	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**1**			---	---	---	---	---	---	**1**	5	---			µg/L		Phenanthrene
Phenols	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**0.02**	**0.02**		---	---	---	---	---	---	---	---	10.4			mg/L		Phenols
Phenols	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.02**	**0.02**		---	---	---	---	---	---	---	---	10.4			mg/L		Phenols
Phosphate	No Standard						---	---	---	---	---	---								Phosphate
Pyrene	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**4,000**	---	---	---	---			830	**4,000**	---	---	830			µg/L		Pyrene
Pyrene	DRBC WQRs - Table 7	**Delaware River Upstream of RM 81.8**	**Maximum**	**4,000**	---	---	---	---			830	**4,000**	---	---	830			µg/L		Pyrene
Pyrene	DRBC WQRs - Table 7 / PA Code Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**830**	---	---	---	---			**830**	4,000	---	---	**830**			µg/L		Pyrene
Radioactivity - alpha emitters	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**3**	**3**		---	---	---	---	---	---						pc/L		Radioactivity - alpha emitters
Radioactivity - beta emitters	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**1,000**	**1,000**		---	---	---	---	---	---						pc/L		Radioactivity - beta emitters
Radioactivity - alpha emitters	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**3**	**3**		---	---	---	---	---	---						pc/L		Radioactivity - alpha emitters
Radioactivity - beta emitters	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**1,000**	**1,000**		---	---	---	---	---	---						pc/L		Radioactivity - beta emitters
Selenium (Se)	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**20**	---	---	**20**	5.0	---	---	170	4,200	4.6	---	---	---	5.0	µg/L	Total recoverable criteria	Selenium (Se)
Selenium (Se)	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**20**	---	---	**20**	5.0	---	---	170	4,200	4.6	---	---	---	5.0	µg/L	Total recoverable criteria	Selenium (Se)
Selenium (Se)	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**4.6**	---	---	20	5.0	---	---	170	4,200	**4.6**	---	---	---	5.0	µg/L	Total recoverable criteria	Selenium (Se)
Silver (Ag)	DRBC WQRs - Tables 5 & 7 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**0.85*EXP(1.72*LN(hardness)-6.59)**	---	---	**0.85*EXP(1.72*LN(hardness)-6.59)**	NA	---	---	170	40,000	---	**0.850 x Exp(1.72 x LN(hardness) - 6.590)**	---	3.2	---	µg/L	Dissolved criteria	Silver (Ag)
Sulfide	No Standard						---	---	---	---	---	---								Sulfide
Synthetic Detergents (B)	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum 30-day Average**	**1.0**	**1.0**		---	---	---	---	---	---						mg/L		Synthetic Detergents (B)
Synthetic Detergents (B)	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum 30-day Average**	**1.0**	**1.0**		---	---	---	---	---	---						mg/L		Synthetic Detergents (B)
Temperature (A) (1)	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**30**	**30**		---	---	---	---	---	---						°C		Temperature (A)
Temperature (A) (1)	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**2.8 Deg above 24-hr gradient during the 1961-66 period**	**2.8 Deg above 24-hr gradient during the 1961-66 period**		---	---	---	---	---	---						°C		Temperature (A)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Temperature [A] [1]	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**30**	**30**		---	---	---	---	---	---						°C		Temperature [A]
Temperature [A] [1]	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**2.8 Deg above 24-hr gradient during the 1961-66 period**	**2.8 Deg above 24-hr gradient during the 1961-66 period**		---	---	---	---	---	---						°C		Temperature [A]
Temperature [2]	PA Code (WWF, TSF)	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Maximum**	**Varies - see table on pg. 93-21 & 93-22**		**Varies - see table on pg. 93-21 & 93-22**	---	---	---	---	---	---						°F	Use the more stringent standard above from DRBC Zone 4 for the Delaware River	Temperature
Tetrachloroethene/ Tetrachloroethylene	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**700**			---	---	0.69	3.3	---	1,300	140	**700**				µg/L		Tetrachloroethene/ Tetrachloroethylene
Tetrachloroethene/ Tetrachloroethylene	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**140**			---	---	0.69	3.3	---	1,300	**140**	700				µg/L		Tetrachloroethene/ Tetrachloroethylene
Tetrachloroethene/ Tetrachloroethylene	DRBC WQRs - Table 6	**Delaware River Upstream of R.M. 81.8**	**Maximum**	**3.3**			---	---	0.69	**3.3**	---	1,300	140	700				µg/L		Tetrachloroethene/ Tetrachloroethylene
Tetrachloroethene/ Tetrachloroethylene	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**3.3**			---	---	0.69	**3.3**	---	1,300	140	700				µg/L		Tetrachloroethene/ Tetrachloroethylene
Tetrachloroethene/ Tetrachloroethylene	DRBC WQRs - Table 6	**Delaware River Downstream of R.M. 81.8**	**Maximum**	**0.69**			---	---	**0.69**	3.3	---	1,300	140	700				µg/L		Tetrachloroethene/ Tetrachloroethylene
Thallium	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**65**							0.24	0.47	13	**65**				µg/L		Thallium
Thallium	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**13**							0.24	0.47	**13**	65				µg/L		Thallium
Thallium	DRBC WQRs - Table 7	**Delaware River Upstream of R.M. 81.8**	**Maximum**	**0.47**							0.24	**0.47**	13	65				µg/L		Thallium
Thallium	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.47**							0.24	**0.47**	13	65				µg/L		Thallium
Thallium	DRBC WQRs - Table 7	**Delaware River Downstream of R.M. 81.8**	**Maximum**	**0.24**							**0.24**	0.47	13	65				µg/L		Thallium
Threshold Odor Number	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**24 at 60 °C**	**24 at 60 °C**		---	---	---	---	---	---						--		Threshold Odor Number
Threshold Odor Number	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**24 at 60 °C**	**24 at 60 °C**		---	---	---	---	---	---						--		Threshold Odor Number
Toluene	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Acute Maximum**	**1,700**	---	---	---	---			1,300	15,000	330	**1,700**	1,300			µg/L		Toluene
Toluene	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Chronic Maximum**	**330**	---	---	---	---			1,300	15,000	**330**	1,700	1,300			µg/L		Toluene
Toluene	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**1,300**	---	---	---	---			**1,300**	15,000	330	1,700	**1,300**			µg/L		Toluene
Total Dissolved Solids (TDS)	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**133% of background**	**133% of background**		---	---	---	---	---	---						mg/L		Total Dissolved Solids (TDS)
Total Dissolved Solids (TDS)	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**133% of background**	**133% of background**		---	---	---	---	---	---						mg/L		Total Dissolved Solids (TDS)
TKN	No Standard						---	---	---	---	---	---								TKN
Total Organic Carbon (TOC)	No Standard						---	---	---	---	---	---								Total Organic Carbon (TOC)
Total Organic Halides (T.O.X.)	No Standard						---	---	---	---	---	---								Total Organic Halides (T.O.X.)
Total Nitrogen	No Standard						---	---	---	---	---	---								Total Nitrogen
Total Petroleum Hydrocarbon (TPH)	No Standard																			Total Petroleum Hydrocarbon (TPH)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Total Phosphorus	No Standard						---	---	---	---	---	---								Total Phosphorus
Total Suspended Solids (TSS)	No Standard						---	---	---	---	---	---								Total Suspended Solids (TSS)
Turbidity [C]	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum 30-day Average**	**40**	**40**		---	---	---	---	---	---						NTU		Turbidity [C]
Turbidity [C]	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**150**	**150**		---	---	---	---	---	---						NTU		Turbidity [C]
Turbidity [C]	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum 30-day Average**	**40**	**40**		---	---	---	---	---	---						NTU		Turbidity [C]
Turbidity [C]	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**150**	**150**		---	---	---	---	---	---						NTU		Turbidity [C]
Xylenes (total)	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**1,100**			---	---	---	---	---	---	210	**1,100**	70,000			µg/L		Xylenes (total)
Xylenes (total)	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**210**			---	---	---	---	---	---	**210**	1,100	70,000			µg/L		Xylenes (total)
Zinc	DRBC WQRs - Tables 5 & 7	**Delaware River**	**Acute Maximum**	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	**0.95*EXP(0.8473*LN(hardness)+0.884)**	0.95*EXP(0.8473*LN(hardness)+0.884)	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	DRBC WQRs - Tables 5 & 7	**Delaware River**	**Chronic Maximum**	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	0.95*EXP(0.8473*LN(hardness)+0.884)	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	DRBC WQRs - Tables 5 & 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	**0.95*EXP(0.8473*LN(hardness)+0.884)**	0.95*EXP(0.8473*LN(hardness)+0.884)	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	DRBC WQRs - Tables 5 & 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	0.95*EXP(0.8473*LN(hardness)+0.884)	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**0.978 x Exp(0.8473 x LN(hardness) + 0.884)**	---	---	0.95*EXP(0.8473*LN(hardness)+0.884)	0.95*EXP(0.8473*LN(hardness)+0.884)	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	**0.978 x Exp(0.8473 x LN(hardness) + 0.884)**	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.986 x Exp(0.8473 x LN(hardness) + 0.884)**	---	---	0.95*EXP(0.8473*LN(hardness)+0.884)	0.95*EXP(0.8473*LN(hardness)+0.884)	---	---	7,400	26,000	**0.986 x Exp(0.8473 x LN(hardness) + 0.884)**	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc

(A) Temperature shall not exceed 5 °F (2.8 °C) above the average 24-hour temperature gradient displayed during the 1961-66 period, or a maximum of 86 °F (30.0 °C) - whichever is less.

(B) Using M.B.A.S assay, with a maximum 30-day average of 1.0 mg/L.

(C) Unless exceeded due to natural conditions.

NOTES:

DRBC standards in their WQRs are referred to as "Stream Quality Objectives". DRBC's Stream Quality Objectives have primacy over the PA Code standards for the Delaware River.

PA CODE refers to the standards as "Water Quality Standards".

Ridley Creek is "TSF & MF" Critical Use from Rt. 320 Bridge upstream to the Media Water Intake. Ridley Creek is "WWF & MF" downstream from the Rt. 320 Bridge to mouth.

Chester Creek has a "TSF" Critical Use designation as well, but this is well upstream of the CSO discharge furthest upstream on Chester Creek and does not apply for this analysis.

APPENDIX C

ID OF SENSITIVE AREAS & POCS REPORT

- DELCORA Sensitive Areas and POC Report dated February 2016 (Revised May 2016)
- USEPA Approval of the Sensitive Areas and POC Report dated October 13, 2016

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

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

Identification of Sensitive Areas and Pollutants of Concern Report (Final)

February 2016
(May 2016)

GREELEY AND HANSEN

REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Identification of Sensitive Areas and Pollutants of Concern 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*	2/9/16 *Date*
DELCORA ENGINEERING		
Director of Engineering	*Signature*	2/9/16 *Date*
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	*Signature*	2/3/16 *Date*

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES
1	5/17/16	Greeley and Hansen	• Updated Sections ES-3 and ES-4 to reflect changes in the report. • Updated Section 1.1, second paragraph. • Updated Sections 1.3.1, revised text reading 13.3 to be 20 MGD. • Clarified Sections 1.3.2, and 2.1.2 • Updated Table 2-1 and Section 2.3.1.2 to address USEPA comment. • Revised Sections 2.3.2, 2.3.4, 2.3.4.2, 2.3.5.1 to address USEPA comment on sensitive areas. • Updated Figure 2-1 • Revised Sections 2.4, 2.4.1, 2.4.2 to address USEPA comments. • Revised Section 3.7 to address USEPA comments. • Updated Section 3.7.2 • Updated Attachment A and Added Attachment K

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Executive Summary

ES-1 Background

The Delaware County Regional Water Quality Control Authority (DELCORA) is a municipal authority originally organized under the Pennsylvania Municipal Authorities Act of 1945 (P.L. 382), as amended and supplemented, pursuant to action taken by the Delaware County Council on October 20, 1971. Under County of Delaware Ordinance 2002-1, the term of existence of DELCORA was extended to January 15, 2052.

DELCORA is in the process of developing a Long Term Control Plan (LTCP) Update for the Combined Sewer System (CSS) as part of a Consent Decree entered with the United States Environmental Protection Agency (USEPA or EPA) and the Pennsylvania Department of Environmental Protection (PADEP or DEP). DELCORA's Combined Sewer System is comprised of a sewer that accepts stormwater and sanitary wastewater which is treated at DELCORA's Western Regional Treatment Plant WRTP. As part of this comprehensive effort, DELCORA is to submit a report to the USEPA and PADEP that identifies all Sensitive Areas and Pollutants of Concern (POCs) that are impacted by Combined Sewer Overflows (CSOs) and are within the Model Area for each of its receiving waters. DELCORA is also to identify any additional areas that have been determined by DELCORA as being appropriate for prioritization.

The purpose of this report is to meet the requirement in the Consent Decree for the submission of a report that identifies the Sensitive Areas and Pollutants of Concern that are impacted by DELCORA's CSOs.

ES-2 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.11 (Identification of Sensitive Areas and Pollutants of Concern) requires that within six (6) months after the Date of Lodging, DELCORA shall submit a report that identifies all Sensitive Areas and Pollutants of Concern that are impacted by CSOs and are within the Model Area for each of its receiving waters. The receiving water bodies impacted by DELCORA's CSOs include the Delaware River, Chester Creek and Ridley Creek.

For the Identification of Sensitive Areas, Section V.A.11 of the Consent Decree specifically states:

> *"For each of its Receiving Waters, DELCORA shall contact appropriate agencies, access available data sources, and collect additional data as necessary to identify Sensitive*

Areas. DELCORA shall fully document all such contacts and the associated responses, and all additional investigations carried out to identify Sensitive Areas. DELCORA shall also identify any additional areas that, while not Sensitive Areas, have been identified by DELCORA as being appropriate for prioritization ("Priority Areas")." Additionally, *"For each of its Receiving Waters, DELCORA shall conduct community outreach and appropriate studies to determine whether and to what extent primary contact recreation is occurring in each Receiving Water, and shall fully document its outreach and study methods, and its findings."*

For the Identification of Pollutants of Concern, Section V.A.11 of the Consent Decree specifically states:

"For each of its Receiving Waters, DELCORA shall review existing water quality data and recent PADEP CWA § 303(d) listings to identify POCs. Even if a water body has not been formally listed as out of compliance with its water quality standards and designated uses, if available data indicate such impairment exists and such impairment involves pollutants associated with CSOs, DELCORA shall consider the related pollutants to be POCs."

ES-3 Sensitive Areas Summary

A comprehensive review of online databases, correspondence with regulatory agencies and local environmental organizations and review of responses to the public survey was conducted to identify potential Sensitive Areas within the combined sewer system portion of the collection system.

Outstanding National Resource Waters (ONRW) are maintained and protected by Tier 3 of the USEPA's Antidegradation Policy which can be accessed through the Agency's web portal. Only waters of "exceptional ecological significance" qualify as ONRWs, and States and Tribes determine whether or not a water body will be classified as such. In Chapter 93 of the Pennsylvania Code, it is stated that a water body will be classified as having Exceptional Value (EV) if it is considered by the Commonwealth of Pennsylvania to be an ONRW. No Outstanding National Resource Waters were located within the project boundaries.

The goal of the National Marine Sanctuaries Act (Title 16, Chapter 32, Section 1431 last amended in November 2000) is to identify and designate as National Marine Sanctuaries (NMS) areas of the marine environment which are of special national significance and to manage these areas as the National Marine Sanctuary System. The Office of National Marine Sanctuaries (ONMS) is the trustee of all national marine sanctuaries and as such, it currently recognizes fourteen (14) national marine sanctuaries, none of which are located within DELCORA's service area. Therefore, none of DELCORA's receiving waters, the Delaware River, Chester Creek or Ridley Creek, are considered to be a National Marine Sanctuary.

There are no commercial shellfish harvesters that operate within the study area. The Partnership for the Delaware Estuary reported shellfish areas well downstream of the most southern outfall in DELCORA's system. The uppermost shellfish harvesting area is approximately 32 miles outside the project boundaries. No shellfish beds are located within the project boundaries.

There are numerous drinking water intakes in this geographical area but none are located on the Delaware River downstream in close proximity to DELCORA's CSOs. There are no drinking water intakes located along Chester Creek or Ridley Creek in proximity to DELCORA's service area. Therefore, the Sensitive Area criteria for Drinking Water Intakes does not apply to the Chester or Ridley Creeks.

While the US Fish and Wildlife Service identified several Endangered or Threatened species which potentially could live in the project area, critical habitat was found for Atlantic Sturgeon only. The habitat for year-of-young Atlantic Sturgeon downstream of CSO #002 in the Delaware River meets the Sensitive Area criteria for Endangered or Threatened species. The Atlantic Sturgeon is listed as a threatened species by the US Fish and Wildlife Service with documented habitat in the Delaware River downstream approximately one-half mile downstream of DELCORA's most southern outfall. Therefore, the habitat for year-of-young Atlantic Sturgeon is considered a sensitive area.

The northern reaches of Ridley Creek within DELCORA's service area are designated as Approved Trout Waters and Trout Stocked Streams. The portion of the approved trout waters from CSO #033 downstream to Chestnut Street is considered a Priority Area because of this special environmental use.

The boat launch located between CSO #007 and #008 along the Delaware River is located within the portion of the waterbody rated for primary contact and may be impacted by CSO discharge. The boat launch is considered a Priority Area.

ES-4 Pollutants of Concern Summary

A comprehensive review of existing receiving water quality data was conducted to identify the Pollutants of Concern and this review was performed in accordance with the requirements of the Consent Decree and the CSO Guidance Manual. This review included on-line USEPA STORET data from the Years 2010-2015, results of sampling performed during the preparation of DELCORA's 1999 LTCP and additional CSO sampling. A parameter associated with CSO discharges was considered to be a POC when more than 10% of the total samples reviewed indicated an exceedance of the applicable water quality standard. A secondary category called Parameters of Potential Concern (POPC) was established for those parameters associated with CSO discharges where 2 to 10% of the total samples reviewed indicated an exceedance of the applicable water quality standard.

The specific parameters identified by DELCORA as POCs in each of the receiving water bodies are listed below.

- For the lower Delaware River (Downstream of R.M. 81.8)
  - Fecal Coliform Bacteria
  - Enterococcus Bacteria
  - E. coli Bacteria
- For the upper Delaware River (Upstream of R.M. 81.8)
  - Fecal Coliform Bacteria
  - Enterococcus Bacteria
  - E. coli Bacteria
- For the Chester Creek
  - Fecal Coliform Bacteria
  - Enterococcus Bacteria
  - E. coli Bacteria
- For the Ridley Creek
  - Fecal Coliform Bacteria
  - Enterococcus Bacteria
  - E. coli Bacteria

The identified POCs for DELCORA's receiving water bodies have been listed and discussed in detail in Section 3.7. No POCP (Parameters of Potential Concern) were identified.

Section 1 Introduction

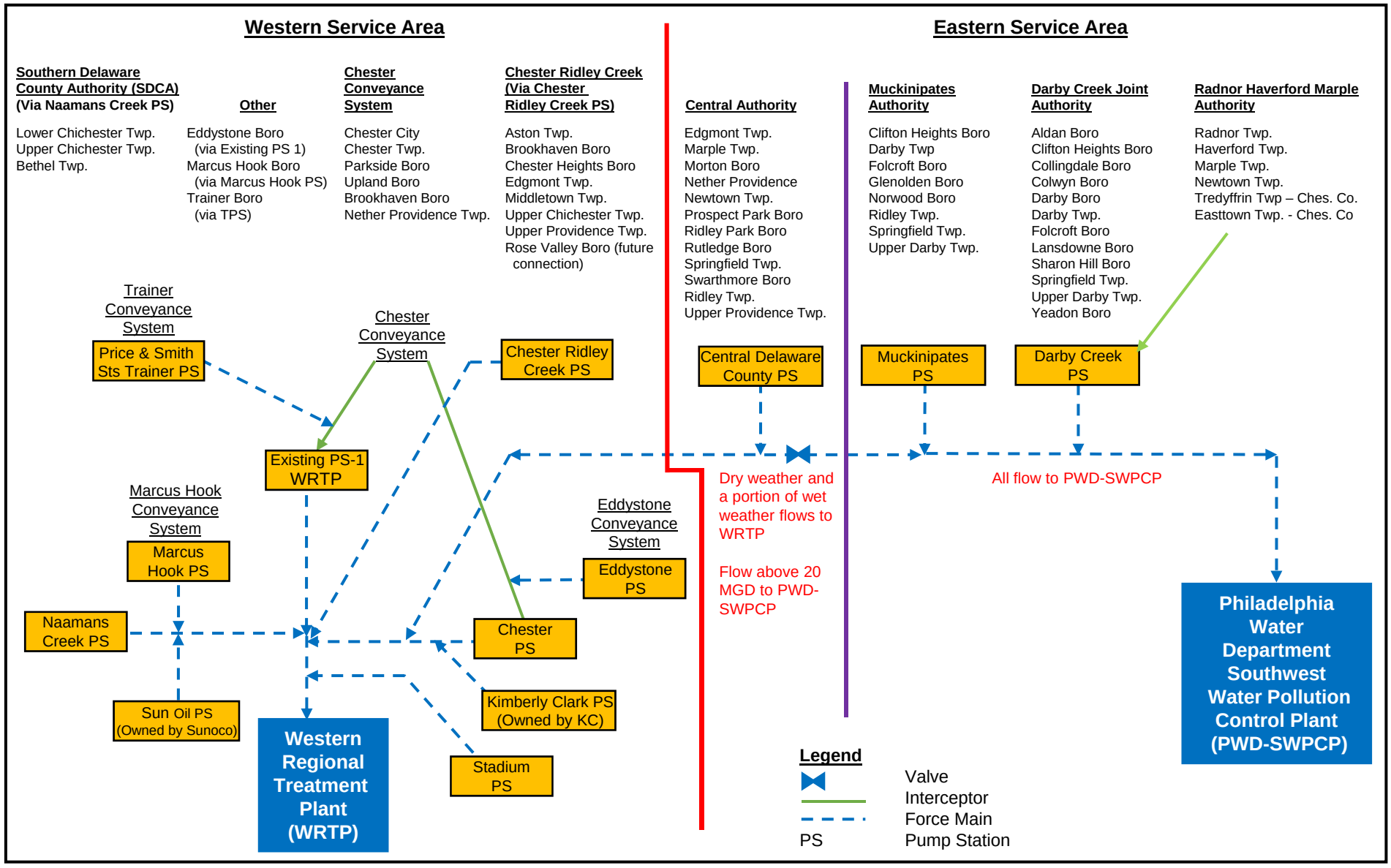
1.1 Background of DELCORA's Facilities

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.



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

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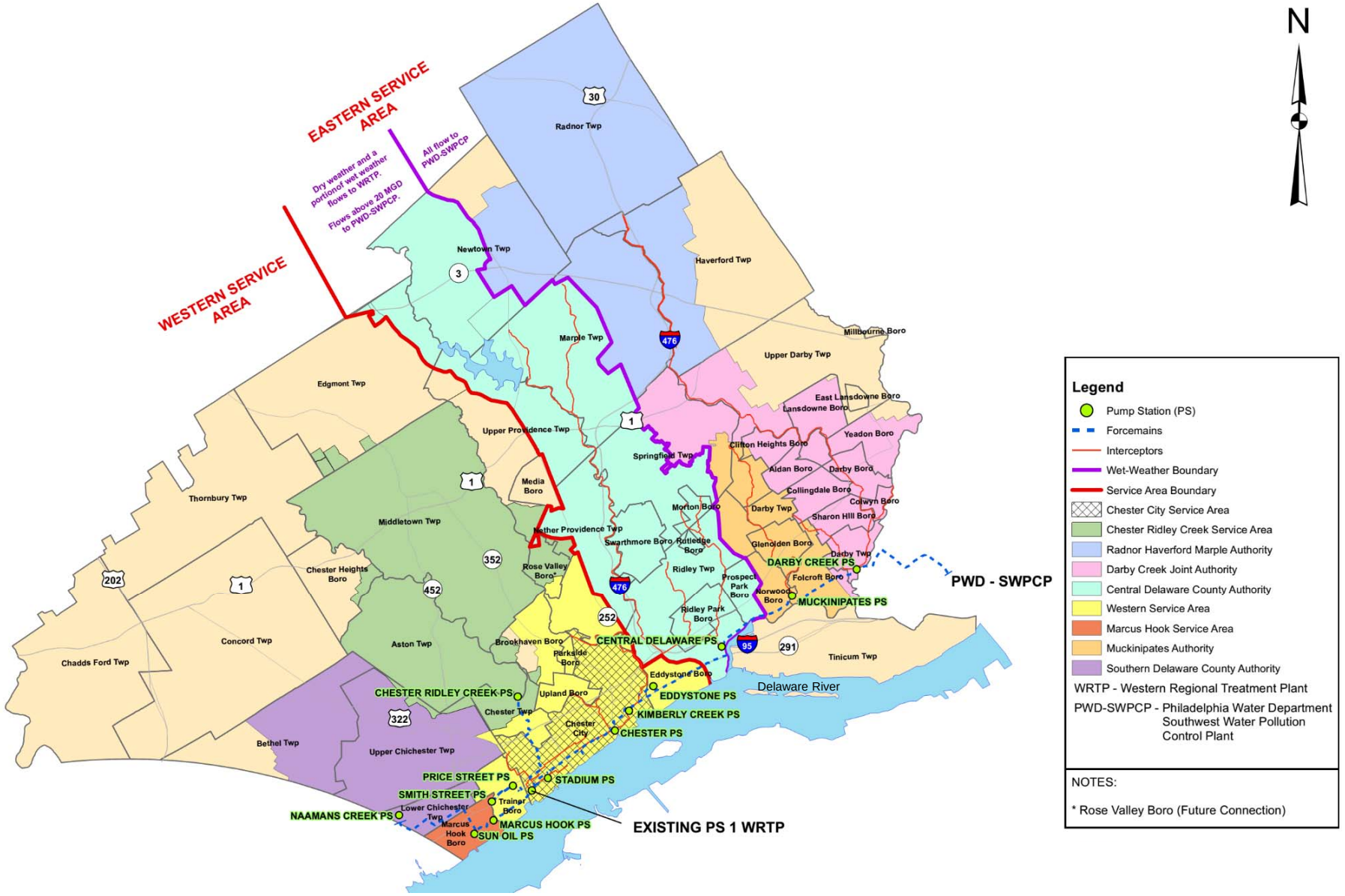
WESTON SOLUTIONS
Restoring Resource Efficiency

Figure 1-1
DELCORA'S CONVEYANCE SYSTEM



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

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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.11 (Identification of Sensitive Areas and Pollutants of Concern) requires that within six (6) months after the Date of Lodging, DELCORA shall submit a report to the USEPA and PADEP that identifies all Sensitive Areas and Pollutants of Concern that are impacted by CSOs and are within the Model Area for each of its receiving waters. Details of the Consent Decree requirements for Sensitive Areas and POCs are respectively found in Sections 1.2 and 3.1.

1.3 CSO System Description

1.3.1 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.

1.3.2 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 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 as listed in Table 1-1, 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.

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

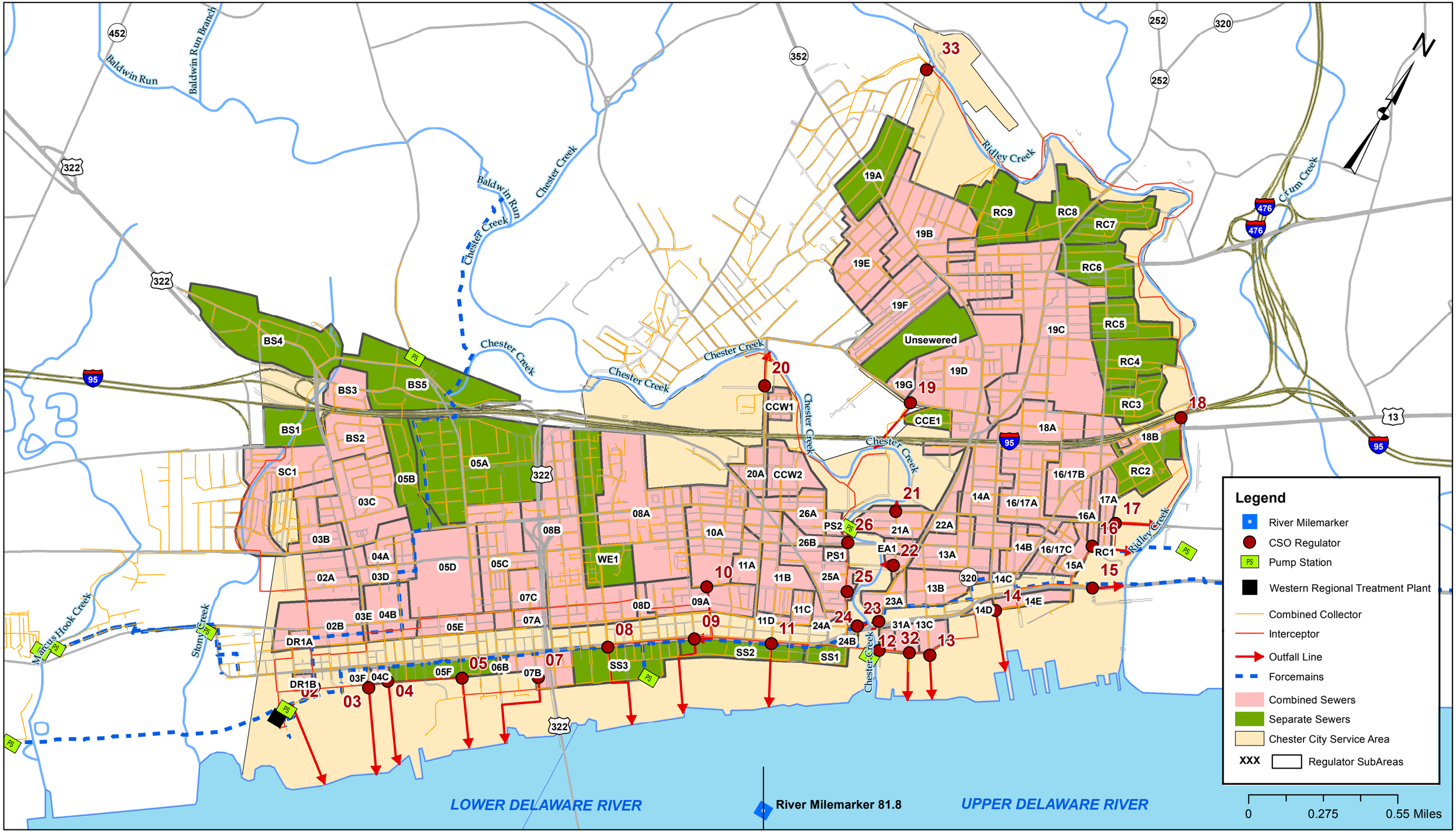
Name of Receiving Stream	CSO Outfall	Interceptor/CSO Regulator Location	Latitude	Longitude
Chester Creek	026	7th and Penn	39°50'58"N	75°21'55"W
Ridley Creek	015	4th and Melrose	39°51'03"N	75°20'48"W
Ridley Creek	016	8th and McDowell	39°51'15"N	75°20'53"W
Ridley Creek	017	9th and Campbell	39°51'16"N	75°20'51"W
Ridley Creek	018	Sun Drive and Hancock Street	39°51'47"N	75°20'57"W
Ridley Creek(2)	033	Elkington Boulevard and 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 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.



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

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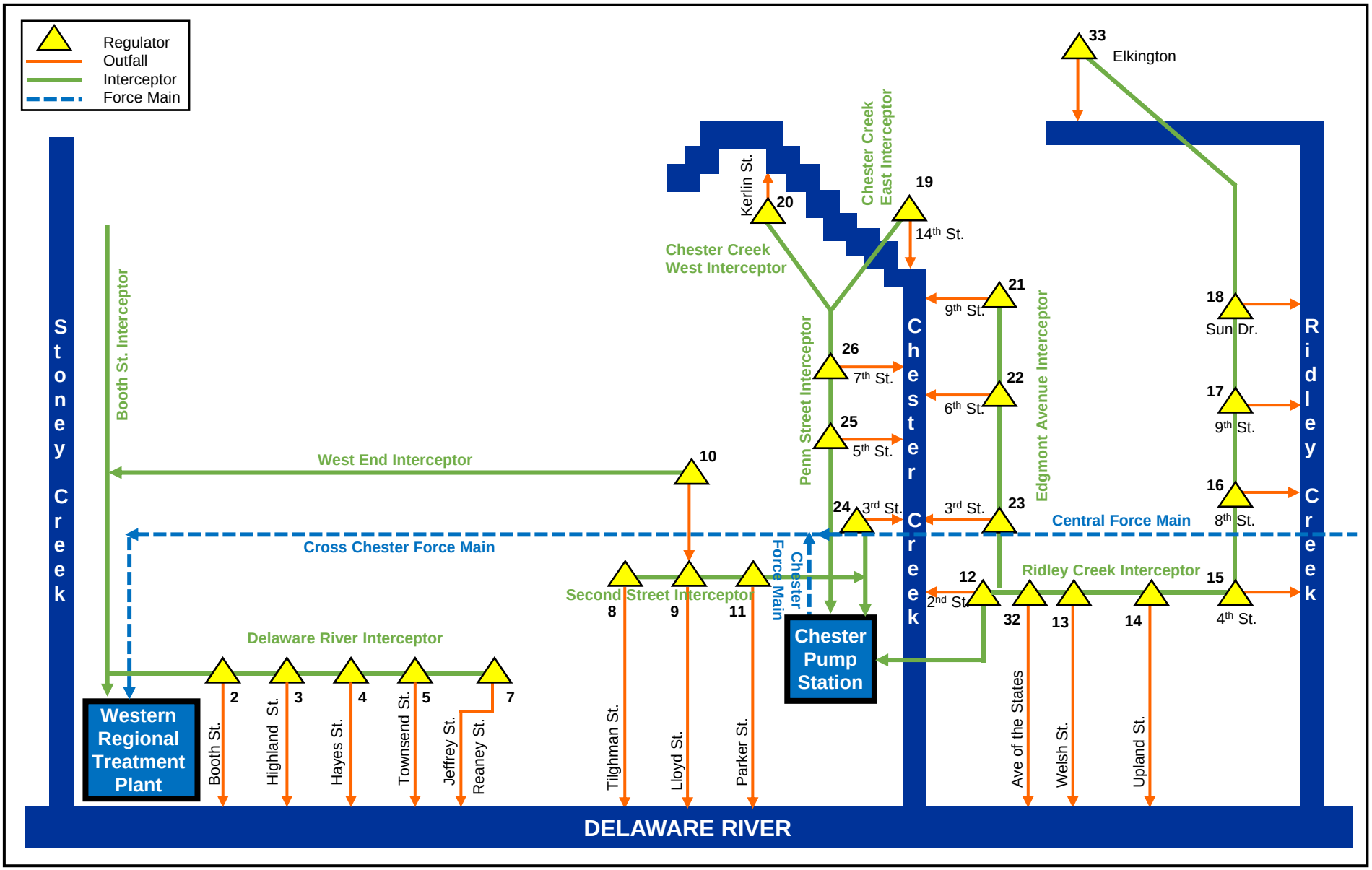
Identification of Sensitive Areas and Pollutants of Concern Report

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



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

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Figure 1-4
SCHEMATIC OF CHESTER CSO SYSTEM

Section 2 Identification of Sensitive Areas

2.1 Regulatory Requirements

2.1.1 Consent Decree Requirements

For the Identification of Sensitive Areas, Section V.A.11 of the Consent Decree states:

> *"For each of its Receiving Waters, DELCORA shall contact appropriate agencies, access available data sources, and collect additional data as necessary to identify Sensitive Areas. DELCORA shall fully document all such contacts and the associated responses, and all additional investigations carried out to identify Sensitive Areas. DELCORA shall also identify any additional areas that, while not Sensitive Areas, have been identified by DELCORA as being appropriate for prioritization ("Priority Areas")."*
>
> Additionally, *"For each of its Receiving Waters, DELCORA shall conduct community outreach and appropriate studies to determine whether and to what extent primary contact recreation is occurring in each Receiving Water, and shall fully document its outreach and study methods, and its findings."*

2.1.2 Requirements of the USEPA's CSO Control Policy and Sensitive Areas Definition

The USEPA's CSO Control Policy (Federal Register 59 [April 19, 1994]: 18688-18698) "expects a permittee's long-term CSO control plan to give the highest priority to controlling overflows to sensitive areas" (Section II.C.3). The CSO Control Policy states the six (6) criteria for defining an area as a "Sensitive Area" include:

1. Designated Outstanding National Resource Waters
2. National Marine Sanctuaries
3. Waters with threatened or endangered species and their habitat
4. Waters with primary contact recreation
5. Public drinking water intakes or their designated protected areas
6. Shellfish beds

The CSO Control Policy states that if Sensitive Areas are present and impacted, the LTCP should include provisions to:

- Prohibit new or significantly increased overflows
- Eliminate or relocate overflows wherever physically possible and economically achievable

- Treat overflows where necessary
- Where elimination or treatment is not achievable, reassess impacts each permit cycle

Sensitive Areas should be considered prior to the evaluation of CSO control alternatives. This allows a CSO community to identify and estimate costs for controls that could eliminate or relocate CSOs from Sensitive Areas where pollutant loadings pose a high environmental or public health risk and where control efforts should be focused. The cost of these controls can then be considered, along with the community's financial capability, to evaluate cost-effective controls for all of the receiving waters.

2.2 Priority Areas Definition

The term "Priority Areas" is not specifically defined by the USEPA in the Consent Decree nor in the CSO Control Policy or Guidance Document. For the purposes of this report, the term "Priority Areas" is defined as follows:

> *"Areas having some environmental significance but not to the level of "sensitive areas" as defined in the federal CSO Control Policy. These priority areas may include: public access areas (i.e., near marinas, schools, playgrounds, parks, or athletic fields); or use of shallow streams for recreational activity, with something less than full contact (i.e., wading)".*

In compliance with the Consent Decree, DELCORA conducted community outreach in order to determine whether and to what extent primary contact recreation is occurring in each Receiving Water. In order to cover DELCORA's large service area, a public survey was deemed to be the most comprehensive method to actively solicit community outreach. Multiple regulatory agencies and environmental organizations were also contacted.

2.3 Assessment of Sensitive and Priority Areas

The six criteria for Sensitive Areas identified in the CSO policy were evaluated for the Delaware River, Chester Creek and Ridley Creek within DELCORA's service area including reaches upstream of the CSOs. Special consideration was given to areas downstream and within the tidal influence of DELCORA's CSOs as any potential Sensitive Areas within hydraulic proximity to outfalls that may be impacted by their discharge.

2.3.1 Methodology

In order to develop a comprehensive understanding of the presence of designated Sensitive Areas within the study area, multiple strategies were used to complete these investigations including searching online data resources, sending letters to regulatory agencies and environmental organizations, and conducting a public survey. The goal of this multi-faceted approach was to

gain a thorough understanding of the presence of sensitive and priority areas to support the development of future CSO control alternatives.

2.3.1.1 Letters with Regulatory Agencies

Letters were drafted and issued to key regulatory agencies at the federal and state levels, and environmental organizations at the state and local levels. Contacts were identified based on their governance over the three waterbodies of concern including the Delaware River, Chester Creek and Ridley Creek, or their local involvement with those associated watersheds. Agencies in New Jersey and Delaware were also contacted to further understand the surrounding environment even though the study area is limited to the boundaries of the Commonwealth of Pennsylvania. Table 2-1 lists the agencies which received requests for information. Follow-up telephone calls were made to all agencies that had not responded by November 30, 2015.

Table 2-1: Letters Issued to Agencies and Organizations

Agency	Contact	Title	Date Sent	Response Date
U.S. Fish and Wildlife Agency	Robert Anderson	Fish & Wildlife Biologist	10/29/2015	11/2/2015
U.S. Fish and Wildlife - John Heinz NWR Birds	Brendalee Phillips	Wildlife Biologist	10/29/2015	No Comments
PA DEP	Jennifer Fields	Clean Water Section Program Manager	10/29/2015	11/17/15 - phone call
Delaware River Basin Commission (DRBC)	Steve Tambini	Executive Director	10/29/2015	No Comments
PA Game Commission	Patti Barber	Endangered Bird Biologist	10/29/2015	12/29/2015 – phone call
PA Game Commission	Ian Gregg	Wildlife Biologist	10/29/2015	No Response
PA Environmental Council	Carol F. McCabe, Esq.	Chair	10/29/2015	No Response
Chester Ridley Crum Watersheds Association	Brian Byrnes	Executive Director	10/29/2015	11/23/15 – phone call

Agency	Contact	Title	Date Sent	Response Date
New Jersey Department of Environmental Protection (NJDEP)	David Chanda	Director Fish and Wildlife	10/29/2015	No Response
Delaware Department of Natural Resources and Environmental Control (DNREC)	Matt Fisher	Director Fish and Wildlife	10/29/2015	11/30/2015
PA Fish and Boat Commission (PFBC)	John Buzzar, Kathy Gipe and Greg Murphy	Fisheries Biologists	10/29/2015	12/22/15; follow-up 3/11/16 and 5/2/16
Partnership for the Delaware Estuary (PDE)	Dr. Danielle Kreeger	Science Director	10/29/2015	11/25/2015

Each letter requested information related to all six Sensitive Area criteria with the exception of the letter to the U.S. Fish and Wildlife Service, which was tailored based on telephone conversations held prior to issuance of the letter. Copies of the letters issued requesting information and responses are included in Attachment A.

2.3.1.2 Online Database Searches

An abundance of information is available online regarding the Delaware River, Chester Creek, and Ridley Creek waterbodies. The following entities and on-line databases were searched for information related to Sensitive Areas and Priority Areas within the study area boundary:

- National Oceanic and Atmospheric Administration (NOAA)
  - NOAA 2014 Environmental Sensitivity Index Maps
- United States Environmental Protection Agency
- Pennsylvania Department of Environmental Protection
- Office of National Marine Sanctuaries
- John Heinz National Wildlife Refuge
- Chester Creek Rails-to-Trails Project
- Ridley Creek State Park
- Pennsylvania Department of Conservation and Natural Resources (PA DCNR)

The results of these searches were used to determine the presence of Sensitive Areas and/or Priority Areas located within the study area boundaries.

2.3.1.3 Public Survey

DELCORA prepared a public survey requesting information from local residents specifically about how the public is using the waterbodies within the CSS. Furthermore, the public survey also asked for the frequency that the residents are using the waterbody and within what time of the year they use the waterbody. Respondents were also provided an opportunity to leave comments in an open-ended format. The survey was mailed to approximately 14,000 customers within DELCORA's service area. The individuals contacted had the option to complete a hard copy of the survey or to complete the survey online. In addition to the 14,000 customers that received a hard copy of the survey, all members of the public (not just the individuals that received a copy of the survey) had the ability to complete the survey online at DELCORA's website. A copy of the survey, survey map, and the Public Survey Tally Sheet is included as Attachment B. A summary of the responses received by the residents in the Public Survey is included in Table 2-2.

Table 2-2: River and Creeks Use Survey Summary

Rivers and Creek Use Survey Summary						
	Delaware River		Chester River		Ridley Creek	
Activities	Percent Use per Year	Percent Never Used	Percent Use per Year	Percent Never Used	Percent Use per Year	Percent Never Used
Fishing Bank/Boat	1.28%	98.72%	1.53%	98.47%	0.55%	99.45%
Fishing from Wading	0.25%	99.75%	0.84%	99.16%	0.51%	99.49%
Rowing/Canoeing	0.05%	99.95%	0.02%	99.98%	0.02%	99.98%
Motor Boating	0.55%	99.45%	0.02%	99.98%	0.02%	99.98%
Kayaking	0.05%	99.95%	0.03%	99.97%	0.02%	99.98%
Jet Skiing	0.25%	99.75%	0.01%	99.99%	0.01%	99.99%
Water Skiing	0.01%	99.99%	0.00%	100.00%	0.00%	100.00%
Swimming	0.01%	99.99%	0.03%	99.97%	0.04%	99.96%
Wading	0.24%	99.76%	0.09%	99.91%	0.26%	99.74%
Other	0.01%	99.99%	0.01%	99.99%	0.01%	99.99%

2.3.2 Outstanding National Resource Waters

Outstanding National Resource Waters (ONRW) are maintained and protected by Tier 3 of the USEPA's Antidegradation Policy which can be accessed through the Agency's web portal at http://www.epa.gov/sites/production/files/2014-10/documents/diamond-outstanding-memo.pdf. Only waters of "exceptional ecological significance" qualify as ONRWs, and States and Tribes determine whether or not a water body will be classified as such.

In Chapter 93 of the Pennsylvania Code, it is stated that a water body will be classified as having Exceptional Value (EV) if it is considered by the Commonwealth of Pennsylvania to be an

ONRW. Chapter 93 of the PA Code lists water bodies alongside their protected water uses. Neither the Delaware River, Chester Creek nor Ridley Creek are listed as being of Exceptional Value. Therefore, none of DELCORA's receiving waters, the Delaware River, Chester Creek or Ridley Creek, are considered to be an ONRW.

2.3.3 National Marine Sanctuaries

The goal of the National Marine Sanctuaries Act (Title 16, Chapter 32, Section 1431 last amended in November 2000) is to identify and designate as National Marine Sanctuaries (NMS) areas of the marine environment which are of special national significance and to manage these areas as the National Marine Sanctuary System. Receiving this designation results in the conservation and management of these special habitats, support of the natural biological communities through protection and restoration, enhances the public's awareness, understanding and appreciation for the marine sanctuary, and supports the vitality of these communities through research and Federal, State and Local government collaboration.

In order for a marine environment to be designated a National Marine Sanctuary, the United States Secretary of Commerce will determine if any of the following criteria apply:

"Criteria 1
The area's natural resources and ecological qualities are of special significance and contribute to: biological productivity or diversity; maintenance or enhancement of ecosystem structure and function; maintenance of ecologically or commercially important species or species assemblages, or both; or maintenance or enhancement of connectivity to other ecologically significant resources.

Criteria 2
The area contains submerged maritime heritage resources of special historical, cultural, or archaeological significance, that: individually or collectively are consistent with the criteria of eligibility for listing on the National Register of Historic Places; have met or which would meet the criteria for designation as a National Historic Landmark; or have special or sacred meaning to the indigenous people of the region or nation.

Criteria 3
The area supports present and potential economic uses, such as: tourism; commercial and recreational fishing; subsistence and traditional uses; diving; and other recreational uses that depend on conservation and management of the area's resources.

Criteria 4
The publically-derived benefits of the area, such as aesthetic value, public recreation, and access to places depend on conservation and management of the area's resources."

The above criteria for National Marine Sanctuaries was taken directly from the Sanctuary Nomination Process Guide which can be found at http://www.nominate.noaa.gov/guide.html#document.

The Office of National Marine Sanctuaries (ONMS) is the trustee of all national marine sanctuaries and as such, it currently recognizes fourteen (14) national marine sanctuaries, none of which are located within DELCORA's service area. Therefore, none of DELCORA's receiving waters, the Delaware River, Chester Creek or Ridley Creek, are considered to be a National Marine Sanctuary.

2.3.4 Threatened or Endangered Species Criterion

The Federal CSO Policy states "waters with threatened or endangered species and their habitat" are considered a Sensitive Area. The U.S. Fish and Wildlife Service and PA Fish and Boat Commission were contacted and the NOAA Environmental Sensitivity Index maps reviewed to identify any threatened or endangered species with habitat within the project boundaries. Threatened and endangered species that could potentially occur within the project study area are listed in Table 2-3 below. A copy of the letters received from the U.S. Fish and Wildlife Service and PA Fish and Boat Commission can be found in Attachment A to this report.

Table 2-3: Federally-Listed Threatened and Endangered Species

Species	Status
Bog Turtle	Threatened
Eastern Redbelly Turtle	Threatened
Indiana Bat	Endangered
Northern Long-Eared Bat	Endangered
Atlantic Sturgeon	Threatened
Shortnose Sturgeon	Endangered

These species could potentially use the Delaware River, Chester Creek or Ridley Creek as habitat. However, the U.S. Fish and Wildlife Service stated that no critical habitat has been designated for any of the threated and endangered listed species in the Delaware River, Chester and Ridley Creeks as of November 2015.

The NOAA Environmental Sensitivity Index Maps for the project area, ESI-18 and ESI-19, were then reviewed to locate specific habitat for the above listed species. These NOAA maps are included as Attachment K. No habitat was found for the Bog Turtle, Indiana Bat, or Northern Long-Eared Bat within the project boundaries. The NOAA ESI maps do indicate the Shortnose Sturgeon concentrations are "medium" from April through October, and "high" November through March in the Delaware River. However, the NOAA ESI maps generically state this migratory species is present in the Delaware River and does not include any specific portion of the project area as being a nursery, spawning or year-of-young habitat for the species.

The Eastern Redbelly Turtle habitat is located within the Heinz National Wildlife Refuge which enters the Delaware River approximately 2 miles upstream of the northern most CSO outfall. The Refuge is not directly on the Delaware River and outside the project boundaries.

Atlantic Sturgeon habitat is shown on NOAA map ESI-18 spanning the Pennsylvania/Delaware border. High concentrations of year-of-young Atlantic Sturgeon has been documented in this area. The most northern portion of the Atlantic Sturgeon habitat, as shown on Figure 2-1, is one-half mile from DELCORA's most down steam CSO #002. The criteria for a Sensitive Area is met because both a threatened species and its habitat are identified.

In the previously submitted 2012 DELCORA LTCP report, tidal flats were identified as a Sensitive Area meeting the criteria of critical habitat for threatened or endangered species. However, the current request for information from the U.S. Fish and Wildlife Service on threatened or endangered species and their habitat present within the project boundaries found that no critical habitat has been identified. The response from the U.S. Fish and Wildlife Service stating the same can be found in Attachment A. Therefore, the most current information is used in this report and the tidal flats are no longer considered a Sensitive Area.

2.3.4.1 Bald and Golden Eagle

Bald eagles are known to nest in the vicinity of the project area. While the bald eagle has been removed from the Federal list of threatened and endangered species, the bald eagle along with the golden eagle continues to be protected under the Bald and Golden Eagle Protection Act (BGEPA) and the Migratory Bird Treaty Act (MBTA). These Acts prohibit anyone to "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, disturb, or otherwise harm eagles, their nests, or their eggs". Under the BGEPA, "disturb" means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available: (1) injury to an eagle; (2) decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior; or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior. Since the Bald Eagle has been removed from the Federal list of threatened and endangered species, the Sensitive Area criteria for Threatened or Endangered Species does not apply to the project study area. However, it is acknowledged that these species require special consideration. During the development of CSO abatement alternatives, the project will be evaluated for project size, location and layout in order to comply with the BGEPA and MBTA.

2.3.4.2 Special Considerations

The northern reaches of Ridley Creek within DELCORA's service area are designated as Approved Trout Waters and Trout Stocked Streams. The portion approved for stocking trout begins at Brookhaven Road upstream of CSO #033 and ends downstream of CSO #033 at Chestnut Street in Chester City as shown on Figure 2-1. The portion of the approved trout waters from CSO #033 downstream to Chestnut Street is considered a Priority Area because of



Priority Area 1: Approved Trout Waters

Priority Area 2: Boat Launch

Sensitive Area: Atlantic Sturgeon

River Milemarker 81.8

LOWER DELAWARE RIVER
(primary contact recreation)

UPPER DELAWARE RIVER
(recreation/secondary contact)

Chester Island

Legend
- River Milemarker
- CSO Regulator
- Boat Launch Ramp
- Combined Sewer Outfall
- Pump Station
- Western Regional Treatment Plant
- Upper Tidal Limit
- Trout Stocked Streams
- Approved Trout Waters
- Sensitive Area
- Priority Areas
- Chester City Service Area

0 0.5 1 Miles

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 2-1
Sensitive and Priority Areas

this special environmental use and the need to meet water quality standards to continue to support trout stocking. Additionally, the public is provided an opportunity to use Ridley Creek for recreational purposes and that may include wading which further meets the criteria of a Priority Area.

2.3.5 Primary Contact Recreation Criterion

Primary contact is defined as an activity where people come directly in contact with the waterbody, such as at bathing beaches. The Upper Delaware River (defined as the portion of the river upstream of River Mile 81.8), Chester Creek and Ridley Creek are all designated for secondary contact and are not suitable for direct contact with the waterbody. The Lower Delaware River (downstream of River Mile 81.8), is rated for primary contact. Special water quality standards are used for water contact areas in order to protect the public from being exposed to waterborne diseases. The study area is located in a densely populated urban area with a mix of recreational uses including boating, fishing, hiking, and other uses by the public.

2.3.5.1 Delaware River

The Delaware River is designated as suitable for Water Contact (WC) Recreation below River Mile (R.M.) 81.8 (between CSO #009 and #011). It is to be noted that this stretch (Zone 4) of the Delaware River is not listed in the 2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report (PADEP, 2014) (a.k.a. the "303(d) list") as impaired for its WC use, and it has not been reported as impaired or not meeting designated uses from coliform bacteria or any other parameter commonly associated with CSOs or municipal wastewater treatment plant discharges. There are no designated bathing beaches or approved swimming facilities along the Delaware River within the project area boundaries.

There is one boat launch owned by the Chester Economic Development Authority located along the Delaware River within the project study area boundaries as shown on Figure 2-1. This boat launch is located between CSO #007 and #008 and may be impacted by CSO discharges. Additionally, this boat ramp is located within the portion of the waterbody rated for primary contact. Therefore, it was determined that this location does not qualify as a Sensitive Area because it is neither impaired, failing to meet the associated water quality standards, the public is not provided with access to the waterbody and is not using it for primary contact recreation activities according to the public survey. It is however considered a Priority Area because it provides the public with direct access to the Delaware River in a portion rated for primary contact. The Priority Area at the boat launch is shown in Figure 2-1 to extend for a total length of 500 feet along the shoreline; or 250 feet upstream and 250 feet downstream from the location of the boat launch. The Priority Area around the boat launch is also shown to extend into the river 250 feet from the shoreline. There are no defining boundaries for priority areas, however, a buffer zone of 250 feet around the boat launch includes the area one block upstream and one block downstream of the boat launch.

2.3.5.2 Chester Creek and Ridley Creek

There are no identified boat launch ramps, boat docks, or designated bathing beaches within Chester or Ridley Creek within the project area boundaries. Results of the public survey indicate the public is not using Chester Creek or Ridley Creek for primary contact activities. Of all the activities listed, fishing was the most frequently identified use of the waterbodies which does not qualify as primary contact. Of the over 460 respondents only a few reported using the waterbodies for boating, wading or swimming. It was therefore concluded these waterbodies are not considered a Sensitive Area for primary contact.

As mentioned above, the approved trout waters of Ridley Creek are being considered a Priority Area. In addition to its environmental significance as approved trout waters, they provide the public with wading access to the water for recreational fishing activities. This further supports this section of Ridley Creek being considered a Priority Area worthy of special consideration.

2.3.6 Drinking Water Intakes

Several drinking water providers are located within the study area. The majority of Delaware County is served by Aqua Pennsylvania. Chester Water Authority serves portions of western Delaware County in Thornbury Township, Chester Heights Borough, Chadds Ford Township, Concord Township, Bethel Township, Aston Township, Upper Chichester, Lower Chichester, Trainer, Brookhaven, Parkside, Upland, Chester Township, and Chester City. All drinking water intakes for both Aqua Pennsylvania and the Chester Water Authority are upstream of the CSOs and are not affected by their discharges as they are located on tributaries of the Delaware River.

Upstream of DELCORA's service area (and upstream of Center City Philadelphia), the Delaware River is still tidal and the Philadelphia's Water Department's Baxter Water Treatment Plant is located alongside the tidal portion of the river. DELCORA's most upstream CSO on the Delaware, CSO #014, is over 26 miles downstream of this drinking water intake.

Downstream of DELCORA's service area and located in the State of Delaware, United Water customers receive most of their water from the Stanton Water Treatment Plant, which is capable of treating 30 million gallons of water per day. The Stanton Plant draws water from the White Clay and Red Clay Creeks which are tributary to the Christiana River, itself a tributary to the Delaware River. DELCORA's most downstream CSO, CSO #002, is over 10 miles upstream of the confluence of the Delaware and Christiana Rivers. The Stanton's plant drinking water intake is several miles upstream of this location.

Due to the large distances of the drinking water intakes noted above to DELCORA's CSOs, the Sensitive Area criteria for Drinking Water Intakes on the Delaware River does not apply to the areas associated with DELCORA's CSO discharges.

There are no drinking water intakes located along Chester Creek or Ridley Creek in proximity to DELCORA's service area. Therefore, the Sensitive Area criteria for Drinking Water Intakes does not apply to the Chester or Ridley Creeks.

2.3.7 Shellfish Beds

There are no commercial shellfish harvesters that operate within the study area. The Partnership for the Delaware Estuary reported shellfish areas well downstream of the most southern outfall in DELCORA's system. Shellfish consumption as a DRBC designated use, only applies to DRBC WQM Zone 6. The DRBC's 2014 Delaware River and Bay Water Quality Assessment presents a map that shows the approved shellfish harvesting areas in the Delaware Bay, and this map is re-presented in this report as Figure 2-2. The uppermost shellfish harvesting area is approximately 32 miles downstream from DELCORA's closest CSO discharge (CSO #002). The influence of tidal mixing and dilution coupled with the 32 mile separation between the most downstream discharge point and beginning of the shellfish harvest zone result in the CSO discharge having a negligible impact on the shellfish beds. Therefore, the Sensitive Area criteria for Shellfish Beds does not apply to the areas associated with DELCORA's CSO discharges.

2.4 Summary of Sensitive and Priority Areas

A comprehensive review of online databases, correspondence with regulatory agencies and local environmental organizations, and responses to the public survey was conducted to identify potential Sensitive Areas and Priority Areas within the CSS portion of the collection system.

2.4.1 Summary of Sensitive Areas

The habitat for year-of-young Atlantic Sturgeon downstream of CSO #002 in the Delaware River meets the Sensitive Area criteria for Endangered or Threatened species. The Atlantic Sturgeon is listed as a threatened species by the US Fish and Wildlife Service with documented habitat in the Delaware River downstream approximately one-half mile downstream of DELCORA's most southern outfall.

There are no Outstanding National Resource Waters nor National Marine Sanctuaries within the project area. Shellfish beds are located well downstream of the CSO locations and are outside the project boundaries. There are numerous drinking water intakes in the geographical area but none are located in close proximity downstream of DELCORA's CSOs on the Delaware River. No drinking water intake locations were found that meet the criteria of a Sensitive Area.

Figure 2-2: Shellfish Harvesting Areas in Zone 6 of the Delaware River

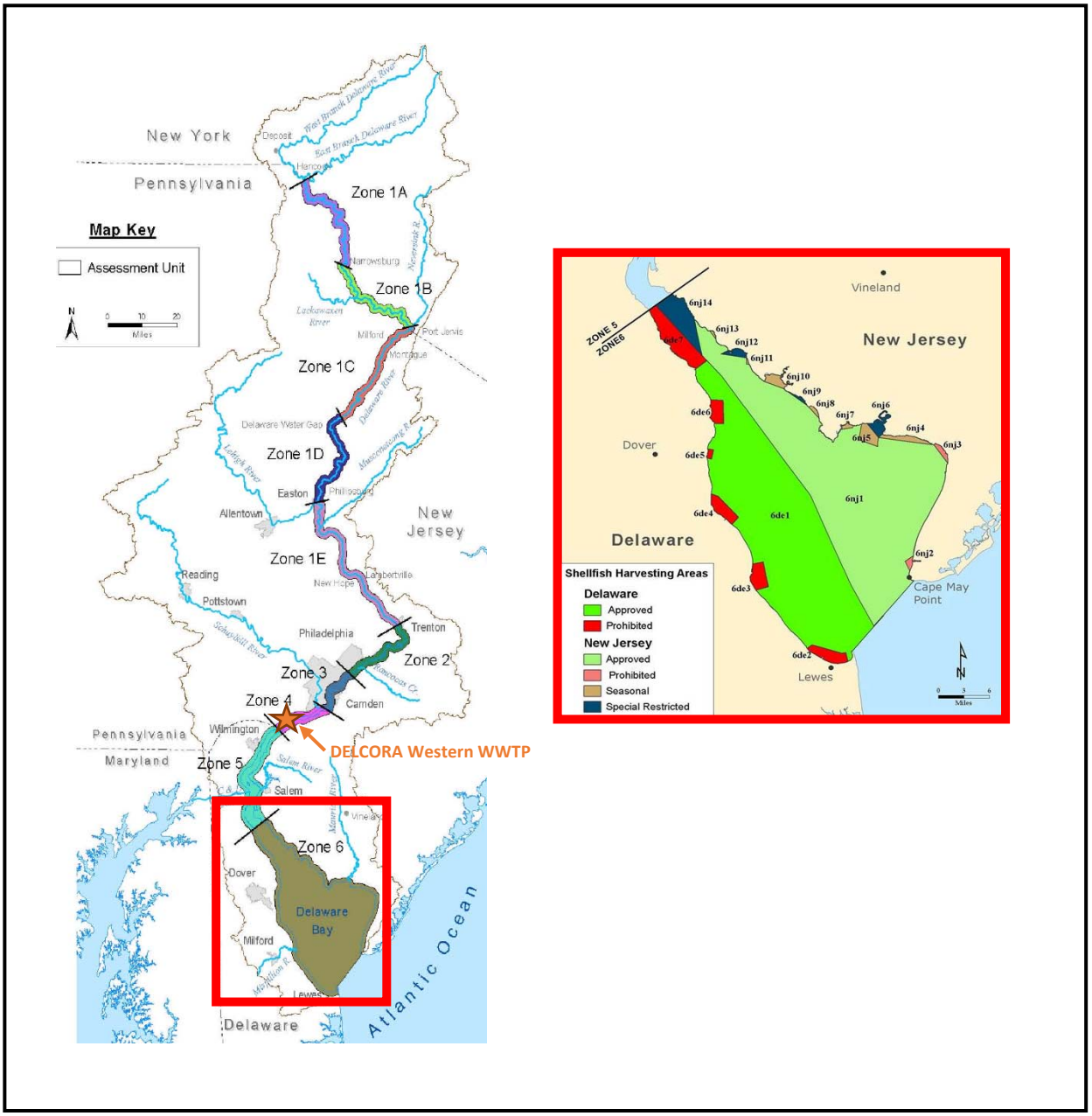

*Image courtesy of the Delaware River Basin Commission

2.4.2 Summary of Priority Areas

Priority Areas include areas having some environmental significance but not to the level of "Sensitive Areas" as defined in the federal CSO Control Policy. Two Priority Areas were identified:

- Approved trout waters in Ridley Creek,
- Chester Economic Development Authority's boat launch in Chester City.

The northern reaches of Ridley Creek within DELCORA's service area are designated as Approved Trout Waters and Trout Stocked Streams. The portion of the approved trout waters from CSO #033 downstream to Chestnut Street is considered a Priority Area because of this special environmental use.

The boat launch located between CSO #007 and #008 along the Delaware River is located within the portion of the waterbody rated for primary contact. The boat launch is considered a Priority Area due to its location to CSO #007 and #008.

Section 3 Pollutants of Concern

3.1 Regulatory Requirements

3.1.1 Consent Decree Requirements

For the Identification of Pollutants of Concern, Section V.A.11 of the Consent Decree specifically states:

> *"For each of its Receiving Waters, DELCORA shall review existing water quality data and recent PADEP CWA § 303(d) listings to identify POCs. Even if a water body has not been formally listed as out of compliance with its water quality standards and designated uses, if available data indicate such impairment exists and such impairment involves pollutants associated with CSOs, DELCORA shall consider the related pollutants to be POCs."*

3.1.2 Requirements of the USEPA's CSO Guidance Document

Section 2.5.3.3 of the USEPA's CSO Guidance document states that to assess the impacts of wet weather runoff, the water quality of the receiving waters should be understood for normal dry weather periods. The water quality data that is collected during dry weather conditions provides a basis for comparing the data collected during wet weather conditions. The CSO Guidance Document says:

> *"Receiving water monitoring should include identified parameters of concern. These parameters typically include those previously identified for combined sewage and CSO monitoring.*
>
> - *pH*
> - *BOD*
> - *TDS*
> - *TSS*
> - *Nutrients*
> - *Metals*
> - *Indicator bacteria*
>
> *Knowledge of the site-specific water quality concerns could expand the list to include dissolved oxygen, toxics, biological assessment, and sediment."*

3.2 Receiving Water Use Designations and General Water Quality Standards

Information about the applicable water quality standards (WQS) and designated uses for the three receiving water bodies impacted by DELCORA's CSOs were obtained from the PADEP's 2014 Integrated Water Quality Monitoring and Assessment Report (or "303(d) list"), the Pennsylvania Code, the Delaware River Basin Commission's (DRBC's) Water Quality Regulations (WQRs) and from the DRBC's 2014 Delaware River and Bay Water Quality Assessment.

3.2.1 2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report (303(d) list)

The primary source of information about the causes of impairment, and the Total Maximum Daily Load (TMDL) status of the water bodies (if any) is the 2014 PA Integrated Water Quality Monitoring and Assessment Report (PA Integrated Report), which satisfies Pennsylvania's requirement of both Section 303(d) and 305(b) of the Clean Water Act (CWA). The PA Integrated Report lists all impaired surface waters within Pennsylvania that are not attaining designated and existing uses, even after appropriate and required pollution control technologies have been applied. A TMDL is designed to reduce pollutant loads to impaired waters and enable these waters to meet water quality standards.

The Integrated Report uses a five-part categorization (lists) of water according to their use attainment status. The categories represent varying levels of use attainment, ranging from Category 1, where all designated water uses are met to Category 5, where impairment by pollutants required the development of a TMDL to correct. Each segment of the waterbody is placed into one of these five categories.

The PADEP's website explains the categories as follows:

- *"Category 1: Waters attaining all designated uses.*
- *Category 2: Waters where some, but not all, designated uses are met. Attainment status of the remaining designated uses maybe unknown because data are insufficient to categorize a water body consistent with the states' listing methodology or may be impaired.*
- *Category 3: Waters for which there are insufficient or no data and information to determine, consistent with the state's listing methodology, if designated uses are met.*
- *Category 4: Waters impaired for one or more designated use but not needing a TMDL. States may place these waters in one of the following three subcategories:*
    - *Category 4A: TMDL is approved.*
    - *Category 4B: Expected to meet all designated uses within a reasonable timeframe (three years).*
    - *Category 4C: Not impaired by a pollutant.*

- *Category 5:* *Waters impaired for one or more designated uses by any pollutant and requiring the development of a TMDL. Category five includes waters shown to be impaired as the result of biological assessment used to evaluate aquatic life even if the specific pollutant is not known unless the state can demonstrate that non-pollutant stressors cause impairment or that no pollutant(s) causes or contribute to the impairment.*"

The Category 5 list constitutes the Section 303(d) list that the USEPA will approve or disapprove under the CWA. For the purposes of the determination of Pollutants of Concern, Categories 4A and 5 are the relevant categories as they indicate the need for a TMDL in the receiving water body and the limiting of additional loadings for those parameters. All of the lists are sorted by an 8-digit Hydrologic Unit Code (HUC) that is particular for the water body of interest. For DELCORA's drainage area, the HUC for the Lower Delaware River (02040202) was used for searching the data in the PA Integrated Report for all three of DELCORA's receiving water bodies.

3.2.2 PA Code Chapter 25 §93.9g

The primary source of information for the Critical Use Designation for each section of the three receiving water bodies is Chapter 25 §93.9g – Drainage List from the Pennsylvania Code. The relevant Critical Use Designations for DELCORA's receiving water bodies include Warm Water Fishes (WWF), Migratory Fishes (MF), Trout Stocking (TSF), and Water Contact Sports/Recreation (WC).

- The "WWF" designation indicates the maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
- The "MF" designation indicates the passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which move to or from flowing waters to complete their life cycle in other waters.
- The "TSF" designation indicates maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.
- The "WC" designation indicates the use of the water for swimming and related activities.

3.2.3 DRBC's Water Quality Regulations and PA Code Chapter 25 §93.7

The applicable water quality standards for the three receiving water bodies were found in the Delaware River Basin Commission's Water Quality Regulations, and in Water Quality Criteria lists found in Chapter 25 §93.7 and §93.8c of the Pennsylvania Code. For the Delaware River, the water quality standards are dictated by the DRBC's WQRs that have primacy over the standards in the PA Code. The water quality standards in the PA Code apply to the non-tidal

portions of the Chester Creek and Ridley Creek, and to the Delaware River if there is no standard listed for a particular parameter in the DRBC's WQRs.

3.2.4 DRBC's 2014 Delaware River and Bay Water Quality Assessment

The DRBC's 2014 Delaware River and Bay Water Quality Assessment (2014 Assessment) reports the extent to which waters of the Delaware River and Bay are attaining designated uses in accordance with Delaware River Basin Commissions' Water Quality Regulations for the period October 1, 2008 through September 30, 2013. The 2014 Assessment involves the comparison of key water quality parameters with the applicable DRBC water quality regulations. The states of Pennsylvania, New Jersey, Delaware and New York consider the DRBC's Assessment report as part of their determinations as to whether sections of the Delaware River should be listed on the state 303(d) list for a certain pollutant.

3.2.5 Delaware River

3.2.5.1 303(d) List Designation

The 2014 PA Integrated Water Quality and Assessment Report ("the 303(d) List") lists a 61.02 mile segment of the Lower Delaware River in Category 4A as having an approved TMDL for polychlorinated biphenyls (PCBs) from an unknown source related to its fish consumption use. The USEPA approved a TMDL for PCBs for Zone 2 through Zones 5 in 2003, and a second PCB TMDL was approved for Zone 6 in 2006. The TMDLs for PCBs encompass the Delaware River Estuary and stretch from the mouth of the Delaware River upstream to the Trenton, NJ /Morrisville, PA Bridge. The segment of the Delaware River having an approved TMDL for PCBs is shown in yellow in the map in Figure 3-1, which was derived from the PADEP's eMapPA website. Attachment C presents an excerpt from the 2014 PA Integrated Water Quality Monitoring and Assessment Report, and includes the applicable pages for the Delaware River.

Consequently, the impacts of DELCORA's CSO discharges on the level of PCBs within the Delaware River was evaluated further and is discussed herein.

3.2.5.2 Designated Critical Uses and Specific Water Quality Criteria from PA Code

The Critical Uses for the Delaware River in the area of DELCORA's CSO discharges are designated in Chapter 25 §93.9 of the PA Code. All stretches of the Delaware River in this area are designated as Warm Water Fishes (WWF) (maintenance only) and Migratory Fishes (MF) (passage only). Additionally the Delaware River has a Water Contact (WC) designation downstream of River Mile 81.8, which is located directly adjacent to the City of Chester between CSO #009 and #011.



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 3-1
Non-Attaining and TMDL Streams/River
Within DELCORA's Service Area

For WC-designated waters, Chapter 25 §93.7 of the PA Code establishes the following as the water quality criterion for fecal coliform bacteria:

- **Fecal Coliform** – A geometric mean of 200 colonies per 100 mL during the swimming season (May 1 through September 30) based on a minimum of five samples collected during a 30-day period. For the remainder of the year, the maximum fecal coliform level shall be a geometric mean of 2,000 colonies/100 mL based on a minimum of five samples collected during a 30-day period. There are no fecal coliform bacteria criteria for the Delaware River or tributaries that are not designated as WC waters or for Potable Water Supply (PWS).

For WWF and MF waters the WWF designation is the more restrictive of the two, and Chapter 25 §93.7 of the PA Code establishes the following additional standards for WWF waters:

- **Dissolved Oxygen** – The minimum value for dissolved oxygen must be above 5.0 mg/L, with the 7-day average value above 5.5 mg/L
- **Alkalinity** – A minimum of 20 mg/L as $CaCO_3$, except where naturally occurring conditions are less
- **Ammonia Nitrogen** – the maximum total ammonia nitrogen concentration (in mg/L) at all times shall be the numerical value given by un-ionized ammonia nitrogen (NH_3-N) x ($\log^{-1}[pK_T\text{-}pH] + 1$)
- **Iron** – 30-day average 1.5 mg/L as total recoverable
- **pH** – From 6.0 to 9.0 inclusive
- **Temperature** – A table is included within Chapter 25 §93.7 for maximum water temperatures in the receiving water body at various times of the year
- **Total Residual Chlorine** – Four-day average 0.011 mg/L; 1-hour average 0.019 mg/L

3.2.5.3 Designated Zone and Water Quality Regulations from the DRBC

Chapter 25 §93.9 of the PA Code lists the DRBC regulations for Water Quality Zone 4 as exceptions to PA Code's specific water quality criteria. The DRBC's water quality regulations have primacy over the standards in the PA Code for the Delaware River.

The DRBC defines Zone 4 as that part of the Delaware River extending from R.M. 78.8 to R.M. 95.0, the Pennsylvania-Delaware state boundary line to the upstream side of the Philadelphia Navy Yard, including the tidal portions of the tributaries thereof. The DRBC states that the quality of Zone 4 waters shall be maintained in a safe and satisfactory condition for the following uses:

- Industrial water supplies after reasonable treatment
- Maintenance of resident fish and other aquatic life

- Passage of anadromous fish
- Wildlife
- Recreation - secondary contact above R.M. 81.8
- Recreation (all water-contact sports) below R.M. 81.8
- Navigation

The DRBC's Stream Quality Objectives for Zone 4 are as follows:

1. **Dissolved Oxygen**
   - 24-hour average concentration shall not be less than 3.5 mg/L.
   - During the periods from April 1 to June 15, and September 16 to December 31, the DO shall not have a seasonal average less than 6.5 mg/L.

2. **Temperature** shall not exceed:
   - 5°F (2.8°C) above the average 24-hour temperature gradient displayed during the 1961-66 period, or
   - A maximum of 86°F (30.0°C), whichever is less.

   (NOTE: The DRBC's 2014 Delaware River and Bay Water Quality Assessment states that *"atmospheric temperatures and meteorological conditions are strong drivers of water temperature. DRBC previously demonstrated that water temperatures are strongly liked to air temperatures, and that a notable increase in air temperatures is observable between the temperature gradient period (1961-1966) and the current period. At present, we* [i.e., DRBC] *lack the tools to determine which portion of the exceedance is attributable to potentially controllable anthropogenic thermal inputs, and which portion is due to metrological drivers beyond our control".*

3. **pH** between 6.5 and 8.5 inclusive, unless outside this range due to natural conditions.

4. **Phenols** maximum 0.02 mg/l, unless exceeded due to natural conditions.

5. **Threshold Odor Number** not to exceed 24 at 60°C.

6. **Synthetic Detergents.** (M.B.A.S.). Maximum 30- day average 1.0 mg/L.

7. **Radioactivity**
   - Alpha emitters - maximum 3 pc/L (picocuries per liter);
   - Beta emitters - maximum 1,000 pc/L.

8. **Bacteria**
   - **Fecal Coliform**
     - Above R.M. 81.8: maximum geometric average 770 per 100 milliliters
     - Below R.M. 81.8: maximum geometric average 200 per 100 milliliters
   - **Enterococcus**
     - Above R.M. 81.8: maximum geometric average 88 per 100 milliliters
     - Below R.M. 81.8: maximum geometric average 33 per 100 milliliters

9. **Total Dissolved Solids** not to exceed 133% of background.
(NOTE: The background TDS concentration is at present undefined, according to the DRBC's 2014 Delaware River and Bay Water Quality Assessment.)

10. **Turbidity** unless exceeded due to natural conditions.
    - Maximum 30-day average 40 units (NTU)
    - Maximum 150 NTU

11. **Alkalinity** between 20 and 120 mg/L.

12. **Toxic Pollutants**
    - Applicable criteria to protect the taste and odor of ingested water and fish are presented in the DRBC's WQRs Table 4.
    - Applicable freshwater stream quality objectives for the protection of aquatic life are presented in the DRBC's WQRs Table 5.
    - Applicable freshwater stream quality objectives for the protection of human health are presented in the DRBC's WQRs Tables 6 and 7.

3.2.5.4 DRBC Evaluation of Use Attainment Status

Table 3-1 presents a summary of Table 23 from the DRBC's 2014 Delaware River and Bay Water Quality Assessment for Zone 4 of the Delaware River. Zone 4 is the portion of the Delaware River directly impacted by DELCORA's CSO discharges and it extends from R.M. 95.0 to R.M. 78.8, the Pennsylvania-Delaware state line including the tidal portions of the tributaries thereof. The extent of Zone 4 can be seen in Figure 2-2.

Table 3-1: Summary of the 2014 DRBC Integrated Assessment for Zone 4 of the Delaware River

Zone	Designated Use			
	Aquatic Life	Drinking Water	Recreation	Fish Consumption
4	NS	N/A	S	NS

Notes:
N/A - Not applicable
NS - The Designated Use is not supported
S - The Designated Use is supported

3.2.5.4.1 Water Contact Recreation

Table 3-1 shows that the designated use for Water Contact Recreation is being attained for the Delaware River below R.M. 81.8.

3.2.5.4.2 Aquatic Life

Table 3-1 shows that the designated use for Aquatic Life is not being attained. According to the DRBC's Assessment report, "*the composite aquatic life assessment for 2014 yields a result of "Not Supporting" for all assessment units* (or zones). *It is important to note, however, that this result is largely driven by the requirement to categorize as not meeting criteria any assessment unit* (or zone) *with 1 exceedance plus 1 confirmatory exceedance."*

The DRBC's Assessment Report also states: *"Data showed multiple exceedances of aluminum acute and chronic freshwater objectives for the support of aquatic life in Zone 4. Of 35 surface water samples tested for aluminum in Zone 4 during the assessment period, 34 exceeded the chronic criterion and 8 exceeded the acute criterion at 21PA_WQX-WQN0182 near Marcus Hook, PA. No exceedances of aluminum were reported in Zones 2, 3, 5 and 6."* As part of the Recommendations for Future Action at the end of the report, the DRBC states that the *"exceedances of aluminum criteria in Zone 4 warrant further attention"*.

3.2.5.4.3 Fish Consumption

Table 3-1 shows that the designated use for Fish Consumption is not being attained. The DRBC's 2014 Delaware River and Bay Water Quality Assessment report states that their assessment criterion for fish consumption is based on the presence of fish consumption advisories from the four Basin states for the mainstem of the Delaware River. If a fish consumption advisory is present, this resulted in the DRBC making an assessment of "not supporting the designated use".

The Assessment report states that the violation criteria for PCBs is also supported by the presence of measureable concentrations of PCBs in the river that exceeded the surface water quality standard. Twenty-two mainstem channel sites were sampled for PCBs in 2012, from

Biles Channel near Trenton, NJ to the ocean boundary between Cape May and Lewis. It was found that all of the samples exceeded the current PCB water quality criteria of 16 µg/L for the protection of human health from carcinogenic effects.

The 2016 Commonwealth of Pennsylvania Fish Consumption Advisories for Zones 2, 3, and 4 of the Delaware River (Trenton, NJ/Morrisville, PA Bridge to PA/DE border) are as shown below in Table 3-2. These advisories identify PCBs as a pollutant of concern in fish tissue.

Table 3-2: PA Fish Consumption Advisory Summary for PCBs in the Delaware River

Fish Species	Meal Frequency	Contaminant
White Perch	1 meal/month	PCB
Flathead Catfish	1 meal/month	PCB
Channel Catfish	1 meal/month	PCB
Striped Bass: over 28 inches in length	1 meal/month	PCB
Carp	6 meals/year	PCB
American Eel	Do Not Eat	PCB

3.2.6 Chester Creek

3.2.6.1 303(d) List Designation

Chester Creek is listed in Category 5 of the 2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report as not meeting its recreational use due to pathogens, and for not meeting its aquatic life use due to siltation. "Pathogens" were listed in 2006 for three segments totaling 0.94 miles, and a TMDL is anticipated in 2019. The source for the pathogens is listed as "unknown", and these three stream segments are all well upstream of DELCORA's service area. Therefore it appears that the noted impairment of the Chester Creek due to pathogens is not related to DELCORA' CSO discharges.

"Siltation" was listed in 2014 for four segments of the creek totaling 18.41 miles, and a TMDL is anticipated in 2027. The source for the siltation was identified as "urban runoff/storm sewers". The majority of Chester Creek is not attaining its designated use for aquatic life due to siltation, and the vast majority of these impaired segments are located upstream of DELCORA's service area and are shown in red in the map in Figure 3-1. However, one of DELCORA's CSO outfalls does discharge to the furthest downstream segment of the Chester Creek that is impaired by siltation, which is Outfall #020 near Kerlin Street and Finland Drive. Siltation is measured by the water quality parameter Turbidity with units of Nephelometric Turbidity Units (NTU). The impacts of DELCORA's CSO discharges on the levels of Turbidity within the impaired sections of the Chester Creek have been evaluated further and are discussed herein.

Category 4A lists a 0.81-mile segment of Chester Creek at its mouth that does not meet its designated use for fish consumption due to PCBs from an unknown source, and for which a TMDL for PCBs was issued in 2006. This is shown in yellow in the map in Figure 3-1, and is related to the TMDL for PCBs in the Delaware River Estuary. As a consequence, the impacts of DELCORA's CSO discharges on the level of PCBs within the section of the Chester Creek for which there is an approved TMDL for PCBs has been evaluated further and is discussed herein.

Attachment C presents an excerpt from the 2014 PA Integrated Water Quality Monitoring and Assessment Report, and includes the applicable pages for the Chester Creek. It is to be noted that the Integrated Report also identifies an approved TMDL for the protection of two segments of the creek for aquatic life, but after consultation with staff in the Clean Water Section of the PADEP's Southeast Regional Office it was determined that those two stream segments were listed in the Integrated Monitoring Report in error.

3.2.6.2 Designated Critical Uses and Specific Water Quality Criteria from PA Code

The Critical Uses for the Chester Creek in the area of DELCORA's CSO discharges are designated in Chapter 25 §93.9 of the PA Code. All stretches of the Chester Creek in this area are designated as Warm Water Fishes (WWF) (maintenance only) and Migratory Fishes (MF) (passage only). The same specific water quality criteria apply to the WWF and MF Critical Use designations for Chester Creek as was listed previously for the Delaware River in Section 3.2.5.2.

3.2.7 Ridley Creek

3.2.7.1 303(d) List Designation:

Ridley Creek is listed in Category 5 of the 2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report as not meeting its aquatic life use due to siltation. The "Siltation" was listed in 2012 for five segments totaling 26.76 miles, and a TMDL is anticipated in 2025. The source for the siltation was identified as "unknown" or from "urban runoff/storm sewers".

In actuality, it appears that the majority of Ridley Creek is not attaining its designated use for aquatic life due to siltation, and the vast majority of these impaired segments are located well upstream of DELCORA's service area and are shown in red in the map in Figure 3-1. However, all of Ridley Creek within DELCORA's service area is shown as impaired for aquatic life due to siltation. Attachment C presents an excerpt from the 2014 PA Integrated Water Quality Monitoring and Assessment Report, and includes the applicable pages for the Ridley Creek.

Siltation is measured by the water quality parameter Turbidity, and consequently the impacts of DELCORA's CSO discharges on the levels of Turbidity within the impaired sections of the Ridley Creek have been evaluated further and are discussed herein.

3.2.7.2 Designated Critical Uses and Specific Water Quality Criteria from PA Code:

The Critical Uses for the Ridley Creek in the area of DELCORA's CSO discharges are designated in Chapter 25 §93.9 of the PA Code. All stretches of the Ridley Creek in this area are designated as Warm Water Fishes (WWF) (maintenance only), Migratory Fishes (MF) (passage only), or Trout Stocking (TSF). The TSF stretch only applies in the sections of the Ridley Creek upstream of the Chestnut Street bridge crossing.

The same specific water quality criteria apply to the WWF and MF Critical Use designations for Ridley Creek as was listed previously for the Delaware River in Section 3.2.5.2, except for the parameters of Dissolved Oxygen and Temperature – which are more stringent because of the high oxygen needs of trout.

Specifically, for TSF waters Chapter 25 §93.7 of the PA Code establishes the following additional standards:

- **Dissolved Oxygen** – For the period February 15 to July 31 of any year, the minimum value for dissolved oxygen must be above 5.0 mg/L, with the 7-day average value above 6.0 mg/L. For the remainder of the year, the minimum value for dissolved oxygen must be above 5.0 mg/L, with the 7-day average value above 5.5 mg/L.
- **Temperature** – A separate table is included within Chapter 25 §93.7 for maximum water temperatures in the receiving water body at various times of the year for TSF waters.

3.3 Approach for the Identification of the Applicable Water Quality Standards

For the Delaware River and the tidal portions of its tributaries, the DRBC's Water Quality Regulations are the prime source for the water quality standards, and the PA Code Chapter 93 WQS for the designated use serves as a secondary source. The DRBC's regulations have primacy over the PA Code for the Delaware River and the tidal portions of its tributaries. For the non-tidal portions of the Chester Creek and Ridley Creek, the specific designated use for the water body in the PA Code serves as the prime source of the WQS. If a parameter is not listed in the DRBC's Water Quality Regulations or in the PA Code, then there is not a WQS for that parameter that applies to the Delaware River, Chester Creek or Ridley Creeks.

A conservative approach was taken in the identification of the applicable WQS, such that the more stringent standard was used where the standards from the DRBC's Water Quality Regulations and the PA Code overlapped. The methodology for identifying the applicable WQS was complicated by the fact that the WQS vary for the three receiving water bodies and can also vary within the same water body depending on where the sample was taken.

Attachment D in the List of Attachments contains the master table that was developed to determine the applicable water quality standards for the expanded list of Parameters Considered for the Delaware River downstream of R.M. 81.8, the Delaware River upstream of R.M. 81.8,

the Chester Creek and Ridley Creek within the area impacted by DELCORA's CSO discharges. The specific methodology for identification of the applicable water quality standards is described in greater detail below.

In order to determine WQS for metals, an average hardness value of 84 mg/l (as $CaCO_3$) was used for the Delaware River based on an average of the hardness values obtained from the USEPA's Storage and Retrieval Data Repository (STORET) study data from the Years 2010-2015 for this portion of the Delaware River. Due to unavailable hardness data on STORET for the Chester and Ridley Creeks, an average hardness value of 74 mg/l (as $CaCO_3$) was used for the Chester and Ridley Creeks based on guidance in the DRBC Water Quality Regulations, Section 4.20.05, Paragraph A.2.

3.3.1 Delaware River Downstream of R.M. 81.8 (Water Contact Use Designation)

The "lower" Delaware River downstream of R.M. 81.8 has a Water Contact designated use. Therefore, there is stricter criteria for the lower Delaware River below R.M. 81.8 than there is for the "upper" Delaware River upstream of R.M. 81.8 that does not have the Water Contact use designation.

The following bullets describe the approach that was used for the identification of the applicable water quality standards on the Delaware River downstream of R.M. 81.8:

- The basis for determining the WQRs was to first look to the DRBC's WQRs in Section 3.30.4 for Zone 4.
- If there were no listings for a parameter in Section 3.30.4, we next referred to the "Human Health Criteria" in 25 PA Code Ch. 93 WQS, 93.8c, Table 5 as the primary water quality standard, unless a more restrictive standard was listed in the PA Code that applies to the Delaware River. The Human Health Criteria includes probable modes of exposure such as, but not limited to ingestion from drinking water and fish consumption, inhalation and dermal absorption and is the most appropriate for protecting human health from water contact or immersion.
- If there were no Human Health Criteria listed in Table 5 of the PA Code, we referred to the standards in the DRBC WQRs Tables 6 and 7 and used the more restrictive standard for Fish and Water Ingestion. These tables are respectfully titled "Stream Quality Objectives for Carcinogens" and "Stream Quality Objectives for Systemic Toxicants".

3.3.2 Delaware River Upstream of R.M. 81.8 (WWF and MF Use Designation)

The following bullets describe the approach that was used for the identification of the applicable water quality standards on the Delaware River upstream of R.M. 81.8:

- The basis for determining the WQRs was to first look to the DRBC's WQRs in Section 3.30.4 for Zone 4.
- If there was no listing for a parameter in Section 3.30.4, we next referred to the DRBC's WQRs Table 5 "Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life" and used both the Acute and Chronic standards. If none was listed, we referred to DRBC Tables 6 and 7, and used the listed standard that is the next less restrictive than the Primary Contact standard that was used above for the Water Contact portion of the Delaware River. We used the Fish Ingestion Only criteria, not the Fish and Water Ingestion criteria for the Upper Delaware.
- If there is no DRBC standard listed for the parameter, we used the 25 PA Code Ch. 93 WQS Table 3 – "Specific Water Quality Criteria" for the particular Critical Use Designation of the water body and also the 25 PA Code Ch. 93 WQS Table 5 "Fish and Aquatic Life Criteria" (for both Acute and Chronic) as the source of the water quality standard – these tables are complimentary and do not overlap.

3.3.3 Chester Creek and Ridley Creek (TSF, WWF and MF Use Designations)

The following bullets describe the approach that was used for the identification of the applicable water quality standards on the Chester and Ridley Creeks:

- For the tidal portions of the creeks, we used as the basis the DRBC's WQRs in Section 3.30.4 for Zone 4. The DRBC regulations that were applied were for the Delaware River upstream of R.M. 81.8, since both creeks discharge to the Delaware River upstream of R.M. 81.8.
- For the non-tidal portions of the creeks, we used the 25 PA Code Ch. 93 WQS Table 3 – "Specific Water Quality Criteria" for the particular Critical Use Designation of the water body and also the 25 PA Code Ch. 93 WQS Table 5 "Fish and Aquatic Life Criteria" (for both Acute and Chronic) as the source of the water quality standard – these tables are complimentary and do not overlap.

3.4 Sampling of Select CSO Outfalls

3.4.1 Historical Sampling of Select CSO Outfalls

Under the current permit (NPDES Permit No. PA 0027103, Amendment 1, dated December 17, 2013), DELCORA is required to conduct on-going monitoring of its CSO outfalls at the following three locations within thirty (30) minutes of a rainfall:

- 2nd and Dock Streets Pump Station (wet well) (Chester Pump Station-CPS)
- CSO Outfall #018 – Sun Drive and Hancock Street
- CSO Outfall #019 – 14th Street and Crozer Hospital

The NPDES permit requires that the three (3) above locations be monitored for the five (5) parameters, sample type and at the frequency specified in Table 3-3 below. The grab samples are to be collected within the first 30 minutes of the discharge.

Table 3-3: Permit-Specified CSO Monitoring Program Parameters, Sample Type and Frequency

Parameter	Sample Type	Measurement Frequency
Biological Oxygen Demand (BOD_5)	Grab (mg/l)	Annual
Ammonia	Grab (mg/l)	Annual
Total Suspended Solids (TSS)	Grab (mg/l)	Annual
Phosphorus	Grab (mg/l)	Annual
Fecal Coliform	Grab (#/ 100 ml)	Annual

DELCORA annually obtains CSO water quality samples in conformance with the NPDES permit requirements. The permit required CSO sampling results for the most recent three years (2012, 2013 and 2014) are contained in Attachment E and summarized in Table 3-4. Analyses for the consideration of these 5 parameters as a Pollutant of Concern are included within Sections 3.7 and 3.8.

Table 3-4: Summary of NPDES Permit-Required CSO Samples (2012-2014)

Sample Location	Parameters				
	BOD5 (mg/L)	Ammonia (mg/L)	TSS (mg/L)	Phosphorus (mg/L)	Fecal Coliform (#/100 mL)
2012 Samples					
2nd & Dock Streets (Chester Pump Station) (wet well) 10/29/2012	35	2.18	106	0.823	>600,000
Sun Drive & Hancock Street (CSO #018) 10/29/2012	28	1.79	47	0.813	>600,000
14th Street & Crozer Hospital (CSO #019) 10/29/2012	21	0.81	48	0.499	>600,000
2013 Samples					
2nd & Dock Streets (Chester Pump Station) (wet well) 11/27/2013	65	2.1	204	1.32	>200,000
Sun Drive & Hancock Street (CSO #018) 11/27/2013	13	0.2	40	0.35	150,000

Sample Location	Parameters				
	BOD5 (mg/L)	Ammonia (mg/L)	TSS (mg/L)	Phosphorus (mg/L)	Fecal Coliform (#/100 mL)
14th Street & Crozer Hospital (CSO #019) 11/27/2013	40	0.9	163	1.21	190,000
2014 Samples					
2nd & Dock Streets (Chester Pump Station) (wet well) 09/25/2014	100	6.72	134	1.6	811,000
Sun Drive & Hancock Street (CSO #018) 09/25/2014	42.5	1.88	56	0.55	169,000
14th Street & Crozer Hospital (CSO #019) 09/25/2014	39.5	3.26	45	0.78	430,000

3.4.2 Additional Sampling of CSO Outfalls

Additional sampling was undertaken at the three monitored CSOs by DELCORA on November 19th and December 1st, 2015 for a much longer list of parameters than is required by the NPDES permit. The sampling results were used to confirm the actual parameters prevalent in DELCORA's CSO discharges.

Attachment F in the List of Attachments includes the laboratory data for the additional sampling of the CSOs. Wet weather samples were collected primarily to analyze for the parameters thought to have been present at the plant influent due to the industrial wastewater discharged at that location (see Section 3.6.1). These wet weather samples were also intended to capture those parameters due to the first flush during a wet weather overflow event. The wet weather samples were collected when the minimum rainfall was 0.5" with a high intensity, and the samples were collected within 30 minutes from the beginning of a wet weather overflow event as required by the NPDES permit.

Figure 3-2 presents a map that shows the locations that were used for DELCORA's sampling of the combined sewer system, select CSOs, for the historical sampling of the Chester and Ridley Creeks, and for the USEPA's STORET Database monitoring stations on the receiving water bodies.

3.5 Sampling of Receiving Waters

3.5.1 USEPA'S STORET Database

The USEPA's STORET database was used as the primary source for existing water quality data for all three receiving water bodies. Data was extracted using the appropriate hydrologic unit code for the Lower Delaware River, and all monitoring stations associated with the three receiving bodies within the area of DELCORA's CSO discharges were selected for gathering of water quality data. The water quality data was first extracted from STORET for the period of September 1, 2014 through September 1, 2015. The water quality data for this period was evaluated against the applicable water quality standards. The parameters (during this period) that were found to be exceeding the water quality standards and/or were found to be associated with CSO discharges (as "detects" through the additional CSO sampling) were considered for further evaluation. The water quality data of these particular parameters was then extracted from STORET for a five year period ranging from September 1, 2010 through September 1, 2015 and evaluated against the applicable water quality standards. This five-year STORET data was used to confirm the presence of these parameters and to calculate the total number of observations as well as exceedance percentages in the receiving bodies. The evaluation of the STORET data is discussed in detail under Section 3.7 and 3.8.

Table 3-5 shows a list of the STORET monitoring stations that were used, along with their station identification numbers. There were a total of two stations that belong to Delaware River Basin Commission on the Delaware River and three station that belong to Pennsylvania Department of Environmental Protection on the Delaware River, Chester Creek and Ridley Creek. Figure 3-2 shows the locations of the STORET database monitoring stations with their respective identification numbers.

The parameters that were searched within the STORET database from the monitoring stations in Table 3-5 were based on the expanded list of the Parameters Considered discussed in Section 3.6 of this report. Once the data from the USEPA STORET database was extracted, each parameter was sorted based on its characteristic name and station identification number.



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Figure 3-2
Sampling Locations
2010 - 2015

Table 3-5: Water Quality Monitoring Stations Used from USEPA's STORET Database

Station Name	Station Identification Number	Agency	Period of Record	Latitude	Longitude
Marcus Hook (R.M. 78.1)	332049	DRBC	9/1/2014 – 9/1/2015	39.798611	-75.430111
Eddystone (R.M. 84.0)	892062	DRBC	9/1/2014 – 9/1/2015	39.849139	-75.329628
Chester Creek	DRBC422094	PADEP	9/1/2014 – 9/1/2015	39.8447	-75.36
Ridley Creek	DRBC422120	PADEP	9/1/2014 – 9/1/2015	39.8533	-75.3461
Delaware River	WQN0182	PADEP	9/1/2014 – 9/1/2015	39,8069	-75.4064

3.5.2 Historical Sampling of Chester and Ridley Creeks

The USEPA's STORET Database only has data for one monitoring station each for both the Chester and Ridley Creeks, and those stations are each located near the mouths of the creeks. In order to supplement the receiving water data for the Chester and Ridley Creeks and to obtain representative samples of the water quality in the creeks upstream of DELCORA's CSO discharge locations, DELCORA took its own water quality samples for the Chester and Ridley Creeks on five dates in 2010. Two samples were obtained during a storm event on October 14, 2010, including a sample taken at the beginning of the storm and a second sample taken after a minimum of 0.45 inch of rain had fallen.

In addition to the parameters listed in Table 3-3 for DELCORA's NPDES permit-specified CSO monitoring program, the following in-situ field measurements were also collected during the 2010 sampling:

- Temperature
- pH
- Conductivity
- Dissolved Oxygen (DO)

Besides being specified in DELCORA's NPDES permit, the parameters in Table 3-5 are indicative of the presence of wastewater. Dissolved Oxygen can also be used to indicate a water body that is being stressed and may inhibit natural biological activity.

The sampling plan for the collection of the 2010 water quality samples from the Chester and Ridley Creeks specified collection during dry weather and during storm events in order to examine the impacts of CSO discharges on the water bodies. Discrete samples of receiving water collected for laboratory analyses were specified at four locations along the Chester and Ridley Creeks. The dry- and wet-weather water quality sampling locations that were used are listed below in Table 3-6, and are shown on the map in Figure 3-2. The data from the 2010 historical receiving water quality sampling is presented in Attachment G.

Table 3-6: Receiving Water Body Sample Locations for Chester and Ridley Creeks

Sample Location Name as Shown in Figure 3-2	Sample Collection Location	Latitude	Longitude	Closest Upstream CSO	Closest Downstream CSO	Nearest Access Road or Address
Ridley Creek 1 (RC1)	Upstream Chester Park Drive crossing of Ridley Creek	39°52'23.83"N	75°22'30.82"W	None	33	Chester Park Drive
Ridley Creek 3 (RC3)	Downstream East 2nd Street Bridge crossing of Ridley Creek	39°51'12.58"N	75°20'47.13"W	15	None	Old East 2nd Street
Chester Creek 1 (CC1)	Upstream Kerlin Street crossing of Chester Creek	39°51'20.76"N	75°22'36.02"W	None	20	1556 Kerlin Street
Chester Creek 3 (CC3)	Downstream 2nd Street Bridge crossing of Chester Creek	39°50'41.08"N	75°21'36.15"W	023, 024	12	Adjacent to Chester Pump Station

The sampling locations were carefully selected to provide an upstream (or background) sample above the furthest upstream CSO discharges on each creek to compare against a sample from a downstream location that is impacted by the CSO discharges.

3.6 Methodology for Identification of the Parameters Considered

For the identification of the POCs, DELCORA took an inclusive approach to determine that all relevant water quality parameters were appropriately considered and evaluated. The first step was to develop a comprehensive list of the overall "Parameters Considered", which was then further evaluated and refined to determine the list of the applicable POCs. Development of the list of Parameters Considered was meant to cast a wide net as the first step towards identifying any parameters that might possibly be of concern.

3.6.1 Development of the Parameters Considered List

The initial list of the Parameters Considered was compiled from six (6) primary reference sources from the USEPA, PADEP and the DRBC. The Parameters Considered list initially consisted of those specific parameters listed in the USEPA's CSO Guidance Document (as noted in Section 3.1.2). Additional parameters were added from the parameters requiring sampling per DELCORA's NPDES permit, from the PA Code's specific water quality criteria for DELCORA's three receiving water bodies, from the DRBC's Water Quality Regulations for Zone 4 of the Delaware River, from the 2014 PA Integrated Water Quality Monitoring and Assessment Report (a.k.a. "303(d) List"), and from the DRBC's 2014 Delaware River and Bay Water Quality Assessment report. Attachment H provides the full version of the table used to develop the initial Parameters Considered list and includes the reference source for each of the parameters noted.

Table 3-7 provides a summary of the initial Parameters Considered list that was developed by compiling the parameters listed in each of the six primary reference sources noted above.

Table 3-7: Initial List of Parameters Considered

Bacteria - Enterococcus	Nutrients
Bacteria - Fecal Coliform	Oil and Grease
Alkalinity	PCBs (Fish Consumption)
Aluminum (Aquatic Life)	pH
Ammonia	Phenols
Biological Oxygen Demand (BOD)	Phosphorus
Cadmium	Radioactivity - alpha emitters
CBOD20	Radioactivity - beta emitters
CBOD5	Synthetic Detergents
Chlorine	Temperature
Chlorodibromomethane	Threshold Odor Number (TON)

Copper	Total Kjeldahl Nitrogen (TKN)
Cyanide	Total Dissolved Solids (TDS)
Dichlorobromomethane	Total Phosphorus
Dissolved Oxygen	Total Residual Chlorine (TRC)
Iron	Total Suspended Solids (TSS)
Lead	Toxics
Metals	Turbidity
Nitrate	Zinc
Nitrite	

As shown in the table in Attachment H and as noted in Section 3.1.2, the USEPA's CSO Guidance Document lists "Metals", "Nutrients", and "Toxics" as parameters of concern but does not provide any further definition of the individual parameters in these three categories. Tables 3-8, 3-9, and 3-10 below list the specific parameters that were added onto the initial Parameters Considered list for Nutrients, Metals, and Toxics and the reference source stating the reason for the inclusion of each of the parameters.

Table 3-8: Nutrients Included in the Initial List of Parameters Considered

Parameter (Nutrients)	Reference Source
Ammonia	NPDES Permit Required Sampling for CSO Discharges
Nitrate	NPDES Permit Required Sampling for Outfall #001
Nitrite	NPDES Permit Required Sampling for Outfall #001
Phosphate	Implied by EPA CSO Guidance for LTCP
TKN	NPDES Permit Required Sampling for Outfall #001
Total Nitrogen	Implied by EPA CSO Guidance for LTCP
Total Phosphorus	NPDES Permit Required Sampling for CSO Discharges

Table 3-9: Metals Included in the Initial List of Parameters Considered

Parameter (Metals)	Reference Source
Aluminum (Al)	Listed in DRBC WQRs Table 5
Arsenic (trivalent) (As III)	Listed in DRBC WQRs Table 5
Cadmium (Cd)	Listed in DRBC WQRs Table 5
Chromium (trivalent) (Cr III)	Listed in DRBC WQRs Table 5
Chromium (hexavalent) (Cr VI)	Listed in DRBC WQRs Table 5
Copper (Cu)	Listed in DRBC WQRs Table 5
Iron (Fe)	PA Code for TSF, WWF, and MF Critical Use
Lead (Pb)	Listed in DRBC WQRs Table 5
Mercury (Hg)	Listed in DRBC WQRs Table 5
Nickel (Ni)	Listed in DRBC WQRs Table 5
Selenium (Se)	Listed in DRBC WQRs Table 5
Silver (Ag)	Listed in DRBC WQRs Table 5
Zinc (Zn)	Listed in DRBC WQRs Table 5

Table 3-10: Toxics Included in the Initial List of Parameters Considered

Parameter (Toxics)	Reference Source
Phenols	Required by DRBC Zone 4 WQRs
Chlorodibromomethane	NPDES Permit Required Sampling for Outfall #001
Cyanide	NPDES Permit Required Sampling for Outfall #001
Dichlorobromomethane	NPDES Permit Required Sampling for Outfall #001

Once the initial list of Parameters Considered was developed, additional parameters were added onto the list if they had been detected during the historical sampling data of the influent to the WRTP (WRTP data), and in the existing CSO monitoring data (as required by the NPDES permit). One year's worth of DELCORA's plant influent historical sampling data from September 1, 2014 through September 1, 2015 was collected and analyzed to identify additional Parameters Considered.

It is important to state that that the historical sampling data noted above for the influent to the WRTP also included industrial wastewater from DELCORA's forty-five (45) Significant Industrial Users (SIUs). The industrial wastewater from forty-three (43) of DELCORA's SIUs is trucked directly to the WRTP and is discharged downstream of all CSOs into the combined sewer flow prior to the plant's influent sampling location. Consequently, the historical sampling data for the influent to the plant detected twenty-eight (28) industrial-type chemicals from these SIUs that are not normally associated with sanitary sewage or combined sewer overflows. Since the trucked-in industrial wastewater is discharged directly to the WRTP, it is not able to migrate back into the combined sewer system and, therefore, this industrial wastewater cannot be

discharged from any of DELCORA's CSOs. However, as part of the due diligence to address all possible POCs, the 28 industrial chemicals that were detected in the historical sampling of the plant influent were added onto an expanded list of Parameters Considered.

DELCORA actively maintains an Industrial Pretreatment program, and all of its industrial users are controlled by the sewer use regulations, Resolution No. 91-03, "The DELCORA Standards, Rules and Regulations," and the Local Limits, Resolution No. 95-11. In addition, all Significant and/or Categorical Industrial Users are further controlled by a permit, which is issued for not more than four (4) years. Each SIU is reviewed to determine how its wastewater is conveyed to the treatment plant. The only two (2) SIUs that discharge into the CSS, are commercial laundries with relatively benign wastewater compared to some of the truly industrial facilities that truck their wastewater to the WRTP. All of the parameters that are required to be analyzed by these commercial laundries in their wastewater based on their permit requirements were confirmed to be on the expanded list of the Parameters Considered. The two SIUs that discharge directly into DELCORA's combined sewer system are listed in Table 3-11 below.

Table 3-11: Industrial Users Discharging into DELCORA's Combined Sewer System

ID No	Permit #	Industry	Activity	Site Address	Discharge Route
W1	1DE-01-02	Ace Linen Service, Inc.	Laundry Service	3120 W. 6th St., Chester, PA 19013	Flows to Booth St. Interceptor to Delaware Interceptor to WRTP
W32	1DE-01-12	Delco Linen	Laundry Service	2626 W. 4th St., Chester, PA 19013	To 36-inch brick sewer on 4th St., to 48-inch brick sewer on Townsend St., to CSO Regulator #005, to Delaware River Interceptor, to WRTP

To help eliminate from the expanded list of the Parameters Considered the industrial chemicals that were detected as a result of the SIUs discharging to the WRTP, it was determined that additional wet weather sampling at the CSOs was required as noted in Section 3.4.2. The purpose of the additional sampling was to verify and confirm that the industrial-type chemicals not normally associated with CSOs that were detected in the historical sampling of the plant influent were in fact actually from the trucked-in industrial wastewater and not a part of the normal flow within the CSS that might overflow at a CSO. The CSO sampling results were used to screen non-detected parameters from the list of the Parameters Considered.

Review of the November 19th and December 1st, 2015 additional sampling results allows for shortening of the list of the Parameters Considered as possible POCs by screening those parameters that were introduced from the historical sampling of the plant influent that included the trucked-in industrial wastewater. The additional sampling results more accurately reflect the actual characteristics of the wastewater discharged at the CSOs, than does the historical data at the plant influent since the trucked-in industrial wastewater only goes into the plant and does not enter into the CSS. Therefore, if a parameter on the expanded Parameters Considered list was

not detected in the November and December 2015 wet weather sampling of the CSOs, those parameters were not considered further as POCs.

3.7 Methodology for Identification of the Pollutants of Concern List

Once the Parameters Considered list was narrowed using the November/December 2015 additional sampling results at the CSOs, the parameters remaining on the narrowed list of Parameters Considered were further evaluated to determine if they are Pollutants of Concern, or Parameters of Potential Concern (POPC). A parameter is considered a "Pollutant of Concern" for a water body if more than 10% of the samples exceeded the applicable water quality standard. This criteria is based on guidance provided by the USEPA, which recommends a "greater than 10% exceedance percentage" for determining that waters only partially meet their designated use for aquatic life support. A parameter is considered a "Parameter of Potential Concern" if 2 – 10% of the samples exceeded the water quality standard.

Water quality data for the parameters on the narrowed Parameters Considered list were collected from the STORET data repository for the one-year period from September 1, 2014 to September 1, 2015, from the water quality monitoring stations on each of the three receiving water bodies as noted in Section 3.5.1.

The segments of the Delaware River, Chester Creek and Ridley Creek have unique water quality standards that apply to them depending on the regulating authority, their designated uses, and the specific location within the waterbody. The maximum concentrations detected for each of the Parameters Considered were compared against the applicable surface water quality standards to determine which parameters were exceeding their standards. Attachment I in the List of Attachments provides a table with the final Parameters Considered list for each of the three receiving water bodies for which there is a water quality standard. The Delaware River was broken down into two tables; one for the Delaware River upstream of R.M 81.8 ("upper Delaware") and one for the Delaware River downstream of R.M 81.8 ("lower Delaware") based on the Water Contact Recreation designated use for the Delaware River below R.M. 81.8 and the more stringent requirements associated with primary contact.

The receiving stream water quality data from the USEPA STORET data warehouse was compared against the applicable WQS to check for exceedances. Both the acute and chronic conditions for the Parameters Considered were compared to the WQS, where applicable, to determine if there were exceedances. In addition to listing the Parameters Considered for each receiving water body, the table in Attachment I list the applicable water quality standards for each of the receiving water bodies, and identifies those parameters were the STORET sample data exceeded the water quality standards.

A flowchart was created to help illustrate the decision-making methodology used for developing the Pollutants of Concern list. The flowchart represents the process used for answering five (5) screening questions about the Parameters Considered in order to determine if a parameter is to be

considered a Pollutant of Concern, a Parameter of Potential Concern, or neither. The 5 screening questions for each Parameter Considered are:

1. Does a Water Quality Standard Exist for the parameter?
2. Do the available data indicate impairment exists and the impairment involves pollutants associated with CSOs?
3. Do greater than 10% of the samples for the receiving water body exceed the WQS?
4. Do 2% - 10% of the samples for the receiving water body exceed the WQS?
5. Was the parameter detected in the additional sampling of the CSOs?

Figure 3-3 presents the Methodology Flowchart used for developing the list of POCs and POPCs, and the following subsections provide additional details about the methodology used to answer the 5 screening questions.

3.7.1 Screening of Parameters with No Water Quality Standard

The Methodology Flowchart for POC and POPC Determination shows that the first step is to determine if a Parameter Considered has an applicable PA State or DRBC water quality standard. If a parameter does not have an applicable water quality standard, there is no standard to exceed. Therefore, those parameters without a water quality standard are not considered further as a POC or a POPC. These include many of the Parameters Considered.

As noted previously in Section 3.1.2, the USEPA's CSO Guidance document states that receiving water monitoring should include identified parameters of concern and these typically include those previously identified for combined sewage and CSO monitoring:

- pH
- BOD
- TDS
- TSS
- Nutrients
- Metals
- Indicator bacteria

A number of the above listed parameters were screened as not a POC or POPC because they do not have an applicable surface water quality standard for the Delaware River, Chester Creek, or Ridley Creek. These include the parameters of BOD/CBOD, TDS and TSS, and the nutrients nitrate, nitrite, phosphorus, and TKN.

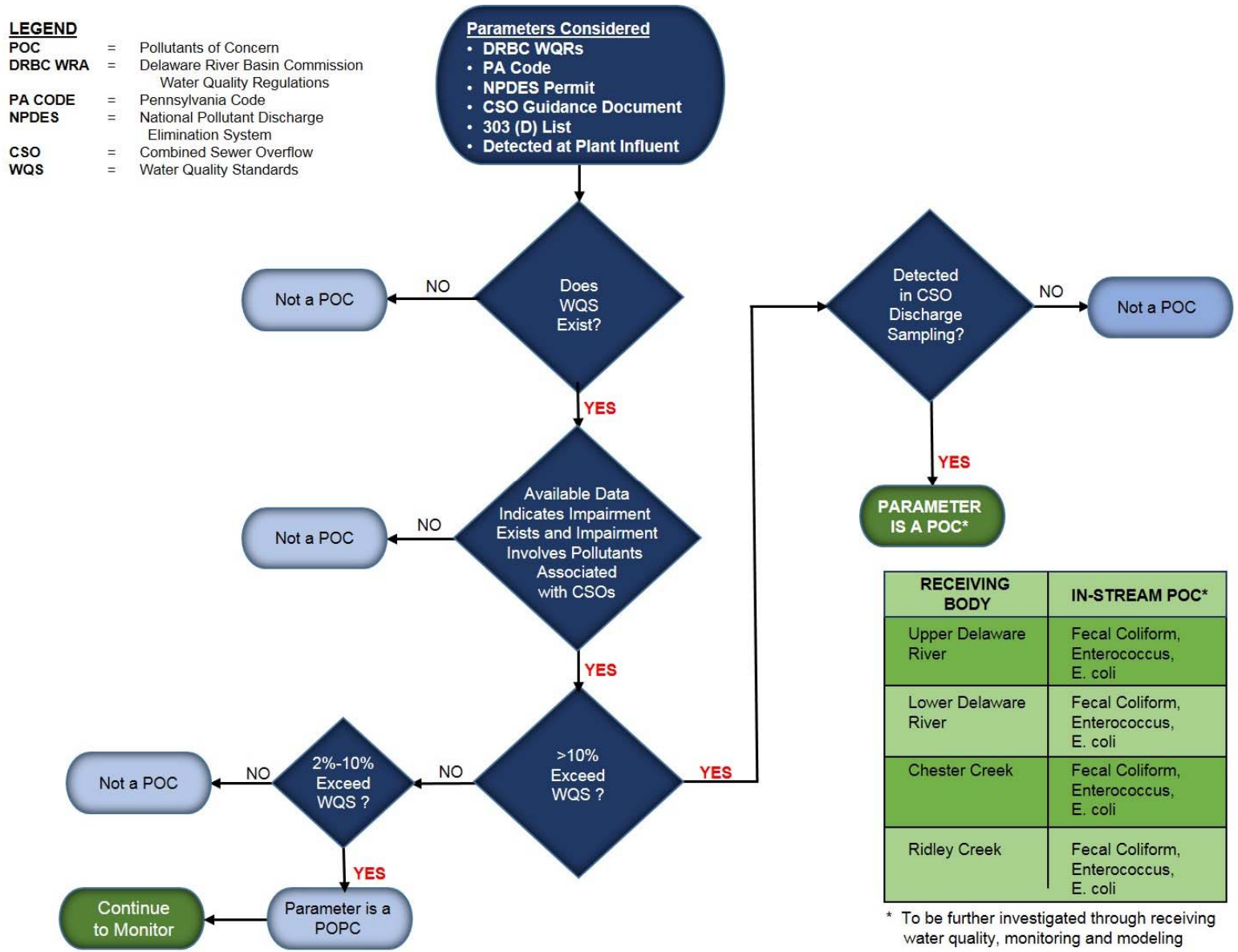

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Figure 3-3
METHODOLOGY FLOWCHART FOR POC AND POPC DETERMINATION

The table of the final Parameters Considered in Attachment I shows in gray-highlighting those Parameters Considered that were screened-out as not being a POC because they do not have an applicable water quality standard. Of the 76 Parameters Considered, 25 were removed from further consideration because they do not have an applicable water quality standard.

3.7.2 Screening of Parameters Causing Impairment and that are Associated with CSOs

For the 51 Parameters Considered that do have an applicable water quality standard, the Methodology Flowchart shows that the second screening decision is to determine if existing water quality data indicate impairment of the receiving water bodies exists and the impairment involves pollutants associated with CSOs. The inclusion of this determination comes directly from the requirements of the Consent Decree as noted in Section 3.1.1.

"Impairment" of a receiving water body is "indicated" to exist in one of two ways. First, the receiving water body is considered impaired for a particular parameter if the parameter appears in the 2014 PA Integrated Water Quality & Assessment Report (303(d) List). The PA Integrated Report identifies surface water bodies that are not attaining their designated and existing uses as "impaired".

Secondly, for the purpose of this report, a receiving water body is also considered impaired for a parameter if any of the available sampling data for that parameter in the water body shows that there had been an exceedance of the applicable water quality standard. Those parameters that showed exceedances of the WQS and that may be associated with CSOs were evaluated further to determine if they should be considered as a POC.

The 2014 PA Integrated Water Quality & Assessment Report shows the Delaware River to be impaired for Fish Consumption by PCBs from an unknown source, and there is a PCB TMDL on the Delaware River stretching far upstream to Trenton, NJ. While the Delaware River is impaired from PCBs, the PCBs are not normally associated with CSOs. Given this reason, and the fact that the PCB impairment begins well upstream of DELCORA's service area – PCBs were screened as not being a POC. Furthermore, the additional CSO sampling results from November/December 2015 in Attachment I show that PCBs were found to be at a lower concentration than the Reporting Detection Limit (RDL). For this additional reason it was determined that PCBs are not associated with DELCORA's CSO discharges.

For the Chester Creek and Ridley Creeks, the 2014 PA Integrated Water Quality & Assessment Report shows that both of the creeks are impaired for Aquatic Life from siltation, with Urban Runoff/Storm Sewers identified as the source. The impairment of the Chester Creek and Ridley Creek by siltation primarily occurs upstream of DELCORA's service area as shown in Figure 3-1. The term "Siltation" is not defined in the 2014 PA Integrated Water Quality & Assessment Report, but through various sources could be defined as:

> *"the pollution of water by fine particulate terrestrial clastic material, with a particle size dominated by silt or clay. It refers both to the increased concentration of suspended sediments, and to the increased accumulation (temporary or permanent) of fine sediments on bottoms where they are undesirable. Siltation is most often caused by soil erosion or sediment spill."*

There is not a water quality standard for "siltation", however, siltation can be considered as closely related to the widely used water quality parameter of "Turbidity", which is associated with CSO discharges. For this reason "Turbidity" was reviewed further as a surrogate for siltation to determine if it might be considered as a POC. Per available USEPA STORET data, the Turbidity concentrations on all of the three receiving water bodies were found to be below the WQS (see Attachment I) and therefore siltation was screened-out as not being a POC.

3.7.3 Screening of Parameters where > 10% of Observations Exceed WQS

The concentrations of those Parameters Considered that were detected within the receiving water bodies from USEPA's STORET data for the years 2010 - 2015 were compared to the applicable water quality standards to determine if a Parameter Considered should be viewed as a Pollutant of Concern.

If 10% or more of the total number of samples for a Parameter Considered listed in Attachment I exceeded the WQS, then the parameter was further evaluated to see if it was detected in the CSO discharges.

If 2% - 10% of the total number of samples for a Parameter Considered exceeded the WQS, then the parameter was considered a Parameter of Potential Concern. The concentrations of the Parameters of Potential Concern will continued to be monitored over time, and re-evaluated should the monitoring show their concentrations to increase over time.

Per the flowchart, if 2% - 10% of the total number of samples for a Parameter Considered do not exceed the WQS, then the parameter was not considered to be a POC or POPC.

3.7.4 Screening of Parameters Not Detected at CSO Discharges

The Methodology Flowchart shows that additional analysis is required for those parameters that exceeded the water quality standards for the receiving water bodies in more than 10% of the samples. For those parameters, the concentration of the parameter detected in the November/December 2015 sampling of the CSO discharges was reviewed.

If the parameter was "Not Detected (ND)" or was below the Reporting Detection Limit (see Attachment F) in the November/December 2015 CSO sampling results, it indicates that the parameter was not observed in DELCORA's CSO discharges. In this case, the parameter is not considered to be a POC. In this manner, the industrial-type chemicals that had been originally

detected in the historic sampling results from the influent to the WRTP were able to be removed from further consideration as a POC or POPC.

If the parameter was detected within the November/December 2015 CSO sampling results, it indicates that the parameter was in DELCORA's CSO discharge. In these cases the parameter is considered as a POC, and is to be further investigated through additional receiving water quality monitoring and modeling.

3.8 Discussion of the Pollutants of Concern and Parameters of Potential Concern

The Parameters Considered shown in Attachment I were analyzed against the WQS. The parameters that exceeded the WQS in the receiving bodies are shown in the summary table in Attachment J. The summary table also provides information on the number of observations for each parameter as well as the total number of exceedances for each parameter in all the receiving water bodies from 2010 to 2015. The POCs are shown in red highlight within the table, and POPCs are shown in yellow highlight.

The following discussion of the individual parameters is focused only on those parameters shown in the tables in Attachments I and J to be either a POC or a POPC.

3.8.1 Fecal Coliform Bacteria

Fecal coliform bacteria are the most common microbiological contaminants of natural waters, and are used to indicate contamination by human pathogens. Fecal coliform live in the digestive tracks of warm-blooded animals, including humans, and are excreted in the feces. The DRBC collects fecal coliform bacteria data at Stations 332049 and 892062 on the Delaware River. Additionally, DELCORA sampled the Chester and Ridley Creeks in 2010 for fecal coliform concentrations. The 2010 receiving water sampling results for the Chester and Ridley Creeks are presented in Attachment G.

There are no PA Code, Chapter 93 fecal coliform bacteria water quality standards for streams designated WWF, MF or TSF with no other qualifiers. However, the DRBC's Delaware River Zone 4 has a Stream Quality Objective for fecal coliform of no more than 770 CFU/100 mL for the section upstream of R.M. 81.8, which includes the tidal portions of the Chester and Ridley Creeks, and 200 CFU/100 mL for the section of the river downstream of R.M. 81.8. The tidal extent on Chester Creek and Ridley Creek is shown on Figure 3-1. Compliance with the DRBC Stream Quality Objectives for fecal coliform bacteria is based on a geometric average of samples taken at such frequency and location as to permit valid interpretation.

Of the six samples taken by DELCORA in 2010 on the Ridley Creek at RC1 (upstream) and RC3 (downstream), four show exceedances of the Stream Quality Objective for fecal coliform. These values indicate that the Ridley Creek was not meeting the DRBC Stream Quality Objective, however, more sampling is recommended to further confirm these results.

Of the six samples taken by DELCORA on the Chester Creek at CC1 (upstream) and CC3 (downstream), four show exceedances of the Stream Quality Objective for fecal coliform. These values indicate that the Chester Creek was also not meeting the DRBC WQS at that time, however as with the Ridley Creek, more sampling is recommended to further confirm these results.

The table in Attachment I shows that the available data indicates that there were no exceedances observed of fecal coliform in the Delaware River.

Given that more than 10% of the fecal coliform samples for both the Ridley and Chester Creeks exceeded the WQS, fecal coliform should be considered as a POC for the two creeks. However, although the existing data for the Delaware River has demonstrated that there were no exceedances observed of fecal coliform, since fecal coliform is a primary pollutant typically associated with CSO discharges it has been decided to also include it as a POC for the Delaware River in the interest of minimizing potential impacts to human health and the environment.

- For the lower Delaware River (Downstream of R.M. 81.8)
  - Fecal Coliform considered to be a Pollutant of Concern.
- For the upper Delaware River (Upstream of R.M. 81.8)
  - Fecal Coliform considered to be a Pollutant of Concern.
- For the Chester Creek
  - Fecal Coliform considered to be a Pollutant of Concern.
- For the Ridley Creek
  - Fecal Coliform considered to be a Pollutant of Concern.

3.8.2 Enterococcus Bacteria

Enterococcus is a second bacteria genus that also resides in the digestive system of humans and animals, and that is used to indicate the presence of human pathogens. They have been long recognized as important human pathogens and are becoming increasingly so.

Unlike fecal coliform, the DRBC does not collect enterococcus bacteria data at Stations 332049 and 892062 on the Delaware River, and DELCORA did not collect samples for enterococcus bacteria in 2010 as it did for fecal coliform. Enterococcus are used as an indicator bacteria for marine waters.

As with fecal coliform, there are no PA Code, Chapter 93 water quality standards for enterococcus bacteria for streams designated WWF, MF or TSF with no other qualifiers. However, the DRBC's Delaware River Zone 4 has a WQS for enterococcus bacteria of no more

than 88 CFU/100 mL for the section upstream of R.M. 81.8, which includes tidal portions of the Chester and Ridley Creeks, and 33 CFU/100 mL for the section of the river downstream of R.M. 81.8. Compliance with the DRBC WQS for enterococcus bacteria is based on a geometric average of samples taken at such frequency and location as to permit valid interpretation.

Very little existing data was available for enterococcus bacteria concentrations in the Delaware River, Chester Creek and Ridley Creek in the area of DELCORA's CSO discharges. However, enterococcus bacteria and fecal coliform bacteria are similar to each other, they are both produced in the human digestive tract, and are both considered to be parameters typically associated with CSOs. For this reason it was decided to also include enterococcus bacteria as a POC at the same locations identified for fecal coliform bacteria, which includes all three of DELCORA's receiving water bodies.

- For the lower Delaware River (Downstream of R.M. 81.8)
  - Enterococcus considered to be a Pollutant of Concern.
- For the upper Delaware River (Upstream of R.M. 81.8)
  - Enterococcus considered to be a Pollutant of Concern.
- For the Chester Creek
  - Enterococcus considered to be a Pollutant of Concern.
- For the Ridley Creek
  - Enterococcus considered to be a Pollutant of Concern.

3.8.3 Escherichia Coli Bacteria

Escherichia coli (also known as E. coli) is a facultative anaerobic, rod-shaped bacterium of the genus *Escherichia* that is commonly found in the lower intestine of warm-blooded organisms. E. coli is expelled into the environment within fecal matter. Fecal material can enter the environment from many sources including wastewater treatment plants, CSO discharges, livestock or poultry manure, sanitary landfills, septic systems, sewage sludge, pets and wildlife.

E. coli was not listed as an initial Parameter Considered because it is listed in the applicable reference sources from the PA Code or DRBC. However, in consultation with the PADEP it is understood that Enterococcus bacteria could be replaced with E. coli in future regulations (on the anticipation that national standards for E. coli will be adopted in Pennsylvania) and therefore E. coli is included as a POC for all the receiving water bodies.

- For the lower Delaware River (Downstream of R.M. 81.8)
  - E. coli considered to be a Pollutant of Concern.

- For the upper Delaware River (Upstream of R.M. 81.8)
  - E. coli considered to be a Pollutant of Concern.

- For the Chester Creek
  - E. coli considered to be a Pollutant of Concern.

- For the Ridley Creek
  - E. coli considered to be a Pollutant of Concern.

3.8.4 Metals

During the data analysis, it was detected that some metal concentrations, in the receiving water bodies, exceeded the water quality standards. These metals include Aluminum, Copper, Iron, Lead, and Mercury. The appropriate control measures for metals from CSO discharges are the continued implementation of and compliance with the Nine Minimum Controls (NMCs) as required by DELCORA's NPDES permit.

The NPDES permit requires DELCORA to submit an annual report each year to the PADEP, with appropriate documentation demonstrating the continued implantation of and compliance with the NMC required on a system wide basis.

Additionally, the USEPA's guidance document *Guidance for Nine Minimum Controls* states;

> *"…municipalities should immediately implement best available technology economically achievable (BAT) or best conventional pollutant control technology (BCT). At a minimum, BAT/BCT should include the nine minimum controls, which are determined on a best professional judgement (BPJ) basis by the NPDES permitting authority".*

For the removal of metals, the most applicable Nine Minimum Controls include the maximum use of the collection system for storage, the review and modification of pretreatment requirements to ensure that CSO impacts are minimized, maximization of flow to the POTW for treatment and pollution prevention programs (such as street sweeping) to reduce these contaminants in the CSOs.

Therefore, metals are not considered to be POCs.

3.9 Summary for Pollutants of Concern

In the effort to identify Pollutants of Concerns related to its CSO discharges, DELCORA has reviewed the 2014 PA Integrated Water Quality Monitoring and Assessment Report (303(d) List), the historic sampling data for the influent to the Western Regional Treatment Plant, the USEPA's STORET Data repository, historic water quality sampling data from the Chester and

Ridley Creeks, and additional sampling results from the CSOs from November and December of 2015.

Three (3) POCs were determined. These include Fecal Coliform bacteria, Enterococcus bacteria and E. coli bacteria. These three POCs are parameters typically associated with CSO discharges. The list of POCs is summarized in Table 3-12 with their respective exceedance percentage (%) for each of the receiving water bodies. The concentrations of these identified POCs in the Delaware River, Chester Creek and Ridley Creek will be further investigated through receiving water quality monitoring and modeling.

No Parameters of Potential Concern were identified at this time.

Table 3-12: 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.

Section 4 References

1. Commonwealth of Pennsylvania (PA) - Pennsylvania Code, Title 25, Ch. 93 Water Quality Criteria, October 20, 2013 http://www.pacode.com/secure/data/025/chapter93/025_0093.pdf

2. CRC Watersheds Association, chester_creek_watershed_conservation_plan, 2001 http://www.crcwatersheds.org/chester-creek.html

3. CRC Watersheds Association, ridley_creek_watershed_conservation_plan, 1995 http://www.crcwatersheds.org/ridley-creek.html

4. Delaware River Basin Commission (DRBC) - 2014 Delaware River and Bay Water Quality Assessment, August 2014 http://www.nj.gov/drbc/library/documents/WQAssessmentReport2014.pdf

5. Delaware River Basin Commission (DRBC) - Delaware River Main Stem Interstate Zones (Drawing) http://www.nj.gov/drbc/library/documents/maps/InterstateZones-MainStem.pdf

6. Delaware River Basin Commission (DRBC) – DRBC_InterstateZones-MainStem. http://www.state.nj.us/drbc/library/documents/maps/InterstateZones-

7. Delaware River Basin Commission (DRBC) – DRBC_StreamMileageJuly2007, 2007 http://www.state.nj.us/drbc/library/documents/StreamMileageJuly2007.pdf

8. Delaware River Basin Commission (DRBC) - DRBC Water Quality Regulations, December 4, 2013 http://www.state.nj.us/drbc/library/documents/WQregs.pdf

9. Delaware River Basin Commission (DRBC) - Delaware River Main Stem Interstate Zones (Drawing) http://www.nj.gov/drbc/library/documents/maps/InterstateZones-MainStem.pdf

10. Delaware River Basin Commission (DRBC) - DRBC Water Quality Regulations, December 4, 2013 http://www.state.nj.us/drbc/library/documents/WQregs.pdf

11. Fish and Wildlife Service http://ecos.fws.gov/crithab/

12. National Oceanic and Atmospheric Administration, National Marine Sanctuaries - NOAA Endangered Species List, 2015

13. National Oceanic and Atmospheric Administration, National Marine Sanctuaries http://sanctuaries.noaa.gov/visit/welcome.html#locations

14. National Oceanic and Atmospheric Administration, National Marine Sanctuaries http://www.nominate.noaa.gov/guide.html#document

15. National Oceanic and Atmospheric Administration, Waters with threatened or endangered species or their critical habitat, 2014 http://response.restoration.noaa.gov/maps-and-spatial-data/download-esi-maps-and-gis-data.html

16. National Oceanic and Atmospheric Administration (NOAA) -_DE_NJ_PA_2014_PDFs, 2014 http://response.restoration.noaa.gov/maps-and-spatial-data/download-esi-maps-and-gis-data.html

17. PA Code Chapter 93 WQS, 2010 http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

18. PA Code Chapter 93 WQS, 2011 http://www.pacode.com/secure/data/025/chapter93/chap93toc.html

19. PADEP - 2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report (aka 303(D) List), 2014 http://www.portal.state.pa.us/portal/server.pt/community/water_quality_standards/10556/integrated_water_quality_report_-_2014/1702856

20. PADEP - DELCORA's NPDES Permit, October 17, 2013

21. Partnership for the Delaware Estuary (PDE), PDE-Report-15-02_FreshwaterMusselScientificResearch, 2015. http://delawareestuary.org/science_reports_partnership.asp

22. Partnership for the Delaware Estuary (PDE) http://www.delawareestuary.org/mussel-survey-program

23. Pennsylvania Fish and Boat Commission – Map and Biologist Reports. http://fishandboat.com/afm.htm

24. Pennsylvania Department of Environmental Protection (PADEP) - 2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report (aka 303(D) List), 2014 http://www.portal.state.pa.us/portal/server.pt/community/water_quality_standards/10556/integrated_water_quality_report_-_2014/1702856

25. Pennsylvania Department of Environmental Protection (PADEP) - DELCORA's NPDES Permit, October 17, 2013

26. Pennsylvania Natural Heritage Program (PNHP),2011 http://www.naturalheritage.state.pa.us/CNAI_Download.aspx

27. Pennsylvania Natural Heritage Program (PNHP),2007 http://www.naturalheritage.state.pa.us/Aquatic_GIS.aspx

28. Pennsylvania Natural Heritage Program (PNHP),2015 http://www.gis.dcnr.state.pa.us/maps/index.html?nha=true

29. Pennsylvania Natural Heritage Program (PNHP) – PNHP Species List http://www.naturalheritage.state.pa.us/Species.aspx

30. Philadelphia Water Department - PWD LTCPU ("Green City Clean Waters"), September 1, 2009 http://www.phillywatersheds.org/ltcpu/LTCPU_Complete.pdf

31. United States Environmental Protection Agency (USEPA) - 2006_12_01_standards_outstanding, 1989 http://www.epa.gov/sites/production/files/2014-10/documents/diamond-outstanding-memo.pdf

32. United States Environmental Protection Agency (USEPA) - EPA CSO Guidance for LTCP, September, 1995 http://water.epa.gov/polwaste/npdes/cso/upload/owm0272.pdf

33. United States Environmental Protection Agency)USEPA) - STORET Data Warehouse http://www.epa.gov/storet/

34. WREN, WRENWaterSupplyReport_000, 2006 http://wren.palwv.org/products/documents/WaterSupplyReport_000.pdf

ATTACHMENT A

Letters with Regulatory Agencies Regarding Sensitive Areas

DELCORA CSO LTCP
Sensitive Areas Contact Sheet

No.	Sensitive Area Item	Contact	Title	Agency	Street	City	State	Zip	Phone Number	Date Sent	Response Date
1	Endangered Species	Robert Anderson	Fish & Wildlife Biologist	US Fish and Wildlife Agency	110 Radnor Road, Suite 101	State College	PA	16801-7987	814-237-4090 x7447	10/28/2015	11/2/2015
2	Threatened and Endangered Birds	Brendalee Phillips	Wildlife Biologist	US Fish and Wildlife - John Heinz NWR Birds	8601 Lindbergh Blvd.	Philadelphia	PA	19153	215-365-3118 x119	10/29/2015	No Comments
3		Jennifer Fields	Program Manager jefields@pa.gov	PA DEP	2 East Main Street	Norristown	PA	19401	484-250-5192	10/29/2015	11/17/15 - phone call
4		Steve Tambini	Executive Director	Delaware River Basin Commission (DRBC)	25 State Police Drive	West Trenton	NJ	08628-0360	609-883-9500 x203	10/29/2015	No Comments
5	Threatened and Endangered Birds	Patti Barber	Endangered Bird Biologist	PA Game Commission	2001 Elmerton Ave	Harrisburg	PA	17110-9797	717-303-4482	10/29/2015	12/31/15 return call
6	Threatened and Endangered Birds	Ian Gregg	Wildlife Biologist	PA Game Commission	2001 Elmerton Ave	Harrisburg	PA	17110-9797	814-422-8239	10/29/2015	No Response
7		Carol F. McCabe, Esq.	Chair	PA Environmental Council	1315 Walnut Street, Suite 532	Philadelphia	PA	19107	215-545-4570	10/29/2015	No Response
8	Primary Contact Areas	Brian Byrnes	Executive Director	Chester Ridley Crum Watersheds Association	P.O. Box 227	Gradyville	PA	19039	610-359-1440	10/29/2015	11/23/15 - called
9		David Chanda	Director Fish and Wildlife	New Jersey Department of Environmental Protection (NJDEP)	P.O. Box 420 501 E State Street, 3rd Floor	Trenton	NJ	08625	609-292-9410	10/29/2015	No Response
10	Atlantic and Shortnose Sturgeon, river herring, shad	Matt Fisher	Director Fish and Wildlife	Delaware Department of Natural Resources and Environmental Control (DNREC)	89 Kings Highway	Dover	DE	19901	302-735-8663	10/29/2015	11/30/2015
11	Delaware River and tributaries	John Buzzar Kathy Gipe	Fisheries Biologist	PA Fish and Boat Commission (PFBC)	1601 Elmerton Ave	Harrisburg	PA	17110	717-705-7800 610-847-5983 814-359-5186	10/29/2015	12/22/2015 Follow up 3/11/16 and 5/2/16
12	Freshwater Mussels	Dr. Danielle Kreeger	Science Director	Patnership for the Delaware Estuary (PDE)	110 S Poplar Street, Suite 202	Wilmington	DE	19801	302-655-4990 x 104	10/29/2015	11/25/2015

GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Carol F. McCabe, Esquire
PA Environmental Council
1315 Walnut Street
Suite 532
Philadelphia, PA 19107

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Ms. McCabe:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

Sensitive Areas are defined by the United States Environmental Protection Agency (USEPA) Federal Register Combined Sewer Overflow (CSO) Control Policy and the US EPA Guidance for Long Term Control Plan as follows:

- Outstanding National Resource Waters (ONRW)
- National Marine Sanctuaries
- Waters with threatened or endangered species and their habitat
- Waters with primary contact recreation (i.e. beaches, boat ramps, boat launches, etc.)
- Public drinking water intakes or their designated protection areas
- Shellfish beds

USEPA requirements indicate that sensitive areas are given the highest priority during the development of technical alternatives.

This letter is being submitted to your agency as a formal request for information that your agency may have on sensitive areas within Delaware County, PA. Specifically, we are interested in sensitive areas located within the area of study as shown in GREEN on the attached map. If portions of the study area meet the above sensitive area criteria, we request that you provide the following information:

- Complete list of identified Sensitive Areas;
- Narrative description of how the sensitive area criteria listed above applies to the study area;
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- Any additional information you deem appropriate.

DELCORA is under a Consent Decree to submit this study to USEPA in February 2016. In order to meet project milestones, we respectfully request you provide a response within 30 days of receipt of this letter, no later than November 23, 2015. We appreciate your cooperation and assistance in completing this study. Should you need any additional information, please feel free to contact me at (215) 553-7919 or Julia Spicher at (215) 553-7926.

Yours very truly,

Greeley and Hansen LLC

Marlene Finizio
Project Manager

c: Robert Willert, DELCORA
Michael DeSantis, DELCORA
Edwin Bothwell, DELCORA
Michael Hope, Greeley and Hansen
Julia Spicher, Greeley and Hansen

GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Ms. Patti Barber
PA Game Commission
2001 Elmerton Avenue
Harrisburg, PA 17110-9797

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Ms. Barber:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

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GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Ms. Jennifer Fields
Pennsylvania Department of Environmental
Protection
2 East Main Street
Norristown, PA 19401

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Ms. Fields:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

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GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Mr. Ian Gregg
PA Game Commission
2001 Elmerton Avenue
Harrisburg, PA 17110-9797

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Mr. Gregg:

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1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Mr. Steven Tambini
Executive Director
Delaware River Basin Commission
25 State Police Drive
West Trenton, NJ 08628-0360

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Mr. Tambini:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

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1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Ms. Brendalee Phillips
US Fish and Wildlife - John Heinz
NWR Birds
8601 Lindbergh Boulevard
Philadelphia, PA 19153

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Ms. Phillips:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pennsylvania Field Office
110 Radnor Road, Suite 101
State College, Pennsylvania 16801-4850

November 2, 2015

Marlene Finizio
Greeley and Hansen LLC
1700 Market Street, Suite 2130
Philadelphia, PA 19103

RE: USFWS Project #2016-0026
PNDI Large Project

Dear Ms. Finizio:

This responds to your letter received on October 9, 2015, requesting information about federally listed and proposed endangered and threatened species within the area affected by the development of a Long Term Control Plan for the Delaware County Regional Authority. The project area is located in Delaware County, Pennsylvania. The following comments are provided pursuant to the Endangered Species Act of 1973 (Act, 87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.), the Migratory Bird Treaty Act (MBTA, 16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat. 755, as amended), and the Bald and Golden Eagle Protection Act (BGEPA, 16 U.S.C. 668-668d).

Federally Listed Species

There are a number of federally listed species that are either known to occur, or have the potential to occur, in the proposed study area. We describe general information about these species, but without more specific project information and locations are not able to provide additional information regarding potential avoidance or conservation measures. We fully support your planning efforts and desires to protect sensitive areas and overall water quality. Let us know how we can be of additional assistance.

No critical habitat has been designated for any of the below listed species, at this time.

Bog turtle

The project is within the known range of the bog turtle (*Clemmys muhlenbergii*), a species that is federally listed as threatened. Bog turtles inhabit shallow, spring-fed fens, sphagnum bogs, swamps, marshy meadows, and pastures characterized by soft, muddy bottoms; clear, cool, slow-flowing water, often forming a network of rivulets; high humidity; and an open canopy. Bog

turtles usually occur in small, discrete populations occupying suitable wetland habitat dispersed along a watershed. The occupied "intermediate successional stage" wetland habitat is usually a mosaic of micro-habitats ranging from dry pockets, to areas that are saturated with water, to areas that are periodically flooded. Some wetlands occupied by bog turtles are located in agricultural areas and are subject to grazing by livestock. More information on this species can be found at: http://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=C048

Indiana bat

The project area is within the range of the federally endangered Indiana bat (*Myotis sodalis*). Indiana bats hibernate in caves and abandoned mines during the winter months (November through March), and use a variety of forested upland and wetland habitats during the spring, summer, and fall. Indiana bats usually roost in dead or living trees with exfoliating bark, crevices or cavities. Female Indiana bats form nursery colonies under the exfoliating bark of dead or living trees, such as shagbark hickory, black birch, red oak, white oak, and sugar maple, in upland or riparian areas. More information on this species can be found at: http://www.fws.gov/MIDWEST/endangered/mammals/inba/index.html

Northern long-eared bat

The project is within the known range of the northern long-eared bat (*Myotis septentrionalis*), a species that is federally listed as threatened. Northern long-eared bats hibernate in caves and abandoned mines during the winter months, and use a variety of forested upland and wetland habitats during the spring, summer, and fall. More information on this species can be found at: http://www.fws.gov/midwest/endangered/mammals/nlba/index.html

Atlantic sturgeon

The project is within the known range of the Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), a species that is federally listed as threatened. The Atlantic sturgeon is a long-lived, estuarine dependent, anadromous fish. Adult sturgeon spawn in freshwater in the spring and early summer and migrate into "estuarine" and marine waters where they spend most of their lives. The Atlantic sturgeon is under the jurisdiction of the National Marine Fisheries Service (NMFS). Please contact NMFS regarding this species or visit their website at: http://www.nmfs.noaa.gov/pr/species/fish/atlanticsturgeon.htm#status

Shortnose sturgeon

The project is within the known range of the Shortnose sturgeon (*Acipenser brevirostrum*), a species that is federally listed as endangered. The shortnose sturgeon is the smallest of the three sturgeon species that occur in eastern North America. The shortnose sturgeon is anadromous, living mainly in the slower moving riverine waters or nearshore marine waters, and migrating periodically into faster moving fresh water areas to spawn. The shortnose sturgeon is under the jurisdiction of the NMFS. Please contact NMFS regarding this species or visit their website at: http://www.nmfs.noaa.gov/pr/species/fish/shortnosesturgeon.htm

In cases where adverse effects to federally listed species cannot be avoided, further consultation with the Service would be necessary to avoid potential violations of section 9 (prohibiting "take" of listed species) and/or section 7 (requiring federal agencies to consult) of the Endangered Species Act. Information about the section 7 and section 10 consultation processes (for federal and non-federal actions, respectively) can be obtained by contacting this office or accessing the Service's Endangered Species Home Page (http://endangered.fws.gov).

Bald and golden eagles

Bald eagles (*Haliaeetus leucocephalus*) are known to nest in the vicinity of the project area. While the bald eagle has been removed from the Federal list of threatened and endangered species (August 8, 2007; 72 FR 37346), the bald eagle along with the golden eagle (*Aquila chrysaetos*) continues to be protected under the BGEPA and MBTA. Both the BGEPA and the

MBTA prohibit take as defined as "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, disturb, or otherwise harm eagles, their nests, or their eggs." Under the BGEPA, "disturb" means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available: (1) injury to an eagle; (2) decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior; or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.

We recommend that you evaluate the project type, size, location and layout in light of the National *Bald Eagle Management Guidelines* to determine whether or not bald eagles might be disturbed as a direct or indirect result of this project. If it appears that disturbance may occur, we recommend that you consider modifying your project consistent with the Guidelines. These guidelines, as well as additional eagle information, are available at http://www.fws.gov/northeast/EcologicalServices/eagle.html To assist you in making a decision regarding impacts to bald eagles, a screening form can be found at http://www.fws.gov/northeast/pafo/bald_eagle.html.

Migratory Birds

The Service is the principal Federal agency charged with protecting and enhancing populations and habitat of migratory bird species. The MBTA prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. While the MBTA has no provision for authorizing incidental take, the Service recognizes that some birds may be killed even if all reasonable measures to avoid take are implemented.

The potential exists for avian mortality if there is habitat destruction and alteration within the project boundaries. Site-specific factors that should be considered in project siting to avoid and minimize the risk to birds include avian abundance; the quality, quantity and type of habitat; geographic location; type and extent of bird use (e.g. breeding, foraging, migrating, etc.); and landscape features. Please review the enclosed information for general recommendations for avoiding and minimizing impacts to migratory birds within and around the project area. Please

be aware that since these are general guidelines, some of them may not be applicable to the current project design or they may have already been included in the project design.

The project area is located in the vicinity of the Important Bird Area (IBA) known as Upper Ridley-Crum Creek. IBAs are designated by the Pennsylvania Ornithological Technical Committee. They are the most critical regions in the Commonwealth for conserving bird diversity and abundance, and are the primary focus of Audubon Pennsylvania's conservation efforts. To find out more information about this IBA, including which bird species breed there, visit: http://netapp.audubon.org/IBA/State/US-PA

Please contact Brian Scofield of my staff at 814-234-4090 if you have any questions or require further assistance regarding this matter.

Sincerely,

Lora L. Zimmerman
Field Office Supervisor

Enclosure

Adaptive Management Practices for Conserving Migratory Birds

The Fish and Wildlife Service is the principal Federal agency charged with protecting and enhancing populations and habitat of migratory bird species. The Migratory Bird Treaty Act (MBTA, 16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat. 755, as amended) prohibits the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. While the MBTA has no provision for authorizing incidental take, the Service recognizes that some birds may be killed even if all reasonable measures to avoid take are implemented. Unless the take is authorized, it is not possible to absolve individuals, companies or agencies from liability (even if they implement avian mortality avoidance or similar conservation measures). However, the Office of Law Enforcement focuses on those individuals, companies, or agencies that take migratory birds with disregard for their actions and the law.

The potential exists for avian mortality from habitat destruction and alteration within the project boundaries. Site-specific factors that should be considered in project siting to avoid and minimize the risk to birds include avian abundance; the quality, quantity and type of habitat; geographic location; type and extent of bird use (*e.g.* breeding, foraging, migrating, etc.); and landscape features.

We offer the following recommendations to avoid and minimize impacts to migratory birds within and around the project area:

1. Where disturbance is necessary, clear natural or semi-natural habitats (*e.g.*, forests, woodlots, reverting fields, shrubby areas) and perform maintenance activities (*e.g.*, mowing) between September 1 and March 31, which is outside the nesting season for most native bird species. Without undertaking specific analysis of breeding species and their respective nesting seasons on the project site, implementation of this seasonal restriction will avoid take of most breeding birds, their nests, and their young (*i.e.*, eggs, hatchlings, fledglings).

2. Minimize land and vegetation disturbance during project design and construction. To reduce habitat fragmentation, co-locate roads, fences, lay down areas, staging areas, and other infrastructure in or immediately adjacent to already-disturbed areas (*e.g.*, existing roads, pipelines, agricultural fields) and cluster development features (*e.g.*, buildings, roads) as opposed to distributing them throughout land parcels. Where this is not possible, minimize roads, fences, and other infrastructure.

3. Avoid permanent habitat alterations in areas where birds are highly concentrated. Examples of high concentration areas for birds are wetlands, State or Federal refuges, Audubon Important Bird Areas, private duck clubs, staging areas, rookeries, leks, roosts, and riparian areas. Avoid establishing sizable structures along known bird migration pathways or known daily movement flyways (*e.g.*, between roosting and feeding areas).

4. To conserve area-sensitive species, avoid fragmenting large, contiguous tracts of wildlife habitat, especially if habitat cannot be fully restored after construction. Maintain

contiguous habitat corridors to facilitate wildlife dispersal. Where practicable, concentrate construction activities, infrastructure, and man-made structures (*e.g.*, buildings, cell towers, roads, parking lots) on lands already altered or cultivated, and away from areas of intact and healthy native habitats. If not feasible, select fragmented or degraded habitats over relatively intact areas.

5. Develop a habitat restoration plan for the proposed site that avoids or minimizes negative impacts to birds, and that creates functional habitat for a variety of bird species. Use only plant species that are native to the local area for revegetation of the project area.

If you have any questions regarding these measures, please contact Lora Zimmerman of the Pennsylvania Field Office located in State College, PA at 814-234-4090.

GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Mr. Brian Byrnes
Executive Director
Chester Ridley Crum Watersheds Association
38 Bishop Hollow Road
Newtown Square, PA 19073

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Mr. Byrnes:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

Sensitive Areas are defined by the United States Environmental Protection Agency (USEPA) Federal Register Combined Sewer Overflow (CSO) Control Policy and the US EPA Guidance for Long Term Control Plan as follows:

- Outstanding National Resource Waters (ONRW)
- National Marine Sanctuaries
- Waters with threatened or endangered species and their habitat
- Waters with primary contact recreation (i.e. beaches, boat ramps, boat launches, etc.)
- Public drinking water intakes or their designated protection areas
- Shellfish beds

USEPA requirements indicate that sensitive areas are given the highest priority during the development of technical alternatives.

This letter is being submitted to your agency as a formal request for information that your agency may have on sensitive areas within Delaware County, PA. Specifically, we are interested in sensitive areas located within the area of study as shown in GREEN on the attached map. If portions of the study area meet the above sensitive area criteria, we request that you provide the following information:

- Complete list of identified Sensitive Areas;
- Narrative description of how the sensitive area criteria listed above applies to the study area;
- Map of specific locations within our study area identifying the specific sensitive areas; and
- Any additional information you deem appropriate.

DELCORA is under a Consent Decree to submit this study to USEPA in February 2016. In order to meet project milestones, we respectfully request you provide a response within 30 days of receipt of this letter, no later than November 23, 2015. We appreciate your cooperation and assistance in completing this study. Should you need any additional information, please feel free to contact me at (215) 553-7919 or Julia Spicher at (215) 553-7926.

Yours very truly,

Greeley and Hansen LLC

Marlene Finizio
Project Manager

c: Robert Willert, DELCORA
Michael DeSantis, DELCORA
Edwin Bothwell, DELCORA
Michael Hope, Greeley and Hansen
Julia Spicher, Greeley and Hansen

GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Ms. Danielle Kreeger
Partnership for the Delaware Estuary
110 S. Poplar Street
Suite 202
Wilmington, DE 19801

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Ms. Kreeger:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

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Yours very truly,

Greeley and Hansen LLC

Marlene Finizio
Project Manager

c: Robert Willert, DELCORA
Michael DeSantis, DELCORA
Edwin Bothwell, DELCORA
Michael Hope, Greeley and Hansen
Julia Spicher, Greeley and Hansen

Finizio, Marlene

From: Spicher, Julia
Sent: Friday, January 15, 2016 3:25 PM
To: Finizio, Marlene
Subject: FW: Sensitive Areas Study
Attachments: Sensitive Areas Study.docx

From: Kurt Cheng [mailto:kcheng@delawareestuary.org]
Sent: Tuesday, November 24, 2015 4:34 PM
To: Spicher, Julia <jspicher@greeley-hansen.com>
Cc: Danielle Kreeger <DKreeger@delawareestuary.org>
Subject: Sensitive Areas Study

Hi Julia,

On behalf of Dr. Danielle Kreeger, please find attached the sensitive areas study document. Let me know if you have any questions.

Thanks,

Kurt

--
Kurt Cheng
Shellfish Specialist

Partnership for the Delaware Estuary
110 South Poplar Street, Suite 202
Wilmington, DE 19801

302-655-4990 x107

www.delawareestuary.org



Sensitive Areas Study

Partnership for the Delaware Estuary has identified sensitive areas within the study area which are listed and described below along with a visual representation on the provided map. Additional information on the study area is also presented.

Sensitive Areas

- **Ridley Creek watershed**
- **Schuylkill River watershed**
- **Darby Creek mouth / John Heinz National Wildlife Refuge at Tinicum**

Ridley Creek watershed

Ridley Creek begins north of Delaware County and flows through the county and into the Delaware River. Healthy freshwater mussel populations comprised of the Eastern elliptio (*Elliptio complanata*) exist throughout the creek which warrants protection. Additionally, there are long term freshwater mussel monitoring studies within the creek. Therefore, the Ridley Creek watershed should be considered a sensitive area.

Schuylkill River watershed

The northeast section of Delaware County drains into the Schuylkill River which flows just east of the county. Freshwater mussel beds have been qualitatively identified and quantitatively surveyed within the Schuylkill River and include multiple species including the eastern elliptio, the alewife floater (*Anodonta implicata*), and the tidewater mucket (*Leptodea ochracea*). Surveys have also identified juvenile mussels in the river indicating the population is successfully reproducing.

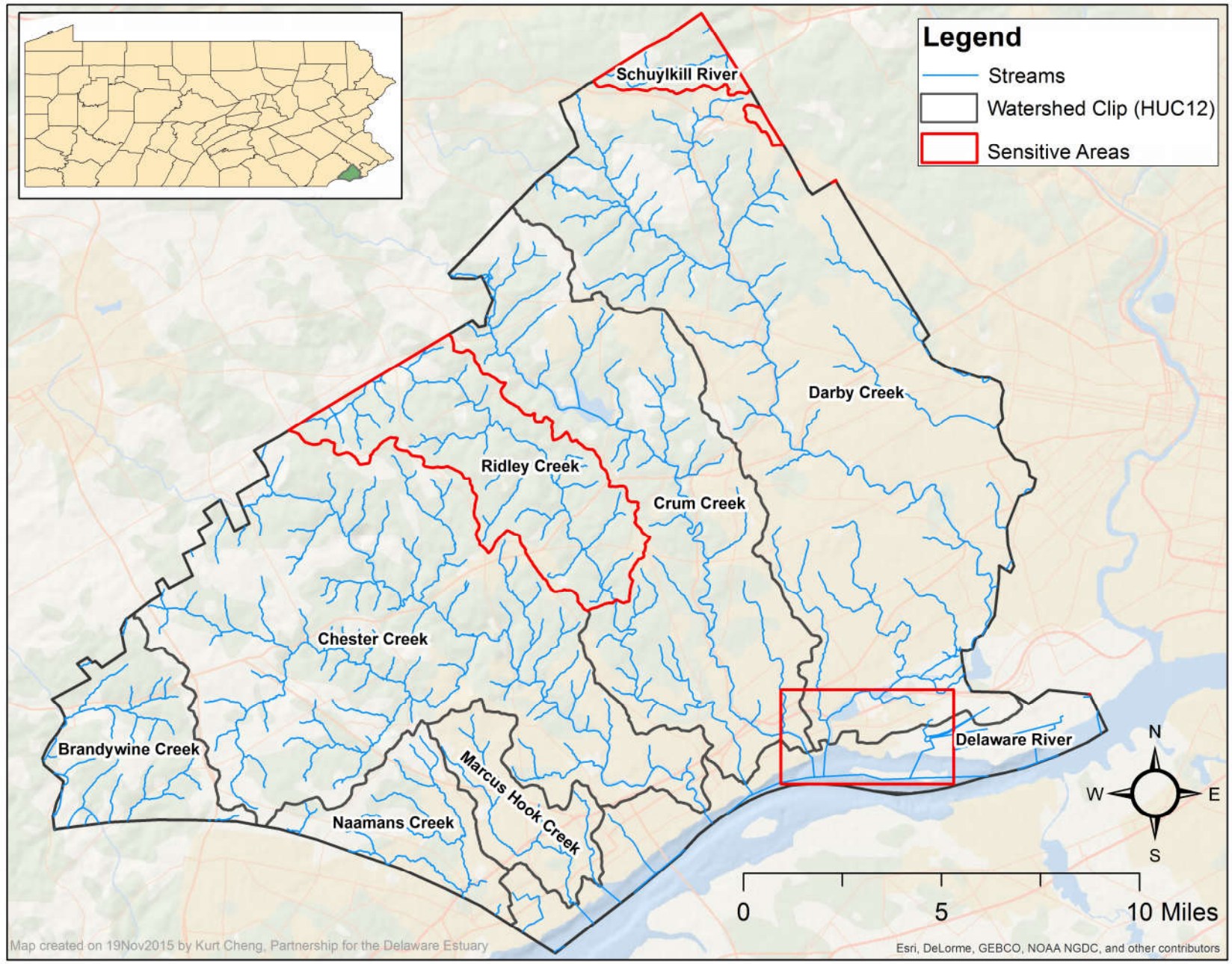
Darby Creek mouth / John Heinz National Wildlife Refuge at Tinicum

Access to Darby Creek is made possible via the Ridley Township Municipal Marina where boaters may access the Delaware River as well as the John Heinz National Wildlife Refuge at Tinicum. As well as serving as a primary contact for recreation, freshwater mussel surveys at the mouth of Darby Creek have yielded positive detections of the eastern elliptio and the alewife floater.

Although a few sensitive areas have been described above, it should be noted that Partnership for the Delaware Estuary and other organizations has only surveyed a portion of all streams in Delaware County. Historical data and museum records indicate that multiple species of freshwater mussels were found in Chester and Crum Creeks (Ortmann 1919). It is possible that additional freshwater mussel beds still exist in some streams that have not been properly surveyed. Attention should be paid to areas with hydrological connectivity to downstream sites that support freshwater mussels. In example, although outside of the highlighted study area, freshwater mussel populations as well as beds of submerged aquatic vegetation between Pennsylvania's coast and Little Tinicum Island may be impacted from waters draining the Darby Creek watershed.

Ortmann, A.E. 1919. A monograph of the naiades of Pennsylvania. Part III: Systematic account of the genera and species. Memoirs of the Carnegie Museum 8(1): xvi -385 + 21 plates.

Sensitive Areas in Delaware County, PA November 2015



GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Mr. John Buzzar
PA Fish and Boat Commission
1601 Elmerton Avenue
Harrisburg, PA 17110

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Mr. Buzzar:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

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- Shellfish beds

USEPA requirements indicate that sensitive areas are given the highest priority during the development of technical alternatives.

This letter is being submitted to your agency as a formal request for information that your agency may have on sensitive areas within Delaware County, PA. Specifically, we are interested in sensitive areas located within the area of study as shown in GREEN on the attached map. If portions of the study area meet the above sensitive area criteria, we request that you provide the following information:

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- Map of specific locations within our study area identifying the specific sensitive areas; and
- Any additional information you deem appropriate.

DELCORA is under a Consent Decree to submit this study to USEPA in February 2016. In order to meet project milestones, we respectfully request you provide a response within 30 days of receipt of this letter, no later than November 23, 2015. We appreciate your cooperation and assistance in completing this study. Should you need any additional information, please feel free to contact me at (215) 553-7919 or Julia Spicher at (215) 553-7926.

Yours very truly,

Greeley and Hansen LLC

Marlene Finizio
Project Manager

c: Robert Willert, DELCORA
Michael DeSantis, DELCORA
Edwin Bothwell, DELCORA
Michael Hope, Greeley and Hansen
Julia Spicher, Greeley and Hansen

Pennsylvania Fish & Boat Commission
established 1866

Division of Environmental Services
Natural Diversity Section
450 Robinson Lane
Bellefonte, PA 16823
814-359-5237

December 22, 2015

IN REPLY REFER TO
SIR# 45340

Greeley & Hansen
Marlene Finizio
1700 Market Street
Philadelphia, Pennsylvania 19103

RE: Species Impact Review (SIR) – Rare, Candidate, Threatened and Endangered Species
PNDI Search No.
Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Delaware County

Dear Ms. Finizio:

This responds to your inquiry about a Pennsylvania Natural Diversity Inventory (PNDI) Internet Database search "potential conflict" or a threatened and endangered species impact review. These projects are screened for potential conflicts with rare, candidate, threatened or endangered species under Pennsylvania Fish & Boat Commission jurisdiction (fish, reptiles, amphibians, aquatic invertebrates only) using the Pennsylvania Natural Diversity Inventory (PNDI) database and our own files. These species of special concern are listed under the Endangered Species Act of 1973, the Wild Resource Conservation Act, and the Pennsylvania Fish & Boat Code (Chapter 75), or the Wildlife Code.

Based on records maintained in the Pennsylvania Natural Diversity Inventory (PNDI) database and our own files, the following rare or protected species are known from the vicinity of the project site:

Common Name (Scientific Name, PA Status)
Atlantic Sturgeon (*Acipenser oxyrinchus*, Endangered)
Shortnose Sturgeon (*Acipenser brevirostrum*, Endangered)
Eastern Redbelly Turtle (*Pseudemys rubriventris*, Threatened)

The Shortnose and Atlantic Sturgeon, which are listed by both Pennsylvania and the U.S. Fish and Wildlife Service/National Marine Fisheries Service, occur in the Delaware River. They are especially vulnerable to physical (dredging, rip-rap, etc.) and chemical (pH, dissolved oxygen, temperature, heavy metals, and organic contaminants) changes to the aquatic environment. Although the mobile adults of these protected fish species may be capable of moving from the project area, their spawning grounds (including eggs, larvae, and immature fish) are vulnerable to burial, crushing by equipment, and siltation

from construction projects. In-stream activities during their spawning period may also disrupt the adults' reproductive behavior. Both Atlantic Sturgeon and Shortnose Sturgeon adults and juveniles may also forage and migrate through the proposed project area and could be adversely impacted by the proposed project.

The Eastern Redbelly Turtle is one of Pennsylvania's largest native aquatic turtles. This turtle species is known to inhabit relatively large, deep streams, rivers, ponds, lakes, and marshes with permanent water and ample basking sites. Redbelly turtles are documented in the Delaware River, Darby Creek, Crum Creek, Ridley Creek, and Chester Creek within the project area. They can be found in deep, slow water habitats in the creeks, as well as impoundments and nearby ponds and lakes. The existence of this turtle species is threatened by habitat destruction, poor water quality and competition with aggressive non-native turtle species that share its range and habitat (e.g. red-eared slider).

Additionally, in response to your request, we recommend that you access county information on our website, at http://fishandboat.com/county.htm for locations of public boat launches on Darby Creek and the Delaware River.

This response represents the most up-to-date summary of the PNDI data and our files and is valid for two (2) years from the date of this letter. An absence of recorded species information does not necessarily imply species absence. Our data files and the PNDI system are continuously being updated with species occurrence information. Should project plans change or additional information on listed or proposed species become available, this determination may be reconsidered, and consultation shall be re-initiated.

If you have any questions regarding this review, please contact Kathy Gipe at 814-359-5186 and refer to the SIR # 45340. Thank you for your cooperation and attention to this important matter of species conservation and habitat protection.

Sincerely,

Christopher A. Urban, Chief
Natural Diversity Section

CAU/KDG/dn

Cc: John Buzzar, PFBC

GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

April 29, 2016

Ms. Kathy Gipe
PA Fish and Boat Commission
Division of Environmental Services
Natural Diversity Section
450 Robinson Lane
Bellefonte, PA 16823

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study
In Reply to SIR# 45340

Dear Ms. Gipe:

Greeley and Hansen is developing a Long Term Control Plan Update (LTCPU) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. As per our phone conversation on Wednesday, March 9, 2016, we are requesting additional information on the specific habitat location of the species listed in SIR #45340.

Two maps of the study area are provided as attachments to this letter including a map highlighting the specific focus area of Chester City and a second map showing the exact location of the combine sewer outfalls (CSOs). Per our telephone conversation, it is our understanding that a map of the specific habitat locations cannot be provided as this information is confidential. In order to properly determine if CSOs will impact these threatened and endangered species we need to better understand the species location within the focus project area. We request that you review the attached maps against your records and complete the table below.

CSO	Receiving Stream	Location	Distance Upstream to Nearest Species Habitat (miles)	Distance Downstream to Species Habitat (miles)	Above Tidal Boundary? (Yes or No)	Notes
2		Front & Booth				
3		Front & Highland				
4		Front & Hayes				
5		Front & Townsend				
7		Delaware & Reaney				
8		2nd & Tilghman				
9		2nd & Lloyd				
10		5th & Pusey				
11		2nd & Parker				
12		2nd & Edgmont				
13		2nd & Welsh				
14		3rd & Upland				
15		4th & Melrose				
16		8th & McDowell				
17		9th & Campbell				
18		Sun Drive & Hancock				
19		14th & Crozer				
20		Kerlin & Finland				
21		9th & Sproul				

CSO	Receiving Stream	Location	Distance Upstream to Nearest Species Habitat (miles)	Distance Downstream to Species Habitat (miles)	Above Tidal Boundary? (Yes or No)	Notes
22		6th & Sproul				
23		3rd & Edgmont				
24		3rd & Dock				
25		5th & Penn				

Additionally, information on the type of habitat (i.e. – spawning, nesting, siting) or other pertinent information would also be helpful. We appreciate your cooperation and assistance in completing this task. Should you need any additional information, please feel free to contact me at (215) 553-7919 or Julia Spicher at (215) 553-7926.

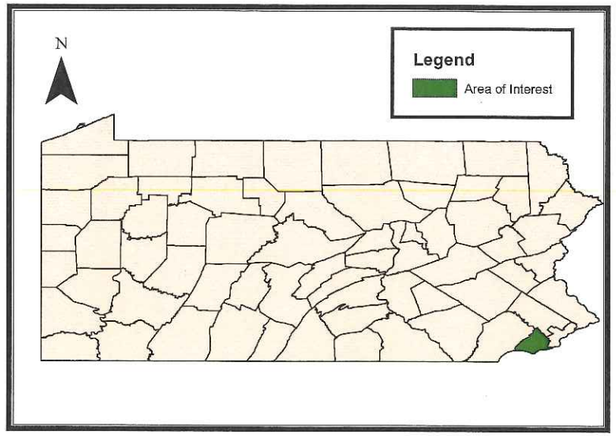
Yours very truly,

Greeley and Hansen LLC

Marlene Finizio
Project Manager

/js
Enclosures

c: Michael DeSantis, DELCORA, w/enclosures
Edwin Bothwell, DELCORA, w/enclosures
Michael Hope, Greeley and Hansen
Julia Spicher, Greeley and Hansen



N

Radnor Twp
Haverford Twp
Newtown Twp
Marple Twp
Millbourne Boro
Upper Darby Twp
Edgmont Twp
Upper Providence Twp
Upper Providence Twp
Upper Providence Twp
East Lansdowne Boro
Lansdowne Boro
Springfield Twp
Clifton Heights Boro
Yeadon Boro
Aldan Boro
Darby Boro
Collingdale Boro
Morton Boro
Darby Twp
Colwyn Boro
Sharon Hill Boro
Media Boro
Thornbury Twp
Middletown Twp
Nether Providence Twp
Swarthmore Boro
Rutledge Boro
Glenolden Boro
Darby Twp
Chester Heights Boro
Rose Valley Boro
Ridley Twp
Folcroft Boro
Prospect Park Boro
Norwood Boro
Ridley Park Boro
Concord Twp
Aston Twp
Brookhaven Boro
Parkside Boro
Tinicum Twp
Chadds Ford Twp
Upland Boro
Eddystone Boro
Chester Twp
Chester City
Bethel Twp
Upper Chichester Twp
Trainer Boro
Lower Chichester Twp
Marcus Hook Boro

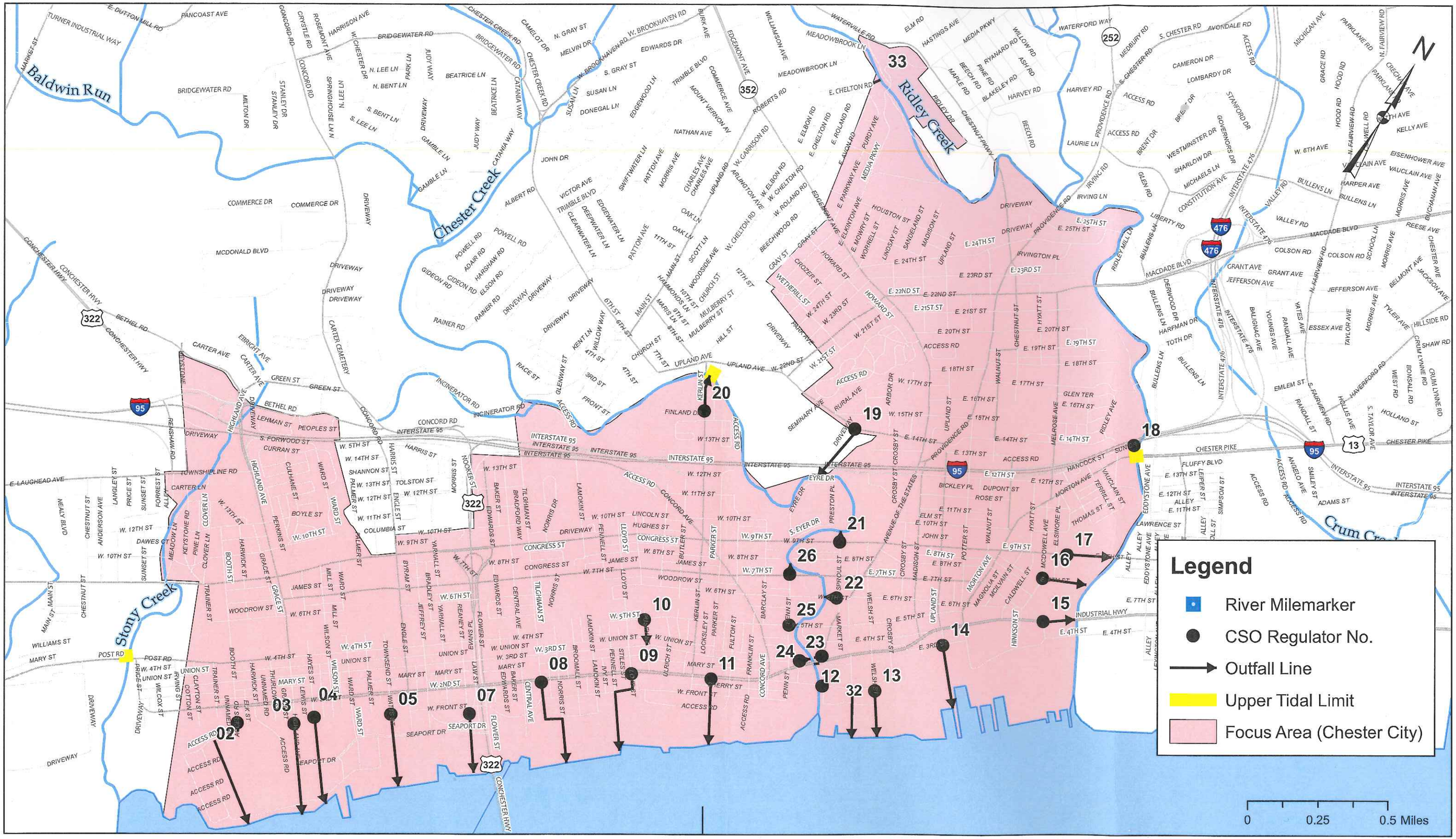
0 0.5 1 2 3 4 5 Miles

Legend
Focus Area (Chester City)
Study Area

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

IDENTIFCATION OF SENSITIVE AREAS
STUDY AREA MAP
March 2015

GREELEY AND HANSEN



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

IDENTIFCATION OF SENSITIVE AREAS
OUTFALL LOCATOIN MAP
March 2015

GREELEY AND HANSEN

GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Mr. Matthew Fisher
Delaware Department of Natural Resources
and Environmental Control
89 Kings Highway
Dover, DE 19901

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Mr. Fisher:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

Sensitive Areas are defined by the United States Environmental Protection Agency (USEPA) Federal Register Combined Sewer Overflow (CSO) Control Policy and the US EPA Guidance for Long Term Control Plan as follows:

- Outstanding National Resource Waters (ONRW)
- National Marine Sanctuaries
- Waters with threatened or endangered species and their habitat
- Waters with primary contact recreation (i.e. beaches, boat ramps, boat launches, etc.)
- Public drinking water intakes or their designated protection areas
- Shellfish beds

USEPA requirements indicate that sensitive areas are given the highest priority during the development of technical alternatives.

This letter is being submitted to your agency as a formal request for information that your agency may have on sensitive areas within Delaware County, PA. Specifically, we are interested in sensitive areas located within the area of study as shown in GREEN on the attached map. If portions of the study area meet the above sensitive area criteria, we request that you provide the following information:

- Complete list of identified Sensitive Areas;
- Narrative description of how the sensitive area criteria listed above applies to the study area;
- Map of specific locations within our study area identifying the specific sensitive areas; and
- Any additional information you deem appropriate.

DELCORA is under a Consent Decree to submit this study to USEPA in February 2016. In order to meet project milestones, we respectfully request you provide a response within 30 days of receipt of this letter, no later than November 23, 2015. We appreciate your cooperation and assistance in completing this study. Should you need any additional information, please feel free to contact me at (215) 553-7919 or Julia Spicher at (215) 553-7926.

Yours very truly,

Greeley and Hansen LLC

Marlene Finizio
Project Manager

c: Robert Willert, DELCORA
Michael DeSantis, DELCORA
Edwin Bothwell, DELCORA
Michael Hope, Greeley and Hansen
Julia Spicher, Greeley and Hansen

STATE OF DELAWARE
DEPARTMENT OF NATURAL RESOURCES
& ENVIRONMENTAL CONTROL
DIVISION OF FISH & WILDLIFE
89 Kings Highway
Dover, Delaware 19901

Phone: (302) 739-9910
Fax: (302) 739-6157

11/25/2015

Marlene Finizio
Greeley and Hansen LLC
1700 Market St. Suite 2130
Philadelphia, Pennsylvania 19103

Dear Marlene Finizio:

In response to your request to comment on the Long Term Control Plan for the Delaware County Regional Water Quality Control Authority the Delaware Department of Natural Resources and Environmental Control Division of Fish and Wildlife would like to notify you that the Delaware River adjacent to your study area is inhabited by both the Atlantic Sturgeon, and the Shortnose Sturgeon. Both species are considered endangered and are protected by the Endangered Species Act. In addition this area is utilized by several anadromous fish species including but not limited to Striped Bass and American Shad. In regards to your specific study site, or further information on species that can be found in the Delaware River you should contact the Pennsylvania Fish and Boat Commission.

Thank You,

Ian Park

GREELEY AND HANSEN

1700 Market Street, Suite 2130
Philadelphia, Pennsylvania 19103
p 215 563 3460
f 215 563 1139
www.greeley-hansen.com

October 29, 2015

Mr. David Chanda
Director Fish and Wildlife
New Jersey Department of
Environmental Protection
P.O. Box 420
501 E. State Street, 3rd Floor
Trenton, NJ 08625

Subject: Delaware County Regional Water Quality Authority
CSO Long Term Control Plan Update
Sensitive Areas Study

Dear Mr. Chanda:

Greeley and Hansen is developing a Long Term Control Plan (LTCP) for the Delaware County Regional Water Quality Control Authority (DELCORA) located in Chester, PA. A map of the study area is provided as an attachment to this letter. The goal of this LTCP is to reduce the frequency, duration and intensity of combined sewer overflow events into the local waterbodies, including portions of the Delaware River, Chester Creek and Ridley Creek. As part of this evaluation, environmentally sensitive areas within the study area need to be identified so that appropriate considerations can be made to reduce combined sewer overflows to these areas.

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USEPA requirements indicate that sensitive areas are given the highest priority during the development of technical alternatives.

This letter is being submitted to your agency as a formal request for information that your agency may have on sensitive areas within Delaware County, PA. Specifically, we are interested in sensitive areas located within the area of study as shown in GREEN on the attached map. If portions of the study area meet the above sensitive area criteria, we request that you provide the following information:

- Complete list of identified Sensitive Areas;
- Narrative description of how the sensitive area criteria listed above applies to the study area;
- Map of specific locations within our study area identifying the specific sensitive areas; and
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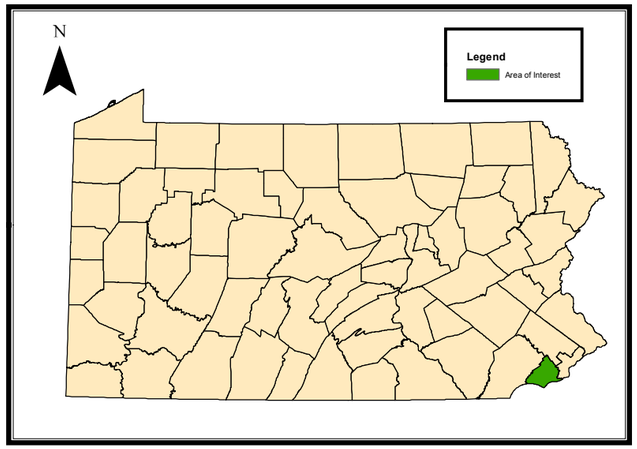
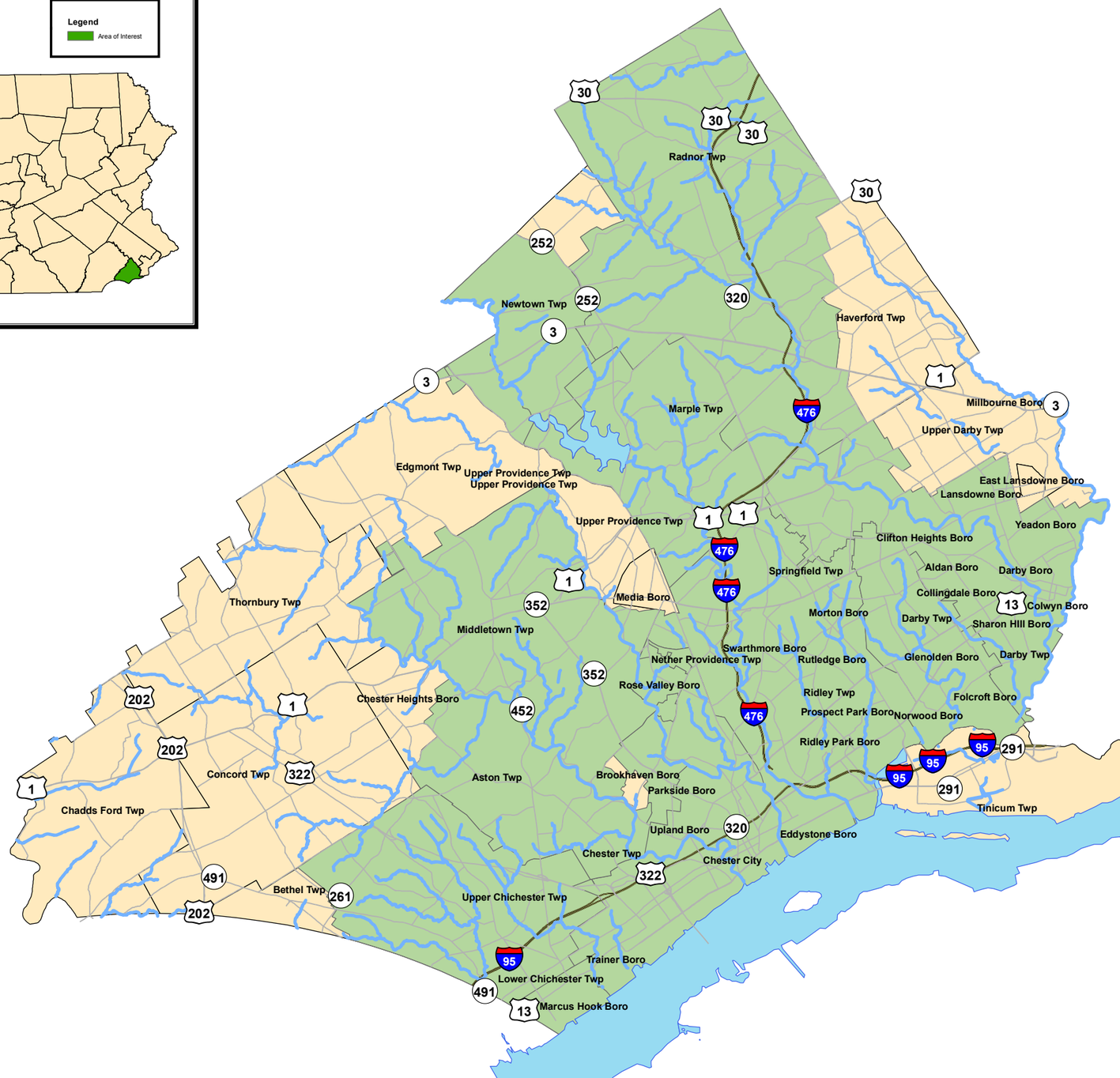
Yours very truly,

Greeley and Hansen LLC

Marlene Finizio
Project Manager

c: Robert Willert, DELCORA
Michael DeSantis, DELCORA
Edwin Bothwell, DELCORA
Michael Hope, Greeley and Hansen
Julia Spicher, Greeley and Hansen





N

Legend
Study Area

0 0.5 1 2 3 4 5 Miles

IDENTIFCATION OF SENSITIVE AREAS
STUDY AREA MAP
OCTOBER 2015

DELCORA

GREELEY AND HANSEN

ATTACHMENT B

Public Survey Tally Sheet

CSO Long Term Control Plan
Delaware County Regional Water Quality Control Authority
River and Creeks Use Survey

The Delaware River, Chester Creek and Ridley Creek provide enjoyment through many recreational activities (i.e. boating, fishing). The Delaware County Regional Water Quality Control Authority (DELCORA) is committed to enhancing the quality of the River and Creeks to support these uses. To assist in planning water quality improvements, please let us know how you use the Delaware River, Chester Creek and Ridley Creek by completing this survey. You can also go online to www.DELCORA.org and click on River and Creeks Use Survey to complete the survey. This survey only pertains to specific areas along the Delaware River, Chester Creek and Ridley Creek as identified by the green area of interest on the attached map (see reverse side). Please fill out only one (1) survey per household. Please return survey in the enclosed self-addressed envelope by December 18, 2015.

1. Do you or anyone in your household use the Delaware River, Chester Creek and/or Ridley Creek for any recreational activities (i.e. boating, swimming, fishing etc)?

   YES [72] NO [421] (If no, skip questions 2 and 3)

2. Please check the appropriate water activities and how frequently you or members of your household participate in these activities along the Delaware River, Chester Creek and Ridley Creek, focusing only in the area indicated in GREEN on the map.4Participation of water activities along the river or creeks outside the green area should not be included.

Activities															
	Delaware River					***Chester Creek***					***Ridley Creek***				
	Frequency					Frequency					Frequency				
	Daily	1x week	1x month	1x year	Never	Daily	1x week	1x month	1x year	Never	Daily	1x week	1x month	1x year	Never
Fishing Bank/Boat	4	10	12	10	457	6	5	9	12	461	1	8	11	14	459
Fishing from Wading	1	1	2	7	482	3	5	7	7	471	1	8	8	4	472
Rowing/Canoeing		1	3	4	485			3	3	487			3	2	488
Motor Boating	2	2	10	5	474			3	1	489			3	1	489
Kayaking			7	4	482			4	3	486			3	2	488
Jet Skiing	1	1	2	1	488			1	1	491			1	1	491
Water Skiing			1	2	490				2	491				2	491
Swimming			2	1	490			4	3	486			6	1	486
Wading	1	1	1	1	489		2	4	2	485	1		7	5	480
Other (Define) Tubing, Sailing			1	2	490			1		492			1		492

3. Please check the appropriate time of year you or a member of your household participates in any of the water activities.

Time of Year			
	Delaware River	***Chester Creek***	***Ridley Creek***
Year Round	11	8	8
April – October	37	35	34
November - March		1	2

4. Respondent Profile (please check all that apply)

Male	178
Female	289

Age less than 18	6
Age 18-39	37

Age 40-64	179
Age 65 and over	295

5. Comments:_____

ATTACHMENT C

Applicable Pages from the 2014 PA Integrated Water Quality and Assessment Report (303(d) List)

2014 PA INTEGRATED WATER QUALITY MONITORING AND ASSESSMENT REPORT

Category 5 Streams

(Pollutants Requiring a TMDL)

2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report - Streams, Category 5 Waterbodies, Pollutants Requiring a TMDL

Stream Name
HUC
Use Assessed (Assessment ID) - Miles

Source	Cause	Date Listed	TMDL Date
Chester Creek HUC: 02040202			
Recreational (12466) - 0.57 miles			
Source Unknown	Pathogens	2006	2019
Recreational (12469) - 0.11 miles			
Source Unknown	Pathogens	2006	2019
Recreational (12474) - 0.26 miles			
Source Unknown	Pathogens	2006	2019
Aquatic Life (17135) - 7.88 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027
Aquatic Life (17136) - 0.35 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027
Aquatic Life (17138) - 7.68 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027
Aquatic Life (17372) - 2.5 miles			
Urban Runoff/Storm Sewers	Siltation	2014	2027
Chester Creek Unnamed Of (ID:25605816) HUC: 02040202			
Aquatic Life (17136) - 0.29 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027
Chester Creek Unnamed Of (ID:25606068) HUC: 02040202			
Aquatic Life (17136) - 0.39 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027
Chester Creek Unnamed Of (ID:25606113) HUC: 02040202			
Aquatic Life (17136) - 0.58 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027
Chester Creek Unnamed Of (ID:25606116) HUC: 02040202			
Aquatic Life (17136) - 0.21 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027
Chester Creek Unnamed Of (ID:25606161) HUC: 02040202			
Aquatic Life (17136) - 0.59 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027

Stream sections in red box are far upstream of DELCORA's CSO discharges

2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report - Streams, Category 5 Waterbodies, Pollutants Requiring a TMDL

Stream Name HUC Use Assessed (Assessment ID) - Miles Source	Cause	Date Listed	TMDL Date
Poquessing Creek Unnamed To (ID:25600765) HUC: 02040202			
Aquatic Life (9687) - 0.6 miles			
Urban Runoff/Storm Sewers	Excessive Algal Growth	2002	2015
Preston Run HUC: 02040202			
Aquatic Life (17117) - 1.43 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027
Reeses Run HUC: 02040202			
Aquatic Life (17117) - 1.93 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2027
	Siltation	2014	2027
Ridley Creek HUC: 02040202			
Aquatic Life (16609) - 2.39 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2012	2025
	Siltation	2012	2025
Aquatic Life (16610) - 0.64 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2012	2025
	Siltation	2012	2025
Aquatic Life (16613) - 5.9 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2012	2025
	Siltation	2012	2025
Aquatic Life (16619) - 5.11 miles			
Source Unknown	Cause Unknown	2012	2025
Aquatic Life (16622) - 12.72 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2012	2025
	Siltation	2012	2025
Ridley Creek Unnamed Of (ID:25601429) HUC: 02040202			
Aquatic Life (16620) - 0.91 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2002	2015
	Siltation	2002	2015
Ridley Creek Unnamed Of (ID:25602007) HUC: 02040202			
Aquatic Life (16608) - 0.52 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2012	2025
	Siltation	2012	2025

Stream sections in red box are far upstream of DELCORA's CSO discharges

2014 PA INTEGRATED WATER QUALITY MONITORING AND ASSESSMENT REPORT

Category 4a Streams

(Approved TMDLs)

2014 Pennsylvania Integrated Water Quality Monitoring and Assessment Report - Streams, Category 4a Waterbodies, Approved TMDLs

Stream Name / *Use Designation (Assessment ID)* / *Source*	*Cause*	*Date Listed*	*TMDL Date*
Hydrologic Unit Code: 02040202-Lower Delaware			
Chester Creek			
HUC: 02040202			
Aquatic Life (9900) - 1.05 miles			
Municipal Point Source	Cause Unknown	2002	2008
Aquatic Life (17372) - 2.5 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2008
Fish Consumption (17455) - 0.81 miles			
Source Unknown	PCB	1996	2006
Chester Creek Unnamed Of (ID:25621262)			
HUC: 02040202			
Aquatic Life (9900) - 0.98 miles			
Municipal Point Source	Cause Unknown	2002	2008
Chester Creek Unnamed Of (ID:25621282)			
HUC: 02040202			
Aquatic Life (9900) - 0.68 miles			
Municipal Point Source	Cause Unknown	2002	2008
Chester Creek Unnamed Of (ID:25621286)			
HUC: 02040202			
Aquatic Life (9900) - 0.6 miles			
Municipal Point Source	Cause Unknown	2002	2008
Chester Creek Unnamed Of (ID:25621308)			
HUC: 02040202			
Aquatic Life (9900) - 0.59 miles			
Municipal Point Source	Cause Unknown	2002	2008
Chester Creek Unnamed To (ID:25621322)			
HUC: 02040202			
Aquatic Life (9900) - 4.89 miles			
Municipal Point Source	Cause Unknown	2002	2008
Chester Creek Unnamed To (ID:25621352)			
HUC: 02040202			
Aquatic Life (17372) - 0.65 miles			
Urban Runoff/Storm Sewers	Cause Unknown	2014	2008
Crum Creek			
HUC: 02040202			
Fish Consumption (17455) - 1.4 miles			
Source Unknown	PCB	1996	2006
Delaware River			
HUC: 02040202			
Fish Consumption (17455) - 61.02 miles			
Source Unknown	PCB	1996	2006
Delaware River Unnamed To (ID:133072413)			
HUC: 02040202			
Fish Consumption (17455) - 0.34 miles			
Source Unknown	PCB	1996	2006
Delaware River Unnamed To (ID:134395494)			
HUC: 02040202			
Fish Consumption (17455) - 2.4 miles			
Source Unknown	PCB	1996	2006

Stream sections in red box are far upstream of DELCORA's CSO discharges

ATTACHMENT D

Applicable Water Quality Standards (WQS) Master Table

DELCORA CSO LTCPU - Applicable Water Quality Standards

Rev: 12-18-2015

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Alkalinity	DRBC WQRs - for Zone 4 / PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**Minimum**	**20**	**20**	**20**	---	---	---	---	---	---	---	---	---	---	**20**	mg/L as $CaCO_3$	Can eliminate from POCs since it is naturally occurring	Alkalinity
Alkalinity	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**120**	**120**		---	---	---	---	---	---	---	---	---	---	---	mg/L as $CaCO_3$	Can eliminate from POCs since it is naturally occurring	Alkalinity
Alkalinity	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**120**	**120**		---	---	---	---	---	---	---	---	---	---	---	mg/L as $CaCO_3$	Can eliminate from POCs since it is naturally occurring	Alkalinity
Aluminum	DRBC WQRs - Table 5 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**750**	---	---	**750**	87	---	---	---	---	---	**750**	---	**750**	87	µg/L	Total recoverable, restricted to pH 6.5 - 9	Aluminum
Aluminum	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**87**	---	---	750	**87**	---	---	---	---	---	750	---	750	**87**	µg/L	Total recoverable, restricted to pH 6.5 - 9	Aluminum
Aluminum	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**87**	---	---	750	**87**	---	---	---	---	---	750	---	750	**87**	µg/L	Total recoverable, restricted to pH 6.5 - 9	Aluminum
Ammonia	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**Maximum**	**$(NH_3 - N) \times (\log^{-1}[pK_T - pH] + 1)$**	---	**$(NH_3 - N) \times (\log^{-1}[pK_T - pH] + 1)$**	---	---	---	---	---	---	---	---	---	---	---	mg/L	pH dependent	Ammonia
Anthracene	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River**	**Maximum**	**8,300**	---	---	---	---	---	---	**8,300**	40,000	---	---	**8,300**	---	---	µg/L		Anthracene
Anthracene	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**8,300**	---	---	---	---	---	---	**8,300**	40,000	---	---	**8,300**	---	---	µg/L		Anthracene
Antimony	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**1,100**	---	---	---	---	---	---	5.6	640	220	**1,100**	5.6	---	---	µg/L		Antimony
Antimony	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**200**	---	---	---	---	---	---	5.6	640	**220**	1,100	5.6	---	---	µg/L		Antimony
Antimony	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River**	**Maximum**	**5.6**	---	---	---	---	---	---	**5.6**	640	220	1,100	**5.6**	---	---	µg/L		Antimony
Antimony	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**5.6**	---	---	---	---	---	---	**5.6**	640	220	1,100	**5.6**	---	---	µg/L		Antimony
Arsenic (trivalent) (As III)	DRBC WQRs - Table 5 / PA Code - Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Acute Maximum**	**340**	---	---	**340**	150	---	---	---	---	150	**340**	10	**340**	150	µg/L	Dissolved criteria	Arsenic (trivalent) (As III)
Arsenic (trivalent) (As III)	DRBC WQRs - Table 5 / PA Code - Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Chronic Maximum**	**150**	---	---	340	**150**	---	---	---	---	**150**	340	10	340	**150**	µg/L	Dissolved criteria	Arsenic (trivalent) (As III)
Arsenic (trivalent) (As III)	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**10**	---	---	340	150	---	---	---	---	150	340	**10**	340	150	µg/L	Dissolved criteria	Arsenic (trivalent) (As III)
Bacteria - Enterococcus (Above R.M. 81.8)	DRBC WQRs - for Zone 4	**Delaware River Upstream of RM 81.8**	**Maximum Geometric Average**	**88**	**88**	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Enterococcus (Above R.M. 81.8)
Bacteria - Enterococcus (Below R.M. 81.8)	DRBC WQRs - for Zone 4	**Delaware River Downstream of RM 81.8**	**Maximum Geometric Average**	**33**	**33**	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Enterococcus (Below R.M. 81.8)
Bacteria - Enterococcus	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum Geometric Average**	**88**	**88**	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Enterococcus (Above R.M. 81.8)
Bacteria - Fecal Coliform (Above R.M. 81.8)	DRBC WQRs - for Zone 4	**Delaware River Upstream of RM 81.8**	**Maximum Geometric Average**	**770**	**770**	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Fecal Coliform (Above R.M. 81.8)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Bacteria - Fecal Coliform (Below R.M. 81.8)	DRBC WQRs - for Zone 4	**Delaware River Downstream of RM 81.8**	**Maximum Geometric Average**	**200**	**200**	---	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL	DRBC WQRs and PA Code PA Code for WC Critical Use agree from May 1 - Sept 30, but PA Code of 2000 CFU/100 mL from Oct. 1 - April 30 for WC exceeds that allowed by DRBC Zone 4.	Bacteria - Fecal Coliform (Below R.M. 81.8)
Bacteria - Fecal Coliform	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum Geometric Average**	**770**	**770**	---	---	---	---	---	---	---	---	---	---	---	---	---	CFU/100 mL		Bacteria - Fecal Coliform (Above R.M. 81.8)
Barium	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Acute Maximum**	**21,000**			---	---	---	---	---	---	4,100	**21,000**	2,400			µg/L		Barium
Barium	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Chronic Maximum**	**4,100**			---	---	---	---	---	---	**4,100**	21,000	2,400			µg/L		Barium
Barium	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**2,400**			---	---	---	---	---	---	4,100	21,000	**2,400**			µg/L		Barium
Benzene	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**640**	---	---	---	---	0.61	14	---	3,100	130	**640**	1.2			µg/L		Benzene
Benzene	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**130**	---	---	---	---	0.61	14	---	3,100	**130**	640	1.2			µg/L		Benzene
Benzene	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**14**	---	---	---	---	0.61	**14**	---	3,100	130	640	1.2			µg/L		Benzene
Benzene	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**14**	---	---	---	---	0.61	**14**	---	3,100	130	640	1.2			µg/L		Benzene
Benzene	DRBC WQRs - Table 6	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.61**	---	---	---	---	**0.61**	14	---	3,100	130	640	1.2			µg/L		Benzene
benzo (a) anthracene	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Acute Maximum**	**0.5**	---	---	---	---	---	---	---	---	0.1	**0.5**	0.0038			µg/L		benzo (a) anthracene
benzo (a) anthracene	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Chronic Maximum**	**0.1**	---	---	---	---	---	---	---	---	**0.1**	0.5	0.0038			µg/L		benzo (a) anthracene
benzo (a) anthracene	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.0038**	---	---	---	---	---	---	---	---	0.1	0.5	**0.0038**			µg/L		benzo (a) anthracene
Beryllium	DRBC WQRs - Table 7	**Delaware River**	**Maximum**	**420**							---	**420**	---	---				µg/L		Beryllium
Beryllium	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**420**							---	**420**	---	---				µg/L		Beryllium
Biological Oxygen Demand (BOD)	No Standard						---	---	---	---	---	---	---	---	---					Biological Oxygen Demand (BOD)
Bis (2-ethylhexyl) phthalate	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**4,500**	---	---	---	---	1.2	2.2	---	620	910	**4,500**	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bis (2-ethylhexyl) phthalate	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**910**	---	---	---	---	1.2	2.2	---	620	**910**	4,500	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bis (2-ethylhexyl) phthalate	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**2.2**	---	---	---	---	1.2	**2.2**	---	620	910	4,500	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bis (2-ethylhexyl) phthalate	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**2.2**	---	---	---	---	1.2	**2.2**	---	620	910	4,500	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bis (2-ethylhexyl) phthalate	DRBC WQRs - Table 6	**Delaware River Downstream of RM 81.8**	**Maximum**	**1.2**	---	---	---	---	**1.2**	2.2	---	620	910	4,500	1.2			µg/L		Bis (2-ethylhexyl) phthalate
Bromodichloromethane (aka Dichlorobromomethane)	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**17**					0.55	**17**	680	---	---	---	0.55			µg/L		Bromodichloromethane (aka Dichlorobromomethane)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Bromodichloromethane (aka Dichlorobromomethane)	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**17**					0.55	**17**	680	---	---	---	0.55			µg/L		Bromodichloromethane (aka Dichlorobromomethane)
Bromodichloromethane (aka Dichlorobromomethane)	PA Code 25 - 93.8c, Table 5 / DRBC WQRs - Table 6	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.55**					**0.55**	17	680	---	---	---	**0.55**			µg/L		Bromodichloromethane (aka Dichlorobromomethane)
Butylbenzyl phthalate	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**140**	---	---	---	---			1,500	1,900	35	**140**	150			µg/L		Butylbenzyl phthalate
Butylbenzyl phthalate	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**35**	---	---	---	---			1,500	1,900	**35**	140	150			µg/L		Butylbenzyl phthalate
Cadmium	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**0.651*EXP(1.0166*LN(hardness)-3.924)**	---	---	**0.651*EXP(1.0166*LN(hardness)-3.924)**	0.651*EXP(0.7409*LN(hardness)-4.719)	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**0.651*EXP(0.7409*LN(hardness)-4.719)**	---	---	0.651*EXP(1.0166*LN(hardness)-3.924)	**0.651*EXP(0.7409*LN(hardness)-4.719)**	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.651*EXP(1.0166*LN(hardness)-3.924)**	---	---	**0.651*EXP(1.0166*LN(hardness)-3.924)**	0.651*EXP(0.7409*LN(hardness)-4.719)	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.651*EXP(0.7409*LN(hardness)-4.719)**	---	---	0.651*EXP(1.0166*LN(hardness)-3.924)	**0.651*EXP(0.7409*LN(hardness)-4.719)**	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	PA Code - Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)**	---	---	0.651*EXP(1.0166*LN(hardness)-3.924)	0.651*EXP(0.7409*LN(hardness)-4.719)	---	---	3.4	16	(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)	**(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)**	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
Cadmium	PA Code - Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)**	---	---	0.651*EXP(1.0166*LN(hardness)-3.924)	0.651*EXP(0.7409*LN(hardness)-4.719)	---	---	3.4	16	**(1.101672-(LN(hardness)x0.041838)) x Exp(0.7409 x LN(hardness)-4.719)**	(1.136672-(LN(hardness)x0.041838)) x Exp(1.0166 x LN(hardness)-3.924)	---	2.0	0.25	µg/L	Dissolved criteria	Cadmium
CBOD5	No Standard						---	---	---	---	---	---	---	---	---					CBOD5
CBOD20	No Standard						---	---	---	---	---	---	---	---	---					CBOD20
Chlorine (Total Residual Chlorine)	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**4-day Average (Chronic Maximum)**	**11**		**11**	---	---	---	---	---	---				19	**11**	µg/L		Chlorine (Total Residual Chlorine)
Chlorine (Total Residual Chlorine)	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**1-hour Average (Acute Maximum)**	**19**		**19**	---	---	---	---	---	---				**19**	11	µg/L		Chlorine (Total Residual Chlorine)
Chlorodibromomethane	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**13**	---	---	---	---	0.4	**13**			---	---	0.4			µg/L		Chlorodibromomethane
Chlorodibromomethane	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**13**	---	---	---	---	0.4	**13**			---	---	0.4			µg/L		Chlorodibromomethane
Chlorodibromomethane	DRBC WQRs - Table 6 / PA Code Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.4**	---	---	---	---	**0.4**	13			---	---	**0.4**			µg/L		Chlorodibromomethane
Chloroform	DRBC WQRs - Tables 6 & 7 / PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**1,900**	---	---	---	---	5.7	470	68	2,100	390	**1,900**	5.7			µg/L		Chloroform
Chloroform	DRBC WQRs - Tables 6 & 7 / PA Code Table 5	**Chester Creek, Ridley Creek, Delaware River Upstream of RM 81.8**	**Chronic Maximum**	**390**	---	---	---	---	5.7	470	68	2,100	**390**	1,900	5.7			µg/L		Chloroform
Chloroform	DRBC Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**470**	---	---	---	---	5.7	**470**	68	2,100	390	1,900	**5.7**			µg/L		Chloroform
Chloroform	DRBC Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**470**	---	---	---	---	5.7	**470**	68	2,100	390	1,900	**5.7**			µg/L		Chloroform

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Chloroform	PA Code 25 - 93.8c, Table 5 / DRBC Table 6	**Delaware River Downstream of RM 81.8**	**Maximum**	**5.7**	---	---	---	---	**5.7**	470	68	2,100	390	1,900	**5.7**			µg/L		Chloroform
COD	No Standard						---	---	---	---	---	---								COD
Chromium (trivalent) (Cr III)	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**0.277*EXP(0.819*LN(hardness)+3.7256)**	---	---	**0.277*EXP(0.819*LN(hardness)+3.7256)**	0.277*EXP(0.819*LN(hardness)+0.6848)	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**0.277*EXP(0.819*LN(hardness)+0.6848)**	---	---	0.277*EXP(0.819*LN(hardness)+3.7256)	**0.277*EXP(0.819*LN(hardness)+0.6848)**	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.277*EXP(0.819*LN(hardness)+3.7256)**	---	---	**0.277*EXP(0.819*LN(hardness)+3.7256)**	0.277*EXP(0.819*LN(hardness)+0.6848)	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.277*EXP(0.819*LN(hardness)+0.6848)**	---	---	0.277*EXP(0.819*LN(hardness)+3.7256)	**0.277*EXP(0.819*LN(hardness)+0.6848)**	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**(0.819 x LN(hardness)+3.7256)**	---	---	0.277*EXP(0.819*LN(hardness)+3.7256)	0.277*EXP(0.819*LN(hardness)+0.6848)	---	---	---	380,000	(0.819 x LN(hardness)+0.6848)	**(0.819 x LN(hardness)+3.7256)**	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (trivalent) (Cr III)	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**(0.819 x LN(hardness)+0.6848)**	---	---	0.277*EXP(0.819*LN(hardness)+3.7256)	0.277*EXP(0.819*LN(hardness)+0.6848)	---	---	---	380,000	**(0.819 x LN(hardness)+0.6848)**	(0.819 x LN(hardness)+3.7256)	---	570	74	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Chromium (trivalent) (Cr III)
Chromium (hexavalent) (Cr VI)	DRBC WQRs - Tables 5 & 7 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**16**	---	---	**16**	11	---	---	92	---	10	**16**	---	16	11	µg/L	Dissolved criteria	Chromium (hexavalent) (Cr VI)
Chromium (hexavalent) (Cr VI)	PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**10**	---	---	16	11	---	---	92	---	**10**	16	---	16	11	µg/L	Dissolved criteria	Chromium (hexavalent) (Cr VI)
Chyrsene	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**18**	---	---	---	---	3.8	**18**	---	---	---	---	0.0038			µg/L		Chyrsene
Chyrsene	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**18**	---	---	---	---	3.8	**18**	---	---	---	---	0.0038			µg/L		Chyrsene
Chyrsene	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.0038**	---	---	---	---	3.8	18	---	---	---	---	**0.0038**			µg/L		Chyrsene
Copper	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**0.908*EXP(0.9422*LN(hardness)-1.7)**	---	---	**0.908*EXP(0.9422*LN(hardness)-1.7)**	0.908*EXP(0.8545*LN(hardness)-1.702)	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Copper	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**0.908*EXP(0.8545*LN(hardness)-1.702)**	---	---	0.908*EXP(0.9422*LN(hardness)-1.7)	**0.908*EXP(0.8545*LN(hardness)-1.702)**	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Copper	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.908*EXP(0.9422*LN(hardness)-1.7)**	---	---	**0.908*EXP(0.9422*LN(hardness)-1.7)**	0.908*EXP(0.8545*LN(hardness)-1.702)	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Copper	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.908*EXP(0.8545*LN(hardness)-1.702)**	---	---	0.908*EXP(0.9422*LN(hardness)-1.7)	**0.908*EXP(0.8545*LN(hardness)-1.702)**	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Copper	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**0.960 x Exp(0.9422*LN(hardness)-1.70)**	---	---	0.908*EXP(0.9422*LN(hardness)-1.7)	0.908*EXP(0.8545*LN(hardness)-1.702)	---	---	---	---	0.960 x Exp(0.8545*LN(hardness)-1.702)	**0.960 x Exp(0.9422*LN(hardness)-1.70)**	---	---	---	µg/L	Dissolved criteria	Copper
Copper	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.960 x Exp(0.8545*LN(hardness)-1.702)**	---	---	0.908*EXP(0.9422*LN(hardness)-1.7)	0.908*EXP(0.8545*LN(hardness)-1.702)	---	---	---	---	**0.960 x Exp(0.8545*LN(hardness)-1.702)**	0.960 x Exp(0.9422*LN(hardness)-1.70)	---	---	---	µg/L	Dissolved criteria	Copper
Cyanide (free)	DRBC WQRs - Table 5 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**22**	---	---	**22**	5.2	---	---	140	140	5.2	**22**	140	**22**	5.2	µg/L		Cyanide (free)
Cyanide (free)	DRBC WQRs - Table 5 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**5.2**	---	---	22	**5.2**	---	---	140	140	**5.2**	22	140	22	**5.2**	µg/L		Cyanide (free)
Dieldrin	PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**0.24**	---	---	0.24	0.056	0.000052	0.000054	0.041	0.043	0.056	**0.24**	0.000052	**0.24**	0.056	µg/L		Dieldrin
Dieldrin	PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.056**	---	---	0.24	0.056	0.000052	0.000054	0.041	0.043	**0.056**	0.24	0.000052	0.24	**0.056**	µg/L		Dieldrin

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Dieldrin	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**0.000054**	---	---	0.24	0.056	0.000052	**0.000054**	0.041	0.043	0.056	0.24	0.000052	0.24	0.056	µg/L		Dieldrin
Dieldrin	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.000054**	---	---	0.24	0.056	0.000052	**0.000054**	0.041	0.043	0.056	0.24	0.000052	0.24	0.056	µg/L		Dieldrin
Dieldrin	DRBC WQRs - Table 6 / PA Code - Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.000052**	---	---	0.24	0.056	**0.000052**	0.000054	0.041	0.043	0.056	0.24	**0.000052**	0.24	0.056	µg/L		Dieldrin
Diethylphthalate	PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**4,000**	---	---	---	---			17,000	44,000	800	**4,000**	17,000			µg/L		Diethylphthalate
Diethylphthalate	PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**800**	---	---	---	---			17,000	44,000	**800**	4,000	17,000			µg/L		Diethylphthalate
Dissolved Oxygen (DO)$_1$	DRBC WQRs - for Zone 4	**Delaware River**	**24 hr. Average Minimum**	**3.5**	**3.5**		---	---	---	---	---	---						mg/L	**Year Round Minimum**	Dissolved Oxygen (DO)$_1$
Dissolved Oxygen (DO)$_1$	DRBC WQRs - for Zone 4	**Delaware River**	**24 hr. Average Minimum**	**6.5**	**6.5**		---	---	---	---	---	---						mg/L	**Minimum for April 1 to June 15 and Sept. 16 to Dec. 31**	Dissolved Oxygen (DO)$_1$
Dissolved Oxygen (DO)$_1$	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**24 hr. Average Minimum**	**3.5**	**3.5**		---	---	---	---	---	---						mg/L	**Year Round Minimum**	Dissolved Oxygen (DO)$_1$
Dissolved Oxygen (DO)$_1$	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**24 hr. Average Minimum**	**6.5**	**6.5**		---	---	---	---	---	---						mg/L	**Minimum for April 1 to June 15 and Sept. 16 to Dec. 31**	Dissolved Oxygen (DO)$_1$
Dissolved Oxygen (DO)$_2$	PA Code (WWF)	**Chester Creek upstream of OF#20, & Ridley Creek from OF#18 upstream to Rt. 320**	**7-day Average**	**5.5**		**5.5**	---	---	---	---	---	---						mg/L		Dissolved Oxygen (DO)$_2$
Dissolved Oxygen (DO)$_2$	PA Code (WWF)	**Chester Creek upstream of OF#20, & Ridley Creek from OF#18 upstream to Rt. 320**	**Minimum**	**5.0**		**5.0**	---	---	---	---	---	---						mg/L		Dissolved Oxygen (DO)$_2$
Dissolved Oxygen (DO)$_3$ (Feb. 15 - July 31)	PA Code (TSF)	**Ridley Creek from Rt. 320 upstream to Media Water Intake**	**7-day Average**	**6.0**		**6.0**	---	---	---	---	---	---						mg/L	TSF only applies to Ridley Creek for impacts by DELCORA CSOs	Dissolved Oxygen (DO)$_3$
Dissolved Oxygen (DO)$_3$ (Feb. 15 - July 31)	PA Code (TSF)	**Ridley Creek from Rt. 320 upstream to Media Water Intake**	**Minimum**	**5.0**		**5.0**	---	---	---	---	---	---						mg/L	TSF only applies to Ridley Creek for impacts by DELCORA CSOs	Dissolved Oxygen (DO)$_3$
Dissolved Oxygen (DO)$_3$ (Aug. 1 - Feb. 14)	PA Code (TSF)	**Ridley Creek from Rt. 320 upstream to Media Water Intake**	**7-day Average**	**5.5**		**5.5**												mg/L	TSF only applies to Ridley Creek for impacts by DELCORA CSOs	Dissolved Oxygen (DO)$_3$
Dissolved Oxygen (DO)$_3$ (Aug. 1 - Feb. 14)	PA Code (TSF)	**Ridley Creek from Rt. 320 upstream to Media Water Intake**	**Minimum**	**5.0**		**5.0**												mg/L	TSF only applies to Ridley Creek for impacts by DELCORA CSOs	Dissolved Oxygen (DO)$_3$
Ethylbenzene	PA Code - Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**2,900**	---	---	---	---			530	2,100	580	**2,900**	530			µg/L		Ethylbenzene
Ethylbenzene	PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**580**	---	---	---	---			530	2,100	**580**	2,900	530			µg/L		Ethylbenzene
Ethylbenzene	DRBC WQRs - Table 7	**Delaware River Upstream of RM 81.8**	**Maximum**	**2,100**	---	---	---	---			530	**2,100**	580	2,900	530			µg/L		Ethylbenzene
Ethylbenzene	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**2,100**	---	---	---	---			530	**2,100**	580	2,900	530			µg/L		Ethylbenzene

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Ethylbenzene	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**530**	---	---	---	---			**530**	2,100	580	2,900	**530**			µg/L		Ethylbenzene
Fluorene	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River Upstream of RM 81.8**	**Maximum**	**5,300**	---	---	---	---			1,100	**5,300**	---	---	1,100			µg/L		Fluorene
Fluorene	DRBC WQRs - Table 7 / PA Code - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**5,300**	---	---	---	---			1,100	**5,300**	---	---	1,100			µg/L		Fluorene
Fluorene	DRBC WQRs - Table 7 / PA Code - Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**1,100**	---	---	---	---			**1,100**	5,300	---	---	**1,100**			µg/L		Fluorene
Hardness	No Standard	**Delaware River, Chester Creek, Ridley Creek**	--		--	--	---	---	---	---	---	---						$mg/L\ as\ CaCO_3$	Needed to calculate some of the metal concentrations	Hardness
Iron (Fe)	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**30-day Average**	**1.5**		**1.5**	---	---	---	---	---	---						mg/L as total recoverable	Iron as total recoverable	$Iron\ (Fe)_{(1)}$
Iron (Fe)	PA Code (WWF, MF, TSF)	**Delaware River, Chester Creek, Ridley Creek**	**Maximum**	**0.3**		**0.3**	---	---	---	---	---	---				---	1.0	mg/L as dissolved	Iron as dissolved	$Iron\ (Fe)_{(2)}$
Lead	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**38**	---	---	**38**	5.4	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	DRBC WQRs - Table 5	**Delaware River**	**Chronic Maximum**	**5.4**	---	---	38	**5.4**	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**38**	---	---	**38**	5.4	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**5.4**	---	---	38	**5.4**	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)**	---	---	38	5.4	---	---	---	---	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)	**(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)**	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Lead	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)**	---	---	38	5.4	---	---	---	---	**(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -4.705)**	(1.46203 - (LN(hardness) x 0.145712)) x Exp(1.273 x LN(hardness) -1.460)	---	65	2.5	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Lead
Mercury (Hg)	PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**1.4**	---	---	1.4	0.77	---	---	0.05	0.051	0.77 (Hg2+)	**1.4 (Hg2+)**	0.05	**1.4**	0.77	µg/L	Dissolved criteria	Mercury (Hg)
Mercury (Hg)	PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.77**	---	---	1.4	0.77	---	---	0.05	0.051	**0.77 (Hg2+)**	1.4 (Hg2+)	0.05	1.4	**0.77**	µg/L	Dissolved criteria	Mercury (Hg)
Mercury (Hg)	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.051**	---	---	1.4	0.77	---	---	0.05	**0.051**	0.77 (Hg2+)	1.4 (Hg2+)	0.05	1.4	**0.77**	µg/L	Dissolved criteria	Mercury (Hg)
Mercury (Hg)	DRBC WQRs - Table 7	**Delaware River Upstream of RM 81.8**	**Maximum**	**0.051**	---	---	1.4	0.77	---	---	0.05	**0.051**	0.77 (Hg2+)	1.4 (Hg2+)	0.05	1.4	**0.77**	µg/L	Dissolved criteria	Mercury (Hg)
Mercury (Hg)	DRBC WQRs - Table 7 / PA Code Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.05**	---	---	1.4	0.77	---	---	**0.05**	0.051	0.77 (Hg2+)	1.4 (Hg2+)	**0.05**	1.4	0.77	µg/L	Dissolved criteria	Mercury (Hg)
Methylene chloride (Dichloromethane)	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**12,000**	---	---	---	---	---	590	---	260,000	2,400	**12,000**	4.6			µg/L		Methylene chloride (Dichloromethane)
Methylene chloride (Dichloromethane)	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**2,400**	---	---	---	---	---	590	---	260,000	**2,400**	12,000	4.6			µg/L		Methylene chloride (Dichloromethane)
Methylene chloride (Dichloromethane)	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**590**	---	---	---	---	---	**590**	---	260,000	2,400	12,000	4.6			µg/L		Methylene chloride (Dichloromethane)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Methylene chloride (Dichloromethane)	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**590**	---	---	---	---	---	**590**	---	260,000	2,400	12,000	4.6			µg/L		Methylene chloride (Dichloromethane)
Methylene chloride (Dichloromethane)	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**4.6**	---	---	---	---	---	590	---	260,000	2,400	12,000	**4.6**			µg/L		Methylene chloride (Dichloromethane)
Molybdenum	No Standard						---	---	---	---	---	---								Molybdenum
MTBE	No Standard						---	---	---	---	---	---								MTBE
Naphthalene	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**140**			---	---	---	---	---	---	43	**140**	---			µg/L		Naphthalene
Naphthalene	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**43**			---	---	---	---	---	---	**43**	140	---			µg/L		Naphthalene
Nickel	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**0.998 x Exp(0.846 x LN(hardness)+2.255)**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	**0.998 x Exp(0.846 x LN(hardness)+2.255)**	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.997 x Exp(0.846 x LN(hardness)+0.0584)**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	500	1,700	**0.997 x Exp(0.846 x LN(hardness)+0.0584)**	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.846*EXP(0.846*LN(hardness)+2.255)**	---	---	**0.846*EXP(0.846*LN(hardness)+2.255)**	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.846*EXP(0.846*LN(hardness)+0.0584)**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	**0.846*EXP(0.846*LN(hardness)+0.0584)**	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 5	**Delaware River Upstream of RM 81.8**	**Acute Maximum**	**0.846*EXP(0.846*LN(hardness)+2.255)**	---	---	**0.846*EXP(0.846*LN(hardness)+2.255)**	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 5	**Delaware River Upstream of RM 81.8**	**Chronic Maximum**	**0.846*EXP(0.846*LN(hardness)+0.0584)**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	**0.846*EXP(0.846*LN(hardness)+0.0584)**	---	---	500	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nickel	DRBC WQRs - Table 7	**Delaware River Downstream of RM 81.8**	**Maximum**	**500**	---	---	0.846*EXP(0.846*LN(hardness)+2.255)	0.846*EXP(0.846*LN(hardness)+0.0584)	---	---	**500**	1,700	0.997 x Exp(0.846 x LN(hardness)+0.0584)	0.998 x Exp(0.846 x LN(hardness)+2.255)	610	470	52	µg/L	Dissolved criteria. Values for federal regulations are based on a hardness of 100 mg/L.	Nickel
Nitrate	No Standard						---	---	---	---	---	---								Nitrate
Nitrite	No Standard						---	---	---	---	---	---								Nitrite
Nitrate + Nitrate	No Standard																			Nitrate + Nitrate
N-Nitroso-di-n-propylamine	DRBC WQRs - Table 6	**Delaware River Upstream of RM 81.8**	**Maximum**	**0.51**	---	---	---	---	0.005	**0.51**					0.005			µg/L		N-Nitroso-di-n-propylamine
N-Nitroso-di-n-propylamine	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.51**	---	---	---	---	0.005	**0.51**					0.005			µg/L		N-Nitroso-di-n-propylamine
N-Nitroso-di-n-propylamine	DRBC WQRs - Table 6 / PA Code Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**0.005**	---	---	---	---	**0.005**	0.51					**0.005**			µg/L		N-Nitroso-di-n-propylamine
Oil and Grease	No Standard						---	---	---	---	---	---								Oil and Grease
Osmotic Pressure (OP)	**PA Code (WWF, MF, TSF)**	**Delaware River, Chester Creek, Ridley Creek**	**Maximum**	**50**		**50**	---	---	---	---	---	---						milliosmoles/kg		Osmotic Pressure (OP)
PCBs (Total)	DRBC WQRs - Table 5 / PA Code Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.014**	---	---	1.0	**0.014**	0.000016	0.000016	0.008390	0.008490	**0.014**	---	0.000064	---	**0.014**	µg/L		PCBs (Total)
PCBs (Total)	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.000016**	---	---	1.0	0.014	**0.000016**	**0.000016**	0.008390	0.008490	0.014	---	0.000064	---	0.014	µg/L		PCBs (Total)
PCBs (Total)	DRBC WQRs - Table 6	**Delaware River**	**Maximum**	**0.000016**	---	---	1.0	0.014	**0.000016**	**0.000016**	0.008390	0.008490	0.014	---	0.000064	---	0.014	µg/L		PCBs (Total)
pH$_{(1)}$	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**8.5**	**8.5**		---	---	---	---	---	---				---	6.5 - 9	--	Exceeds criteria from PA Code for WWF, MF, & TSF of pH 6 - 9	pH$_{(1)}$
pH$_{(1)}$	DRBC WQRs - for Zone 4	**Delaware River**	**Minimum**	**6.5**	**6.5**		---	---	---	---	---	---						--	Exceeds criteria from PA Code for WWF, MF, & TSF of pH 6 - 9	pH$_{(1)}$

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
pH(1)	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**8.5**	**8.5**		---	---	---	---	---	---				---	6.5 - 9	--	Exceeds criteria from PA Code for WWF, MF, & TSF of pH 6 - 9	pH(1)
pH(1)	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Minimum**	**6.5**	**6.5**		---	---	---	---	---	---						--	Exceeds criteria from PA Code for WWF, MF, & TSF of pH 6 - 9	pH(1)
pH(2)	PA Code (WWF, MF, TSF)	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Maximum**	**9.0**		**9.0**	---	---	---	---	---	---						--	Use the more stringent standard above from DRBC Zone 4 for the Delaware River	pH(2)
pH(2)	PA Code (WWF, MF, TSF)	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Minimum**	**6.0**		**6.0**	---	---	---	---	---	---						--	Use the more stringent standard above from DRBC Zone 4 for the Delaware River	pH(2)
Phenanthrene	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**5**			---	---	---	---	---	---	1	**5**	---			µg/L		Phenanthrene
Phenanthrene	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**1**			---	---	---	---	---	---	**1**	5	---			µg/L		Phenanthrene
Phenols	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**0.02**	**0.02**		---	---	---	---	---	---	---	---	10.4			mg/L		Phenols
Phenols	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.02**	**0.02**		---	---	---	---	---	---	---	---	10.4			mg/L		Phenols
Phosphate	No Standard						---	---	---	---	---	---								Phosphate
Pyrene	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**4,000**	---	---	---	---			830	**4,000**	---	---	830			µg/L		Pyrene
Pyrene	DRBC WQRs - Table 7	**Delaware River Upstream of RM 81.8**	**Maximum**	**4,000**	---	---	---	---			830	**4,000**	---	---	830			µg/L		Pyrene
Pyrene	DRBC WQRs - Table 7 / PA Code Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**830**	---	---	---	---			**830**	4,000	---	---	**830**			µg/L		Pyrene
Radioactivity - alpha emitters	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**3**	**3**		---	---	---	---	---	---						pc/L		Radioactivity - alpha emitters
Radioactivity - beta emitters	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**1,000**	**1,000**		---	---	---	---	---	---						pc/L		Radioactivity - beta emitters
Radioactivity - alpha emitters	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**3**	**3**		---	---	---	---	---	---						pc/L		Radioactivity - alpha emitters
Radioactivity - beta emitters	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**1,000**	**1,000**		---	---	---	---	---	---						pc/L		Radioactivity - beta emitters
Selenium (Se)	DRBC WQRs - Table 5	**Delaware River**	**Acute Maximum**	**20**	---	---	**20**	5.0	---	---	170	4,200	4.6	---	---	---	5.0	µg/L	Total recoverable criteria	Selenium (Se)
Selenium (Se)	DRBC WQRs - Table 5	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**20**	---	---	**20**	5.0	---	---	170	4,200	4.6	---	---	---	5.0	µg/L	Total recoverable criteria	Selenium (Se)
Selenium (Se)	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**4.6**	---	---	20	5.0	---	---	170	4,200	**4.6**	---	---	---	5.0	µg/L	Total recoverable criteria	Selenium (Se)
Silver (Ag)	DRBC WQRs - Tables 5 & 7 / PA Code - Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**0.85*EXP(1.72*LN(hardness)-6.59)**	---	---	**0.85*EXP(1.72*LN(hardness)-6.59)**	NA	---	---	170	40,000	---	**0.850 x Exp(1.72 x LN(hardness) - 6.590)**	---	3.2	---	µg/L	Dissolved criteria	Silver (Ag)
Sulfide	No Standard						---	---	---	---	---	---								Sulfide
Synthetic Detergents (B)	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum 30-day Average**	**1.0**	**1.0**		---	---	---	---	---	---						mg/L		Synthetic Detergents (B)
Synthetic Detergents (B)	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum 30-day Average**	**1.0**	**1.0**		---	---	---	---	---	---						mg/L		Synthetic Detergents (B)
Temperature (A) (1)	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**30**	**30**		---	---	---	---	---	---						°C		Temperature (A)
Temperature (A) (1)	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**2.8 Deg above 24-hr gradient during the 1961-66 period**	**2.8 Deg above 24-hr gradient during the 1961-66 period**		---	---	---	---	---	---						°C		Temperature (A)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Temperature [A] [1]	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**30**	**30**		---	---	---	---	---	---						°C		Temperature [A]
Temperature [A] [1]	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**2.8 Deg above 24-hr gradient during the 1961-66 period**	**2.8 Deg above 24-hr gradient during the 1961-66 period**		---	---	---	---	---	---						°C		Temperature [A]
Temperature [2]	PA Code (WWF, TSF)	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Maximum**	**Varies - see table on pg. 93-21 & 93-22**		**Varies - see table on pg. 93-21 & 93-22**	---	---	---	---	---	---						°F	Use the more stringent standard above from DRBC Zone 4 for the Delaware River	Temperature
Tetrachloroethene/ Tetrachloroethylene	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**700**			---	---	0.69	3.3	---	1,300	140	**700**				µg/L		Tetrachloroethene/ Tetrachloroethylene
Tetrachloroethene/ Tetrachloroethylene	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**140**			---	---	0.69	3.3	---	1,300	**140**	700				µg/L		Tetrachloroethene/ Tetrachloroethylene
Tetrachloroethene/ Tetrachloroethylene	DRBC WQRs - Table 6	**Delaware River Upstream of R.M. 81.8**	**Maximum**	**3.3**			---	---	0.69	**3.3**	---	1,300	140	700				µg/L		Tetrachloroethene/ Tetrachloroethylene
Tetrachloroethene/ Tetrachloroethylene	DRBC WQRs - Table 6	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**3.3**			---	---	0.69	**3.3**	---	1,300	140	700				µg/L		Tetrachloroethene/ Tetrachloroethylene
Tetrachloroethene/ Tetrachloroethylene	DRBC WQRs - Table 6	**Delaware River Downstream of R.M. 81.8**	**Maximum**	**0.69**			---	---	**0.69**	3.3	---	1,300	140	700				µg/L		Tetrachloroethene/ Tetrachloroethylene
Thallium	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**65**							0.24	0.47	13	**65**				µg/L		Thallium
Thallium	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**13**							0.24	0.47	**13**	65				µg/L		Thallium
Thallium	DRBC WQRs - Table 7	**Delaware River Upstream of R.M. 81.8**	**Maximum**	**0.47**							0.24	**0.47**	13	65				µg/L		Thallium
Thallium	DRBC WQRs - Table 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**0.47**							0.24	**0.47**	13	65				µg/L		Thallium
Thallium	DRBC WQRs - Table 7	**Delaware River Downstream of R.M. 81.8**	**Maximum**	**0.24**							**0.24**	0.47	13	65				µg/L		Thallium
Threshold Odor Number	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**24 at 60 °C**	**24 at 60 °C**		---	---	---	---	---	---						--		Threshold Odor Number
Threshold Odor Number	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**24 at 60 °C**	**24 at 60 °C**		---	---	---	---	---	---						--		Threshold Odor Number
Toluene	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Acute Maximum**	**1,700**	---	---	---	---			1,300	15,000	330	**1,700**	1,300			µg/L		Toluene
Toluene	PA Code 25 - 93.8c, Table 5	**Chester Creek, Ridley Creek, Delaware Upstream of RM 81.8**	**Chronic Maximum**	**330**	---	---	---	---			1,300	15,000	**330**	1,700	1,300			µg/L		Toluene
Toluene	PA Code 25 - 93.8c, Table 5	**Delaware River Downstream of RM 81.8**	**Maximum**	**1,300**	---	---	---	---			**1,300**	15,000	330	1,700	**1,300**			µg/L		Toluene
Total Dissolved Solids (TDS)	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**133% of background**	**133% of background**		---	---	---	---	---	---						mg/L		Total Dissolved Solids (TDS)
Total Dissolved Solids (TDS)	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**133% of background**	**133% of background**		---	---	---	---	---	---						mg/L		Total Dissolved Solids (TDS)
TKN	No Standard						---	---	---	---	---	---								TKN
Total Organic Carbon (TOC)	No Standard						---	---	---	---	---	---								Total Organic Carbon (TOC)
Total Organic Halides (T.O.X.)	No Standard						---	---	---	---	---	---								Total Organic Halides (T.O.X.)
Total Nitrogen	No Standard						---	---	---	---	---	---								Total Nitrogen
Total Petroleum Hydrocarbon (TPH)	No Standard																			Total Petroleum Hydrocarbon (TPH)

Parameter	Source of Standard	Applicable Water Body	WQS Type	Water Quality Standard To Use	Standard Criterion (DRBC Zone 4 WQRs) *Applies to Delaware & Tidal Portions of Chester & Ridley*	Standard Criterion (25 PA Code Ch. 93 WQS, 93.7 Table 3 for TSF, WWF, MF & WC Critical Use Designations) *Applies to Delaware, Chester, Ridley*	Freshwater Objectives (DRBC WQRs Table 5 - Stream Quality Objectives for Toxic Pollutants for the Protection of Aquatic Life) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 6 - Stream Quality Objectives for Carcinogens) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Freshwater Objectives (DRBC WQRs Table 7 - Stream Quality Objectives for Systemic Toxicants) *Applies to Delaware & Tidal Portions of Chester & Ridley*		Fish & Aquatic Life Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*		Human Criteria (25 PA Code Ch. 93 WQS, 93.8c, Table 5) *Applies to Delaware, Chester, Ridley*	US EPA National *Recommended* Water Quality Criteria Aquatic Life Criteria Table *Applies to Delaware, Chester, Ridley*		Units	Notes	Parameter
							Acute	Chronic	Fish & Water Ingestion	Fish Ingestion Only	Fish & Water Ingestion	Fish Ingestion Only	Criteria Continuous Concentrations	Criteria Maximum Concentrations	Health Criteria	Acute Criteria Maximum Concentration (CMC)	Chronic Criteria Continuous Concentration (CCC)			
Total Phosphorus	No Standard						---	---	---	---	---	---								Total Phosphorus
Total Suspended Solids (TSS)	No Standard						---	---	---	---	---	---								Total Suspended Solids (TSS)
Turbidity [C]	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum 30-day Average**	**40**	**40**		---	---	---	---	---	---						NTU		Turbidity [C]
Turbidity [C]	DRBC WQRs - for Zone 4	**Delaware River**	**Maximum**	**150**	**150**		---	---	---	---	---	---						NTU		Turbidity [C]
Turbidity [C]	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum 30-day Average**	**40**	**40**		---	---	---	---	---	---						NTU		Turbidity [C]
Turbidity [C]	DRBC WQRs - for Zone 4	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Maximum**	**150**	**150**		---	---	---	---	---	---						NTU		Turbidity [C]
Xylenes (total)	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Acute Maximum**	**1,100**			---	---	---	---	---	---	210	**1,100**	70,000			µg/L		Xylenes (total)
Xylenes (total)	PA Code 25 - 93.8c, Table 5	**Delaware River, Chester Creek, Ridley Creek**	**Chronic Maximum**	**210**			---	---	---	---	---	---	**210**	1,100	70,000			µg/L		Xylenes (total)
Zinc	DRBC WQRs - Tables 5 & 7	**Delaware River**	**Acute Maximum**	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	**0.95*EXP(0.8473*LN(hardness)+0.884)**	0.95*EXP(0.8473*LN(hardness)+0.884)	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	DRBC WQRs - Tables 5 & 7	**Delaware River**	**Chronic Maximum**	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	0.95*EXP(0.8473*LN(hardness)+0.884)	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	DRBC WQRs - Tables 5 & 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Acute Maximum**	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	**0.95*EXP(0.8473*LN(hardness)+0.884)**	0.95*EXP(0.8473*LN(hardness)+0.884)	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	DRBC WQRs - Tables 5 & 7	**Chester Creek - Mouth to OF#20 (Tidal limit), & Ridley Creek - Mouth to OF#18 (Tidal limit)**	**Chronic Maximum**	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	0.95*EXP(0.8473*LN(hardness)+0.884)	**0.95*EXP(0.8473*LN(hardness)+0.884)**	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Acute Maximum**	**0.978 x Exp(0.8473 x LN(hardness) + 0.884)**	---	---	0.95*EXP(0.8473*LN(hardness)+0.884)	0.95*EXP(0.8473*LN(hardness)+0.884)	---	---	7,400	26,000	0.986 x Exp(0.8473 x LN(hardness) + 0.884)	**0.978 x Exp(0.8473 x LN(hardness) + 0.884)**	---	120	120	µg/L	Dissolved criteria	Zinc
Zinc	PA Code 25 - 93.8c, Table 5	**Chester Creek upstream of OF#20, & Ridley Creek upstream from OF#18**	**Chronic Maximum**	**0.986 x Exp(0.8473 x LN(hardness) + 0.884)**	---	---	0.95*EXP(0.8473*LN(hardness)+0.884)	0.95*EXP(0.8473*LN(hardness)+0.884)	---	---	7,400	26,000	**0.986 x Exp(0.8473 x LN(hardness) + 0.884)**	0.978 x Exp(0.8473 x LN(hardness) + 0.884)	---	120	120	µg/L	Dissolved criteria	Zinc

(A) Temperature shall not exceed 5 °F (2.8 °C) above the average 24-hour temperature gradient displayed during the 1961-66 period, or a maximum of 86 °F (30.0 °C) - whichever is less.

(B) Using M.B.A.S assay, with a maximum 30-day average of 1.0 mg/L.

(C) Unless exceeded due to natural conditions.

NOTES:

DRBC standards in their WQRs are referred to as "Stream Quality Objectives". DRBC's Stream Quality Objectives have primacy over the PA Code standards for the Delaware River.

PA CODE refers to the standards as "Water Quality Standards".

Ridley Creek is "TSF & MF" Critical Use from Rt. 320 Bridge upstream to the Media Water Intake. Ridley Creek is "WWF & MF" downstream from the Rt. 320 Bridge to mouth.

Chester Creek has a "TSF" Critical Use designation as well, but this is well upstream of the CSO discharge furthest upstream on Chester Creek and does not apply for this analysis.

ATTACHMENT E

CSO Outfalls Historical Sampling Data

CSO Sampling
25 – Sept – 14

Sample Point	Parameters				
	BOD (mg/L)	Ammonia (mg/L)	TSS (mg/L)	Phosphorus (mg/L)	Fecal Coliform (# / 100mL)
2nd & Dock Street	100	6.72	134	1.6	811,000
14th & Crozer	39.5	3.26	45	0.78	430,000
Sun Drive and Hancock Street	42.5	1.88	56	0.55	169,000

ALS Environmental

34 Dogwood Lane ■ Middletown, PA 17057 ■ Phone: 717-944-5541 ■ Fax: 717-944-1430 ■ www.alsglobal.com

NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

October 2, 2014

Mike Krause
DELCORA
P.O. Box 999
Chester, PA 19016

Certificate of Analysis

Project Name:	**Annual Stormwaters**	Workorder:	**2031197**
Purchase Order:		Workorder ID:	**CSO Sampling**

Dear Mike Krause:

Enclosed are the analytical results for samples received by the laboratory on Thursday, September 25, 2014.

The ALS Environmental laboratory in Middletown, Pennsylvania is a National Environmental Laboratory Accreditation Program (NELAP) accredited laboratory and as such, certifies that all applicable test results meet the requirements of NELAP.

If you have any questions regarding this certificate of analysis, please contact Mrs. Vanessa N Badman (Project Coordinator) at (717) 944-5541.

Analyses were performed according to our laboratory's NELAP-approved quality assurance program and any applicable state requirements. The test results meet requirements of the current NELAP standards or state requirements, where applicable. For a specific list of accredited analytes, refer to the certifications section of the ALS website at www.alsglobal.com/en/Our-Services/Life-Sciences/Environmental/Downloads.

This laboratory report may not be reproduced, except in full, without the written approval of ALS Environmental.

ALS Spring City: 10 Riverside Drive, Spring City, PA 19475 610-948-4903

CC: Ms. Irene Fitzgerald , Joe DiMatteo

This page is included as part of the Analytical Report and must be retained as a permanent record thereof.

Vanessa N. Badman

Mrs. Vanessa N Badman
Project Coordinator

ALS Environmental

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NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

SAMPLE SUMMARY

Workorder: 2031197 CSO Sampling

Lab ID	Sample ID	Matrix	Date Collected	Date Received	Collected By
2031197001	14th & Crozer	Water	9/25/2014 10:00	9/25/2014 20:30	Mike Krause
2031197002	2nd & Dock	Water	9/25/2014 09:40	9/25/2014 20:30	Mike Krause
2031197003	Sun & Hancock	Water	9/25/2014 09:50	9/25/2014 20:30	Mike Krause
2031197004	14th & Crozer	Water	9/25/2014 10:00	9/25/2014 16:10	Mike Krause
2031197005	2nd & Dock	Water	9/25/2014 09:40	9/25/2014 16:10	Mike Krause
2031197006	Sun & Hancock	Water	9/25/2014 09:50	9/25/2014 16:10	Mike Krause

Notes

-- Samples collected by ALS personnel are done so in accordance with the procedures set forth in the ALS Field Sampling Plan (20 - Field Services Sampling Plan).
-- All Waste Water analyses comply with methodology requirements of 40 CFR Part 136.
-- All Drinking Water analyses comply with methodology requirements of 40 CFR Part 141.
-- Unless otherwise noted, all quantitative results for soils are reported on a dry weight basis.
-- The Chain of Custody document is included as part of this report.
-- All Library Search analytes should be regarded as tentative identifications based on the presumptive evidence of the mass spectra. Concentrations reported are estimated values.
-- Parameters identified as "analyze immediately" require analysis within 15 minutes of collection. Any "analyze immediately" parameters not listed under the header "Field Parameters" are preformed in the laboratory and are therefore analyzed out of hold time.
-- Method references listed on this report beginning with the prefix “S” followed by a method number (such as S2310B-97) refer to methods from “Standard Methods for the Examination of Water and Wastewater”.

Standard Acronyms/Flags

J	Indicates an estimated value between the Method Detection Limit (MDL) and the Practical Quantitation Limit (PQL) for the analyte
U	Indicates that the analyte was Not Detected (ND)
N	Indicates presumptive evidence of the presence of a compound
MDL	Method Detection Limit
PQL	Practical Quantitation Limit
RDL	Reporting Detection Limit
ND	Not Detected - indicates that the analyte was Not Detected at the RDL
Cntr	Analysis was performed using this container
RegLmt	Regulatory Limit
LCS	Laboratory Control Sample
MS	Matrix Spike
MSD	Matrix Spike Duplicate
DUP	Sample Duplicate
%Rec	Percent Recovery
RPD	Relative Percent Difference
LOD	DoD Limit of Detection
LOQ	DoD Limit of Quantitation
DL	DoD Detection Limit

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ANALYTICAL RESULTS

Workorder: 2031197 CSO Sampling

Lab ID: **2031197001** Date Collected: 9/25/2014 10:00 Matrix: Water

Sample ID: **14th & Crozer** Date Received: 9/25/2014 20:30

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
WET CHEMISTRY										
Ammonia-N	3.26		mg/L	0.100	D6919-09			9/30/14 15:23	JAM	B
Biochemical Oxygen Demand	39.5		mg/L	2.0	S5210B-01			9/26/14 06:30	NAK	A
Phosphorus, Total	0.78		mg/L	0.10	EPA 365.1	9/26/14	LJF	9/30/14 06:57	LJF	B
Total Suspended Solids	45		mg/L	5	S2540D-97			9/29/14 21:30	NV	A

Vanessa N. Badman

Mrs. Vanessa N Badman
Project Coordinator

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2031197 CSO Sampling

Lab ID: **2031197002** Date Collected: 9/25/2014 09:40 Matrix: Water

Sample ID: **2nd & Dock** Date Received: 9/25/2014 20:30

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
WET CHEMISTRY										
Ammonia-N	6.72		mg/L	0.100	D6919-09			9/30/14 15:43	JAM	B
Biochemical Oxygen Demand	100		mg/L	2.0	S5210B-01			9/26/14 06:30	NAK	A
Phosphorus, Total	1.6		mg/L	0.10	EPA 365.1	9/26/14	LJF	9/30/14 06:57	LJF	B
Total Suspended Solids	134		mg/L	5	S2540D-97			9/29/14 21:30	NV	A

Vanessa N. Badman

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2031197 CSO Sampling

Lab ID: **2031197003** Date Collected: 9/25/2014 09:50 Matrix: Water

Sample ID: **Sun & Hancock** Date Received: 9/25/2014 20:30

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
WET CHEMISTRY										
Ammonia-N	1.88		mg/L	0.100	D6919-09			9/30/14 16:03	JAM	B
Biochemical Oxygen Demand	42.5		mg/L	2.0	S5210B-01			9/26/14 06:30	NAK	A
Phosphorus, Total	0.55		mg/L	0.10	EPA 365.1	9/26/14	LJF	9/30/14 06:57	LJF	B
Total Suspended Solids	56		mg/L	5	S2540D-97			9/29/14 21:30	NV	A

Vanessa N. Badman

Mrs. Vanessa N Badman
Project Coordinator

ALS Environmental

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2031197 CSO Sampling

Lab ID: **2031197004** Date Collected: 9/25/2014 10:00 Matrix: Water

Sample ID: **14th & Crozer** Date Received: 9/25/2014 16:10

Parameters	Results	Flag	Units	RDL	Method	Prepared By	Analyzed	By	*Cntr*
Spring City-PA1504546,NJPA071									
Fecal Coliform	430000		col/100mL	1	S9222D-97		9/25/14 17:50	BSM	A

Vanessa N. Badman

Mrs. Vanessa N Badman
Project Coordinator

ALS Environmental

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2031197 CSO Sampling

Lab ID: **2031197005** Date Collected: 9/25/2014 09:40 Matrix: Water

Sample ID: **2nd & Dock** Date Received: 9/25/2014 16:10

Parameters	Results	Flag	Units	RDL	Method	Prepared By	Analyzed	By	*Cntr*
Spring City-PA1504546,NJPA071									
Fecal Coliform	811000	1	col/100mL	1	S9222D-97		9/25/14 16:45	BSM	A

Vanessa N. Badman

Mrs. Vanessa N Badman
Project Coordinator

ALS Environmental

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NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2031197 CSO Sampling

Lab ID: **2031197006** Date Collected: 9/25/2014 09:50 Matrix: Water

Sample ID: **Sun & Hancock** Date Received: 9/25/2014 16:10

Parameters	Results	Flag	Units	RDL	Method	Prepared By	Analyzed	By	*Cntr*
Spring City-PA1504546,NJPA071									
Fecal Coliform	169000	1	col/100mL	1	S9222D-97		9/25/14 17:08	BSM	A

Vanessa N. Badman

Mrs. Vanessa N Badman
Project Coordinator

ALS Environmental

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NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

PARAMETER QUALIFIERS

Lab ID	#	Sample ID	Analytical Method	Analyte
2031197005	1	2nd & Dock	S9222D-97	Fecal Coliform
This is an estimated result.				
2031197006	1	Sun & Hancock	S9222D-97	Fecal Coliform
This is an estimated result.				

ALS Environmental
34 Dogwood Lane
Middletown, PA 17057
P. 717-944-5541
F.717-944-1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

COC #:

ALS Quot

2031197

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

Client Name: DELCORA
Address: 3201 W. Front Street
Chester PA 19013
Contact: Mike Krause
Phone#: 610-876-5523 x218
Project Name/#: CSO Sampling
Bill To: Same

TAT [X] Normal-Standard TAT is 10-12 business days.
[ ] Rush-Subject to ALS approval and surcharges.
Date Required: _____ Approved By: _____
Email? [X] -Y _____
Fax? [ ] -Y No.: _____

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	BOD, TSS	Phosphorus, NH3	Fecal Coliform							
Container Type					plastic	plastic	plastic							
Container Size					1L	500ml	250ml							
Preservative					none	H2SO4	Na2S2O3							
ANALYSES/METHOD REQUESTED														
Enter Number of Containers Per Sample or Field Results Below.														
1 14th & Crozer	9/25/2014	10:00	C	WW	1	1	1							
2 2nd & Dock	9/25/2014	9:40	C	WW	1	1	1							
3 Sun & Hancock	9/25/2014	9:50	C	WW	1	1	1							
4														
5														
6														
7														
8														
9														
10														

Rec

Cooler Temp: 2°c Therm ID: TH294
No. of Coolers: 1

	Y	N	Initial
Custody Seals Present?			BSM
~~(if present) Seals Intact?~~			
Received on Ice?	✓		
COC/Labels Complete/Accurate?	✓		
Cont. in Good Cond.?	✓		
Correct Containers?	✓		
Correct Sample Volumes?	✓		
Correct Preservation?	✓		
Headspace/Volatiles?			

Courier/Tracking #:

Sample/COC Comments

Fecal Analyzed @ Spring City SPRC/BSM 9-25-14 1610

ALS Field Services: X Pickup _Labor
_Composite Sampling _Rental Equipment
_Other: _____

Project Comments:

LOGGED BY(signature): [signature] DATE 9/26 TIME 0229
REVIEWED BY(signature): DATE TIME

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1 [signature]	9/25/14	1300	2 [signature]	9-25	1300
3 [signature]	9.20	1830	4 [signature]	9-25-14	1830
5 [signature]	9-25-14	2030	6 [signature] 9-25	9-25	2030
7			8		
9			10		

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE [ ]
Special Processing: USACE [ ] Navy [ ] [ ]
State Samples Collected In: [ ] NY [ ] NJ [X] PA [ ] NC [ ]
Reportable to PADEP? Yes [ ] PWSID # _____
Sample Disposal: Lab [ ] Special [ ]
EDDS: Format Type- _____

* G=Grab; C=Composite
**Matrix - Al=Air; DW=Drinking Water; GW=Groundwater; OI=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

ALS ENVIRONMENTAL SHIPPING ADDRESS: 34 DOGWOOD LANE, MIDDLETOWN, PA 17057

Rev 10/11

C.S.O. Sampling
29-Oct-12

Sample Point	Parameters				
	BOD (mg/L)	Ammonia (mg/L)	TSS (mg/L)	Phosphorus (mg/L)	Fecal Coliform (# / 100mL)
2nd & Dock St	35	2.18	106	0.823	>600,000
14th & Crozer	21	0.81	48	0.499	>600,000
Sun Drive and Hancock St.	28	1.79	47	0.813	>600,000

QC Laboratories

Analytical Report

MIKE KRAUSE
DELCORA PRE-TREATMENT
PO BOX 999
CHESTER, PA 19016

Regarding:
MIKE KRAUSE
DELCORA PRE-TREATMENT
3201 W. FRONT STREET
CHESTER, PA 19016

Account No:AL0069, DELCORA
Project No: AL0069, DELCORA

P.O. No:

Inv. No: 1468769
PWSID No:

Sample Number Sample Description
L4369219-1 SUN & HANCOCK GRAB
Received Date/Time/Temp 10/31/12 07:45pm 1.1 C Iced (Y/N): Y

Samp. Date/Time/Temp Sampled by
10/29/12 09:40am NA C Customer

Parameter	Method	Result	RLs	Test Date, Time, Analyst
GENERAL CHEMISTRY				
AMMONIA NITROGEN AS N	SM 4500NH3 B,D	1.79 mg/l	0.100 mg/l	11/08/12 03:55PM MRP
PHOSPHORUS TOTAL	SM 4500P B.5 E	0.813 mg/l	0.0600 mg/l	11/01/12 09:00AM NM
TOTAL SUSPENDED SOLIDS	SM 2540D	47.0 mg/l	2.00 mg/l	11/01/12 12:21PM LMB

Notes:
A result of "ND" indicates that the analyte tested was either not detected or the concentration was below the RLs.
Definitions: NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC= Too numerous to count; pres=presumptive
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
MCL= EPA recommended "maximum contaminant level", PLs = Customer-specific permit limits.
The test results meet all requirements of NELAC unless otherwise specified.
The report shall not be reproduced except in full without the written consent of the laboratory.
Unless otherwise specified, the Environmental and Food Chemistry testing except Field Parameters were performed by QC Inc. located at 1205 Industrial Blvd., Southampton, PA 18966; Pharmaceutical, Dairy and Food Microbiological tests were performed by QC Inc. located at 702 Electronic Dr., Horsham, PA 19044.
QCL Accreditations: Southampton Div: EPA ID PA00018; NELAP ID's: PA 09-00131, NJ PA166, NY 11223
State ID's: CT PH-0768, DE PA-018, MD 206, SC 89021001; FDA Reg. # : 2515238
ACL Div: NELAP ID's: PA 68-335, NJ DE568; State ID's: DE 00011, MD 138; Wind Gap Div: State ID's: PA 48-01334, NJ PA001
E. Rutherford Div: State ID: NJ 02015; Vineland Div: State ID: NJ 06005; Reading Div: State ID: PA 06-03543
The reported results relate only to the samples.
All samples are collected as "grab" samples unless otherwise identified.

Regulatory authorities are assessing substantial fines for testing omissions. Please track your sample collections and results on a weekly, monthly, or quarterly basis to ensure compliance. QC's internet program 'LIVE ACCESS' will provide you with real-time access to collection dates and results. Please contact Customer Service for further information on acquiring LIVE ACCESS.

Serial Number: 2460396

Sun & Hancock

CHAIN OF CUSTODY RECORD

Atlantic Coast Laboratories, Inc.
630 churchmans Road
Newark, Delaware 19702
(302)266-9121 * 454-8720 (FAX)

Client
Client Name Delcora
Address 3201 W Front St
Chester, PA 19013
Contact Mike Krause
Phone (610) 876-5523 x 218
Work ID

Due
Quote
Misc.
Sampled by:

Sample ID	Comp Date Time Start	Date Smpl	Time	Container Size	Container G/P	Grab Sample	Composite	No. of Containers	Sample Matrix	Preservative	TSS	Phos-phorus, NH3						Comments
Sun & Hancock		10/29/12	9:40	1000	P	X		1	WW	NONE	X							
Sun & Hancock		10/29/12	9:40	500	P	X		1	WW	H2SO4		X						

Relinquished by:	Date/Time	Received by:	Relinquished by:	Date \ Time	Received by:
[signature]	10/31/12 1035	[signature]			
Relinquished by:	Date/Time	Received by:	Relinquished by:	Date \ Time	Received for Laboratory by:

Lab Use Only	Yes	No	Remarks
Samples Iced			
Samples Prsrvd			

QC Laboratories

Analytical Report

MIKE KRAUSE
DELCORA PRE-TREATMENT
PO BOX 999
CHESTER, PA 19016

Regarding:
MIKE KRAUSE
DELCORA PRE-TREATMENT
3201 W. FRONT STREET
CHESTER, PA 19016

Account No:AL0069, DELCORA
Project No: AL0069, DELCORA

P.O. No:

Inv. No: 1468768
PWSID No:

Sample Number Sample Description
L4369218-1 2ND & DOCK GRAB
Received Date/Time/Temp 10/31/12 07:45pm 1.1 C Iced (Y/N): Y

Samp. Date/Time/Temp Sampled by
10/29/12 10:00am NA C Customer

Parameter	Method	Result	RLs	Test Date, Time, Analyst
GENERAL CHEMISTRY				
AMMONIA NITROGEN AS N	SM 4500NH3 B,D	2.18 mg/l	0.100 mg/l	11/08/12 03:55PM MRP
PHOSPHORUS TOTAL	SM 4500P B.5 E	0.823 mg/l	0.0600 mg/l	11/01/12 09:00AM NM
TOTAL SUSPENDED SOLIDS	SM 2540D	106 mg/l	2.00 mg/l	11/01/12 12:50PM LMB

Notes:
A result of "ND" indicates that the analyte tested was either not detected or the concentration was below the RLs.
Definitions: NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC= Too numerous to count; pres=presumptive
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The test results meet all requirements of NELAC unless otherwise specified.
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Unless otherwise specified, the Environmental and Food Chemistry testing except Field Parameters were performed by QC Inc. located at 1205 Industrial Blvd., Southampton, PA 18966; Pharmaceutical, Dairy and Food Microbiological tests were performed by QC Inc. located at 702 Electronic Dr., Horsham, PA 19044.
QCL Accreditations: Southampton Div: EPA ID PA00018; NELAP ID's: PA 09-00131, NJ PA166, NY 11223
State ID's: CT PH-0768, DE PA-018, MD 206, SC 89021001; FDA Reg. # : 2515238
ACL Div: NELAP ID's: PA 68-335, NJ DE568; State ID's: DE 00011, MD 138; Wind Gap Div: State ID's: PA 48-01334, NJ PA001
E. Rutherford Div: State ID: NJ 02015; Vineland Div: State ID: NJ 06005; Reading Div: State ID: PA 06-03543
The reported results relate only to the samples.
All samples are collected as "grab" samples unless otherwise identified.

Regulatory authorities are assessing substantial fines for testing omissions. Please track your sample collections and results on a weekly, monthly, or quarterly basis to ensure compliance. QC's internet program 'LIVE ACCESS' will provide you with real-time access to collection dates and results. Please contact Customer Service for further information on acquiring LIVE ACCESS.

Serial Number: 2460395

Client
Client Name Delcora
Address 3201 W Front St
Chester, PA 19013
Contact Mike Krause
Phone (610) 876-5523 x 218
Work ID

CHAIN OF CUSTODY RECORD

Due
Quote
Misc.
Sampled by:

Atlantic Coast Laboratories, Inc.
630 churchmans Road
Newark, Delaware 19702
(302)266-9121 * 454-8720 (FAX)

Sample ID	Comp Date Time Start	Date Smpl	Time	Container Size	Container G/P	Grab Sample	Composite	No. of Containers	Sample Matrix	Preservative	TSS	Phos-phorus, NH3						Comments
2nd & Dock		10/29/12	10:00	1000	P	X		1	WW	NONE	X							
2nd & Dock		10/29/12	10:00	500	P	X		1	WW	H2SO4		X						

Relinquished by:	Date/Time	Received by:	Relinquished by:	Date \ Time	Received by:
	10/31/12 1035				
Relinquished by:	Date/Time	Received by:	Relinquished by:	Date \ Time	Received for Laboratory by:

Lab Use Only	Yes	No	Remarks
Samples Iced			
Samples Prsrvd			

QC Laboratories

Analytical Report

MIKE KRAUSE
DELCORA PRE-TREATMENT
PO BOX 999
CHESTER, PA 19016

Regarding:
MIKE KRAUSE
DELCORA PRE-TREATMENT
3201 W. FRONT STREET
CHESTER, PA 19016

Account No:AL0069, DELCORA
Project No: AL0069, DELCORA

P.O. No:

Inv. No: 1468767
PWSID No:

Sample Number Sample Description
L4369220-1 14TH & CROZER GRAB
Received Date/Time/Temp 10/31/12 07:45pm 1.1 C Iced (Y/N): Y

Samp. Date/Time/Temp Sampled by
10/29/12 09:20am NA C Customer

Parameter	Method	Result	RLs	Test Date, Time, Analyst
GENERAL CHEMISTRY				
AMMONIA NITROGEN AS N	SM 4500NH3 B,D	0.810 mg/l	0.100 mg/l	11/08/12 03:55PM MRP
PHOSPHORUS TOTAL	SM 4500P B.5 E	0.499 mg/l	0.0300 mg/l	11/02/12 08:50AM NM
TOTAL SUSPENDED SOLIDS	SM 2540D	48.0 mg/l	2.00 mg/l	11/01/12 12:50PM LMB

Notes:
A result of "ND" indicates that the analyte tested was either not detected or the concentration was below the RLs.
Definitions: NEG=negative; POS=positive; COL=colonies; RLs=laboratory reporting limits; L/A=laboratory accident; TNTC= Too numerous to count; pres=presumptive
A result marked with "DRY" indicates that the result was calculated and reported on a dry weight basis.
MCL= EPA recommended "maximum contaminant level", PLs = Customer-specific permit limits.
The test results meet all requirements of NELAC unless otherwise specified.
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State ID's: CT PH-0768, DE PA-018, MD 206, SC 89021001; FDA Reg. # : 2515238
ACL Div: NELAP ID's: PA 68-335, NJ DE568; State ID's: DE 00011, MD 138; Wind Gap Div: State ID's: PA 48-01334, NJ PA001
E. Rutherford Div: State ID: NJ 02015; Vineland Div: State ID: NJ 06005; Reading Div: State ID: PA 06-03543
The reported results relate only to the samples.
All samples are collected as "grab" samples unless otherwise identified.

Regulatory authorities are assessing substantial fines for testing omissions. Please track your sample collections and results on a weekly, monthly, or quarterly basis to ensure compliance. QC's internet program 'LIVE ACCESS' will provide you with real-time access to collection dates and results. Please contact Customer Service for further information on acquiring LIVE ACCESS.

Serial Number: 2460389

Client
Client Name Delcora
Address 3201 W Front St
Chester, PA 19013
Contact Mike Krause
Phone (610) 876-5523 x 218
Work ID

CHAIN OF CUSTODY RECORD

Due
Quote
Misc.
Sampled by:

Atlantic Coast Laboratories, Inc.
630 churchmans Road
Newark, Delaware 19702
(302)266-9121 * 454-8720 (FAX)

Sample ID	Comp Date Time Start	Date Smpl	Time	Container Size	Container G/P	Grab Sample	Composite	No. of Containers	Sample Matrix	Preservative	TSS	Phos-phorus, NH3						Comments
14th & Crozer		10/29/12	9:20	1000	P	X		1	WW	NONE	X							
14th & Crozer		10/29/12	9:20	500	P	X		1	WW	H2SO4		X						

Relinquished by:	Date/Time	Received by:	Relinquished by:	Date \ Time	Received by:
	10/29/12 1035				
Relinquished by:	Date/Time	Received by:	Relinquished by:	Date \ Time	Received for Laboratory by:

Lab Use Only	Yes	No	Remarks
Samples Iced			
Samples Prsrvd			

Fecal Daily Worksheet

	Analyst	Date	Time		
Setup & Sample Date	MK	10/29/2012	2:25 PM		
Read	MK	10/30/2012	2:00 PM		
14th & Crozer					
Dilutions	Blank 1	5TNTC	1TNTC	0.1TNTC	0.01
Raw Count (CFU)	0	TNTC	TNTC	TNTC	TNTC
Actual Density (CFU/100mL)					
Meets Target (20-40 CFU)?		Above	Above	Above	Above
Results that Meet Target					
Target Results Count/100mL					
Average (CFU/100mL)			>	600000	

	Analyst	Date	Time		
Setup & Sample Date	MK	10/29/2012	2:25 PM		
Read	MK	10/30/2012	2:00 PM		
2nd & Dock					
Dilutions	Blank 1	5TNTC	1TNTC	0.1TNTC	0.01
Raw Count (CFU)	0	TNTC	TNTC	TNTC	TNTC
Actual Density (CFU/100mL)					
Meets Target (20-40 CFU)?		Above	Above	Above	Above
Results that Meet Target					
Target Results Count/100mL					
Average (CFU/100mL)			>	600,000	

	Analyst	Date	Time		
Setup & Sample Date	MK	10/29/2012	2:25 PM		
Read	MK	10/30/2012	2:00 PM		
Sun & Hancock					
Dilutions	Blank 1	5TNTC	1TNTC	0.1TNTC	0.01
Raw Count (CFU)	0	TNTC	TNTC	TNTC	TNTC
Actual Density (CFU/100mL)					
Meets Target (20-40 CFU)?		Above	Above	Above	Above
Results that Meet Target					
Target Results Count/100mL					
Average (CFU/100mL)			>	600,000	

	Analyst	Date	Time		
Setup & Sample Date					
Read					
Dilutions	Blank 1	125	75	25	5
Raw Count (CFU)					
Actual Density (CFU/100mL)					
Meets Target (20-40 CFU)?					
Results that Meet Target					
Target Results Count/100mL					
Average (CFU/100mL)					

	Analyst	Date	Time
Setup & Sample Date			
Read			

BOD Worksheet

Date of Analysis		10/30/12
Date of WRTP Sample		10/29/12
Date of CFR Sample		
Date of CFTM Sample		
Date of SF and TB Sample		
Setup	TPB	10/30/12
Read 5 Day	MK	11/04/12
Read 20 Day		11/19/12

	LOT #	Op'd Date	EXP. Date
GGA Control	B109-01	10/7/2012	11/21/2012

Soln. T°	Calib. T°
20.5	20.4
20.8	23.6

Theor. DO

Seed Lot #	52017	3/13/2013
6L Nutrient Lot #	A2254	9/31/2017
3L Nutrient Lot #	A0316	11/15/2015
300mL Nutrient Lot #	A0344	12/31/2015
N Inhibitor Lot #	A2093	5/31/2015

CBOD5

	Bottle #	Sample Volume (mL)	Volume Fraction	Extra Nutrient	Nitr. Inhib	Initial DO	Final DO	Depletion	Seed Volume	Seed Blank	BOD5 (mg/L)	BOD5 (AVG.)	Quality Control
BLANK 1		0	0.00		x				-				
BLANK 2		0	0.00		x				-				
BLANK 3		0	0.00		x				-				
CONTROL 1		6	0.02		x				2				
CONTROL 2		6	0.02		x				2				
SEED 1		18	0.06		x				-				
SEED 2		20	0.07		x				-			0.00	
SEED 3		22	0.07		x				-				
EFF 1					x				2				
EFF 2					x				2				
EFF 3					x				2				
EFF 1					x				2				
EFF 2					x				2				RPD
EFF 3					x				2				AVG
INF 1					x				2				
INF 2					x				2				
INF 3					x				2				
CFR EFF 1					x				2				
CFR EFF 2					x				2				
CFR EFF 3					x				2				
CFTM EFF 1					x				2				
CFTM EFF 2					x				2				
CFTM EFF 3					x				2				
SF EFF 1					x				2				
SF EFF 2					x				2				
SF EFF 3					x				2				
THBY EFF 1					x				2				
THBY EFF 2					x				2				
THBY EFF 3					x				2				
RV EFF 1					x				2				
RV EFF 2					x				2				
RV EFF 3					x				2				
PP EFF 1					x				2				
PP EFF 2					x				2				
PP EFF 3					x				2				
PR EFF 1					x				2				
PR EFF 2					x				2				
PR EFF 3					x				2				

BOD5

	Bottle #	Sample Volume (mL)	Volume Fraction	Extra Nutrient	Nitr. Inhib	Initial DO	Final DO	Depletion	Seed Volume	Seed Blank	BOD5 (mg/L)	BOD5 (AVG.)	Quality Control
BLANK 1	239	0	0.00			8.63	8.37	0.26	-		0.26		
BLANK 2	215	0	0.00			8.62	8.40	0.22	-		0.22	**0.19**	
BLANK 3	12	0	0.00			8.63	8.53	0.10	-		0.10		**Pass**
CONTROL 1	231	6	0.02			8.66	3.80	4.86	2		215	**208**	
CONTROL 2	226	6	0.02			8.66	4.09	4.57	2		200		**Pass**
SEED 1	112	16	0.05			8.61	4.07	4.54	-	53%	0.57		
SEED 2	77	18	0.06			8.60	3.52	5.08	-	59%	0.56	**0.56**	
SEED 3	61	20	0.07			8.60	3.05	5.55	-	65%	0.56		
SUN 1	11	30	0.10			8.68	5.35	3.33	2		28		
SUN 2	0	60	0.20			8.72	2.63	6.09	2		28	**28**	
SUN 3	79	90	0.30			8.77	0.25		2				
14TH 1	616	30	0.10			8.66	5.94	2.72	2		22		
14th 2	123	60	0.20			8.70	3.82	4.88	2		22	**21**	
14th 3	71	90	0.30			8.73	1.97	6.76	2		21		
CPS 1	301	30	0.10			8.64	4.51	4.13	2		36		
CPS 2	272	60	0.20			8.63	1.01	7.62	2		35	**35**	
CPS 3	183	90	0.30			8.62	0.02		2				
CFR INF 1									2				Duplicate
CFR INF 2									2				Results
CFR INF 3									2				**RPD%**
CFTM INF 1									2				
CFTM INF 2									2				
CFTM INF 3									2				
SF INF 1									2				
SF INF 2									2				
SF INF 3									2				
THBY INF 1									2				
THBY INF 2									2				
THBY INF 3									2				
RV INF 1									2				
RV INF 2									2				
RV INF 3									2				
PP INF 1									2				
PP INF 2									2				
PP INF 3									2				
PR INF 1									2				
PR INF 2									2				
PP INF 3									2				

C.S.O. Sampling
27-Nov-13

Sample Point	Parameters				
	BOD (mg/L)	Ammonia (mg/L)	TSS (mg/L)	Phosphorus (mg/L)	Fecal Coliform (# / 100mL)
2nd & Dock St	65	2.1	204	1.32	>200,000
14th & Crozer	40	0.9	163	1.21	190,000
Sun Drive and Hancock St.	13	0.2	40	0.350	150,000

CERTIFICATE OF ANALYSIS
M.J. Reider Associates, Inc.

Attention: Michael Krause
Reported To: DELCORA Plant Sampling
3201 West Front St.
Chester PA 19016-0000

Date of Report: 12/06/13
Lab ID: 2991-13-0053078

Date Collected: 11/27/13 00:00
Collected By: Client

Sample Desc: CSO Outfall (Site 1) 14th + Crozer

Date Received: 11/27/13 14:05

	Result	Unit	Rep Limit	Dilutn Factor	Procedure	Test Date	Test Time	Analyst
CHEMISTRY								
COLORMETRIC								
Phosphorus as P, Total	1.21	mg/l	.05	1	SM 4500P-E	12/02	11:15	ALD
NITROGENS								
Nitrogen, Ammonia	0.9	mg/l	.1	1	D6919-03	11/27	17:37	JCL
OTHER								
Biochemical Oxygen Demand	40	mg/l	2	1	SM 5210B	11/27	16:00	EMW
RESIDUES								
Solids, Total Suspended	163	mg/l	1	1	SM 2540D	12/03	08:40	TMH

Distribution of Reports:

Reviewed and Approved by:

Barbara R Coyle

Barbara Coyle
Laboratory Director

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THE NELAC INSTITUTE

ENVIRONMENTAL TESTING LABORATORY 107 ANGELICA STREET, READING, PA 19611
PHONE: 610-374-5129 • FAX: 610-374-7234 • **www.mjreider.com**

NELAP accredited by PA. (PADEP #06-00003) (NYSDOH11630) Visit our website to view our current NELAC accreditations for various drinking water, wastewater and solid & chemical materials analytes.

ACIL Seal of Excellence

CERTIFICATE OF ANALYSIS
M.J. Reider Associates, Inc.

Attention: Michael Krause
Reported To: DELCORA Plant Sampling
3201 West Front St.
Chester PA 19016-0000

Date of Report: 12/06/13
Lab ID: 2991-13-0053079

Date Collected: 11/27/13 00:15
Collected By: Client

Sample Desc: CSO Outfall (Site 2) Sun + Hancock

Date Received: 11/27/13 14:05

	Result	Unit	Rep Limit	Dilutn Factor	Procedure	Test Date	Test Time	Analyst
CHEMISTRY								
COLORMETRIC								
Phosphorus as P, Total	0.35	mg/l	.05	1	SM 4500P-E	12/02	11:15	ALD
NITROGENS								
Nitrogen, Ammonia	0.2	mg/l	.1	1	D6919-03	11/27	17:37	JCL
OTHER								
Biochemical Oxygen Demand	13	mg/l	2	1	SM 5210B	11/27	16:00	EMW
RESIDUES								
Solids, Total Suspended	40	mg/l	1	1	SM 2540D	12/03	08:40	TMH

Distribution of Reports:

Reviewed and Approved by:

Barbara R Coyle

Barbara Coyle
Laboratory Director

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THE NELAC INSTITUTE

ACIL Seal of Excellence

CERTIFICATE OF ANALYSIS
M.J. Reider Associates, Inc.

Attention: Michael Krause
Reported To: DELCORA Plant Sampling
3201 West Front St.
Chester PA 19016-0000

Date of Report: 12/06/13
Lab ID: 2991-13-0053080

Date Collected: 11/27/13 00:30
Collected By: Client

Sample Desc: CSO Outfall (Site 3) 2nd + Dock (CPS)

Date Received: 11/27/13 14:05

	Result	Unit	Rep Limit	Dilutn Factor	Procedure	Test Date	Test Time	Analyst
CHEMISTRY								
COLORMETRIC								
Phosphorus as P, Total	1.32	mg/l	.05	1	SM 4500P-E	12/02	11:15	ALD
NITROGENS								
Nitrogen, Ammonia	2.1	mg/l	.1	1	D6919-03	11/27	17:37	JCL
OTHER								
Biochemical Oxygen Demand	65	mg/l	2	1	SM 5210B	11/27	16:00	EMW
RESIDUES								
Solids, Total Suspended	204	mg/l	1	1	SM 2540D	12/03	08:40	TMH

Distribution of Reports:

Reviewed and Approved by:

Barbara R Coyle

Barbara Coyle
Laboratory Director

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ACIL Seal of Excellence

brc
12/31/12 8:15:57 AM

M. J. REIDER ASSOCIATES, INC.

COFC.
Page:

Chain of Custody

Account: 2991 Work Order: 005523 Project Leader: BRC No: 211349
Work Order Description: Annual CSO Outfalls

Customer: Michael Krause

Address: DELCORA Plant Sampling
3201 West Front St.
Chester PA 19016-0000

Remarks: _____

Phone: 610.876.5523 Ext: 218

Total Sampling Time (hours): _____ Bottle Prep by: _____

Samplers: CST

Laboratory Receipt Temp: 5 Deg C. If Temp Unacceptable, On Ice? (Y) N
Approved By: _____

==========

Sample No: 1 Desc: CSO Outfall (Site 1) 14TH + CROZER
53078 nh3-n, tss, po4-p, bod, ~~fec~~

Matrix: ww Date: 11/27/13
Time: 0200
A - 1 X L BOD/TSS P w/ Cool to 6 C;
B - 1 X Pt NH3/PO4 P w/ H2S04(pH<2);
~~C - 1 X 4oz FECAL P w/ Sterile/Na2S203;~~

Sample No: 2 Desc: CSO Outfall (Site 2) SUN + HANCOCK
53079 nh3-n, tss, po4-p, bod, ~~fec~~

Matrix: ww Date: 11/27/13
Time: 0015
A - 1 X L BOD/TSS P w/ Cool to 6 C;
B - 1 X Pt NH3/PO4 P w/ H2S04(pH<2);
~~C - 1 X 4oz FECAL P w/ Sterile/Na2S203;~~

Sample No: 3 Desc: CSO Outfall (Site 3) 2ND + DOCK (CPS)
53080 nh3-n, tss, po4-p, bod, ~~fec~~

Matrix: ww Date: 11/27/13
Time: 0030
A - 1 X L BOD/TSS P w/ Cool to 6 C;
B - 1 X Pt NH3/PO4 P w/ H2S04(pH<2);
~~C - 1 X 4oz FECAL P w/ Sterile/Na2S203;~~

Relinquished by: _____ Received by: _____ Received for laboratory by: _____

Date: 11/27/13 Time: 1020 Date: 11/27/13 Time: 1905

Sample entered by: DSM

	Analyst	Date	Time
Setup & Sample Date	MK	11/27/2013	2:40 AM
Read	MK	11/28/2013	2:00 AM
14th & Crozer			

Dilutions	Blank 1	5tntc	1tntc	0.5tntc	0.1
Raw Count (CFU)	0	tntc	tntc	tntc	190
Actual Density (CFU/100mL)					190000
Meets Target (20-40 CFU)?		Above	Above	Above	Above
Results that Meet Target					
Target Results Count/100mL					
Average (CFU/100mL)	190,000				

	Analyst	Date	Time
Setup & Sample Date	MK	11/27/2013	2:40 AM
Read	MK	11/28/2013	2:00 AM
Sun & Hancock			

Dilutions	Blank 1	5tntc	1tntc	0.5tntc	0.1
Raw Count (CFU)	0	tntc	tntc	tntc	150
Actual Density (CFU/100mL)					150000
Meets Target (20-40 CFU)?		Above	Above	Above	Above
Results that Meet Target					
Target Results Count/100mL					
Average (CFU/100mL)	150,000				

	Analyst	Date	Time
Setup & Sample Date	MK	11/27/2013	2:40 AM
Read	MK	11/28/2013	2:00 AM
2nd & Dock (CPS)			

Dilutions	Blank 1	5tntc	1tntc	0.5tntc	0.1
Raw Count (CFU)		tntc	tntc	tntc	tntc
Actual Density (CFU/100mL)					
Meets Target (20-40 CFU)?		Above	Above	Above	Above
Results that Meet Target					
Target Results Count/100mL					
Average (CFU/100mL)			>	200,000	

	Analyst	Date	Time
Setup & Sample Date			
Read			
Spring Hill Farm			

Dilutions	Blank 1	125	75	25	5
Raw Count (CFU)					
Actual Density (CFU/100mL)					
Meets Target (20-40 CFU)?					
Results that Meet Target					
Target Results Count/100mL					
Average (CFU/100mL)					

	Analyst	Date	Time
Setup & Sample Date			
Read			

ATTACHMENT F

Laboratory Data for Additional Sampling of the CSO Outfalls

ALS Environmental

34 Dogwood Lane ■ Middletown, PA 17057 ■ Phone: 717-944-5541 ■ Fax: 717-944-1430 ■ www.alsglobal.com

NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

December 3, 2015

Ms. Irene Fitzgerald
DELCORA
P.O. Box 999
Chester, PA 19016

Certificate of Analysis

Project Name:	**2015-LOWER DELAWARE TESTING**	Workorder:	**2107040**
Purchase Order:		Workorder ID:	**CSO WW LTCP**

Dear Ms. Fitzgerald:

Enclosed are the analytical results for samples received by the laboratory on Tuesday, November 10, 2015.

The ALS Environmental laboratory in Middletown, Pennsylvania is a National Environmental Laboratory Accreditation Program (NELAP) accredited laboratory and as such, certifies that all applicable test results meet the requirements of NELAP.

If you have any questions regarding this certificate of analysis, please contact Mr. Brad W Kintzer (Project Coordinator) at (717) 944-5541.

Analyses were performed according to our laboratory's NELAP-approved quality assurance program and any applicable state requirements. The test results meet requirements of the current NELAP standards or state requirements, where applicable. For a specific list of accredited analytes, refer to the certifications section of the ALS website at www.alsglobal.com/en/Our-Services/Life-Sciences/Environmental/Downloads.

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ALS Spring City: 10 Riverside Drive, Spring City, PA 19475 610-948-4903

CC: Mr. Ray Rios , Mr. Mike Krause

This page is included as part of the Analytical Report and must be retained as a permanent record thereof.

Mr. Brad W Kintzer
Project Coordinator

ALS Environmental

34 Dogwood Lane ▪ Middletown, PA 17057 ▪ Phone: 717-944-5541 ▪ Fax: 717-944-1430 ▪ www.alsglobal.com

NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

SAMPLE SUMMARY

Workorder: 2107040 CSO WW LTCP

Lab ID	Sample ID	Matrix	Date Collected	Date Received	Collected By
2107040001	CPS/EPS1 (74/26)	Water	11/10/2015 05:00	11/10/2015 12:05	Collected by Client

Notes

-- Samples collected by ALS personnel are done so in accordance with the procedures set forth in the ALS Field Sampling Plan (20 - Field Services Sampling Plan).
-- All Waste Water analyses comply with methodology requirements of 40 CFR Part 136.
-- All Drinking Water analyses comply with methodology requirements of 40 CFR Part 141.
-- Unless otherwise noted, all quantitative results for soils are reported on a dry weight basis.
-- The Chain of Custody document is included as part of this report.
-- All Library Search analytes should be regarded as tentative identifications based on the presumptive evidence of the mass spectra. Concentrations reported are estimated values.
-- Parameters identified as "analyze immediately" require analysis within 15 minutes of collection. Any "analyze immediately" parameters not listed under the header "Field Parameters" are preformed in the laboratory and are therefore analyzed out of hold time.
-- Method references listed on this report beginning with the prefix “S” followed by a method number (such as S2310B-97) refer to methods from “Standard Methods for the Examination of Water and Wastewater”.

Standard Acronyms/Flags

J	Indicates an estimated value between the Method Detection Limit (MDL) and the Practical Quantitation Limit (PQL) for the analyte
U	Indicates that the analyte was Not Detected (ND)
N	Indicates presumptive evidence of the presence of a compound
MDL	Method Detection Limit
PQL	Practical Quantitation Limit
RDL	Reporting Detection Limit
ND	Not Detected - indicates that the analyte was Not Detected at the RDL
Cntr	Analysis was performed using this container
RegLmt	Regulatory Limit
LCS	Laboratory Control Sample
MS	Matrix Spike
MSD	Matrix Spike Duplicate
DUP	Sample Duplicate
%Rec	Percent Recovery
RPD	Relative Percent Difference
LOD	DoD Limit of Detection
LOQ	DoD Limit of Quantitation
DL	DoD Detection Limit
I	Indicates reported value is greater than or equal to the Method Detection Limit (MDL) but less than the Report Detection Limit (RDL)
(S)	Surrogate Compound
NC	Not Calculated
*	Result outside of QC limits

ALS Environmental

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NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

PROJECT SUMMARY

Workorder: 2107040 CSO WW LTCP

Workorder Comments

See attached subcontracted radiological results from ALS-Ft. Collins. VLF 12/1/15

Sample Comments

Lab ID: 2107040001 **Sample ID:** CPS/EPS1 (74/26) **Sample Type:** SAMPLE

MBAS calculated as LAS molecular weight 342 g/mol.

The reporting limits for GCMS volatile analytes were raised due to the dilution of the sample caused by matrix.

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2107040 CSO WW LTCP

Lab ID: **2107040001** Date Collected: 11/10/2015 05:00 Matrix: Water

Sample ID: **CPS/EPS1 (74/26)** Date Received: 11/10/2015 12:05

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
VOLATILE ORGANICS										
Benzene	ND		ug/L	5.0	EPA 624			11/11/15 06:32	CJG	R
Bromodichloromethane	ND		ug/L	5.0	EPA 624			11/11/15 06:32	CJG	R
Chlorodibromomethane	ND		ug/L	5.0	EPA 624			11/11/15 06:32	CJG	R
Chloroform	9.0		ug/L	5.0	EPA 624			11/11/15 06:32	CJG	R
Ethylbenzene	ND		ug/L	5.0	EPA 624			11/11/15 06:32	CJG	R
Methyl t-Butyl Ether	ND		ug/L	5.0	EPA 624			11/11/15 06:32	CJG	R
Methylene Chloride	ND		ug/L	5.0	EPA 624			11/11/15 06:32	CJG	R
Tetrachloroethene	ND		ug/L	5.0	EPA 624			11/11/15 06:32	CJG	R
Toluene	ND		ug/L	5.0	EPA 624			11/11/15 06:32	CJG	R
Total Xylenes	ND		ug/L	15.0	EPA 624			11/11/15 06:32	CJG	R
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
1,2-Dichloroethane-d4 (S)	93.5		%	72 - 142	EPA 624			11/11/15 06:32	CJG	R
4-Bromofluorobenzene (S)	89.7		%	73 - 119	EPA 624			11/11/15 06:32	CJG	R
Dibromofluoromethane (S)	87.5		%	74 - 132	EPA 624			11/11/15 06:32	CJG	R
Toluene-d8 (S)	88.8		%	75 - 133	EPA 624			11/11/15 06:32	CJG	R
SEMIVOLATILES										
Benzo(a)anthracene	ND		ug/L	1.4	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
Chrysene	ND		ug/L	1.4	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
bis(2-Ethylhexyl)phthalate	8.5		ug/L	2.8	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
N-Nitroso-di-n-propylamine	ND		ug/L	2.8	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
Phenanthrene	ND		ug/L	1.4	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
2,4,6-Tribromophenol (S)	98.7		%	38 - 134	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
2-Fluorobiphenyl (S)	84.7		%	37 - 113	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
2-Fluorophenol (S)	44		%	17 - 73	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
Nitrobenzene-d5 (S)	73.6		%	37 - 124	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
Phenol-d5 (S)	29.8		%	11 - 53	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
Terphenyl-d14 (S)	86.3		%	33 - 125	EPA 625	11/16/15	LEH	11/17/15 04:41	DHF	T
Pesticides and PCBs										
Dieldrin	0.024		ug/L	0.019	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
Total Polychlorinated Biphenyl	|		ug/L		EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
Aroclor-1016	ND		ug/L	0.46	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
Aroclor-1221	ND		ug/L	0.46	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
Aroclor-1232	ND		ug/L	0.46	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
Aroclor-1242	ND		ug/L	0.46	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2107040 CSO WW LTCP

Lab ID: **2107040001** Date Collected: 11/10/2015 05:00 Matrix: Water

Sample ID: **CPS/EPS1 (74/26)** Date Received: 11/10/2015 12:05

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
Aroclor-1248	ND		ug/L	0.46	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
Aroclor-1254	ND		ug/L	0.46	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
Aroclor-1260	ND		ug/L	0.46	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
Decachlorobiphenyls (S)	36		%	30 - 150	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
Tetrachloro-m-xylene (S)	46.9		%	36 - 112	EPA 608	11/14/15	GEC	11/17/15 20:35	RWS	V
WET CHEMISTRY										
Ammonia-N	5.93		mg/L	0.100	D6919-09			11/12/15 17:43	JAM	A
Biochemical Oxygen Demand	126		mg/L	2.0	S5210B-11			11/11/15 16:30	GMM	B
Carbonaceous BOD	76.9	1	mg/L	2.0	S5210B-11			11/11/15 06:30	GMM	B
Carbonaceous BOD 20 Day	101		mg/L	2.0	S5210B-11			11/11/15 11:20	RMM	B
Cyanide, Total	ND		mg/L	0.0050	EPA 335.4	11/11/15	MMA	11/13/15 09:53	SYB	F
Dissolved Oxygen	ND		mg/L	1.0	S4500OG-01			11/16/15 08:00	RMM	B
Halogen, Total Organic (TOX)	41.8		ug/L	20.0	SW846 9020B			11/18/15 13:29	PAG	M
Hexavalent Chromium	ND		mg/L	0.010	S3500CrB-09			11/10/15 23:37	MSA	B
Nitrate-N	ND		mg/L	0.20	EPA 300.0			11/11/15 17:20	FSC	B
Nitrite-N	ND		mg/L	0.20	EPA 300.0			11/11/15 17:20	FSC	B
Odor	20		T.O.N.	1	S2150B-97			11/10/15 23:36	MSA	L
Oil/Grease Hexane Extractable	12.0		mg/L	2.2	EPA 1664B			11/15/15 13:20	AT	G
Oil/Grease Silica Gel Treated	ND		mg/L	2.2	EPA 1664B			11/15/15 13:20	AT	G
Phenolics	0.010		mg/L	0.005	EPA 420.4	11/19/15	AMH	11/25/15 15:32	AMH	I
Phosphorus, Total	2.4		mg/L	0.10	EPA 365.1	11/16/15	NV	11/20/15 13:05	C_W	A
Sulfide, Total	ND		mg/L	1.0	S4500S2F-00			11/12/15 14:30	THB	K
Surfactants (MBAS)	0.357		mg/L	0.025	S5540C-00			11/11/15 03:30	MBW	J
Total Dissolved Solids	173		mg/L	5	S2540C-11			11/12/15 12:42	ML	B
Total Kjeldahl Nitrogen	13.4		mg/L	4.0	S4500NH3G-11	11/11/15	J1H	11/11/15 13:31	DRM	A
Total Nitrogen	13.4		mg/L	1.00	Calculation			11/22/15 15:33	NJA	A
Total Suspended Solids	222		mg/L	5	S2540D-11			11/11/15 21:56	NV	B
Turbidity	69.2		NTU	0.10	S2130B-01			11/11/15 00:00	MSA	B
METALS										
Hardness	93.7		mg/L	1.7	EPA 200.7	11/11/15	JPS	11/12/15 09:58	TSS	O1
Aluminum, Total	1.8		mg/L	0.040	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Antimony, Total	0.0014		mg/L	0.0010	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Arsenic, Total	ND		mg/L	0.0015	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2107040 CSO WW LTCP

Lab ID: **2107040001** Date Collected: 11/10/2015 05:00 Matrix: Water

Sample ID: **CPS/EPS1 (74/26)** Date Received: 11/10/2015 12:05

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
Cadmium, Total	ND		mg/L	0.00050	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Chromium, Total	0.0045		mg/L	0.0010	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Copper, Total	0.056		mg/L	0.0025	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Iron, Total	3.7		mg/L	0.15	EPA 200.7	11/11/15	JPS	11/12/15 09:58	TSS	O1
Lead, Total	0.021		mg/L	0.0010	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Mercury, Total	0.00025		mg/L	0.00020	EPA 245.1	11/23/15	MNP	11/23/15 09:41	MNP	O3
Molybdenum, Total	0.0022		mg/L	0.0010	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Selenium, Total	ND		mg/L	0.0020	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Silver, Total	ND		mg/L	0.0010	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Thallium, Total	ND		mg/L	0.00050	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
Zinc, Total	0.13		mg/L	0.0025	EPA 200.8	11/12/15	JPS	11/13/15 04:07	ZMC	O2
MICROBIOLOGY										
Enterococcus	68700		col/100mL	100	S9230D			11/10/15 12:14	LLJ	Q
Fecal Coliform	3600000	2	col/100mL	100000	S9222D-97			11/10/15 14:50	LLJ	P
Sub'd to NELAP CERTIFIED Lab										
Gross Alpha	0.00		pCi/L		EPA 900.0			11/24/15 09:30	SUB	X
Gross Alpha Uncertainty +/-	1.10		pCi/L		EPA 900.0			11/24/15 09:30	SUB	X
Gross Beta	8.20		pCi/L		EPA 900.0			11/24/15 09:30	SUB	X
Gross Beta Uncertainty +/-	2.10		pCi/L		EPA 900.0			11/24/15 09:30	SUB	X

Mr. Brad W Kintzer
Project Coordinator

PARAMETER QUALIFIERS

Lab ID	#	Sample ID	Analytical Method	Analyte
2107040001	1	CPS/EPS1 (74/26)	S5210B-11	Carbonaceous BOD
The laboratory control sample associated with this analysis was recovered at 83% which is outside the acceptance limit of 86% to 114%. Reanalysis was not performed due to holding time restrictions.				
2107040001	2	CPS/EPS1 (74/26)	S9222D-97	Fecal Coliform
Analyte was analyzed past the 8 hour holding time.				

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CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

BWK

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC
ALS

2107040

1 of 2

Client Name: DELCORA
Address: 3201 W. Front Street
Chester PA 19013
Contact: Mike Krause
Phone#: 610-876-5523 x218
Project Name/#: CSO WW LTCP
Bill To: Same

TAT [x] Normal-Standard TAT is 10-12 business days.
[ ] Rush-Subject to ALS approval and surcharges.
Date Required: _____ Approved By: _____
Email? [x] -Y
Fax? [ ] -Y No.:

Container Type	plastic	plastic	plastic	plastic	plastic	plastic	glass	glass	glass	plastic
Container Size	250ml	1L	500ml	500ml	120ml	120ml	1L	1L	40ml	1L
Preservative	H/Zn(O2C	none	HNO3	none	Na2S2O3	Na2S2O3	none	none	none	None

ANALYSES/METHOD REQUESTED

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Total Sulfide	CBOD5, CBOD20, BOD5	Metals, Total Hardness	Hexavalent Chromium, Triavalent Chromium	Fecal Coliform	Enterococcus	608	625	624	Gross Alpha/ Beta
1 CPS/ EPS1 (74/26)	11/10/15	5:00	G	WW	1	2	1	1	1	1	2	2	2	1
2														
3														
4														
5														
6														
7														
8														
9														
10														

Enter Number of Containers Per Sample or Field Results Below.

Cooler Temp: 2° Therm ID: TH-294
No. of Coolers: _____

	Y	N	Initial
Custody Seals Present?		✓	
(If present) Seals Intact?			
Received on Ice?	✓		
COC/Labels Complete/Accurate?	✓		
Cont. in Good Cond.?	✓		
Correct Containers?	✓		
Correct Sample Volumes?	✓		
Correct Preservation?	✓		
Headspace/Volatiles?		✓	

Courier/Tracking #:

Sample/COC Comments

ALS Field Services: [x] Pickup __Labor __Composite Sampling __Rental Equipment __Other:

Project Comments:

LOGGED BY(signature): [signature] DATE 11/10/15 TIME 1452
REVIEWED BY(signature): DATE TIME

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1 Raymond Rice	11/10/15	1000	2 [signature]	11/10	1000
3 [signature]	11/10	1045	4 [signature] ALS	11/10/15	1045
5 [signature] ALS	11/10/15	1205	6 [signature] ALS	11/10	1205
7			8		
9			10		

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE [ ]

Special Processing: USACE [ ] Navy [ ] [ ]

State Samples Collected In: [ ] NY [ ] NJ [x] PA [ ] NC [ ]

Reportable to PADEP? Yes [ ]
PWSID #

Sample Disposal: Lab [ ] Special [ ]

EDDS: Format Type-

* G=Grab; C=Composite **Matrix - AI=Air; DW=Drinking Water; GW=Groundwater; OI=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

ALS ENVIRONMENTAL SHIPPING ADDRESS: 34 DOGWOOD LANE, MIDDLETOWN, PA 17057

Rev 10/11

ALS Environmental
34 Dogwood Lane
Middletown, PA 17057
P. 717-944-5541
F.717-944-1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: 210240 — 2 of 2
ALS Quote #: 514787

Client Name: DELCORA
Address: 3201 W. Front Street
Chester PA 19013
Contact: Mike Krause
Phone#: 610-876-5523 x218
Project Name/#: CSO WW LTCP
Bill To: Same

TAT [X] Normal-Standard TAT is 10-12 business days. [ ] Rush-Subject to ALS approval and surcharges.
Date Required: _____ Approved By: _____
Email? [X] -Y
Fax? [ ] -Y No.: _____

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Container Type	Container Size	Preservative	Oil and Grease	TPH	Nitrate, Nitrite, Turbidity	Total Cyanide	Total Phosphorus, Ammonia, TKN, Total Nitrogen	Phenolics	TOX	TSS, TDS, DO	Odor	MBAS
					glass	glass	plastic	plastic	plastic	glass	glass	plastic	glass	plastic			
					1L	1L	500ml	500ml	1L	500ml	250ml	1L	1L	2L			
					H2SO4	H2SO4	none	NaOH	H2SO4	H2SO4	H2SO4	none	none	none			
					ANALYSES/METHOD REQUESTED												
					Enter Number of Containers Per Sample or Field Results Below.												
1 CPS/ EPS1 (74/26)	11/10/15	5:00	G	WW	1	1	1	1	1	1	2	1	1	1			
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Receipt Information (completed by Receiving Lab)
Cooler Temp: 2°C Therm ID: TH-294
No. of Coolers: _____

	Y	N	Initial
Custody Seals Present?			
(if present) Seals Intact?			
Received on Ice?	✓		
COC/Labels Complete/Accurate?	✓		
Cont. in Good Cond.?	✓		
Correct Containers?	✓		
Correct Sample Volumes?	✓		
Correct Preservation?	✓		
Headspace/Volatiles?			

Courier/Tracking #:

Sample/COC Comments

ALS Field Services: Pickup Labor
Composite Sampling Rental Equipment
Other: _____

Project Comments:

LOGGED BY(signature): [signature] DATE 11/10/15 TIME 1452
REVIEWED BY(signature): [signature] DATE 11/10/15 TIME

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE [ ]
Special Processing: USACE [ ] Navy [ ] [ ]
State Samples Collected In: [ ] NY [ ] NJ [X] PA [ ] NC [ ]
Reportable to PADEP? Yes [ ]
PWSID # _____
Sample Disposal: Lab [ ] Special [ ]
EDDS: Format Type- _____

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1 Raymond Rios	11/10/15	1000	2 [signature]	11-10	1000
3 [signature] ALS 4th 4/10	11-10	1645	4 [signature] ALS	11/10/15	1645
5 [signature] ALS	11/10/15	1265	6 [signature] ALS	11/10/15	1265
7			8		
9			10		

* G=Grab; C=Composite
**Matrix - AI=Air; DW=Drinking Water; GW=Groundwater; OI=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

ALS ENVIRONMENTAL SHIPPING ADDRESS: 34 DOGWOOD LANE, MIDDLETOWN, PA 17057

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Environmental • Industrial Hygiene • Field Services
34 Dogwood Lane • Middletown, PA 17057 • 717.944.5541 • Fax: 717.944.1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: 1 of 1

ALSI Quote #:

Client Name: ALS Environmental

Address: 34 Dogwood Lane
Middletown, PA 17057

Contact: Brad Kintzer

Phone#: (717) 944-5541

Project Name/#:

Bill To: ALS Environmental

TAT [X] Normal-Standard TAT is 10-12 business days.
[ ] Rush-Subject to ALSI approval and surcharges.

Date Required: _____ Approved By: _____

Email? [X] -Y ALMDT.Subcontract@ALSGlobal.com

Fax? [ ] -Y No.: _____

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Container Type	Container Size	Preservative	Gross Alpha & Beta								
					Plastic	1 L	NONE	ANALYSES/METHOD REQUESTED								
1 2107040 001	11/10/15	0500	G	WW				1								
2																
3																
4																
5																
6																
7																
8																
9																
10																

Receipt Information (completed by Receiving Lab)

Cooler Temp: _____ Therm. ID: _____

No. of Coolers: _____

	Y	N	Initial
Custody Seals Present?			
(if present) Seals Intact?			
Received on Ice?			
COC/Labels Complete/Accurate?			
Cont. in Good Cond.?			
Correct Containers?			
Correct Sample Volumes?			
Correct Preservation?			
Headspace/Volatiles?			

Courier tracking #: _____

Sample/COC Comments

Subcontract: ALS Ft. Collins

ALSI Field Services: ☐Pickup ☐Labor
☐Composite Sampling ☐Rental Equipment
☐Other: _____

Project Comments:

LOGGED BY(signature): _____ Date: _____ Time: _____

REVIEWED BY(signature): _____ Date: _____ Time: _____

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1	11/11/15	1530	2		
3			4		
5			6		
7			8		
9			10		

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE

Special Processing: USACE [ ] Navy [ ]

State Samples Collected In: [ ] NY [ ] NJ [ ] PA [ ] NC [ ] other

Reportable to PADEP? Yes [ ]

PWSID #: _____

Sample Disposal: Lab [ ] Special [ ]

EDDs: Format Type: _____

* G=Grab; C=Composite **Matrix - AI=Air; DW=Drinking Water; GW=Groundwater; OI=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

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Rev 5/05

ALS

Monday, November 30, 2015

Brad Kintzer
ALS Environmental
34 Dogwood Lane
Middletown, PA 17057

Re: ALS Workorder: 1511233
Project Name:
Project Number: 2107040

Dear Mr. Kintzer:

One water sample was received from ALS Environmental, on 11/12/2015. The sample was scheduled for the following analysis:

Gross Alpha/Beta

The results for these analyses are contained in the enclosed reports.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Thank you for your confidence in ALS Environmental. Should you have any questions, please call.

Sincerely,

ALS Environmental
Jeff R. Kujawa
Project Manager

ALS Environmental – Fort Collins is accredited by the following accreditation bodies for various testing scopes in accordance with requirements of each accreditation body. All testing is performed under the laboratory management system, which is maintained to meet these requirement and regulations. Please contact the laboratory or accreditation body for the current scope testing parameters.

ALS Environmental – Fort Collins	
Accreditation Body	License or Certification Number
Alaska (AK)	UST-086
Alaska (AK)	CO01099
Arizona (AZ)	AZ0742
California (CA)	06251CA
Colorado (CO)	CO01099
Connecticut (CT)	PH-0232
Florida (FL)	E87914
Idaho (ID)	CO01099
Kansas (KS)	E-10381
Kentucky (KY)	90137
L-A-B (DoD ELAP/ISO 170250)	L2257
Louisiana (LA)	05057
Maryland (MD)	285
Missouri (MO)	175
Nebraska(NE)	NE-OS-24-13
Nevada (NV)	CO000782008A
New York (NY)	12036
North Dakota (ND)	R-057
Oklahoma (OK)	1301
Pennsylvania (PA)	68-03116
Tennessee (TN)	2976
Texas (TX)	T104704241
Utah (UT)	CO01099
Washington (WA)	C1280

ALS Environmental

1511233

Gross Alpha/Beta:
The samples were analyzed for gross alpha and beta activity by gas flow proportional counting according to the current revision of SOP 724. Gross alpha results are referenced to ^{241}Am. Gross beta results are referenced to $^{90}Sr/Y$.

All acceptance criteria were met.

ALS Environmental -- FC

Sample Number(s) Cross-Reference Table

OrderNum: 1511233
Client Name: ALS Environmental
Client Project Name:
Client Project Number: 2107040
Client PO Number: 2107040

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
2107040001	1511233-1		WATER	10-Nov-15	5:00

Analytical Laboratory Services, Inc.
Environmental • Industrial Hygiene • Field Services
34 Dogwood Lane • Middletown, PA 17057 • 717.944.5541 • Fax: 717.944.1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: 151233 | 1 of 1
ALSI Quote #:

Client Name: ALS Environmental
Address: 34 Dogwood Lane, Middletown, PA 17057
Contact: Brad Kintzer
Phone#: (717) 944-5541
Project Name/#:
Bill To: ALS Environmental

TAT: [X] Normal-Standard TAT is 10-12 business days. [ ] Rush-Subject to ALSI approval and surcharges.
Date Required: ASAP Approved By:
Email? [X] Y ALMDT.Subcontract@ALSGlobal.com
Fax? [ ] Y No

	Container Type	Container Size	Preservative
	Plastic	1 L	NONE

ANALYSES/METHOD REQUESTED: Gross Alpha & Beta

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Gross Alpha & Beta
1 2107040 001	11/10/15	0500	G	WW	1
2					
3					
4					
5					
6					
7					
8					
9					
10					

Project Comments:

LOGGED BY(signature): Date: Time:
REVIEWED BY(signature): Date: Time:

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1	11/11/15	1530	2 ALS FC	11-12-15	0940
3			4		
5			6		
7			8		
9			10		

Receipt Information (completed by Receiving Lab)
Cooler Temp: ____ Therm. ID: ____
No. of Coolers: ____

	Y	N	Initial
Custody Seals Present?			
(If present) Seals Intact?			
Received on Ice?			
COC/Labels Complete/Accurate?			
Cont. in Good Cond.?			
Correct Containers?			
Correct Sample Volumes?			
Correct Preservation?			
Headspace/Volatiles?			

Lounen tracking #:

Sample/COC Comments
Subcontract: ALS Ft. Collins

ALSI Field Services: ☐Pickup ☐Labor ☐Composite Sampling ☐Rental Equipment ☐Other:

Data Deliverables: [ ] Standard (Level) [ ] CLP-like [ ] USACE
Special Processing: [ ] USACE [ ] Navy [ ]
State Samples Collected In: [ ] NY [ ] NJ [ ] PA [ ] NC [ ] Other
Reportable to PADEP? [ ] Yes [ ]
PWSID #:
Sample Disposal: [ ] Lab [ ] Special
EDDs: Format Type:

* G=Grab; C=Composite
**Matrix - Al=Air; DW=Drinking Water; GW=Groundwater; Ol=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

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ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: ALS PA Workorder No: 1511233

Project Manager: SRK Initials: SOM Date: 11-12-15

1. Does this project require any special handling in addition to standard ALS procedures?		YES	(NO)
2. Are custody seals on shipping containers intact?	(NONE)	YES	NO
3. Are Custody seals on sample containers intact?	(NONE)	YES	NO
4. Is there a COC (Chain-of-Custody) present or other representative documents?		(YES)	NO
5. Are the COC and bottle labels complete and legible?		(YES)	NO
6. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)		(YES)	NO
7. Were airbills / shipping documents present and/or removable?	DROP OFF	(YES)	NO
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	N/A	(YES)	NO
9. Are all aqueous non-preserved samples pH 4-9?	(N/A)	YES	NO
10. Is there sufficient sample for the requested analyses?		(YES)	NO
11. Were all samples placed in the proper containers for the requested analyses?		(YES)	NO
12. Are all samples within holding times for the requested analyses?		(YES)	NO
13. Were all sample containers received intact? (not broken or leaking, etc.)		(YES)	NO
14. Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: ____ < green pea ____ > green pea	(N/A)	YES	NO
15. Do any water samples contain sediment? Amount of sediment: X dusting ____ moderate ____ heavy	N/A	(YES)	NO
16. Were the samples shipped on ice?		YES	(NO)
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #2 #4	(GRD ONLY)	YES	NO

Cooler #:	1							
Temperature (°C):	Amb							
No. of custody seals on cooler:	0							
DOT Survey/ Acceptance Information: External µR/hr reading:	11							
DOT Survey/ Acceptance Information: Background µR/hr reading:	12							

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? (YES) NO / NA (If no, see Form 008.)

Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EXCEPT #1 AND #16.

⇒ 15.) light dusting of sediment.

If applicable, was the client contacted? YES / NO (NA) Contact: _____ Date/Time: _____

Project Manager Signature / Date: [signature] 11-12-15

*IR Gun #2: Oakton, SN 29922500201-0066
*IR Gun #4: Oakton, SN 2372220101-0002

Form 201r24.xls (06/04/2012)

Client:	ALS Environmental	**Date:**	*30-Nov-15*
Project:	2107040	**Work Order:**	1511233
Sample ID:	2107040001	**Lab ID:**	1511233-1
Legal Location:		**Matrix:**	WATER
Collection Date:	11/10/2015 05:00	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gross Alpha/Beta by GFPC			**PAI 724**		Prep Date: **11/20/2015**	PrepBy: **ECP**
GROSS ALPHA	ND (+/- 1.1)	U	2.6	pCi/l	NA	11/24/2015 09:30
GROSS BETA	**8.2 (+/- 2.1)**		**2.8**	**pCi/l**	NA	11/24/2015 09:30

Client:	ALS Environmental	**Date:**	*30-Nov-15*
Project:	2107040	**Work Order:**	1511233
Sample ID:	2107040001	**Lab ID:**	1511233-1
Legal Location:		**Matrix:**	WATER
Collection Date:	11/10/2015 05:00	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed

Explanation of Qualifiers

Radiochemistry:

U or ND - Result is less than the sample specific MDC.
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
Y2 - Chemical Yield outside default limits.
W - DER is greater than Warning Limit of 1.42
* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'.
# - Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'.
G - Sample density differs by more than 15% of LCS density.
D - DER is greater than Control Limit
M - Requested MDC not met.
LT - Result is less than requested MDC but greater than achieved MDC.
M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.
L - LCS Recovery below lower control limit.
H - LCS Recovery above upper control limit.
P - LCS, Matrix Spike Recovery within control limits.
N - Matrix Spike Recovery outside control limits
NC - Not Calculated for duplicate results less than 5 times MDC
B - Analyte concentration greater than MDC.
B3 - Analyte concentration greater than MDC but less than Requested MDC.

Inorganics:

B - Result is less than the requested reporting limit but greater than the instrument method detection limit (MDL).
U or ND - Indicates that the compound was analyzed for but not detected.
E - The reported value is estimated because of the presence of interference. An explanatory note may be included in the narrative.
M - Duplicate injection precision was not met.
N - Spiked sample recovery not within control limits. A post spike is analyzed for all ICP analyses when the matrix spike and or spike duplicate fail and the native sample concentration is less than four times the spike added concentration.
Z - Spiked recovery not within control limits. An explanatory note may be included in the narrative.
* - Duplicate analysis (relative percent difference) not within control limits.
S - SAR value is estimated as one or more analytes used in the calculation were not detected above the detection limit.

Organics:

U or ND - Indicates that the compound was analyzed for but not detected.
B - Analyte is detected in the associated method blank as well as in the sample. It indicates probable blank contamination and warns the data user.
E - Analyte concentration exceeds the upper level of the calibration range.
J - Estimated value. The result is less than the reporting limit but greater than the instrument method detection limit (MDL).
A - A tentatively identified compound is a suspected aldol-condensation product.
X - The analyte was diluted below an accurate quantitation level.
* - The spike recovery is equal to or outside the control criteria used.
+ - The relative percent difference (RPD) equals or exceeds the control criteria.
G - A pattern resembling gasoline was detected in this sample.
D - A pattern resembling diesel was detected in this sample.
M - A pattern resembling motor oil was detected in this sample.
C - A pattern resembling crude oil was detected in this sample.
4 - A pattern resembling JP-4 was detected in this sample.
5 - A pattern resembling JP-5 was detected in this sample.
H - Indicates that the fuel pattern was in the heavier end of the retention time window for the analyte of interest.
L - Indicates that the fuel pattern was in the lighter end of the retention time window for the analyte of interest.
Z - This flag indicates that a significant fraction of the reported result did not resemble the patterns of any of the following petroleum hydrocarbon products:
- gasoline
- JP-8
- diesel
- mineral spirits
- motor oil
- Stoddard solvent
- bunker C

Batch ID: **AB151120-1-5** Instrument ID **LB4100-C** Method: **Gross Alpha/Beta by GFPC**

LCS Sample ID: **AB151120-1** Units: **pCi/l** Analysis Date: **11/24/2015 09:30**

Client ID: Run ID: **AB151120-1A** Prep Date: **11/20/2015** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
GROSS ALPHA	248 (+/- 41)	3	225.4		110	70-130					P
GROSS BETA	201 (+/- 33)	5	203.9		98.7	70-130					P,M3

MB Sample ID: **AB151120-1** Units: **pCi/l** Analysis Date: **11/24/2015 15:01**

Client ID: Run ID: **AB151120-1A** Prep Date: **11/20/2015** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
GROSS ALPHA	ND	0.94									U
GROSS BETA	ND	1.08									U

The following samples were analyzed in this batch: 1511233-1

ALS Environmental

34 Dogwood Lane ■ Middletown, PA 17057 ■ Phone: 717-944-5541 ■ Fax: 717-944-1430 ■ www.alsglobal.com

NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

December 16, 2015

Ms. Irene Fitzgerald
DELCORA
P.O. Box 999
Chester, PA 19016

Certificate of Analysis

Project Name:	**2015-LOWER DELAWARE TESTING**	Workorder:	**2109302**
Purchase Order:		Workorder ID:	**2015-LOWER DELAWARE TESTING**

Dear Ms. Fitzgerald:

Enclosed are the analytical results for samples received by the laboratory on Thursday, November 19, 2015.

The ALS Environmental laboratory in Middletown, Pennsylvania is a National Environmental Laboratory Accreditation Program (NELAP) accredited laboratory and as such, certifies that all applicable test results meet the requirements of NELAP.

If you have any questions regarding this certificate of analysis, please contact Mr. Brad W Kintzer (Project Coordinator) at (717) 944-5541.

Analyses were performed according to our laboratory's NELAP-approved quality assurance program and any applicable state requirements. The test results meet requirements of the current NELAP standards or state requirements, where applicable. For a specific list of accredited analytes, refer to the certifications section of the ALS website at www.alsglobal.com/en/Our-Services/Life-Sciences/Environmental/Downloads.

This laboratory report may not be reproduced, except in full, without the written approval of ALS Environmental.

ALS Spring City: 10 Riverside Drive, Spring City, PA 19475 610-948-4903

CC: Mr. Ray Rios , Mr. Mike Krause

This page is included as part of the Analytical Report and must be retained as a permanent record thereof.

Brad W. Kintzer

Mr. Brad W Kintzer
Project Coordinator

ALS Environmental

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NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

SAMPLE SUMMARY

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID	Sample ID	Matrix	Date Collected	Date Received	Collected By
2109302001	CPS/EPS1 (72/28)	Water	11/19/2015 15:20	11/19/2015 21:10	Collected by Client
2109302002	CPS1	Water	11/19/2015 15:20	11/19/2015 21:10	Collected by Client
2109302003	14th & Crozer	Water	11/19/2015 15:10	11/19/2015 21:10	Collected by Client
2109302004	Sun & Hancock	Water	11/19/2015 16:10	11/19/2015 21:10	Collected by Client

Notes

-- Samples collected by ALS personnel are done so in accordance with the procedures set forth in the ALS Field Sampling Plan (20 - Field Services Sampling Plan).
-- All Waste Water analyses comply with methodology requirements of 40 CFR Part 136.
-- All Drinking Water analyses comply with methodology requirements of 40 CFR Part 141.
-- Unless otherwise noted, all quantitative results for soils are reported on a dry weight basis.
-- The Chain of Custody document is included as part of this report.
-- All Library Search analytes should be regarded as tentative identifications based on the presumptive evidence of the mass spectra. Concentrations reported are estimated values.
-- Parameters identified as "analyze immediately" require analysis within 15 minutes of collection. Any "analyze immediately" parameters not listed under the header "Field Parameters" are preformed in the laboratory and are therefore analyzed out of hold time.
-- Method references listed on this report beginning with the prefix “S” followed by a method number (such as S2310B-97) refer to methods from “Standard Methods for the Examination of Water and Wastewater”.

Standard Acronyms/Flags

J	Indicates an estimated value between the Method Detection Limit (MDL) and the Practical Quantitation Limit (PQL) for the analyte
U	Indicates that the analyte was Not Detected (ND)
N	Indicates presumptive evidence of the presence of a compound
MDL	Method Detection Limit
PQL	Practical Quantitation Limit
RDL	Reporting Detection Limit
ND	Not Detected - indicates that the analyte was Not Detected at the RDL
Cntr	Analysis was performed using this container
RegLmt	Regulatory Limit
LCS	Laboratory Control Sample
MS	Matrix Spike
MSD	Matrix Spike Duplicate
DUP	Sample Duplicate
%Rec	Percent Recovery
RPD	Relative Percent Difference
LOD	DoD Limit of Detection
LOQ	DoD Limit of Quantitation
DL	DoD Detection Limit
I	Indicates reported value is greater than or equal to the Method Detection Limit (MDL) but less than the Report Detection Limit (RDL)
(S)	Surrogate Compound
NC	Not Calculated
*	Result outside of QC limits

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PROJECT SUMMARY

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Workorder Comments

See attached subcontracted radiological results from ALS-Ft. Collins. VLF

Sample Comments

Lab ID: 2109302001 **Sample ID:** CPS/EPS1 (72/28) **Sample Type:** SAMPLE

MBAS calculated as LAS molecular weight 342 g/mol.

The reporting limits for GCMS volatile analytes were raised due to the dilution of the sample caused by matrix.

Lab ID: 2109302002 **Sample ID:** CPS1 **Sample Type:** SAMPLE

MBAS calculated as LAS molecular weight 342 g/mol.

The reporting limits for GCMS volatile analytes were raised due to the dilution of the sample caused by matrix.

Lab ID: 2109302003 **Sample ID:** 14th **Sample Type:** SAMPLE

MBAS calculated as LAS molecular weight 342 g/mol.

The reporting limits for GCMS volatile analytes were raised due to the dilution of the sample caused by matrix.

Lab ID: 2109302004 **Sample ID:** Sun **Sample Type:** SAMPLE

MBAS calculated as LAS molecular weight 342 g/mol.

The reporting limits for GCMS volatile analytes were raised due to the dilution of the sample caused by matrix.

ALS Environmental

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302001** Date Collected: 11/19/2015 15:20 Matrix: Water

Sample ID: **CPS/EPS1 (72/28)** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
VOLATILE ORGANICS										
Benzene	ND		ug/L	5.0	EPA 624			11/21/15 20:54	CJG	S
Bromodichloromethane	ND		ug/L	5.0	EPA 624			11/21/15 20:54	CJG	S
Chlorodibromomethane	ND		ug/L	5.0	EPA 624			11/21/15 20:54	CJG	S
Chloroform	ND		ug/L	5.0	EPA 624			11/21/15 20:54	CJG	S
Ethylbenzene	ND		ug/L	5.0	EPA 624			11/21/15 20:54	CJG	S
Methyl t-Butyl Ether	ND		ug/L	5.0	EPA 624			11/21/15 20:54	CJG	S
Methylene Chloride	ND		ug/L	5.0	EPA 624			11/21/15 20:54	CJG	S
Tetrachloroethene	ND		ug/L	5.0	EPA 624			11/21/15 20:54	CJG	S
Toluene	ND		ug/L	5.0	EPA 624			11/21/15 20:54	CJG	S
Total Xylenes	ND		ug/L	15.0	EPA 624			11/21/15 20:54	CJG	S
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
1,2-Dichloroethane-d4 (S)	96.4		%	72 - 142	EPA 624			11/21/15 20:54	CJG	S
4-Bromofluorobenzene (S)	110		%	73 - 119	EPA 624			11/21/15 20:54	CJG	S
Dibromofluoromethane (S)	88.4		%	74 - 132	EPA 624			11/21/15 20:54	CJG	S
Toluene-d8 (S)	98.8		%	75 - 133	EPA 624			11/21/15 20:54	CJG	S
SEMIVOLATILES										
Benzo(a)anthracene	ND		ug/L	1.4	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
Chrysene	ND		ug/L	1.4	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
bis(2-Ethylhexyl)phthalate	20.3		ug/L	2.8	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
N-Nitroso-di-n-propylamine	ND		ug/L	2.8	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
Phenanthrene	ND		ug/L	1.4	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
2,4,6-Tribromophenol (S)	95.9		%	47 - 128	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
2-Fluorobiphenyl (S)	74.4		%	52 - 118	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
2-Fluorophenol (S)	38.9		%	20 - 87	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
Nitrobenzene-d5 (S)	84.5		%	27 - 139	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
Phenol-d5 (S)	27		%	10 - 81	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
Terphenyl-d14 (S)	71.2		%	46 - 133	EPA 625	11/25/15	VLM	11/29/15 22:53	GEC	U
Pesticides and PCBs										
Dieldrin	0.022		ug/L	0.019	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
Total Polychlorinated Biphenyl	0.0		ug/L		EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
Aroclor-1016	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
Aroclor-1221	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
Aroclor-1232	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
Aroclor-1242	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302001** Date Collected: 11/19/2015 15:20 Matrix: Water

Sample ID: **CPS/EPS1 (72/28)** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
Aroclor-1248	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
Aroclor-1254	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
Aroclor-1260	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
Decachlorobiphenyls (S)	35.7		%	30 - 150	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
Tetrachloro-m-xylene (S)	52.6		%	36 - 112	EPA 608	11/20/15	JSR	11/23/15 20:34	KJH	W
WET CHEMISTRY										
Ammonia-N	7.36		mg/L	0.100	D6919-09			11/20/15 16:33	JAM	A
Biochemical Oxygen Demand	140	1	mg/L	2.0	S5210B-11			11/20/15 23:22	NAK	B
Carbonaceous BOD	145	2	mg/L	2.0	S5210B-11			11/21/15 06:35	GMM	B
Carbonaceous BOD 20 Day	38.8		mg/L	2.0	S5210B-11			11/21/15 09:00	RMM	B
Cyanide, Total	ND		mg/L	0.0050	EPA 335.4	11/23/15	MMA	11/25/15 05:30	LJF	G
Dissolved Oxygen	2.4		mg/L	1.0	S4500OG-01			11/25/15 06:50	RMM	B
Halogen, Total Organic (TOX)	35.1		ug/L	20.0	SW846 9020B			11/30/15 14:02	PAG	N
Hexavalent Chromium	ND		mg/L	0.010	S3500CrB-09			11/20/15 04:56	MSA	B
Nitrate-N	ND		mg/L	0.50	EPA 300.0			11/20/15 15:08	FSC	B
Nitrite-N	ND		mg/L	0.50	EPA 300.0			11/20/15 15:08	FSC	B
Odor	40		T.O.N.	1	S2150B-97			11/21/16 10:12	MSA	M
Oil/Grease Hexane Extractable	15.0		mg/L	2.0	EPA 1664B			11/22/15 12:00	AT	H
Oil/Grease Silica Gel Treated	3.4		mg/L	2.0	EPA 1664B			11/22/15 12:00	AT	H
Phenolics	0.024		mg/L	0.005	EPA 420.4	12/9/15	NV	12/10/15 16:34	AMH	J
Phosphorus, Total	2.5		mg/L	0.10	EPA 365.1	12/7/15	LJF	12/8/15 04:21	LJF	A
Sulfide, Total	ND		mg/L	1.0	S4500S2F-00			11/25/15 21:15	DRM	L
Surfactants (MBAS)	0.652		mg/L	0.025	S5540C-00			11/21/15 05:00	MBW	K
Total Dissolved Solids	232		mg/L	5	S2540C-11			11/24/15 09:45	ML	B
Total Kjeldahl Nitrogen	19.1		mg/L	4.0	S4500NH3G-11	11/25/15	J1H	11/29/15 11:40	NJA	A
Total Nitrogen	19.1		mg/L	1.00	Calculation			12/2/15 14:27	NJA	A
Total Suspended Solids	532	3	mg/L	5	S2540D-11			11/29/15 18:05	NV	B
Turbidity	117		NTU	0.10	S2130B-01			11/21/15 07:01	MSA	B
METALS										
Hardness	94.9		mg/L	1.7	EPA 200.7	11/23/15	JPS	11/24/15 16:59	TSS	P1
Aluminum, Total	1.4		mg/L	0.20	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2
Antimony, Total	ND		mg/L	0.0010	EPA 200.8	11/29/15	JPS	12/1/15 12:34	MO	P3
Arsenic, Total	ND		mg/L	0.0075	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2

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ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302001** Date Collected: 11/19/2015 15:20 Matrix: Water

Sample ID: **CPS/EPS1 (72/28)** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
Cadmium, Total	ND		mg/L	0.0025	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2
Chromium, Total	ND		mg/L	0.0050	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2
Copper, Total	0.075		mg/L	0.013	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2
Iron, Total	2.9		mg/L	0.15	EPA 200.7	11/23/15	JPS	11/24/15 16:59	TSS	P1
Lead, Total	0.027		mg/L	0.0050	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2
Mercury, Total	0.00029		mg/L	0.00020	EPA 245.1	12/3/15	MNP	12/3/15 14:07	MNP	P4
Molybdenum, Total	0.0011		mg/L	0.0010	EPA 200.8	11/29/15	JPS	12/1/15 12:34	MO	P3
Selenium, Total	ND		mg/L	0.010	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2
Silver, Total	ND		mg/L	0.0050	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2
Thallium, Total	ND		mg/L	0.0025	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2
Zinc, Total	0.22		mg/L	0.013	EPA 200.8	11/23/15	JPS	11/24/15 03:21	ZMC	P2
MICROBIOLOGY										
Enterococcus	199000		col/100mL	100	S9230D			11/19/15 21:58	ABL	R
Fecal Coliform	3200000		col/100mL	100000	SM9222D+EPA 625/R-92/013 APX F			11/19/15 22:24	ABL	Q
Sub'd to NELAP CERTIFIED Lab										
Gross Alpha	ND		pCi/L	2.70	EPA 900.0			12/2/15 12:07	SUB	Y
Gross Alpha Uncertainty +/-	1.60		pCi/L		EPA 900.0			12/2/15 12:07	SUB	Y
Gross Beta	9.00		pCi/L	2.70	EPA 900.0			12/2/15 12:07	SUB	Y
Gross Beta Uncertainty +/-	2.20		pCi/L		EPA 900.0			12/2/15 12:07	SUB	Y

Mr. Brad W Kintzer
Project Coordinator

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ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302002** Date Collected: 11/19/2015 15:20 Matrix: Water

Sample ID: **CPS1** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
VOLATILE ORGANICS										
Benzene	ND		ug/L	5.0	EPA 624			11/21/15 21:16	CJG	S
Bromodichloromethane	ND		ug/L	5.0	EPA 624			11/21/15 21:16	CJG	S
Chlorodibromomethane	ND		ug/L	5.0	EPA 624			11/21/15 21:16	CJG	S
Chloroform	ND		ug/L	5.0	EPA 624			11/21/15 21:16	CJG	S
Ethylbenzene	ND		ug/L	5.0	EPA 624			11/21/15 21:16	CJG	S
Methyl t-Butyl Ether	ND		ug/L	5.0	EPA 624			11/21/15 21:16	CJG	S
Methylene Chloride	ND		ug/L	5.0	EPA 624			11/21/15 21:16	CJG	S
Tetrachloroethene	ND		ug/L	5.0	EPA 624			11/21/15 21:16	CJG	S
Total Xylenes	ND		ug/L	15.0	EPA 624			11/21/15 21:16	CJG	S
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
1,2-Dichloroethane-d4 (S)	100		%	72 - 142	EPA 624			11/21/15 21:16	CJG	S
4-Bromofluorobenzene (S)	115		%	73 - 119	EPA 624			11/21/15 21:16	CJG	S
Dibromofluoromethane (S)	89.6		%	74 - 132	EPA 624			11/21/15 21:16	CJG	S
Toluene-d8 (S)	101		%	75 - 133	EPA 624			11/21/15 21:16	CJG	S
SEMIVOLATILES										
Benzo(a)anthracene	ND		ug/L	1.4	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
Chrysene	ND		ug/L	1.4	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
bis(2-Ethylhexyl)phthalate	12.0		ug/L	2.8	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
N-Nitroso-di-n-propylamine	ND		ug/L	2.8	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
Phenanthrene	ND		ug/L	1.4	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
2,4,6-Tribromophenol (S)	96.5		%	47 - 128	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
2-Fluorobiphenyl (S)	76.5		%	52 - 118	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
2-Fluorophenol (S)	45.3		%	20 - 87	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
Nitrobenzene-d5 (S)	90.8		%	27 - 139	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
Phenol-d5 (S)	30.9		%	10 - 81	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
Terphenyl-d14 (S)	71.2		%	46 - 133	EPA 625	11/25/15	VLM	11/29/15 23:18	GEC	U
Pesticides and PCBs										
Dieldrin	ND		ug/L	0.019	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
Total Polychlorinated Biphenyl	0.0		ug/L		EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
Aroclor-1016	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
Aroclor-1221	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
Aroclor-1232	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
Aroclor-1242	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
Aroclor-1248	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W

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ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302002** Date Collected: 11/19/2015 15:20 Matrix: Water

Sample ID: **CPS1** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
Aroclor-1254	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
Aroclor-1260	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
Decachlorobiphenyls (S)	29.1	4	%	30 - 150	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
Tetrachloro-m-xylene (S)	49.5		%	36 - 112	EPA 608	11/20/15	JSR	11/23/15 20:56	KJH	W
WET CHEMISTRY										
Ammonia-N	7.47		mg/L	0.100	D6919-09			11/21/15 01:03	JAM	A
Biochemical Oxygen Demand	57.7	1	mg/L	2.0	S5210B-11			11/20/15 23:22	NAK	B
Carbonaceous BOD	81.5	2	mg/L	2.0	S5210B-11			11/21/15 06:35	GMM	B
Carbonaceous BOD 20 Day	7.7		mg/L	2.0	S5210B-11			11/21/15 09:00	RMM	B
Cyanide, Total	ND		mg/L	0.0050	EPA 335.4	11/23/15	MMA	11/25/15 05:30	LJF	G
Dissolved Oxygen	2.5		mg/L	1.0	S4500OG-01			11/25/15 06:50	RMM	B
Halogen, Total Organic (TOX)	26.0		ug/L	20.0	SW846 9020B			11/30/15 15:46	PAG	N
Hexavalent Chromium	ND		mg/L	0.010	S3500CrB-09			11/20/15 04:56	MSA	B
Nitrate-N	ND		mg/L	0.50	EPA 300.0			11/20/15 15:21	FSC	B
Nitrite-N	ND		mg/L	0.50	EPA 300.0			11/20/15 15:21	FSC	B
Odor	30		T.O.N.	1	S2150B-97			11/21/16 10:12	MSA	M
Oil/Grease Hexane Extractable	14.8		mg/L	2.1	EPA 1664B			11/22/15 12:00	AT	H
Oil/Grease Silica Gel Treated	ND		mg/L	2.1	EPA 1664B			11/22/15 12:00	AT	H
Phenolics	0.068		mg/L	0.005	EPA 420.4	12/9/15	NV	12/10/15 16:35	AMH	J
Phosphorus, Total	2.1		mg/L	0.10	EPA 365.1	12/7/15	LJF	12/8/15 04:21	LJF	A
Sulfide, Total	1.3		mg/L	1.0	S4500S2F-00			11/25/15 21:15	DRM	L
Surfactants (MBAS)	0.557		mg/L	0.025	S5540C-00			11/21/15 05:00	MBW	K
Total Dissolved Solids	186		mg/L	5	S2540C-11			11/24/15 09:45	ML	B
Total Kjeldahl Nitrogen	21.2		mg/L	4.0	S4500NH3G-11	11/25/15	J1H	11/29/15 11:40	NJA	A
Total Nitrogen	21.2		mg/L	1.00	Calculation			12/2/15 14:27	NJA	A
Total Suspended Solids	108	3	mg/L	5	S2540D-11			11/29/15 18:05	NV	B
Turbidity	126		NTU	0.10	S2130B-01			11/21/15 07:01	MSA	B
METALS										
Hardness	85.2		mg/L	0.33	EPA 200.7	11/23/15	JPS	11/24/15 17:44	TSS	P1
Aluminum, Total	1.2		mg/L	0.20	EPA 200.8	11/23/15	JPS	11/24/15 03:25	ZMC	P2
Antimony, Total	ND		mg/L	0.0010	EPA 200.8	11/29/15	JPS	12/1/15 12:38	MO	P3
Arsenic, Total	ND		mg/L	0.0075	EPA 200.8	11/23/15	JPS	11/24/15 03:25	ZMC	P2
Cadmium, Total	ND		mg/L	0.0025	EPA 200.8	11/23/15	JPS	11/24/15 03:25	ZMC	P2

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ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302002** Date Collected: 11/19/2015 15:20 Matrix: Water

Sample ID: **CPS1** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
Chromium, Total	0.011		mg/L	0.0050	EPA 200.8	11/23/15	JPS	11/24/15 03:25	ZMC	P2
Copper, Total	0.042		mg/L	0.013	EPA 200.8	11/23/15	JPS	11/24/15 03:25	ZMC	P2
Iron, Total	2.9		mg/L	0.030	EPA 200.7	11/23/15	JPS	11/24/15 17:44	TSS	P1
Lead, Total	0.028		mg/L	0.0050	EPA 200.8	11/23/15	JPS	11/24/15 03:25	ZMC	P2
Mercury, Total	0.00020		mg/L	0.00020	EPA 245.1	12/3/15	MNP	12/3/15 14:08	MNP	P4
Molybdenum, Total	0.0013		mg/L	0.0010	EPA 200.8	11/29/15	JPS	12/1/15 12:38	MO	P3
Selenium, Total	ND		mg/L	0.010	EPA 200.8	11/23/15	JPS	11/24/15 03:25	ZMC	P2
Silver, Total	ND		mg/L	0.0010	EPA 200.8	11/29/15	JPS	12/1/15 12:38	MO	P3
Thallium, Total	ND		mg/L	0.0025	EPA 200.8	11/23/15	JPS	11/24/15 03:25	ZMC	P2
Zinc, Total	0.22		mg/L	0.0025	EPA 200.8	11/29/15	JPS	12/1/15 12:38	MO	P3
MICROBIOLOGY										
Enterococcus	>241960 COL/100 ML		col/100mL	100	S9230D			11/19/15 21:58	ABL	R
Fecal Coliform	2600000		col/100mL	100000	SM9222D+EPA 625/R-92/013 APX F			11/19/15 22:24	ABL	Q
Sub'd to NELAP CERTIFIED Lab										
Gross Alpha	2.70		pCi/L	2.10	EPA 900.0			12/2/15 12:07	SUB	Y
Gross Alpha Uncertainty +/-	1.40		pCi/L		EPA 900.0			12/2/15 12:07	SUB	Y
Gross Beta	7.80		pCi/L	2.70	EPA 900.0			12/2/15 12:07	SUB	Y
Gross Beta Uncertainty +/-	2.00		pCi/L		EPA 900.0			12/2/15 12:07	SUB	Y

Mr. Brad W Kintzer
Project Coordinator

ALS Environmental

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ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302003** Date Collected: 11/19/2015 15:10 Matrix: Water

Sample ID: **14th & Crozer** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
VOLATILE ORGANICS										
Benzene	ND		ug/L	5.0	EPA 624			11/21/15 21:38	CJG	S
Bromodichloromethane	ND		ug/L	5.0	EPA 624			11/21/15 21:38	CJG	S
Chlorodibromomethane	ND		ug/L	5.0	EPA 624			11/21/15 21:38	CJG	S
Chloroform	ND		ug/L	5.0	EPA 624			11/21/15 21:38	CJG	S
Ethylbenzene	ND		ug/L	5.0	EPA 624			11/21/15 21:38	CJG	S
Methyl t-Butyl Ether	ND		ug/L	5.0	EPA 624			11/21/15 21:38	CJG	S
Methylene Chloride	ND		ug/L	5.0	EPA 624			11/21/15 21:38	CJG	S
Tetrachloroethene	ND		ug/L	5.0	EPA 624			11/21/15 21:38	CJG	S
Toluene	ND		ug/L	5.0	EPA 624			11/21/15 21:38	CJG	S
Total Xylenes	ND		ug/L	15.0	EPA 624			11/21/15 21:38	CJG	S
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
1,2-Dichloroethane-d4 (S)	101		%	72 - 142	EPA 624			11/21/15 21:38	CJG	S
4-Bromofluorobenzene (S)	112		%	73 - 119	EPA 624			11/21/15 21:38	CJG	S
Dibromofluoromethane (S)	90		%	74 - 132	EPA 624			11/21/15 21:38	CJG	S
Toluene-d8 (S)	100		%	75 - 133	EPA 624			11/21/15 21:38	CJG	S
SEMIVOLATILES										
Benzo(a)anthracene	ND		ug/L	1.4	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
Chrysene	ND		ug/L	1.4	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
bis(2-Ethylhexyl)phthalate	4.4		ug/L	2.8	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
N-Nitroso-di-n-propylamine	ND		ug/L	2.8	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
Phenanthrene	ND		ug/L	1.4	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
2,4,6-Tribromophenol (S)	90.8		%	47 - 128	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
2-Fluorobiphenyl (S)	75		%	52 - 118	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
2-Fluorophenol (S)	40.3		%	20 - 87	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
Nitrobenzene-d5 (S)	86.7		%	27 - 139	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
Phenol-d5 (S)	27.4		%	10 - 81	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
Terphenyl-d14 (S)	69.3		%	46 - 133	EPA 625	11/25/15	VLM	11/29/15 21:38	GEC	U
Pesticides and PCBs										
Dieldrin	ND		ug/L	0.019	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
Total Polychlorinated Biphenyl	0.0		ug/L		EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
Aroclor-1016	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
Aroclor-1221	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
Aroclor-1232	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
Aroclor-1242	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302003** Date Collected: 11/19/2015 15:10 Matrix: Water

Sample ID: **14th & Crozer** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
Aroclor-1248	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
Aroclor-1254	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
Aroclor-1260	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
Decachlorobiphenyls (S)	46.9		%	30 - 150	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
Tetrachloro-m-xylene (S)	49.7		%	36 - 112	EPA 608	11/20/15	JSR	11/23/15 17:14	KJH	W
WET CHEMISTRY										
Ammonia-N	4.85		mg/L	0.100	D6919-09			11/20/15 16:52	JAM	A
Biochemical Oxygen Demand	51.8	1	mg/L	2.0	S5210B-11			11/20/15 23:22	NAK	B
Carbonaceous BOD	66.7	2	mg/L	2.0	S5210B-11			11/21/15 06:35	GMM	B
Carbonaceous BOD 20 Day	12.8		mg/L	2.0	S5210B-11			11/21/15 09:00	RMM	B
Cyanide, Total	ND		mg/L	0.0050	EPA 335.4	11/23/15	MMA	11/25/15 05:30	LJF	G
Dissolved Oxygen	4.3		mg/L	1.0	S4500OG-01			11/25/15 06:50	RMM	B
Halogen, Total Organic (TOX)	26.8		ug/L	20.0	SW846 9020B			12/1/15 13:58	PAG	N
Hexavalent Chromium	ND		mg/L	0.010	S3500CrB-09			11/20/15 04:56	MSA	B
Nitrate-N	0.85		mg/L	0.50	EPA 300.0			11/20/15 15:35	FSC	B
Nitrite-N	ND		mg/L	0.50	EPA 300.0			11/20/15 15:35	FSC	B
Odor	20		T.O.N.	1	S2150B-97			11/21/16 10:12	MSA	M
Oil/Grease Hexane Extractable	7.2		mg/L	2.0	EPA 1664B			11/22/15 12:00	AT	H
Oil/Grease Silica Gel Treated	2.3		mg/L	2.0	EPA 1664B			11/22/15 12:00	AT	H
Phenolics	0.016		mg/L	0.005	EPA 420.4	12/9/15	NV	12/10/15 16:36	AMH	J
Phosphorus, Total	1.4		mg/L	0.10	EPA 365.1	12/7/15	LJF	12/8/15 04:21	LJF	A
Sulfide, Total	ND		mg/L	1.0	S4500S2F-00			11/25/15 21:15	DRM	L
Surfactants (MBAS)	0.485		mg/L	0.025	S5540C-00			11/21/15 05:00	MBW	K
Total Dissolved Solids	150		mg/L	5	S2540C-11			11/24/15 09:45	ML	B
Total Kjeldahl Nitrogen	14.1		mg/L	4.0	S4500NH3G-11	11/25/15	J1H	11/29/15 11:40	NJA	A
Total Nitrogen	15.0		mg/L	1.00	Calculation			12/7/15 21:21	NJA	A
Total Suspended Solids	140	3	mg/L	5	S2540D-11			11/29/15 18:05	NV	B
Turbidity	37.2		NTU	0.10	S2130B-01			11/21/15 07:01	MSA	B
METALS										
Hardness	58.1		mg/L	0.33	EPA 200.7	11/23/15	JPS	11/24/15 17:48	TSS	P1
Aluminum, Total	0.64		mg/L	0.20	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2
Antimony, Total	0.0013		mg/L	0.0010	EPA 200.8	11/29/15	JPS	12/1/15 12:42	MO	P3
Arsenic, Total	ND		mg/L	0.0075	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2

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ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302003** Date Collected: 11/19/2015 15:10 Matrix: Water

Sample ID: **14th & Crozer** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
Cadmium, Total	ND		mg/L	0.0025	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2
Chromium, Total	0.0094		mg/L	0.0050	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2
Copper, Total	0.033		mg/L	0.013	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2
Iron, Total	0.76		mg/L	0.030	EPA 200.7	11/23/15	JPS	11/24/15 17:48	TSS	P1
Lead, Total	0.016		mg/L	0.0050	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2
Mercury, Total	ND		mg/L	0.00020	EPA 245.1	12/3/15	MNP	12/3/15 14:09	MNP	P4
Molybdenum, Total	0.0027		mg/L	0.0010	EPA 200.8	11/29/15	JPS	12/1/15 12:42	MO	P3
Selenium, Total	ND		mg/L	0.010	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2
Silver, Total	ND		mg/L	0.0050	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2
Thallium, Total	ND		mg/L	0.0025	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2
Zinc, Total	0.11		mg/L	0.013	EPA 200.8	11/23/15	JPS	11/24/15 03:36	ZMC	P2
MICROBIOLOGY										
Enterococcus	77000		col/100mL	100	S9230D			11/19/15 21:58	ABL	R
Fecal Coliform	470000		col/100mL	10000	SM9222D+EPA 625/R-92/013 APX F			11/19/15 22:24	ABL	Q
Sub'd to NELAP CERTIFIED Lab										
Gross Alpha	2.30		pCi/L	2.30	EPA 900.0			12/2/15 12:07	SUB	Y
Gross Alpha Uncertainty +/-	1.30		pCi/L		EPA 900.0			12/2/15 12:07	SUB	Y
Gross Beta	10.7		pCi/L	2.60	EPA 900.0			12/2/15 12:07	SUB	Y
Gross Beta Uncertainty +/-	2.40		pCi/L		EPA 900.0			12/2/15 12:07	SUB	Y

Mr. Brad W Kintzer
Project Coordinator

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ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302004** Date Collected: 11/19/2015 16:10 Matrix: Water

Sample ID: **Sun & Hancock** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
VOLATILE ORGANICS										
Benzene	ND		ug/L	5.0	EPA 624			11/21/15 22:00	CJG	S
Bromodichloromethane	ND		ug/L	5.0	EPA 624			11/21/15 22:00	CJG	S
Chlorodibromomethane	ND		ug/L	5.0	EPA 624			11/21/15 22:00	CJG	S
Chloroform	ND		ug/L	5.0	EPA 624			11/21/15 22:00	CJG	S
Ethylbenzene	ND		ug/L	5.0	EPA 624			11/21/15 22:00	CJG	S
Methyl t-Butyl Ether	ND		ug/L	5.0	EPA 624			11/21/15 22:00	CJG	S
Methylene Chloride	ND		ug/L	5.0	EPA 624			11/21/15 22:00	CJG	S
Tetrachloroethene	ND		ug/L	5.0	EPA 624			11/21/15 22:00	CJG	S
Toluene	ND		ug/L	5.0	EPA 624			11/21/15 22:00	CJG	S
Total Xylenes	ND		ug/L	15.0	EPA 624			11/21/15 22:00	CJG	S
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
1,2-Dichloroethane-d4 (S)	101		%	72 - 142	EPA 624			11/21/15 22:00	CJG	S
4-Bromofluorobenzene (S)	115		%	73 - 119	EPA 624			11/21/15 22:00	CJG	S
Dibromofluoromethane (S)	92.3		%	74 - 132	EPA 624			11/21/15 22:00	CJG	S
Toluene-d8 (S)	99.9		%	75 - 133	EPA 624			11/21/15 22:00	CJG	S
SEMIVOLATILES										
Benzo(a)anthracene	ND		ug/L	1.5	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
Chrysene	ND		ug/L	1.5	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
bis(2-Ethylhexyl)phthalate	11.8		ug/L	3.1	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
N-Nitroso-di-n-propylamine	ND		ug/L	3.1	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
Phenanthrene	ND		ug/L	1.5	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
2,4,6-Tribromophenol (S)	96.9		%	47 - 128	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
2-Fluorobiphenyl (S)	76.5		%	52 - 118	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
2-Fluorophenol (S)	46.8		%	20 - 87	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
Nitrobenzene-d5 (S)	87.1		%	27 - 139	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
Phenol-d5 (S)	31.8		%	10 - 81	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
Terphenyl-d14 (S)	80.3		%	46 - 133	EPA 625	11/25/15	VLM	11/29/15 23:43	GEC	U
Pesticides and PCBs										
Dieldrin	ND		ug/L	0.019	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
Total Polychlorinated Biphenyl	0.0		ug/L		EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
Aroclor-1016	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
Aroclor-1221	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
Aroclor-1232	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
Aroclor-1242	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W

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ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302004** Date Collected: 11/19/2015 16:10 Matrix: Water

Sample ID: **Sun & Hancock** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
Aroclor-1248	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
Aroclor-1254	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
Aroclor-1260	ND		ug/L	0.46	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
Decachlorobiphenyls (S)	56.1		%	30 - 150	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
Tetrachloro-m-xylene (S)	50.7		%	36 - 112	EPA 608	11/20/15	JSR	11/23/15 14:16	KJH	W
WET CHEMISTRY										
Ammonia-N	1.63		mg/L	0.100	D6919-09			11/20/15 17:11	JAM	A
Biochemical Oxygen Demand	26.2	1	mg/L	2.0	S5210B-11			11/20/15 23:22	NAK	B
Carbonaceous BOD	17.3	2	mg/L	2.0	S5210B-11			11/21/15 06:35	GMM	B
Carbonaceous BOD 20 Day	ND		mg/L	20.0	S5210B-11			11/21/15 09:00	RMM	B
Cyanide, Total	ND		mg/L	0.0050	EPA 335.4	11/23/15	MMA	11/25/15 05:30	LJF	G
Dissolved Oxygen	5.4		mg/L	1.0	S4500OG-01			11/25/15 06:50	RMM	B
Halogen, Total Organic (TOX)	ND		ug/L	20.0	SW846 9020B			12/1/15 14:34	PAG	N
Hexavalent Chromium	ND		mg/L	0.010	S3500CrB-09			11/20/15 04:56	MSA	B
Nitrate-N	ND		mg/L	0.50	EPA 300.0			11/20/15 15:48	FSC	B
Nitrite-N	ND		mg/L	0.50	EPA 300.0			11/20/15 15:48	FSC	B
Odor	2		T.O.N.	1	S2150B-97			11/21/16 10:12	MSA	M
Oil/Grease Hexane Extractable	ND		mg/L	2.1	EPA 1664B			11/22/15 12:00	AT	H
Oil/Grease Silica Gel Treated	ND		mg/L	2.1	EPA 1664B			11/22/15 12:00	AT	H
Phenolics	0.012		mg/L	0.005	EPA 420.4	12/9/15	NV	12/10/15 16:37	AMH	J
Phosphorus, Total	0.56		mg/L	0.10	EPA 365.1	12/7/15	LJF	12/8/15 04:21	LJF	A
Sulfide, Total	ND		mg/L	1.0	S4500S2F-00			11/25/15 21:15	DRM	L
Surfactants (MBAS)	0.123		mg/L	0.025	S5540C-00			11/21/15 05:00	MBW	K
Total Dissolved Solids	39		mg/L	5	S2540C-11			11/24/15 09:45	ML	B
Total Kjeldahl Nitrogen	5.3	4	mg/L	1.0	S4500NH3G-11	12/1/15	DRM	12/1/15 12:57	DRM	A
Total Nitrogen	5.30		mg/L	1.00	Calculation			12/7/15 21:21	NJA	A
Total Suspended Solids	76	3	mg/L	5	S2540D-11			11/29/15 18:05	NV	B
Turbidity	26.2		NTU	0.10	S2130B-01			11/21/15 07:01	MSA	B
METALS										
Hardness	18.9		mg/L	0.33	EPA 200.7	11/23/15	JPS	11/24/15 17:52	TSS	P1
Aluminum, Total	0.47		mg/L	0.040	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2
Antimony, Total	0.0023		mg/L	0.0010	EPA 200.8	11/30/15	JPS	12/1/15 12:49	MO	P3
Arsenic, Total	ND		mg/L	0.0015	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2

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ANALYTICAL RESULTS

Workorder: 2109302 2015-LOWER DELAWARE TESTING

Lab ID: **2109302004** Date Collected: 11/19/2015 16:10 Matrix: Water

Sample ID: **Sun & Hancock** Date Received: 11/19/2015 21:10

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
Cadmium, Total	ND		mg/L	0.00050	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2
Chromium, Total	0.0032		mg/L	0.0010	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2
Copper, Total	0.025		mg/L	0.0025	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2
Iron, Total	0.72		mg/L	0.030	EPA 200.7	11/23/15	JPS	11/24/15 17:52	TSS	P1
Lead, Total	0.0081		mg/L	0.0010	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2
Mercury, Total	ND		mg/L	0.00020	EPA 245.1	12/3/15	MNP	12/3/15 14:10	MNP	P4
Molybdenum, Total	0.0031		mg/L	0.0010	EPA 200.8	11/30/15	JPS	12/1/15 12:49	MO	P3
Selenium, Total	ND		mg/L	0.0020	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2
Silver, Total	ND		mg/L	0.0010	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2
Thallium, Total	ND		mg/L	0.00050	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2
Zinc, Total	0.14		mg/L	0.0025	EPA 200.8	11/23/15	JPS	11/24/15 03:40	ZMC	P2
MICROBIOLOGY										
Enterococcus	8160		col/100mL	10	S9230D			11/19/15 21:58	ABL	R
Fecal Coliform	1260000		col/100mL	10000	SM9222D+EPA 625/R-92/013 APX F			11/19/15 22:24	ABL	Q
Sub'd to NELAP CERTIFIED Lab										
Gross Alpha	2.30		pCi/L	2.20	EPA 900.0			12/2/15 12:07	SUB	Y
Gross Alpha Uncertainty +/-	1.30		pCi/L		EPA 900.0			12/2/15 12:07	SUB	Y
Gross Beta	6.50		pCi/L	2.70	EPA 900.0			12/2/15 12:07	SUB	Y
Gross Beta Uncertainty +/-	1.90		pCi/L		EPA 900.0			12/2/15 12:07	SUB	Y

Mr. Brad W Kintzer
Project Coordinator

PARAMETER QUALIFIERS

Lab ID	#	Sample ID	Analytical Method	Analyte
2109302001	1	CPS/EPS1 (72/28)	S5210B-11	Biochemical Oxygen Demand
The dilution water blank associated with this analyte had a dissolved oxygen depletion of 0.26 mg/l. Criteria states that the depletion should be at a maximum 0.2 mg/l.				
2109302001	2	CPS/EPS1 (72/28)	S5210B-11	Carbonaceous BOD
The dilution water blank associated with this analyte had a dissolved oxygen depletion of 0.22 mg/l. Criteria states that the depletion should be at a maximum 0.2 mg/l.				
2109302001	3	CPS/EPS1 (72/28)	S2540D-11	Total Suspended Solids
This sample was analyzed after the 7 day holding time for total suspended solids had expired.				
2109302002	1	CPS1	S5210B-11	Biochemical Oxygen Demand
The dilution water blank associated with this analyte had a dissolved oxygen depletion of 0.26 mg/l. Criteria states that the depletion should be at a maximum 0.2 mg/l.				
2109302002	2	CPS1	S5210B-11	Carbonaceous BOD
The dilution water blank associated with this analyte had a dissolved oxygen depletion of 0.22 mg/l. Criteria states that the depletion should be at a maximum 0.2 mg/l.				
2109302002	3	CPS1	S2540D-11	Total Suspended Solids
This sample was analyzed after the 7 day holding time for total suspended solids had expired.				
2109302002	4	CPS1	EPA 608	Decachlorobiphenyls
The surrogate Decachlorobiphenyls for method EPA 608 was outside of control limits. The % Recovery was reported as 29.1 and the control limits were 30 to 150. This result was reported at a dilution of 1.				
2109302003	1	14th & Crozer	S5210B-11	Biochemical Oxygen Demand
The dilution water blank associated with this analyte had a dissolved oxygen depletion of 0.26 mg/l. Criteria states that the depletion should be at a maximum 0.2 mg/l.				
2109302003	2	14th & Crozer	S5210B-11	Carbonaceous BOD
The dilution water blank associated with this analyte had a dissolved oxygen depletion of 0.22 mg/l. Criteria states that the depletion should be at a maximum 0.2 mg/l.				
2109302003	3	14th & Crozer	S2540D-11	Total Suspended Solids
This sample was analyzed after the 7 day holding time for total suspended solids had expired.				
2109302004	1	Sun & Hancock	S5210B-11	Biochemical Oxygen Demand
The dilution water blank associated with this analyte had a dissolved oxygen depletion of 0.26 mg/l. Criteria states that the depletion should be at a maximum 0.2 mg/l.				
2109302004	2	Sun & Hancock	S5210B-11	Carbonaceous BOD
The dilution water blank associated with this analyte had a dissolved oxygen depletion of 0.22 mg/l. Criteria states that the depletion should be at a maximum 0.2 mg/l.				
2109302004	3	Sun & Hancock	S2540D-11	Total Suspended Solids
This sample was analyzed after the 7 day holding time for total suspended solids had expired.				
2109302004	4	Sun & Hancock	S4500NH3G-11	Total Kjeldahl Nitrogen
The recovery of the Matrix Spike (MS) associated to this analyte was outside of the established control limits.				

ALS Environmental

34 Dogwood Lane
Middletown, PA 17057
P. 717-944-5541
F.717-944-1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

B

COC
ALS

2109302

1 of 2

Client Name: DELCORA
Address: 3201 W. Front Street
Chester PA 19013
Contact: Mike Krause
Phone#: 610-876-5523 x218
Project Name/#: CSO WW LTCP
Bill To: Same

TAT [x] Normal-Standard TAT is 10-12 business days.
[ ] Rush-Subject to ALS approval and surcharges.
Date Required: _____ Approved By: _____
Email? [x] -Y
Fax? [ ] -Y No.:

Container Type					plastic	plastic	plastic	plastic	plastic	plastic	glass	glass	glass	plastic
Container Size					250ml	1L	500ml	500ml	120ml	120ml	1L	1L	40ml	1L
Preservative					H/Zn(O2C	none	HNO3	none	Na2S2O3	Na2S2O3	none	none	none	None
Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Total Sulfide	CBOD5, CBOD20, BOD5	Metals, Total Hardness	Hexavalent Chromium, Triavalent Chromium	Fecal Coliform	Enterococcus	608	625	624	Gross Alpha/ Beta
1 CPS/ EPS1 (72/28)	11/19/15	15:20	G	WW	1	2	1	1	1	1	2	2	2	1
2 CPS1	11/19/15	15:20	G	WW	1	2	1	1	1	1	2	2	2	1
3 14th & Crozer	11/19/15	15:10	G	WW	1	2	1	1	1	1	2	2	2	1
4 Sun & Hancock	11/19/15	16:10	G	WW	1	2	1	1	1	1	2	2	2	1
5														
6														
7														
8														
9														
10														

ANALYSES/METHOD REQUESTED

Enter Number of Containers Per Sample or Field Results Below.

Receipt Information (completed by Receiving Lab)

Cooler Temp: 1 Therm ID: 294
No. of Coolers: _____

	Y	N	Initial
Custody Seals Present?		✓	
(if present) Seals Intact?	✓		
Received on Ice?	✓		
COC/Labels Complete/Accurate?	✓		
Cont. in Good Cond.?	✓		
Correct Containers?	✓		
Correct Sample Volumes?	✓		
Correct Preservation?	✓		
Headspace/Volatiles?		✓	

Courier/Tracking #:

Sample/COC Comments

MICRO REC'D AB 11/19/15 2110

ALS Field Services: __Pickup __Labor __Composite Sampling __Rental Equipment __Other:

Project Comments:

LOGGED BY(signature): [signature] DATE 11/20/15 TIME 1910
REVIEWED BY(signature): B DATE TIME

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1 Raymond Rice	11/19/15	1704	2 [signature]	11-19	1705
3 [signature]	11-19	1905	4 [signature]	11/19	1905
5 [signature]	11/19	2110	6 [signature]	11-19-15	2110
7			8		
9			10		

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE [ ]

Special Processing: USACE [ ] Navy [ ] [ ]

State Samples Collected In: [ ] NY [ ] NJ [x] PA [ ] NC [ ]

Reportable to PADEP? Yes [ ]
PWSID #

Sample Disposal: Lab [ ] Special [ ]

EDDS: Format Type-

* G=Grab; C=Composite **Matrix - AI=Air; DW=Drinking Water; GW=Groundwater; OI=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

ALS ENVIRONMENTAL SHIPPING ADDRESS: 34 DOGWOOD LANE, MIDDLETOWN, PA 17057

Rev 10/11

Wednesday, December 16, 2015 5:19:04 PM
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ALS Environmental
34 Dogwood Lane
Middletown, PA 17057
P. 717-944-5541
F.717-944-1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: 210930 — 2 of 2
ALS Quote #: 514787

Client Name: DELCORA
Address: 3201 W. Front Street
Chester PA 19013
Contact: Mike Krause
Phone#: 610-876-5523 x218
Project Name/#: CSO WW LTCP
Bill To: Same

TAT: [x] Normal-Standard TAT is 10-12 business days. [ ] Rush-Subject to ALS approval and surcharges.
Date Required: _____ Approved By: _____
Email? [x] -Y
Fax? [ ] -Y No.: _____

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Oil and Grease	TPH	Nitrate, Nitrite, Turbidity	Total Cyanide	Total Phosphorus, Ammonia, TKN, Total Nitrogen	Phenolics	TOX	TSS, TDS, DO	Odor	MBAS
Container Type					glass	glass	plastic	plastic	plastic	glass	glass	plastic	glass	plastic
Container Size					1L	1L	500ml	500ml	1L	500ml	250ml	1L	1L	2L
Preservative					H2SO4	H2SO4	none	NaOH	H2SO4	H2SO4	H2SO4	none	none	none
1 CPS/ EPS1 (72/28)	11-19-15	15:20	G	WW	1	1	1	1	1	1	2	1	1	1
2 CPS1	11-19-15	15:20	G	WW	1	1	1	1	1	1	2	1	1	1
3 14th & Crozer	11-19-15	15:10	G	WW	1	1	1	1	1	1	2	1	1	1
4 Sun & Hancock	11-19-15	16:10	G	WW	1	1	1	1	1	1	2	1	1	1
5	FB#1119													
6														
7														
8														
9														
10														

Enter Number of Containers Per Sample or Field Results Below.

Receipt Information (completed by Receiving Lab)
Cooler Temp: 1 Therm ID: 244
No. of Coolers: _____

	Y	N	Initial
Custody Seals Present?			
(if present) Seals Intact?			
Received on Ice?	✓		
COC/Labels Complete/Accurate?	✓		
Cont. in Good Cond.?	✓		
Correct Containers?	✓		
Correct Sample Volumes?	✓		
Correct Preservation?	✓		
Headspace/Volatiles?		✓	

Courier/Tracking #:

Sample/COC Comments

ALS Field Services: __Pickup __Labor __Composite Sampling __Rental Equipment __Other: _____

Project Comments:

LOGGED BY(signature): _____ DATE: 11/20/15 TIME: 0940
REVIEWED BY(signature): _____ DATE: _____ TIME: _____

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1 Raymond Reed	11/19/15	17:05	2 Fed Ex	11/19	17:05
3	11-19	1805	4	11/19	1805
5	11/19	2100	6	11/20-15	2110
7			8		
9			10		

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE [ ]
Special Processing: USACE [ ] Navy [ ]
State Samples Collected In: [ ] NY [ ] NJ [x] PA [ ] NC [ ]
Reportable to PADEP? Yes [ ]
PWSID # _____
Sample Disposal: Lab [ ] Special [ ]
EDDS: Format Type- _____

*G=Grab; C=Composite **Matrix - AI=Air; DW=Drinking Water; GW=Groundwater; OI=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

ALS ENVIRONMENTAL SHIPPING ADDRESS: 34 DOGWOOD LANE, MIDDLETOWN, PA 17057

Rev 10/11

ALS Environmental
34 Dogwood Lane
Middletown, PA 17057
P. 717-944-5541
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CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: _____ of _____

ALS Quote #: _____

Client Name: ALS Environmental - Middletown

Address: 34 Dogwood Lane
Middletown, PA 17057

Contact: Brad Kintzer

Phone#:

Project Name/#: DELCORA

Bill To:

TAT [X] Normal-Standard TAT is 10-12 business days.
[ ] Rush-Subject to ALS approval and surcharges.

Date Required: _____ Approved By: _____

Email? [x] -Y

Fax? [ ] -Y No.: _____

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Container Type	Container Size	Preservative	Gross Alpha/Beta					Subcontract to: ALS - Ft. Collins			
					P	1L	HNO3									
					ANALYSES/METHOD REQUESTED											
					Enter Number of Containers Per Sample or Field Results Below.											
1 2109302001	11/19/15	1520	G	WW				1								
2 2109302002	11/19/15	1520	G	WW				1								
3 2109302003	11/19/15	1510	G	WW				1								
4 2109302~~003~~ 004	11/19/15	1610	G	WW				1								
5 SSL	11/24/15	23														
6																
7																
8																
9																
10																

Receipt Information (completed by Receiving Lab)

Cooler Temp: _____ Therm ID: _____

	Y	N	Initial
No. of Coolers:			
Custody Seals Present?			
(if present) Seals Intact?			
Received on Ice?			
COC/Labels Complete/Accurate?			
Cont. in Good Cond.?			
Correct Containers?			
Correct Sample Volumes?			
Correct Preservation?			
Headspace/Volatiles?			

Courier/Tracking #:

Sample/COC Comments

ALS Field Services: _Pickup _Labor
_Composite Sampling _Rental Equipment
_Other: _____

Project Comments:

LOGGED BY(signature): DATE: TIME:

REVIEWED BY(signature): DATE: TIME:

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1 [signature]	11/23/15	1520	2		
3			4		
5			6		
7			8		
9			10		

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE [ ]

Special Processing: USACE [ ] Navy [ ]

State Samples Collected In: [ ] NY [ ] NJ [ ] PA [ ] NC [ ]

Reportable to PADEP? Yes [ ]

PWSID # _____

Sample Disposal: Lab [ ] Special [ ]

EDDS: Format Type- _____

* G=Grab; C=Composite

**Matrix - AI=Air; DW=Drinking Water; GW=Groundwater; OI=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

ALS ENVIRONMENTAL SHIPPING ADDRESS: 34 DOGWOOD LANE, MIDDLETOWN, PA 17057

Rev 10/11

ALS

Thursday, December 10, 2015

Brad Kintzer
ALS Environmental
34 Dogwood Lane
Middletown, PA 17057

Re: ALS Workorder: 1511447
Project Name:
Project Number: 2109302

Dear Mr. Kintzer:

Four water samples were received from ALS Environmental, on 11/24/2015. The samples were scheduled for the following analysis:

Gross Alpha/Beta

The results for these analyses are contained in the enclosed reports.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Thank you for your confidence in ALS Environmental. Should you have any questions, please call.

Sincerely,

ALS Environmental
Jeff R. Kujawa
Project Manager

ALS Environmental – Fort Collins is accredited by the following accreditation bodies for various testing scopes in accordance with requirements of each accreditation body. All testing is performed under the laboratory management system, which is maintained to meet these requirement and regulations. Please contact the laboratory or accreditation body for the current scope testing parameters.

ALS Environmental – Fort Collins	
Accreditation Body	License or Certification Number
Alaska (AK)	UST-086
Alaska (AK)	CO01099
Arizona (AZ)	AZ0742
California (CA)	06251CA
Colorado (CO)	CO01099
Connecticut (CT)	PH-0232
Florida (FL)	E87914
Idaho (ID)	CO01099
Kansas (KS)	E-10381
Kentucky (KY)	90137
L-A-B (DoD ELAP/ISO 170250)	L2257
Louisiana (LA)	05057
Maryland (MD)	285
Missouri (MO)	175
Nebraska(NE)	NE-OS-24-13
Nevada (NV)	CO000782008A
New York (NY)	12036
North Dakota (ND)	R-057
Oklahoma (OK)	1301
Pennsylvania (PA)	68-03116
Tennessee (TN)	2976
Texas (TX)	T104704241
Utah (UT)	CO01099
Washington (WA)	C1280

ALS Environmental

1511451

Gross Alpha/Beta:
The sample was analyzed for gross alpha and beta activity by gas flow proportional counting according to the current revision of SOP 724. Gross alpha results are referenced to ^{241}Am. Gross beta results are referenced to $^{90}Sr/Y$.

All acceptance criteria were met.

ALS Environmental -- FC

Sample Number(s) Cross-Reference Table

OrderNum: 1511447
Client Name: ALS Environmental
Client Project Name:
Client Project Number: 2109302
Client PO Number: 2109302

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
2109302001	1511447-1		WATER	19-Nov-15	15:20
2109302002	1511447-2		WATER	19-Nov-15	15:20
2109302003	1511447-3		WATER	19-Nov-15	15:10
2109302004	1511447-4		WATER	19-Nov-15	16:10

ALS Environmental
34 Dogwood Lane
Middletown, PA 17057
P. 717-944-5541
F.717-944-1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: 151447 of
ALS Quote #:

Client Name: ALS Environmental - Middletown
Address: 34 Dogwood Lane
Middletown, PA 17057
Contact: Brad Kintzer
Phone#:
Project Name/#: DELCORA
Bill To:
TAT: [X] Normal-Standard TAT is 10-12 business days [ ] Rush-Subject to ALS approval and surcharges.
Date Required: Approved By:
Email? [X] Y
Fax? [ ] Y No

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Container Type	Container Size	Preservative	Gross Alpha/Beta	Subcontract to ALS-Ft Collins	Enter Number of Containers Per Sample or Field Results Below.
					P	1L	HNO3			
1 2109302001 (1)	11/19/15	1520	G	WW						
2 2109302002 (2)	11/19/15	1520	G	WW						
3 2109302003 (3)	11/19/15	1510	G	WW						
4 2109302003 (4)	11/19/15	1610	G	WW				1		
5										
6										
7										
8										
9										
10										

ANALYSES/METHOD REQUESTED

Receipt Information (completed by Receiving Lab)
Cooler Temp: ____ Therm ID: ____
No. of Coolers: ____

	Y	N	Initial
Custody Seals Present?			
(if present) Seals Intact?			
Received on Ice?			
COC/Labels Complete/Accurate?			
Cont. in Good Cond.?			
Correct Containers?			
Correct Sample Volumes?			
Correct Preservation?			
Headspace/Volatiles?			

Courier/Tracking #:

Sample/COC Comments

ALS Field Services: _Pickup _Labor _Composite Sampling _Rental Equipment _Other:

Project Comments:

LOGGED BY(signature): Date:
REVIEWED BY(signature): Date:

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1	11/23/15	1520	2 ALS FC	11/24/15	0950
3			4		
5			6		
7			8		
9			10		

Deliverables: [ ] Standard [ ] CLP-like [ ] USACE
Special Processing: [ ] USACE [ ] Navy [ ]
State Samples Collected In: [ ] NY [ ] NJ [ ] PA [ ] NC [ ]
Reportable to PADEP? [ ] Yes
PWSID #:
Sample Disposal: [ ] Lab [ ] Special
EDDS: Format Type:

* G=Grab; C=Composite **Matrix - Al=Air; DW=Drinking Water; GW=Groundwater; Ol=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

ALS ENVIRONMENTAL SHIPPING ADDRESS: 34 DOGWOOD LANE, MIDDLETOWN, PA 17057

Rev 10/11

ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: ALS PA Workorder No: 15 11447

Project Manager: JRK Initials: SDM Date: 11-24-15

1. Does this project require any special handling in addition to standard ALS procedures?		YES	(NO)
2. Are custody seals on shipping containers intact?	(NONE)	YES	NO
3. Are Custody seals on sample containers intact?	(NONE)	YES	NO
4. Is there a COC (Chain-of-Custody) present or other representative documents?		(YES)	NO
5. Are the COC and bottle labels complete and legible?		(YES)	NO
6. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)		YES	(NO)
7. Were airbills / shipping documents present and/or removable?	DROP OFF	(YES)	NO
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	N/A	(YES)	NO
9. Are all aqueous non-preserved samples pH 4-9?	(N/A)	YES	NO
10. Is there sufficient sample for the requested analyses?		(YES)	NO
11. Were all samples placed in the proper containers for the requested analyses?		(YES)	NO
12. Are all samples within holding times for the requested analyses?		(YES)	NO
13. Were all sample containers received intact? (not broken or leaking, etc.)		(YES)	NO
14. Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: ____ < green pea ____ > green pea	(N/A)	YES	NO
15. Do any water samples contain sediment? Amount Amount of sediment: X dusting ____ moderate ____ heavy	N/A	(YES)	NO
16. Were the samples shipped on ice?		YES	(NO)
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #2 #4	(RAD ONLY)	YES	NO

Cooler #:	1							
Temperature (°C):	4.6							
No. of custody seals on cooler:	0							
DOT Survey/ Acceptance Information External µR/hr reading:	12							
Background µR/hr reading:	12							

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? (YES) / NO / NA (If no, see Form 008.)

Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EXCEPT #1 AND #16.

6.) Sample 4 ⇒ Sample ID on bottle says ⇒ 2109302004
COC says 2109302003 ⇒ Sample date & time match.

15.) Samples 1 through 4 have a dusting of sediment.

If applicable, was the client contacted? YES / NO / (NA) Contact: _____ Date/Time: _____

Project Manager Signature / Date: _____ 11-24-15

*IR Gun #2: Oakton, SN 29922500201-0066
*IR Gun #4: Oakton, SN 2372220101-0002

Form 201r24.xls (06/04/2012)

Page 1 of 1

7 of 13

ORIGIN ID:MDTA (717) 944-5541
STEVE SMITH
34 DOGWOOD LANE
MIDDLETOWN, PA 17057
UNITED STATES US

SHIP DATE: 23NOV15
ACTWGT: 42.00 LB
CAD: 107353163/INET3670

BILL SENDER

TO AMY WOLF
ALSENV. - FORT COLLINS
225 COMMERCE DR
FORT COLLINS CO 80524
(000) 000-0000
INV:
PO:
REF: AEF-001
DEPT: ADMIN

539J2/3F56/3100

TUE - 24 NOV 3:00P
STANDARD OVERNIGHT

TRK# 0201 7750 4462 5706

NA FTCA

80524
CO-US DEN

After printing this label:
1. Use the 'Print' button on this page to print your label to your laser or inkjet printer.
2. Fold the printed page along the horizontal line.
3. Place label in shipping pouch and affix it to your shipment so that the barcode portion of the label can be read and scanned.

Warning: Use only the printed original label for shipping. Using a photocopy of this label for shipping purposes is fraudulent and could result in additional billing charges, along with the cancellation of your FedEx account number.
Use of this system constitutes your agreement to the service conditions in the current FedEx Service Guide, available on fedex.com.FedEx will not be responsible for any claim in excess of $100 per package, whether the result of loss, damage, delay, non-delivery,misdelivery,or misinformation, unless you declare a higher value, pay an additional charge, document your actual loss and file a timely claim.Limitations found in the current FedEx Service Guide apply. Your right to recover from FedEx for any loss, including intrinsic value of the package, loss of sales, income interest, profit, attorney's fees, costs, and other forms of damage whether direct, incidental,consequential, or special is limited to the greater of $100 or the authorized declared value. Recovery cannot exceed actual documented loss.Maximum for items of extraordinary value is $1,000, e.g. jewelry, precious metals, negotiable instruments and other items listed in our ServiceGuide. Written claims must be filed within strict time limits, see current FedEx Service Guide.

Client:	ALS Environmental	**Date:**	*10-Dec-15*
Project:	2109302	**Work Order:**	1511447
Sample ID:	2109302001	**Lab ID:**	1511447-1
Legal Location:		**Matrix:**	WATER
Collection Date:	11/19/2015 15:20	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gross Alpha/Beta by GFPC		**PAI 724**			Prep Date: **11/30/2015**	PrepBy: **ECP**
GROSS ALPHA	ND (+/- 1.6)	U	2.7	pCi/l	NA	12/2/2015 12:07
GROSS BETA	**9 (+/- 2.2)**		**2.7**	**pCi/l**	NA	12/2/2015 12:07

Client:	ALS Environmental	**Date:**	*10-Dec-15*
Project:	2109302	**Work Order:**	1511447
Sample ID:	2109302002	**Lab ID:**	1511447-2
Legal Location:		**Matrix:**	WATER
Collection Date:	11/19/2015 15:20	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gross Alpha/Beta by GFPC		**PAI 724**			Prep Date: **11/30/2015**	PrepBy: **ECP**
GROSS ALPHA	2.7 (+/- 1.4)	LT	2.1	pCi/l	NA	12/2/2015 12:07
GROSS BETA	**7.8 (+/- 2)**		**2.7**	**pCi/l**	NA	12/2/2015 12:07

Client:	ALS Environmental	**Date:**	*10-Dec-15*
Project:	2109302	**Work Order:**	1511447
Sample ID:	2109302003	**Lab ID:**	1511447-3
Legal Location:		**Matrix:**	WATER
Collection Date:	11/19/2015 15:10	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gross Alpha/Beta by GFPC		**PAI 724**			Prep Date: **11/30/2015**	PrepBy: **ECP**
GROSS ALPHA	2.3 (+/- 1.3)	LT	2.3	pCi/l	NA	12/2/2015 12:07
GROSS BETA	**10.7 (+/- 2.4)**		**2.6**	**pCi/l**	NA	12/2/2015 12:07

Client:	ALS Environmental	**Date:**	*10-Dec-15*
Project:	2109302	**Work Order:**	1511447
Sample ID:	2109302004	**Lab ID:**	1511447-4
Legal Location:		**Matrix:**	WATER
Collection Date:	11/19/2015 16:10	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gross Alpha/Beta by GFPC		**PAI 724**			Prep Date: **11/30/2015**	PrepBy: **ECP**
GROSS ALPHA	2.3 (+/- 1.3)	LT	2.2	pCi/l	NA	12/2/2015 12:07
GROSS BETA	**6.5 (+/- 1.9)**		**2.7**	**pCi/l**	NA	12/2/2015 12:07

Client:	ALS Environmental	**Date:**	*10-Dec-15*
Project:	2109302	**Work Order:**	1511447
Sample ID:	2109302004	**Lab ID:**	1511447-4
Legal Location:		**Matrix:**	WATER
Collection Date:	11/19/2015 16:10	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed

Explanation of Qualifiers

Radiochemistry:

U or ND - Result is less than the sample specific MDC.

Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.

Y2 - Chemical Yield outside default limits.

W - DER is greater than Warning Limit of 1.42

* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'.

- Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'.

G - Sample density differs by more than 15% of LCS density.

D - DER is greater than Control Limit

M - Requested MDC not met.

LT - Result is less than requested MDC but greater than achieved MDC.

M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.

L - LCS Recovery below lower control limit.

H - LCS Recovery above upper control limit.

P - LCS, Matrix Spike Recovery within control limits.

N - Matrix Spike Recovery outside control limits

NC - Not Calculated for duplicate results less than 5 times MDC

B - Analyte concentration greater than MDC.

B3 - Analyte concentration greater than MDC but less than Requested MDC.

Inorganics:

B - Result is less than the requested reporting limit but greater than the instrument method detection limit (MDL).

U or ND - Indicates that the compound was analyzed for but not detected.

E - The reported value is estimated because of the presence of interference. An explanatory note may be included in the narrative.

M - Duplicate injection precision was not met.

N - Spiked sample recovery not within control limits. A post spike is analyzed for all ICP analyses when the matrix spike and or spike duplicate fail and the native sample concentration is less than four times the spike added concentration.

Z - Spiked recovery not within control limits. An explanatory note may be included in the narrative.

* - Duplicate analysis (relative percent difference) not within control limits.

S - SAR value is estimated as one or more analytes used in the calculation were not detected above the detection limit.

Organics:

U or ND - Indicates that the compound was analyzed for but not detected.

B - Analyte is detected in the associated method blank as well as in the sample. It indicates probable blank contamination and warns the data user.

E - Analyte concentration exceeds the upper level of the calibration range.

J - Estimated value. The result is less than the reporting limit but greater than the instrument method detection limit (MDL).

A - A tentatively identified compound is a suspected aldol-condensation product.

X - The analyte was diluted below an accurate quantitation level.

* - The spike recovery is equal to or outside the control criteria used.

+ - The relative percent difference (RPD) equals or exceeds the control criteria.

G - A pattern resembling gasoline was detected in this sample.

D - A pattern resembling diesel was detected in this sample.

M - A pattern resembling motor oil was detected in this sample.

C - A pattern resembling crude oil was detected in this sample.

4 - A pattern resembling JP-4 was detected in this sample.

5 - A pattern resembling JP-5 was detected in this sample.

H - Indicates that the fuel pattern was in the heavier end of the retention time window for the analyte of interest.

L - Indicates that the fuel pattern was in the lighter end of the retention time window for the analyte of interest.

Z - This flag indicates that a significant fraction of the reported result did not resemble the patterns of any of the following petroleum hydrocarbon products:
- gasoline
- JP-8
- diesel
- mineral spirits
- motor oil
- Stoddard solvent
- bunker C

ALS Environmental -- FC

Client: ALS Environmental
Work Order: 1511447
Project: 2109302

Date: *12/10/2015 4:58*

QC BATCH REPORT

Batch ID: **AB151130-1-3** Instrument ID **LB4100-C** Method: **Gross Alpha/Beta by GFPC**

LCS Sample ID: **AB151130-1** Units: **pCi/l** Analysis Date: **12/2/2015 13:39**
Client ID: Run ID: **AB151130-1A** Prep Date: **11/30/2015** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
GROSS ALPHA	239 (+/- 43)	7	225.4		106	70-130					P,M3
GROSS BETA	197 (+/- 34)	12	203.8		96.6	70-130					P,M3

LCSD Sample ID: **AB151130-1** Units: **pCi/l** Analysis Date: **12/2/2015 13:39**
Client ID: Run ID: **AB151130-1A** Prep Date: **11/30/2015** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
GROSS ALPHA	208 (+/- 39)	7	225.4		92.5	70-130		239	0.5	2.1	P,M3
GROSS BETA	200 (+/- 35)	11	203.8		98.2	70-130		197	0.07	2.1	P,M3

MB Sample ID: **AB151130-1** Units: **pCi/l** Analysis Date: **12/3/2015 12:06**
Client ID: Run ID: **AB151130-1A** Prep Date: **11/30/2015** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
GROSS ALPHA	ND	0.81									U
GROSS BETA	ND	1.04									U

The following samples were analyzed in this batch: 1511447-1 1511447-2 1511447-3 1511447-4

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State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

January 7, 2016

Ms. Irene Fitzgerald
DELCORA
P.O. Box 999
Chester, PA 19016

Certificate of Analysis

Revised Report - 1/7/2016 6:17:18 AM - See workorder comment section for explanation

Project Name:	**2015-LOWER DELAWARE TESTING**	Workorder:	**2110770**
Purchase Order:		Workorder ID:	**2015-LOWER DELAWARE TESTING**

Dear Ms. Fitzgerald:

Enclosed are the analytical results for samples received by the laboratory on Tuesday, December 1, 2015.

The ALS Environmental laboratory in Middletown, Pennsylvania is a National Environmental Laboratory Accreditation Program (NELAP) accredited laboratory and as such, certifies that all applicable test results meet the requirements of NELAP.

If you have any questions regarding this certificate of analysis, please contact Mr. Brad W Kintzer (Project Coordinator) at (717) 944-5541.

Analyses were performed according to our laboratory's NELAP-approved quality assurance program and any applicable state requirements. The test results meet requirements of the current NELAP standards or state requirements, where applicable. For a specific list of accredited analytes, refer to the certifications section of the ALS website at www.alsglobal.com/en/Our-Services/Life-Sciences/Environmental/Downloads.

This laboratory report may not be reproduced, except in full, without the written approval of ALS Environmental.

ALS Spring City: 10 Riverside Drive, Spring City, PA 19475 610-948-4903

CC: Mr. Ray Rios , Mr. Mike Krause

This page is included as part of the Analytical Report and must be retained as a permanent record thereof.

Mr. Brad W Kintzer
Project Coordinator

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SAMPLE SUMMARY

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID	Sample ID	Matrix	Date Collected	Date Received	Collected By
2110770001	CPS/EPS1 (72/28) LTCPWWCSO	Water	12/1/2015 09:43	12/1/2015 13:55	Mr. Ray Rios
2110770002	CPS1	Water	12/1/2015 09:43	12/1/2015 13:55	Mr. Ray Rios
2110770003	14th & Crozer	Water	12/1/2015 09:20	12/1/2015 13:55	Mr. Ray Rios
2110770004	Sun & Hancock	Water	12/1/2015 11:00	12/1/2015 13:55	Mr. Ray Rios

Notes

-- Samples collected by ALS personnel are done so in accordance with the procedures set forth in the ALS Field Sampling Plan (20 - Field Services Sampling Plan).
-- All Waste Water analyses comply with methodology requirements of 40 CFR Part 136.
-- All Drinking Water analyses comply with methodology requirements of 40 CFR Part 141.
-- Unless otherwise noted, all quantitative results for soils are reported on a dry weight basis.
-- The Chain of Custody document is included as part of this report.
-- All Library Search analytes should be regarded as tentative identifications based on the presumptive evidence of the mass spectra. Concentrations reported are estimated values.
-- Parameters identified as "analyze immediately" require analysis within 15 minutes of collection. Any "analyze immediately" parameters not listed under the header "Field Parameters" are preformed in the laboratory and are therefore analyzed out of hold time.
-- Method references listed on this report beginning with the prefix “S” followed by a method number (such as S2310B-97) refer to methods from “Standard Methods for the Examination of Water and Wastewater”.

Standard Acronyms/Flags

J	Indicates an estimated value between the Method Detection Limit (MDL) and the Practical Quantitation Limit (PQL) for the analyte
U	Indicates that the analyte was Not Detected (ND)
N	Indicates presumptive evidence of the presence of a compound
MDL	Method Detection Limit
PQL	Practical Quantitation Limit
RDL	Reporting Detection Limit
ND	Not Detected - indicates that the analyte was Not Detected at the RDL
Cntr	Analysis was performed using this container
RegLmt	Regulatory Limit
LCS	Laboratory Control Sample
MS	Matrix Spike
MSD	Matrix Spike Duplicate
DUP	Sample Duplicate
%Rec	Percent Recovery
RPD	Relative Percent Difference
LOD	DoD Limit of Detection
LOQ	DoD Limit of Quantitation
DL	DoD Detection Limit
I	Indicates reported value is greater than or equal to the Method Detection Limit (MDL) but less than the Report Detection Limit (RDL)
(S)	Surrogate Compound
NC	Not Calculated
*	Result outside of QC limits

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PROJECT SUMMARY

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Workorder Comments

See attached subcontracted radiological results from ALS-Ft. Collins. VLF 12/23/15

This report was modified on 1/6/16 to add Total Nitogen to all samples. BWK

Sample Comments

Lab ID: 2110770001 **Sample ID:** CPS/EPS1 (72/28) LTCPWWCSO **Sample Type:** SAMPLE

MBAS calculated as LAS molecular weight 342 g/mol.

The reporting limits for GCMS volatile analytes were raised due to the dilution of the sample caused by matrix.

Lab ID: 2110770002 **Sample ID:** CPS1 **Sample Type:** SAMPLE

MBAS calculated as LAS molecular weight 342 g/mol.

The reporting limits for GCMS volatile analytes were raised due to the dilution of the sample caused by matrix.

Lab ID: 2110770003 **Sample ID:** 14th **Sample Type:** SAMPLE

MBAS calculated as LAS molecular weight 342 g/mol.

The reporting limits for GCMS volatile analytes were raised due to the dilution of the sample caused by matrix.

Lab ID: 2110770004 **Sample ID:** Sun **Sample Type:** SAMPLE

MBAS calculated as LAS molecular weight 342 g/mol.

The reporting limits for GCMS volatile analytes were raised due to the dilution of the sample caused by matrix.

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770001** Date Collected: 12/1/2015 09:43 Matrix: Water

Sample ID: **CPS/EPS1 (72/28) LTCPWWCSO** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
VOLATILE ORGANICS										
Benzene	ND		ug/L	5.0	EPA 624			12/2/15 23:49	DD	S
Bromodichloromethane	ND		ug/L	5.0	EPA 624			12/2/15 23:49	DD	S
Chlorodibromomethane	ND		ug/L	5.0	EPA 624			12/2/15 23:49	DD	S
Chloroform	5.7		ug/L	5.0	EPA 624			12/2/15 23:49	DD	S
Ethylbenzene	ND		ug/L	5.0	EPA 624			12/2/15 23:49	DD	S
Methyl t-Butyl Ether	ND		ug/L	5.0	EPA 624			12/2/15 23:49	DD	S
Methylene Chloride	ND		ug/L	5.0	EPA 624			12/2/15 23:49	DD	S
Tetrachloroethene	ND		ug/L	5.0	EPA 624			12/2/15 23:49	DD	S
Toluene	8.6		ug/L	5.0	EPA 624			12/2/15 23:49	DD	S
Total Xylenes	ND		ug/L	15.0	EPA 624			12/2/15 23:49	DD	S
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
1,2-Dichloroethane-d4 (S)	100		%	72 - 142	EPA 624			12/2/15 23:49	DD	S
4-Bromofluorobenzene (S)	97.4		%	73 - 119	EPA 624			12/2/15 23:49	DD	S
Dibromofluoromethane (S)	86		%	74 - 132	EPA 624			12/2/15 23:49	DD	S
Toluene-d8 (S)	90.5		%	75 - 133	EPA 624			12/2/15 23:49	DD	S
SEMIVOLATILES										
Benzo(a)anthracene	ND		ug/L	1.4	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
Chrysene	ND		ug/L	1.4	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
bis(2-Ethylhexyl)phthalate	9.1		ug/L	2.8	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
N-Nitroso-di-n-propylamine	ND		ug/L	2.8	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
Phenanthrene	ND		ug/L	1.4	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
2,4,6-Tribromophenol (S)	100		%	47 - 128	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
2-Fluorobiphenyl (S)	74		%	52 - 118	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
2-Fluorophenol (S)	35.2		%	20 - 87	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
Nitrobenzene-d5 (S)	72.4		%	27 - 139	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
Phenol-d5 (S)	28		%	10 - 81	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
Terphenyl-d14 (S)	81		%	46 - 133	EPA 625	12/3/15	CAC	12/4/15 09:54	DHF	U
Pesticides and PCBs										
Dieldrin	0.023		ug/L	0.019	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
Total Polychlorinated Biphenyl	|		ug/L		EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
Aroclor-1016	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
Aroclor-1221	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
Aroclor-1232	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
Aroclor-1242	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770001** Date Collected: 12/1/2015 09:43 Matrix: Water

Sample ID: **CPS/EPS1 (72/28) LTCPWWCSO** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
Aroclor-1248	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
Aroclor-1254	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
Aroclor-1260	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
Decachlorobiphenyls (S)	43.6		%	30 - 150	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
Tetrachloro-m-xylene (S)	52.3		%	36 - 112	EPA 608	12/7/15	JSR	12/9/15 17:33	RWS	W
WET CHEMISTRY										
Ammonia-N	27.4		mg/L	0.100	D6919-09			12/2/15 19:05	JAM	A
Biochemical Oxygen Demand	119		mg/L	2.0	S5210B-11			12/2/15 04:20	GMM	B
Carbonaceous BOD	105		mg/L	2.0	S5210B-11			12/2/15 06:55	GMM	B
Carbonaceous BOD 20 Day	260		mg/L	2.0	S5210B-11			12/2/15 11:27	GMM	B
Cyanide, Total	ND		mg/L	0.0050	EPA 335.4	12/14/15	MMA	12/15/15 00:20	LJF	G
Dissolved Oxygen	2.2		mg/L	1.0	S4500OG-01			12/7/15 07:28	RMM	B
Halogen, Total Organic (TOX)	53.4		ug/L	20.0	SW846 9020B			12/9/15 11:01	PAG	N
Hexavalent Chromium	ND		mg/L	0.010	S3500CrB-09			12/2/15 01:11	MSA	B
Nitrate-N	0.65		mg/L	0.50	EPA 300.0			12/2/15 11:57	JP	B
Nitrite-N	ND		mg/L	0.50	EPA 300.0			12/2/15 11:57	JP	B
Odor	10		T.O.N.	1	S2150B-97			12/2/15 04:05	MSA	M
Oil/Grease Hexane Extractable	20.7		mg/L	2.0	EPA 1664B			12/6/15 14:00	AT	H
Oil/Grease Silica Gel Treated	ND		mg/L	2.0	EPA 1664B			12/6/15 14:00	AT	H
Phenolics	0.050		mg/L	0.005	EPA 420.4	12/14/15	NV	12/17/15 11:42	AMH	J
Phosphorus, Total	3.4		mg/L	0.10	EPA 365.1	12/4/15	NV	12/10/15 04:17	LJF	A
Sulfide, Total	ND		mg/L	1.0	S4500S2F-00			12/2/15 19:10	DRM	L
Surfactants (MBAS)	0.539		mg/L	0.025	S5540C-00			12/3/15 02:25	MBW	K
Total Dissolved Solids	300		mg/L	5	S2540C-11			12/2/15 08:53	ML	B
Total Kjeldahl Nitrogen	33.9		mg/L	4.0	S4500NH3G-11	12/3/15	J1H	12/8/15 11:00	C_W	A
Total Nitrogen	34.6		mg/L	1.20	Calculation			1/6/16 20:51	NJA	A
Total Suspended Solids	190		mg/L	5	S2540D-11			12/1/15 22:18	NV	B
Turbidity	87.2		NTU	0.10	S2130B-01			12/3/15 03:09	MSA	B
METALS										
Hardness	137		mg/L	0.66	EPA 200.7	12/2/15	JPS	12/3/15 13:05	TSS	P1
Trivalent Chromium	ND		mg/L	0.010	Calculation			12/15/15 10:51	AGM	B
Aluminum, Total	0.75		mg/L	0.040	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Antimony, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770001** Date Collected: 12/1/2015 09:43 Matrix: Water

Sample ID: **CPS/EPS1 (72/28) LTCPWWCSO** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
Arsenic, Total	ND		mg/L	0.0015	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Cadmium, Total	ND		mg/L	0.00050	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Chromium, Total	0.0048		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Copper, Total	0.066		mg/L	0.0025	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Iron, Total	2.7		mg/L	0.060	EPA 200.7	12/2/15	JPS	12/3/15 13:05	TSS	P1
Lead, Total	0.0094		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Mercury, Total	ND		mg/L	0.00020	EPA 245.1	12/10/15	MNP	12/10/15 12:09	MNP	P3
Molybdenum, Total	0.0018		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Selenium, Total	ND		mg/L	0.0020	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Silver, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Thallium, Total	ND		mg/L	0.00050	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
Zinc, Total	0.12		mg/L	0.0025	EPA 200.8	12/3/15	JPS	12/4/15 04:29	ZMC	P2
MICROBIOLOGY										
Enterococcus	242000		col/100mL	100	S9230D			12/1/15 14:18	LLJ	R
Fecal Coliform	21000000		col/100mL	1000000	SM9222D+EPA 625/R-92/013 APX F			12/1/15 15:04	LLJ	Q
Sub'd to NELAP CERTIFIED Lab										
Gross Alpha	ND		pCi/L	2.60	EPA 900.0			12/11/15 10:43	SUB	Y
Gross Alpha Uncertainty +/-	1.20		pCi/L		EPA 900.0			12/11/15 10:43	SUB	Y
Gross Beta	10.5		pCi/L	2.80	EPA 900.0			12/11/15 10:43	SUB	Y
Gross Beta Uncertainty +/-	2.40		pCi/L		EPA 900.0			12/11/15 10:43	SUB	Y

Mr. Brad W Kintzer
Project Coordinator

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770002** Date Collected: 12/1/2015 09:43 Matrix: Water

Sample ID: **CPS1** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
VOLATILE ORGANICS										
Benzene	ND		ug/L	5.0	EPA 624			12/2/15 23:27	DD	S
Bromodichloromethane	ND		ug/L	5.0	EPA 624			12/2/15 23:27	DD	S
Chlorodibromomethane	ND		ug/L	5.0	EPA 624			12/2/15 23:27	DD	S
Chloroform	ND		ug/L	5.0	EPA 624			12/2/15 23:27	DD	S
Ethylbenzene	ND		ug/L	5.0	EPA 624			12/2/15 23:27	DD	S
Methyl t-Butyl Ether	ND		ug/L	5.0	EPA 624			12/2/15 23:27	DD	S
Methylene Chloride	ND		ug/L	5.0	EPA 624			12/2/15 23:27	DD	S
Tetrachloroethene	ND		ug/L	5.0	EPA 624			12/2/15 23:27	DD	S
Toluene	ND		ug/L	5.0	EPA 624			12/2/15 23:27	DD	S
Total Xylenes	ND		ug/L	15.0	EPA 624			12/2/15 23:27	DD	S
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
1,2-Dichloroethane-d4 (S)	97.1		%	72 - 142	EPA 624			12/2/15 23:27	DD	S
4-Bromofluorobenzene (S)	97.8		%	73 - 119	EPA 624			12/2/15 23:27	DD	S
Dibromofluoromethane (S)	86.1		%	74 - 132	EPA 624			12/2/15 23:27	DD	S
Toluene-d8 (S)	89.4		%	75 - 133	EPA 624			12/2/15 23:27	DD	S
SEMIVOLATILES										
Benzo(a)anthracene	ND		ug/L	1.4	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
Chrysene	ND		ug/L	1.4	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
bis(2-Ethylhexyl)phthalate	7.3		ug/L	2.8	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
N-Nitroso-di-n-propylamine	ND		ug/L	2.8	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
Phenanthrene	ND		ug/L	1.4	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
2,4,6-Tribromophenol (S)	98.4		%	47 - 128	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
2-Fluorobiphenyl (S)	74		%	52 - 118	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
2-Fluorophenol (S)	35		%	20 - 87	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
Nitrobenzene-d5 (S)	74.3		%	27 - 139	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
Phenol-d5 (S)	26.6		%	10 - 81	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
Terphenyl-d14 (S)	82.4		%	46 - 133	EPA 625	12/3/15	CAC	12/4/15 10:21	DHF	U
Pesticides and PCBs										
Dieldrin	0.020		ug/L	0.019	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
Total Polychlorinated Biphenyl	|		ug/L		EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
Aroclor-1016	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
Aroclor-1221	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
Aroclor-1232	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
Aroclor-1242	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770002** Date Collected: 12/1/2015 09:43 Matrix: Water

Sample ID: **CPS1** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
Aroclor-1248	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
Aroclor-1254	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
Aroclor-1260	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
Decachlorobiphenyls (S)	32.1		%	30 - 150	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
Tetrachloro-m-xylene (S)	51.2		%	36 - 112	EPA 608	12/7/15	JSR	12/9/15 17:55	RWS	W
WET CHEMISTRY										
Ammonia-N	20.0		mg/L	0.100	D6919-09			12/2/15 19:24	JAM	A
Biochemical Oxygen Demand	94.0		mg/L	2.0	S5210B-11			12/2/15 04:20	GMM	B
Carbonaceous BOD	92.3		mg/L	2.0	S5210B-11			12/2/15 06:55	GMM	B
Carbonaceous BOD 20 Day	151		mg/L	2.0	S5210B-11			12/2/15 11:27	GMM	B
Cyanide, Total	ND		mg/L	0.0050	EPA 335.4	12/14/15	MMA	12/15/15 00:20	LJF	G
Dissolved Oxygen	2.5		mg/L	1.0	S4500OG-01			12/7/15 07:28	RMM	B
Halogen, Total Organic (TOX)	36.1		ug/L	20.0	SW846 9020B			12/9/15 11:36	PAG	N
Hexavalent Chromium	ND		mg/L	0.010	S3500CrB-09			12/2/15 01:11	MSA	B
Nitrate-N	0.90		mg/L	0.50	EPA 300.0			12/2/15 12:10	JP	B
Nitrite-N	ND		mg/L	0.50	EPA 300.0			12/2/15 12:10	JP	B
Odor	5		T.O.N.	1	S2150B-97			12/2/15 04:05	MSA	M
Oil/Grease Hexane Extractable	12.4		mg/L	2.1	EPA 1664B			12/6/15 14:00	AT	H
Oil/Grease Silica Gel Treated	ND		mg/L	2.1	EPA 1664B			12/6/15 14:00	AT	H
Phenolics	0.028		mg/L	0.005	EPA 420.4	12/14/15	NV	12/17/15 11:43	AMH	J
Phosphorus, Total	2.5		mg/L	0.10	EPA 365.1	12/4/15	NV	12/10/15 04:17	LJF	A
Sulfide, Total	ND		mg/L	1.0	S4500S2F-00			12/2/15 19:10	DRM	L
Surfactants (MBAS)	0.505		mg/L	0.025	S5540C-00			12/3/15 02:25	MBW	K
Total Dissolved Solids	277		mg/L	5	S2540C-11			12/2/15 08:53	ML	B
Total Kjeldahl Nitrogen	23.5		mg/L	4.0	S4500NH3G-11	12/3/15	J1H	12/8/15 11:00	C_W	A
Total Nitrogen	24.4		mg/L	1.20	Calculation			12/14/15 14:11	NJA	A
Total Suspended Solids	186		mg/L	5	S2540D-11			12/1/15 22:18	NV	B
Turbidity	81.9		NTU	0.10	S2130B-01			12/3/15 03:09	MSA	B
METALS										
Hardness	127		mg/L	0.66	EPA 200.7	12/2/15	JPS	12/3/15 13:17	TSS	P1
Trivalent Chromium	ND		mg/L	0.010	Calculation			12/15/15 10:52	AGM	B
Aluminum, Total	0.40		mg/L	0.040	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Antimony, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770002** Date Collected: 12/1/2015 09:43 Matrix: Water

Sample ID: **CPS1** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
Arsenic, Total	ND		mg/L	0.0015	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Cadmium, Total	ND		mg/L	0.00050	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Chromium, Total	0.0014		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Copper, Total	0.041		mg/L	0.0025	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Iron, Total	1.3		mg/L	0.060	EPA 200.7	12/2/15	JPS	12/3/15 13:17	TSS	P1
Lead, Total	0.0096		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Mercury, Total	ND		mg/L	0.00020	EPA 245.1	12/10/15	MNP	12/10/15 12:10	MNP	P3
Molybdenum, Total	0.0012		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Selenium, Total	ND		mg/L	0.0020	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Silver, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Thallium, Total	ND		mg/L	0.00050	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
Zinc, Total	0.13		mg/L	0.0025	EPA 200.8	12/3/15	JPS	12/4/15 04:33	ZMC	P2
MICROBIOLOGY										
Enterococcus	199000		col/100mL	100	S9230D			12/1/15 14:18	LLJ	R
Fecal Coliform	3700000		col/100mL	100000	SM9222D+EPA 625/R-92/013 APX F			12/1/15 16:28	LLJ	Q
Sub'd to NELAP CERTIFIED Lab										
Gross Alpha	ND		pCi/L	2.50	EPA 900.0			12/11/15 10:43	SUB	Y
Gross Alpha Uncertainty +/-	1.00		pCi/L		EPA 900.0			12/11/15 10:43	SUB	Y
Gross Beta	9.50		pCi/L	2.70	EPA 900.0			12/11/15 10:43	SUB	Y
Gross Beta Uncertainty +/-	2.20		pCi/L		EPA 900.0			12/11/15 10:43	SUB	Y

Mr. Brad W Kintzer
Project Coordinator

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770003** Date Collected: 12/1/2015 09:20 Matrix: Water

Sample ID: **14th & Crozer** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
VOLATILE ORGANICS										
Benzene	ND		ug/L	5.0	EPA 624			12/3/15 00:11	DD	S
Bromodichloromethane	ND		ug/L	5.0	EPA 624			12/3/15 00:11	DD	S
Chlorodibromomethane	ND		ug/L	5.0	EPA 624			12/3/15 00:11	DD	S
Chloroform	ND		ug/L	5.0	EPA 624			12/3/15 00:11	DD	S
Ethylbenzene	ND		ug/L	5.0	EPA 624			12/3/15 00:11	DD	S
Methyl t-Butyl Ether	ND		ug/L	5.0	EPA 624			12/3/15 00:11	DD	S
Methylene Chloride	ND		ug/L	5.0	EPA 624			12/3/15 00:11	DD	S
Tetrachloroethene	ND		ug/L	5.0	EPA 624			12/3/15 00:11	DD	S
Toluene	ND		ug/L	5.0	EPA 624			12/3/15 00:11	DD	S
Total Xylenes	ND		ug/L	15.0	EPA 624			12/3/15 00:11	DD	S
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
1,2-Dichloroethane-d4 (S)	100		%	72 - 142	EPA 624			12/3/15 00:11	DD	S
4-Bromofluorobenzene (S)	98		%	73 - 119	EPA 624			12/3/15 00:11	DD	S
Dibromofluoromethane (S)	83.4		%	74 - 132	EPA 624			12/3/15 00:11	DD	S
Toluene-d8 (S)	90.5		%	75 - 133	EPA 624			12/3/15 00:11	DD	S
SEMIVOLATILES										
Benzo(a)anthracene	ND		ug/L	1.4	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
Chrysene	ND		ug/L	1.4	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
bis(2-Ethylhexyl)phthalate	8.0		ug/L	2.8	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
N-Nitroso-di-n-propylamine	ND		ug/L	2.8	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
Phenanthrene	ND		ug/L	1.4	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
2,4,6-Tribromophenol (S)	99.3		%	47 - 128	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
2-Fluorobiphenyl (S)	64.3		%	52 - 118	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
2-Fluorophenol (S)	40.9		%	20 - 87	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
Nitrobenzene-d5 (S)	68.9		%	27 - 139	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
Phenol-d5 (S)	31		%	10 - 81	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
Terphenyl-d14 (S)	85.6		%	46 - 133	EPA 625	12/4/15	CAC	12/6/15 18:58	GEC	U
Pesticides and PCBs										
Dieldrin	ND		ug/L	0.019	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
Total Polychlorinated Biphenyl	|		ug/L		EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
Aroclor-1016	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
Aroclor-1221	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
Aroclor-1232	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
Aroclor-1242	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770003** Date Collected: 12/1/2015 09:20 Matrix: Water

Sample ID: **14th & Crozer** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
Aroclor-1248	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
Aroclor-1254	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
Aroclor-1260	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
Decachlorobiphenyls (S)	23.9	2	%	30 - 150	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
Tetrachloro-m-xylene (S)	43.8		%	36 - 112	EPA 608	12/7/15	JSR	12/9/15 18:18	RWS	W
WET CHEMISTRY										
Ammonia-N	13.4		mg/L	0.100	D6919-09			12/2/15 19:43	JAM	A
Biochemical Oxygen Demand	81.9		mg/L	2.0	S5210B-11			12/2/15 04:20	GMM	B
Carbonaceous BOD	63.4		mg/L	2.0	S5210B-11			12/2/15 06:55	GMM	B
Carbonaceous BOD 20 Day	72.2		mg/L	2.0	S5210B-11			12/2/15 11:27	GMM	B
Cyanide, Total	ND		mg/L	0.0050	EPA 335.4	12/14/15	MMA	12/15/15 00:20	LJF	G
Dissolved Oxygen	1.5		mg/L	1.0	S4500OG-01			12/7/15 07:28	RMM	B
Halogen, Total Organic (TOX)	41.2		ug/L	20.0	SW846 9020B			12/9/15 12:08	PAG	N
Hexavalent Chromium	ND		mg/L	0.010	S3500CrB-09			12/2/15 01:11	MSA	B
Nitrate-N	2.0		mg/L	0.50	EPA 300.0			12/2/15 07:51	JP	B
Nitrite-N	ND		mg/L	0.50	EPA 300.0			12/2/15 07:51	JP	B
Odor	10		T.O.N.	1	S2150B-97			12/2/15 04:05	MSA	M
Oil/Grease Hexane Extractable	8.4		mg/L	2.0	EPA 1664B			12/6/15 14:00	AT	H
Oil/Grease Silica Gel Treated	ND		mg/L	2.0	EPA 1664B			12/6/15 14:00	AT	H
Phenolics	0.016		mg/L	0.005	EPA 420.4	12/14/15	NV	12/17/15 11:44	AMH	J
Phosphorus, Total	2.3		mg/L	0.10	EPA 365.1	12/4/15	NV	12/10/15 04:17	LJF	A
Sulfide, Total	ND		mg/L	1.0	S4500S2F-00			12/2/15 19:10	DRM	L
Surfactants (MBAS)	0.383		mg/L	0.025	S5540C-00			12/3/15 02:25	MBW	K
Total Dissolved Solids	230		mg/L	5	S2540C-11			12/2/15 08:53	ML	B
Total Kjeldahl Nitrogen	21.0		mg/L	4.0	S4500NH3G-11	12/3/15	J1H	12/8/15 11:00	C_W	A
Total Nitrogen	23.0		mg/L	1.20	Calculation			12/14/15 14:11	NJA	A
Total Suspended Solids	112		mg/L	5	S2540D-11			12/1/15 22:18	NV	B
Turbidity	57.4		NTU	0.10	S2130B-01			12/3/15 03:09	MSA	B
METALS										
Hardness	102		mg/L	0.66	EPA 200.7	12/2/15	JPS	12/3/15 13:21	TSS	P1
Trivalent Chromium	ND		mg/L	0.010	Calculation			12/15/15 10:52	AGM	B
Aluminum, Total	0.25		mg/L	0.040	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Antimony, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770003** Date Collected: 12/1/2015 09:20 Matrix: Water

Sample ID: **14th & Crozer** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
Arsenic, Total	ND		mg/L	0.0015	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Cadmium, Total	ND		mg/L	0.00050	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Chromium, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Copper, Total	0.029		mg/L	0.0025	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Iron, Total	0.47		mg/L	0.060	EPA 200.7	12/2/15	JPS	12/3/15 13:21	TSS	P1
Lead, Total	0.0060		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Mercury, Total	ND		mg/L	0.00020	EPA 245.1	12/10/15	MNP	12/10/15 12:11	MNP	P3
Molybdenum, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Selenium, Total	ND		mg/L	0.0020	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Silver, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Thallium, Total	ND		mg/L	0.00050	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
Zinc, Total	0.067		mg/L	0.0025	EPA 200.8	12/3/15	JPS	12/4/15 04:37	ZMC	P2
MICROBIOLOGY										
Enterococcus	173000		col/100mL	100	S9230D			12/1/15 14:18	LLJ	R
Fecal Coliform	1030000	1	col/100mL	10000	SM9222D+EPA 625/R-92/013 APX F			12/1/15 16:28	LLJ	Q
Sub'd to NELAP CERTIFIED Lab										
Gross Alpha	ND		pCi/L	2.30	EPA 900.0			12/11/15 10:43	SUB	Y
Gross Alpha Uncertainty +/-	1.20		pCi/L		EPA 900.0			12/11/15 10:43	SUB	Y
Gross Beta	8.20		pCi/L	2.70	EPA 900.0			12/11/15 10:43	SUB	Y
Gross Beta Uncertainty +/-	2.10		pCi/L		EPA 900.0			12/11/15 10:43	SUB	Y

Mr. Brad W Kintzer
Project Coordinator

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ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770004** Date Collected: 12/1/2015 11:00 Matrix: Water

Sample ID: **Sun & Hancock** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
VOLATILE ORGANICS										
Benzene	ND		ug/L	5.0	EPA 624			12/3/15 00:33	DD	S
Bromodichloromethane	ND		ug/L	5.0	EPA 624			12/3/15 00:33	DD	S
Chlorodibromomethane	ND		ug/L	5.0	EPA 624			12/3/15 00:33	DD	S
Chloroform	ND		ug/L	5.0	EPA 624			12/3/15 00:33	DD	S
Ethylbenzene	ND		ug/L	5.0	EPA 624			12/3/15 00:33	DD	S
Methyl t-Butyl Ether	ND		ug/L	5.0	EPA 624			12/3/15 00:33	DD	S
Methylene Chloride	ND		ug/L	5.0	EPA 624			12/3/15 00:33	DD	S
Tetrachloroethene	ND		ug/L	5.0	EPA 624			12/3/15 00:33	DD	S
Toluene	ND		ug/L	5.0	EPA 624			12/3/15 00:33	DD	S
Total Xylenes	ND		ug/L	15.0	EPA 624			12/3/15 00:33	DD	S
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
1,2-Dichloroethane-d4 (S)	98.7		%	72 - 142	EPA 624			12/3/15 00:33	DD	S
4-Bromofluorobenzene (S)	95		%	73 - 119	EPA 624			12/3/15 00:33	DD	S
Dibromofluoromethane (S)	85.1		%	74 - 132	EPA 624			12/3/15 00:33	DD	S
Toluene-d8 (S)	90.7		%	75 - 133	EPA 624			12/3/15 00:33	DD	S
SEMIVOLATILES										
Benzo(a)anthracene	ND		ug/L	1.4	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
Chrysene	ND		ug/L	1.4	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
bis(2-Ethylhexyl)phthalate	4.9		ug/L	2.8	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
N-Nitroso-di-n-propylamine	ND		ug/L	2.8	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
Phenanthrene	ND		ug/L	1.4	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
2,4,6-Tribromophenol (S)	45.9	2	%	47 - 128	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
2-Fluorobiphenyl (S)	69.3		%	52 - 118	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
2-Fluorophenol (S)	17.5	1	%	20 - 87	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
Nitrobenzene-d5 (S)	76.9		%	27 - 139	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
Phenol-d5 (S)	23.6		%	10 - 81	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
Terphenyl-d14 (S)	88.4		%	46 - 133	EPA 625	12/4/15	CAC	12/6/15 19:23	GEC	U
Pesticides and PCBs										
Dieldrin	ND		ug/L	0.019	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
Total Polychlorinated Biphenyl	|		ug/L		EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
Aroclor-1016	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
Aroclor-1221	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
Aroclor-1232	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
Aroclor-1242	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W

ALS Environmental

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NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770004** Date Collected: 12/1/2015 11:00 Matrix: Water

Sample ID: **Sun & Hancock** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	Cntr
Aroclor-1248	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
Aroclor-1254	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
Aroclor-1260	ND		ug/L	0.47	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
Surrogate Recoveries	*Results*	*Flag*	*Units*	*Limits*	*Method*	*Prepared*	*By*	*Analyzed*	*By*	*Cntr*
Decachlorobiphenyls (S)	39.8		%	30 - 150	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
Tetrachloro-m-xylene (S)	52.9		%	36 - 112	EPA 608	12/7/15	JSR	12/9/15 18:40	RWS	W
WET CHEMISTRY										
Ammonia-N	3.63		mg/L	0.100	D6919-09			12/2/15 20:02	JAM	A
Biochemical Oxygen Demand	70.7		mg/L	2.0	S5210B-11			12/2/15 04:20	GMM	B
Carbonaceous BOD	49.4		mg/L	2.0	S5210B-11			12/2/15 06:55	GMM	B
Carbonaceous BOD 20 Day	96.8		mg/L	2.0	S5210B-11			12/2/15 11:27	GMM	B
Cyanide, Total	ND		mg/L	0.0050	EPA 335.4	12/14/15	MMA	12/15/15 00:20	LJF	G
Dissolved Oxygen	4.4		mg/L	1.0	S4500OG-01			12/7/15 07:28	RMM	B
Halogen, Total Organic (TOX)	ND		ug/L	20.0	SW846 9020B			12/9/15 12:40	PAG	N
Hexavalent Chromium	ND		mg/L	0.010	S3500CrB-09			12/2/15 01:11	MSA	B
Nitrate-N	ND		mg/L	0.50	EPA 300.0			12/2/15 09:26	JP	B
Nitrite-N	ND		mg/L	0.50	EPA 300.0			12/2/15 09:26	JP	B
Odor	2		T.O.N.	1	S2150B-97			12/2/15 04:05	MSA	M
Oil/Grease Hexane Extractable	2.6		mg/L	2.1	EPA 1664B			12/6/15 14:00	AT	H
Oil/Grease Silica Gel Treated	ND		mg/L	2.1	EPA 1664B			12/6/15 14:00	AT	H
Phenolics	0.009		mg/L	0.005	EPA 420.4	12/14/15	NV	12/17/15 11:45	AMH	J
Phosphorus, Total	1.4		mg/L	0.10	EPA 365.1	12/4/15	NV	12/10/15 04:17	LJF	A
Sulfide, Total	ND		mg/L	1.0	S4500S2F-00			12/2/15 19:10	DRM	L
Surfactants (MBAS)	0.067		mg/L	0.025	S5540C-00			12/3/15 02:25	MBW	K
Total Dissolved Solids	26		mg/L	5	S2540C-11			12/2/15 08:53	ML	B
Total Kjeldahl Nitrogen	8.3		mg/L	4.0	S4500NH3G-11	12/3/15	J1H	12/8/15 11:00	C_W	A
Total Nitrogen	8.30		mg/L	1.20	Calculation			12/14/15 14:11	NJA	A
Total Suspended Solids	200		mg/L	5	S2540D-11			12/1/15 22:18	NV	B
Turbidity	80.6		NTU	0.10	S2130B-01			12/3/15 03:09	MSA	B
METALS										
Hardness	31.5		mg/L	1.7	EPA 200.7	12/3/15	JPS	12/4/15 07:50	TSS	P1
Trivalent Chromium	ND		mg/L	0.010	Calculation			12/15/15 10:53	AGM	B
Aluminum, Total	0.44		mg/L	0.040	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Antimony, Total	0.0018		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2

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NELAP Certifications: NJ PA010 , NY 11759 , PA 22-293 DoD ELAP: A2LA 0818.01
State Certifications: DE ID 11 , MA PA0102 , MD 128 , VA 460157 , WV 343

ANALYTICAL RESULTS

Workorder: 2110770 2015-LOWER DELAWARE TESTING

Lab ID: **2110770004** Date Collected: 12/1/2015 11:00 Matrix: Water

Sample ID: **Sun & Hancock** Date Received: 12/1/2015 13:55

Parameters	Results	Flag	Units	RDL	Method	Prepared	By	Analyzed	By	*Cntr*
Arsenic, Total	ND		mg/L	0.0015	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Cadmium, Total	ND		mg/L	0.00050	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Chromium, Total	0.0031		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Copper, Total	0.032		mg/L	0.0025	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Iron, Total	1.5		mg/L	0.15	EPA 200.7	12/3/15	JPS	12/4/15 07:50	TSS	P1
Lead, Total	0.020		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Mercury, Total	0.0011		mg/L	0.00020	EPA 245.1	12/10/15	MNP	12/10/15 12:12	MNP	P3
Molybdenum, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Selenium, Total	ND		mg/L	0.0020	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Silver, Total	ND		mg/L	0.0010	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Thallium, Total	ND		mg/L	0.00050	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
Zinc, Total	0.20		mg/L	0.0025	EPA 200.8	12/3/15	JPS	12/4/15 04:40	ZMC	P2
MICROBIOLOGY										
Enterococcus	34500		col/100mL	100	S9230D			12/1/15 14:18	LLJ	R
Fecal Coliform	2100000		col/100mL	100000	SM9222D+EPA 625/R-92/013 APX F			12/1/15 16:28	LLJ	Q
Sub'd to NELAP CERTIFIED Lab										
Gross Alpha	2.70		pCi/L	2.40	EPA 900.0			12/11/15 10:43	SUB	Y
Gross Alpha Uncertainty +/-	1.50		pCi/L		EPA 900.0			12/11/15 10:43	SUB	Y
Gross Beta	4.20		pCi/L	2.70	EPA 900.0			12/11/15 10:43	SUB	Y
Gross Beta Uncertainty +/-	1.60		pCi/L		EPA 900.0			12/11/15 10:43	SUB	Y

Mr. Brad W Kintzer
Project Coordinator

PARAMETER QUALIFIERS

Lab ID	#	Sample ID	Analytical Method	Analyte
2110770003	1	14th & Crozer	SM9222D+EPA 625/R-92/013 APX F	Fecal Coliform
This is an estimated result.				
2110770003	2	14th & Crozer	EPA 608	Decachlorobiphenyls
The surrogate Decachlorobiphenyls for method EPA 608 was outside of control limits. The % Recovery was reported as 23.9 and the control limits were 30 to 150. This result was reported at a dilution of 1.				
2110770004	1	Sun & Hancock	EPA 625	2-Fluorophenol
The surrogate 2-Fluorophenol for method EPA 625 was outside of control limits. The % Recovery was reported as 17.5 and the control limits were 20 to 87. This result was reported at a dilution of 1.				
2110770004	2	Sun & Hancock	EPA 625	2,4,6-Tribromophenol
The surrogate 2,4,6-Tribromophenol for method EPA 625 was outside of control limits. The % Recovery was reported as 45.9 and the control limits were 47 to 128. This result was reported at a dilution of 1.				

ALS Environmental
34 Dogwood Lane
Middletown, PA 17057
P. 717-944-5541
F. 717-944-1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

* 2 1 1 0 7 7 0 *

Client Name: DELCORA
Address: 3201 W. Front Street
Chester PA 19013
Contact: Mike Krause
Phone#: 610-876-5523 x218
Project Name/#: CSO WW LTCP
Bill To: Same

TAT: [x] Normal-Standard TAT is 10-12 business days. [ ] Rush-Subject to ALS approval and surcharges.
Date Required: _____ Approved By: _____
Email? [x] -Y
Fax? [ ] -Y No.: _____

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Total Sulfide	CBOD5, CBOD20, BOD5	Metals, Total Hardness	Hexavalent Chromium, Trivalent Chromium	Fecal Coliform	Enterococcus	608	625	624	Gross Alpha/ Beta
Container Type					plastic	plastic	plastic	plastic	plastic	plastic	glass	glass	gla	
Container Size					250ml	1L	500ml	500ml	120ml	120ml	1L	1L	40ml	1L
Preservative					H/Zn(O2C	none	HNO3	none	Na2S2O3	Na2S2O3	none	none	none	None
					Enter Number of Containers Per Sample or Field Results Below.									
1 CPS/ EPS1 (72/28) *	12/1/2015	9:43	G	WW	1	2	1	1	1	1	2	2	2	1
2 CPS1 - Labeled as CPS	12/1/2015	9:43	G	WW	1	2	1	1	1	1	2	2	2	1
3 14th & Crozer	12/1/2015	9:20	G	WW	1	2	1	1	1	1	2	2	2	1
4 Sun & Hancock	12/1/2015	11:00	G	WW	1	2	1	1	1	1	2	2	2	1
5 * Labeled as LTCPWWCSO	AS 12/1/15													
6														
7 MICRO REC'D	W 12/1/15 1355													
8														
9														
10														

Cooler Temp: 4°c Therm ID: IR-284
No. of Coolers: _____ Y N (initial)

	Y	N	(initial)
Custody Seals Present?			
(if present) Seals Intact?			
Received on Ice?	✓		
COC/Labels Complete/Accurate?	✓		
Cont. in Good Cond.?	✓		
Correct Containers?	✓		
Correct Sample Volumes?	✓		
Correct Preservation?	✓		
Headspace/Volatiles?			N/A

Courier/Tracking #:

Sample/COC Comments

ALS Field Services: [x] Pickup [ ] Labor [ ] Composite Sampling [ ] Rental Equipment [ ] Other: _____

Project Comments:

LOGGED BY(signature): _____ DATE 12-1-15 TIME 1223
REVIEWED BY(signature): _____ DATE _____ TIME _____

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1 Raymond Rig	12/1/15	1135	2 Ron Horner	12-1	1135
3	12-1	1305	4 ALS	12/1/15	1305
5 ALS	12/1/15	1355	6	12/1/15	1355
7			8		
9			10		

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE [ ]
Special Processing: USACE [ ] Navy [ ] [ ]
State Samples Collected In: [ ] NY [ ] NJ [x] PA [ ] NC [ ]
Reportable to PADEP? Yes [ ] PWSID # _____
Sample Disposal: Lab [ ] Special [ ]
EDDS: Format Type- _____

* G=Grab; C=Composite **Matrix - AI=Air; DW=Drinking Water; GW=Groundwater; OI=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

ALS ENVIRONMENTAL SHIPPING ADDRESS: 34 DOGWOOD LANE, MIDDLETOWN, PA 17057

Rev 10/11

ALS Environmental
34 Dogwood Lane
Middletown, PA 17057
P. 717-944-5541
F. 717-944-1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: 2110770 — 2 of 2
ALS Quote #: 514787

Client Name: DELCORA
Address: 3201 W. Front Street, Chester-PA-19013
Contact: Mike Krause
Phone#: 610-876-5523 x218
Project Name/#: CSO WW LTCP
Bill To: Same

TAT: [x] Normal-Standard TAT is 10-12 business days. [ ] Rush-Subject to ALS approval and surcharges.
Date Required: _____ Approved By: _____
Email? [x] -Y
Fax? [ ] -Y No.: _____

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Oil and Grease	TPH	Nitrate, Nitrite, Turbidity	Total Cyanide	Total Phosphorus, Ammonia, TKN, Total Nitrogen	Phenolics	TOX	TSS, TDS, DO	Odor	MBAS
Container Type					glass	glass	plastic	plastic	plastic	glass	glass	plastic	glass	plastic
Container Size					1L	1L	500ml	500ml	1L	500ml	250ml	1L	1L	2L
Preservative					H2SO4	H2SO4	none	NaOH	H2SO4	H2SO4	H2SO4	none	none	none
					Enter Number of Containers Per Sample or Field Results Below.									
1 CPS/ EPS1 (72/28)	12/1/2015	9:43	G	WW	1	1	1	1	1	1	2	1	1	1
2 CPS1	12/1/2015	9:43	G	WW	1	1	1	1	1	1	2	1	1	1
3 14th & Crozer	12/1/2015	9:20	G	WW	1	1	1	1	1	1	2	1	1	1
4 Sun & Hancock	12/1/2015	11:00	G	WW	1	1	1	1	1	1	2	1	1	1
5														
6														
7														
8														
9														
10														

ANALYSES/METHOD REQUESTED

Receipt Information (completed by Receiving Lab)
Cooler Temp: 4°C Therm ID: TH-294
No. of Coolers: _____

	Y	N	Initial
Custody Seals Present?		✓	AM
(if present) Seals Intact?			
Received on Ice?	✓		
COC/Labels Complete/Accurate?	✓		
Cont. in Good Cond.?	✓		
Correct Containers?	✓		
Correct Sample Volumes?	✓		
Correct Preservation?	✓		
Headspace/Volatiles?			

Courier/Tracking #:

Sample/COC Comments

ALS Field Services: [x] Pickup [ ] Labor [ ] Composite Sampling [ ] Rental Equipment [ ] Other: _____

Project Comments:

LOGGED BY(signature): _____ DATE 12-1-15 TIME 1725
REVIEWED BY(signature): _____ DATE _____ TIME _____

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE [ ]
Special Processing: USACE [ ] Navy [ ]
State Samples Collected In: [ ] NY [ ] NJ [x] PA [ ] NC [ ]
Reportable to PADEP? Yes [ ] PWSID # _____
Sample Disposal: Lab [ ] Special [ ]
EDDS: Format Type- _____

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1 Raymond Rios	12.1.15	1135	2 Ron Horgan	12.1	1135
3 Ron H	12.4	1355	4 ALS	12/4/15	1355
5 ALS	12/4/15	1355	6	12/4/15	1355
7			8		
9			10		

*G=Grab; C=Composite
**Matrix - AI=Air; DW=Drinking Water; GW=Groundwater; OI=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

ALS ENVIRONMENTAL SHIPPING ADDRESS: 34 DOGWOOD LANE, MIDDLETOWN, PA 17057

Rev 10/11

Thursday, January 07, 2016 6:17:25 AM
Page 19 of 32

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Environmental • Industrial Hygiene • Field Services
34 Dogwood Lane • Middletown, PA 17057 • 717.944.5541 • Fax: 717.944.1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: 1 of 1
ALSI Quote #:

Client Name: ALS Environmental
Address: 34 Dogwood Lane
Middletown, PA 17057
Contact: Brad Kintzer
Phone#: (717) 944-5541
Project Name/#:
Bill To: ALS Environmental

TAT [X] Normal-Standard TAT is 10-12 business days.
[ ] Rush-Subject to ALSI approval and surcharges.
Date Required: _____ Approved By: _____
Email? [X] -Y ALMDT.Subcontract@ALSGlobal.com
Fax? [ ] -Y No.: _____

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Container Type	Container Size	Preservative	Gross Alpha & Beta
					Plastic	1 L	NONE	ANALYSES/METHOD REQUESTED
1 2110770 001	12/1/15	0943	G	WW				1
2 2110770 002	12/1/15	0943	G	WW				1
3 2110770 003	12/1/15	0920	G	WW				1
4 2110770 004	12/1/15	1100	G	WW				1
5								
6								
7								
8								
9								
10								

Receipt Information (completed by Receiving Lab)
Cooler Temp: _____ Therm. ID: _____
No. of Coolers: _____

	Y	N	Initial
Custody Seals Present?			
(If present) Seals Intact?			
Received on Ice?			
COC/Labels Complete/Accurate?			
Cont. in Good Cond.?			
Correct Containers?			
Correct Sample Volumes?			
Correct Preservation?			
Headspace/Volatiles?			

Courier Tracking #: _____

Sample/COC Comments
Subcontract: ALS Ft. Collins

ALSI Field Services: ☐Pickup ☐Labor
☐Composite Sampling ☐Rental Equipment
☐Other: _____

Project Comments:

LOGGED BY(signature): Date: Time:
REVIEWED BY(signature): Date: Time:

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1	12/2/15	1602	2		
3			4		
5			6		
7			8		
9			10		

Data Deliverables: [ ] Standard [ ] CLP-like [ ] USACE [ ]
Special Processing: USACE [ ] Navy [ ]
State Samples Collected In: [ ] NY [ ] NJ [ ] PA [ ] NC [ ] other
Reportable to PADEP? Yes [ ]
PWSID # _____
Sample Disposal: Lab [ ] Special [ ]
EDDs: Format Type: _____

* G=Grab; C=Composite
**Matrix - Al=Air; DW=Drinking Water; GW=Groundwater; Oil=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

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Rev 5/05

ALS

Tuesday, December 22, 2015

Brad Kintzer
ALS Environmental
34 Dogwood Lane
Middletown, PA 17057

Re: ALS Workorder: 1512056
Project Name:
Project Number: 2110770

Dear Mr. Kintzer:

Four water samples were received from ALS Environmental, on 12/3/2015. The samples were scheduled for the following analysis:

Gross Alpha/Beta

The results for these analyses are contained in the enclosed reports.

The data contained in the following report have been reviewed and approved by the personnel listed below. In addition, ALS certifies that the analyses reported herein are true, complete and correct within the limits of the methods employed.

Thank you for your confidence in ALS Environmental. Should you have any questions, please call.

Sincerely,

ALS Environmental
Jeff R. Kujawa
Project Manager

ALS Environmental – Fort Collins is accredited by the following accreditation bodies for various testing scopes in accordance with requirements of each accreditation body. All testing is performed under the laboratory management system, which is maintained to meet these requirement and regulations. Please contact the laboratory or accreditation body for the current scope testing parameters.

ALS Environmental – Fort Collins	
Accreditation Body	License or Certification Number
Alaska (AK)	UST-086
Alaska (AK)	CO01099
Arizona (AZ)	AZ0742
California (CA)	06251CA
Colorado (CO)	CO01099
Connecticut (CT)	PH-0232
Florida (FL)	E87914
Idaho (ID)	CO01099
Kansas (KS)	E-10381
Kentucky (KY)	90137
L-A-B (DoD ELAP/ISO 170250)	L2257
Louisiana (LA)	05057
Maryland (MD)	285
Missouri (MO)	175
Nebraska(NE)	NE-OS-24-13
Nevada (NV)	CO000782008A
New York (NY)	12036
North Dakota (ND)	R-057
Oklahoma (OK)	1301
Pennsylvania (PA)	68-03116
Tennessee (TN)	2976
Texas (TX)	T104704241
Utah (UT)	CO01099
Washington (WA)	C1280

ALS Environmental

1512056

Gross Alpha/Beta:
The samples were analyzed for gross alpha and beta activity by gas flow proportional counting according to the current revision of SOP 724. Gross alpha results are referenced to ^{241}Am. Gross beta results are referenced to $^{90}Sr/Y$.

All acceptance criteria were met.

ADDRESS 225 Commerce Drive, Fort Collins Colorado 80524 USA | PHONE +1 970 490 1511 | FAX +1 970 490 1522
ALS GROUP USA, CORP. Part of the ALS Group An ALS Limited Company

ALS Environmental -- FC

Sample Number(s) Cross-Reference Table

OrderNum: 1512056
Client Name: ALS Environmental
Client Project Name:
Client Project Number: 2110770
Client PO Number: 2110770

Client Sample Number	Lab Sample Number	COC Number	Matrix	Date Collected	Time Collected
2110770001	1512056-1		WATER	01-Dec-15	9:43
2110770002	1512056-2		WATER	01-Dec-15	9:43
2110770003	1512056-3		WATER	01-Dec-15	9:20
2110770004	1512056-4		WATER	01-Dec-15	11:00

Thursday, January 07, 2016 6:17:25 AM
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Analytical Laboratory Services, Inc.
Environmental • Industrial Hygiene • Field Services
34 Dogwood Lane • Middletown, PA 17057 • 717.944.5541 • Fax 717.944.1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: 1 of 1
ALSI Quote #:

Client Name: ALS Environmental
Address: 34 Dogwood Lane, Middletown, PA 17057
Contact: Brad Kintzer
Phone#: (717) 944-5541
Project Name/#:
Bill To: ALS Environmental

TAT [X] Normal-Standard TAT is 10-12 business days. [ ] Rush-Subject to ALSI approval and surcharges.
Date Required: Approved By:
Email? [X] Y ALMOT.Subcontract@ALSGlobal.com
Fax? [ ] Y No:

Sample Description/Location (as it will appear on the lab report)	Sample Date	Time	*G or C	**Matrix	Container Type	Container Size	Preservative	Gross Alpha & Beta								
					Plastic	1L	NONE	ANALYSES/METHOD REQUESTED								
1 2110770 001	12/1/15	0943	G	WW				1								
2 2110770 002	12/1/15	0943	G	WW				1								
3 2110770 003	12/1/15	0920	G	WW				1								
4 2110770 004	12/1/15	1100	G	WW				1								
5																
6																
7																
8																
9																
10																

1 2 3 4

Project Comments:
LOGGED BY(signature): Date Time
REVIEWED BY(signature): Date Time

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1	12/2/15	1602	ALS Environmental	12/5/15	1000
3			4		
5			6		
7			8		
9			10		

Receipt Information (completed by Receiving Lab)
Cooler Temp: Therm. ID:
No. of Coolers:

	Y	N	Initial
Custody Seals Present?			
(if present) Seals Intact?			
Received on Ice?			
COC/Labels Complete/Accurate?			
Cont. in Good Cond.?			
Correct Containers?			
Correct Sample Volumes?			
Correct Preservation?			
Headspace/Volatiles?			

Courier tracking #:

Sample/COC Comments
Subcontract: ALS Ft. Collins

ALSI Field Services: ☐Pickup ☐Labor ☐Composite Sampling ☐Rental Equipment ☐Other:

Data Deliverables: [ ] Standard [ ] CLP-like [X] USACE
Special Processing: USACE [X] Navy [ ]
State Samples Collected in: [ ] NY [ ] NJ [ ] PA [ ] NC [ ] other

Reportable to PADEP? [ ] Yes
Sample Disposal: Lab [ ] Special [ ]
PWSID #:
EDDs: Format Type:

* G=Grab; C=Composite **Matrix - Al=Air; DW=Drinking Water; GW=Groundwater; Oi=Oil; OL=Other Liquid; SL=Sludge; SO=Soil; WP=Wipe; WW=Wastewater

Copies: WHITE - ORIGINAL CANARY - CUSTOMER MAILING PINK - FILE GOLDENROD - CUSTOMER COPY Rev 5/05

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ALS

ALS Environmental - Fort Collins
CONDITION OF SAMPLE UPON RECEIPT FORM

Client: ALS Penn Workorder No: 1512056

Project Manager: ~~ARW~~ JRK Initials: [illegible] Date: 12/3/15

1. Does this project require any special handling in addition to standard ALS procedures?		YES	NO
2. Are custody seals on shipping containers intact?	NONE	YES	NO
3. Are Custody seals on sample containers intact?	NONE	YES	NO
4. Is there a COC (Chain-of-Custody) present or other representative documents?		YES	NO
5. Are the COC and bottle labels complete and legible?		YES	NO
6. Is the COC in agreement with samples received? (IDs, dates, times, no. of samples, no. of containers, matrix, requested analyses, etc.)		YES	NO
7. Were airbills / shipping documents present and/or removable?	DROP OFF	YES	NO
8. Are all aqueous samples requiring preservation preserved correctly? (excluding volatiles)	N/A	YES	NO
9. Are all aqueous non-preserved samples pH 4-9?	N/A	YES	NO
10. Is there sufficient sample for the requested analyses?		YES	NO
11. Were all samples placed in the proper containers for the requested analyses?		YES	NO
12. Are all samples within holding times for the requested analyses?		YES	NO
13. Were all sample containers received intact? (not broken or leaking, etc.)		YES	NO
14. Are all samples requiring no headspace (VOC, GRO, RSK/MEE, Rx CN/S, radon) headspace free? Size of bubble: ____ < green pea ____ > green pea	N/A	YES	NO
15. Do any water samples contain sediment? Amount Amount of sediment: ____ dusting X moderate ____ heavy	N/A	YES	NO
16. Were the samples shipped on ice?		YES	NO
17. Were cooler temperatures measured at 0.1-6.0°C? IR gun used*: #2 #4	RAD ONLY	YES	NO

Cooler #:	1							
Temperature (°C):	AMB							
No. of custody seals on cooler:	0							
DOT Survey/ Acceptance Information — External µR/hr reading:	10							
Background µR/hr reading:	11							

Were external µR/hr readings ≤ two times background and within DOT acceptance criteria? YES / NO / NA (If no, see Form 008.)

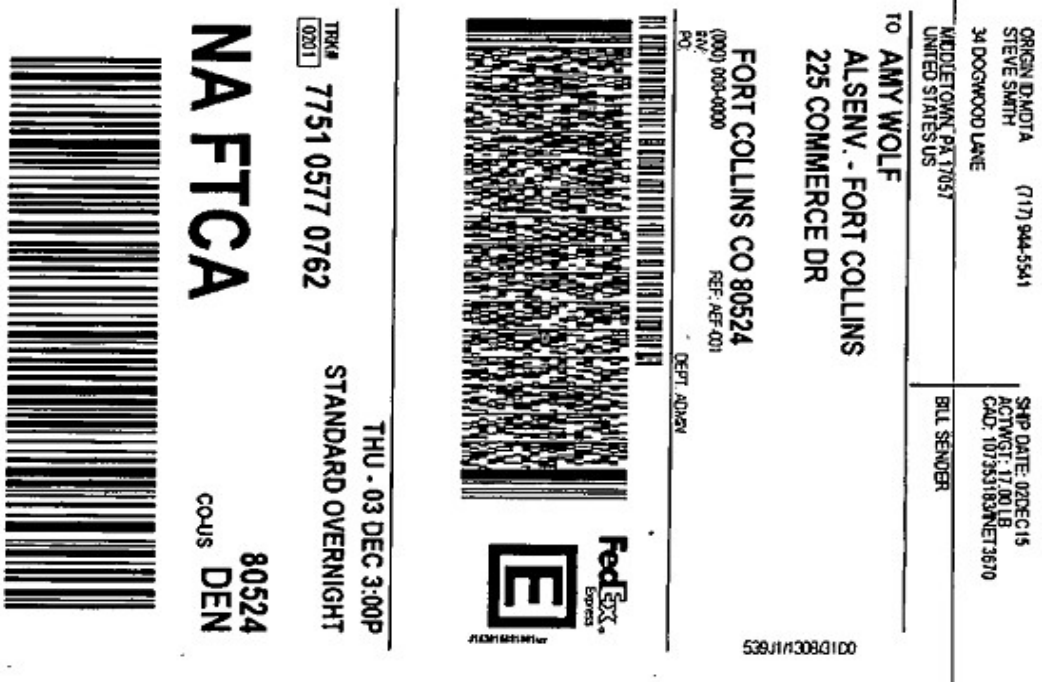
Additional Information: PROVIDE DETAILS BELOW FOR A NO RESPONSE TO ANY QUESTION ABOVE, EXCEPT #1 AND #16.

If applicable, was the client contacted? YES / NO / NA Contact: _____ Date/Time: _____

Project Manager Signature / Date: [signature] 12-3-15

*IR Gun #2: Oakton, SN 29922500201-0066
*IR Gun #4: Oakton, SN 2372220101-0002

Form 201r24.xls (06/04/2012)



After printing this label:
1. Use the 'Print' button on this page to print your label to your laser or inkjet printer.
2. Fold the printed page along the horizontal line.
3. Place label in shipping pouch and affix it to your shipment so that the barcode portion of the label can be read and scanned.

Warning: Use only the printed original label for shipping. Using a photocopy of this label for shipping purposes is fraudulent and could result in additional billing charges, along with the cancellation of your FedEx account number.
Use of this system constitutes your agreement to the service conditions in the current FedEx Service Guide, available on fedex.com.FedEx will not be responsible for any claim in excess of $100 per package, whether the result of loss, damage, delay, non-delivery,misdelivery,or misinformation, unless you declare a higher value, pay an additional charge, document your actual loss and file a timely claim.Limitations found in the current FedEx Service Guide apply. Your right to recover from FedEx for any loss, including intrinsic value of the package, loss of sales, income interest, profit, attorney's fees, costs, and other forms of damage whether direct, incidental,consequential, or special is limited to the greater of $100 or the authorized declared value. Recovery cannot exceed actual documented loss.Maximum for items of extraordinary value is $1,000, e.g. jewelry, precious metals, negotiable instruments and other items listed in our ServiceGuide. Written claims must be filed within strict time limits, see current FedEx Service Guide.

Client:	ALS Environmental	**Date:**	*22-Dec-15*
Project:	2110770	**Work Order:**	1512056
Sample ID:	2110770001	**Lab ID:**	1512056-1
Legal Location:		**Matrix:**	WATER
Collection Date:	12/1/2015 09:43	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gross Alpha/Beta by GFPC			**PAI 724**		Prep Date: **12/9/2015**	PrepBy: **ECP**
GROSS ALPHA	ND (+/- 1.2)	U	2.6	pCi/l	NA	12/11/2015 10:43
GROSS BETA	**10.5 (+/- 2.4)**		**2.8**	**pCi/l**	NA	12/11/2015 10:43

Client:	ALS Environmental	**Date:**	*22-Dec-15*
Project:	2110770	**Work Order:**	1512056
Sample ID:	2110770002	**Lab ID:**	1512056-2
Legal Location:		**Matrix:**	WATER
Collection Date:	12/1/2015 09:43	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gross Alpha/Beta by GFPC		**PAI 724**			Prep Date: **12/9/2015**	PrepBy: **ECP**
GROSS ALPHA	ND (+/- 1)	U	2.5	pCi/l	NA	12/11/2015 10:43
GROSS BETA	**9.6 (+/- 2.2)**		**2.7**	**pCi/l**	NA	12/11/2015 10:43

Client:	ALS Environmental	**Date:**	*22-Dec-15*
Project:	2110770	**Work Order:**	1512056
Sample ID:	2110770003	**Lab ID:**	1512056-3
Legal Location:		**Matrix:**	WATER
Collection Date:	12/1/2015 09:20	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gross Alpha/Beta by GFPC			**PAI 724**		Prep Date: **12/9/2015**	PrepBy: **ECP**
GROSS ALPHA	ND (+/- 1.2)	U	2.3	pCi/l	NA	12/11/2015 10:43
GROSS BETA	**8.2 (+/- 2.1)**		**2.7**	**pCi/l**	NA	12/11/2015 10:43

Client:	ALS Environmental	**Date:**	*22-Dec-15*
Project:	2110770	**Work Order:**	1512056
Sample ID:	2110770004	**Lab ID:**	1512056-4
Legal Location:		**Matrix:**	WATER
Collection Date:	12/1/2015 11:00	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed
Gross Alpha/Beta by GFPC		**PAI 724**			Prep Date: **12/9/2015**	PrepBy: **ECP**
GROSS ALPHA	2.7 (+/- 1.5)	LT	2.4	pCi/l	NA	12/11/2015 10:43
GROSS BETA	**4.2 (+/- 1.6)**		**2.7**	**pCi/l**	NA	12/11/2015 10:43

Client:	ALS Environmental	**Date:**	*22-Dec-15*
Project:	2110770	**Work Order:**	1512056
Sample ID:	2110770004	**Lab ID:**	1512056-4
Legal Location:		**Matrix:**	WATER
Collection Date:	12/1/2015 11:00	**Percent Moisture:**	

Analyses	Result	Qual	Report Limit	Units	Dilution Factor	Date Analyzed

Explanation of Qualifiers

Radiochemistry:

U or ND - Result is less than the sample specific MDC.
Y1 - Chemical Yield is in control at 100-110%. Quantitative yield is assumed.
Y2 - Chemical Yield outside default limits.
W - DER is greater than Warning Limit of 1.42
* - Aliquot Basis is 'As Received' while the Report Basis is 'Dry Weight'.
# - Aliquot Basis is 'Dry Weight' while the Report Basis is 'As Received'.
G - Sample density differs by more than 15% of LCS density.
D - DER is greater than Control Limit
M - Requested MDC not met.
LT - Result is less than requested MDC but greater than achieved MDC.
M3 - The requested MDC was not met, but the reported activity is greater than the reported MDC.
L - LCS Recovery below lower control limit.
H - LCS Recovery above upper control limit.
P - LCS, Matrix Spike Recovery within control limits.
N - Matrix Spike Recovery outside control limits
NC - Not Calculated for duplicate results less than 5 times MDC
B - Analyte concentration greater than MDC.
B3 - Analyte concentration greater than MDC but less than Requested MDC.

Inorganics:

B - Result is less than the requested reporting limit but greater than the instrument method detection limit (MDL).
U or ND - Indicates that the compound was analyzed for but not detected.
E - The reported value is estimated because of the presence of interference. An explanatory note may be included in the narrative.
M - Duplicate injection precision was not met.
N - Spiked sample recovery not within control limits. A post spike is analyzed for all ICP analyses when the matrix spike and or spike duplicate fail and the native sample concentration is less than four times the spike added concentration.
Z - Spiked recovery not within control limits. An explanatory note may be included in the narrative.
* - Duplicate analysis (relative percent difference) not within control limits.
S - SAR value is estimated as one or more analytes used in the calculation were not detected above the detection limit.

Organics:

U or ND - Indicates that the compound was analyzed for but not detected.
B - Analyte is detected in the associated method blank as well as in the sample. It indicates probable blank contamination and warns the data user.
E - Analyte concentration exceeds the upper level of the calibration range.
J - Estimated value. The result is less than the reporting limit but greater than the instrument method detection limit (MDL).
A - A tentatively identified compound is a suspected aldol-condensation product.
X - The analyte was diluted below an accurate quantitation level.
* - The spike recovery is equal to or outside the control criteria used.
+ - The relative percent difference (RPD) equals or exceeds the control criteria.
G - A pattern resembling gasoline was detected in this sample.
D - A pattern resembling diesel was detected in this sample.
M - A pattern resembling motor oil was detected in this sample.
C - A pattern resembling crude oil was detected in this sample.
4 - A pattern resembling JP-4 was detected in this sample.
5 - A pattern resembling JP-5 was detected in this sample.
H - Indicates that the fuel pattern was in the heavier end of the retention time window for the analyte of interest.
L - Indicates that the fuel pattern was in the lighter end of the retention time window for the analyte of interest.
Z - This flag indicates that a significant fraction of the reported result did not resemble the patterns of any of the following petroleum hydrocarbon products:
- gasoline
- JP-8
- diesel
- mineral spirits
- motor oil
- Stoddard solvent
- bunker C

QC BATCH REPORT

Batch ID: **AB151209-3-2** Instrument ID **LB4100-C** Method: **Gross Alpha/Beta by GFPC**

LCS Sample ID: **AB151209-3** Units: **pCi/l** Analysis Date: **12/10/2015 13:22**
Client ID: Run ID: **AB151209-3A** Prep Date: **12/9/2015** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
GROSS ALPHA	235 (+/- 43)	7	225.4		104	70-130					P,M3
GROSS BETA	204 (+/- 35)	12	203.7		100	70-130					P,M3

LCSD Sample ID: **AB151209-3** Units: **pCi/l** Analysis Date: **12/10/2015 13:22**
Client ID: Run ID: **AB151209-3A** Prep Date: **12/9/2015** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
GROSS ALPHA	249 (+/- 45)	8	225.4		111	70-130		235	0.2	2.1	P,M3
GROSS BETA	201 (+/- 35)	12	203.7		98.8	70-130		204	0.05	2.1	P,M3

MB Sample ID: **AB151209-3** Units: **pCi/l** Analysis Date: **12/20/2015 09:01**
Client ID: Run ID: **AB151209-3A** Prep Date: **12/9/2015** DF: **NA**

Analyte	Result	ReportLimit	SPK Val	SPK Ref Value	%REC	Control Limit	Decision Level	DER Ref	DER	DER Limit	Qual
GROSS ALPHA	ND	0.85									U
GROSS BETA	ND	1.11									U

The following samples were analyzed in this batch:

1512056-1	1512056-2	1512056-3
1512056-4	1511473-9	

ATTACHMENT G

Historical Receiving Water Sampling for the Chester and Ridley Creeks

Dry Events

Sample Date	Site	Test	Result	Units	RDL	Method	Analysis Date
7/20/2010 (Test Run)	CC1	DO	8.38	mg/L		Multimeter Probe	7/20/2010 16:21 PM
		Temperature	25.9	^{0}C			7/20/2010 16:21 PM
		Conductivity	461	µS			7/20/2010 16:21 PM
		pH	7.81	pH			7/20/2010 16:21 PM
		BOD-5	<3	mg/L	3	SM 5210 B	7/21/10 7:45 AM
		TSS	4	mg/L	4	SM 2540D	7/26/10 12:34 PM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	7/26/10 11:44 AM
		Digestion, TKN-TP	7/22/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.42	mg/L	0.05	EPA 365.2	7/23/10 11:30 AM
		Fecal Coliform, MF	3400	colonies/100mL	N/A	SM 9222 D	7/20/10 5:49 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:29 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:29 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:29 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:29 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:29 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/4/2011 10:59 P.M.
		ICP-OES	2/4/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:29 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:29 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:29 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:29 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:29 P.M.
		Zinc, Total, ICP	0.011	mg/L	0.005	EPA 200.7	2/4/2011 10:59 P.M.
	CC3	DO	6.6	mg/L			7/20/2010 15:05:00 PM
		Temperature	25	^{0}C			7/20/2010 15:05:00 PM
		Conductivity	447	µS			7/20/2010 15:05:00 PM
		pH	7.54	pH			7/20/2010 15:05:00 PM
		BOD-5	<3	mg/L	3	SM 5210 B	7/21/10 7:45 AM
		TSS	6	mg/L	4	SM 2540D	7/26/10 12:34 PM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	7/26/10 11:44 AM
		Digestion, TKN-TP	7/22/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.39	mg/L	0.05	EPA 365.2	7/23/10 11:30 AM
		Fecal Coliform, MF	7400	colonies/100mL	N/A	SM 9222 D	7/20/10 5:49 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:33 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:33 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:33 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:33 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:33 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/4/2011 11:05 P.M.
		ICP-OES	2/4/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:33 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:33 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:33 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:33 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:33 P.M.
		Zinc, Total, ICP	0.011	mg/L	0.005	EPA 200.7	2/4/2011 11:05 P.M.

Dry Events

Sample Date	Site	Test	Result	Units	RDL	Method	Analysis Date
7/20/2010 (Test Run)	RC1	DO	8.53	mg/L			7/20/2010 15:55 PM
		Temperature	25.6	^{0}C			7/20/2010 15:55 PM
		Conductivity	311	µS			7/20/2010 15:55 PM
		pH	8.05	pH			7/20/2010 15:55 PM
		BOD-5	<3	mg/L	3	SM 5210 B	7/21/10 7:45 AM
		TSS	5	mg/L	4	SM 2540D	7/26/10 12:34 PM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	7/26/10 11:44 AM
		Digestion, TKN-TP	7/22/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.13	mg/L	0.05	EPA 365.2	7/23/10 11:30 AM
		Fecal Coliform, MF	1300	colonies/100mL	N/A	SM 9222 D	7/20/10 5:49 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:52 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:52 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:52 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:52 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:52 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/4/2011 11:11 P.M.
		ICP-OES	2/4/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:52 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:52 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:52 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:52 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:52 P.M.
		Zinc, Total, ICP	0.012	mg/L	0.005	EPA 200.7	2/4/2011 11:11 P.M.
	RC3	DO	7.39	mg/L			7/20/2010 15:25 AM
		Temperature	26	^{0}C			7/20/2010 15:25 AM
		Conductivity	333	µS			7/20/2010 15:25 AM
		pH	7.57	pH			7/20/2010 15:25 AM
		BOD-5	<3	mg/L	3	SM 5210 B	7/21/10 7:45 AM
		TSS	13	mg/L	4	SM 2540D	7/26/10 12:34 PM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	7/26/10 11:44 AM
		Digestion, TKN-TP	7/22/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.16	mg/L	0.05	EPA 365.2	7/23/10 11:30 AM
		Fecal Coliform, MF	3200	colonies/100mL	N/A	SM 9222 D	7/20/10 5:49 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:56 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:56 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:56 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:56 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:56 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/4/2011 11:17 P.M.
		ICP-OES	2/4/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:56 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:56 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:56 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 2:56 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 2:56 P.M.
		Zinc, Total, ICP	0.014	mg/L	0.005	EPA 200.7	2/4/2011 11:17 P.M.

Dry Events

Sample Date	Site	Test	Result	Units	RDL	Method	Analysis Date
7/23/2010 (Run 1)	CC1	DO	8.44	mg/L		Multimeter Probe	7/23/10 10:05 AM
		Temperature	25.2	^{0}C			7/23/10 10:05 AM
		Conductivity	483	µS			7/23/10 10:05 AM
		pH	7.81	pH			7/23/10 10:05 AM
		BOD-5	<3	mg/L	3	SM 5210 B	7/23/10 4:00 PM
		TSS	<4	mg/L	4	SM 2540D	7/29/10 10:09 AM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	7/26/10 3:30 PM
		Digestion, TKN-TP	07/30/010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.36	mg/L	0.05	EPA 365.2	7/30/10 10:01 AM
		Fecal Coliform, MF	1400	colonies/100mL	N/A	SM 9222 D	7/23/10 2:55 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:00 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:00 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:00 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:00 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:00 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/4/2011 11:23 P.M.
		ICP-OES	2/4/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:00 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:00 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:00 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:00 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:00 P.M.
		Zinc, Total, ICP	0.016	mg/L	0.005	EPA 200.7	2/4/2011 11:23 P.M.
	CC3	DO	5.86	mg/L			7/23/10 9:10 AM
		Temperature	25.7	^{0}C			7/23/10 9:10 AM
		Conductivity	390	µS			7/23/10 9:10 AM
		pH	7.54	pH			7/23/10 9:10 AM
		BOD-5	<9	mg/L	3	SM 5210 B	7/23/10 4:00 PM
		TSS	18	mg/L	4	SM 2540D	7/29/10 10:09 AM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	7/26/10 3:30 PM
		Digestion, TKN-TP	7/30/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.09	mg/L	0.05	EPA 365.2	7/30/10 10:01 AM
		Fecal Coliform, MF	580	colonies/100mL	N/A	SM 9222 D	7/23/10 2:55 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:04 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:04 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:04 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:04 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:04 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/4/2011 11:34 P.M.
		ICP-OES	2/4/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:04 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:04 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:04 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:04 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:04 P.M.
		Zinc, Total, ICP	0.011	mg/L	0.005	EPA 200.7	2/4/2011 11:34 P.M.

Dry Events

Sample Date	Site	Test	Result	Units	RDL	Method	Analysis Date
7/23/2010 (Run 1)	RC1	DO	9.18	mg/L			7/23/10 9:50 AM
		Temperature	24.4	^{o}C			7/23/10 9:50 AM
		Conductivity	332	µS			7/23/10 9:50 AM
		pH	8.03	pH			7/23/10 9:50 AM
		BOD-5	<3	mg/L	3	SM 5210 B	7/23/10 4:00 PM
		TSS	<4	mg/L	4	SM 2540D	7/29/10 10:09 AM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	7/26/10 3:30 PM
		Digestion, TKN-TP	7/30/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.16	mg/L	0.05	EPA 365.2	7/30/10 10:01 AM
		Fecal Coliform, MF	590	colonies/100mL	N/A	SM 9222 D	7/23/10 2:55 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:28 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:28 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:28 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:28 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:28 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/5/2011 12:09 A.M.
		ICP-OES	2/5/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:28 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:28 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:28 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:28 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:28 P.M.
		Zinc, Total, ICP	0.006	mg/L	0.005	EPA 200.7	2/5/2011 12:09 A.M.
	RC3	DO	6.12	mg/L			7/23/10 9:25 AM
		Temperature	28.6	^{o}C			7/23/10 9:25 AM
		Conductivity	366	µS			7/23/10 9:25 AM
		pH	7.39	pH			7/23/10 9:25 AM
		BOD-5	5	mg/L	3	SM 5210 B	7/23/10 4:00 PM
		TSS	22	mg/L	4	SM 2540D	7/29/10 10:09 AM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	7/26/10 3:30 PM
		Digestion, TKN-TP	7/30/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.07	mg/L	0.05	EPA 365.2	7/30/10 10:01 AM
		Fecal Coliform, MF	540	colonies/100mL	N/A	SM 9222 D	7/23/10 2:55 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:32 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:32 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:32 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:32 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:32 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/5/2011 12:15 A.M.
		ICP-OES	2/5/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:32 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:32 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:32 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:32 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:32 P.M.
		Zinc, Total, ICP	0.014	mg/L	0.005	EPA 200.7	2/5/2011 12:15 A.M.

Dry Events

Sample Date	Site	Test	Result	Units	RDL	Method	Analysis Date
8/12/2010 (Attempted Wet Run, Rained but not hard enough)	CC1	DO	5.65	mg/L		Multimeter Probe	8/12/10 10:02 AM
		Temperature	25.1	^{0}C			8/12/10 10:02 AM
		Conductivity	597	µS			8/12/10 10:02 AM
		pH	7.39	pH			8/12/10 10:02 AM
		BOD-5	229	mg/L	3	SM 5210 B	8/12/10 2:50 PM
		TSS	7	mg/L	4	SM 2540D	8/17/10 2:10 PM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	8/18/10 10:49 AM
		Digestion, TKN-TP	8/17/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.57	mg/L	0.05	EPA 365.2	8/17/10 1:39 PM
		Fecal Coliform, MF	9700	colonies/100mL	N/A	SM 9222 D	8/12/10 2:38 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:36 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:36 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:36 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:36 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:36 P.M.
		Copper, Total, ICP	0.007	mg/L	0.005	EPA 200.7	2/5/2011 12:21 A.M.
		ICP-OES	2/5/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:36 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:36 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:36 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:36 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:36 P.M.
		Zinc, Total, ICP	0.019	mg/L	0.005	EPA 200.7	2/5/2011 12:21 A.M.
	CC3	DO	5.42	mg/L			8/12/10 9:09 AM
		Temperature	25.1	^{0}C			8/12/10 9:09 AM
		Conductivity	651	µS			8/12/10 9:09 AM
		pH	7.47	pH			8/12/10 9:09 AM
		BOD-5	<3	mg/L	3	SM 5210 B	8/13/10 11:00 AM
		TSS	12	mg/L	4	SM 2540D	8/17/10 2:10 PM
		Ammonia as N	<.2		0.2	SM 4500 NH3 G	8/18/10 10:49 AM
		Digestion, TKN-TP	8/17/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.5	mg/L	0.05	EPA 365.2	8/17/10 1:39 PM
		Fecal Coliform, MF	830	colonies/100mL	N/A	SM 9222 D	8/12/10 2:38 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:56 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:56 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:56 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:56 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:56 P.M.
		Copper, Total, ICP	0.006	mg/L	0.005	EPA 200.7	2/5/2011 12:26 A.M.
		ICP-OES	2/5/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:56 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:56 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:56 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:56 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:56 P.M.
		Zinc, Total, ICP	0.018	mg/L	0.005	EPA 200.7	2/5/2011 12:26 A.M.

Dry Events

Sample Date	Site	Test	Result	Units	RDL	Method	Analysis Date
8/12/2010 (Attempted Wet Run, Rained but not hard enough)	RC1	DO	6.85	mg/L			8/12/10 9:49 AM
		Temperature	24.4	^{o}C			8/12/10 9:49 AM
		Conductivity	407	µS			8/12/10 9:49 AM
		pH	7.38	pH			8/12/10 9:49 AM
		BOD-5	<3	mg/L	3	SM 5210 B	8/13/10 11:00 AM
		TSS	<4	mg/L	4	SM 2540D	8/17/10 2:10 PM
		Ammonia as N	<.2		0.2	SM 4500 NH3 G	8/18/10 10:49 AM
		Digestion, TKN-TP	8/17/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.3	mg/L	0.05	EPA 365.2	8/17/10 1:39 PM
		Fecal Coliform, MF	720	colonies/100mL	N/A	SM 9222 D	8/12/10 2:38 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:59 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:59 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:59 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:59 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:59 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/5/2011 12:32 A.M.
		ICP-OES	2/5/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:59 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:59 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:59 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 3:59 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 3:59 P.M.
		Zinc, Total, ICP	0.012	mg/L	0.005	EPA 200.7	2/5/2011 12:32 A.M.
	RC3	DO		mg/L			8/12/10 9:22 AM
		Temperature	25.4	^{o}C			8/12/10 9:22 AM
		Conductivity		µS			8/12/10 9:22 AM
		pH	7.2	pH			8/12/10 9:22 AM
		BOD-5	<3	mg/L	3	SM 5210 B	8/13/10 11:00 AM
		TSS	8	mg/L	4	SM 2540D	8/17/10 2:10 PM
		Ammonia as N	<.2		0.2	SM 4500 NH3 G	8/18/10 10:49 AM
		Digestion, TKN-TP	8/17/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.27	mg/L	0.05	EPA 365.2	8/17/10 1:39 PM
		Fecal Coliform, MF	880	colonies/100mL	N/A	SM 9222 D	8/12/10 2:38 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:03 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:03 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 4:03 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 4:03 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:03 P.M.
		Copper, Total, ICP	<0.005	mg/L	0.005	EPA 200.7	2/5/2011 12:38 A.M.
		ICP-OES	2/5/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:03 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:03 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:03 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 4:03 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:03 P.M.
		Zinc, Total, ICP	0.01	mg/L	0.005	EPA 200.7	2/5/2011 12:38 A.M.

Dry Events

Sample Date	Site	Test	Result	Units	RDL	Method	Analysis Date
9/30/2010	CC1	DO	8.36	mg/L		Multimeter Probe	9/30/10 10:12 AM
		Temperature	21	^{0}C			9/30/10 10:12 AM
		Conductivity	202	µS			9/30/10 10:12 AM
		pH	7.76	pH			9/30/10 10:12 AM
		BOD-5	<4	mg/L	3	SM 5210 B	10/1/10 11:15 AM
		TSS	158	mg/L	4	SM 2540D	10/4/10 1:50 PM
		Ammonia as N	<.2		0.2	SM 4500 NH3 G	10/2/10 11:50 AM
		Digestion, TKN-TP	10/5/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.46	mg/L	0.05	EPA 365.2	10/11/10 11:58 AM
		Fecal Coliform, MF	>10000	colonies/100mL	N/A	SM 9222 D	9/30/10 2:32 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:23 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:23 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 4:23 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 4:23 P.M.
		Chromium, Total, MS	0.016	mg/L	0.002	EPA 200.8	2/4/2011 4:23 P.M.
		Copper, Total, ICP	0.017	mg/L	0.005	EPA 200.7	2/8/2011 3:27 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	0.013	mg/L	0.002	EPA 200.8	2/4/2011 4:23 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.019	mg/L	0.002	EPA 200.8	2/4/2011 4:23 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:23 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 4:23 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 4:23 P.M.
		Zinc, Total, ICP	0.051	mg/L	0.005	EPA 200.7	2/8/2011 3:27 P.M.
	CC3	DO	7.33	mg/L			9/30/10 10:28 AM
		Temperature	21.5	^{0}C			9/30/10 10:28 AM
		Conductivity	206	µS			9/30/10 10:28 AM
		pH	7.73	pH			9/30/10 10:28 AM
		BOD-5	8	mg/L	3	SM 5210 B	10/1/10 11:15 AM
		TSS	56	mg/L	4	SM 2540D	10/4/10 1:50 PM
		Ammonia as N	<.2		0.2	SM 4500 NH3 G	10/2/10 11:50 AM
		Digestion, TKN-TP	10/5/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.21	mg/L	0.05	EPA 365.2	10/11/10 11:58 AM
		Fecal Coliform, MF	>10000	colonies/100mL	N/A	SM 9222 D	9/30/10 2:32 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:07 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:07 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:07 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:07 P.M.
		Chromium, Total, MS	0.005	mg/L	0.002	EPA 200.8	2/4/2011 5:07 P.M.
		Copper, Total, ICP	0.008	mg/L	0.005	EPA 200.7	2/8/2011 3:50 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	0.006	mg/L	0.002	EPA 200.8	2/4/2011 5:07 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.003	mg/L	0.002	EPA 200.8	2/4/2011 5:07 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:07 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:07 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:07 P.M.
		Zinc, Total, ICP	0.027	mg/L	0.005	EPA 200.7	2/8/2011 3:50 P.M.

Dry Events

Sample Date	Site	Test	Result	Units	RDL	Method	Analysis Date
9/30/2010	RC1	DO	7.49	mg/L			9/30/10 9:48 AM
		Temperature	21.4	^{o}C			9/30/10 9:48 AM
		Conductivity	209	µS			9/30/10 9:48 AM
		pH	6.3	pH			9/30/10 9:48 AM
		BOD-5	<4	mg/L	3	SM 5210 B	10/1/10 11:15 AM
		TSS	58	mg/L	4	SM 2540D	10/4/10 1:50 PM
		Ammonia as N	<.2		0.2	SM 4500 NH3 G	10/2/10 11:50 AM
		Digestion, TKN-TP	10/5/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.26	mg/L	0.05	EPA 365.2	10/11/10 11:58 AM
		Fecal Coliform, MF	>10000	colonies/100mL	N/A	SM 9222 D	9/30/10 2:32 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:10 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:10 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:10 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:10 P.M.
		Chromium, Total, MS	0.005	mg/L	0.002	EPA 200.8	2/4/2011 5:10 P.M.
		Copper, Total, ICP	0.015	mg/L	0.005	EPA 200.7	2/8/2011 3:56 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	0.008	mg/L	0.002	EPA 200.8	2/4/2011 5:10 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.006	mg/L	0.002	EPA 200.8	2/4/2011 5:10 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:10 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:10 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:10 P.M.
		Zinc, Total, ICP	0.034	mg/L	0.005	EPA 200.7	2/8/2011 3:56 P.M.
	RC3	DO	7.09	mg/L			9/30/10 9:53 AM
		Temperature	21.6	^{o}C			9/30/10 9:53 AM
		Conductivity	172.5	µS			9/30/10 9:53 AM
		pH	7.52	pH			9/30/10 9:53 AM
		BOD-5	6	mg/L	3	SM 5210 B	10/1/10 11:15 AM
		TSS	44	mg/L	4	SM 2540D	10/4/10 1:50 PM
		Ammonia as N	<.2		0.2	SM 4500 NH3 G	10/2/10 11:50 AM
		Digestion, TKN-TP	10/5/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.2	mg/L	0.05	EPA 365.2	10/11/10 11:58 AM
		Fecal Coliform, MF	>10000	colonies/100mL	N/A	SM 9222 D	9/30/10 2:32 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:14 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:14 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:14 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:14 P.M.
		Chromium, Total, MS	0.003	mg/L	0.002	EPA 200.8	2/4/2011 5:14 P.M.
		Copper, Total, ICP	0.009	mg/L	0.005	EPA 200.7	2/8/2011 4:02 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	0.004	mg/L	0.002	EPA 200.8	2/4/2011 5:14 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.004	mg/L	0.002	EPA 200.8	2/4/2011 5:14 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:14 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:14 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:14 P.M.
		Zinc, Total, ICP	0.029	mg/L	0.005	EPA 200.7	2/8/2011 4:02 P.M.

Wet Events

T+0							
Sample Date	**Site**	**Test**	**Result**	**Units**	**RDL**	**Method**	**Analysis Date**
10/14/2010	CC1	DO	8.5	mg/L		Multimeter Probe	12:54 P.M.
		Temperature	14.5	^{0}C			12:54 P.M.
		Conductivity	497	µS			12:54 P.M.
		pH	7.6				12:54 P.M.
		BOD-5	<4	mg/L	3	SM 5210 B	10/15/2010 11:00 A.M.
		TSS	<4	mg/L	4	SM 2540D	10/18/2010 9:31 A.M.
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	10/21/2010 1:04 P.M.
		Digestion, TKN-TP	10/18/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.31	mg/L	0.05	EPA 365.2	10/19/2010 12:39 P.M.
		Fecal Coliform, MF	240	colonies/100mL	N/A	SM 9221 E	10/14/2010 5:35 P.M.
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:18 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:18 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:18 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:18 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:18 P.M.
		Copper, Total, ICP	0.007	mg/L	0.005	EPA 200.7	2/8/2011 4:08 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:18 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:18 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:18 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:18 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:18 P.M.
		Zinc, Total, ICP	0.02	mg/L	0.005	EPA 200.7	2/8/2011 4:08 P.M.
	CC3	DO	7.2	mg/L			11:45 A.M.
		Temperature	15.1	^{0}C			11:45 A.M.
		Conductivity	480	µS			11:45 A.M.
		pH	7.34				11:45 A.M.
		BOD-5	<4	mg/L	3	SM 5210 B	10/15/2010 11:00 A.M.
		TSS	<4	mg/L	4	SM 2540D	10/18/2010 9:31 A.M.
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	10/21/2010 1:01 P.M.
		Digestion, TKN-TP	10/19/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.33	mg/L	0.05	EPA 365.2	10/19/2010 12:39 P.M.
		Fecal Coliform, MF	350	colonies/100mL	N/A	SM 9221 E	10/14/2010 5:21 P.M.
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:22 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:22 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:22 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:22 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:22 P.M.
		Copper, Total, ICP	0.007	mg/L	0.005	EPA 200.7	2/8/2011 4:25 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:22 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:22 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:22 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:22 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:22 P.M.
		Zinc, Total, ICP	0.025	mg/L	0.005	EPA 200.7	2/8/2011 4:25 P.M.

Wet Events

T+0							
Sample Date	**Site**	**Test**	**Result**	**Units**	**RDL**	**Method**	**Analysis Date**
10/14/2010	RC1	DO	7.6	mg/L			12:24 PM
		Temperature	13.6	^{0}C			12:24 PM
		Conductivity	345	µS			12:24 PM
		pH	7.69				12:24 PM
		BOD-5	<4	mg/L	3	SM 5210 B	10/15/2010 11:00 A.M.
		TSS	<4	mg/L	4	SM 2540D	10/18/2010 9:31 A.M.
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	10/21/2010 1:04 P.M.
		Digestion, TKN-TP	10/19/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.17	mg/L	0.05	EPA 365.2	10/19/2010 12:39 P.M.
		Fecal Coliform, MF	240	colonies/100mL	N/A	SM 9221 E	10/14/2010 5:32 P.M.
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:26 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:26 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:26 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:26 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:26 P.M.
		Copper, Total, ICP	0.006	mg/L	0.005	EPA 200.7	2/8/2011 4:31 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:26 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:26 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:26 P.M.
		Silver, Total, MS	0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:26 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:26 P.M.
		Zinc, Total, ICP	0.013	mg/L	0.005	EPA 200.7	2/8/2011 4:31 P.M.
	RC3	DO	8.4	mg/L			11:56 A.M.
		Temperature	13.6	^{0}C			11:56 A.M.
		Conductivity	349	µS			11:56 A.M.
		pH	7.11				11:56 A.M.
		BOD-5	8	mg/L	3	SM 5210 B	10/15/2010 11:00 A.M.
		TSS	<4	mg/L	4	SM 2540D	10/18/2010 9:31 A.M.
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	10/21/2010 1:04 P.M.
		Digestion, TKN-TP	10/19/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.16	mg/L	0.05	EPA 365.2	10/19/2010 12:39 P.M.
		Fecal Coliform, MF	>1600	colonies/100mL	N/A	SM 9221 E	10/14/2010 5:29 P.M.
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:30 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:30 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:30 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:30 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:30 P.M.
		Copper, Total, ICP	0.006	mg/L	0.005	EPA 200.7	2/8/2011 4:37 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:30 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.004	mg/L	0.002	EPA 200.8	2/4/2011 5:30 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:30 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:30 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:30 P.M.
		Zinc, Total, ICP	0.013	mg/L	0.005	EPA 200.7	2/8/2011 4:37 P.M.

Wet Events After Storm

T+0							
Sample Date	**Site**	**Test**	**Result**	**Units**	**RDL**	**Method**	**Analysis Date**
10/14/2010	CC1	DO	9.3	mg/L		Multimeter Probe	3:53 P.M.
		Temperature	14.3	^{0}C			3:53 P.M.
		Conductivity	442	µS			3:53 P.M.
		pH	7.52				3:53 P.M.
		BOD-5	15	mg/L	3	SM 5210 B	10/15/10 11:00 AM
		TSS	13	mg/L	4	SM 2540D	10/18/10 9:31 AM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	10/21/10 1:04 PM
		Digestion, TKN-TP	10/18/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.31	mg/L	0.05	EPA 365.2	10/19/10 12:39 PM
		Fecal Coliform, MF	1600	colonies/100mL	N/A	SM 9221 E	10/14/10 5:20 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:34 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:34 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:34 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:34 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:34 P.M.
		Copper, Total, ICP	0.011	mg/L	0.005	EPA 200.7	2/8/2011 4:43 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	0.003	mg/L	0.002	EPA 200.8	2/4/2011 5:34 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:34 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:34 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:34 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:34 P.M.
		Zinc, Total, ICP	0.031	mg/L	0.005	EPA 200.7	2/8/2011 4:43 P.M.
	CC3	DO	6.7	mg/L			3:08 P.M.
		Temperature	16.4	^{0}C			3:08 P.M.
		Conductivity	218	µS			3:08 P.M.
		pH	6.95				3:08 P.M.
		BOD-5	7	mg/L	3	SM 5210 B	10/15/10 11:00 AM
		TSS	28	mg/L	4	SM 2540D	10/18/10 9:31 AM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	10/21/10 1:04 PM
		Digestion, TKN-TP	10/18/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.12	mg/L	0.05	EPA 365.2	10/19/10 12:39 PM
		Fecal Coliform, MF	240	colonies/100mL	N/A	SM 9221 E	10/14/10 5:26 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:54 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:54 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:54 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:54 P.M.
		Chromium, Total, MS	0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:54 P.M.
		Copper, Total, ICP	0.008	mg/L	0.005	EPA 200.7	2/8/2011 4:48 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:54 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:54 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:54 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:54 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:54 P.M.
		Zinc, Total, ICP	0.017	mg/L	0.005	EPA 200.7	2/8/2011 4:48 P.M.

Wet Events After Storm

T+0							
Sample Date	**Site**	**Test**	**Result**	**Units**	**RDL**	**Method**	**Analysis Date**
		DO	9.3	mg/L		Multimeter Probe	3:53 P.M.
10/14/2010	RC1	DO	8.9	mg/L			3:40 P.M.
		Temperature	14.3	^{0}C			3:40 P.M.
		Conductivity	287	µS			3:40 P.M.
		pH	7.39				3:40 P.M.
		BOD-5	11	mg/L	3	SM 5210 B	10/15/10 11:00 AM
		TSS	4	mg/L	4	SM 2540D	10/18/10 9:31 AM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	10/21/10 1:04 PM
		Digestion, TKN-TP	10/18/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.13	mg/L	0.05	EPA 365.2	10/19/10 12:39 PM
		Fecal Coliform, MF	1600	colonies/100mL	N/A	SM 9221 E	10/14/10 5:23 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:58 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:58 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:58 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:58 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:58 P.M.
		Copper, Total, ICP	0.008	mg/L	0.005	EPA 200.7	2/8/2011 5:00 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:58 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:58 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:58 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 5:58 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 5:58 P.M.
		Zinc, Total, ICP	0.022	mg/L	0.005	EPA 200.7	2/8/2011 5:00 P.M.
	RC3	DO	8.3	mg/L			3:17 P.M.
		Temperature	16.4	^{0}C			3:17 P.M.
		Conductivity	204	µS			3:17 P.M.
		pH	6.72				3:17 P.M.
		BOD-5	13	mg/L	3	SM 5210 B	10/15/10 11:00 AM
		TSS	10	mg/L	4	SM 2540D	10/18/10 9:31 AM
		Ammonia as N	<0.2		0.2	SM 4500 NH3 G	10/21/10 1:04 PM
		Digestion, TKN-TP	10/18/2010	Date completed	N/A	EPA 351.2	
		Total Phosphorous as P	0.09	mg/L	0.05	EPA 365.2	10/19/10 12:39 PM
		Fecal Coliform, MF	80	colonies/100mL	N/A	SM 9221 E	10/14/10 5:16 PM
		Antimony, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 6:21 P.M.
		Arsenic, Total , MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 6:21 P.M.
		Beryllium, Total , MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 6:21 P.M.
		Cadmium, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 6:21 P.M.
		Chromium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 6:21 P.M.
		Copper, Total, ICP	0.007	mg/L	0.005	EPA 200.7	2/8/2011 5:34 P.M.
		ICP-OES	2/8/2011	Date completed	N/A	EPA 200.7	
		Lead, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 6:21 P.M.
		Metals Preparation, D2002	2/2/2011	Date completed	N/A	EPA 200.2	
		Nickel, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 6:21 P.M.
		Selenium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 6:21 P.M.
		Silver, Total, MS	<0.001	mg/L	0.001	EPA 200.8	2/4/2011 6:21 P.M.
		Thallium, Total, MS	<0.002	mg/L	0.002	EPA 200.8	2/4/2011 6:21 P.M.
		Zinc, Total, ICP	0.017	mg/L	0.005	EPA 200.7	2/8/2011 5:34 P.M.

ATTACHMENT H

Development of the Initial Parameters Considered List

DEVELOPMENT OF THE INITIAL PARAMETERS CONSIDERED LIST

REFERENCES FOR THE LIST								SUMMARY
From 2014 PA Integrated Water Quality Monitoring and Assessment Report [aka 303(d) List]	**From PA Code CH 93, 25 §93.7 for TSF, WWF & MF Designations**	**From DRBC for Zone 4**	**From DRBC's 2014 Delaware River and Bay Water Quality Assessment**	**FROM NPDES PERMIT - required sampling of CSO discharges**	**FROM NPDES PERMIT - required sampling of Stormwater Outfall #28 at Plant**	**FROM NPDES PERMIT - required sampling of Plant's Effluent at Outfall 001**	**FROM EPA's CSO Guidance Document (Pg. 2-32)**	**INITIAL LIST OF PARAMETERS CONSIDERED**
PCBs (Fish Consumption)	Alkalinity	Alkalinity	Aluminum (Aquatic Life)	Ammonia	CBOD5	Ammonia	Indicator Bacteria	Bacteria - Enterococcus
Siltation (TSS)	Ammonia	Bacteria - Enterococcus	PCBs (Fish Consumption)	Biological Oxygen Demand	Chemical Oxygen Demand	Bacteria - Fecal Coliform	BOD	Bacteria - Fecal Coliform
	Bacteria - Fecal Coliform	Bacteria - Fecal Coliform		Fecal Coliform	Dissolved Iron	Cadmium	Metals	Alkalinity
	Total Residual Chlorine (TRC)	Dissolved Oxygen (DO)		Phosphorus	pH	CBOD20	Nutrients	Aluminum (Aquatic Life)
	Dissolved Oxygen (DO)	pH		TSS	Oil and Grease	CBOD5	pH	Ammonia
	Fecal Coliform Bacteria	Phenols			TKN	Chlorine	TDS	Biological Oxygen Demand (BOD)
	Iron (Fe)	Radioactivity - alpha emitters			Total Phosphorus	Chlorodibromomethane	TSS	Cadmium
	Osmotic Pressure	Radioactivity - beta emitters			TSS	Copper	Dissolved Oxygen (DO)	CBOD20
	pH	Synthetic Detergents				Cyanide	Toxics	CBOD5
	Temperature	Temperature				Dichlorobromomethane	Biological Assessment	Chlorine
		Threshold Odor Number (TON)				Lead	Sediment	Chlorodibromomethane
		Total Dissolved Solids (TDS)				Nitrate		Copper
		Turbidity				Nitrite		Cyanide
						Oil and Grease		Dichlorobromomethane
						PCBs		Dissolved Oxygen (DO)
						pH		Iron (Fe)
						TDS		Lead
						Total Kjeldahl Nitrogen (TKN)		Metals
						TSS		Nitrate
						Zinc		Nitrite
								Nutrients
								Oil and Grease
								PCBs (Fish Consumption)
								pH
								Phenols
								Phosphorus
								Radioactivity - alpha emitters
								Radioactivity - beta emitters
								Synthetic Detergents
								Temperature
								Threshold Odor Number (TON)
								Total Kjeldahl Nitrogen (TKN)
								Total Dissolved Solids (TDS)
								Total Phosphorus
								Total Residual Chlorine (TRC)
								Total Suspended Solids (TSS)
								Toxics
								Turbidity
								Zinc

ATTACHMENT I

Final Parameters Considered List with STORET Data

DELCORA LTCPU
POI Sampling Results Comparison
1/15/2016

Parameter of Interest (POIs)	Units	Upper Delaware 100% WQS	WET WEATHER CPS WET WELL SAMPLING RESULTS		STORET/ Dry Upper Delaware River Sampling results				Lower Delaware 100% WQS	STORET/ Dry Lower Delaware River Sampling results				STORET/ Wet Lower Delaware River Sampling results	Chester 100% WQS	WET WEATHER CSO 19 SAMPLING RESULTS		Historical Chester Creek Sampling results						STORET/ Chester Creek Wet Sampling results	Ridley 100% WQS	WET WEATHER CSO 18 SAMPLING RESULTS		Historical Ridley Creek Sampling results						STORET/ Ridley Creek Wet Sampling results
Sampling Date Sampling location			Nov 19, 2015 CPS1	Dec 1, 2015 CPS1	9/15/2014 892062 1.16 miles Upstream of Outfall 14	10/20/2014 892062 1.16 miles Upstream of Outfall 14	4/21/2015 892062 1.16 miles Upstream of Outfall 14	5/19/2015 892062 1.16 miles Upstream of Outfall 14		9/15/2014 332049 2.82 miles Downstream of Outfall 2	10/20/2014 332049 2.82 miles Downstream of Outfall 2	4/21/2015 332049 2.82 miles Downstream of Outfall 2	5/19/2015 332049 2.82 miles Downstream of Outfall 2	12/3/2014 WQN0182 1.98 miles Downstream of Outfall 2		Nov 19, 2015 14TH & CROZER	Dec 1, 2015 14TH & CROZER	8/12/2010 Baseline/ Upstream of 14TH & CROZER	9/30/2010 Baseline/ Upstream of 14TH & CROZER	10/14/2010 Baseline/ Upstream of 14TH & CROZER	8/12/2010 Downstream of 14TH & CROZER	9/30/2010 Downstream of 14TH & CROZER	10/14/2010 Downstream of 14TH & CROZER	5/12/2010 DRBC422094 0.09 miles Downstream of Outfall 12		Nov 19, 2015 SUN & HANCOCK	Dec 1, 2015 SUN & HANCOCK	8/12/2010 Baseline/ Upstream of SUN & HANCOCK	9/30/2010 Baseline/ Upstream of SUN & HANCOCK	10/14/2010 Baseline/ Upstream of SUN & HANCOCK	8/12/2010 Downstream of SUN & HANCOCK	9/30/2010 Downstream of SUN & HANCOCK	10/14/2010 Downstream of SUN & HANCOCK	5/12/2010 DRBC422120 0.13 miles Downstream of Outfall 15
Benzene	ug/L	14	ND	ND					0.61						14	ND	ND								14	ND	ND							
Bromodichloromethane	ug/L	17	ND	ND					0.55						17	ND	ND								17	ND	ND							
Chlorodibromomethane	ug/L	13	ND	ND					0.4						13	ND	ND								13	ND	ND							
Chloroform	ug/L	470	ND	ND					1900						470	ND	ND							0.5	470	ND	ND							0.5
Ethylbenzene	ug/L	2100	ND	ND					530						2100	ND	ND							0.5	2100	ND	ND							0.5
Methyl t-Butyl Ether	ug/L	No Standard	ND	ND					No Standard						No Standard	ND	ND							0.5	No Standard	ND	ND							0.5
Methylene Chloride	ug/L	590	ND	ND					4.6						590	ND	ND								590	ND	ND							
Tetrachloroethene	ug/L	3.3	ND	ND					0.69						3.3	ND	ND								3.3	ND	ND							
Toluene	ug/L	1700	ND	ND					1300						1700	ND	ND							0.5	1700	ND	ND							0.5
Total Xylenes, Acute	ug/L	1100	ND	ND					1100						1100	ND	ND								1100	ND	ND							
Total Xylenes, Chronic	ug/L	210	ND	ND					210						210	ND	ND								210	ND	ND							
Benzo(a)anthracene, Acute	ug/L	0.5	ND	ND	ND	ND			0.0038	ND	ND				0.5	ND	ND								0.5	ND	ND							
Benzo(a)anthracene, Chronic	ug/L	0.1	ND	ND	ND	ND			0.0038	ND	ND				0.1	ND	ND								0.1	ND	ND							
Chrysene	ug/L	18	ND	ND					0.0038	ND	ND				18	ND	ND								18	ND	ND							
bis(2-Ethylhexyl)phthalate	ug/L	2.2	12.0	7.3					1.2						2.2	4.4	8.0								2.2	11.8	4.9							
N-Nitroso-di-n-propylamine	ug/L	0.51	ND	ND			ND	ND	0.005	ND	ND				0.51	ND	ND								0.51	ND	ND							
Phenanthrene, Acute	ug/L	5	ND	ND					5						5	ND	ND								5	ND	ND							
Phenanthrene, Chronic	ug/L	1	ND	ND					1						1	ND	ND								1	ND	ND							
Dieldrin	ug/L	0.000054	ND	0.020					0.000052						0.000054	ND	ND								0.000054	ND								
Total Polychlorinated Biphenyl (PCB)	ug/L	0.000016	0.0	|					0.000016						0.000016	0.0	|								0.000016	0.0	|							
Aroclor-1016	ug/L	No Standard	ND	ND					No Standard						No Standard	ND	ND								No Standard	ND	ND							
Aroclor-1221	ug/L	No Standard	ND	ND					No Standard						No Standard	ND	ND								No Standard	ND	ND							
Aroclor-1232	ug/L	No Standard	ND	ND					No Standard						No Standard	ND	ND								No Standard	ND	ND							
Aroclor-1242	ug/L	No Standard	ND	ND					No Standard						No Standard	ND	ND								No Standard	ND	ND							
Aroclor-1248	ug/L	No Standard	ND	ND					No Standard						No Standard	ND	ND								No Standard	ND	ND							
Aroclor-1254	ug/L	No Standard	ND	ND					No Standard						No Standard	ND	ND								No Standard	ND	ND							
Aroclor-1260	ug/L	No Standard	ND	ND					No Standard						No Standard	ND	ND								No Standard	ND	ND							
Ammonia-N	mg/L	10.45[a]	7.47	20.0					10.45[a]						10.45[a]	4.85	13.4								10.45[a]	1.63	3.63							
Biochemical Oxygen Demand	mg/L	No Standard	57.7	94.0					No Standard						No Standard	51.8	81.9								No Standard	26.2	70.7							
Carbonaceous BOD	mg/L	No Standard	81.5	92.3					No Standard						No Standard	66.7	63.4								No Standard	17.3	49.4							
Carbonaceous BOD 20 Day	mg/L	No Standard	7.7	151					No Standard						No Standard	12.8	72.2								No Standard	ND	96.8							
Cyanide, Acute	mg/L	22	ND	ND					22						22	ND	ND								22	ND	ND							
Cyanide, Chronic	mg/L	5.2	ND	ND					5.2						5.2	ND	ND								5.2	ND	ND							
Dissolved Oxygen	mg/L	3.5	2.5	2.5	6.56	8.59	10.39	6.84	3.5	7.17	8.14	10.32	7.20	13.04	3.5	4.3	1.5	5.65	8.36	8.50	5.42	7.33	7.20		3.5	5.4	4.4	6.85	7.49	7.6		7.09	8.4	
Halogen, Total Organic (TOX)	ug/L	No Standard	26.0	36.1					No Standard						No Standard	26.8	41.2								No Standard	ND	ND							
Hexavalent Chromium, Acute	mg/L	16	ND	ND					16						16	ND	ND								16	ND	ND							
Hexavalent Chromium, Chronic	mg/L	10	ND	ND					10						10	ND	ND								10	ND	ND							
Nitrate-N	mg/L	No Standard	ND	0.90					No Standard						No Standard	0.85	2.0								No Standard	ND	ND							
Nitrite-N	mg/L	No Standard	ND	ND					No Standard						No Standard	ND	ND								No Standard	ND	ND							
Odor	T.O.N.	24	30	5					24						24	20	10								24	2	2							
Oil/Grease Hexane Extractable	mg/L	No Standard	14.8	12.4					No Standard						No Standard	7.2	8.4								No Standard	ND	2.6							
Oil/Grease Silica Gel Treated	mg/L	No Standard	ND	ND					No Standard						No Standard	2.3	ND								No Standard	ND	ND							
Phenolics	mg/L	0.020	0.068	0.028	ND	ND			0.020	ND	ND				0.020	0.016	0.016								0.020	0.012	0.009							
Phosphorus, Total	mg/L	No Standard	2.1	2.5					No Standard						No Standard	1.4	2.3								No Standard	0.56	1.4							
Sulfide, Total	mg/L	No Standard	1.3	ND					No Standard						No Standard	ND	ND								No Standard	ND	ND							
Surfactants (MBAS)	mg/L	1.000	0.557	0.505					1.000						1.000	0.485	0.383								1.000	0.123	0.067							
Total Dissolved Solids	mg/L	No Standard	186	277					No Standard						No Standard	150	230								No Standard	39	26							
Total Kjeldahl Nitrogen	mg/L	No Standard	21.2	23.5					No Standard						No Standard	14.1	21.0								No Standard	5.3	8.3							
Total Nitrogen	mg/L	No Standard	21.2	24.4					No Standard						No Standard	15.0	23.0								No Standard	5.30	8.30							
Total Suspended Solids	mg/L	No Standard	108	186	30	36	21	30	No Standard	27	35	22	19	124	No Standard	140	112	7	158	4	12	56	4	10	No Standard	76	200	<4	58	<4	8	44	<4	
Turbidity	NTU	150.0	126	81.9	26	29	16	16	150.0	26	33	17	14		150.0	37.2	57.4								150.0	26.2	80.6							
Hardness	mg/L	No Standard	85.2	127					No Standard						No Standard	58.1	102								No Standard	18.9	31.5							
Trivalent Chromium, Acute	mg/L	0.4994	ND	ND					0.4994						0.4994	ND	ND								0.4994	ND	ND							
Trivalent Chromium, Chronic	mg/L	0.0239	ND	ND					0.0239						0.0239	ND	ND								0.0239	ND	ND							
Aluminum, Acute	mg/L	0.75	1.2	0.40					0.75					2.875	0.75	0.64	0.25								0.75	0.47	0.44							
Aluminum, Chronic	mg/L	0.09	1.2	0.40					0.09					2.875	0.09	0.64	0.25								0.09	0.47	0.44							
Antimony, Total	mg/L	0.0056	ND	ND					0.0056						0.0056	0.0013	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		0.0056	0.0023	0.0018	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
Arsenic, Acute	mg/L	0.34	ND	ND					0.01						0.34	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		0.34	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
Arsenic, Chronic	mg/L	0.15	ND	ND					0.01						0.15	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		0.15	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
Cadmium, Acute	mg/L	0.0010[b]	ND	ND					0.0010[b]						0.0010[b]	ND	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		0.0010[b]	ND	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Cadmium, Chronic	mg/L	0.0001[b]	ND	ND					0.0001[b]						0.0001[b]	ND	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		0.0001[b]	ND	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Chromium, Total	mg/L	No Standard	0.011	0.0014					No Standard	ND					No Standard	0.0094	ND	<0.002	0.016	<0.002	<0.002	0.005	<0.002		No Standard	0.0032	0.0031	<0.002	0.005	<0.002	<0.002	0.003	<0.002	
Copper, Acute	mg/L	0.011[b]	0.042	0.041			0.0028	0.0032	0.011[b]	0.005	0.0068			0.0103	0.010[c]	0.033	0.029	0.007	0.017	0.007	0.006	0.008	0.007	<0.010	0.010[c]	0.025	0.032	<0.005	0.015	0.006	<0.005	0.009	0.006	<0.010
Copper, Chronic	mg/L	0.007[b]	0.042	0.041			0.0028	0.0032	0.007[b]					0.0103	0.007[c]	0.033	0.029	0.007	0.017	0.007	0.006	0.008	0.007	<0.010	0.007[c]	0.025	0.032	<0.005	0.015	0.006	<0.005	0.009	0.006	<0.010
Iron, Total	mg/L	0.3	2.9	1.3					0.3					4.2	0.30	0.76	0.47							0.37	0.3	0.72	1.5							0.561
Lead, Acute	mg/L	0.0380	0.028	0.0096			0.0016	0.0023	0.0380	ND	ND			0.0069	0.0380	0.016	0.0060	0.002	0.013	0.002	0.002	0.006	0.002		0.0380	0.0081	0.020	<0.002	0.008	<0.002	<0.002	0.004	<0.002	
Lead, Chronic	mg/L	0.0054	0.028	0.0096			0.0016	0.0023	0.0054					0.0069	0.0054	0.016	0.0060	0.002	0.013	0.002	0.002	0.006	0.002		0.0054	0.0081	0.020	<0.002	0.008	<0.002	<0.002	0.004	<0.002	
Mercury, Total	mg/L	0.000051	0.00020	ND			ND	0.000022	0.00005	ND	ND				0.000051	ND	ND								0.000051	ND	0.0011							
Molybdenum, Total	mg/L	No Standard	0.0013	0.0012					No Standard						No Standard	0.0027	ND								No Standard	0.0031	ND							
Selenium, Acute	mg/L	0.02	ND	ND					0.02						0.02	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		0.02	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
Selenium, Chronic	mg/L	0.0046	ND	ND					0.0046						0.0046	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		0.0046	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
Silver, Total	mg/L	0.0019[b]	ND	ND					0.0019[b]						0.0019[b]	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		0.0019[b]	ND	ND	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Thallium, Total	mg/L	0.00047	ND	ND					0.00024						0.00047	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002		0.00047	ND	ND	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
Zinc, Total	mg/L	0.098[b]	0.22	0.13	0.0042	0.0138	0.0033	0.0112	0.098[b]	0.0020	0.0087	0.0032	0.0102	0.025	0.088[b]	0.11	0.067	0.019	0.051	0.020	0.018	0.027	0.025	0.012	0.088[b]	0.14	0.20	0.012	0.034	0.013	0.01	0.029	0.013	0.011
Enterococcus	CFU/100ml	88	241960	199000					33						88	77000	173000								88	8160	34500							
Fecal Coliform	CFU/100ml	770	2600000	3700000	160	170	160	93	200	83	120		110		770	470000	1030000	9700	10000	240	830	10000	350		770	1260000	2100000	720	>10000	240	880	>10000	1600	

	LEGEND:
	Value Exceeds WQS
ND	Non Detection
~~ND~~	Screening of POIs
	303(d) list Impairement
I	Value Greater than or Equal to Method Detection Limit but Below Reportable Detection Limit (RDL)
	No Standard but Present in Combined Sewer Discharge

	Footnotes
a	Value for pH = 7.1 found in DRBC Water Quality Regulations, Section 4.20.5 Paragraph A.3
b	Value for Average Ca, Mg Hardness = 84 mg/l. Average value is based on EPA STORET station data from 2010-2015 in Delaware River
c	Value for Average Ca, Mg Hardness = 74 mg/l found in DRBC Water Quality Regulations, Section 4.20.5 Paragraph A.2 in Chester and Ridley Creeks

ATTACHMENT J

Summary of STORET Data Exceedances

DELCORA LTCPU
Summary of STORET Data Showing Exceedance in All Receiving Bodies
2010-2015

Parameter	Number of Storet Observations (2010-2015)				Number of Exceedances (2010-2015)				Number of Non Detects (2010-2015)				Note
Location	Delaware		Chester	Ridley	Delaware		Chester	Ridley	Delaware		Chester	Ridley	
Station ID (Upstream or Downstream of Outfall)	892062 (Upstream of Outfall 14)	WQN0182, 332049 (Downstream of Outfall 2)	422094 (Downstream of Outfall 12)	422120 (Downstream of Outfall 15)	892062 (Upstream of Outfall 14)	WQN0182, 332049 (Downstream of Outfall 2)	422094 (Downstream of Outfall 12)	422120 (Downstream of Outfall 15)	892062 (Upstream of Outfall 14)	WQN0182, 332049 (Downstream of Outfall 2)	422094 (Downstream of Outfall 12)	422120 (Downstream of Outfall 15)	
bis(2-Ethylhexyl)phthalate	0	0	0	0	0	0	0	0	0	0	0	0	
Dieldrin	0	0	0	0	0	0	0	0	0	0	0	0	
Total Polychlorinated Biphenyl	0	0	0	0	0	0	0	0	0	0	0	0	
Ammonia-N	0	25	0	0	0	0	0	0	0	0	0	0	
Biochemical Oxygen Demand	0	0	0	0	0	0	0	0	0	0	0	0	No Standard
Carbonaceous BOD	0	0	0	0	0	0	0	0	0	0	0	0	No Standard
Carbonaceous BOD 20 Day	0	0	0	0	0	0	0	0	0	0	0	0	No Standard
Dissolved Oxygen	34	61	0	0	0	0	0	0	0	0	0	0	
Nitrate-N	0	0	0	0	0	0	0	0	0	0	0	0	No Standard
Nitrite-N	0	0	0	0	0	0	0	0	0	0	0	0	
Odor	0	0	0	0	0	0	0	0	0	0	0	0	
Phenolics	7	10	0	0	0	0	0	0	7	8	0	0	
Phosphorus, Total	0	10	1	1	0	0	0	0	0	0	0	0	No Standard
Surfactants (MBAS)	0	0	0	0	0	0	0	0	0	0	0	0	
Total Dissolved Solids	34	64	1	1	0	0	0	0	0	0	0	0	No Standard
Total Kjeldahl Nitrogen	0	0	1	1	0	0	0	0	0	0	0	0	No Standard
Total Nitrogen	0	0	0	0	0	0	0	0	0	0	0	0	No Standard
Total Suspended Solids	34	64	1	1	0	0	0	0	0	0	0	0	No Standard
Turbidity	34	35	0	0	0	0	0	0	0	0	0	0	
Hardness	36	66	0	0	0	0	0	0	0	0	0	0	No Standard
Aluminum, Acute	0	29	0	0	0	**14**	0	0	0	0	0	0	
Aluminum, Chronic	0	29	0	0	0	**29**	0	0	0	0	0	0	
Antimony, Total	4	0	0	0	0	0	0	0	4	0	0	0	
Arsenic, Acute	0	0	0	0	0	0	0	0	0	0	0	0	
Arsenic, Chronic	0	0	0	0	0	0	0	0	0	0	0	0	
Copper, Acute	36	67	1	1	0	**3**	0	0	10	6	1	1	
Copper, Chronic	36	67	1	1	0	**6**	**1**	**1**	10	6	0	0	
Iron, Total	0	29	1	1	0	**29**	**1**	**1**	0	0	0	0	
Lead, Acute	36	67	0	0	0	0	0	0	31	37	0	0	
Lead, Chronic	36	67	0	0	0	**4**	0	0	31	37	0	0	
Mercury, Total	10	16	0	0	**1**	0	0	0	6	10	0	0	
Zinc, Total	36	67	1	1	0	0	0	0	5	5	0	0	
Enterococcus*	0	0	0	0	**0**	**0**	**0**	**0**	0	0	0	0	
Fecal Coliform*	34	35	0	0	**0**	**0**	**0**	**0**	0	0	0	0	

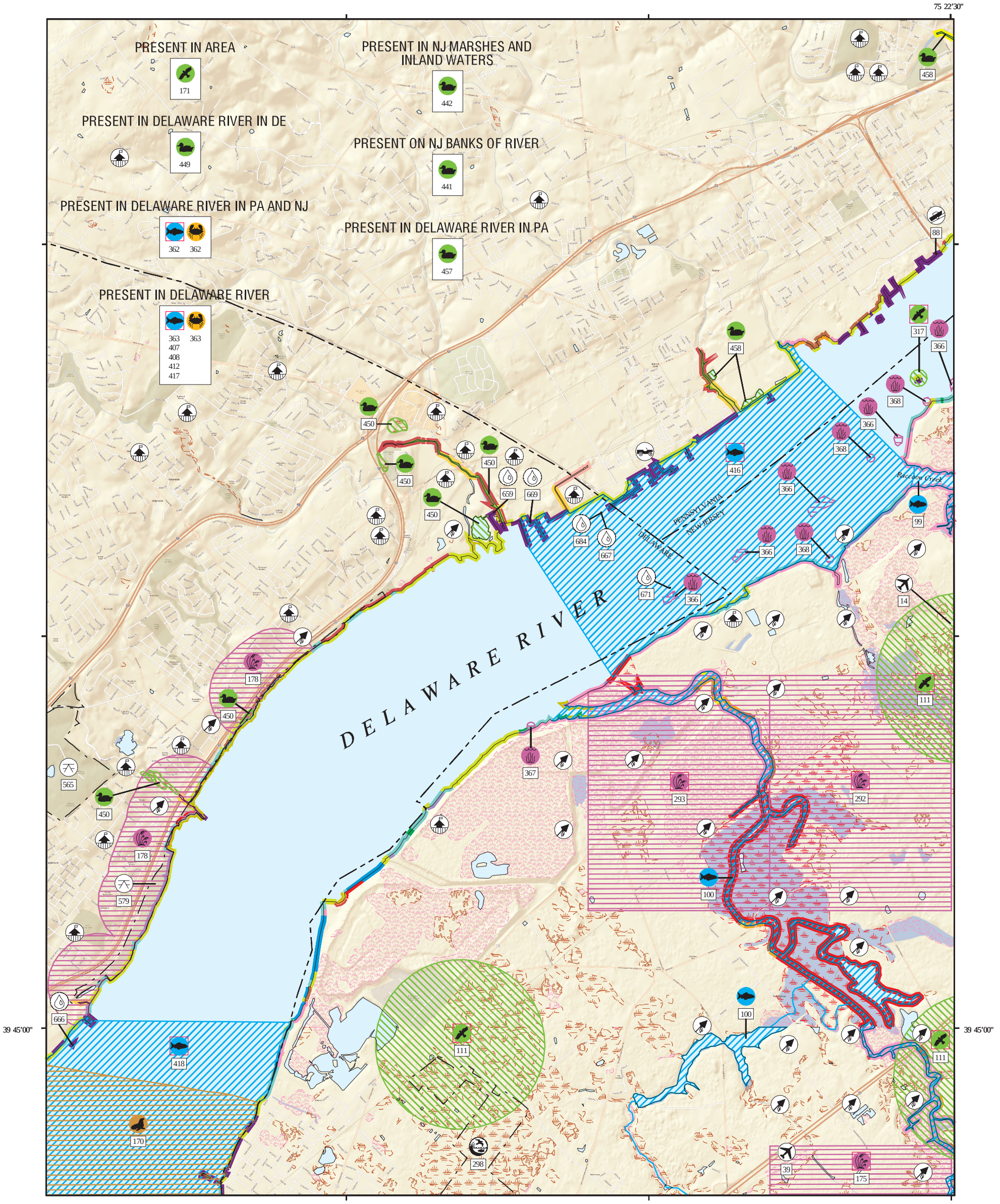
*Fecal Coliform was identified as a parameter exceeding water quality standards (WQS) for Chester and Ridley Creeks based on historical data from 2010 (see Attachment J). Sufficient historical data indicating WQS exceedance for all receiving waterbodies was unavailable, however Enterococcus and Fecal Coliform are considered typical parameters associated with CSOs and for this reason are included as POCs.

	LEGEND
	Pollutant Of Concern (POC)
	Parameter of Potential Concern (POPC)

ATTACHMENT K

NOAA Environmental Sensitivity Index Maps

ENVIRONMENTAL SENSITIVITY INDEX MAP



SHORELINE HABITATS (ESI)

- 1B EXPOSED, SOLID MAN- MADE STRUCTURES
- 2A EXPOSED WAVE- CUT PLATFORMS IN CLAY, MUD, OR BEDROCK
  2B EXPOSED SCARPS AND STEEP SLOPES IN CLAY OR MUD
- 3A FINE- TO MEDIUM- GRAINED SAND BEACHES
  3B SCARPS AND STEEP SLOPES IN SAND
- 4 COARSE- GRAINED SAND BEACHES
- 5 MIXED SAND AND GRAVEL (SHELL) BEACHES
- 6A GRAVEL BEACHES
- 6B RIPRAP
- 7 EXPOSED TIDAL FLATS
- 8A SHELTERED SCARPS IN CLAY OR MUD
- 8B SHELTERED, SOLID MAN- MADE STRUCTURES
- 8C SHELTERED RIPRAP
  8E PEAT SHORELINES
- 9A SHELTERED TIDAL FLATS
  9B VEGETATED LOW BANKS
- 10A SALT- AND BRACKISH- WATER MARSHES
- 10B FRESHWATER MARSHES
- 10C SWAMPS
- 10D SCRUB- SHRUB WETLANDS

N W E S

SCALE 1:45000

1 .5 0 1 KILOMETER

1 .5 0 1 MILE

1 .5 0 1 NAUTICAL MILE

Not For Navigation

Published: March 2014

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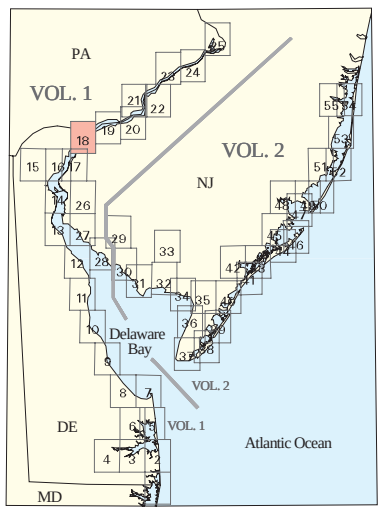
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Response and Restoration
Emergency Response Division



Delaware Bay ESI - Volume 1 **ESI-18**

Delaware/New Jersey/Pennsylvania: ESIMAP 18

BIOLOGICAL RESOURCES:

BIRD:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Nesting	Migrating	Molting
111	Endangered raptor 2	E		NJ		X	X	X	X	X	X	X	X	X	X	X	X	JAN-JUL	-	-
171	Osprey							X	X	X	X	X	X	X	X			MAR-AUG	MAR-MAR SEP-OCT	-
317	Threatened raptor	T		NJ				X	X	X	X	X	X	X	X			APR-AUG	SEP-OCT	-
441	Bufflehead				10S	X	X	X	X	X					X	X	X	-	MAR-APR OCT-DEC	-
	Canada goose				1000S	X	X	X	X	X	X	X	X	X	X	X	X	-	MAR-APR SEP-NOV	-
	Canvasback				100S	X	X	X	X	X						X	X	-	MAR-APR NOV-DEC	-
	Common goldeneye				10S	X	X	X	X	X						X	X	-	MAR-APR NOV-DEC	-
	Hooded merganser				10S	X	X	X							X	X	X	-	FEB-MAR OCT-DEC	-
	Red-breasted merganser				10S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Ring-necked duck				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Ruddy duck				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-NOV	-
	Scaup				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Snow goose				1000S	X	X	X	X	X				X	X	X	X	-	FEB-MAY SEP-OCT	-
442	American black duck				1000S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-APR SEP-DEC	-
	American coot				100S	X	X	X	X	X		X	X	X	X	X	X	-	FEB-MAR SEP-NOV	-
	American wigeon				100S	X	X	X	X	X		X	X	X	X	X	X	-	MAR-APR AUG-NOV	-
	Bufflehead				10S	X	X	X	X	X					X	X	X	-	MAR-APR OCT-DEC	-
	Canada goose				1000S	X	X	X	X	X	X	X	X	X	X	X	X	-	MAR-APR SEP-NOV	-
	Canvasback				100S	X	X	X	X	X						X	X	-	MAR-APR NOV-DEC	-
	Common goldeneye				10S	X	X	X	X	X						X	X	-	MAR-APR NOV-DEC	-
	Common merganser				100S	X	X	X	X							X	X	-	FEB-MAR NOV-DEC	-
	Gadwall				100S	X	X	X	X	X	X	X	X	X	X	X	X	MAY-JUL	MAR-APR OCT-NOV	-
	Green-winged teal				100S	X	X	X	X	X		X	X	X	X	X	X	-	FEB-MAR SEP-NOV	-
	Hooded merganser				10S	X	X	X							X	X	X	-	FEB-MAR OCT-DEC	-
	Mallard				1000S	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	-	-
	Mute swan				10S	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-
	Northern pintail				100S	X	X	X	X			X	X	X	X	X	X	-	FEB-APR AUG-SEP	-
	Northern shoveler				10S	X	X	X	X	X			X	X	X	X	X	-	MAR-APR SEP-OCT	-
	Red-breasted merganser				10S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Ring-necked duck				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Ruddy duck				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-NOV	-
	Scaup				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Snow goose				1000S	X	X	X	X	X				X	X	X	X	-	FEB-MAY SEP-OCT	-
	Tundra swan				100S	X	X	X	X						X	X	X	-	FEB-APR OCT-NOV	-
449	Bufflehead				10S	X	X	X	X	X					X	X	X	-	MAR-MAR OCT-NOV	-
	Canada goose				10000S	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-APR SEP-NOV	-
	Ring-necked duck				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-NOV	-
	Ruddy duck				1000S	X	X	X	X	X	X	X	X	X	X	X	X	-	FEB-MAR OCT-NOV	-
	Scaup				1000S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Snow goose				100S	X	X	X	X						X	X	X	-	FEB-APR OCT-NOV	-
450	American black duck				100S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	OCT-APR	-
	American coot				1000S	X	X	X	X	X			X	X	X	X	X	-	FEB-APR OCT-NOV	-
	American wigeon				10S	X	X	X	X	X			X	X	X	X	X	-	MAR-APR SEP-OCT	-
	Bufflehead				10S	X	X	X	X	X					X	X	X	-	MAR-MAR OCT-NOV	-
	Canada goose				10000S	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-APR SEP-NOV	-
	Common merganser				10S	X	X	X	X							X	X	-	FEB-MAR NOV-DEC	-
	Gadwall				100S	X	X	X	X	X	X	X	X	X	X	X	X	MAY-JUL	MAR-APR OCT-NOV	-
	Green-winged teal				100S	X	X	X	X	X	X	X	X	X	X	X	X	MAY-JUL	MAR-APR AUG-SEP	-
	Mallard				100S	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUL	FEB-MAY OCT-DEC	-
	Mute swan				10S	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-
	Northern pintail				100S	X	X	X	X	X			X	X	X	X	X	-	FEB-MAY SEP-DEC	-
	Northern shoveler				100S	X	X	X	X	X			X	X	X	X	X	-	MAR-APR OCT-NOV	-
	Ring-necked duck				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-NOV	-
	Ruddy duck				1000S	X	X	X	X	X	X	X	X	X	X	X	X	-	FEB-MAR OCT-NOV	-
	Scaup				1000S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Snow goose				100S	X	X	X	X						X	X	X	-	FEB-APR OCT-NOV	-
	Wood duck				10S	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	FEB-MAR OCT-DEC	-
457	Bufflehead				100S	X	X	X	X	X	X				X	X	X	-	MAR-MAY OCT-DEC	-
	Canada goose				100S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUL	FEB-APR SEP-NOV	-
	Canvasback				100S	X	X	X	X	X			X	X	X	X	X	-	FEB-APR SEP-NOV	-
	Common goldeneye				10S	X	X	X	X	X					X	X	X	-	FEB-APR NOV-DEC	-
	Long-tailed duck				10S	X	X	X	X						X	X	X	-	FEB-APR OCT-NOV	-
	Mergansers				100S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	FEB-APR OCT-DEC	-
	Northern shoveler				10S	X	X	X	X	X			X	X	X	X	X	-	MAR-APR AUG-NOV	-
	Ruddy duck				1000S	X	X	X	X	X	X			X	X	X	X	-	MAR-APR OCT-NOV	-
	Scaup				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
458	American black duck				1000S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	FEB-APR OCT-DEC	-
	Bufflehead				100S	X	X	X	X	X	X				X	X	X	-	MAR-MAY OCT-DEC	-
	Canada goose				100S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUL	FEB-APR SEP-NOV	-
	Canvasback				100S	X	X	X	X	X	X			X	X	X	X	-	FEB-APR SEP-NOV	-
	Common goldeneye				10S	X	X	X	X	X	X				X	X	X	-	FEB-APR NOV-DEC	-
	Green-winged teal				100S	X	X	X	X	X		X	X	X	X	X	X	-	MAR-MAY AUG-NOV	-
	Long-tailed duck				10S	X	X	X	X						X	X	X	-	FEB-APR OCT-NOV	-
	Mallard				1000S	X	X	X	X	X	X	X	X	X	X	X	X	APR-AUG	FEB-MAY SEP-DEC	-
	Mergansers				100S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	FEB-APR OCT-DEC	-
	Northern pintail				100S	X	X	X	X	X			X	X	X	X	X	-	FEB-APR SEP-DEC	-
	Northern shoveler				10S	X	X	X	X	X		X	X	X	X	X	X	-	MAR-APR AUG-NOV	-
	Ruddy duck				1000S	X	X	X	X	X	X			X	X	X	X	-	MAR-APR OCT-NOV	-
	Scaup				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Tundra swan				100S	X	X	X	X						X	X	X	-	FEB-APR OCT-DEC	-

FISH:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Spawning	Eggs	Larvae	Juveniles	Adults
99	Alewife				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	MAR-MAY	MAR-MAY	APR-JUN	JAN-DEC	MAR-JUN
	American eel				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	DEC-APR	JAN-DEC	JAN-DEC
	American shad				HIGH SPAWNING			X	X	X	X	X	X	X	X			MAR-JUN	APR-JUN	MAY-JUL	JUN-NOV	MAR-JUN OCT-NOV
	Blueback herring				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	MAY-JUL	JAN-DEC	MAR-JUN OCT-NOV
100	Alewife				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	MAR-MAY	MAR-MAY	APR-JUN	JAN-DEC	MAR-JUN
	American eel				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	DEC-APR	JAN-DEC	JAN-DEC
	Blueback herring				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	MAY-JUL	JAN-DEC	MAR-JUN OCT-NOV
362	Alewife				HIGH SPAWNING			X	X	X	X	X	X	X				MAR-MAY	MAR-MAY	APR-JUN	JUN-AUG	MAR-OCT
	American eel				LOW	X	X	X	X	X	X	X	X	X	X	X	X	-	-	DEC-APR	JAN-DEC	JAN-DEC
	American shad				HIGH SPAWNING			X	X	X	X	X	X	X	X			MAR-JUN	APR-JUN	MAY-JUL	JUN-NOV	MAR-NOV
	Atlantic croaker				MED					X	X	X	X	X				-	-	-	JUL-OCT	JUN-NOV
	Atlantic menhaden				HIGH					X	X	X						-	-	-	JUN-JUL	JUN-AUG
	Bay anchovy				MED							X	X	X	X			-	-	-	AUG-OCT	AUG-NOV
	Blueback herring				HIGH			X	X	X	X	X	X	X	X			MAR-JUN	MAR-JUN	MAR-JUN	JUN-NOV	MAR-NOV
	Channel catfish				PRESENT					X	X	X	X	X	X			-	-	-	JUL-SEP	JUN-NOV
	Gizzard shad				LOW					X	X	X	X	X	X			-	-	-	JUN-OCT	JUL-NOV
	Hickory shad				LOW			X	X	X								MAR-JUN	MAR-JUN	MAR-JUN	-	MAR-JUN
	Hickory shad	E		PA	LOW			X	X	X								MAR-JUN	MAR-JUN	MAR-JUN	-	MAR-JUN
	Spot				HIGH SPRING							X	X	X				-	-	-	JUL-SEP	JUL-SEP

Biological information shown on the maps represents known concentration areas or occurrences, but does not necessarily represent the full distribution or range of each species. DNREC, NJDEP ENSP, and PGC provided information for some of the federally and state listed species and species of conservation concern for display in the ESI atlas and accompanying digital data in 2013-2014. These data represent existing information known to these agencies at the time of the request and should never be substituted for consultation with these agencies. This atlas was developed using NJDEP GIS digital data for archaeological and historic sites, but this secondary product has not been verified by NJDEP and is not state-authorized. Archaeological and historical site information for Delaware was provided by DE Division of Historical and Cultural Affairs.

Delaware/New Jersey/Pennsylvania: ESIMAP 18 (cont.)

BIOLOGICAL RESOURCES: (cont.)

FISH: (cont.)

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Spawning	Eggs	Larvae	Juveniles	Adults
362	Striped bass				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-JUN	APR-JUL	JAN-DEC	APR-NOV
	White perch				HIGH	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	APR-JUL	JAN-DEC	JAN-DEC
	Yellow perch				LOW					X	X	X	X	X				-	-	-	JUN-AUG	JUN-OCT
363	Alewife				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	MAR-MAY	MAR-MAY	APR-JUN	JAN-DEC	MAR-OCT
	American eel				MED	X	X	X	X	X	X	X	X	X	X	X	X	-	-	DEC-APR	JAN-DEC	JAN-DEC
	American shad				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	JAN-DEC	MAR-OCT
	Atlantic croaker				HIGH			X	X	X	X	X	X	X	X	X		-	-	-	JUL-OCT	APR-NOV
	Atlantic menhaden				HIGH				X	X	X	X	X	X				-	-	-	JUN-OCT	MAY-OCT
	Bay anchovy				MED			X	X	X	X	X	X	X	X			-	-	-	APR-NOV	APR-NOV
	Blueback herring				HIGH	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	APR-JUN	JAN-DEC	APR-NOV
	Bluefish				LOW					X	X	X	X	X				-	-	-	JUN-OCT	-
	Channel catfish				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	JUN-OCT	JAN-DEC
	Gizzard shad				LOW					X	X	X	X	X	X			-	-	-	JUN-OCT	JUL-NOV
	Hickory shad				MED			X	X	X	X	X	X	X	X			-	-	-	MAY-OCT	MAR-JUN OCT-NOV
	Hickory shad	E		PA	MED			X	X	X	X	X	X	X	X			-	-	-	MAY-OCT	MAR-JUN OCT-NOV
	Spot				MED				X	X	X	X	X	X				-	-	-	JUN-OCT	MAY-OCT
	Striped bass				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-JUN	APR-JUL	JAN-DEC	APR-NOV
	Weakfish				PRESENT					X	X	X	X	X				-	-	-	JUN-OCT	-
	White perch				HIGH	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	APR-JUL	JAN-DEC	JAN-DEC
	Yellow perch				LOW					X	X	X	X	X	X			-	-	-	JUN-NOV	JUN-NOV
407	Shortnose sturgeon	E	E	DE	MED				X	X	X	X	X	X	X			-	-	-	APR-OCT	APR-OCT
	Shortnose sturgeon	E	E	NJ	MED				X	X	X	X	X	X	X			-	-	-	APR-OCT	APR-OCT
	Shortnose sturgeon	E	E	PA	MED				X	X	X	X	X	X	X			-	-	-	APR-OCT	APR-OCT
408	Shortnose sturgeon	E	E	DE	HIGH	X	X	X								X	X	-	-	-	NOV-MAR	-
	Shortnose sturgeon	E	E	NJ	HIGH	X	X	X								X	X	-	-	-	NOV-MAR	-
	Shortnose sturgeon	E	E	PA	HIGH	X	X	X								X	X	-	-	-	NOV-MAR	-
412	Atlantic sturgeon	E	E	DE	HIGH				X	X	X							APR-JUN	APR-JUN	MAY-JUN	APR-JUN	APR-JUN
	Atlantic sturgeon	E	E	NJ	HIGH				X	X	X							APR-JUN	APR-JUN	MAY-JUN	APR-JUN	APR-JUN
	Atlantic sturgeon	E	E	PA	HIGH				X	X	X							APR-JUN	APR-JUN	MAY-JUN	APR-JUN	APR-JUN
416	Atlantic sturgeon	E	E	DE	HIGH YOY	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-JUN	MAY-JUN	JAN-DEC	MAR-NOV
	Atlantic sturgeon	E	E	NJ	HIGH YOY	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-JUN	MAY-JUN	JAN-DEC	MAR-NOV
	Atlantic sturgeon	E	E	PA	HIGH YOY	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-JUN	MAY-JUN	JAN-DEC	MAR-NOV
417	Atlantic sturgeon	E	E	DE	PRESENT	X	X	X			X	X	X	X	X	X	X	-	-	-	JUL-MAR	MAR-MAR JUL-NOV
	Atlantic sturgeon	E	E	NJ	PRESENT	X	X	X			X	X	X	X	X	X	X	-	-	-	JUL-MAR	MAR-MAR JUL-NOV
	Atlantic sturgeon	E	E	PA	PRESENT	X	X	X			X	X	X	X	X	X	X	-	-	-	JUL-MAR	MAR-MAR JUL-NOV
418	Atlantic sturgeon	E	E	DE	PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	JAN-DEC	MAR-NOV
	Atlantic sturgeon	E	E	NJ	PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	JAN-DEC	MAR-NOV

HABITAT:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D
175	Endangered plant	E		NJ		X	X	X	X	X	X	X	X	X	X	X	X
178	Rare plant					X	X	X	X	X	X	X	X	X	X	X	X
292	Endangered plant	E		NJ		X	X	X	X	X	X	X	X	X	X	X	X
	Sensitive Joint-vetch	E	T	NJ		X	X	X	X	X	X	X	X	X	X	X	X
293	Sensitive Joint-vetch	E	T	NJ		X	X	X	X	X	X	X	X	X	X	X	X
366	Eelgrass (water celery)					X	X	X	X	X	X	X	X	X	X	X	X
367	Eelgrass (water celery)					X	X	X	X	X	X	X	X	X	X	X	X
368	Submerged aquatic vegetation					X	X	X	X	X	X	X	X	X	X	X	X

INVERTEBRATE:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Spawning	Eggs	Larvae	Juveniles	Adults
362	Blue crab				LOW						X	X	X	X	X	X		-	-	-	JUN-OCT	JUN-NOV
363	Blue crab				LOW	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	JAN-DEC	JAN-DEC

MARINE MAMMAL:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Mating	Calving	Pupping	Molting
170	Gray seal				OCCASIONAL	X	X	X	X							X	X	-	-	-	-
	Harbor seal				COMMON	X	X	X	X							X	X	-	-	-	-
	Harp seal				OCCASIONAL	X	X	X	X	X						X	X	-	-	-	-
	Hooded seal				VERY RARE	X	X	X	X	X						X	X	-	-	-	-

HUMAN USE RESOURCES:

AIRPORT:

HUN#	Name	Contact	Phone
14	BRIDGEPORT-CAHILL FIELD		
39	SPITFIRE AERODROME		

BOAT RAMP:

HUN#	Name	Contact	Phone
88	FLOWER STREET- CHESTER CITY BOAT RAMP	CITY OF CHESTER	

MANAGEMENT AREA:

HUN#	Name	Contact	Phone
298	GAME BRANCH	NJ DEPT OF NATURAL LANDS TRUST	

PARK:

HUN#	Name	Contact	Phone
565	BELLEVUE STATE PARK	DELAWARE STATE PARKS	
579	FOX POINT STATE PARK	DELAWARE STATE PARKS	

WATER INTAKE:

HUN#	Name	Contact	Phone
659	CLAYMONT STEEL, INC.		
666	DUPONT EDGEMOOR PLANT		
667	FPL ENERGY		
669	GENERAL CHEMICAL		
671	LOGAN GENERATING CORP.		
684	SUNOCO INC (R&M)		

Biological information shown on the maps represents known concentration areas or occurrences, but does not necessarily represent the full distribution or range of each species. DNREC, NJDEP ENSP, and PGC provided information for some of the federally and state listed species and species of conservation concern for display in the ESI atlas and accompanying digital data in 2013-2014. These data represent existing information known to these agencies at the time of the request and should never be substituted for consultation with these agencies. This atlas was developed using NJDEP GIS digital data for archaeological and historic sites, but this secondary product has not been verified by NJDEP and is not state-authorized. Archaeological and historical site information for Delaware was provided by DE Division of Historical and Cultural Affairs.

ENVIRONMENTAL SENSITIVITY INDEX MAP

75 15'00"

39 52'30"

PRESENT IN PA MARSHES AND INLAND WATERS
458

PRESENT IN HEINZ NWR
248

PRESENT IN AREA
111 175

PRESENT IN NJ MARSHES AND INLAND WATERS
442

PRESENT IN DELAWARE RIVER
362 362
407
408
412
417

PRESENT IN DELAWARE RIVER IN PA
457

PRESENT ON NJ BANKS OF RIVER
441

DELAWARE RIVER

PENNSYLVANIA
NEW JERSEY

LITTLE TINICUM ISLAND

CRAB POINT

BRAMELL POINT

Raccoon Creek

123 691 247 207 371 442 168 330 181 283 368 371 416 443 317 366 339 100 316 395 368 294 99 492 298

SHORELINE HABITATS (ESI)

- 1B EXPOSED, SOLID MAN- MADE STRUCTURES
- 2A EXPOSED WAVE- CUT PLATFORMS IN CLAY, MUD, OR BEDROCK
  2B EXPOSED SCARPS AND STEEP SLOPES IN CLAY OR MUD
- 3A FINE- TO MEDIUM- GRAINED SAND BEACHES
  3B SCARPS AND STEEP SLOPES IN SAND
- 4 COARSE- GRAINED SAND BEACHES
- 5 MIXED SAND AND GRAVEL (SHELL) BEACHES
- 6A GRAVEL BEACHES
- 6B RIPRAP
- 7 EXPOSED TIDAL FLATS
- 8A SHELTERED SCARPS IN CLAY OR MUD
- 8B SHELTERED, SOLID MAN- MADE STRUCTURES
- 8C SHELTERED RIPRAP
  8E PEAT SHORELINES
- 9A SHELTERED TIDAL FLATS
  9B VEGETATED LOW BANKS
- 10A SALT- AND BRACKISH- WATER MARSHES
- 10B FRESHWATER MARSHES
- 10C SWAMPS
- 10D SCRUB- SHRUB WETLANDS

N
W E
S

SCALE 1:45000

1 .5 0 1 KILOMETER

1 .5 0 1 MILE

1 .5 0 1 NAUTICAL MILE

Not For Navigation

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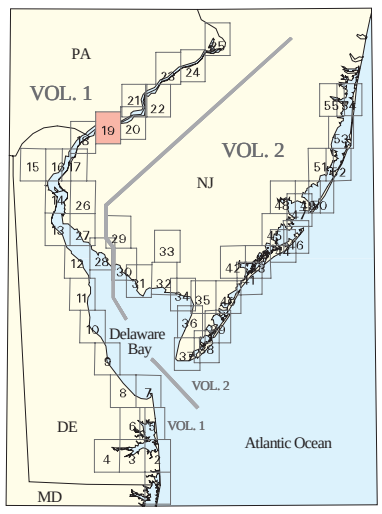

Delaware Bay ESI - Volume 1 ESI-19

Delaware/New Jersey/Pennsylvania: ESIMAP 19

BIOLOGICAL RESOURCES:

BIRD:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Nesting	Migrating	Molting
111	Endangered raptor 2	E		NJ		X	X	X	X	X	X	X	X	X	X	X	X	JAN-JUL	-	-
	Endangered raptor 2	T		PA		X	X	X	X	X	X	X	X	X	X	X	X	JAN-JUL	-	-
247	American bittern	E		PA	COMMON	X	X	X	X	X	X	X	X	X	X	X	X	MAY-AUG	-	-
	American black duck				ABUNDANT	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	FEB-APR OCT-DEC	-
	American coot				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	-	-
	American woodcock				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	-	-
	Bald eagle	T		PA	UNCOMMON	X	X	X	X	X	X	X	X	X	X	X	X	FEB-APR	-	-
	Barn owl				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	JAN-DEC	-	-
	Black tern	E		PA	OCCASIONAL				X	X	X	X	X					-	-	-
	Black-bellied plover				COMMON			X	X	X	X	X	X	X				-	MAY-OCT	-
	Black-crowned night-heron	E		PA	ABUNDANT	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUL	MAR-APR JUL-DEC	-
	Blackpoll warbler	E		PA	COMMON					X	X		X	X	X			-	MAY-JUN AUG-OCT	-
	Blue-winged teal				COMMON			X	X	X	X	X	X	X	X	X	X	MAY-JUN	MAR-MAY AUG-OCT	-
	Canada goose				ABUNDANT	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUL	FEB-APR SEP-NOV	-
	Common moorhen				UNCOMMON			X	X	X	X	X	X	X	X			MAY-SEP	-	-
	Common snipe				COMMON	X	X	X	X	X		X	X	X	X	X	X	-	MAR-MAY JUL-NOV	-
	Common tern	E		PA	RARE				X	X	X	X	X	X	X			-	APR-MAY AUG-SEP	-
	Double-crested cormorant				COMMON	X		X	X	X	X	X	X	X	X	X	X	-	MAR-MAY AUG-DEC	-
	Forster's tern				COMMON				X	X	X	X	X	X	X	X		-	APR-MAY JUL-OCT	-
	Great blue heron				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	-	MAR-MAY	-
	Great egret	E		PA	ABUNDANT			X	X	X	X	X	X	X	X	X	X	APR-JUL	MAR-MAY JUL-DEC	-
	Greater scaup				COMMON	X	X	X	X			X	X	X	X	X	X	-	NOV-APR	-
	Greater yellowlegs				COMMON			X	X	X		X	X	X	X	X		-	MAR-MAY JUL-NOV	-
	Green heron							X	X	X	X	X	X	X	X			-	-	-
	Green-winged teal				ABUNDANT	X	X	X	X	X	X	X	X	X	X	X	X	JUL-AUG	MAR-MAY AUG-NOV	-
	Herring gull				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-
	Hooded merganser				OCCASIONAL	X	X	X	X	X	X	X	X	X	X	X	X	MAY-AUG	MAR-APR OCT-JAN	-
	Killdeer				ABUNDANT	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	FEB-MAR AUG-NOV	-
	King rail	E		PA	OCCASIONAL			X	X	X	X	X	X	X	X			MAY-AUG	-	-
	Laughing gull				COMMON			X	X	X	X	X	X	X	X	X	X	-	APR-MAY AUG-OCT	-
	Least bittern	E		PA	COMMON				X	X	X	X	X	X	X			MAY-AUG	-	-
	Little blue heron				COMMON				X	X	X	X	X	X				-	-	-
	Loggerhead shrike	E		PA	RARE				X	X			X	X	X	X	X	-	MAR-APR AUG-SEP	-
	Mallard				ABUNDANT	X	X	X	X	X	X	X	X	X	X	X	X	APR-AUG	FEB-MAY SEP-DEC	-
	Marsh wren				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	MAY-AUG	-	-
	Northern harrier	T		PA	COMMON	X	X	X	X	X	X	X	X	X	X	X	X	MAY-JUN	OCT-FEB	-
	Northern pintail				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	MAY-JUN	FEB-APR SEP-DEC	-
	Northern shoveler				COMMON	X	X	X	X	X	X			X	X	X	X	MAY-JUN	MAR-APR SEP-NOV	-
	Osprey	T		PA	OCCASIONAL			X	X	X	X	X	X	X	X			-	MAR-MAY AUG-OCT	-
	Peregrine falcon	E		PA	RARE	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-
	Pied-billed grebe				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	MAY-AUG	MAR-MAY AUG-AUG	-
	Piping plover	E	E	PA	RARE				X	X	X	X	X	X				-	-	-
	Ring-billed gull				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	-	OCT-MAR	-
	Ruddy duck				COMMON	X	X	X	X				X	X	X			-	MAR-APR OCT-NOV	-
	Sedge wren	E		PA	RARE				X	X	X	X	X	X				JUN-AUG	-	-
	Semipalmated plover				COMMON				X	X	X	X	X	X	X			-	APR-OCT	-
	Semipalmated sandpiper				COMMON				X	X	X	X	X	X	X			-	APR-OCT	-
	Short-eared owl	E		PA	OCCASIONAL	X	X	X	X					X	X	X		-	MAR-APR OCT-NOV	-
	Snowy egret				ABUNDANT			X	X	X	X	X	X	X	X			APR-AUG	MAR-MAY JUL-SEP	-
	Solitary sandpiper				COMMON				X	X		X	X	X	X			-	APR-MAY JUL-OCT	-
	Sora				OCCASIONAL			X	X	X	X	X	X	X	X			MAY-JUL	-	-
	Spotted sandpiper				COMMON				X	X	X	X	X	X	X			MAY-JUN	APR-MAY JUL-OCT	-
	Swamp sparrow					X	X	X	X	X	X	X	X	X	X	X	X	MAY-JUL	-	-
	Upland sandpiper	E		PA	RARE				X	X	X	X	X	X				-	APR-MAY JUL-SEP	-
	Virginia rail				OCCASIONAL			X	X	X	X	X	X	X	X			MAY-AUG	-	-
	Wood duck				ABUNDANT	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	MAR-APR SEP-NOV	-
	Yellow-bellied flycatcher	E		PA	UNCOMMON					X	X		X	X	X			-	MAY-JUN AUG-OCT	-
	Yellow-crowned night-heron	E		PA	RARE				X	X	X	X	X	X				-	-	-
317	Threatened raptor	T		NJ					X	X	X	X	X	X	X			APR-AUG	SEP-OCT	-
330	Peregrine falcon	E		PA	1 NEST	X	X	X	X	X	X	X	X	X	X	X	X	FEB-JUL	MAR-MAY	-
441	Bufflehead				10S	X	X	X	X	X				X	X	X		-	MAR-APR OCT-DEC	-
	Canada goose				1000S	X	X	X	X	X	X	X	X	X	X	X	X	-	MAR-APR SEP-NOV	-
	Canvasback				100S	X	X	X	X	X					X	X		-	MAR-APR NOV-DEC	-
	Common goldeneye				10S	X	X	X	X	X					X	X		-	MAR-APR NOV-DEC	-
	Hooded merganser				10S	X	X	X						X	X	X		-	FEB-MAR OCT-DEC	-
	Red-breasted merganser				10S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Ring-necked duck				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Ruddy duck				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-NOV	-
	Scaup				100S	X	X	X	X						X	X	X	-	MAR-APR OCT-DEC	-
	Snow goose				1000S	X	X	X	X	X				X	X	X	X	-	FEB-MAY SEP-OCT	-
442	American black duck				1000S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-APR SEP-DEC	-
	American coot				100S	X	X	X	X	X			X	X	X	X	X	-	FEB-MAR SEP-NOV	-
	American wigeon				100S	X	X	X	X	X			X	X	X	X	X	-	MAR-APR AUG-NOV	-
	Bufflehead				10S	X	X	X	X	X				X	X	X		-	MAR-APR OCT-DEC	-
	Canada goose				1000S	X	X	X	X	X	X	X	X	X	X	X	X	-	MAR-APR SEP-NOV	-
	Canvasback				100S	X	X	X	X	X					X	X		-	MAR-APR NOV-DEC	-
	Common goldeneye				10S	X	X	X	X	X					X	X		-	MAR-APR NOV-DEC	-
	Common merganser				100S	X	X	X	X						X	X		-	FEB-MAR NOV-DEC	-
	Gadwall				100S	X	X	X	X	X	X	X	X	X	X	X	X	MAY-JUL	MAR-APR OCT-NOV	-
	Green-winged teal				100S	X	X	X	X	X		X	X	X	X	X		-	FEB-MAR SEP-NOV	-
	Hooded merganser				10S	X	X	X						X	X	X		-	FEB-MAR OCT-DEC	-
	Mallard				1000S	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	-	-
	Mute swan				10S	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-
	Northern pintail				100S	X	X	X	X			X	X	X	X	X		-	FEB-APR AUG-SEP	-
	Northern shoveler				10S	X	X	X	X	X			X	X	X	X		-	MAR-APR SEP-OCT	-
	Red-breasted merganser				10S	X	X	X	X					X	X	X		-	MAR-APR OCT-DEC	-
	Ring-necked duck				100S	X	X	X	X					X	X	X		-	MAR-APR OCT-DEC	-
	Ruddy duck				100S	X	X	X	X					X	X	X		-	MAR-APR OCT-NOV	-
	Scaup				100S	X	X	X	X					X	X	X		-	MAR-APR OCT-DEC	-
	Snow goose				1000S	X	X	X	X	X			X	X	X	X		-	FEB-MAY SEP-OCT	-
	Tundra swan				100S	X	X	X	X					X	X	X		-	FEB-APR OCT-NOV	-
443	Bufflehead				10S	X	X	X	X	X				X	X	X		-	MAR-APR OCT-DEC	-
	Canada goose				10000S	X	X	X	X	X	X	X	X	X	X	X	X	-	MAR-APR SEP-NOV	-
	Canvasback				100S	X	X	X	X	X					X	X		-	MAR-APR NOV-DEC	-
	Common goldeneye				10S	X	X	X	X	X					X	X		-	MAR-APR NOV-DEC	-
	Red-breasted merganser				10S	X	X	X	X					X	X	X		-	MAR-APR OCT-DEC	-
	Ring-necked duck				10S	X	X	X	X					X	X	X		-	MAR-APR OCT-DEC	-
	Ruddy duck				10S	X	X	X	X					X	X	X		-	MAR-APR OCT-NOV	-
	Scaup				100S	X	X	X	X					X	X	X		-	MAR-APR OCT-DEC	-
457	Bufflehead				100S	X	X	X	X	X	X			X	X	X		-	MAR-MAY OCT-DEC	-
	Canada goose				100S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUL	FEB-APR SEP-NOV	-
	Canvasback				100S	X	X	X	X	X	X			X	X	X	X	-	FEB-APR SEP-NOV	-
	Common goldeneye				10S	X	X	X	X	X	X				X	X	X	-	FEB-APR NOV-DEC	-
	Long-tailed duck				10S	X	X	X	X					X	X	X		-	FEB-APR OCT-NOV	-

Biological information shown on the maps represents known concentration areas or occurrences, but does not necessarily represent the full distribution or range of each species. DNREC, NJDEP ENSP, and PGC provided information for some of the federally and state listed species and species of conservation concern for display in the ESI atlas and accompanying digital data in 2013-2014. These data represent existing information known to these agencies at the time of the request and should never be substituted for consultation with these agencies. This atlas was developed using NJDEP GIS digital data for archaeological and historic sites, but this secondary product has not been verified by NJDEP and is not state-authorized. Archaeological and historical site information for Delaware was provided by DE Division of Historical and Cultural Affairs.

Delaware/New Jersey/Pennsylvania: ESIMAP 19 (cont.)

BIOLOGICAL RESOURCES: (cont.)

BIRD: (cont.)

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Nesting	Migrating	Molting
457	Mergansers				100S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	FEB-APR OCT-DEC	-
	Northern shoveler				10S	X	X	X	X	X		X	X	X	X	X		-	MAR-APR AUG-NOV	-
	Ruddy duck				1000S	X	X	X	X	X	X		X	X	X	X		-	MAR-APR OCT-NOV	-
	Scaup				100S	X	X	X	X					X	X	X		-	MAR-APR OCT-DEC	-
458	American black duck				1000S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	FEB-APR OCT-DEC	-
	Bufflehead				100S	X	X	X	X	X	X			X	X	X		-	MAR-MAY OCT-DEC	-
	Canada goose				100S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUL	FEB-APR SEP-NOV	-
	Canvasback				100S	X	X	X	X	X			X	X	X	X		-	FEB-APR SEP-NOV	-
	Common goldeneye				10S	X	X	X	X	X				X	X	X		-	FEB-APR NOV-DEC	-
	Green-winged teal				100S	X	X	X	X	X		X	X	X	X	X		-	MAR-MAY AUG-NOV	-
	Long-tailed duck				10S	X	X	X	X					X	X	X		-	FEB-APR OCT-NOV	-
	Mallard				1000S	X	X	X	X	X	X	X	X	X	X	X	X	APR-AUG	FEB-MAY SEP-DEC	-
	Mergansers				100S	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	FEB-APR OCT-DEC	-
	Northern pintail				100S	X	X	X	X	X				X	X	X	X	-	FEB-APR SEP-DEC	-
	Northern shoveler				10S	X	X	X	X	X		X	X	X	X	X		-	MAR-APR AUG-NOV	-
	Ruddy duck				1000S	X	X	X	X	X	X		X	X	X	X		-	MAR-APR OCT-NOV	-
	Scaup				100S	X	X	X	X					X	X	X		-	MAR-APR OCT-DEC	-
	Tundra swan				100S	X	X	X	X					X	X	X		-	FEB-APR OCT-DEC	-

FISH:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Spawning	Eggs	Larvae	Juveniles	Adults
99	Alewife				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	MAR-MAY	MAR-MAY	APR-JUN	JAN-DEC	MAR-JUN
	American eel				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	DEC-APR	JAN-DEC	JAN-DEC
	American shad				HIGH SPAWNING			X	X	X	X	X	X	X	X			MAR-JUN	APR-JUN	MAY-JUL	JUN-NOV	MAR-JUN OCT-NOV
	Blueback herring				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	MAY-JUL	JAN-DEC	MAR-JUN OCT-NOV
100	Alewife				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	MAR-MAY	MAR-MAY	APR-JUN	JAN-DEC	MAR-JUN
	American eel				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	DEC-APR	JAN-DEC	JAN-DEC
	Blueback herring				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	MAY-JUL	JAN-DEC	MAR-JUN OCT-NOV
248	Alewife				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	MAR-MAY	MAR-MAY	APR-JUN	JAN-DEC	MAR-JUN
	American eel				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	DEC-APR	JAN-DEC	JAN-DEC
	Atlantic croaker				PRESENT					X	X	X	X	X	X			-	-	-	JUL-OCT	JUN-NOV
	Atlantic menhaden				PRESENT					X	X	X						-	-	-	JUN-JUL	JUN-AUG
	Blueback herring				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	MAY-JUL	JAN-DEC	MAR-JUN OCT-NOV
	Channel catfish				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	JUN-OCT	JAN-DEC
	Gizzard shad				PRESENT					X	X	X	X	X	X			-	-	-	JUN-OCT	JUL-NOV
	Hickory shad				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	MAR-JUN	JAN-DEC	MAR-JUN OCT-NOV
	Hickory shad	E		PA	PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	MAR-JUN	JAN-DEC	MAR-JUN OCT-NOV
	Largemouth bass				PRESENT				X	X	X	X	X	X	X	X		APR-MAY	APR-MAY	APR-MAY	MAY-JUL	APR-NOV
	Smallmouth bass				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	-	-
	Spot				PRESENT						X	X	X					-	-	-	JUL-SEP	JUL-SEP
	Striped bass				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	-	APR-JUN	APR-JUL	JAN-DEC	MAR-DEC
	White perch				PRESENT	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	APR-JUL	JAN-DEC	JAN-DEC
	Yellow perch				PRESENT					X	X	X	X	X				-	-	-	JUN-AUG	JUN-OCT
362	Alewife				HIGH SPAWNING			X	X	X	X	X	X	X				MAR-MAY	MAR-MAY	APR-JUN	JUN-AUG	MAR-OCT
	American eel				LOW	X	X	X	X	X	X	X	X	X	X	X	X	-	-	DEC-APR	JAN-DEC	JAN-DEC
	American shad				HIGH SPAWNING			X	X	X	X	X	X	X	X			MAR-JUN	APR-JUN	MAY-JUL	JUN-NOV	MAR-NOV
	Atlantic croaker				MED					X	X	X	X	X	X			-	-	-	JUL-OCT	JUN-NOV
	Atlantic menhaden				HIGH					X	X	X						-	-	-	JUN-JUL	JUN-AUG
	Bay anchovy				MED							X	X	X	X			-	-	-	AUG-OCT	AUG-NOV
	Blueback herring				HIGH			X	X	X	X	X	X	X	X			MAR-JUN	MAR-JUN	MAR-JUN	JUN-NOV	MAR-NOV
	Channel catfish				PRESENT					X	X	X	X	X	X			-	-	-	JUL-SEP	JUN-NOV
	Gizzard shad				LOW					X	X	X	X	X	X			-	-	-	JUN-OCT	JUL-NOV
	Hickory shad				LOW			X	X	X	X							MAR-JUN	MAR-JUN	MAR-JUN	-	MAR-JUN
	Hickory shad	E		PA	LOW			X	X	X	X							MAR-JUN	MAR-JUN	MAR-JUN	-	MAR-JUN
	Spot				HIGH SPRING							X	X	X				-	-	-	JUL-SEP	JUL-SEP
	Striped bass				HIGH SPAWNING	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-JUN	APR-JUL	JAN-DEC	APR-NOV
	White perch				HIGH	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	MAR-JUN	APR-JUL	JAN-DEC	JAN-DEC
	Yellow perch				LOW					X	X	X	X	X				-	-	-	JUN-AUG	JUN-OCT
407	Shortnose sturgeon	E	E	NJ	MED				X	X	X	X	X	X	X			-	-	-	APR-OCT	APR-OCT
	Shortnose sturgeon	E	E	PA	MED				X	X	X	X	X	X	X			-	-	-	APR-OCT	APR-OCT
408	Shortnose sturgeon	E	E	NJ	HIGH	X	X	X								X	X	-	-	-	NOV-MAR	-
	Shortnose sturgeon	E	E	PA	HIGH	X	X	X								X	X	-	-	-	NOV-MAR	-
412	Atlantic sturgeon	E	E	NJ	HIGH				X	X	X							APR-JUN	APR-JUN	MAY-JUN	APR-JUN	APR-JUN
	Atlantic sturgeon	E	E	PA	HIGH				X	X	X							APR-JUN	APR-JUN	MAY-JUN	APR-JUN	APR-JUN
416	Atlantic sturgeon	E	E	NJ	HIGH YOY	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-JUN	MAY-JUN	JAN-DEC	MAR-NOV
	Atlantic sturgeon	E	E	PA	HIGH YOY	X	X	X	X	X	X	X	X	X	X	X	X	APR-JUN	APR-JUN	MAY-JUN	JAN-DEC	MAR-NOV
417	Atlantic sturgeon	E	E	NJ	PRESENT	X	X	X			X	X	X	X	X	X	X	-	-	-	JUL-MAR	MAR-MAR JUL-NOV
	Atlantic sturgeon	E	E	PA	PRESENT	X	X	X			X	X	X	X	X	X	X	-	-	-	JUL-MAR	MAR-MAR JUL-NOV

HABITAT:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D
175	Endangered plant	E		NJ		X	X	X	X	X	X	X	X	X	X	X	X
247	Field dodder	T		PA		X	X	X	X	X	X	X	X	X	X	X	X
	Forked rush	E		PA		X	X	X	X	X	X	X	X	X	X	X	X
	Walter's barnyard grass	E		PA		X	X	X	X	X	X	X	X	X	X	X	X
294	Endangered plant	E		NJ		X	X	X	X	X	X	X	X	X	X	X	X
	Swamp-pink	E	T	NJ		X	X	X	X	X	X	X	X	X	X	X	X
298	Swamp-pink	E	T	NJ		X	X	X	X	X	X	X	X	X	X	X	X
366	Eelgrass (water celery)					X	X	X	X	X	X	X	X	X	X	X	X
368	Submerged aquatic vegetation					X	X	X	X	X	X	X	X	X	X	X	X
371	Submerged aquatic vegetation					X	X	X	X	X	X	X	X	X	X	X	X

INVERTEBRATE:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Spawning	Eggs	Larvae	Juveniles	Adults
283	Eastern elliptio				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	JAN-DEC	JAN-DEC
	Eastern floater				COMMON	X	X	X	X	X	X	X	X	X	X	X	X	-	-	-	JAN-DEC	JAN-DEC
362	Blue crab				LOW						X	X	X	X	X			-	-	-	JUN-OCT	JUN-NOV

REPTILE:

RAR#	Species	S	F	ST	Conc.	J	F	M	A	M	J	J	A	S	O	N	D	Nesting	Hatching	Internesting	Juveniles	Adults
247	Eastern redbelly turtle	T		PA	UNCOMMON	X	X	X	X	X	X	X	X	X	X	X	X	JUN-JUL	-	-	-	-
	Southern leopard frog	E		PA	COMMON	X	X	X	X	X	X	X	X	X	X	X	X	MAR-JUN	-	-	-	-

==========

Biological information shown on the maps represents known concentration areas or occurrences, but does not necessarily represent the full distribution or range of each species. DNREC, NJDEP ENSP, and PGC provided information for some of the federally and state listed species and species of conservation concern for display in the ESI atlas and accompanying digital data in 2013-2014. These data represent existing information known to these agencies at the time of the request and should never be substituted for consultation with these agencies. This atlas was developed using NJDEP GIS digital data for archaeological and historic sites, but this secondary product has not been verified by NJDEP and is not state-authorized. Archaeological and historical site information for Delaware was provided by DE Division of Historical and Cultural Affairs.

Delaware/New Jersey/Pennsylvania: ESIMAP 19 (cont.)

HUMAN USE RESOURCES:

BOAT RAMP:

HUN#	Name	Contact	Phone
123	RIDLEY TOWNSHIP MARINA	RIDLEY TOWNSHIP MARINA	

HELIPORT:

HUN#	Name	Contact	Phone
168	BOEING HELICOPTERS CENTER 3 SOUTH		
181	CROZER-CHESTER		
207	PIAC		

MANAGEMENT AREA:

HUN#	Name	Contact	Phone
316	LOGAN POND WMA	NJ DIV OF FISH AND WILDLIFE	
339	NEHONSEY BROOK PRESERVE	NJ DEPT OF NATURAL LANDS TRUST	

MARINA:

HUN#	Name	Contact	Phone
395	BRIDGEPORT BOAT YARD(ON RACCOON CREEK)	ALLEN	856/467-0943
442	ISLAND MARINA	ISLAND MARINA	
492	RICHARD'S BUTTONWOOD MARINA	JAMES RICHARDS 215-397-7583	856/467-9173

WILDLIFE REFUGE:

HUN#	Name	Contact	Phone
691	JOHN HEINZ NTL WILDLIFE REFUGE TINICUM	USFWS	

Biological information shown on the maps represents known concentration areas or occurrences, but does not necessarily represent the full distribution or range of each species. DNREC, NJDEP ENSP, and PGC provided information for some of the federally and state listed species and species of conservation concern for display in the ESI atlas and accompanying digital data in 2013-2014. These data represent existing information known to these agencies at the time of the request and should never be substituted for consultation with these agencies. This atlas was developed using NJDEP GIS digital data for archaeological and historic sites, but this secondary product has not been verified by NJDEP and is not state-authorized. Archaeological and historical site information for Delaware was provided by DE Division of Historical and Cultural Affairs.

Greeley and Hansen LLC
1700 Market Street, Suite 2130
Philadelphia, PA 19103
(215) 563-3460
www.greeley-hansen.com



GREELEY AND HANSEN

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 1 3 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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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

OCT 1 3 2016

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) Alternatives Evaluation Approach Report (AEAR) dated April 27, 2016. EPA understands DELCORA has chosen the "Demonstration Approach" and hereby approves the AEAR.

Sincerely,

Andrew F. Seligman, Environmental Scientist
Water Enforcement Branch

cc: R. Smolski, EPA
P. Yeany, EPA
M. DeSantis, DELCORA

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APPENDIX D

H&H MODEL UPDATE AND CALIBRATION PLAN

- DELCORA Hydrologic and Hydraulic Model Update and Calibration Plan (Final) dated October 2015
- USEPA Approval of the Hydrologic and Hydraulic Model Update and Calibration Plan dated March 1, 2016

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

Delaware County Regional Water Quality Control Authority (DELCORA)
CSO Long Term Control Plan

Hydrologic and Hydraulic Model Update and Calibration Plan. (Final)

October 2015

GREELEY AND HANSEN

REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Hydrologic and Hydraulic Model Update and Calibration Plan.

DELCORA MANAGEMENT		
Executive Director	Signature	10/14/15 Date
DELCORA ENGINEERING		
Director of Engineering	Signature	10/14/15 Date
(type in other as needed / delete row if unused)	Signature	Date
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	Signature	10/14/15 Date
(type in other as needed / delete row if unused)	Signature	Date
	Signature	Date
	Signature	Date

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES

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Section 1 Introduction

1.1 DELCORA's System

Delaware County Regional Water Quality Control Authority (DELCORA) is responsible for the safe 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 is approximately 82,977 acres, as shown on **Figure 1-2,** which illustrates that DELCORA serves a significant and widespread portion of Delaware County. The combined sewer area simulated in the original model, also shown in **Figure 1-2**, is located within the Chester City. It comprises approximately 49% of the 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.

Historically, DELCORA has characterized its service areas as "Eastern" and "Western." The Western service area discharges to the 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 to be directed to the PWD-SWPCP. As such, dry weather flow and a portion of the wet weather flow from the Central Delaware County Authority in the Eastern Service Area are discharged to the WRTP.

Under National Pollutant Discharge Elimination System (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 (CSO) outfalls (002-026, 032, 033) that ultimately discharge to the Delaware River, Chester Creek and/or Ridley Creek.

There are a total of 26 combined sewer overflow (CSO) outfalls listed with 25 discharge points (Outfalls 009 and 010 both discharge at Outfall 009) in DELCORA's existing NPDES Permit.

Figure 1-1 DELCORA's Conveyance System

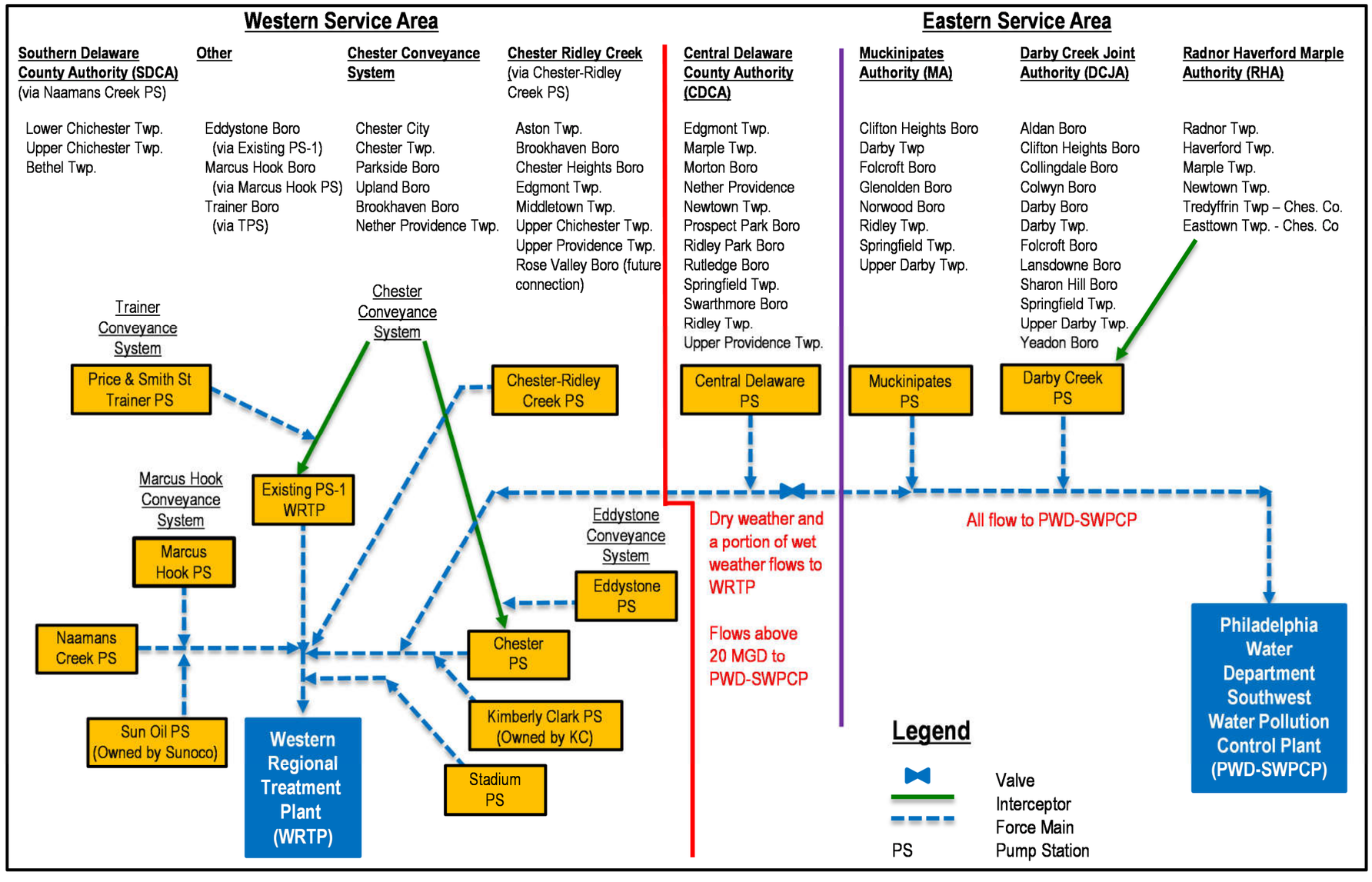
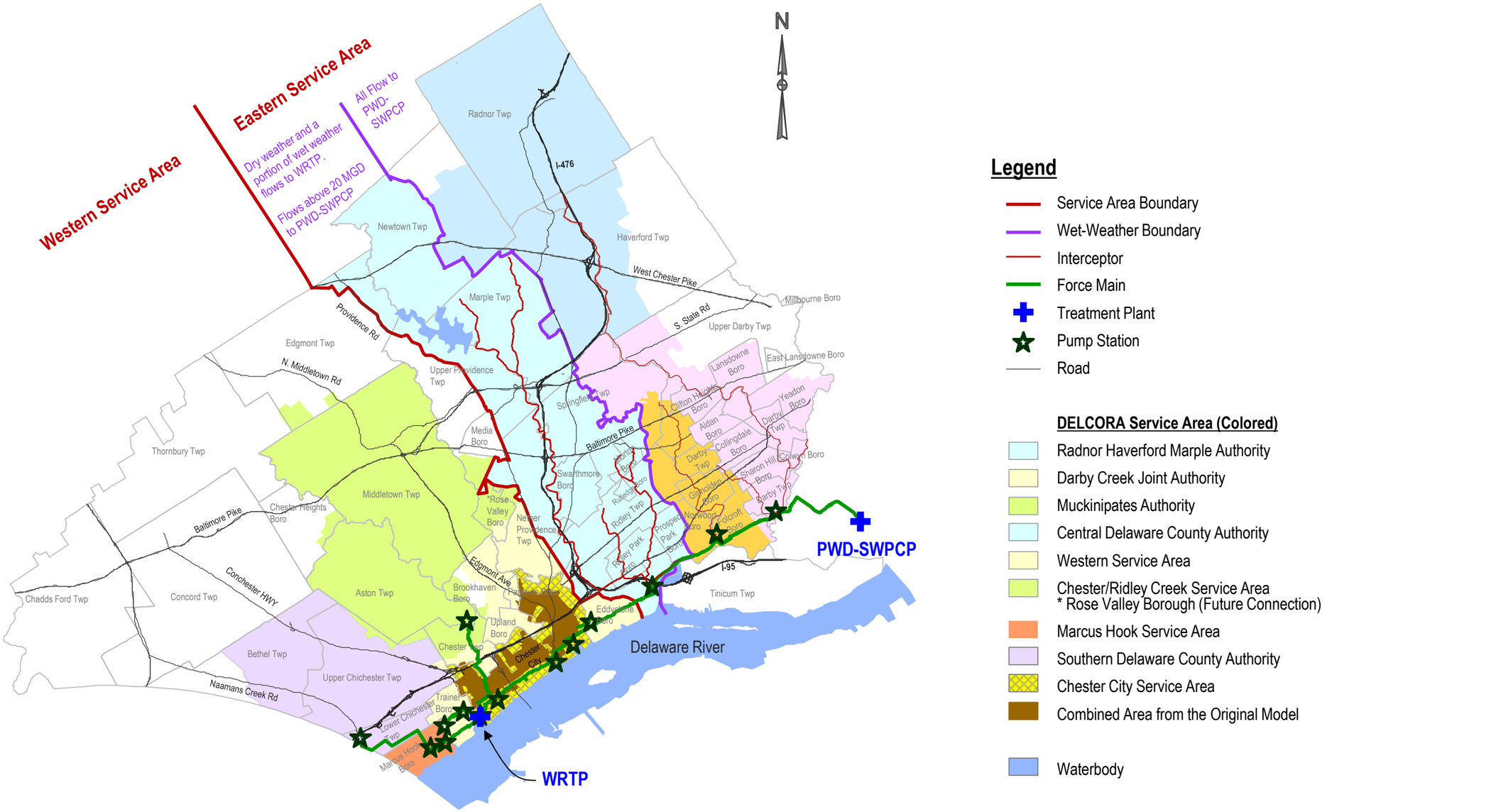


Figure 1-2 DELCORA's Service Area



1.2 DELCORA's Consent Decree

DELCORA prepared and submitted their original Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) to the PADEP in 1999. This LTCP was subsequently approved by the PADEP, and DELCORA had started to implement the CSO control elements selected in the LTCP. In 2009, the United States Environmental Protection Agency (USEPA) informed DELCORA that the original LTCP was not in compliance with the requirements of the USEPA's CSO Policy. As such, DELCORA prepared and submitted a revised LTCP in April 2012. Subsequent to the receipt of the revised LTCP, DELCORA and the USEPA had corresponded various times including requests for additional information from the USEPA in accordance with Section 308 of the Clean Water Act. A Consent Decree was issued by the USEPA to DELCORA in June 2015. The Consent Decree requires a new LTCP to be prepared based on an agreed upon schedule, which will include interim deliverables and milestones that must be met.

According to the Consent Decree between the US EPA, PADEP, and DELCORA, DELCORA's Hydrologic and Hydraulic Model (H&H Model) will 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 shall be submitted not later than sixty (60) days after August 17, 2015, the lodging date.

1.3 Contents in This Plan

This Model Update and Calibration Plan (Plan) was prepared based on the requirements listed in the Consent Decree. **Table 1-1** lists individual sections of the Plan and contents.

Table 1-1 DELCORA H&H Model Update and Calibration Plan

Section	Description
Section 1 Introduction	This section introduces DELCORA's system and Consent Decree, as well as individual sections of the Plan.
Section 2 Review of the Original H&H Model	This section summarizes review of the original H&H model, assesses the model's adequacy for use in DELCORA's Long Term Control Plan Update (LTCPU), identifies gaps with the original model in meeting the requirements in the Consent Decree, and determines refinement needs for the model update.
Section 3 DELCORA H&H Model Update	This section describes general methodology used in model update, and provides detail model update needs for service area delineation, combined area delineation, model network extension, regulator, and model inputs.
Section 4 Additional Rainfall and Flow Monitoring	This section provides an overview of the existing rain gauge and flow meter conditions, describes the additional rain gauges and flow monitoring needs and a monitoring work plan.

Section	Description
Section 5 DELCORA H&H Model Calibration and Validation	This section provides detailed data analysis needed for model calibration and validation, lists criteria for dry weather and wet weather calibration, and illustrates calibration and validation results.
Section 6 Model Development and Implementation Schedule.	This section provides a schedule for model development and implementation, including integration into LTCP development consistent with other dates required pursuant to the Consent Decree.

Section 2 Review of the Original H&H Model

The original DELCORA H&H model was developed and calibrated for the 1999 LTCP. The model was updated and expanded over the years to account for changes in the CSO system, but it was not re-calibrated during the development of the 2012 LTCP.

The project team will update the model as needed to reflect current hydrologic and hydraulic conditions of DELCORA's collection system. The updated model will then be calibrated and validated with the additional rainfall and flow monitoring data before being applied to evaluate CSO control alternatives for DELCORA's Long Term Control Plan Update.

In order to appropriately update the original H&H model, it has been reviewed to address the following

- Assess adequacy of the original model for use in DELCORA's LTCPU,
- Identify gaps with the original model in meeting the requirements in the Consent Decree, and
- Determine refinements needed for the model update.

2.1 General Observation

The original H&H model was built with EPASWMM Version 5. It includes one (1) rain gage, 67 subcatchments, 29 outfall nodes, 736 storage nodes, 735 conduit links, and 34 orifice links. The detail layout of the model is shown in **Figure 2-1**. The model was set up to simulate monthly CSO discharges with reasonable continuity error in EPASWMM 5.0.

Major observations of the original model and comments are summarized in **Table 2-1**.

Figure 2-1 The Original Model Layout

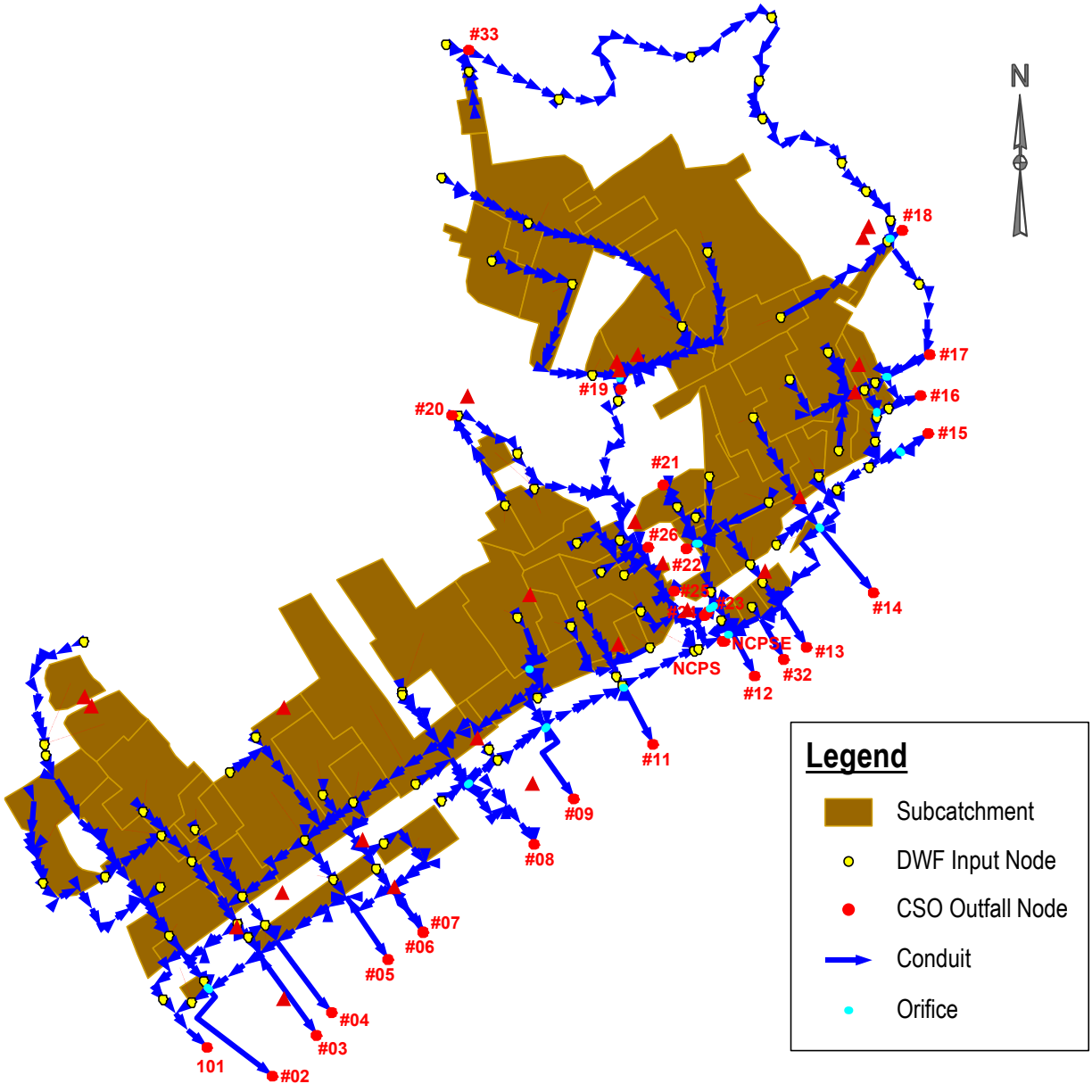


Table 2-1 Review Summary of the Original Model

Review Item	Observation	Comments
Model Software	- EPA SWMM 5.0	
Vertical Datum	- NAVD 88	- To be verified
General Sub Models	- EPASWMM for the runoff model - Horton Equation for the infiltration model - Hydrodynamic wave for the flow routing model	- All these choices are commonly seen in collection system modeling practices
Rain Gauge	- One (1) rain gage, located at the Western Regional Treatment Plant (WRTP)	- One rain gauge is not sufficient for the entire service area in the model
Service Area	- 67 subcatchments, all for combined area - One set of Horton infiltration parameters are applied to most of the subcatchments (66 out of 67 subcatchments) - The infiltration parameters applied in the model is equivalent to infiltration parameters for soil type C/D	- All service area including separated area that contribute flow to the DELCORA collection system should be included in the model - Combined area delineation will be checked to include any changes along the years - Soil type need to be checked to verify Horton infiltration parameters in all subcatchments
Sewer Manhole	- 736 storage nodes. - All sewer manholes are simulated as storage units in the model. - The majority of the storage units (732 out of the 736) have a diameter of 4-ft, and the rest (4 units) have a surface area of 100 square feet (sf.) (equivalent to 10'x10'). - All storage units are set-up with a ponding area of 9,999 sf. to allow excess water to collect atop of the nodes and be re-introduced into the system as conditions permit.	- Sewer manholes will be simulated as common junction node - This will help with SSO evaluation in the collection system
CSO Outfall	- 29 outfall nodes - All CSO outfalls are free outfall	- All outfalls are located in the Delaware River in the tidal reach, a tidal stage instead of free outfall should be assigned to the outfalls - Outfall ID 101 has dry weather input of 1.76 cfs, it represents WRTP in the model

Review Item	Observation	Comments
Sewer Mains	- 735 conduit links. - Negative slopes at Nodes 73803 and 70709 not matching the GIS. - Pipe connectivity is not consistent with the GIS in Subcatchment EA1, 25A. - Pipe size and connectivity is not consistent with the GIS around Node: 5201242, 5201234. - Pipe size is not consistent with the GIS around Node: 52018-52015. - Pipe size is not consistent with the GIS around Node: 531-527, 522-517, 516-513, 510020301-5100202, 403-NCPS, 40801-40801A, 32405-32404, and 1110402-11103. - Pipe size and slope are not consistent with the GIS around Node: 422-4140. - NREG06 outfall pipe direction is opposite.	- All the negative slopes and inconsistencies need to be checked with the most updated GIS and record drawings during the model update
CSO Regulators	- 34 orifice links. - All CSO regulators are simulated using orifices to intercept dry weather flows and partial wet weather flows to the collection system, and with elevated conduits to convey extra flows to the CSO outfalls. - Approximately 75% of the orifices (25 out of 34) are modeled with Real Time Control (RTC) to mimic regulator gate opening based on level. - None of the regulator diverting weir structures is simulated in the model.	- Diverting weir structures need to be added in the model - The slopes of all overflow pipes connected to the CSO outfalls need to verified - All orifice opening dimensions verified will be verified - All the RTC rules regulating orifice opening will be verified with actual operation
Pump Station	- No pump station is included in the model	- All pump stations that contribute flow to the DELCORA collection system should be added to the model, with related force mains
Dry Weather Flow	- 94 dry weather flow (DWF) inputs - Total DWF is 7.01 MGD - No diurnal curve - DWF does not include all the separated service areas that contribute to the DELCORA system -	- DWF should be updated to include all the service areas that contribute to the DELCORA system - Weekday and weekend diurnal curve should be included in the model to effectively simulate dry weather diurnal pattern
RDII	- No rainfall-derived infiltration/inflow (RDII) element was found in the model	- RDII should be included in the model to estimate reasonable wet weather inflow from RDII

2.2 Limitation of the Original Model and Update Needs

A thorough review of the original model reveals major gaps in its ability to meet the requirements in the Consent Decree, including the following:

- The model was created to estimate CSO overflows from the combined area, but some of the communities that contribute Rainfall Derived Infiltration and Inflow (RDII) from the separated areas to the DELCORA collection system were not included in the model. To accurately reflect the collection system, all service areas should be included in the simulation. As such, the model network will need to be expanded to the separated service areas.
- Based on discussions with Weston, the roofs are not connected to the sewer system in the separated area. Therefore, the wet weather flow from the separated areas is RDII instead of surface runoff as in the combined area. However, the RDII can contribute a significant portion of wet weather flow to a collection system, especially from areas with old/leaky sewers. The RDII component should be evaluated and included in the model for all individual sewer service areas.
- The model does not include any pump stations. All related pump stations and force mains that convey flows to the DELCORA system will need to be included in the model, with appropriate pump curves and pump operating rules.
- All CSO regulators and outfall pipes need to be revisited in the model. The regulator simulated in the original model does not include any flow diverting weirs, and the invert of the outfall pipes were adjusted to match the diverting weir crest level. The regulators will be set-up in the model based on the real configuration, including regulating gates, overflow weirs, and overflow pipes with correct slopes. This will be done by a review of the record drawings for the regulators, as well as field survey, if needed.
- The dry weather input in the model will need to be updated with additional rainfall and flow monitoring data that covers the entire service area. Weekday and weekend diurnal curves will need to be included in the model to accurately reflect dry weather peaks and valleys.
- Sewer manhole will be simulated as a junction node instead of a storage node, with a proper surcharge level to reflect actual manhole cover type. Storage nodes will only be used for actual storage facilities such as pump station wet wells or any storage unit proposed in the CSO control alternatives.

Section 3 DELCORA H&H Model Update

The original H&H Model will be updated based on the review results and current collection system conditions. The updated model will be calibrated and applied to evaluate CSO control alternatives for DELCORA's LTCPU.

The purpose of this section is to introduce the model update methodology and detail model refinement needs.

3.1 Model Update Methodology

3.1.1 Hydrologic Representation

Per Section V.A.14b of the Consent Decree (Page 15), " *The updated H&H Model shall specifically include hydrologic representation of all areas tributary to the entire Collection System, as well as all areas tributary to all municipal wastewater collection and transmission systems that are, as of the date the LTCP is submitted, hydraulically connected to, or that directly or indirectly influence flow to, the CSOs and/or the WRTP, regardless of who owns or operates the system(s), including but not limited to the entire "Western Service Area" and "Eastern Service Area" depicted on Figure 1-2 of the Long-Term Control Plan submitted by DELCORA in April 2012.*"

Instead of including only the combined area for the subcatchments as in the original model, the updated model will have subcatchments for both combined and separated service areas. All the areas that contribute dry weather flow and/or wet weather flow to DELCORA's CSOs and/or the WRTP will be included in the service area for the model.

Wet weather flows generated from both surface runoff from the combined area and RDII will be simulated in the updated model.

3.1.2 Hydraulic Representation

Per Section V.A.14c of the Consent Decree (Page 16), " *The H&H Model shall accurately represent the response of the Model Area to wet weather events, including the flows that result from wet weather events to and from DELCORA's CSOs and to the WRTP. To accomplish this, the model shall explicitly include all interceptors, diversion structures, CSOs, pump stations and major trunk sewers within the Collection System, as well as such pipes and appurtenances within the areas outside the Collection System that are needed to ensure adequate H&H Model accuracy. The H&H Model shall also include all sewers required for model continuity and/or that hydraulically impact or are downstream of known chronic unpermitted releases. DELCORA shall investigate and collect current system attribute information as necessary to update the H&H Model.*"

Pipe network in the updated model will be extended to the updated service areas for both the combined and separated areas. All hydraulic structures that control flows in the collection system, including pump stations, regulator orifices and weirs, and their operating rules, will be simulated in the updated model.

3.2 Model Refinement

The updated DELCORA H&H model will be created based on NAVD 88 datum. InfoSWMM will be used during the model developing and the calibration phase and the final model can be submitted with either the InfoSWMM or EPASWMM platform.

The model update will be based on information obtained from a variety of sources including DELCORA's input, GIS, Sewer Atlas, record drawings, and field survey. Other documents including flow agreements between DELCORA and individual communities, pump discharge curves, standard/actual operating procedures for CSO regulators, pump station and WRTP, etc. will also be used to set up real time control in the model.

3.2.1 Delineation of Service Area and Combined Area

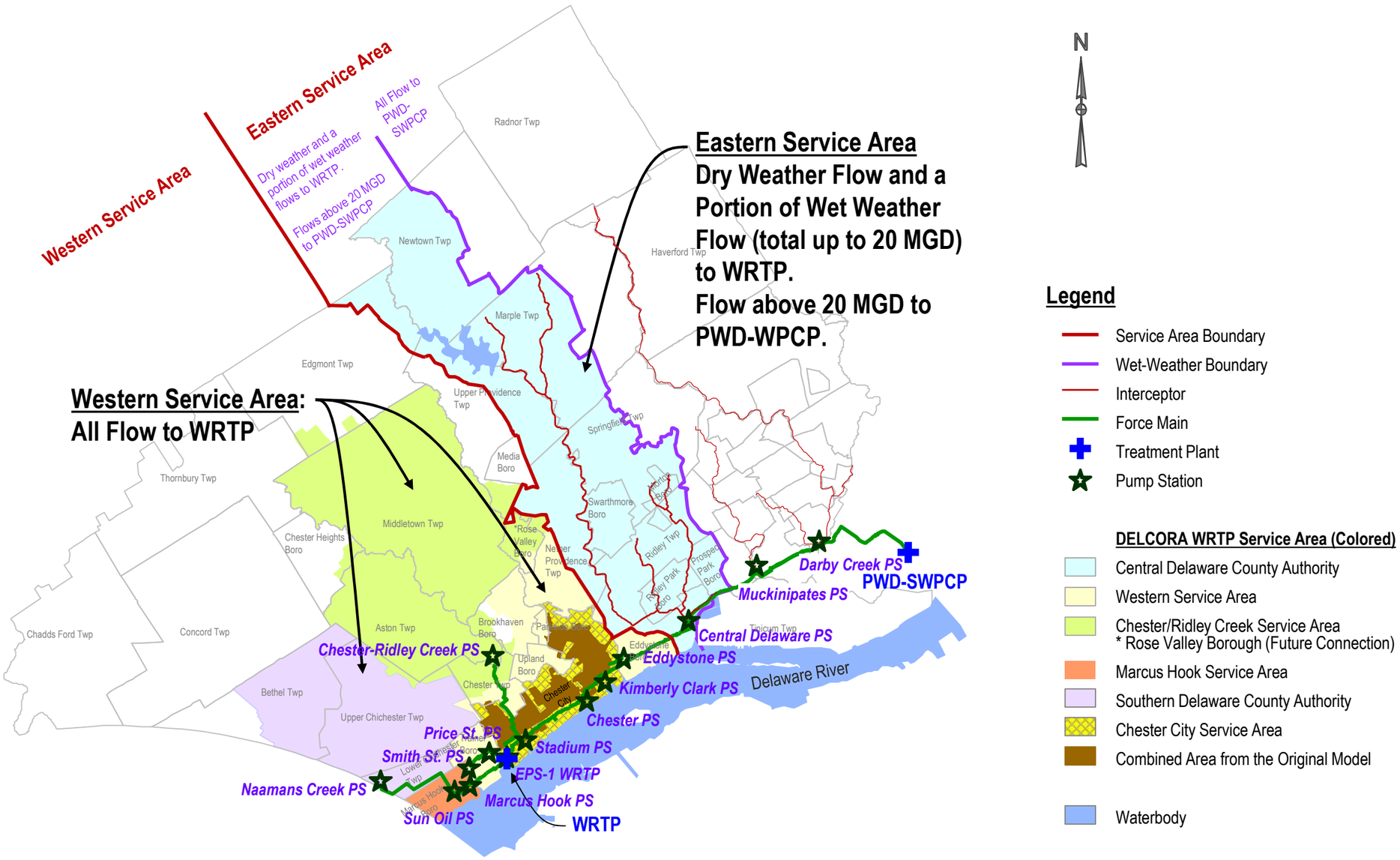
3.2.1.1 Delineation of Service Area

DELCORA serves a significant and widespread portion of Delaware County. Historically, DELCORA Western Regional Treatment Plant (WRTP) received both dry and wet weather flows from the Western Service Area only. 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 PWD-SWPCP. As such, dry weather flow and a portion of the wet weather flow from the Central Delaware County Authority (CDCA) in the Eastern Service Area also discharge to the WRTP.

Historically, municipalities in the Central Delaware County Authority that contribute flows to the WRTP include Marple Township, Morton Borough, Nether Providence Township, Newtown Township, Prospect Park Borough, Ridley Park Borough, Rutledge Borough, Springfield Township, Swarthmore Borough, Ridley Township, and Upper Providence Township. In October 2012, DELCORA signed an agreement with Edgmont Township to provide sewer service to the eastern portion of the Township. The sanitary sewage of the Township will be collected and transported using the Crum Creek Sewer District System through the CDCA collection and conveyance facilities to the DELCORA System for treatment and ultimate disposal and discharge.

Figure 3-1 shows the entire service area for the WRTP, including the updated Eastern Service Area. Facilities and conveyance schematic is shown in **Figure 1-1**.

Figure 3-1 DELCORA's Western Regional Treatment Plant (WRTP) Service Area



Eastern Service Area

The DELCORA Eastern Service Area is composed of four subareas that are served by conveyance authorities: Radnor Haverford Marple (RHM) Authority, Darby Creek Joint Authority (DCJA), Muckinipates Authority (MA), and Central Delaware County Authority (CDCA) and are delineated in **Figure 1-2**. Each of these authorities has a legal agreement with their member municipalities to dispose of their wastewater. In turn, DELCORA has legal agreements with each of the authorities, except RHM, to receive, treat, and dispose of the collected wastewater. RHM discharges to the DCJA. DELCORA owns and operates three large pump stations that serve DELCORA's Eastern service area; they are the Central Delaware Pump Station, the Muckinipates Pump Station, and the Darby Creek Pump Station. These pump stations were originally designed to pump the wastewater from DELCORA's Eastern Service Area to PWD-SWPCP for treatment.

The Central Delaware Pump Station (serving CDCA) is rated for 40 MGD. It was constructed in the 1970s to discharge all flow through a force main that is routed northeast toward the Muckinipates Pump Station. The operation of the pump station had been modified in 2002 to allow for flow from the CDPS to be discharged to the WRTP. Currently the wastewater flows above 20 MGD are conveyed to PWD-SWPCP. The next pump station is the 24-MGD Muckinipates Pump Station (serving MA). Here, the force main increases to 48 inches in diameter and continues approximately 1.65 miles northeast to the Darby Creek Pump Station. Upon reaching the 60-MGD Darby Creek Pump Station (serving DCJA and RHM), the force main increases in diameter to 66 inches and continues approximately 2.5 miles for ultimate discharge at PWD-SWPCP.

Western Service Area

The DELCORA Western Service Area is shown in **Figure 3-1**. DELCORA owns and operates the collection system in the following communities in the Western Service Area.

- Chester City
- Chester Township (parts of)*
- Marcus Hook Borough
- Parkside Borough
- Rose Valley Borough *
- Upland Borough
- Trainer Borough

*Note:

- DELCORA owns only a portion of Chester Township's collection system, but all flow comes to WRTP as some goes through the CRC PS service area.
- Rose Valley Borough collection system discharges to its own treatment plant (this portion will be discharged to the CRC PS service area in future) and the remaining portion is discharged to the Western Service Area to the WRTP.

DELCORA does not own or operate the collection system in the following communities in the

Western Service Area, however, these communities will be included as part of the service areas in the updated H&H model because they contribute flows to the WRTP.

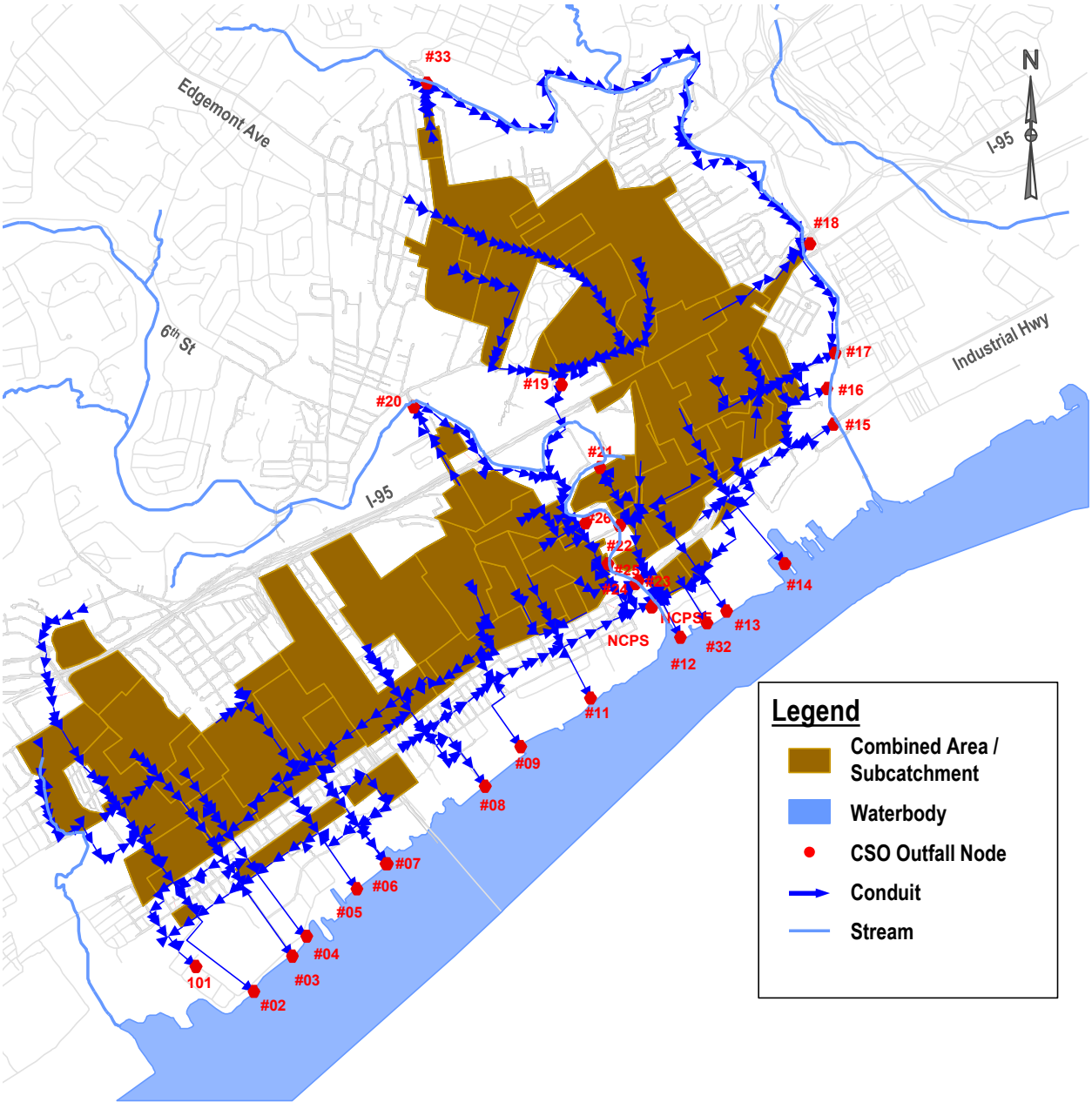
- Brookhaven Borough
- Lower Chichester Township
- Nether Providence Township
- Eddystone Borough

3.2.1.2 Delineation of Combined Area

The entire combined area of DELCORA's collection system is located in the City of Chester. The combined sewer area is shown in **Figure 3-1**. The combined area according to the original model is shown in in **Figure 3-2**.

The combined area delineation will be updated with separation projects completed in recent years. The latest GIS database, survey, and record drawings will be used to perform the desktop combined sewer area check. Field verifications will be conducted as necessary to verify the boundaries and to generate an accurate representation of the combined areas for the updated model.

Figure 3-2 Combined Area Delineation in the Original Model



3.2.2 Model Network

The collection system network in the original model (**Figure 3-2**) will be updated with the following.

- To extend sewers to the updated delineation of the combined and separated areas,
- To include all pump stations that control flows in the DELCORA collection system, and
- To reflect actual configuration of the CSO regulators.

DELCORA's WRTP treats all wastewater from the Southern Delaware County Authority, Marcus Hook Borough, Trainer Borough, Upland Borough, Parkside Borough, Eddystone Borough, Chester Township, the City of Chester, a portion of the wastewater from Brookhaven Borough and Nether Providence Township, as well as the dry weather flow and a portion of the wet weather flow from the Central Delaware County Authority.

A flow diagram presented in **Figure 1-2** shows all the connections on DELCORA's system and related facilities including interceptors, force mains, pump stations and treatment plants. The interconnectivity coupled with the legal agreements that DELCORA maintains with the municipalities and conveyance authorities in Delaware County creates the complicated legal/financial framework under which DELCORA operates.

3.2.2.1 Sewer Lines and Manholes

3.2.2.2 Regulators

Since the approval of the first LTCP in 1999, DELCORA has under-taken a program to replace and/or rehabilitate CSO regulators and tide gates in the City of Chester CSO system. As indicated in **Table 3-1**, the majority of the City's CSO regulators are Brown & Brown type regulators. The operation of the CSO regulators has been changed from being controlled by the level in the trunk sewer entering the CSO regulator chamber to being controlled by the level in the interceptor. This change is being implemented as part of the CSO regulator replacement program. This ensures that the flow sent to the WRTP for treatment is maximized.

During dry-weather operations, the sewage flow levels entering the CSO regulator chamber are below the top of the diversion weir and will pass through the CSO regulator gate. Once through the CSO regulator gate, the flow will be sent to the WRTP via the interceptors. During wet-weather events, the level in the combined sewer will begin to rise thus raising the float assembly and beginning to close the CSO regulator gate.

Regulator gates, diversion weirs, and operating rules will be simulated in the updated model.

Table 3-1 CSO Regulator Information

CSO Regulator No.	CSO Regulator Location	CSO Receiving Water	CSO Regulator Type
002	Front & Booth	Delaware River	Brown & Brown
003	Front & Highland	Delaware River	Brown & Brown
004	Front & Hayes	Delaware River	McNulty
005	Front & Townsend	Delaware River	Brown & Brown
006	Delaware & Jeffrey	Delaware River	Separated, CSO Outfall removed.
007	Delaware & Reaney	Delaware River	Brown & Brown
008	2nd & Tilghman	Delaware River	Brown & Brown
009	2nd & Lloyd	Delaware River	Brown & Brown
010*	5th & Pusey	Delaware River	Brown & Brown
011	2nd & Parker	Delaware River	Brown & Brown
012	2nd & Edgmont	Delaware River	Brown & Brown
013	2nd & Welsh	Delaware River	Brown & Brown
014	3rd & Upland	Delaware River	Brown & Brown
015	4th & Melrose	Ridley Creek	Brown & Brown
016	8th & McDowell	Ridley Creek	Brown & Brown
017	9th & Campbell	Ridley Creek	Brown & Brown
018	Sun Dr. & Hancock	Ridley Creek	Brown & Brown
019	14th & Crozer Hospital	Chester Creek	Brown & Brown
020	Kerlin & Finland	Chester Creek	Brown & Brown
021	9th & Sproul	Chester Creek	Brown & Brown
022	6th & Sproul	Chester Creek	Brown & Brown
023	3rd & Edgmont	Chester Creek	Brown & Brown
024	3rd & Dock	Chester Creek	Brown & Brown
025	5th & Penn	Chester Creek	Brown & Brown
026	7th & Penn	Chester Creek	Brown & Brown
027	2nd & Dock Pump Station	Chester Creek	Overflow pump removed.
032	2nd & Avenue of the States	Delaware River	No CSO Regulator
033	Elkington Blvd. and Ridley Creek	Ridley Creek	No CSO Regulator

Note: CSO 010 discharges at Outfall 009.

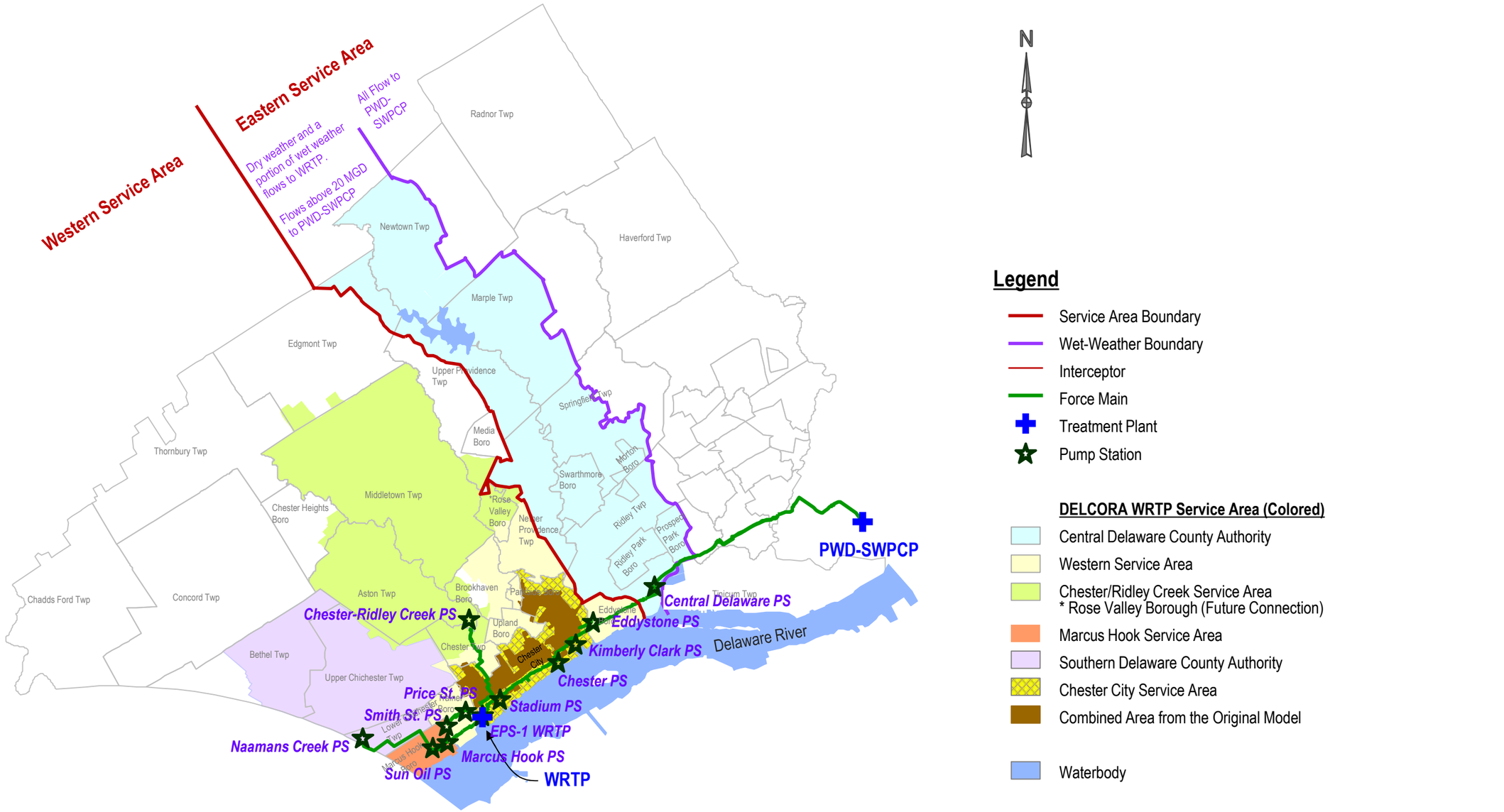
3.2.2.3 Pump Stations

All major pump stations in the Western Service Area and CDPS in the Eastern Service Area will be added in the updated model, as well as force mains connecting the pump stations to the interceptor/WRTP. The list of the pump stations include (**Figure 3-3**):

- Chester PS
- Existing PS-1 WRTP
- Price & Smith Street Trainer PS
- Marcus Hook PS
- Naamans Creek PS
- Sun Oil PS (Owned by Sunoco)
- Kimberly Clark PS (Owned by KC)
- Eddystone PS
- Central Delaware PS
- Chester Ridley Creek PS
- Stadium PS

DELCORA owns or operates a number of lift stations that contribute to the Western Service Area and whose flows are handled by the above list of pumps stations. These lift stations will also be evaluated during the model updating process and included only if they have significant impact on DELCORA's system hydraulics.

Figure 3-3 Pumping Stations to be Included in the Updated Model



3.2.3 Model Input

3.2.3.1 Subcatchments

The following subcatchment information is required by the model:

- Area
- Percent of directly connected impervious area (effective impervious area)
- Width
- Slope
- Manning's roughness coefficient (n) for both pervious and impervious areas
- Depression storage for both pervious and impervious areas (initial subtraction)
- Soil and soil infiltration parameters
- Rainfall dependent inflow and infiltration (RDII) parameters
- Base flow

Area
Area of the combined sewer subcatchment is the geographical area of the subcatchment. It will be estimated from the GIS by geometry calculation of the area of the subcatchment.

Percent of Directly Connected Impervious Area
Directly connected impervious area means the impervious area that is effectively connected to the sewer collection system. As a result, runoff from these areas is completely captured by the collection system. Runoff from the rest of the impervious area is deemed not to be captured by the system due to various potential reasons, including drains to pervious area/creek/streams, limited number and capacity of stormwater inlets, and bypassing etc. For model construction, the percent imperviousness calculated based on GIS shapefiles will be used as the initial input and then adjusted during the model calibration process to best simulate the observed hydrologic response over a range of precipitation events.

The initial percent imperviousness for the combined area will be calculated based on the impervious coverage shape file and zoning shape file. An example of percent imperviousness applied to different land uses are shown in **Table 3-2**. This table will be modified with specific land use types observed in the combined area and it will provide the basis of calculating the initial percent imperviousness inputs in a combined sewer subcatchment.

Table 3-2 Percent Imperviousness Applied for Different Land Use Types

Land Use Type	% Imperviousness
Driveway	100%
Parking_Paved	100%
Parking_Unpaved	90%
Roadway	100%
Sidewalk	100%
Building - Connected Rooftops	100%
Building - Commercial and Industrial	80%
Building - Residential; with Disconnected Rooftop	50%

For the separated area, the initial percent imperviousness will be set at 0% because the impervious area in the separated area is not contributing runoff to the sewer collection system, therefore it is not effectively connected. *Subcatchment parameters mentioned hereafter will be set at default values for the separated subcatchments*.

Width
The width of a subcatchment relates to sheet flow path and affects time of concentration and the shape of the runoff hydrograph. The initial estimate of the width will be estimated by the subcatchment area divided by the representative overland flow length. Width is one of the calibration parameters for runoff.

Slope
The slope of a subcatchment should reflect the average slope along the pathway of overland flow to inlet locations. For the combined sewer subcatchments, the slopes will be determined by the elevation difference divided by the length of flow path. GIS contours will be used to estimate elevations.

Manning's roughness coefficient (n)
Manning's roughness coefficient (n) will be estimated for both pervious and impervious overland flow. The initial values will be set to 0.013 for impervious surfaces and 0.15 for pervious surface. A typical range of Manning's n suggested by the SWMM is 0.011-0.024 for impervious area and 0.06-0.80 for pervious area. Roughness is an empirical value and may be treated as a calibration parameter if necessary.

Depression Storage
Depression storage is the rainfall abstraction volume that must be filled prior to the occurrence of runoff. It represents the loss (initial abstraction) caused by surface ponding, surface wetting, etc. The initial values of depression storage will be set to 0.05 for impervious surface and 0.15 for pervious surface. Typical depression storage values are 0.05-0.10 for impervious surfaces and 0.10-0.30 for pervious surfaces. Depression storage is an empirical value and may be treated as a calibration parameter, especially to adjust runoff volumes.

In the model, the subcatchment is divided into three subareas: pervious area with depression storage, impervious area with depression storage, and impervious area without depression storage. The initial percent of the impervious area without depression storage will be set to 0.10.

Soil and Soil Infiltration Parameters

Soil information is needed to estimate infiltration in the pervious area. The rate of infiltration is a function of soil properties and antecedent soil conditions. Three infiltration methods are available in the software: Horton method, Green-Ampt method, or NRCS Curve Number method. The Horton method has been extensively used for similar type of modeling work and it will be used in this modeling effort to estimate infiltration. The required soil parameters for Horton method include:

- Maximum Infiltration rate (in/hr)
- Minimum Infiltration Rate (in/hr)
- Decay Constant (/hr)
- Drying time (d)
- Maximum Infiltration Volume Possible (inch)

Horton's infiltration parameters for Soil B and C will be estimated based on typical values from literature, shown in **Table 3-3**.

Table 3-3 Horton Infiltration Parameters

Horton Infiltration Parameter	Soil B	Soil C
Max Infiltration Rate (in/hr)	3	2
Min Infiltration Rate (in/hr)	0.43	0.13
Decay Constant (1/hr)	4	4
Drying Time (d)	3	8
Max Volume (in)	13.2	12.5

3.2.3.2 Manhole

Sewer manholes will be simulated as junction nodes in the model. The following information is required:

- Node ID
- Invert
- Maximum Depth (approximated as the difference from manhole rim and manhole invert)
- Surcharge Depth

Manhole ID will be inherited from the name of the manhole in the sewer GIS. Manhole input information will be updated based on the latest available GIS information.

Most of the manhole input parameters, including invert and rim will be found or estimated from record drawings, design drawings, and the sewer manhole shape file. If information is not available, then estimations will be made based on city topography and sewer connectivity. Ground elevation estimated from contours will be used as the manhole rim elevation, and manhole inverts will be estimated assuming constant pipe slope as the upstream or downstream pipes.

For water tight manholes or manholes with bolted down covers, a surcharge depth of 50-ft will be applied.

3.2.3.3 Sewer Mains

Sewer mains are the conveyance element and will be simulated as conduits in the model. The following input information is needed:

- Conduit ID
- Shape
- Number of barrels
- Upstream and downstream nodes
- Upstream and downstream offset
- Dimension (length, diameter/depth)
- Manning's roughness coefficient
- Minor loss coefficient (entry loss, exit loss, average loss)
- Flap gate installed or not (set at no flap gate for most of the sewer mains)

Conduit ID will be inherited from the sewer GIS. Manhole input information will be updated based on the latest available GIS information.

Most of the pipe input parameters, including upstream and downstream nodes, dimension, shape, number of barrels, and flap gate information, will be found or estimated from record drawings, design drawings and sewer gravity main GIS shape file. For pipes that do not begin or end at the invert of the upstream or downstream node, an offset value will be provided to describe the difference from the invert of the pipe to the invert of the upstream or downstream node.

Manning's roughness coefficient is related to the pipe material. The initial input of the Manning's n for different materials is summarized in **Table 3-4**. The Manning's n may be changed during calibration to account for minor loss or additional sediment depositions in the pipe.

The initial minor loss for pipe will be set at zero for most pipes. For those pipes with sharp turns, a higher minor loss will be applied.

If sewer main information is not available, sewer length will be estimated in GIS geometry measurement; sewer size will be assumed based on upstream and downstream sewers; sewer upstream and downstream offsets will be estimated based on sewer connectivity assuming constant slope.

Table 3-4 Manning's Roughness Coefficient for Sewer Mains

Pipe Material	Manning's N
Polyvinyl Chloride (PVC)	0.011
Reinforced Concrete Pipe (RCP)	0.013
Ductile Iron (DI)	0.013
Cast Iron (CI)	0.013
Corrugated Metal Pipe (CMP)	0.020
Masonry	0.025
Unknown	0.013

3.2.3.4 CSO Outfalls

CSO outfalls will be simulated as outfall nodes in the model. The following information is required:

- Outfall ID
- Type (free, normal, fixed stage, tidal stage, time series, stage-flow, flap gate)
- Invert
- Boundary conditions

Outfalls are the discharge points in the model. The outfalls can either be free outfalls without any boundary conditions or the outfalls can have a boundary condition that the head needs to overcome for outflow to occur. The outfalls in the DELCORA's collection system are mostly in the tidal river reach. Therefore, appropriate tidal stages will be needed to set boundary conditions. Outfalls can have a flap gate at the end to prevent backflow.

Outfall ID will be named according to the CSO overflow points. For example, the outfall for CSO 02 will be named "Outfall_02". The inverts of outfalls will be estimated based on record drawings and design drawings, and will be confirmed/adjusted from the field survey, if necessary.

3.2.3.5 Flow Diversion Structure

Orifices

Regulator gates will be simulated as orifices in the updated model. The following information is required to model an orifice in the model:

- Orifice ID
- Upstream and downstream nodes
- Type (two types: side, bottom)
- Shape (two shapes: circle, rectangular)
- Dimension (Height, Width, Crest Height)

- Discharge Coefficient
- Flap gate

Orifice ID will be named according to the CSO overflow points. For example, the orifice for CSO 03 will be named "Ori_03". All orifices in the collection system are side orifices. The dimensions will be based on record drawings and will be field verified, if necessary.

Weirs

Diversion weirs will be simulated as weirs in the model. The following information is required to model a weir in the model:

- Weir ID
- Upstream and downstream nodes
- Type (four types: transverse, sideflow, V-notch, trapezoidal)
- Dimension (Height, Weir Length, Weir Crest Height)
- Coefficient of Discharge
- Flap gate
- Number of End Contractions

Weir ID will be named according to the CSO overflow points. For example, the weir for CSO 03 will be named "Weir_03". Weir information will be obtained from record drawings and will be field verified, if necessary.

3.2.3.6 Pump Stations

The wet well in the pump stations will be simulated as storage nodes, and pumps will be simulated as pumps in the model. Dimensions of the storage will be based on record drawings. For pumps, the following information is required:

- Pump ID
- Upstream and downstream nodes
- Pump Type
- Pump Curve
- Startup Depth
- Shutoff Depth

Pump startup depth and shutoff depth will be set up in the model according to the typical pump operation. Pump head-discharge curves will be based on the manufacturer's performance curve. Pump curves at different speeds can be developed based on the Affinity Laws.

3.2.3.7 Dry Weather Flow (DWF)

Average day dry weather flows (DWF) will be allocated to each sewershed based on the flow monitoring data and land use. A dry weather flow diurnal curve will be developed for each meter's service area and applied to all sewersheds within that metershed. The total daily average DWF from all sewersheds add up to the DWF measured at the influent to the WRTP. DWF analysis is described in detail in Section 5.

For simulation of CSO control scenarios, the DWF projection will be performed to account for the future development and population growth in the service area. The future land use map (FLUM) and development densities will be used to project future DWF.

3.2.3.8 Rainfall Derived Infiltration and Inflow (RDII)

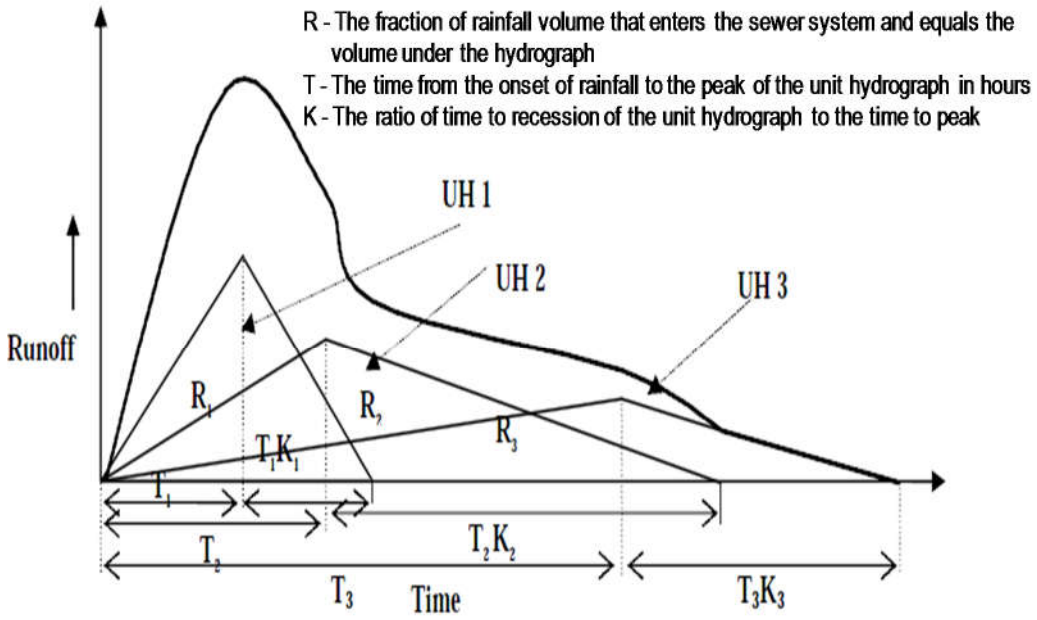
The model will use the RTK unit hydrograph (UH) to estimate RDII into the sewer system. A RTK UH set contains up to three hydrographs (**Figure 3-4**): one for a short-term response (UH1), one for an intermediate-term response (UH2), and one for a long-term response (UH3). UH1 represents the most rapidly responding inflow component and has a short T value, UH2 includes both inflow and infiltration and has a longer T value, and UH3 includes infiltration that may continue long after the storm event has ended and has the longest T value. The unit hydrograph is defined by the following three parameters:

- R: the fraction of rainfall volume that enters the sewer system and equals to the volume under the hydrograph,
- T: the time from the onset of rainfall event to the peak of the unit hydrograph in hours, and
- K: the ratio of time to recession of the unit hydrograph to the time to peak.

The same set of RDII parameters will be applied in the same metershed because of the availability of the flow hydrograph for model calibration. The initial values of RTK will be estimated using the RDII Analyst tool in the InfoSWMM. The RTK values are calibration parameters to be refined during model calibration.

Rainfall and sewershed area information will be needed for RDII calculation. Sewershed area will be estimated based on areas of the parcels with wastewater services and the areas along the sewer pipes outside parcel areas.

Figure 3-4 RTK Unit Hydrographs



Source: M.K. Muleta and P.F. Boulos, Analysis and Calibration of RDII and Design of Sewer Collection Systems, ASCE Conference Proceedings 316, 642 (2008)

Section 4 Additional Rainfall and Flow Monitoring

4.1 Existing Rainfall and Flow Monitoring Data Review

4.1.1 Existing Rainfall Monitoring Data Review

DELCORA operates and maintains four (4) rainfall gauges 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)
- Central Delaware County Pump Station (CDPS)
- Muckinipates Pump Station (MPS)
- Darby Creek Pump Station (DCPS)

The three rain gauges located at the pump stations were installed in January 2009 and are a tipping bucket style gauge (Texas Electronics, Inc. TR-525I Rainfall Sensor with a six-inch diameter funnel). The accuracy of the gauges are 1.0% up to 2"/hr or less and each tip represents 0.01" of precipitation. The rainfall gauges are connected to a Telog RU-33 units which sums the number of tips in a 5 minute interval and then logs the total. Data is downloaded daily.

The rain gauge located at the WRTP has been in operation since the mid-1990s. The current gauge is a BlueBugBox Weather Station from WeatherBug.

In addition to these four gauges, precipitation records are available from the National Oceanic and Atmospheric Administration (NOAA) station located at the Philadelphia International Airport. Precipitation records for this station go back to 1/1/1900. This data has been obtained and will be used to select the typical year.

The data from the four DELCORA gauges, the NOAA station and other available gauges will also be used as part of the process.

4.1.2 Existing Flow Monitoring Data Review

DELCORA owns and operates a flow monitoring network across Delaware County. The monitoring network includes various types of flow meters located throughout DELCORA's Eastern Service Area and Western Service Area, at the WRTP, in each of the Pump Stations, and at the tie-in points where other municipal collection systems tie-into the CSO system.

At the pump stations, DELCORA uses magnetic flow meters due to their high accuracy (±1%) and repeatability. In the collection system, area-velocity type meters are used due to the number of locations and the ability to install them without collection system retrofit. Typically these meters are accurate to ±5-7%. The metered flow in the collection system meters is read and recorded once every 15 minutes.

Figure 4-1 shows all the existing flow meters in the DELCORA collection system. A description of the flow monitoring system for each of the defined areas is as follows:

- Eastern Service Area – In the Eastern Service Area, there are a total of 117 flow meters deployed in the collection system to record flow data from the contributing municipalities. These flow meters capture approximately 75% of the EDUs in this service area. The data from these flow meters are used to generate an apportionment percentage assigned to each member municipality in the CDCA, MA, and DCJA. The apportionment percentage is used to distribute the treatment and O&M costs of DELCORA and each of the authorities. The majority of the flow meters, one hundred thirteen (113), are area-velocity type meters installed in the collection system pipes and or manholes at key locations. The remaining flow meters are magnetic flow meters and are located at small pump stations in Upper Providence Township and Newtown Township. Flow from all these meter locations eventually passed through one of DELCORA's primary pump stations (CDPS, MPS, and DCPS) which are equipped with magnetic type flow meters to record flow data. The flow meters in the collection system were installed in 2006. The magnetic flow meters located at the pump stations measure and record flow on a continuous basis. The installation dates area listed in **Table 4-1**.

Table 4-1 Installation Date of the Existing Magnetic Flow Meters at Pump Stations

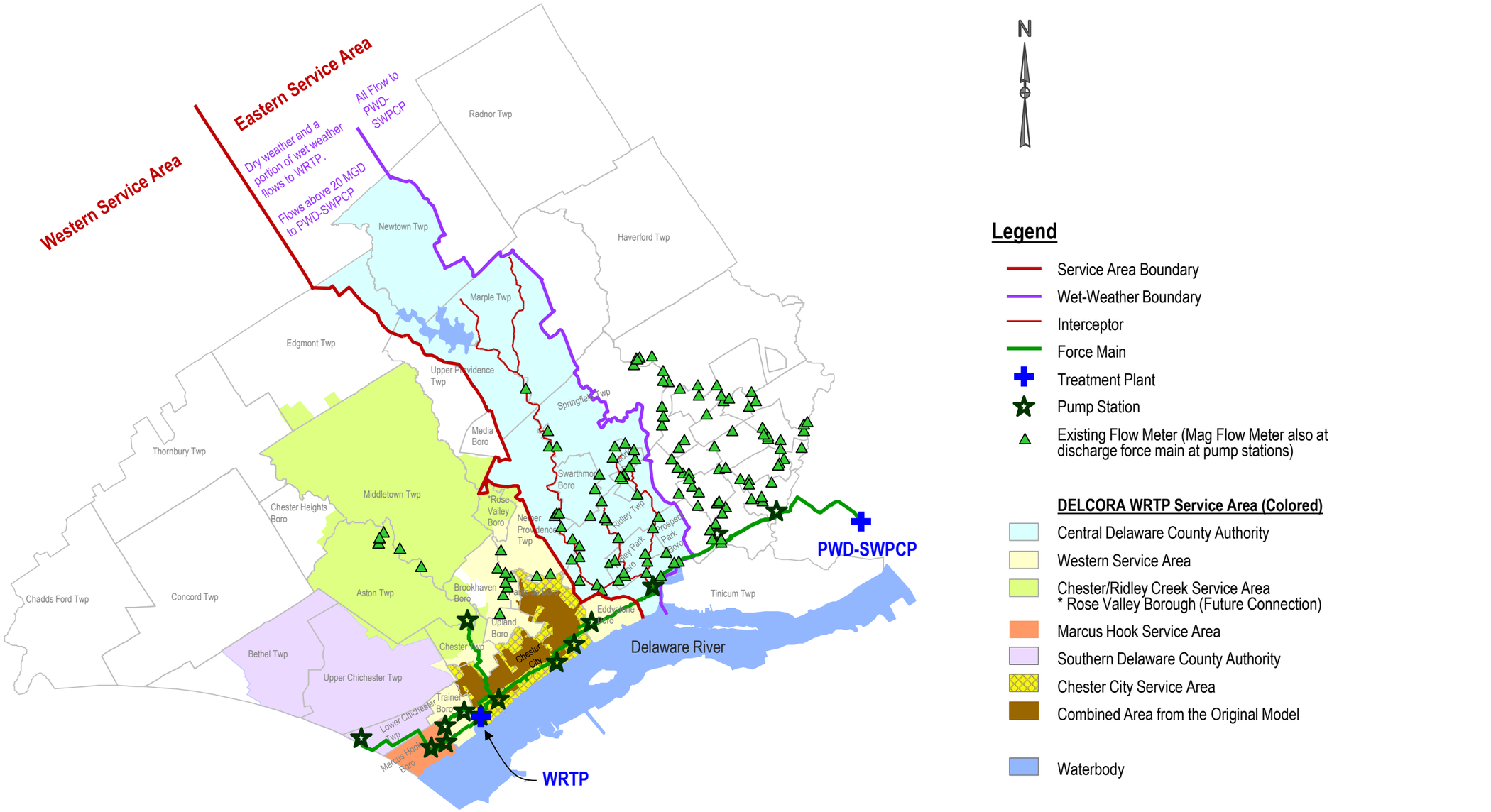
Pump Station	Magnetic Flow Meter Installation Date
Darby Creek PS	1/2008
Muckinipates PS	1/2004
Central Delaware PS	12/2002
WRTP Main Influent PS	1/1998
Chester PS	6/2004
EPS-1	7/2007

- Western Service Area – In the Western Service Area there are a total of eighteen (18) flow meters deployed throughout the collection system that record the flow. All of these meters are area-velocity type flow meters. Ten (10) flow meters are located in the portions of Brookhaven Borough and Nether Providence Township that are connected directly to interceptors in the Chester Collection System and were installed in 2008. The remaining seven (7) meters, located in Rose Valley Borough, Aston Township, and Middletown Township, are located upstream of pump stations with magnetic flow meters.
- Pump Stations – At each of the pump stations shown on **Figure 1-1**, DELCORA has a magnetic flow meter installed on the discharge force main to record flow data. At the CDPS there are two (2) flow meters, one (1) on the force main tributary to the Western Regional Treatment Plant and one (1) on the force main to the City of Philadelphia treatment plant. All of the pump station flow meters measure and record flow on a continuous basis.

- WRTP – There is one flow meter located in the influent pipe line into the WRTP. This flow meter is a magnetic type meter and measures all of the flow to the treatment plant. The flow is recorded continuously.

Data from the pump station magnetic meters, the 10 collection system meters in the Western Service Area, and 61 meters in the Central Delaware County Authority (CDCA) will be used as direct input to the H&H model.

Figure 4-1 DELCORA Existing Flow Meters



4.2 Additional Rainfall and Flow Monitoring Locations

4.2.1 Proposed Rainfall Monitoring Locations

The existing rain gauges in the WRTP service area, including one in the combined area at the WRTP and one in the separated area at the CDCA Pump Station (rain gauges at the Muckinipates PS and Darby Creek PS are out of the WRTP service area), are not sufficient to provide effective spatial coverage of the entire service area. Additional rain gauge is needed for the additional rainfall and flow monitoring program if rain gauge is used as the only source of precipitation data.

Rain gauge network density can be determined from watershed area by the following equation. The number of gauges, N, is,

$N=A^{0.33}$ (U.S. Army Corps of Engineers, 1996)
where A is the watershed area in mi^2

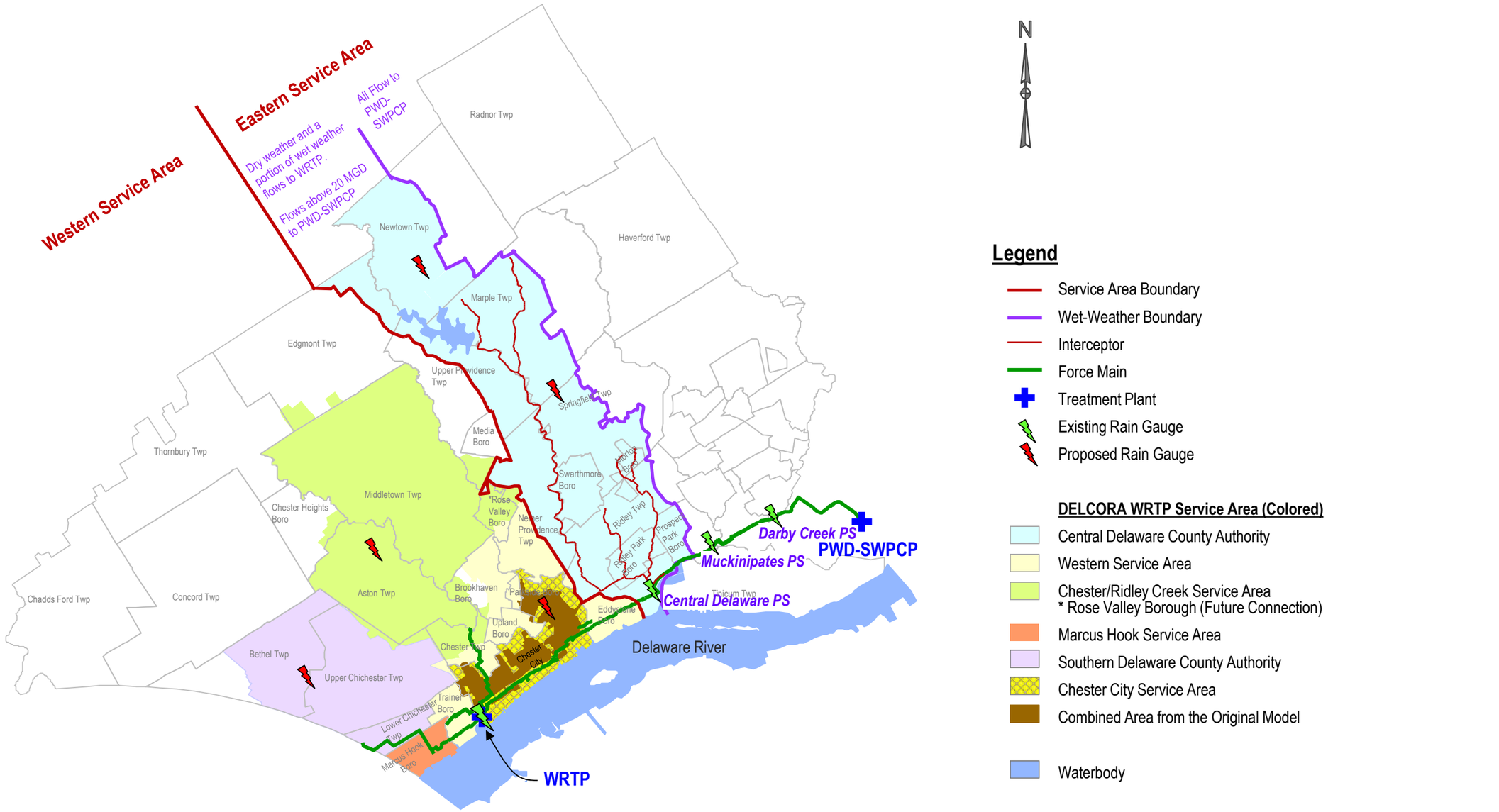
The number of gauges recommended by the Equation is quite small when compared to typical urban rain gauge networks where densities may be as great as one gauge per 10 to 20 km^2.

In this Plan, rain gauge intensity is estimated based on one gauge per 3 km^2 for the combined area and based on the Equation for the separated area. With this, the DELCORA System requires one (1) additional rain gauges in the combined areas and four (4) additional rain gauges in the separated areas.

Figure 4-2 shows the potential locations for the additional rain gauges, locations of the existing rain gauges are also shown.

Another approach of rainfall monitoring is to use the Gauge-Adjusted Radar Rainfall (GARR). A detail comparison of these two approaches will be evaluated during preparation of the Rainfall and Flow Monitoring Work Plan.

Figure 4-2 Proposed Rain Gauge Locations



4.2.2 Proposed Flow Monitoring Locations

In addition to the existing flow meters in the separated area measuring flows from individual contributing municipalities and pump stations, additional flow meters are needed, mainly in the combined area, to characterize surface runoff from the combined area and CSO discharges, meters in the separated area are also needed to characterize RDII from the Western Service Area.

Proposed flow meter locations can be categorized into the following four types: (**Table 4-2**):

- Located on the influent pipe to CSO regulators, this is to measure the influent flow to CSO regulators and for combined area runoff calibration. 15 meters are proposed for this category.
- Located on the overflow pipe, this is to measure the CSO overflows and calibrate CSO regulator parameters. Five (5) meters are proposed with four (4) for four largest CSO overflow points, including CSO 19, CSO 08, CSO 05, and CSO 02, and one (1) for a small overflow point CSO 14.
- 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 are proposed for this category.
- Located upstream of the combined area, this is to measure flows from the upstream separated area for RDII characterization. Four (4) meters are proposed for this category.

In total, 26 additional flow meters are proposed. **Table 4-2** lists approximate flow meter locations and location categories. **Figure 4-3** shows a map of the proposed additional flow meters, with zoom into the combined area in **Figure 4-4**.

Table 4-2 Proposed Additional Flow Meters

Proposed Flow Meter	Approximate Location	Type
In-02	Influent pipe to CSO 02 Regulator	On the influent pipe to regulator
In-03	Influent pipe to CSO 03 Regulator	On the influent pipe to regulator
In-05	Influent pipe to CSO 05 Regulator	On the influent pipe to regulator
In-08	Influent pipe to CSO 08 Regulator	On the influent pipe to regulator
In-10	Influent pipe to CSO 10 Regulator	On the influent pipe to regulator
In-11	Influent pipe to CSO 11 Regulator	On the influent pipe to regulator
In-13	Influent pipe to CSO 13 Regulator	On the influent pipe to regulator
In-14	Influent pipe to CSO 14 Regulator	On the influent pipe to regulator
In-16	Influent pipe to CSO 16 Regulator	On the influent pipe to regulator
In-17	Influent pipe to CSO 17 Regulator	On the influent pipe to regulator
In-18	Influent pipe to CSO 18 Regulator	On the influent pipe to regulator
In-19-1	Influent pipe to CSO 19 Regulator (from East)	On the influent pipe to regulator
In-19-2	Influent pipe to CSO 19 Regulator (from West)	On the influent pipe to regulator
In-25	Influent pipe to CSO 25 Regulator	On the influent pipe to regulator
In-26	Influent pipe to CSO 26 Regulator	On the influent pipe to regulator
Side-1	Side line on Penn St. to 2nd St. Interceptor	On the side-line from the combined area
Side-2	Side line on Highland Ave. to CSO 02 influent pipe	On the side-line from the combined area
Sep-1	Upstream of the CSO 02 Drainage	On the separated area
Sep-2	Upstream of the CSO 05 Drainage	On the separated area
Sep-3	Upstream from Upland Borough	On the separated area
Sep-4	Upstream from Eastern Chester	On the separated area
CSO-02	Outfall pipe from CSO 02 Regulator	On the outfall pipe
CSO-05	Outfall pipe from CSO 05 Regulator	On the outfall pipe
CSO-08	Outfall pipe from CSO 08 Regulator	On the outfall pipe
CSO-14	Outfall pipe from CSO 14 Regulator	On the outfall pipe
CSO-19	Outfall pipe from CSO 19 Regulator	On the outfall pipe

Figure 4-3 Proposed Flow Meters

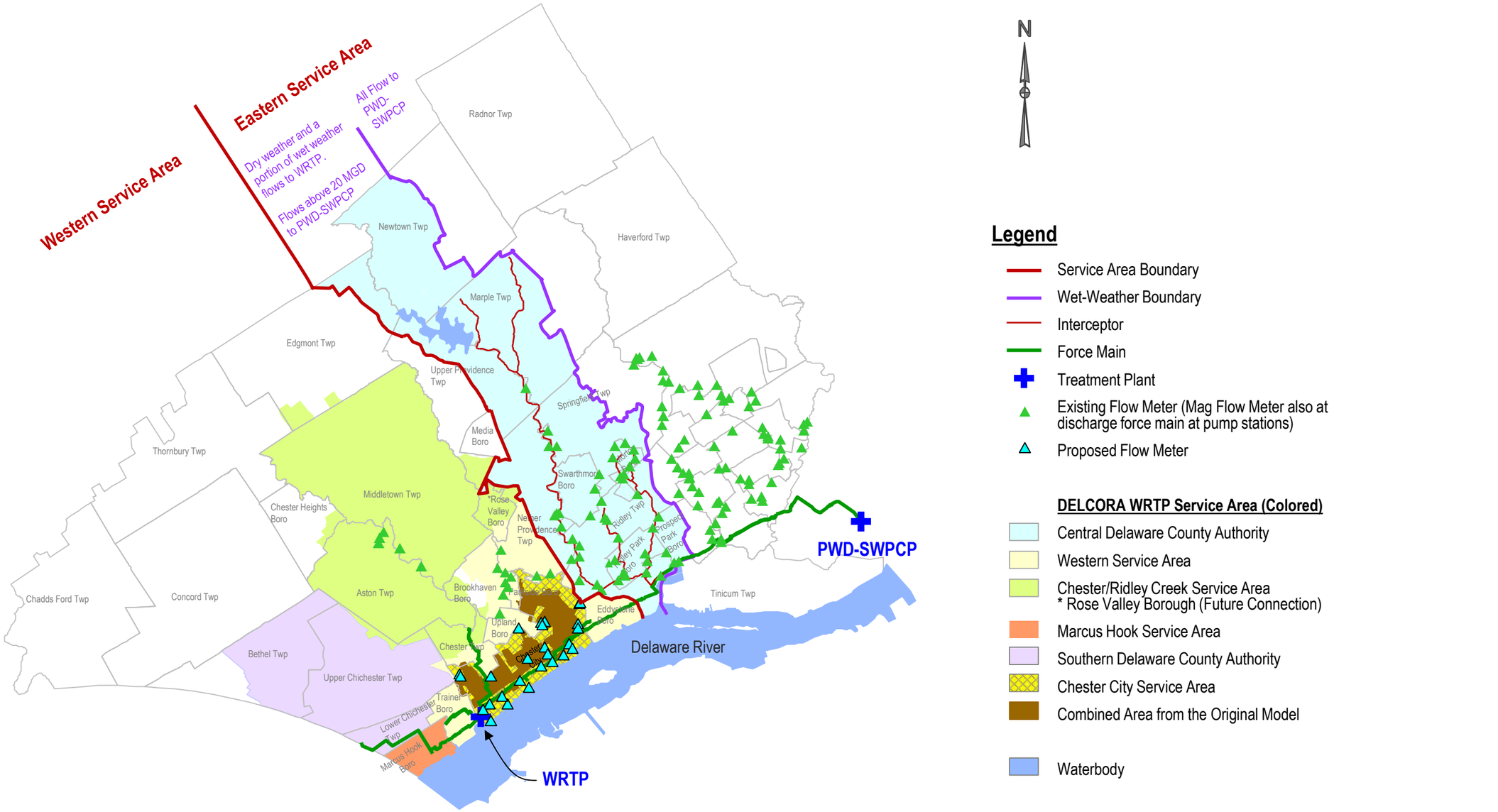
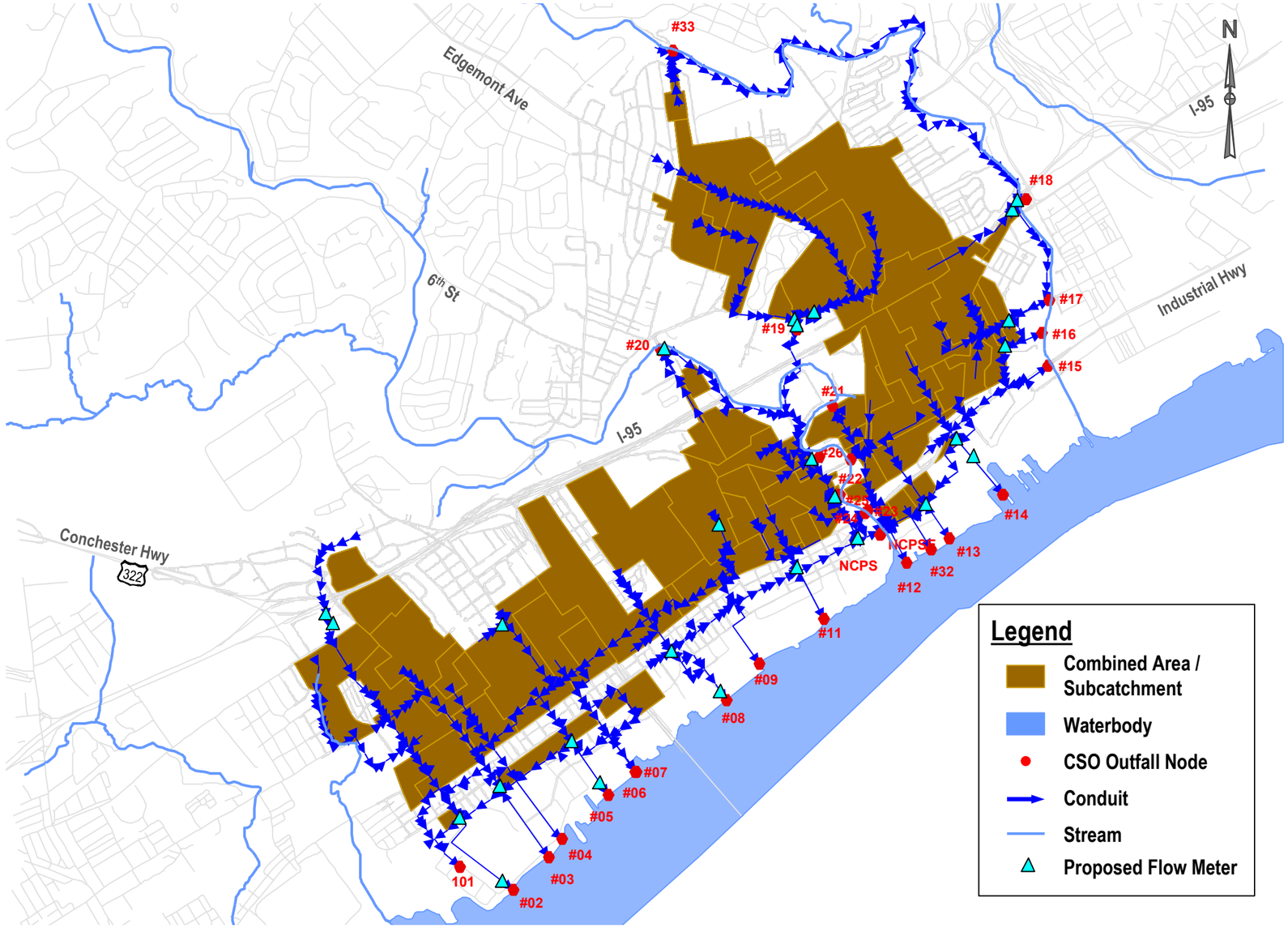


Figure 4-4 Additional Flow Meters (Zoom into the Combined Area)



4.3 Rainfall and Flow Monitoring Work Plan

Per the Consent Decree, the additional rainfall and flow monitoring need to be carried out at least for 12 months. Key tasks of the monitoring program include the following. A detail work plan will be prepared during the first Task (Prepare Rainfall and Flow Monitoring Work Plan).

- Prepare Rainfall and Flow Monitoring Work Plan in October 2015, exact locations of the proposed rain gauge and flow meter will be field verified and finalized during plan development,
- Procure Flow Metering and Rain Gauge Services in November 2015,
- Install and Calibrate Rain Gauge and Flow Meters for Official Data Gathering in November through December 2015,
- Conduct Rainfall and Flow Monitoring continuously for 12-month through Year 2016.
- Monitoring data collection and analysis, within two months after the monitoring program is completed.

Section 5 DELCORA H&H Model Calibration and Validation

5.1 Rainfall and Flow Monitoring Data Analysis

A rainfall and flow monitoring data analysis will be performed for the data collected from the additional rainfall and flow monitoring program listed in Section 4. The purposes of this data analysis are to:

- document rainfall and flow monitoring locations,
- overview monitoring data quality,
- analyze rainfall data to identify dry weather and wet weather conditions and to characterize individual rainfall event for precipitation depth, duration, maximum intensity, and return frequency,
- analyze flow data to determine dry weather flow and diurnal pattern, wet weather flow and peak factor, and system response to wet weather events, and
- determine wet weather events for H&H model calibration and validation.

5.1.1 Rainfall Monitoring Data Analysis

A rain gauge location map will be prepared, together with a Thiessen polygon. A system-wide area-weighted average rainfall will be calculated based on the Thiessen polygons.

Monthly rainfall depth and total rainfall depth will be calculated for each rain gauge to characterize geographical rainfall distribution throughout the collection system.

An inter-event time of 6 hours will be used to identify individual rainfall event. The inter-event time specifies the minimum duration in which precipitation does not occur. Based on this criterion, a dry weather time period and the number of total rainfall events will be identified. The rainfall events during the flow monitoring periods should have a wide variation in terms of total depth, intensity, duration, and antecedent conditions to provide a large dataset for balanced model calibration and validation.

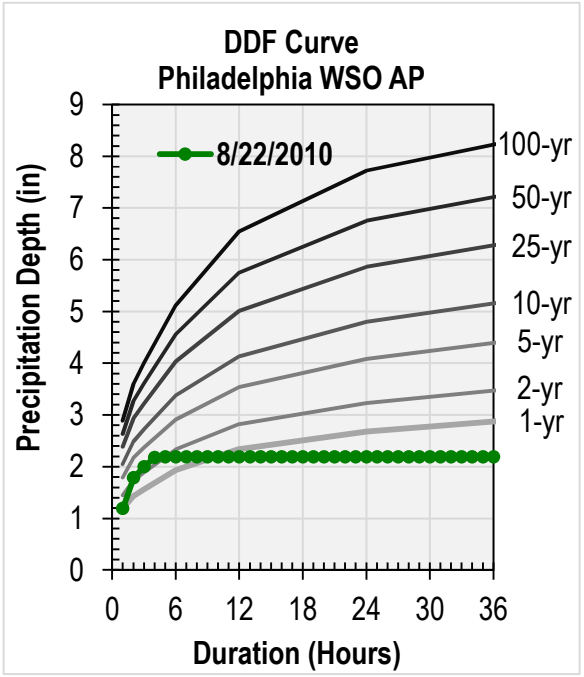
Table 5-1 shows NOAA precipitation frequency estimates for the Philadelphia International Airport. The original NOAA table contains rainfall data for 1-year to 1000-year return frequencies. A regression model can be used to derive the data for once per 3 months (four times a year) and once per 6 months (twice a year) storms. Based on **Table 5-1**, a Depth-Duration-Frequency (DDF) curve can be developed for individual rainfall event. For example, **Figure 5-1** shows the August 22, 2010 rainfall event as a 2-year storm and the August 3, 2011 rainfall event as a 1-yr storm.

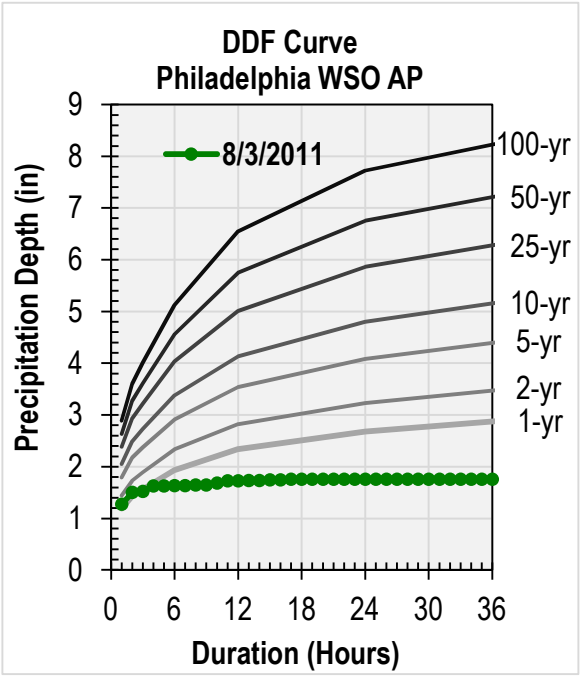
All the rainfall events will be characterized by event start time, event end time, rainfall depth, duration, maximum intensity, and return frequency in a summary table. Top 10 rainfall events will be identified as candidate events for model calibration and validation.

Table 5-1 NOAA Philadelphia Precipitation Frequency Estimates

Duration	Precipitation Frequency Estimates (rainfall: in)						
	1	2	5	10	25	50	100
5-min	0.347	0.414	0.486	0.537	0.598	0.64	0.681
10-min	0.555	0.661	0.778	0.858	0.954	1.02	1.08
15-min	0.694	0.831	0.984	1.08	1.21	1.29	1.37
30-min	0.951	1.15	1.4	1.57	1.79	1.94	2.1
1-hr	1.19	1.44	1.79	2.05	2.38	2.63	2.89
2-hr	1.43	1.73	2.17	2.49	2.93	3.27	3.6
3-hr	1.56	1.89	2.37	2.73	3.22	3.61	4.01
6-hr	1.93	2.33	2.91	3.38	4.03	4.56	5.12
12-hr	2.34	2.82	3.54	4.13	5.01	5.75	6.55
24-hr	2.68	3.23	4.08	4.8	5.86	6.75	7.72
2-day	3.07	3.71	4.7	5.51	6.69	7.67	8.73
3-day	3.26	3.93	4.96	5.81	7.03	8.05	9.14
4-day	3.44	4.15	5.22	6.1	7.37	8.42	9.54

Figure 5-1 Rainfall with 1-yr and 2-yr Return Frequency



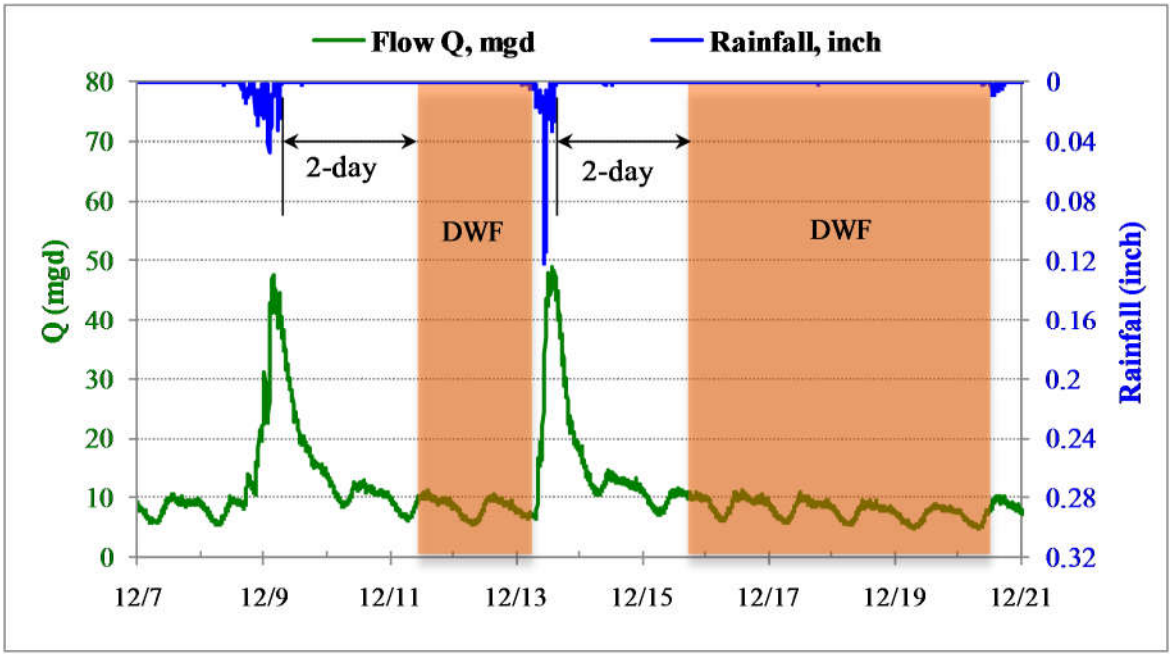


5.1.2 Flow Monitoring Data Analysis

5.1.2.1 Dry Weather Flow (DWF) Analysis

A "dry weather" condition was defined as a period with no precipitation that begins two days after the last wet weather event and lasts until the beginning of the next precipitation event. **Figure 5-2** is an example plot showing both rainfall data and a flow hydrograph. Periods of dry weather flow are also shown in the plot based on the definition. Flow hydrographs will be screened for each metering site to confirm that the data used for the DWF calculation was appropriate. **Figure 5-3** shows an example that some portion of the flow data measured needs to be exempted from the DWF calculation because the data was not consistent with other dry weather flows measured during the monitoring periods.

Figure 5-2 Hydrograph to Show Dry Weather Flow (Example Plot)



Average dry weather flow will be calculated by averaging the monitored flows from the dry weather periods identified in the rainfall data analysis. The overall and monthly DWFs for all monitoring sites will be analyzed.

The dry weather flows vary throughout the day, with the highest flows normally occurring around noon and the lowest rates between midnight and early morning. Flow data from the dry weather periods will be used to develop a flow diurnal pattern for each flow meter site. Diurnal patterns will be analyzed for both weekdays and weekends because they are usually different. In the example plot shown on **Figure 5-4**, the weekend DWF peak and valley have a 3-hour lag compared to the weekday pattern.

Figure 5-3 Data Screening for Dry Weather Flow Calculation (Example Plot)

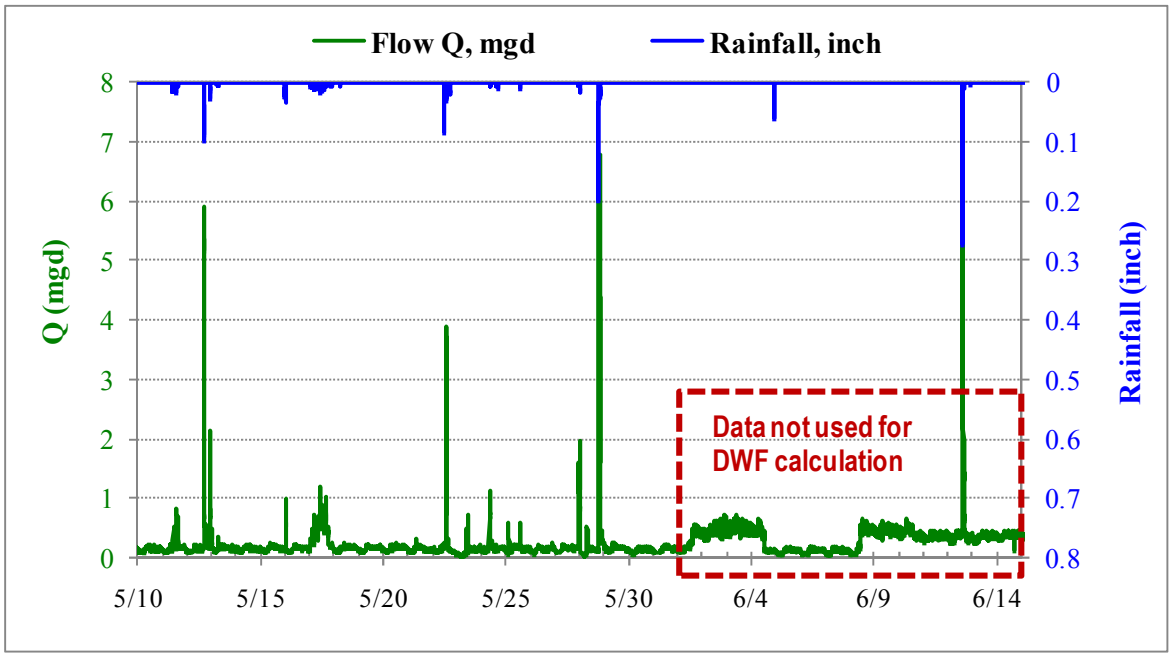
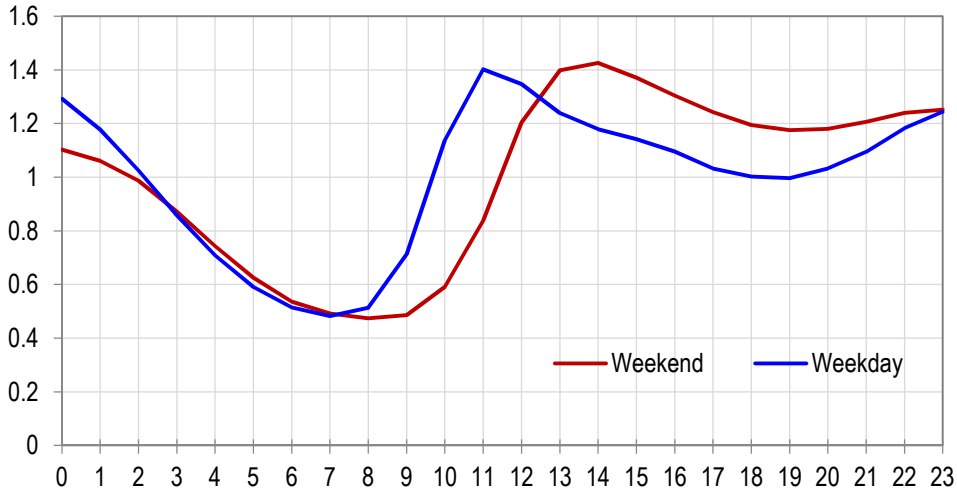


Figure 5-4 Weekday and Weekend Dry Weather Flow Diurnal Pattern (Example Plot)



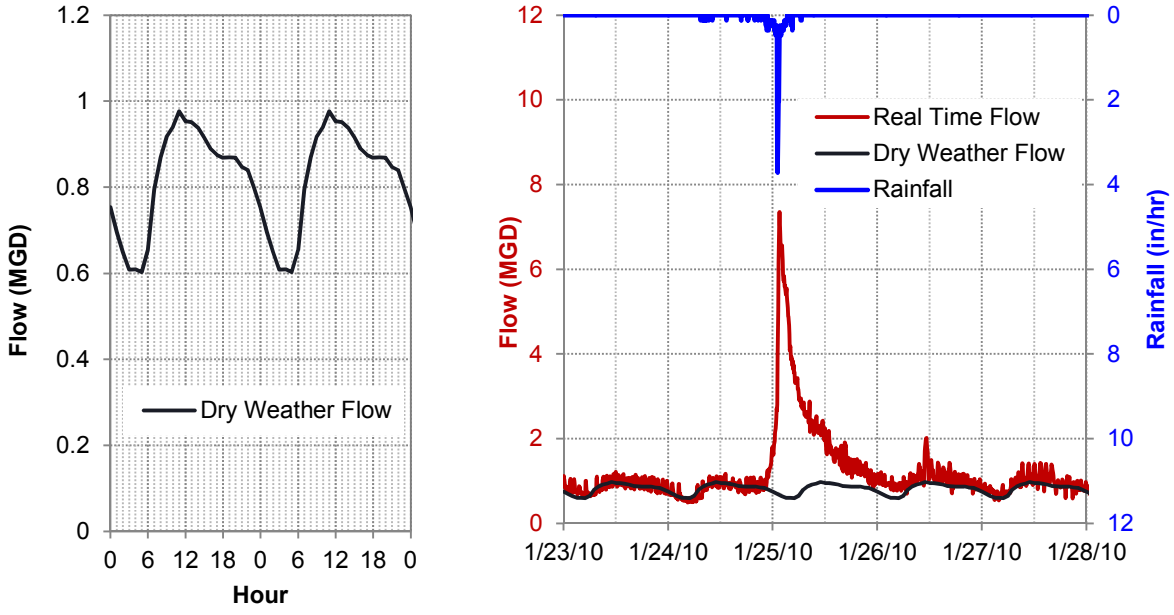
5.1.2.2 Wet Weather Flow Analysis

Wet weather flows are the combination of dry weather flows and additional flows that enter the system during wet weather conditions. The additional flows are from combined area surface runoff and RDII.

Inflow normally occurs when rainfall enters the system through direct connections such as roof leaders, yard drains, catch basins, sump pumps, manhole covers and frame seals or indirect connections with storm sewers. Inflow is usually recognized graphically by large magnitude, short duration spikes immediately following a rain event. Infiltration occurs during wet weather conditions when water enters a sewer system from the ground through means which include, but not limited to, deteriorated pipes, pipe joints, connections, or manholes. It is significantly influenced by the size and duration of the rainfall event. Infiltration is often recognized graphically by a gradual increase in flow after a wet weather event. The increased flow typically sustains for a short period after rainfall has stopped and then gradually drops off.

The peaking factor represents the ratio of the peak wet weather flow to the average dry weather flow. Usually, an hourly peaking factor is used to represent the wet weather peaking factor. Peaking factors will be analyzed for each flow monitoring site. The peaking factors in the separated area can be used to determine the extent of the RDII within a particular basin. **Figure 5-5** is an example flow hydrograph plot showing an hourly peaking factor of approximately 9 for the monitoring site. This high peaking factor indicates that a significant amount of RDII enters the collection system. The immediate flow increase shortly after the rainfall indicates significant inflow into the collection pipes, and the long tail back to the base flow indicates infiltration occurrence at the site as well.

Figure 5-5 Hydrographs of Flow Meters in Separated Area (Example Plot)



5.1.3 Wet Weather Event Selection for Model Calibration and Validation

Based on the rainfall and flow monitoring data analysis, four to six rainfall events will be selected for model calibration. The event selection should cover wide variation in terms of rainfall return frequency, rainfall depth, intensity, duration, antecedent conditions, and back-to-back storms. With this, the calibrated model can be reasonably applied for various hydrologic conditions. The selected calibrating period shall have good wet weather response from most of the flow monitoring locations.

One to two other rainfall events will be selected for model validation.

5.2 Model Calibration and Validation

Model credibility is developed through model calibration and validation. Model calibration involves application of the model to known external inputs (e.g., rainfall), evaluation of the model's ability to replicate monitored conditions (e.g., flow and volume), and adjustment of key model parameters as needed until an acceptable level of agreement is reached between simulated and monitored conditions.

After the model is satisfactorily calibrated it must be validated by running known storms with known flow results and having the model replicate the known events. Storms used in model validation should be independent from the storms used in the model calibration.

5.2.1 Calibration/Validation Criteria

5.2.1.1 Dry Weather Flow Calibration Criteria

A dry weather flow (DWF) analysis will be conducted based on the rainfall and flow monitoring results. DWF distribution in the collection system will be based on land use or water consumption data.

Weekday and weekend diurnal factor will be analyzed and applied for each flow meter service area and a monthly factor will be used, if necessary.

DWF calibration will adhere to industry standards and the criteria below:

- The simulated hydrograph should match the general observed hydrograph shape,
- The simulated time of peaks and troughs will be within 1 hour of the observed,
- The simulated peak flow will be within 10% of the observed flow, and
- The simulated flow volume over 24 hours will be within 10% of observed flow.

5.2.1.2 Wet Weather Flow Calibration Criteria

Wet weather flow (WWF) includes surface runoff from the combined area, RDII from the entire service area, and connected rooftops, if any, from the separated area. RDII parameters will be developed based on the separated area, and surface runoff parameters will be adjusted for the combined area to calibrate the system response to the wet weather conditions.

Four (4) to six (6) wet weather events will be selected for wet weather calibration, depending on the rainfall and flow monitoring results, and various rainfall intensities and volume should also be considered.

WWF calibration will adhere to industry standards and the criteria below:

- The simulated hydrograph should match the general observed hydrograph shape,
- The simulated time of peaks and troughs will be within 1 hour of the observed,
- The simulated peak flow will be within 10% of the observed flow, and
- The simulated flow volume over 24 hours will be within 10% of observed flow.

5.2.2 Model Calibration Approach

The runoff calibration for the combined sewer area is achieved by primarily adjusting width and percent imperviousness. The RDII calibration is achieved by adjusting RTK values. The calibration of hydraulic control structures (weirs and orifices) is achieved by adjustment the discharge coefficients. The conduit hydraulics calibration is achieved by adjusting Manning's n and head loss coefficients. Flow depth, as well as flow rate, is checked while calibrating the hydraulic model.

Once the model is calibrated, different sets of flow monitoring data are used to validate the model calibration. Model calibration and validation is an iterative process.

Percent Imperviousness
The percent imperviousness for combined sewer subcatchment is the key parameter to be adjusted to calibrate runoff to the observed wet weather flow volumes. Site visits of the combined sewer areas may be needed to verify real connectivity. If runoff from a large portion of the impervious surface could not be captured by the combined sewers due to a limited number and size of storm inlets, the percent imperviousness will need to be reduced significantly from its initial value calculated based on impervious land cover. This is done to represent a more reasonable "effectively connected area" and to achieve a satisfactory calibration for runoff volume.

Width
The width for the combined sewer sub catchments, in conjunction with percent imperviousness, will be adjusted to calibrate to the observed wet weather flow peaks.

Depression Storage
The depression storage is another hydrologic parameter for wet weather volume calibration. It can also be adjusted to achieve a satisfactory calibration for the wet weather flow start timing.

RDII Parameters
RDII parameters are to be adjusted to calibrate to the observed wet weather volumes and flow hydrograph shape for the separate sewer areas. The RDII parameters for the combined sewer areas will use the same as those for the immediate upstream separate sewer areas. Then, the runoff parameters will be adjusted to calibrate to the observed data.

Pipe Roughness
Pipe roughness will be adjusted to calibrate to the observed flow depths and velocities at the meter locations.

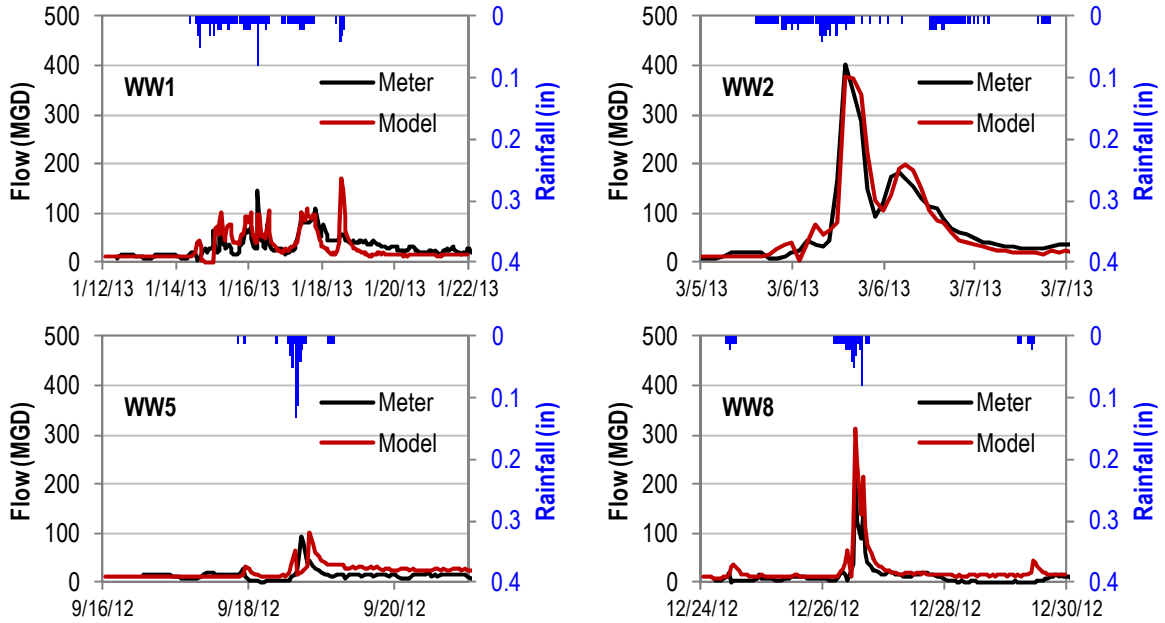
Orifice and Weir
Orifice and weir parameters discharge coefficients will be adjusted to calibrate to the observed overflows at the outfall meter locations.

Minor Loss
Minor loss values will be applied in the model where necessary to refine observed flow/depth relationships at the meter locations.

5.2.3 Model Calibration Results

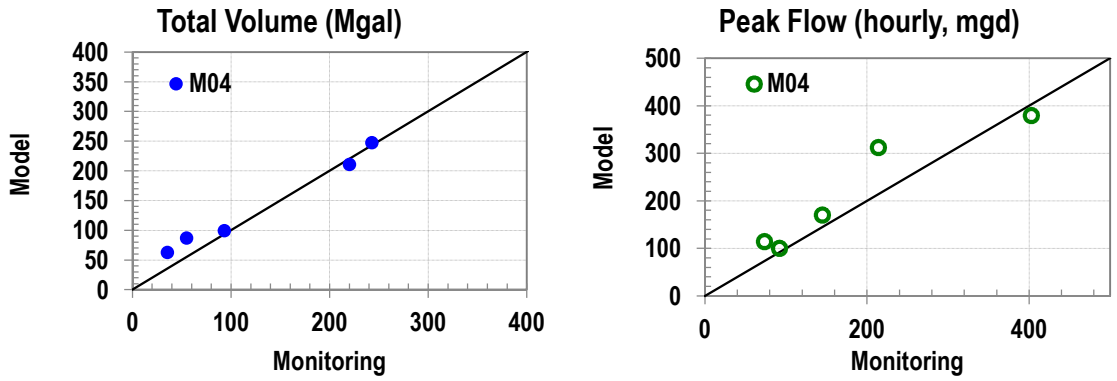
Generally, the model predictions should be in great agreement with the metering data. **Figure 5-6** is an example plot showing metered and modeled flow at one monitoring site for four wet weather events (WW1, WW2, WW5, and WW8). A great agreement between metered and modeled data may not be achievable for each individual wet weather event. The larger storm events will have more weighting factor in the calibration process because the large events are the ones that dominate the total overflow volume.

Figure 5-6 Model Calibration Hydrograph (Example Plot)



Comparisons of the predicted total volume against the monitoring total volume and predicted peak flow against monitoring peak flow will be analyzed and shown in 1:1 ratio plots for all calibrated meters (see example **Figure 5-7**). This is to evaluate the overall calibration and validation from all the events. The event points in **Figure 5-7** are distributed close to the 1:1 ratio line, which means that the model predicted peak flow and wet weather event volume are in a great agreement with the metered data.

Figure 5-7 Model Calibration Hydrograph (Example Plot)

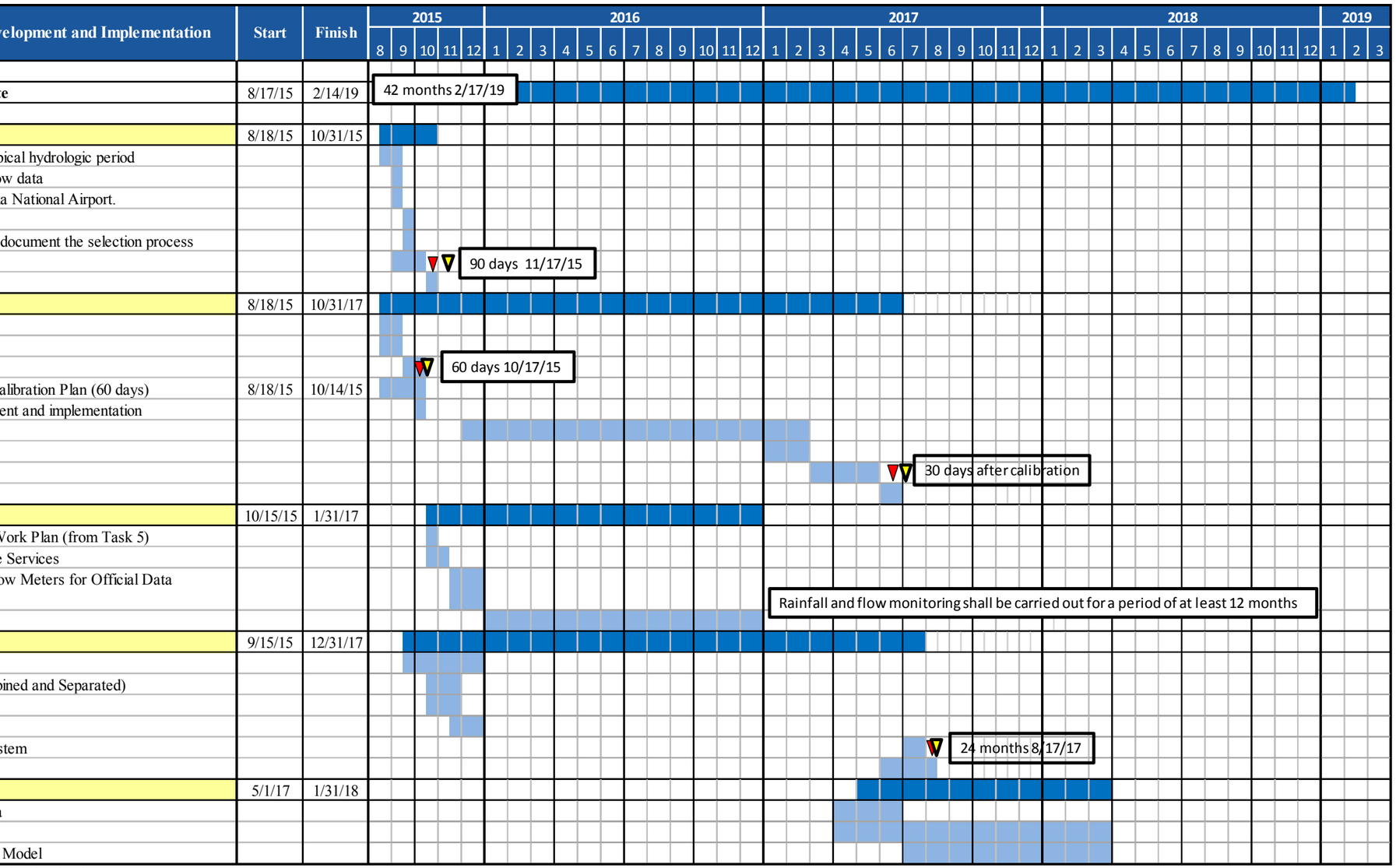


Section 6 Model Development and Implementation Schedule

The schedule for model development and implementation is shown in **Figure 6-1**. All LTCPU tasks related to the H&H model construction, application, and implementation are included in the schedule. The schedule is integrated into LTCP development consistent with other dates required pursuant to the Consent Decree.

Figure 6-1 Schedule for H&H Model Development and Implementation

	Tasks of DELCORA H&H Model Development and Implementation	Start	Finish
	Lodging date of Consent Decree (8/17/15)		
	DELCORA Long Term Control Plan Update	8/17/15	2/14/19
	TASK 3 - Typical Year Rainfall Record (90 days)	8/18/15	10/31/15
1	Develop criteria for determination of typical hydrologic period		
2	Review available historic rainfall and flow data		
3	Obtain rainfall data from the Philadelphia National Airport.		
4	Review with DELCORA		
5	Select the typical hydrologic period and document the selection process		
6	Draft Report		
7	Final Report		
	TASK 5 - Hydrologic & Hydraulic Model	8/18/15	10/31/17
1	Initial assessment of GIS Model		
2	Initial assessment of H&H Model		
3	Report summarizing Initial Assessment		
4	Develop an H&H Model Update and Calibration Plan (60 days)	8/18/15	10/14/15
5	Develop Schedule for Model Development and implementation		
6	H&H Model Update		
7	Flow Monitoring Data Analysis		
8	H&H Model Calibration		
9	H&H Model Report		
	TASK 6 - Rainfall and Flow Monitoring	10/15/15	1/31/17
1	Prepare Rainfall and Flow Monitoring Work Plan (from Task 5)		
2	Procure Flow Metering and Rain Gauge Services		
3	Install and Calibrate Rain Gauge and Flow Meters for Official Data Gathering		
4	Conduct Rainfall and Flow Monitoring		
	TASK 7 - Existing Service Area Characterization	9/15/15	12/31/17
1	GIS Mapping Review and Update		
2	Refine Service Area Delineation (Combined and Separated)		
3	Investigate Existing CSO Facilities		
4	Investigate Service Agreements		
5	Perform H&H Modeling of Existing System		
6	Documentation		
	Evaluation of CSO Alternatives (Part of Task 11)	5/1/17	1/31/18
1	Develop Future DWF and Service Area		
2	Develop CSO Alternatives		
3	Evaluate CSO Alternatives using H&H Model		



Consent Order Deadline Draft and Final submittals

Greeley and Hansen LLC
1700 Market Street, Suite 2130
Philadelphia, PA 19103
(215) 563-3460
www.greeley-hansen.com

GREELEY AND HANSEN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

MAR 01 2016

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) Hydrologic and Hydraulic Model Update and Calibration Plan. EPA has consulted with the Pennsylvania Department of the Environment (PaDEP).

EPA hereby approves the plan with the understanding that the term "two days" as stated in paragraph 5.1.2.1 (Dry Weather Overflow Analysis) shall mean 48 hours.

Thank you for your continued cooperation with this matter. Please do not hesitate to contact me at (215)814-2097 if you have any questions.

Sincerely,

Andrew F. Seligman, Environmental Scientist
Water Enforcement Branch

cc: R. Smolski, EPA
P. Yeany, EPA
M. DeSantis, DELCORA

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APPENDIX E

TYPICAL HYDROLOGIC PERIOD REPORT

- DELCORA Typical Hydrologic Period Report (Final) dated November 2015 (Updated April 2016)
- USEPA Approval of the Typical Hydrologic Period Report dated May 23, 2016

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

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

Typical Hydrologic Period Report (Final)

November 2015
(Updated April 2016)

GREELEY AND HANSEN

REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Typical Hydrologic Period Report.

DELCORA MANAGEMENT		
Executive Director	*Signature*	11/5/15 *Date*
DELCORA ENGINEERING		
Director of Engineering	*Signature*	11/5/15 *Date*
(type in other as needed / delete row if unused)	*Signature*	*Date*
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	*Signature*	11/5/15 *Date*
(type in other as needed / delete row if unused)	*Signature*	*Date*
	Signature	*Date*
	Signature	*Date*

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES
1	4/26/16	Greeley and Hansen	• Pg. 1-3, Section 1-4: Deleted paragraph at end of section. • Pg. 2-7: Added Table 2-6 – Top 5 Ranked Hydrologic Periods (IET = 12 hr). Renumbered tables accordingly. • Page 2-10: Added new Section 2.6. • Page 2-10: Added Figures 2-4, 2-5 and 2-6 and renumbered figures accordingly.

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Section 1 Introduction

1.1 DELCORA's Consent Decree

DELCORA prepared and submitted their original Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) to the PADEP in 1999. This LTCP was subsequently approved by the PADEP, and DELCORA had started to implement the CSO control elements selected in the LTCP. In 2009, the United States Environmental Protection Agency (USEPA) informed DELCORA that the original LTCP was not in compliance with the requirements of the USEPA's CSO Policy. As such, DELCORA prepared and submitted a revised LTCP in April 2012. Subsequent to the receipt of the revised LTCP, DELCORA and the USEPA had corresponded various times including requests for additional information from the USEPA in accordance with Section 308 of the Clean Water Act. A Consent Decree was issued by the USEPA to DELCORA in June 2015. The Consent Decree requires a new LTCP to be prepared based on an agreed upon schedule, which will include interim deliverables and milestones that must be met.

According to the Consent Decree between the US EPA, PADEP, and DELCORA, within ninety (90) days after August 17, 2015 (the lodging date), DELCORA shall submit to Plaintiffs a report or technical memorandum describing DELCORA's statistical evaluation of long-term local rainfall patterns and the identification of an appropriate typical period for LTCP development purposes.

The statistical evaluation in this study utilizes local long-term rainfall record from the Philadelphia International Airport. It considers various appropriate rain year characteristics, including distributions of event rainfall totals, event durations, and peak and average rainfall intensities.

1.2 Typical Year for CSO LTCP Development

Precipitation generates urban storm water, combined sewer overflows (CSOs), and increased wet weather flows to the wastewater treatment plant. These will contribute bacteria and pollutants to the Delaware River and its tributaries. The effect of these contributors on the Delaware River mainly depends on the magnitude and duration of rainfall events and on the prevailing ambient river conditions controlling dilution and transport of the pollutants. This variability and complexity poses a significant challenge for assessing the performance of wet weather and CSO control alternatives.

In accordance with the USEPA CSO Control Policy (CSO Policy), dated April 19, 1994, the CSO control alternatives should be assessed on a "system-wide, annual average basis". This is accomplished by continuous simulation using a typical hydrologic period for the combined sewer system (CSS) and receiving water quality modeling applications. The CSO Policy supports continuous simulation modeling, i.e., using long-term rainfall records rather than records for individual storms. Long-term continuous rainfall records enable simulations to be based on a sequence of storms so that the additive effect of storms occurring close together can be examined. They also enable storms with a range of characteristics to be included.

Typically, a 3- to 5-year period is evaluated to balance between manageable model simulation time and representation of various rainfall/river conditions. In this study, a 3-year period is deemed most appropriate considering the modeling complexity. The representative three-year period is intended to

contain a relatively wet year, a dry year and an average year. Average year conditions are defined as the arithmetic average of the predictions for the selected period.

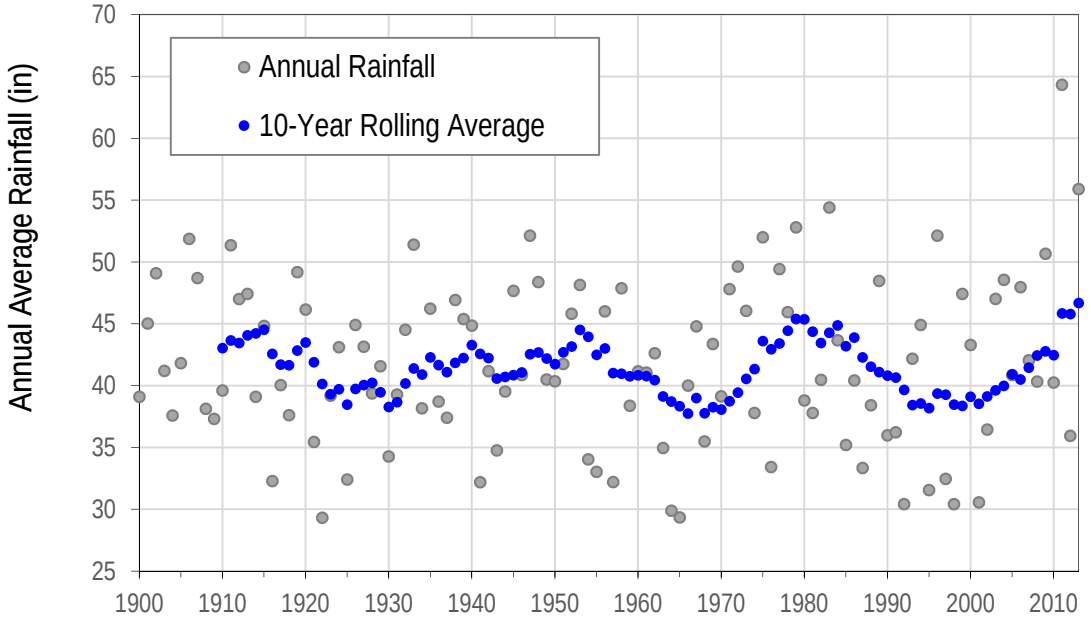
1.3 Climate Change Considerations

Average U.S. precipitation has increased since 1900, but there are regional differences, with some areas having larger increases, and others, decreases. Local climate change should be considered when selecting appropriate data records for the typical period analysis.

Rainfall data from the Philadelphia International Airport were obtained from the National Oceanic and Atmospheric Administration (NOAA). Hourly rainfall data is available from 1900 through 2013. This provides sufficient data to evaluate climate change in the area. **Figure 1-1** shows annual rainfall from 1900 to 2013. A 10-year rolling average trend line is also shown in the figure for characterizing long-term precipitation pattern. In the past 114 years, annual rainfall ranges from 29.3 to 64.33 inches, with the wettest year in 2011. The 10-year rolling average rainfall indicates that precipitation in the area runs through various dry and wet cycles, however with more extreme conditions (dry and wet) in recent years.

Considering the climate change, it is determined that the typical period for the LTCPU be selected based on statistical analysis of rainfall records in recent 30 years (i.e., 1984-2013).

Figure 1-1 Historical Annual Rainfall at Philadelphia International Airport



1.4 Methodology of Typical Year Selection

The typical hydrologic period is selected to provide representative and unbiased approximations of expected future conditions in terms of both averages and historical variability. Representativeness is

assessed using objective criteria for each of the ambient factors (i.e., river flow and rainfall). As indicated in the previous section, the selection of the typical hydrologic period is based on the historical records in the past 30 years from 1984 through 2013.

The following datasets are used for the analysis of the typical hydrologic period:

- Hourly precipitation data for the National Climate Data Center gauge at Philadelphia International Airport for 1984 - 2013.
- Daily Delaware River stream flow data from the U.S. Geological Survey gauge at Trenton, NJ (USGS 01463500) for 1984 - 2013. This is the closest USGS gauge that with daily river flow available.

Key criteria parameters used in the evaluation are listed in **Table 1-1**. Each parameter is given a weighting factor to describe the individual importance on the averageness of the analyzed time period. The parameters that are given the highest impact weighting include the following:

- The total annual rainfall depth, which drives the total runoff volume.
- The maximum peak intensity, which usually defines the biggest overflow event.
- The median Delaware River flow; the impact of sewer overflows on the water quality of the receiving water is dependent on the magnitude of the flows in river, and in the project area, intense local rainfall events are typically independent from watershed wide high flow events.

Table 1-1 Hydrologic Period Ranking Parameters

Key Parameter	Weighting Factor	Comments
Annual rainfall depth	25.0%	Important for evaluating annual overflow volume
Number of events > 0.1” rainfall depth	2.5%	Typically storms over 0.1” would start to cause surface runoff
Number of events > 0.25” rainfall depth	2.5%	Previous model indicates system overflows at storms over 0.25”
Number of events > 1.5” rainfall depth	7.5%	Storms to be controlled to meet potential presumption approach
Number of back-to-back events	5.0%	Important for evaluating the antecedent conditions
Maximum peak intensity	20.0%	Storms with high intensity causes overflows
Average rainfall duration	2.5%	Important for evaluating wet weather durations
Average rainfall intensity	5.0%	Important for evaluating overall rainfall intensity
Delaware River flow - 25th percentile	2.5%	Important for evaluating dilution power of the Delaware River flow for water quality
Delaware River flow - 50th percentile	25.0%	
Delaware River flow - 75th percentile	2.5%	

Section 2 Typical Year Selection for DELCORA

2.1 Annual Rainfall and River Flow Statistics

30-year hourly precipitation data (1984 - 2013) from the Philadelphia International Airport was analyzed to evaluate all individual rainfall events in the period. An inter-event time (IET) of 6 hours (i.e. minimum dry time of 6 hours between rainfall events was used to differentiate between individual events. Precipitation periods with a total rainfall volume of greater than 0.1 inch were counted as rainfall events. If the next rainfall event's starting time is within one day of the previous rainfall event's ending time, these two rainfall events are considered as back-to-back rainfall events. All rainfall events for the data period were analyzed for duration, inter-event duration, total rainfall amount, as well as maximum and average rainfall intensities.

A total of 1,934 rainfall events were counted for the period of 1984 - 2013. **Table 2-1** summarizes rainfall events on an annual basis for rainfall volume, max rainfall intensity, average intensity, average rainfall duration, quantities of rainfall events above 0.1 inch and 0.25 inch, and back-to-back rainfall event number. Statistical river flow information is also included in **Table 2-1**.

Table 2-1 Annual Rainfall and River Flow Statistics 1984-2013

Year	Rainfall								Delaware River Flow (cfs)		
	Annual Rainfall (in)	Max Rainfall Intensity (in/hr)	Average Rainfall Intensity (in/hr)	Average Rainfall Duration (hr)	Events ≥0.10 in.	Events ≥0.25 in.	Events ≥1.5 in.	Back-to-Back Event	25th Percentile	50th Percentile	75th Percentile
1984	43.7	1.14	0.096	9.6	70	50	5	14	4,675	8,615	15,675
1985	35.2	1.10	0.091	9.7	56	40	3	8	4,470	6,340	9,000
1986	40.4	1.06	0.079	11.0	62	44	5	12	5,190	9,190	16,500
1987	33.3	0.66	0.073	11.3	56	40	1	7	5,660	9,000	12,500
1988	38.4	1.69	0.083	10.3	57	37	7	9	4,473	6,605	10,775
1989	48.5	1.50	0.076	11.0	69	51	8	14	5,210	7,610	13,400
1990	36.0	0.48	0.070	10.2	64	44	1	8	7,110	10,800	17,600
1991	36.2	1.26	0.082	11.2	55	40	5	7	3,240	5,720	12,400
1992	30.4	1.31	0.057	11.0	64	31	2	9	5,460	7,610	10,900
1993	42.2	1.11	0.098	9.8	61	43	8	6	4,070	7,210	13,600
1994	44.9	1.50	0.088	11.0	67	50	4	8	5,680	8,460	15,000
1995	31.6	1.00	0.070	9.5	53	34	3	1	4,260	6,670	10,700
1996	52.1	1.03	0.087	9.7	75	57	8	12	6,893	14,000	24,625
1997	32.5	0.84	0.078	10.2	65	46	1	11	3,860	6,870	13,000
1998	30.4	0.54	0.065	11.2	58	39	2	12	3,070	8,550	19,100
1999	47.4	0.95	0.077	11.7	60	47	6	10	3,500	7,650	11,400
2000	43.3	2.43	0.111	10.3	61	48	5	6	5,243	8,510	16,575
2001	30.6	1.03	0.072	11.0	50	36	5	4	3,370	5,400	9,770
2002	36.4	0.69	0.082	12.5	53	39	4	4	3,630	7,610	13,600

Year	Rainfall								Delaware River Flow (cfs)		
	Annual Rainfall (in)	Max Rainfall Intensity (in/hr)	Average Rainfall Intensity (in/hr)	Average Rainfall Duration (hr)	Events ≥0.10 in.	Events ≥0.25 in.	Events ≥1.5 in.	Back-to-Back Event	25th Percentile	50th Percentile	75th Percentile
2003	47.0	0.62	0.068	10.9	78	52	7	17	10,300	15,600	26,400
2004	48.6	1.17	0.077	10.8	67	48	6	8	8,158	12,500	18,125
2005	40.9	1.55	0.084	11.1	58	45	5	8	4,690	11,200	17,000
2006	48.0	1.23	0.089	10.2	64	52	8	13	8,180	12,200	19,000
2007	42.1	1.09	0.091	10.5	60	38	4	9	5,220	7,950	16,600
2008	40.3	1.29	0.083	11.1	59	38	7	6	4,910	9,825	20,200
2009	50.7	1.42	0.100	11.5	76	51	10	18	8,700	11,100	16,400
2010	40.3	1.24	0.094	12.4	52	39	5	8	4,680	9,610	14,100
2011	64.3	1.31	0.109	10.5	68	49	11	11	10,400	18,100	28,600
2012	35.9	1.46	0.098	7.9	62	44	4	10	5,255	8,235	12,700
2013	55.9	2.86	0.118	10.2	64	50	9	10	5,750	8,900	12,000
Average 1984-2013	**41.6**	**1.22**	**0.085**	**10.6**	**62**	**44**	**5.3**	**9.3**	**5,510**	**9,255**	**15,575**

2.2 Three-year Rainfall and River Flow Analysis

Three-year rainfall and river flow characteristics were developed based on an annual average of the three consecutive years. **Table 2-2** summarizes rainfall and river flow statistics in the 28 individual three-year periods.

Table 2-2 Three-year Rainfall and River Flow Statistics 1984-2013

Year	Rainfall								Delaware River Flow (cfs)		
	Annual Rainfall (in)	Max Rainfall Intensity (in/hr)	Average Rainfall Intensity (in/hr)	Average Rainfall Duration (hr)	Events ≥0.10 in.	Events ≥0.25 in.	Events ≥1.5 in.	Back-to-Back Event	25th Percentile	50th Percentile	75th Percentile
1984-1986	39.8	1.14	0.089	10.1	63	45	4	11	4,778	8,048	13,725
1985-1987	36.3	1.10	0.081	10.7	58	41	3	9	5,107	8,177	12,667
1986-1988	37.4	1.69	0.078	10.9	58	40	4	9	5,108	8,265	13,258
1987-1989	40.1	1.69	0.077	10.9	61	43	5	10	5,114	7,738	12,225
1988-1990	41.0	1.69	0.076	10.5	63	44	5	10	5,598	8,338	13,925
1989-1991	40.2	1.50	0.075	10.8	63	45	5	10	5,187	8,043	14,467
1990-1992	34.2	1.31	0.069	10.8	61	38	3	8	5,270	8,043	13,633
1991-1993	36.3	1.31	0.079	10.7	60	38	5	7	4,257	6,847	12,300
1992-1994	39.2	1.50	0.081	10.6	64	41	5	8	5,070	7,760	13,167
1993-1995	39.5	1.50	0.086	10.2	60	42	5	5	4,670	7,447	13,100
1994-1996	42.9	1.50	0.083	10.1	65	47	5	7	5,611	9,710	16,775
1995-1997	38.7	1.03	0.079	9.8	64	46	4	8	5,004	9,180	16,108
1996-1998	38.3	1.03	0.078	10.3	66	47	4	12	4,608	9,807	18,908

Year	Rainfall								Delaware River Flow (cfs)		
	Annual Rainfall (in)	Max Rainfall Intensity (in/hr)	Average Rainfall Intensity (in/hr)	Average Rainfall Duration (hr)	Events ≥0.10 in.	Events ≥0.25 in.	Events ≥1.5 in.	Back-to-Back Event	25th Percentile	50th Percentile	75th Percentile
1997-1999	36.8	0.95	0.074	11.0	61	44	3	11	3,477	7,690	14,500
1998-2000	40.4	2.43	0.085	11.1	60	45	4	9	3,938	8,237	15,692
1999-2001	40.4	2.43	0.087	11.0	57	44	5	7	4,038	7,187	12,582
2000-2002	36.8	2.43	0.090	11.2	55	41	5	5	4,081	7,173	13,315
2001-2003	38.0	1.03	0.073	11.4	60	42	5	8	5,767	9,537	16,590
2002-2004	44.0	1.17	0.075	11.3	66	46	6	10	7,363	11,903	19,375
2003-2005	45.5	1.55	0.075	10.9	68	48	6	11	7,716	13,100	20,508
2004-2006	45.8	1.55	0.083	10.7	63	48	6	10	7,009	11,967	18,042
2005-2007	43.6	1.55	0.088	10.6	61	45	6	10	6,030	10,450	17,533
2006-2008	43.4	1.29	0.088	10.6	61	43	6	9	6,103	9,992	18,600
2007-2009	44.3	1.42	0.092	11.1	65	42	7	11	6,277	9,625	17,733
2008-2010	43.7	1.42	0.093	11.6	62	43	7	11	6,097	10,178	16,900
2009-2011	51.7	1.42	0.102	11.4	65	46	9	12	7,927	12,937	19,700
2010-2012	46.8	1.46	0.101	10.2	61	44	7	10	6,778	11,982	18,467
2011-2013	52.1	2.86	0.109	9.6	65	48	8	10	7,135	11,745	17,767
Average 1984-2013	41.3	1.18	0.084	10.7	62	44	5	9	5,540	9,325	15,770

2.3 Ranking Analysis

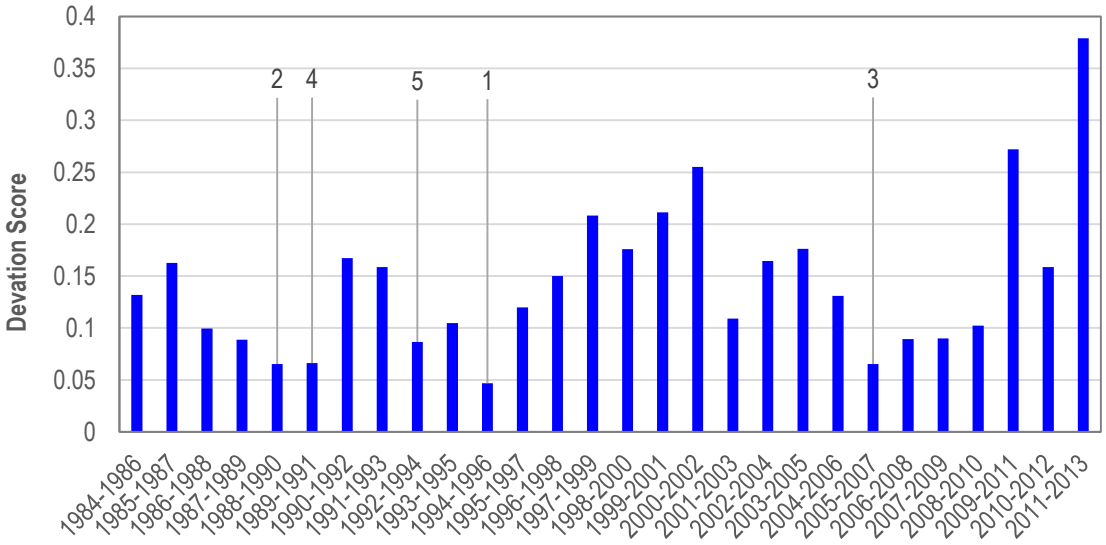
From **Table 2-2** the relative deviation for each parameter was calculated for individual 3-year period. With the weighting factors listed in **Table 1-1**, a deviation score was developed for each individual period. The 3-year periods were then ranked based on the deviation score. The lower the deviation score (**Figure 2-1** Y-axis), the higher the rank for the hydrologic period (i.e., the closer it is to the average condition). **Table 2-3** and **Figure 2-1** shows the ranking results of the 28 hydrologic periods, with a ranking of 1 being the highest and a ranking of 28 being the lowest ranked hydrologic period. Hydrologic period 1994-1996 is ranked No.1 because it has the lowest deviation score of 0.047.

Table 2-3 Typical Period Ranking Analysis

Year	Rainfall								Delaware River Flow			Deviation Score	Rank
	Annual Rainfall	Max Rainfall Intensity	Average Rainfall Intensity	Average Rainfall Duration	Events ≥0.10 in	Events ≥0.25 in	Events ≥1.5 in.	Back-to-Back Event	25th Pct	50th Pct	75th Pct		
Wt. Factor	25%	20%	5%	2.5%	2.5%	2.5%	7.5%	5%	2.5%	25%	2.5%		
1984-1986	4%	26%	6%	6%	1%	2%	18%	23%	14%	14%	13%	0.132	15
1985-1987	12%	28%	3%	0%	6%	6%	43%	2%	8%	12%	20%	0.163	19
1986-1988	10%	10%	7%	1%	6%	8%	18%	1%	8%	11%	16%	0.100	9

Year	Rainfall								Delaware River Flow			Deviation Score	Rank
	Annual Rainfall	Max Rainfall Intensity	Average Rainfall Intensity	Average Rainfall Duration	Events ≥0.10 in	Events ≥0.25 in	Events ≥1.5 in.	Back-to-Back Event	25th Pct	50th Pct	75th Pct		
Wt. Factor	25%	20%	5%	2.5%	2.5%	2.5%	7.5%	5%	2.5%	25%	2.5%		
1987-1989	3%	10%	8%	1%	2%	3%	1%	9%	8%	17%	22%	0.089	6
1988-1990	1%	10%	9%	2%	2%	0%	1%	12%	1%	11%	12%	0.065	2
1989-1991	3%	2%	10%	1%	1%	3%	11%	5%	6%	14%	8%	0.066	4
1990-1992	17%	15%	18%	1%	2%	13%	49%	13%	5%	14%	14%	0.167	21
1991-1993	12%	15%	6%	1%	3%	13%	5%	20%	23%	27%	22%	0.159	18
1992-1994	5%	2%	3%	1%	3%	6%	11%	17%	8%	17%	17%	0.087	5
1993-1995	4%	2%	3%	5%	3%	3%	5%	46%	16%	20%	17%	0.105	11
1994-1996	4%	2%	1%	6%	5%	7%	5%	24%	1%	4%	6%	0.047	1
1995-1997	6%	33%	5%	8%	4%	4%	24%	13%	10%	2%	2%	0.120	13
1996-1998	7%	33%	7%	4%	6%	8%	30%	27%	17%	5%	20%	0.150	16
1997-1999	11%	38%	12%	3%	2%	0%	43%	19%	37%	18%	8%	0.208	24
1998-2000	2%	58%	1%	3%	4%	2%	18%	1%	29%	12%	0%	0.176	22
1999-2001	2%	58%	4%	3%	8%	0%	1%	28%	27%	23%	20%	0.211	25
2000-2002	11%	58%	7%	5%	12%	6%	11%	49%	26%	23%	16%	0.255	26
2001-2003	8%	33%	13%	6%	3%	3%	1%	10%	4%	2%	5%	0.109	12
2002-2004	6%	24%	11%	5%	6%	6%	8%	5%	33%	28%	23%	0.165	20
2003-2005	10%	1%	10%	2%	9%	10%	14%	19%	39%	40%	30%	0.176	23
2004-2006	11%	1%	0%	0%	2%	10%	20%	5%	27%	28%	14%	0.131	14
2005-2007	6%	1%	5%	1%	2%	3%	8%	9%	9%	12%	11%	0.065	3
2006-2008	5%	16%	5%	1%	2%	3%	20%	1%	10%	7%	18%	0.089	7
2007-2009	7%	7%	10%	3%	5%	3%	33%	19%	13%	3%	12%	0.090	8
2008-2010	6%	7%	11%	8%	1%	3%	39%	16%	10%	9%	7%	0.102	10
2009-2011	25%	7%	21%	6%	5%	6%	65%	34%	43%	39%	25%	0.272	27
2010-2012	13%	5%	21%	5%	2%	0%	27%	5%	22%	28%	17%	0.159	17
2011-2013	26%	86%	30%	11%	4%	9%	52%	12%	29%	26%	13%	0.379	28

Figure 2-1 Ranking Score of 3-year Period, 1984-2013



2.4 Top 5 Ranked 3-year Hydrologic Periods

Based on the ranking analysis, the top 5 ranked hydrologic periods are:

- Rank 1: 1994-1996
- Rank 2: 1988-1990
- Rank 3: 2005-2007
- Rank 4: 1989-1991
- Rank 5: 1992-1994

Table 2-4 shows rainfall and river flow statistics for these top ranked hydrologic periods.

Table 2-4 Top 5 Ranked Hydrologic Periods

Rank	Year	Rainfall								Delaware River Flow (cfs)		
		Annual Rainfall (in)	Max Rainfall Intensity (in/hr)	Average Rainfall Intensity (in/hr)	Average Rainfall Duration (hr)	Events ≥0.10 in.	Events ≥0.25 in.	Events ≥1.5 in.	Back-to-Back Event	25th Percentile	50th Percentile	75th Percentile
1	1994-1996	42.9	1.50	0.08	10.1	65	47	5	7	5,611	9,710	16,775
2	1988-1990	41.0	1.69	0.08	10.5	63	44	5	10	5,598	8,338	13,925
3	2005-2007	43.6	1.55	0.09	10.6	61	45	6	10	6,030	10,450	17,533
4	1989-1991	40.2	1.50	0.08	10.8	63	45	5	10	5,187	8,043	14,467
5	1992-1994	39.2	1.50	0.08	10.6	64	41	5	8	5,070	7,760	13,167
Average 1984-2013		41.3	1.53	0.08	10.7	62	44	5	9	5,540	9,325	15,770

Figure 2-2(a) shows the max rainfall day for each month from 1988 through 2013. Max rainfall day in the month is determined by analyzing the daily rainfall amount and the day with the maximum rainfall amount is selected as the max rainfall day for the month. Max rainfall day in the month is probably the precipitation day that causes the maximum wet weather inflow to the collection system and CSO overflows in the month. **Figure 2-2(b)** shows the river flow and flow statistics for the max rainfall day in the month. The selected typical hydrologic period must ensure that large storm events do not occur under the extremely low river flow conditions. **Figure 2-2** indicates that all the top 5 ranked hydrologic periods meet this criteria.

Rainfall return frequency during 1988 through 2013 was analyzed to understand the distribution of the large rainfall events with return frequencies above 1-year. Rainfall return frequency is shown for each month in **Figure 2-2** (the number in the parentheses indicates the quantity of rain events at the return frequency). **Table 2-5** summarizes quantity of large rainfall events with return frequencies for the top 5 ranked hydrologic periods.

- All of the top 5 hydrologic periods have a 25-yr storm.
- Hydrologic period 1994-1996 (Rank 1) contains one 25-yr storm, one 10-yr storm and three 1-year storm. Hydrologic period 1988-1990 (Rank 2) contains one 25-yr storm, one 10-yr storm, three 2-year storm and one 1-year storm.
- Hydrologic period 1994-1996 (Rank 1) is more conservative because its annual average rainfall amount of 42.9" is slightly greater than the 30-yr average. It is considered a better option than hydrologic period 1988-1990 (Rank 2), which has a slightly less annual rainfall than the average.

Table 2-5 Rainfall Return Frequency Summary for the Top 5 Ranked Hydrologic Periods

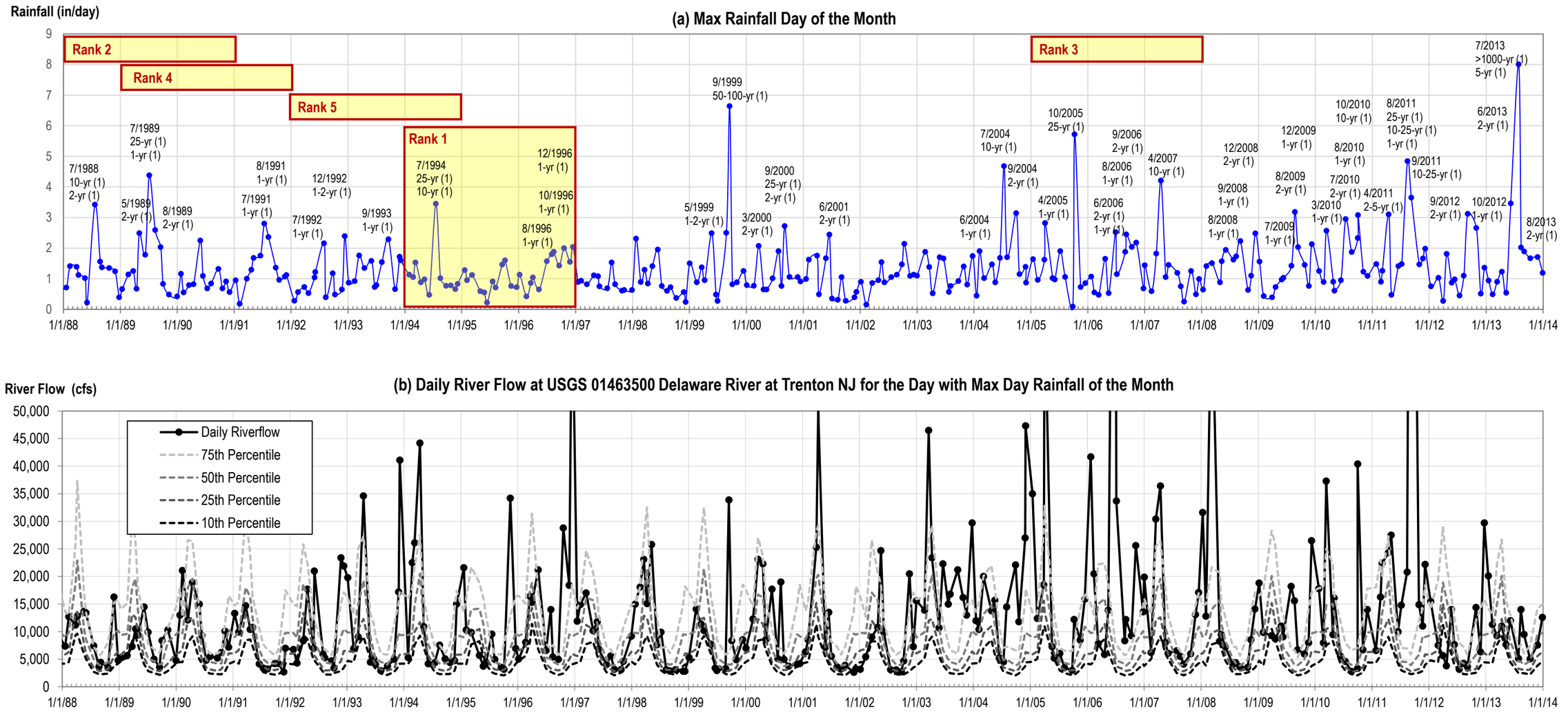
Rank	Year	Quantity of Rainfall Events with Return Frequency above				
		25-yr	10-yr	5-yr	2-yr	1-yr
1	1994-1996	1	1			3
2	1988-1990	1	1		3	1
3	2005-2007	1	1		2	4
4	1989-1991	1			2	3
5	1992-1994	1	1			3

The analysis was also conducted with an IET of 12 hours, and the top five ranked hydrologic periods were shown in **Table 2-6**. The top four hydrologic periods based on the IET of 12 hours are the same as the analysis based on the IET of 6 hours, which include the 3-year period 1994 - 1996 remaining as Rank 1.

Table 2-6 Top 5 Ranked Hydrologic Periods (IET = 12 hr)

Rank	Year	Rainfall								Delaware River Flow (cfs)		
		Annual Rainfall (in)	Max Rainfall Intensity (in/hr)	Average Rainfall Intensity (in/hr)	Average Rainfall Duration (hr)	Events ≥0.10 in.	Events ≥0.25 in.	Events ≥1.5 in.	Back-to-Back Event	25th Percentile	50th Percentile	75th Percentile
1	1994-1996	42.9	1.50	0.08	12.5	62	47	6	4	5,611	9,710	16,775
2	1988-1990	41.0	1.69	0.07	13.9	59	43	6	5	5,598	8,338	13,925
3	2005-2007	43.6	1.55	0.08	14.3	55	43	6	5	6,030	10,450	17,533
4	1989-1991	40.2	1.50	0.06	14.9	57	43	5	4	5,187	8,043	14,467
5	2007-2009	44.3	1.42	0.08	14.6	60	42	8	6	6,277	9,625	17,733
Average 1984-2013		**41.3**	**1.53**	**0.07**	**14.1**	**58**	**43**	**6**	**5**	**5,540**	**9,325**	**15,770**

Figure 2-2 Max Day Rainfall in the Month and Delaware River Daily Flows 1988-2013



2.5 Recommendation

It is recommended the 3-year period 1994-1996 (Rank 1) be selected as the typical hydrologic period for the CSO LTCPU. This period contains a wide range of storms and antecedent conditions. The hydrologic period of 1994-1996 is also evaluated for longer historical rainfall records up to 100 years. It is ranked No. 1 for the 50-years record and No.2 for the 100-year records (**Table 2-7**).

Table 2-7 Rank of Hydrologic Period 1994-1996 from Various Rainfall Data Set

	30-year Rainfall Records, 1984-2013	50-year Rainfall Records, 1964-2013	100-year Rainfall Records, 1914-2013
Rank of 1994-1996	1	1	2 (1925-1927 as Rank 1)

2.6 Additional Information on Statistical Analysis of Rainfall and River Flow Data

Figure 2-3 shows annual rainfall and average annual rainfall for years 1983-2013. The hydrologic period 1994-1996 contains a relatively wet year (1996 with 52.1 inches), a dry year (1995 with 31.6 inches) and a year close to average conditions (1994 with 44.9 inches).

Figure 2-4 shows annual average Delaware River flow and average flow for years 1983-2013. The hydrologic period 1994-1996 contains a relatively high flow year (1996 with 19,000 cfs), a low flow year (1995 with 9,000 cfs) and a year close to average conditions (1994 with 13,500 cfs).

Figure 2-3 Annual Rainfall 1983 - 2013

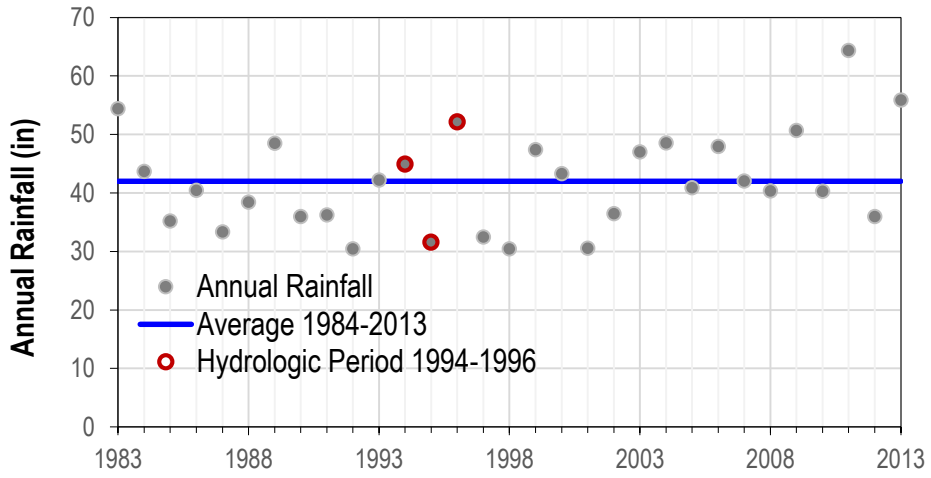
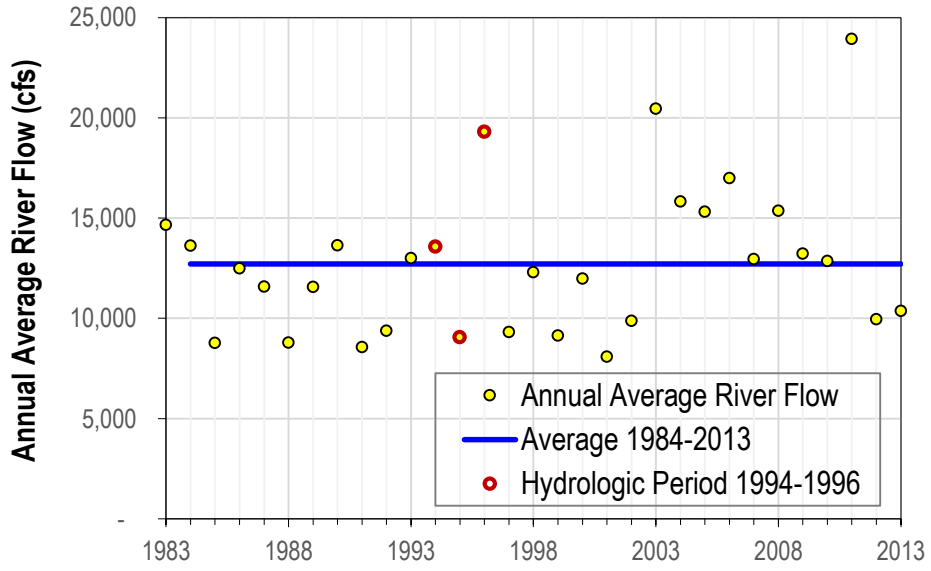


Figure 2-4 Annual Average Delaware River Flow 1983 - 2013



Delaware River flow distribution was developed for each calendar day using 100 years of records from 1913 to 2013, as shown in **Figure 2-5**. The River flow varies through the year with high flow season around March-April, and low flow season around June-August. **Figure 2-6** shows the Delaware River flow distribution during rainfall events at and above 1-year return frequency. Each dot on the plot represents an individual day during the storm events. It is observed that the river flows have a wide range of distribution during rainfall events below 2-yr return frequency. During larger storm events (greater than 5-year storms), the river flows tend to be relatively higher, as indicated by more dots with higher distribution percentiles on the plot. For example, during most of the 10-year storm events, the river flows are above the 35th percentile. In rare cases, large storm events occurred during a relatively low flow condition (e.g., the lowest dot for the 10-year storm), which is not a typical condition.

Figure 2-5 Delaware River Daily Flow Distribution

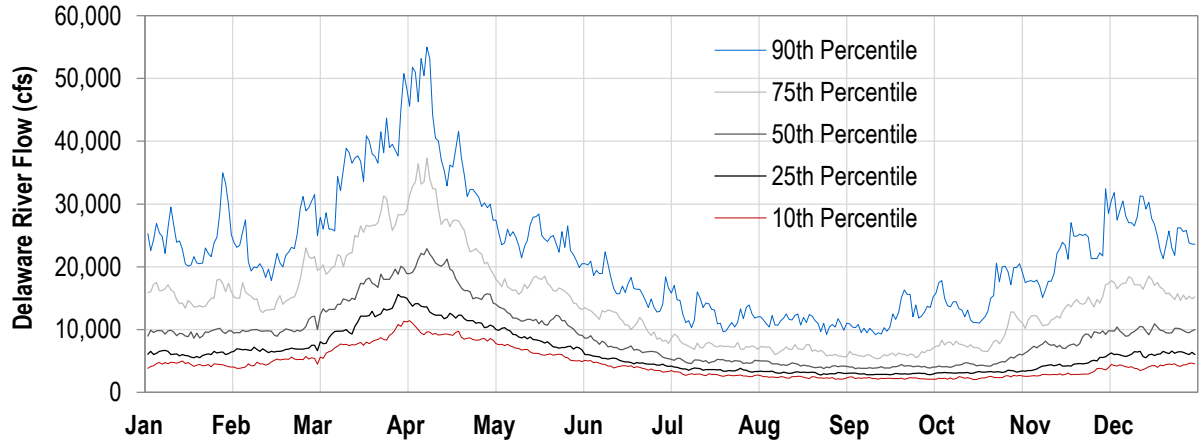


Figure 2-6 River Flow Distribution during Rainfall Events Greater Than 1-year Return Frequency

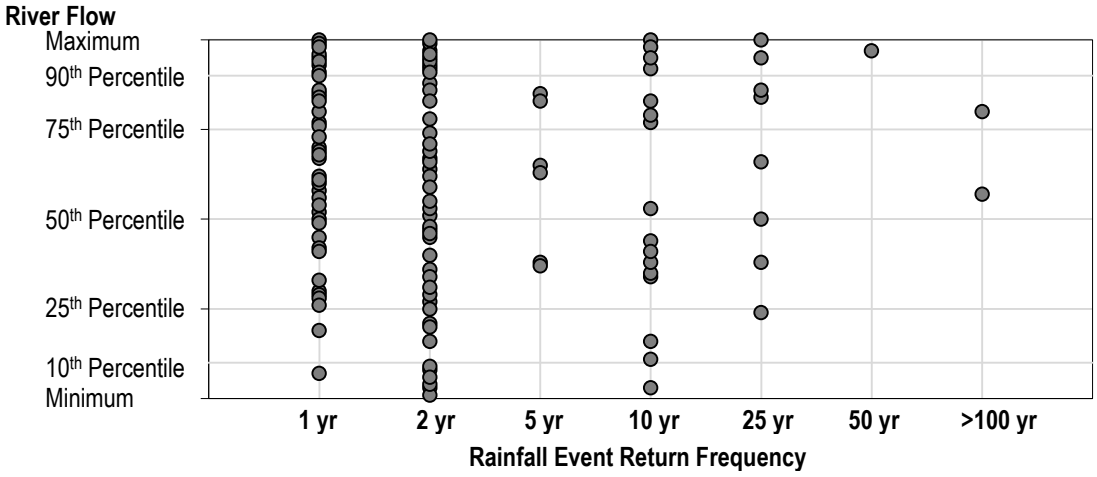


Figure 2-7 shows the daily rainfall profile and daily Delaware River flow hydrograph for the hydrologic period 1994-1996. This period includes two large storm events in July 1994 (a 10-year storm in July 14, 1994 and a 25-year storm in July 18, 1994). During these large storm events, the River flows were around 40th to 50th percentile (**Figure 2-8**). This is consistent with the typical trend shown in **Figure 2-6**. **Figure 2-9** shows Chester Creek and Ridley Creek flows in July 1994, it is obvious that creek flows are highly influenced by local precipitation and the big storms in July 1994 resulted in high creek flows.

Characteristics of the top 10 storms (by rainfall depth) in each year of the hydrologic period 1994-1996 are shown in **Table 2-8**, **Table 2-9**, and **Table 2-10**.

Figure 2-7 Daily Rainfall and River Flow Conditions 1994-1996

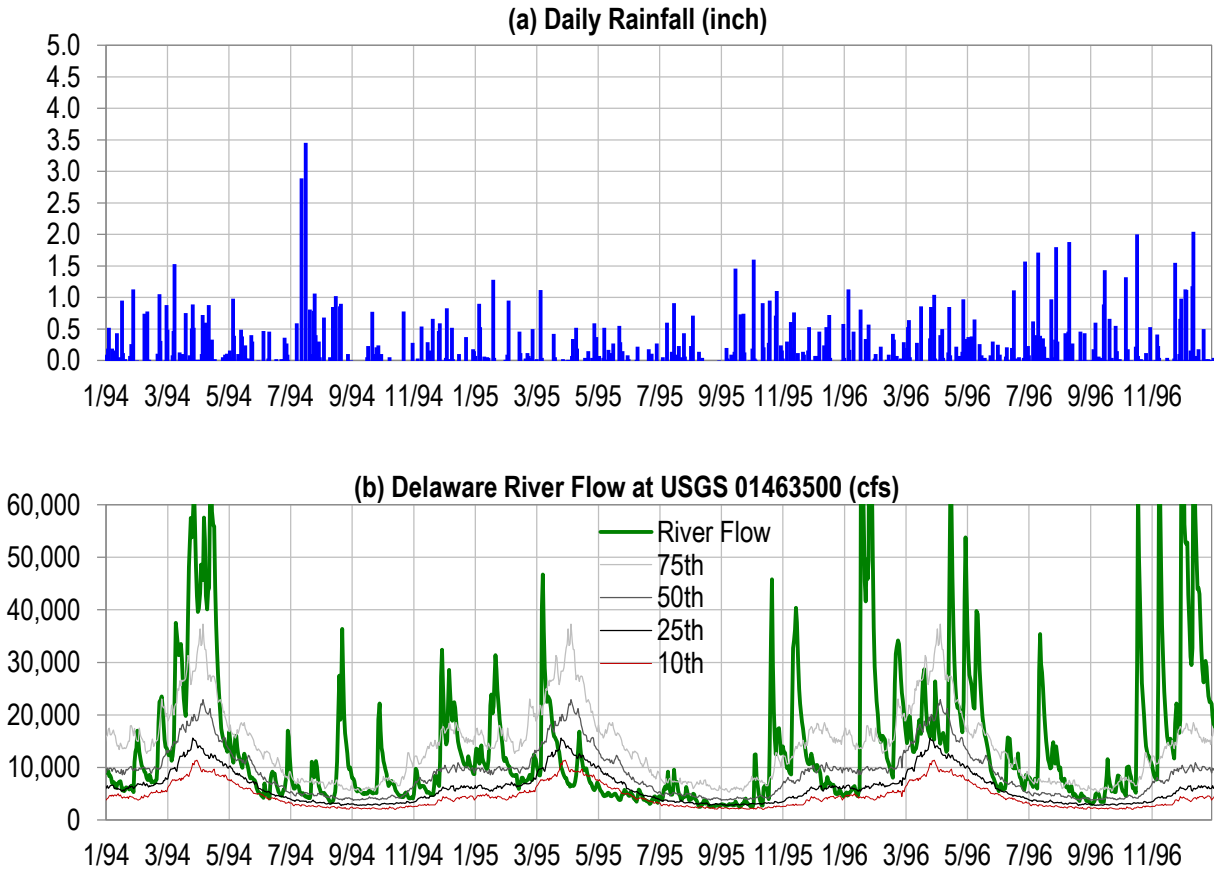


Figure 2-8 Rainfall and River Flow in July, 1994

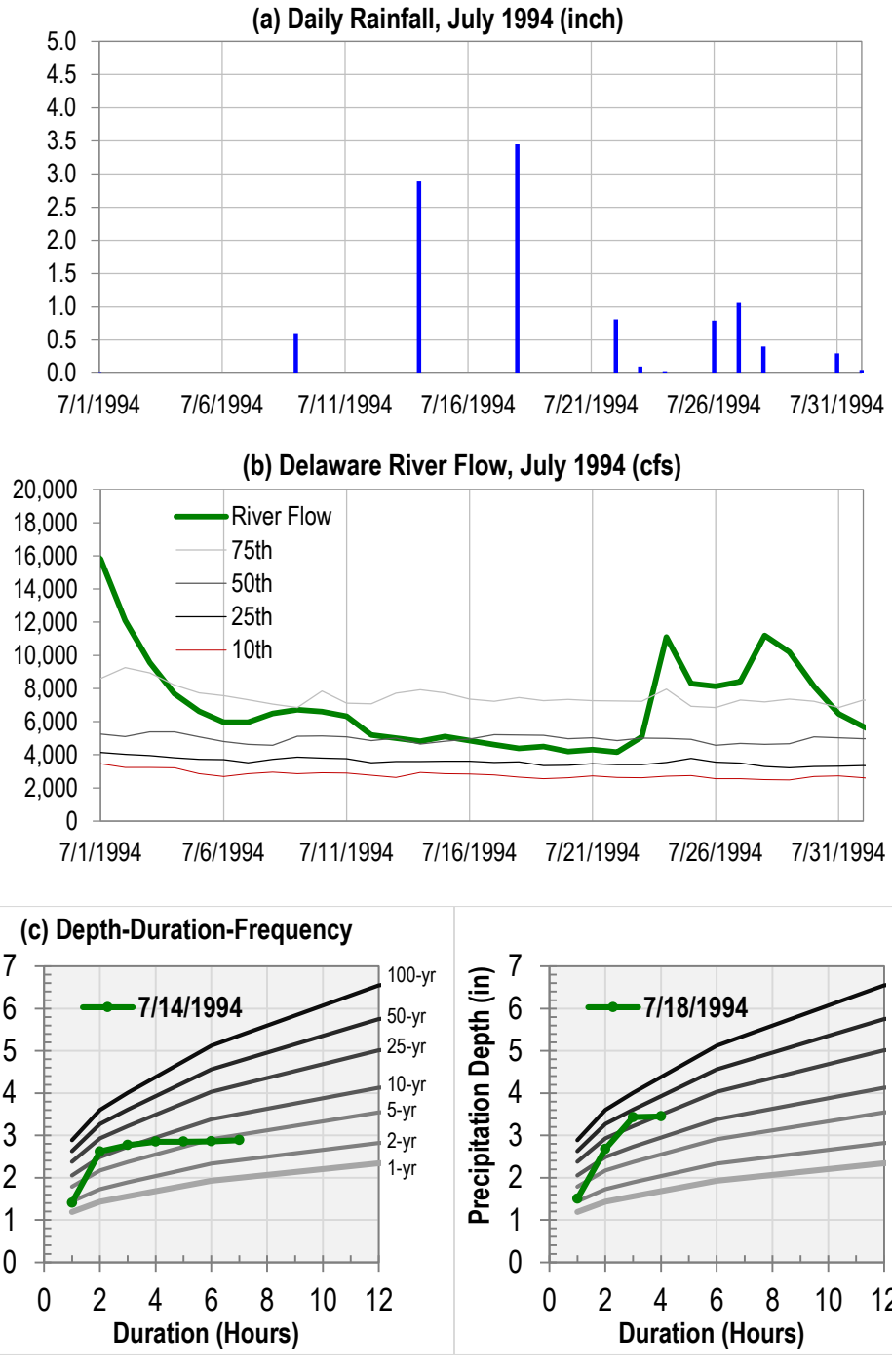


Figure 2-9 Rainfall and Creek Flow in July, 1994

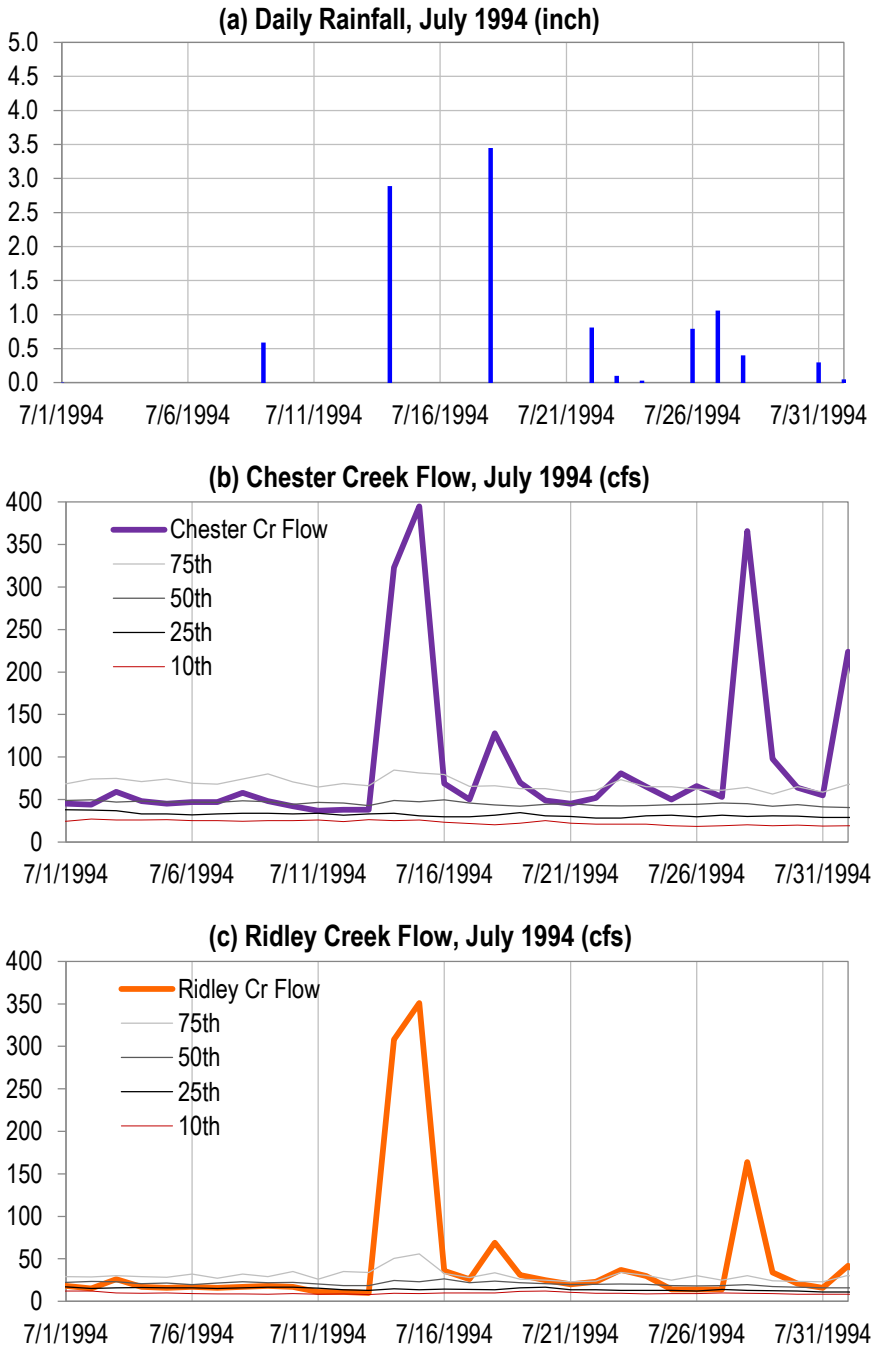


Table 2-8 Ten Largest Storms and Return Frequencies in 1994

Top 10 Rainfall Event	Rainfall Start Date and Time	Rainfall Volume (in)	Rainfall Duration (hr)	Max Rainfall Intensity (in/hr)	Rainfall Return Period
1	7/18/1994 7:00	3.45	4	1.5	25-yr
2	7/14/1994 15:00	2.89	7	1.41	10-yr
3	3/9/1994 11:00	2.00	27	0.37	< 1 year
4	8/21/1994 19:00	1.76	18	0.49	< 1 year
5	3/28/1994 0:00	1.41	37	0.14	< 1 year
6	5/7/1994 15:00	1.37	15	0.25	< 1 year
7	3/2/1994 9:00	1.32	22	0.14	< 1 year
8	1/27/1994 19:00	1.15	20	0.2	< 1 year
9	7/27/1994 17:00	1.11	8	0.49	< 1 year
10	1/17/1994 10:00	1.07	18	0.18	< 1 year

Table 2-9 Ten Largest Storms and Return Frequencies in 1995

Top 10 Rainfall Event	Rainfall Start Date and Time	Rainfall Volume (in)	Rainfall Duration (hr)	Max Rainfall Intensity (in/hr)	Rainfall Return Period
1	10/4/1995 18:00	1.82	33	0.54	< 1 year
2	10/27/1995 20:00	1.81	13	0.5	< 1 year
3	9/16/1995 22:00	1.6	13	0.24	< 1 year
4	1/6/1995 18:00	1.43	11	0.27	< 1 year
5	1/20/1995 0:00	1.25	10	1	< 1 year
6	10/20/1995 21:00	1.21	16	0.52	< 1 year
7	3/8/1995 17:00	1.16	8	0.29	< 1 year
8	10/14/1995 7:00	1.12	21	0.25	< 1 year
9	2/3/1995 22:00	1.04	15	0.2	< 1 year
10	7/17/1995 22:00	1.00	4	0.48	< 1 year

Table 2-10 Ten Largest Storms and Return Frequencies in 1996

Top 10 Rainfall Event	Rainfall Start Date and Time	Rainfall Volume (in)	Rainfall Duration (hr)	Max Rainfall Intensity (in/hr)	Rainfall Return Period
1	12/13/1996 13:00	3.03	33	0.27	1-yr
2	8/12/1996 19:00	2.34	13	0.52	1-yr
3	9/16/1996 14:00	2.26	16	0.38	< 1 year
4	10/18/1996 16:00	2.22	19	0.54	1-yr
5	7/12/1996 15:00	2.11	22	0.4	< 1 year
6	12/1/1996 7:00	1.62	23	0.56	< 1 year
7	6/29/1996 22:00	1.61	17	0.26	< 1 year
8	11/25/1996 23:00	1.58	10	0.38	< 1 year
9	7/31/1996 20:00	1.48	4	1.03	< 1 year
10	10/8/1996 10:00	1.32	11	0.24	< 1 year

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

MAY 23 2016

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Michael J. DiSantis, Director
Operations & Maintenance
Delaware County Regional Quality Control Authority
100 East Fifth Street
Chester, PA 19013

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

Dear Mr. Disantis:

The United States Environmental Protection Agency (EPA) has received the Delaware County Regional Quality Control Authority (DELCORA) Typical Hydrologic Period Report (Updated April 2016). EPA has consulted with the Pennsylvania Department of the Environment (PaDEP). EPA hereby approves the subject plan.

Thank you for your continued cooperation with this matter. Please do not hesitate to contact me at (215) 814-2097 if you have any questions.

Sincerely,

Andrew F. Seligman, Environmental Scientist
Water Enforcement Branch

cc: R. Smolski, EPA
P. Yeany, EPA
M. DiSantis, DELCORA
S. O'Neil, PaDEP SERO
J. Fields, PaDEP SERO

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APPENDIX F

SEWER SYSTEM HYDROLOGIC AND HYDRAULIC MODEL REPORT

- DELCORA Sewer System Hydrologic and Hydraulic Model Report dated June 2017
- Updated Appendix C Updated March 1, 2018 to address USEPA and PADEP Comments Received January 2, 2018
- USEPA Approval of the Sewer System Hydrologic and Hydraulic 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

Sewer System Hydrologic and Hydraulic Model Report

June 2017

GREELEY AND HANSEN

REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Sewer System Hydrologic and Hydraulic 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	6/27/17 Date
DELCORA ENGINEERING		
Director of Engineering	Signature	6/27/17 Date
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	Signature	6/27/17 Date

REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES

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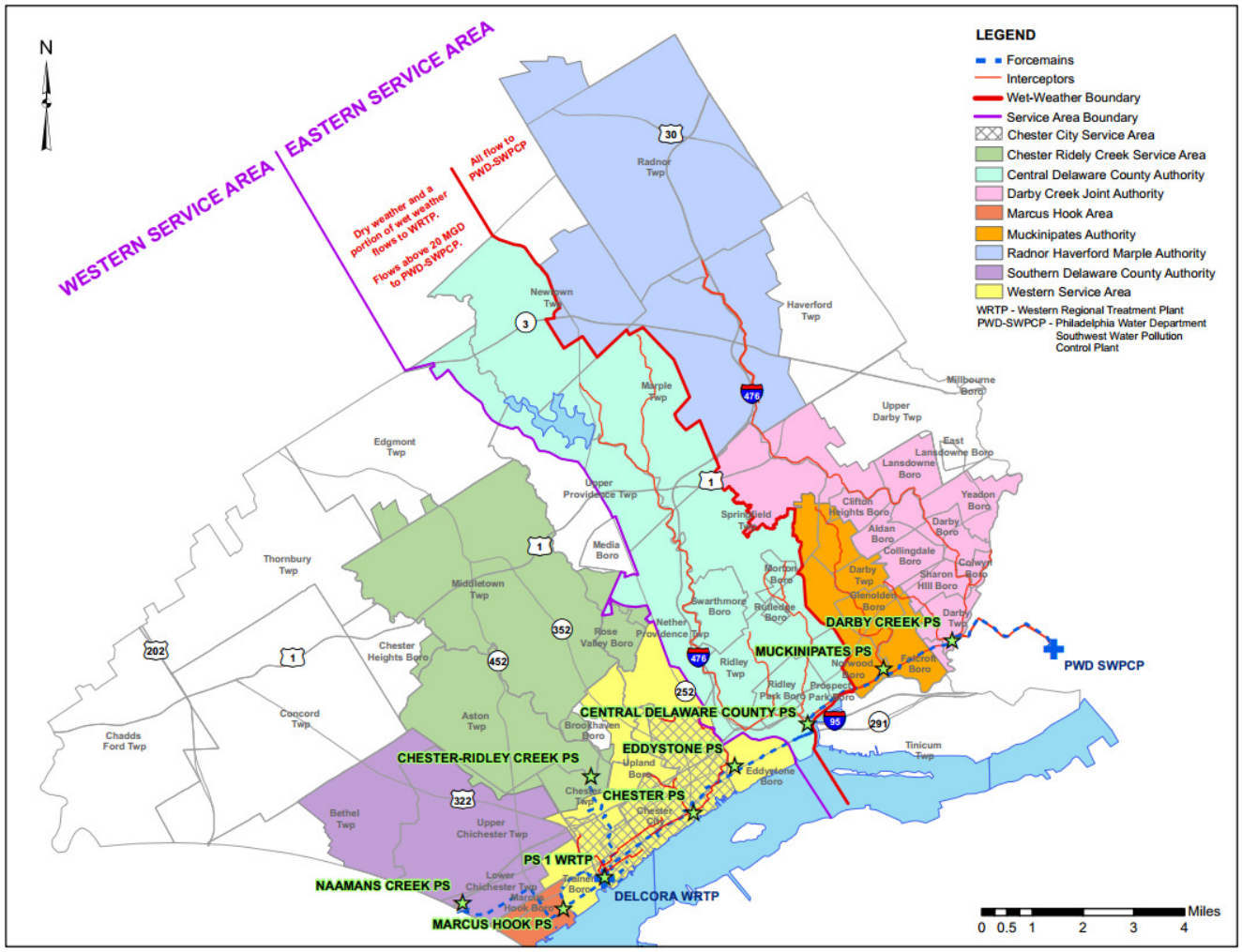
Section 1 Introduction

1.1 DELCORA's Service Area

Delaware County Regional Water Quality Control Authority (DELCORA) is responsible for the safe 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 interconnectivity coupled with the legal agreements that DELCORA maintains with the municipalities and conveyance authorities in Delaware County creates the complicated legal/financial framework under which DELCORA operates. The total service area served by DELCORA is approximately 82,977 acres, as shown on Figure 1-2: DELCORA'S Service Area



, which illustrates that DELCORA serves a significant and widespread portion of Delaware County. 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 combined sewer area simulated in the model, also shown in Figure 1-2, is located within the Chester City. It comprises approximately 49% of the Chester City's serviced area.

DELCORA has characterized its service areas as "Eastern" and "Western." Historically, the Eastern service area discharged to the Philadelphia Water Department's Southwest Water Pollution Control Plant (PWD-SWPCP) while the Western Service Area discharged to DELCORA's Western Regional Treatment Plant (WRTP). 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. Dry weather flow and a portion of the wet weather flow from the Central Delaware County Authority in the Eastern Service Area now discharges to the WRTP while only those CDPS flows above 20 MGD are to be directed to the PWD-SWPCP.

Eastern Service Area

The DELCORA Eastern Service Area is composed of four subareas that are served by conveyance authorities: Radnor Haverford Marple (RHM) Authority, Darby Creek Joint Authority (DCJA), Muckinipates Authority (MA), and Central Delaware County Authority (CDCA) and are delineated in Figure 1-2. Each of these authorities has a legal agreement with their member municipalities to dispose of their wastewater. In turn, DELCORA has legal agreements with each of the authorities, except RHM, to receive, treat, and dispose of the collected wastewater. RHM discharges to the DCJA. DELCORA owns and operates three large pump stations that serve DELCORA's Eastern service area; they are the Central Delaware Pump Station, the Muckinipates Pump Station, and the Darby Creek Pump Station. These pump stations were originally designed to pump the wastewater from DELCORA's Eastern Service Area to PWD-SWPCP for treatment.

The Central Delaware Pump Station (serving CDCA) is rated for 40 MGD. It was constructed in the 1970s to discharge all flow through a force main that is routed northeast toward the Muckinipates Pump Station. The operation of the pump station had been modified in 2002 to allow for flow from the CDPS to be discharged to the WRTP. Currently the wastewater flows above 20 MGD are conveyed to PWD-SWPCP. The next pump station is the 24-MGD Muckinipates Pump Station (serving MA). Here, the force main increases to 48 inches in diameter and continues approximately 1.65 miles northeast to the Darby Creek Pump Station. Upon reaching the 60-MGD Darby Creek Pump Station (serving DCJA and RHM), the force main increases in diameter to 66 inches and continues approximately 2.5 miles for ultimate discharge at PWD-SWPCP.

Under National Pollutant Discharge Elimination System (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 (CSO) outfalls (002-026, 032, 033) that ultimately discharge to the Delaware River, Chester Creek and/or Ridley Creek.

There are a total of 26 combined sewer overflow (CSO) outfalls listed with 25 discharge points (Outfalls 009 and 010 both discharge at Outfall 009) in DELCORA's existing NPDES Permit.

1.2 DELCORA's Consent Decree

DELCORA prepared and submitted their original Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) to the PADEP in 1999. This LTCP was subsequently approved by the PADEP, and DELCORA had started to implement the CSO control elements selected in the LTCP. In 2009, the United States Environmental Protection Agency (USEPA) informed DELCORA that the original LTCP was not in compliance with the requirements of the USEPA's CSO Policy. As such, DELCORA prepared and submitted a revised LTCP in April 2012. Subsequent to the receipt of the revised LTCP, DELCORA and the USEPA had corresponded various times including requests for additional information from the USEPA in accordance with Section 308 of the Clean Water Act. A Consent Decree was issued by the USEPA to DELCORA in June 2015. A Consent Decree was ultimately executed between DELCORA, the Pennsylvania Department of Environmental Protection (PADEP) and USEPA, was lodged on August 17, 2015 and was approved by the Federal District Court on November 10, 2015. The final Consent Decree requires that a new LTCP be prepared based on a 42-month schedule from the date of lodging (August 17, 2015), which includes interim deliverables and milestones that must be met.

DELCORA's original Hydrologic and Hydraulic Model (H&H Model) was updated to meet the requirements in Section V.A.14.a-f of the Consent Decree. These requirements along with a description of submissions made to comply with these requirements appear in Table 1-1.

Figure 1-1: DELCORA's Conveyance System

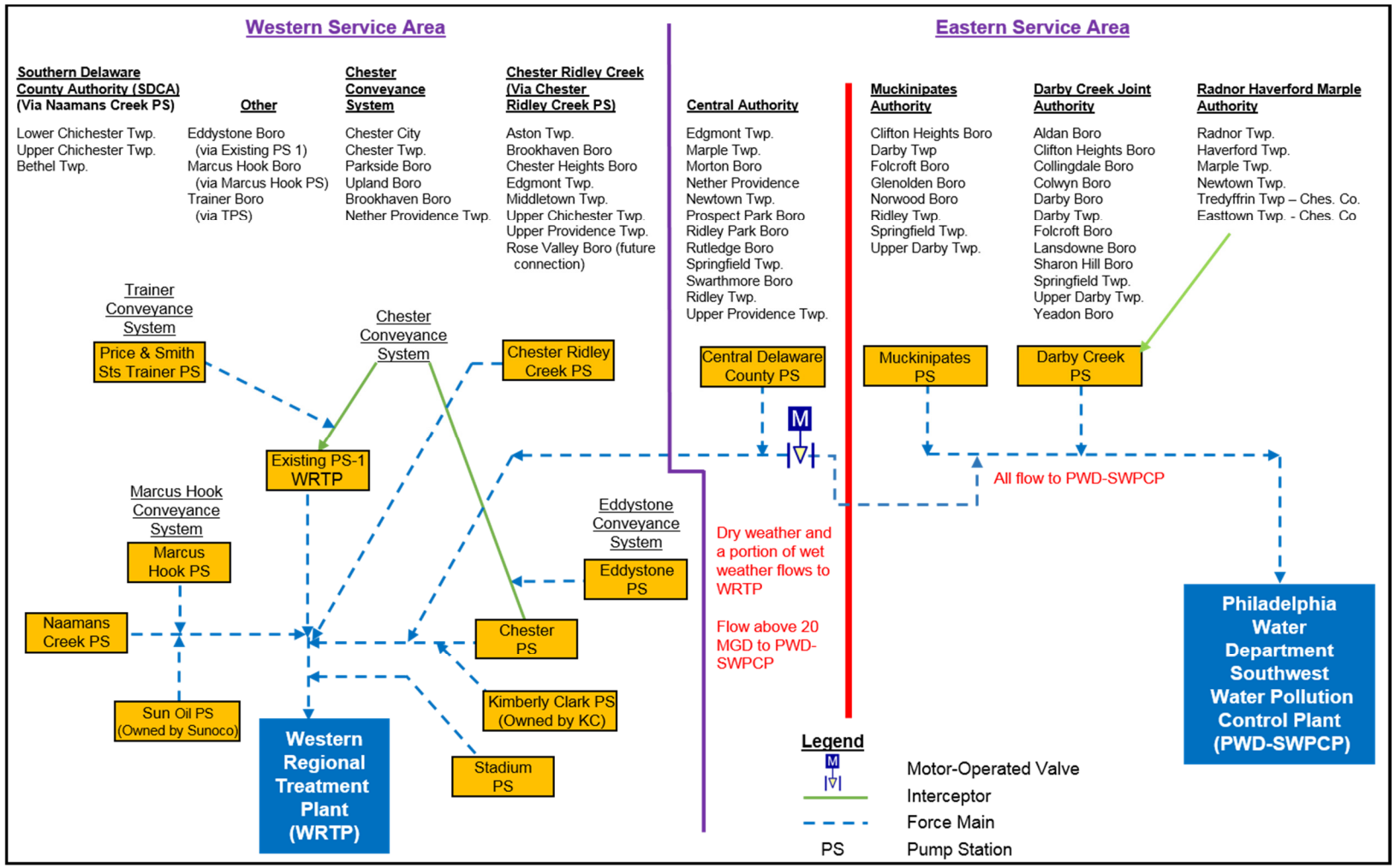


Figure 1-2: DELCORA'S Service Area

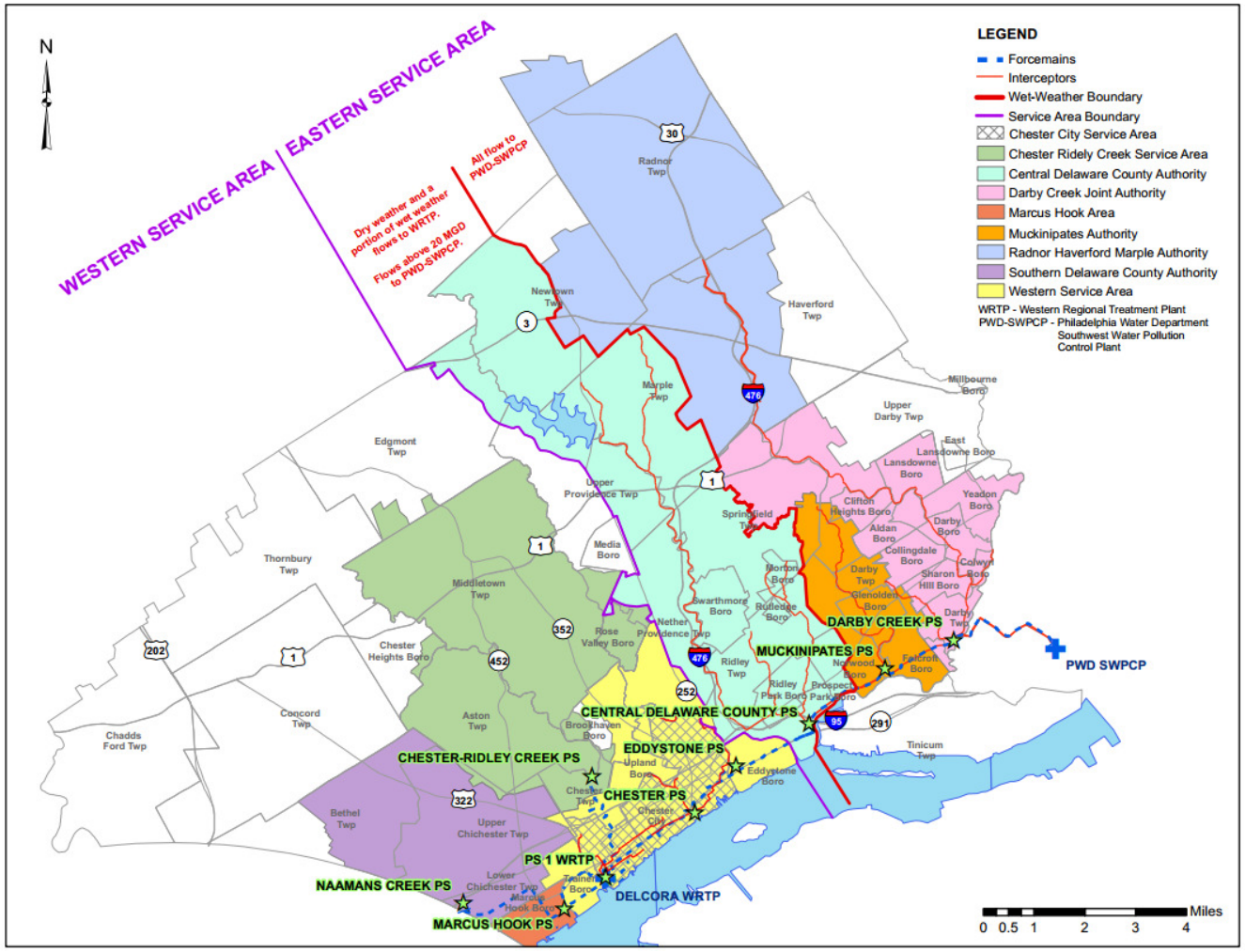


Table 1-1: Summary of Consent Decree Section V.A.14

Consent Decree Requirement	Submission Addressing Consent Decree Requirement
§V.A.14.a *a. Not later than sixty (60) Days after the Date of Lodging of this Consent Decree, DELCORA shall submit a detailed plan to update, calibrate, and validate the H&H Model to Plaintiffs for review and approval pursuant to Section VI (Review and Approval of Submittals). The plan shall address:* *(i) Model Update Methodology.* *(ii) Hydrologic and Hydraulic Model Refinement.* *(iii) Flow Data Assessment, and additional Rainfall and Flow Monitoring to be Carried Out.* *(iv) Dry Weather Flow Calibration, including quantitative and qualitative calibration criteria.* *(v) Wet Weather Flow Calibration, including quantitative and qualitative calibration criteria.* *(vi) Model Validation; and* *(vii) Schedule for model development and implementation, including integration into LTCP development consistent with other dates required pursuant to this Consent Decree.",*	Addressed through submission of the *Hydrologic and Hydraulic Model Update and Calibration Plan* (Greeley and Hansen, 2015) submitted on October 15, 2015 USEPA approved the plan on March 1, 2016. Schedule revised on July 28, 2016. Revised schedule can be found in Appendix A.
§V.A.14.b *b. The updated H&H Model shall specifically include hydrologic representation of all areas tributary to the entire Collection System, as well as all areas tributary to all municipal wastewater collection and transmission systems that are, as of the date the LTCP is submitted, hydraulically connected to, or that directly or indirectly influence flow to, the CSOs and/or the WRTP, regardless of who owns or operates the system(s), including but not limited to the entire "Western Service Area" and "Eastern Service Area" depicted on Figure 1-2 of the Long-Term Control Plan submitted by DELCORA in April 2012, and attached as Appendix A hereto (collectively, the "Model Area")."*	

Consent Decree Requirement	Submission Addressing Consent Decree Requirement
§V.A.14.c *c. The H&H Model shall accurately represent the response of the Model Area to wet weather events, including the flows that result from wet weather events to and from DELCORA's CSOs and to the WRTP. To accomplish this, the model shall explicitly include all interceptors, diversion structures, CSOs, pump stations and major trunk sewers within the Collection System, as well as such pipes and appurtenances within the areas outside the Collection System that are needed to ensure adequate H&H Model accuracy. The H&H Model shall also include all sewers required for model continuity and/or that hydraulically impact or are downstream of known chronic unpermitted releases. DELCORA shall investigate and collect current system attribute information as necessary to update the H&H Model.",*	Revisions to H&H model characterization of the system described in Section 3 of this report. Calibration and verification of model described in Section 4 of this report.
§V.A.14.d *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.*	Rainfall and flow monitoring approach described in Section 2 of this report Rainfall and flow monitoring data described in prior quarterly reports (see below) Minimum effective density of 1 gauge/virtual radar based gauge per square km was obtained as described in Section 2 of this report.
§V.A.14.e *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.*	Addressed through submission of the *Rainfall and Flow Monitoring Quarterly reports*. 1st Quarter: August 08, 2016 2nd Quarter: November 01, 2016 3rd Quarter: February 01, 2017 4th Quarter: May 01, 2017

Consent Decree Requirement	Submission Addressing Consent Decree Requirement
§V.A.14.f *Within 30 Days after the H&H Model is revised, calibrated, and validated in accordance with the schedule set forth in the plan, DELCORA shall submit a Sewer System H&H Model Report to Plaintiffs for review and approval in accordance with the requirements of Section VI (Review and Approval of Submittals). The Sewer System H&H Model Report shall specifically address each item set forth in Subparagraphs 14(a)(i)-(vii) hereof."*	Addressed through submission of the *Sewer System H&H Model Report*.

In order to comply with Sections V.A.14.d.and e of the Consent Decree, the 12-month rainfall and flow monitoring period was completed on March 31, 2017 and quarterly rainfall and flow monitoring memoranda were submitted.

The outstanding requirements described in Sections V.A.14b, c and f will be addressed in this Sewer System H&H Model Report (hereinafter referred to as Report). This Report will evaluate the Model Area comprising those areas hydraulically connected to the WRTP. Section V.A.14.b of the Consent Decree describes the Model Area as follows:

> *"b. The updated H&H Model shall specifically include hydrologic representation of all areas tributary to the entire Collection System, as well as all areas tributary to all municipal wastewater collection and transmission systems that are, as of the date the LTCP is submitted, hydraulically connected to, or that directly or indirectly influence flow to, the CSOs and/or the WRTP, regardless of who owns or operates the system(s), including but not limited to the entire "Western Service Area" and "Eastern Service Area" depicted on Figure 1-2 of the Long-Term Control Plan submitted by DELCORA in April 2012, and attached as Appendix A hereto (collectively, the "Model Area")."*

As shown in the schematic of DELCORA's conveyance system (see Figure 1-1), the conveyance system is divided into the Western Service Area and the Eastern Service Area. The Western Service Area discharges to DELCORA's WRTP and is therefore included in the Model Area. The Eastern Service Area is served by three pumps stations: the Central Delaware Pump Station, the Muckinipates Pump Station and the Darby Creek Pump Station. Up to 20 MGD (which includes both dry and wet weather flows) from the Central Delaware Pump Station can be pumped to, and thus is hydraulically connected to, DELCORA's WRTP. Therefore, municipalities connected to the Central Delaware Pump Station are considered part of the Model Area. Sewage from the Muckinipates Pump Station and the Darby Creek Pump Station flows to the PWD-SWPCP and cannot pump flow to the WRTP. Therefore, municipalities connected to these pump stations are not hydraulically connected to the WRTP and do not directly or indirectly influence CSOs or flow to the WRTP, and, therefore, are not considered part of the Model Area. In summary, the Model Area includes the municipalities in the Western Service Area plus those municipalities that are connected to the Central Delaware Pump Station, as described in Table 1-2.

Table 1-2: Model Area

Municipality ID No.	Municipality	Service Area
1	Aston Township	Western
2	Bethel Township	Western
3	Brookhaven Borough	Western
4	Chester City	Western
5	Chester Township	Western
6	Eddystone Borough	Western
7	Edgmont Township	Eastern
8	Lower Chichester Township	Western
9	Marcus Hook Borough	Western
10	Marple	Eastern
11	Middletown Township	Western
12	Morton	Eastern
13	Nether Providence*	Eastern and Western
14	Newtown Township	Eastern
15	Parkside Borough	Western
16	Prospect Park	Eastern
17	Ridley Park Borough	Eastern
18	Ridley Township	Eastern
19	Rose Valley Borough	Western
20	Rutledge	Eastern
21	Springfield	Eastern
22	Swarthmore	Eastern
23	Trainer Borough	Western
24	Upland Borough	Western
25	Upper Chichester Township	Western
26	Upper Providence Township	Eastern and Western

As outlined in the *Hydrologic and Hydraulic Model Update and Calibration Plan* (Greeley and Hansen, 2015) and in conformance with Section V.A.14.c, the original H&H model was evaluated and updated as necessary to ensure inclusion of necessary components of the collection and conveyance system.

In addition, this Report includes results of the gauge-adjusted rainfall analysis (GARR) to demonstrate compliance with the requirement of Sections V.A.14.d that "…*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.*"

1.3 Contents in This Report

This report was prepared based on the requirements listed in the Consent Decree. The purpose of this document is to describe the development, calibration and validation of the updated sewer collection system H&H model. The 2012 H&H model was expanded to the Model Area and updated as needed to reflect current hydrologic and hydraulic conditions of DELCORA's collection system. After updating, the revised model was calibrated and validated with the additional rainfall and flow monitoring data so it can then be used to assist the Delaware County Regional Water Authority (DELCORA) throughout its combined sewer overflow (CSO) long-term control plan (LTCP) update process. Table 1-3 lists individual sections of this Report and their contents.

Table 1-3: DELCORA Sewer System H&H Model Report

Section	Description
Section 1 Introduction	Section 1 introduces DELCORA's system, Consent Decree requirements and the purpose of this report.
Section 2 Rainfall and Flow Monitoring	Section 2 provides an overview of the rain gauge and flow monitoring program and data analysis process for model input.
Section 3 DELCORA H&H Model Update	Section 3 summarizes the review of the original H&H model, describes general methodology used in the model update, and details the model updates made to the service area delineation, combined and separated area delineation, model network extension, regulator, and model inputs.
Section 4 DELCORA H&H Model Calibration and Validation	Section 4 provides a description of calibration and validation, lists criteria for dry weather and wet weather calibration, and illustrates calibration and validation method and results.
Section 5 Conclusion	Section 5 provides a short summary of the H&H Model Update, including model calibration results.

Section 2 Rainfall and Flow Monitoring

As per the Consent Decree, DELCORA was required to perform a Rainfall and Flow Monitoring program for at least 12 months and submit quarterly reports to document the findings of the program. This program started on March 18, 2016 and was completed on April 4, 2017. The rainfall and flow monitoring data were collected on a monthly basis. This section will discuss the network of rainfall and flow monitoring instrumentation, outline the monitoring program, and describe how the data collected for the Rainfall and Flow Monitoring Program was analyzed for use in the H&H Model calibration and validation.

2.1 Rainfall Monitoring and Analysis

A total of six (6) rain gauges were used for the monitoring program. As shown in Figure 2-1, the gauges are stationed at the following locations:

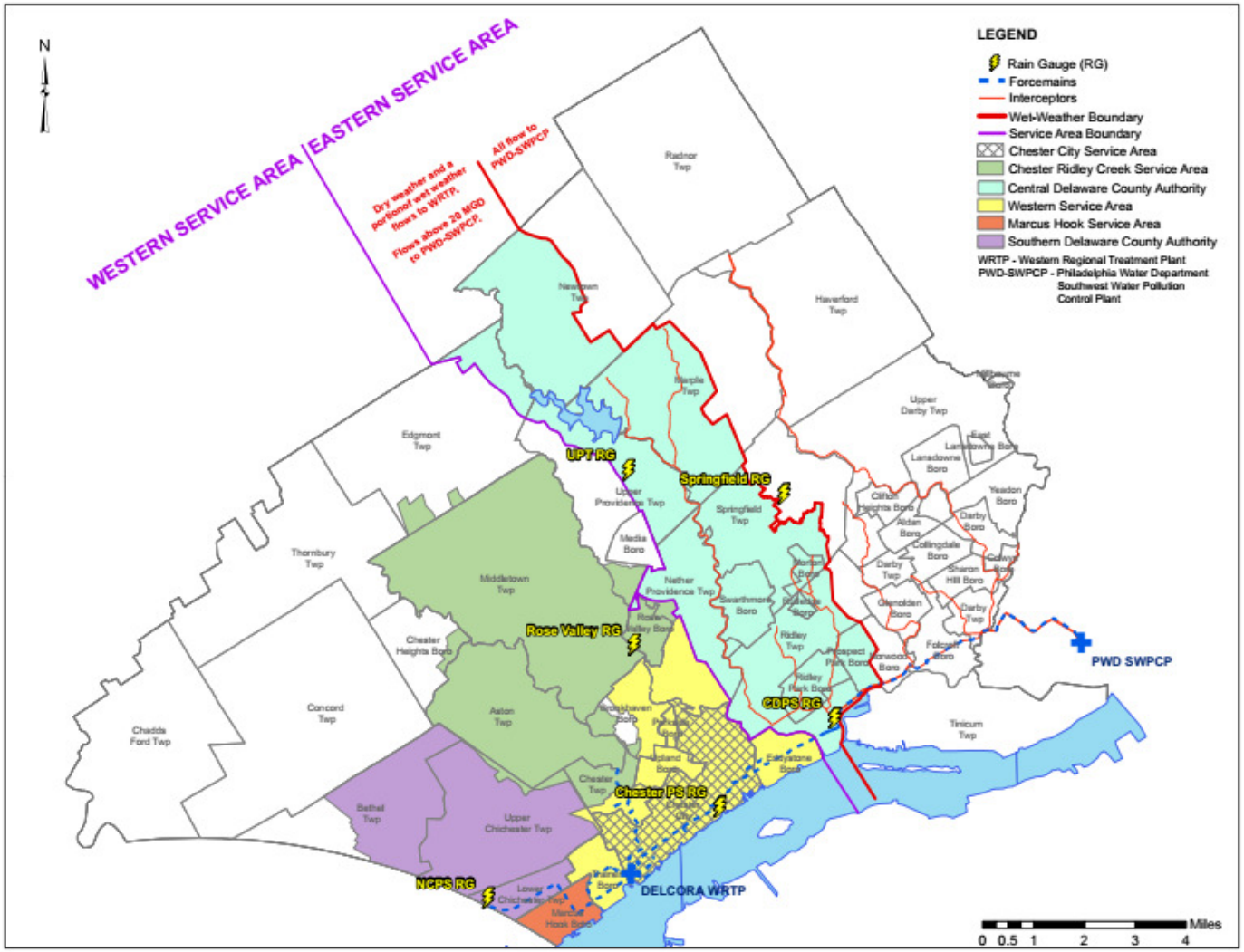
- Rose Valley
- Chester Pump Station (CPS)
- Naaman's Creek Pump Station (NCPS)
- Springfield
- Upper Providence Township (UPT)
- Central Delaware County Pump Station (CDPS)

Five out of six of the gauges provided data at 5 minute intervals. One rain gauge provided data on 15-minute intervals. According to the Consent Decree, rainfall data to be used for calibration and validation of the model *"…shall be obtained at a minimum effective density of 1 gauge/virtual radar-based gauge per kilometer"*. In order to achieve this density, Gauge-Adjusted Radar Rainfall (GARR) was employed. The rain gauges used to complete the flow monitoring program and choose the wet weather events used in calibration and validation were also used in the GARR analysis which provided effective spatial coverage of the entire Model Area. The gauge rainfall data from the six rain gauges installed throughout the DELCORA service area was analyzed and used to:

- Document rainfall and flow monitoring locations,
- Overview flow monitoring data quality,
- Analyze rainfall data to identify dry weather and wet weather conditions and to characterize individual rainfall event for precipitation depth, duration, maximum intensity, and return frequency,
- Analyze flow data to determine dry weather flow and diurnal pattern, wet weather flow and peak factor, and system response to wet weather events, and
- Determine the wet weather events for H&H Model calibration and validation.

An inter-event time of 48 hours was used to identify individual rainfall events. The inter-event time specifies the minimum duration in which precipitation does not occur. Based on this criterion, a dry weather time period and the number of total rainfall events were identified. The rainfall events during the

Figure 2-1: Rain Gauge Locations



flow monitoring periods had a wide variation in terms of total depth, intensity, duration, and antecedent conditions to provide a large dataset for balanced model calibration and validation.

The rainfall events were characterized by event start time, event end time, rainfall depth, duration, maximum intensity, and return frequency. As an initial screening criterion, rainfall events with a minimum of 0.9 inches of rainfall were identified. Further screening based on requiring at least two dry days prior to the event resulted in an initial list of ten (10) candidate events for calibration and validation (see Table 2-1).

Table 2-1: Top 10 Rainfall Events

Event	Event Start	Event End	Chester-PS Rainfall (in)	Duration (hr)	Max Intensity (in/hr)
E1	5/29/16 19:00	5/30/16 5:00	1.82	11.00	0.78
E2	9/28/16 12:00	9/30/16 10:00	2.36	47.00	0.37
E3	11/29/16 7:00	11/29/16 20:00	1.08	14.00	0.21
E4	3/30/17 21:00	4/1/17 3:00	1.83	31.00	0.25
E5	5/21/16 11:00	5/22/16 21:00	1.71	35.00	0.33
E6	7/28/16 15:00	7/29/16 9:00	1.26	19.00	0.74
E7	9/19/16 8:00	9/19/16 16:00	0.96	9.00	0.42
E8	3/13/16 18:00	3/14/16 14:00	1.08	21.00	0.25
E9	5/6/16 4:00	5/7/16 11:00	1.18	32.00	0.24
E10	10/8/16 14:00	10/9/16 11:00	1.00	22.00	0.15

2.2 Flow Monitoring

DELCORA owns and operates a flow monitoring network across the DELCORA Service Area. The monitoring network includes various types of flow meters located throughout DELCORA's Eastern Service Area and Western Service Area, at the WRTP, in each of the Pump Stations, and at the tie-in points where other municipal collection systems tie-into the collection system. Seven existing flow meters in the separated area (outside the CSO area), eight existing flow meters at pump stations and one existing flow meter at WRTP were used for the calibration and validation of the H&H Model. In addition, temporary flow meters were installed at 38 new locations to characterize surface runoff from the combined area and CSO discharges. The locations of flow meters installed specifically for the flow monitoring program and the H&H Model calibration and validation can be categorized into the following five categories:

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.
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.
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.

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.
5. Located in the main interceptors to measure level and flows in the major interceptors. Five (5) meters were installed for this category.

Table 2-2 lists the flow meter locations and location categories of the meters. Figures 2-2 and 2-3 show the locations of the flow meters that were used for H&H Model calibration and validation. After initial installation of the new temporary flow meters, difficulties were encountered at Manhole MH3029. 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 existing flow meter (Ridley Creek MH-28) was already installed for DELCORA. Instead of installing a new temporary flow meter around the site, the existing meter Ridley Creek MH-28 was used for the flow monitoring program. Data was gathered from a total of 55 flow meters, 38 of which were newly installed as part of the flow monitoring program.

The network of flowmeters can be grouped to define metersheds where flow from a given area discharges through a common flowmeter. Subcatchments associated with each metershed are shown in Table 2-3 along with the associated metershed acreage. Rainfall and flow data gathered for each metershed will be used to calibrate the associated subcatchments in the H&H Model.

2.3 Dry Weather Flow (DWF) Analysis

A “dry weather” condition was defined as a period with no precipitation that begins 48 hours after the last wet weather event and lasts until the beginning of the next precipitation event. Dry weather flow periods based on this definition are illustrated in the hydrograph shown in Figure 2-4**.**

Average dry weather flow was calculated by averaging the monitored flows from the dry weather periods identified in the rainfall data analysis. The overall and monthly DWFs for all monitoring sites were analyzed and used as inputs in the H&H Model.

Table 2-2: Flow Monitoring Locations

Flow Meter	Approximate Location	Category
In-02	Influent pipe to CSO 02 Regulator	On the influent pipe to regulator
In-03	Influent pipe to CSO 03 Regulator	On the influent pipe to regulator
In-05	Influent pipe to CSO 05 Regulator	On the influent pipe to regulator
In-08	Influent pipe to CSO 08 Regulator	On the influent pipe to regulator
In-09	Influent pipe to CSO 09 Regulator	On the influent pipe to regulator
In-10	Influent pipe to CSO 10 Regulator	On the influent pipe to regulator
In-11	Influent pipe to CSO 11 Regulator	On the influent pipe to regulator
In-13	Influent pipe to CSO 13 Regulator	On the influent pipe to regulator
In-14	Influent pipe to CSO 14 Regulator	On the influent pipe to regulator
In-16	Influent pipe to CSO 16 Regulator	On the influent pipe to regulator
In-17	Influent pipe to CSO 17 Regulator	On the influent pipe to regulator
In-18	Influent pipe to CSO 18 Regulator	On the influent pipe to regulator
In-19-1	Influent pipe to CSO 19 Regulator (from East)	On the influent pipe to regulator
In-19-2	Influent pipe to CSO 19 Regulator (from West)	On the influent pipe to regulator
In-25	Influent pipe to CSO 25 Regulator	On the influent pipe to regulator
In-26	Influent pipe to CSO 26 Regulator	On the influent pipe to regulator
INT- 2nd St	2nd Street Interceptor	On the interceptor pipe
INT-DRI	Delaware River Interceptor	On the interceptor pipe
INT-Ridley 2	Ridley Creek Interceptor	On the interceptor pipe
INT-Ridley 3	Ridley Creek Interceptor	On the interceptor pipe
INT-West End	West End Interceptor	On the interceptor pipe
Side-1	Side line on Penn St. to 2nd St. Interceptor	On the side-line from the combined area
Side-2	Side line on Highland Ave. to West End Interceptor	On the side-line from the combined area
Sep-1	Upstream of the CSO 02 Drainage	On the separated area
Sep-2	Upstream of the CSO 05 Drainage	On the separated area
Sep-3	Upstream from Upland Borough	On the separated area
Sep-4 (Existing MH-28 after first quarterly report)	Upstream from Eastern Chester	On the separated area
CSO-02	Outfall pipe from CSO 02 Regulator	On the outfall pipe
CSO-03	Outfall pipe from CSO 03 Regulator	On the outfall pipe
CSO-05	Outfall pipe from CSO 05 Regulator	On the outfall pipe

Flow Meter	Approximate Location	Category
CSO-08	Outfall pipe from CSO 08 Regulator	On the outfall pipe
CSO-14	Outfall pipe from CSO 14 Regulator	On the outfall pipe
CSO-19	Outfall pipe from CSO 19 Regulator	On the outfall pipe
Eff-02	Effluent pipe for CSO-02 Regulator	On the effluent pipe
Eff-03	Effluent pipe for CSO-03 Regulator	On the effluent pipe
Eff-05	Effluent pipe for CSO-05 Regulator	On the effluent pipe
Eff-08	Effluent pipe for CSO-08 Regulator	On the effluent pipe
Eff-14	Effluent pipe for CSO-14 Regulator	On the effluent pipe
Eff-19	Effluent pipe for CSO-19 Regulator	On the effluent pipe
BR MH-1 (Existing)	Upstream from Brookhaven MH-1	On the separated area
BR MH-3 (Existing)	Downstream from Brookhaven MH-3	On the separated area
BR MH-5 (Existing)	Downstream from Brookhaven MH-5	On the separated area
BR MH-6 (Existing)	Downstream from Brookhaven MH-6	On the separated area
RC MH-26 (Existing)	Ridley Creek Interceptor	On the interceptor pipe
RC MH-30 (Existing)	Ridley Creek Interceptor	On the interceptor pipe
RC MH-32 (Existing)	Ridley Creek Interceptor	On the interceptor pipe
WRTP (Existing)	At WRTP	At WRTP

Figure 2-2: DELCORA Flow Meters

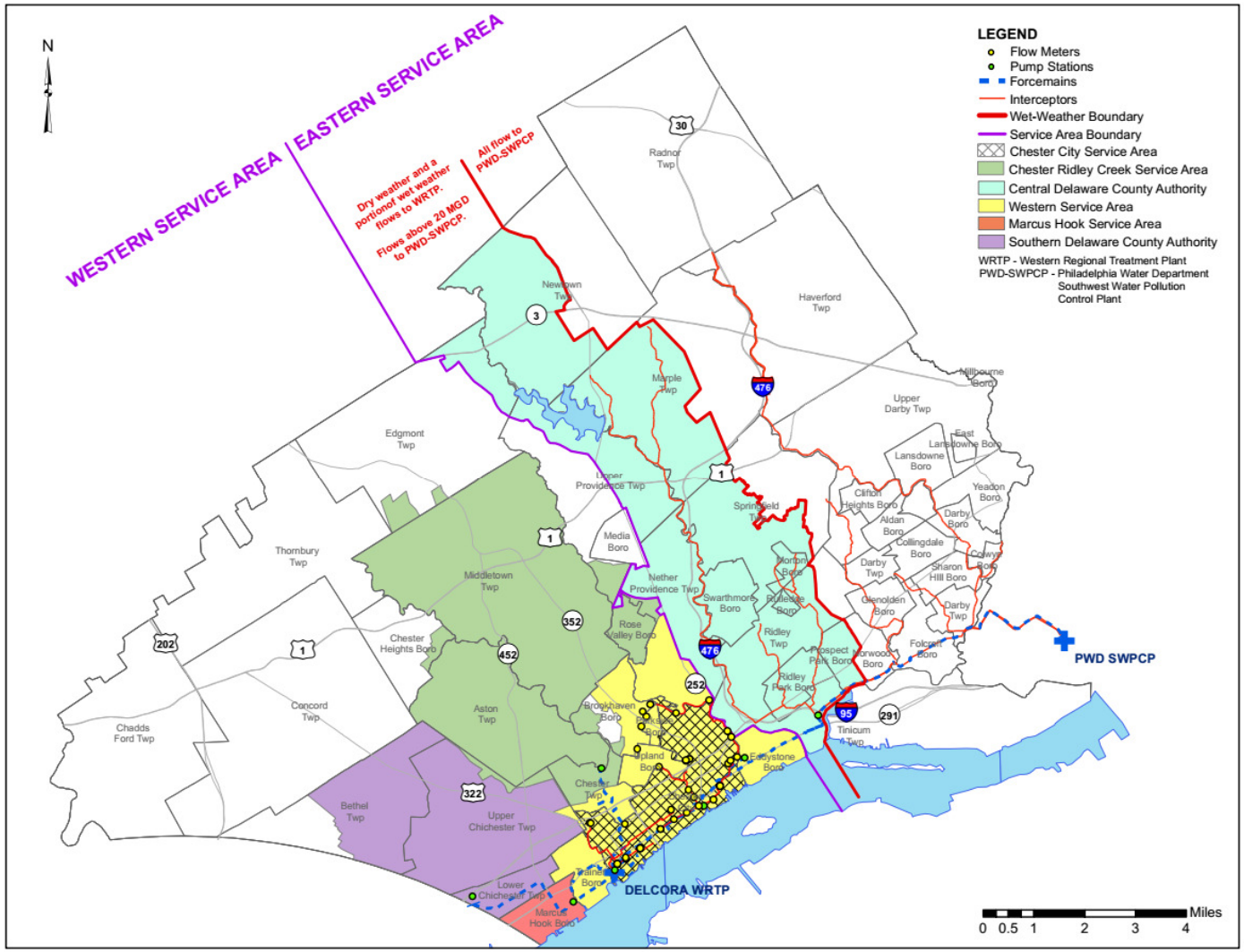


Figure 2-3: Enlarged Map of Flow Meters

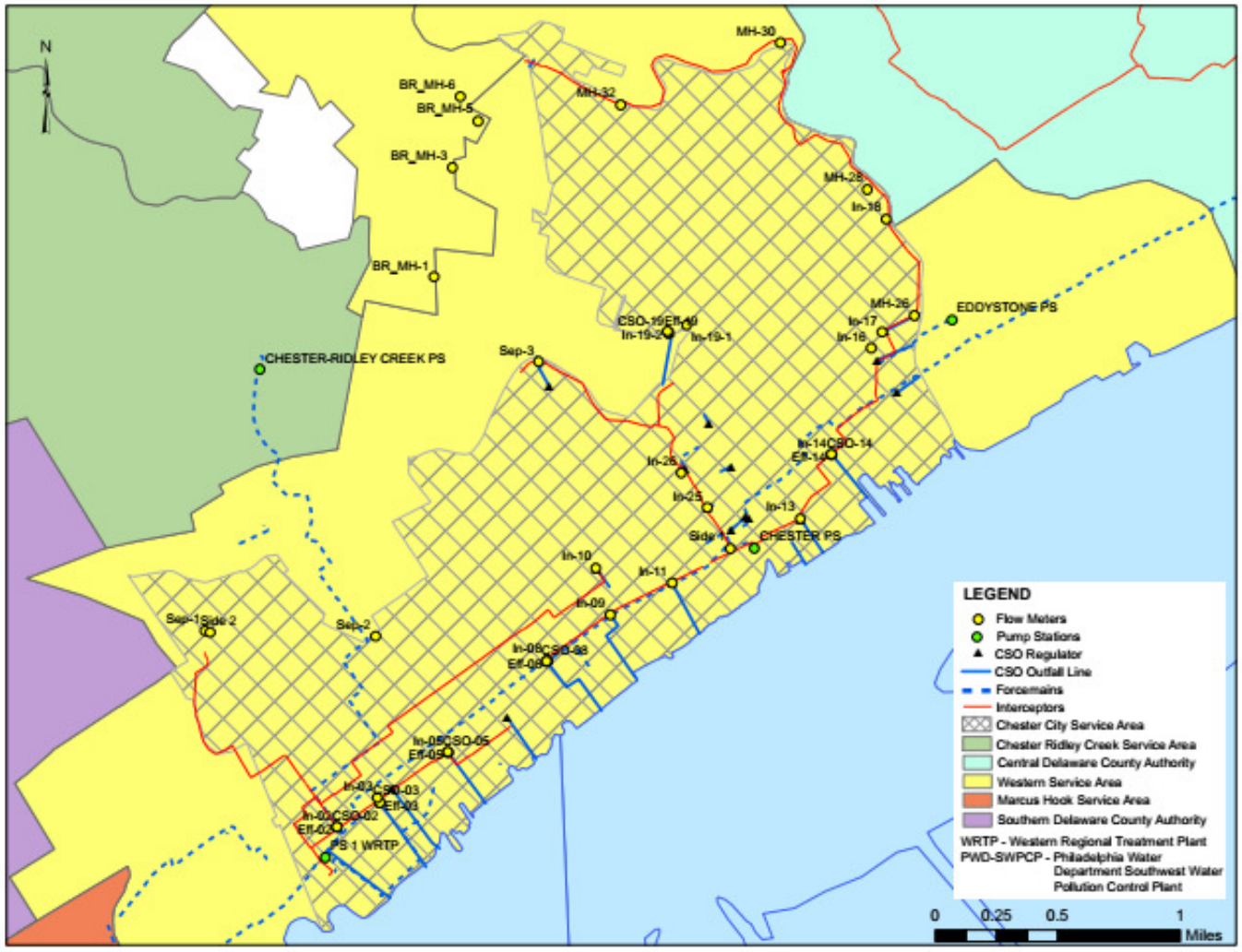


Table 2-3: Metersheds in the H&H Model

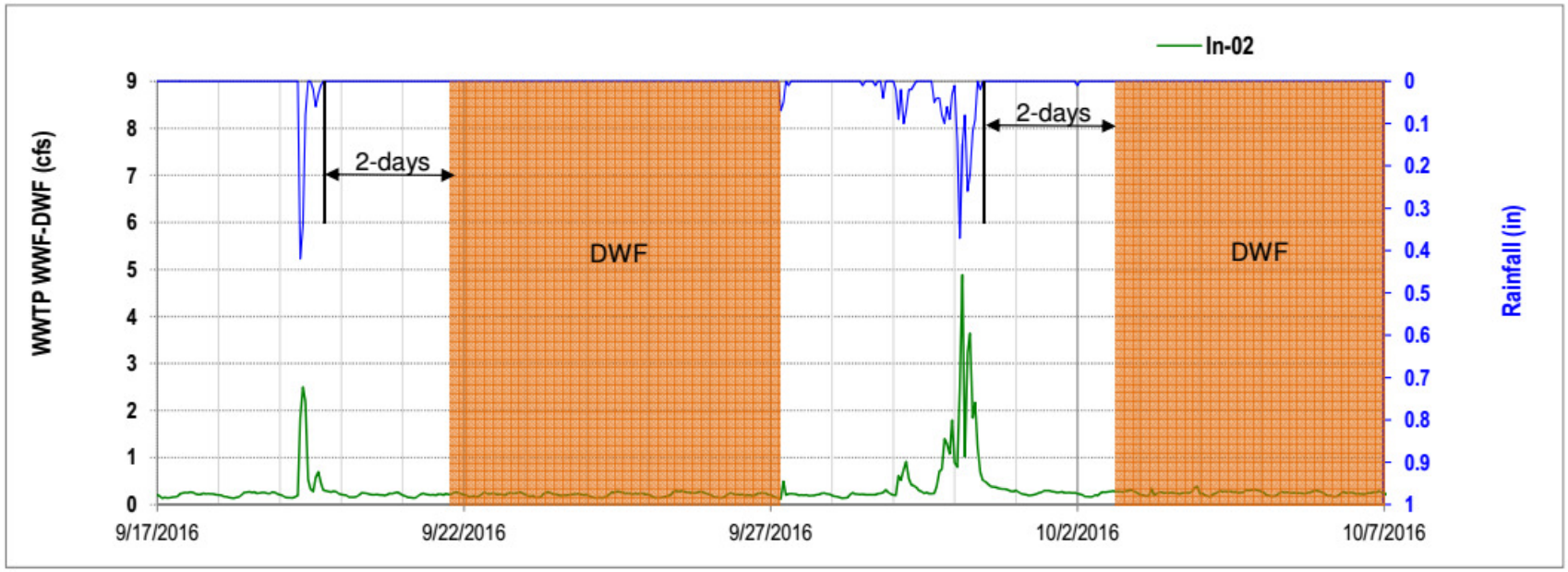
Metershed ID	Subcatchment ID	Metershed Area (ac)
BR_MH-1	BR_TWP_2	48.52
BR_MH-3	BR_TWP_3	236.08
BR_MH-5	BR_TWP_4	21.13
BR_MH-6	BR_TWP_5	43.55
In-02	02A	107.36
	02B	
	SC1	
In-03	03B	87.37
	03C	
	03D	
In-05	05C	160.31
	05D	
	CH_TWP_2	
In-08	08A	236.44
	08B	
	CH_CTY_12	
In-09	09A	27.02
In-10	10A	59.93
In-11	11A	43.54
In-13	13A	50.43
	13C	
In-14	14A	52.99
	14B	
	14C	
In-16	16A	2.18
In-16,In-17	16/17A	77.41
	16/17B	
In-17	17A	11.83
In-18	18A	29.71
	18B	

Metershed ID	Subcatchment ID	Metershed Area (ac)
In-19-1	18C	320.84
	CH_CTY_08	
	19B	
	19D	
	PA_BORO_1	
In-19-2	19E	94.48
	19G	
In-25	25A	11.84
In-26	26A	37.1
INT-2nd St	24A	6.24
INT-DRI	04A	57.01
	04B	
	07A	
	07B	
INT-Ridley 2	15A	9.72
	31A	
	RC1	
INT-Ridley 3	21A	51.8
	22A	
	23A	
	12A	
INT-West End	DR1A	25.69
	DR1C	
	CH_CTY_10	
MH-26	CH_CTY_07	46.62
MH-28 (Sep-4)	CH_CTY_04	135.72
MH-30	CH_CTY_06	1023.46
	NP_TWP_2	
MH-32	PA_BORO_2	523.12
	33A	
	BR_TWP_6	
	CH_CTY_05	

Metershed ID	Subcatchment ID	Metershed Area (ac)
Central PS (PS-1)	CH_CTY_02	502.62
	CH_CTY_03	
Eddystone PS (PS-10)	EDD_BORO_1	652.4
Marcus Hook PS (PS-11)	LC_TWP_1	1393.13
	MH_BORO_1	
Naamans Creek PS (PS-15)	BE_TWP_1	6503.31
	UC_TWP_1	
Chester Ridley Creek PS (PS-24*)	EDG_TWP_2	14369.97
	MI_TWP_1	
	NP_TWP_3	
	RV_BORO_1	
	UPR_TWP_2	
	AS_TWP_1	
	BR_TWP_7	
	CH_BORO_1	
	CH_TWP_4	
	UC_TWP_3	
Existing PS-1 (PS-3)	TR_BORO_1	987
	DR1B	
	CH_CTY_01	
Central Delaware PS Total and Central Delaware PS to WRTP (PS-7)	EDG_TWP_1	18644.24
	MA_TWP_1	
	MO_BORO_1	
	NE_TWP_1	
	NP_TWP_1	
	PR_BORO_1	
	RI_TWP_1	
	RP_BORO_1	
	RU_BORO_1	
	SP_TWP_1	
	SW_BORO_1	
	UPR_TWP_1	

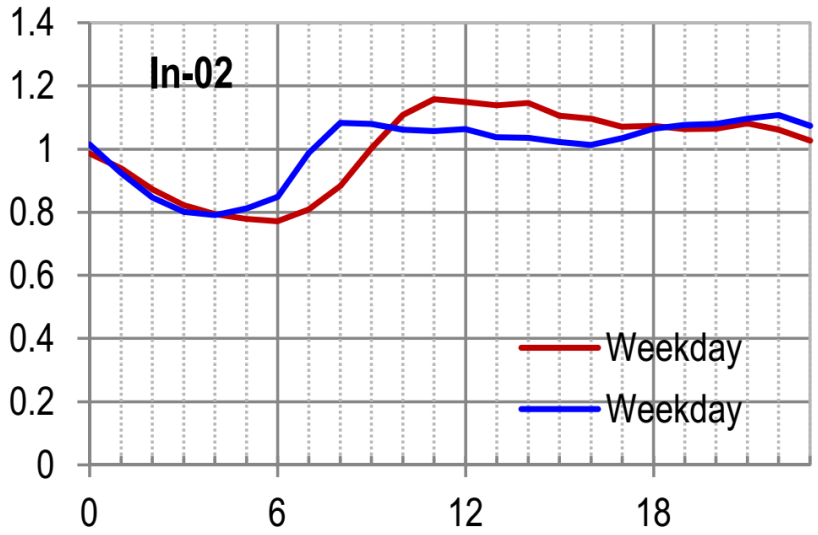
Metershed ID	Subcatchment ID	Metershed Area (ac)
Sep-1	CH_TWP_3	293.29
	UC_TWP_2	
Sep-2	CH_CTY_09	74.57
	CH_TWP_1	
Sep-3	BR_TWP_1	471.58
	CH_CTY_13	
	PA_BORO_3	
	UPL_BORO_1	
Side-1	20A	56.87
	CCE1	
	CCW1	
	CCW2	
	PS1	
	PS3	
	CH_CTY_11	
Side-2	BS3	31.75
	BS2	

Figure 2-4: Hydrograph to Show Dry Weather Flow



The dry weather flows vary throughout the day, with the highest flows normally occurring around noon and the lowest rates between midnight and early morning. Flow data from the dry weather periods were used to develop a flow diurnal pattern for each flow meter site. Diurnal patterns were analyzed for both weekdays and weekends. In the plot shown on Figure 2-5, the weekend DWF peak and valley have a 3-hour lag compared to the weekday pattern.

Figure 2-5: Weekday and Weekend Dry Weather Flow Diurnal Pattern (Example Plot)

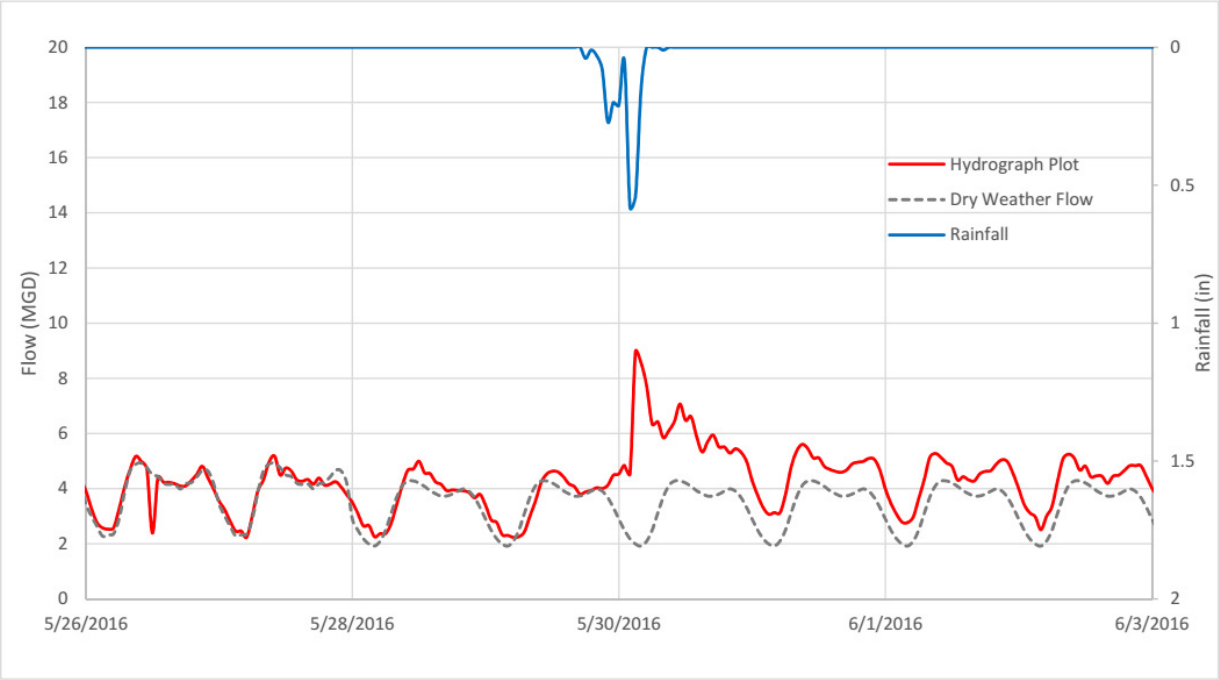


2.4 Wet Weather Flow Analysis

Wet weather flows are the combination of dry weather flows and additional flows that enter the system during wet weather conditions. The additional flows are from combined area surface runoff and RDII. Inflow normally occurs when rainfall enters the system through direct connections such as roof leaders, yard drains, catch basins, sump pumps, manhole covers and frame seals or indirect connections with storm sewers. Inflow is usually recognized graphically by large magnitude, short duration spikes immediately following a rain event. Infiltration occurs during wet weather conditions when water enters a sewer system from the ground through means which include, but not limited to, deteriorated pipes, pipe joints, connections, or manholes. It is significantly influenced by the size and duration of the rainfall event. Infiltration is often recognized graphically by a gradual increase in flow after a wet weather event. The increased flow typically sustains for a short period after rainfall has stopped and then gradually drops off.

The peaking factor represents the ratio of the peak wet weather flow to the average dry weather flow. Usually, an hourly peaking factor is used to represent the wet weather peaking factor. Peaking factors were analyzed for each flow monitoring site. The peaking factors in the separated area can be used to determine the extent of the RDII within a particular basin. Figure 2-6 is a flow hydrograph plot showing an hourly peaking factor of approximately 4.5 for the monitoring site. This high peaking factor indicates that a significant amount of RDII enters the collection system. The immediate flow increase shortly after the rainfall indicates significant inflow into the collection pipes, and the long tail back to the base flow indicates infiltration occurrence at the site as well.

Figure 2-6: Hydrographs of Flow Meters in Separated Area (Example Plot)



2.5 Wet Weather Event Selection for Model Calibration and Validation Flow Analysis

Based on the rainfall and flow monitoring data analysis, the rainfall events shown in Table 2-4 were selected for model calibration and validation. The events were selected to cover variations in terms of rainfall depth, intensity, duration and antecedent conditions. .

Table 2-4: Calibration and Validation Rainfall Events

Event	Start	End
E1	5/29/16 19:00	5/30/16 5:00
E2	9/28/16 12:00	9/30/16 10:00
E3	11/29/16 7:00	11/29/16 20:00
E5	5/21/16 11:00	5/22/16 21:00
E6	7/28/16 15:00	7/29/16 9:00

Section 3 DELCORA H&H Model Update

The original DELCORA H&H model was developed and calibrated for the 1999 LTCP. The model was updated and expanded over the years to account for changes in the CSO system, but it was not re-calibrated during the development of the 2012 LTCP (Weston, 2012). The project team reviewed the 2012 model in order to:

- Assess adequacy of the original model for use in DELCORA's LTCPU,
- Identify gaps with the original model in meeting the requirements in the Consent Decree,
- Identify updates required to reflect current hydrologic and hydraulic conditions of DELCORA's collection system, and
- Determine refinements needed for the model update.

Results from the review of the 2012 H&H Model were presented in the *Hydrologic and Hydraulic Model Update and Calibration Plan* (Greeley and Hansen, 2015). The purpose of this section of the Report is to describe the model update methodology and summarize the revisions incorporated into the updated model.

3.1 Model Update Methodology

3.1.1 Hydrologic Representation

Instead of including only the combined area for the subcatchments as in the original model, the updated model has subcatchments for both combined and separated service areas. All the areas that contribute dry weather flow and/or wet weather flow to DELCORA's CSOs and/or the WRTP were included in the service area for the model. Wet weather flows generated from surface runoff in the combined area and RDII in the separated areas were simulated in the updated model.

3.1.2 Hydraulic Representation

The 2012 H&H model included only the combined sewer system (CSS) area of DELCORA's collection system, which is located within the boundaries of the City of Chester. The CSS area is shown in Figure 3-1. The combined CSS area according to the original model is shown in in Figure 3-2. Per the requirements of the Consent Decree, the H&H model was updated to include the Model Area. Pipe networks in the updated model were extended to the updated service areas for both the combined and separated areas. All hydraulic structures that control flows in the collection system, including pump stations, regulator orifices and weirs, and their operating rules, were simulated in the updated model.

3.2 Model Refinement

A number of hydraulic modeling software packages are available, including EPA SWMM5, InfoSWMM, InfoWorks, Mike Urban and PCSWMM. For this H&H Model update, EPA SWMM, Version 5.0, Build 5.0.022 and Innovyze InfoSWMM Version 14.5 Update 4 were selected as the modeling software. EPA

SWMM5 is a fully dynamic model and has been used extensively throughout the United States and abroad to assess CSO, flooding and water quality issues. It can be applied to simulate single events or long periods of time in a continuous mode. InfoSWMM uses the current EPA SWMM 5 engine as its computational solution and is fully integrated with ArcGIS which provides greater flexibility of importing model network from existing GIS database and preparing initial model inputs from existing datasheets. InfoSWMM was used during the model development and the calibration phase.

The model update is based on information obtained from a variety of sources including DELCORA's input, GIS, record drawings and field survey. Other documents pertaining to standard/actual operating procedures for CSO regulators, pump stations and the WRTP were also used to set up real time controls in the model. The model network consists of all major interceptors and force mains and extends to all active overflow points. The datum for the model is NGVD 29.

3.2.1 Delineation of Model Area and Combined Area

DELCORA's latest GIS database, survey and record drawings were used to perform the desktop CSS delineation to verify the boundaries. The total acreage of the model area is approximately 50,000 acres and the updated combined sewer area is approximately 1,460 acres as of May 2017.

Metersheds were delineated for the purpose of dry weather flow allocation and model calibration. A metershed means the geographical area served by a system of sanitary drains, storm drains, private interceptor, main sewers, and public sewers that drain to a common monitoring point (flow meter location). Metershed delineation was performed based on the location of flow meter, sewer connectivity, and city contours. A listing of metersheds, their acreage and their associated subcatchments can be found in Table 2-3.

Sewersheds (subcatchment) are delineated based on the drainage network, area characteristics, and flow monitor locations. Each sewershed has a dry weather and a wet weather flow input to the model network. The model network comprises 111 sewersheds (subcatchments), including 54 combined and 57 separated subcatchments.

3.2.1.1 Delineation of Model Area

The updated H&H model will evaluate the Model Area comprising those areas hydraulically connected to the WRTP. As shown in the schematic of DELCORA's conveyance system (see Figure 1-1), the conveyance system is divided into the Western Service Area and the Eastern Service Area. The Western Service Area discharges to DELCORA's WRTP and is therefore included in the Model Area. The Eastern Service Area is served by three pumps stations: the Central Delaware Pump Station, the Muckinipates Pump Station and the Darby Creek Pump Station. Up to 20 MGD (which includes both dry and wet weather flows) from the Central Delaware Pump Station can be pumped to, and thus is hydraulically connected to, DELCORA's WRTP. Therefore, municipalities connected to the Central Delaware Pump Station are considered part of the Model Area. Sewage from the Muckinipates Pump Station and the Darby Creek Pump Station flows to the PWD-SWPCP rather than to the WRTP. Therefore, municipalities connected to these pump stations are not hydraulically connected to the WRTP and do not directly or indirectly influence CSOs or flow to the WRTP, and, therefore, are not considered part of the Model Area.

Eastern Service Area

Within the Eastern Service Area, only the municipalities in the Central Delaware County Authority contribute flows to the WRTP and are, therefore, only these municipalities are included in the Model Area. These municipalities include Marple Township, Morton Borough, Nether Providence Township, Newtown Township, Prospect Park Borough, Ridley Park Borough, Rutledge Borough, Springfield Township, Swarthmore Borough, Ridley Township, and Upper Providence Township. In October 2012, DELCORA signed an agreement with Edgmont Township to provide sewer service to the eastern portion of the Township. The sanitary sewage of the Township will be collected and transported using the Crum Creek Sewer District System through the CDCA collection and conveyance facilities to the DELCORA System for treatment and ultimate disposal and discharge.

Western Service Area

DELCORA's Western Service Area (shown in Figure 3-1) contributes flow to their WRTP and is therefore considered part of the Model Area. DELCORA owns and operates the collection system in the following communities in the Western Service Area.

- Chester City
- Chester Township (parts of)[1]
- Marcus Hook Borough
- Parkside Borough
- Rose Valley Borough[1]
- Upland Borough
- Trainer Borough

DELCORA does not own or operate the collection system in the following communities in the Western Service Area, however, these communities will be included as part of the service areas in the updated H&H model because they contribute flows to the WRTP.

- Brookhaven Borough
- Lower Chichester Township
- Nether Providence Township
- Eddystone Borough

Model Area Summary

In summary, the Model Area includes the municipalities in the Western Service Area plus those municipalities in the Eastern Service Area that are connected to the Central Delaware Pump Station, as described in Table 3-1. The Model Area is illustrated in Figure 3-1. A schematic of the facilities and conveyance network are shown in Figure 1-1.

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[1] - DELCORA owns only a portion of Chester Township's collection system, but all flow comes to WRTP as some goes through the CRC PS service area.
- Rose Valley Borough collection system discharges to its own treatment plant (this portion will be discharged to the CRC PS service area in future) and the remaining portion is discharged to the Western Service Area to the WRTP.

Figure 3-1: DELCORA's Western Regional Treatment Plant (WRTP) Model Area

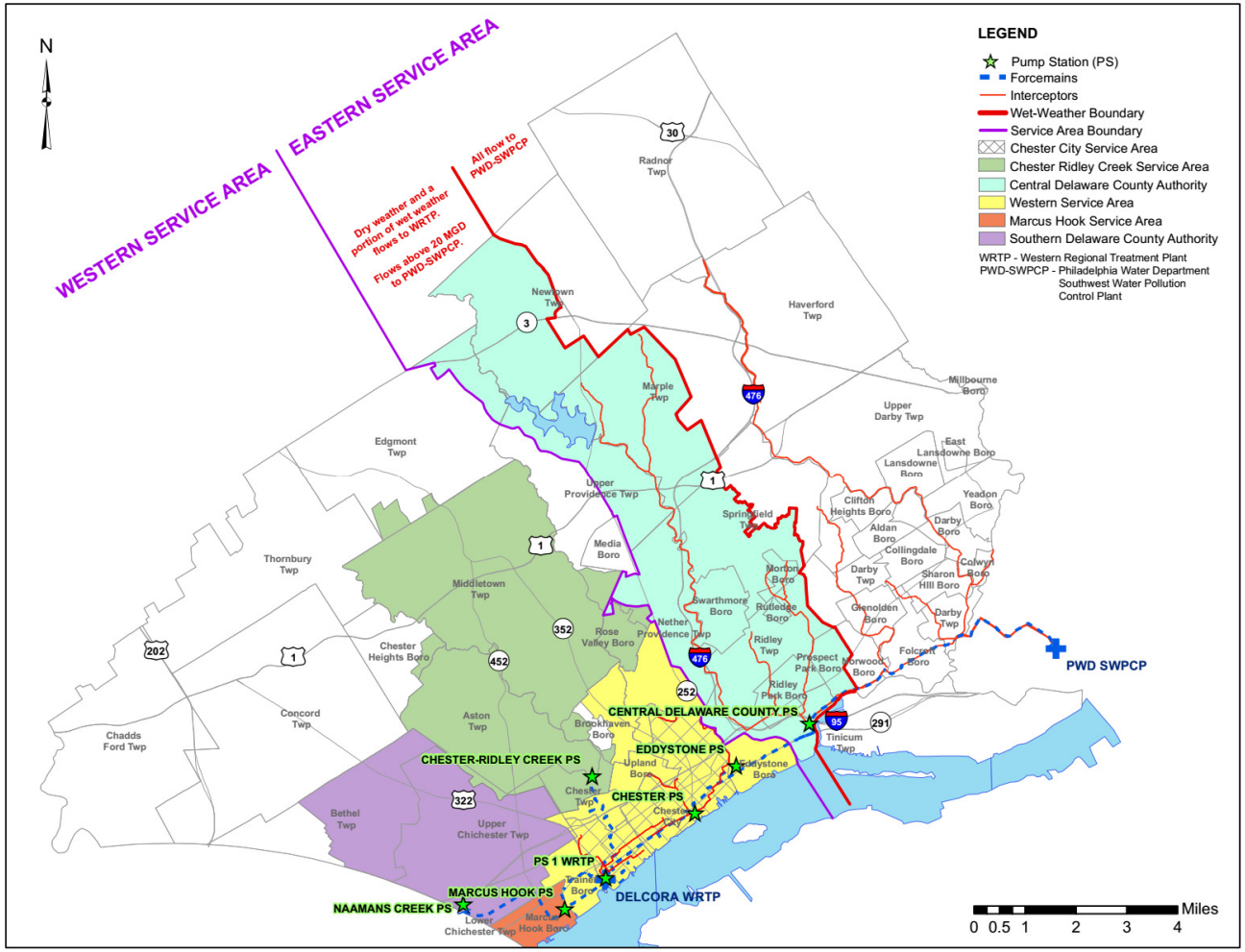


Table 3-1: Model Area

Municipality	Service Area
Aston Township	Western (CRCSA)
Bethel Township*	Western (SDCA)
Brookhaven Borough*	Western
Chester City	Western
Chester Township	Western (CRCSA)
Eddystone Borough	Western
Edgmont Township*	Eastern (CDCA)
Lower Chichester Township	Western (SDCA)
Marcus Hook Borough	Western (MHSA)
Marple Township*	Eastern (CDCA)
Middletown Township	Western (CRCSA)
Morton Borough	Eastern (CDCA)
Nether Providence Township	Eastern (CDCA) and Western
Newtown Township*	Eastern (CDCA)
Parkside Borough	Western
Prospect Park Borough	Eastern (CDCA)
Ridley Park Borough	Eastern (CDCA)
Ridley Township*	Eastern (CDCA)
Rose Valley Borough	Western
Rutledge Borough	Eastern
Springfield Township*	Eastern (CDCA)
Swarthmore Borough	Eastern (CDCA)
Trainer Borough	Western
Upland Borough	Western
Upper Chichester Township	Western (SDCA)
Upper Providence Township*	Eastern (CDCA) and Western
*Indicates that only a portion of the municipality contributes flow to WRTP CDCA: Central Delaware County Authority CRCSA: Chester Ridley Creek Service Area MHSA: Marcus Hook Service Area SDCA: Southern Delaware County Authority	

3.2.1.2 Delineation of Combined Sewer System Area

The entire combined sewer system (CSS) area of DELCORA's collection system is located in the City of Chester and consists of a drainage area of approximately 1,460 acres. It comprises approximately half of Chester City's serviced area. To support this 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[2] (25) combined sewer outfall regulators controlling storm

[2] DELCORA's NPDES permit includes 26 regulators. After the NPDES permit was issued, CSO regulator 033 was disconnected from the CSS.

overflows. The location of the CSS area is shown in Figure 3-1. An enlarged view of the CSS area according to the 2012 H&H model is shown in Figure 3-2.

The CSS area delineation was updated with separation projects completed in recent years. The latest GIS database, survey, and record drawings were used to perform the desktop combined sewer area check. Some areas have separated systems with trunk sewers that subsequently connect to the CSS. For this situation, these particular separate sewer system areas were included within the delineation of the CSS. The revised CSS delineation is illustrated in Figure 3-3.

3.2.2 Model Network Extension

The collection system network in the original model has been updated with the following.

- Extended sewers to the updated delineation of the combined and separated areas
- Included all pump stations that control flows in the DELCORA collection system, and
- Reflect actual configuration of the CSO regulators.

3.2.2.1 Sewer Lines and Manholes

3.2.2.2 Regulators

Since the approval of the first LTCP in 1999, DELCORA has under-taken a program to replace and/or rehabilitate CSO regulators and tide gates in the City of Chester CSO system. In some cases, regulators have been eliminated. The updated model includes twenty-five[2] (25) CSO regulators, which were modeled as weirs and orifices. The configuration of CSO regulators was obtained from both record drawings and field surveys.

As indicated in Table 3-2, the majority of the City's CSO regulators are Brown & Brown type regulators. The operation of the CSO regulators has been changed from being controlled by the level in the trunk sewer entering the CSO regulator chamber to being controlled by the level in the interceptor. This change is being implemented as part of the CSO regulator replacement program. This ensures that the flow sent to the WRTP for treatment is maximized.

During dry-weather operations, the sewage flow levels entering the CSO regulator chamber are below the top of the diversion weir and will pass through the CSO regulator gate. Once through the CSO regulator gate, the flow typically passes through an orifice plate and then will be sent to the WRTP via the interceptors. During wet-weather events, the level in the combined sewer (Type A regulator) or in the interceptor (Type B regulator) will begin to rise thus raising the float assembly and beginning to close the CSO regulator gate. For cases where the regulator float and gate have been removed, dry weather flow and some portion of the wet weather flow will pass through the opening previously covered by the now removed gate. Flow through this opening will be modeled as an orifice. When weather flow exceeds the

Table 3-2: CSO Regulator Information

CSO Regulator No.	CSO Regulator Location	CSO Receiving Water	CSO Regulator Type
002	Front & Booth	Delaware River	Brown & Brown
003	Front & Highland	Delaware River	Brown & Brown
004	Front & Hayes	Delaware River	McNulty
005	Front & Townsend	Delaware River	Brown & Brown
007	Delaware & Reaney	Delaware River	Brown & Brown
008	2nd & Tilghman	Delaware River	Brown & Brown
009	2nd & Lloyd	Delaware River	Brown & Brown
010*	5th & Pusey	Delaware River	Brown & Brown
011	2nd & Parker	Delaware River	Brown & Brown
012	2nd & Edgmont	Delaware River	Brown & Brown
013	2nd & Welsh	Delaware River	Brown & Brown
014	3rd & Upland	Delaware River	Brown & Brown
015	4th & Melrose	Ridley Creek	Brown & Brown
016	8th & McDowell	Ridley Creek	Brown & Brown
017	9th & Campbell	Ridley Creek	Brown & Brown
018	Sun Dr. & Hancock	Ridley Creek	Brown & Brown
019	14th & Crozer Hospital	Chester Creek	Brown & Brown
020	Kerlin & Finland	Chester Creek	Brown & Brown
021	9th & Sproul	Chester Creek	Brown & Brown
022	6th & Sproul	Chester Creek	Brown & Brown
023	3rd & Edgmont	Chester Creek	Brown & Brown
024	3rd & Dock	Chester Creek	Brown & Brown
025	5th & Penn	Chester Creek	Brown & Brown
026	7th & Penn	Chester Creek	Brown & Brown
032	2nd & Avenue of the States	Delaware River	No CSO Regulator
033	Elkington Blvd. and Ridley Creek	Ridley Creek	No CSO Regulator

Notes:
- CSO Regulator 010 discharges at Outfall 009.
- CSO Regulators 006 ad 007 have been disconnected from CSS and removed from NPDES permit
- CSO Regulator 033 has been disconnected from the CSS but had not been removed from NPDES permit at the date of this Report

Figure 3-2: CSS Area Delineation in the Original Model

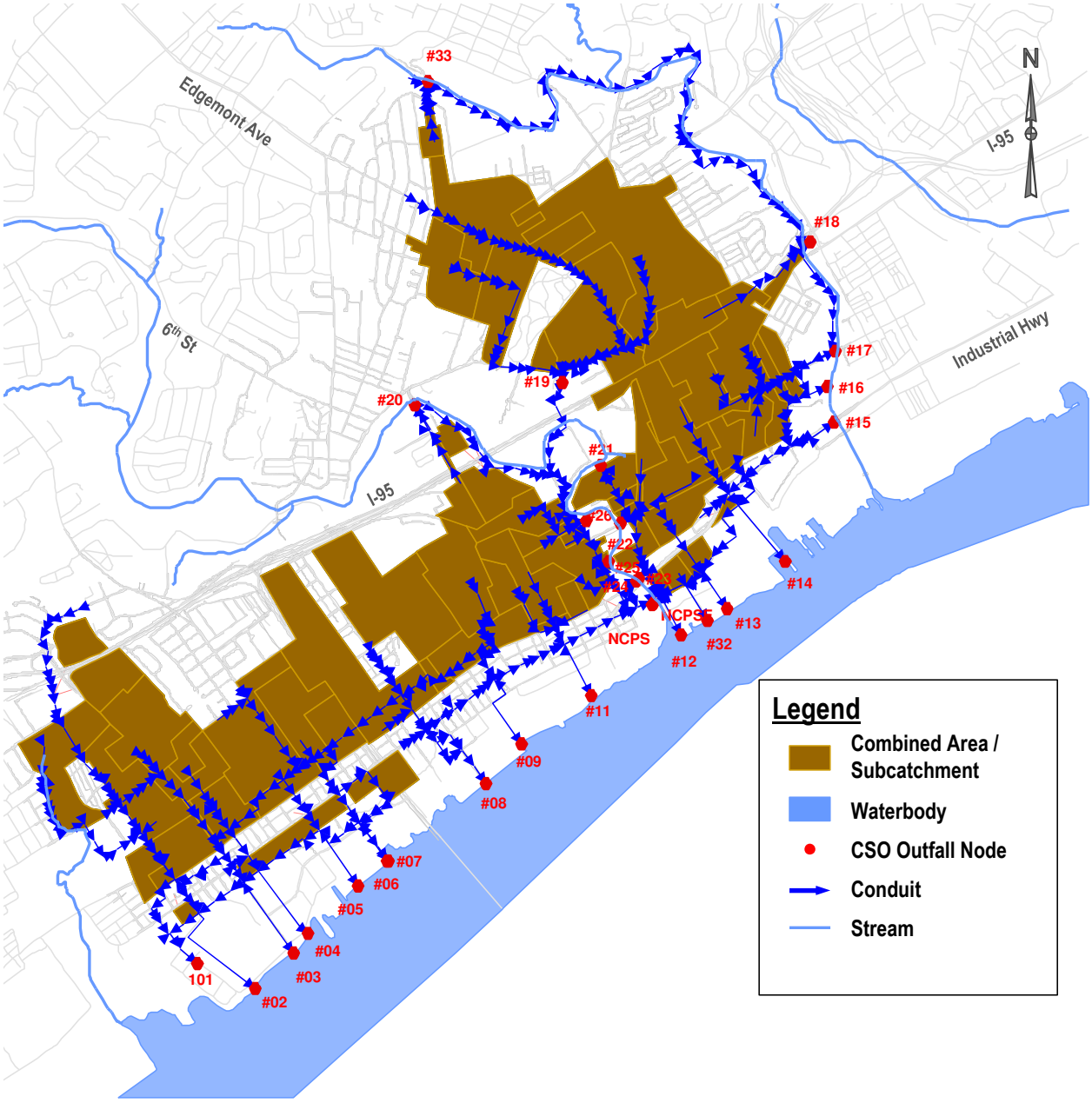
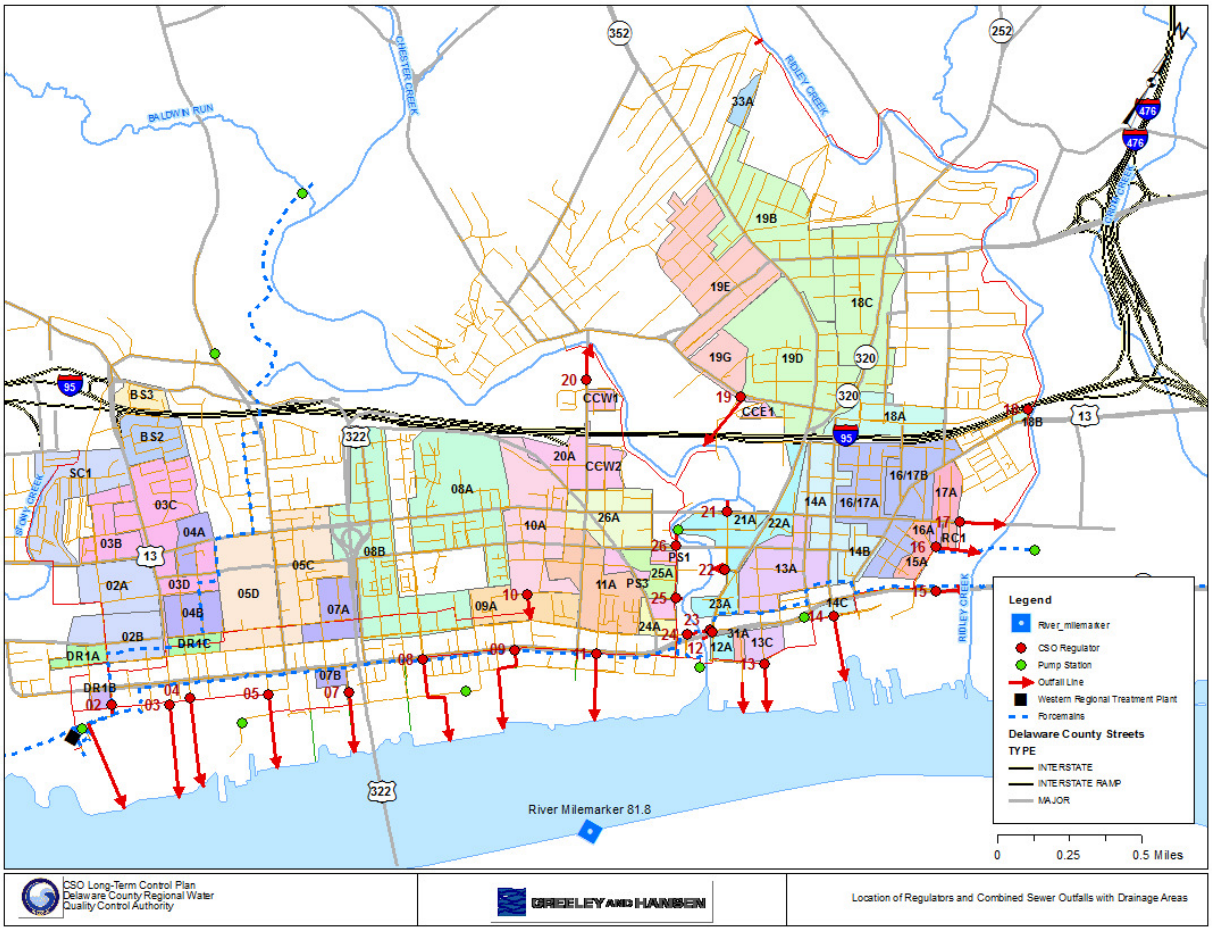


Figure 3-3: CSS Area Delineation in the Revised Model



capacity of the orifice, the level in the sewer will continue to rise until it is high enough for a portion of the flow to pass over the weir be discharge through the associated outfall.

Regulator gates, diversion weirs, and operating rules are simulated in the updated model.

3.2.3 Pump Stations

Major pump stations in the Western Service Area and the Central Delaware Pump Station in the Eastern Service Area were added to the updated model, as well as force mains connecting the pump stations to the interceptor/WRTP. The list of the pump stations includes (Figure 3-4):

- Chester PS
- Existing PS-1 WRTP
- Marcus Hook PS
- Naamans Creek PS

- Eddystone PS
- Central Delaware PS
- Chester Ridley Creek PS

The following pump stations were excluded from the H&H Model:

- Price & Smith Street Trainer PS
- Sun Oil PS (Owned by Sunoco)
- Kimberly Clark PS (Owned by KC)
- Stadium PS

Flow from the Price & Smith Street Trainer PS discharges to the downstream existing PS-1 Pump Station (EPS-1) where it is re-pumped. The updated H&H model assumes that all flow from subcatchments associated with the Price and Smith Street Trainer PS can be treated as an input to EPS-1.

Flow from the Stadium PS is sanitary sewage with no wet weather flow. The Stadium PS discharges flow only during events held at the stadium. Due to the limited flow, its sporadic nature and the lack of wet weather flow, the Stadium PS is expected to have negligible effect on the wet weather capacity of the CSS. Therefore, the Stadium PS was not included in the H&H Model.

DELCORA owns or operates a number of lift stations that contribute to the Western Service Area and whose flows are handled by the above list of pumps stations. It was determined that the behavior of these lift stations would not require modeling and that inflow can be assumed to equal outflow to the downstream conduit.

3.2.4 Model Input

3.2.4.1 Subcatchments

The following subcatchment information is required by the model:

- Area
- Percent of directly connected impervious area (effective impervious area)
- Width
- Slope
- Manning's roughness coefficient (n) for both pervious and impervious areas
- Depression storage for both pervious and impervious areas (initial abstraction)
- Soil and soil infiltration parameters
- Rainfall dependent inflow and infiltration (RDII) parameters
- Base flow

Area

Area of the combined sewer subcatchment is the geographical area of the subcatchment. It was estimated from the GIS by geometry calculation of the area of the subcatchment. Subcatchment areas for the updated H&H model are depicted in Figure 3-3.

Percent of Directly Connected Impervious Area

Directly connected impervious area means the impervious area that is effectively connected to the sewer collection system. As a result, runoff from these areas is completely captured by the collection system. Runoff from the rest of the impervious area is deemed not to be captured by the system due to various potential reasons including, but not limited to, drains to pervious areas/creeks/streams, limited number and capacity of stormwater inlets, and bypassing. For model construction, the percent imperviousness was calculated using the high resolution land cover raster published by the Chesapeake Conservancy (Chesapeake Conservancy, 2017) as well as the land use shapefile published in 2015 by the Delaware Valley Regional Planning Commission as the initial inputs. Then, the impervious percentage values were adjusted during the model calibration process (see Section 4) to best simulate the observed hydrologic response over the selection of precipitation events.

The initial percent imperviousness for the combined area was calculated based on the impervious coverage shape file and the subcatchment shape file. The subcatchment delineations were overlaid on the land cover designation and the percent impervious within each subcatchment was evaluated with the results presented in Table 3-3.

For the separated area, the initial percent imperviousness will be set at 0% because the impervious area in the separated area is not contributing runoff to the CSS, therefore it is not effectively connected. *Subcatchment parameters mentioned hereafter will be set at default values for the separated subcatchments*.

Width

The width of a subcatchment relates to sheet flow path and affects time of concentration and the shape of the runoff hydrograph. The initial estimate of the width was made by dividing the subcatchment area by the representative overland flow length. Width is one of the calibration parameters for runoff.

Slope

The slope of a subcatchment should reflect the average slope along the pathway of overland flow to inlet locations. For the combined sewer subcatchments, slopes from the 2012 H&H model were retained for use in the updated model.

Figure 3-4: Pump Stations Included in the Updated Model

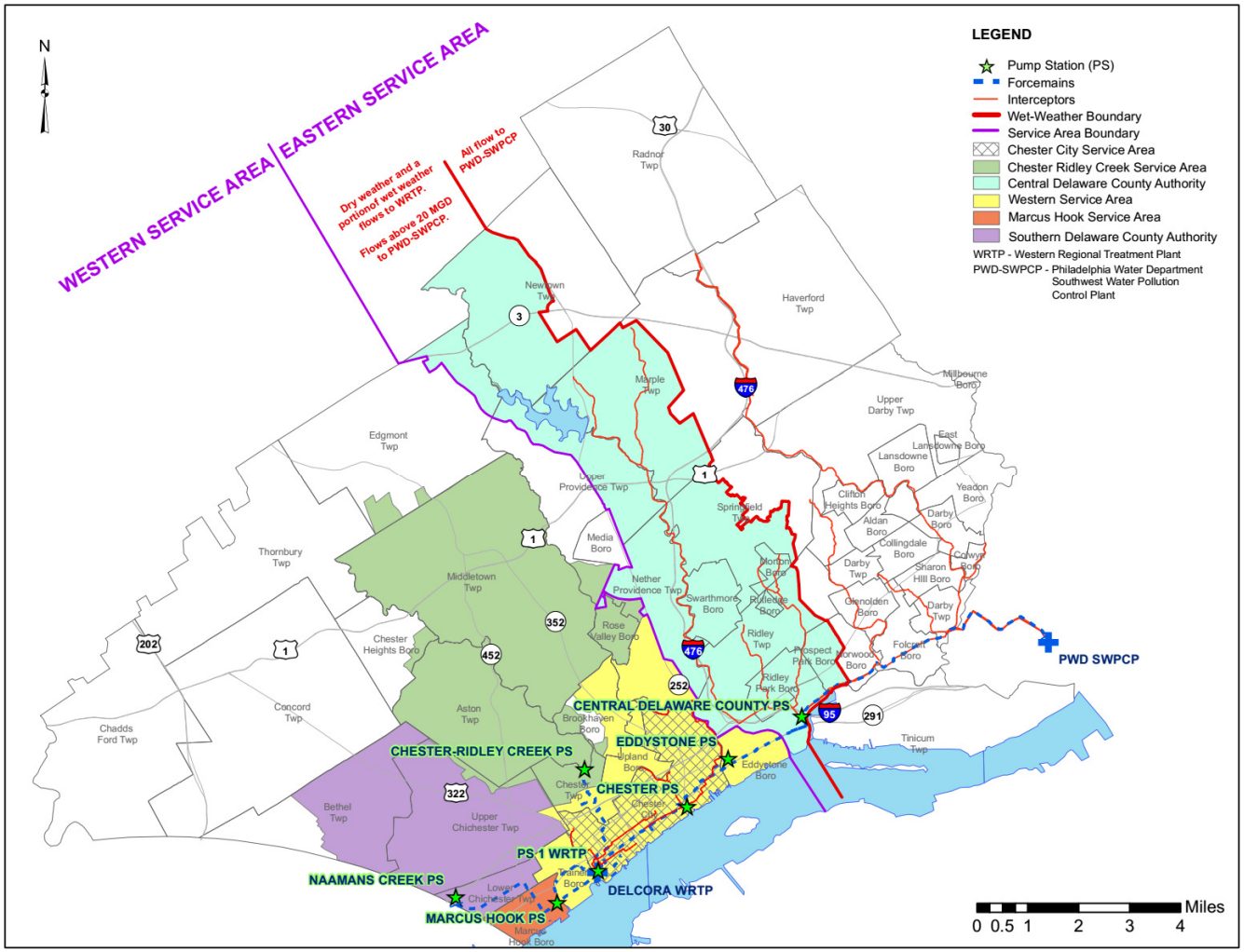


Table 3-3: Percent Imperviousness Applied to Subcatchments

Subcatchment ID	Percent Imperviousness
02A	74%
02B	60%
03B	69%
03C	55%
03D	72%
04A	80%
04B	66%
05C	72%
05D	44%
07A	70%
07B	72%
08A	52%
08B	60%
09A	65%
10A	60%
11A	70%
12A	91%
13A	89%
13C	88%
14A	61%
14B	52%
14C	79%
15A	63%
16/17A	55%
16/17B	65%
16A	76%
17A	79%
18A	58%
18B	70%
18C	64%
19B	57%
19D	49%
19E	58%
19G	34%
20A	64%
21A	85%
22A	85%
23A	93%
24A	60%
25A	76%
26A	77%
31A	91%
BS2	51%
BS3	50%
CCW1	69%
CCW2	58%

Subcatchment ID	Percent Imperviousness
DR1A	69%
DR1B	51%
DR1C	68%
PS1	52%
PS3	64%
RC1	64%
SC1	44%
CCE1	1%

Manning's roughness coefficient (n)

Manning's roughness coefficient (n) was estimated for both pervious and impervious overland flow. The initial values were set to 0.013 for impervious surfaces and 0.15 for pervious surfaces. A typical range of Manning's n suggested by the SWMM is 0.011-0.024 for impervious area and 0.06-0.80 for pervious area. Roughness is an empirical value and may be treated as a calibration parameter if necessary.

Depression Storage

Depression storage is the rainfall abstraction volume that must be filled prior to the occurrence of runoff. It represents the loss (initial abstraction) caused by surface ponding, surface wetting, etc. The initial values of depression storage were set to 0.05 for impervious surfaces and 0.15 for pervious surfaces. Typical depression storage values are 0.05-0.10 for impervious surfaces and 0.10-0.30 for pervious surfaces. Depression storage is an empirical value and may be treated as a calibration parameter, especially to adjust runoff volumes.

In the model, the subcatchment was divided into three subareas: pervious area with depression storage, impervious area with depression storage, and impervious area without depression storage. The initial percent of the impervious area without depression storage was set to 0.10.

Soil and Soil Infiltration Parameters

Soil information was obtained to estimate infiltration in the pervious areas of the CSS. The rate of infiltration is a function of soil properties and antecedent soil conditions. Three infiltration methods are available in the software: Horton method, Green-Ampt method, or National Resources Conservation Service (NRCS) Curve Number method. The Horton method has been extensively used for similar type of modeling work and it was used in this modeling effort to estimate infiltration. The required soil parameters for Horton method include:

- Maximum Infiltration rate (in/hr)
- Minimum Infiltration Rate (in/hr)
- Decay Constant (/hr)
- Drying time (d)
- Maximum Infiltration Volume Possible (inch)

To determine the Horton infiltration parameters, a soil map was first obtained from the NRCS (USDA, 2017). The soil types were then correlated to standard hydrologic soil groups.[3] A map of the hydrologic soil groups found in the CSS is presented in Figure 3-5. Hydrologic soil groups found in DELCORA's CSS are groups A, B, C, B/D and C/D. Horton's infiltration parameters for these soil groups were estimated based on typical values from literature and are shown in Table 3-4.

Table 3-4: Horton Infiltration Parameters

Horton Infiltration Parameter	Soil A	Soil B	Soil C	Soil B/D	Soil C/D
Max Infiltration Rate (in/hr)	5	3	2	2	1.5
Min Infiltration Rate (in/hr)	1.18	0.43	0.2	0.22	0.06
Decay Constant (1/hr)	4	4	4	4	4
Drying Time (d)	2	3	8	8	10.5
Max Volume (in)	14	13.2	12.5	9.8	7.0

3.2.4.2 Manhole

Sewer manholes were simulated as junction nodes in the model. The following information is required:

- Node ID
- Invert
- Maximum Depth (approximated as the difference from manhole rim and manhole invert)
- Surcharge Depth

Manhole ID was inherited from the name of the manhole in the sewer GIS. The naming convention is "MH_XXXX". Manhole input information was updated based on the latest available GIS information.

Manhole input parameters, including invert and rim were found or estimated from record drawings, design drawings, and the sewer manhole shape file. For water tight manholes or manholes with bolted down covers, a surcharge depth of 50-ft will be applied.

[3] Soil types can be categorized into standard hydrologic soil groups A, B, C and D, with group A having the lowest runoff potential and group D having the highest runoff potential. Dual rated groups are group D in their natural state, but can behave according to the first letter if the area is drained. Additional information regarding hydrologic soil group descriptions can be found in the Appendix.

3.2.4.3 Sewer Mains

Sewer mains are the conveyance element and were simulated as conduits in the model. The following input information was needed:

- Conduit ID
- Shape
- Number of barrels
- Upstream and downstream nodes
- Upstream and downstream offset
- Dimension (length, diameter/depth)
- Manning's roughness coefficient
- Minor loss coefficient (entry loss, exit loss, average loss)
- Flap gate installed or not (set at no flap gate for most of the sewer mains)

Conduit ID was inherited from the 2012 H&H Model.

Most of the pipe input parameters, including upstream and downstream nodes, dimension, shape, number of barrels, and flap gate information, were found or estimated from record drawings, design drawings and sewer gravity main GIS shapefiles. For pipes that do not begin or end at the invert of the upstream or downstream node, an offset value was provided to describe the difference from the invert of the pipe to the invert of the upstream or downstream node.

Manning's roughness coefficient is related to the pipe material. The initial input of the Manning's n for different materials is summarized in Table 3-5. The Manning's n may be changed during calibration to account for minor loss or additional sediment depositions in the pipe.

The initial minor loss for pipe will be set at zero for most pipes. For those pipes with sharp turns, a higher minor loss was applied.

If sewer main information was not available, sewer length was estimated in GIS geometry measurement; sewer size were assumed based on upstream and downstream sewers; sewer upstream and downstream offsets were estimated based on sewer connectivity assuming constant slope.

Figure 3-5: Hydrologic Soil Groups for CSS Area

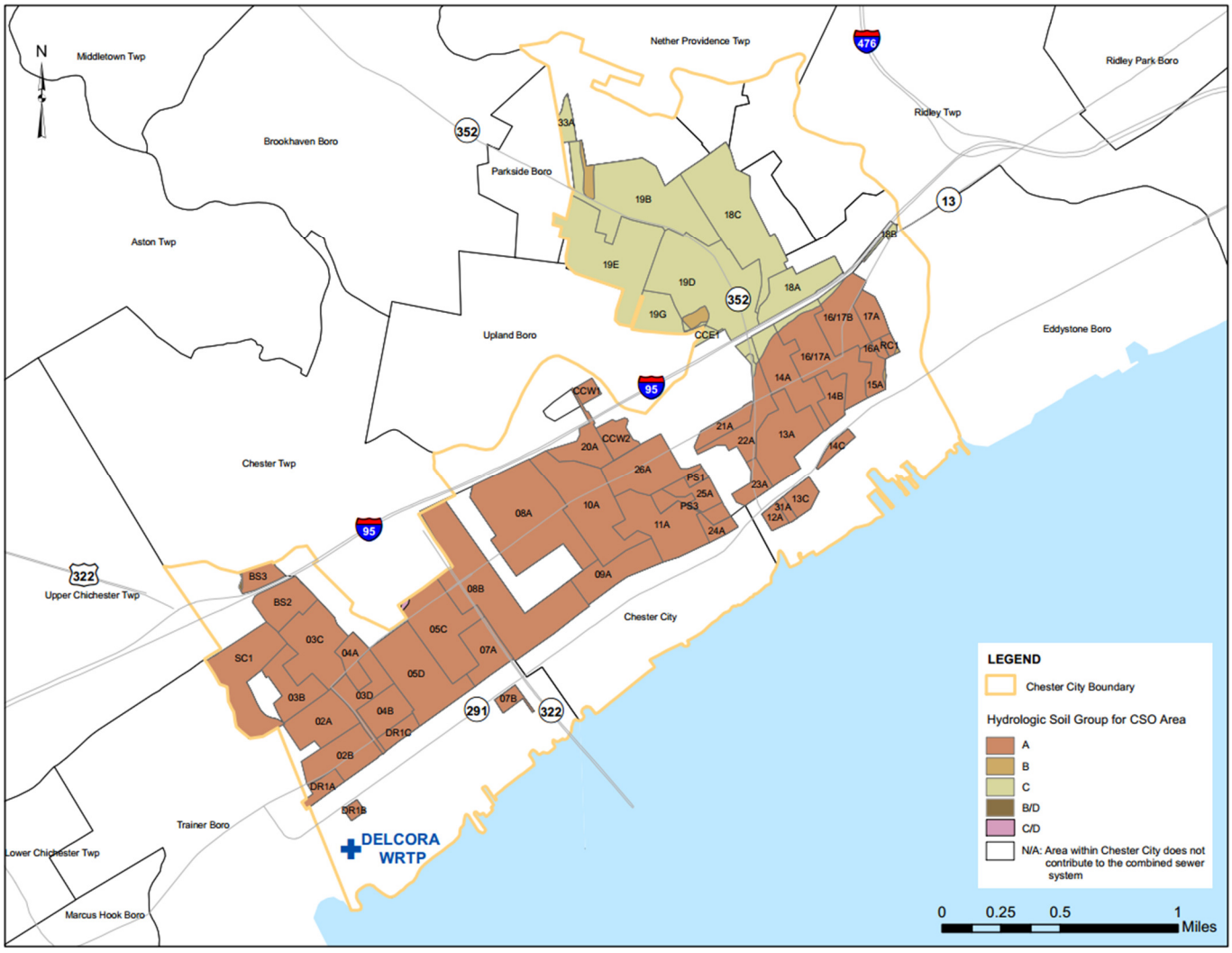


Table 3-5: Manning's Roughness Coefficient for Sewer Mains

Pipe Material	Manning's N
Polyvinyl Chloride (PVC)	0.011
Reinforced Concrete Pipe (RCP)	0.013
Ductile Iron (DI)	0.013
Cast Iron (CI)	0.013
Corrugated Metal Pipe (CMP)	0.020
Masonry	0.025
Unknown	0.013

3.2.4.4 CSO Outfalls

CSO outfalls will be simulated as outfall nodes in the model. The following information is required:

- Outfall ID
- Type (free, normal, fixed stage, tidal stage, time series, stage-flow, flap gate)
- Invert
- Boundary conditions

Outfalls are the discharge points in the model. The outfalls can either be free outfalls without any boundary conditions or the outfalls can have a boundary condition that the head needs to overcome for outflow to occur. The outfalls in the DELCORA's collection system are mostly in the tidal river reach. Therefore, appropriate tidal stages from NOAA data were used to set boundary conditions. Outfalls can have a flap gate at the end to prevent backflow.

Outfall ID will be named according to the CSO regulator overflow points. For example, the outfall for CSO regulator 002 will be named "NREG-002". The inverts of outfalls will be estimated based on record drawings and design drawings, and will be confirmed/adjusted from the field survey, if necessary.

A summary of the outfall data used in the model is contained in Table 3-6. One regulator (Regulator 010) does not have its own outfall, but rather discharges through the same outfall (Outfall 009) as Regulator 009. Also, Regulator 033 has been disconnected from the CSS and, therefore, its outfall is not included in the updated H&H model. As a result, there are a total of 24 CSO outfalls in the updated H&H model.

Table 3-6: CSO Outfall Characteristics Summary

Outfall No.	CSO Receiving Water	Invert at Regulator	Invert at Receiving Stream
002	Delaware River	7.00	-3.5
003	Delaware River	7.98	-3.5
004	Delaware River	8.80	-3.5
005	Delaware River	4.74	-4.5
007	Delaware River	0.81	0.21
008	Delaware River	2.79	0.01
009	Delaware River	2.61	-4
010*	Delaware River	22.5	*
011	Delaware River	7.09	-4
012	Delaware River	1.46	-2
013	Delaware River	1.86	-4
014	Delaware River	-1.09	-4
015	Ridley Creek	0.52	-3
016	Ridley Creek	0.11	-5
017	Ridley Creek	0.09	0.09
018	Ridley Creek	6.28	-5.0
019	Chester Creek	18.00	12.28
020	Chester Creek	8.78	-4
021	Chester Creek	5.78	-1.5
022	Chester Creek	11.5	-3.5
023	Chester Creek	1.33	-3.0
024	Chester Creek	1.21	-4.0
025	Chester Creek	-1.08	-4.0
026	Chester Creek	9.00	-4.0
032	Delaware River	1.00	-4.0
033	Ridley Creek	N/A	N/A

Notes:
*CSO regulator 010 discharges at Outfall 009.
N/A: Not Applicable

3.2.4.5 Flow Diversion Structure

As described in Section 3.2.2.2, most of the flow diversion structures are similar to Brown and Brown type regulators. The key components required for modeling these structures include float-operated gates, orifice plates and diversion weirs. Schematic representations of the flow diversion structures are shown in Figure 3-6.

Regulator Gates

Regulator gates will be simulated as orifices in the updated model. The following information is required to model a regulator gate in the model:

- Regulator Gate ID
- Upstream and downstream nodes
- Type
- Shape (two shapes: circle, rectangular)
- Dimension (Height, Width)
- Discharge Coefficient

Regulator gate ID is named according to the CSO regulator points. For example, the regulator gate for CSO regulator 003 is named "REG_003_Gate." All regulator gates are modeled as side-type orifices and have been assigned a discharge coefficient of 0.65. All regulator gates are modeled as rectangular except for REG_004_Gate which is modeled as a circular orifice. The updated model includes real time control rules for opening and closing of the gates based on levels in the float chamber and regulator limit settings. A summary of regulator gate characteristics is shown in Table 3-7.

Orifices

The following information is required to model an orifice in the model:

- Orifice ID
- Upstream and downstream nodes
- Type (two types: side, bottom)
- Shape (two shapes: circle, rectangular)
- Dimension (Height, Width, Crest Height)
- Discharge Coefficient

Orifice ID will be named according to the CSO overflow points. For example, the orifice for CSO 03 will be named "REG_03_Orifplate". All orifices in the collection system are side orifice type, rectangular in shape and were assigned a discharge coefficient of 0.65. The dimensions are based on record drawings.

A summary of the orifice data used in the model is contained in Table 3-8. The update H&H model has 20 orifices. All orifices are side type and are rectangular in shape. Regulators 004, 015, 017 018 and 032 do not have an orifice plate. Regulators 006, 027 and 033 are no longer connected to the CSS and therefore do not have any orifices, weirs or outfalls included in the H&H model.

Figure 3-6: Flow Diversion Structure Schematic

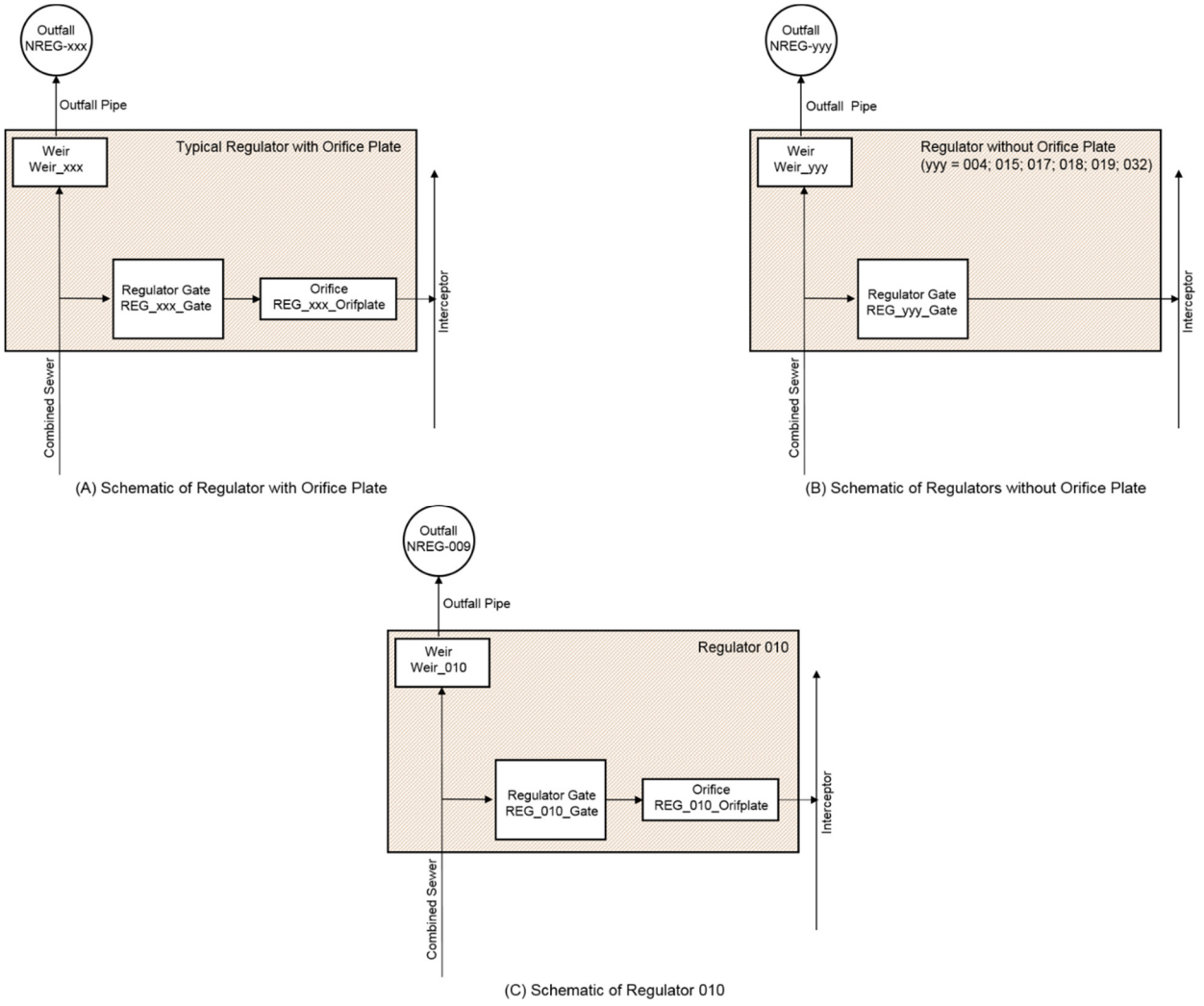


Table 3-7: Regulator Gates Characteristics

Regulator Gate ID No.	Dimensions		Invert EL (ft.)
	Height	Width	
002	5.0 in.	7.5 in.	6.29
003	7.5 in.	7.75 in	7.18
004	8.0 in. dia.	N/A	7.89
005	12.0 in.	12.0 in.	3.99
007	5.0 in.	6.00 in.	0.50
008	7.5 in.	12.375 in.	2.63
009	5.0 in.	7.5 in.	2.45
010*	7.5 in.	15.375 in.	21.50
011	5.0 in.	9.25 in.	6.99
012	2.50	9.25 in.	0.50
013	7.5 in.	7.75 in.	0.84
014	12.0 in.	15.00 in.	-2.50
015	5.0 in.	6.00 in.	0.46
016	7.5 in.	12.375 in.	-0.55
017	5.0 in.	6.00 in.	0.09
018	5.0 in.	6.00 in.	6.06
019	7.5 in.	15.38 in.	16.89
020	7.5 in.	7.75 in.	8.06
021	7.5 in.	7.75 in.	4.56
022	5.00 in.	6.00 in.	10.47
023	7.5 in.	7.75 in.	0.50
024	5.0 in.	9.25 in.	0.50
025	5.0 in.	6.00 in	-2.25
026	7.5 in.	12.375 in.	7.91
032	*	*	-0.20
033	N/A	N/A	N/A
*Gate removed; no data for gate opening dimensions. Regulator modeled as pipe with same diameter as upstream sewer			

Table 3-8: Orifice Characteristics

Orifice ID No.	Orifice Type	Dimensions		Invert EL (ft.)
		Height	Width	
002	Side	4 5/8 in.	6 in.	5.78
003	Side	6 ¼ in.	7 in.	6.68
004	None	N/A No Orifice Plate		N/A
005	Side	7 ½ in.	12 in.	3.49
007	Side	3 ½ in.	5 in.	0
008	Side	6 7/8 in.	18 in.	2.13
009	Side	3 ½ in.	8 in.	1.95
010*	Side	10.563 in.	15 in.	21.09
011	Side	5 7/8 in.	8 in.	6.49
012	Side	4 5/8 in.	14 in.	0.00
013	Side	4 ½ in.	16 in.	0.34
014	Side	7 ½ in.	16 in	-3
015	None	N/A No Orifice Plate		N/A
016	Side	9 1/8 in.	30 in.	-1.05
017	None	N/A No Orifice Plate		N/A
018	None	N/A No Orifice Plate		N/A
019	None	N/A No Orifice Plate		N/A
020	Side	12.15 in.	8 in.	7.41
021	Side	11.33 in.	15 in.	4.47
022	Side	2.9 in.	8 in.	9.97
023	Side	5.75 in.	14 in.	0.00
024	Side	7.5 in.	16 in.	-2.75
025	Side	4.61 in.	5 in.	7.41
026	Side	7.69 in.	30 in.	
032	None	N/A No Orifice Plate		N/A
033	N/A	N/A No longer connected to CSS		N/A

Weirs

Diversion weirs will be simulated as weirs in the model. The following information is required to model a weir in the model:

- Weir ID
- Upstream and downstream nodes
- Type (four potential weir types: transverse, sideflow, V-notch, trapezoidal)
- Dimension (Height, Weir Length, Weir Crest Height)
- Coefficient of Discharge
- Number of End Contractions

Weir ID will be named according to the CSO overflow points. For example, the weir for CSO 03 will be named "Weir_03". Weir information will be obtained from record drawings and will be field verified, if necessary. All weirs were found to be of the transverse type with no end contractions. All weirs are assigned a discharge coefficient of 3.33.

A summary of the weir data used in the model is contained in Table 3-9.

3.2.4.6 Pump Stations

The wet wells in the pump stations were simulated as storage nodes, and pumps were simulated as ideal pumps in the model. Dimensions of the storage nodes were based on record drawings. For pumps, the following information is required:

- Pump ID
- Startup Depth
- Shutoff Depth

Pump startup depth and shutoff depth will be set up in the model according to the typical pump operation.

Table 3-9: Weir Characteristics

Weir ID No.	Dimensions		
	Height	Length	Crest Height
002	2.50 ft.	2.24 ft.	1.21 in.
003	2.50 ft.	2.24 ft.	1.30 in.
004	2.74 ft.	1.69 ft.	1.17 in.
005	3.50 ft.	2.65 ft.	1.25 in.
007	3.50 ft.	2.65 ft.	0.81 in.
008	4.98 ft.	3.54 ft.	1.23 in.
009	3.25 ft.	3.12 ft.	0.94 in.
010*	2.50 ft.	2.24 ft.	1.50 in.
011	2.44 ft.	3.9 ft.	1.76 in.
012	1.58 ft.	1.73 ft.	1.46 in.
013	3.40 ft.	2.65 ft.	1.62 in.
014	2.75 ft.	2.52 ft.	2.33 in.
015	2.79 ft.	1.53 ft.	0.27 in.
016	3.58 ft.	4.51 ft.	2.08 in.
017	2.17 ft.	2.63 ft.	0.96 in.
018	4.33 ft.	2.58 ft.	0.25 in.
019	3.17 ft.	2.05 ft.	1.44 in.
020	2.50 ft.	2.24 ft.	1.44 in.
021	0.63 ft.	1.48 ft.	1.72 in.
022	2.53 ft.	2.24 ft.	1.53 in.
023	1.50 ft.	2.24 ft.	1.25 in.
024	3.00 ft.	2.45 ft.	1.13 in
025	2.50 ft.	2.24 ft.	1.67 in.
026	0.95 ft.	2.43 ft.	2.64 in.
032	2.75 ft.	1.66 ft.	1.54 in.
033	N/A	N/A	N/A

*Height (H) measured from weir crest to pipe crown; Crest Height (H) measured from invert of upstream node to weir crest

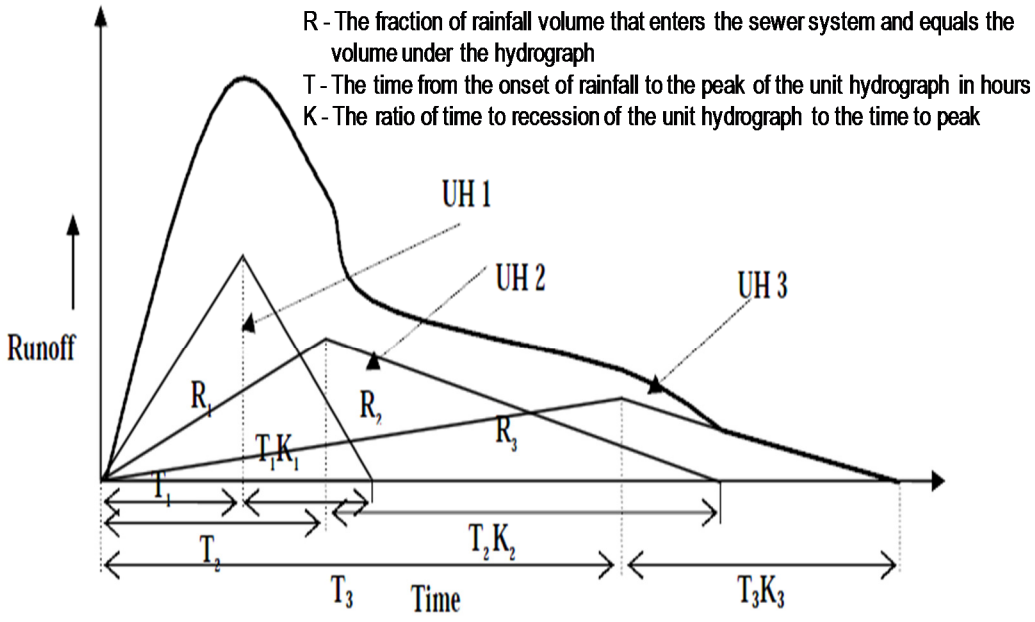
3.2.4.7 Modeling of Separated Areas - Rainfall Derived Infiltration and Inflow (RDII)

The model will use the RTK unit hydrograph (UH) to estimate RDII into the separated area sewer systems. As shown in Figure 3-7 (Muleta & Boulos, 2008), a RTK UH set contains up to three hydrographs: one for a short-term response (UH1), one for an intermediate-term response (UH2), and one for a long-term response (UH3). UH1 represents the most rapidly responding inflow component and has a short T value, UH2 includes both inflow and infiltration and has a longer T value, and UH3 includes infiltration that may continue long after the storm event has ended and has the longest T value. The unit hydrograph is defined by the following three parameters:

- R: the fraction of rainfall volume that enters the sewer system and equals to the volume under the hydrograph,
- T: the time from the onset of rainfall event to the peak of the unit hydrograph in hours, and
- K: the ratio of time to recession of the unit hydrograph to the time to peak.

The same set of RDII parameters will be applied in the same metershed because of the availability of the flow hydrograph for model calibration. The initial values of RTK will be estimated using the RDII Analyst tool in the InfoSWMM. The RTK values are calibration parameters to be refined during model calibration.

Figure 3-7: RTK Unit Hydrographs



Source: M.K. Muleta and P.F. Boulos, Analysis and Calibration of RDII and Design of Sewer Collection Systems, ASCE Conference Proceedings 316, 642 (2008)

3.3 Summary

The 2012 H&H model was updated as described above. A summary of the key revisions is presented in Table 3-10. The detailed layout of the updated model is shown in Figure 3-8 and Figure 3-9.

Table 3-10: Summary of Revised H&H Model

Review Item	2012 Model Review Observation	Comments	Updated Model
Model Software	- EPA SWMM 5.0		Innovyze InfoSWMM version 14.5
Vertical Datum	- NAVD 88	- To be verified	- NGVD29
General Sub Models	- EPASWMM for the runoff model - Horton Equation for the infiltration model - Hydrodynamic wave for the flow routing model	- All these choices are commonly seen in collection system modeling practices	
Rain Gauge	- One (1) rain gage, located at the Western Regional Treatment Plant (WRTP)	- One rain gauge is not sufficient for the entire service area in the model	- Seven (7) rain gauges, as shown in Section 2 - Additional GARR analysis performed
Service Area	- 67 subcatchments, all for combined area - One set of Horton infiltration parameters are applied to most of the subcatchments (66 out of 67 subcatchments) - The infiltration parameters applied in the model is equivalent to infiltration parameters for soil type C/D	- All service area including separated area that contribute flow to the DELCORA collection system should be included in the model - Combined area delineation will be checked to include any changes along the years - Soil type need to be checked to verify Horton infiltration parameters in all subcatchments	- 111 subcatchments, 54 for combined area and 57 for separated areas - Combined area was modified to include newly separated areas. - Horton infiltration parameters applied to 54 out of 111 subcatchments - Horton infiltration parameters varied based on identified soil types -

Review Item	2012 Model Review Observation	Comments	Updated Model
Sewer Manhole	- 736 storage nodes. - All sewer manholes are simulated as storage units in the model. - The majority of the storage units (732 out of the 736) have a diameter of 4-ft, and the rest (4 units) have a surface area of 100 square feet (sf.) (equivalent to 10'x10'). - All storage units are set-up with a ponding area of 9,999 sf. to allow excess water to collect atop of the nodes and be re-introduced into the system as conditions permit.	- Sewer manholes will be simulated as common junction node - This will help with SSO evaluation in the collection system	- 860 common junction nodes. - The majority of the common junction nodes (836 out of the 860) have a diameter of 4-ft, and the rest (4 units) have a surface area of 100 square feet (sf.) (equivalent to 10'x10'). - There are 35 imaginary junctions created to receive flow from the subcatchments gravity network not included in the model network
CSO Outfall	- 29 outfall nodes - All CSO outfalls are free outfall	- All outfalls are located in the Delaware River in the tidal reach, a tidal stage instead of free outfall should be assigned to the outfalls - Outfall ID 101 has dry weather input of 1.76 cfs, it represents WRTP in the model	- 24 CSO outfall nodes - Tidal data is assigned to 24 outfalls using time series - Wherever tide gates are installed, a real time control is applied

Review Item	2012 Model Review Observation	Comments	Updated Model
Sewer Mains	- 735 conduit links. - Negative slopes at Nodes 73803 and 70709 not matching the GIS. - Pipe connectivity is not consistent with the GIS in Subcatchment EA1, 25A. - Pipe size and connectivity is not consistent with the GIS around Node: 5201242, 5201234. - Pipe size is not consistent with the GIS around Node: 52018-52015. - Pipe size is not consistent with the GIS around Node: 531-527, 522-517, 516-513, 510020301-5100202, 403-NCPS, 40801-40801A, 32405-32404, and 1110402-11103. - Pipe size and slope are not consistent with the GIS around Node: 422-4140. - NREG06 outfall pipe direction is opposite.	- All the negative slopes and inconsistencies need to be checked with the most updated GIS and record drawings during the model update	- 817 conduit links. - 45 imaginary conduit links created to receive flows from subcatchment gravity network not included in the model

Review Item	2012 Model Review Observation	Comments	Updated Model
CSO Regulators	- 34 orifice links. - All CSO regulators are simulated using orifices to intercept dry weather flows and partial wet weather flows to the collection system, and with elevated conduits to convey extra flows to the CSO outfalls. - Approximately 75% of the orifices (25 out of 34) are modeled with Real Time Control (RTC) to mimic regulator gate opening based on level. - None of the regulator diverting weir structures is simulated in the model.	- Diverting weir structures need to be added in the model - The slopes of all overflow pipes connected to the CSO outfalls need to verified - All orifice opening dimensions verified will be verified - All the RTC rules regulating orifice opening will be verified with actual operation	- 44 orifice links. - CSO regulators are simulated using orifices and float-operated gates to intercept dry weather flows and partial wet weather flows to the collection system, and with conduits set a verified inverts to convey extra flows to the CSO outfalls. Exceptions occur at several regulators where orifices have been removed and at one regulator where the float and gate have been removed. - Approximately 57% of the orifices (25 out of 45) are modeled with Real Time Control (RTC) to mimic regulator gate opening based on level. - Regulator diverting weir structures added to the model. - All orifice opening dimensions were verified using record drawings excepting Orifice 024 which was field verified.
Pump Station	- No pump station is included in the model	- All pump stations that contribute flow to the DELCORA collection system should be added to the model, with related force mains	- Pump stations added to model. - Related force mains added to model

Review Item	2012 Model Review Observation	Comments	Updated Model
Dry Weather Flow	- 94 dry weather flow (DWF) inputs - Total DWF is 7.01 MGD - No diurnal curve - DWF does not include all the separated service areas that contribute to the DELCORA system -	- DWF should be updated to include all the service areas that contribute to the DELCORA system - Weekday and weekend diurnal curve should be included in the model to effectively simulate dry weather diurnal pattern	- 111 dry weather flow (DWF) inputs - Total DWF is 24.6 MGD - DWF analysis was performed on all flow meters in separated and combined areas as well as pump stations - Weekday and weekend diurnal curves were generated as well as overall, weekday, weekend and monthly DWF factors.
RDII	- No rainfall-derived infiltration/inflow (RDII) element was found in the model	- RDII should be included in the model to estimate reasonable wet weather inflow from RDII	- RDII was included in the model to estimate reasonable wet weather inflow from RDII

Figure 3-8: Updated H&H Model Layout

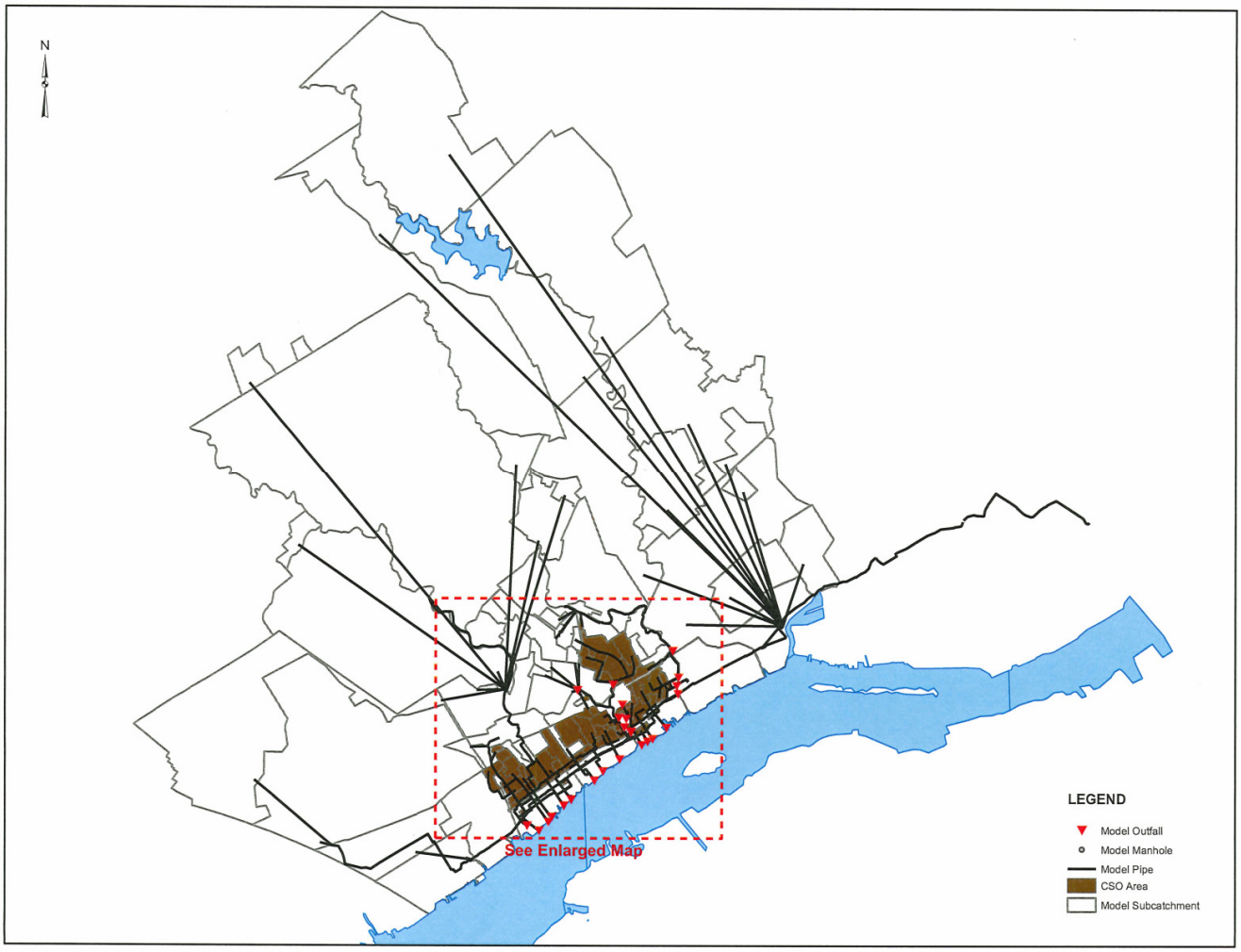
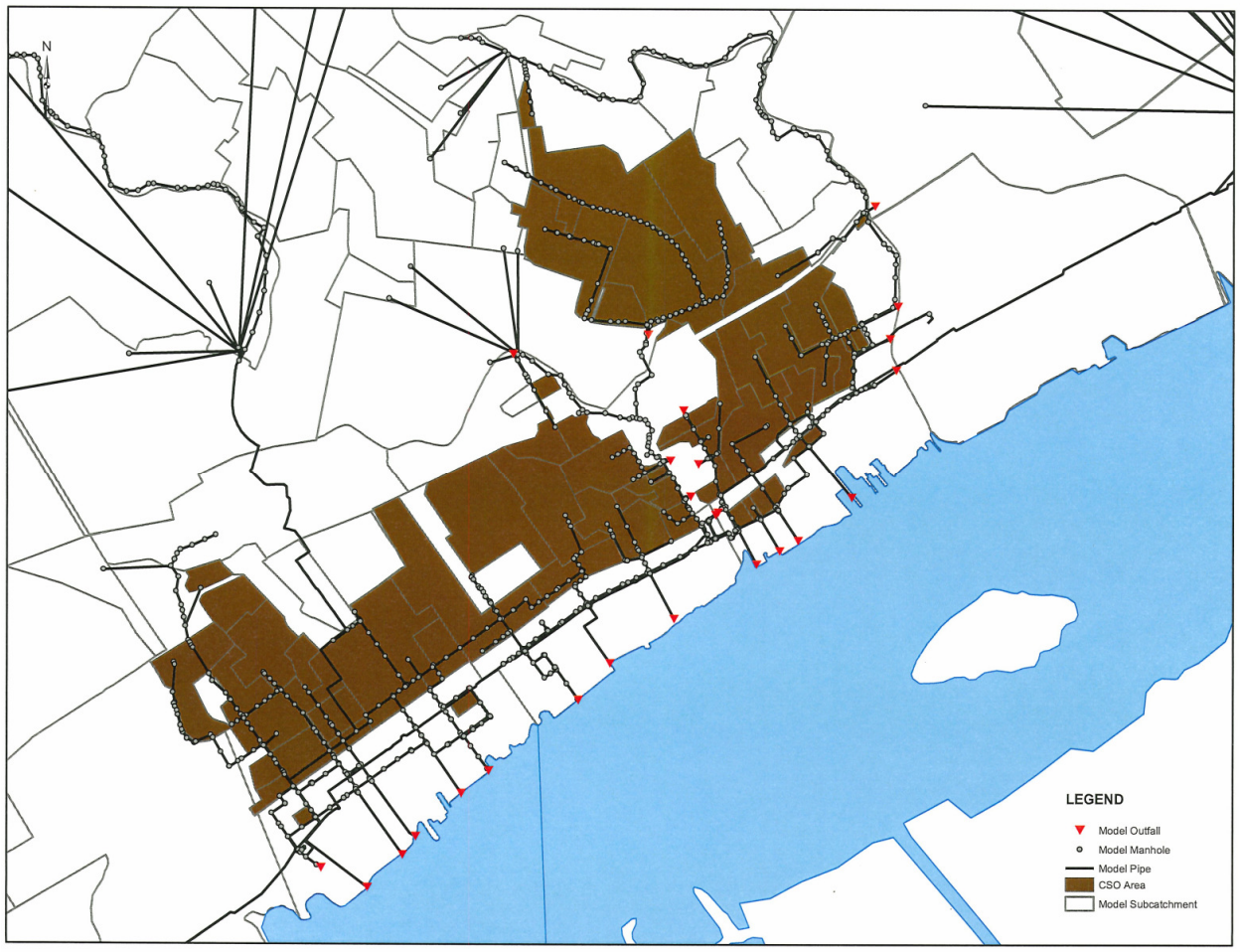


Figure 3-9: Updated H&H Model Layout – CSS Area



Section 4 DELCORA H&H Model Calibration and Validation

4.1 Model Calibration and Validation

Model credibility is developed through model calibration and validation. Model calibration involves application of the model to known external inputs (e.g., rainfall), evaluation of the model's ability to replicate monitored conditions (e.g., flow and volume), and adjustment of key model parameters as needed until an acceptable level of agreement is reached between simulated and monitored conditions.

After the model is satisfactorily calibrated it must be validated by running known storms with known flow results and having the model replicate the known events. Storms used in model validation should be independent from the storms used in the model calibration.

4.1.1 Calibration/Validation Criteria

4.1.1.1 Dry Weather Flow Calibration Criteria

Dry weather flow (DWF) analysis was based on the rainfall and flow monitoring results. DWF distribution in the collection system was based on land use data. Weekday, weekend and monthly diurnal factors from the DWF analysis were applied for each flow meter service area. Upstream meters in the system were calibrated first, then flows through the system to the pumps stations and to the WRTP were balanced. Figure 4-1 shows the arrangement of the meters in the system and meter identification.

DWF calibration will adhere to industry standards and the criteria below:

- The simulated hydrograph should match the general observed hydrograph shape,
- The simulated time of peaks and troughs will be within 1 hour of the observed,
- The simulated peak flow will be within 10% of the observed flow, and
- The simulated flow volume over 24 hours will be within 10% of observed flow.

4.1.1.2 Wet Weather Flow Calibration Criteria

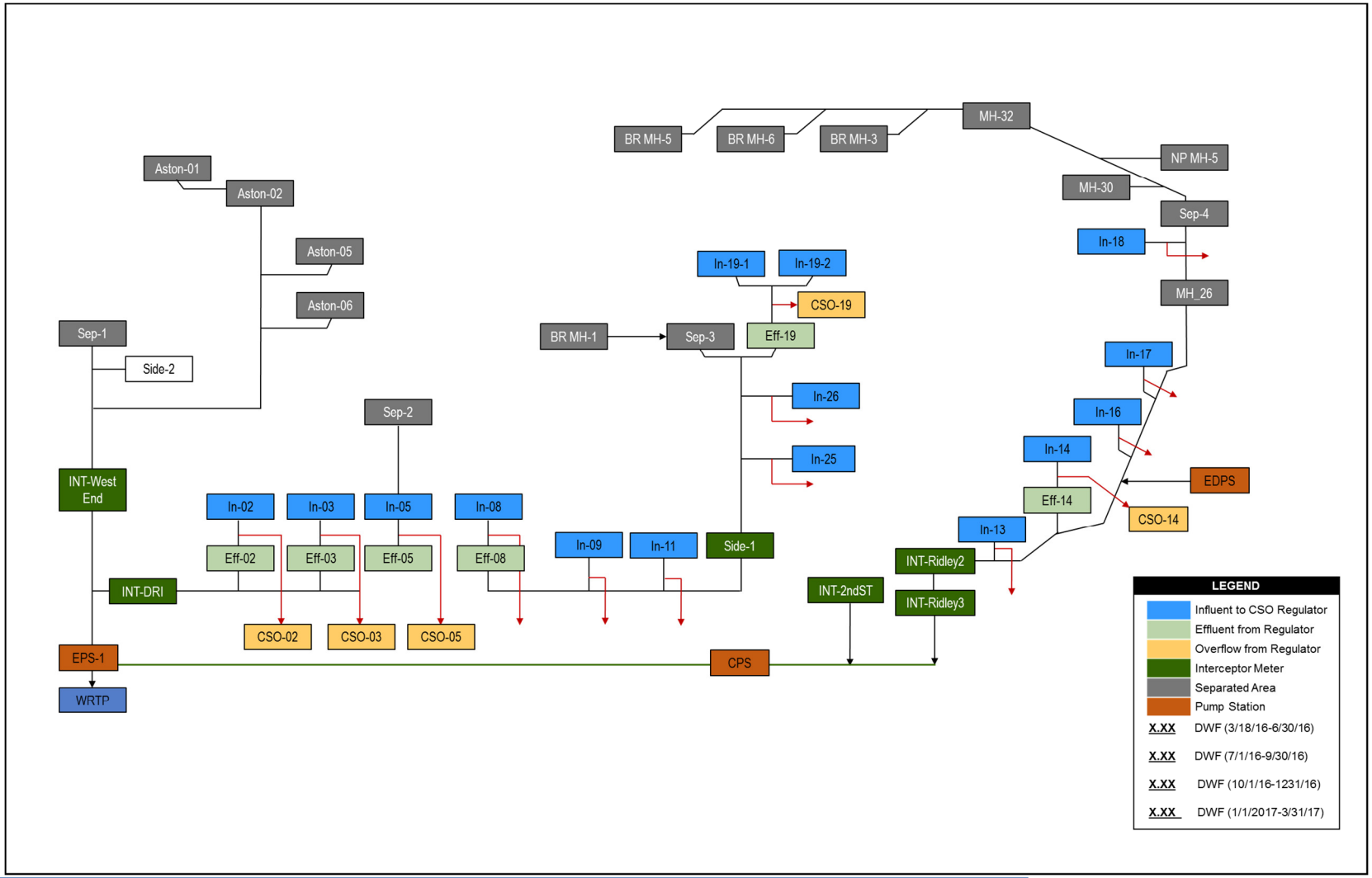
Wet weather flow (WWF) includes surface runoff from the combined area, RDII from the entire service area, and connected rooftops, if any, from the separated area. RDII parameters will be developed based on the separated area, and surface runoff parameters will be adjusted for the combined area to calibrate the system response to the wet weather conditions.

Four (4) wet weather events were selected for wet weather calibration. Final selections include wet weather events with various rainfall intensities and volume.

WWF calibration will adhere to industry standards and the criteria below:

- The simulated hydrograph should match the general observed hydrograph shape,
- The simulated time of peaks and troughs will be similar having regard to the duration of the event,

Figure 4-1: Flow Meter Schematic



- The simulated peak flow for significant peaks will be within the range of -15% to +25%,
- The simulated flow volume will be within the range of -10% to +20%,
- The depth of surcharge will be in the range of -0.1 m to +0.5 m, and
- At key points such as CSOs, the unsurcharged depth will be within ± 100 mm (± 0.33 ft.)

4.1.2 Model Calibration Approach

The runoff calibration for the combined sewer area is achieved by primarily adjusting width and percent imperviousness. The RDII calibration for separated areas was achieved by adjusting RTK values. The calibration of hydraulic control structures (weirs and orifices) is achieved by adjustment the discharge coefficients. The conduit hydraulics calibration is achieved by adjusting Manning's n and head loss coefficients. Flow depth, as well as flow rate, is checked while calibrating the hydraulic model.

After calibration, a different set of flow monitoring data was used to validate the model calibration. Model calibration and validation is an iterative process.

Percent Imperviousness

The percent imperviousness for combined sewer subcatchment is the key parameter to be adjusted to calibrate runoff to the observed wet weather flow volumes. If runoff from a large portion of the impervious surface could not be captured by the combined sewers due to a limited number and size of storm inlets, the percent imperviousness will need to be reduced significantly from its initial value calculated based on impervious land cover. This is done to represent a more reasonable "effectively connected area" and to achieve a satisfactory calibration for runoff volume.

Width

The width for the combined sewer sub catchments, in conjunction with percent imperviousness, will be adjusted to calibrate to the observed wet weather flow peaks.

Depression Storage

The depression storage is another hydrologic parameter for wet weather volume calibration. It can also be adjusted to achieve a satisfactory calibration for the wet weather flow start timing.

RDII Parameters

RDII parameters are to be adjusted to calibrate to the observed wet weather volumes and flow hydrograph shape for the separate sewer areas. Then, the runoff parameters will be adjusted to calibrate to the observed data.

Pipe Roughness

Pipe roughness was adjusted to calibrate to the observed flow depths and velocities at the meter locations.

Orifice and Weir

Orifice and weir parameters discharge coefficients were adjusted to calibrate to the observed overflows at the outfall meter locations.

Minor Loss

Minor loss values were applied in the model where necessary to refine observed flow/depth relationships at the meter locations.

4.1.3 Model Calibration Results

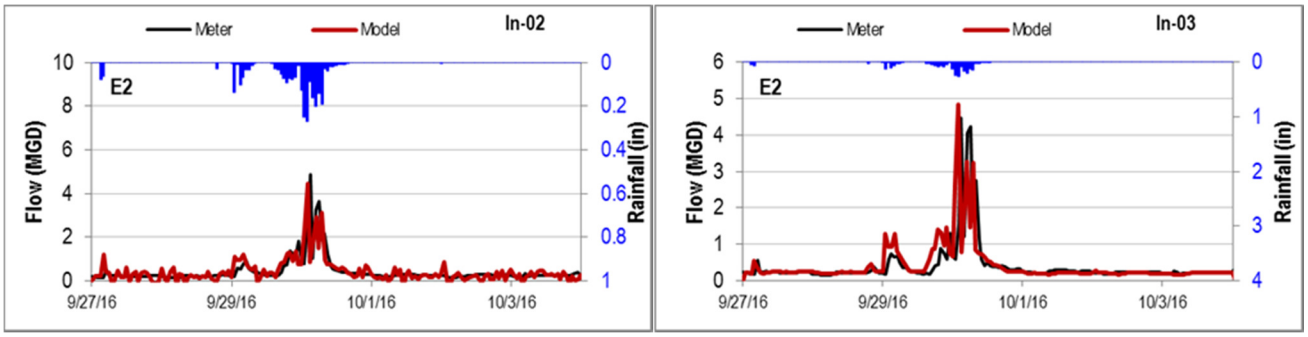
Successful calibration is indicated by satisfying agreements between the model prediction and the flow monitoring data in terms of shape of hydrograph, wet weather volume and peak flow. The calibration was performed and evaluated for various sizes of storms and different antecedent conditions so that the calibrated model can be reasonably applied for various hydrologic conditions. Wet weather events used for model calibration and validation are summarized in listed in Table 4-1. The larger storm events will have more weighting factor in the calibration process because the large events are the ones that dominate the total overflow volume.

Table 4-1: Wet Weather Events for Model Calibration and Validation

Event ID	Start Time	Stop Time	Rainfall Depth* (inches)	Used in Calibration	Used in Validation
E1	5/29/16 19:00	5/30/16 5:00	1.82	C	
E2	9/28/16 12:00	9/30/16 10:00	2.36	C	
E3	11/29/16 7:00	11/29/16 20:00	1.08	C	
E5	5/21/16 11:00	5/22/16 21:00	1.71		V
E6	7/28/16 15:00	7/29/16 9:00	1.26	C	
*At Chester PS rain gauge					

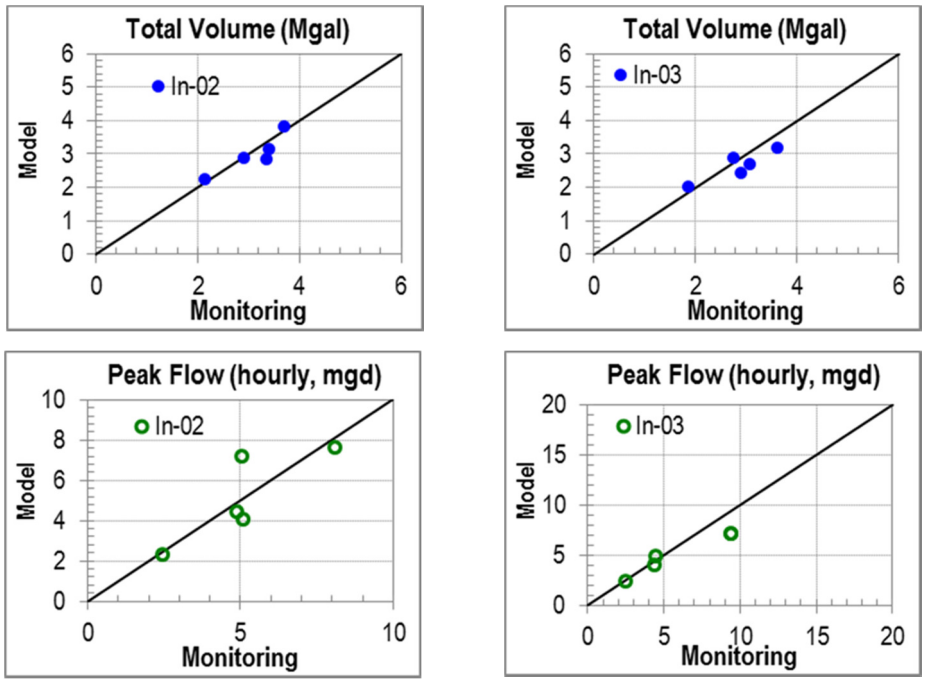
Examples of model calibration results are shown in Figure 4-2. Additional figures for all meters installed at different locations, including meters installed at major trunk interceptor, overflow pipes, influent pipe to overflow control structure, intercepting pipes, previous CSO areas, separate sewer areas and boundaries can be found in Appendix C.

Figure 4-2: Model Calibration Hydrograph (Example Plot)



Comparisons of the predicted total volume against the monitoring total volume and predicted peak flow against monitoring peak flow were analyzed and shown in 1:1 ratio plots for all calibrated meters. This is to evaluate the overall calibration and validation from all the events. The event points in Figure 4-3 are distributed close to the 1:1 ratio line, which means that the model predicted peak flow and wet weather event volume are in good agreement with the metered data. Additional figures for all model calibration plots can be found in Appendix C.

Figure 4-3: Model Calibration Hydrograph (Example Plot)



Section 5 Conclusion

The H&H model from the 2012 DELCORA LTCP Update was reviewed and updated. Data from the rainfall and flow monitoring program was used to calibrate and validate the updated H&H model. The calibrated H&H model will be used to assist DELCORA throughout the remaining steps in the CSO LTCP update process.

In a previous report (Greeley and Hansen, 2016), a typical hydrologic period was selected to represent the average conditions in terms of rainfalls, river flows and combined sewer system response across the DELCORA service area. Subsequent reports will apply the selected typical hydrologic period to the calibrated H&H model to evaluate existing CSO discharge frequency and volume and to evaluate the impacts of proposed LTCP control alternatives on CSO discharges.

Section 6 References

Chesapeake Conservancy. (2017). *Land Cover Data Project*. Retrieved April 10, 2017, from Chesapeak Conservancy Innovation Center: http://chesapeakeconservancy.org/conservation-innovation-center/high-resolution-data/land-cover-data-project/

Greeley and Hansen. (2015). *Hydrologic and Hydraulic Model Update and Calibration Plan.* Report prepared for Delaware County Regional Water Quality Control Authority (DELCORA).

Greeley and Hansen. (2016). *Typical Hydrologic Period Report.* Report prepared for Delaware County Regional Water Quality Control Authority (DELCORA).

Muleta, M., & Boulos, P. (2008). Analysis and Calibration of RDII and Design of Sewer Collection Systems. *ASCE Conference Proceedings 316* (p. 642). American Society of Civil Engineers.

NOAA. (2017). *Tides and Currents*. Retrieved May 05, 2017, from National Oceanic and Atmospheric Administration: https://tidesandcurrents.noaa.gov/

USACE. (1996). *Hydrologic Aspects of Flood Warning - Preparedness Programs, Technical Letter 1110-2-540.* Washington, DC: United States Army Corps of Engineers.

USDA. (2017). *Soil Survey*. Retrieved May 05, 2017, from United States Department of Agriculture Natural Resources Conservation Service Soils: https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/

USDA. (2017a). *Web Soil Survey*. Retrieved June 13, 2017, from United States Department of Agriculture Natural Resources Conservation Service: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

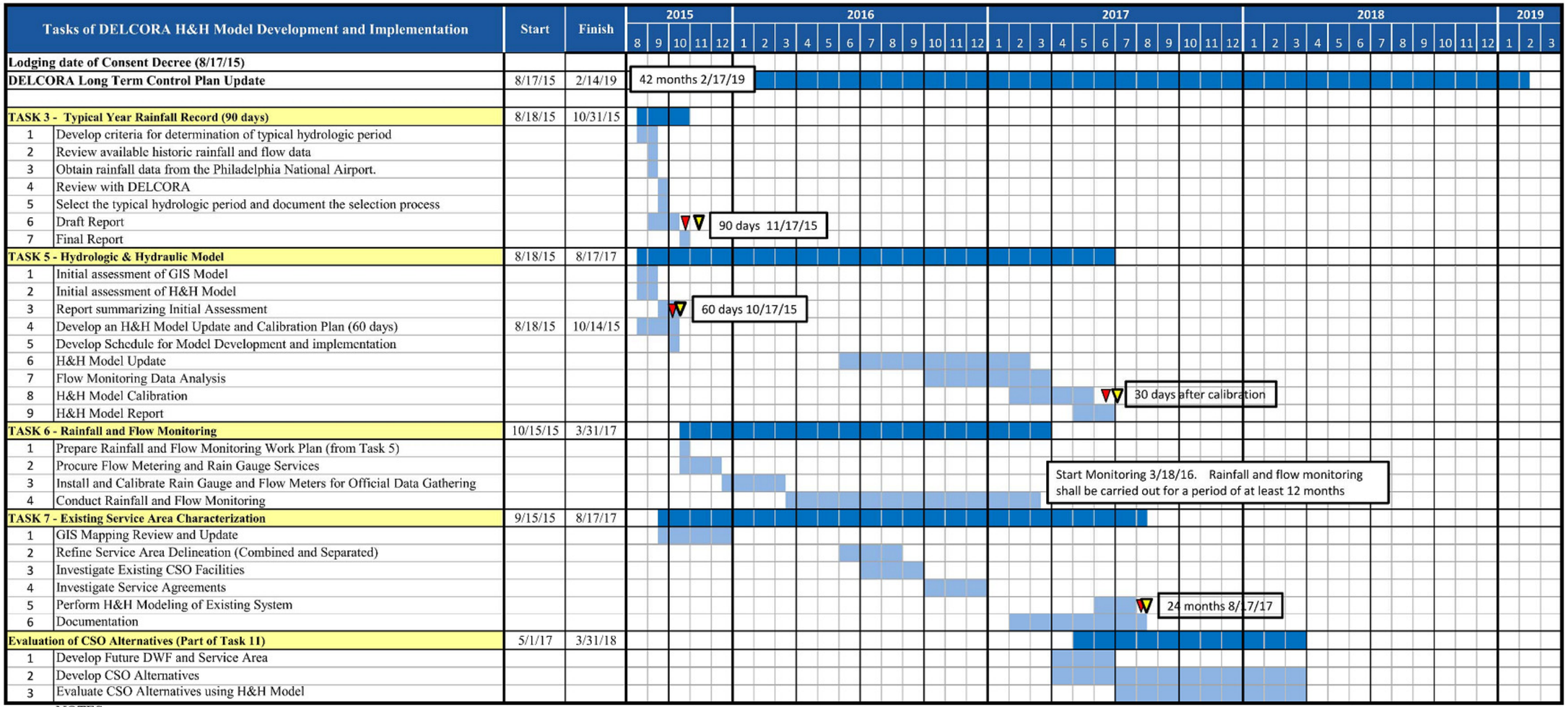
WaPUG. (2002). *Code of Practice for the Hydraulic Modelling of Sewer Systems.* Wastewater Users Planning Group.

Weston. (2012). *Long-Term Control Plan, City of Chester Combined Sewer System.* Report prepared for DELCORA (Revised April 2012).

Appendix A H&H Model Update and Calibration Schedule

Figure 6-1 Schedule for H&H Model Development and Implementation (Updated July 28, 2016)

	Tasks of DELCORA H&H Model Development and Implementation	Start	Finish
	Lodging date of Consent Decree (8/17/15)		
	DELCORA Long Term Control Plan Update	8/17/15	2/14/19
	TASK 3 - Typical Year Rainfall Record (90 days)	8/18/15	10/31/15
1	Develop criteria for determination of typical hydrologic period		
2	Review available historic rainfall and flow data		
3	Obtain rainfall data from the Philadelphia National Airport.		
4	Review with DELCORA		
5	Select the typical hydrologic period and document the selection process		
6	Draft Report		
7	Final Report		
	TASK 5 - Hydrologic & Hydraulic Model	8/18/15	8/17/17
1	Initial assessment of GIS Model		
2	Initial assessment of H&H Model		
3	Report summarizing Initial Assessment		
4	Develop an H&H Model Update and Calibration Plan (60 days)	8/18/15	10/14/15
5	Develop Schedule for Model Development and implementation		
6	H&H Model Update		
7	Flow Monitoring Data Analysis		
8	H&H Model Calibration		
9	H&H Model Report		
	TASK 6 - Rainfall and Flow Monitoring	10/15/15	3/31/17
1	Prepare Rainfall and Flow Monitoring Work Plan (from Task 5)		
2	Procure Flow Metering and Rain Gauge Services		
3	Install and Calibrate Rain Gauge and Flow Meters for Official Data Gathering		
4	Conduct Rainfall and Flow Monitoring		
	TASK 7 - Existing Service Area Characterization	9/15/15	8/17/17
1	GIS Mapping Review and Update		
2	Refine Service Area Delineation (Combined and Separated)		
3	Investigate Existing CSO Facilities		
4	Investigate Service Agreements		
5	Perform H&H Modeling of Existing System		
6	Documentation		
	Evaluation of CSO Alternatives (Part of Task 11)	5/1/17	3/31/18
1	Develop Future DWF and Service Area		
2	Develop CSO Alternatives		
3	Evaluate CSO Alternatives using H&H Model		



NOTES:
- Consent Order Deadline
- Draft and Final submittals

Appendix B Description of Hydrologic Soil Groups

Hydrologic Soil Groups (USDA, 2017a)

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

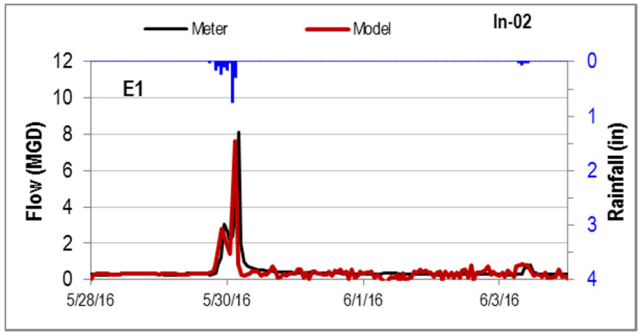
Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

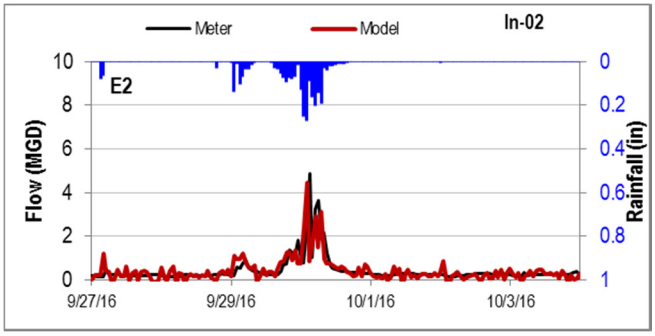
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

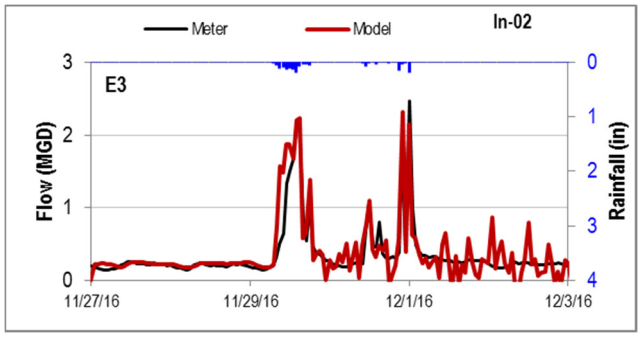
Appendix C Model Calibration and Validation Results

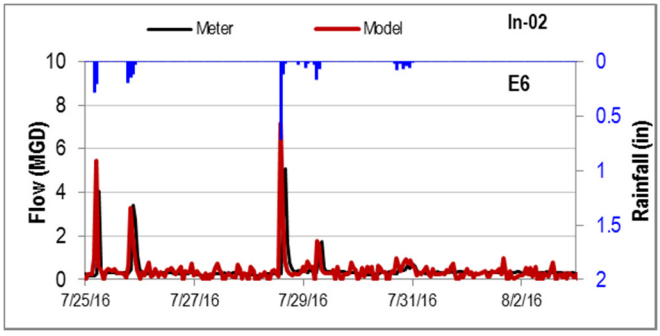
FLOW METER IN-02 MODEL CALIBRATION AND VALIDATION RESULTS

In-02 Model Calibration Results (Metered and Modeled Flow)

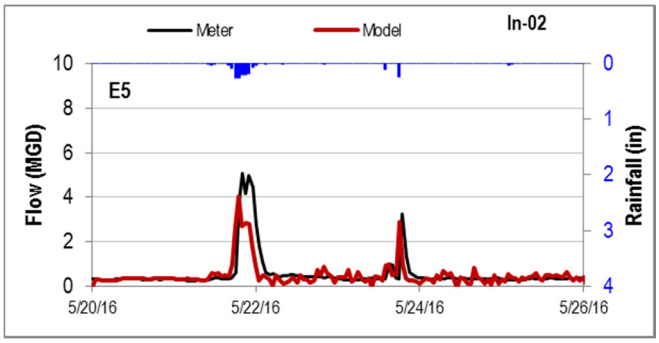




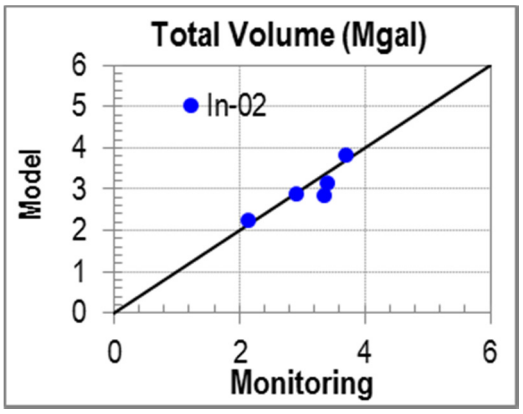


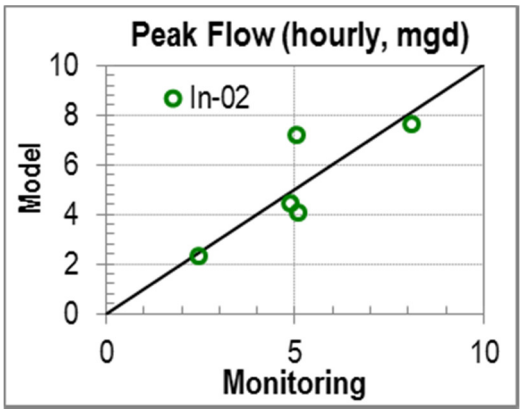


In-02 Model Validation Results (Metered and Modeled Flow)



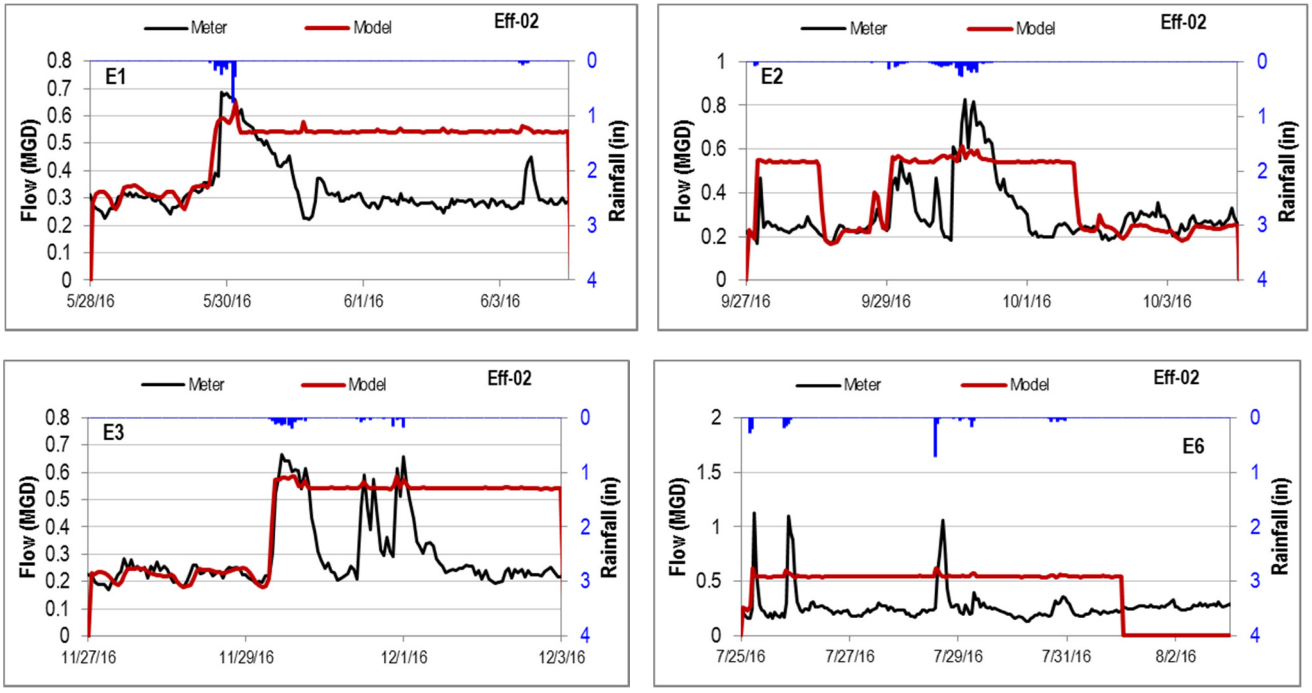
In-02 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



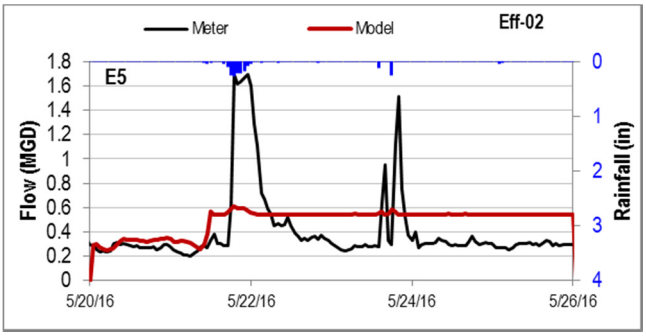


FLOW METER EFF-02 MODEL CALIBRATION AND VALIDATION RESULTS

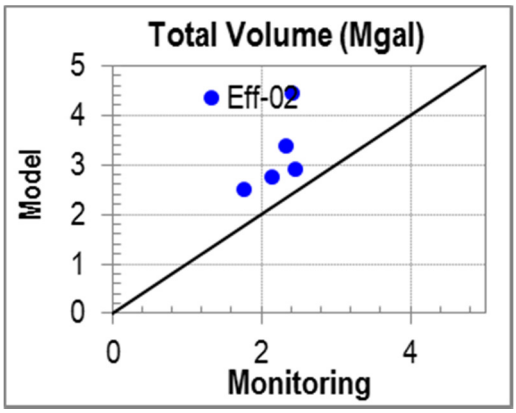
EFF-02 Model Calibration Results (Metered and Modeled Flow)

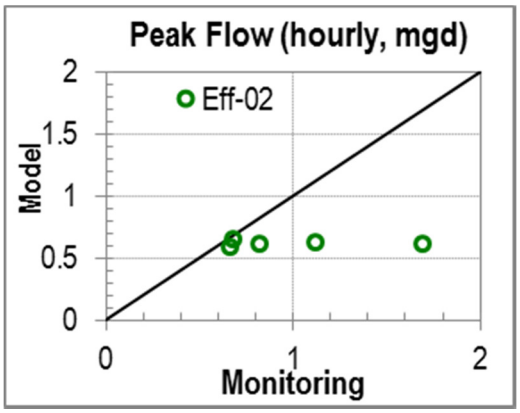


EFF-02 Model Validation Results (Metered and Modeled Flow)



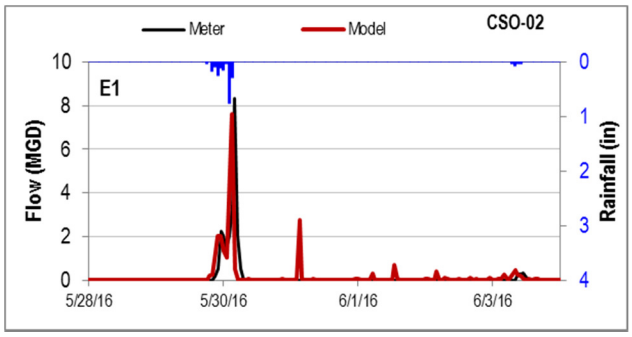
EFF-02 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

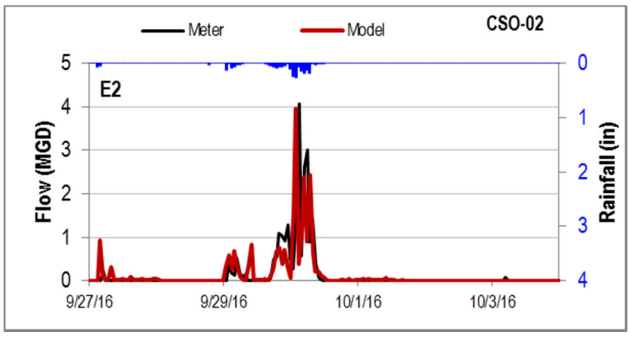


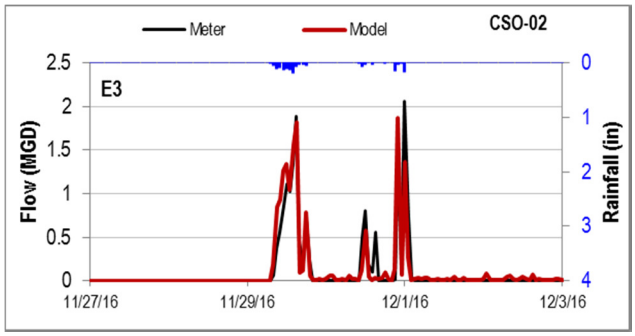


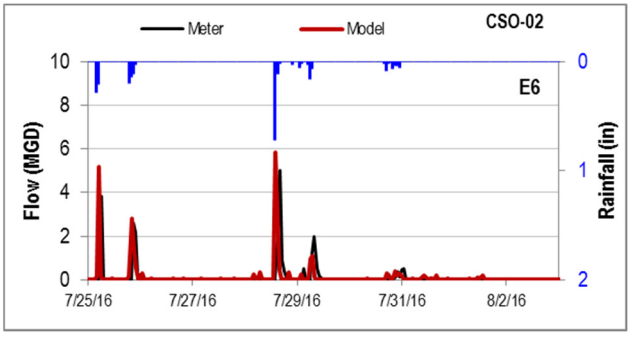
FLOW METER CSO-02 MODEL CALIBRATION AND VALIDATION RESULTS

CSO-02 Model Calibration Results (Metered and Modeled Flow)

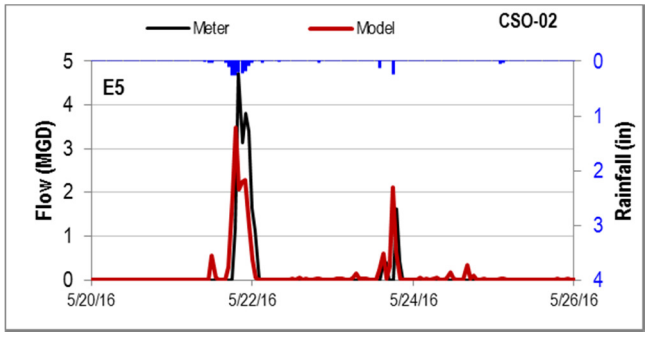




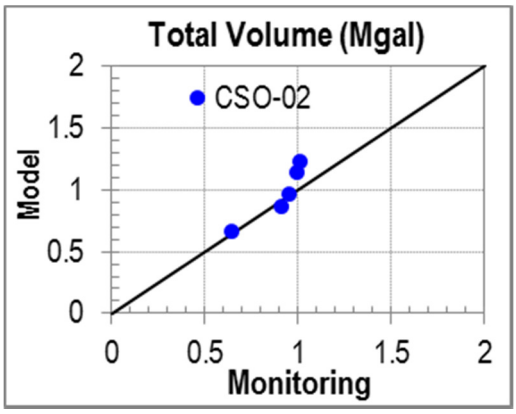


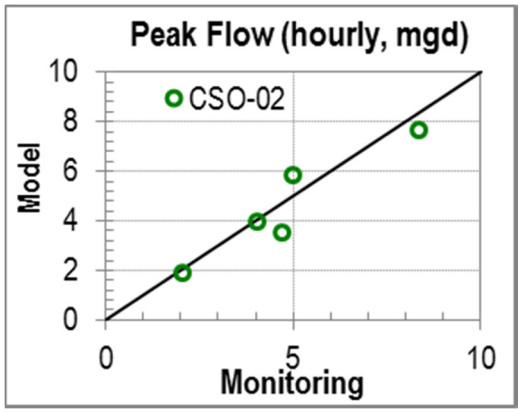


CSO-02 Model Validation Results (Metered and Modeled Flow)



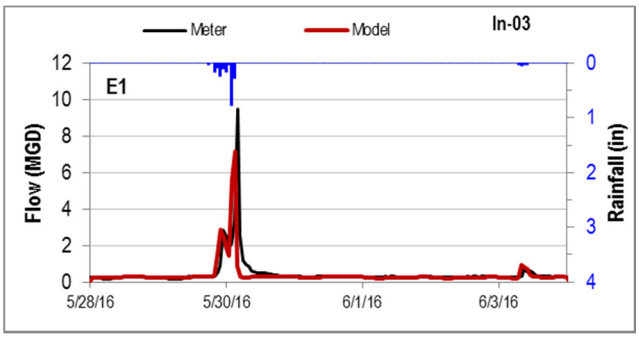
CSO-02 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

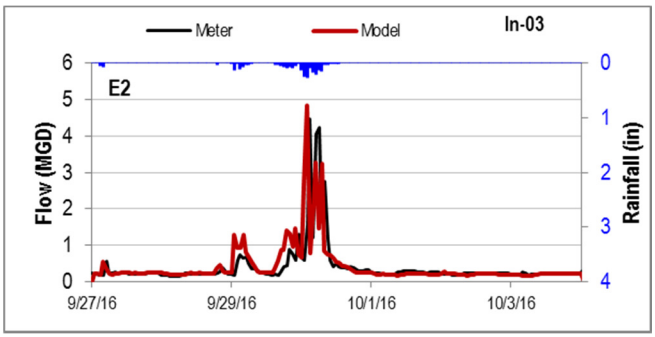


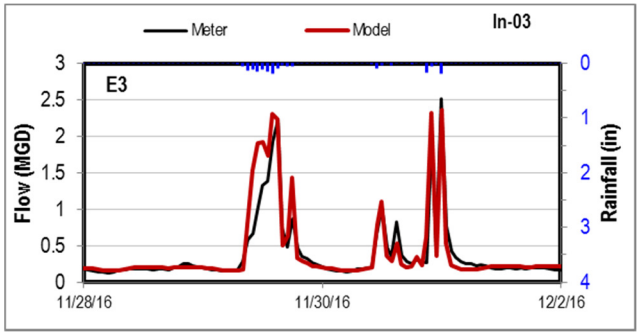


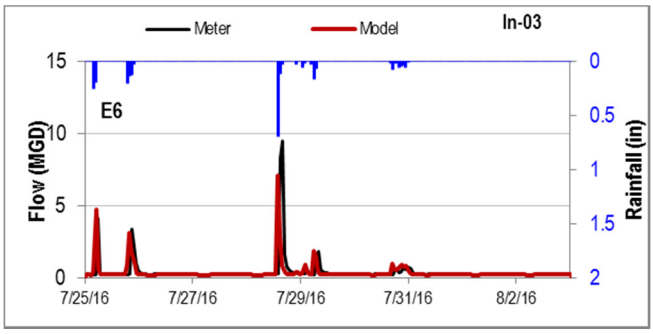
FLOW METER IN-03 MODEL CALIBRATION AND VALIDATION RESULTS

In-03 Model Calibration Results (Metered and Modeled Flow)

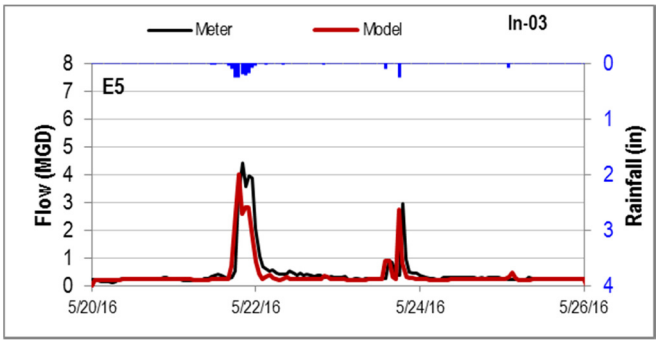




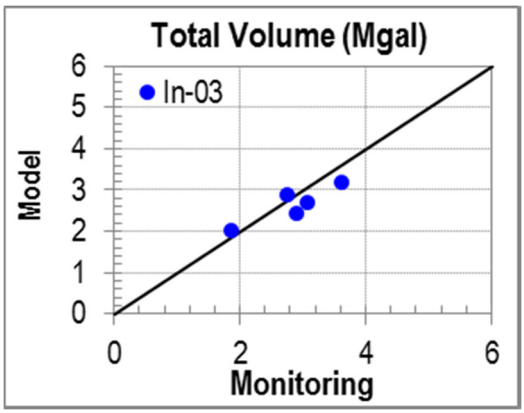


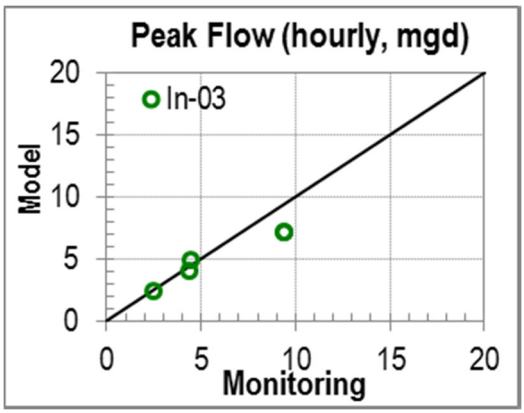


In-03 Model Validation Results (Metered and Modeled Flow)



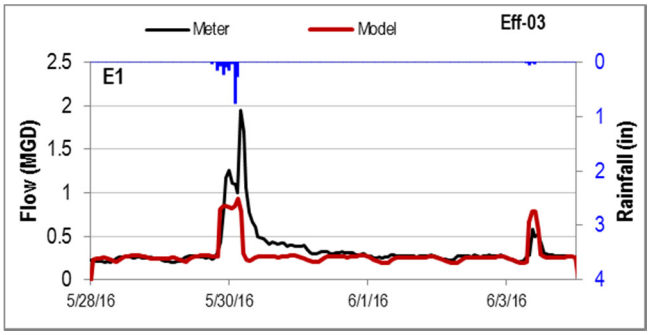
In-03 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

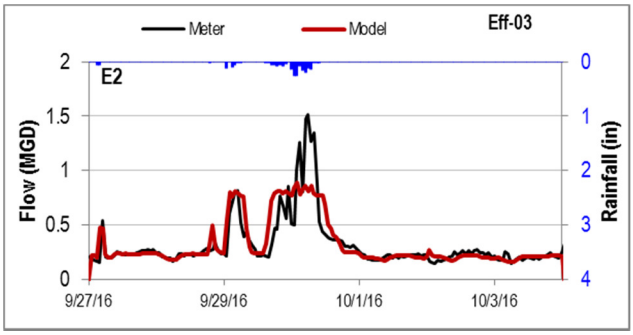


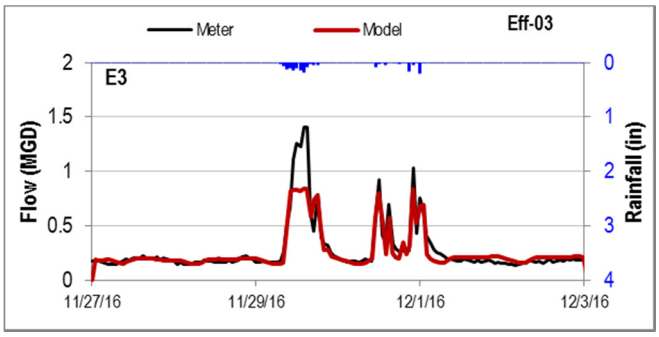


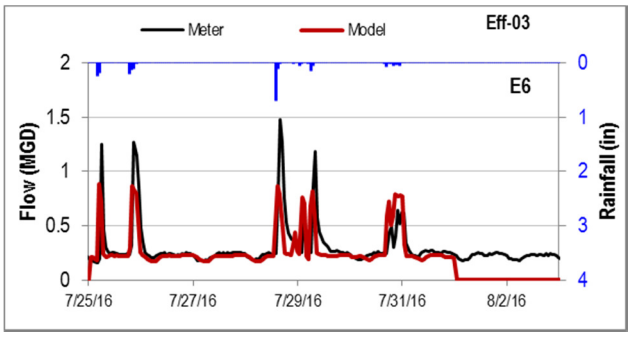
FLOW METER Eff-03 MODEL CALIBRATION AND VALIDATION RESULTS

Eff-03 Model Calibration Results (Metered and Modeled Flow)

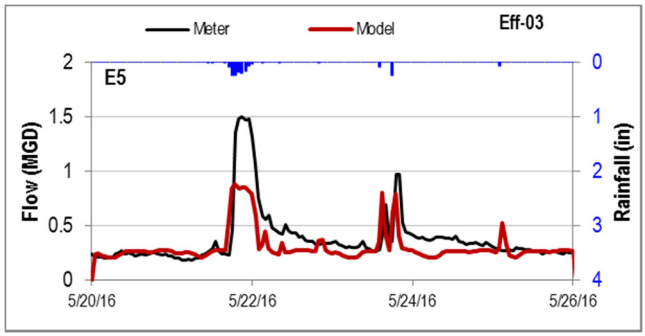




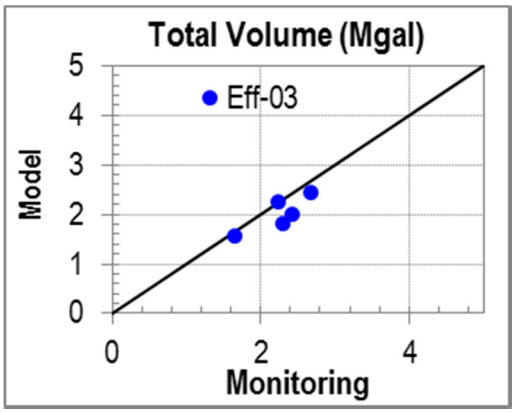


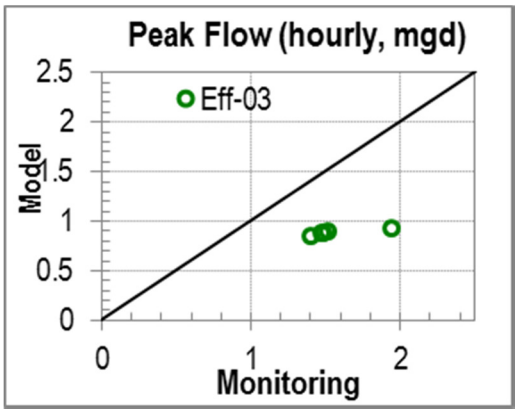


Eff-03 Model Validation Results (Metered and Modeled Flow)



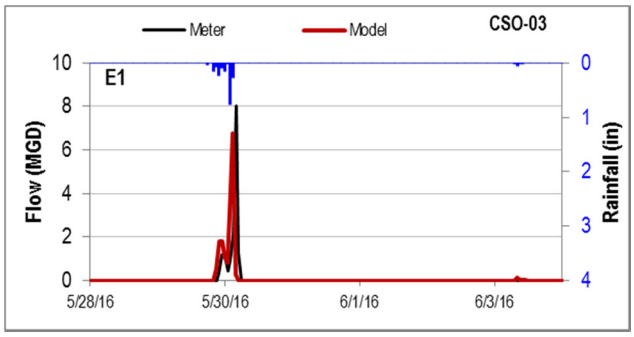
Eff-03 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

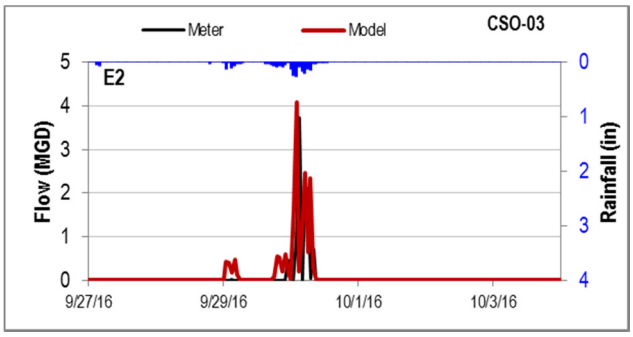


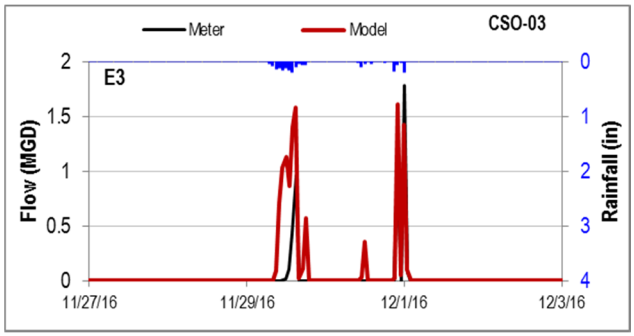


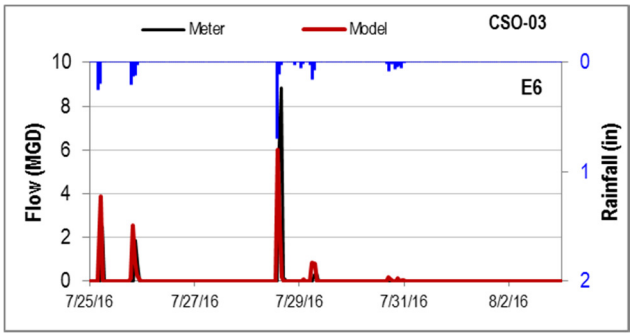
FLOW METER CSO-03 MODEL CALIBRATION AND VALIDATION RESULTS

CSO-03 Model Calibration Results (Metered and Modeled Flow)

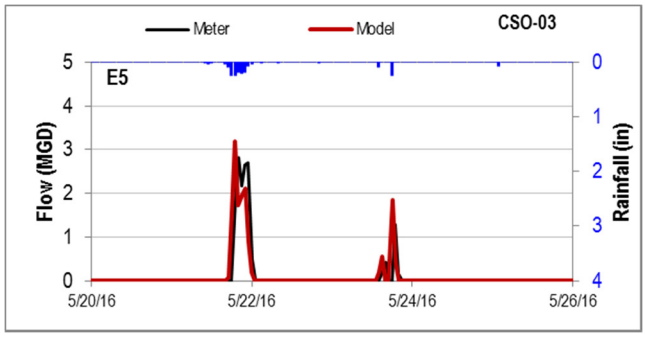




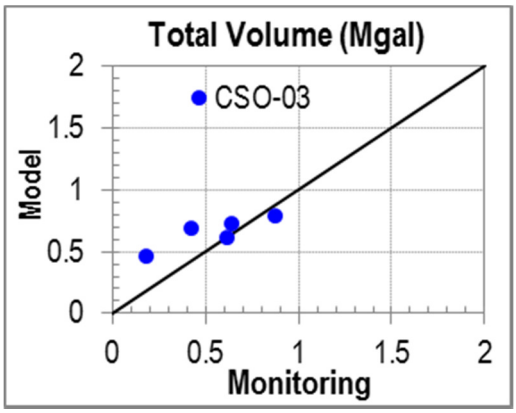


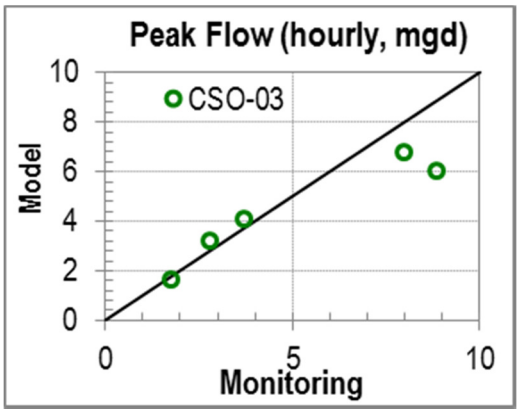


CSO-03 Model Validation Results (Metered and Modeled Flow)



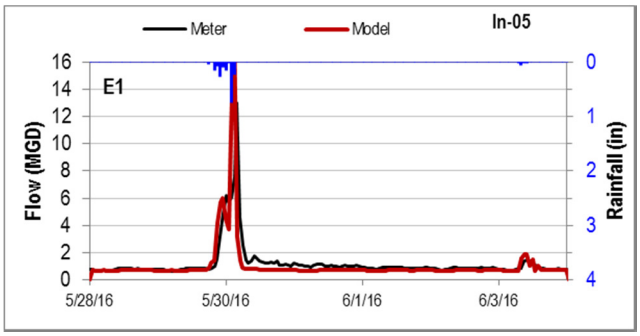
CSO-03 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

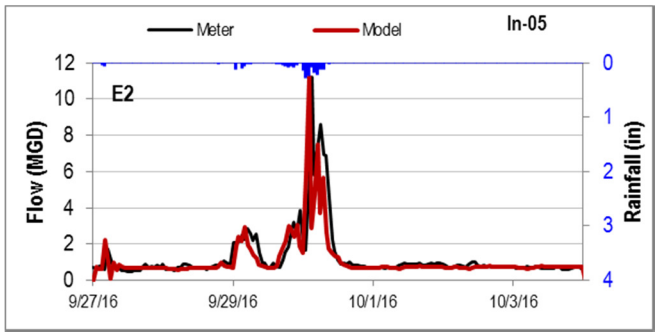


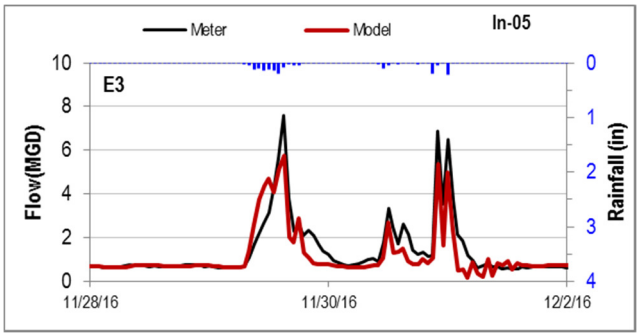


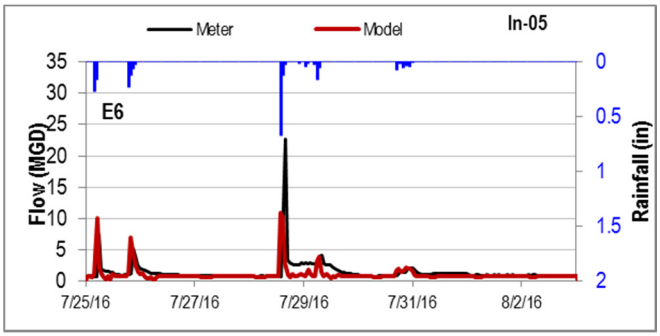
FLOW METER IN-05 MODEL CALIBRATION AND VALIDATION RESULTS

In-05 Model Calibration Results (Metered and Modeled Flow)

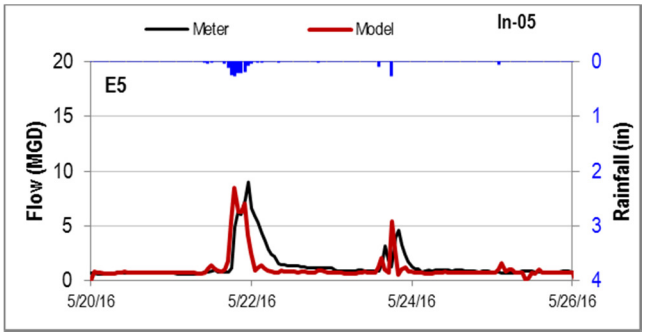




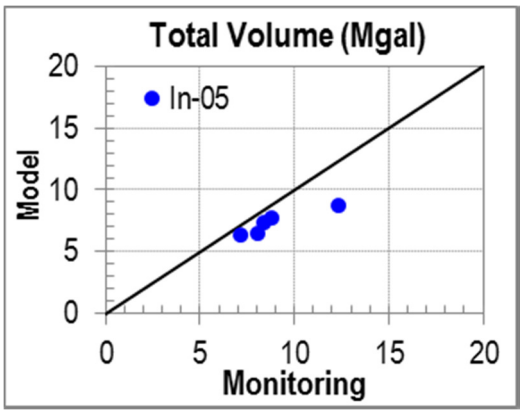


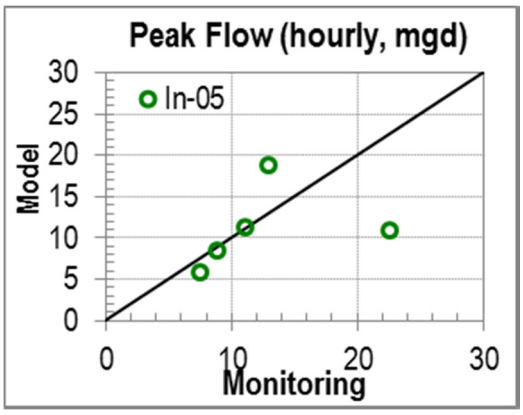


In-05 Model Validation Results (Metered and Modeled Flow)



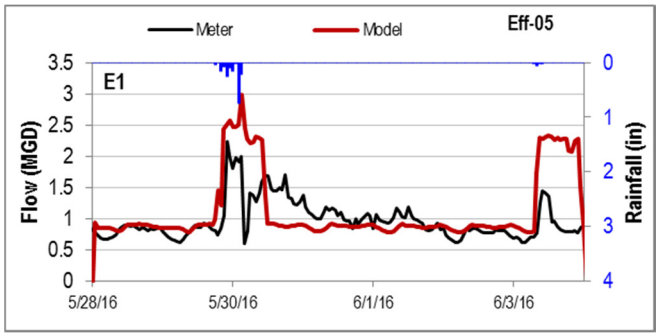
In-05 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

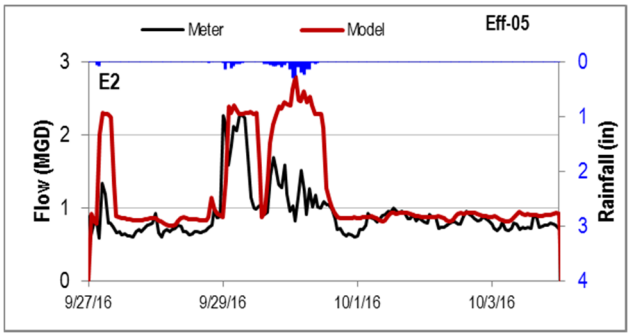


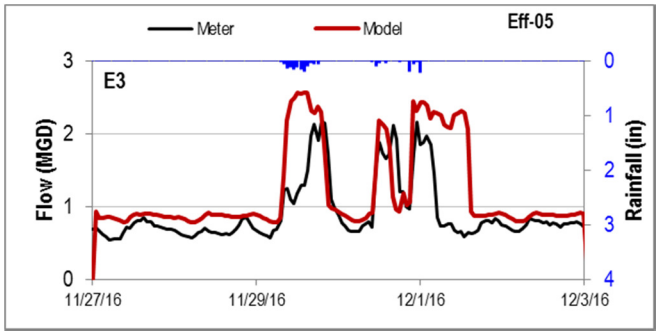


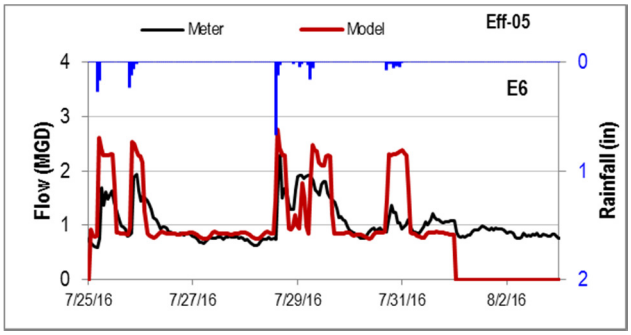
FLOW METER eFF-05 MODEL CALIBRATION AND VALIDATION RESULTS

Eff-05 Model Calibration Results (Metered and Modeled Flow)

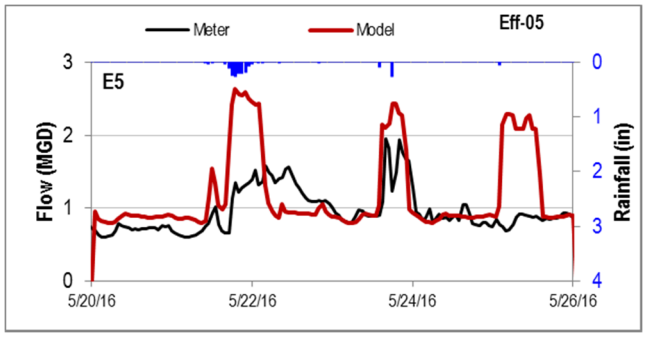




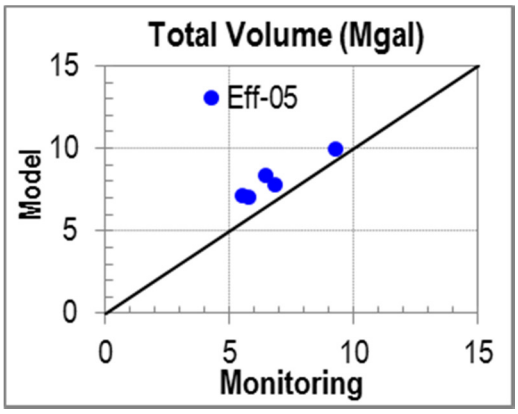


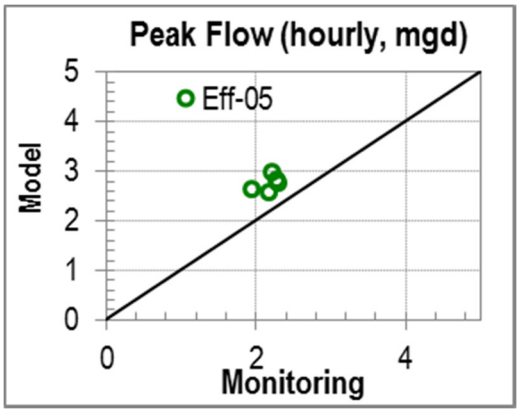


Eff-05 Model Validation Results (Metered and Modeled Flow)



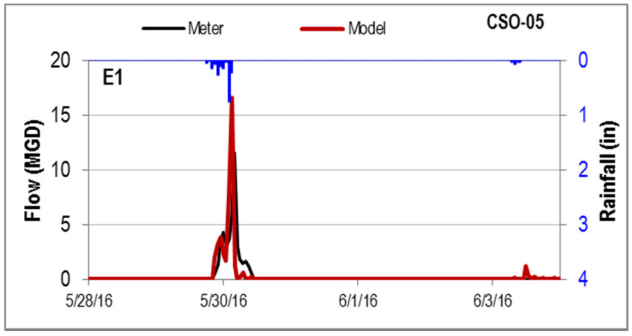
Eff-05 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

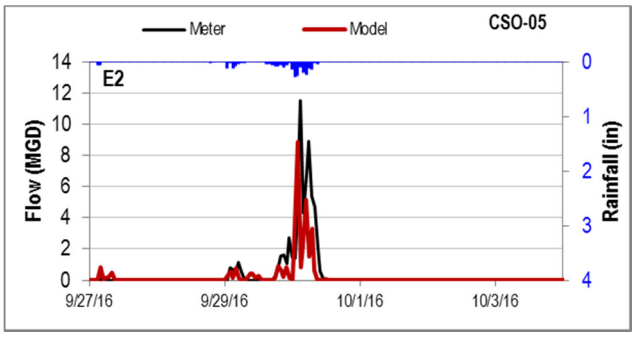


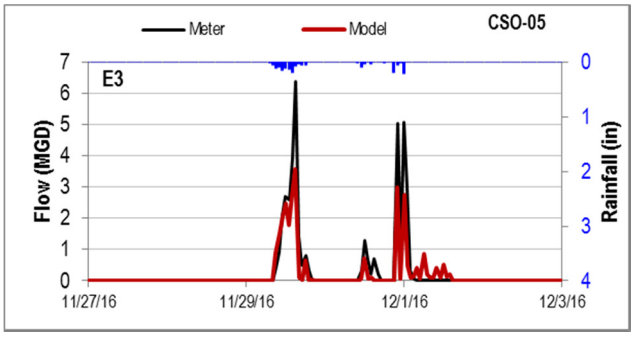


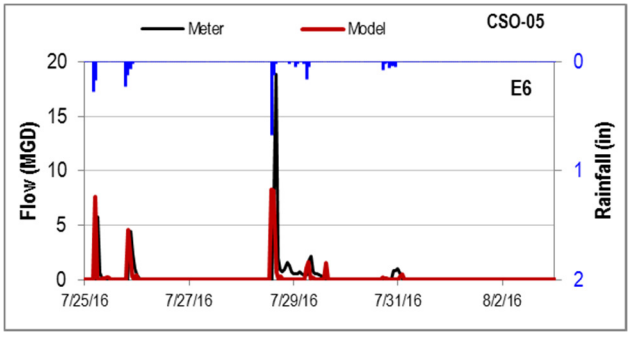
FLOW METER CSO-05 MODEL CALIBRATION AND VALIDATION RESULTS

CSO-05 Model Calibration Results (Metered and Modeled Flow)

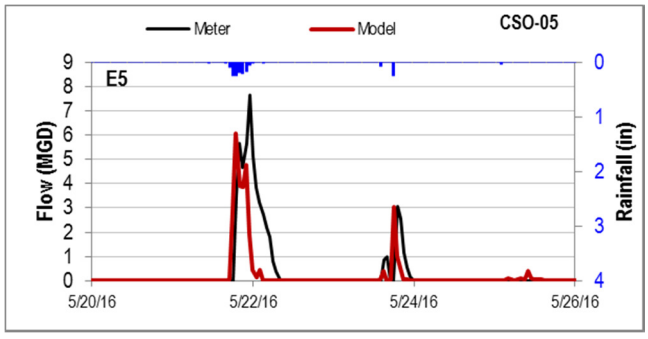




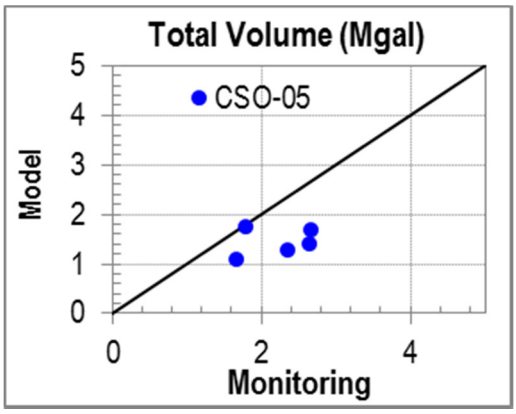


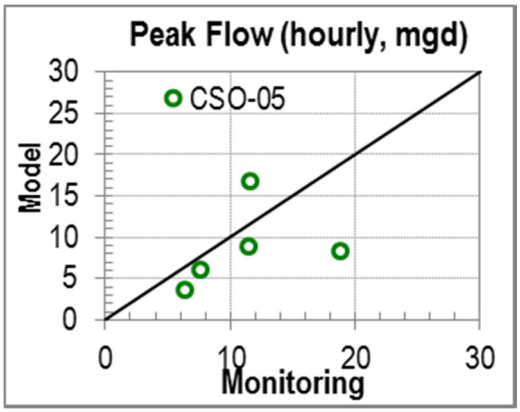


CSO-05 Model Validation Results (Metered and Modeled Flow)



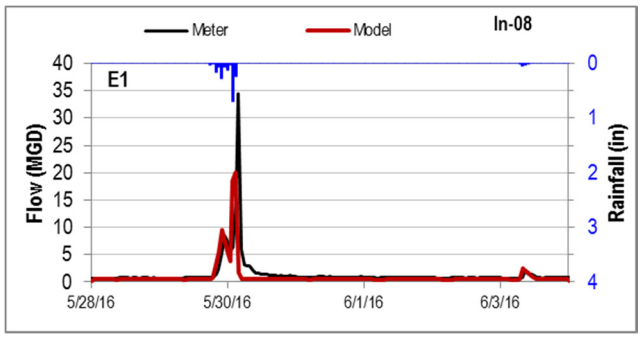
CSO-05 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

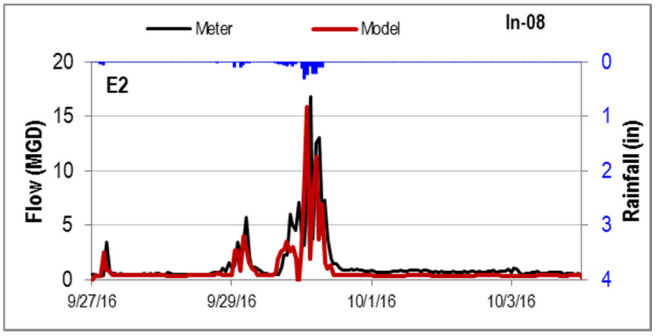


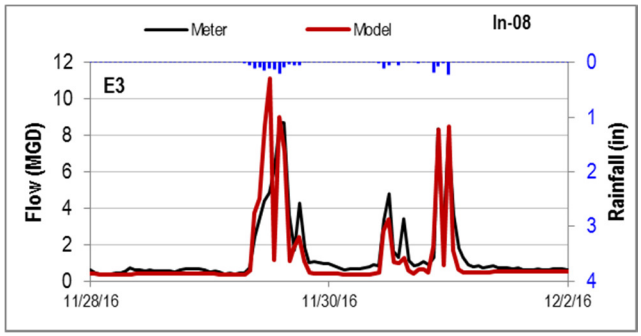


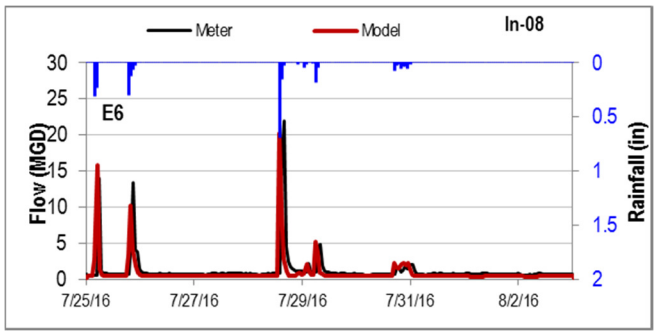
FLOW METER IN-08 MODEL CALIBRATION AND VALIDATION RESULTS

In-08 Model Calibration Results (Metered and Modeled Flow)

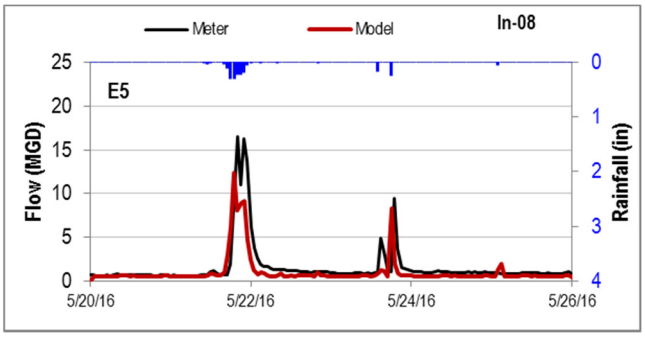




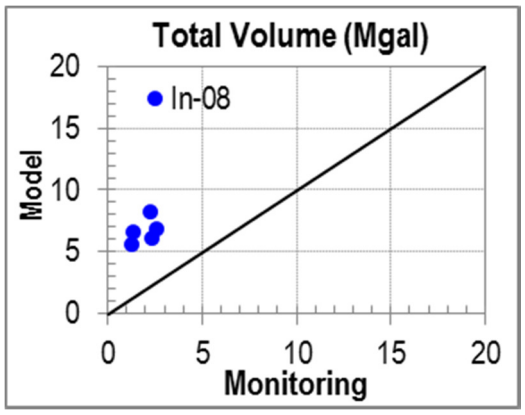


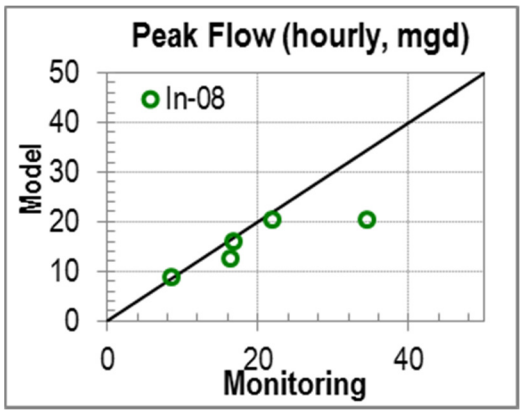


In-08 Model Validation Results (Metered and Modeled Flow)



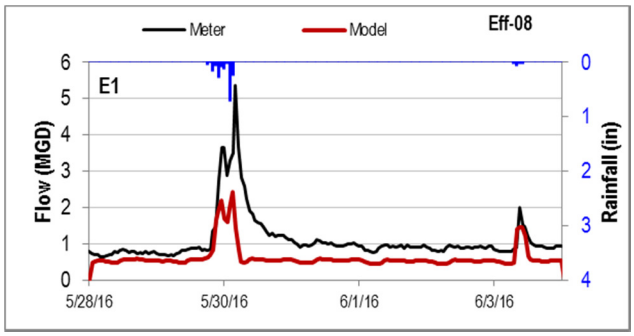
In-08 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

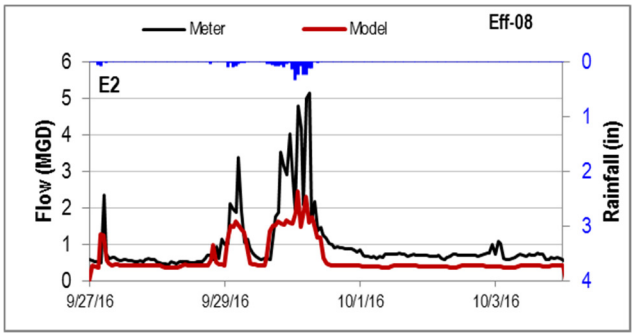


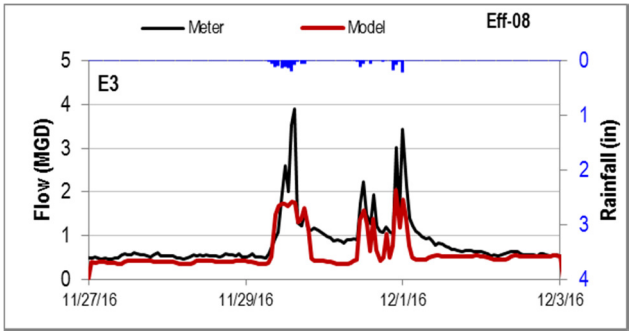


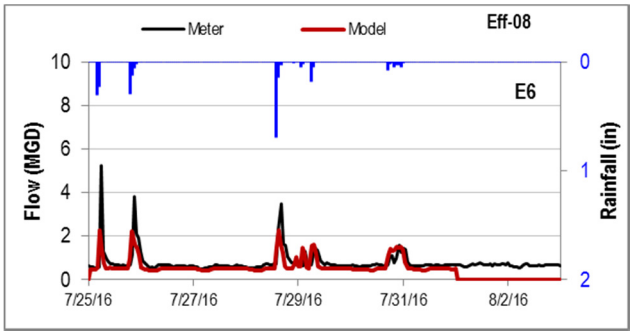
FLOW METER Eff-08 MODEL CALIBRATION AND VALIDATION RESULTS

Eff-08 Model Calibration Results (Metered and Modeled Flow)

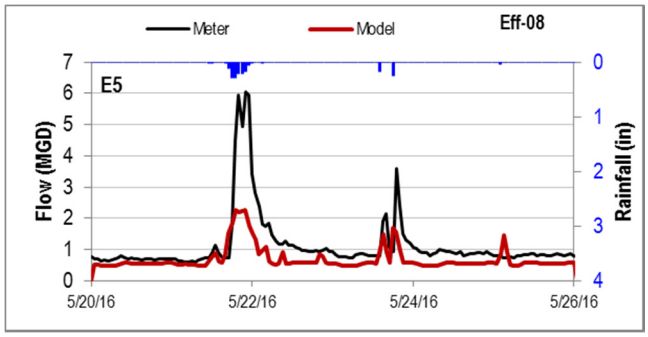




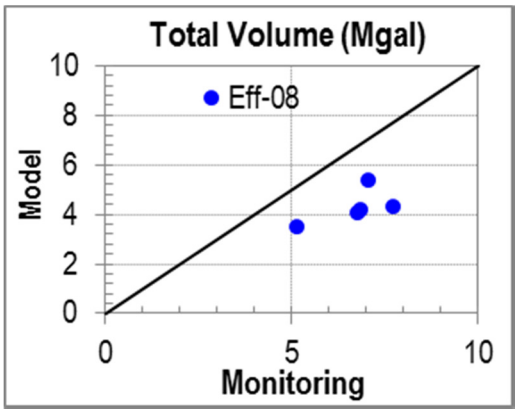


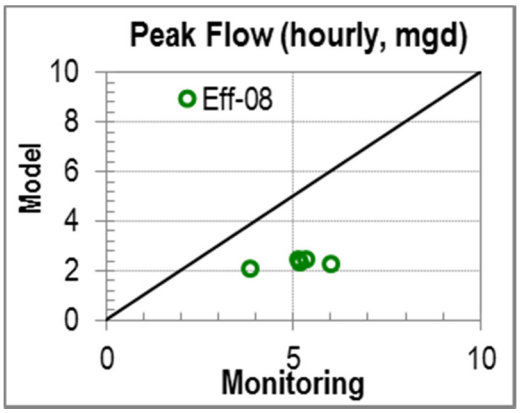


Eff-08 Model Validation Results (Metered and Modeled Flow)



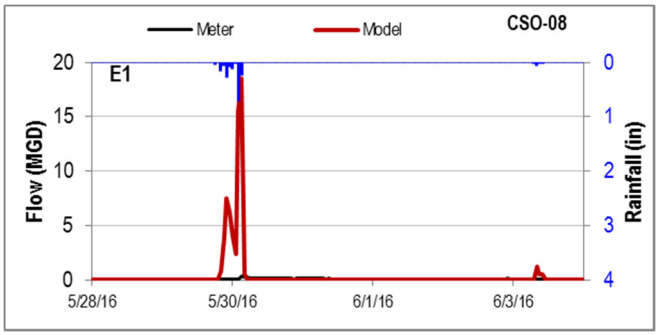
Eff-08 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

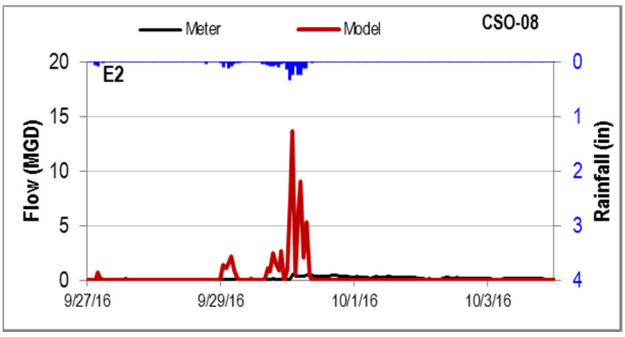


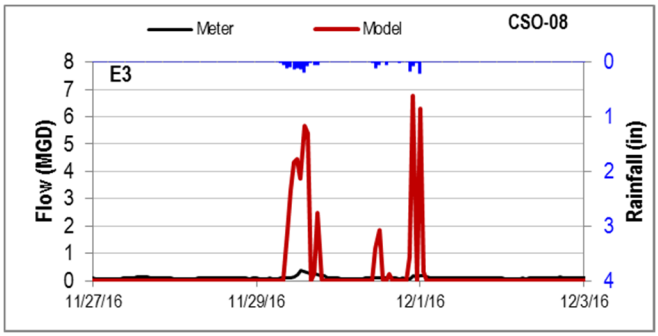


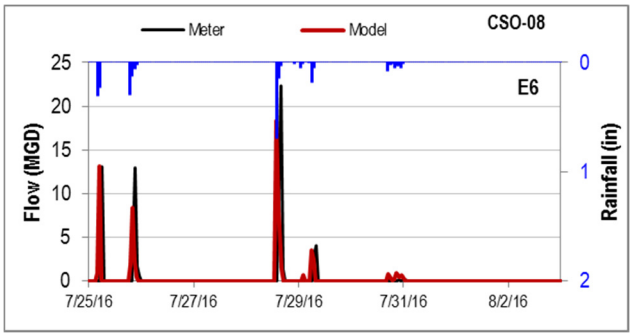
FLOW METER CSO-08 MODEL CALIBRATION AND VALIDATION RESULTS

CSO-08 Model Calibration Results (Metered and Modeled Flow)

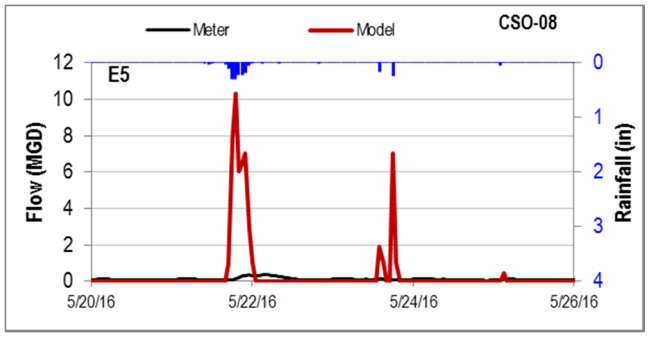




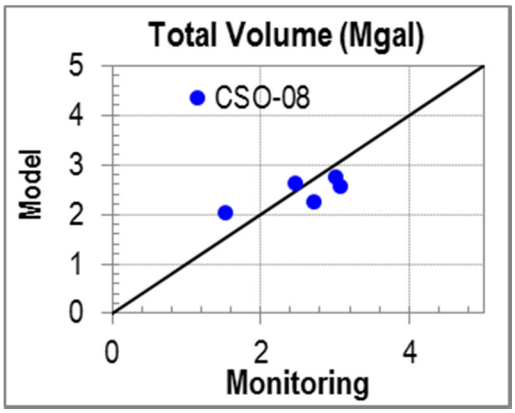


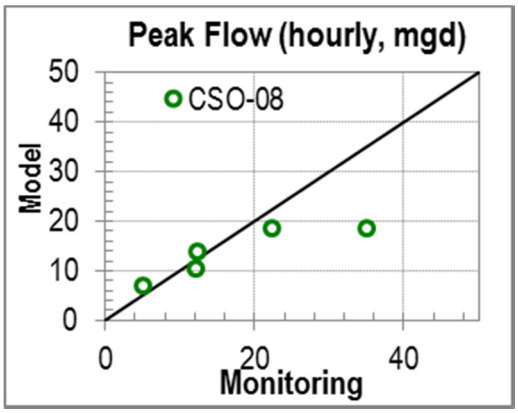


CSO-08 Model Validation Results (Metered and Modeled Flow)



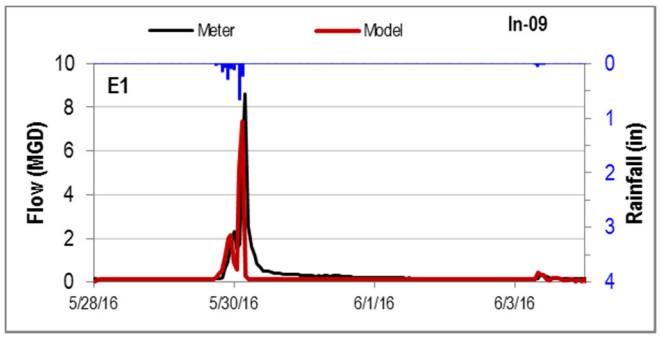
CSO-08 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

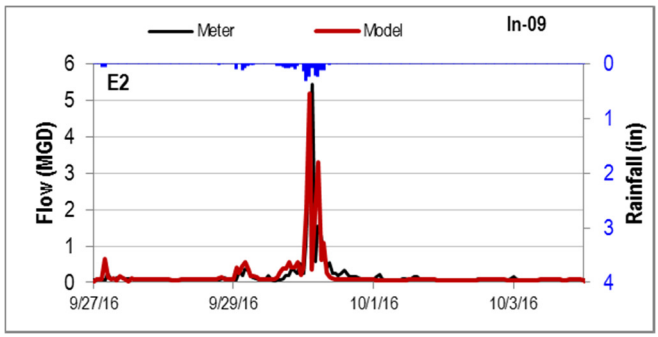


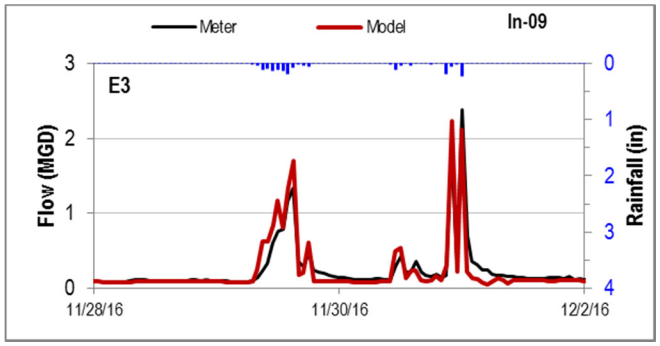


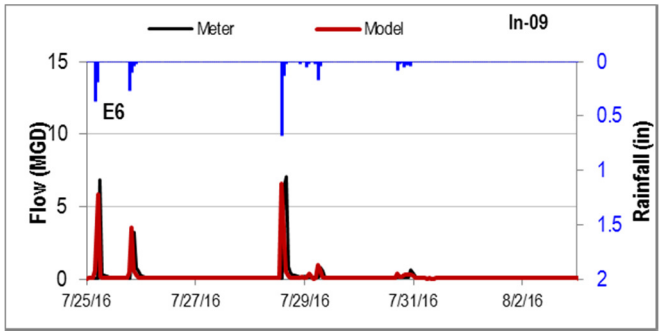
FLOW METER IN-09 MODEL CALIBRATION AND VALIDATION RESULTS

In-09 Model Calibration Results (Metered and Modeled Flow)

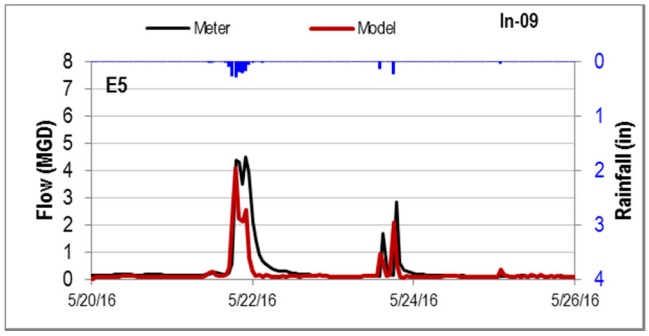




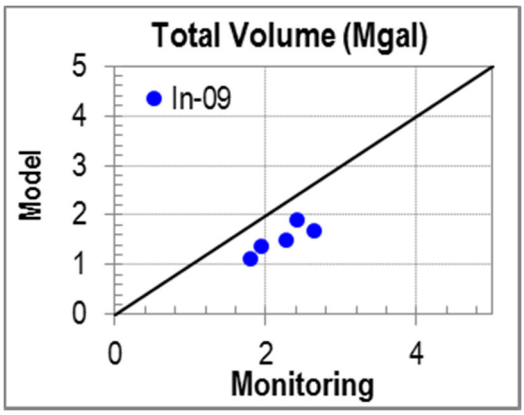


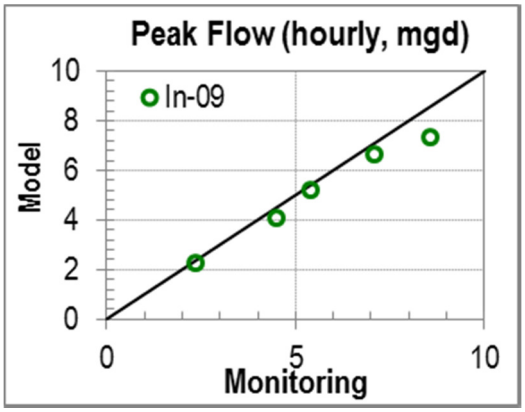


In-09 Model Validation Results (Metered and Modeled Flow)



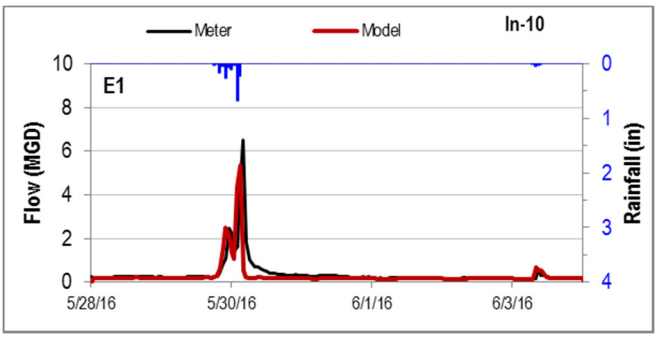
In-09 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

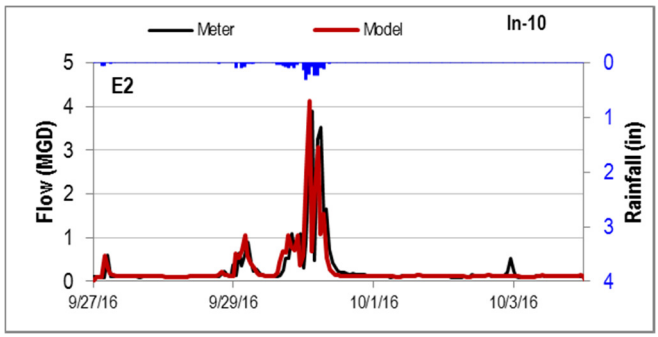


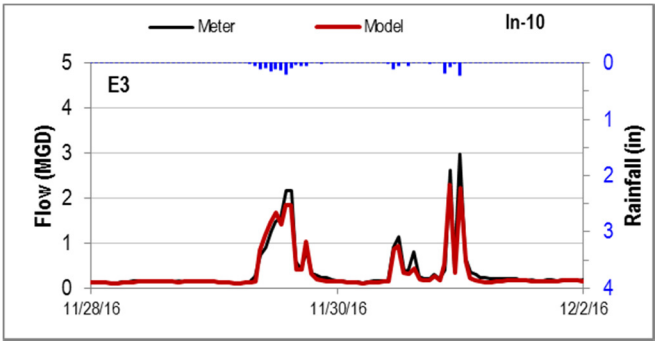


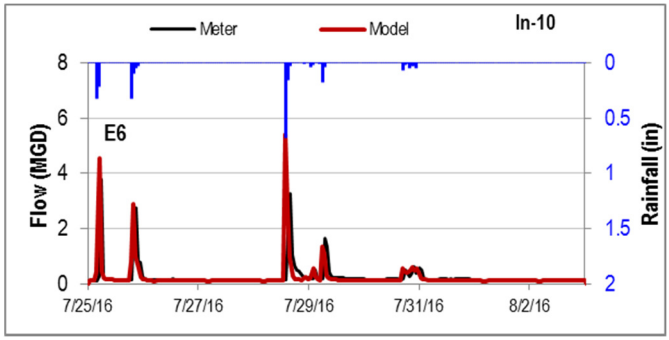
FLOW METER IN-10 MODEL CALIBRATION AND VALIDATION RESULTS

In-10 Model Calibration Results (Metered and Modeled Flow)

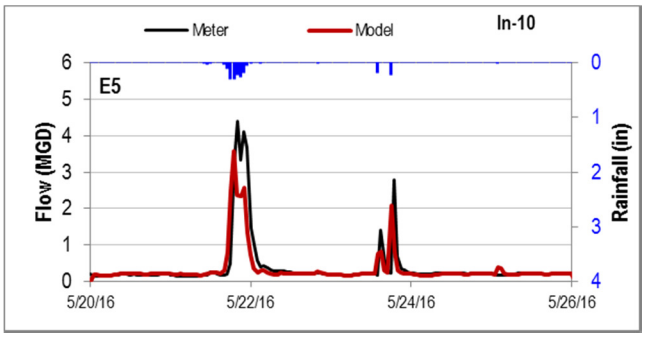




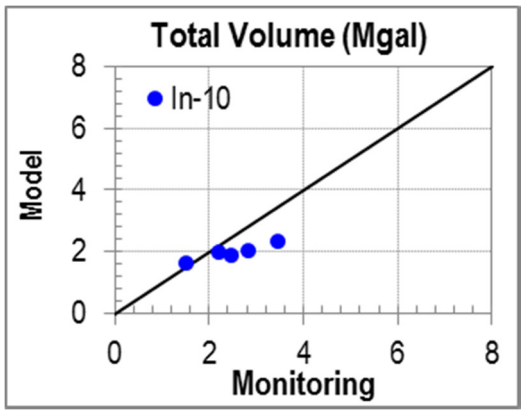


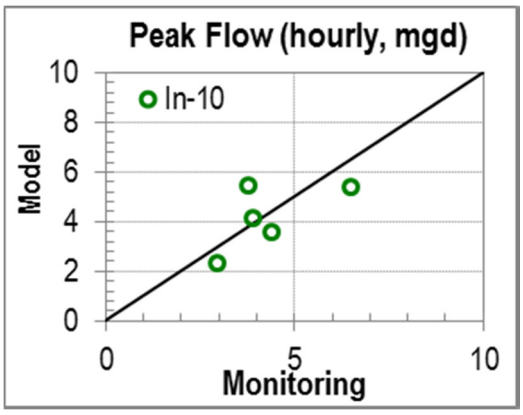


In-10 Model Validation Results (Metered and Modeled Flow)



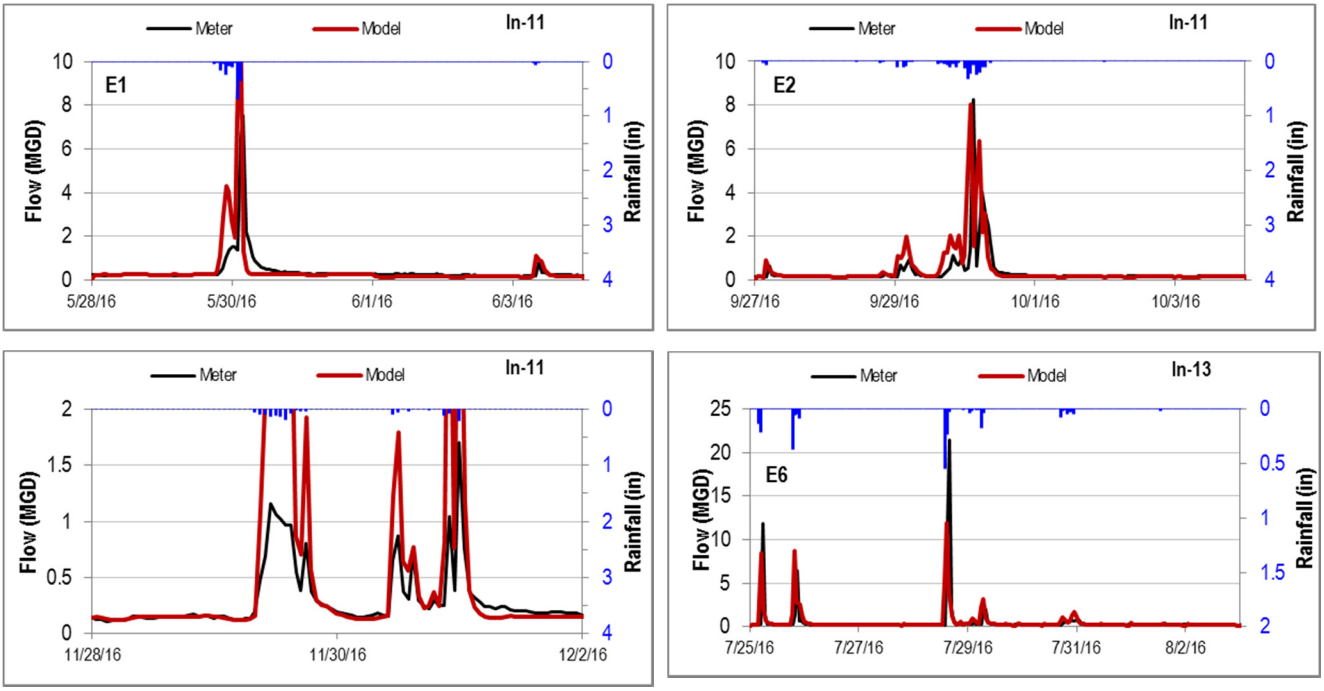
In-10 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



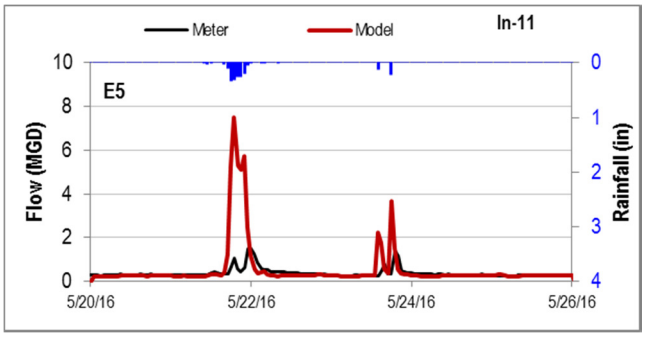


FLOW METER IN-11 MODEL CALIBRATION AND VALIDATION RESULTS

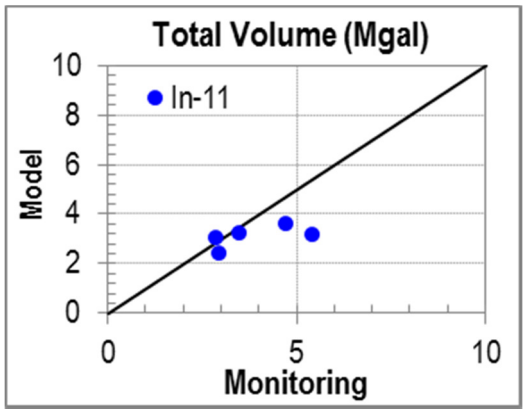
In-11 Model Calibration Results (Metered and Modeled Flow)

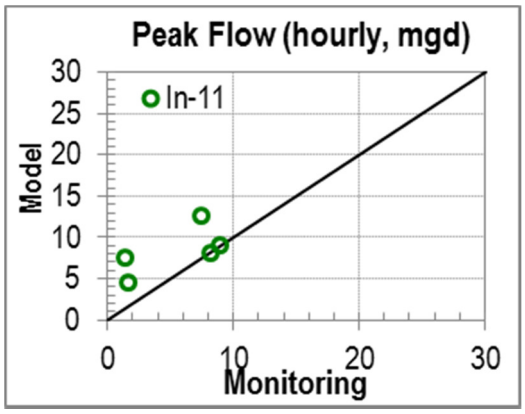


In-11 Model Validation Results (Metered and Modeled Flow)



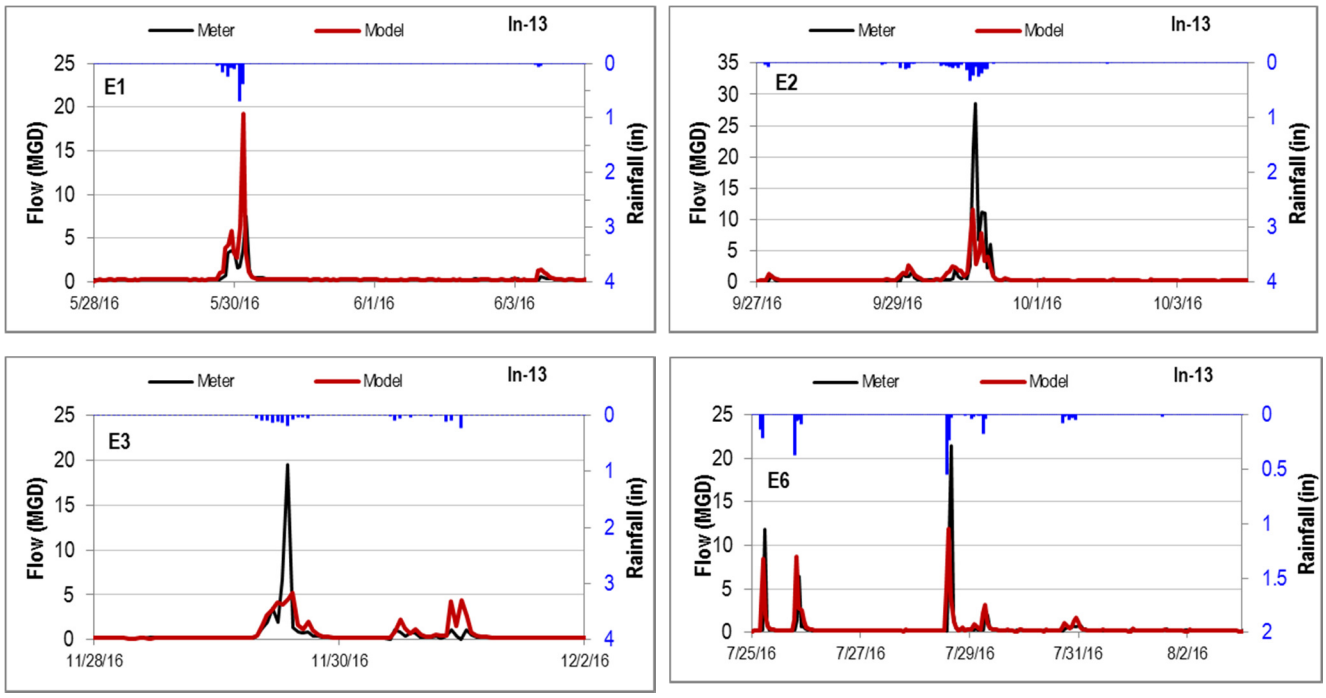
In-11 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



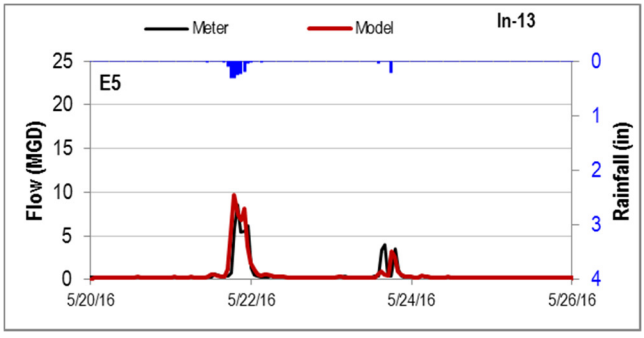


FLOW METER IN-13 MODEL CALIBRATION AND VALIDATION RESULTS

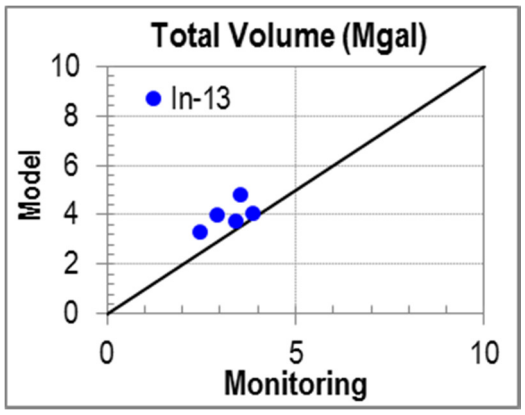
In-13 Model Calibration Results (Metered and Modeled Flow)

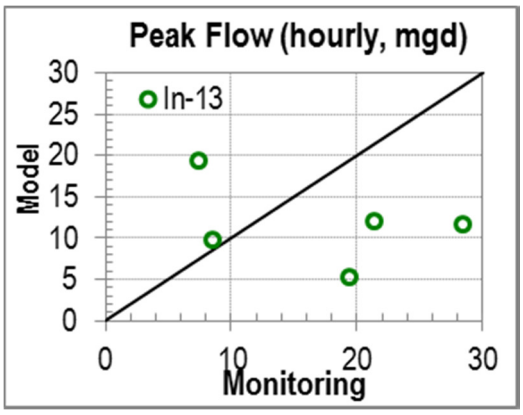


In-13 Model Validation Results (Metered and Modeled Flow)



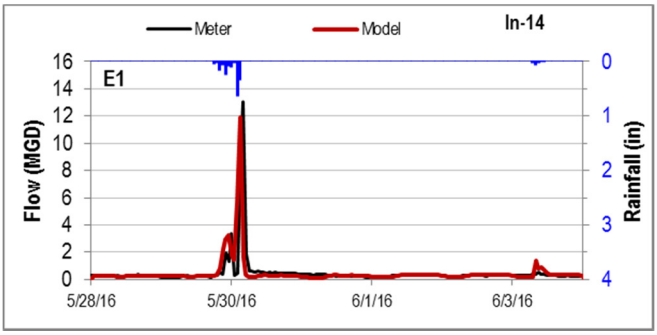
In-13 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

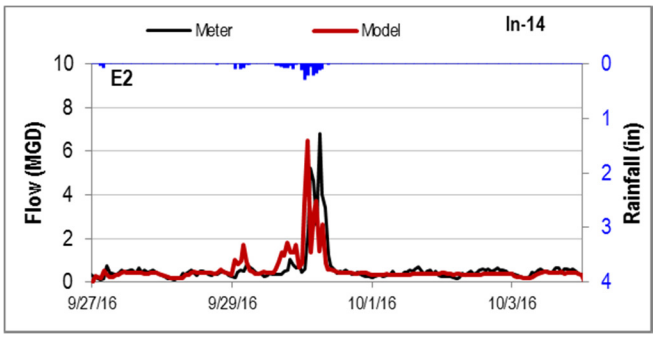


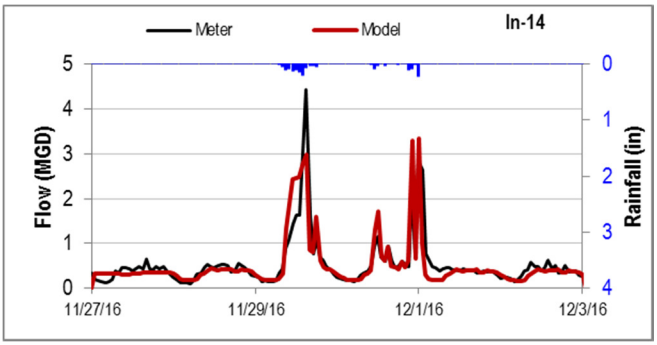


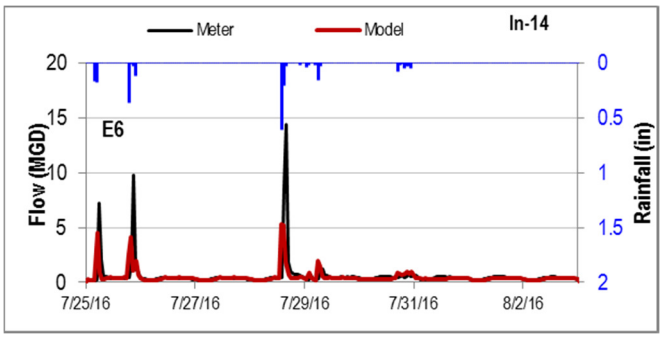
FLOW METER IN-14 MODEL CALIBRATION AND VALIDATION RESULTS

In-14 Model Calibration Results (Metered and Modeled Flow)

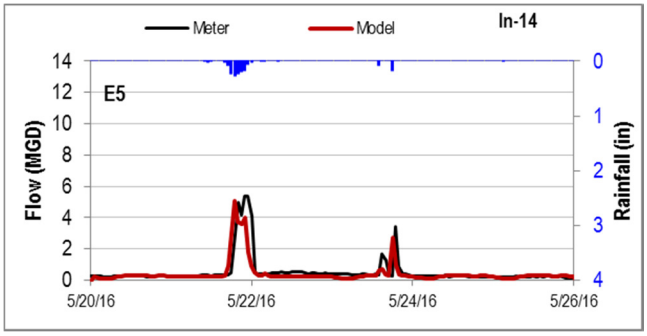




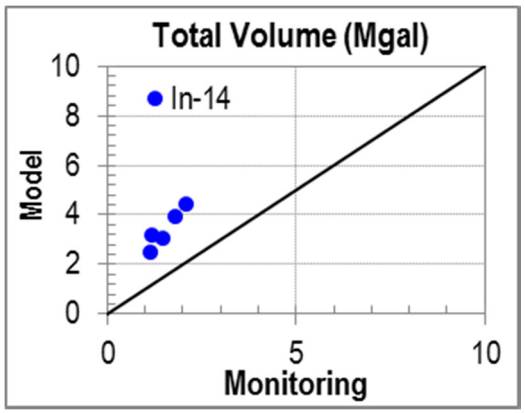


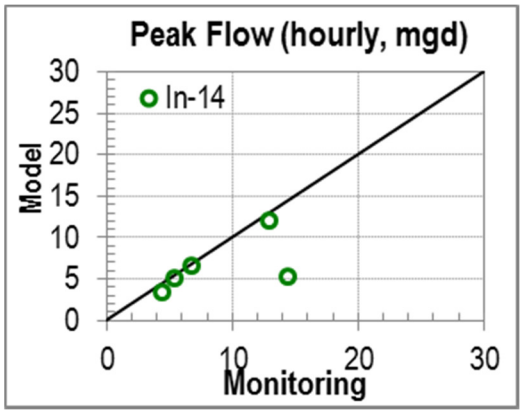


In-14 Model Validation Results (Metered and Modeled Flow)



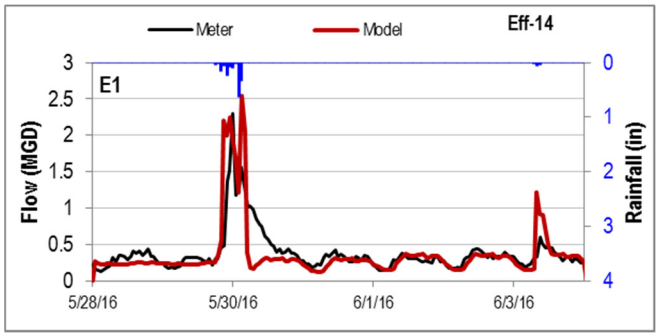
In-14 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

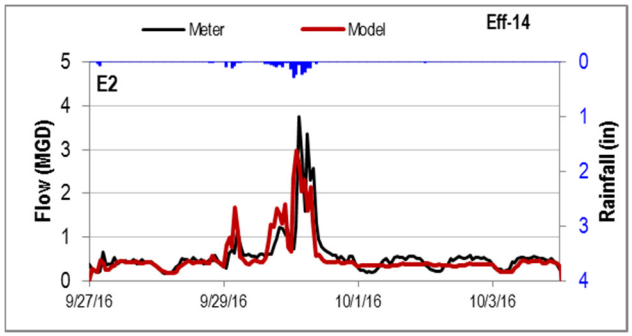


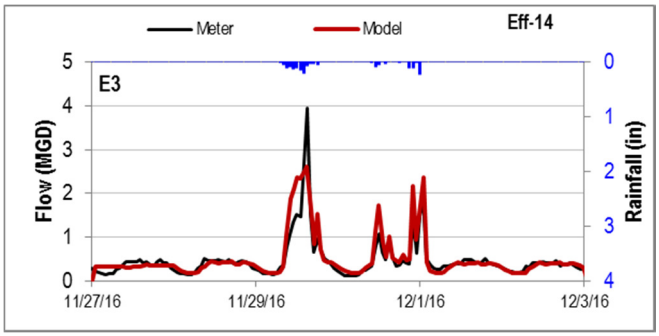


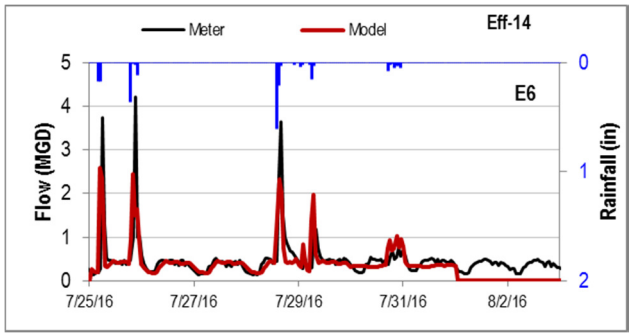
FLOW METER Eff-14 MODEL CALIBRATION AND VALIDATION RESULTS

Eff-14 Model Calibration Results (Metered and Modeled Flow)

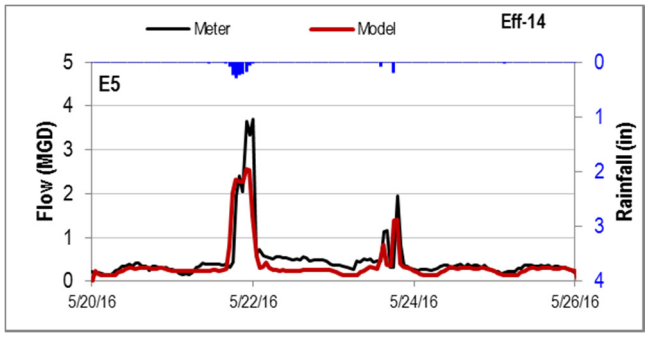




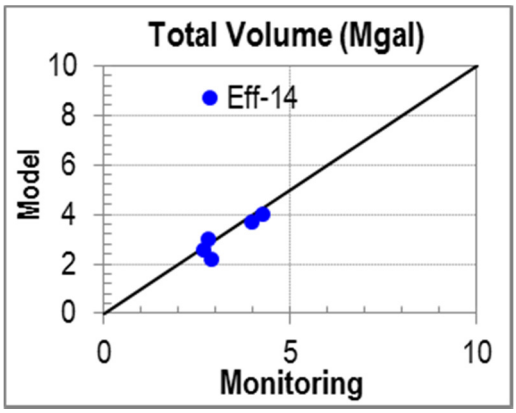


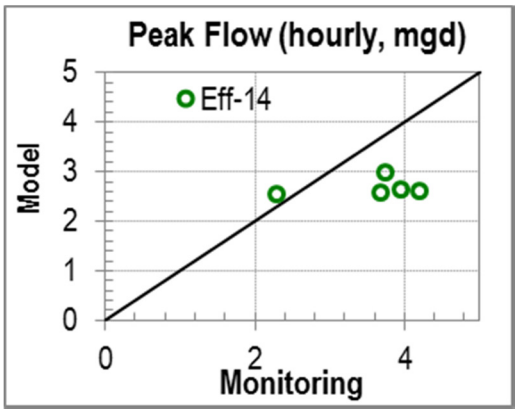


Eff-14 Model Validation Results (Metered and Modeled Flow)



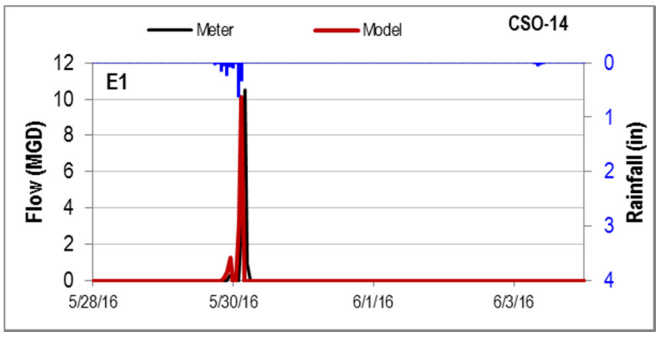
Eff-14 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

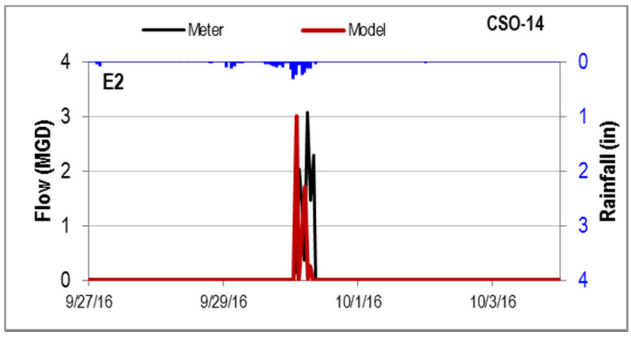


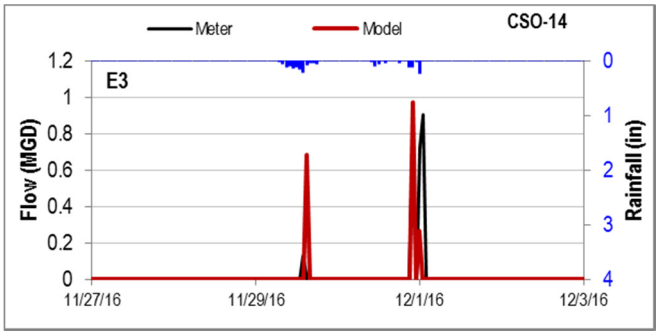


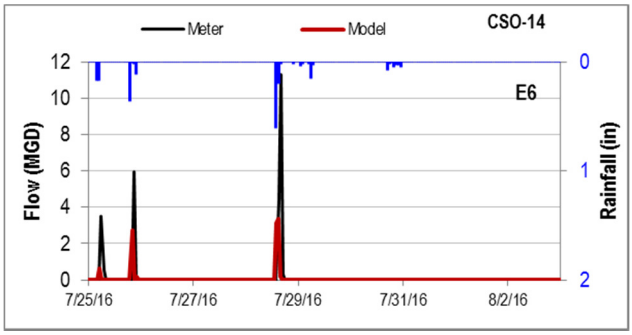
FLOW METER CSO-14 MODEL CALIBRATION AND VALIDATION RESULTS

CSO-14 Model Calibration Results (Metered and Modeled Flow)

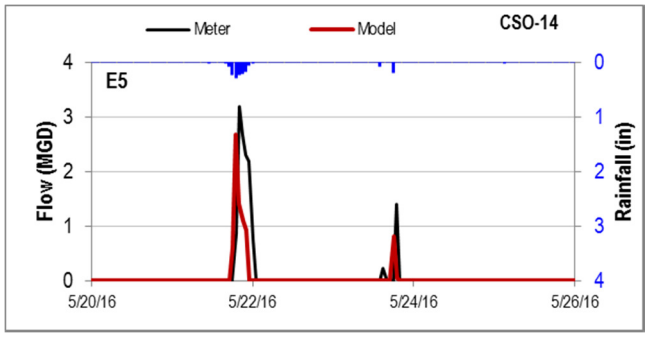




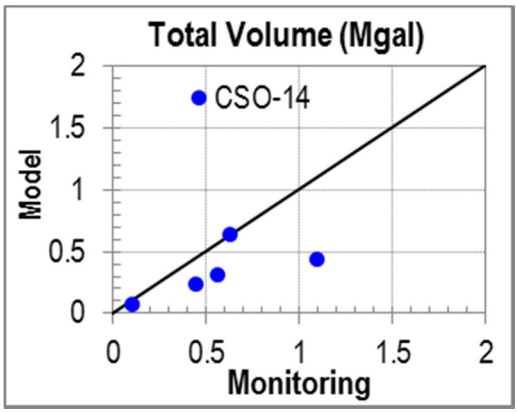


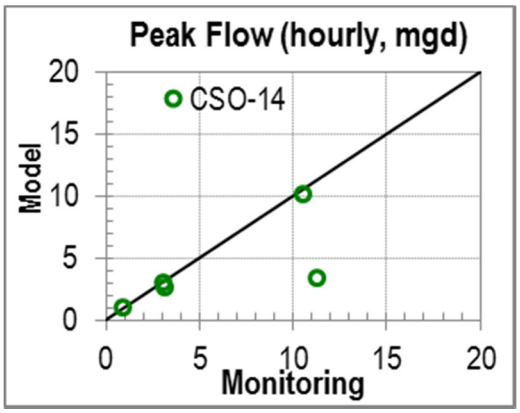


CSO-14 Model Validation Results (Metered and Modeled Flow)



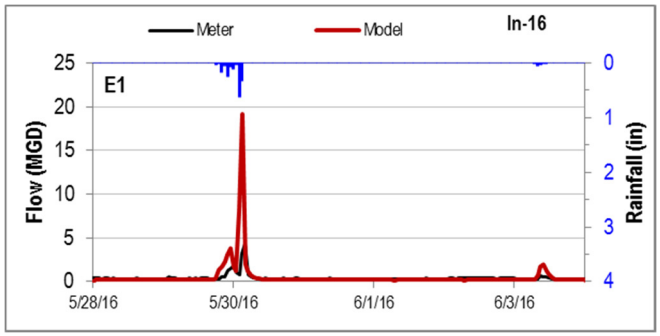
CSO-14 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

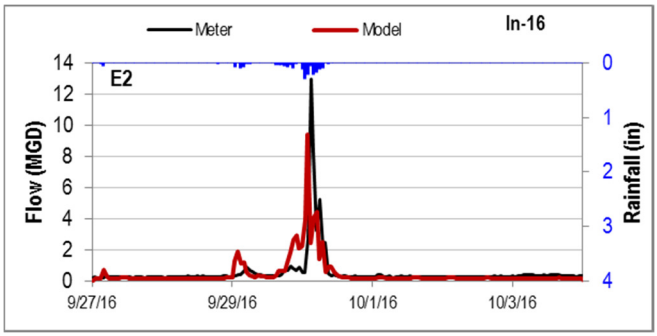


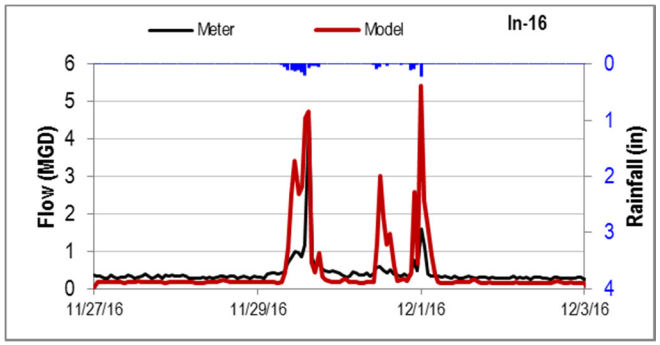


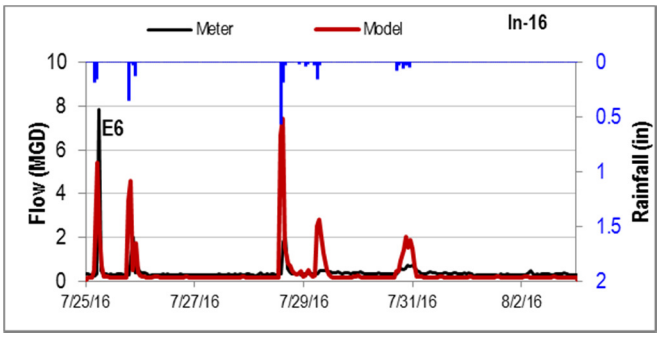
FLOW METER IN-16 MODEL CALIBRATION AND VALIDATION RESULTS

In-16 Model Calibration Results (Metered and Modeled Flow)

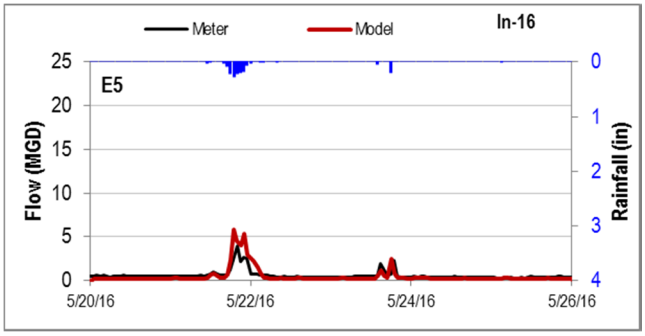




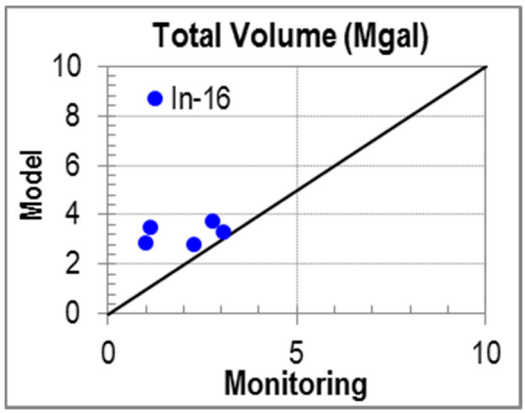


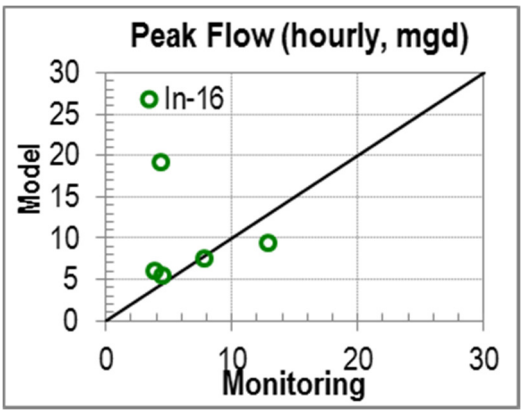


In-16 Model Validation Results (Metered and Modeled Flow)



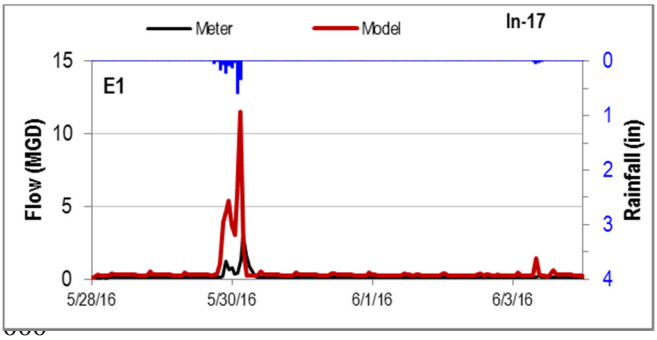
In-16 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

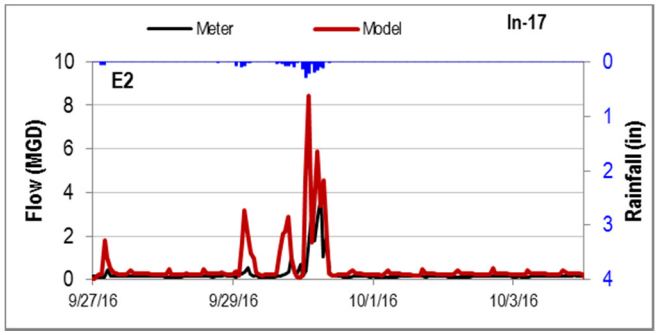


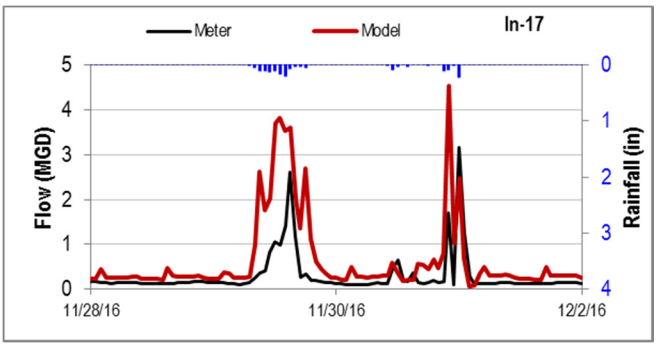


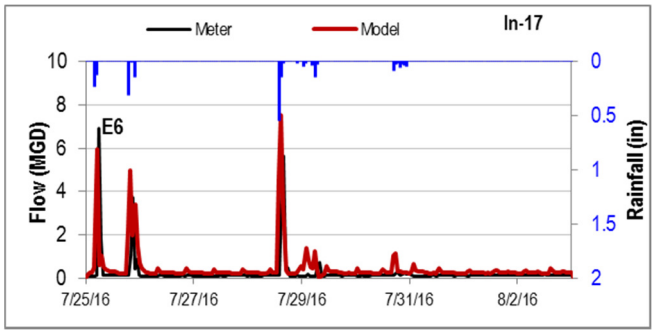
FLOW METER IN-17 MODEL CALIBRATION AND VALIDATION RESULTS

In-17 Model Calibration Results (Metered and Modeled Flow)

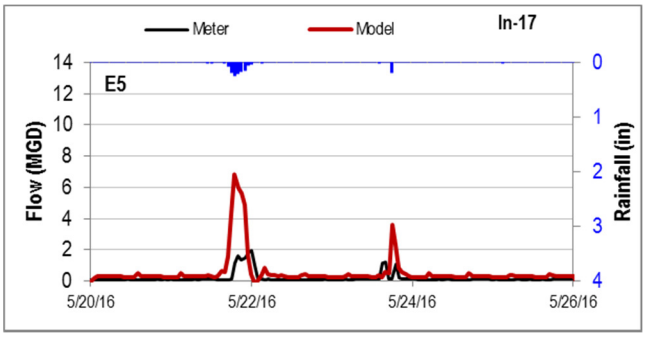




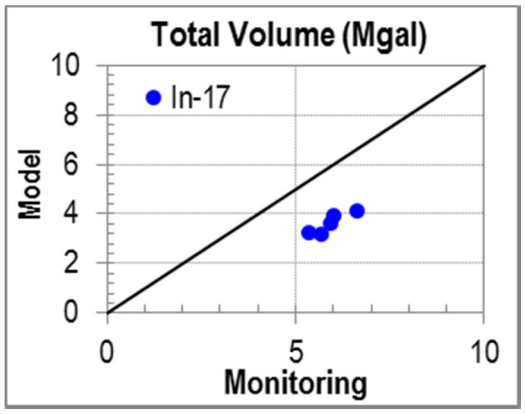


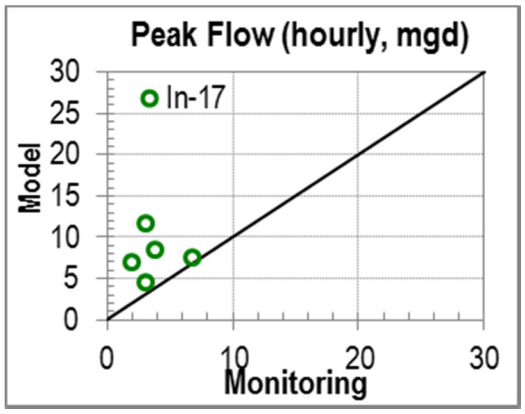


In-17 Model Validation Results (Metered and Modeled Flow)



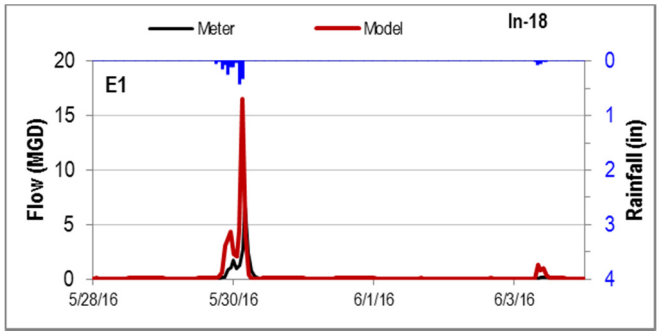
In-17 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

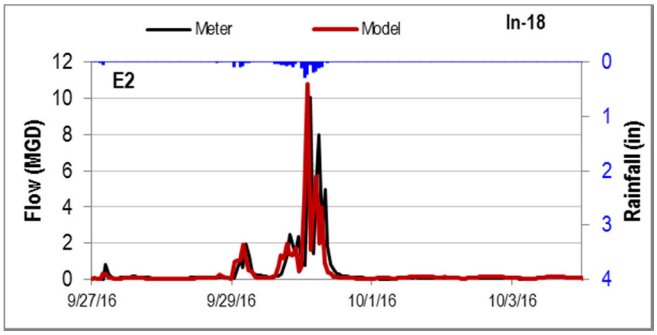


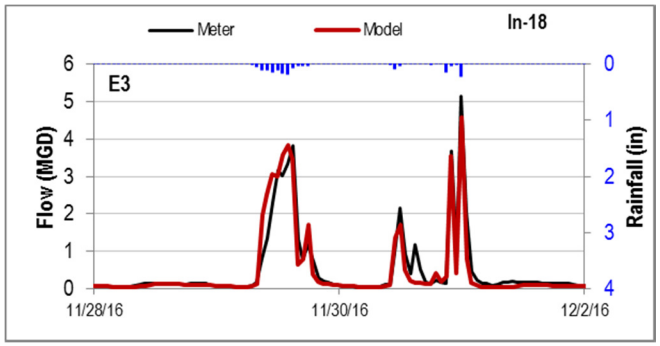


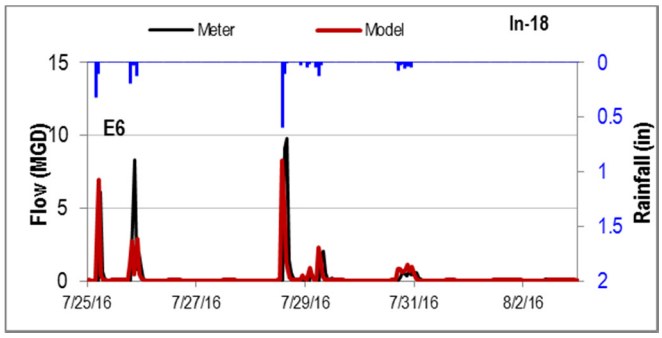
FLOW METER IN-18 MODEL CALIBRATION AND VALIDATION RESULTS

In-18 Model Calibration Results (Metered and Modeled Flow)

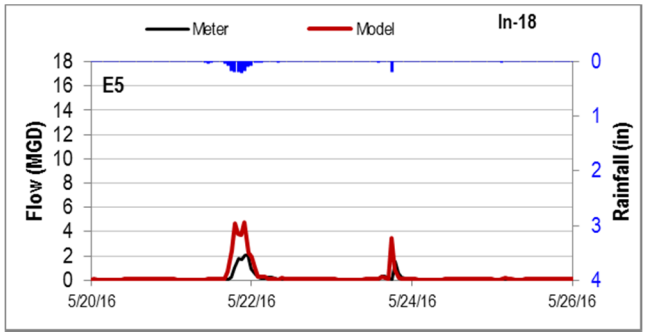




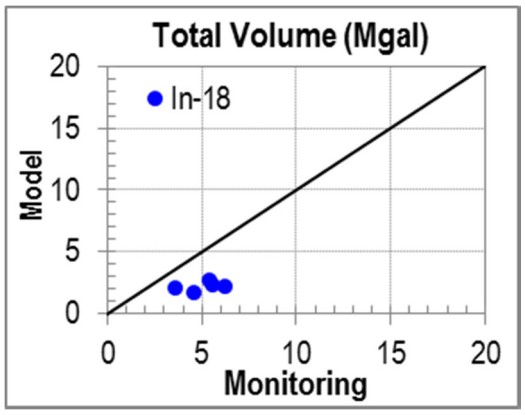


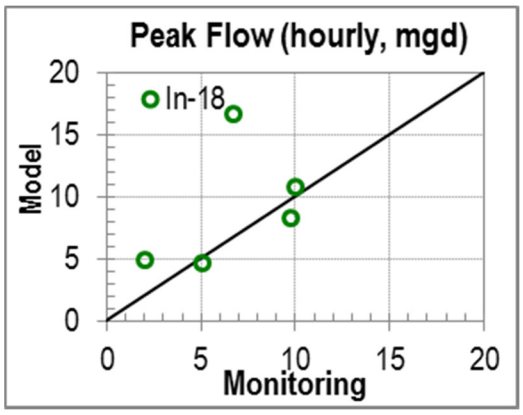


In-18 Model Validation Results (Metered and Modeled Flow)



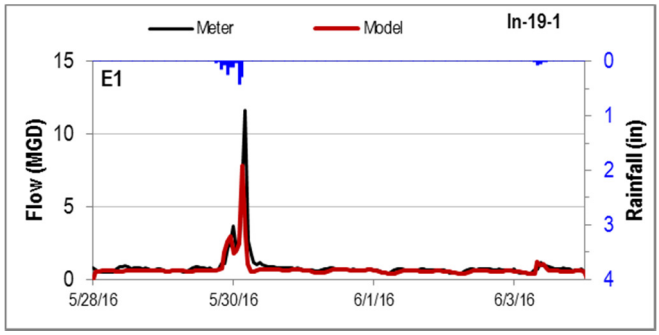
In-18 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

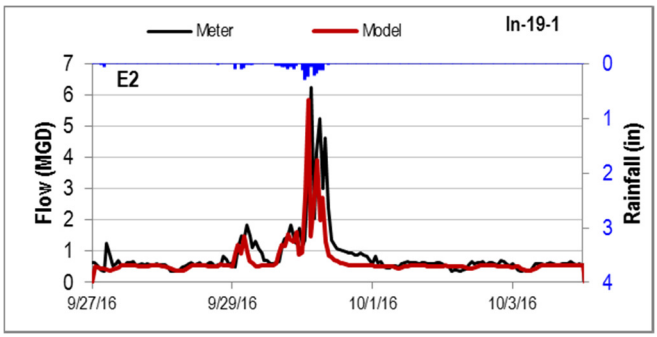


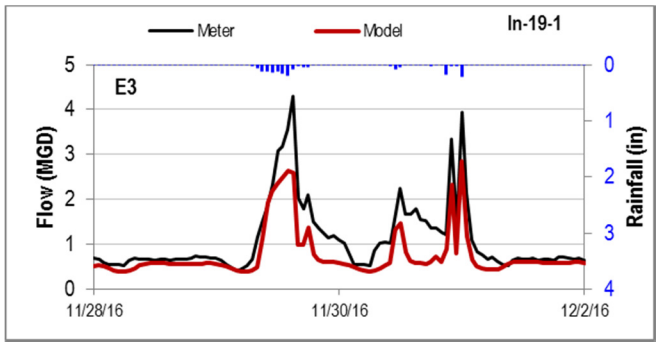


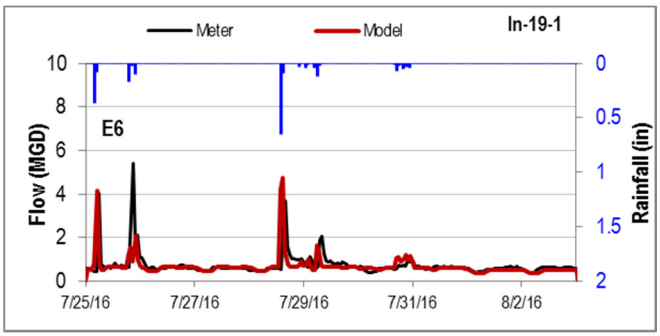
FLOW METER IN-19-1 MODEL CALIBRATION AND VALIDATION RESULTS

In-19-1 Model Calibration Results (Metered and Modeled Flow)

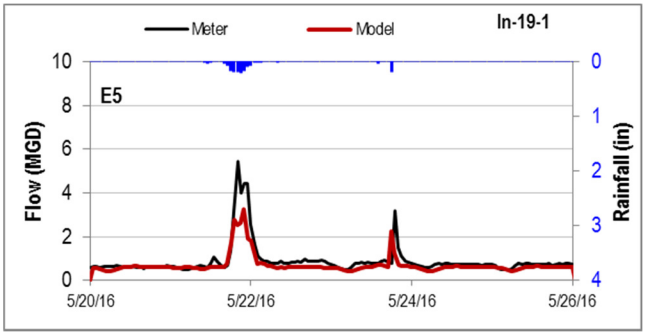




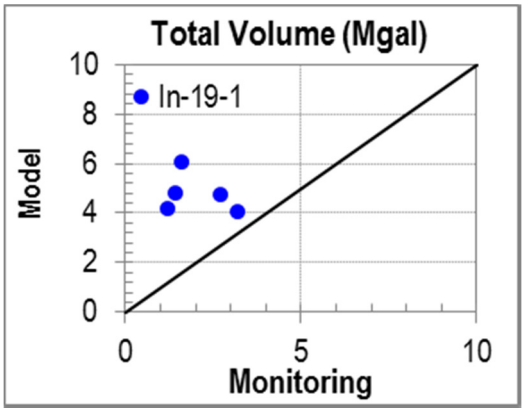


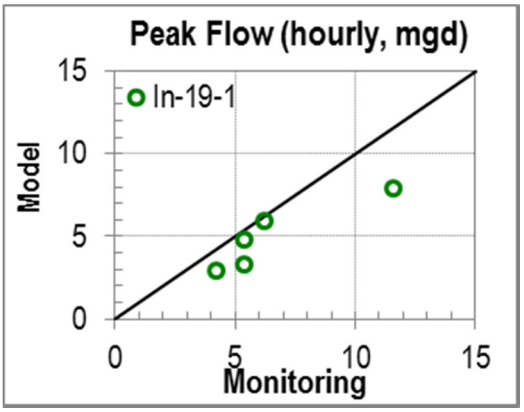


In-19-1 Model Validation Results (Metered and Modeled Flow)



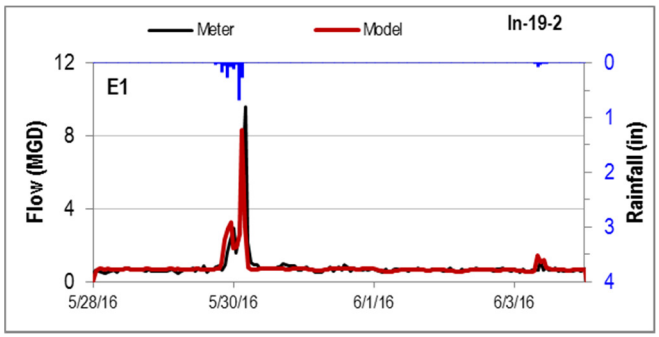
In-19-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

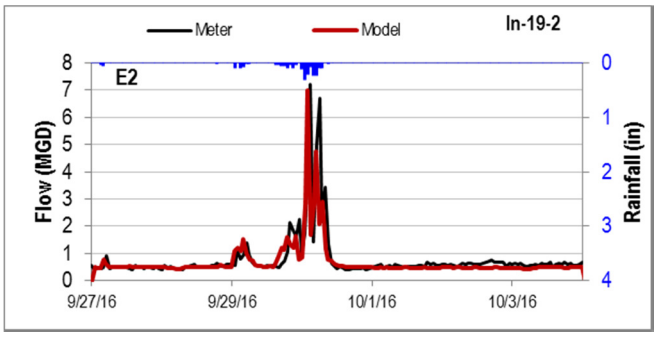


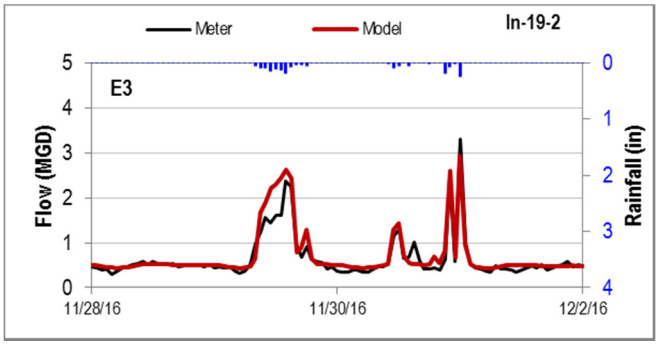


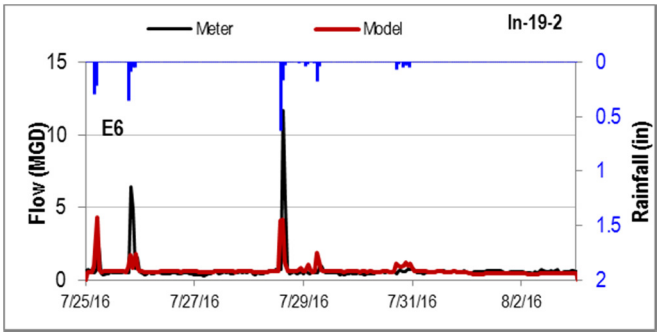
FLOW METER IN-19-2 MODEL CALIBRATION AND VALIDATION RESULTS

In-19-2 Model Calibration Results (Metered and Modeled Flow)

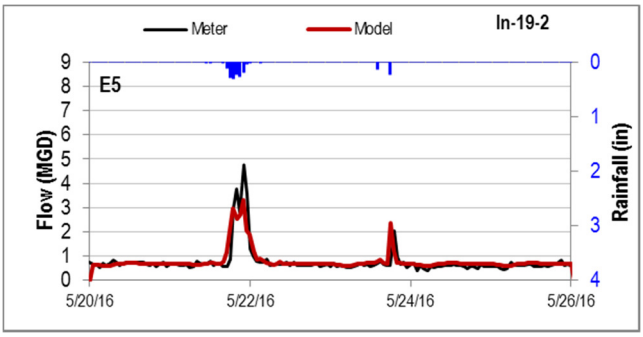




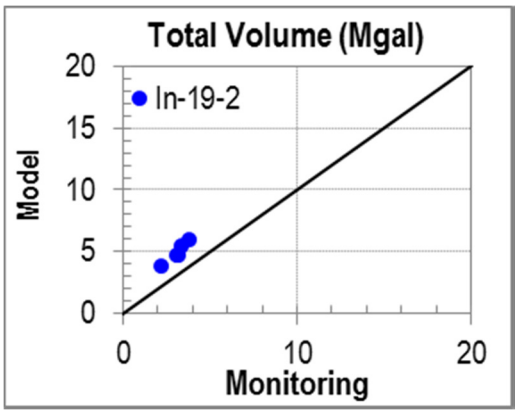


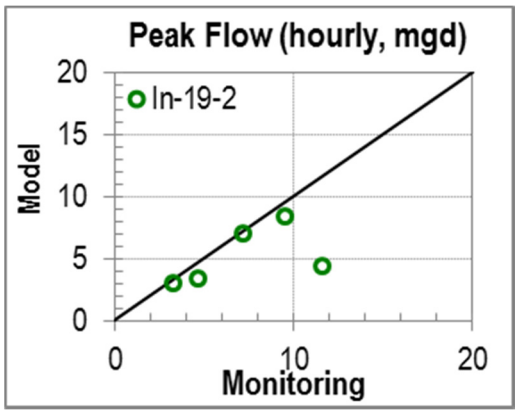


In-19-2 Model Validation Results (Metered and Modeled Flow)



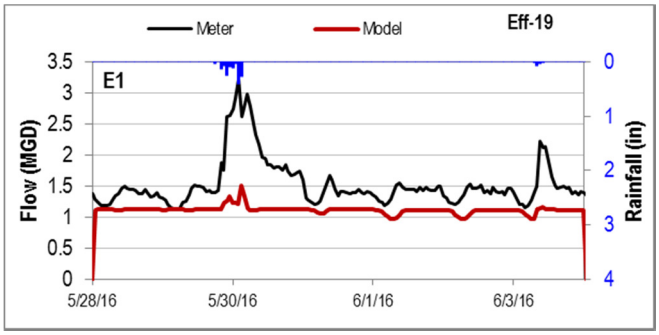
In-19-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

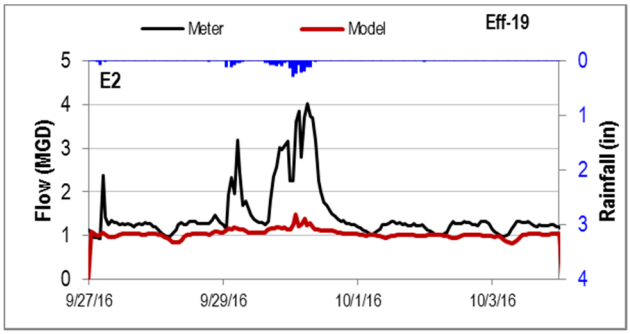


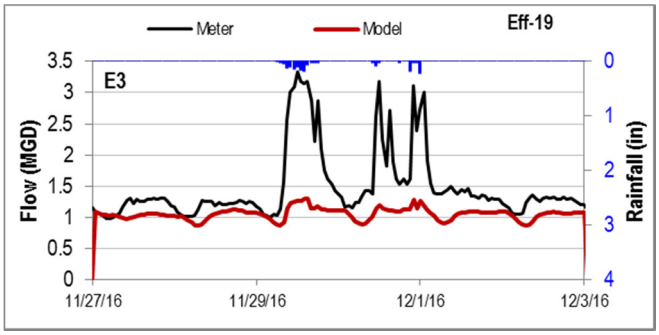


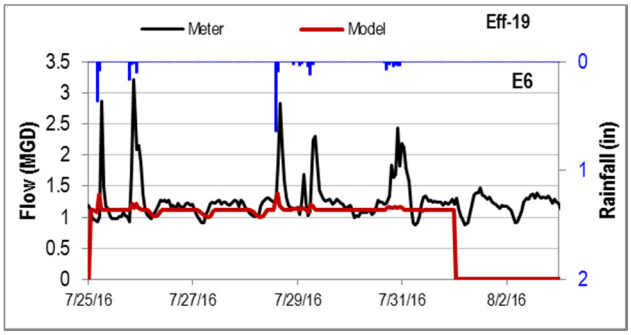
FLOW METER Eff-19 MODEL CALIBRATION AND VALIDATION RESULTS

Eff-19 Model Calibration Results (Metered and Modeled Flow)

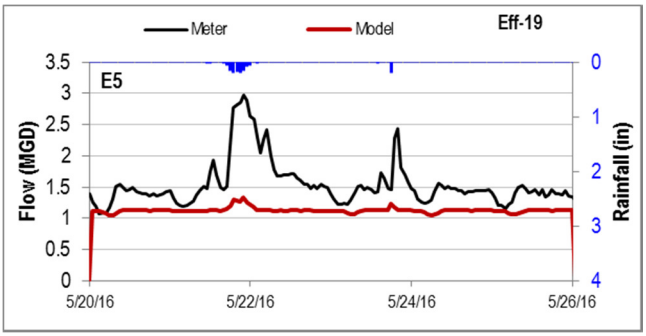




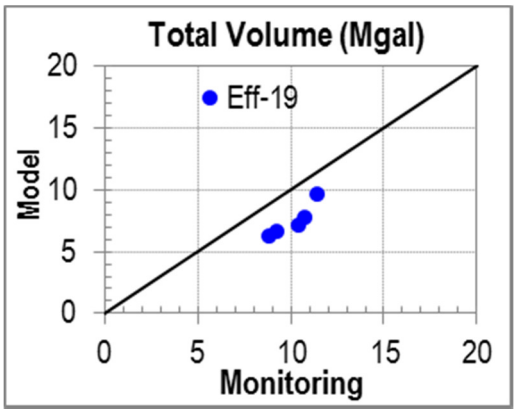


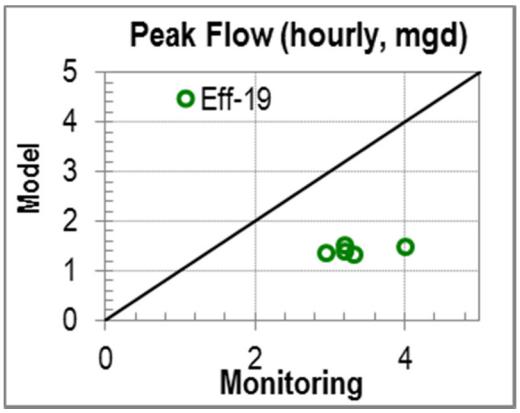


Eff-19 Model Validation Results (Metered and Modeled Flow)



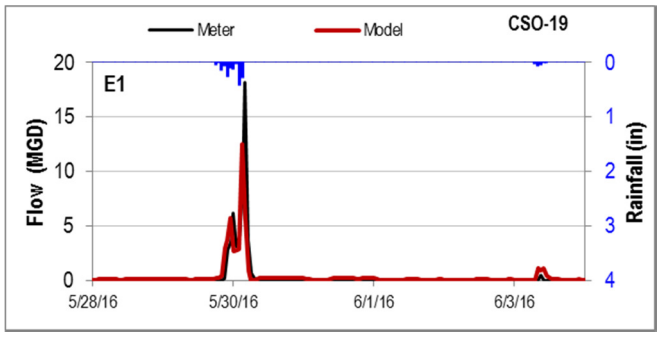
Eff-19 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

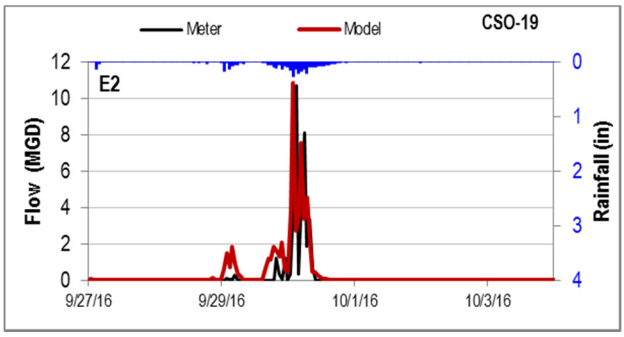


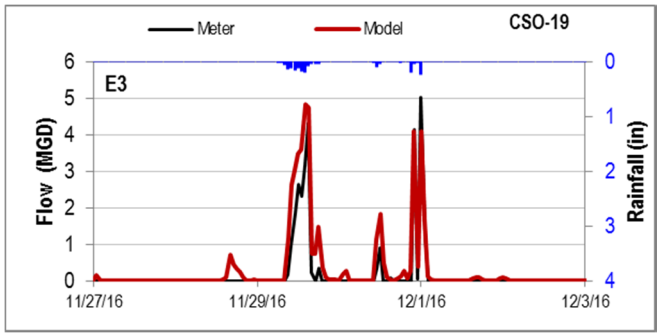


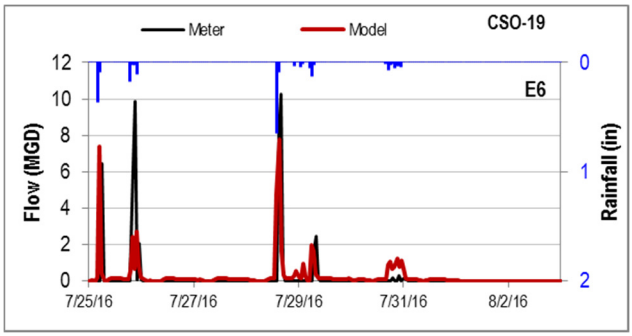
FLOW METER CSO-19 MODEL CALIBRATION AND VALIDATION RESULTS

CSO-19 Model Calibration Results (Metered and Modeled Flow)

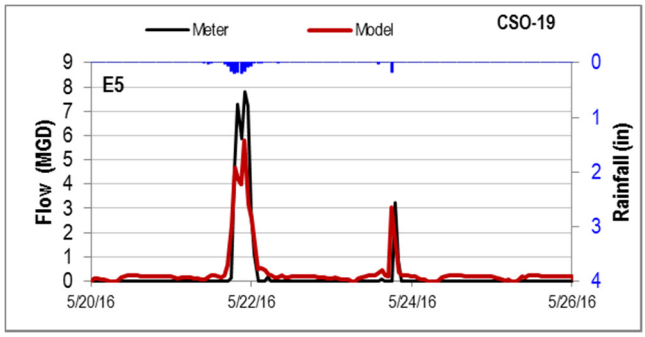




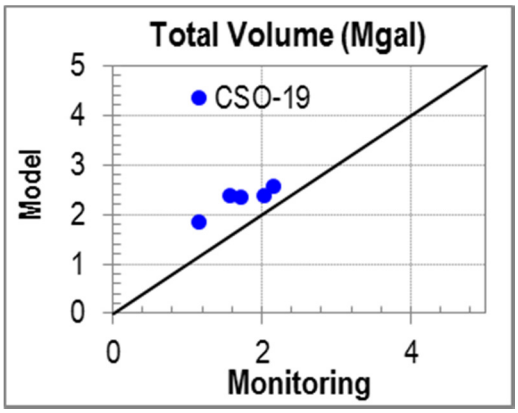


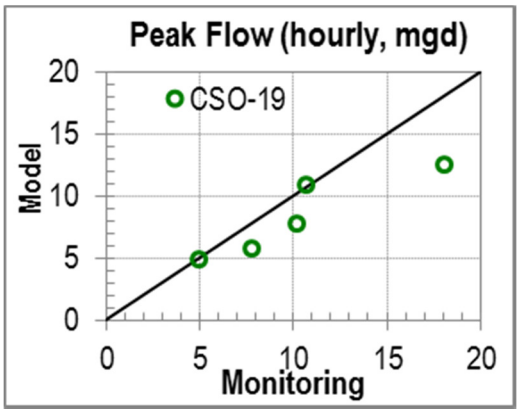


CSO-19 Model Validation Results (Metered and Modeled Flow)



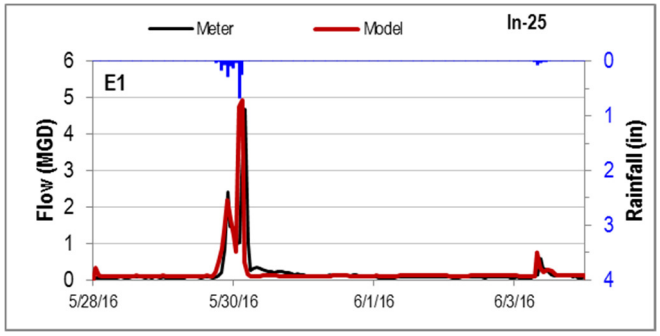
CSO-19 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

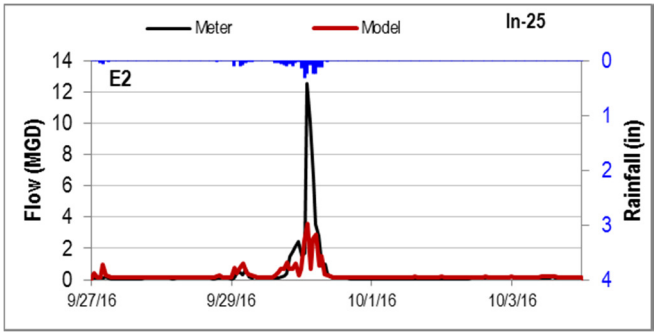


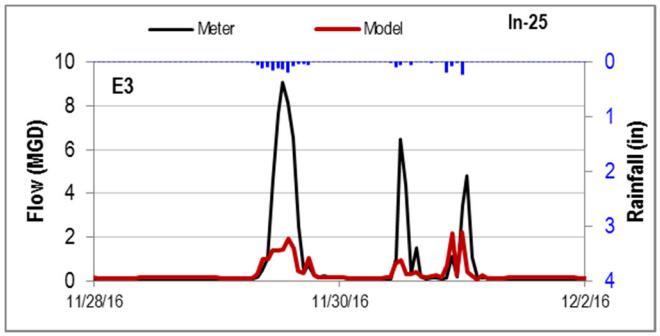


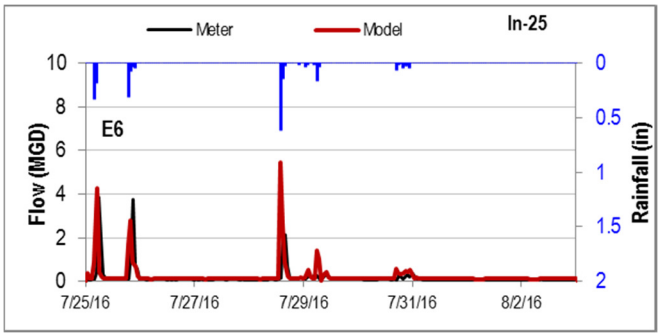
FLOW METER IN-25 MODEL CALIBRATION AND VALIDATION RESULTS

In-25 Model Calibration Results (Metered and Modeled Flow)

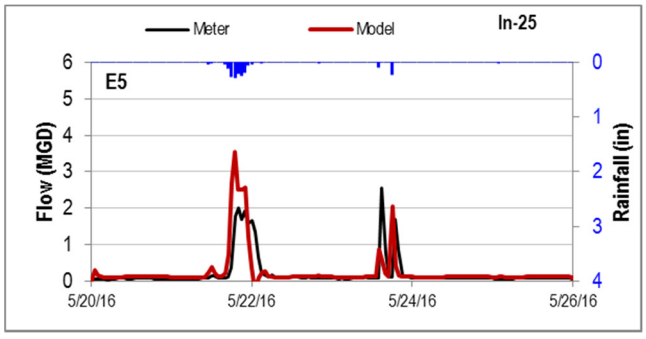




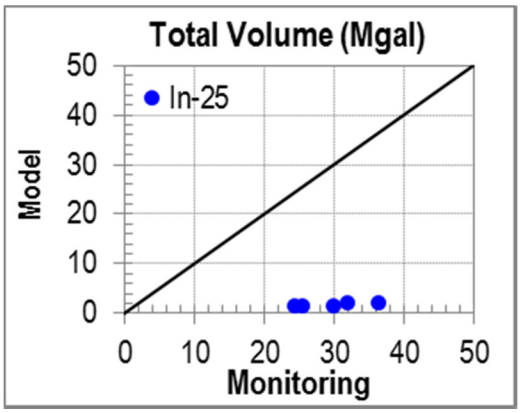


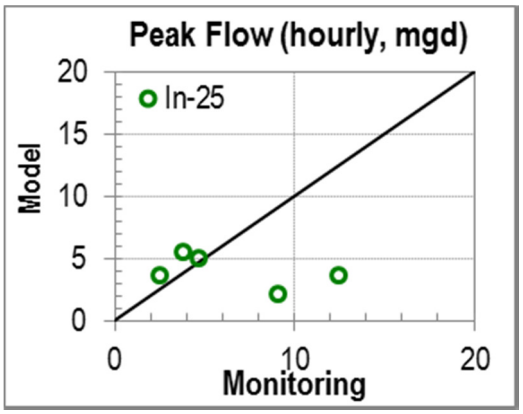


In-25 Model Validation Results (Metered and Modeled Flow)



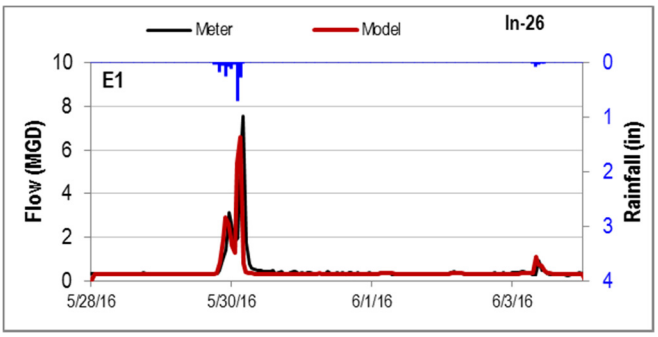
In-25 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

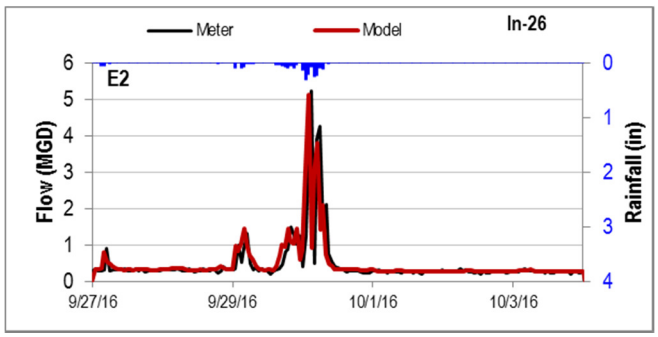


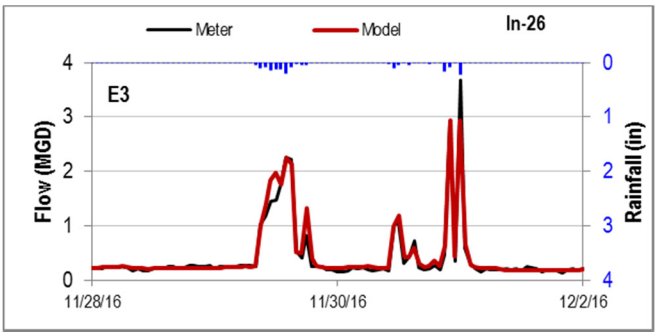


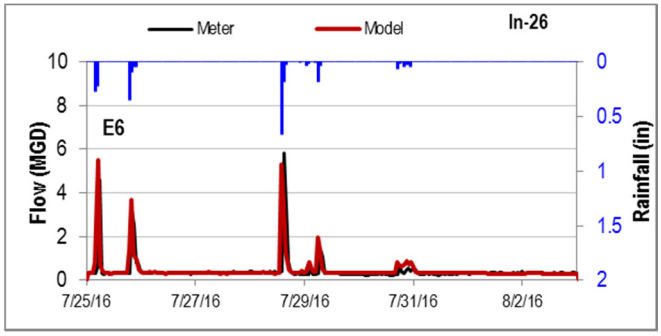
FLOW METER IN-26 MODEL CALIBRATION AND VALIDATION RESULTS

In-26 Model Calibration Results (Metered and Modeled Flow)

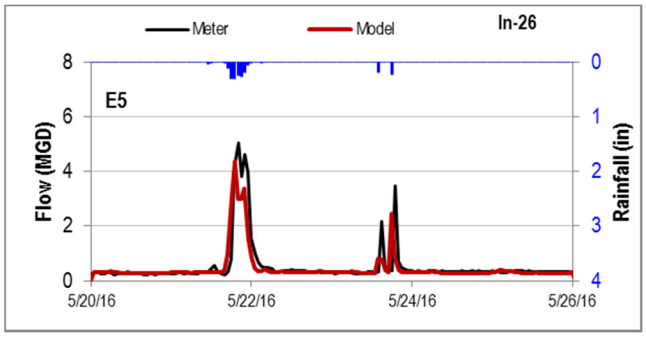




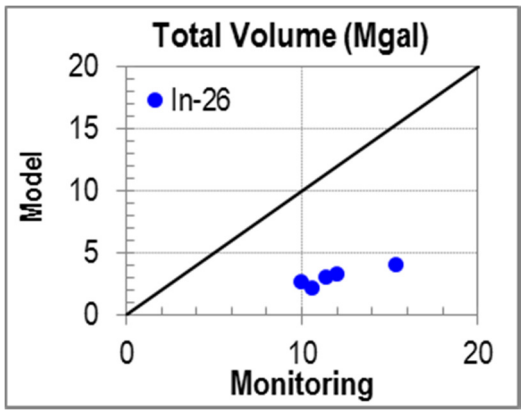


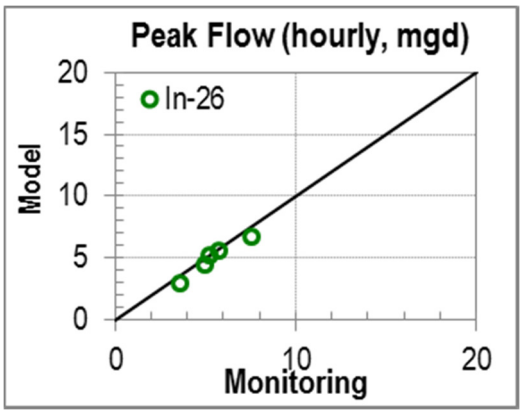


In-26 Model Validation Results (Metered and Modeled Flow)



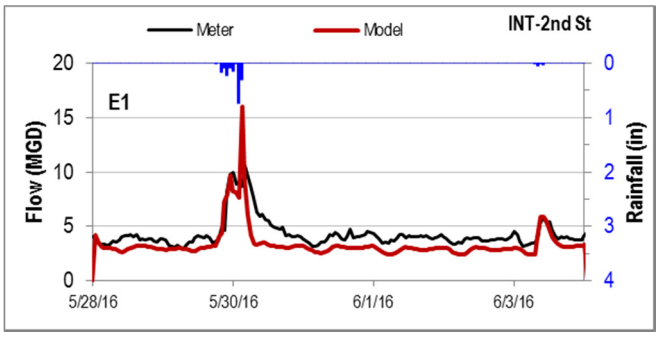
In-26 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

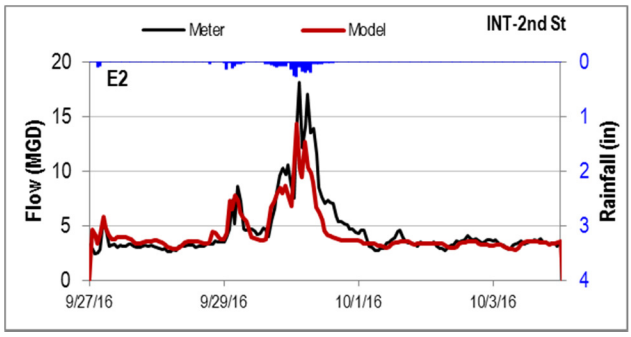


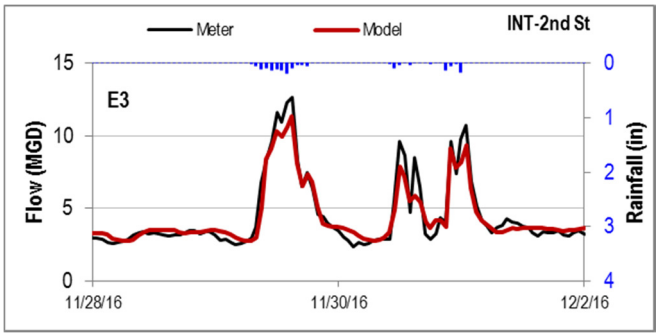


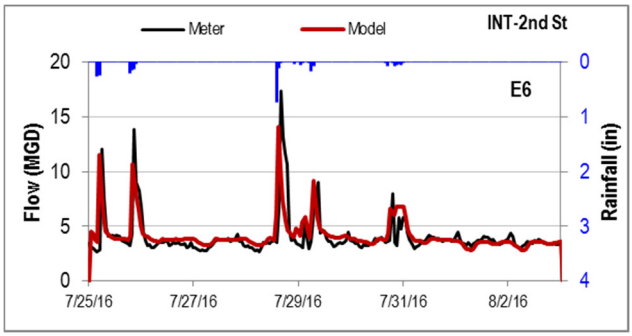
FLOW METER INT-2nd St MODEL CALIBRATION AND VALIDATION RESULTS

INT-2nd St Model Calibration Results (Metered and Modeled Flow)

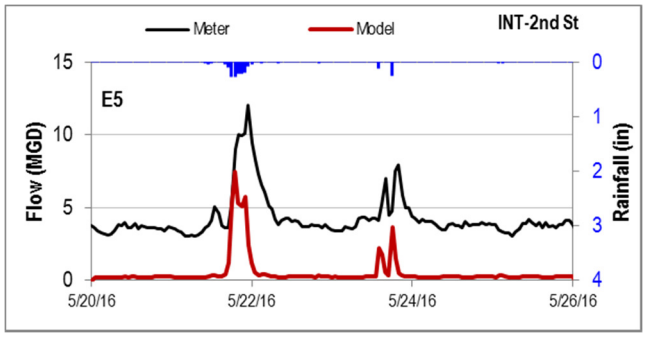




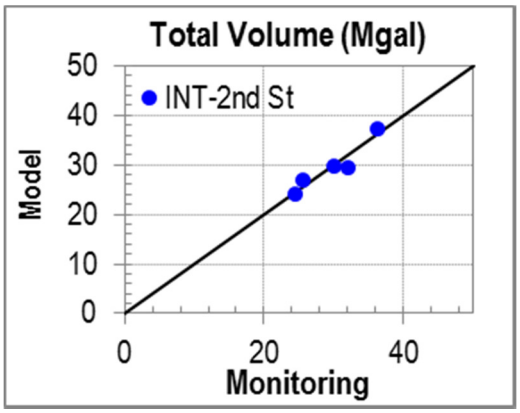


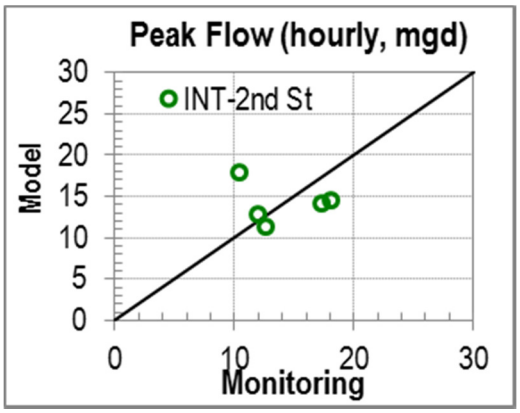


INT-2nd St Model Validation Results (Metered and Modeled Flow)



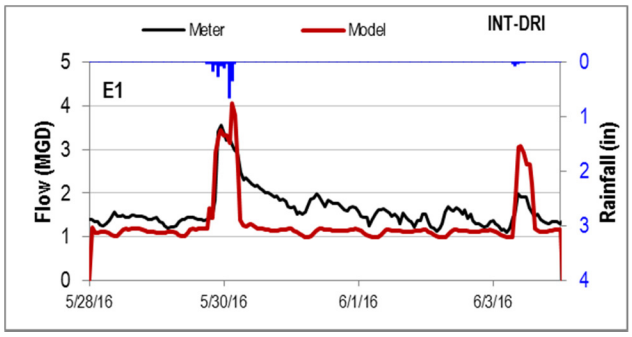
INT-2nd St Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

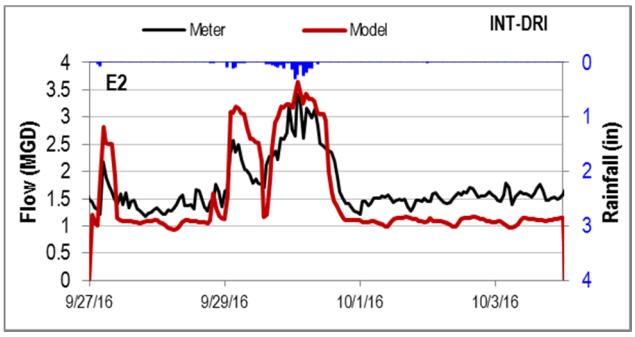


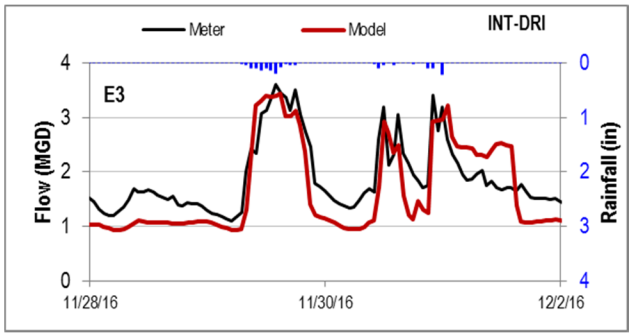


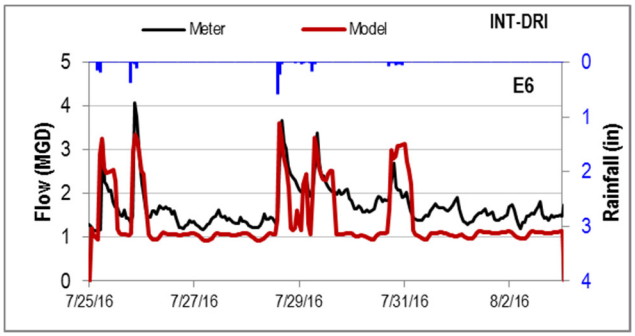
FLOW METER INT-DRI MODEL CALIBRATION AND VALIDATION RESULTS

INT-DRI Model Calibration Results (Metered and Modeled Flow)

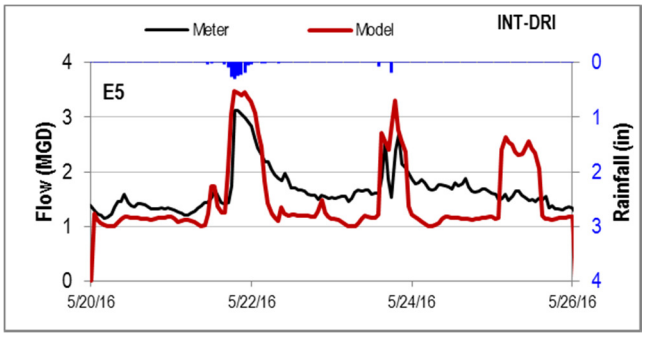




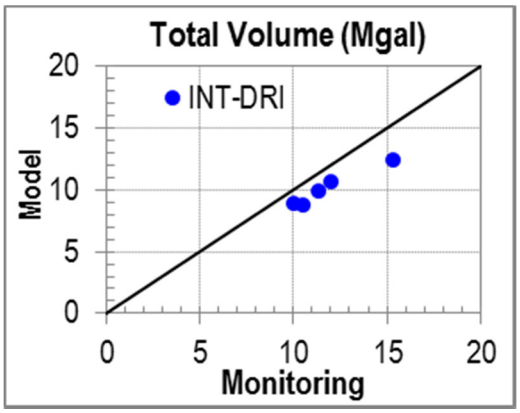


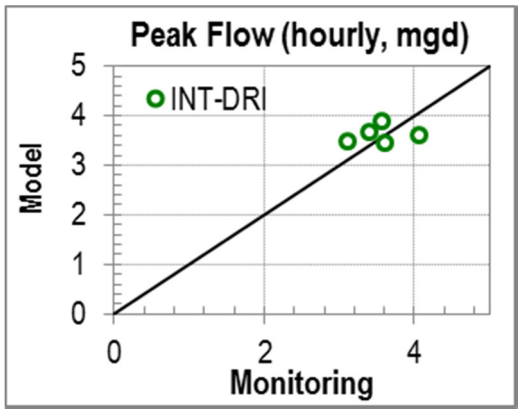


INT-DRI Model Validation Results (Metered and Modeled Flow)



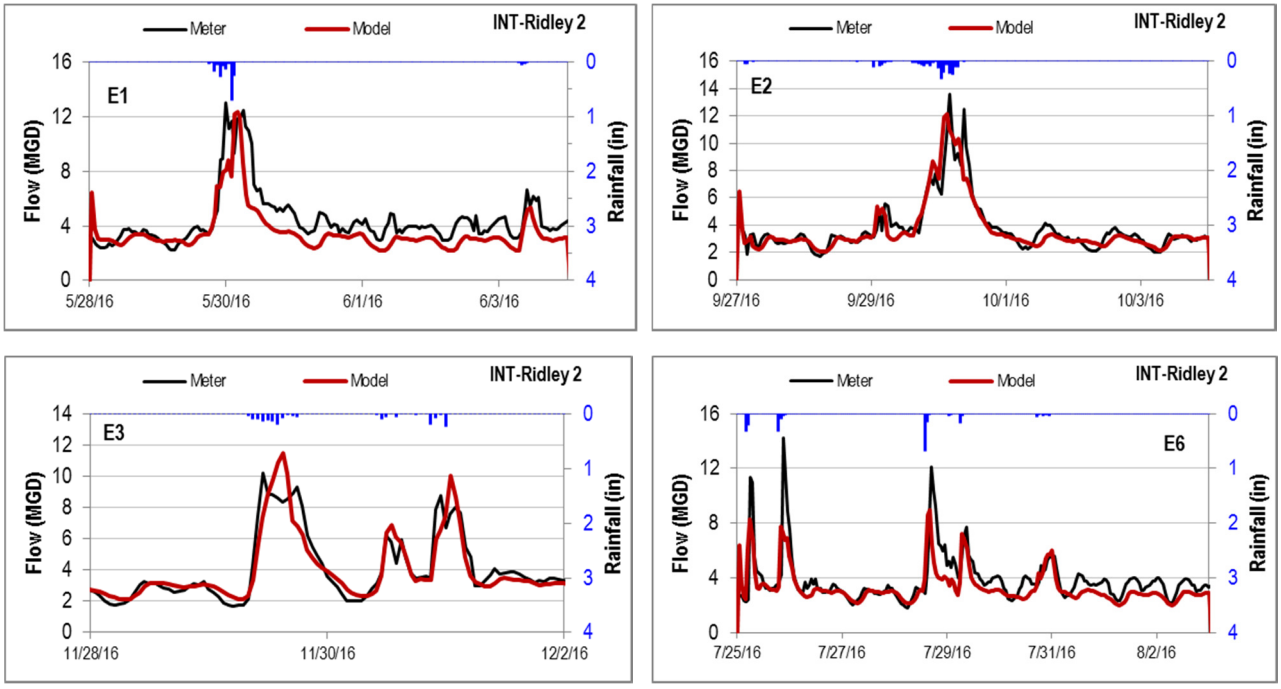
INT-DRI Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



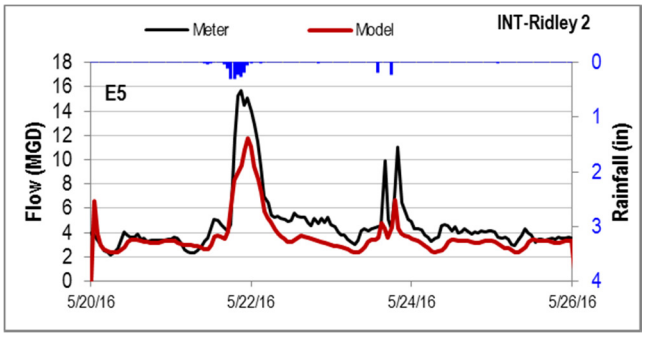


FLOW METER INT-Ridley 2 MODEL CALIBRATION AND VALIDATION RESULTS

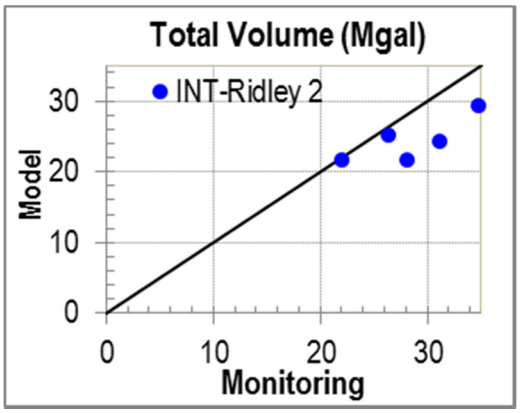
INT-Ridley 2 Model Calibration Results (Metered and Modeled Flow)

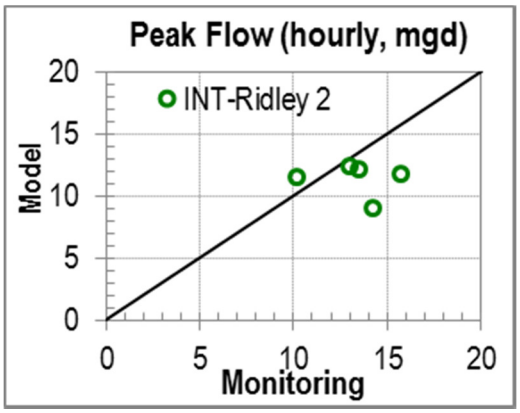


INT-Ridley 2 Model Validation Results (Metered and Modeled Flow)



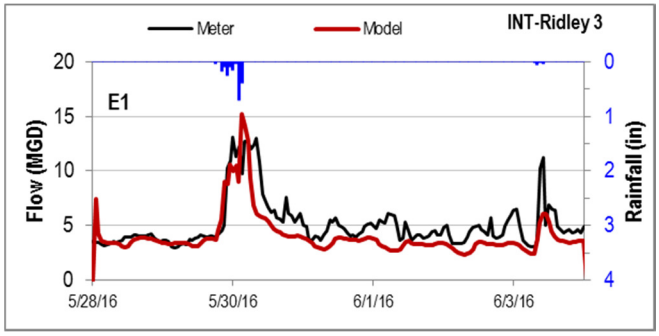
INT-Ridley-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

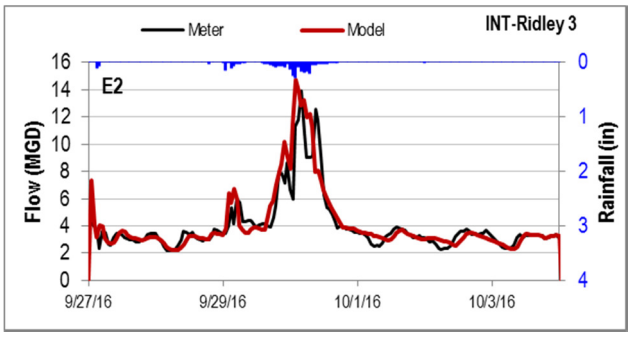


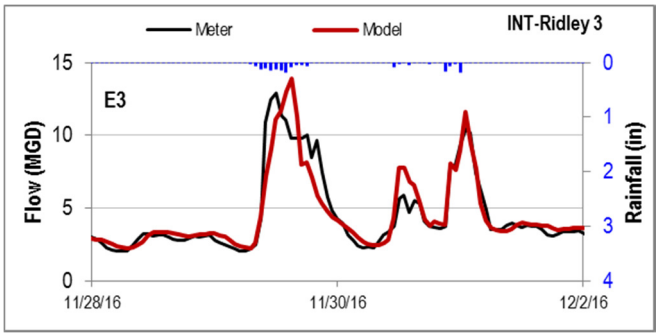


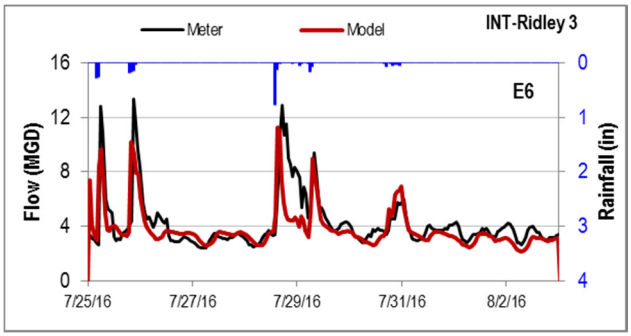
FLOW METER INT-Ridley 3 MODEL CALIBRATION AND VALIDATION RESULTS

INT-Ridley 3 Model Calibration Results (Metered and Modeled Flow)

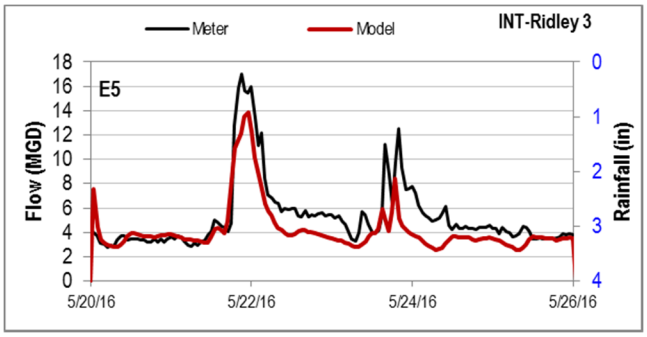




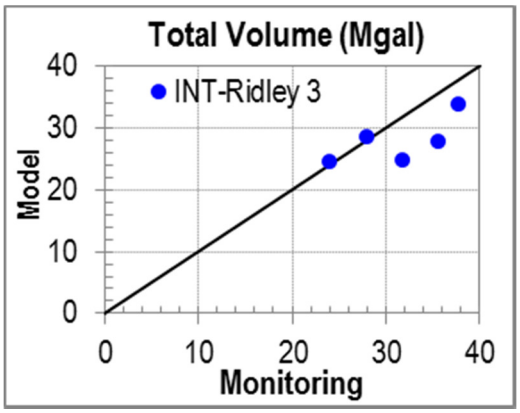


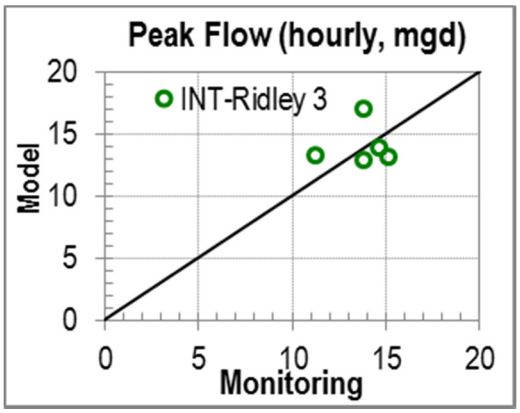


INT-Ridley 3 Model Validation Results (Metered and Modeled Flow)



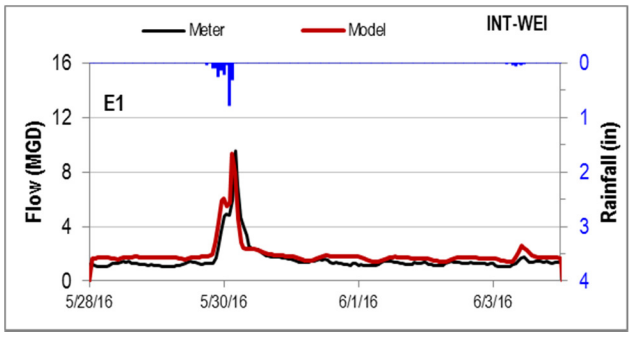
INT-Ridley 3 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

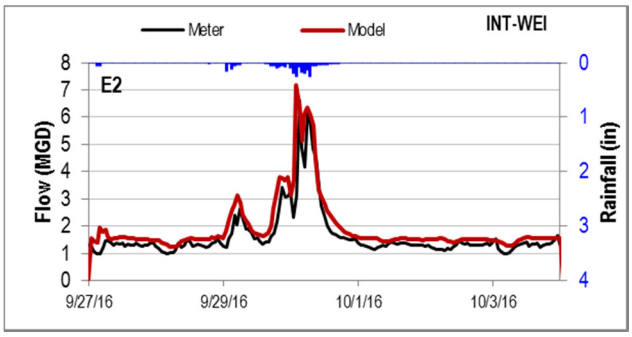


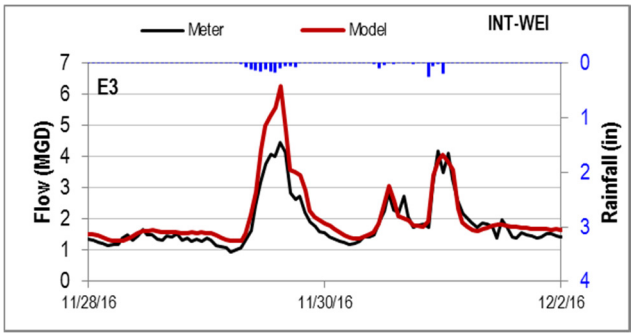


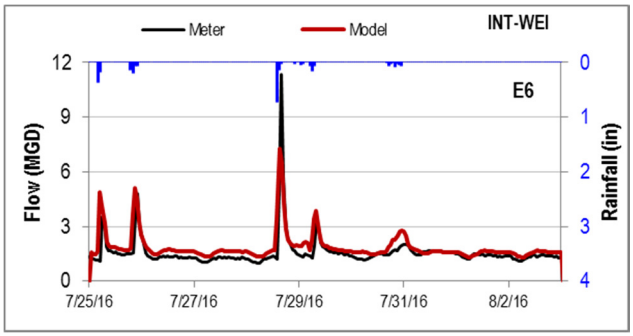
FLOW METER INT-WEI MODEL CALIBRATION AND VALIDATION RESULTS

INT-WEI Model Calibration Results (Metered and Modeled Flow)

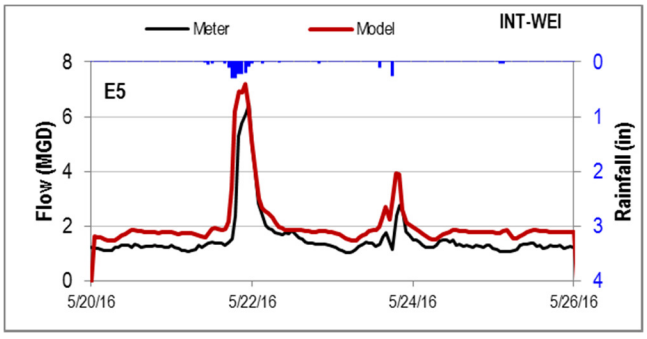




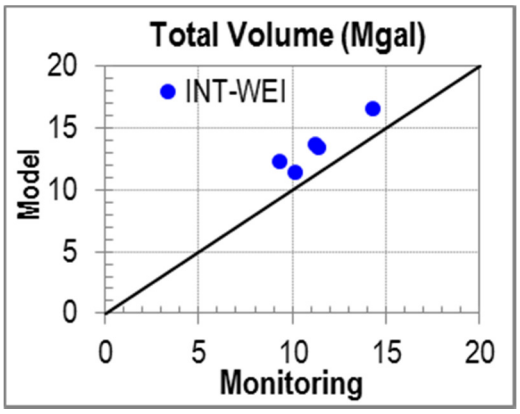


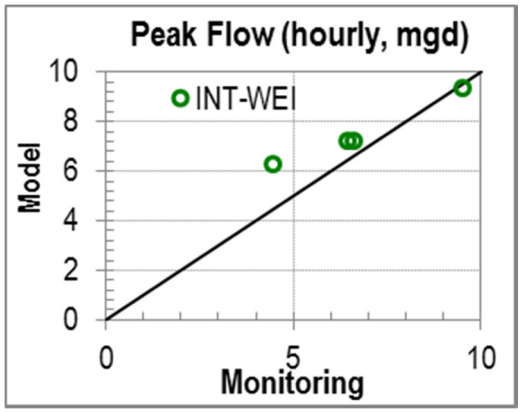


INT-WEI Model Validation Results (Metered and Modeled Flow)



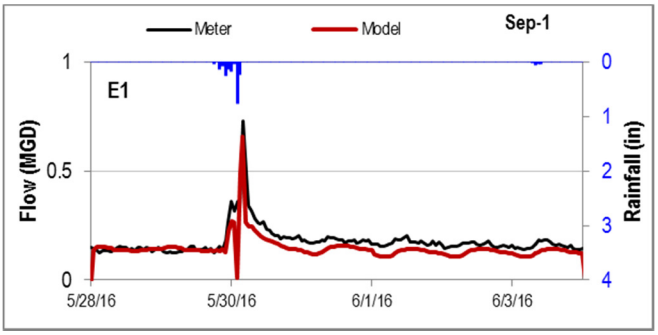
INT-WEI Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

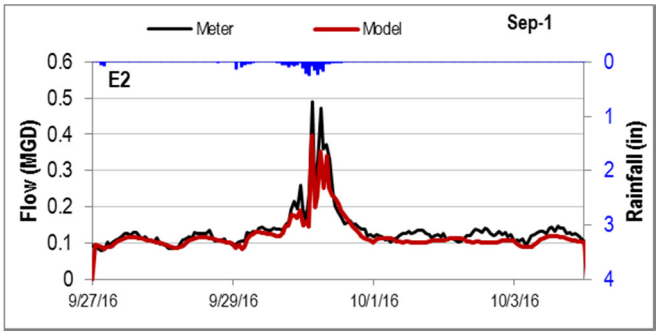


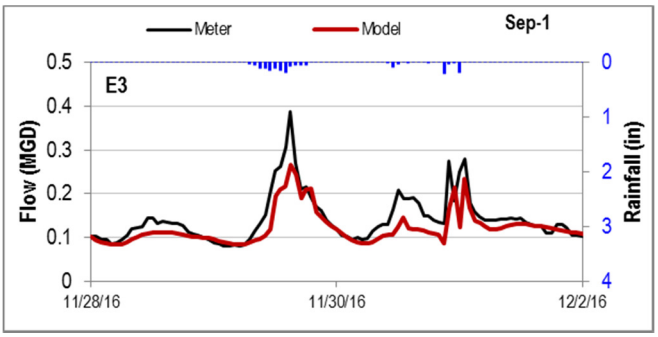


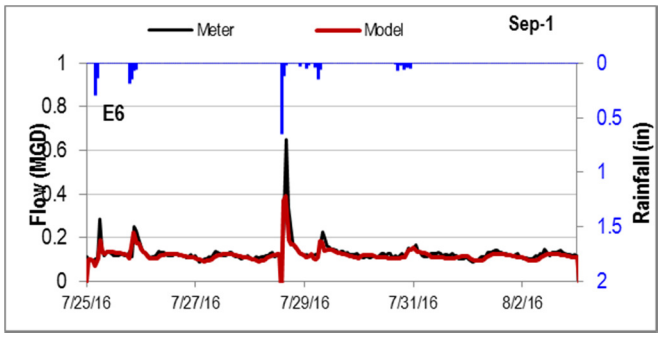
FLOW METER Sep-1 MODEL CALIBRATION AND VALIDATION RESULTS

Sep-1 Model Calibration Results (Metered and Modeled Flow)

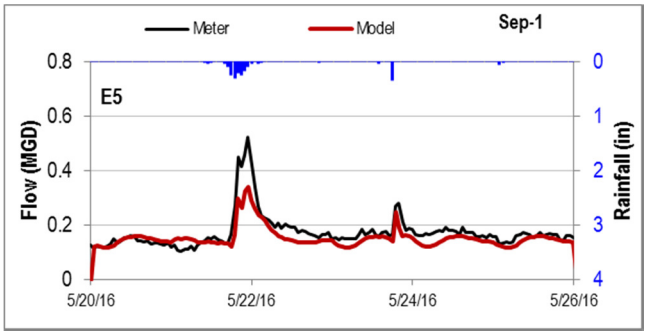




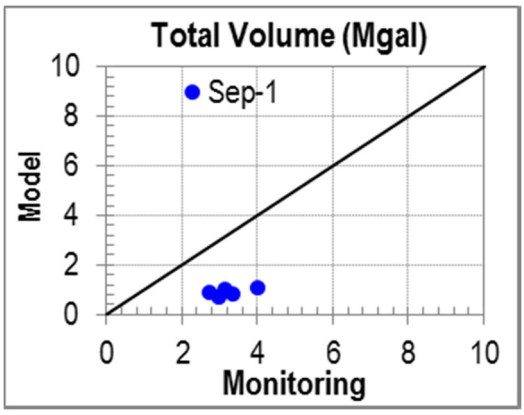


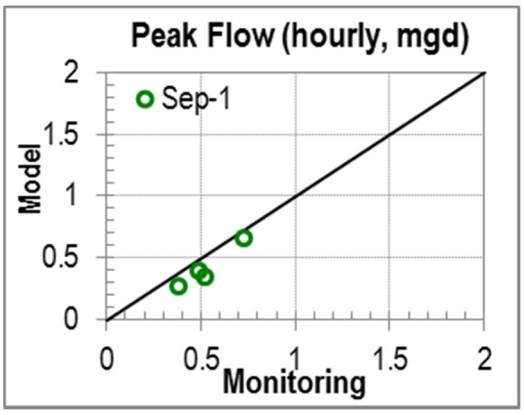


Sep-1 Model Validation Results (Metered and Modeled Flow)



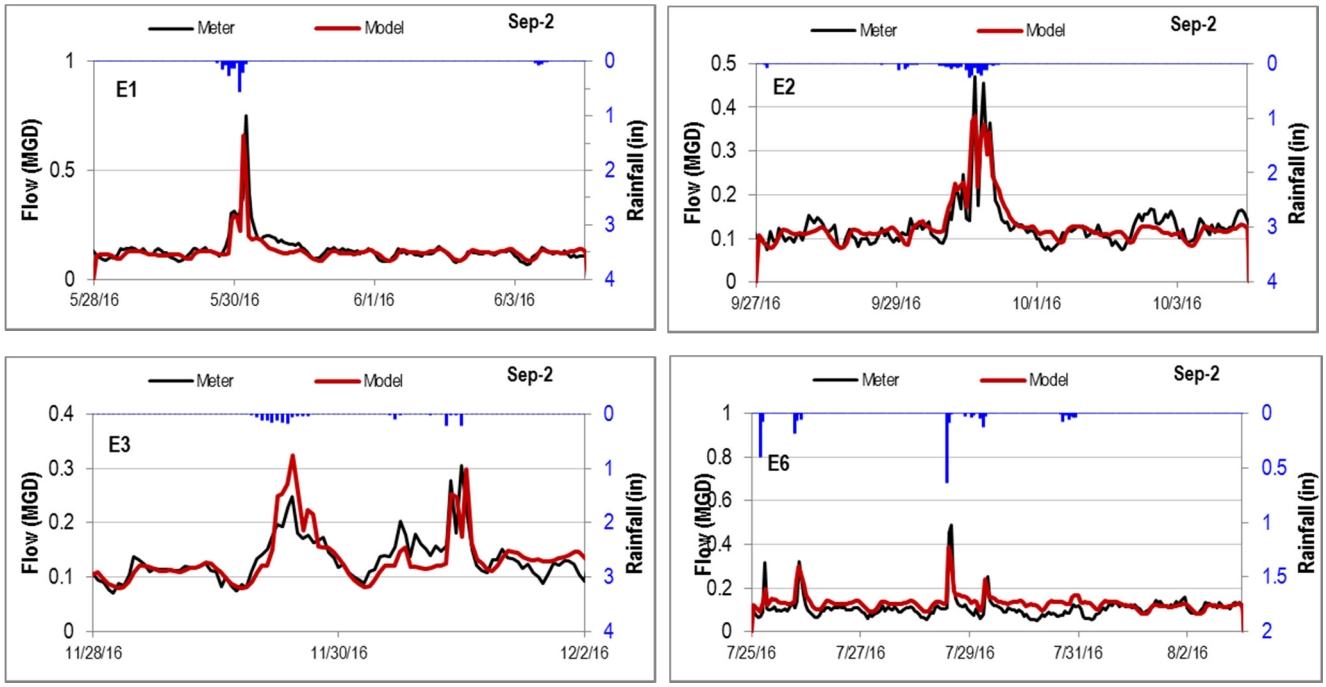
Sep-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



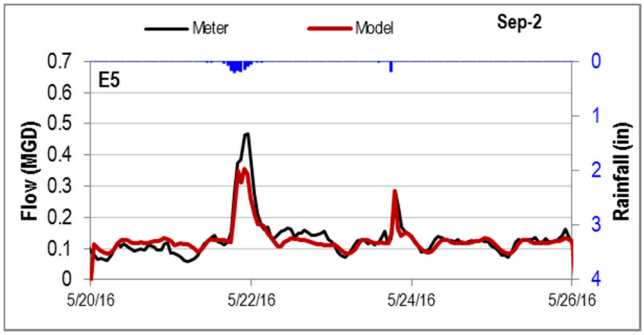


FLOW METER Sep-2 MODEL CALIBRATION AND VALIDATION RESULTS

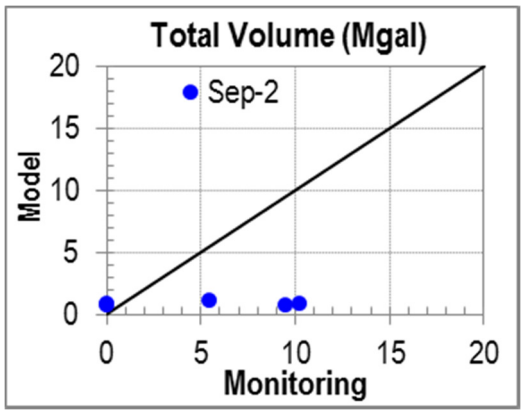
Sep-2 Model Calibration Results (Metered and Modeled Flow)

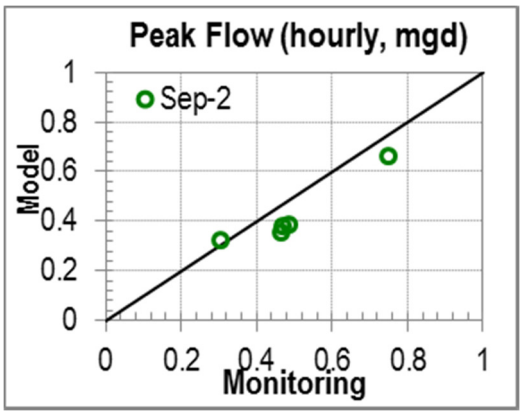


Sep-2 Model Validation Results (Metered and Modeled Flow)



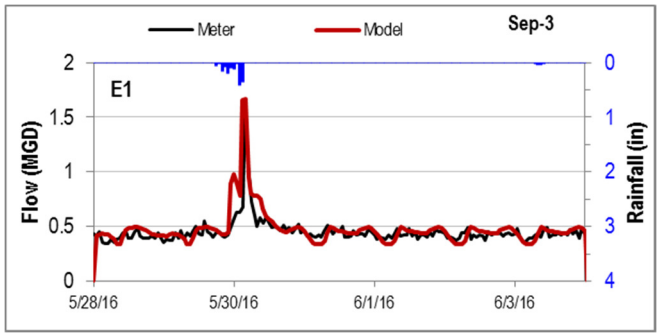
Sep-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

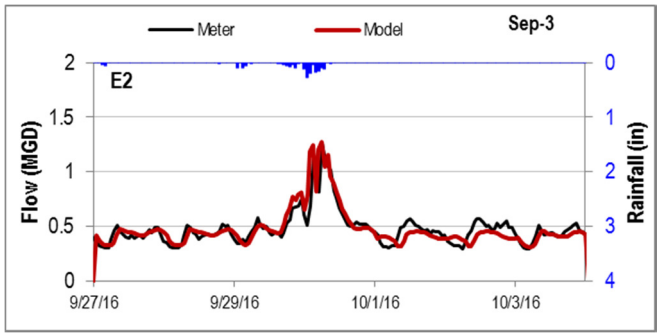


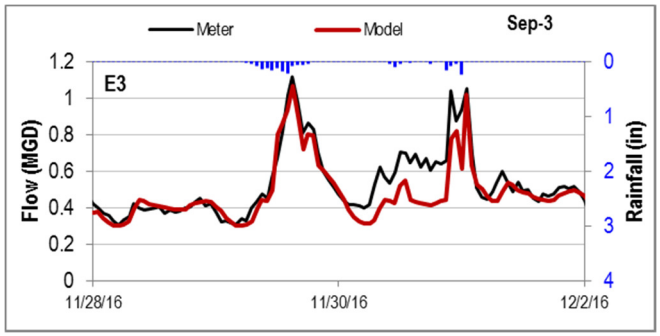


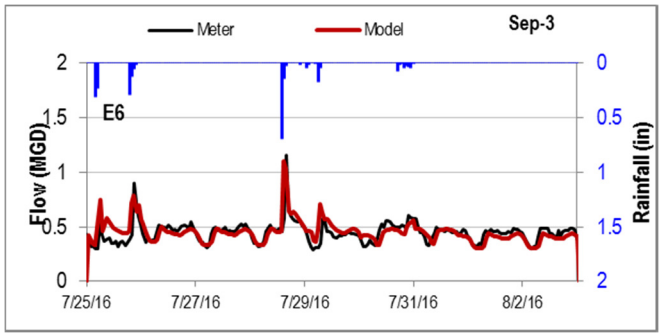
FLOW METER Sep-3 MODEL CALIBRATION AND VALIDATION RESULTS

Sep-3 Model Calibration Results (Metered and Modeled Flow)

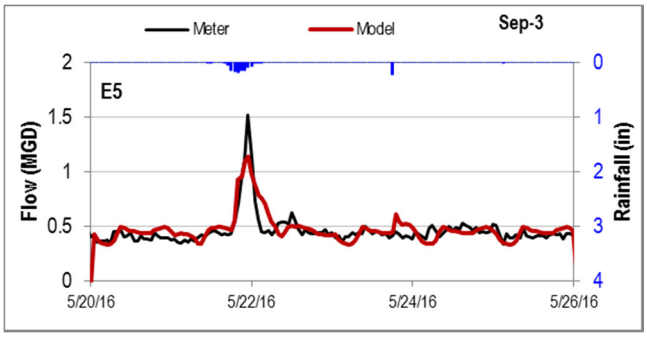




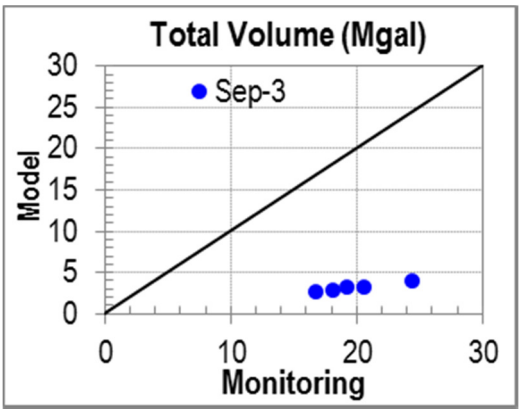


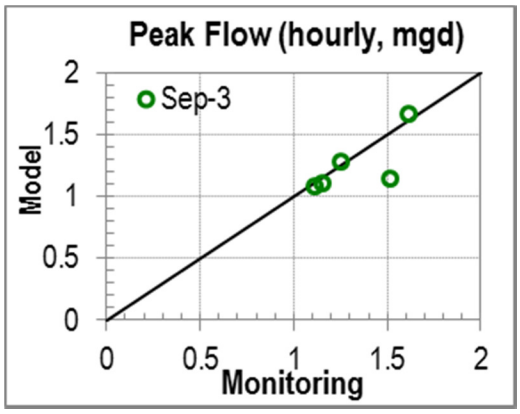


Sep-3 Model Validation Results (Metered and Modeled Flow)



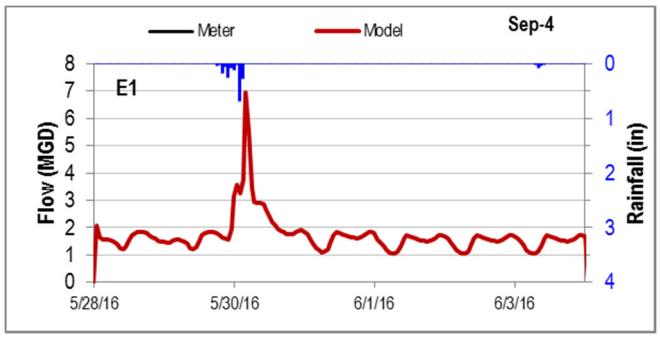
Sep-3 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

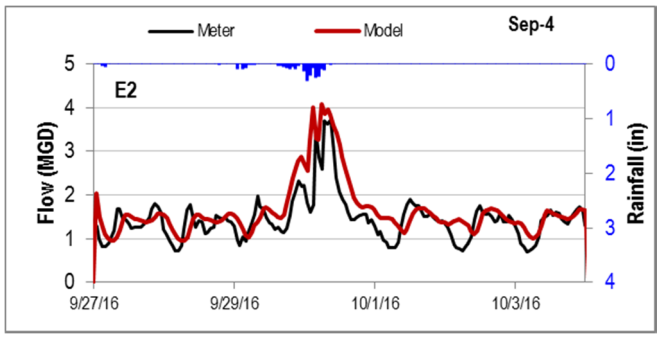


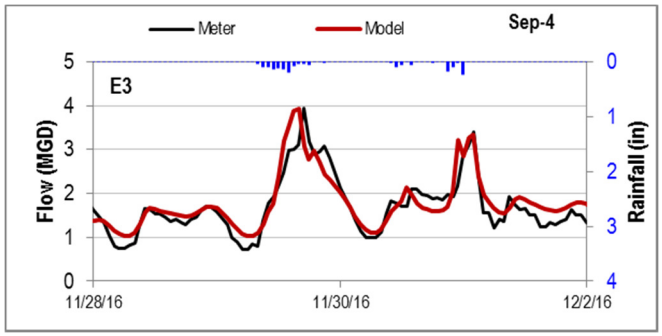


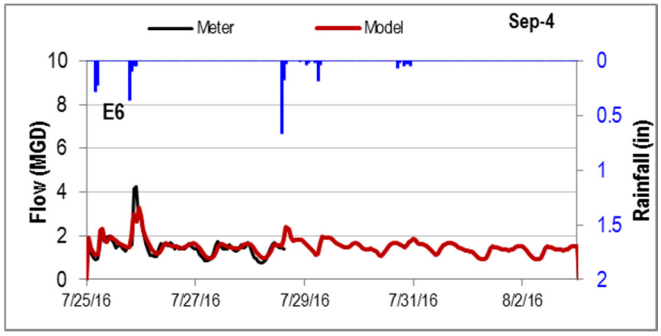
FLOW METER Sep-4 MODEL CALIBRATION AND VALIDATION RESULTS

Sep-4 Model Calibration Results (Metered and Modeled Flow)

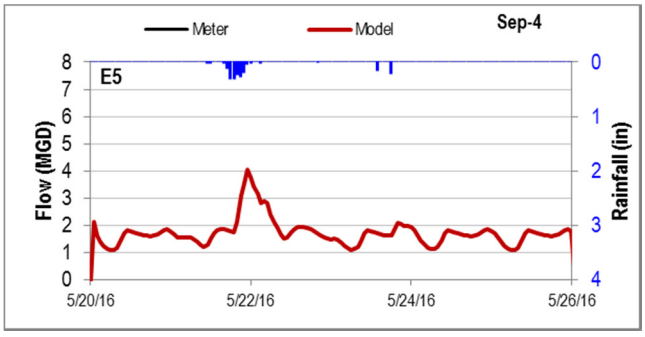




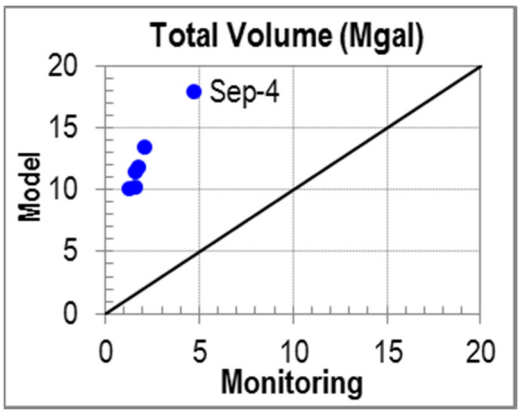


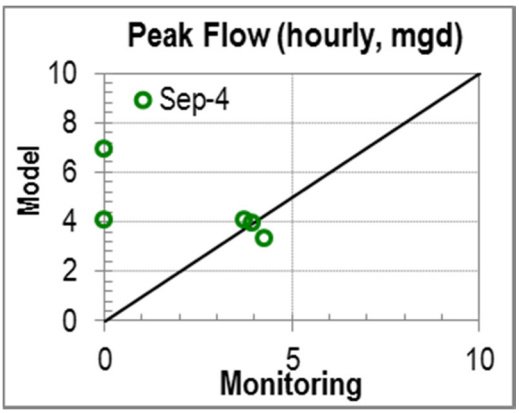


Sep-4 Model Validation Results (Metered and Modeled Flow)



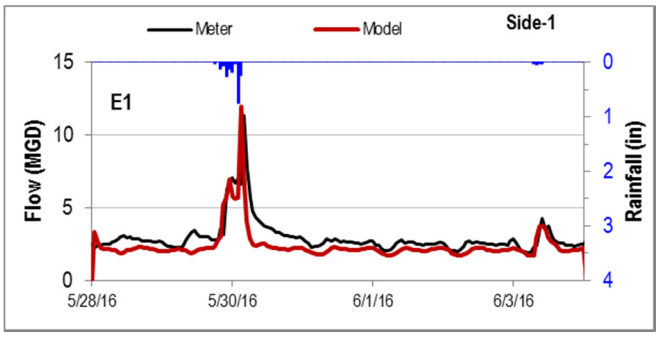
Sep-4 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

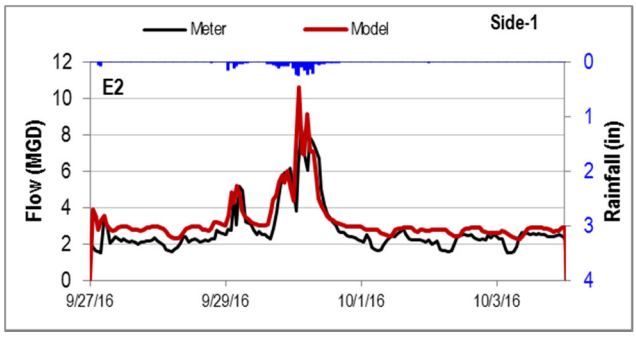


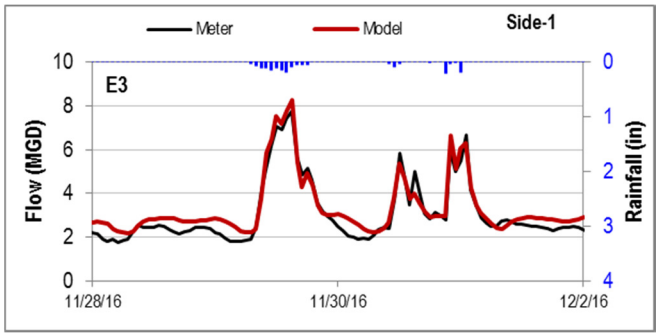


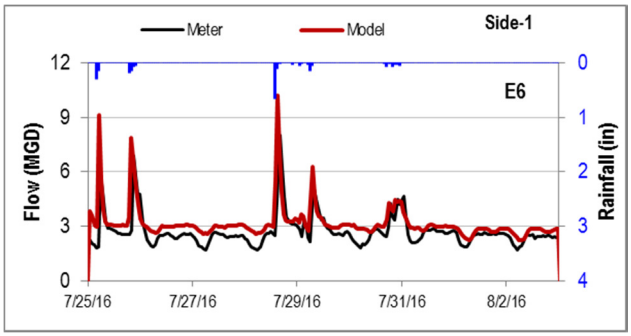
FLOW METER Side-1 MODEL CALIBRATION AND VALIDATION RESULTS

Side-1 Model Calibration Results (Metered and Modeled Flow)

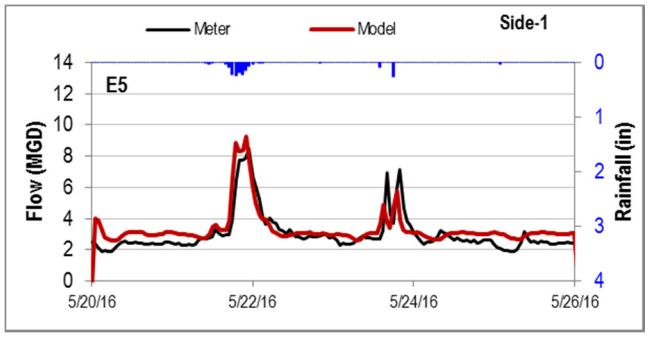




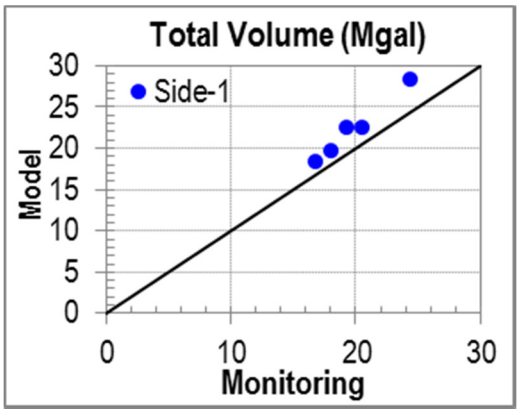


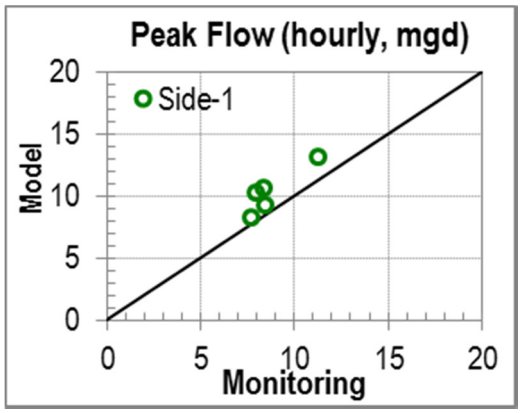


Side-1 Model Validation Results (Metered and Modeled Flow)



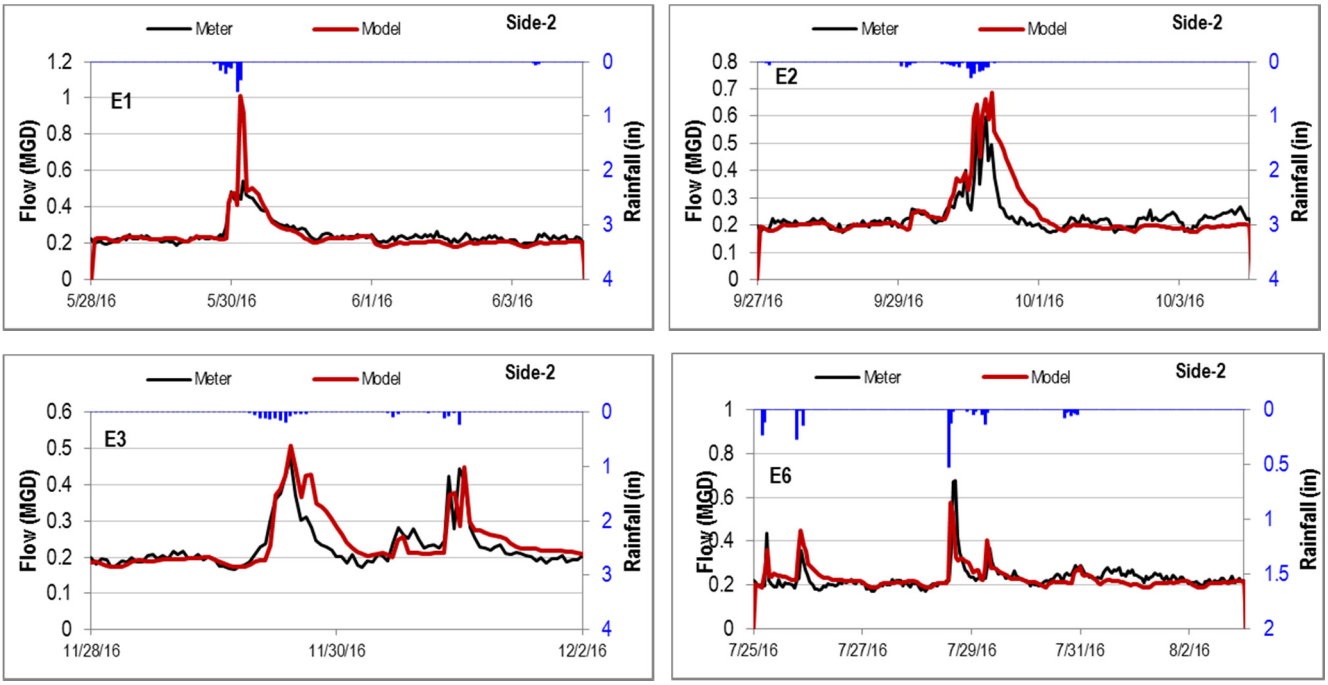
Side-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



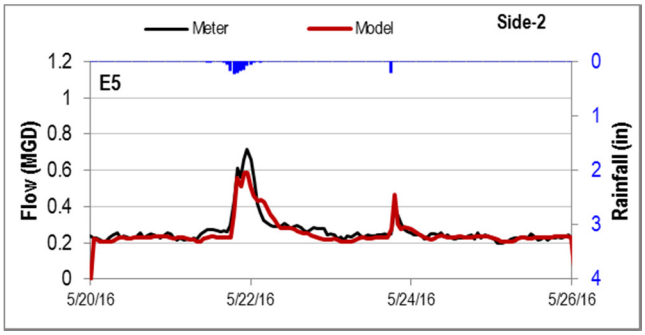


FLOW METER Side-2 MODEL CALIBRATION AND VALIDATION RESULTS

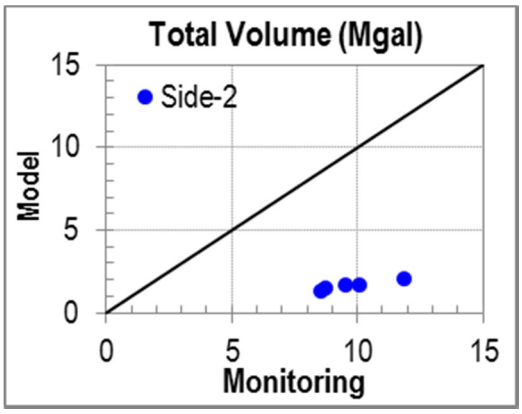
Side-2 Model Calibration Results (Metered and Modeled Flow)

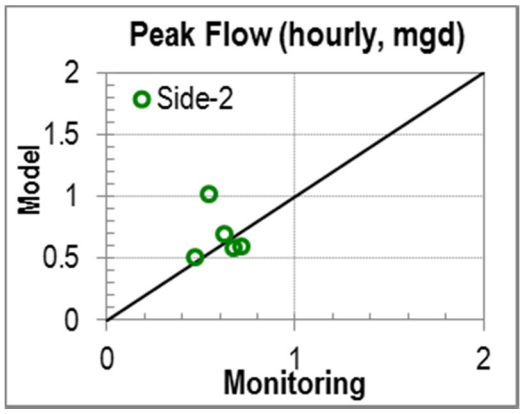


Side-2 Model Validation Results (Metered and Modeled Flow)



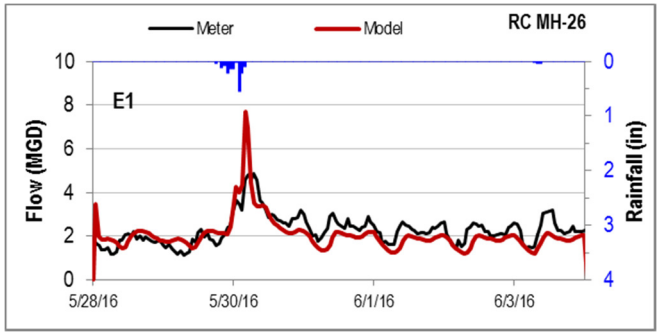
Side-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

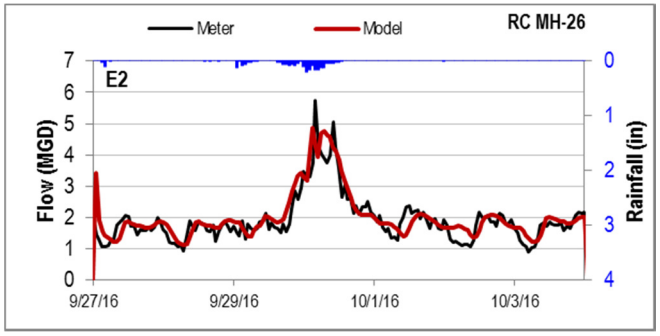


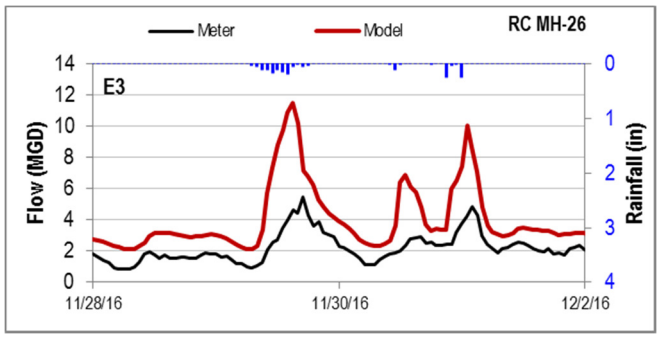


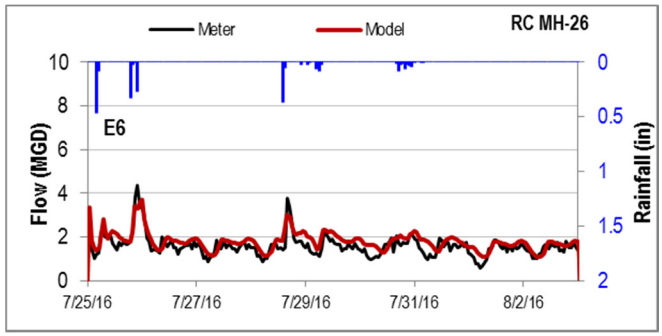
FLOW METER RC MH-26 MODEL CALIBRATION AND VALIDATION RESULTS

RC MH-26 Model Calibration Results (Metered and Modeled Flow)

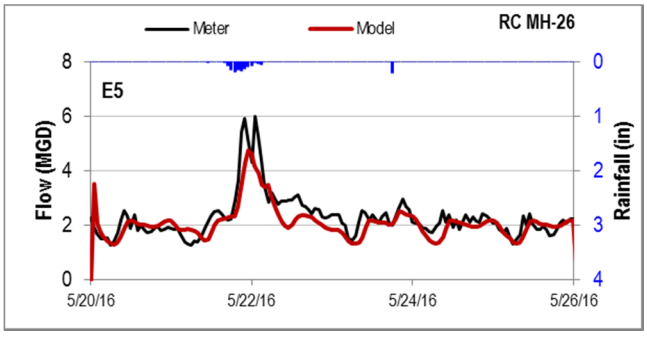




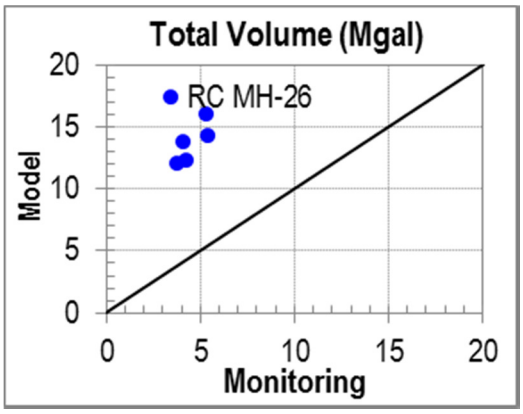


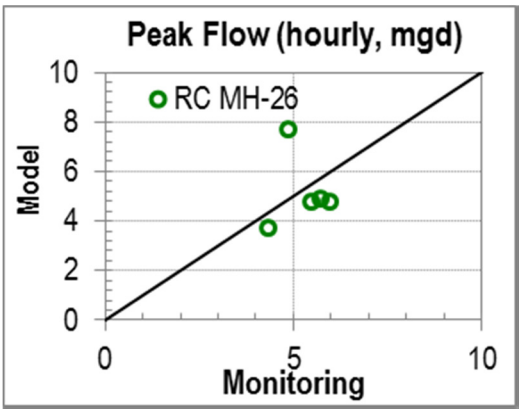


RC MH-26 Model Validation Results (Metered and Modeled Flow)



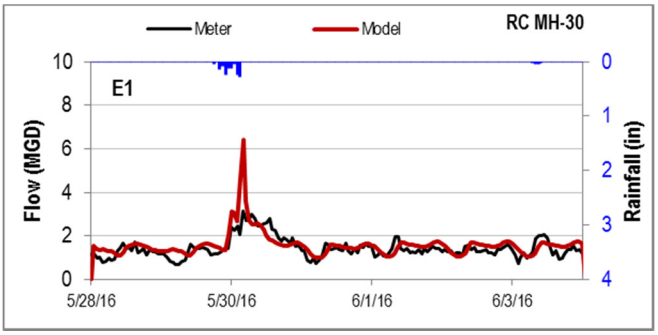
RC MH-26 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

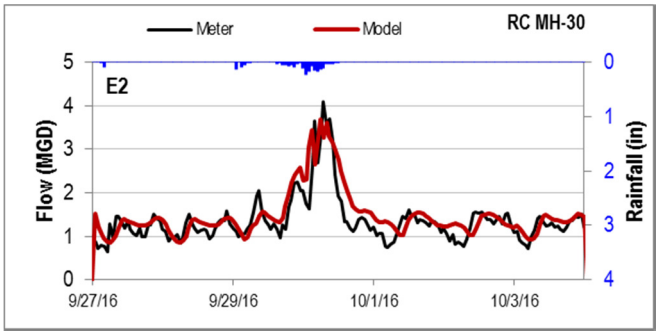


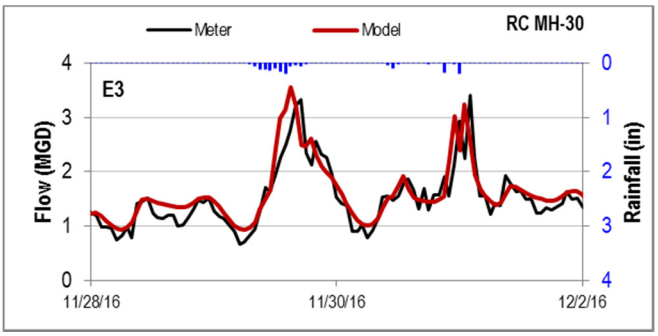


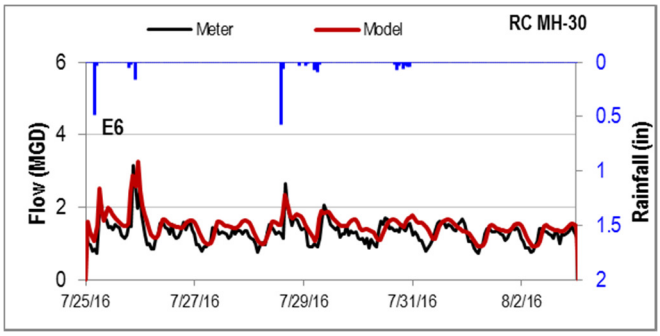
FLOW METER RC MH-30 MODEL CALIBRATION AND VALIDATION RESULTS

RC MH-30 Model Calibration Results (Metered and Modeled Flow)

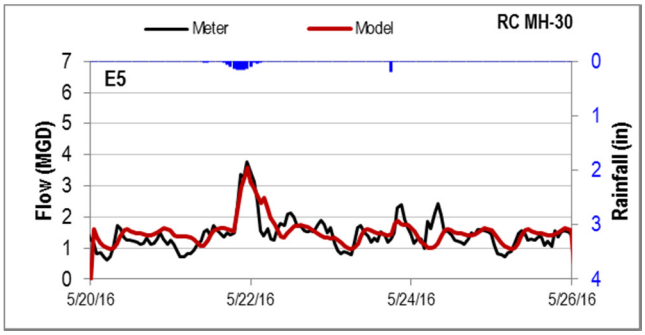




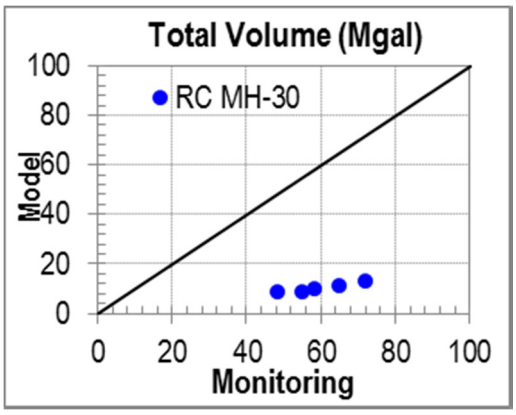


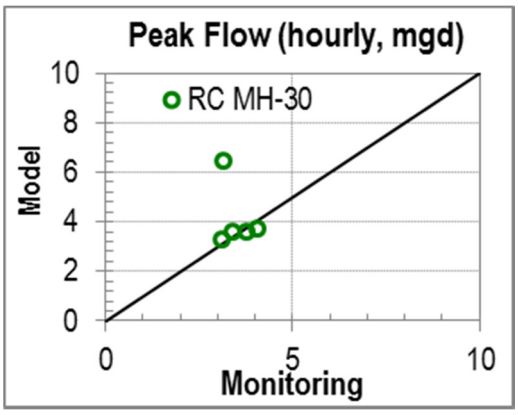


RC MH-30 Model Validation Results (Metered and Modeled Flow)



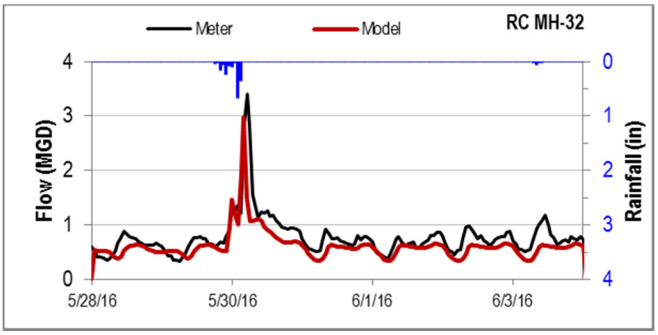
RC MH-30 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

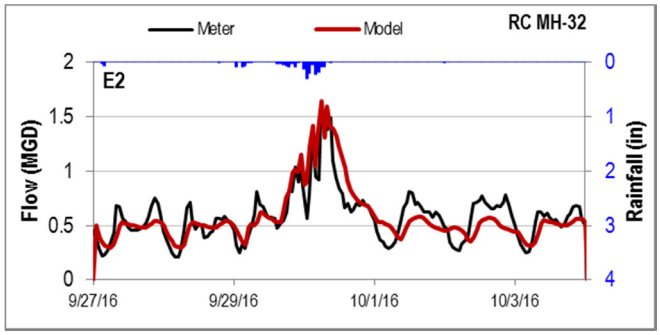


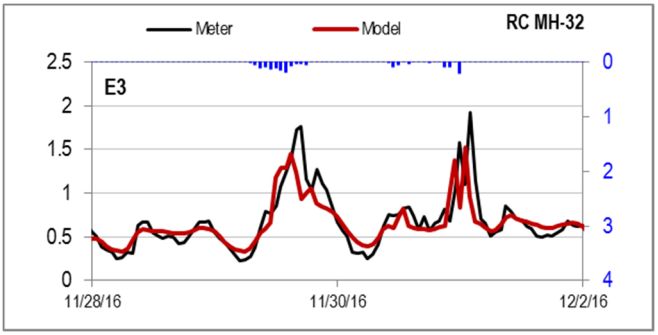


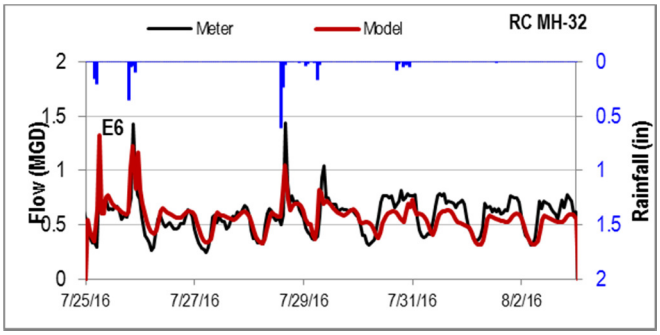
FLOW METER RC MH-32 MODEL CALIBRATION AND VALIDATION RESULTS

RC MH-32 Model Calibration Results (Metered and Modeled Flow)

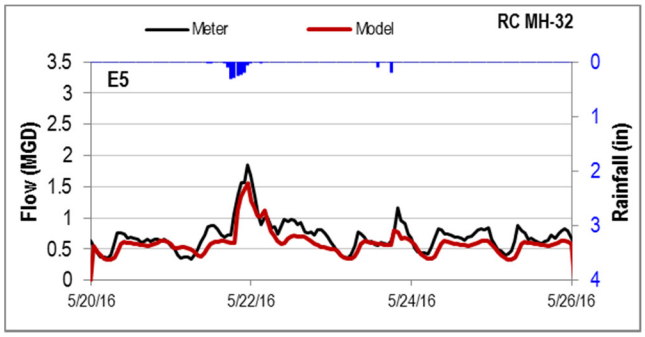




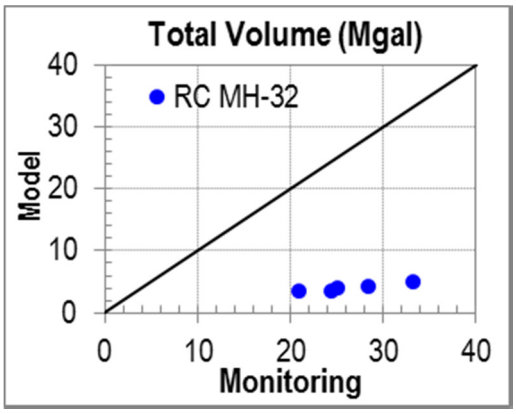


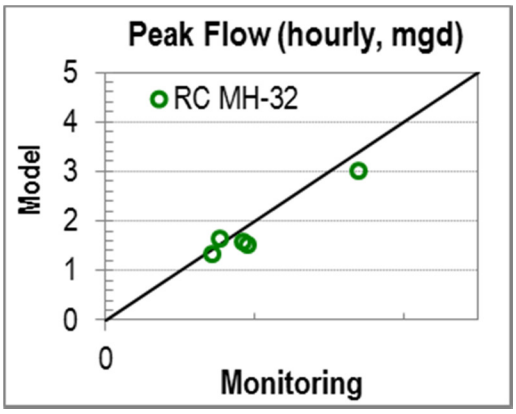


RC MH-32 Model Validation Results (Metered and Modeled Flow)



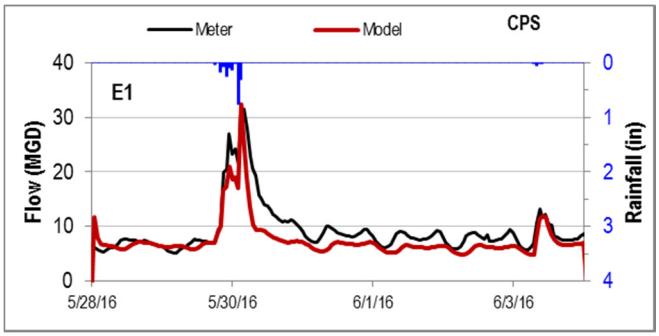
RC MH-32 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

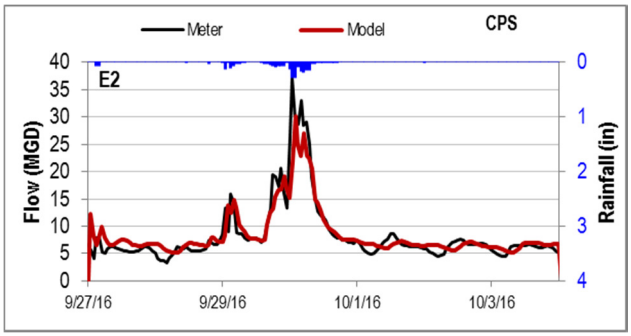


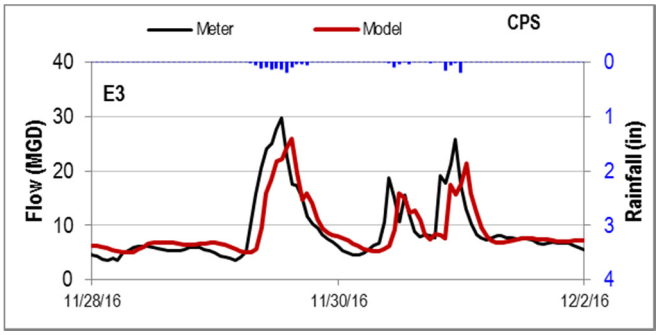


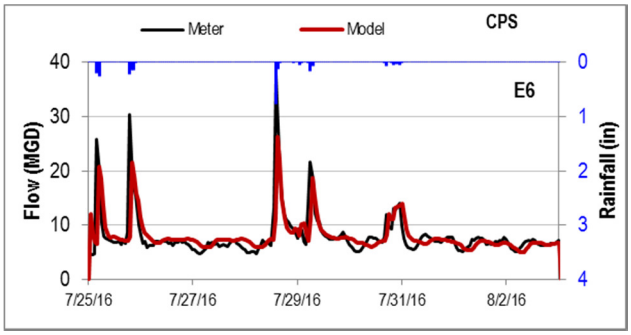
FLOW METER CPS MODEL CALIBRATION AND VALIDATION RESULTS

CPS Model Calibration Results (Metered and Modeled Flow)

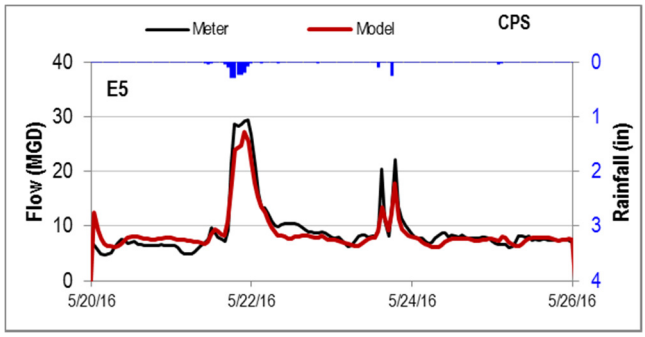




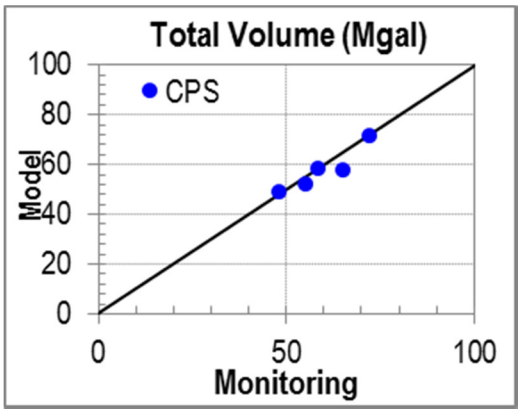


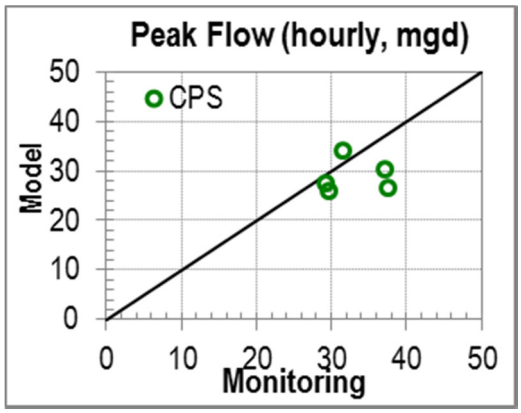


CPS Model Validation Results (Metered and Modeled Flow)



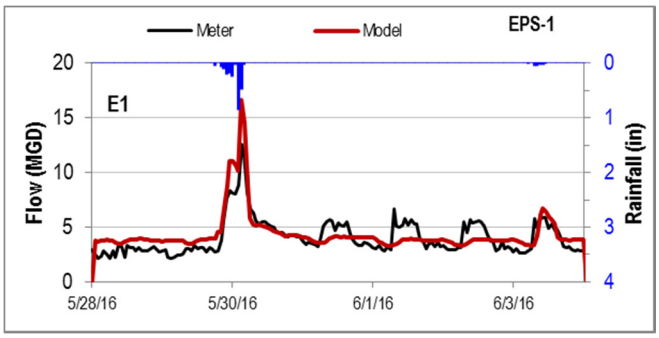
CPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

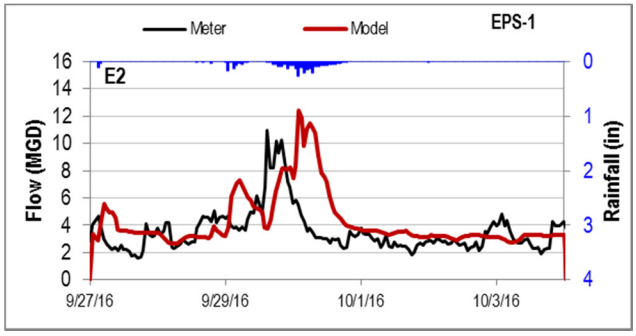


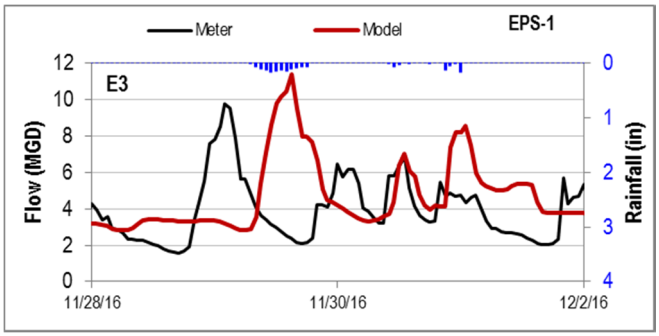


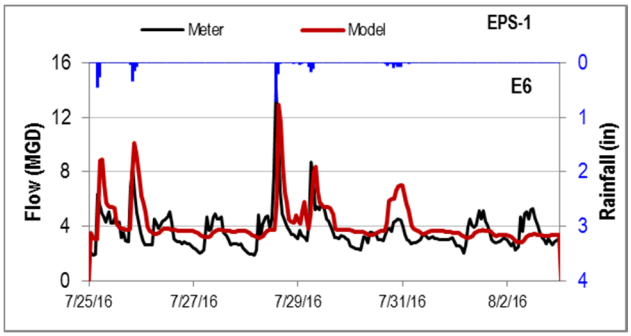
FLOW METER EPS-1 MODEL CALIBRATION AND VALIDATION RESULTS

EPS-1 Model Calibration Results (Metered and Modeled Flow)

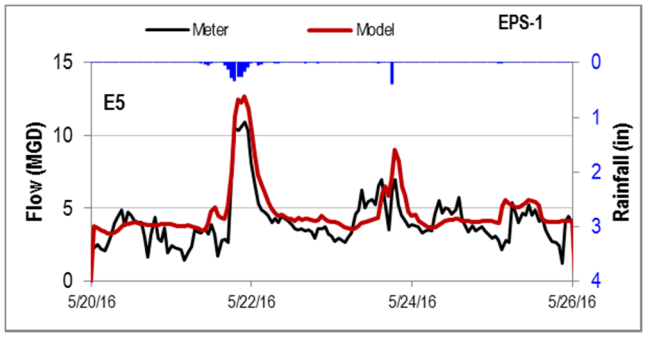




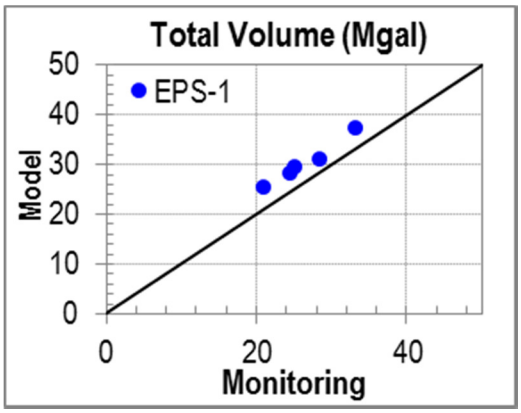


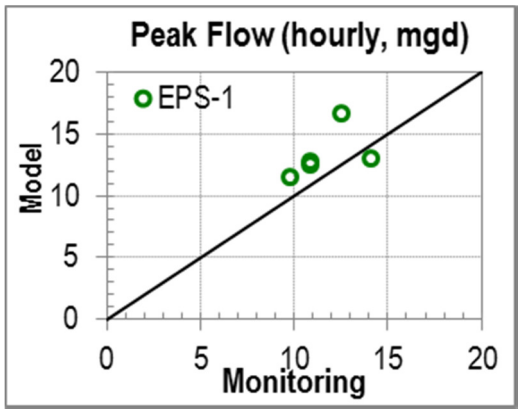


EPS-1 Model Validation Results (Metered and Modeled Flow)



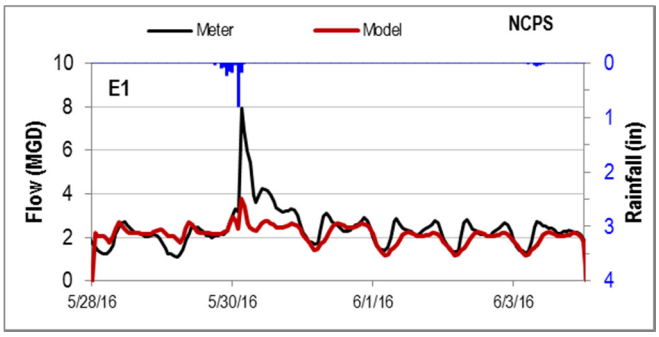
EPS-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

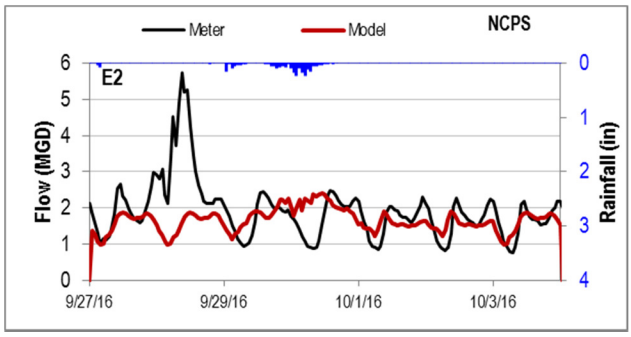


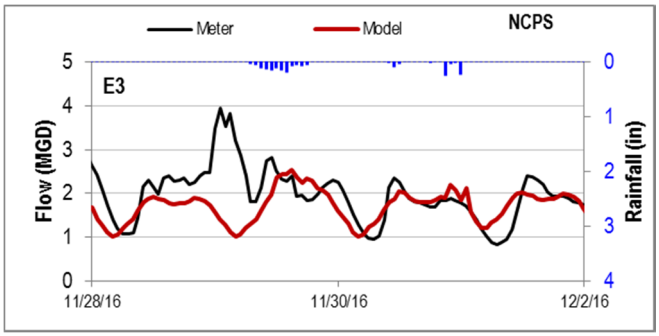


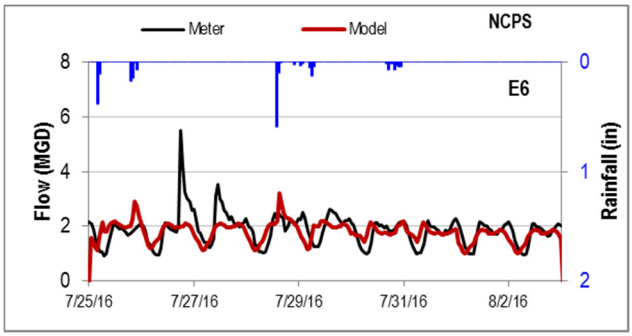
FLOW METER NCPS MODEL CALIBRATION AND VALIDATION RESULTS

NCPS Model Calibration Results (Metered and Modeled Flow)

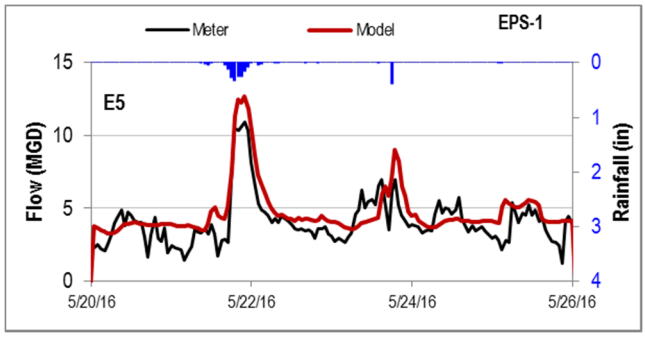




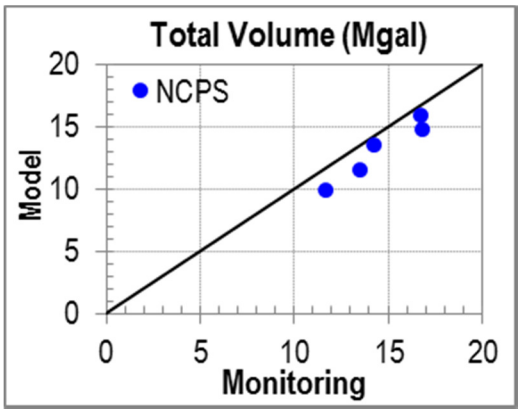


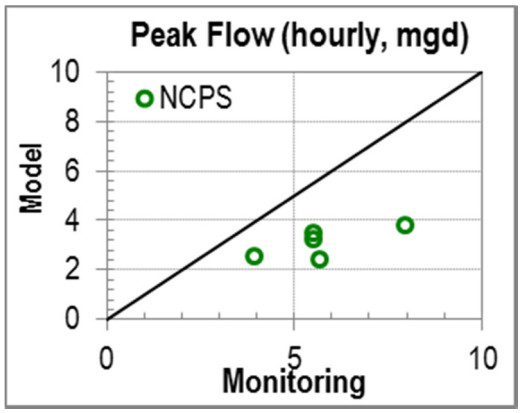


NCPS Model Validation Results (Metered and Modeled Flow)



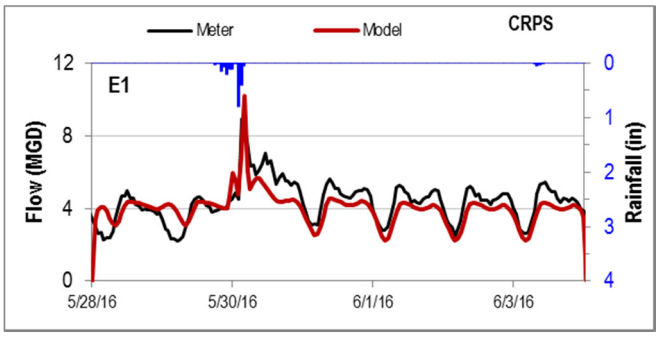
NCPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

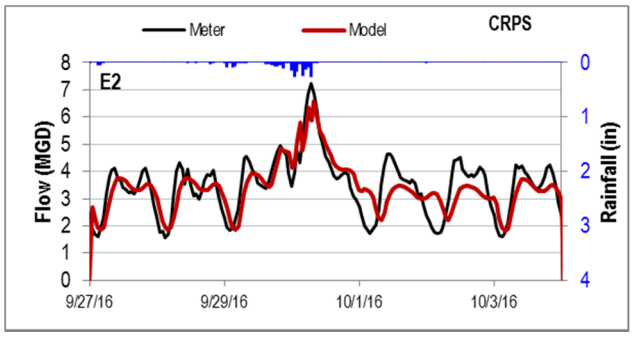


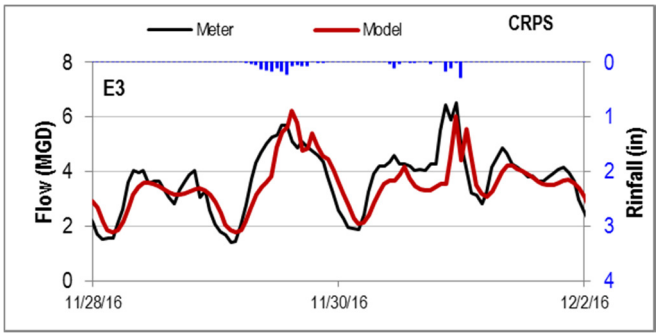


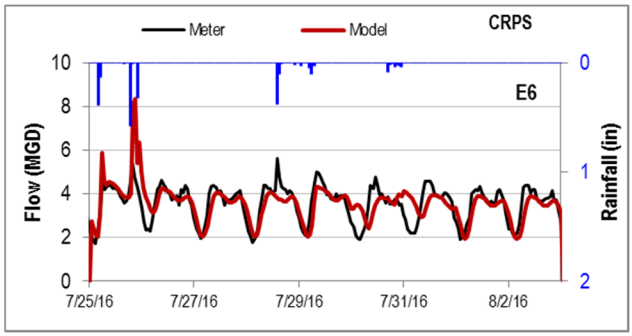
FLOW METER CRPS MODEL CALIBRATION AND VALIDATION RESULTS

CRPS Model Calibration Results (Metered and Modeled Flow)

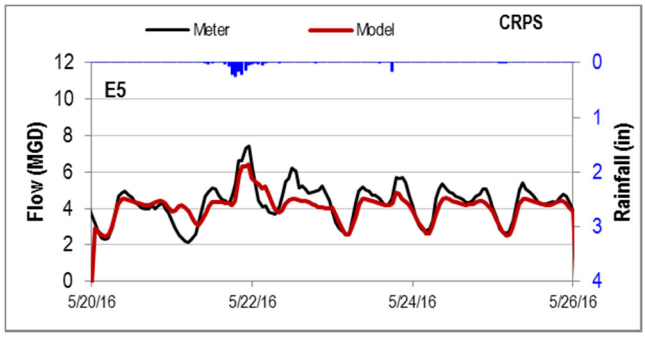




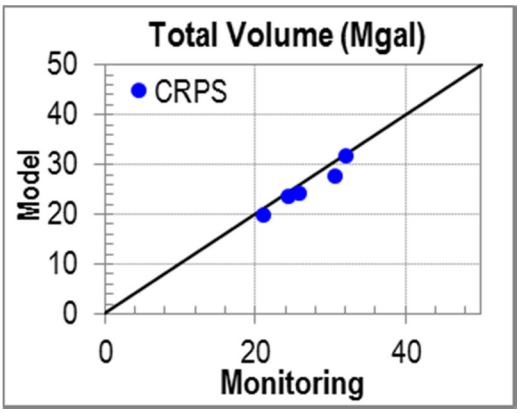


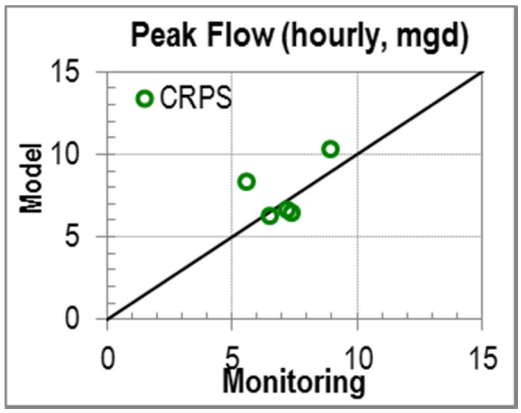


CRPS Model Validation Results (Metered and Modeled Flow)



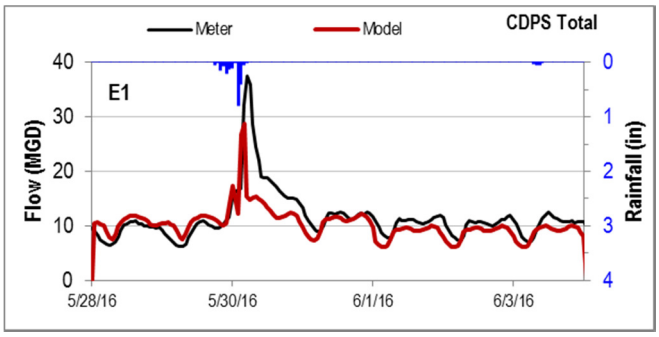
CRPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

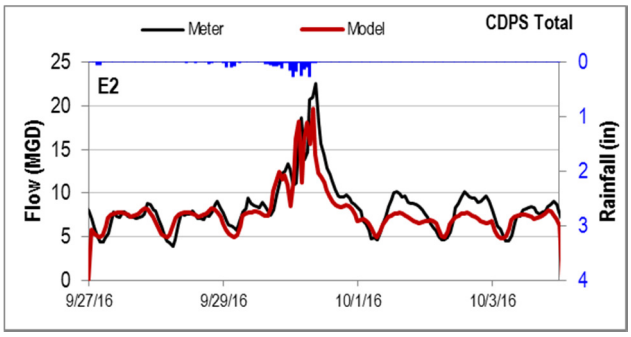


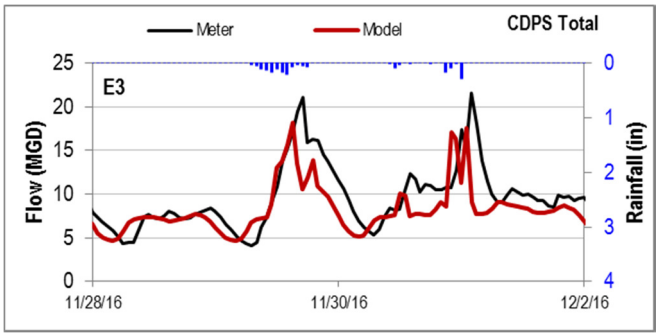


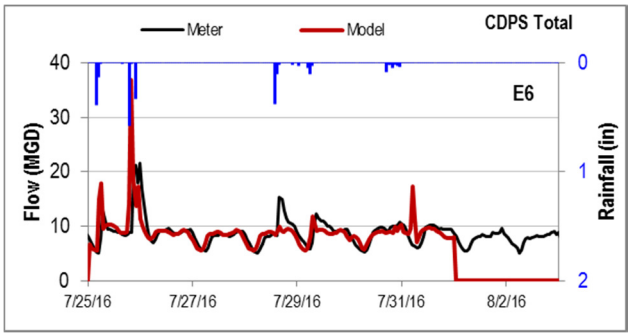
FLOW METER CDPS TOTAL MODEL CALIBRATION AND VALIDATION RESULTS

CDPS Total Model Calibration Results (Metered and Modeled Flow)

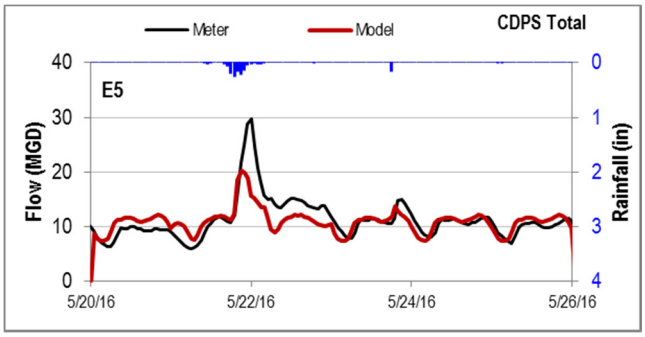




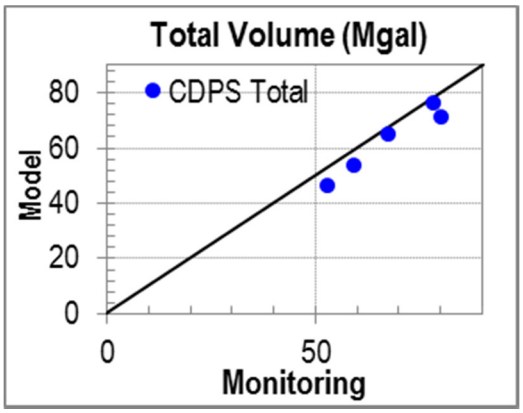


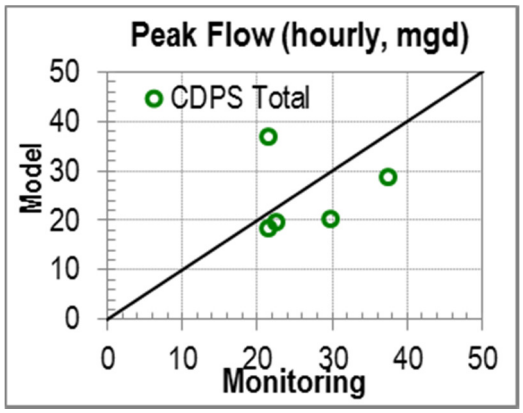


CDPS Total Model Validation Results (Metered and Modeled Flow)



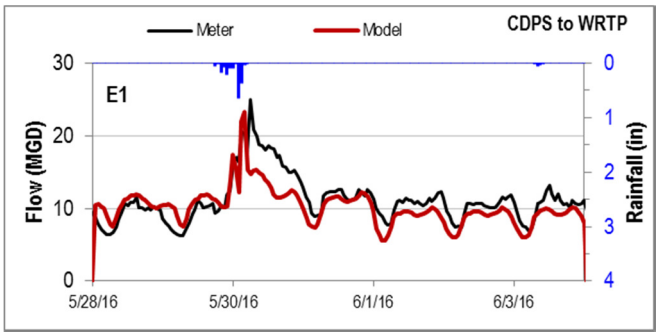
CDPS Total Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

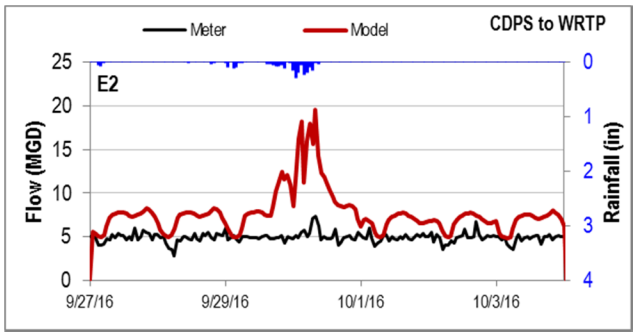


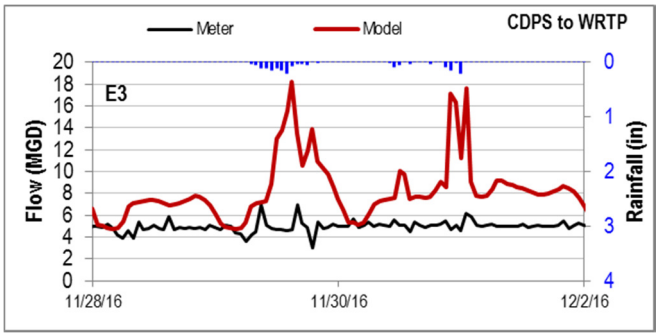


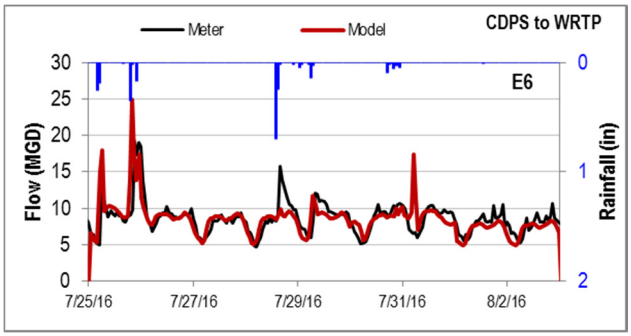
FLOW METER CDPS TO WRTP MODEL CALIBRATION AND VALIDATION RESULTS

CDPS to WRTP Model Calibration Results (Metered and Modeled Flow)

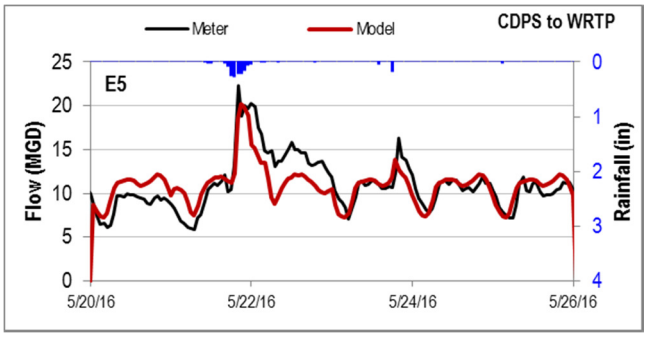




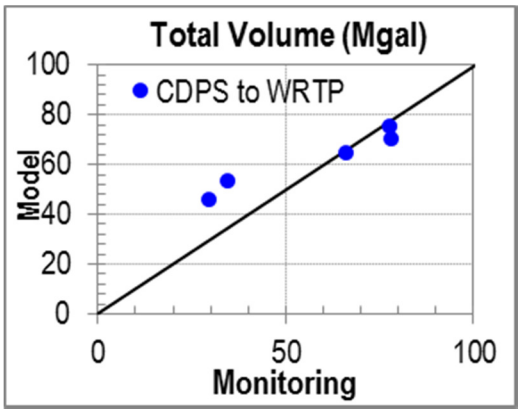


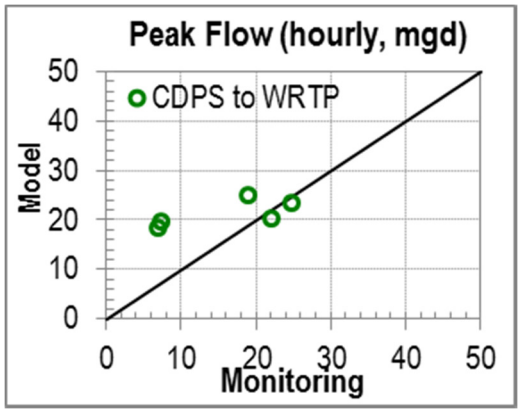


CDPS to WRTP Model Validation Results (Metered and Modeled Flow)



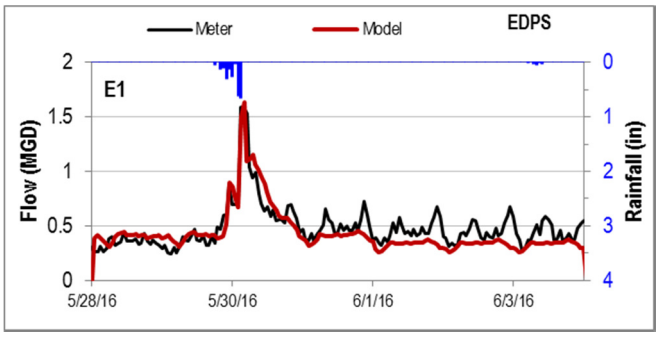
CDPS to WRTP Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

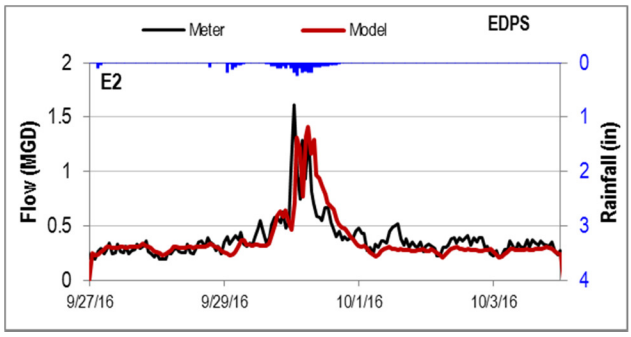


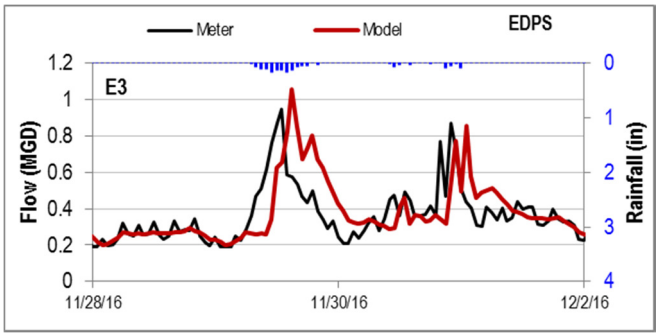


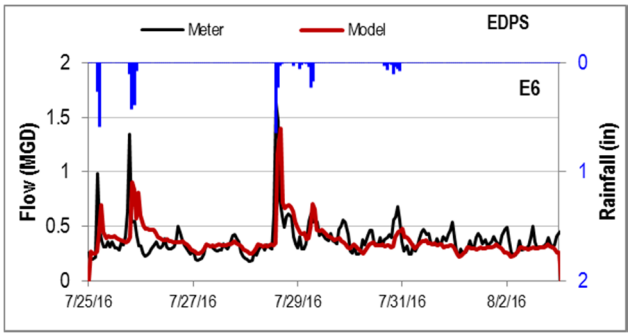
FLOW METER EDPS MODEL CALIBRATION AND VALIDATION RESULTS

EDPS Model Calibration Results (Metered and Modeled Flow)

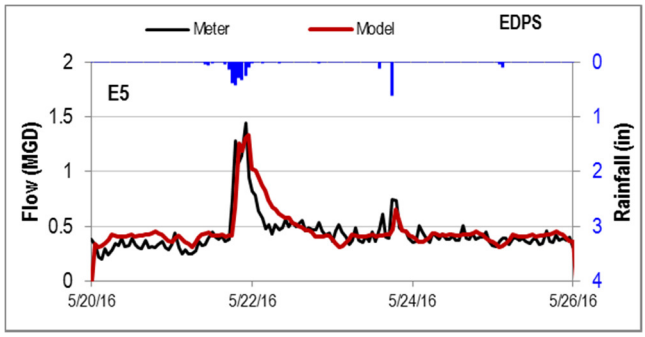




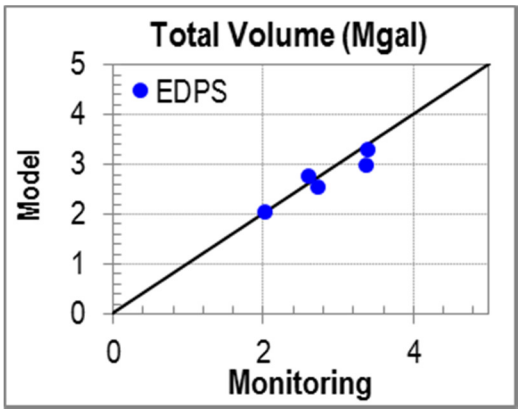


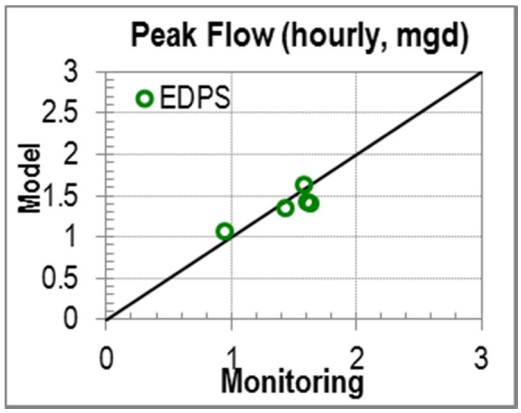


EDPS Model Validation Results (Metered and Modeled Flow)



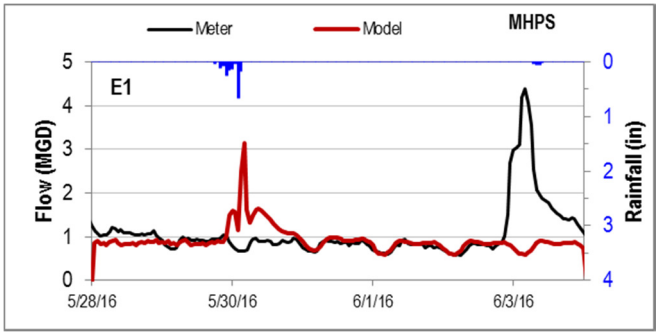
EDPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

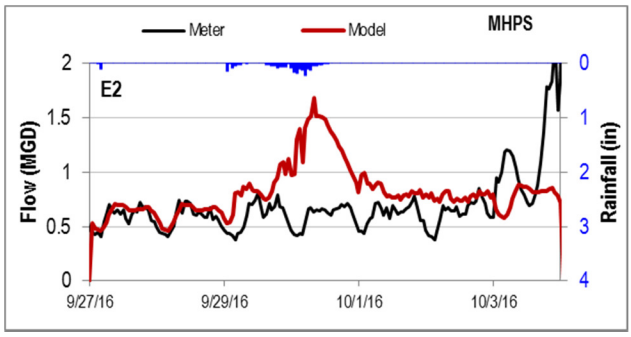


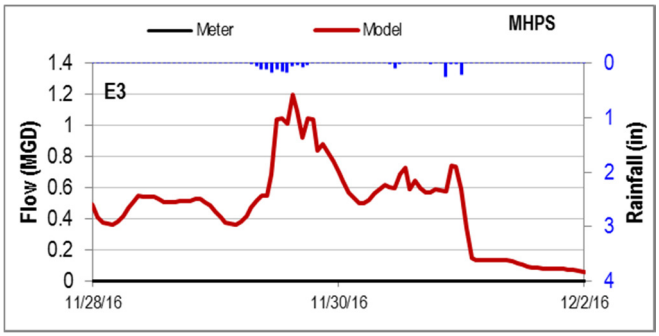


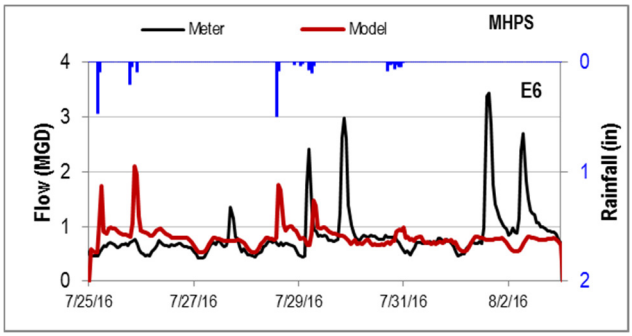
FLOW METER MHPS MODEL CALIBRATION AND VALIDATION RESULTS

MHPS Model Calibration Results (Metered and Modeled Flow)

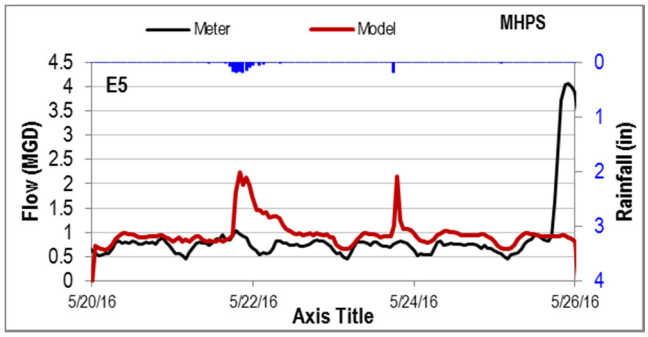




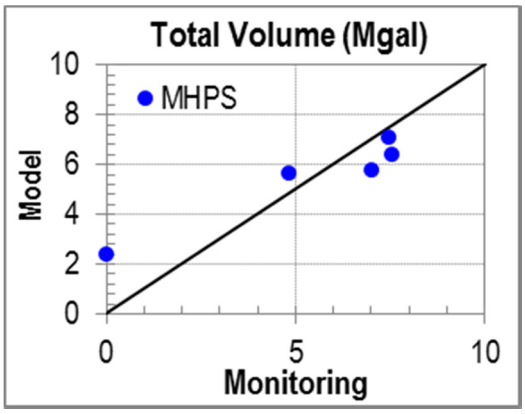


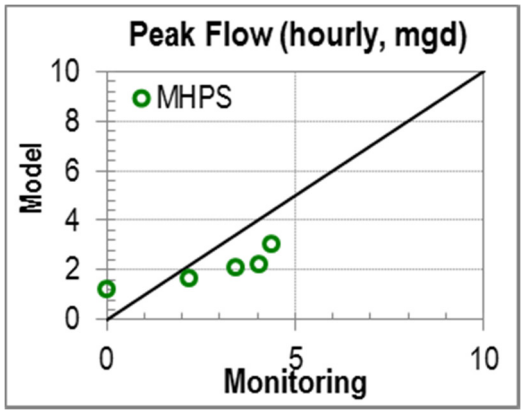


MHPS Model Validation Results (Metered and Modeled Flow)



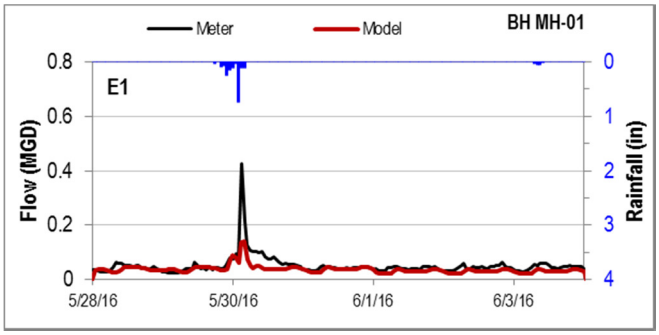
MHPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

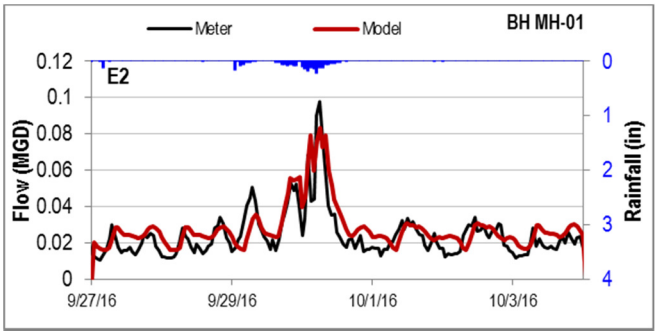


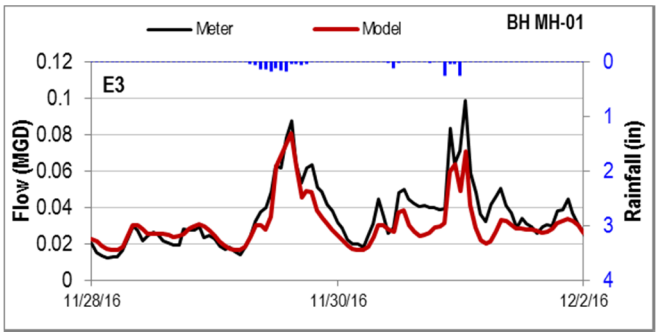


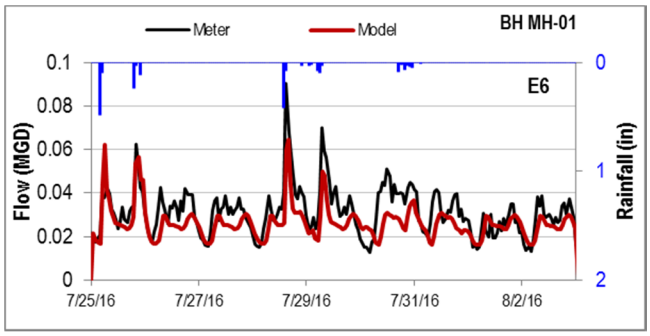
FLOW METER BH MH-01 MODEL CALIBRATION AND VALIDATION RESULTS

BH MH-01 Model Calibration Results (Metered and Modeled Flow)

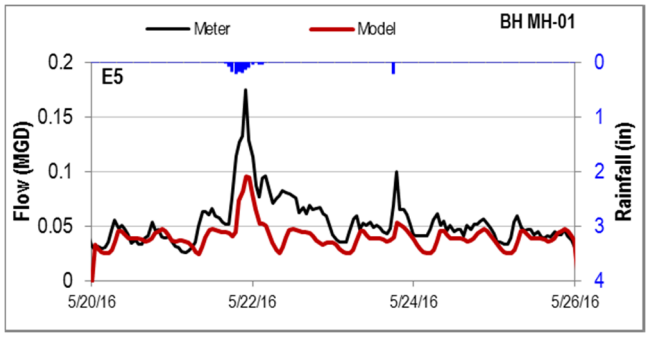




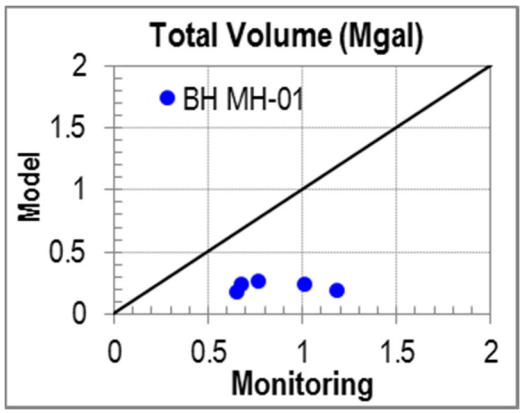


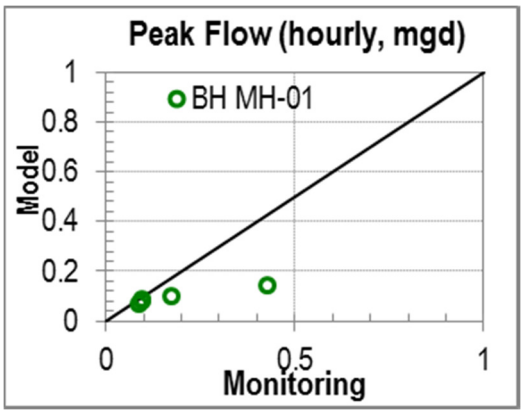


BH MH-01 Model Validation Results (Metered and Modeled Flow)



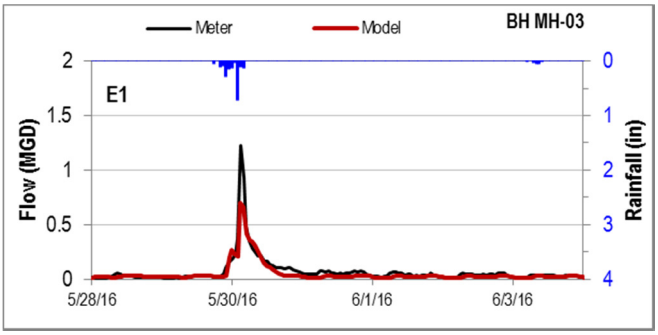
BH MH-01 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

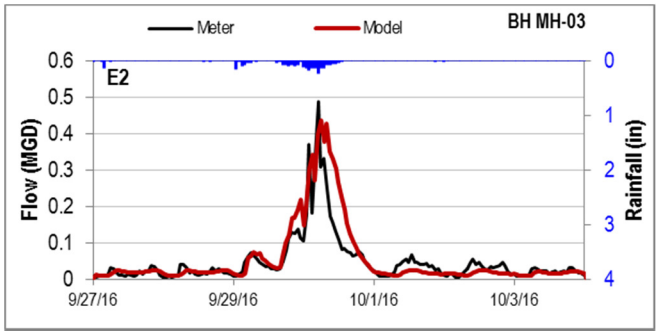


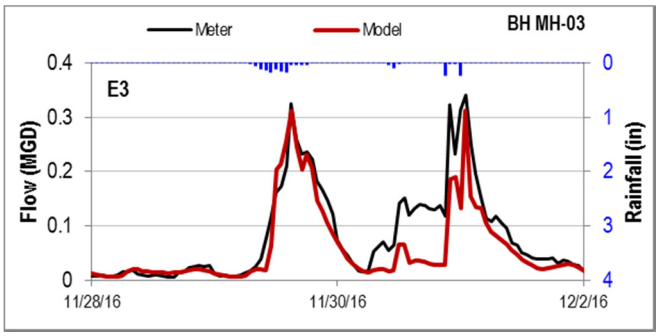


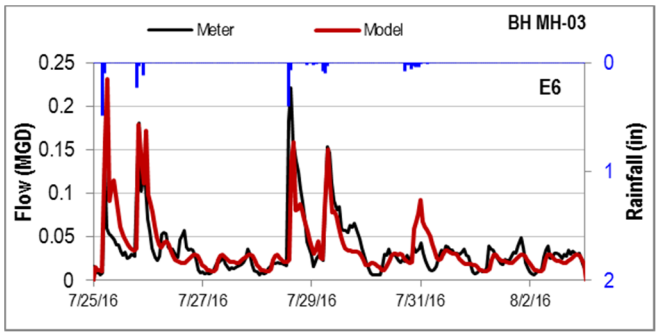
FLOW METER BH MH-03 MODEL CALIBRATION AND VALIDATION RESULTS

BH MH-03 Model Calibration Results (Metered and Modeled Flow)

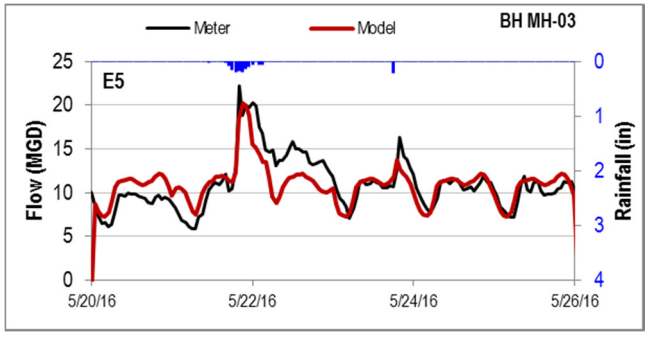




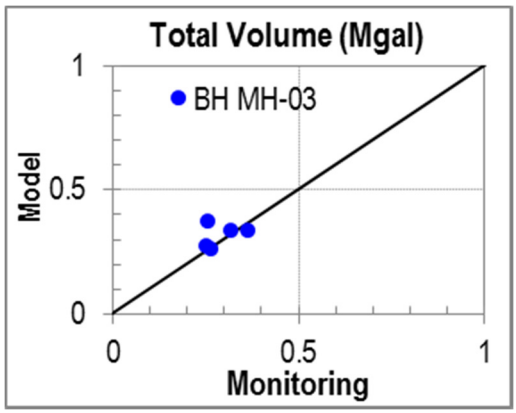


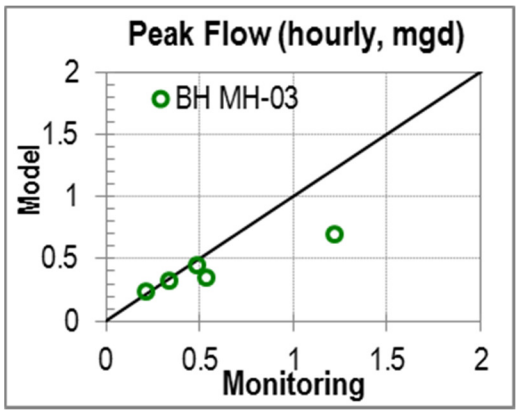


BH MH-03 Model Validation Results (Metered and Modeled Flow)



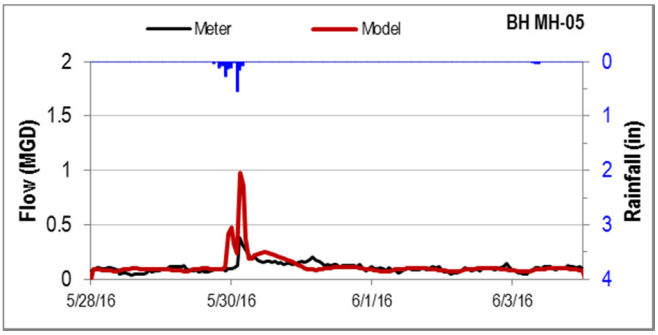
BH MH-03 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

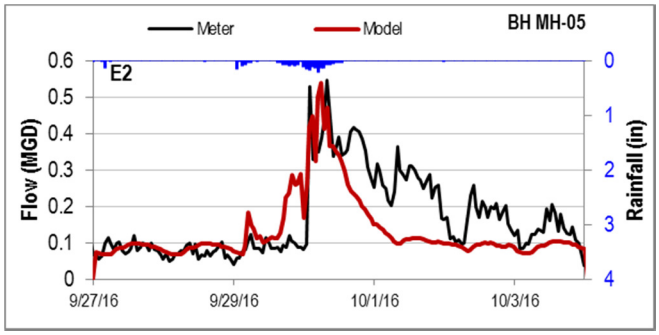


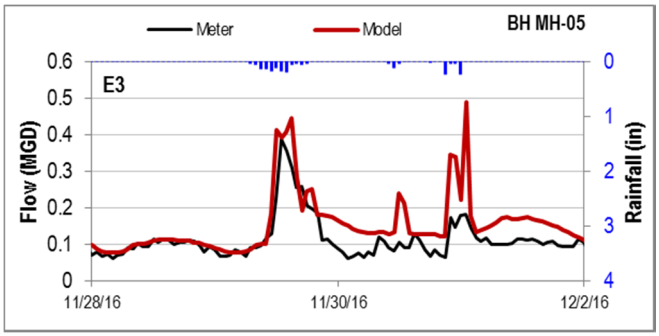


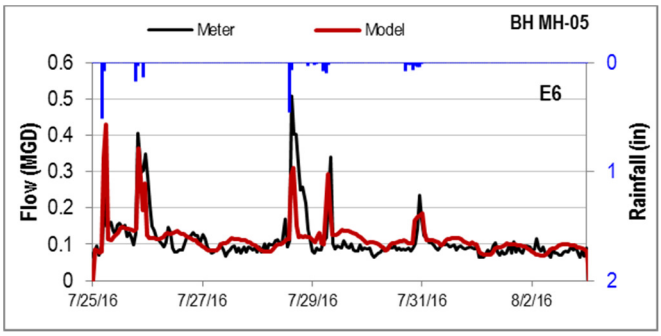
FLOW METER BH MH-05 MODEL CALIBRATION AND VALIDATION RESULTS

BH MH-05 Model Calibration Results (Metered and Modeled Flow)

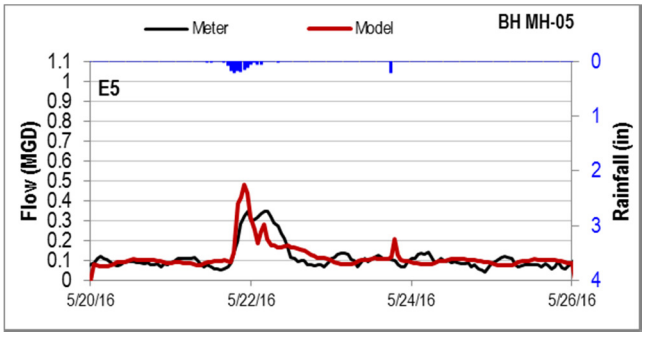




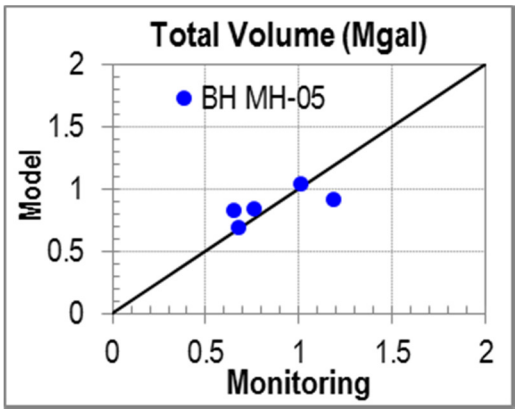


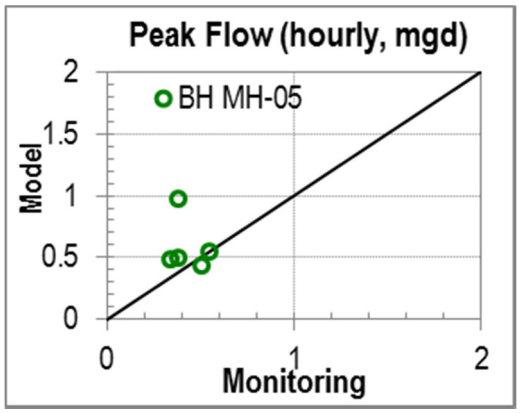


BH MH-05 Model Validation Results (Metered and Modeled Flow)



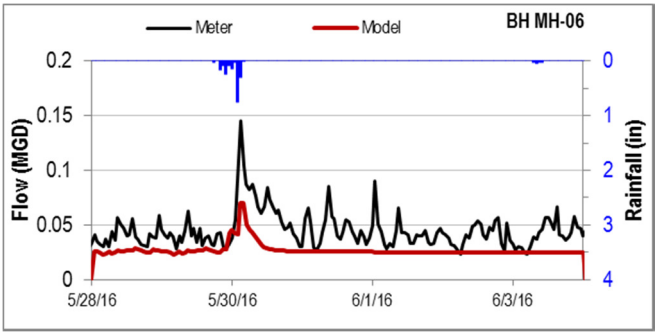
BH MH-05 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

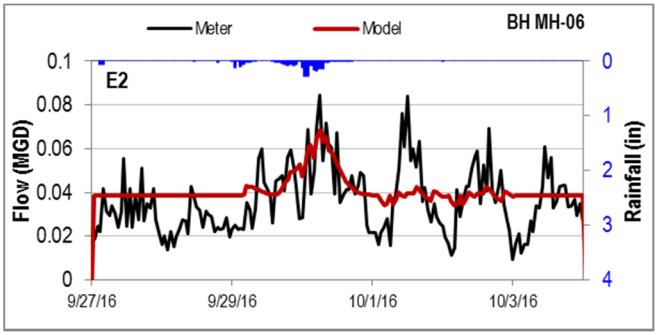


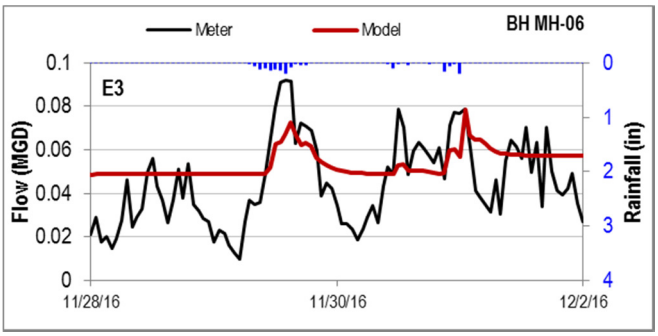


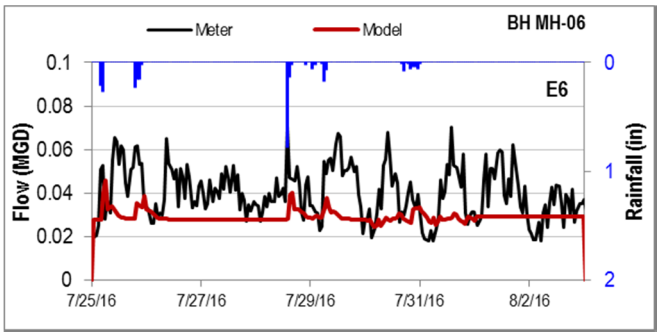
FLOW METER BH MH-06 MODEL CALIBRATION AND VALIDATION RESULTS

BH MH-06 Model Calibration Results (Metered and Modeled Flow)

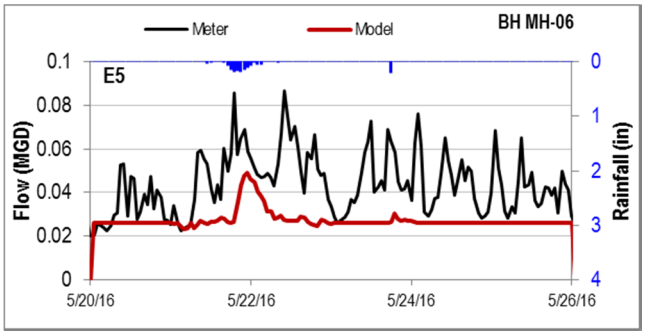




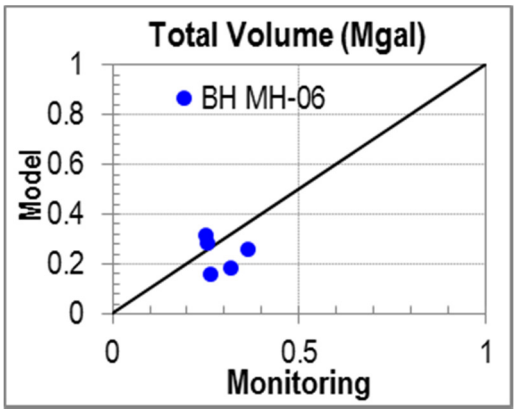


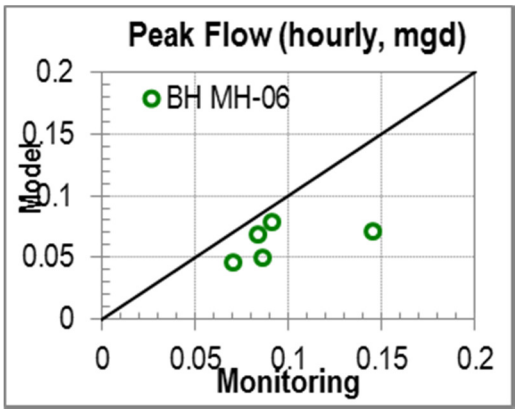


BH MH-06 Model Validation Results (Metered and Modeled Flow)



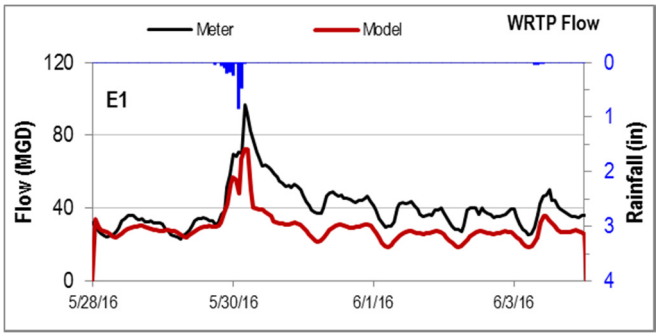
BH MH-06 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

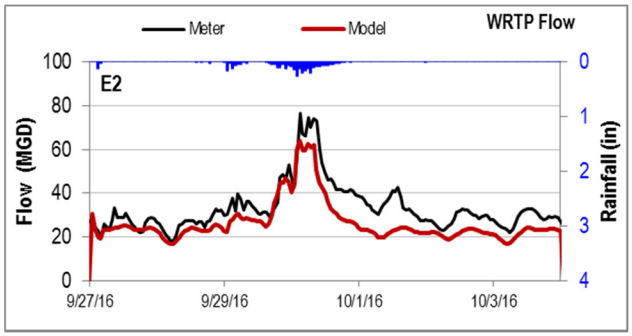


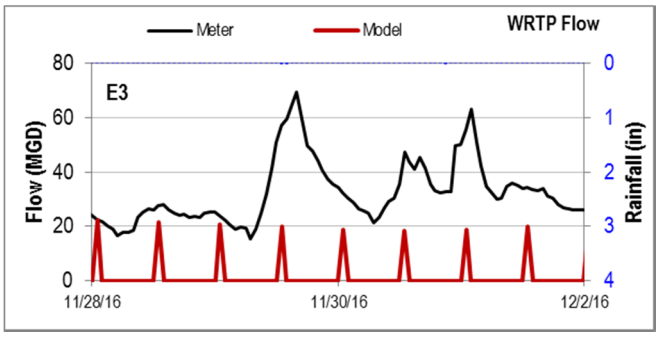


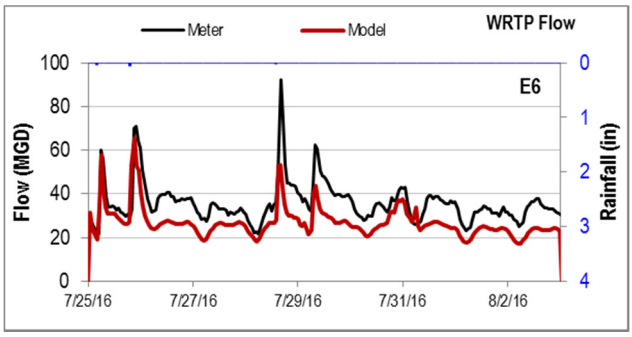
FLOW METER WRTP Flow MODEL CALIBRATION AND VALIDATION RESULTS

WRTP Flow Model Calibration Results (Metered and Modeled Flow)

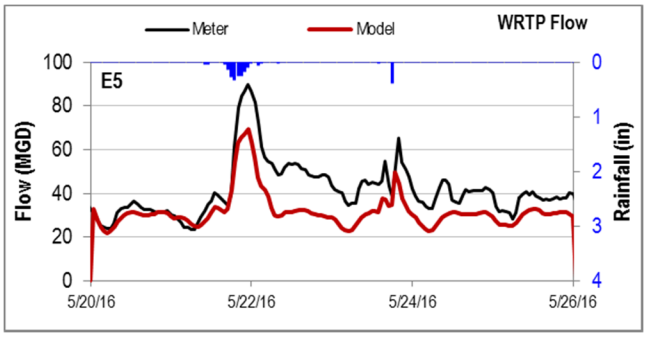




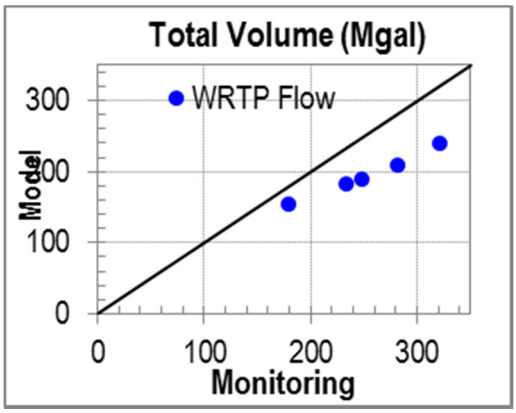


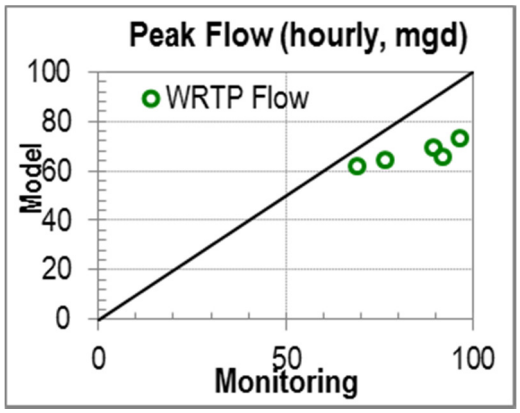


WRTP Flow Model Validation Results (Metered and Modeled Flow)



WRTP Flow Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)





Greeley and Hansen LLC
1700 Market Street, Suite 2130
Philadelphia, PA 19103
(215) 563-3460
www.greeley-hansen.com

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REVISION CONTROL

REV. NO.	DATE ISSUED	PREPARED BY	DESCRIPTION OF CHANGES
1.	3/01/18	Greeley and Hansen / DELCORA	Appendix C – Revised and updated to address USEPA and PADEP comments

Appendix C Model Calibration and Validation Results (Revised and Updated March 1, 2018 to address USEPA and PADEP Comments received January 2, 2018)

H&H MODEL CALIBRATION AND VALIDATION RESULTS
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Statistical Evaluation: Nash-Sutcliffe Efficiencies

The Nash-Sutcliffe efficiency (NSE) was selected as an appropriate statistical measure of the goodness-of-fit for model calibration. It has been widely applied in hydrologic models (Moriasi et al., 2007) and thus can be used to assess the event volume predictions of the hydrologic component of the model. Although interpretation of NSE values may be subjective, model calibration is generally considered satisfactory for values greater than 0.5, with values greater than 0.75 being considered very good (Moriasi et al., 2007).

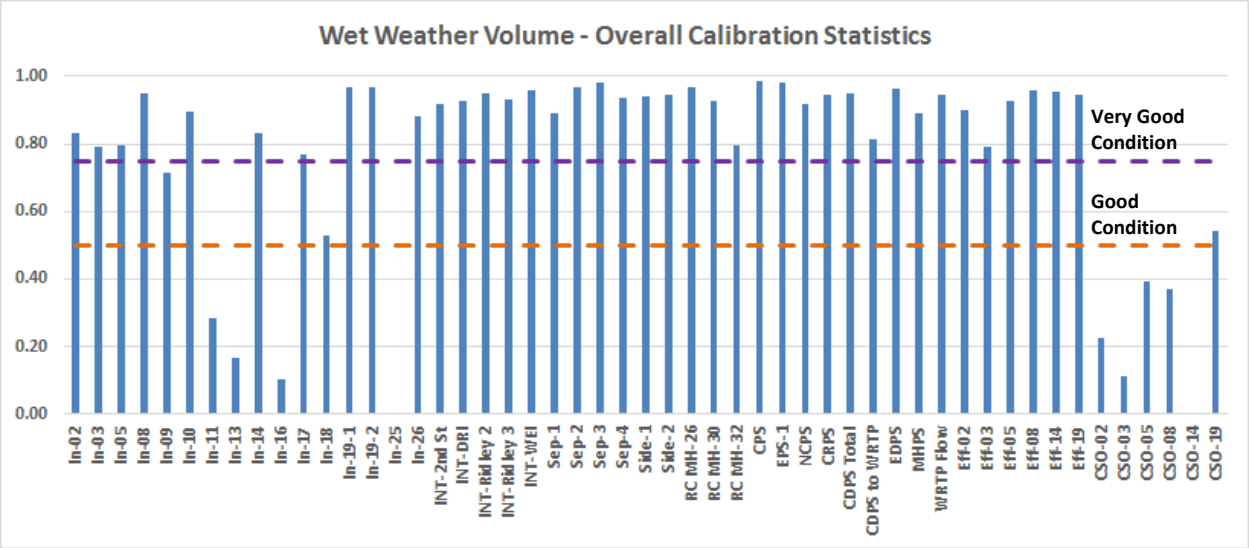
For this application the values were calculated as shown in following equation:

$$NSE = 1 - \left[\frac{\sum_{i=1}^{n}\left(Y_i^{obs} - Y_i^{sim}\right)^2}{\sum_{i=1}^{n}\left(Y_i^{obs} - Y^{mean}\right)^2}\right]$$

where,
Y_i^{obs}: the ith metered event volume
Y_i^{sim}: the ith modeled event volume
Y^{mean}: the mean metered volume
n: the total number of events

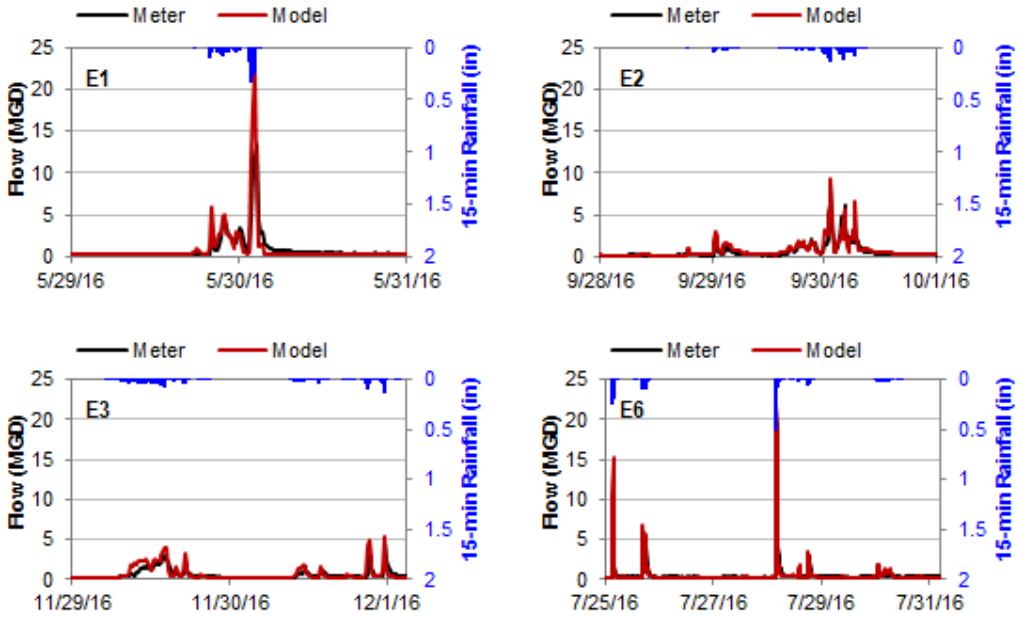
NSE values were calculated for all flow meter calibration and the results are shown in **Figure C-1** for the wet weather events**.** According to the above mentioned criteria wet weather calibration of over 82% of meters are above good condition and over 76% of the meters are above very good condition.

Figure C-1: Wet Weather Volume – Overall Calibration Statistics

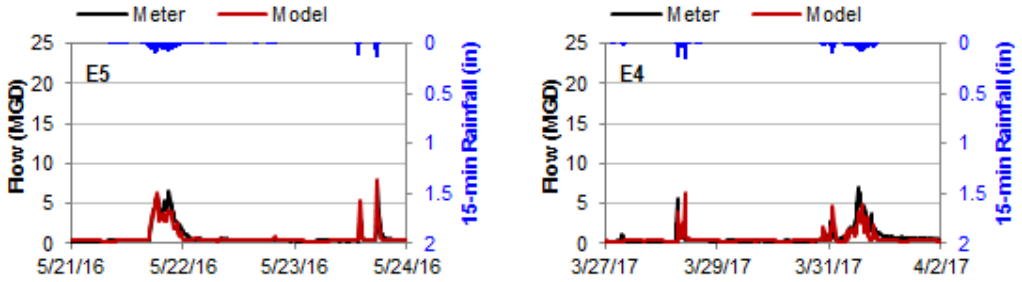


FLOW METER IN-02 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

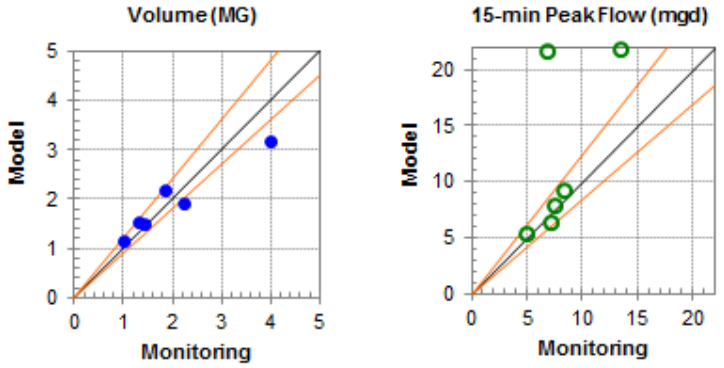
IN-02 Model Calibration Results (Metered and Modeled Flow)



IN-02 Model Validation Results (Metered and Modeled Flow)

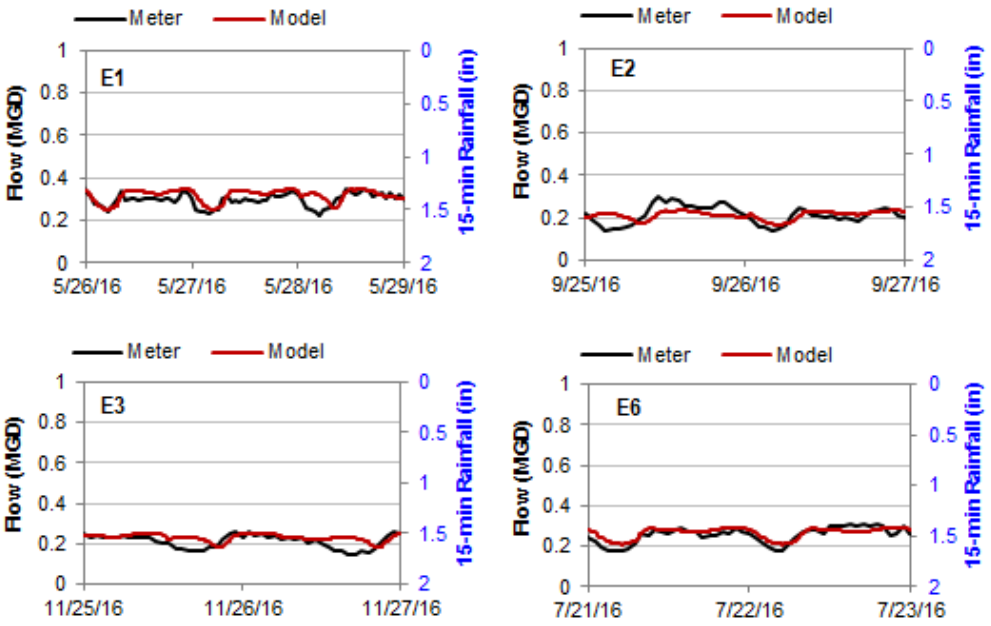


IN-02 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

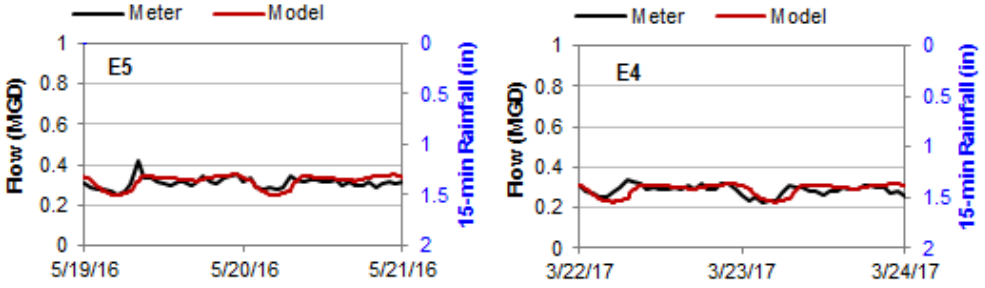


FLOW METER IN-02 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

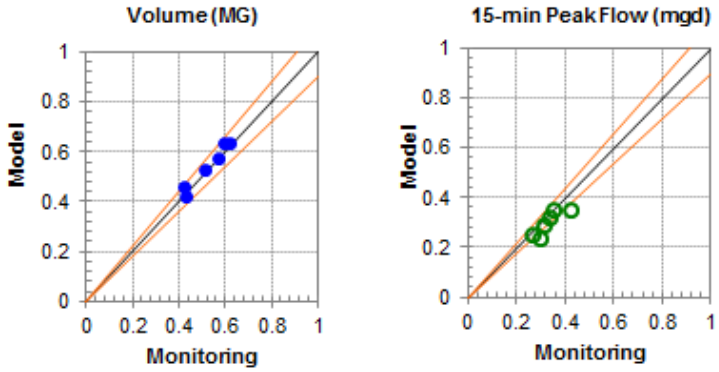
IN-02 Model Calibration Results (Metered and Modeled Flow)



IN-02 Model Validation Results (Metered and Modeled Flow)



IN-02 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



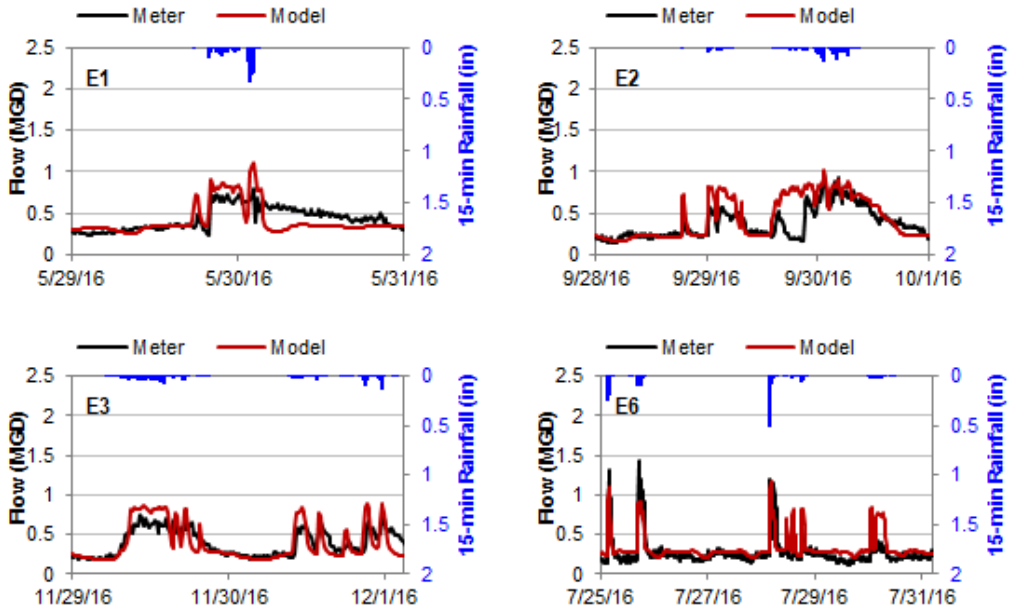
IN-02 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.35	0.35	-10% to +10%	1%	0.59	0.64	-10% to +10%	7%
E2	0.30	0.24	-10% to +10%	-20%	0.43	0.43	-10% to +10%	0%
E3	0.26	0.25	-10% to +10%	-4%	0.42	0.46	-10% to +10%	9%
E4	0.34	0.32	-10% to +10%	-5%	0.57	0.58	-10% to +10%	1%
E5	0.42	0.35	-10% to +10%	-17%	0.62	0.63	-10% to +10%	2%
E6	0.31	0.29	-10% to +10%	-5%	0.51	0.53	-10% to +10%	4%

IN-02 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	13.38	21.82	-15% to +25%	63%	1.43	1.50	-10% to +20%	5%
E2	8.31	9.29	-15% to +25%	12%	1.86	2.19	-10% to +20%	18%
E3	5.00	5.46	-15% to +25%	9%	1.32	1.53	-10% to +20%	15%
E4	7.05	6.37	-15% to +25%	-10%	4.00	3.17	-10% to +20%	-21%
E5	7.54	7.97	-15% to +25%	6%	2.25	1.91	-10% to +20%	-15%
E6	6.81	21.65	-15% to +25%	218%	1.01	1.18	-10% to +20%	17%

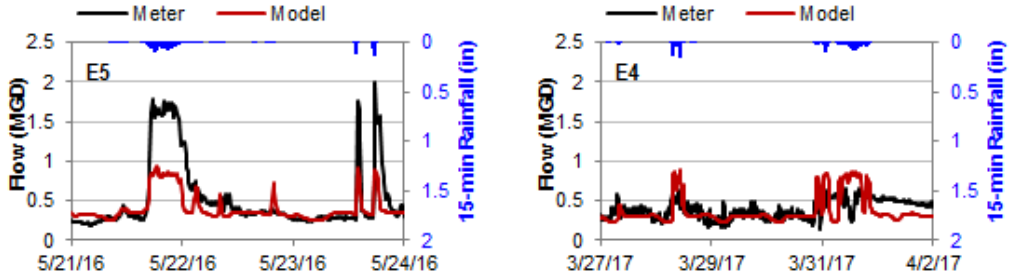
Note: Four of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for Events E1 and E6 is not consistent with the recorded rainfall intensity. These events are expected to have the highest peak flow. This is most likely a result of a malfunctioning flow meter. However, based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER EFF-02 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

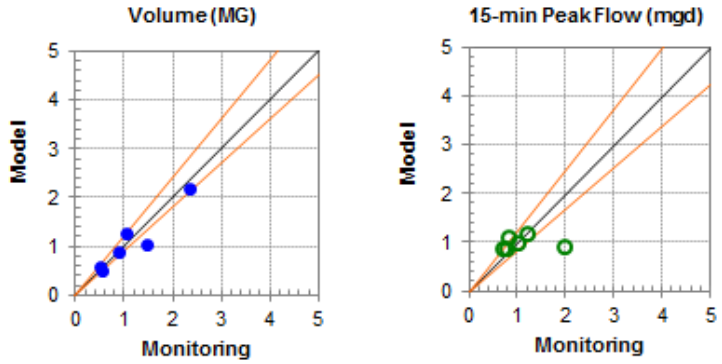
EFF-02 Model Calibration Results (Metered and Modeled Flow)



EFF-02 Model Validation Results (Metered and Modeled Flow)

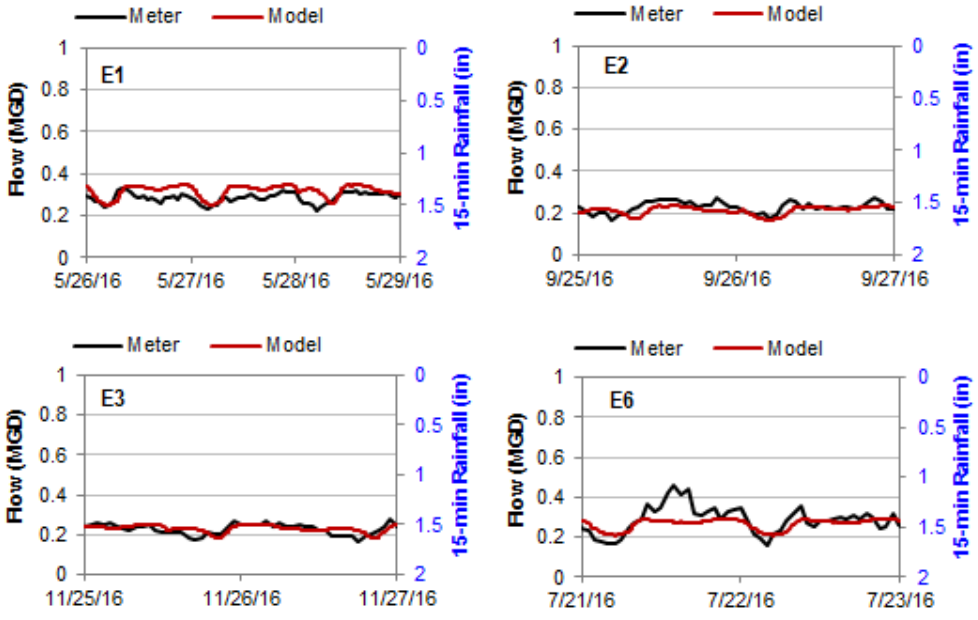


EFF-02 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

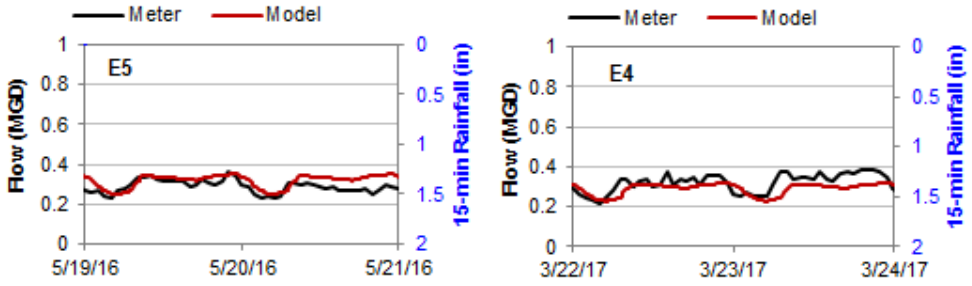


FLOW METER EFF-02 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

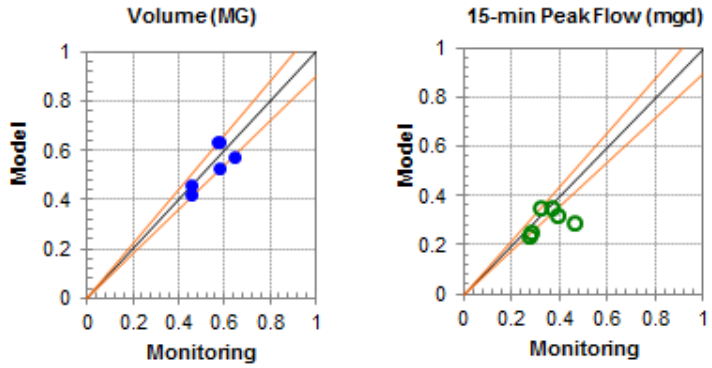
EFF-02 Model Calibration Results (Metered and Modeled Flow)



EFF-02 Model Validation Results (Metered and Modeled Flow)



EFF-02 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



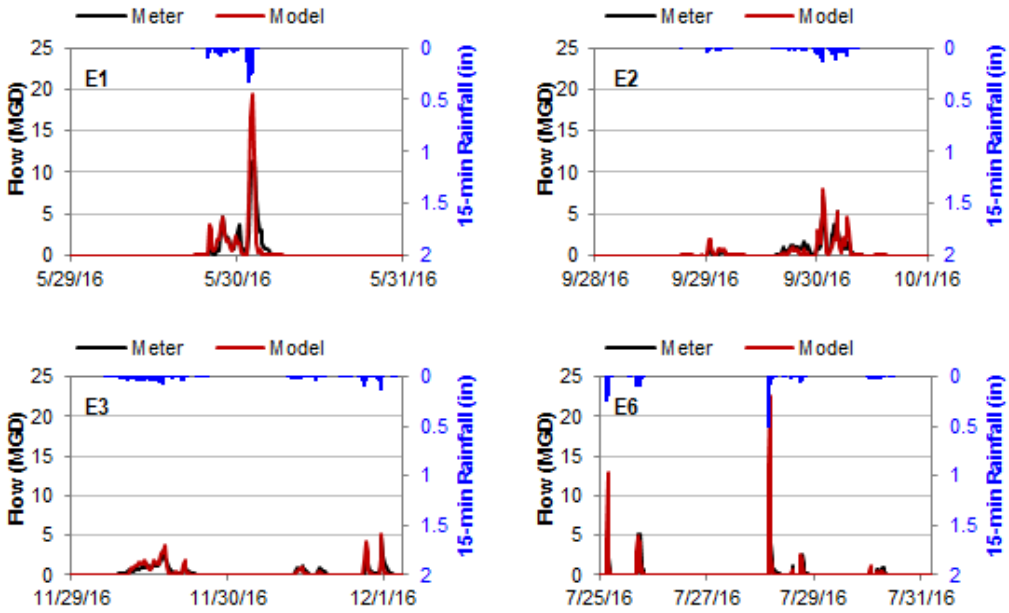
EFF-02 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.32	0.35	-10% to +10%	10%	0.57	0.64	-10% to +10%	12%
E2	0.27	0.24	-10% to +10%	-14%	0.46	0.43	-10% to +10%	-7%
E3	0.28	0.25	-10% to +10%	-10%	0.45	0.46	-10% to +10%	2%
E4	0.39	0.32	-10% to +10%	-18%	0.64	0.58	-10% to +10%	-10%
E5	0.37	0.35	-10% to +10%	-4%	0.58	0.63	-10% to +10%	10%
E6	0.46	0.29	-10% to +10%	-36%	0.58	0.53	-10% to +10%	-8%

EFF-02 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.80	1.12	-15% to +25%	39%	0.53	0.51	-10% to +20%	-3%
E2	1.01	1.01	-15% to +25%	1%	1.03	1.27	-10% to +20%	23%
E3	0.75	0.90	-15% to +25%	20%	0.90	0.88	-10% to +20%	-2%
E4	0.71	0.88	-15% to +25%	24%	2.36	2.20	-10% to +20%	-6%
E5	1.99	0.93	-15% to +25%	-53%	1.45	1.05	-10% to +20%	-27%
E6	1.20	1.17	-15% to +25%	-2%	0.49	0.57	-10% to +20%	17%

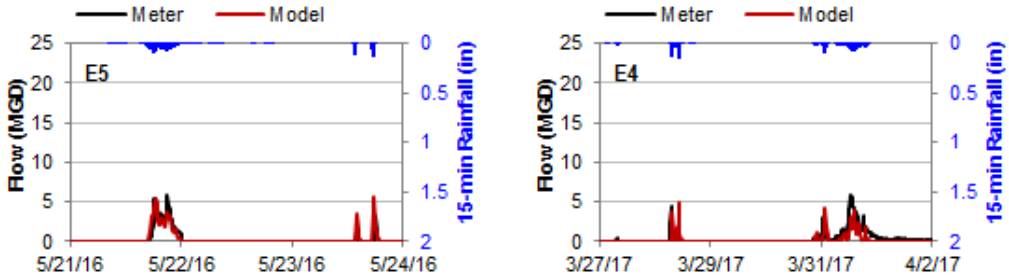
Note: Four of the six wet weather events are calibrated well within the industry criteria. The EFF-02 meter is the effluent meter from Regulator 02. The calibration of Regulator 02 meters (which include the IN-02, EFF-02 and CSO-02 meters) are more focused on the influent IN-02 meter and the overflow CSO-02 meter when the total metered influent flow (IN-02) is not balanced with the total metered effluent flow (EFF-02 plus CSO-02). Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER CSO-02 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

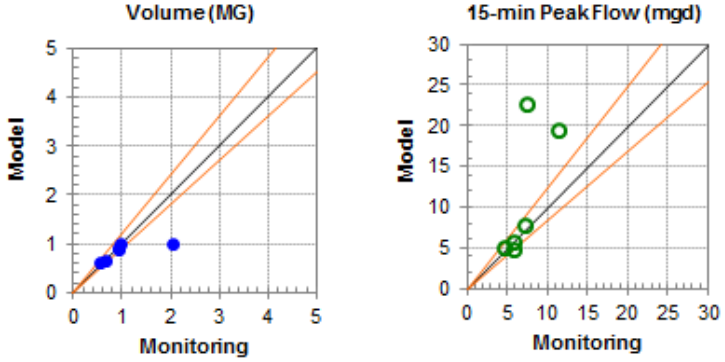
CSO-02 Model Calibration Results (Metered and Modeled Flow)



CSO-02 Model Validation Results (Metered and Modeled Flow)



CSO-02 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

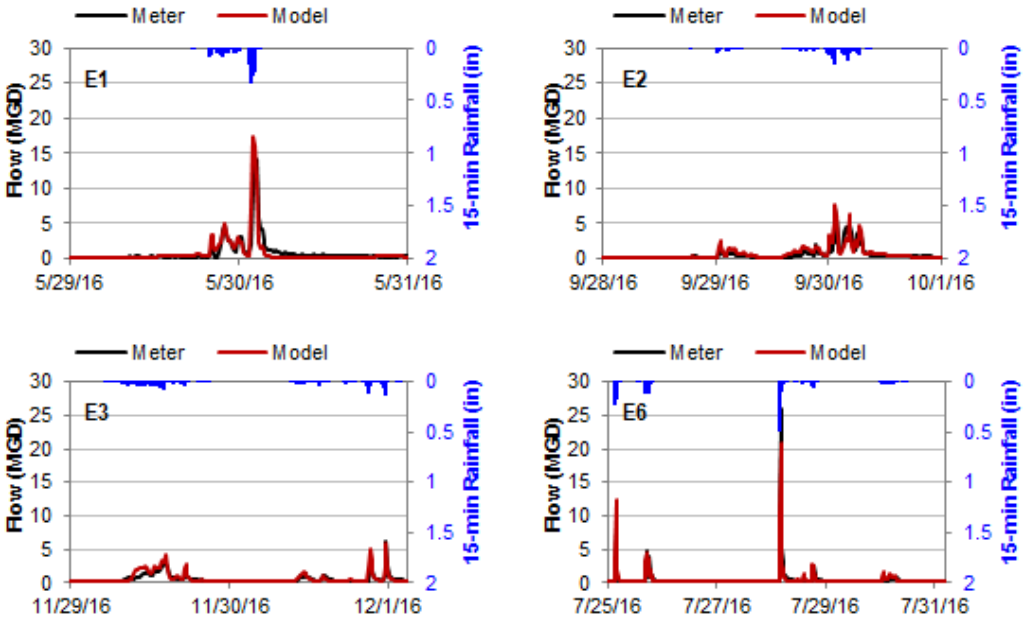


CSO-02 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	11.40	19.39	-15% to +25%	70%	0.95	0.99	-10% to +20%	4%
E2	7.16	7.90	-15% to +25%	10%	0.94	0.94	-10% to +20%	0%
E3	4.69	5.11	-15% to +25%	9%	0.64	0.66	-10% to +20%	3%
E4	5.79	4.82	-15% to +25%	-17%	2.02	0.99	-10% to +20%	-51%
E5	5.82	5.67	-15% to +25%	-3%	0.91	0.88	-10% to +20%	-3%
E6	7.49	22.64	-15% to +25%	202%	0.55	0.63	-10% to +20%	14%

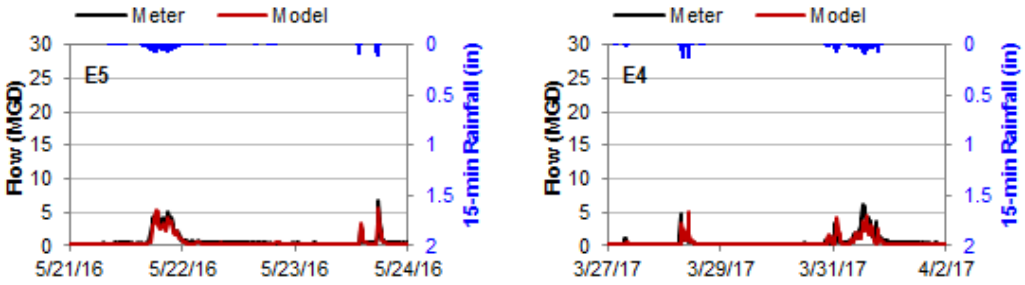
Note: Four of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for some of the Events is not consistent with the recorded rainfall intensity. For instance, it is expected that Event E6 would have a high peak flow due to high rainfall intensity. This is most likely a result of a malfunctioning flow meter. However, based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-03 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

IN-03 Model Calibration Results (Metered and Modeled Flow)

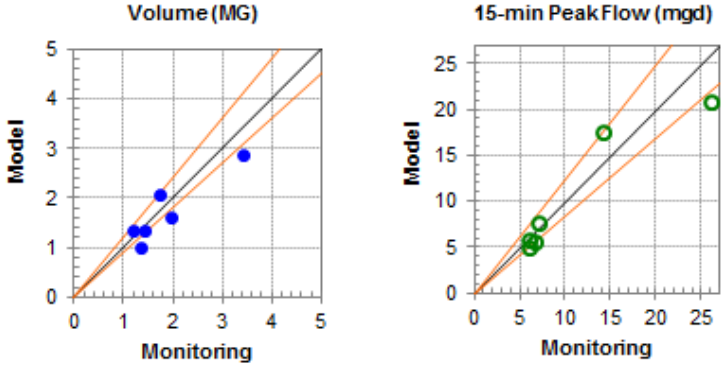


IN-03 Model Validation Results (Metered and Modeled Flow)



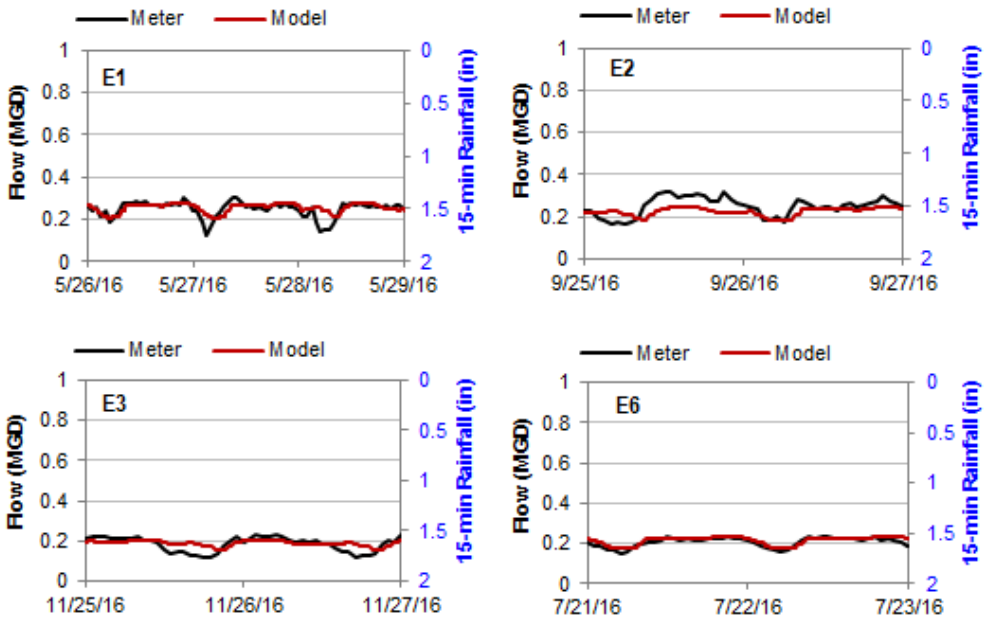
I

IN-03 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

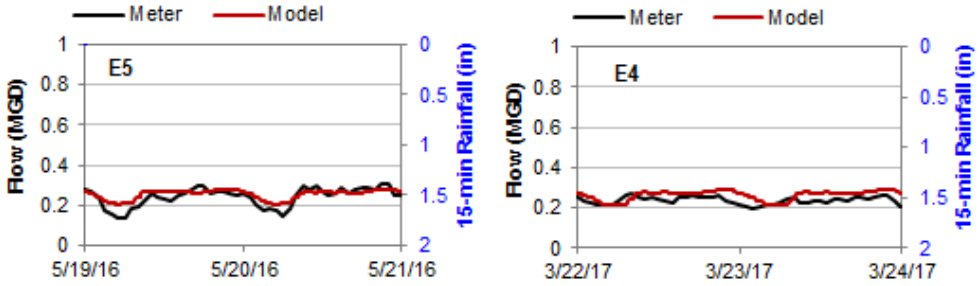


FLOW METER IN-03 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

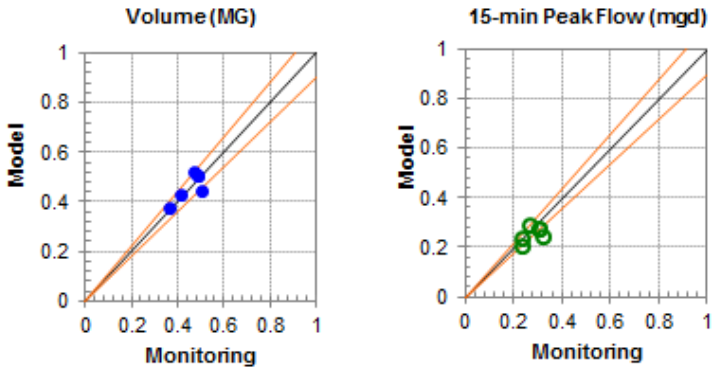
IN-03 Model Calibration Results (Metered and Modeled Flow)



IN-03 Model Validation Results (Metered and Modeled Flow)



IN-03 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



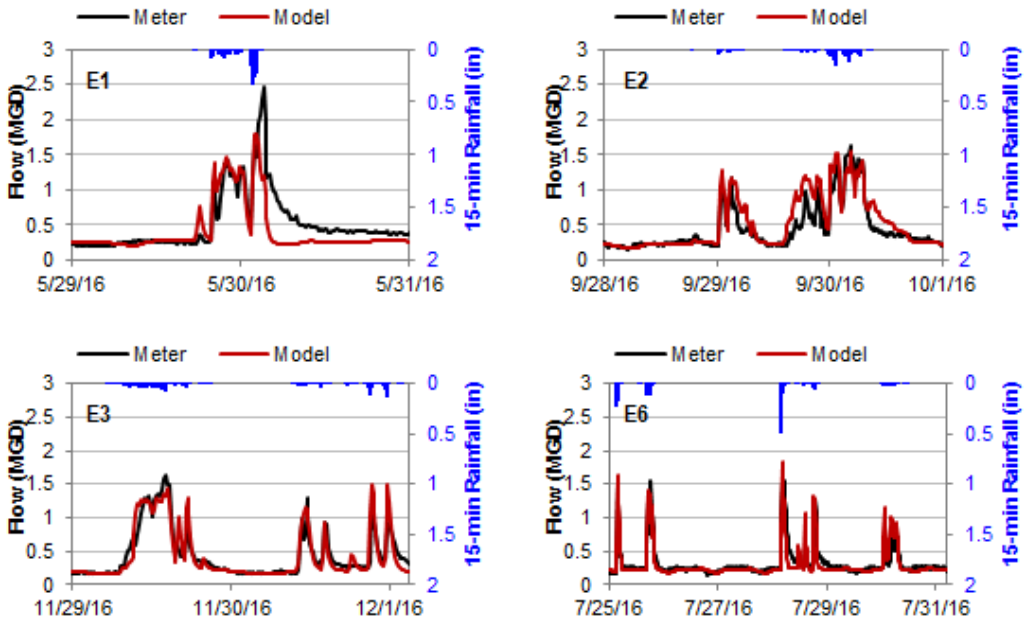
IN-03 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.31	0.28	-10% to +10%	-9%	0.48	0.51	-10% to +10%	5%
E2	0.32	0.25	-10% to +10%	-23%	0.50	0.45	-10% to +10%	-10%
E3	0.23	0.21	-10% to +10%	-12%	0.37	0.38	-10% to +10%	3%
E4	0.27	0.29	-10% to +10%	8%	0.47	0.52	-10% to +10%	11%
E5	0.31	0.28	-10% to +10%	-9%	0.48	0.51	-10% to +10%	5%
E6	0.24	0.24	-10% to +10%	-1%	0.41	0.43	-10% to +10%	4%

IN-03 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	14.09	17.46	-15% to +25%	24%	1.41	1.34	-10% to +20%	-6%
E2	7.06	7.69	-15% to +25%	9%	1.73	2.07	-10% to +20%	20%
E3	6.06	5.79	-15% to +25%	-4%	1.20	1.36	-10% to +20%	13%
E4	6.01	5.07	-15% to +25%	-16%	3.43	2.87	-10% to +20%	-16%
E5	6.71	5.50	-15% to +25%	-18%	1.96	1.60	-10% to +20%	-18%
E6	26.00	20.94	-15% to +25%	-19%	1.36	1.02	-10% to +20%	-25%

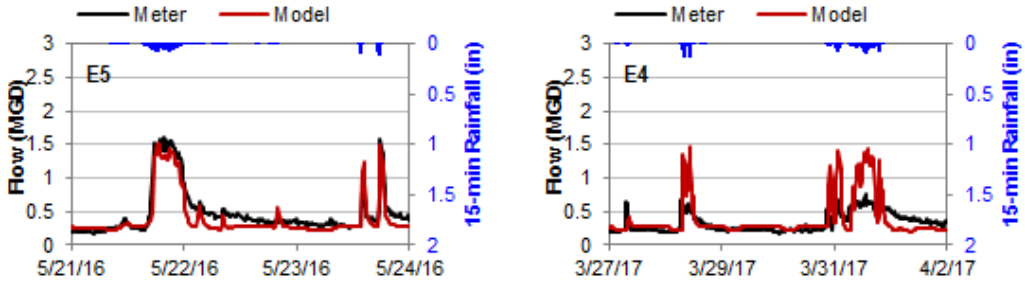
Note: All the six wet weather events are calibrated well within or close to the industry criteria.

FLOW METER EFF-03 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

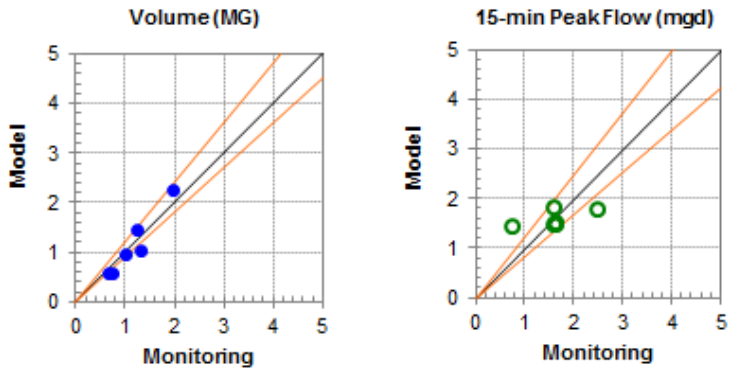
EFF-03 Model Calibration Results (Metered and Modeled Flow)



EFF-03 Model Validation Results (Metered and Modeled Flow)

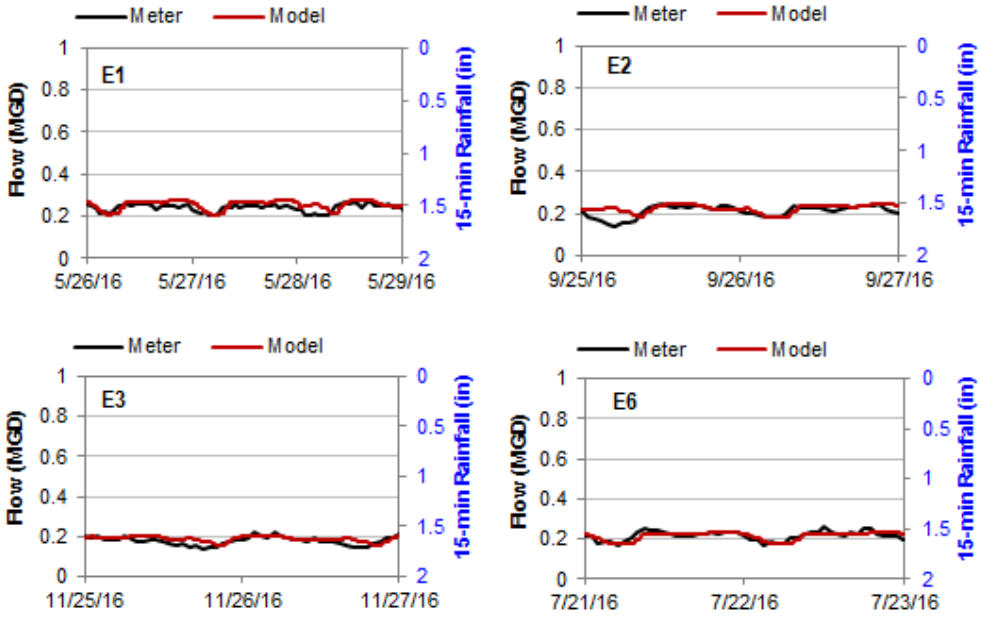


EFF-03 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

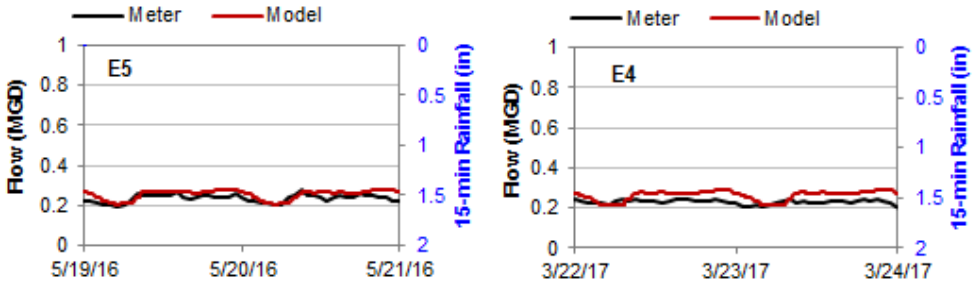


FLOW METER EFF-03 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

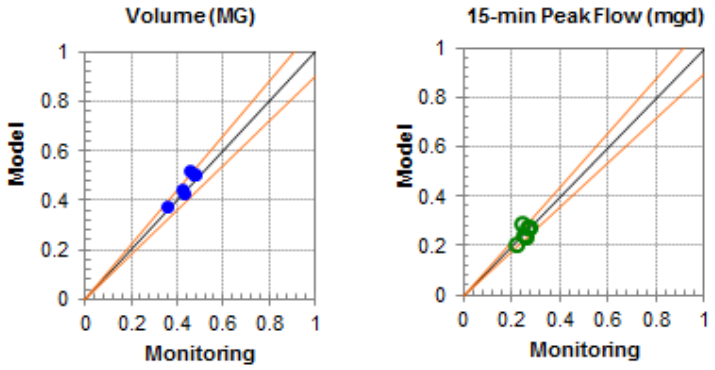
EFF-03 Model Calibration Results (Metered and Modeled Flow)



EFF-03 Model Validation Results (Metered and Modeled Flow)



EFF-03 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



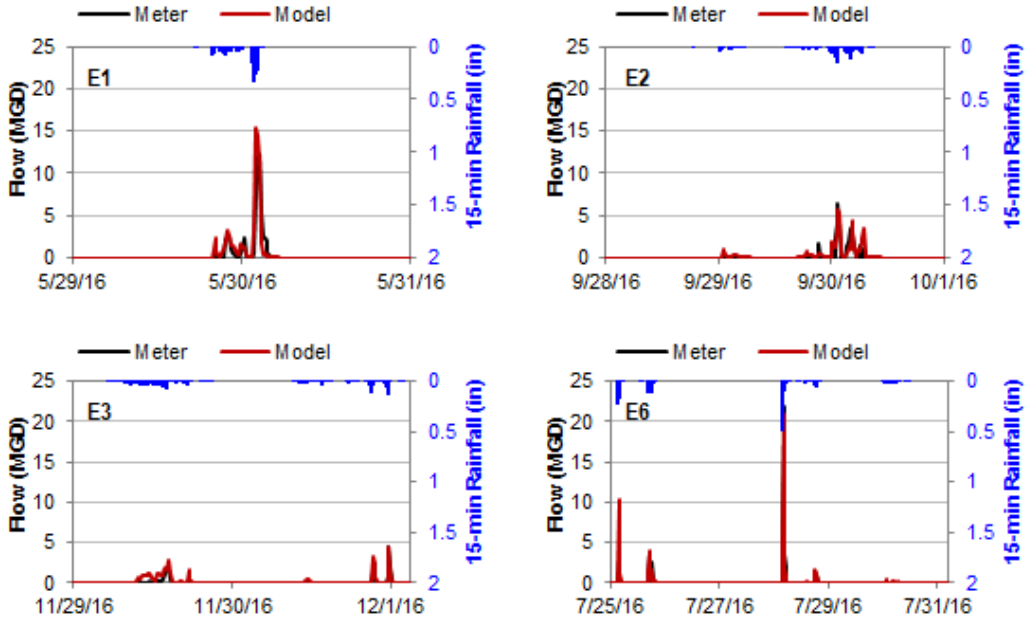
EFF-03 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.27	0.28	-10% to +10%	5%	0.48	0.51	-10% to +10%	6%
E2	0.25	0.25	-10% to +10%	-1%	0.42	0.45	-10% to +10%	6%
E3	0.22	0.21	-10% to +10%	-7%	0.36	0.38	-10% to +10%	6%
E4	0.24	0.29	-10% to +10%	18%	0.46	0.52	-10% to +10%	15%
E5	0.28	0.28	-10% to +10%	1%	0.47	0.51	-10% to +10%	8%
E6	0.26	0.24	-10% to +10%	-9%	0.43	0.43	-10% to +10%	-1%

EFF-03 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	2.47	1.80	-15% to +25%	-27%	0.73	0.59	-10% to +20%	-19%
E2	1.63	1.54	-15% to +25%	-6%	1.24	1.47	-10% to +20%	19%
E3	1.63	1.49	-15% to +25%	-9%	0.99	0.96	-10% to +20%	-3%
E4	0.75	1.47	-15% to +25%	96%	1.98	2.28	-10% to +20%	15%
E5	1.60	1.51	-15% to +25%	-6%	1.31	1.06	-10% to +20%	-19%
E6	1.57	1.84	-15% to +25%	17%	0.67	0.57	-10% to +20%	-15%

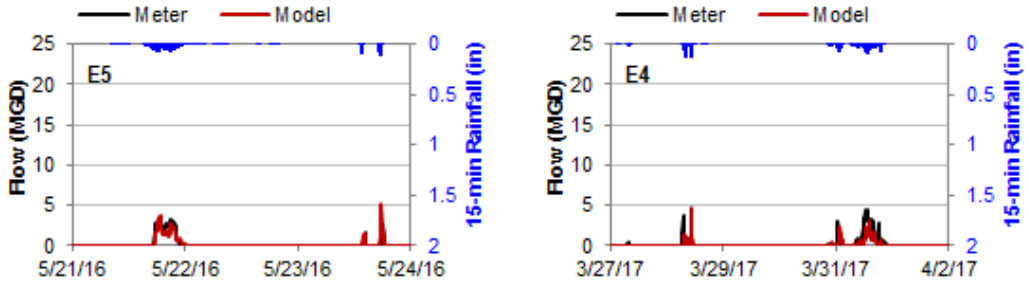
Note: Four of the six wet weather events are calibrated well within the industry criteria. The EFF-03 meter is the effluent meter from Regulator 03. The calibration of Regulator 03 meters (which include the IN-03, EFF-03 and CSO-03 meters) are more focused on the influent IN-03 meter and the overflow CSO-03 meter when the total metered influent flow (IN-03) is not balanced with the total metered effluent flow (EFF-03 plus CSO-03). Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER CSO-03 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

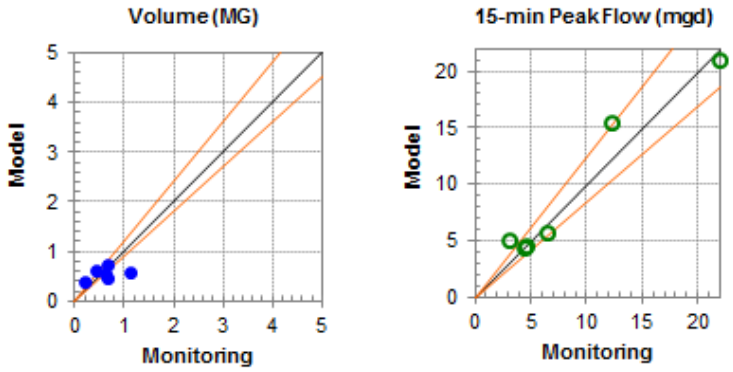
CSO-03 Model Calibration Results (Metered and Modeled Flow)



CSO-03 Model Validation Results (Metered and Modeled Flow)



CSO-03 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

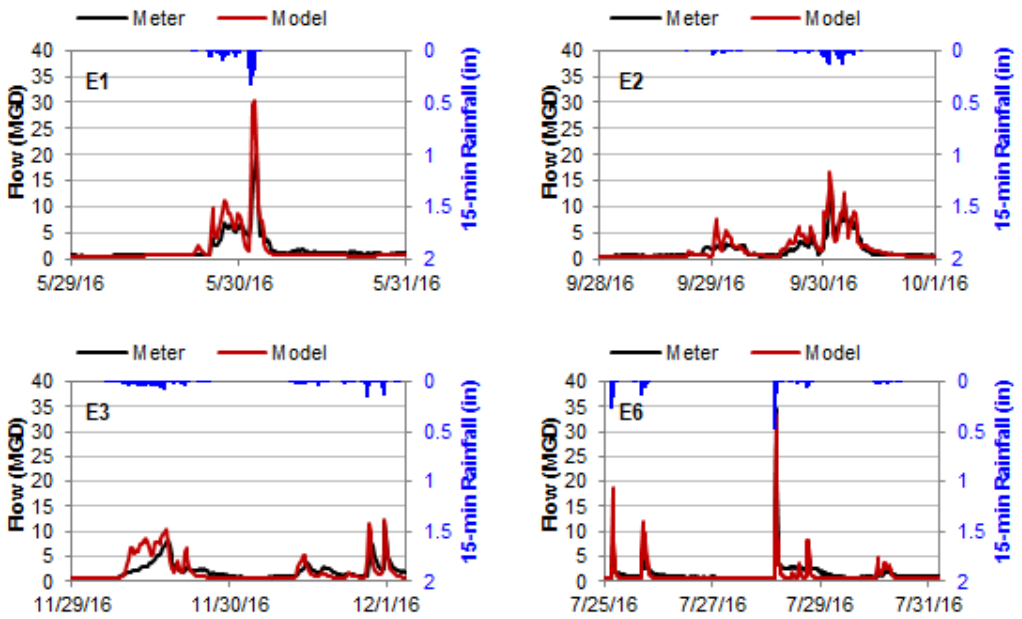


CSO-03 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	12.30	15.47	-15% to +25%	26%	0.64	0.75	-10% to +20%	17%
E2	6.41	5.80	-15% to +25%	-9%	0.42	0.61	-10% to +20%	44%
E3	4.48	4.39	-15% to +25%	-2%	0.19	0.39	-10% to +20%	112%
E4	4.52	4.56	-15% to +25%	1%	1.13	0.58	-10% to +20%	-48%
E5	3.13	5.03	-15% to +25%	61%	0.61	0.54	-10% to +20%	-11%
E6	21.93	21.00	-15% to +25%	-4%	0.66	0.45	-10% to +20%	-31%

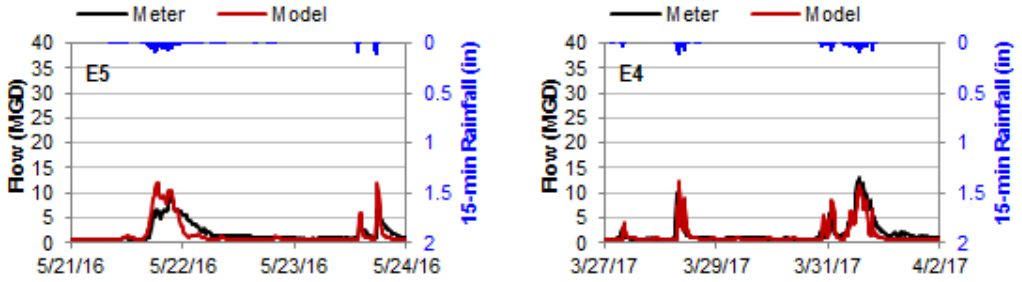
Note: Four of the six wet weather event peak flows are calibrated well within the industry criteria. The overflow volume is more challenging to match, especially for the small overflow event like E3. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-05 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

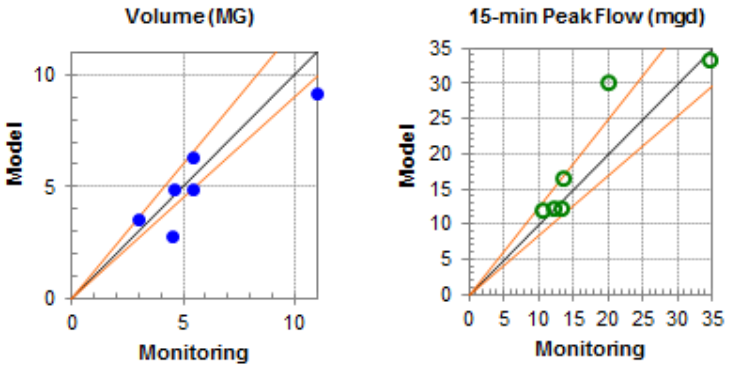
IN-05 Model Calibration Results (Metered and Modeled Flow)



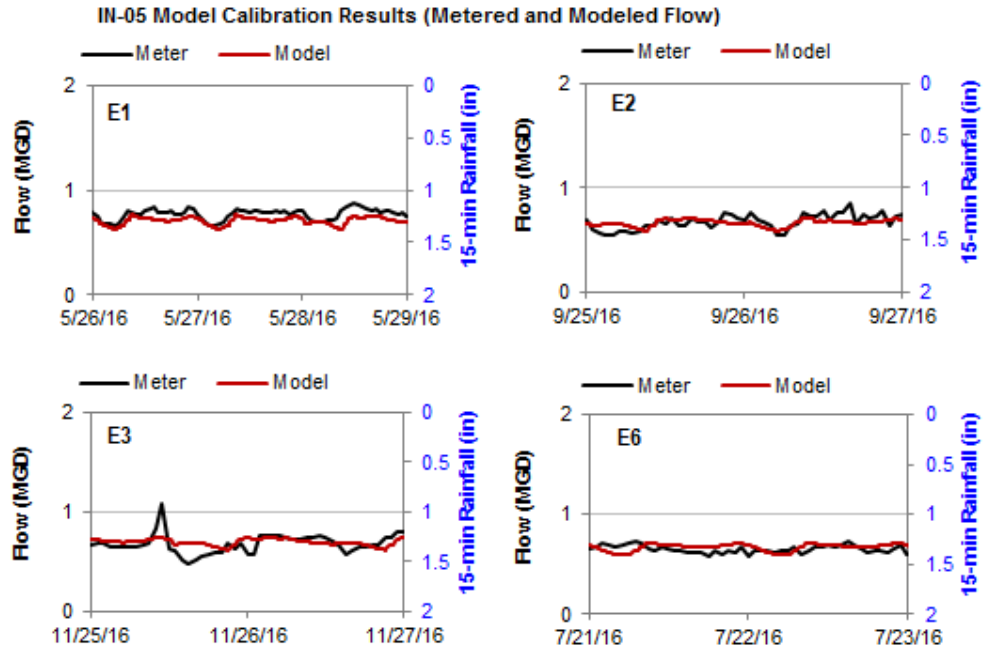
IN-05 Model Validation Results (Metered and Modeled Flow)

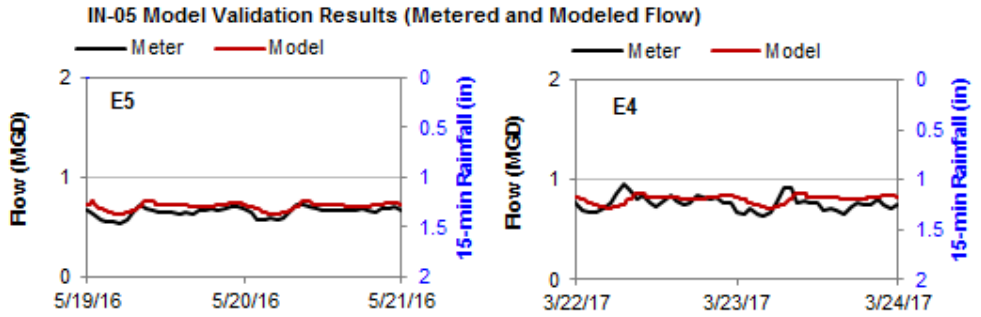


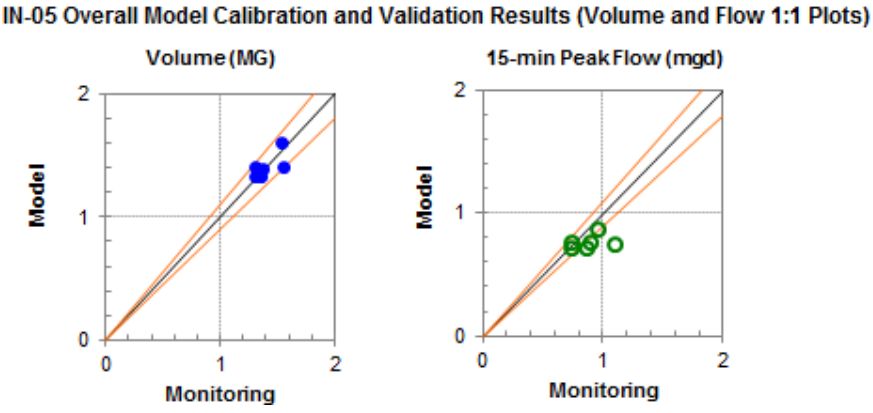
IN-05 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



FLOW METER IN-05 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events







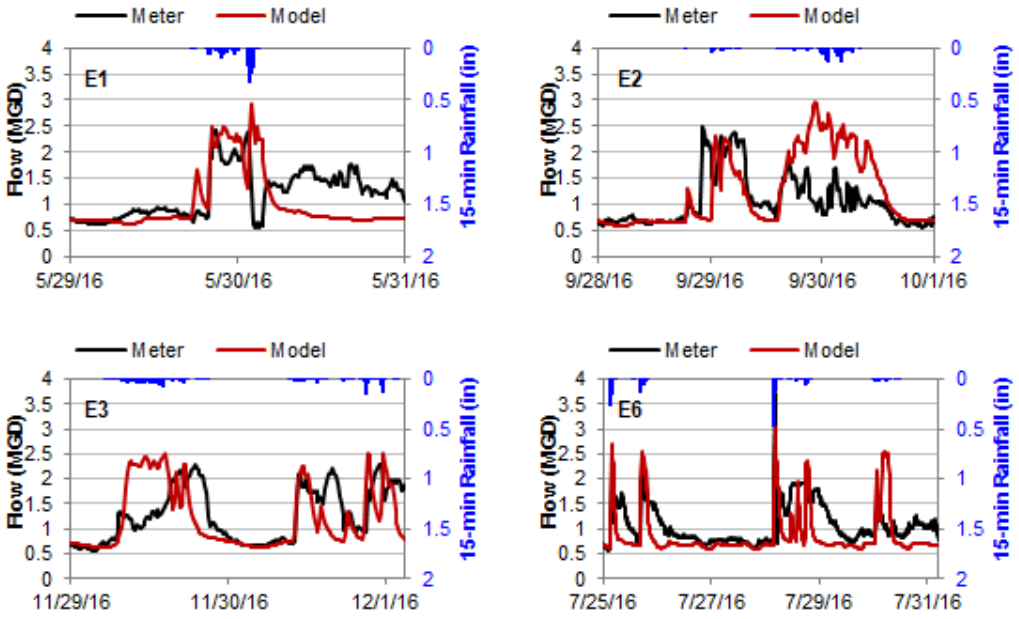
IN-05 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.88	0.76	-10% to +10%	-14%	1.54	1.41	-10% to +10%	-8%
E2	0.86	0.72	-10% to +10%	-16%	1.35	1.33	-10% to +10%	-2%
E3	1.09	0.75	-10% to +10%	-31%	1.36	1.40	-10% to +10%	3%
E4	0.95	0.87	-10% to +10%	-9%	1.53	1.61	-10% to +10%	5%
E5	0.73	0.76	-10% to +10%	4%	1.31	1.42	-10% to +10%	8%
E6	0.73	0.72	-10% to +10%	-1%	1.31	1.34	-10% to +10%	2%

IN-05 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	19.90	30.28	-15% to +25%	52%	3.00	3.57	-10% to +20%	19%
E2	13.38	16.57	-15% to +25%	24%	5.39	6.32	-10% to +20%	17%
E3	12.07	12.28	-15% to +25%	2%	4.57	4.93	-10% to +20%	8%
E4	13.17	12.43	-15% to +25%	-6%	10.98	9.18	-10% to +20%	-16%
E5	10.58	12.02	-15% to +25%	14%	5.42	4.89	-10% to +20%	-10%
E6	34.58	33.54	-15% to +25%	-3%	4.50	2.79	-10% to +20%	-38%

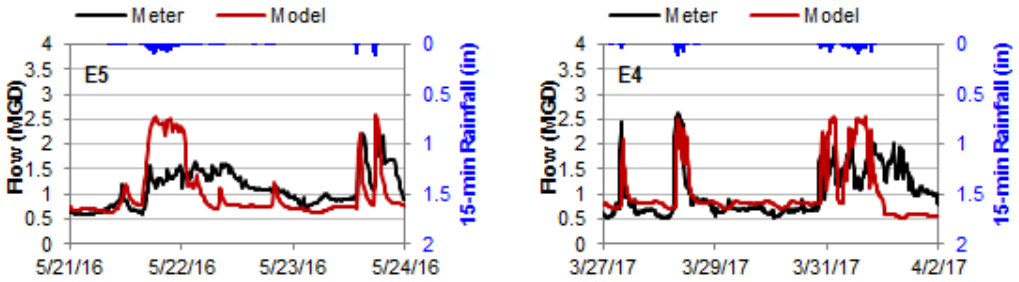
Note: Four of the six wet weather event peak flows are calibrated well within the industry criteria. Flow meter data recorded for some of the events is not consistent with the recorded rainfall intensity. For instance, it is expected that Event E1 would have a high peak flow due to high rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER EFF-05 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

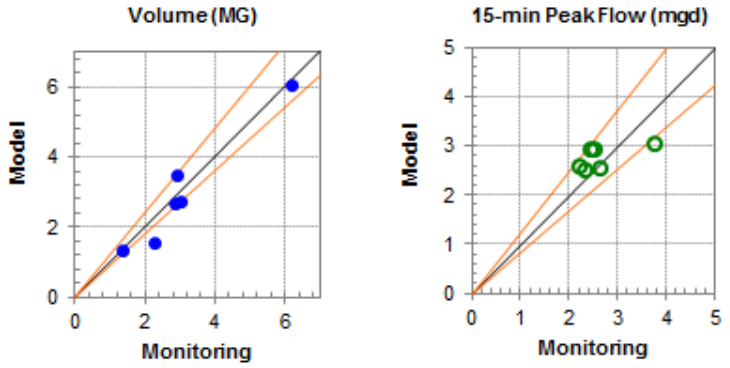
EFF-05 Model Calibration Results (Metered and Modeled Flow)



EFF-05 Model Validation Results (Metered and Modeled Flow)

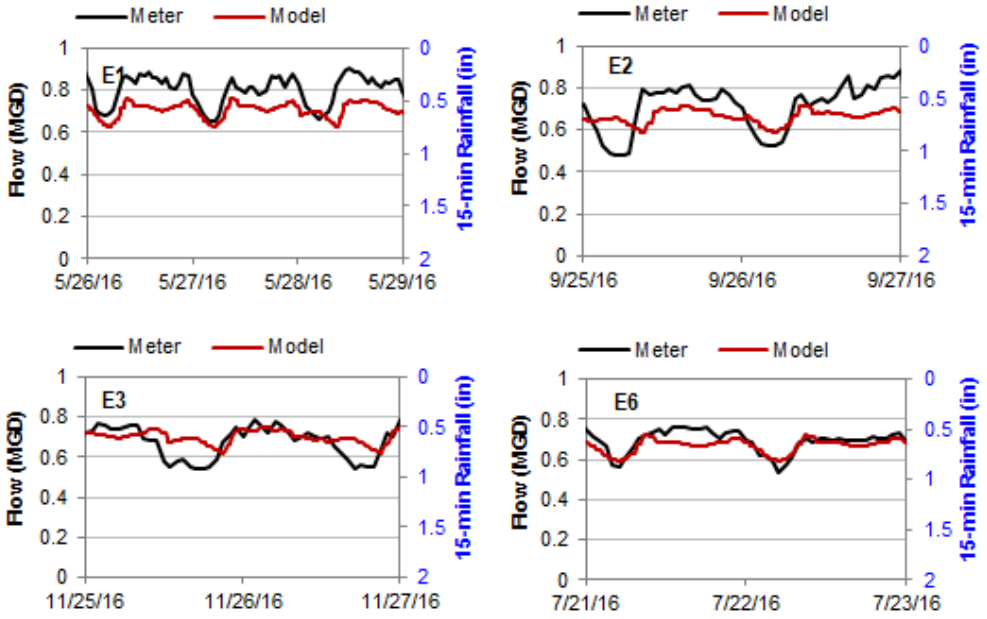


EFF-05 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

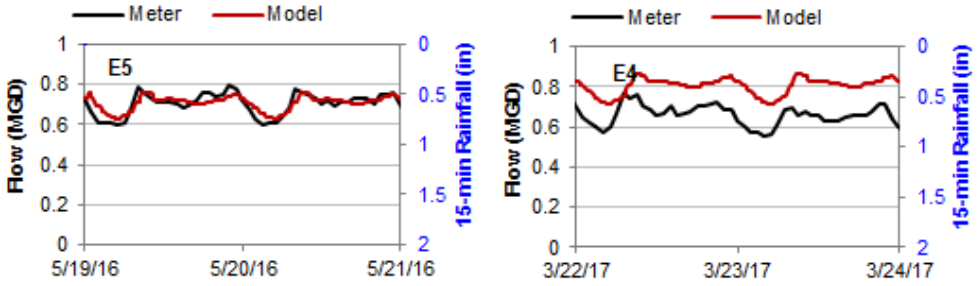


FLOW METER EFF-05 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

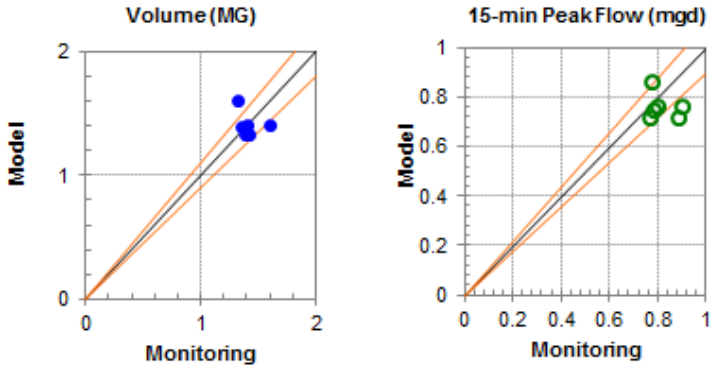
EFF-05 Model Calibration Results (Metered and Modeled Flow)



EFF-05 Model Validation Results (Metered and Modeled Flow)



EFF-05 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



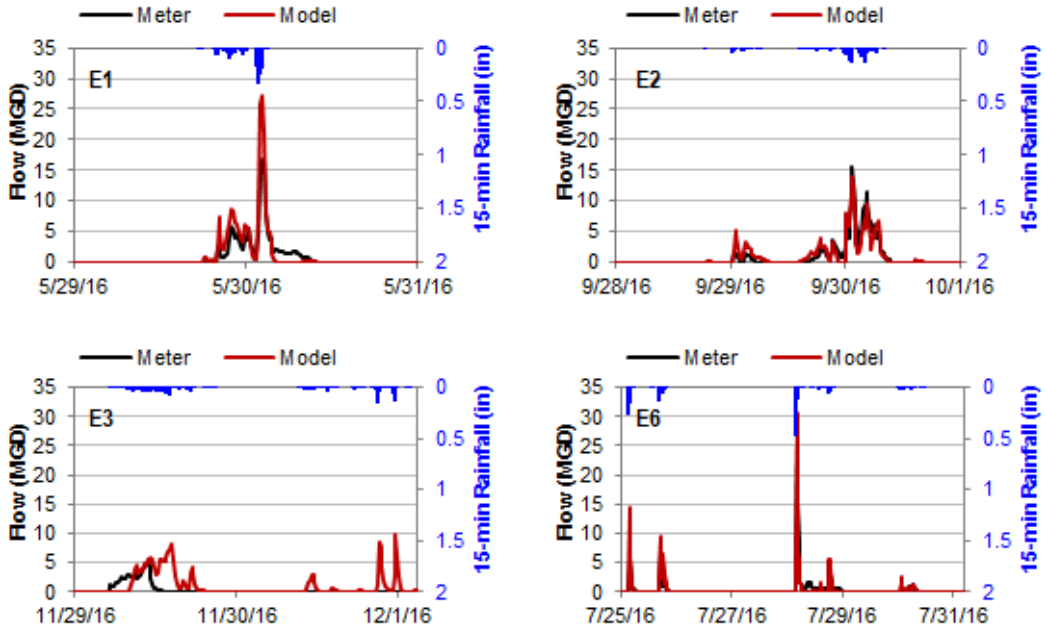
EFF-05 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.90	0.76	-10% to +10%	-16%	1.59	1.41	-10% to +10%	-11%
E2	0.88	0.72	-10% to +10%	-19%	1.42	1.33	-10% to +10%	-6%
E3	0.78	0.75	-10% to +10%	-5%	1.35	1.40	-10% to +10%	4%
E4	0.77	0.87	-10% to +10%	12%	1.32	1.61	-10% to +10%	22%
E5	0.80	0.76	-10% to +10%	-4%	1.41	1.42	-10% to +10%	1%
E6	0.77	0.72	-10% to +10%	-6%	1.38	1.34	-10% to +10%	-3%

EFF-05 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	2.44	2.93	-15% to +25%	20%	1.37	1.35	-10% to +20%	-1%
E2	2.49	2.96	-15% to +25%	19%	2.89	3.49	-10% to +20%	21%
E3	2.30	2.53	-15% to +25%	10%	2.88	2.72	-10% to +20%	-6%
E4	2.61	2.55	-15% to +25%	-3%	6.20	6.07	-10% to +20%	-2%
E5	2.20	2.58	-15% to +25%	18%	3.00	2.73	-10% to +20%	-9%
E6	3.73	3.06	-15% to +25%	-18%	2.28	1.56	-10% to +20%	-32%

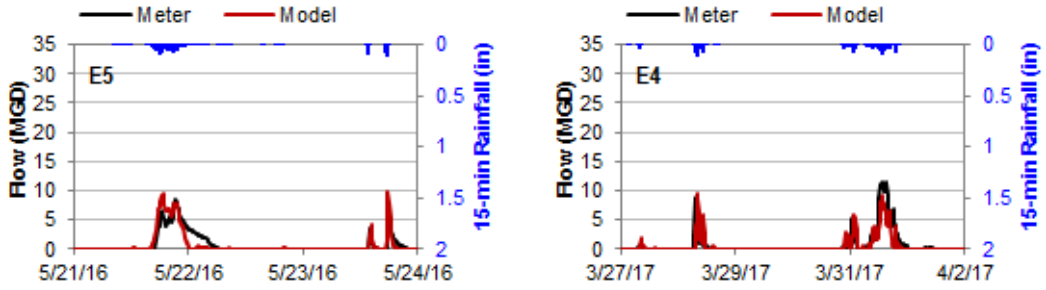
Note: Five of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E2, E3) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER CSO-05 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

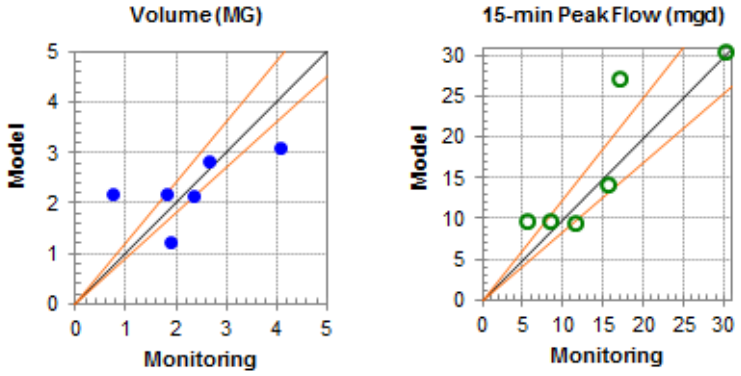
CSO-05 Model Calibration Results (Metered and Modeled Flow)



CSO-05 Model Validation Results (Metered and Modeled Flow)



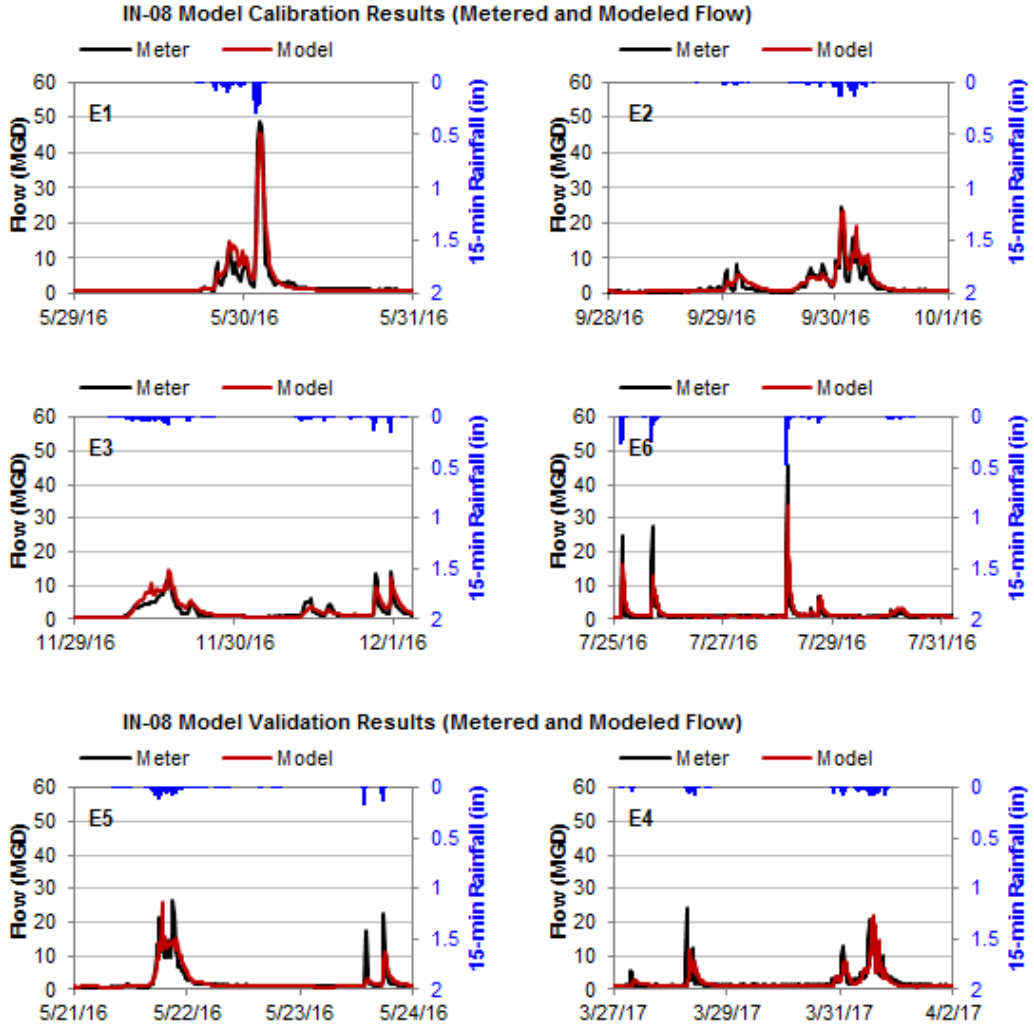
CSO-05 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



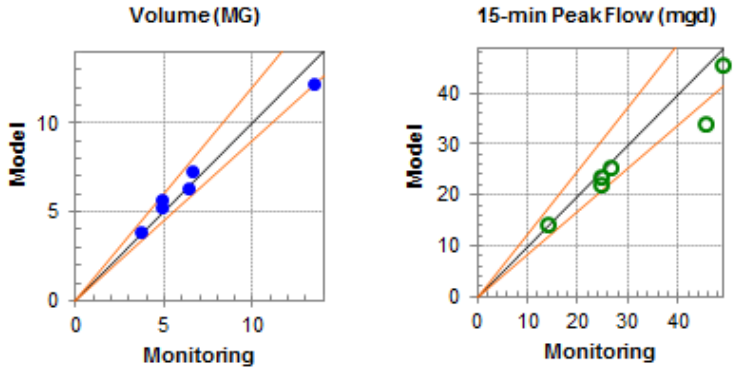
CSO-05 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	16.91	27.24	-15% to +25%	61%	1.79	2.19	-10% to +20%	22%
E2	15.44	14.14	-15% to +25%	-8%	2.64	2.84	-10% to +20%	8%
E3	5.39	9.83	-15% to +25%	82%	0.72	2.18	-10% to +20%	202%
E4	11.39	9.58	-15% to +25%	-16%	4.05	3.09	-10% to +20%	-24%
E5	8.46	9.65	-15% to +25%	14%	2.35	2.15	-10% to +20%	-9%
E6	30.25	30.66	-15% to +25%	1%	1.88	1.24	-10% to +20%	-34%

Note: Four of the six wet weather event peak flows are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E1, E2, E3) is not consistent with the recorded rainfall intensity. The overflow volume calibration is more challenging, especially for the small overflow event like E3. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-08 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

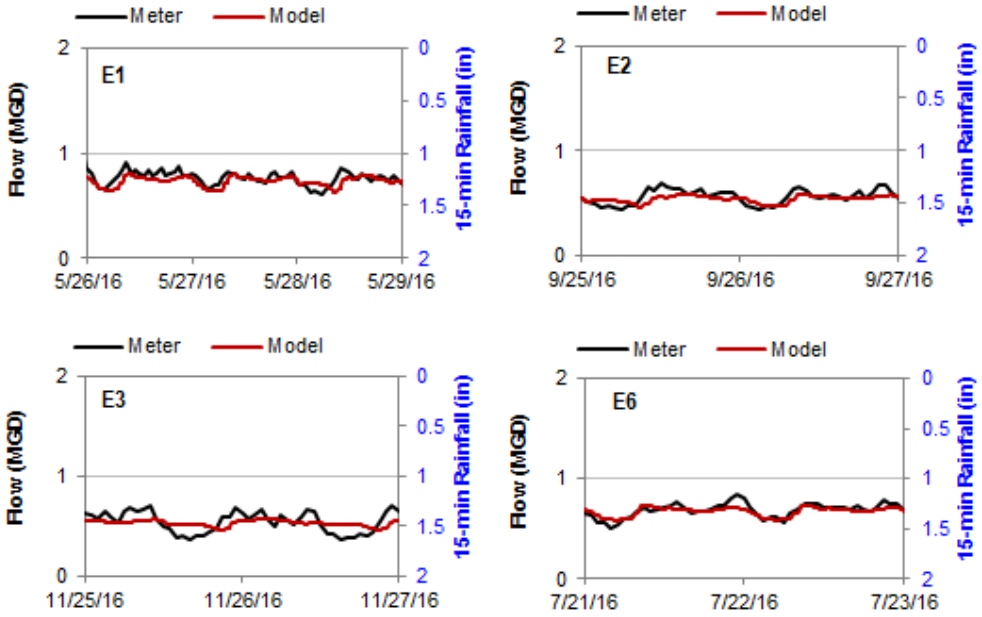


IN-08 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

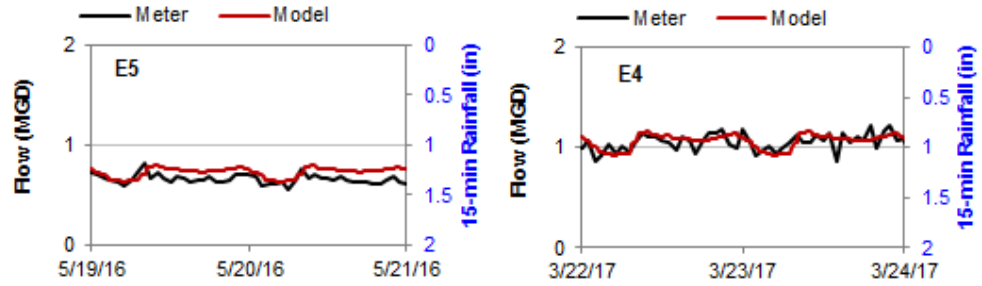


FLOW METER IN-08 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

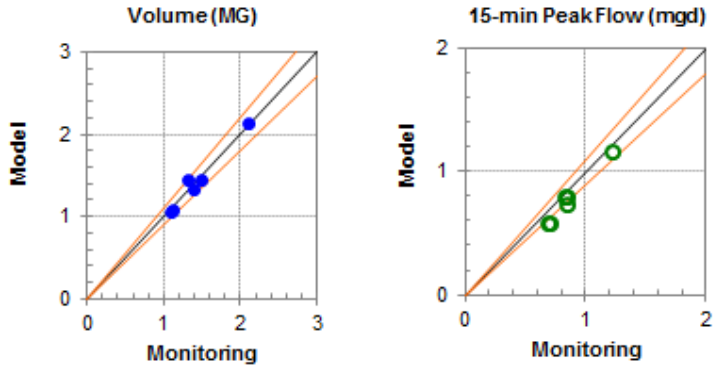
IN-08 Model Calibration Results (Metered and Modeled Flow)



IN-08 Model Validation Results (Metered and Modeled Flow)



IN-08 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

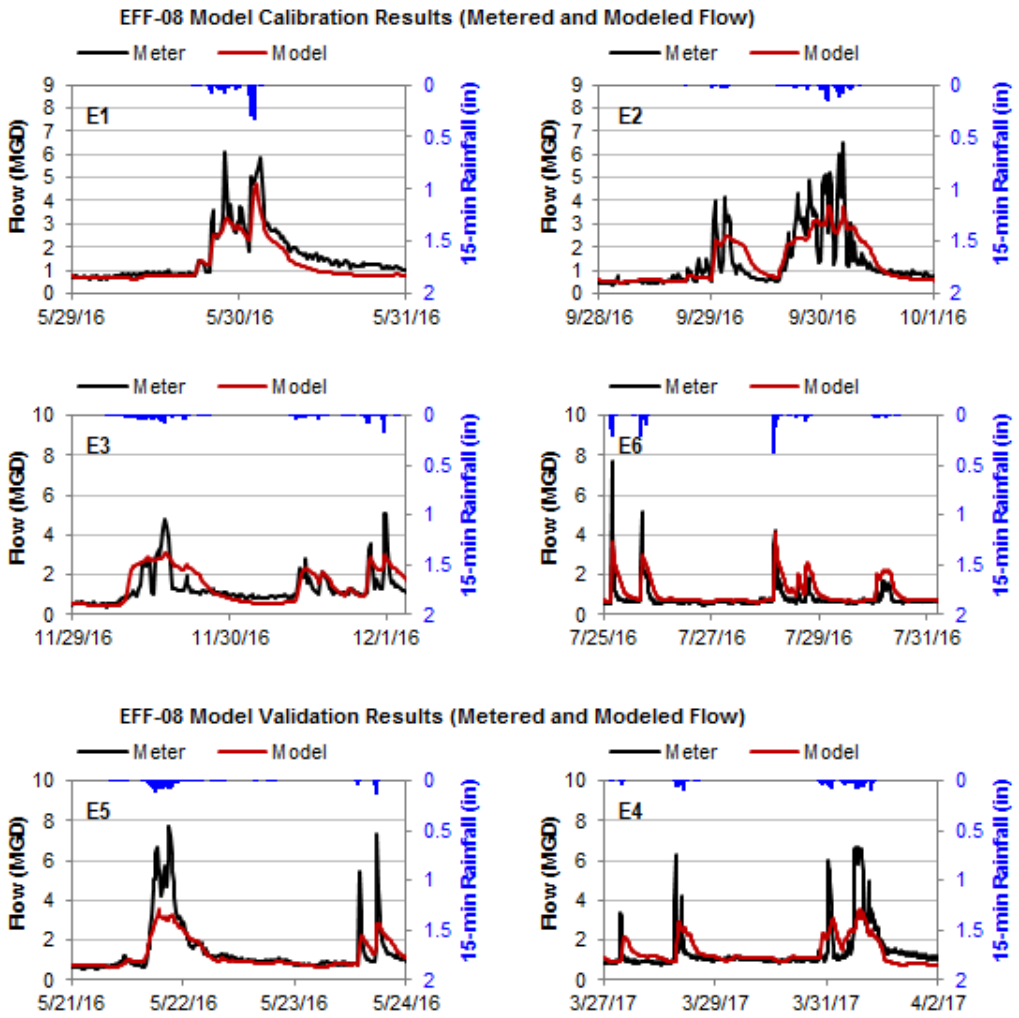


IN-08 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.85	0.80	-10% to +10%	-6%	1.49	1.46	-10% to +10%	-2%
E2	0.69	0.59	-10% to +10%	-15%	1.12	1.08	-10% to +10%	-4%
E3	0.70	0.58	-10% to +10%	-17%	1.09	1.06	-10% to +10%	-3%
E4	1.22	1.16	-10% to +10%	-5%	2.11	2.13	-10% to +10%	1%
E5	0.82	0.80	-10% to +10%	-3%	1.32	1.46	-10% to +10%	11%
E6	0.84	0.73	-10% to +10%	-13%	1.38	1.35	-10% to +10%	-2%

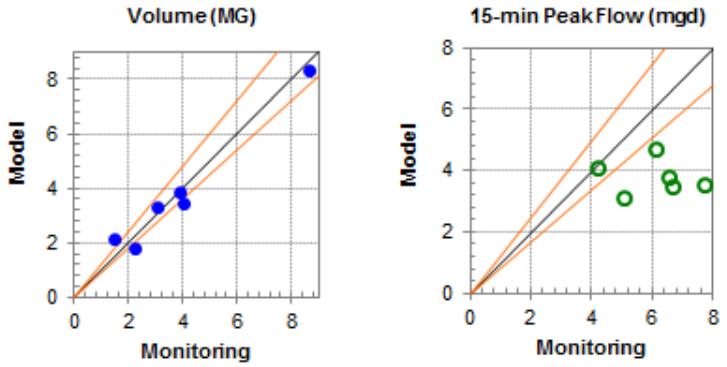
IN-08 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	48.94	45.65	-15% to +25%	-7%	4.81	5.25	-10% to +20%	9%
E2	24.74	23.68	-15% to +25%	-4%	6.55	7.29	-10% to +20%	11%
E3	14.08	14.45	-15% to +25%	3%	4.84	5.73	-10% to +20%	18%
E4	24.42	22.15	-15% to +25%	-9%	13.46	12.23	-10% to +20%	-9%
E5	26.44	25.62	-15% to +25%	-3%	6.39	6.34	-10% to +20%	-1%
E6	45.55	33.93	-15% to +25%	-26%	3.65	3.91	-10% to +20%	7%

Note: All of the six wet weather events are calibrated well within the industry criteria except for the peak flow of E6. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER EFF-08 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

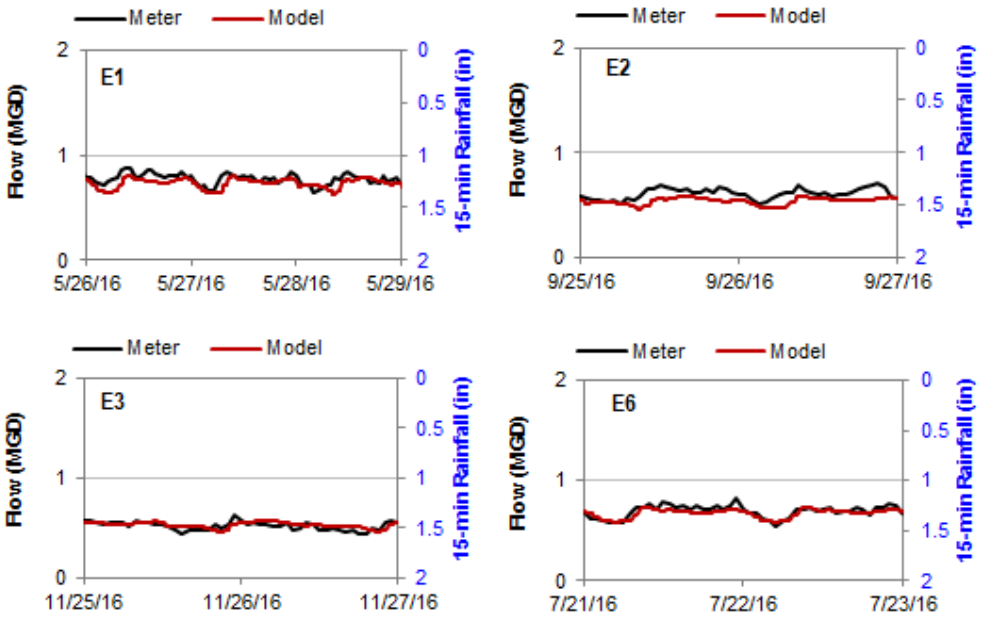


EFF-08 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

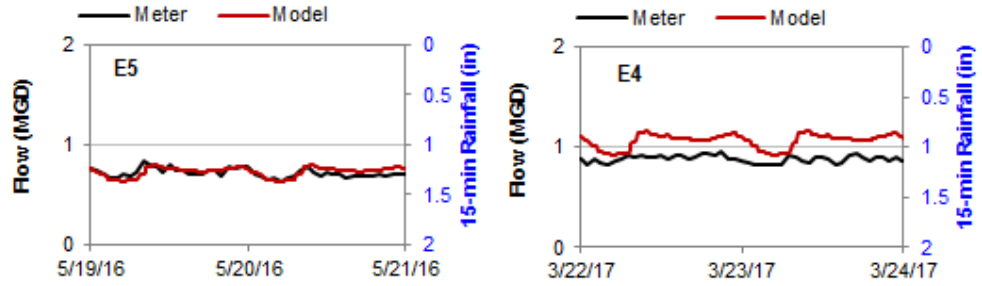


FLOW METER EFF-08 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

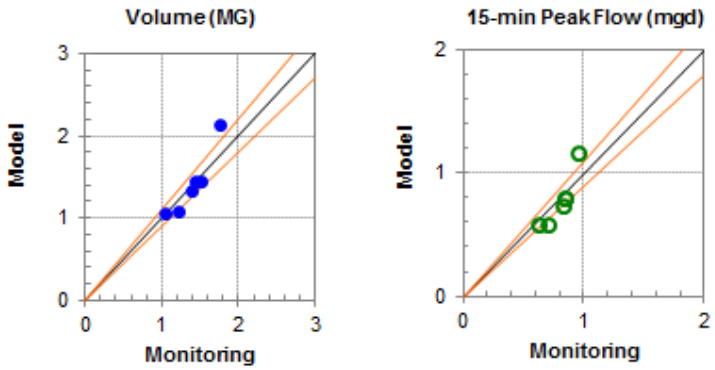
EFF-08 Model Calibration Results (Metered and Modeled Flow)



EFF-08 Model Validation Results (Metered and Modeled Flow)



EFF-08 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

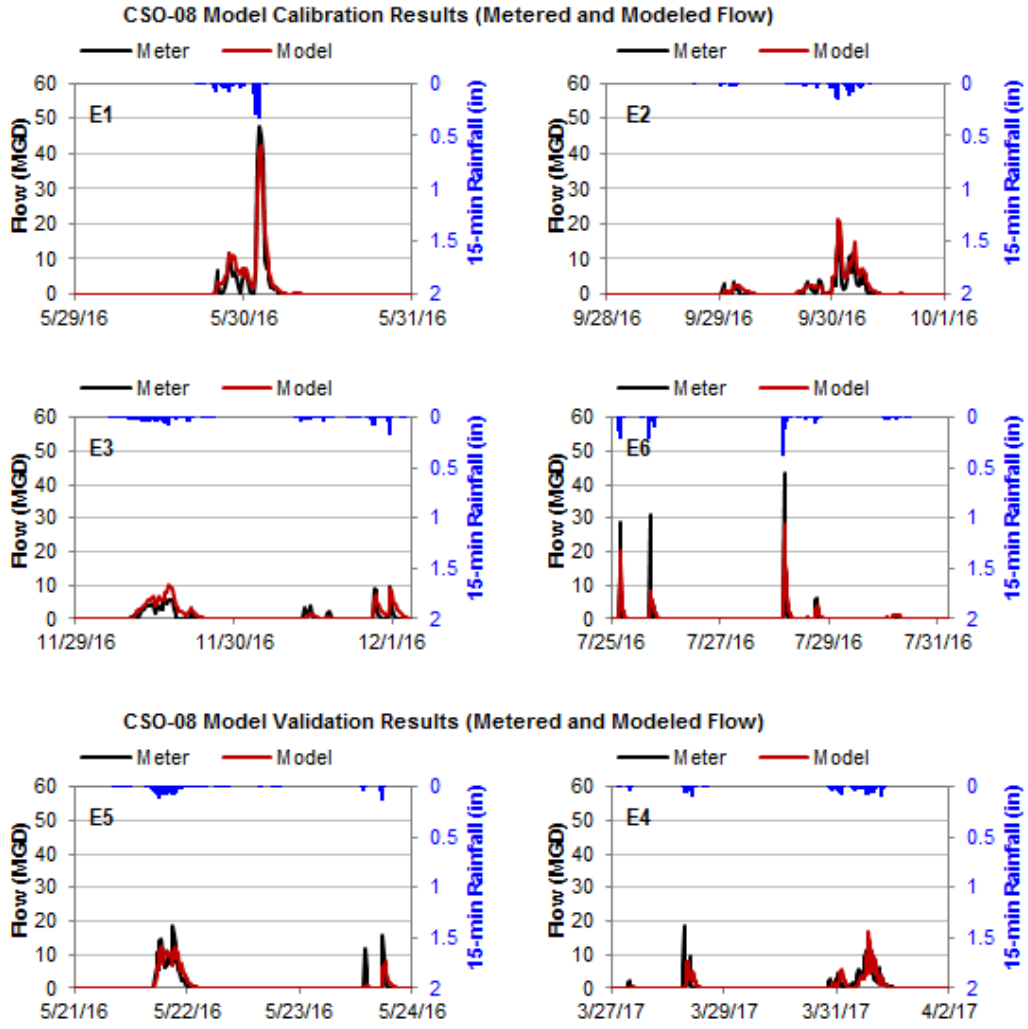


EFF-08 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.85	0.80	-10% to +10%	-6%	1.52	1.46	-10% to +10%	-4%
E2	0.70	0.59	-10% to +10%	-16%	1.22	1.08	-10% to +10%	-12%
E3	0.63	0.58	-10% to +10%	-8%	1.05	1.06	-10% to +10%	2%
E4	0.95	1.16	-10% to +10%	22%	1.76	2.13	-10% to +10%	21%
E5	0.84	0.80	-10% to +10%	-6%	1.44	1.46	-10% to +10%	1%
E6	0.83	0.73	-10% to +10%	-11%	1.39	1.35	-10% to +10%	-3%

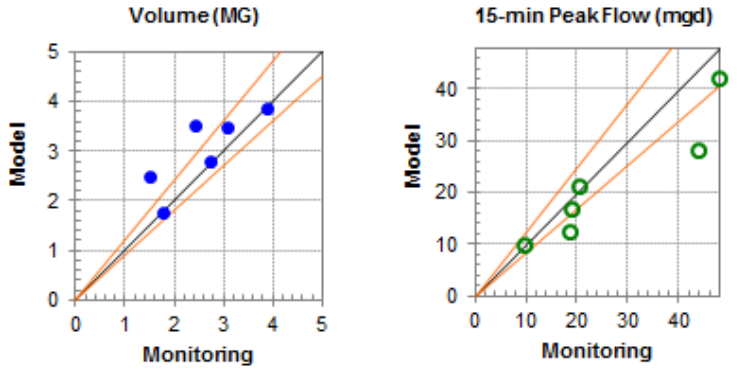
EFF-08 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	6.09	4.57	-15% to +25%	-25%	2.23	1.80	-10% to +20%	-19%
E2	6.53	3.67	-15% to +25%	-44%	3.86	3.80	-10% to +20%	-2%
E3	5.08	3.02	-15% to +25%	-40%	3.02	3.25	-10% to +20%	8%
E4	6.65	3.35	-15% to +25%	-50%	8.66	8.25	-10% to +20%	-5%
E5	7.71	3.20	-15% to +25%	-58%	3.99	3.41	-10% to +20%	-15%
E6	4.18	4.39	-15% to +25%	5%	1.44	2.15	-10% to +20%	49%

Note: Four of the six wet weather events are calibrated well within the industry criteria. The EFF-08 meter is the effluent meter from Regulator 08. The calibration of Regulator 08 meters (which include the IN-08, EFF-08 and CSO-08 meters) are more focused on the influent IN-08 meter and the overflow CSO-08 meter when the total metered influent flow (IN-08) is not balanced with the total metered effluent flow (EFF-08 plus CSO-08). Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER CSO-08 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events



CSO-08 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

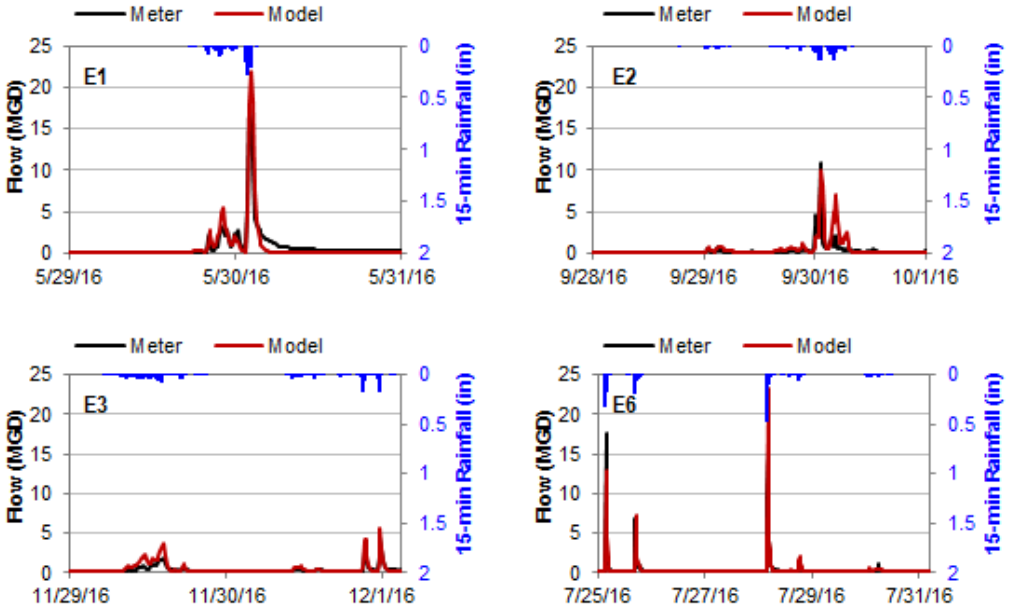


CSO-08 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	47.82	42.26	-15% to +25%	-12%	3.08	3.47	-10% to +20%	13%
E2	20.55	21.32	-15% to +25%	4%	2.42	3.54	-10% to +20%	46%
E3	9.50	9.79	-15% to +25%	3%	1.52	2.48	-10% to +20%	63%
E4	18.72	16.78	-15% to +25%	-10%	3.87	3.87	-10% to +20%	0%
E5	18.35	12.44	-15% to +25%	-32%	2.73	2.81	-10% to +20%	3%
E6	43.63	28.23	-15% to +25%	-35%	1.78	1.77	-10% to +20%	0%

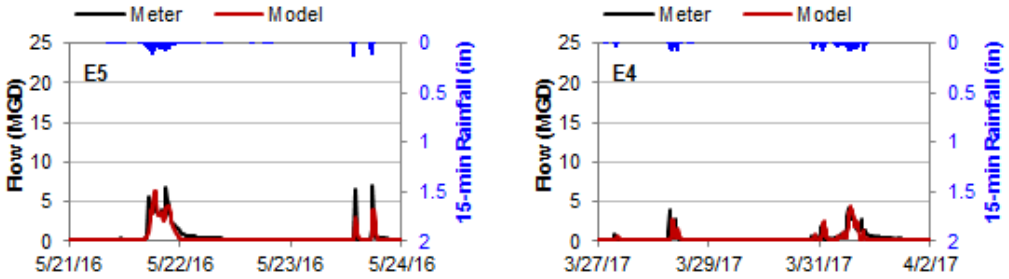
Note: Four of the six wet weather events are calibrated well within the industry criteria. This is the CSO meter from Regulator 08, the calibration of Regulator 08 meters (including Influent meter, effluent meter and CSO meter) are more focused on matching the peak flow and flow volume of the influent and CSO meter. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-09 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

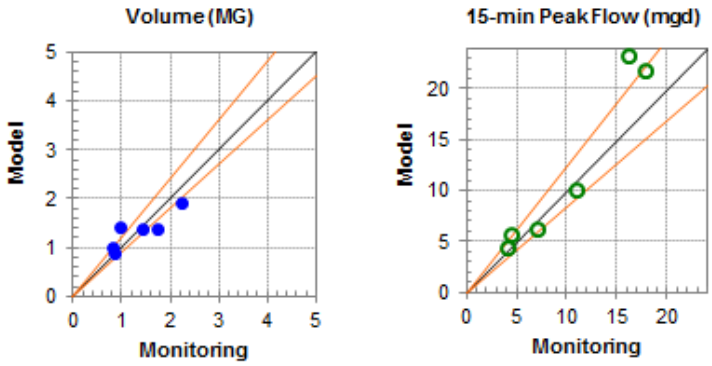
IN-09 Model Calibration Results (Metered and Modeled Flow)



IN-09 Model Validation Results (Metered and Modeled Flow)

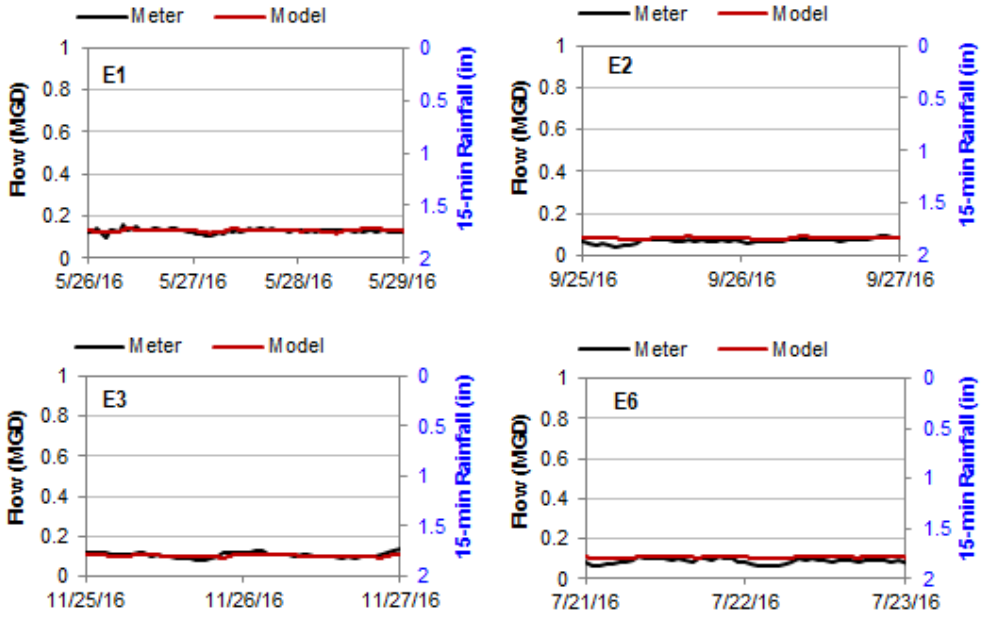


IN-09 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

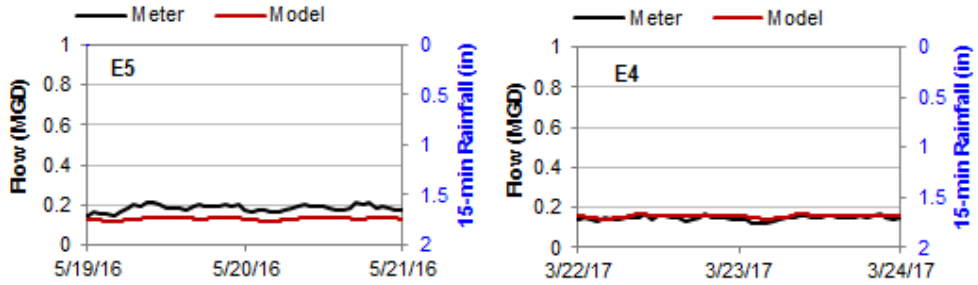


FLOW METER IN-09 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

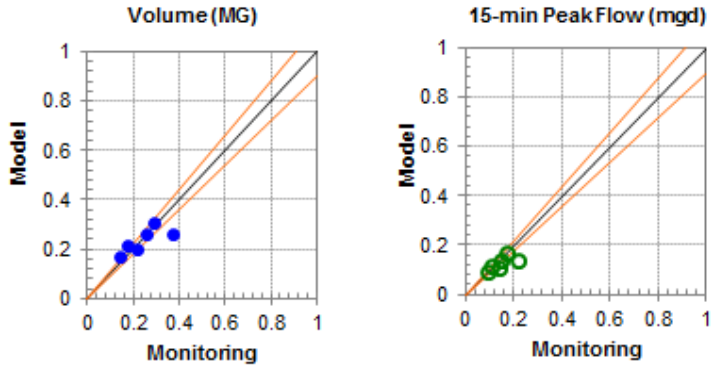
IN-09 Model Calibration Results (Metered and Modeled Flow)



IN-09 Model Validation Results (Metered and Modeled Flow)



IN-09 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

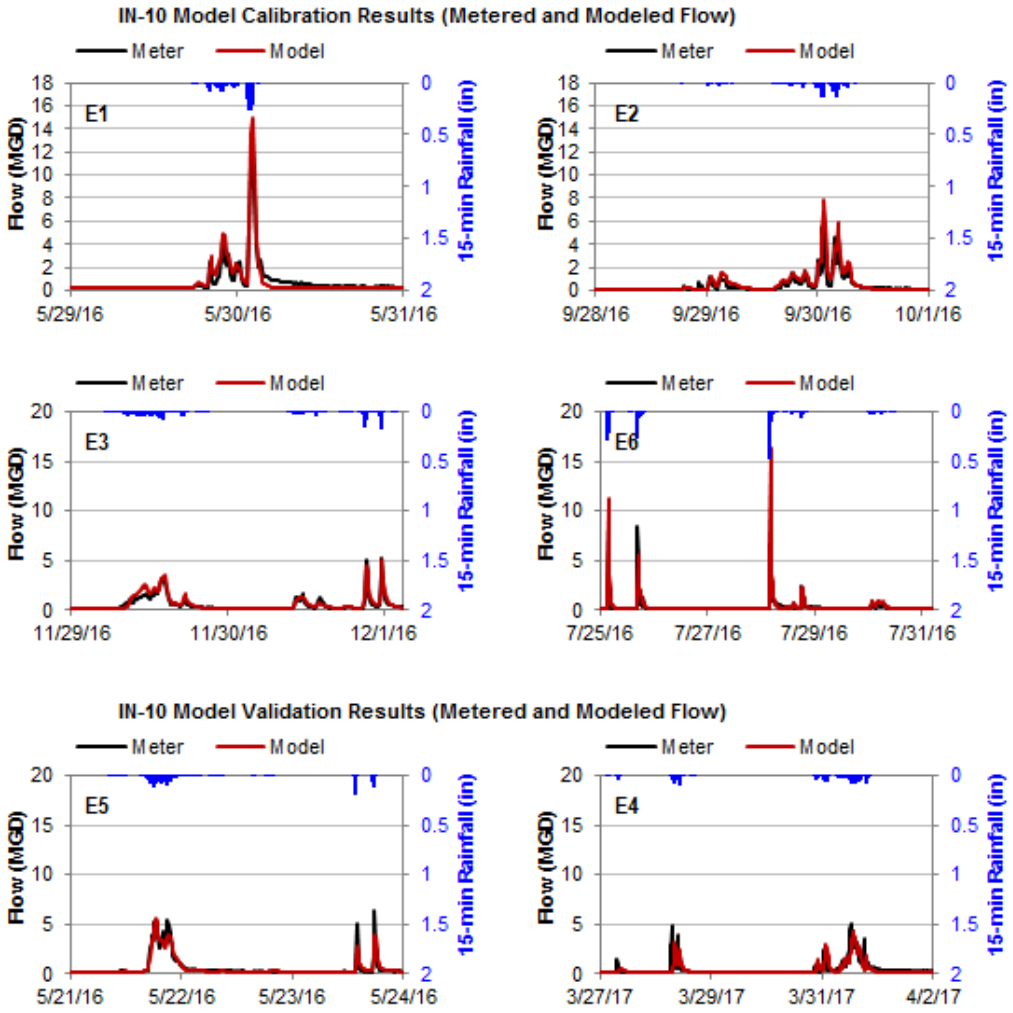


IN-09 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.15	0.14	-10% to +10%	-3%	0.26	0.26	-10% to +10%	2%
E2	0.09	0.09	-10% to +10%	-4%	0.14	0.17	-10% to +10%	19%
E3	0.14	0.11	-10% to +10%	-20%	0.21	0.20	-10% to +10%	-4%
E4	0.17	0.17	-10% to +10%	-2%	0.29	0.31	-10% to +10%	6%
E5	0.21	0.14	-10% to +10%	-35%	0.37	0.26	-10% to +10%	-29%
E6	0.11	0.11	-10% to +10%	6%	0.17	0.21	-10% to +10%	22%

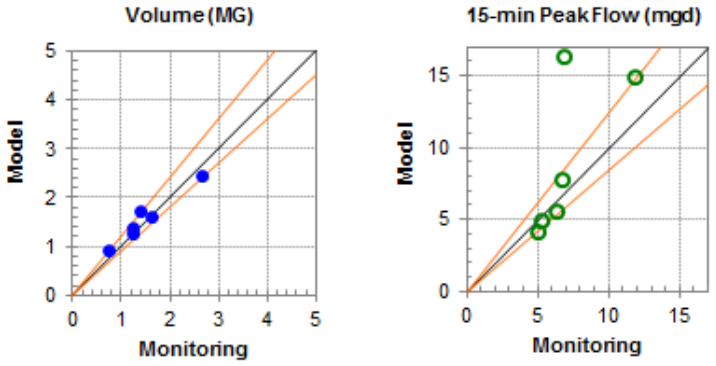
IN-09 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	17.88	21.83	-15% to +25%	22%	1.42	1.39	-10% to +20%	-2%
E2	10.87	10.06	-15% to +25%	-7%	0.96	1.41	-10% to +20%	47%
E3	4.41	5.62	-15% to +25%	28%	0.79	1.01	-10% to +20%	27%
E4	4.10	4.49	-15% to +25%	10%	2.24	1.91	-10% to +20%	-15%
E5	7.10	6.25	-15% to +25%	-12%	1.74	1.41	-10% to +20%	-19%
E6	16.13	23.34	-15% to +25%	45%	0.85	0.88	-10% to +20%	3%

Note: Four of the six wet weather events are calibrated well within or close to the industry criteria. Flow meter data recorded for some of the events (E3, E5, and E6) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-10 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

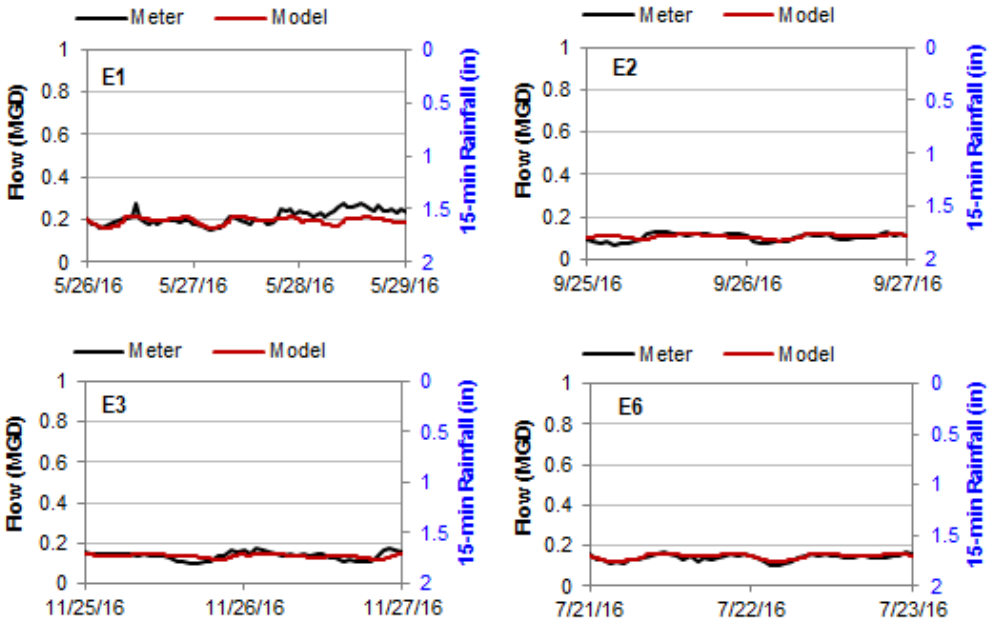


IN-10 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

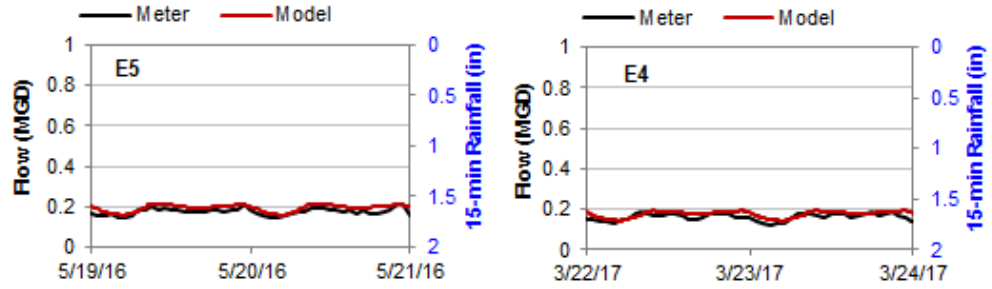


FLOW METER IN-10 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

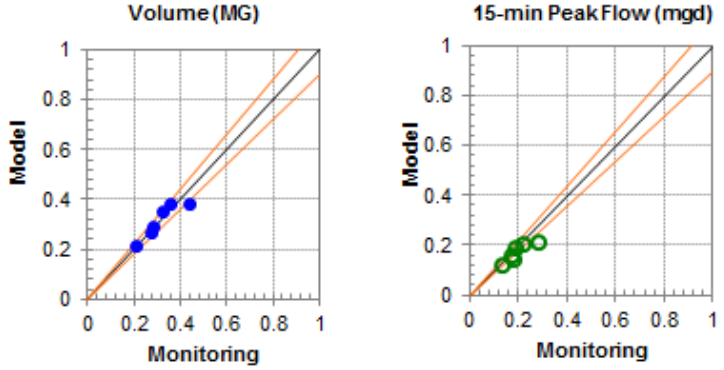
IN-10 Model Calibration Results (Metered and Modeled Flow)



IN-10 Model Validation Results (Metered and Modeled Flow)



IN-10 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



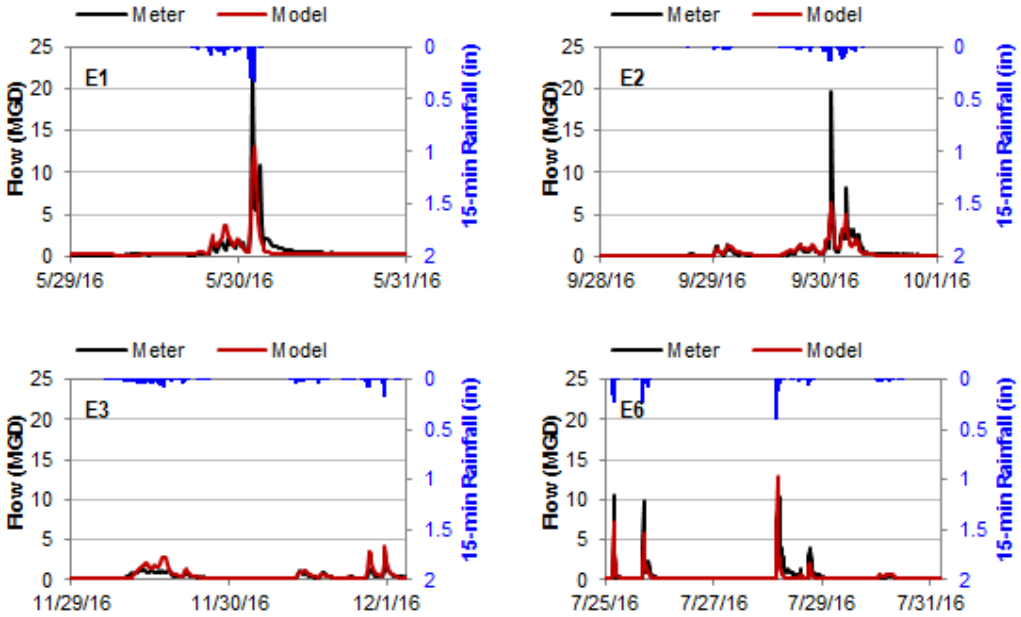
IN-10 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.28	0.21	-10% to +10%	-24%	0.44	0.39	-10% to +10%	-12%
E2	0.13	0.12	-10% to +10%	-10%	0.21	0.22	-10% to +10%	3%
E3	0.18	0.15	-10% to +10%	-16%	0.27	0.27	-10% to +10%	-1%
E4	0.19	0.19	-10% to +10%	1%	0.32	0.35	-10% to +10%	8%
E5	0.22	0.21	-10% to +10%	-2%	0.35	0.39	-10% to +10%	10%
E6	0.17	0.16	-10% to +10%	-6%	0.28	0.29	-10% to +10%	5%

IN-10 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	11.83	14.96	-15% to +25%	26%	1.25	1.28	-10% to +20%	3%
E2	6.70	7.85	-15% to +25%	17%	1.38	1.72	-10% to +20%	24%
E3	5.31	4.99	-15% to +25%	-6%	1.23	1.37	-10% to +20%	11%
E4	5.04	4.22	-15% to +25%	-16%	2.67	2.46	-10% to +20%	-8%
E5	6.31	5.56	-15% to +25%	-12%	1.61	1.60	-10% to +20%	-1%
E6	6.82	16.42	-15% to +25%	141%	0.72	0.94	-10% to +20%	30%

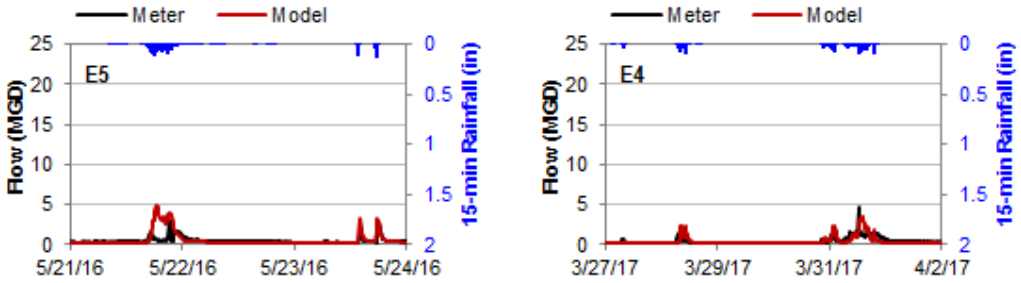
Note: Five of the six wet weather events are calibrated well within or close to the industry criteria. Flow meter data recorded for some of the events (E6) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-11 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

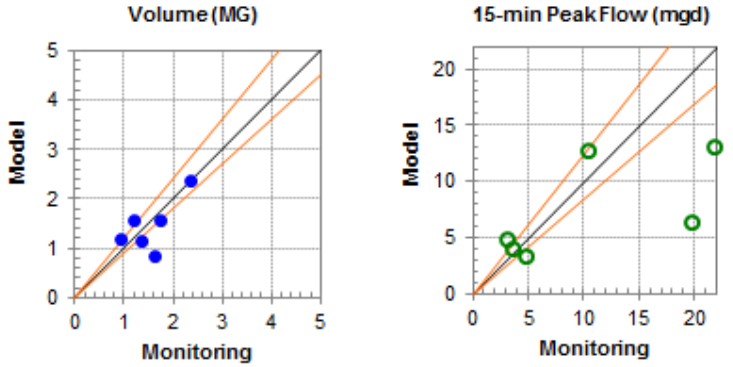
IN-11 Model Calibration Results (Metered and Modeled Flow)



IN-11 Model Validation Results (Metered and Modeled Flow)

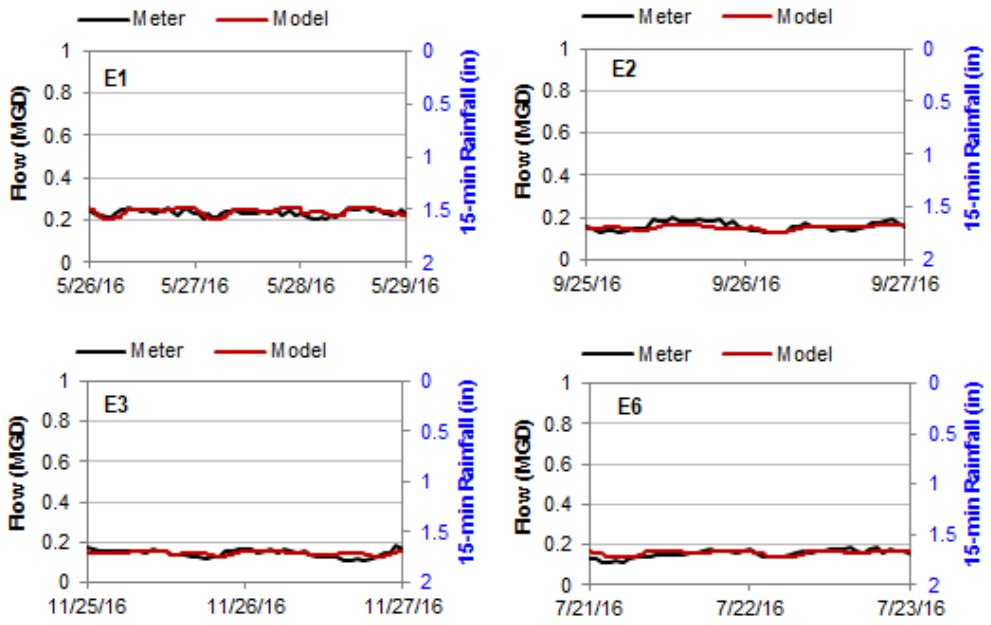


IN-11 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

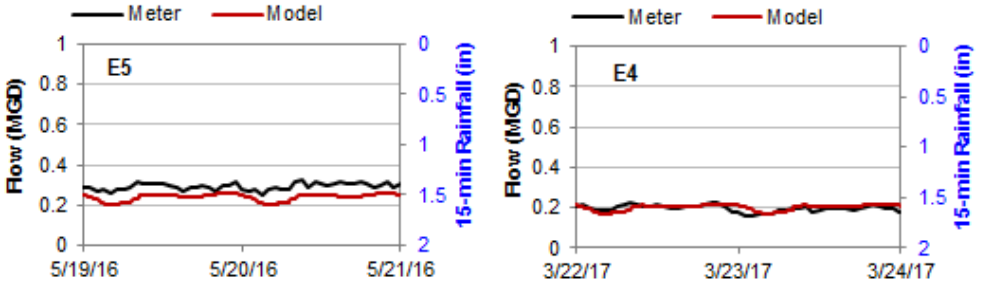


FLOW METER IN-11 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

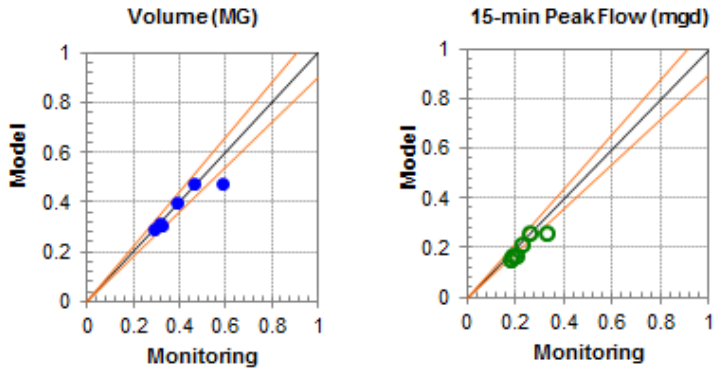
IN-11 Model Calibration Results (Metered and Modeled Flow)



IN-11 Model Validation Results (Metered and Modeled Flow)



IN-11 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



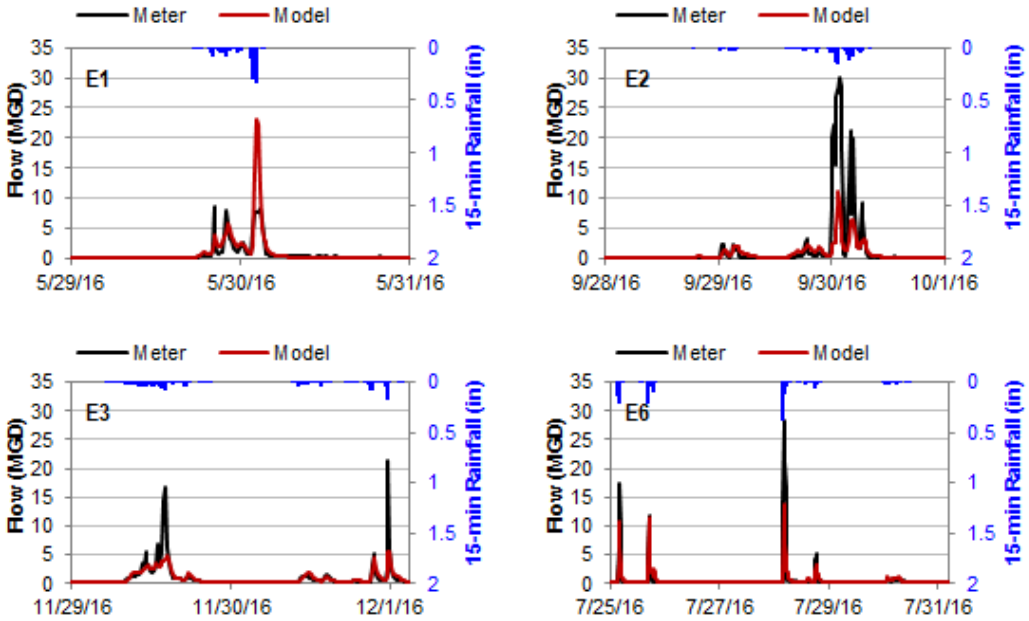
IN-11 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.26	0.26	-10% to +10%	1%	0.46	0.48	-10% to +10%	3%
E2	0.20	0.17	-10% to +10%	-17%	0.32	0.31	-10% to +10%	-4%
E3	0.18	0.16	-10% to +10%	-13%	0.29	0.29	-10% to +10%	1%
E4	0.23	0.22	-10% to +10%	-5%	0.39	0.40	-10% to +10%	2%
E5	0.32	0.26	-10% to +10%	-20%	0.59	0.48	-10% to +10%	-18%
E6	0.19	0.17	-10% to +10%	-8%	0.31	0.32	-10% to +10%	2%

IN-11 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	21.79	13.12	-15% to +25%	-40%	1.34	1.14	-10% to +20%	-15%
E2	19.64	6.48	-15% to +25%	-67%	1.71	1.56	-10% to +20%	-9%
E3	3.59	4.11	-15% to +25%	14%	0.94	1.19	-10% to +20%	27%
E4	4.74	3.44	-15% to +25%	-27%	2.34	2.37	-10% to +20%	1%
E5	3.06	4.84	-15% to +25%	58%	1.19	1.58	-10% to +20%	33%
E6	10.30	12.79	-15% to +25%	24%	1.62	0.86	-10% to +20%	-47%

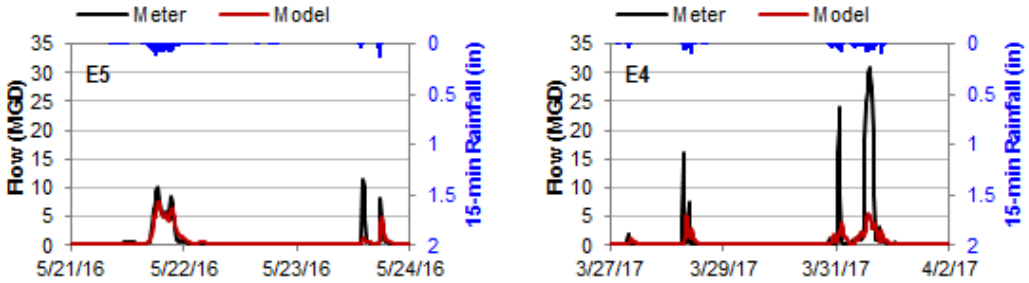
Note: Only two of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E1, E2, E5) is not consistent with the recorded rainfall intensity. The calibration goal is to balance the over-prediction and under-prediction event numbers cross all the events. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-13 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

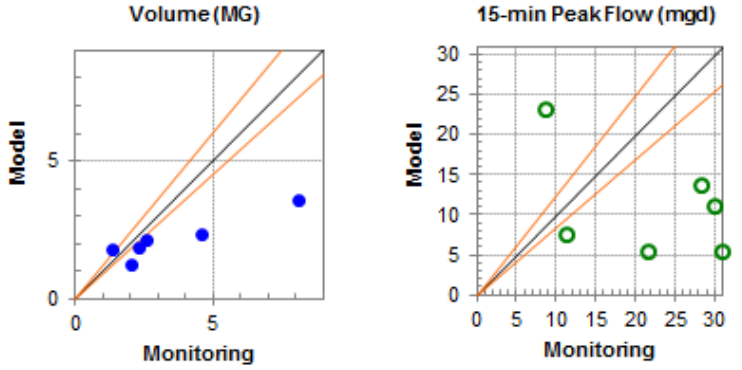
IN-13 Model Calibration Results (Metered and Modeled Flow)



IN-13 Model Validation Results (Metered and Modeled Flow)

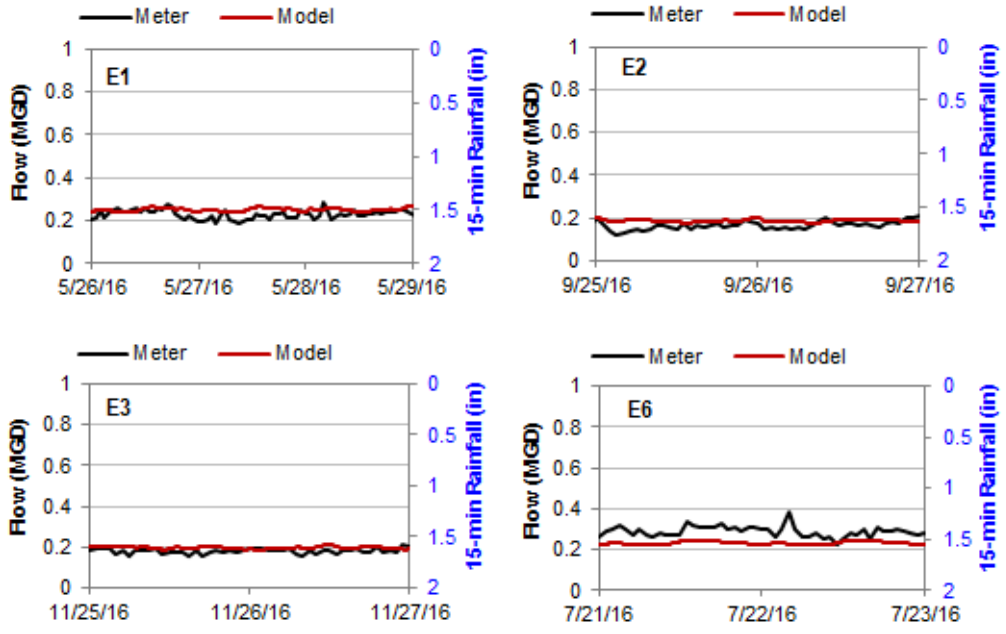


IN-13 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

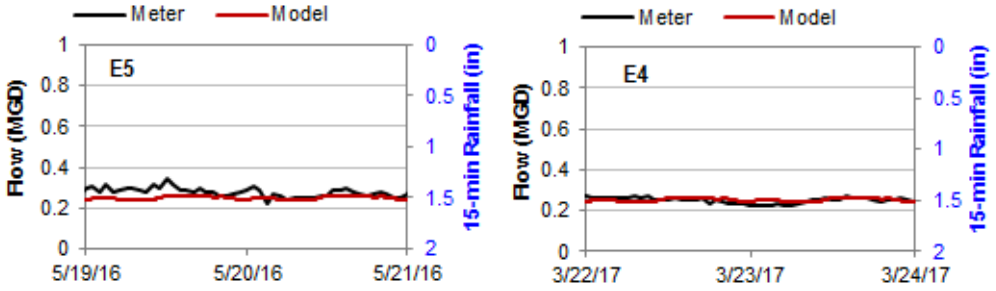


FLOW METER IN-13 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

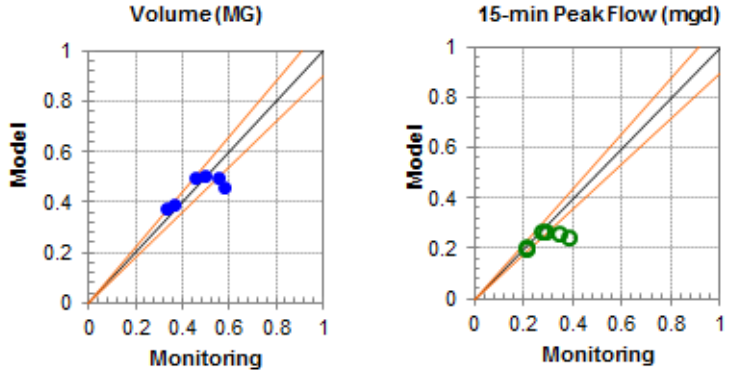
IN-13 Model Calibration Results (Metered and Modeled Flow)



IN-13 Model Validation Results (Metered and Modeled Flow)



IN-13 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



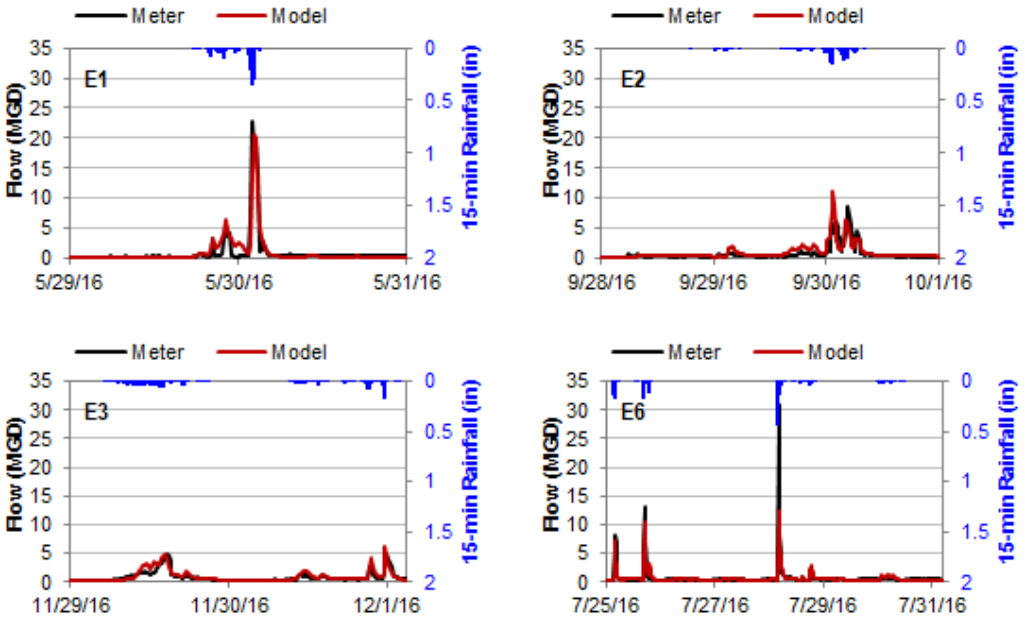
IN-13 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.29	0.27	-10% to +10%	-5%	0.45	0.50	-10% to +10%	11%
E2	0.21	0.20	-10% to +10%	-5%	0.33	0.37	-10% to +10%	13%
E3	0.21	0.21	-10% to +10%	0%	0.36	0.39	-10% to +10%	9%
E4	0.27	0.27	-10% to +10%	-2%	0.50	0.51	-10% to +10%	1%
E5	0.34	0.26	-10% to +10%	-23%	0.56	0.50	-10% to +10%	-10%
E6	0.38	0.24	-10% to +10%	-37%	0.58	0.46	-10% to +10%	-20%

IN-13 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	8.54	23.16	-15% to +25%	171%	1.35	1.80	-10% to +20%	34%
E2	29.87	11.05	-15% to +25%	-63%	4.59	2.37	-10% to +20%	-48%
E3	21.47	5.53	-15% to +25%	-74%	2.28	1.91	-10% to +20%	-16%
E4	30.86	5.54	-15% to +25%	-82%	8.12	3.57	-10% to +20%	-56%
E5	11.35	7.59	-15% to +25%	-33%	2.53	2.15	-10% to +20%	-15%
E6	28.28	13.85	-15% to +25%	-51%	1.98	1.26	-10% to +20%	-36%

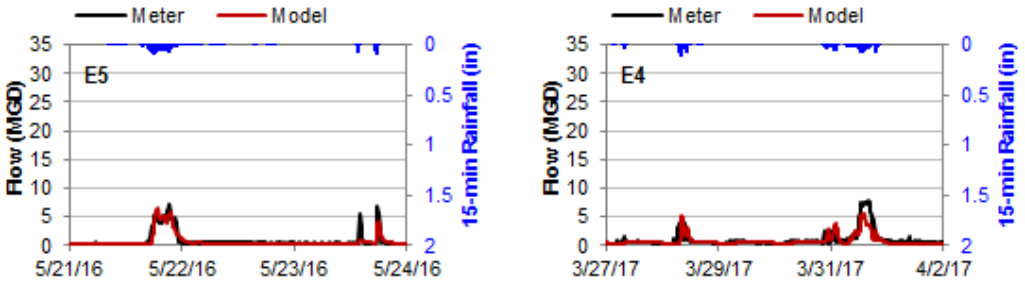
Note: This flow meter is hard to calibrate because flow meter data recorded for most of the events is not consistent with the recorded rainfall intensity. The calibration goal is to calibrate the meter to those wet weather response in line with the rainfall data.

FLOW METER IN-14 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

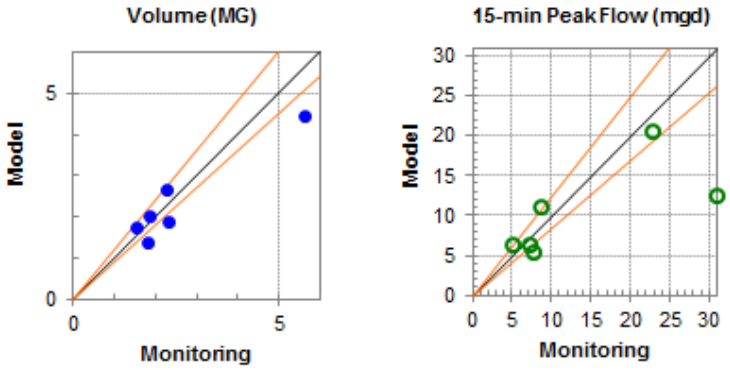
IN-14 Model Calibration Results (Metered and Modeled Flow)



IN-14 Model Validation Results (Metered and Modeled Flow)

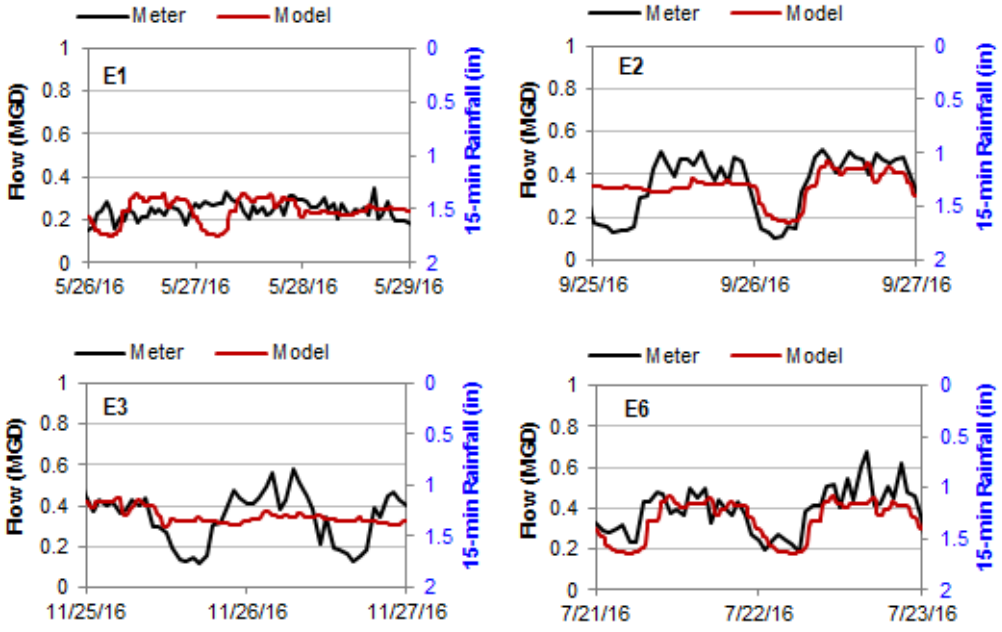


IN-14 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

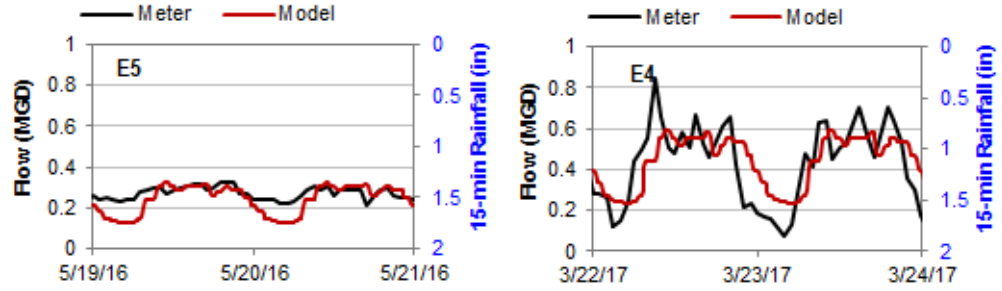


FLOW METER IN-14 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

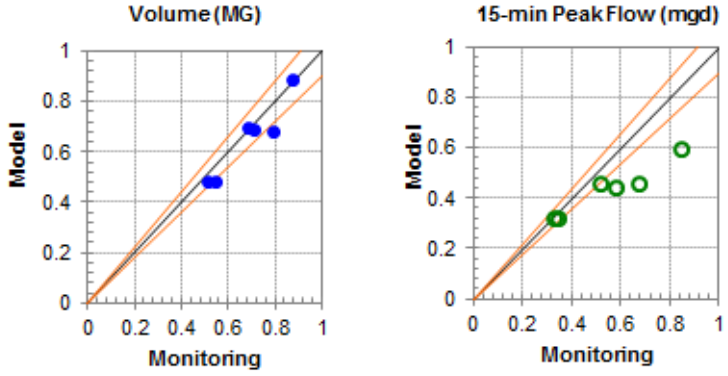
IN-14 Model Calibration Results (Metered and Modeled Flow)



IN-14 Model Validation Results (Metered and Modeled Flow)



IN-14 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

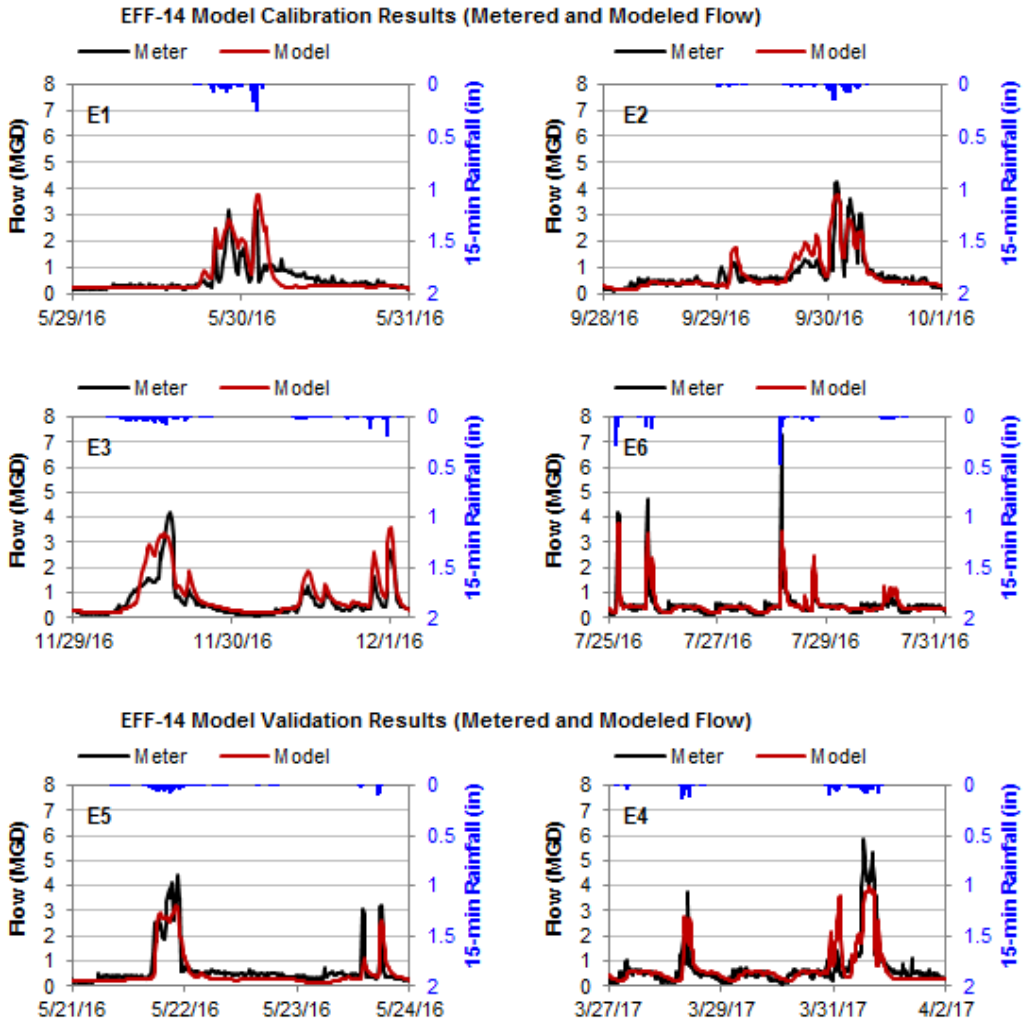


IN-14 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.35	0.32	-10% to +10%	-6%	0.51	0.48	-10% to +10%	-6%
E2	0.52	0.46	-10% to +10%	-11%	0.71	0.69	-10% to +10%	-3%
E3	0.58	0.44	-10% to +10%	-24%	0.68	0.70	-10% to +10%	2%
E4	0.84	0.59	-10% to +10%	-30%	0.87	0.89	-10% to +10%	2%
E5	0.33	0.32	-10% to +10%	0%	0.54	0.48	-10% to +10%	-11%
E6	0.67	0.46	-10% to +10%	-32%	0.79	0.68	-10% to +10%	-13%

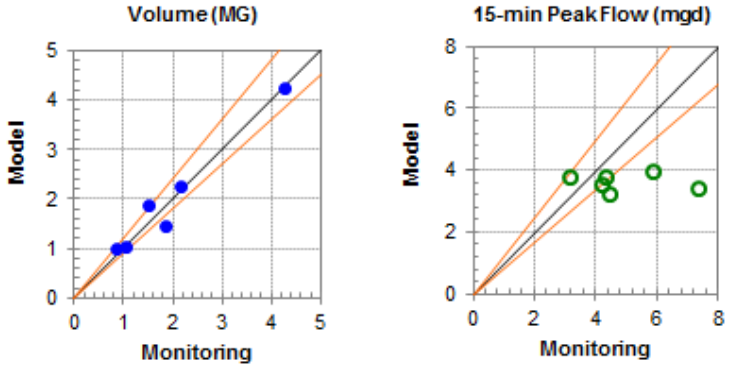
IN-14 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	22.85	20.54	-15% to +25%	-10%	1.54	1.74	-10% to +20%	13%
E2	8.60	11.12	-15% to +25%	29%	2.25	2.67	-10% to +20%	19%
E3	4.98	6.34	-15% to +25%	27%	1.84	2.05	-10% to +20%	11%
E4	7.74	5.54	-15% to +25%	-28%	5.62	4.46	-10% to +20%	-21%
E5	7.13	6.48	-15% to +25%	-9%	2.29	1.88	-10% to +20%	-18%
E6	30.94	12.50	-15% to +25%	-60%	1.81	1.39	-10% to +20%	-23%

Note: Four of the six wet weather events are calibrated well within or close to the industry criteria. Flow meter data recorded for some of the events (E6) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER EFF-14 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

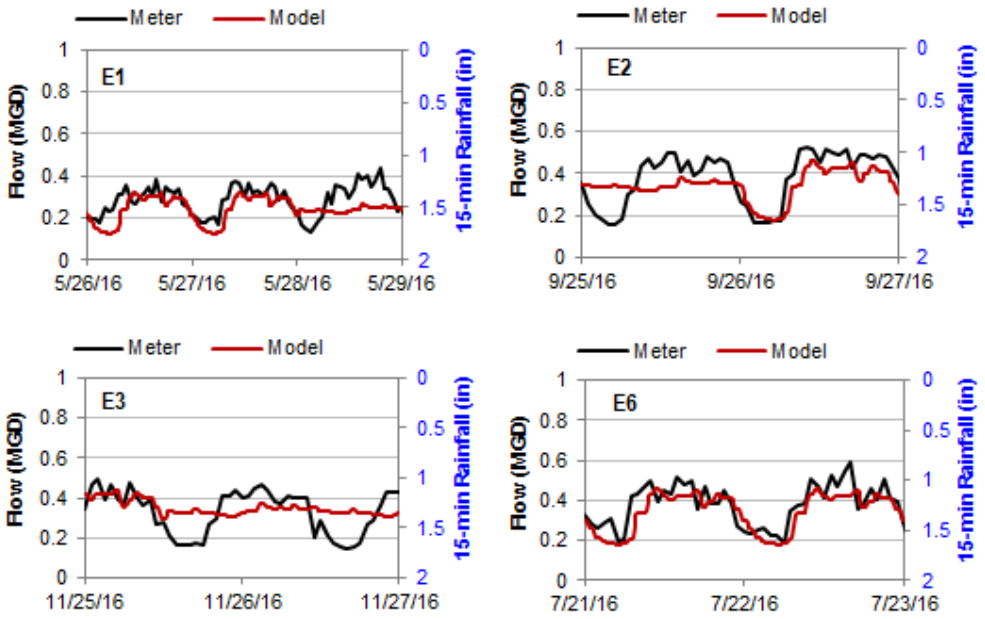


EFF-14 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

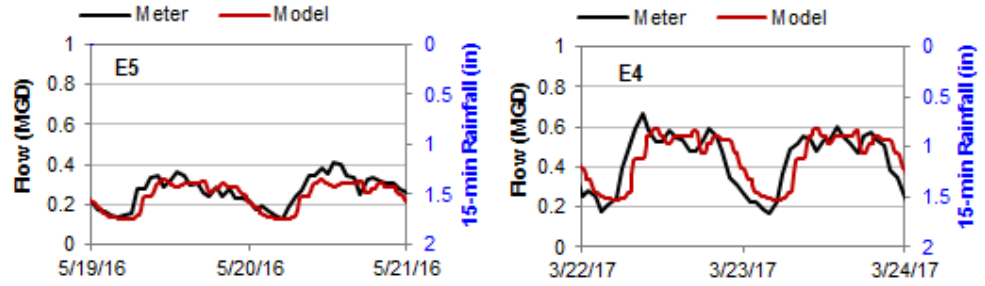


FLOW METER EFF-14 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

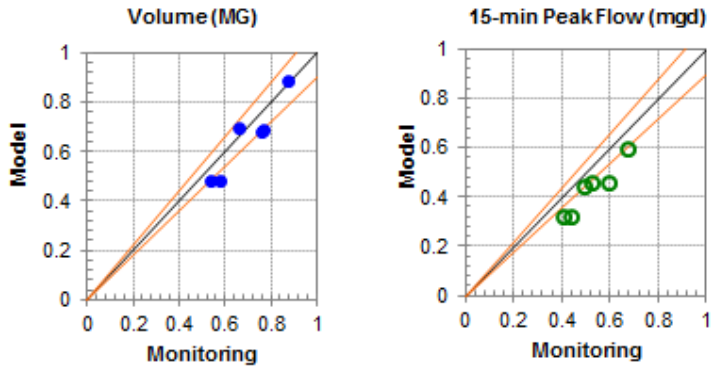
EFF-14 Model Calibration Results (Metered and Modeled Flow)



EFF-14 Model Validation Results (Metered and Modeled Flow)



EFF-14 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



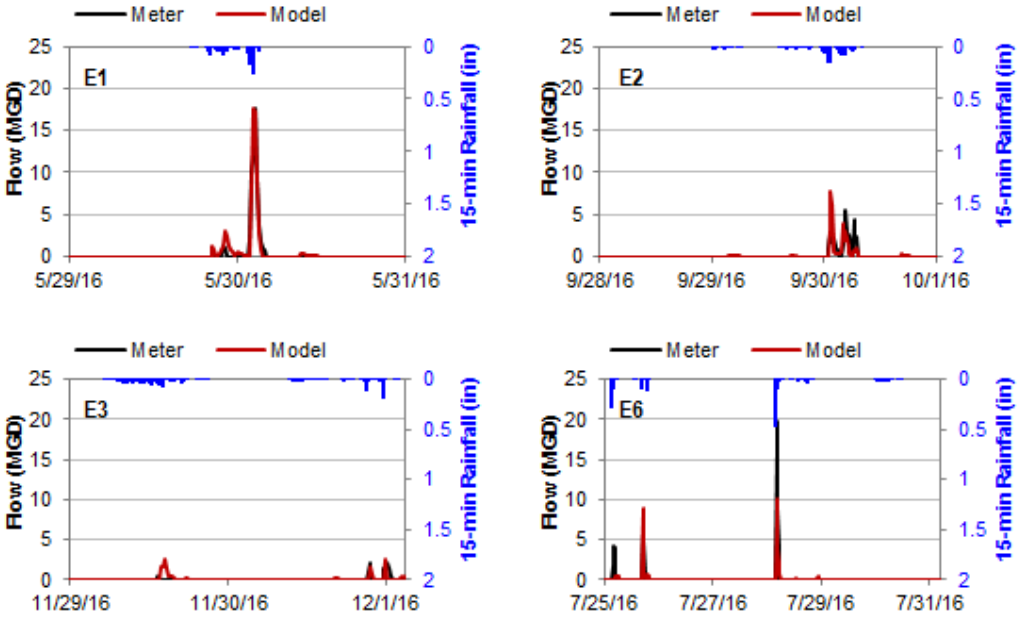
EFF-14 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.44	0.32	-10% to +10%	-26%	0.58	0.48	-10% to +10%	-17%
E2	0.53	0.46	-10% to +10%	-12%	0.76	0.69	-10% to +10%	-10%
E3	0.49	0.44	-10% to +10%	-11%	0.66	0.70	-10% to +10%	6%
E4	0.67	0.59	-10% to +10%	-11%	0.87	0.89	-10% to +10%	2%
E5	0.41	0.32	-10% to +10%	-21%	0.54	0.48	-10% to +10%	-9%
E6	0.59	0.46	-10% to +10%	-23%	0.76	0.68	-10% to +10%	-10%

EFF-14 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	3.17	3.78	-15% to +25%	19%	0.85	1.00	-10% to +20%	17%
E2	4.29	3.77	-15% to +25%	-12%	2.14	2.27	-10% to +20%	6%
E3	4.20	3.56	-15% to +25%	-15%	1.50	1.89	-10% to +20%	26%
E4	5.84	3.99	-15% to +25%	-32%	4.25	4.25	-10% to +20%	0%
E5	4.47	3.25	-15% to +25%	-27%	1.84	1.46	-10% to +20%	-21%
E6	7.32	3.42	-15% to +25%	-53%	1.05	1.05	-10% to +20%	0%

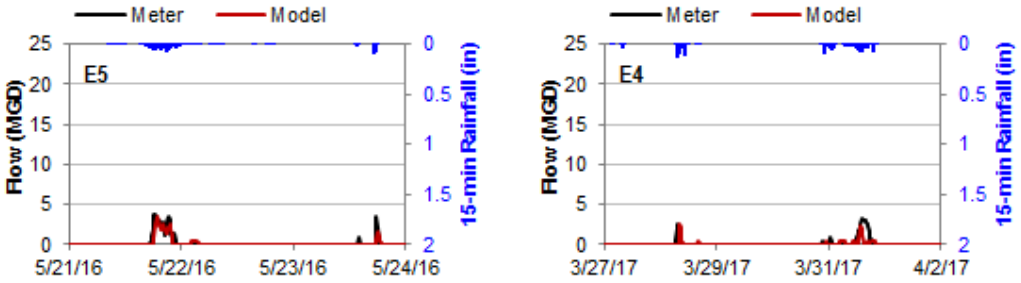
Note: Four of the six wet weather events are calibrated well within the industry criteria. The EFF-14 meter is the effluent meter from Regulator 14. The calibration of Regulator 14 meters (which include the IN-14, EFF-14 and CSO-14 meters) are more focused on the influent IN-14 meter and the overflow CSO-14 meter when the total metered influent flow (IN-14) is not balanced with the total metered effluent flow (EFF-14 plus CSO-14). Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER CSO-14 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

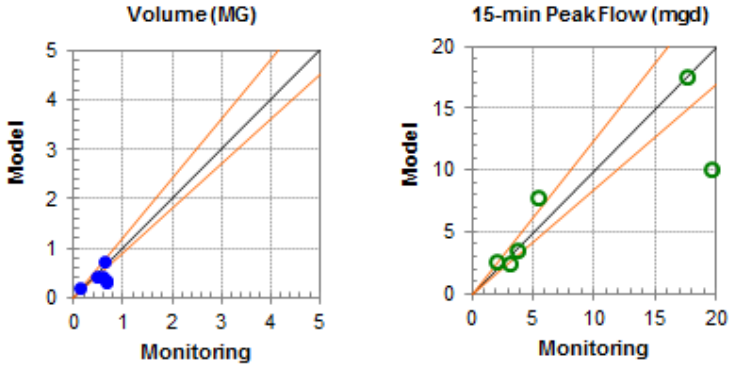
CSO-14 Model Calibration Results (Metered and Modeled Flow)



CSO-14 Model Validation Results (Metered and Modeled Flow)



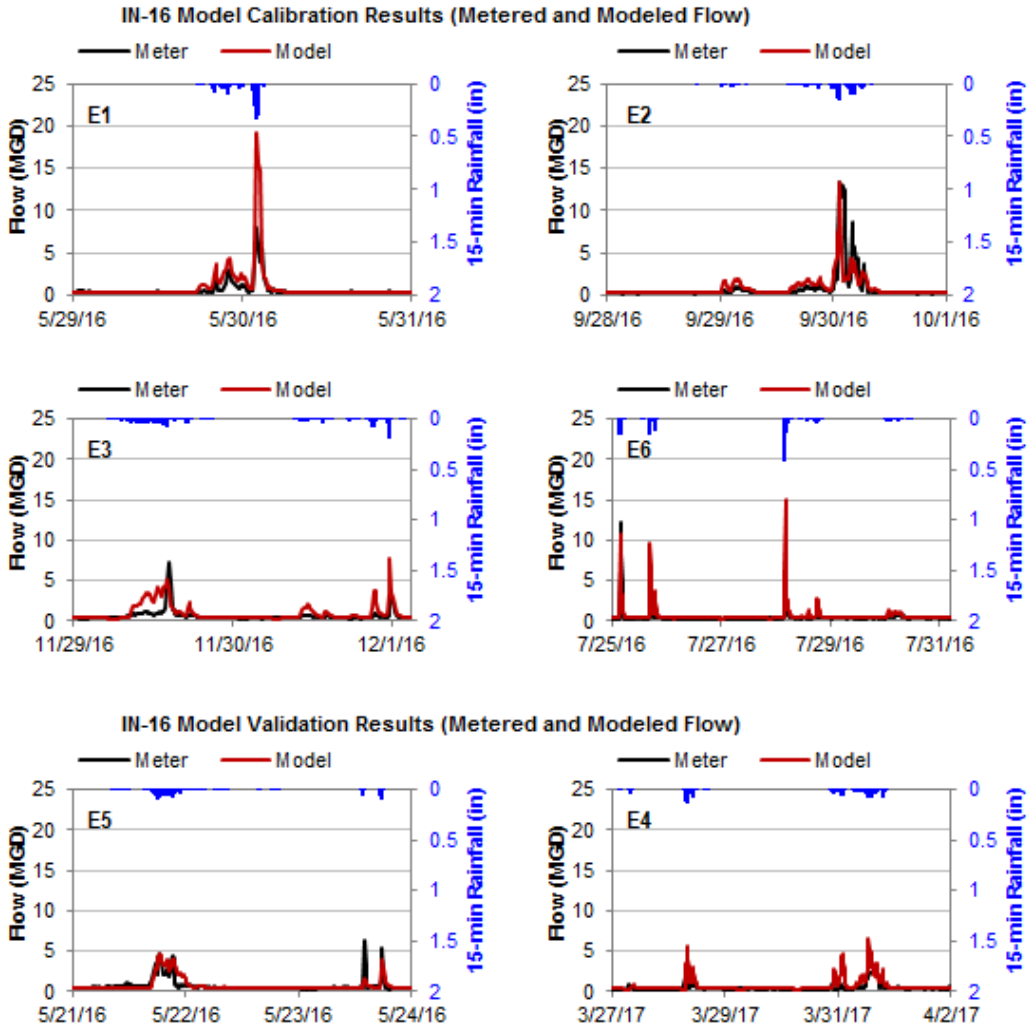
CSO-14 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



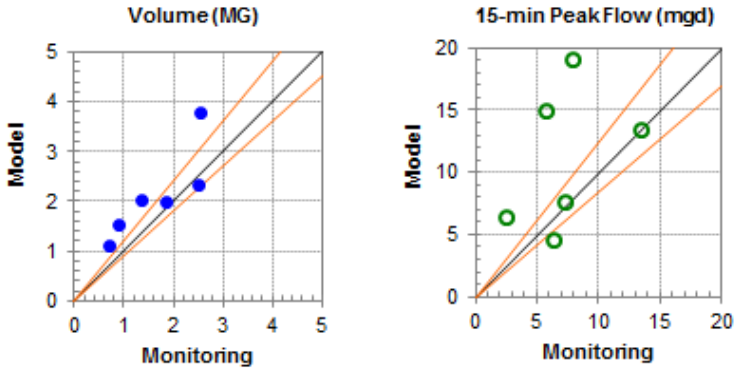
CSO-14 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	17.57	17.55	-15% to +25%	0%	0.63	0.75	-10% to +20%	19%
E2	5.47	7.82	-15% to +25%	43%	0.45	0.43	-10% to +20%	-4%
E3	2.03	2.59	-15% to +25%	27%	0.10	0.21	-10% to +20%	100%
E4	3.16	2.50	-15% to +25%	-21%	0.65	0.33	-10% to +20%	-49%
E5	3.76	3.49	-15% to +25%	-7%	0.57	0.42	-10% to +20%	-25%
E6	19.66	10.03	-15% to +25%	-49%	0.67	0.36	-10% to +20%	-46%

Note: Four of the six wet weather event volumes are calibrated well within or close to the industry criteria. This is the CSO meter from Regulator 14, the calibration of Regulator 14 meters (including Influent meter, effluent meter and CSO meter) are more focused on matching the peak flow and flow volume of the influent and CSO meters. The CSO meter flow volume is challenging to calibrate especially for the small overflow events like E3. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-16 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

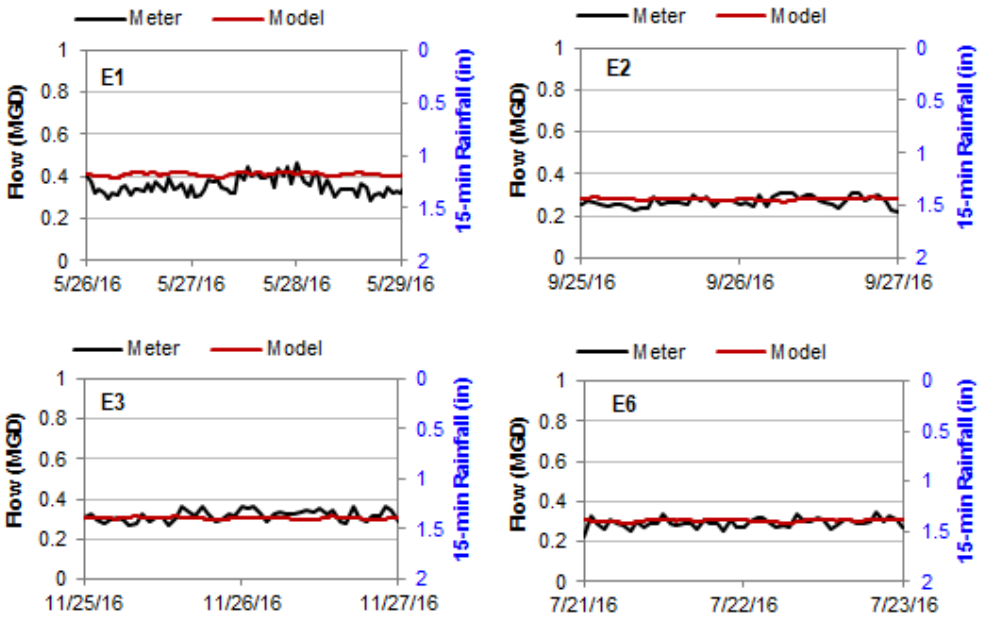


IN-16 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

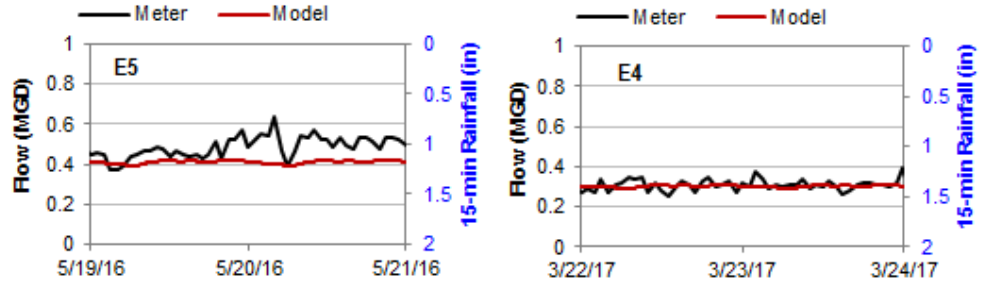


FLOW METER IN-16 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

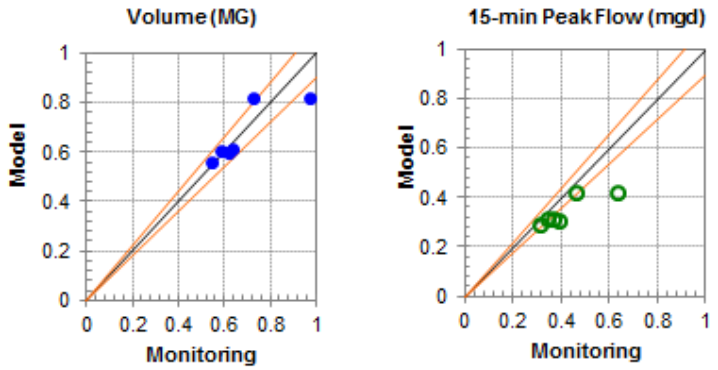
IN-16 Model Calibration Results (Metered and Modeled Flow)



IN-16 Model Validation Results (Metered and Modeled Flow)



IN-16 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



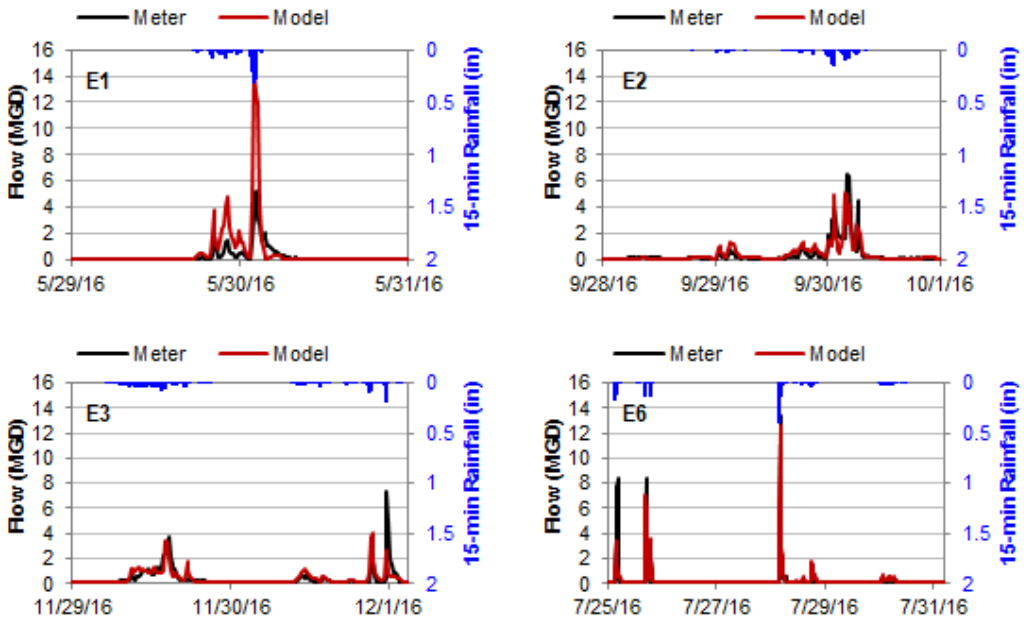
IN-16 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.46	0.42	-10% to +10%	-9%	0.72	0.82	-10% to +10%	13%
E2	0.31	0.29	-10% to +10%	-7%	0.54	0.56	-10% to +10%	4%
E3	0.37	0.31	-10% to +10%	-14%	0.63	0.61	-10% to +10%	-4%
E4	0.39	0.31	-10% to +10%	-20%	0.62	0.60	-10% to +10%	-3%
E5	0.64	0.42	-10% to +10%	-34%	0.97	0.82	-10% to +10%	-16%
E6	0.35	0.31	-10% to +10%	-9%	0.59	0.61	-10% to +10%	4%

IN-16 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	7.94	19.10	-15% to +25%	141%	0.88	1.56	-10% to +20%	77%
E2	13.37	13.45	-15% to +25%	1%	2.48	2.35	-10% to +20%	-5%
E3	7.23	7.64	-15% to +25%	6%	1.35	2.05	-10% to +20%	52%
E4	2.48	6.49	-15% to +25%	161%	2.54	3.80	-10% to +20%	50%
E5	6.35	4.62	-15% to +25%	-27%	1.83	2.02	-10% to +20%	10%
E6	5.72	15.05	-15% to +25%	163%	0.68	1.14	-10% to +20%	66%

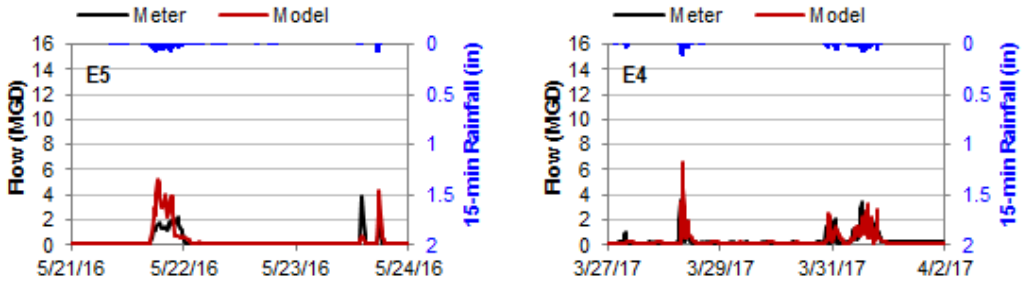
Note: Only two of the six wet weather event volumes are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E1, E4, E5, and E6) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-17 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

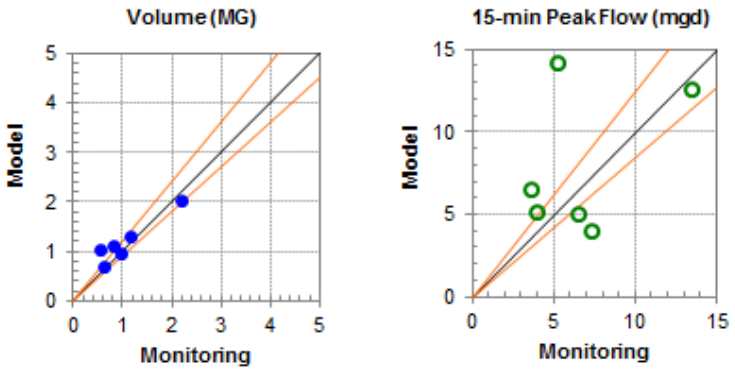
IN-17 Model Calibration Results (Metered and Modeled Flow)



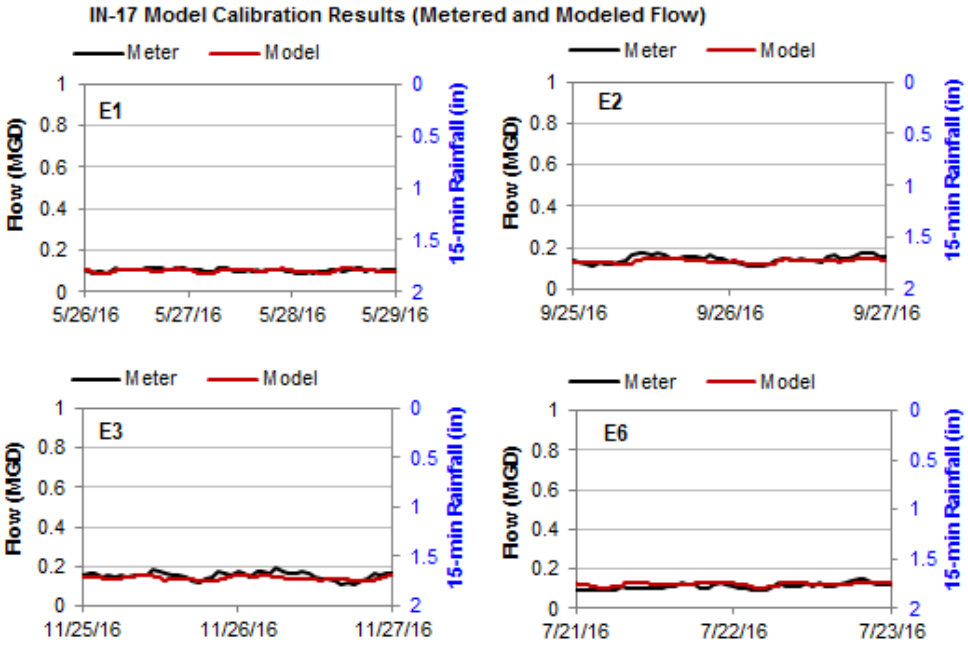
IN-17 Model Validation Results (Metered and Modeled Flow)

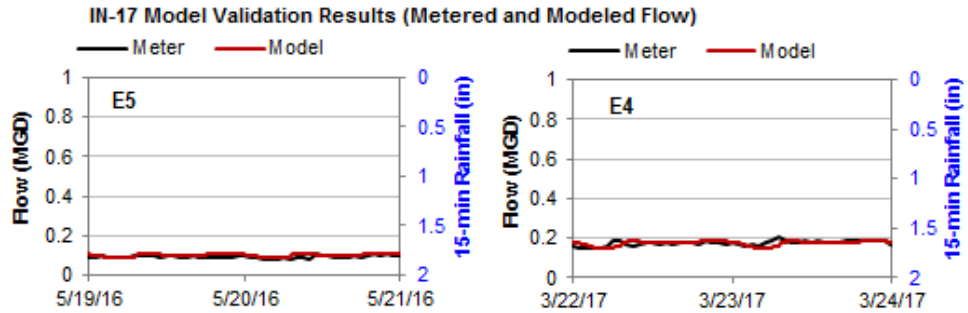


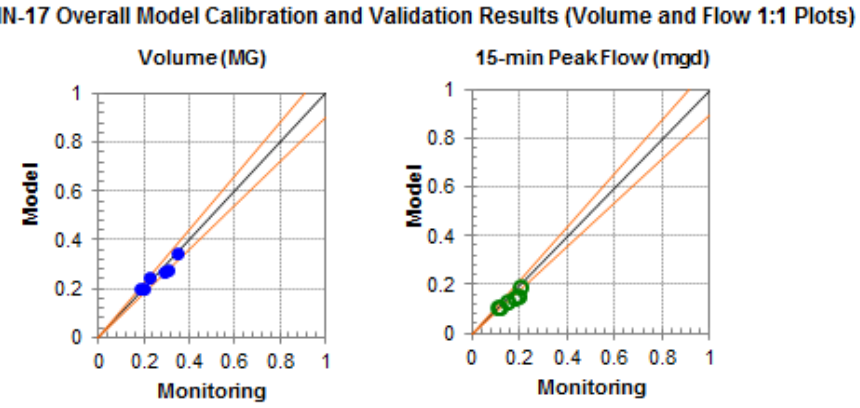
IN-17 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



FLOW METER IN-17 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events







IN-17 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.12	0.11	-10% to +10%	-6%	0.20	0.20	-10% to +10%	0%
E2	0.18	0.15	-10% to +10%	-15%	0.29	0.27	-10% to +10%	-7%
E3	0.19	0.15	-10% to +10%	-19%	0.31	0.28	-10% to +10%	-9%
E4	0.20	0.19	-10% to +10%	-6%	0.35	0.35	-10% to +10%	0%
E5	0.11	0.11	-10% to +10%	1%	0.19	0.20	-10% to +10%	9%
E6	0.15	0.13	-10% to +10%	-11%	0.22	0.24	-10% to +10%	9%

IN-17 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	5.19	14.26	-15% to +25%	175%	0.53	1.06	-10% to +20%	101%
E2	6.54	5.11	-15% to +25%	-22%	1.15	1.30	-10% to +20%	13%
E3	7.31	4.01	-15% to +25%	-45%	0.95	0.99	-10% to +20%	4%
E4	3.64	6.57	-15% to +25%	81%	2.19	2.05	-10% to +20%	-6%
E5	3.95	5.17	-15% to +25%	31%	0.79	1.10	-10% to +20%	39%
E6	13.38	12.67	-15% to +25%	-5%	0.61	0.72	-10% to +20%	18%

Note: Only two of the six wet weather event volumes are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E1, E4) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

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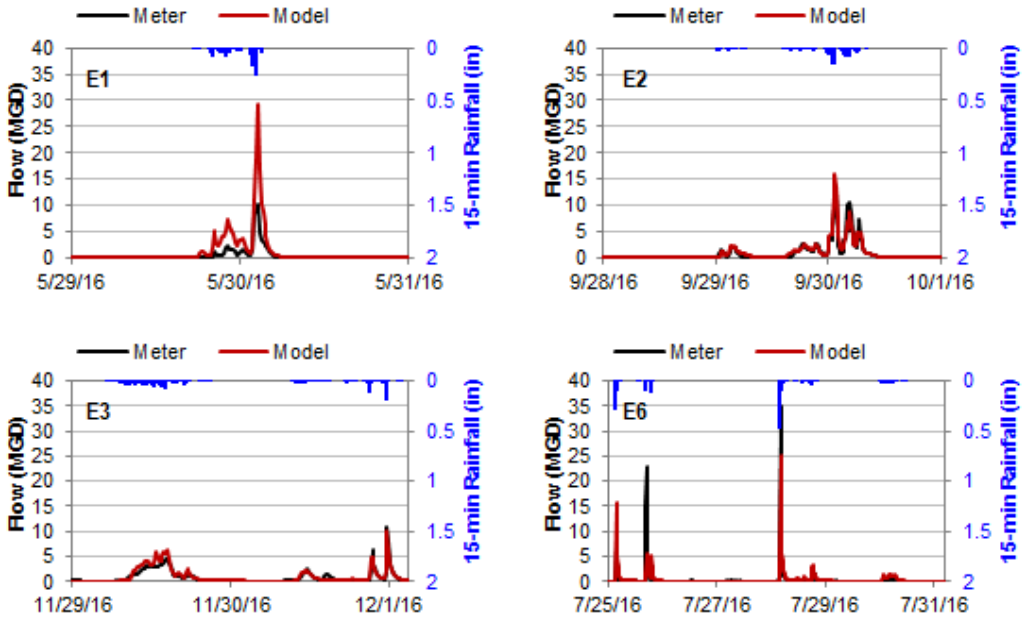
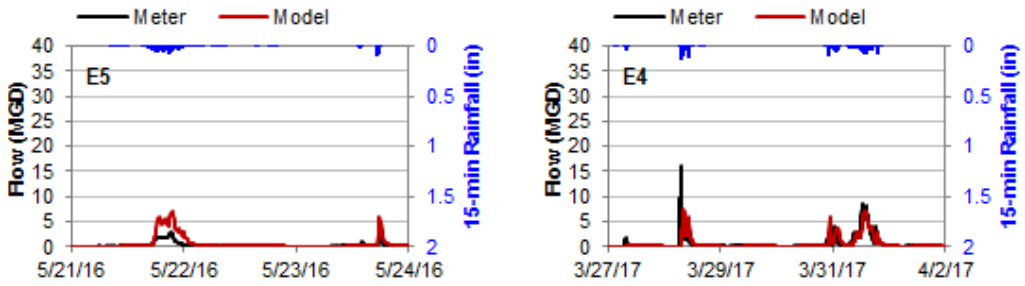
FLOW METER IN-18 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

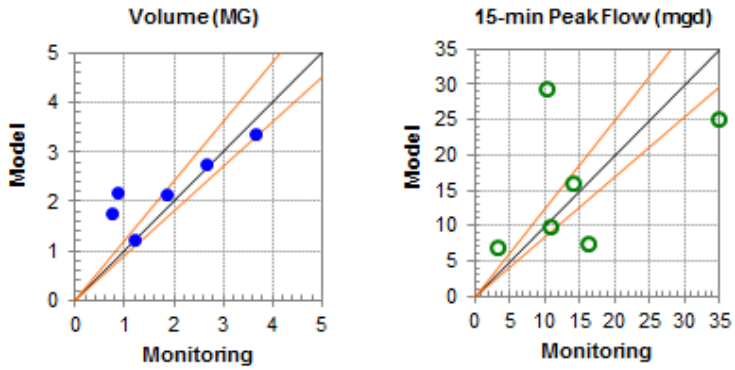
IN-18 Model Calibration Results (Metered and Modeled Flow)



IN-18 Model Validation Results (Metered and Modeled Flow)

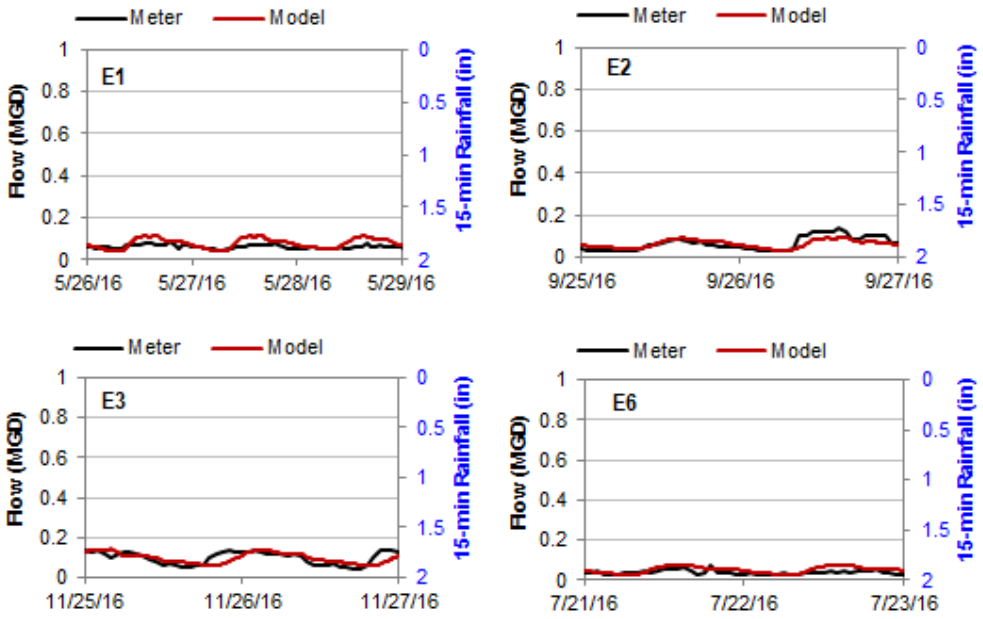


IN-18 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

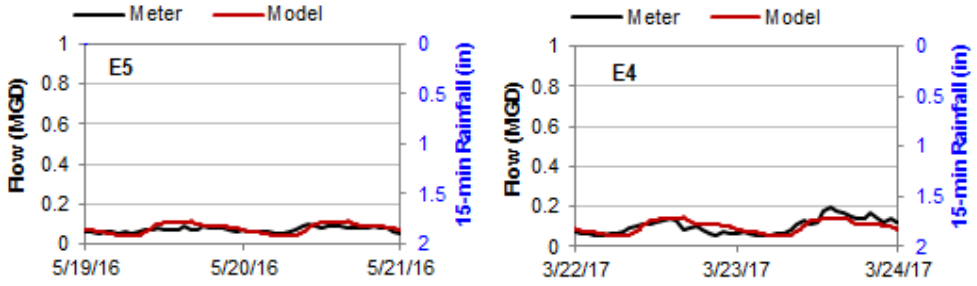


FLOW METER IN-18 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

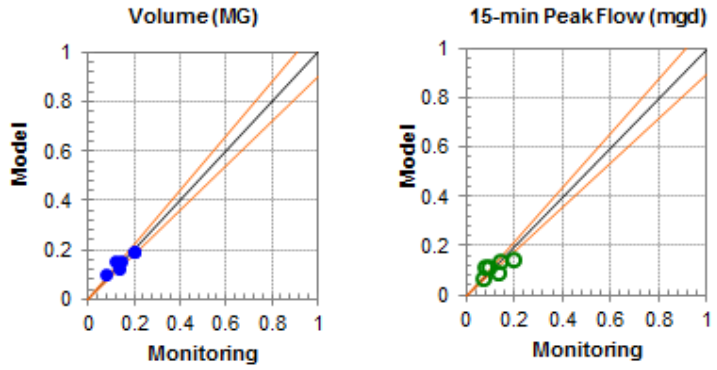
IN-18 Model Calibration Results (Metered and Modeled Flow)



IN-18 Model Validation Results (Metered and Modeled Flow)



IN-18 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



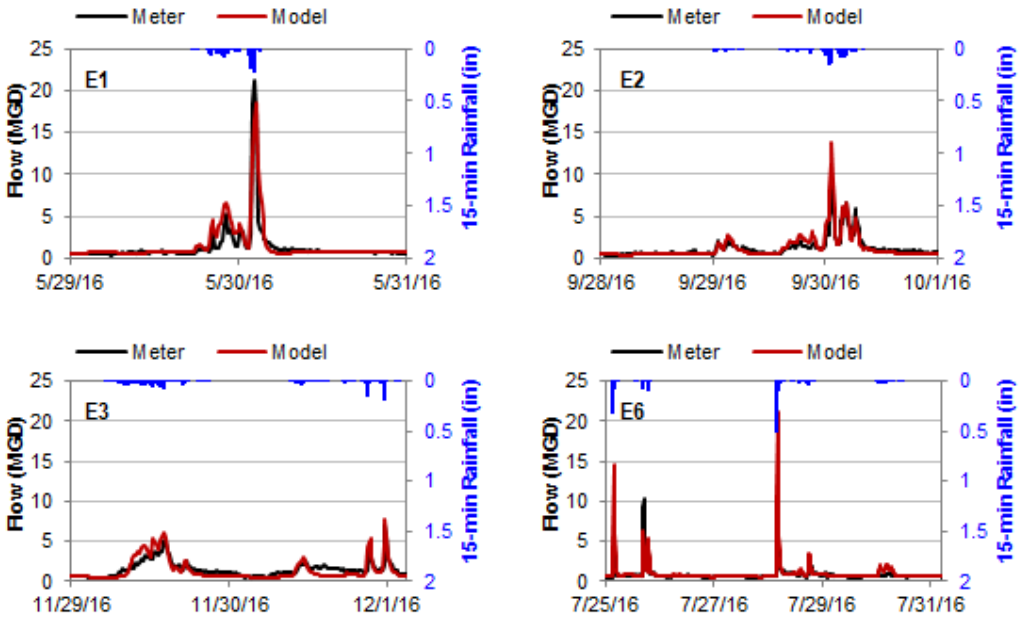
IN-18 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.08	0.11	-10% to +10%	40%	0.12	0.16	-10% to +10%	32%
E2	0.14	0.09	-10% to +10%	-32%	0.13	0.13	-10% to +10%	-5%
E3	0.14	0.14	-10% to +10%	1%	0.20	0.19	-10% to +10%	-1%
E4	0.20	0.14	-10% to +10%	-27%	0.20	0.20	-10% to +10%	-3%
E5	0.09	0.11	-10% to +10%	20%	0.14	0.16	-10% to +10%	9%
E6	0.07	0.07	-10% to +10%	2%	0.08	0.10	-10% to +10%	33%

IN-18 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	10.33	29.33	-15% to +25%	184%	0.83	2.19	-10% to +20%	162%
E2	14.07	16.01	-15% to +25%	14%	2.64	2.78	-10% to +20%	5%
E3	10.70	10.00	-15% to +25%	-7%	1.84	2.14	-10% to +20%	16%
E4	16.28	7.62	-15% to +25%	-53%	3.63	3.39	-10% to +20%	-7%
E5	3.15	6.92	-15% to +25%	119%	0.75	1.78	-10% to +20%	138%
E6	34.92	25.11	-15% to +25%	-28%	1.19	1.22	-10% to +20%	2%

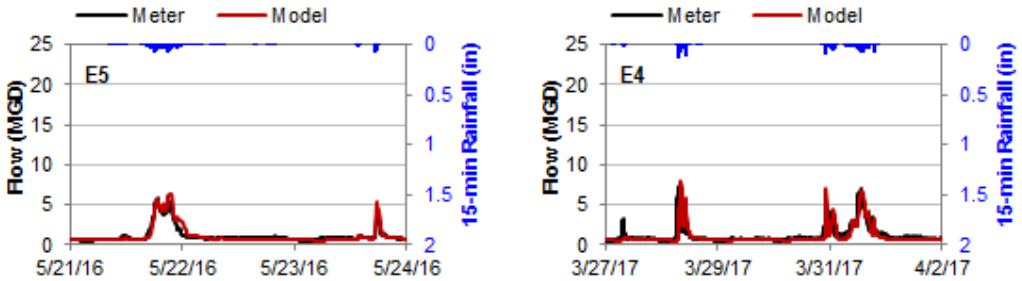
Note: Only two of the six wet weather event volumes are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E1, E4, E5, and E6) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-19-1 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

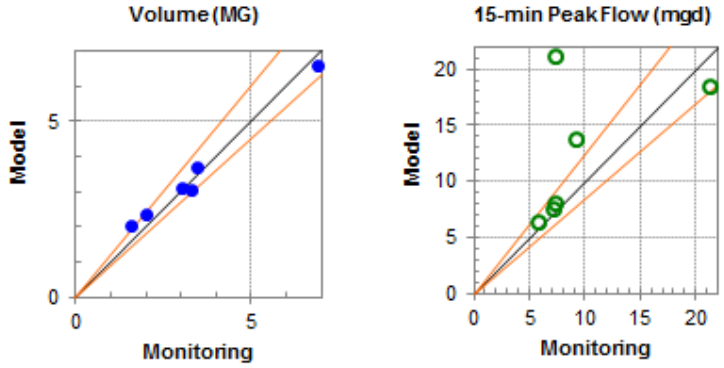
IN-19-1 Model Calibration Results (Metered and Modeled Flow)



IN-19-1 Model Validation Results (Metered and Modeled Flow)

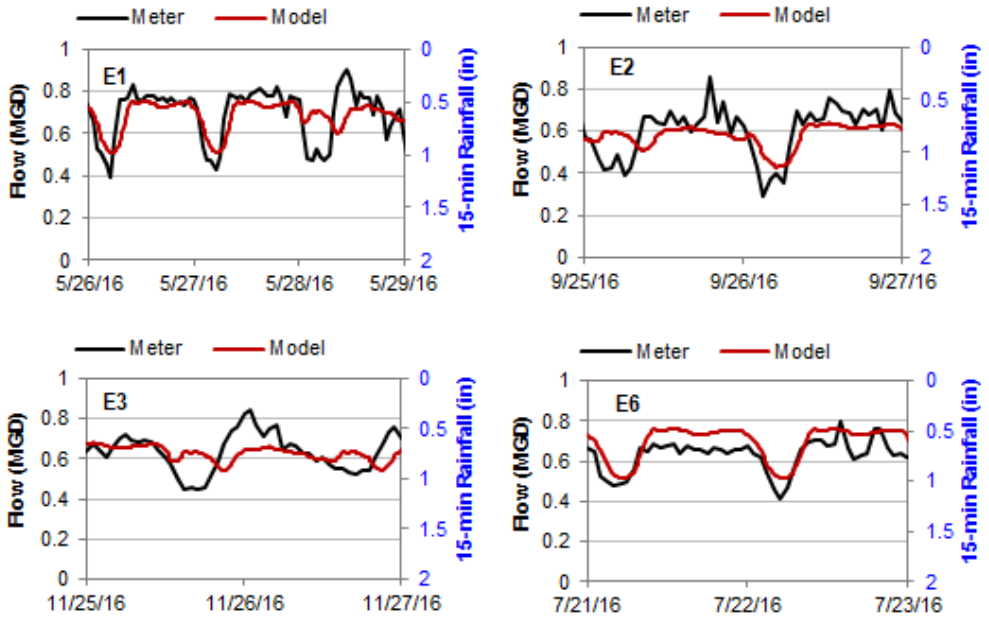


IN-19-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

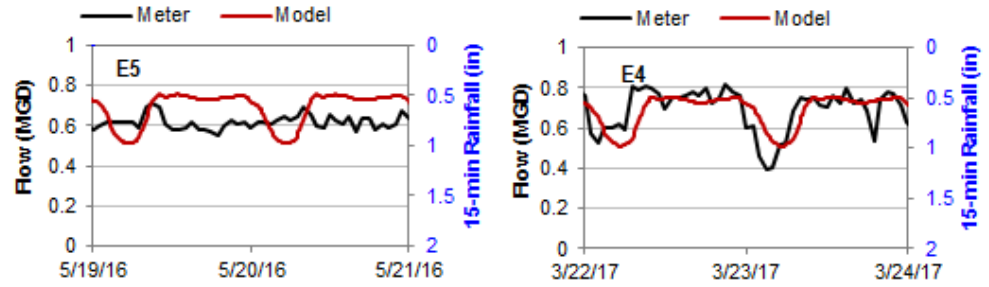


FLOW METER IN-19-1 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

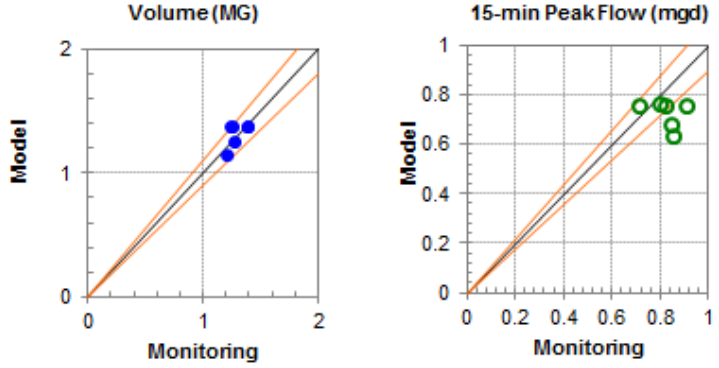
IN-19-1 Model Calibration Results (Metered and Modeled Flow)



IN-19-1 Model Validation Results (Metered and Modeled Flow)



IN-19-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



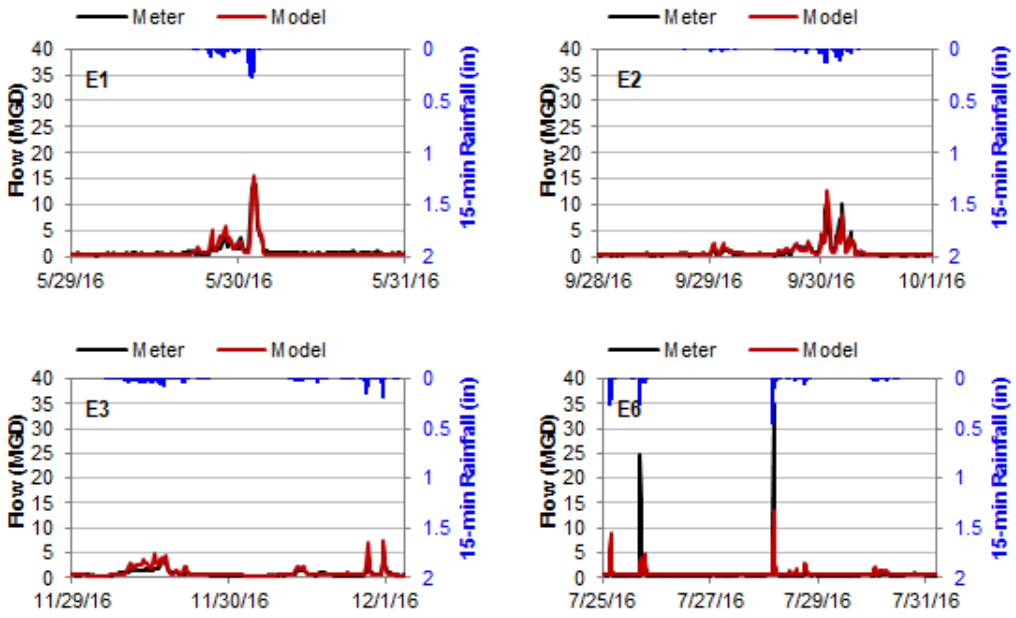
IN-19-1 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.91	0.76	-10% to +10%	-17%	1.38	1.37	-10% to +10%	-1%
E2	0.85	0.64	-10% to +10%	-25%	1.20	1.16	-10% to +10%	-4%
E3	0.84	0.68	-10% to +10%	-20%	1.27	1.25	-10% to +10%	-2%
E4	0.82	0.76	-10% to +10%	-8%	1.38	1.37	-10% to +10%	0%
E5	0.72	0.76	-10% to +10%	6%	1.24	1.38	-10% to +10%	11%
E6	0.79	0.76	-10% to +10%	-4%	1.26	1.39	-10% to +10%	10%

IN-19-1 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	21.30	18.54	-15% to +25%	-13%	2.01	2.36	-10% to +20%	17%
E2	9.15	13.77	-15% to +25%	50%	3.42	3.71	-10% to +20%	9%
E3	7.04	7.66	-15% to +25%	9%	3.28	3.09	-10% to +20%	-6%
E4	7.33	8.01	-15% to +25%	9%	6.87	6.61	-10% to +20%	-4%
E5	5.73	6.40	-15% to +25%	12%	3.00	3.11	-10% to +20%	4%
E6	7.26	21.13	-15% to +25%	191%	1.56	2.04	-10% to +20%	30%

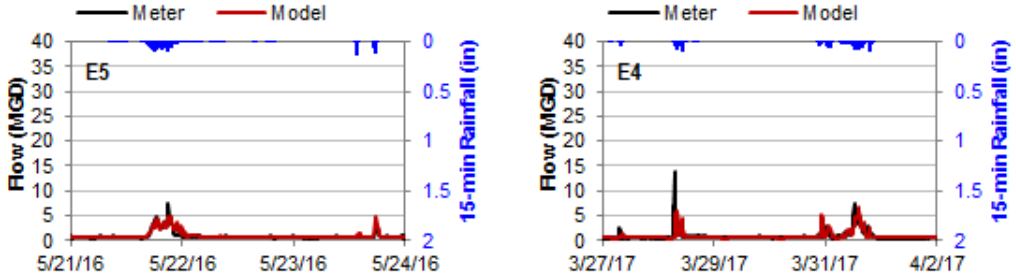
Note: Four of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E2 and E6) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-19-2 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

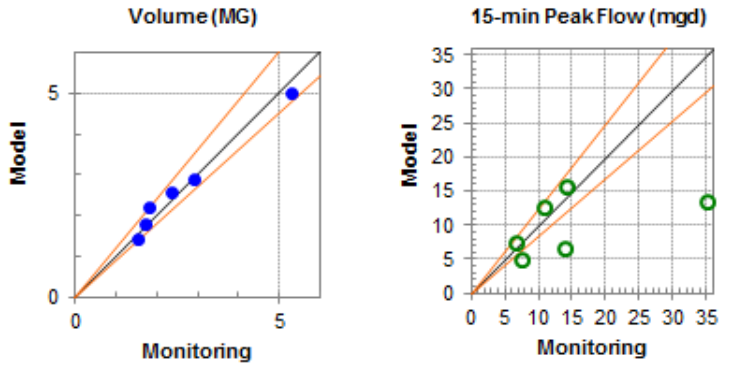
IN-19-2 Model Calibration Results (Metered and Modeled Flow)



IN-19-2 Model Validation Results (Metered and Modeled Flow)

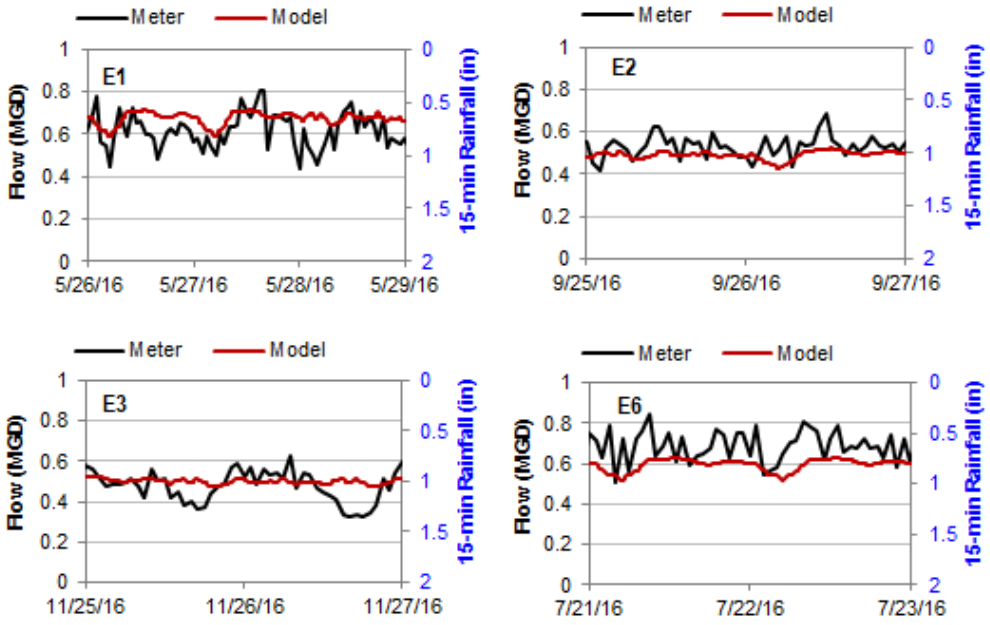


IN-19-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

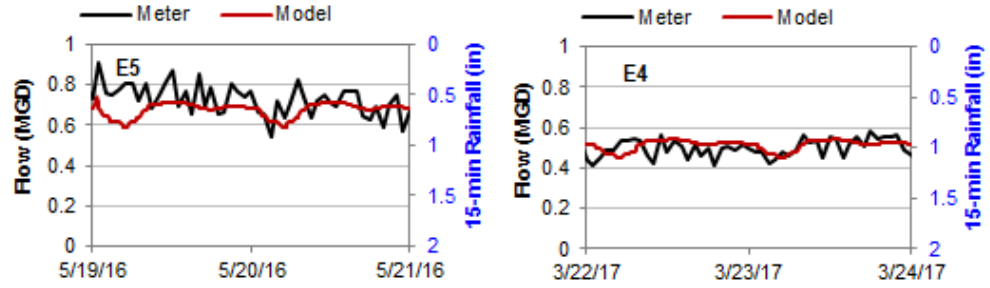


FLOW METER IN-19-2 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

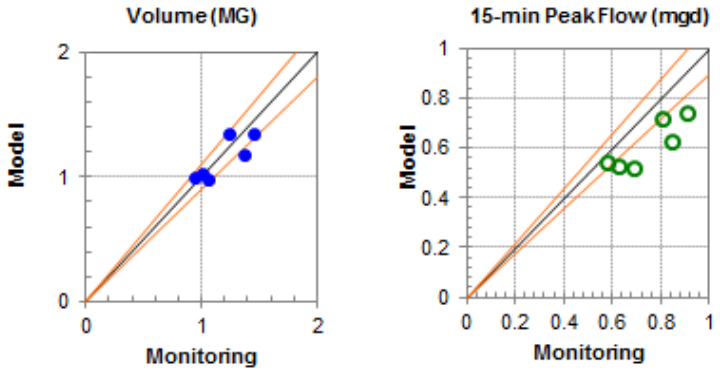
IN-19-2 Model Calibration Results (Metered and Modeled Flow)



IN-19-2 Model Validation Results (Metered and Modeled Flow)



IN-19-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



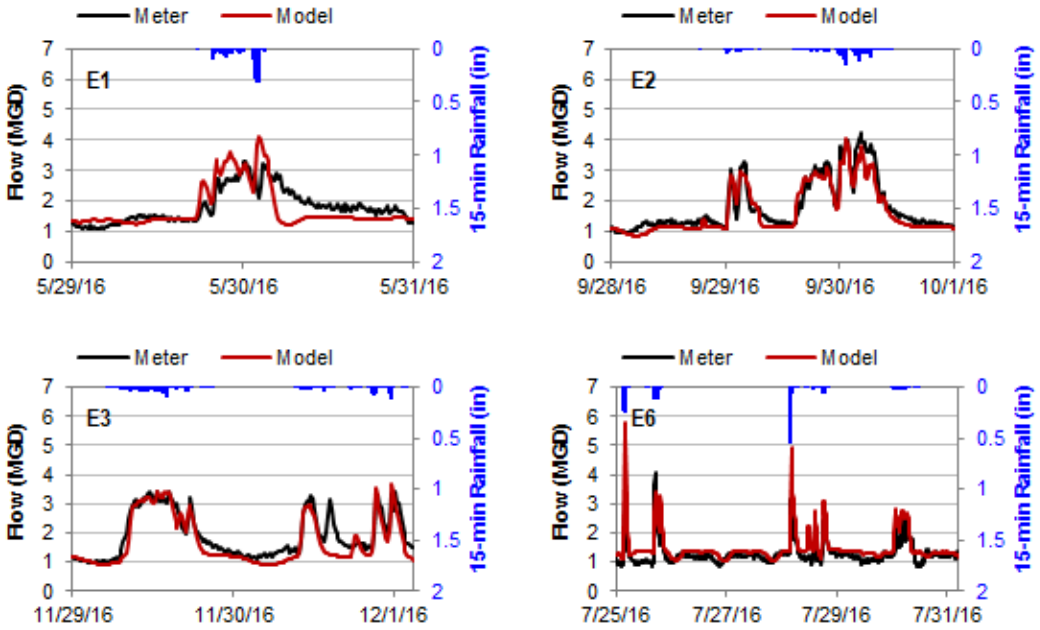
IN-19-2 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.81	0.72	-10% to +10%	-11%	1.24	1.35	-10% to +10%	9%
E2	0.69	0.52	-10% to +10%	-24%	1.06	0.98	-10% to +10%	-7%
E3	0.63	0.53	-10% to +10%	-16%	0.95	1.00	-10% to +10%	5%
E4	0.58	0.54	-10% to +10%	-6%	1.00	1.03	-10% to +10%	3%
E5	0.91	0.74	-10% to +10%	-18%	1.45	1.35	-10% to +10%	-7%
E6	0.85	0.63	-10% to +10%	-25%	1.37	1.19	-10% to +10%	-13%

IN-19-2 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	14.15	15.72	-15% to +25%	11%	1.69	1.80	-10% to +20%	6%
E2	10.79	12.67	-15% to +25%	18%	2.90	2.91	-10% to +20%	0%
E3	6.61	7.58	-15% to +25%	15%	1.80	2.22	-10% to +20%	23%
E4	13.88	6.56	-15% to +25%	-53%	5.29	4.99	-10% to +20%	-6%
E5	7.59	4.90	-15% to +25%	-35%	2.37	2.60	-10% to +20%	10%
E6	35.07	13.51	-15% to +25%	-61%	1.51	1.44	-10% to +20%	-4%

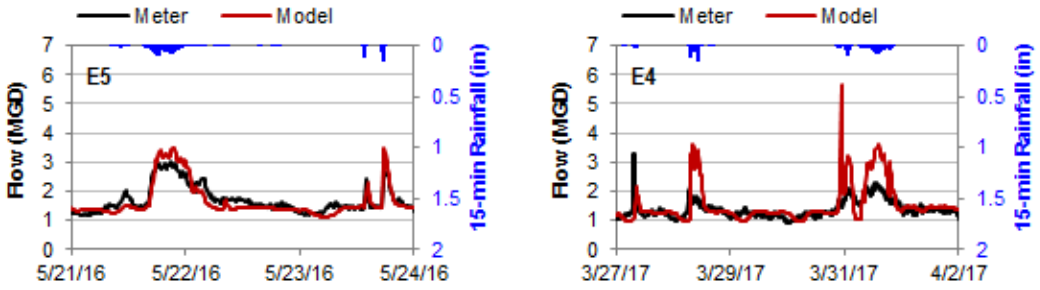
Note: Four of the six wet weather events are calibrated well within or close to the industry criteria. Flow meter data recorded for some of the events (E4, E5 and E6) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER EFF-19 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

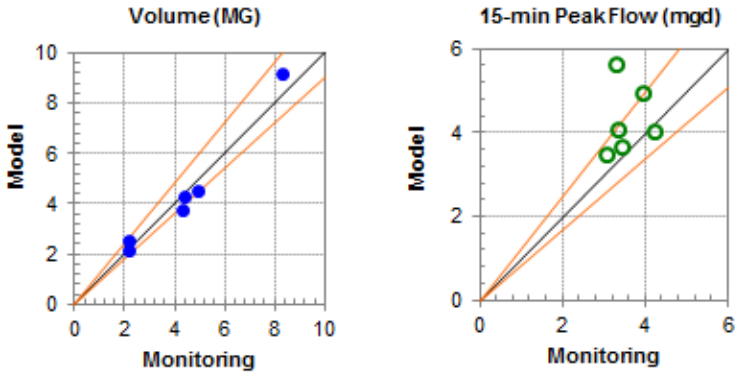
EFF-19 Model Calibration Results (Metered and Modeled Flow)



EFF-19 Model Validation Results (Metered and Modeled Flow)

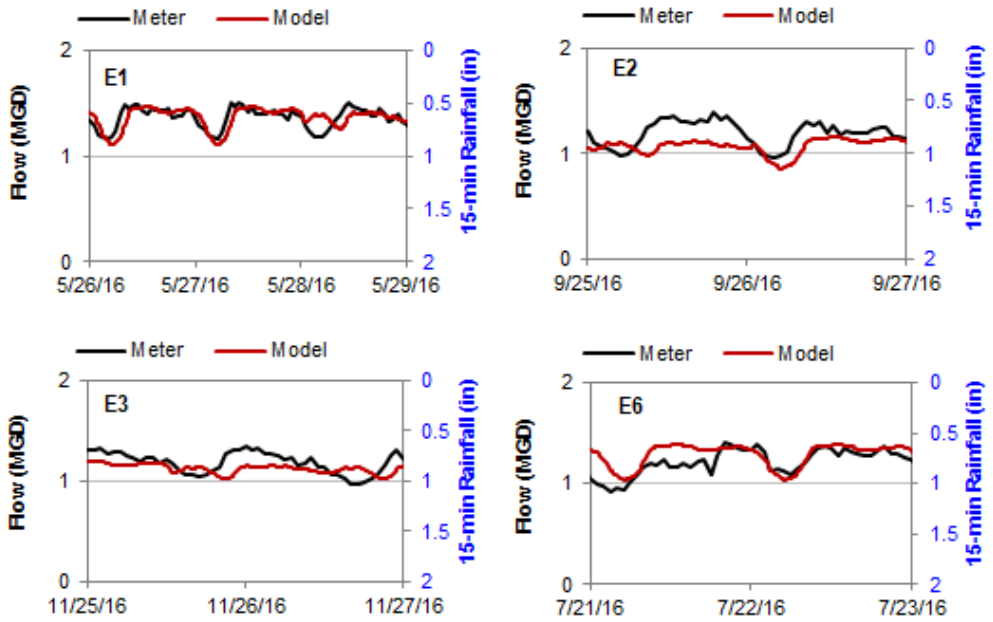


EFF-19 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

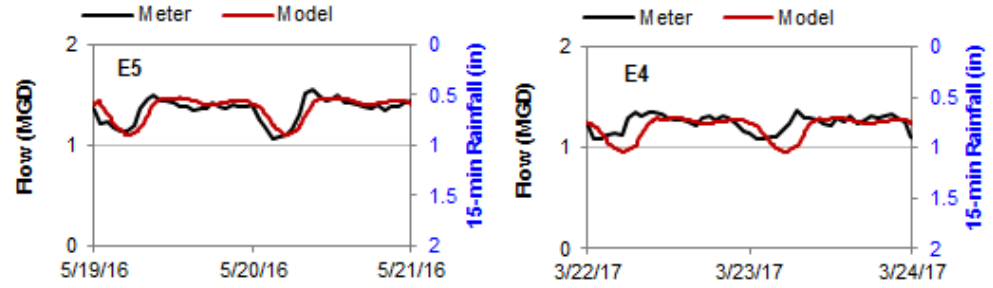


LOW METER EFF-19 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

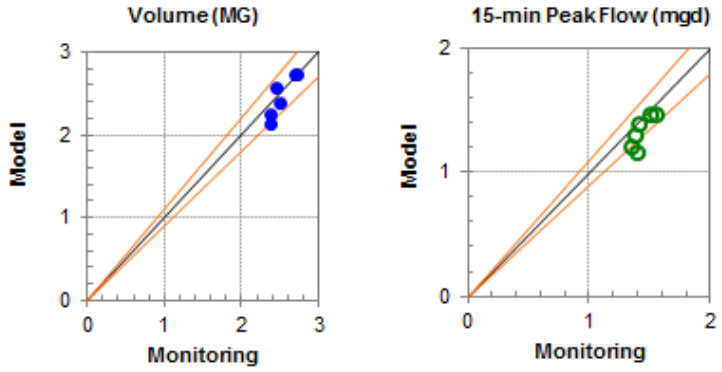
EFF-19 Model Calibration Results (Metered and Modeled Flow)



EFF-19 Model Validation Results (Metered and Modeled Flow)



EFF-19 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



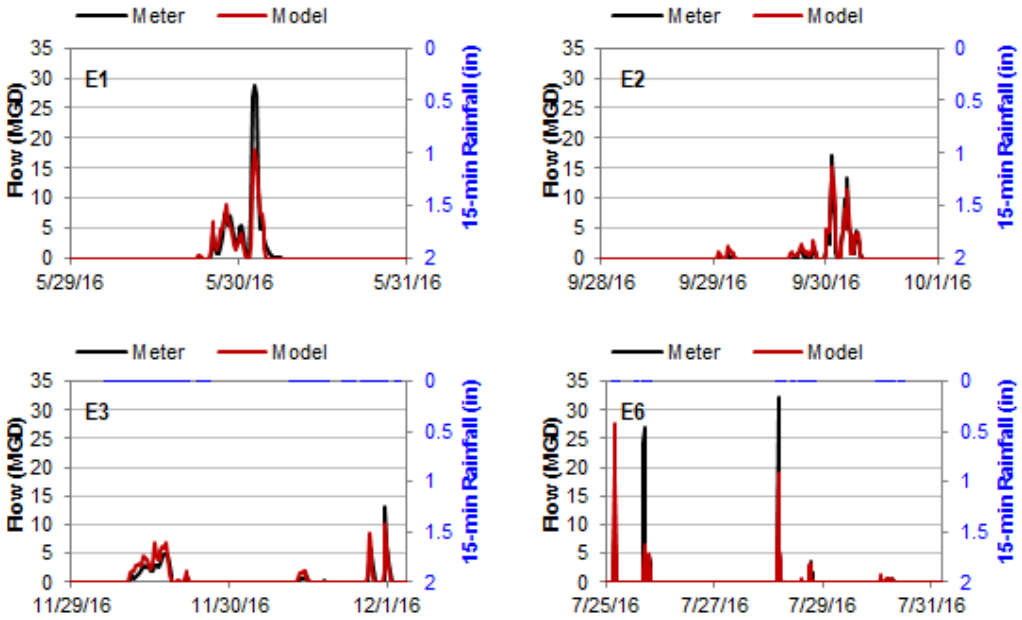
EFF-19 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	1.51	1.47	-10% to +10%	-2%	2.72	2.73	-10% to +10%	0%
E2	1.40	1.16	-10% to +10%	-17%	2.38	2.14	-10% to +10%	-10%
E3	1.34	1.21	-10% to +10%	-10%	2.37	2.25	-10% to +10%	-5%
E4	1.38	1.30	-10% to +10%	-6%	2.49	2.40	-10% to +10%	-4%
E5	1.55	1.47	-10% to +10%	-5%	2.70	2.73	-10% to +10%	1%
E6	1.41	1.39	-10% to +10%	-1%	2.44	2.58	-10% to +10%	6%

EFF-19 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	3.33	4.09	-15% to +25%	23%	2.18	2.13	-10% to +20%	-2%
E2	4.22	4.05	-15% to +25%	-4%	4.90	4.55	-10% to +20%	-7%
E3	3.43	3.69	-15% to +25%	8%	4.33	3.79	-10% to +20%	-12%
E4	3.28	5.63	-15% to +25%	72%	8.28	9.18	-10% to +20%	11%
E5	3.05	3.51	-15% to +25%	15%	4.41	4.31	-10% to +20%	-2%
E6	3.93	4.96	-15% to +25%	26%	2.12	2.54	-10% to +20%	20%

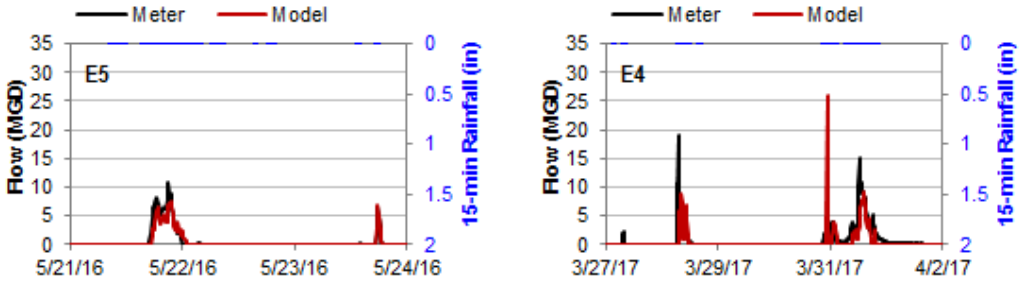
Note: Five of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E4) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER CSO-19 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

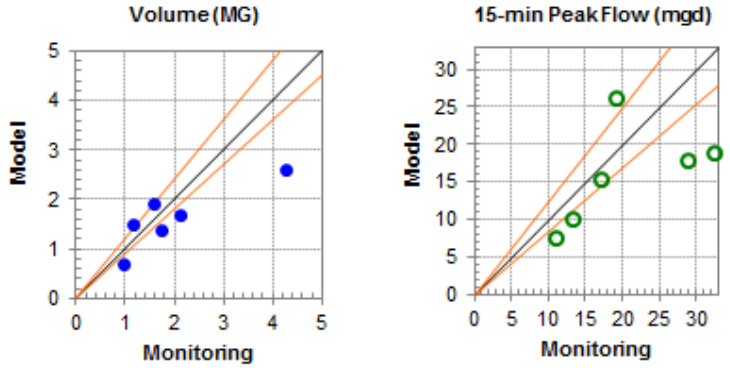
CSO-19 Model Calibration Results (Metered and Modeled Flow)



CSO-19 Model Validation Results (Metered and Modeled Flow)



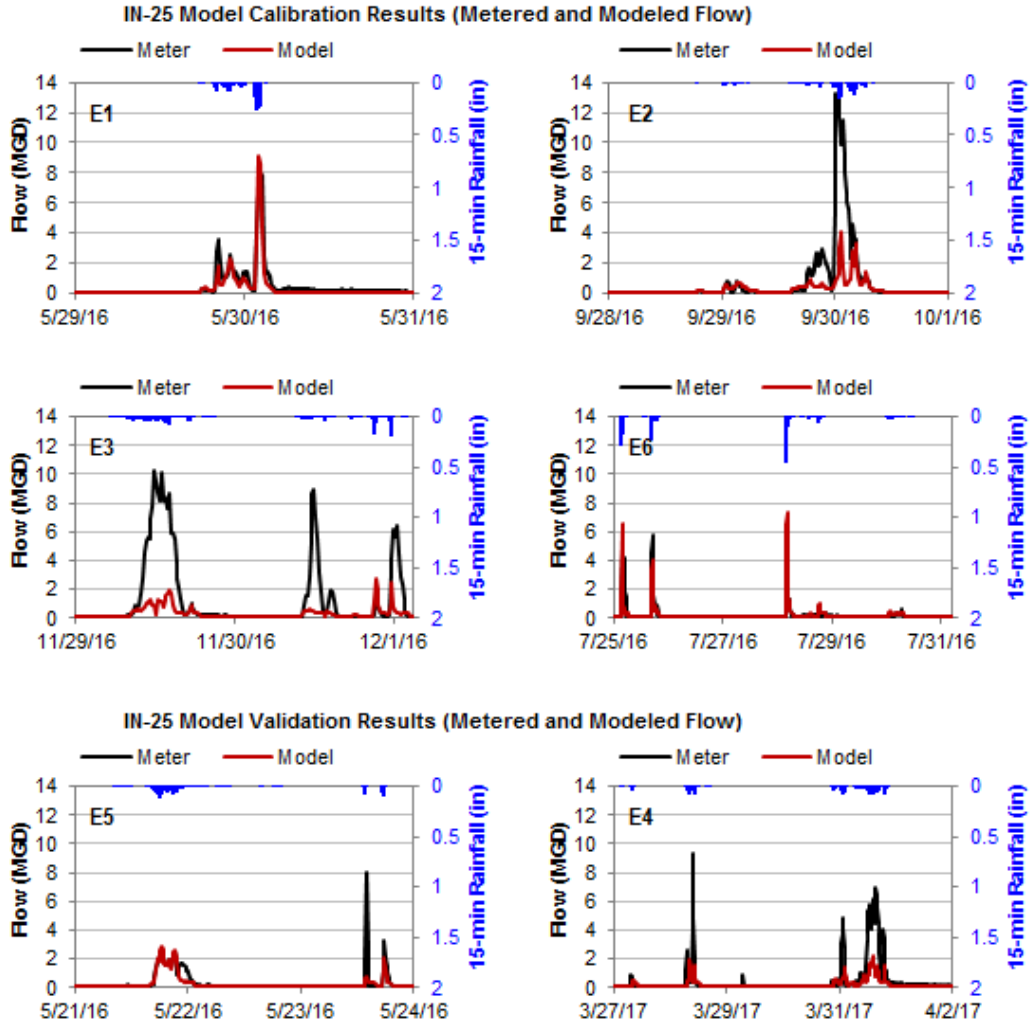
CSO-19 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



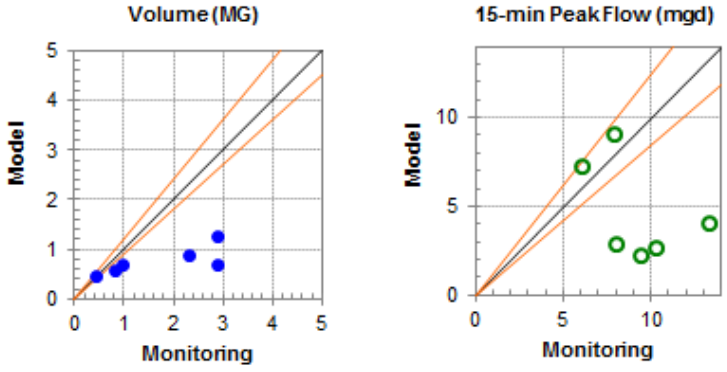
CSO-19 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	28.77	17.93	-15% to +25%	-38%	2.13	1.70	-10% to +20%	-20%
E2	17.03	15.36	-15% to +25%	-10%	1.56	1.91	-10% to +20%	22%
E3	13.23	10.18	-15% to +25%	-23%	1.16	1.51	-10% to +20%	30%
E4	19.16	26.11	-15% to +25%	36%	4.26	2.63	-10% to +20%	-38%
E5	10.84	7.63	-15% to +25%	-30%	1.72	1.40	-10% to +20%	-19%
E6	32.37	19.04	-15% to +25%	-41%	0.98	0.70	-10% to +20%	-28%

Note: Three of the six wet weather events are calibrated well within or close to the industry criteria. Flow meter data recorded for some of the events (E1 and E6) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall Regulator 19 flow meters, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-25 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

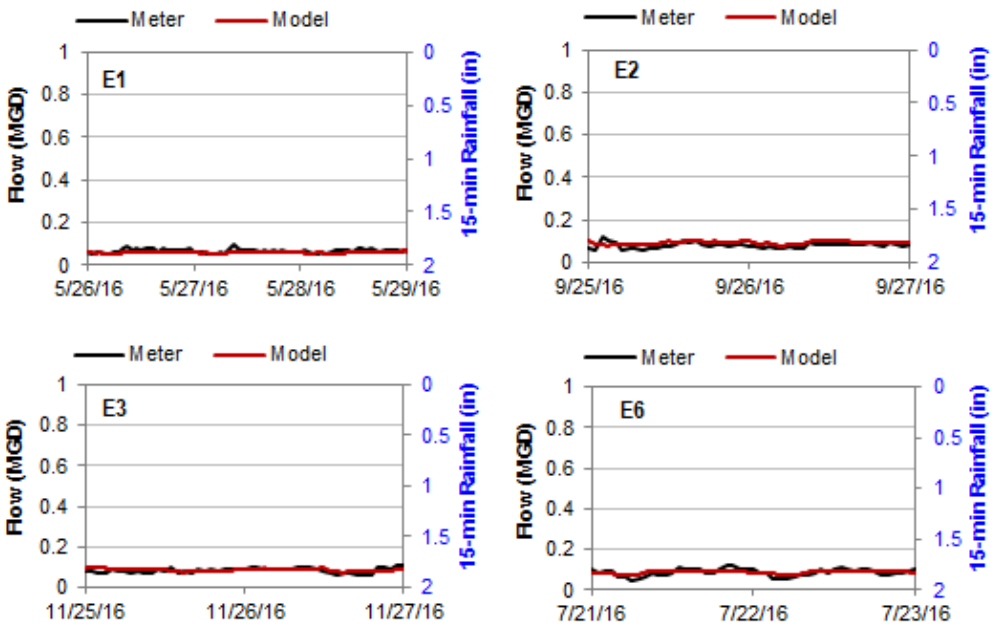


IN-25 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

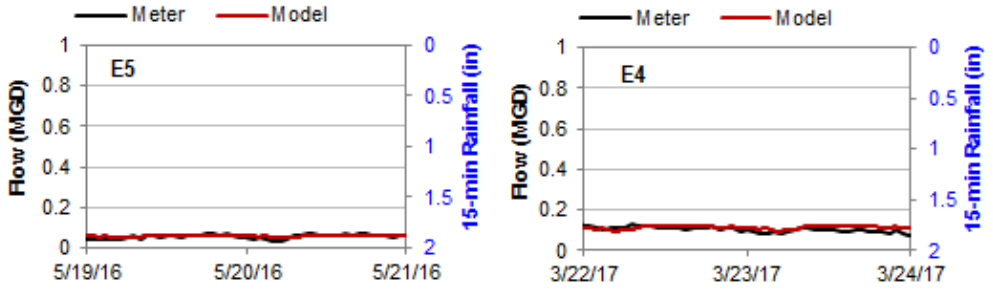


FLOW METER IN-25 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

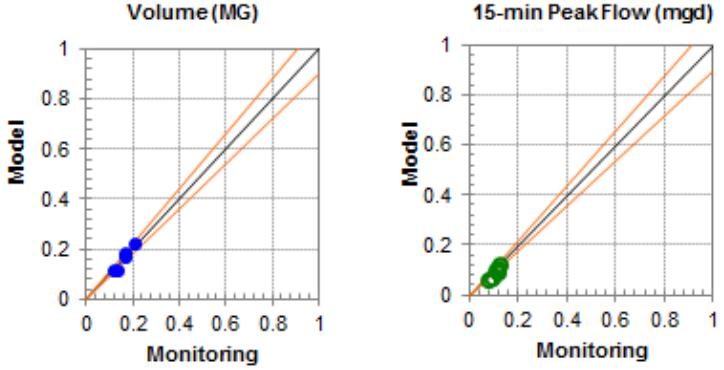
IN-25 Model Calibration Results (Metered and Modeled Flow)



IN-25 Model Validation Results (Metered and Modeled Flow)



IN-25 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

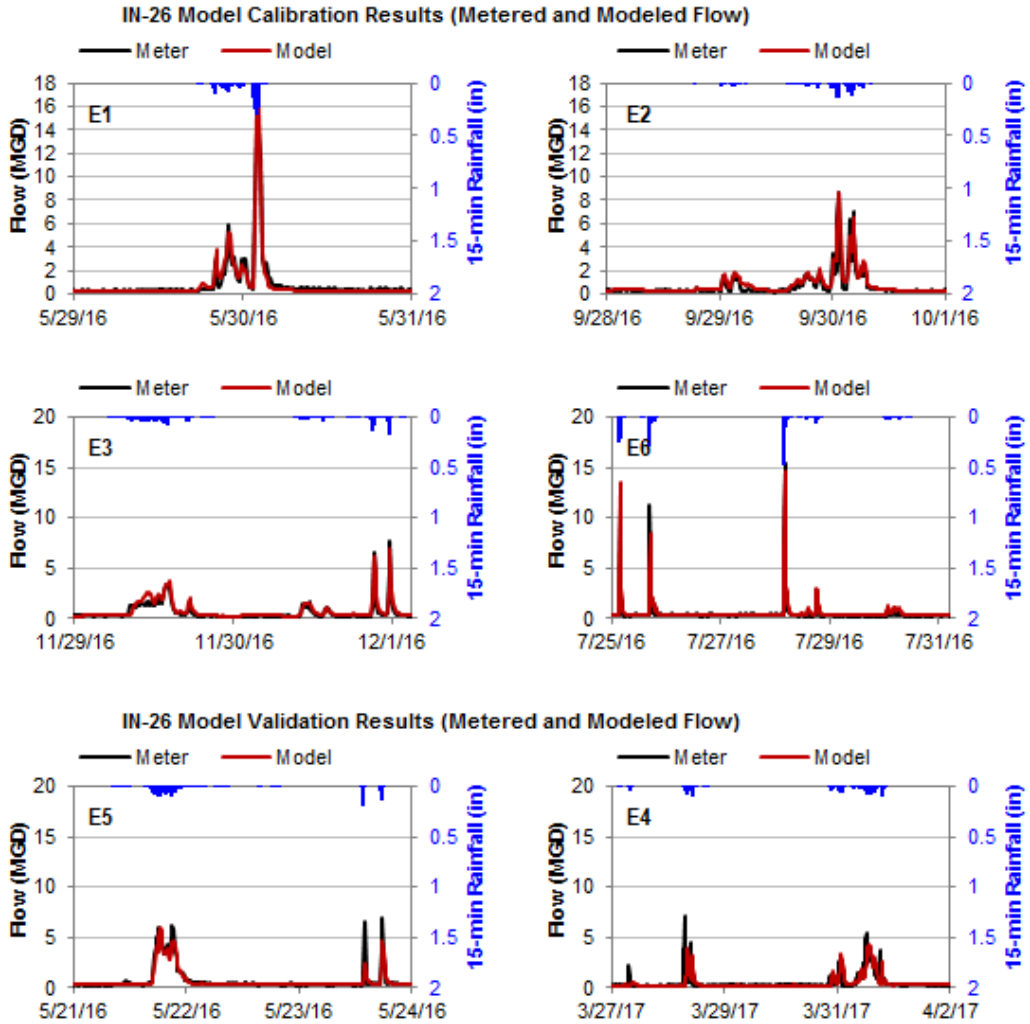


IN-25 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.09	0.07	-10% to +10%	-27%	0.13	0.12	-10% to +10%	-10%
E2	0.12	0.11	-10% to +10%	-9%	0.16	0.19	-10% to +10%	15%
E3	0.11	0.10	-10% to +10%	-9%	0.17	0.17	-10% to +10%	4%
E4	0.13	0.12	-10% to +10%	-3%	0.21	0.22	-10% to +10%	9%
E5	0.07	0.06	-10% to +10%	-14%	0.11	0.12	-10% to +10%	4%
E6	0.12	0.09	-10% to +10%	-19%	0.17	0.17	-10% to +10%	2%

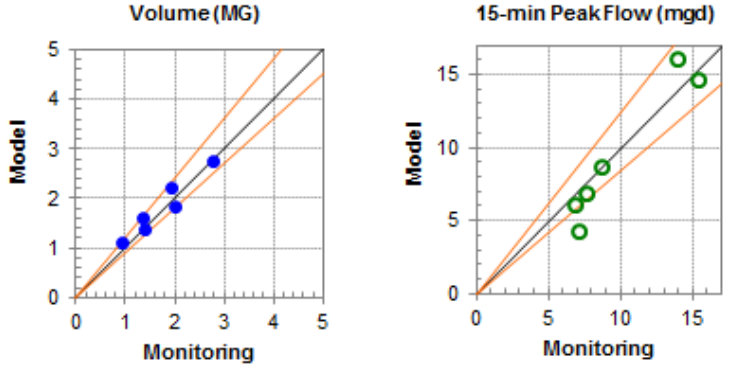
IN-25 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	7.88	9.09	-15% to +25%	15%	0.82	0.60	-10% to +20%	-28%
E2	13.30	4.04	-15% to +25%	-70%	2.30	0.91	-10% to +20%	-61%
E3	10.24	2.68	-15% to +25%	-74%	2.89	0.71	-10% to +20%	-75%
E4	9.39	2.21	-15% to +25%	-76%	2.90	1.29	-10% to +20%	-56%
E5	8.02	2.87	-15% to +25%	-64%	0.97	0.72	-10% to +20%	-26%
E6	6.04	7.32	-15% to +25%	21%	0.42	0.47	-10% to +20%	12%

Note: Only two of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E2, E3, E4, and E5) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER IN-26 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

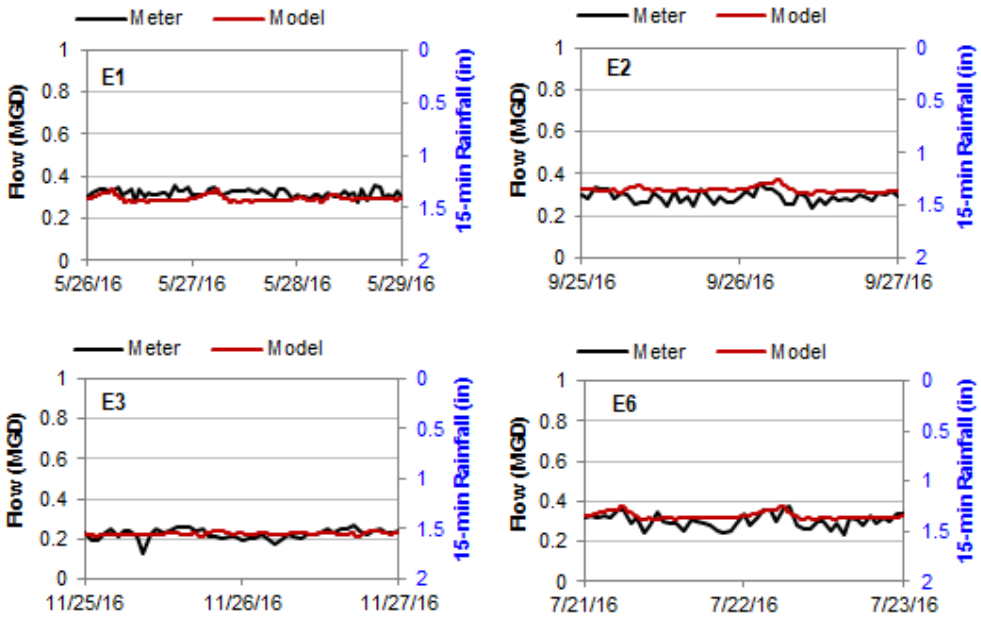


IN-26 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

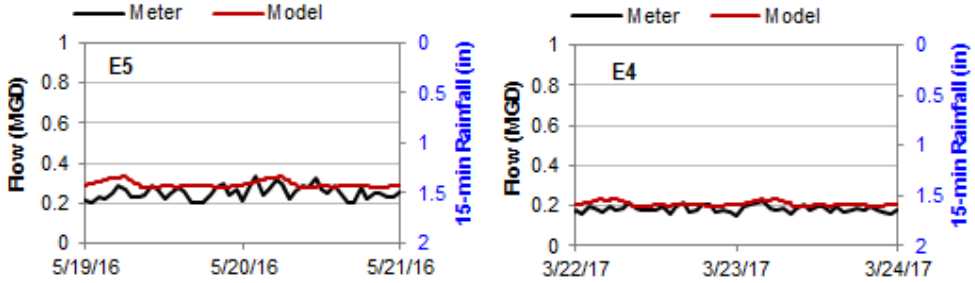


FLOW METER IN-26 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

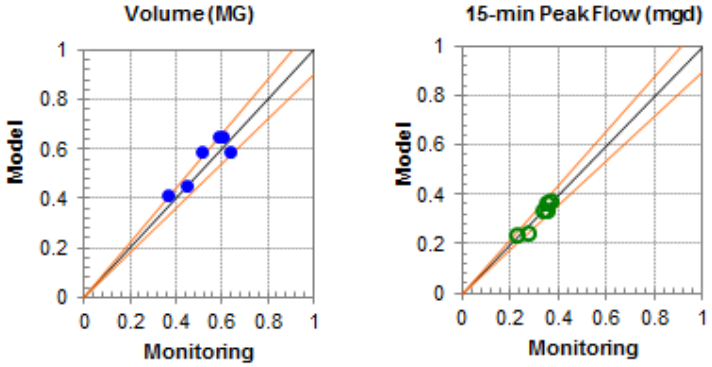
IN-26 Model Calibration Results (Metered and Modeled Flow)



IN-26 Model Validation Results (Metered and Modeled Flow)



IN-26 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



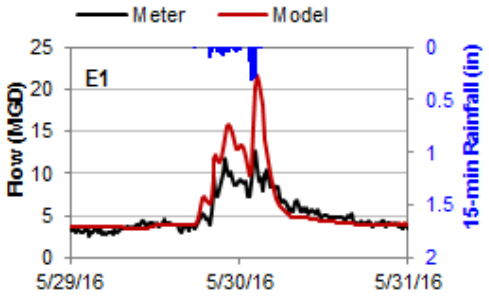
IN-26 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.35	0.34	-10% to +10%	-5%	0.64	0.59	-10% to +10%	-7%
E2	0.35	0.37	-10% to +10%	4%	0.58	0.65	-10% to +10%	12%
E3	0.27	0.24	-10% to +10%	-11%	0.45	0.45	-10% to +10%	1%
E4	0.23	0.24	-10% to +10%	4%	0.37	0.42	-10% to +10%	13%
E5	0.34	0.34	-10% to +10%	0%	0.51	0.59	-10% to +10%	16%
E6	0.37	0.37	-10% to +10%	1%	0.60	0.65	-10% to +10%	8%

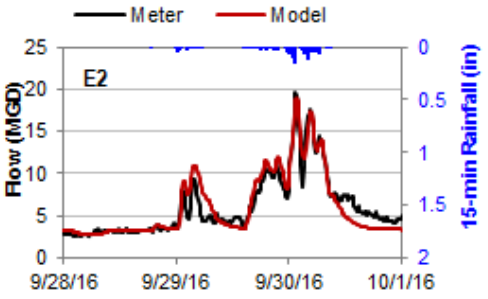
IN-26 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	13.97	16.12	-15% to +25%	15%	1.40	1.38	-10% to +20%	-1%
E2	8.60	8.69	-15% to +25%	1%	1.92	2.24	-10% to +20%	17%
E3	7.66	6.92	-15% to +25%	-10%	1.35	1.61	-10% to +20%	19%
E4	7.06	4.37	-15% to +25%	-38%	2.78	2.78	-10% to +20%	0%
E5	6.84	6.07	-15% to +25%	-11%	2.01	1.83	-10% to +20%	-9%
E6	15.36	14.64	-15% to +25%	-5%	0.92	1.14	-10% to +20%	24%

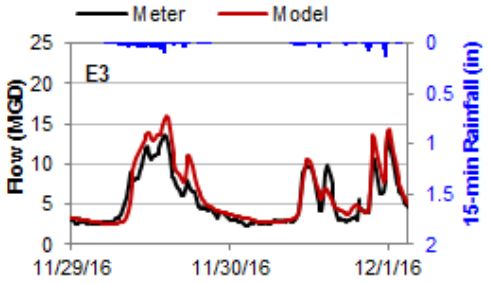
Note: All the six wet weather events are calibrated well within the industry criteria except flow peak for E4 because flow meter data recorded for E4 is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

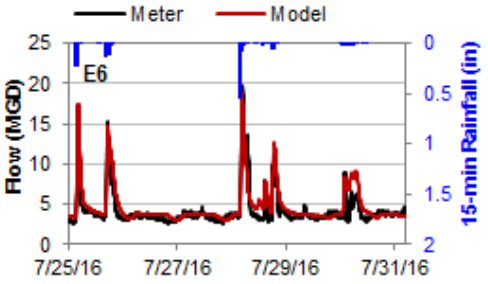
FLOW METER INT-2ND ST MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

INT-2nd St Model Calibration Results (Metered and Modeled Flow)

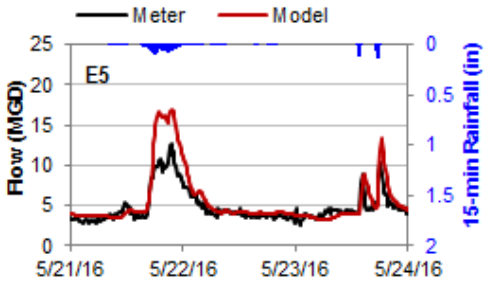


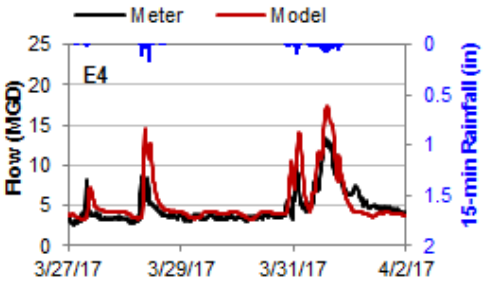




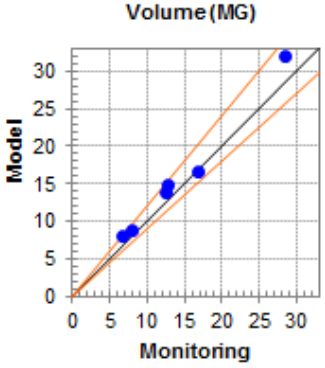


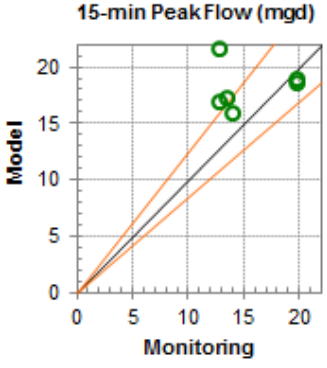
INT-2nd St Model Validation Results (Metered and Modeled Flow)





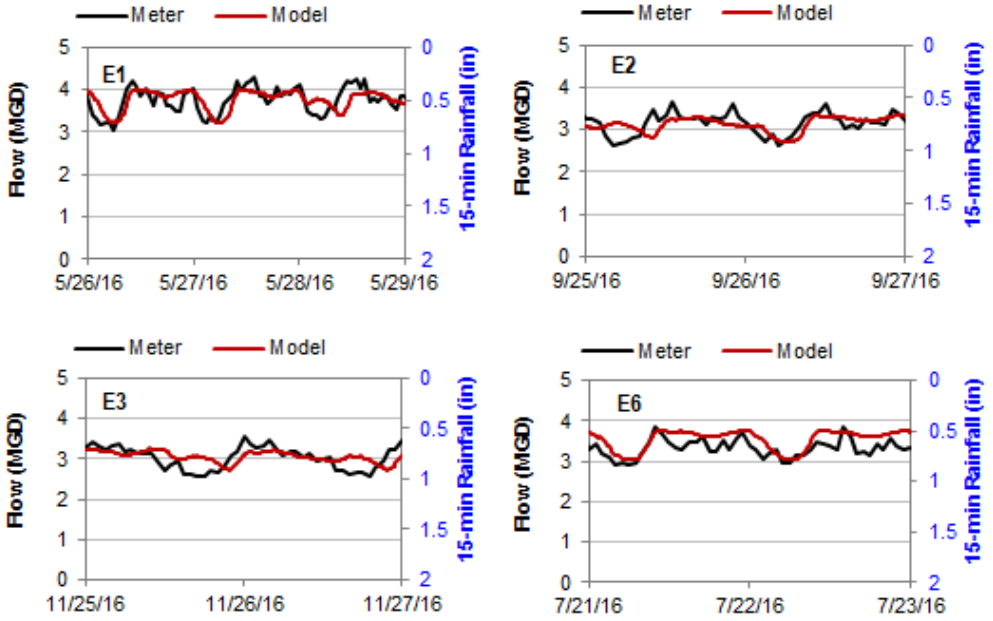
INT-2nd St Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



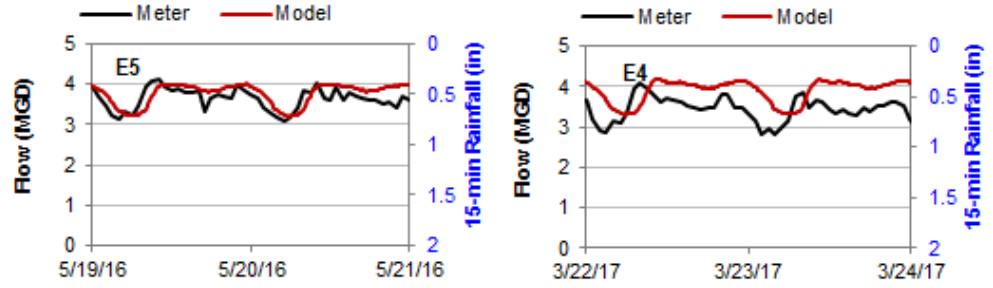


FLOW METER INT-2ND ST MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

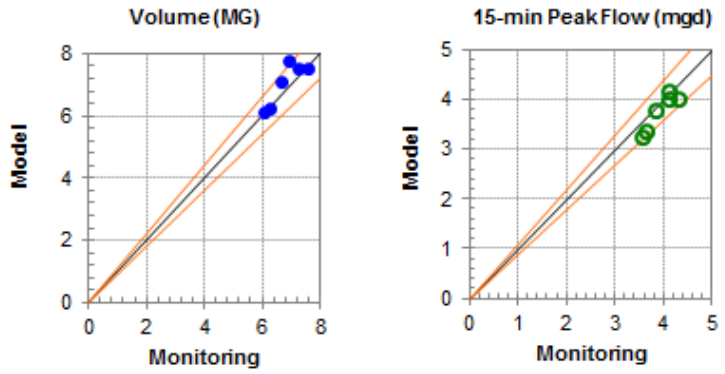
INT-2nd St Model Calibration Results (Metered and Modeled Flow)



INT-2nd St Model Validation Results (Metered and Modeled Flow)



INT-2nd St Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



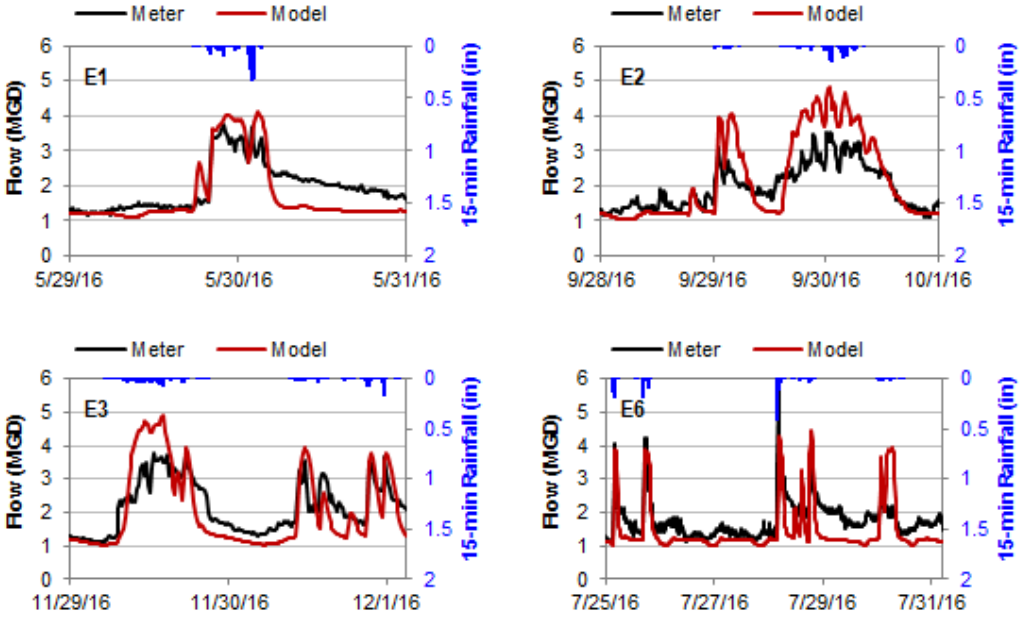
INT-2nd St Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	4.32	4.01	-10% to +10%	-7%	7.58	7.51	-10% to +10%	-1%
E2	3.64	3.35	-10% to +10%	-8%	6.29	6.25	-10% to +10%	-1%
E3	3.56	3.26	-10% to +10%	-8%	6.05	6.10	-10% to +10%	1%
E4	4.11	4.18	-10% to +10%	2%	6.89	7.79	-10% to +10%	13%
E5	4.10	4.01	-10% to +10%	-2%	7.26	7.52	-10% to +10%	4%
E6	3.85	3.78	-10% to +10%	-2%	6.65	7.08	-10% to +10%	7%

INT-2nd St Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	12.71	21.71	-15% to +25%	71%	6.63	8.13	-10% to +20%	23%
E2	19.69	19.00	-15% to +25%	-3%	16.80	16.79	-10% to +20%	0%
E3	13.92	16.04	-15% to +25%	15%	12.44	13.88	-10% to +20%	12%
E4	13.36	17.30	-15% to +25%	30%	28.36	32.16	-10% to +20%	13%
E5	12.76	16.98	-15% to +25%	33%	12.74	15.01	-10% to +20%	18%
E6	19.67	18.72	-15% to +25%	-5%	7.79	8.80	-10% to +20%	13%

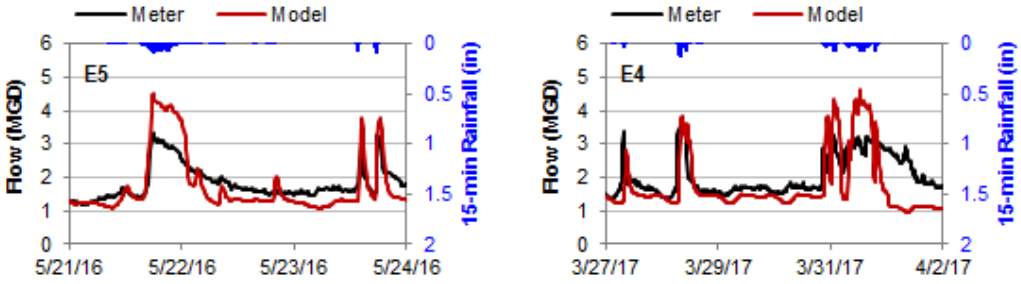
Note: Four of the six wet weather events are calibrated well within or close to the industry criteria. Flow meter data recorded for some events (E1, E4, E5) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER INT-DRI MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

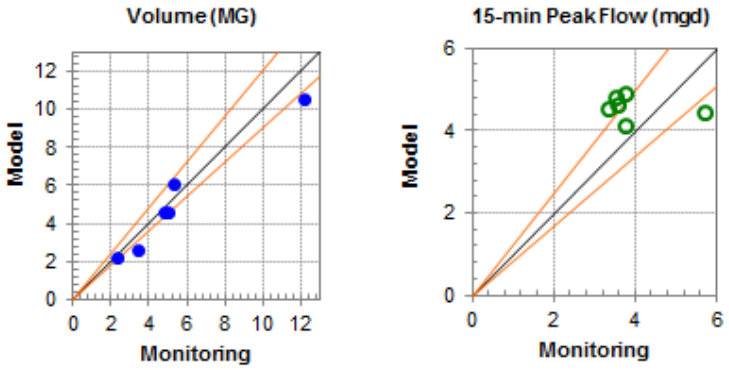
INT-DRI Model Calibration Results (Metered and Modeled Flow)



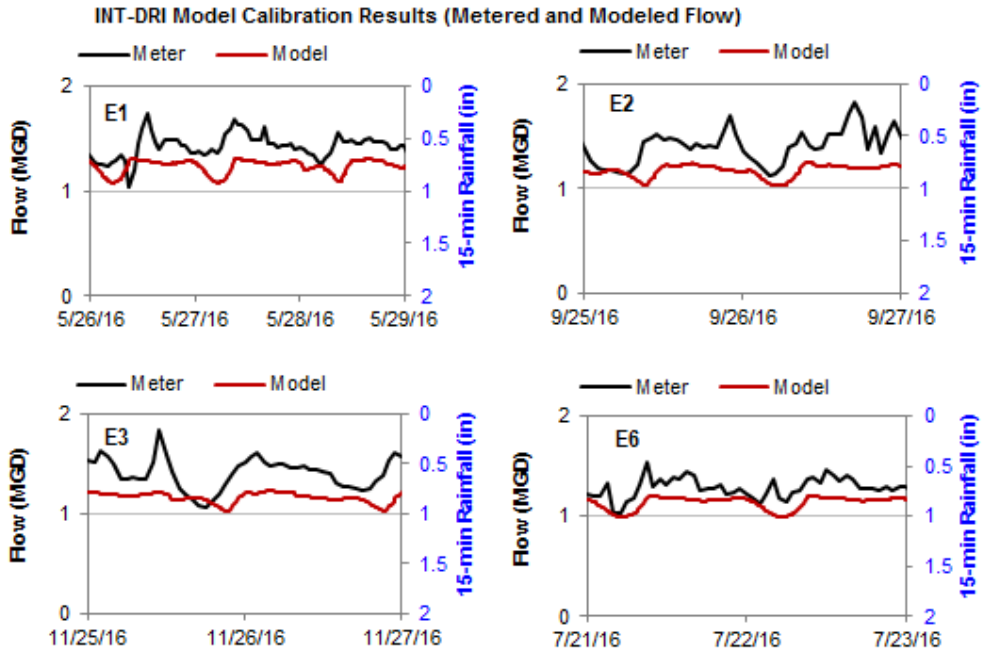
INT-DRI Model Validation Results (Metered and Modeled Flow)

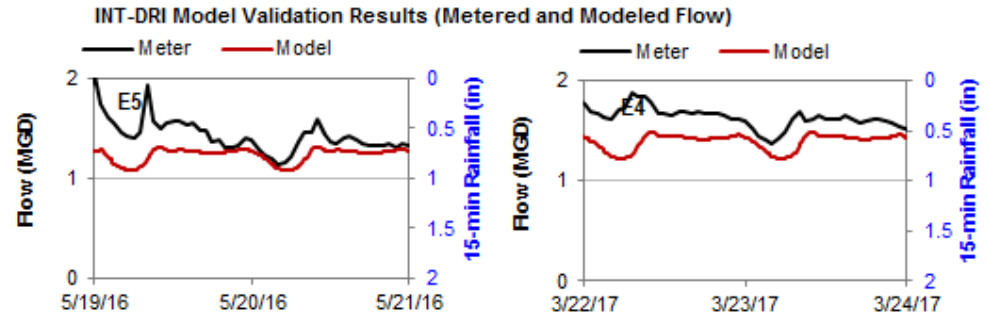


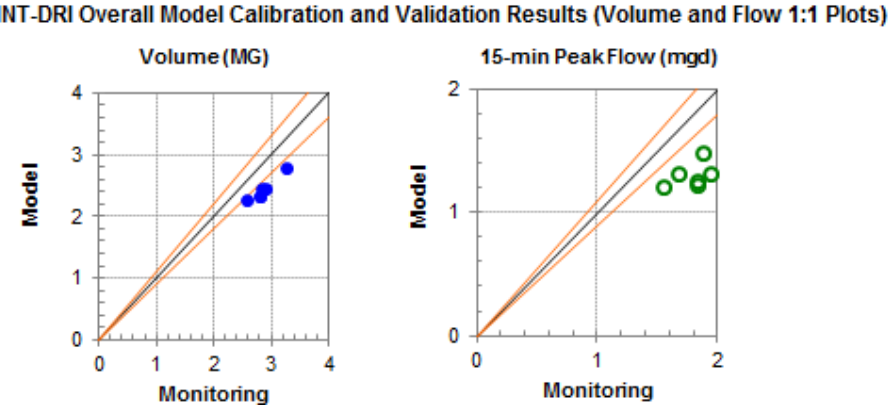
INT-DRI Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



FLOW METER INT-DRI MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events







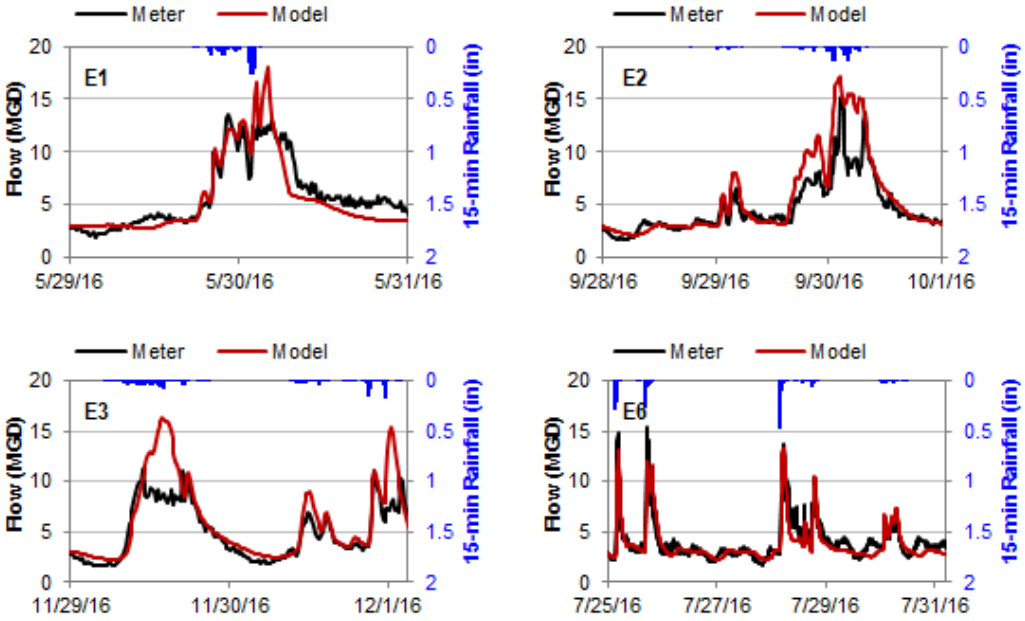
INT-DRI Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	1.68	1.31	-10% to +10%	-22%	2.90	2.47	-10% to +10%	-15%
E2	1.83	1.25	-10% to +10%	-32%	2.80	2.34	-10% to +10%	-17%
E3	1.83	1.23	-10% to +10%	-33%	2.81	2.33	-10% to +10%	-17%
E4	1.88	1.49	-10% to +10%	-21%	3.26	2.78	-10% to +10%	-15%
E5	1.94	1.31	-10% to +10%	-32%	2.84	2.47	-10% to +10%	-13%
E6	1.55	1.21	-10% to +10%	-22%	2.57	2.27	-10% to +10%	-12%

INT-DRI Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	3.75	4.13	-15% to +25%	10%	2.35	2.26	-10% to +20%	-4%
E2	3.51	4.79	-15% to +25%	37%	5.27	6.10	-10% to +20%	16%
E3	3.76	4.92	-15% to +25%	31%	5.00	4.63	-10% to +20%	-7%
E4	3.57	4.62	-15% to +25%	30%	12.18	10.51	-10% to +20%	-14%
E5	3.32	4.53	-15% to +25%	36%	4.78	4.62	-10% to +20%	-3%
E6	5.70	4.45	-15% to +25%	-22%	3.40	2.64	-10% to +20%	-22%

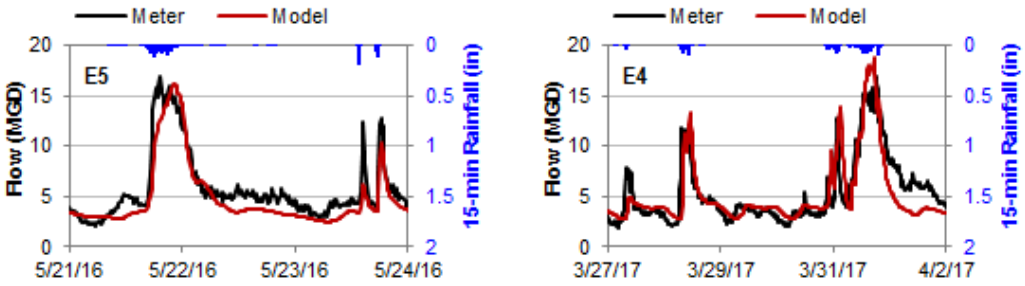
Note: Four of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E2, E3, E4, and E5) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER INT-RIDLEY 2 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

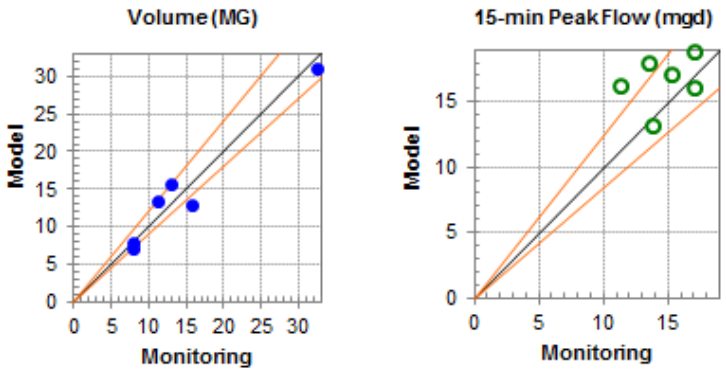
INT-Ridley 2 Model Calibration Results (Metered and Modeled Flow)



INT-Ridley 2 Model Validation Results (Metered and Modeled Flow)

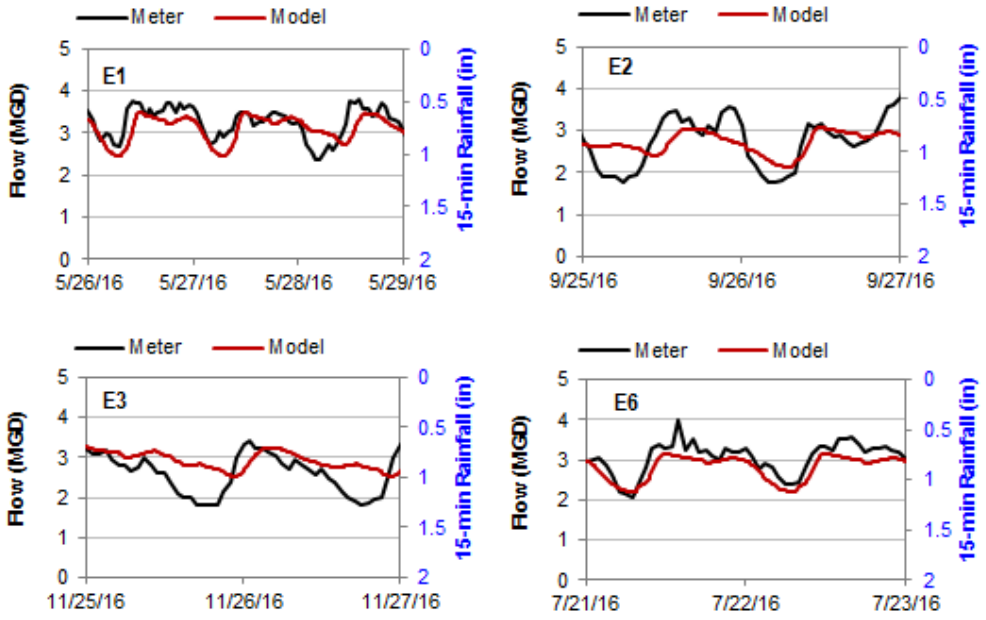


INT-Ridley 2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

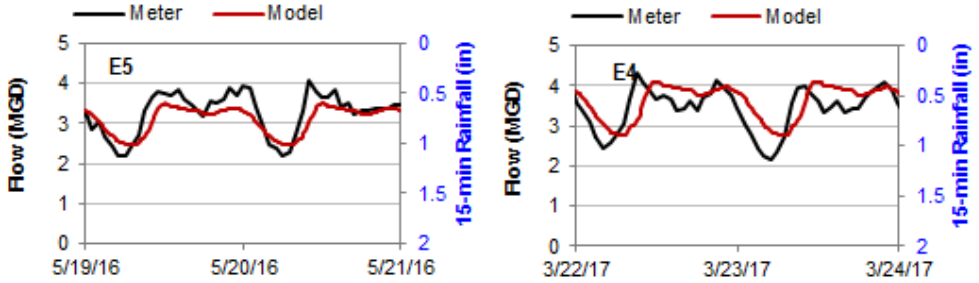


FLOW METER INT-RIDLEY 2 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

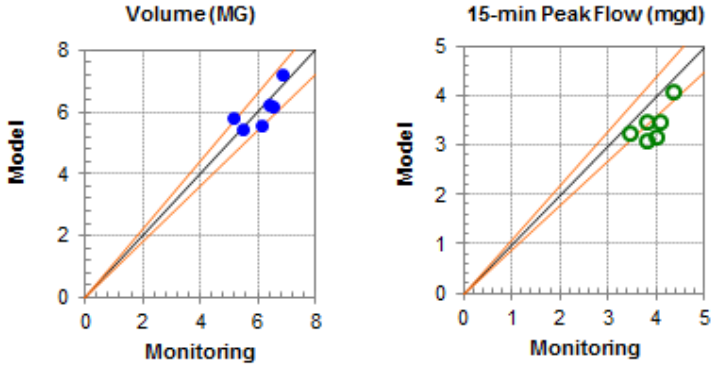
INT-Ridley 2 Model Calibration Results (Metered and Modeled Flow)



INT-Ridley 2 Model Validation Results (Metered and Modeled Flow)



INT-Ridley 2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



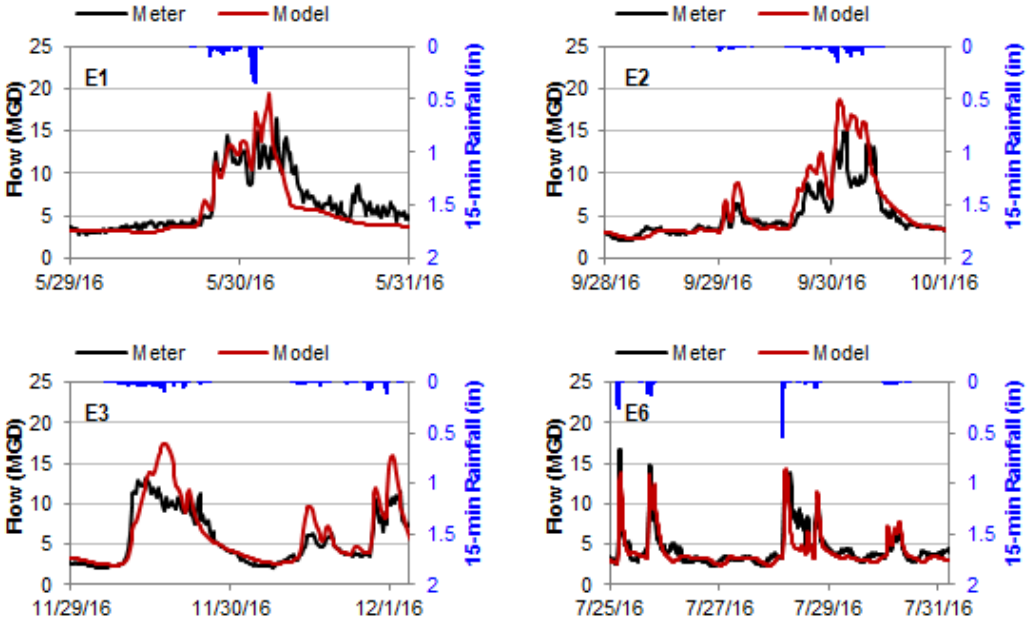
INT-Ridley 2 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	3.81	3.49	-10% to +10%	-8%	6.38	6.23	-10% to +10%	-2%
E2	3.78	3.08	-10% to +10%	-18%	5.45	5.43	-10% to +10%	0%
E3	3.43	3.26	-10% to +10%	-5%	5.15	5.82	-10% to +10%	13%
E4	4.32	4.10	-10% to +10%	-5%	6.84	7.20	-10% to +10%	5%
E5	4.07	3.49	-10% to +10%	-14%	6.54	6.20	-10% to +10%	-5%
E6	4.00	3.16	-10% to +10%	-21%	6.12	5.60	-10% to +10%	-8%

INT-Ridley 2 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	13.52	17.98	-15% to +25%	33%	7.96	7.95	-10% to +20%	0%
E2	15.19	17.15	-15% to +25%	13%	13.05	15.68	-10% to +20%	20%
E3	11.34	16.32	-15% to +25%	44%	11.24	13.57	-10% to +20%	21%
E4	17.00	18.81	-15% to +25%	11%	32.32	31.09	-10% to +20%	-4%
E5	17.00	16.14	-15% to +25%	-5%	15.68	12.99	-10% to +20%	-17%
E6	13.72	13.29	-15% to +25%	-3%	7.98	7.27	-10% to +20%	-9%

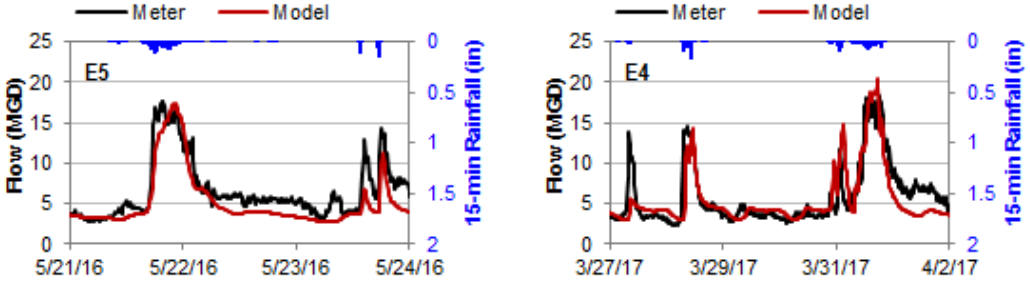
Note: Four of the six wet weather events are calibrated well within or close to the industry criteria. Flow meter data recorded for some of the events (E1 and E3) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER INT-RIDLEY 3 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

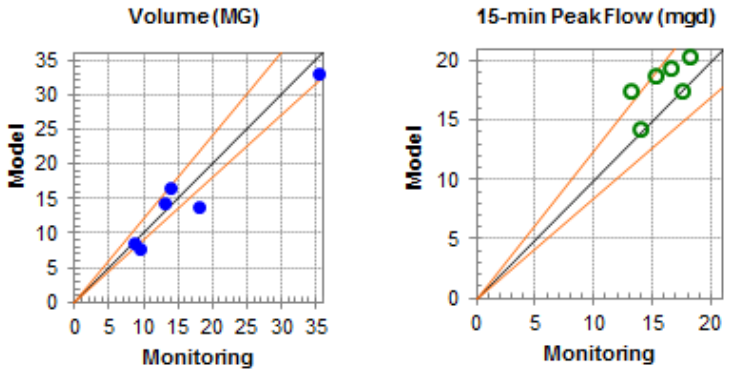
INT-Ridley 3 Model Calibration Results (Metered and Modeled Flow)



INT-Ridley 3 Model Validation Results (Metered and Modeled Flow)

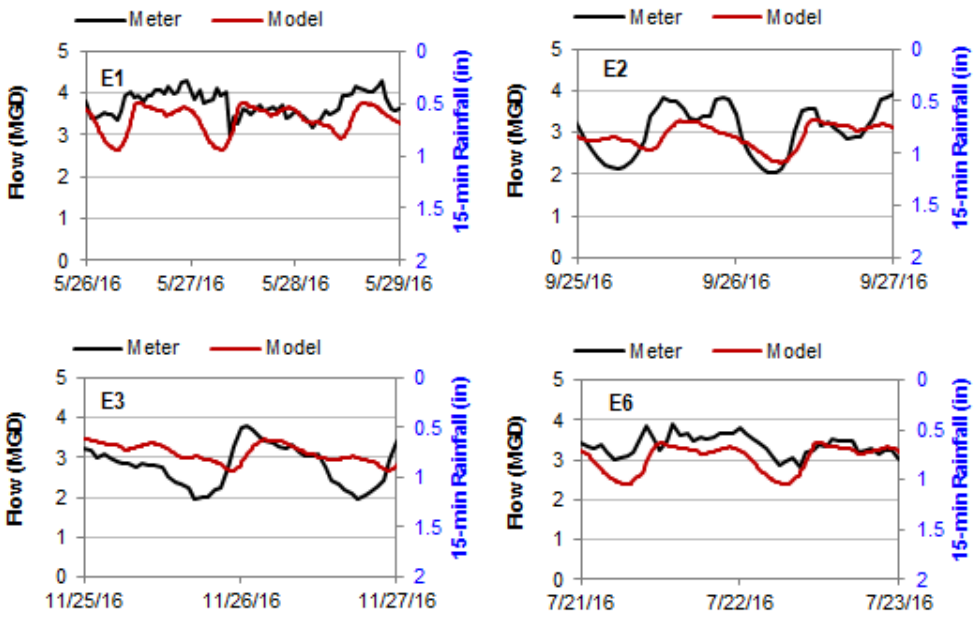


INT-Ridley 3 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

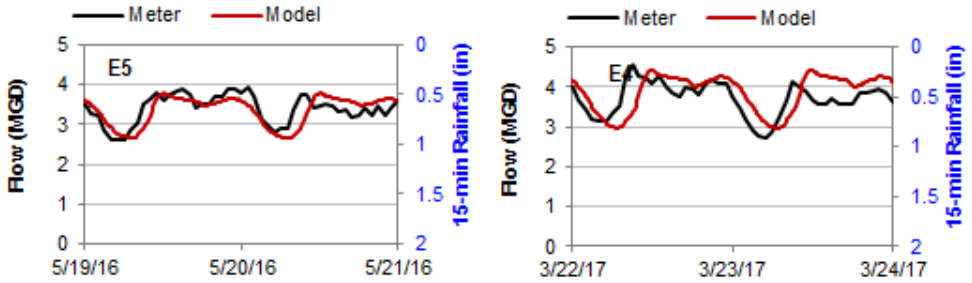


FLOW METER INT-RIDLEY 3 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

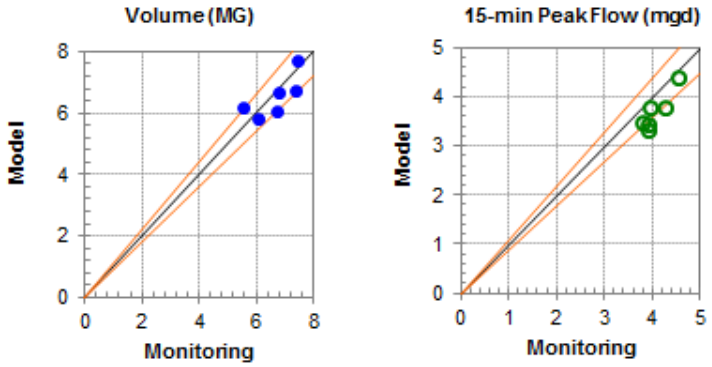
INT-Ridley 3 Model Calibration Results (Metered and Modeled Flow)



INT-Ridley 3 Model Validation Results (Metered and Modeled Flow)



INT-Ridley 3 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



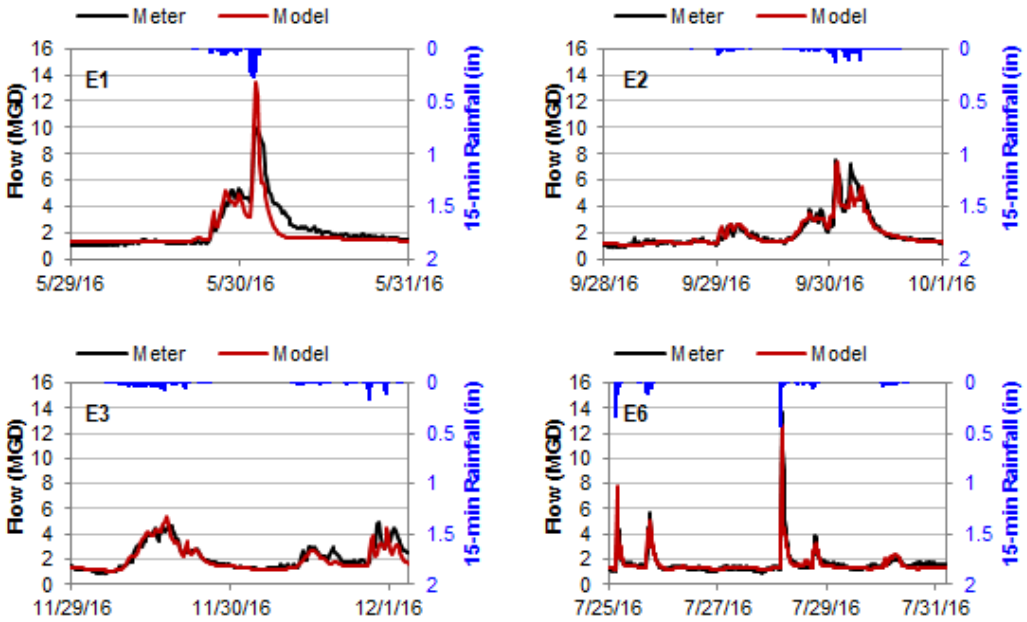
INT-Ridley 3 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	4.28	3.78	-10% to +10%	-12%	7.39	6.74	-10% to +10%	-9%
E2	3.92	3.31	-10% to +10%	-16%	6.07	5.84	-10% to +10%	-4%
E3	3.78	3.48	-10% to +10%	-8%	5.56	6.22	-10% to +10%	12%
E4	4.55	4.41	-10% to +10%	-3%	7.42	7.74	-10% to +10%	4%
E5	3.95	3.77	-10% to +10%	-5%	6.78	6.70	-10% to +10%	-1%
E6	3.90	3.43	-10% to +10%	-12%	6.73	6.07	-10% to +10%	-10%

INT-Ridley 3 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	16.50	19.45	-15% to +25%	18%	8.57	8.49	-10% to +20%	-1%
E2	15.23	18.76	-15% to +25%	23%	13.85	16.70	-10% to +20%	21%
E3	13.11	17.45	-15% to +25%	33%	13.01	14.42	-10% to +20%	11%
E4	18.23	20.42	-15% to +25%	12%	35.43	33.21	-10% to +20%	-6%
E5	17.50	17.44	-15% to +25%	0%	18.03	13.98	-10% to +20%	-22%
E6	13.88	14.34	-15% to +25%	3%	9.31	7.80	-10% to +20%	-16%

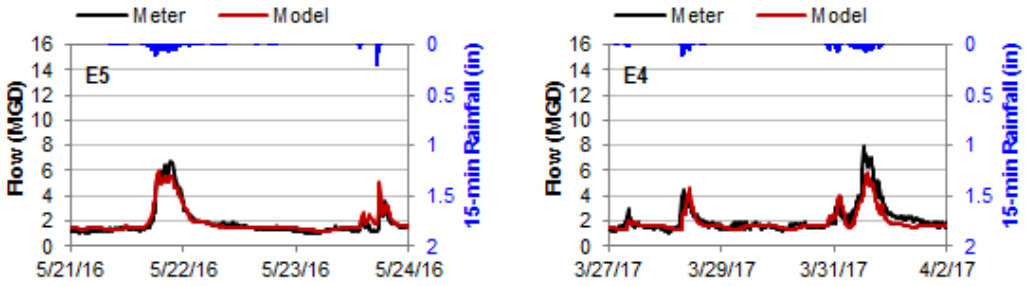
Note: All of the six wet weather events are calibrated well within or close to the industry criteria.

FLOW METER INT-WEI MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

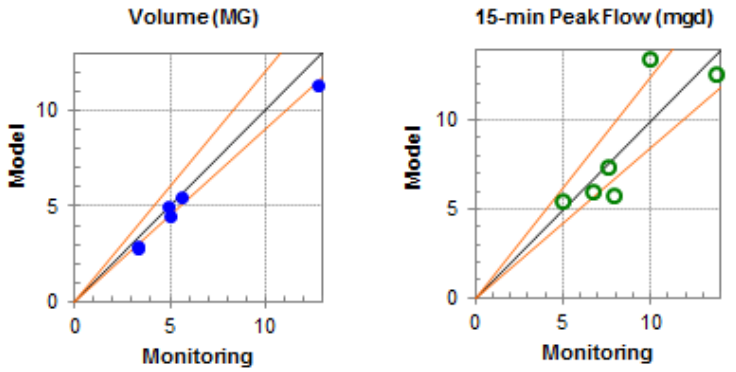
INT-WEI Model Calibration Results (Metered and Modeled Flow)



INT-WEI Model Validation Results (Metered and Modeled Flow)

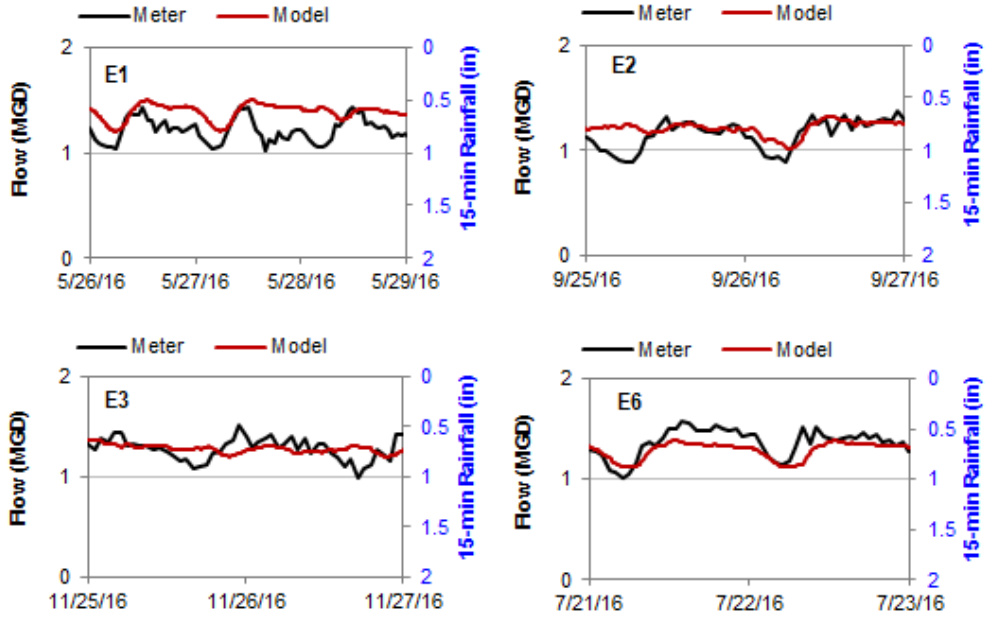


INT-WEI Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

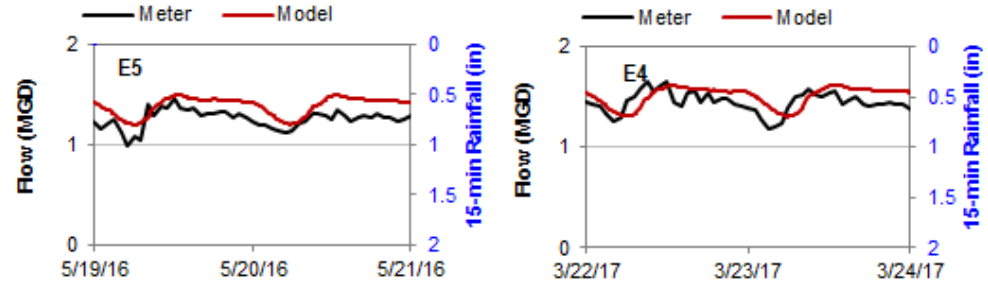


FLOW METER INT-WEI MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

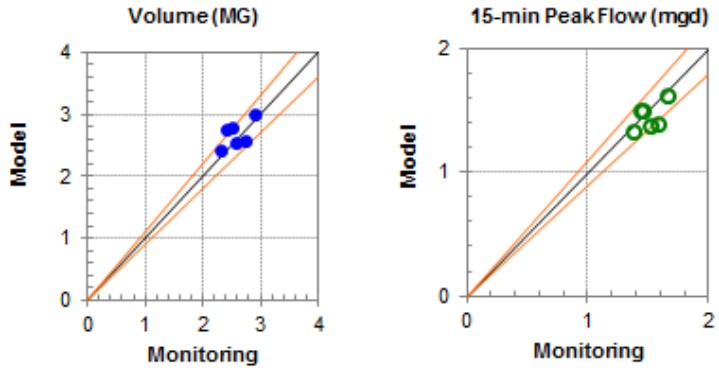
INT-WEI Model Calibration Results (Metered and Modeled Flow)



INT-WEI Model Validation Results (Metered and Modeled Flow)



INT-WEI Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



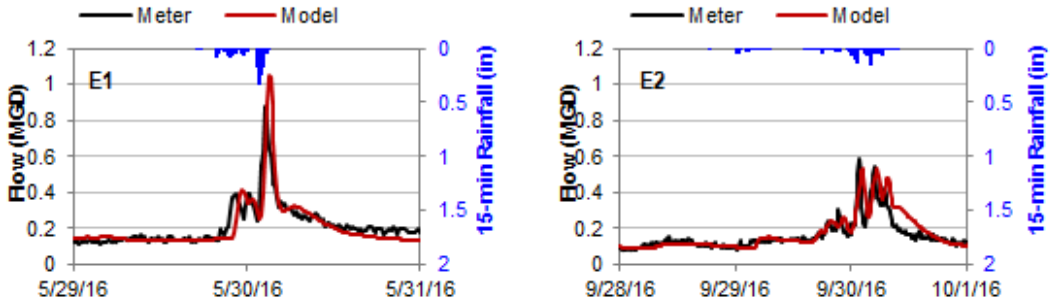
INT-WEI Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	1.44	1.50	-10% to +10%	5%	2.41	2.77	-10% to +10%	15%
E2	1.37	1.33	-10% to +10%	-3%	2.31	2.42	-10% to +10%	5%
E3	1.51	1.37	-10% to +10%	-9%	2.56	2.56	-10% to +10%	0%
E4	1.66	1.62	-10% to +10%	-2%	2.90	3.02	-10% to +10%	4%
E5	1.46	1.50	-10% to +10%	3%	2.52	2.78	-10% to +10%	10%
E6	1.58	1.39	-10% to +10%	-12%	2.73	2.58	-10% to +10%	-6%

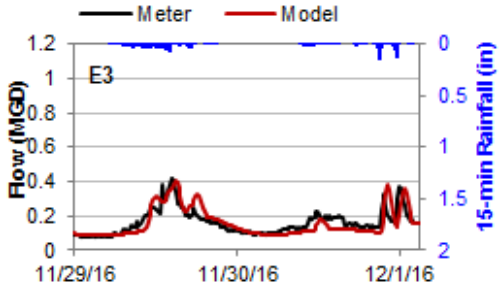
INT-WEI Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	9.99	13.44	-15% to +25%	35%	3.27	2.84	-10% to +20%	-13%
E2	7.54	7.44	-15% to +25%	-1%	5.64	5.46	-10% to +20%	-3%
E3	4.93	5.44	-15% to +25%	10%	5.00	4.55	-10% to +20%	-9%
E4	7.91	5.83	-15% to +25%	-26%	12.77	11.34	-10% to +20%	-11%
E5	6.73	6.03	-15% to +25%	-10%	4.91	5.05	-10% to +20%	3%
E6	13.69	12.65	-15% to +25%	-8%	3.31	2.91	-10% to +20%	-12%

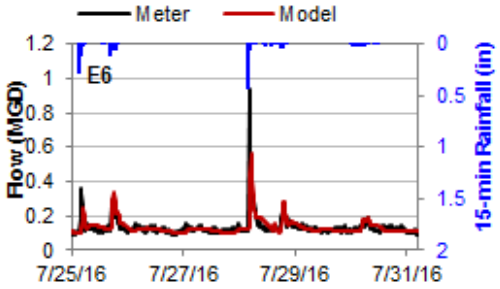
Note: All the six wet weather events are calibrated well within or close to the industry criteria.

FLOW METER SEP-1 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

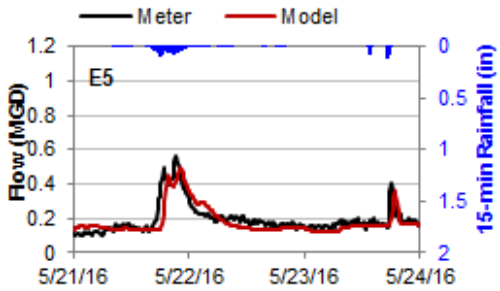
Sep-1 Model Calibration Results (Metered and Modeled Flow)

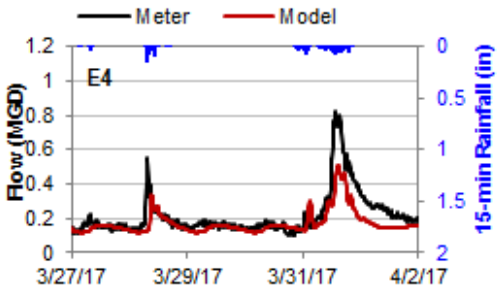




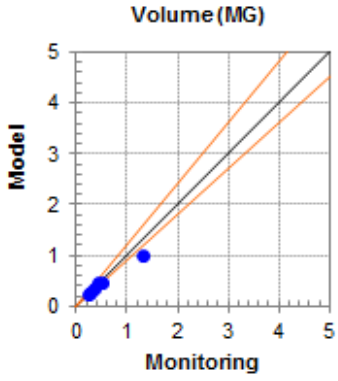


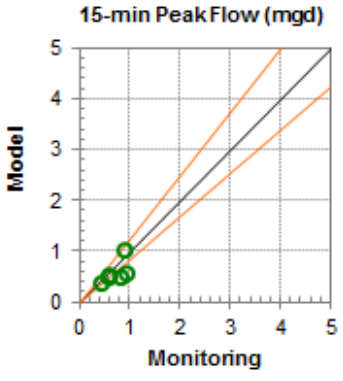
Sep-1 Model Validation Results (Metered and Modeled Flow)



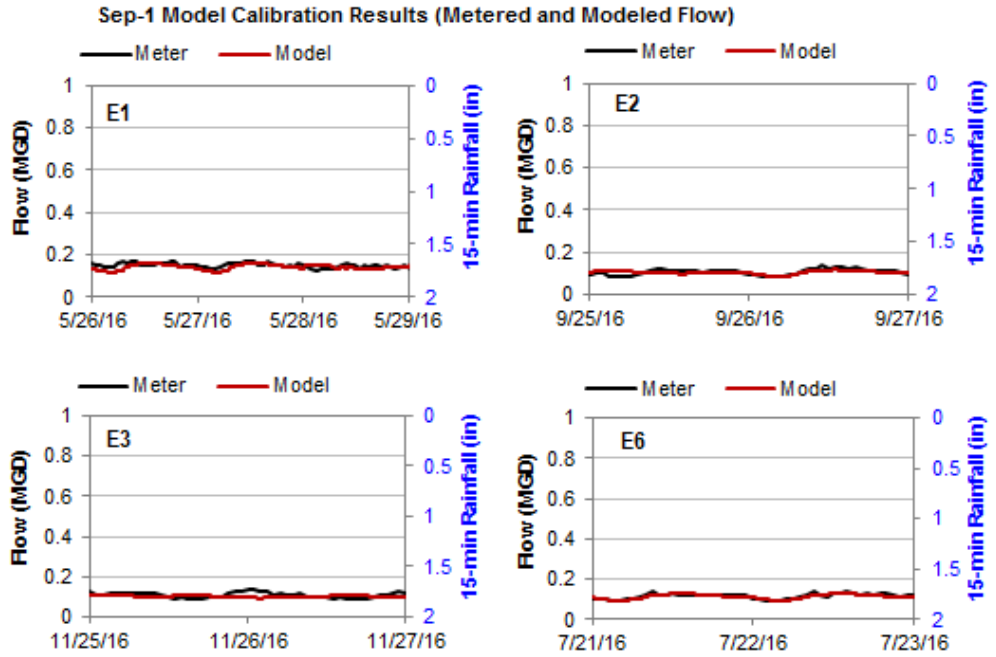


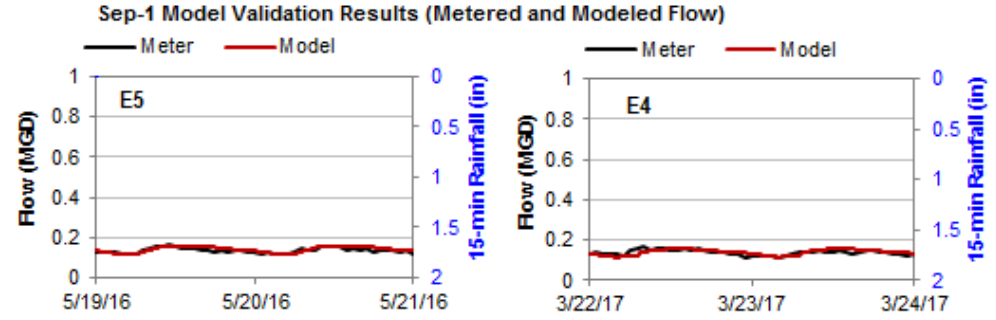
Sep-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

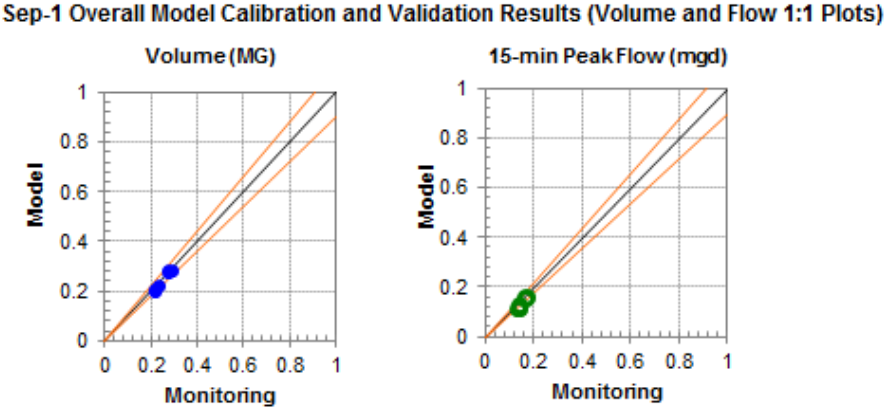




FLOW METER SEP-1 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events







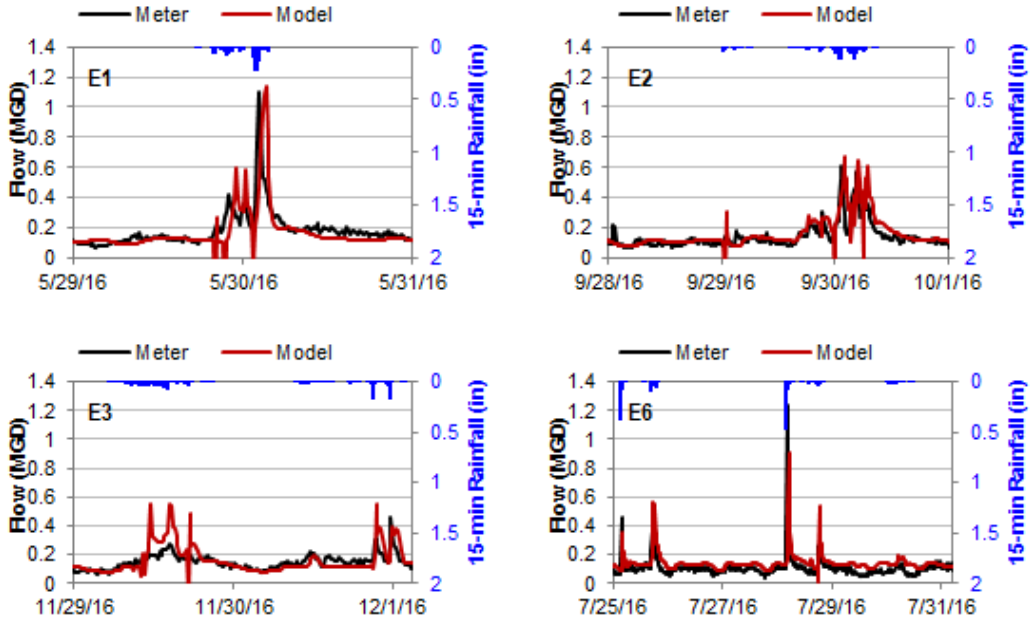
Sep-1 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.17	0.16	-10% to +10%	-7%	0.29	0.28	-10% to +10%	-4%
E2	0.14	0.12	-10% to +10%	-18%	0.22	0.21	-10% to +10%	-3%
E3	0.13	0.11	-10% to +10%	-16%	0.22	0.20	-10% to +10%	-6%
E4	0.16	0.16	-10% to +10%	-4%	0.28	0.28	-10% to +10%	1%
E5	0.17	0.16	-10% to +10%	-4%	0.27	0.28	-10% to +10%	4%
E6	0.14	0.13	-10% to +10%	-7%	0.23	0.22	-10% to +10%	-3%

Sep-1 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.88	1.05	-15% to +25%	19%	0.27	0.27	-10% to +20%	2%
E2	0.58	0.53	-15% to +25%	-8%	0.43	0.47	-10% to +20%	10%
E3	0.42	0.40	-15% to +25%	-5%	0.37	0.36	-10% to +20%	-3%
E4	0.82	0.51	-15% to +25%	-38%	1.30	1.01	-10% to +20%	-22%
E5	0.56	0.49	-15% to +25%	-11%	0.51	0.47	-10% to +20%	-9%
E6	0.94	0.57	-15% to +25%	-40%	0.25	0.25	-10% to +20%	-2%

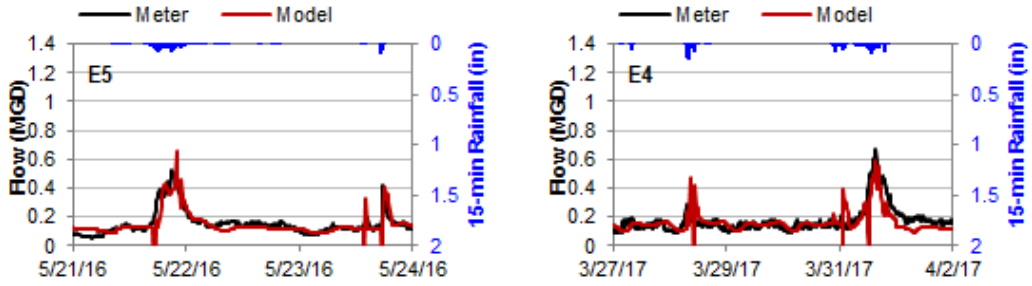
Note: Four of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E4) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER SEP-2 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

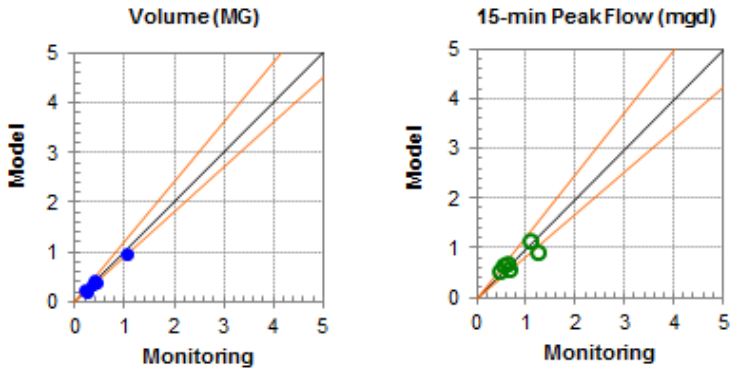
Sep-2 Model Calibration Results (Metered and Modeled Flow)



Sep-2 Model Validation Results (Metered and Modeled Flow)

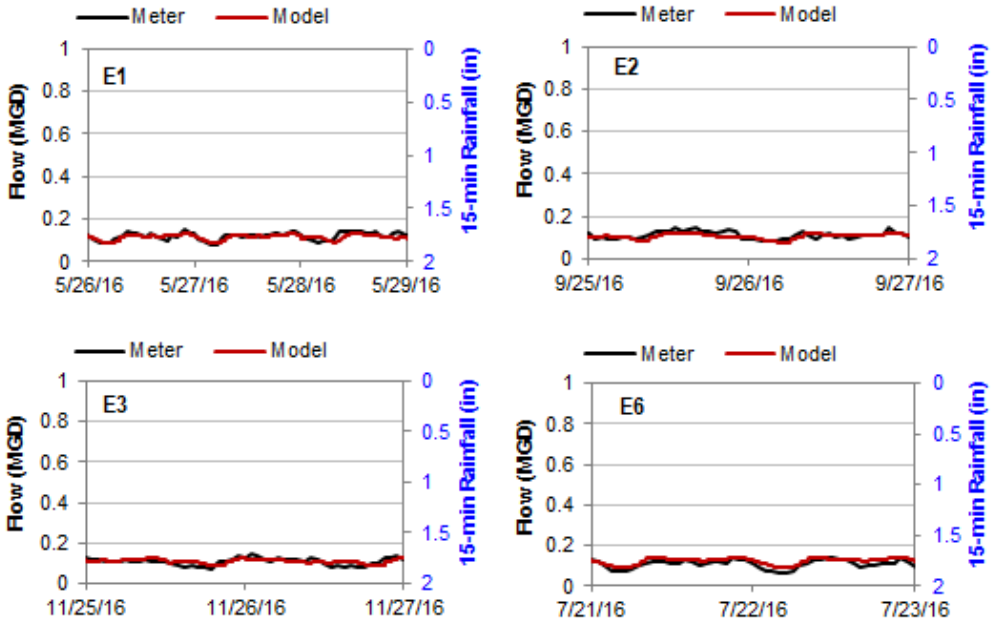


Sep-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

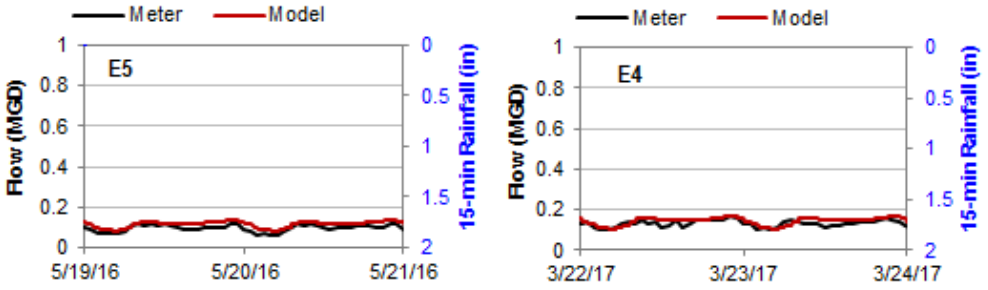


FLOW METER SEP-2 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

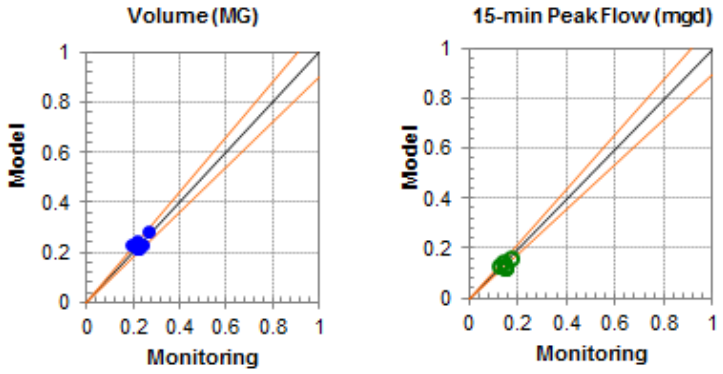
Sep-2 Model Calibration Results (Metered and Modeled Flow)



Sep-2 Model Validation Results (Metered and Modeled Flow)



Sep-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



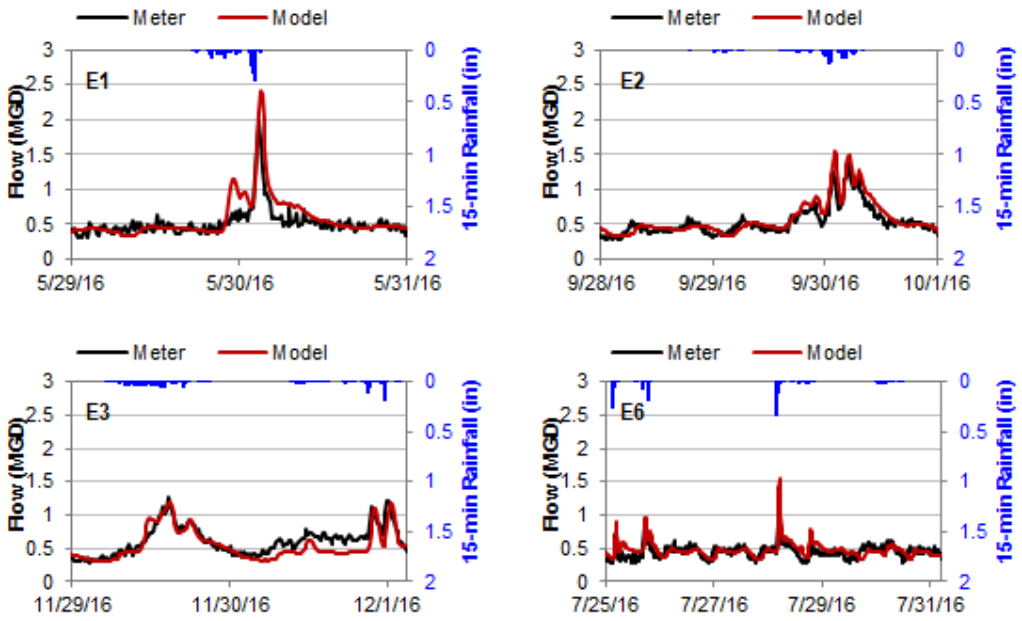
Sep-2 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.15	0.13	-10% to +10%	-8%	0.24	0.23	-10% to +10%	-4%
E2	0.15	0.12	-10% to +10%	-14%	0.23	0.22	-10% to +10%	-5%
E3	0.15	0.13	-10% to +10%	-15%	0.22	0.22	-10% to +10%	2%
E4	0.17	0.17	-10% to +10%	-3%	0.26	0.28	-10% to +10%	9%
E5	0.12	0.13	-10% to +10%	10%	0.19	0.23	-10% to +10%	20%
E6	0.14	0.14	-10% to +10%	2%	0.22	0.25	-10% to +10%	14%

Sep-2 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	1.10	1.15	-15% to +25%	5%	0.24	0.22	-10% to +20%	-7%
E2	0.61	0.66	-15% to +25%	7%	0.38	0.44	-10% to +20%	14%
E3	0.46	0.57	-15% to +25%	22%	0.34	0.36	-10% to +20%	5%
E4	0.67	0.59	-15% to +25%	-11%	1.04	0.95	-10% to +20%	-8%
E5	0.53	0.65	-15% to +25%	22%	0.42	0.38	-10% to +20%	-9%
E6	1.24	0.92	-15% to +25%	-26%	0.20	0.26	-10% to +20%	26%

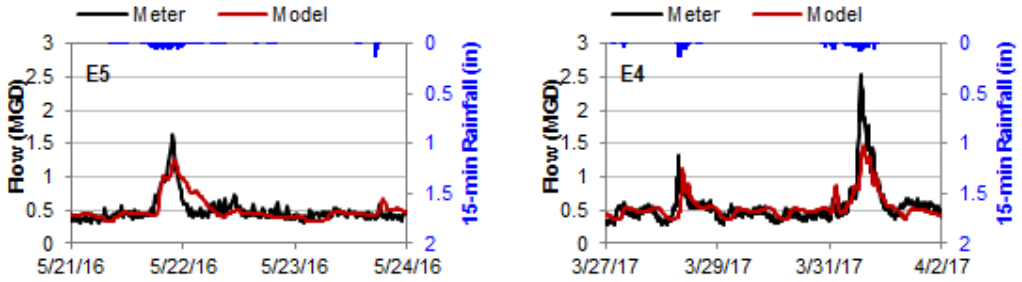
Note: All the six wet weather events are calibrated well within the industry criteria except E6 because the flow meter data recorded for E6 is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER SEP-3 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

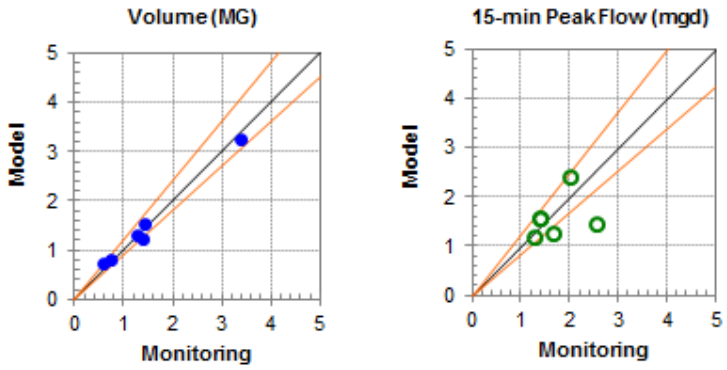
Sep-3 Model Calibration Results (Metered and Modeled Flow)



Sep-3 Model Validation Results (Metered and Modeled Flow)

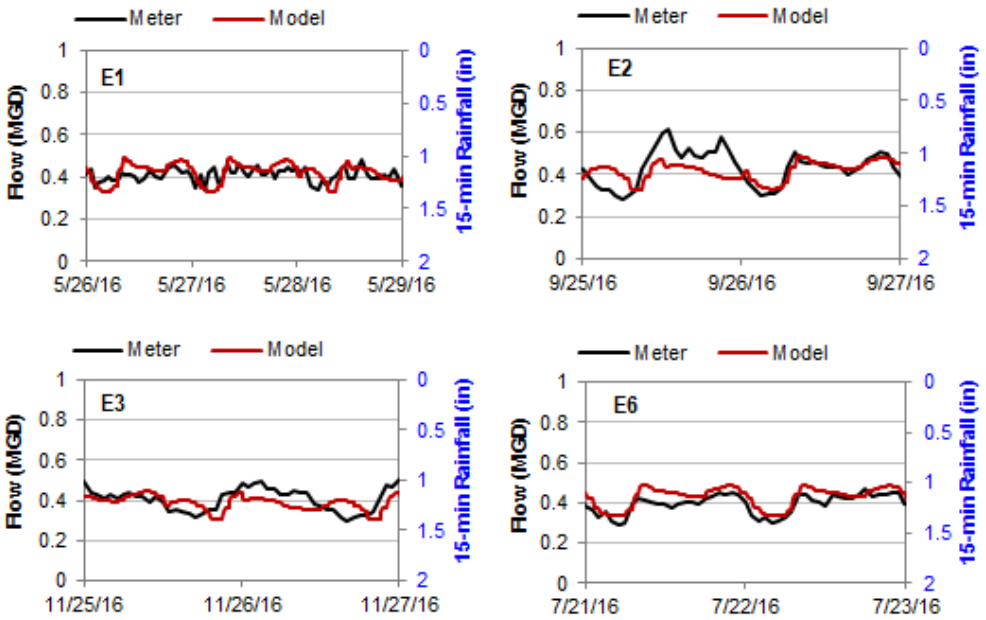


Sep-3 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

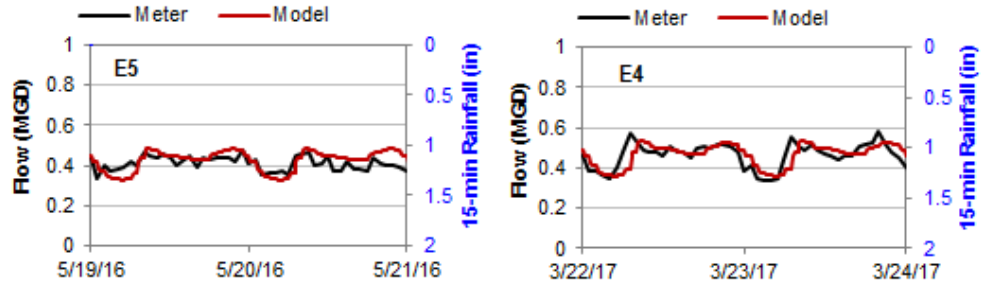


FLOW METER SEP-3 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

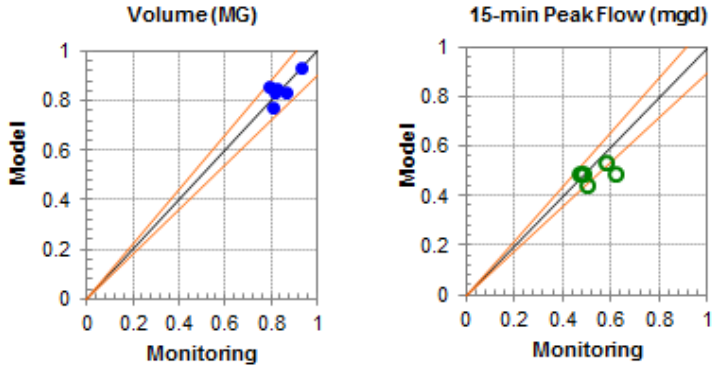
Sep-3 Model Calibration Results (Metered and Modeled Flow)



Sep-3 Model Validation Results (Metered and Modeled Flow)



Sep-3 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



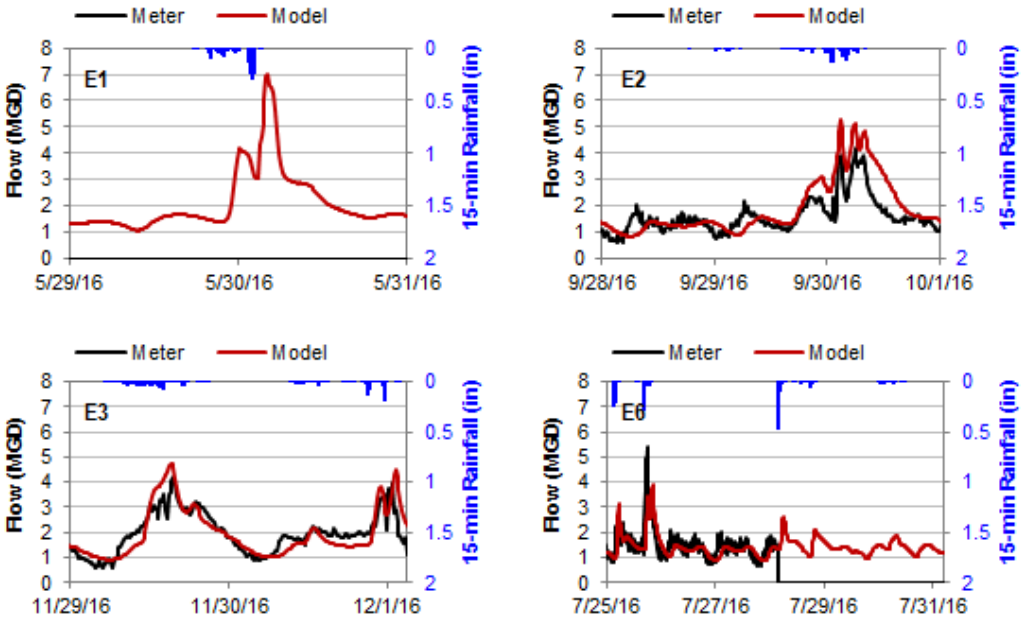
Sep-3 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.48	0.49	-10% to +10%	1%	0.82	0.84	-10% to +10%	2%
E2	0.61	0.49	-10% to +10%	-21%	0.87	0.84	-10% to +10%	-3%
E3	0.50	0.45	-10% to +10%	-11%	0.81	0.77	-10% to +10%	-4%
E4	0.58	0.53	-10% to +10%	-8%	0.93	0.93	-10% to +10%	1%
E5	0.48	0.49	-10% to +10%	2%	0.82	0.85	-10% to +10%	4%
E6	0.47	0.49	-10% to +10%	6%	0.79	0.86	-10% to +10%	9%

Sep-3 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	1.99	2.41	-15% to +25%	21%	0.59	0.73	-10% to +20%	24%
E2	1.40	1.56	-15% to +25%	11%	1.43	1.56	-10% to +20%	9%
E3	1.26	1.19	-15% to +25%	-6%	1.40	1.24	-10% to +20%	-12%
E4	2.55	1.47	-15% to +25%	-42%	3.39	3.26	-10% to +20%	-4%
E5	1.64	1.25	-15% to +25%	-24%	1.27	1.29	-10% to +20%	2%
E6	1.40	1.55	-15% to +25%	11%	0.72	0.83	-10% to +20%	15%

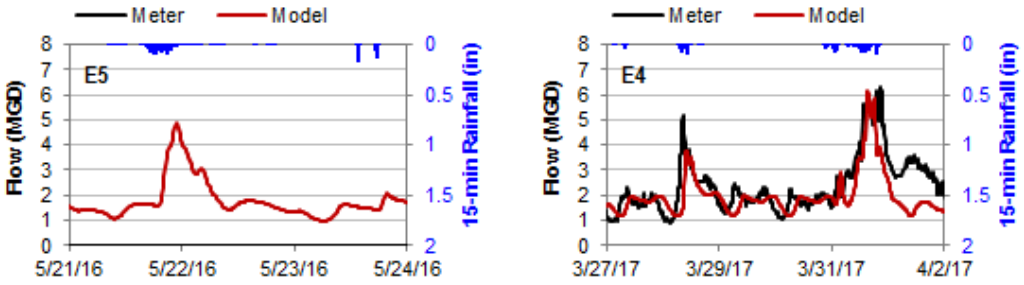
Note: All the six wet weather events are calibrated well within or close to the industry criteria except peak flow for Event E4 because the flow meter data recorded for E4 is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER SEP-4 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

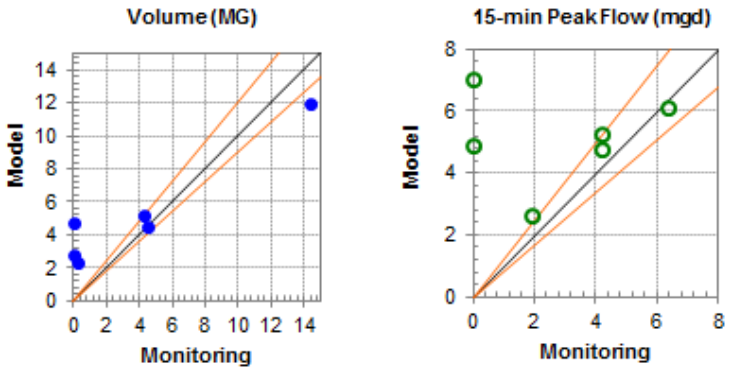
Sep-4 Model Calibration Results (Metered and Modeled Flow)



Sep-4 Model Validation Results (Metered and Modeled Flow)

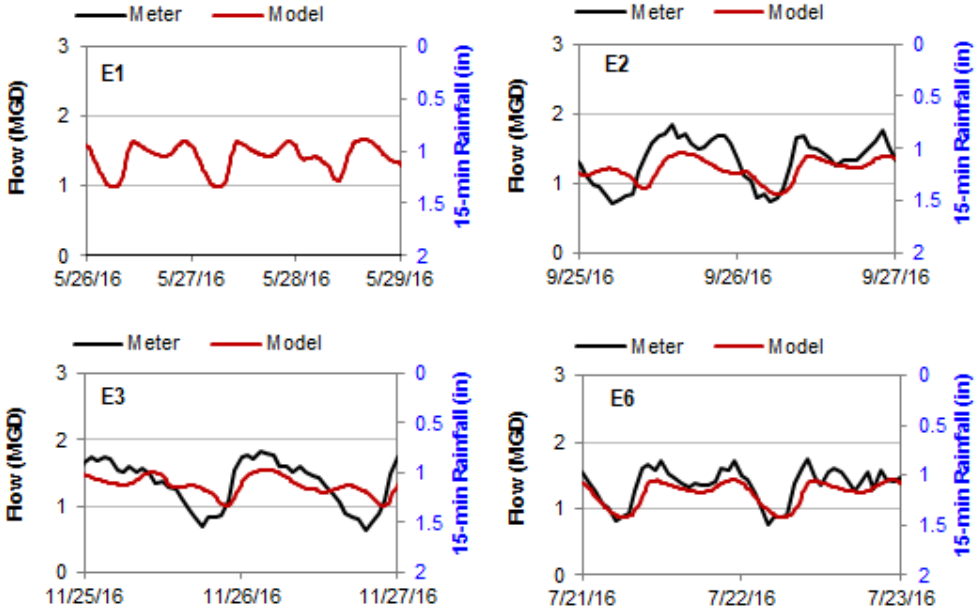


Sep-4 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

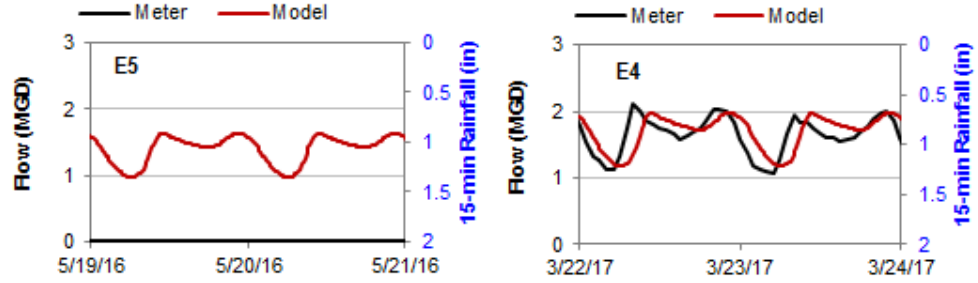


FLOW METER SEP-4 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

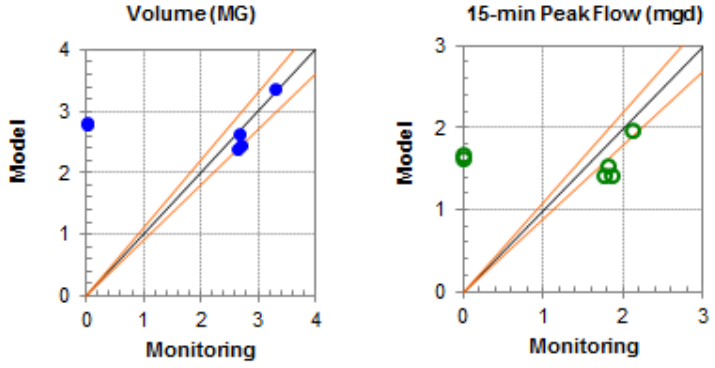
Sep-4 Model Calibration Results (Metered and Modeled Flow)



Sep-4 Model Validation Results (Metered and Modeled Flow)



Sep-4 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



Sep-4 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.00	1.67	-10% to +10%	See Note Below	0.00	2.82	-10% to +10%	See Note Below
E2	1.84	1.43	-10% to +10%	-22%	2.65	2.40	-10% to +10%	-9%
E3	1.82	1.55	-10% to +10%	-15%	2.66	2.62	-10% to +10%	-2%
E4	2.12	1.98	-10% to +10%	-7%	3.29	3.38	-10% to +10%	3%
E5	0.00	1.63	-10% to +10%	See Note Below	0.00	2.79	-10% to +10%	See Note Below
E6	1.75	1.43	-10% to +10%	-19%	2.70	2.45	-10% to +10%	-9%

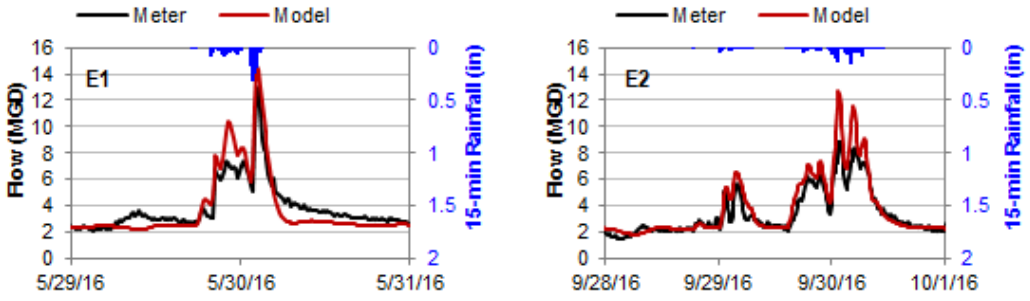
Sep-4 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.00	7.04	-15% to +25%	See Note Below!	0.00	2.77	-10% to +20%	See Note Below
E2	4.19	5.28	-15% to +25%	26%	4.27	5.24	-10% to +20%	23%
E3	4.17	4.77	-15% to +25%	14%	4.45	4.49	-10% to +20%	1%
E4	6.33	6.13	-15% to +25%	-3%	14.38	11.95	-10% to +20%	-17%
E5	0.00	4.91	-15% to +25%	See Note Below	0.00	4.68	-10% to +20%	See Note Below
E6	1.88	2.62	-15% to +25%	See Note Below	0.27	2.32	-10% to +20%	See Note Below

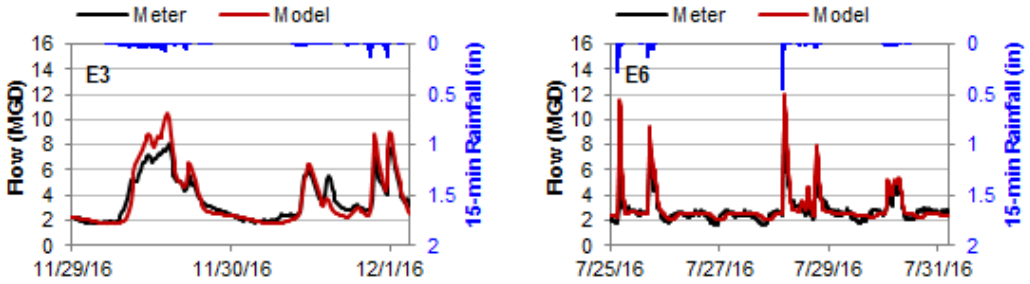
Note: Flow meter was included after the first quarter of flow monitoring; therefore no data was available for Events E1 and E5. Also, meter data was not available for part of E6.

Three of the four available wet weather events are calibrated well within the industry criteria. Flow meter data recorded for E6 is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

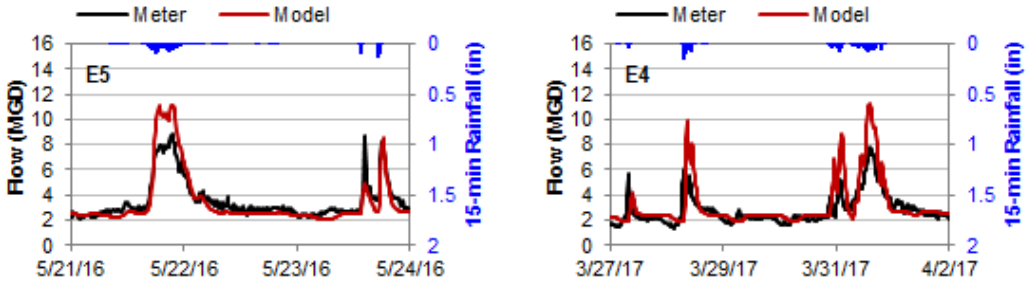
FLOW METER SIDE-1 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

Side-1 Model Calibration Results (Metered and Modeled Flow)

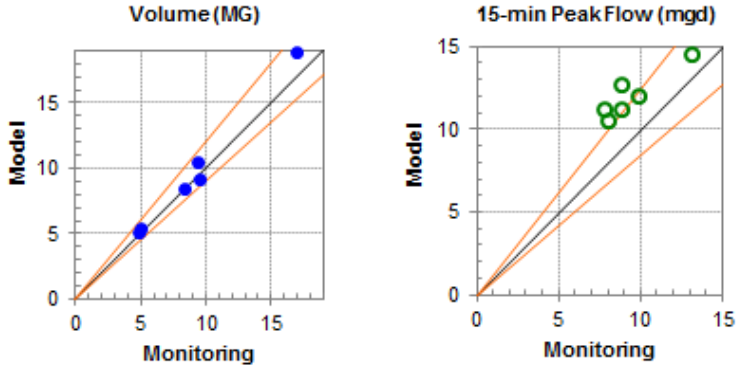




Side-1 Model Validation Results (Metered and Modeled Flow)

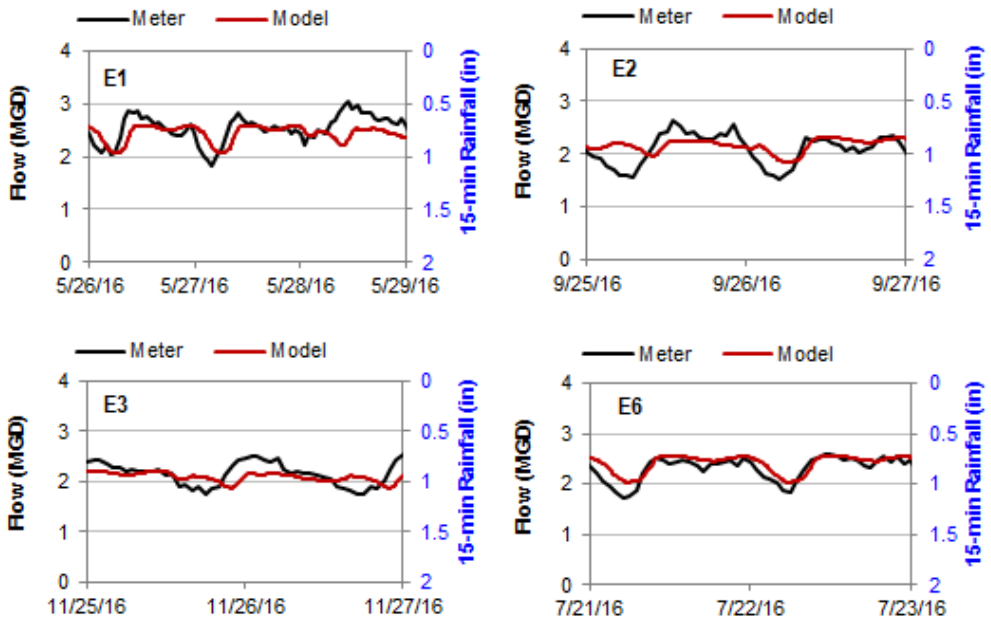


Side-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

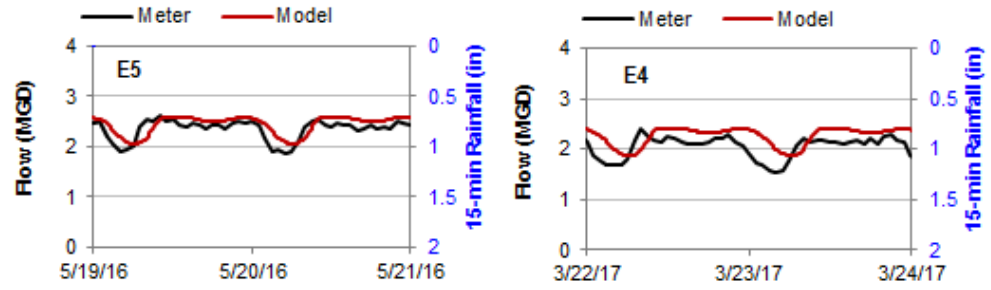


FLOW METER SIDE-1 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

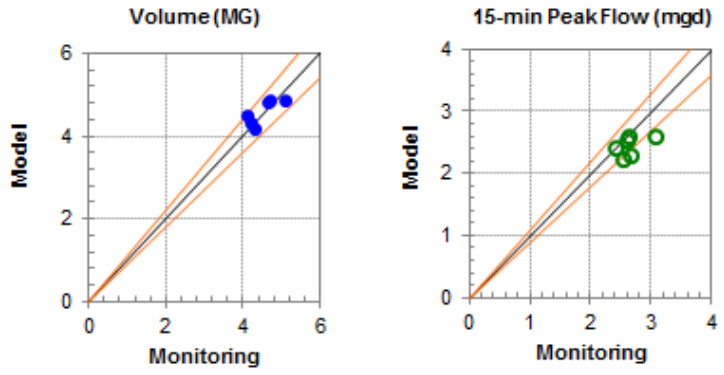
Side-1 Model Calibration Results (Metered and Modeled Flow)



Side-1 Model Validation Results (Metered and Modeled Flow)



Side-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



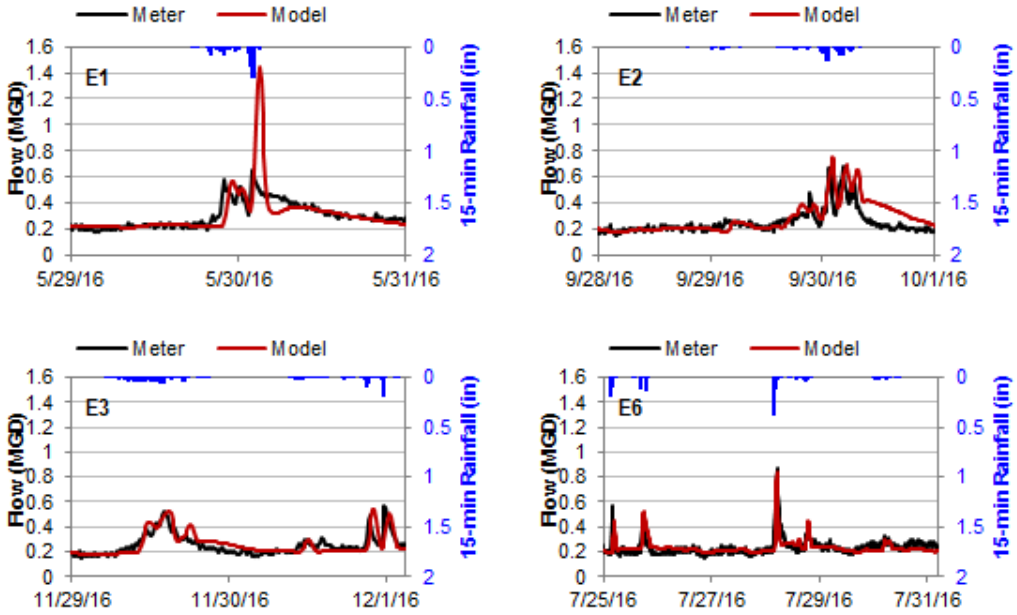
Side-1 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	3.05	2.59	-10% to +10%	-15%	5.11	4.87	-10% to +10%	-5%
E2	2.66	2.31	-10% to +10%	-13%	4.20	4.33	-10% to +10%	3%
E3	2.53	2.22	-10% to +10%	-12%	4.31	4.18	-10% to +10%	-3%
E4	2.42	2.41	-10% to +10%	0%	4.09	4.52	-10% to +10%	11%
E5	2.62	2.59	-10% to +10%	-1%	4.69	4.88	-10% to +10%	4%
E6	2.61	2.55	-10% to +10%	-2%	4.62	4.81	-10% to +10%	4%

Side-1 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	13.05	14.57	-15% to +25%	12%	4.90	5.07	-10% to +20%	3%
E2	8.85	12.75	-15% to +25%	44%	9.30	10.43	-10% to +20%	12%
E3	8.03	10.54	-15% to +25%	31%	8.35	8.49	-10% to +20%	2%
E4	7.73	11.25	-15% to +25%	45%	16.90	18.97	-10% to +20%	12%
E5	8.84	11.19	-15% to +25%	27%	9.43	9.22	-10% to +20%	-2%
E6	9.88	12.03	-15% to +25%	22%	5.02	5.43	-10% to +20%	8%

Note: All the six wet weather events are calibrated well within or close to the industry criteria except peak flows for Event E2 and E4 because the flow meter data recorded for the events is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER SIDE-2 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

Side-2 Model Calibration Results (Metered and Modeled Flow)



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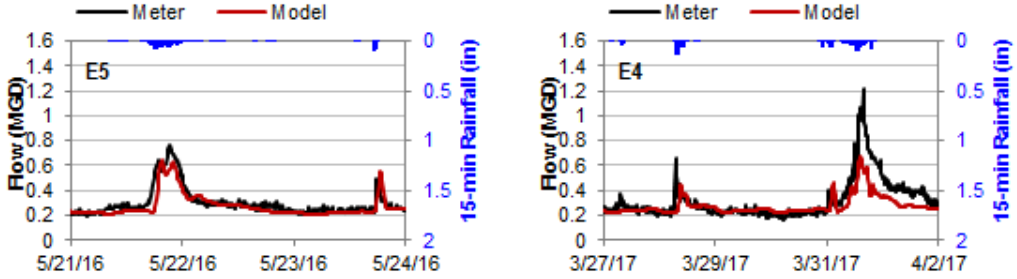
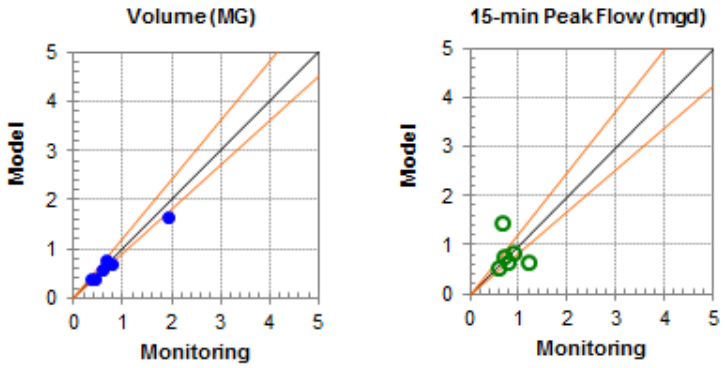
Side-2 Model Validation Results (Metered and Modeled Flow)

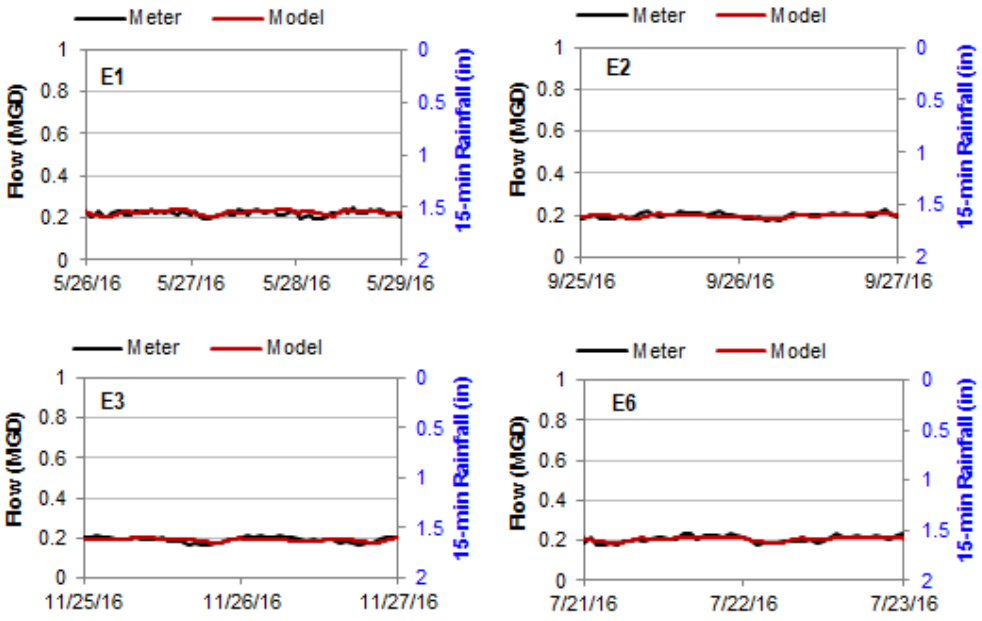


Side-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

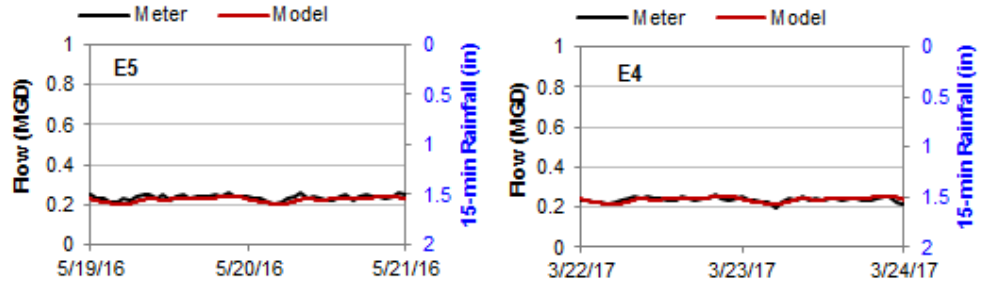


FLOW METER SIDE-2 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

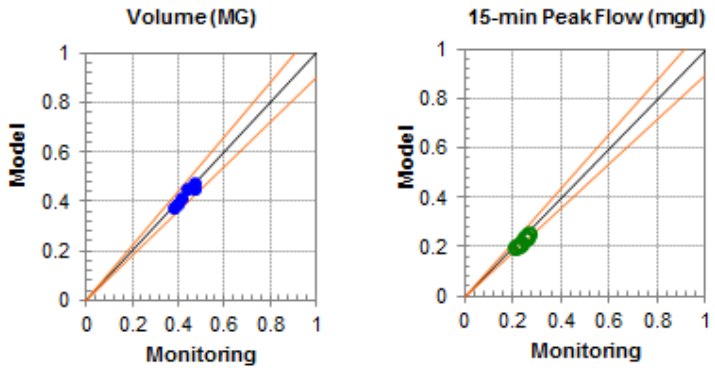
Side-2 Model Calibration Results (Metered and Modeled Flow)



Side-2 Model Validation Results (Metered and Modeled Flow)



Side-2 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

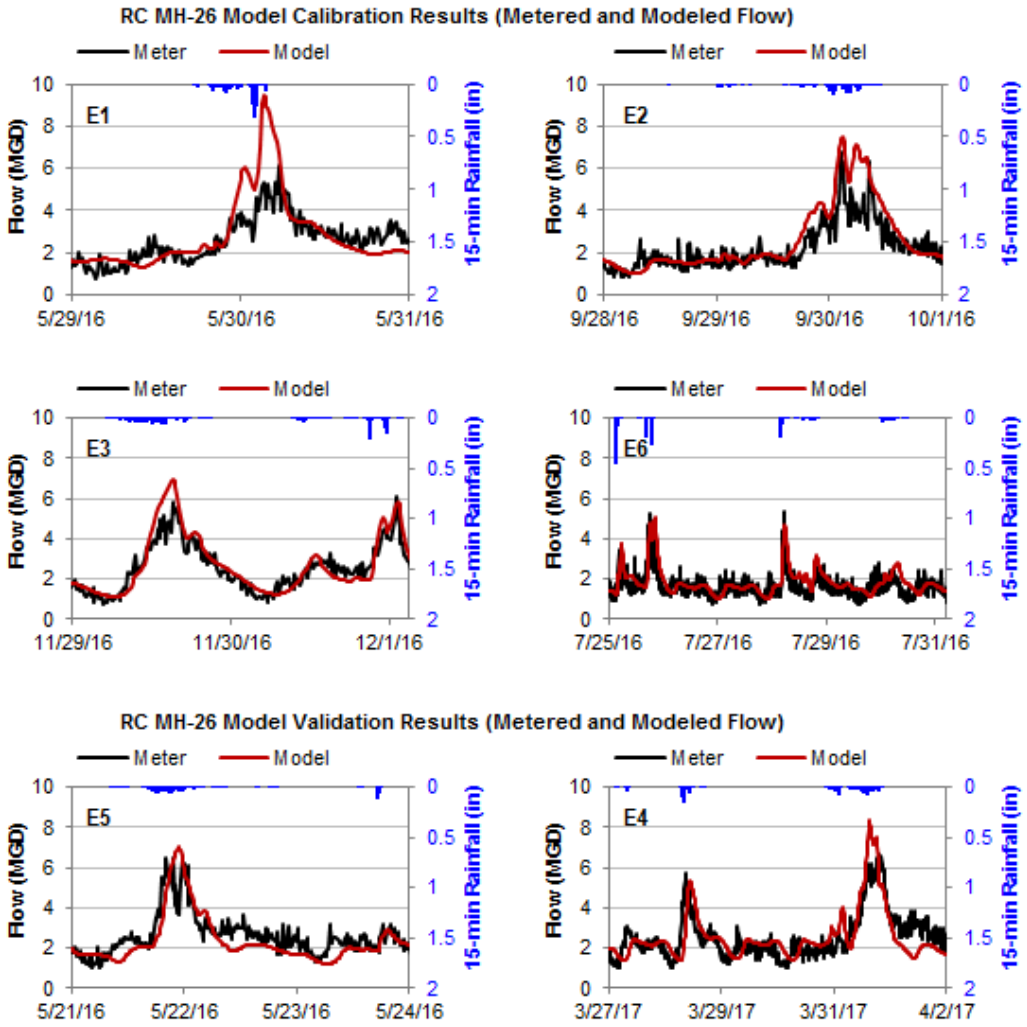


Side-2 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.25	0.24	-10% to +10%	-4%	0.44	0.45	-10% to +10%	2%
E2	0.23	0.21	-10% to +10%	-8%	0.40	0.39	-10% to +10%	-1%
E3	0.21	0.20	-10% to +10%	-4%	0.38	0.38	-10% to +10%	0%
E4	0.26	0.25	-10% to +10%	-5%	0.47	0.47	-10% to +10%	0%
E5	0.26	0.24	-10% to +10%	-7%	0.47	0.45	-10% to +10%	-5%
E6	0.23	0.22	-10% to +10%	-7%	0.41	0.41	-10% to +10%	-1%

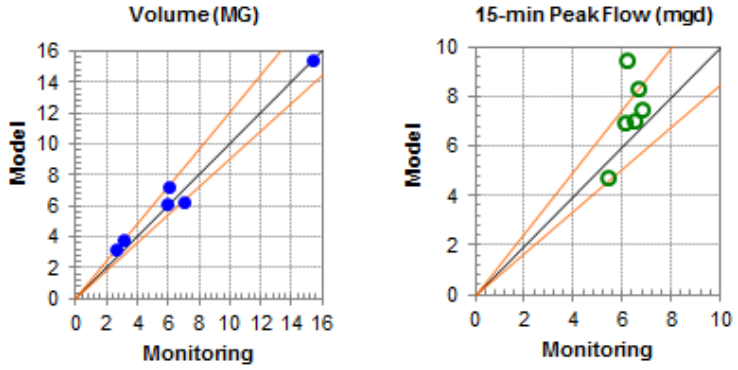
Side-2 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.65	1.44	-15% to +25%	120%	0.36	0.38	-10% to +20%	5%
E2	0.68	0.75	-15% to +25%	10%	0.67	0.76	-10% to +20%	15%
E3	0.56	0.54	-15% to +25%	-3%	0.58	0.59	-10% to +20%	2%
E4	1.21	0.67	-15% to +25%	-45%	1.94	1.66	-10% to +20%	-14%
E5	0.76	0.65	-15% to +25%	-14%	0.78	0.71	-10% to +20%	-8%
E6	0.87	0.85	-15% to +25%	-3%	0.42	0.41	-10% to +20%	-4%

Note: Four of the six wet weather events are calibrated well within the industry criteria. Flow meter data recorded for some of the events (E1 and E4) is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER RC MH-26 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

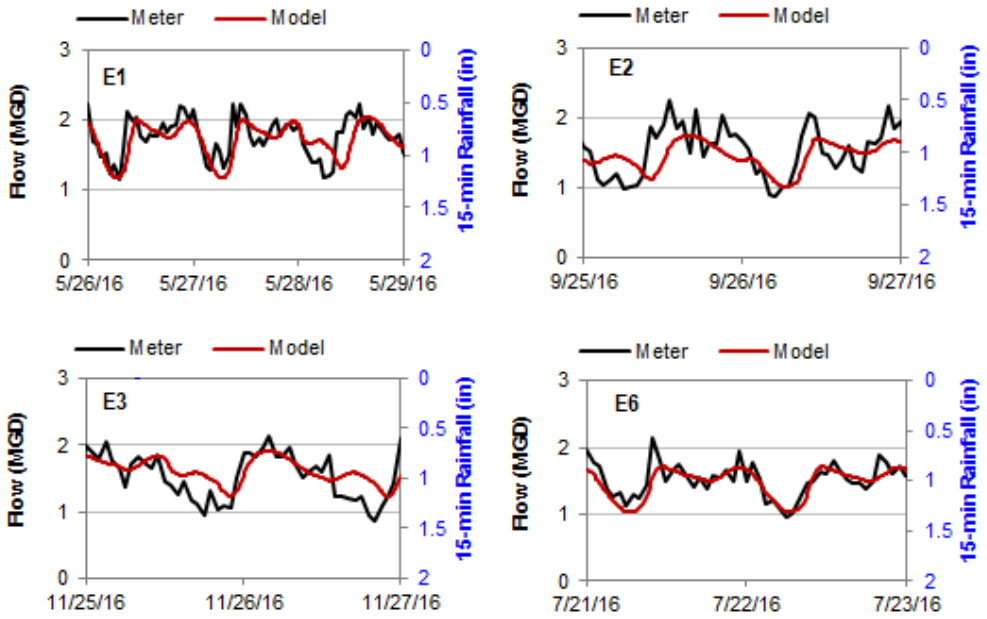


RC MH-26 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

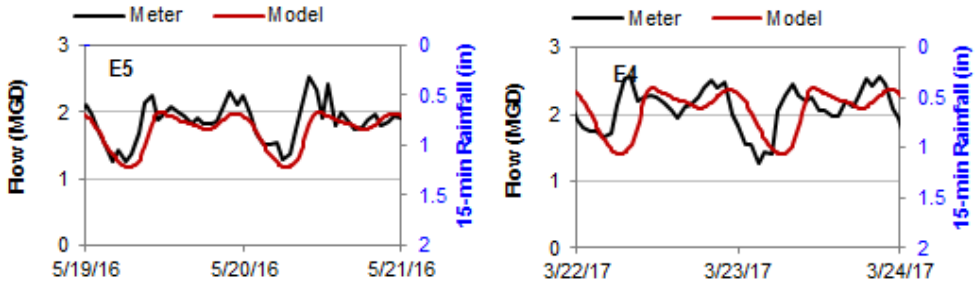


FLOW METER RC MH-26 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

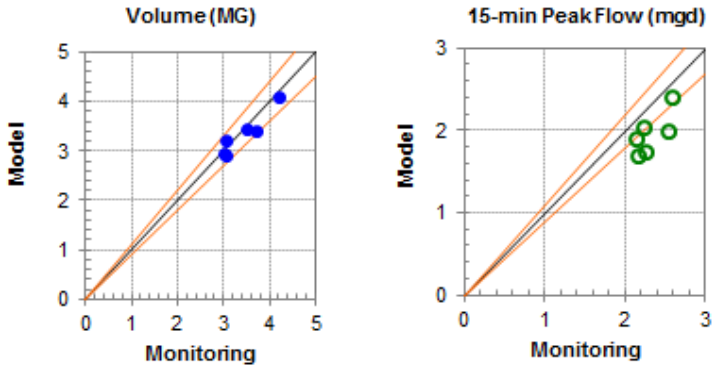
RC MH-26 Model Calibration Results (Metered and Modeled Flow)



RC MH-26 Model Validation Results (Metered and Modeled Flow)



RC MH-26 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



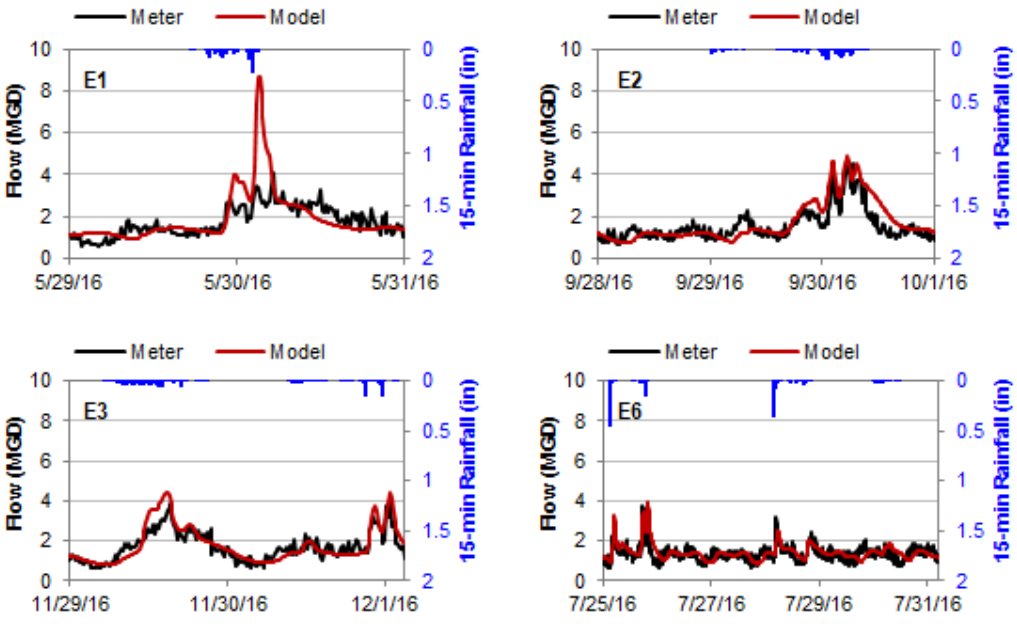
RC MH-26 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	2.23	2.04	-10% to +10%	-8%	3.49	3.44	-10% to +10%	-1%
E2	2.25	1.74	-10% to +10%	-23%	3.04	2.90	-10% to +10%	-5%
E3	2.14	1.91	-10% to +10%	-11%	3.04	3.21	-10% to +10%	6%
E4	2.58	2.40	-10% to +10%	-7%	4.20	4.09	-10% to +10%	-3%
E5	2.53	2.00	-10% to +10%	-21%	3.70	3.41	-10% to +10%	-8%
E6	2.15	1.71	-10% to +10%	-21%	3.02	2.94	-10% to +10%	-3%

RC MH-26 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	6.14	9.50	-15% to +25%	55%	3.08	3.89	-10% to +20%	26%
E2	6.76	7.46	-15% to +25%	10%	5.99	7.22	-10% to +20%	21%
E3	6.07	6.93	-15% to +25%	14%	5.85	6.18	-10% to +20%	6%
E4	6.64	8.33	-15% to +25%	25%	15.34	15.43	-10% to +20%	1%
E5	6.48	7.02	-15% to +25%	8%	7.01	6.25	-10% to +20%	-11%
E6	5.39	4.72	-15% to +25%	-12%	2.64	3.24	-10% to +20%	23%

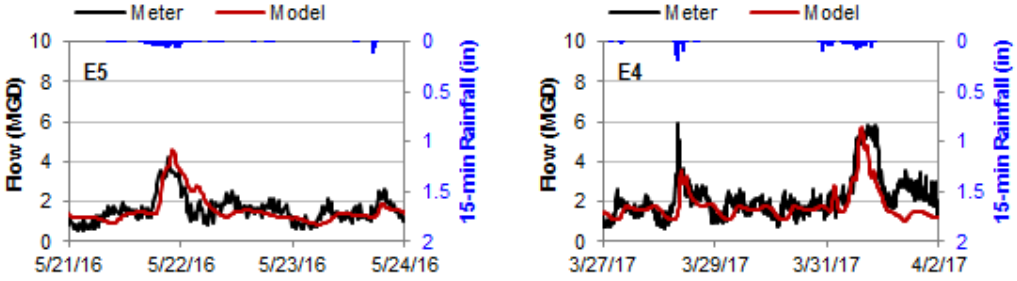
Note: All the six wet weather events are calibrated well within the industry criteria except Event E1. Flow meter data recorded for E1 is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER RC MH-30 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

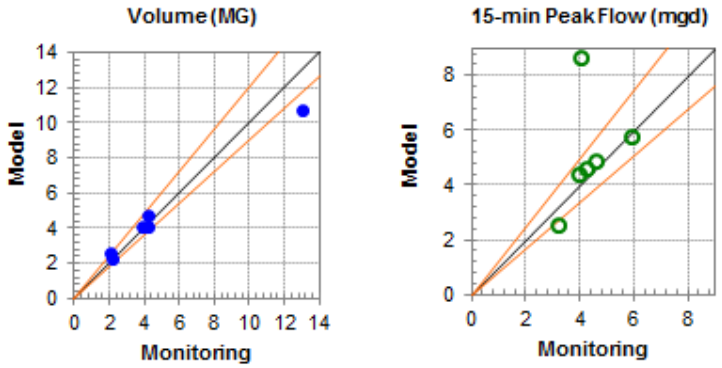
RC MH-30 Model Calibration Results (Metered and Modeled Flow)



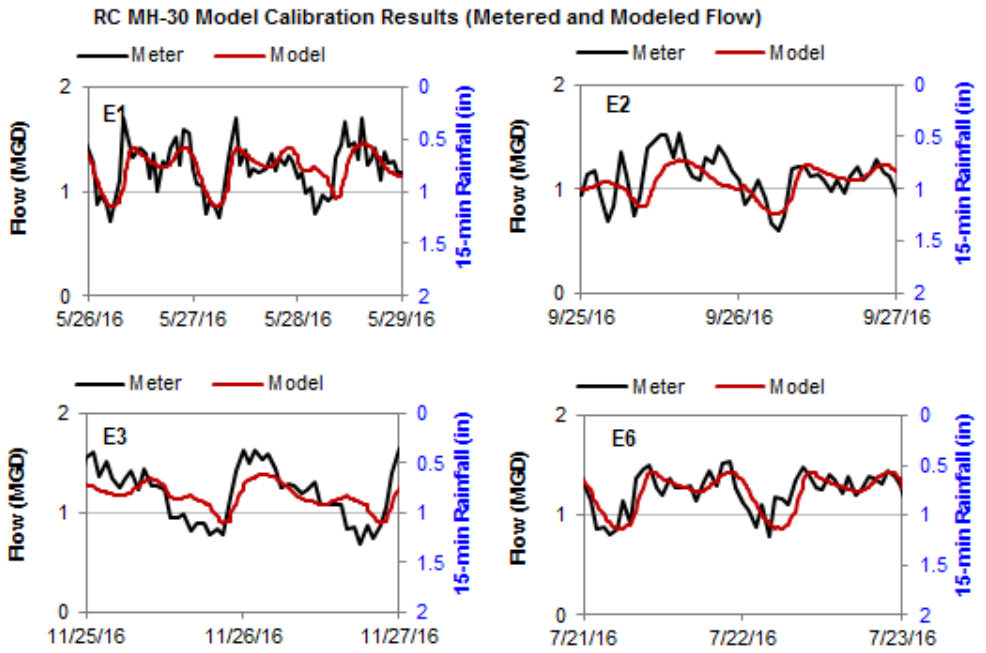
RC MH-30 Model Validation Results (Metered and Modeled Flow)

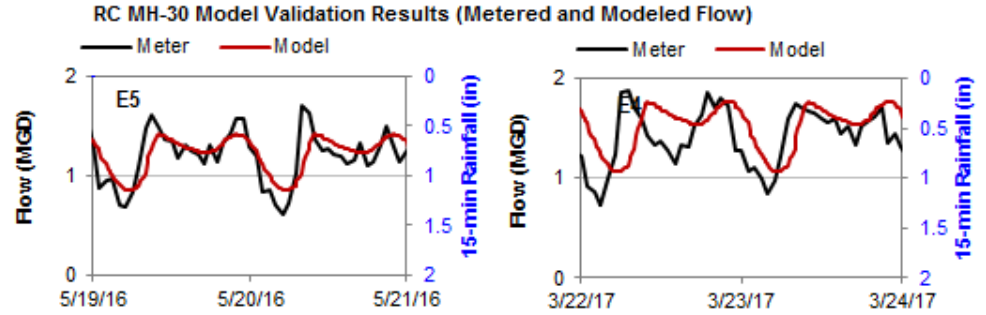


RC MH-30 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

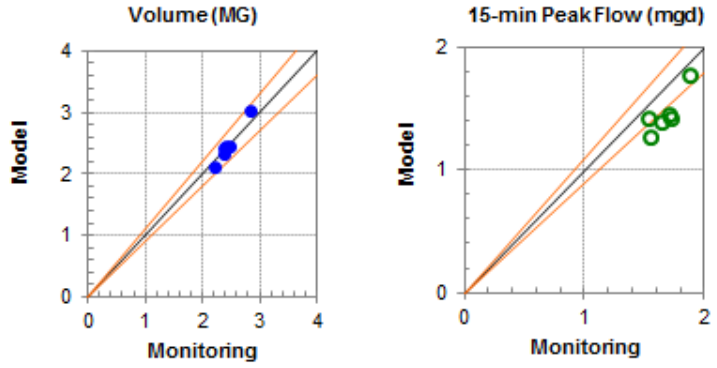


FLOW METER RC MH-30 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events





RC MH-30 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



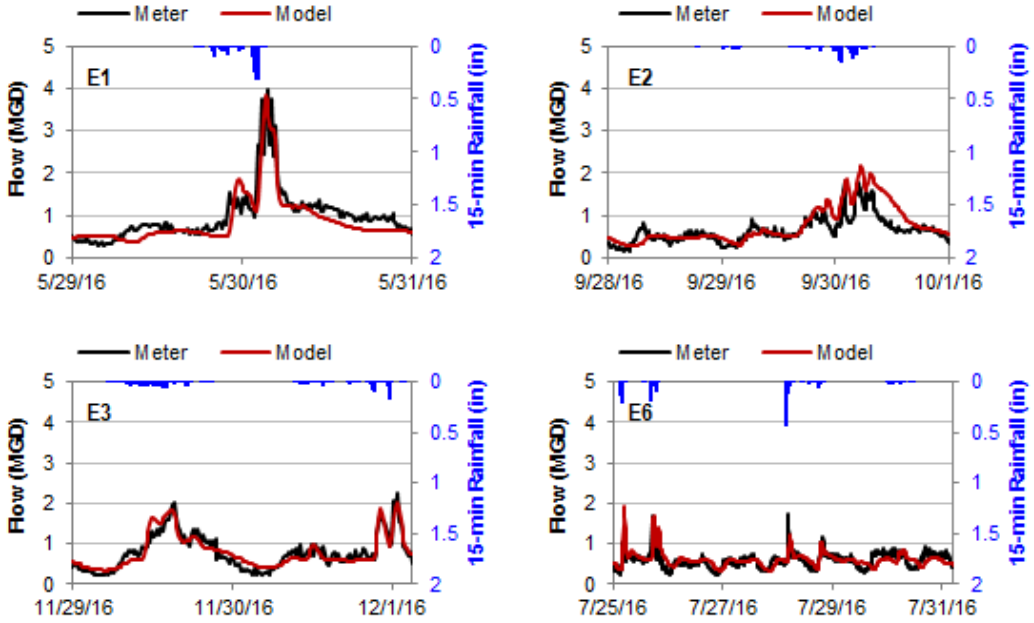
RC MH-30 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	1.71	1.46	-10% to +10%	-15%	2.41	2.44	-10% to +10%	2%
E2	1.54	1.28	-10% to +10%	-17%	2.23	2.13	-10% to +10%	-4%
E3	1.65	1.39	-10% to +10%	-16%	2.38	2.34	-10% to +10%	-2%
E4	1.88	1.77	-10% to +10%	-6%	2.84	3.03	-10% to +10%	7%
E5	1.71	1.42	-10% to +10%	-17%	2.38	2.43	-10% to +10%	2%
E6	1.53	1.43	-10% to +10%	-7%	2.48	2.45	-10% to +10%	-1%

RC MH-30 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	4.04	8.67	-15% to +25%	114%	2.11	2.59	-10% to +20%	23%
E2	4.57	4.88	-15% to +25%	7%	4.17	4.73	-10% to +20%	13%
E3	3.97	4.44	-15% to +25%	12%	3.91	4.05	-10% to +20%	4%
E4	5.94	5.77	-15% to +25%	-3%	13.02	10.72	-10% to +20%	-18%
E5	4.24	4.63	-15% to +25%	9%	4.24	4.13	-10% to +20%	-3%
E6	3.23	2.55	-15% to +25%	-21%	2.15	2.27	-10% to +20%	6%

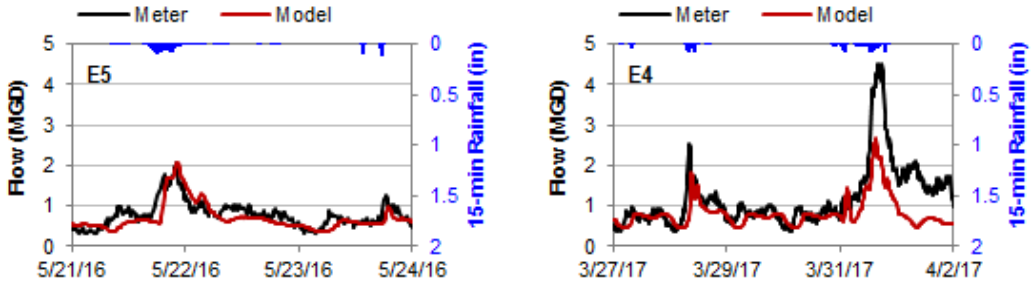
Note: All the six wet weather events are calibrated well within or close to the industry criteria except peak flow for Event E1. Flow meter data recorded for E1 is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER RC MH-32 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

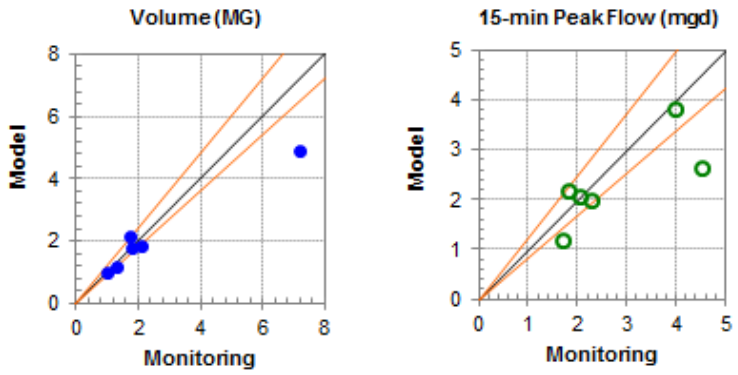
RC MH-32 Model Calibration Results (Metered and Modeled Flow)



RC MH-32 Model Validation Results (Metered and Modeled Flow)

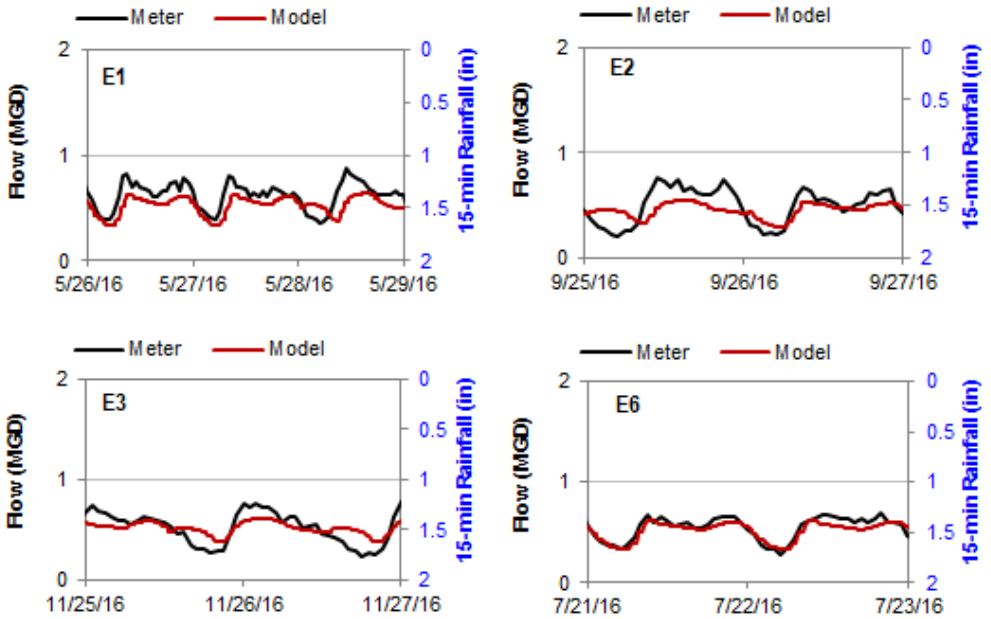


RC MH-32 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

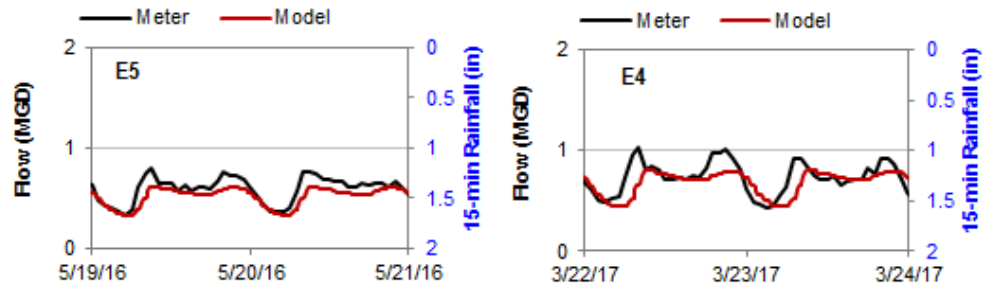


FLOW METER RC MH-32 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

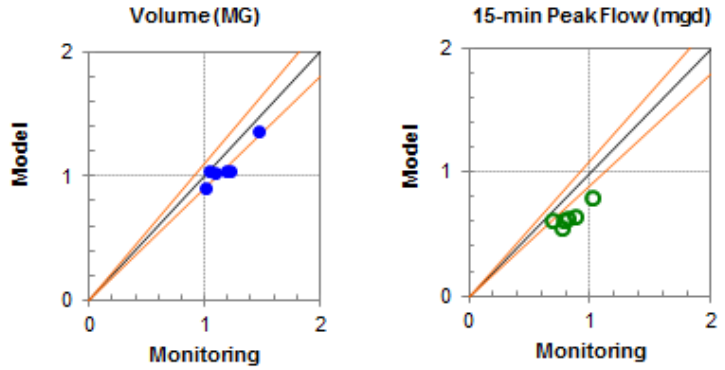
RC MH-32 Model Calibration Results (Metered and Modeled Flow)



RC MH-32 Model Validation Results (Metered and Modeled Flow)



RC MH-32 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



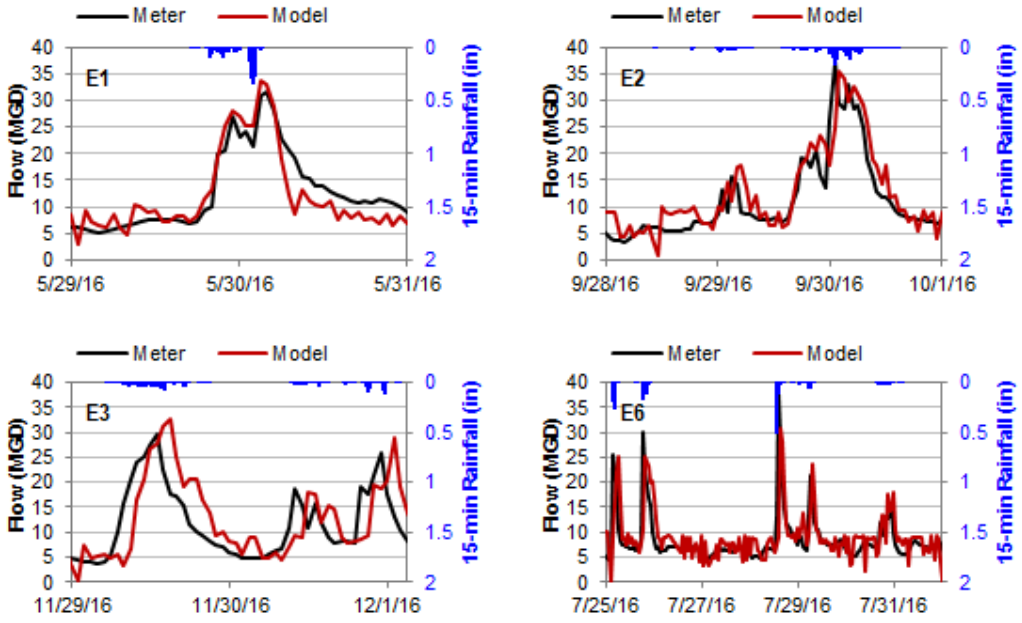
RC MH-32 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.88	0.64	-10% to +10%	-28%	1.22	1.05	-10% to +10%	-14%
E2	0.76	0.55	-10% to +10%	-28%	1.00	0.91	-10% to +10%	-9%
E3	0.77	0.62	-10% to +10%	-20%	1.04	1.04	-10% to +10%	0%
E4	1.02	0.80	-10% to +10%	-22%	1.47	1.36	-10% to +10%	-8%
E5	0.81	0.62	-10% to +10%	-23%	1.19	1.04	-10% to +10%	-13%
E6	0.69	0.61	-10% to +10%	-11%	1.09	1.03	-10% to +10%	-5%

RC MH-32 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	3.98	3.83	-15% to +25%	-4%	1.27	1.19	-10% to +20%	-7%
E2	1.80	2.20	-15% to +25%	22%	1.75	2.13	-10% to +20%	22%
E3	2.27	1.99	-15% to +25%	-12%	1.78	1.79	-10% to +20%	0%
E4	4.52	2.65	-15% to +25%	-41%	7.18	4.89	-10% to +20%	-32%
E5	2.04	2.08	-15% to +25%	2%	2.07	1.85	-10% to +20%	-11%
E6	1.72	1.19	-15% to +25%	-30%	0.98	0.98	-10% to +20%	0%

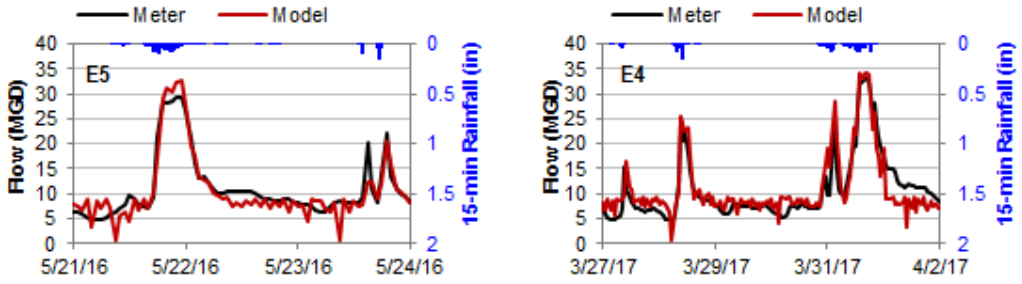
Note: All the six wet weather events are calibrated well within or close to the industry criteria except Event E4. Flow meter data recorded for E4 is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER CPS MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

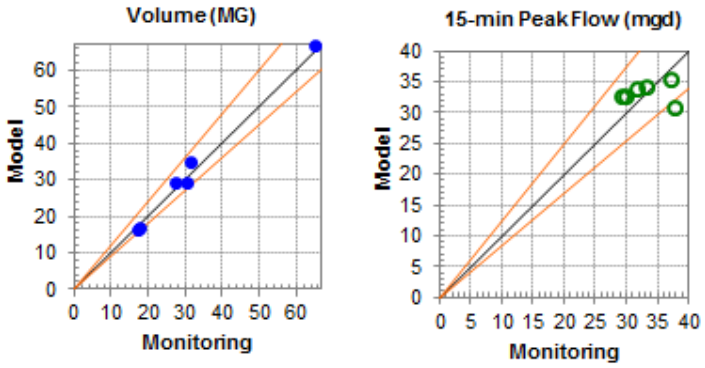
CPS Model Calibration Results (Metered and Modeled Flow)



CPS Model Validation Results (Metered and Modeled Flow)

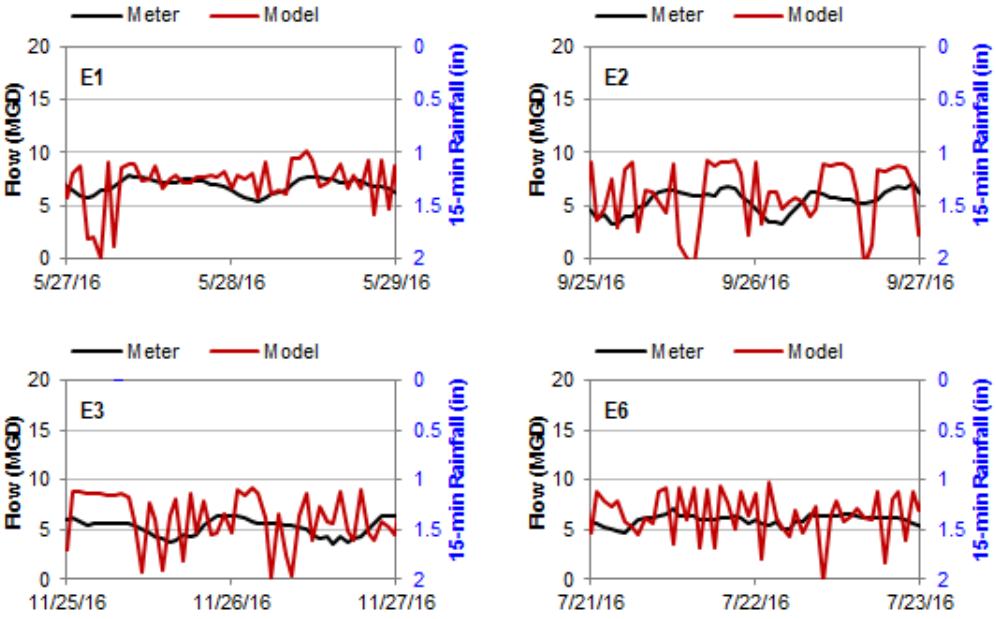


CPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

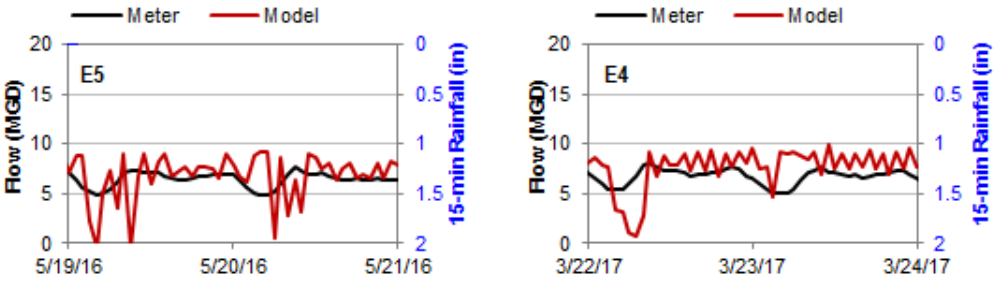


FLOW METER CPS MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

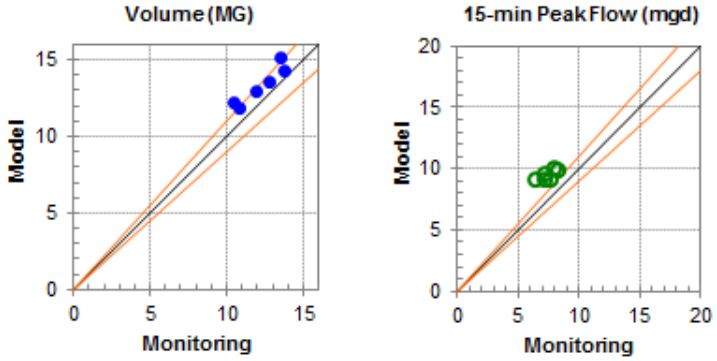
CPS Model Calibration Results (Metered and Modeled Flow)



CPS Model Validation Results (Metered and Modeled Flow)



CPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



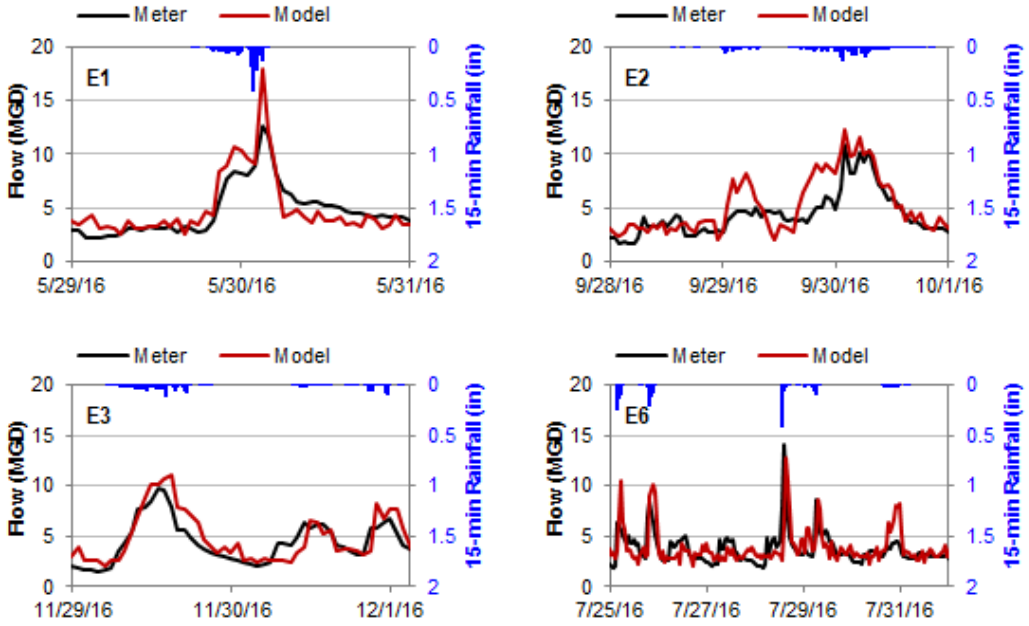
CPS Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	7.93	10.12	-10% to +10%	28%	13.69	14.37	-10% to +10%	5%
E2	7.16	9.19	-10% to +10%	28%	10.80	11.93	-10% to +10%	10%
E3	6.41	9.17	-10% to +10%	43%	10.42	12.30	-10% to +10%	18%
E4	8.12	9.96	-10% to +10%	23%	13.45	15.24	-10% to +10%	13%
E5	7.62	9.23	-10% to +10%	21%	12.79	13.56	-10% to +10%	6%
E6	7.11	9.69	-10% to +10%	36%	11.93	12.99	-10% to +10%	9%

CPS Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	31.54	33.89	-15% to +25%	7%	17.67	17.16	-10% to +20%	-3%
E2	37.19	35.56	-15% to +25%	-4%	31.53	35.06	-10% to +20%	11%
E3	29.85	32.57	-15% to +25%	9%	27.12	29.09	-10% to +20%	7%
E4	33.24	34.24	-15% to +25%	3%	64.77	66.78	-10% to +20%	3%
E5	29.39	32.86	-15% to +25%	12%	30.35	29.10	-10% to +20%	-4%
E6	37.62	30.86	-15% to +25%	-18%	16.98	16.47	-10% to +20%	-3%

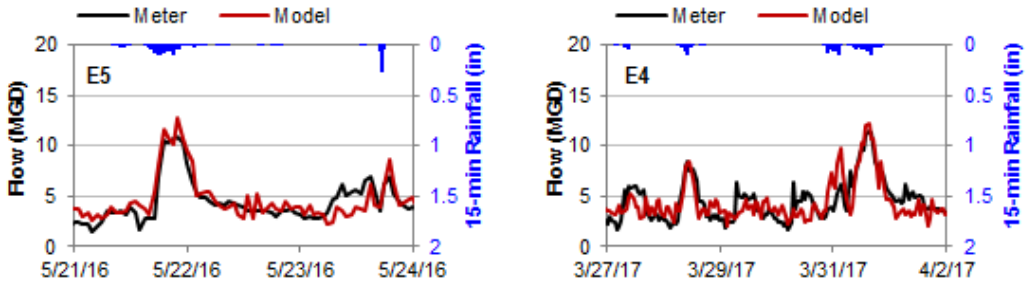
Note: All the six wet weather events are calibrated well within the industry criteria.

FLOW METER EPS-1 MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

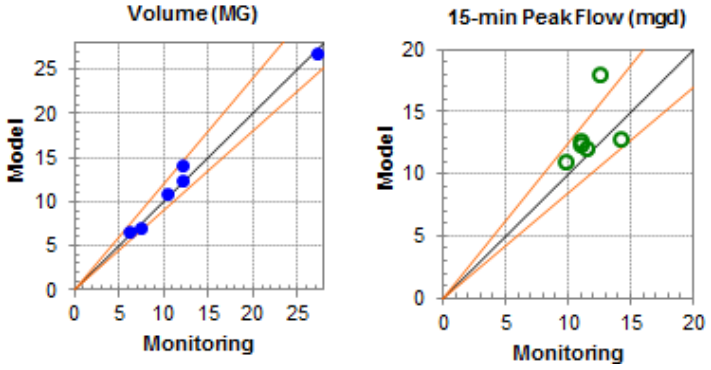
EPS-1 Model Calibration Results (Metered and Modeled Flow)



EPS-1 Model Validation Results (Metered and Modeled Flow)

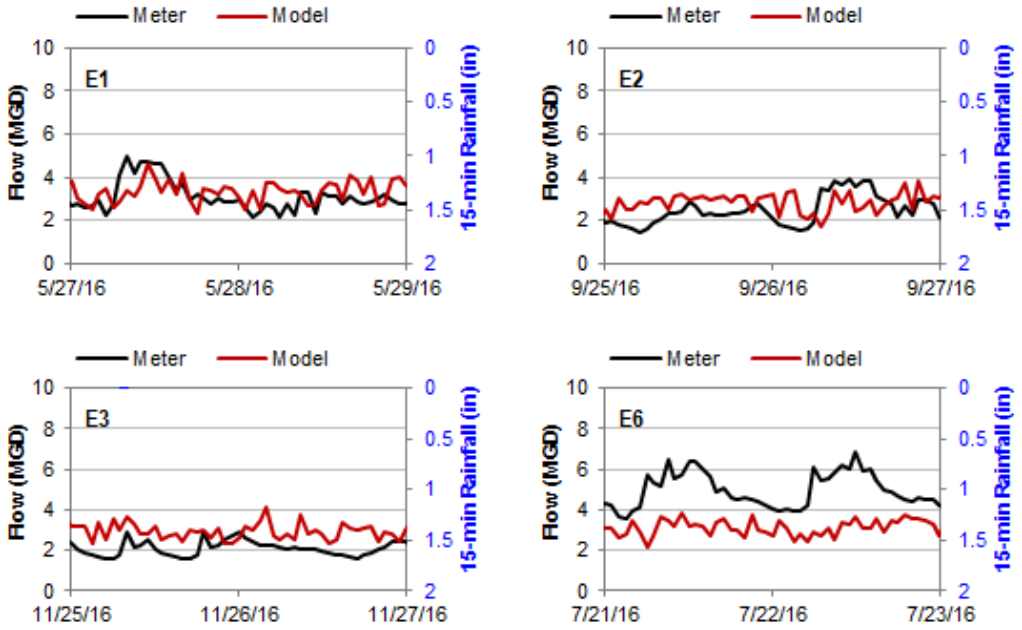


EPS-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

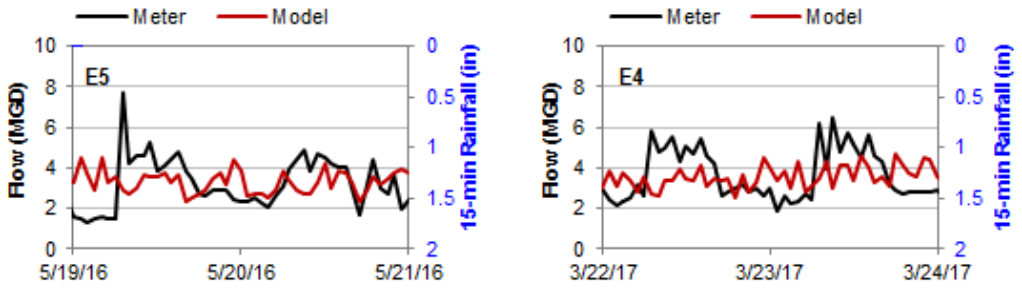


FLOW METER EPS-1 MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

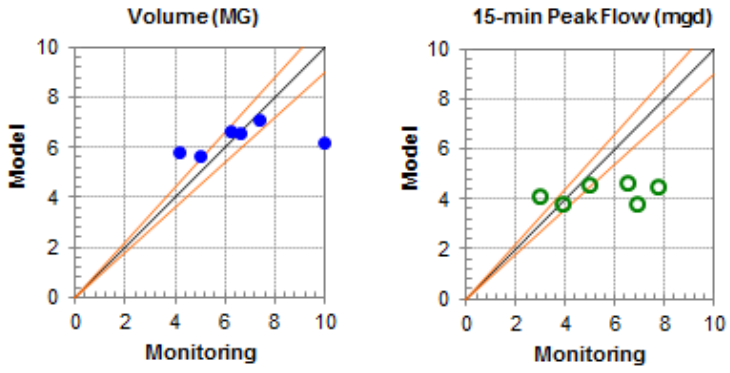
EPS-1 Model Calibration Results (Metered and Modeled Flow)



EPS-1 Model Validation Results (Metered and Modeled Flow)



EPS-1 Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



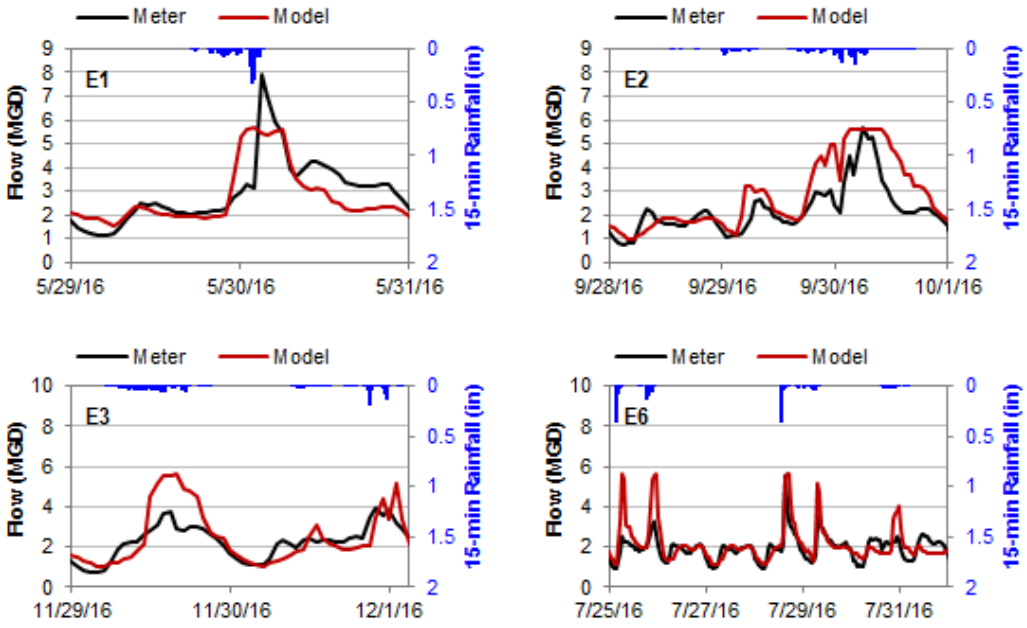
EPS-1 Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	4.95	4.61	-10% to +10%	-7%	6.25	6.65	-10% to +10%	7%
E2	3.88	3.81	-10% to +10%	-2%	4.96	5.69	-10% to +10%	15%
E3	2.90	4.11	-10% to +10%	42%	4.15	5.83	-10% to +10%	40%
E4	6.51	4.67	-10% to +10%	-28%	7.34	7.14	-10% to +10%	-3%
E5	7.72	4.50	-10% to +10%	-42%	6.57	6.62	-10% to +10%	1%
E6	6.83	3.86	-10% to +10%	-43%	9.97	6.23	-10% to +10%	-38%

EPS-1 Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	12.57	18.03	-15% to +25%	43%	6.19	6.60	-10% to +20%	6%
E2	10.94	12.32	-15% to +25%	13%	11.99	14.22	-10% to +20%	19%
E3	9.79	11.08	-15% to +25%	13%	10.30	10.88	-10% to +20%	6%
E4	11.50	12.12	-15% to +25%	5%	27.24	26.82	-10% to +20%	-2%
E5	10.92	12.74	-15% to +25%	17%	12.06	12.37	-10% to +20%	3%
E6	14.11	12.83	-15% to +25%	-9%	7.32	7.02	-10% to +20%	-4%

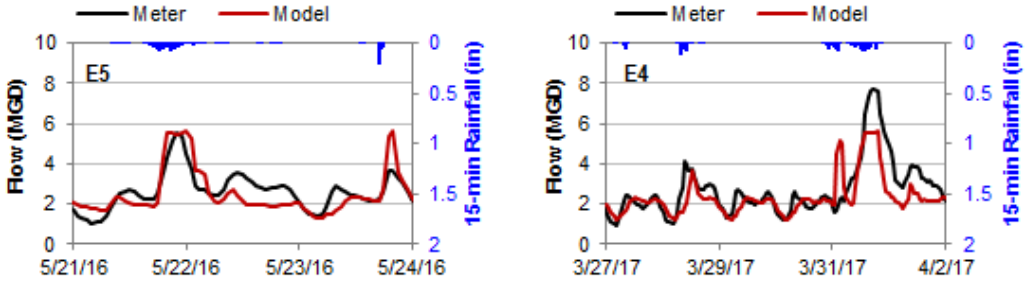
Note: All the six wet weather events are calibrated well within the industry criteria except peak flow for Event E1. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER NCPS MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

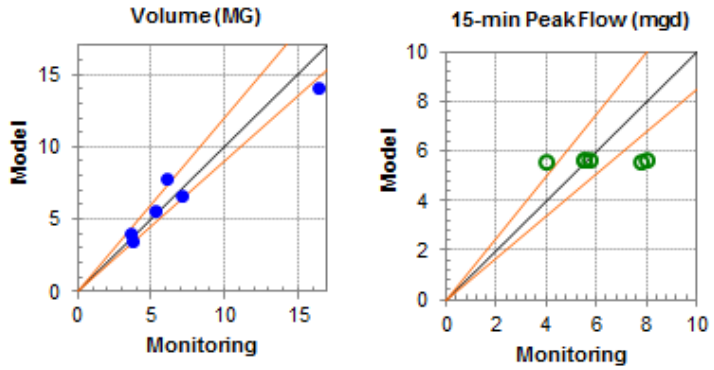
NCPS Model Calibration Results (Metered and Modeled Flow)



NCPS Model Validation Results (Metered and Modeled Flow)

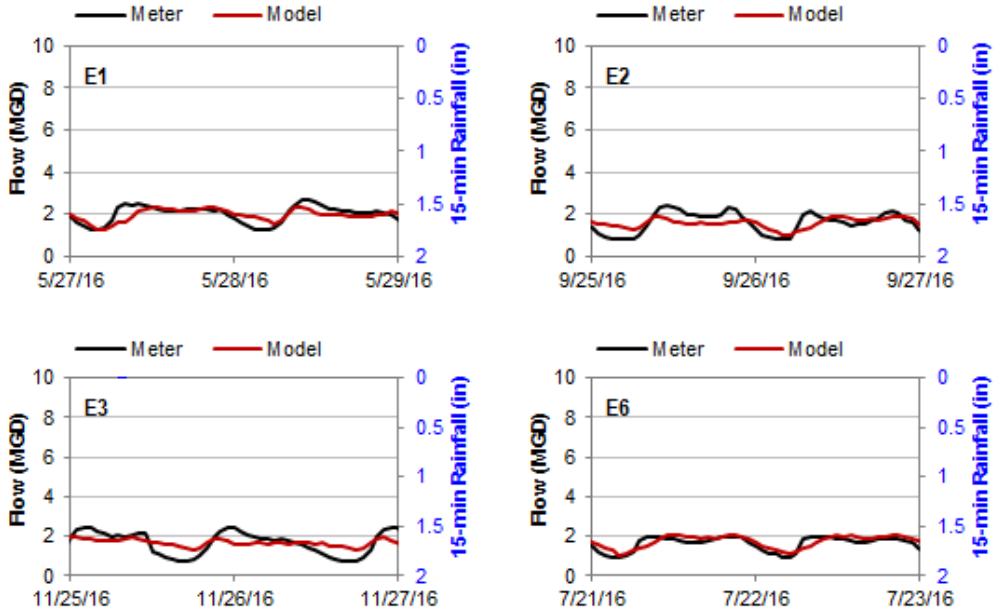


NCPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

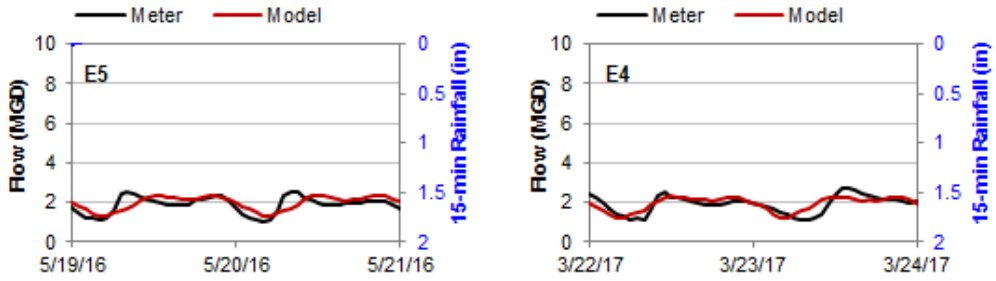


FLOW METER NCPS MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

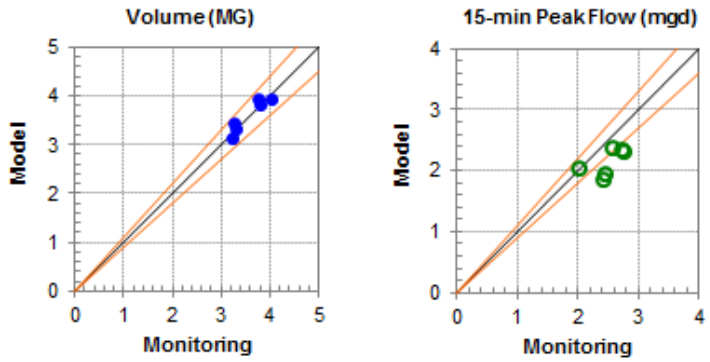
NCPS Model Calibration Results (Metered and Modeled Flow)



NCPS Model Validation Results (Metered and Modeled Flow)



NCPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



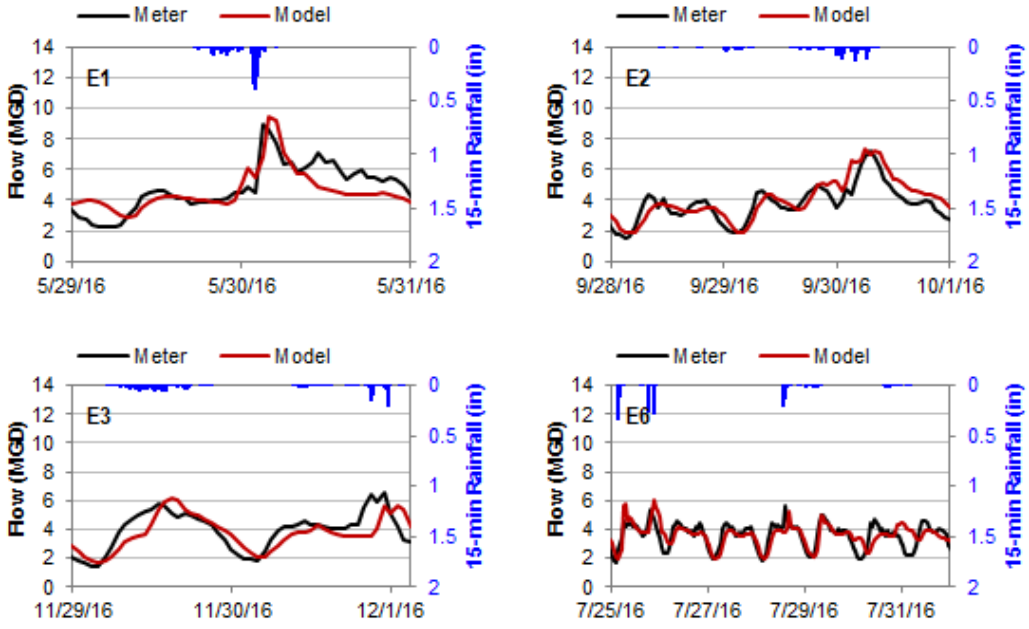
NCPS Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	2.72	2.36	-10% to +10%	-13%	4.02	3.93	-10% to +10%	-2%
E2	2.41	1.86	-10% to +10%	-23%	3.22	3.14	-10% to +10%	-2%
E3	2.45	1.94	-10% to +10%	-21%	3.31	3.33	-10% to +10%	1%
E4	2.74	2.31	-10% to +10%	-16%	3.78	3.84	-10% to +10%	2%
E5	2.55	2.38	-10% to +10%	-7%	3.77	3.95	-10% to +10%	5%
E6	1.99	2.05	-10% to +10%	3%	3.25	3.44	-10% to +10%	6%

NCPS Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	7.95	5.65	-15% to +25%	-29%	3.67	3.51	-10% to +20%	-4%
E2	5.71	5.63	-15% to +25%	-1%	6.02	7.83	-10% to +20%	30%
E3	3.95	5.62	-15% to +25%	42%	5.29	5.61	-10% to +20%	6%
E4	7.75	5.61	-15% to +25%	-28%	16.38	14.07	-10% to +20%	-14%
E5	5.51	5.66	-15% to +25%	3%	7.07	6.64	-10% to +20%	-6%
E6	5.51	5.67	-15% to +25%	3%	3.53	4.03	-10% to +20%	14%

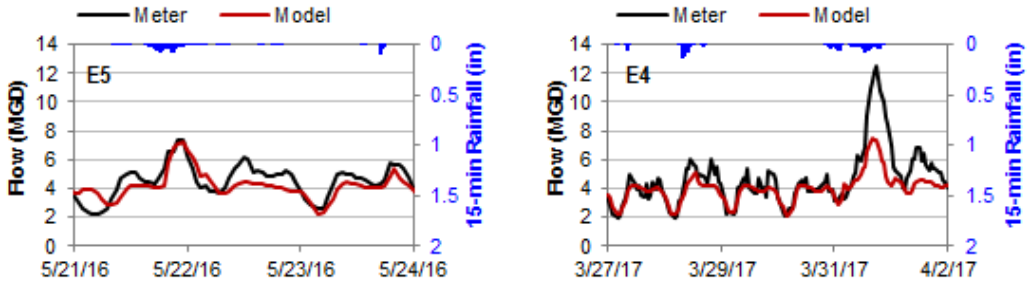
Note: Four of the six wet weather events are calibrated well within the industry criteria. The under-predicted peak flow for E1 and E4 is probably due to the pump capacity limit put in the model based on received pump curves. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER CRPS MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

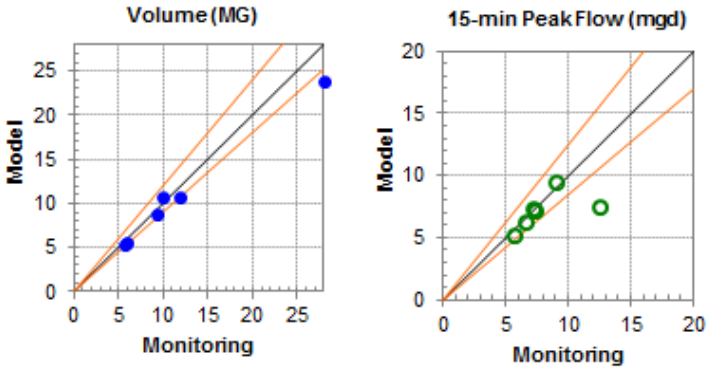
CRPS Model Calibration Results (Metered and Modeled Flow)



CRPS Model Validation Results (Metered and Modeled Flow)

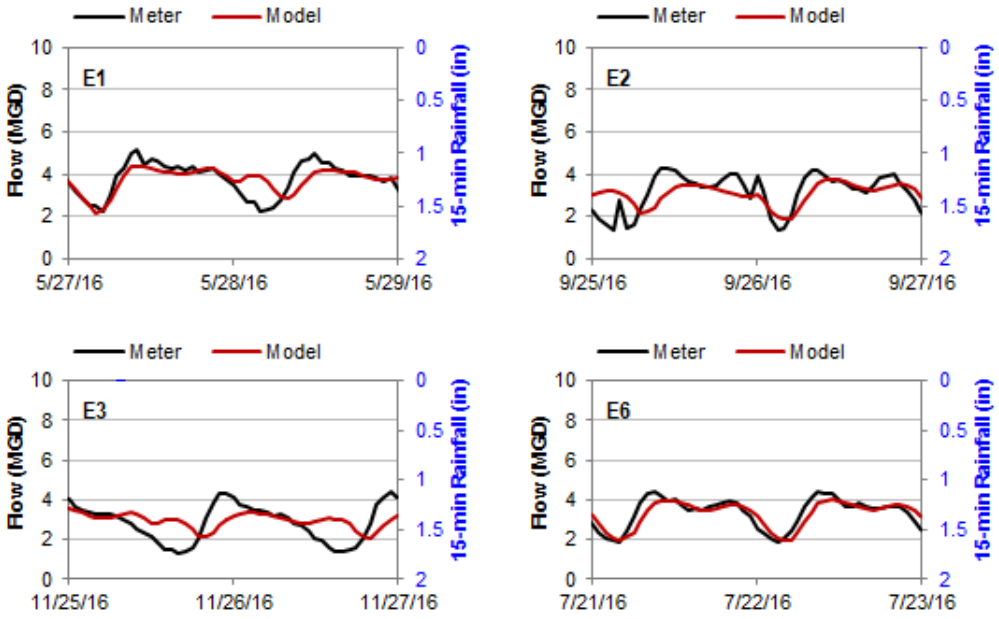


CRPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

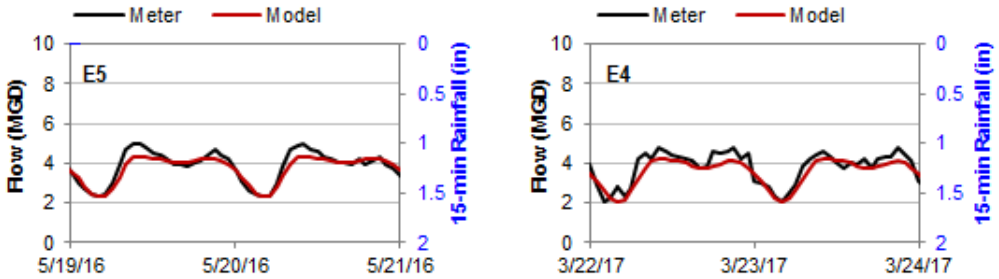


FLOW METER CRPS MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

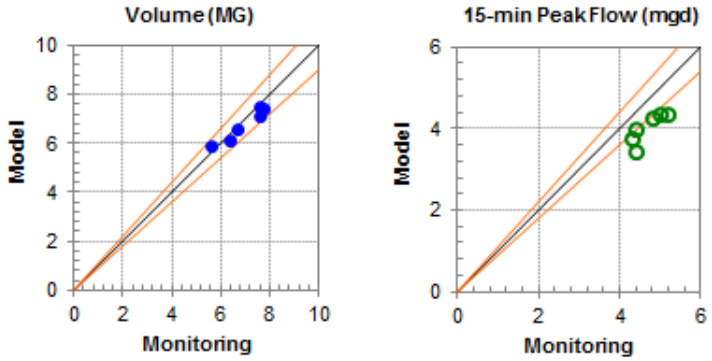
CRPS Model Calibration Results (Metered and Modeled Flow)



CRPS Model Validation Results (Metered and Modeled Flow)



CRPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



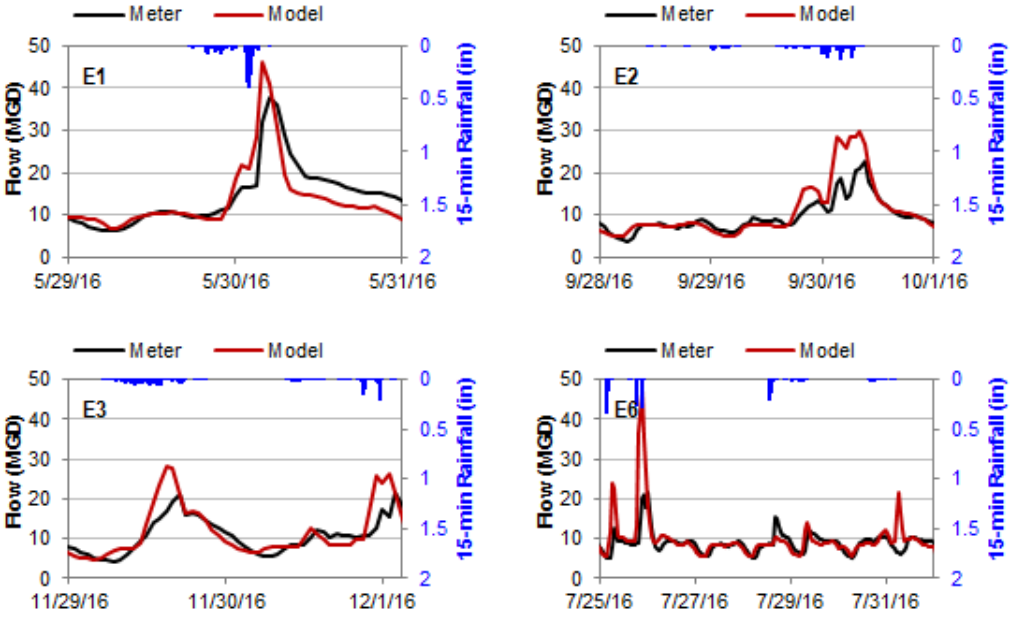
CRPS Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	5.18	4.36	-10% to +10%	-16%	7.58	7.49	-10% to +10%	-1%
E2	4.30	3.75	-10% to +10%	-13%	6.36	6.13	-10% to +10%	-4%
E3	4.38	3.44	-10% to +10%	-21%	5.64	5.87	-10% to +10%	4%
E4	4.81	4.26	-10% to +10%	-12%	7.59	7.10	-10% to +10%	-6%
E5	4.97	4.36	-10% to +10%	-12%	7.71	7.45	-10% to +10%	-3%
E6	4.42	3.99	-10% to +10%	-10%	6.71	6.56	-10% to +10%	-2%

CRPS Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	8.96	9.48	-15% to +25%	6%	5.67	5.45	-10% to +20%	-4%
E2	7.22	7.29	-15% to +25%	1%	10.03	10.80	-10% to +20%	8%
E3	6.54	6.21	-15% to +25%	-5%	9.27	8.75	-10% to +20%	-6%
E4	12.48	7.48	-15% to +25%	-40%	27.92	23.89	-10% to +20%	-14%
E5	7.40	7.17	-15% to +25%	-3%	11.95	10.82	-10% to +20%	-9%
E6	5.64	5.18	-15% to +25%	-8%	5.84	5.64	-10% to +20%	-3%

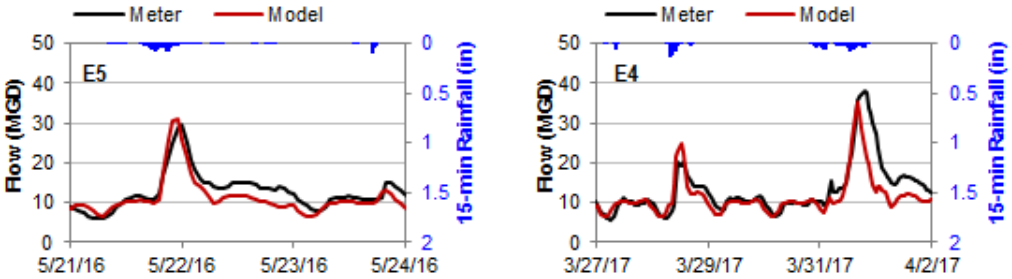
Note: All the six wet weather events are calibrated well within the industry criteria except peak flow for Event E4. Flow meter data recorded for E4 is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER CDPS TOTAL MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

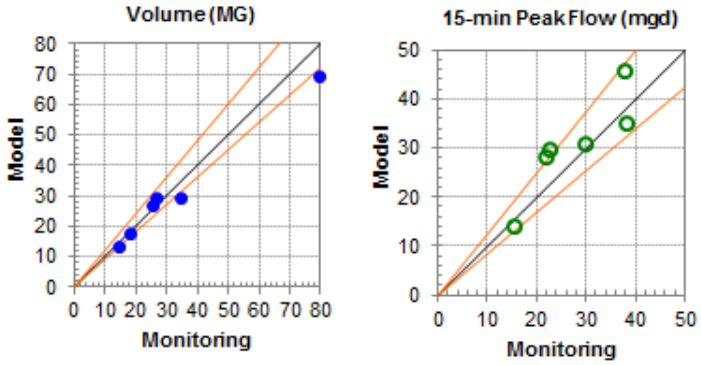
CDPS Total Model Calibration Results (Metered and Modeled Flow)



CDPS Total Model Validation Results (Metered and Modeled Flow)

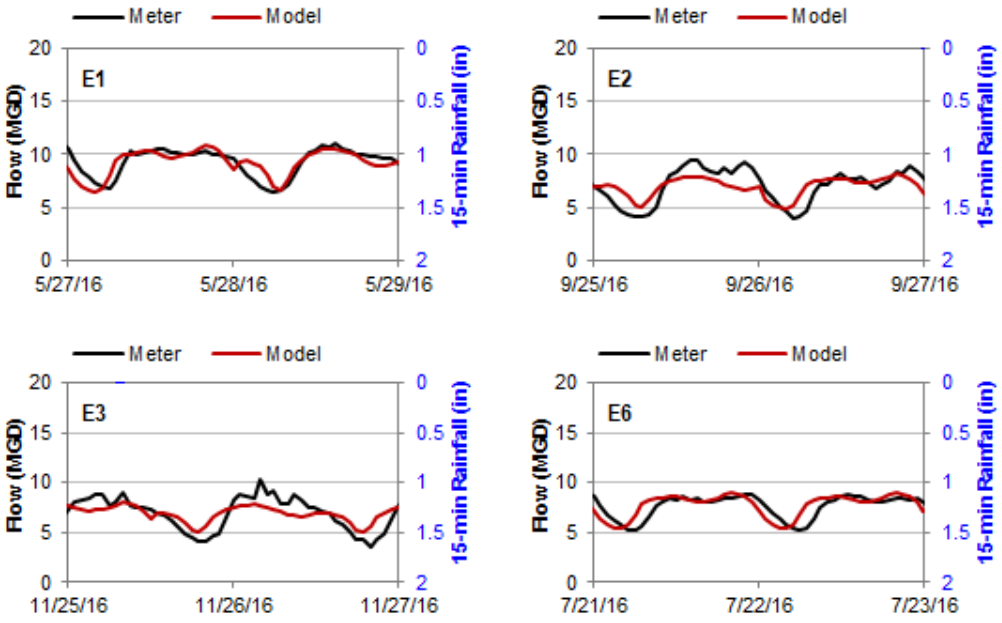


CDPS Total Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

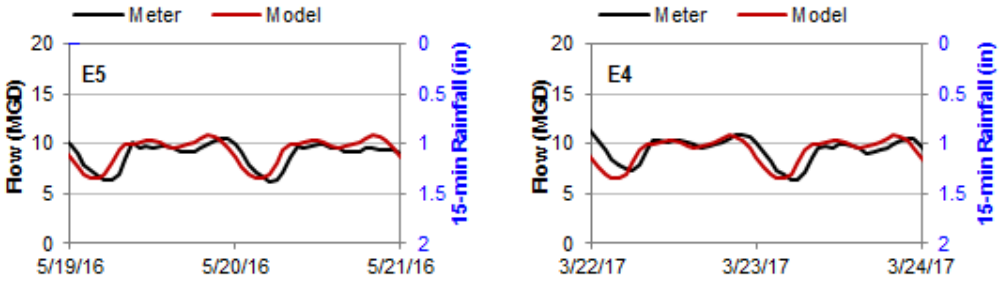


FLOW METER CDPS TOTAL MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

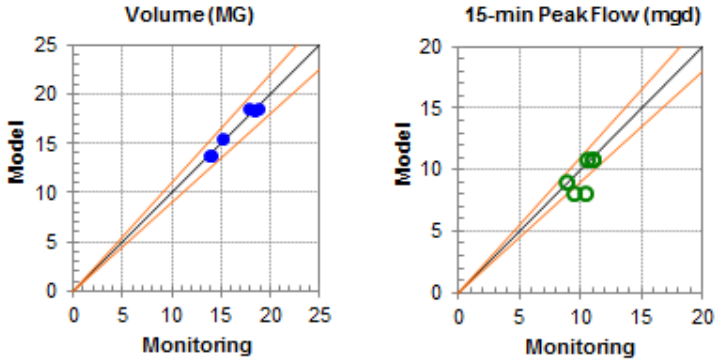
CDPS Total Model Calibration Results (Metered and Modeled Flow)



CDPS Total Model Validation Results (Metered and Modeled Flow)



CDPS Total Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



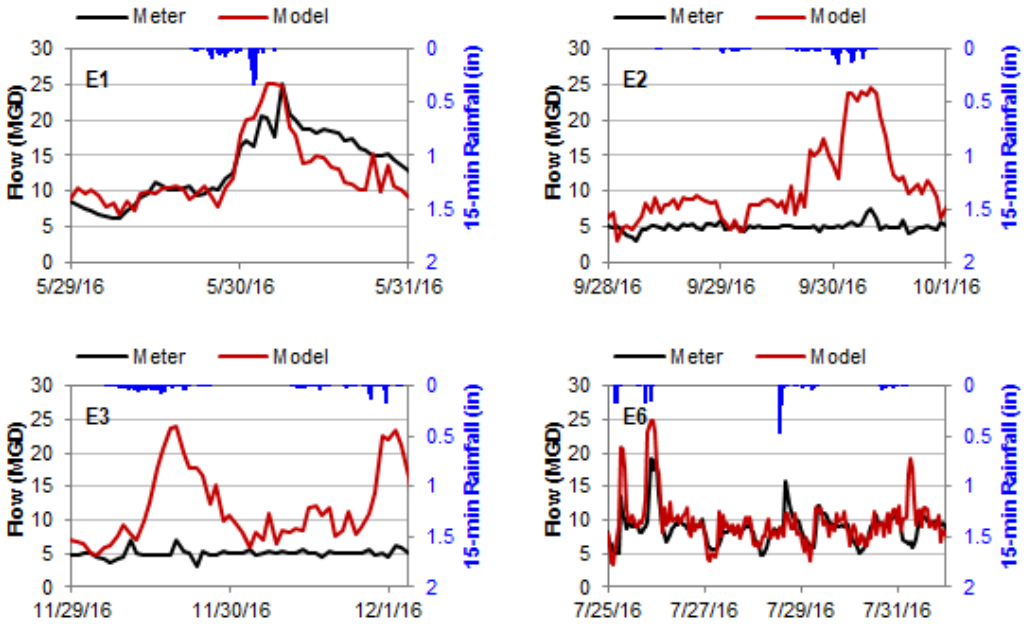
CDPS Total Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	10.96	10.82	-10% to +10%	-1%	18.43	18.45	-10% to +10%	0%
E2	9.44	8.14	-10% to +10%	-14%	14.04	13.87	-10% to +10%	-1%
E3	10.39	8.04	-10% to +10%	-23%	13.84	13.76	-10% to +10%	-1%
E4	10.97	10.82	-10% to +10%	-1%	18.70	18.50	-10% to +10%	-1%
E5	10.52	10.82	-10% to +10%	3%	17.77	18.50	-10% to +10%	4%
E6	8.81	9.06	-10% to +10%	3%	15.18	15.50	-10% to +10%	2%

CDPS Total Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	37.59	46.03	-15% to +25%	22%	18.12	17.80	-10% to +20%	-2%
E2	22.62	29.77	-15% to +25%	32%	26.28	29.53	-10% to +20%	12%
E3	21.62	28.12	-15% to +25%	30%	25.07	27.13	-10% to +20%	8%
E4	38.01	35.13	-15% to +25%	-8%	79.48	69.36	-10% to +20%	-13%
E5	29.79	31.11	-15% to +25%	4%	34.43	29.65	-10% to +20%	-14%
E6	15.30	14.01	-15% to +25%	-8%	14.43	13.30	-10% to +20%	-8%

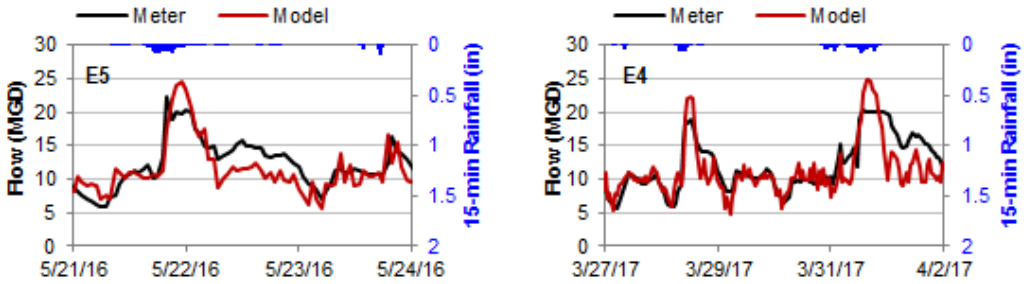
Note: All the six wet weather events are calibrated well within or close to the industry criteria.

FLOW METER CDPS TO WRTP MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

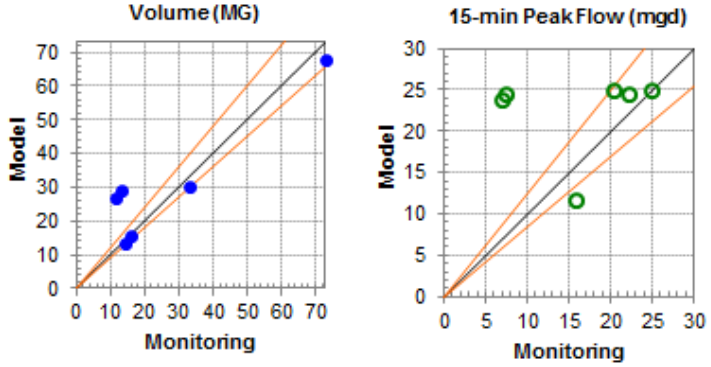
CDPS to WRTP Model Calibration Results (Metered and Modeled Flow)



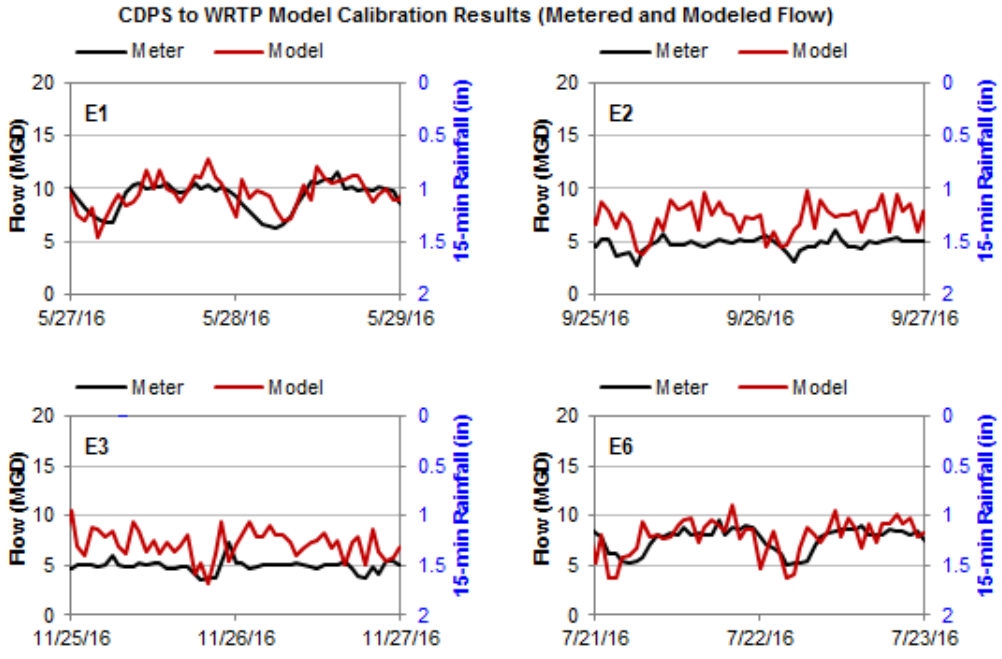
CDPS to WRTP Model Validation Results (Metered and Modeled Flow)

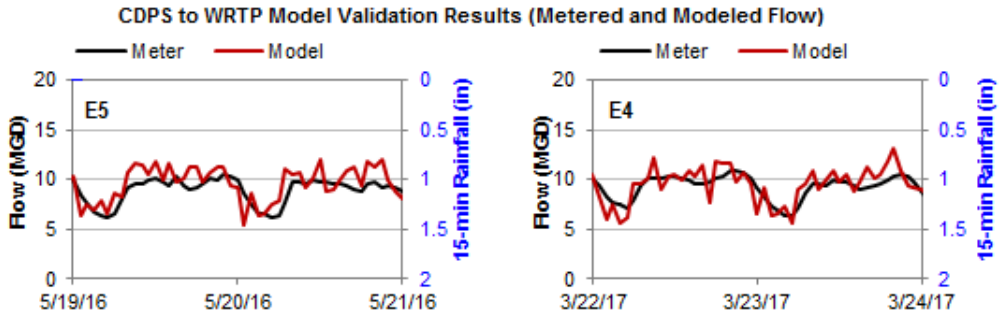


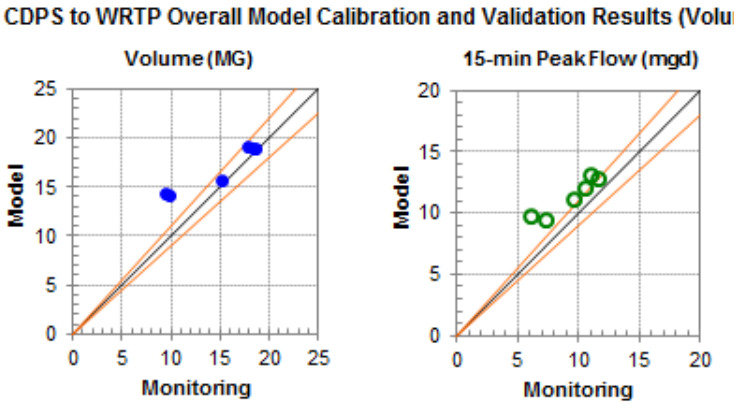
CDPS to WRTP Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



FLOW METER CDPS TO WRTP MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events







CDPS to WRTP Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	11.51	12.85	-10% to +10%	12%	18.39	19.01	-10% to +10%	3%
E2	6.00	9.79	-10% to +10%	63%	9.45	14.29	-10% to +10%	51%
E3	7.22	9.46	-10% to +10%	31%	9.83	14.19	-10% to +10%	44%
E4	10.89	13.14	-10% to +10%	21%	18.50	18.96	-10% to +10%	2%
E5	10.44	12.10	-10% to +10%	16%	17.76	19.21	-10% to +10%	8%
E6	9.56	11.13	-10% to +10%	16%	15.20	15.76	-10% to +10%	4%

CDPS to WRTP Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	24.93	24.93	-15% to +25%	0%	15.92	15.55	-10% to +20%	-2%
E2	7.41	24.61	-15% to +25%	232%	12.92	29.02	-10% to +20%	125%
E3	6.95	23.88	-15% to +25%	243%	11.69	26.99	-10% to +20%	131%
E4	20.25	24.89	-15% to +25%	23%	72.78	68.00	-10% to +20%	-7%
E5	22.24	24.53	-15% to +25%	10%	33.04	30.02	-10% to +20%	-9%
E6	15.80	11.79	-15% to +25%	-25%	14.31	13.26	-10% to +20%	-7%

Note: During Rainfall Events E2 and E3, CDPS flow to the WRTP was capped due to the aeration replacement project at WRTP.

All the remaining four wet weather events are calibrated well within the industry criteria.

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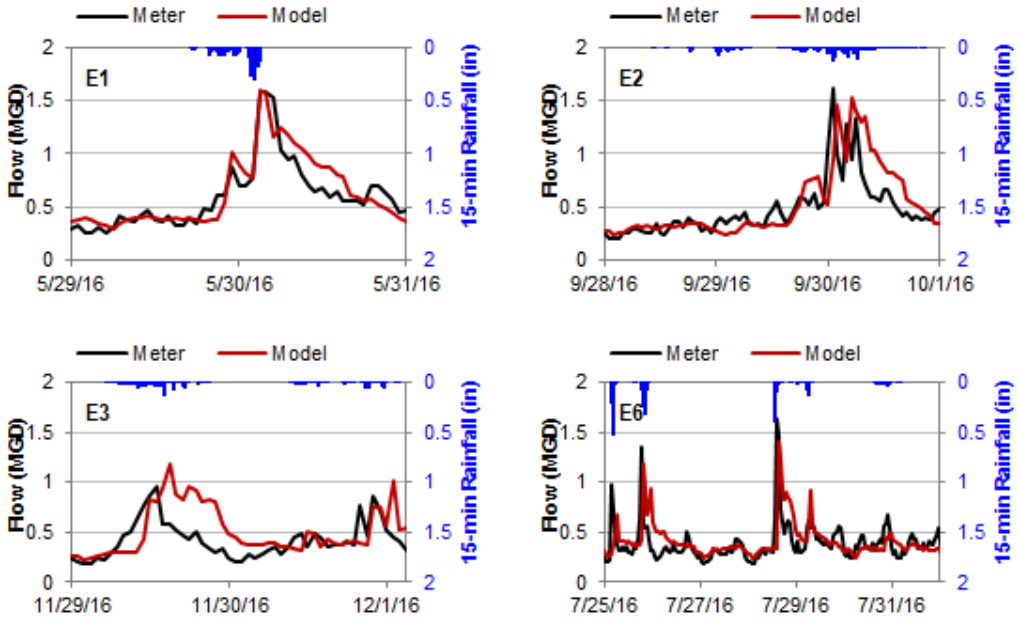
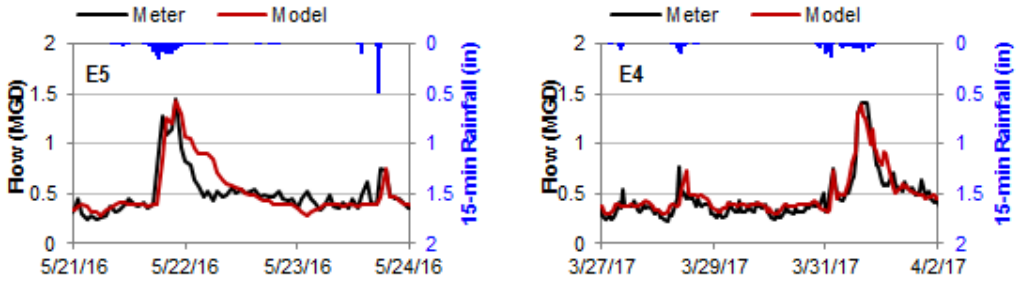
FLOW METER EDPS MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

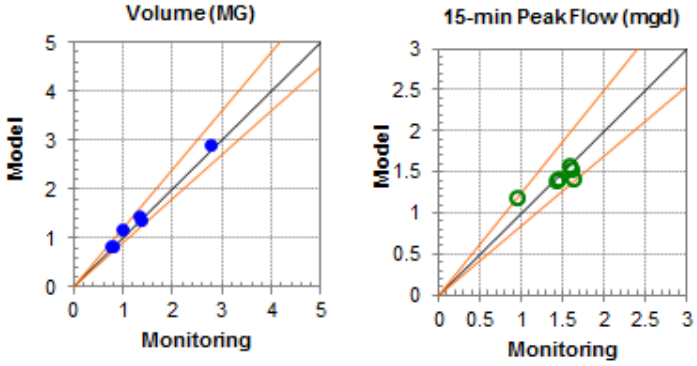
EDPS Model Calibration Results (Metered and Modeled Flow)



EDPS Model Validation Results (Metered and Modeled Flow)

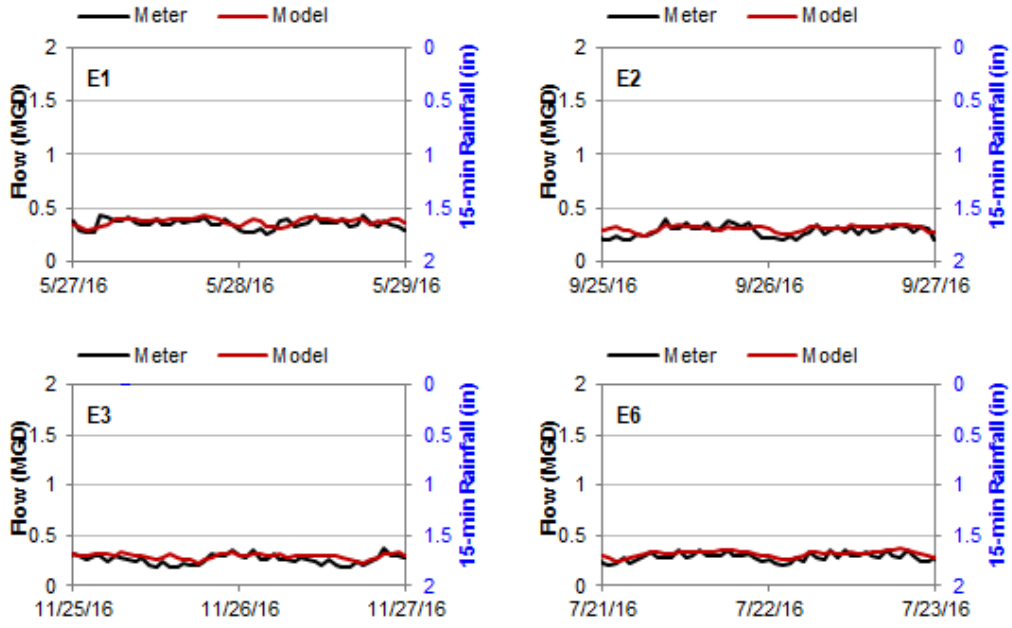


EDPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

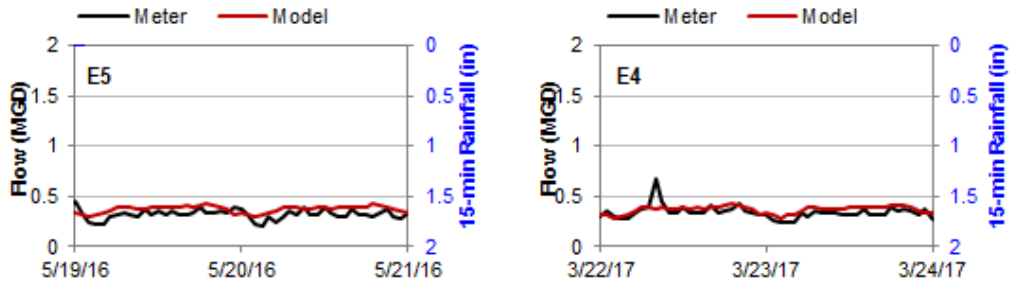


FLOW METER EDPS MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

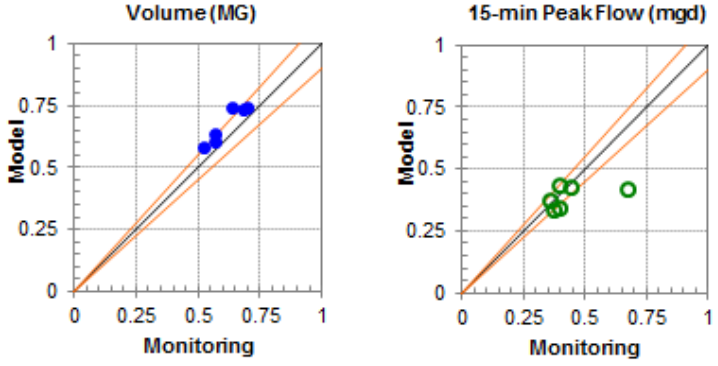
EDPS Model Calibration Results (Metered and Modeled Flow)



EDPS Model Validation Results (Metered and Modeled Flow)



EDPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



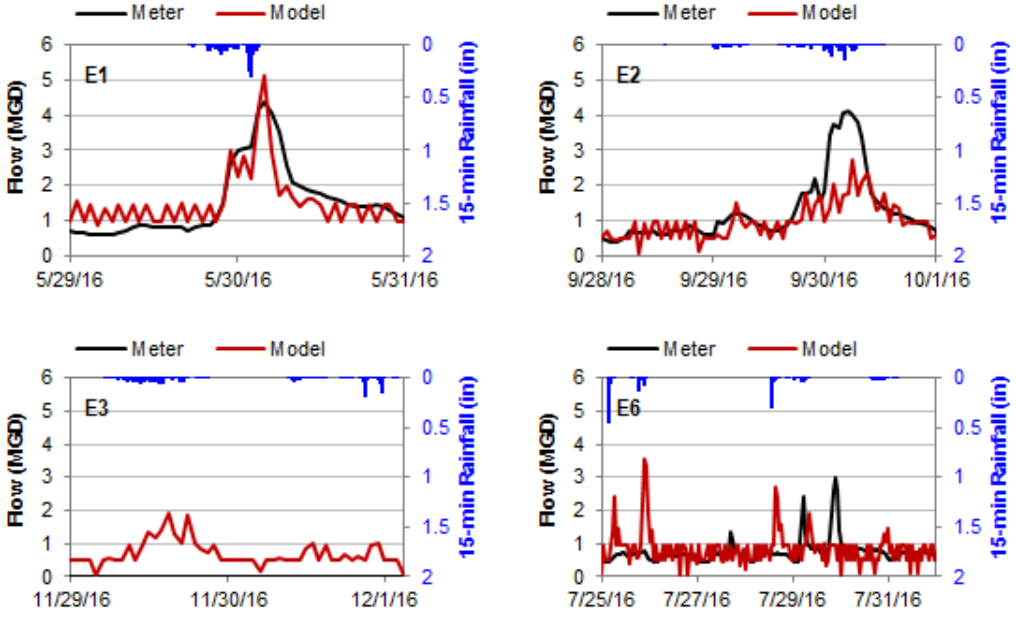
EDPS Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.44	0.43	-10% to +10%	-2%	0.70	0.74	-10% to +10%	6%
E2	0.39	0.35	-10% to +10%	-12%	0.57	0.61	-10% to +10%	7%
E3	0.37	0.34	-10% to +10%	-8%	0.52	0.58	-10% to +10%	12%
E4	0.67	0.42	-10% to +10%	-37%	0.68	0.74	-10% to +10%	8%
E5	0.40	0.43	-10% to +10%	10%	0.64	0.74	-10% to +10%	17%
E6	0.36	0.37	-10% to +10%	5%	0.57	0.64	-10% to +10%	12%

EDPS Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	1.59	1.59	-15% to +25%	0%	0.77	0.83	-10% to +20%	8%
E2	1.61	1.53	-15% to +25%	-5%	1.32	1.44	-10% to +20%	9%
E3	0.95	1.19	-15% to +25%	25%	0.98	1.20	-10% to +20%	23%
E4	1.41	1.40	-15% to +25%	-1%	2.76	2.92	-10% to +20%	6%
E5	1.44	1.42	-15% to +25%	-2%	1.35	1.39	-10% to +20%	3%
E6	1.63	1.42	-15% to +25%	-13%	0.77	0.85	-10% to +20%	11%

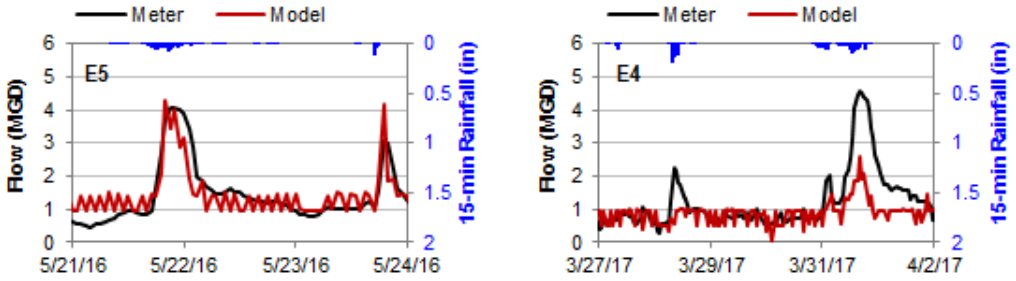
Note: All the six wet weather events are calibrated well within or close to the industry criteria.

FLOW METER MHPS MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

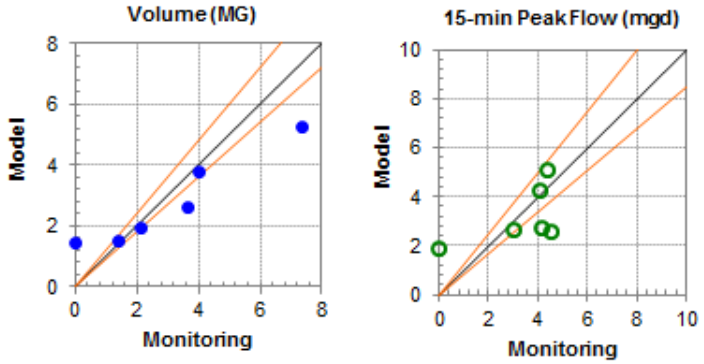
MHPS Model Calibration Results (Metered and Modeled Flow)



MHPS Model Validation Results (Metered and Modeled Flow)

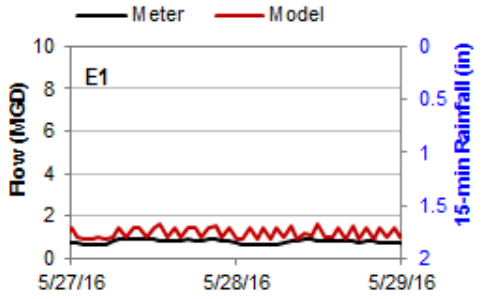


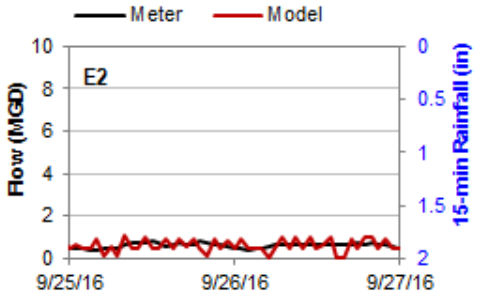
MHPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)

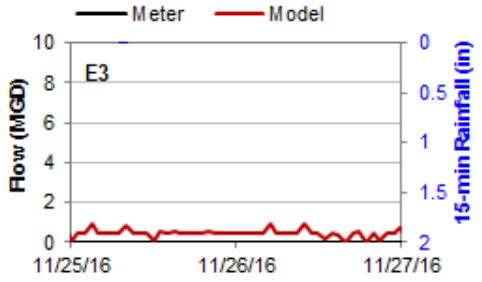


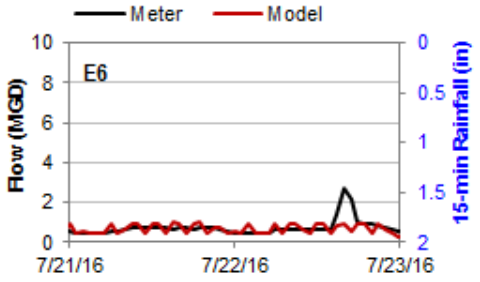
FLOW METER MHPS MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events

MHPS Model Calibration Results (Metered and Modeled Flow)

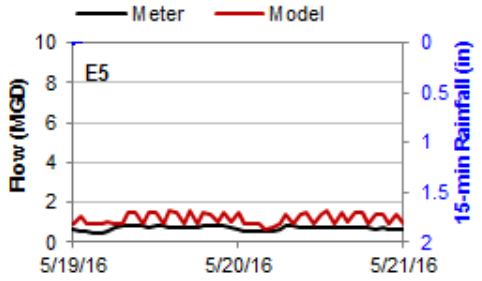


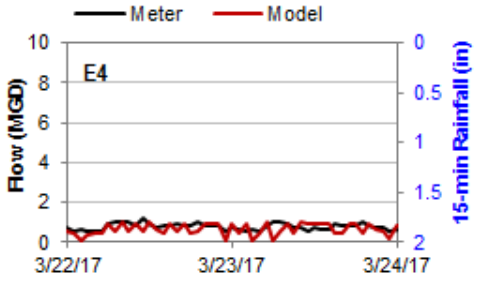




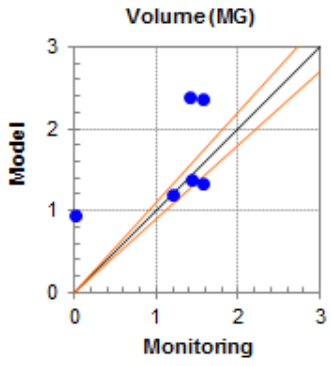


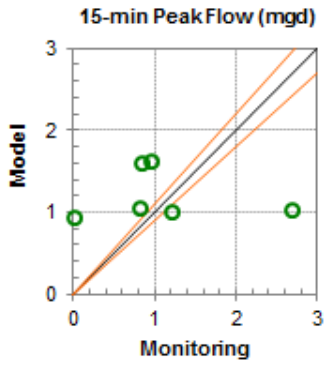
MHPS Model Validation Results (Metered and Modeled Flow)





MHPS Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)





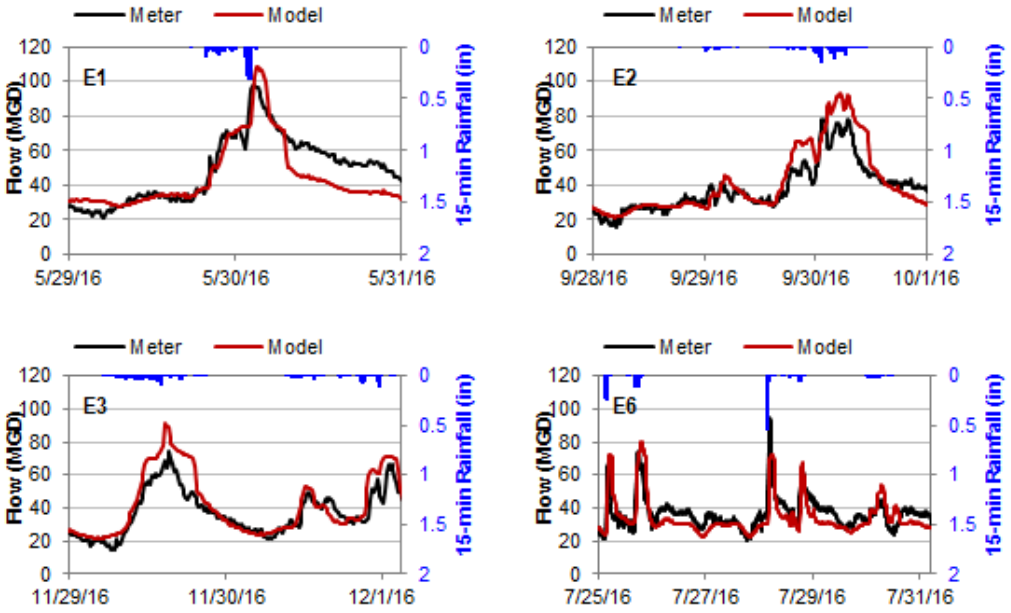
MHPS Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	0.94	1.63	-10% to +10%	73%	1.58	2.36	-10% to +10%	50%
E2	0.81	1.06	-10% to +10%	32%	1.20	1.20	-10% to +10%	1%
E3	0.00	0.95	-10% to +10%	See Note Below	0.00	0.93	-10% to +10%	See Note Below
E4	1.20	1.02	-10% to +10%	-15%	1.58	1.33	-10% to +10%	-16%
E5	0.83	1.60	-10% to +10%	93%	1.40	2.38	-10% to +10%	70%
E6	2.68	1.04	-10% to +10%	-61%	1.43	1.38	-10% to +10%	-4%

MHPS Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	4.39	5.09	-15% to +25%	16%	2.11	1.95	-10% to +20%	-8%
E2	4.12	2.73	-15% to +25%	-34%	3.62	2.65	-10% to +20%	-27%
E3	0.00	1.91	-15% to +25%	See Note Below	0.00	1.46	-10% to +20%	See Note Below
E4	4.54	2.61	-15% to +25%	-43%	7.36	5.28	-10% to +20%	-28%
E5	4.05	4.27	-15% to +25%	5%	4.00	3.81	-10% to +20%	-5%
E6	2.99	2.70	-15% to +25%	-10%	1.39	1.50	-10% to +20%	8%

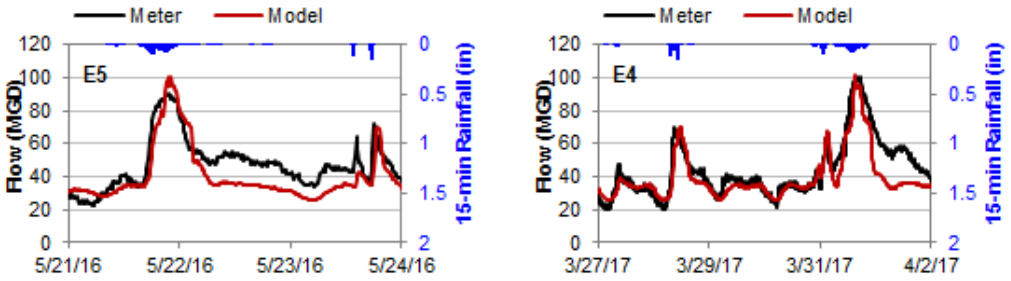
Note: Flow meter data not available for Event E3. Three of the remaining five wet weather events are calibrated well within the industry criteria. Flow meter data recorded for E2 and E4 is not consistent with the recorded rainfall intensity. Based on the calibration results of the overall model, the model calibration is adequate for purposes of long term control planning.

FLOW METER WRTP FLOW MODEL CALIBRATION AND VALIDATION RESULTS_Wet Weather Events

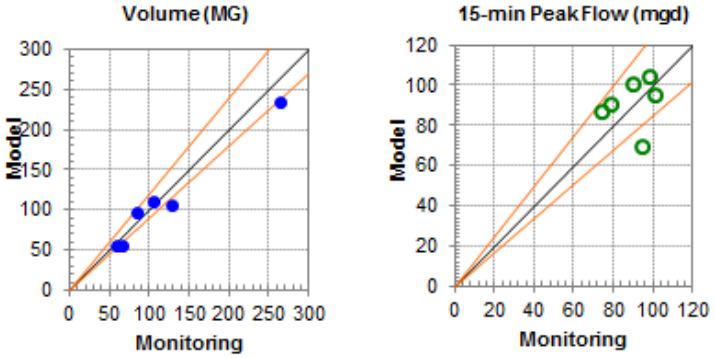
WRTP Flow Model Calibration Results (Metered and Modeled Flow)



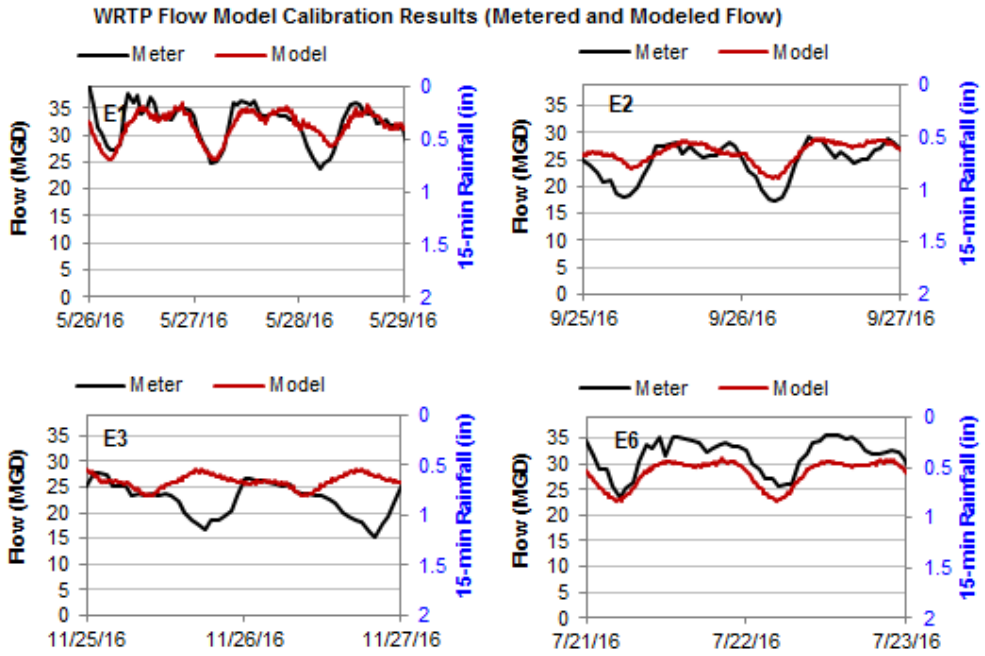
WRTP Flow Model Validation Results (Metered and Modeled Flow)

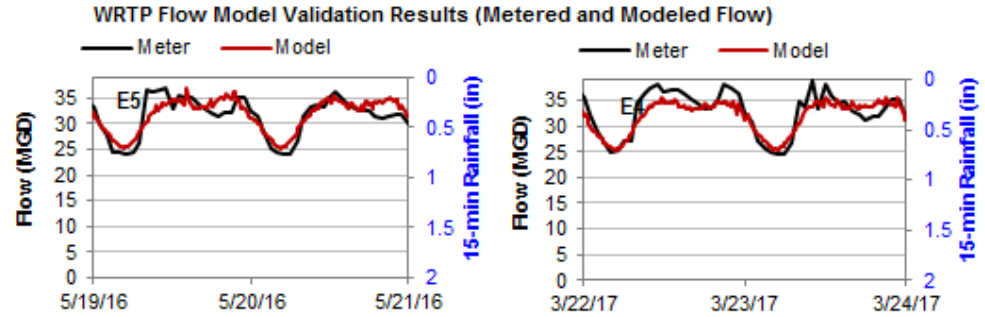


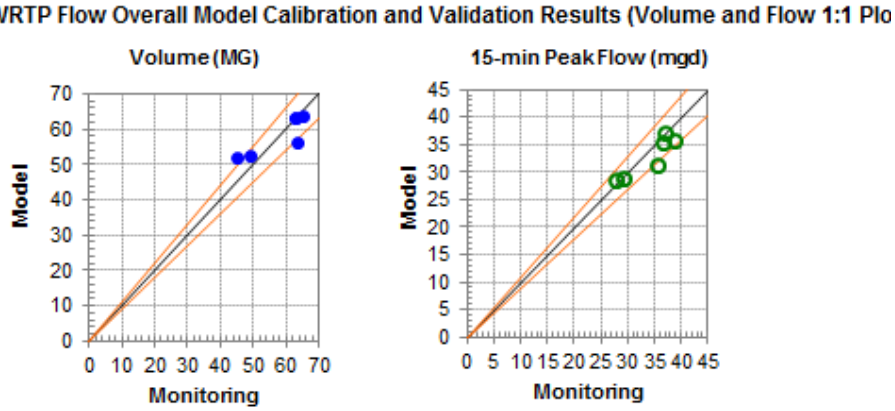
WRTP Flow Overall Model Calibration and Validation Results (Volume and Flow 1:1 Plots)



FLOW METER WRTP FLOW MODEL CALIBRATION AND VALIDATION RESULTS_Dry Weather Events







WRTP Flow Model Dry Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	36.45	38.89	-10% to +10%	7%	62.91	63.52	-10% to +10%	1%
E2	29.28	29.03	-10% to +10%	-1%	49.02	52.61	-10% to +10%	7%
E3	27.68	28.79	-10% to +10%	4%	45.05	52.52	-10% to +10%	17%
E4	38.76	36.21	-10% to +10%	-7%	65.29	63.80	-10% to +10%	-2%
E5	36.88	36.10	-10% to +10%	-2%	62.75	63.47	-10% to +10%	1%
E6	35.61	31.18	-10% to +10%	-12%	63.12	56.27	-10% to +10%	-11%

WRTP Flow Model Wet Weather Calibration and Validation Summary								
Event	Peak Flow (MGD)				Volume (MG)			
	Monitored	Model	Criteria	Achieved	Monitored	Model	Criteria	Achieved
E1	97.94	108.55	-15% to +25%	11%	59.32	56.46	-10% to +20%	-5%
E2	78.26	93.19	-15% to +25%	19%	104.19	113.52	-10% to +20%	9%
E3	74.21	91.44	-15% to +25%	23%	85.10	95.25	-10% to +20%	12%
E4	100.93	101.13	-15% to +25%	0%	263.84	235.90	-10% to +20%	-11%
E5	89.95	100.49	-15% to +25%	12%	127.56	106.30	-10% to +20%	-17%
E6	94.40	72.14	-15% to +25%	-24%	66.96	57.10	-10% to +20%	-15%

Note: All the six wet weather events are calibrated well within or close to the industry criteria.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

Oreg. Mich Santis

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APR 19 2018
By 2018-0505

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. DiSantis:

The United States Environmental Protection Agency (EPA) has received the Delaware County Regional Quality Regional Water Quality Control Authority (DELCORA) Sewer System Hydrologic and Hydraulic Model Report Revised Appendix C dated March 1, 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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Customer Service Hotline: 1-800-438-2474

APPENDIX G

RAINFALL AND FLOW MONITORING QUARTERLY REPORT

- DELCORA Rainfall and Flow Monitoring Quarterly Report No. 1 dated July 2016
- DELCORA Rainfall and Flow Monitoring Quarterly Report No. 2 (July 1, 2016 to September 30, 2016) (Final) dated October 2016
- DELCORA Rainfall and Flow Monitoring Quarterly Report No. 3 (October 1, 2016 to December 31, 2016) (Final) dated January 2017
- DELCORA Rainfall and Flow Monitoring Quarterly Report No. 4 (January 1, 2017 to April 1, 2017) - Final dated April 2017
- DELCORA Transmittal Letter of Rainfall and Flow Monitoring Quarterly Report No. 1 dated July 29, 2016
- DELCORA Transmittal Letter of Rainfall and Flow Monitoring Quarterly Report No. 2 dated October 25, 2016
- DELCORA Transmittal Letter of Rainfall and Flow Monitoring Quarterly Report No. 3 dated January 26, 2017
- DELCORA Transmittal Letter of Rainfall and Flow Monitoring Quarterly Report No. 4 dated April 28, 2017

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

Rainfall and Flow Monitoring Quarterly Report No. 1 ~~(Draft)~~ (FINAL)

July 2016

GREELEY AND HANSEN

REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Rainfall and Flow Monitoring Report No. 1.

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.

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DELCORA ENGINEERING		
Director of Engineering	*Signature*	7/26/16 *Date*
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	*Signature*	7/26/16 *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 38 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 first quarter reporting for Rainfall and Flow Monitoring during March 18, 2016 to June 30, 2016.

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 31 rainfall events during reporting period. **Table 2** lists rainfall events with total precipitation greater than 0.1 inch.

Figure 1: Rain Gauge Locations

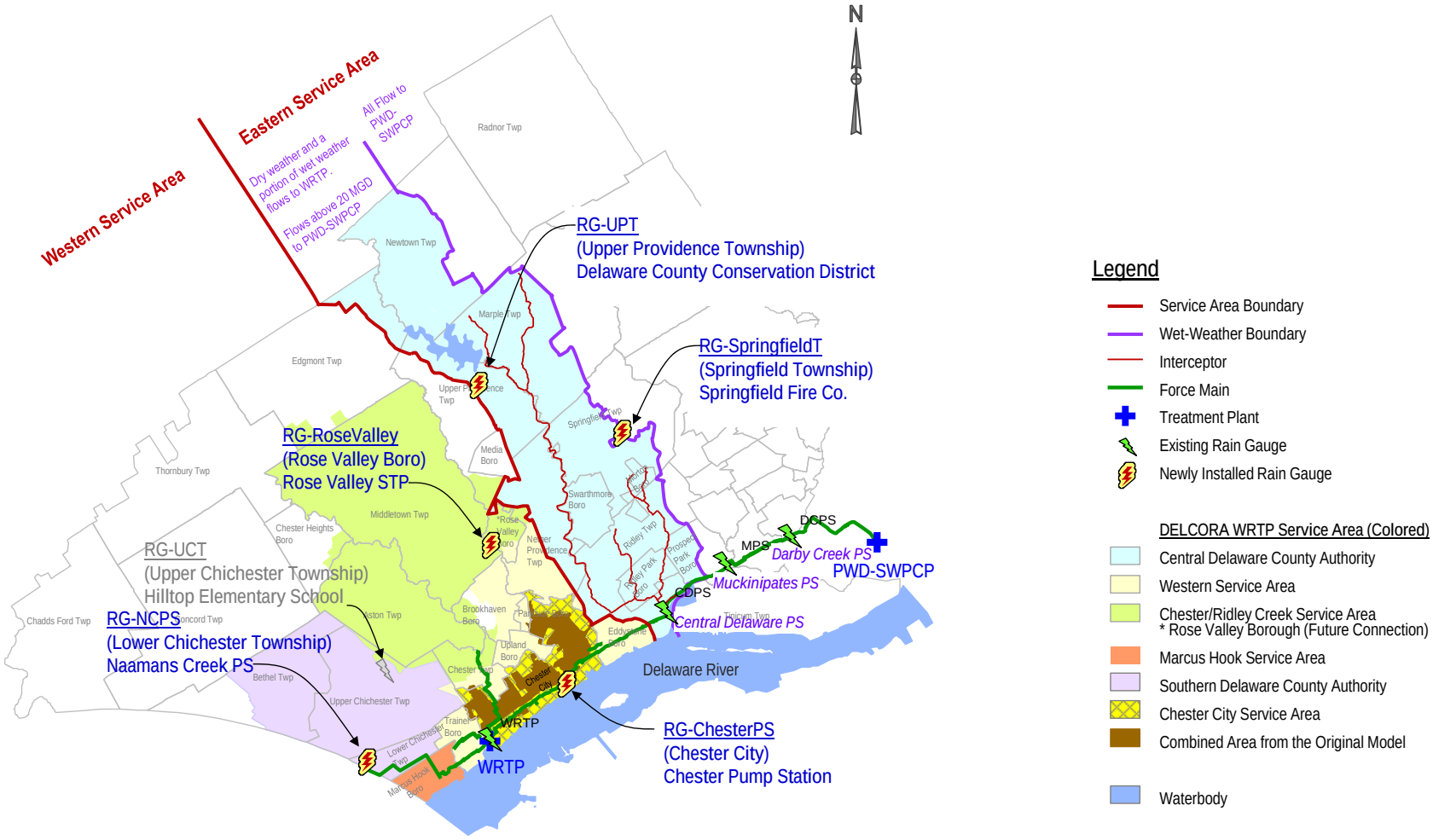


Figure 2 shows rainfall amounts at each rain gauge in each month for April (includes March data), May and June. It is obvious that rainfall in the area has significant spatial and temporal variance. As an example, during this reporting period, the rain gauge at the Chester Pump Station (Chester PS) recorded a total rainfall of 9.1 inches while the gauge at the Naamans Creek Pump Station (NCPS) recorded 13.39 inches. **Figure 3** shows the 1-hour rainfall profile for all of the 5 new rain gauges.

Table 2: Rainfall Event Summary, 3/18/16 - 6/30/16

	Rain Event Starting Time	Rose Valley	Chester-PS	NCPS	Springfield	UCT
1	3/28/2016 0:25	0.42	0.31	0.37	See Note	See Note
2	4/1/2016 10:35	0.23	0.23	0.28	See Note	See Note
3	4/4/2016 7:35	0.24	0.24	0.26	See Note	See Note
4	4/7/2016 11:45	0.26	0.09	0.23	0.02	See Note
5	4/9/2016 8:10	0.67	0.56	0.56	0.53	See Note
6	4/12/2016 6:40	0.39	0.35	0.31	0.35	See Note
7	4/23/2016 1:00	0.36	0.07	0.21	0.34	0.49
8	4/26/2016 0:35	0.42	0.29	0.2	0.22	0.56
9	4/28/2016 13:00	0.15	0.08	0.16	0.12	0.2
10	5/1/2016 2:05	0.82	0.47	0.65	0.51	0.66
11	5/2/2016 22:00	0.61	0.55	0.9	0.53	0.84
12	5/6/2016 3:00	1.47	1.18	2.12	1.4	1.97
13	5/13/2016 12:15	0.12	0.1	0.13	0.09	0.21
14	5/17/2016 11:30	0.14	0.14	0.17	0.1	0.16
15	5/21/2016 10:20	1.5	1.71	2.2	1.26	1.6
16	5/23/2016 14:30	0.23	0.49	0.47	0.38	0.31
17	5/29/2016 18:20	2.17	1.82	2.73	2.06	2.41
18	6/3/2016 4:35	0.22	0.15	0.24	0.24	0.48
19	6/5/2016 3:35	0.4	0.57	0.79	0.33	0.88
20	6/7/2016 15:45	0.01	0.01	0.18	0	0
21	6/8/2016 11:35	0.07	0.09	0.24	0.14	0.25
22	6/16/2016 0:20	0.44	0.44	0.65	0.31	0.49
23	6/23/2016 8:20	0.2	0.35	0.85	0.15	0.36
24	6/27/2016 18:35	0.89	0.59	0.5	1.24	1.25
	Subtotal (4/16-6/30)	**10.22**	**9.1**	**13.39**	**9.42**	**13.12**

Note: Meter not in service. See Table 1 above.

Figure 2: Rainfall Event Summary, 3/18/16 – 6/30/16

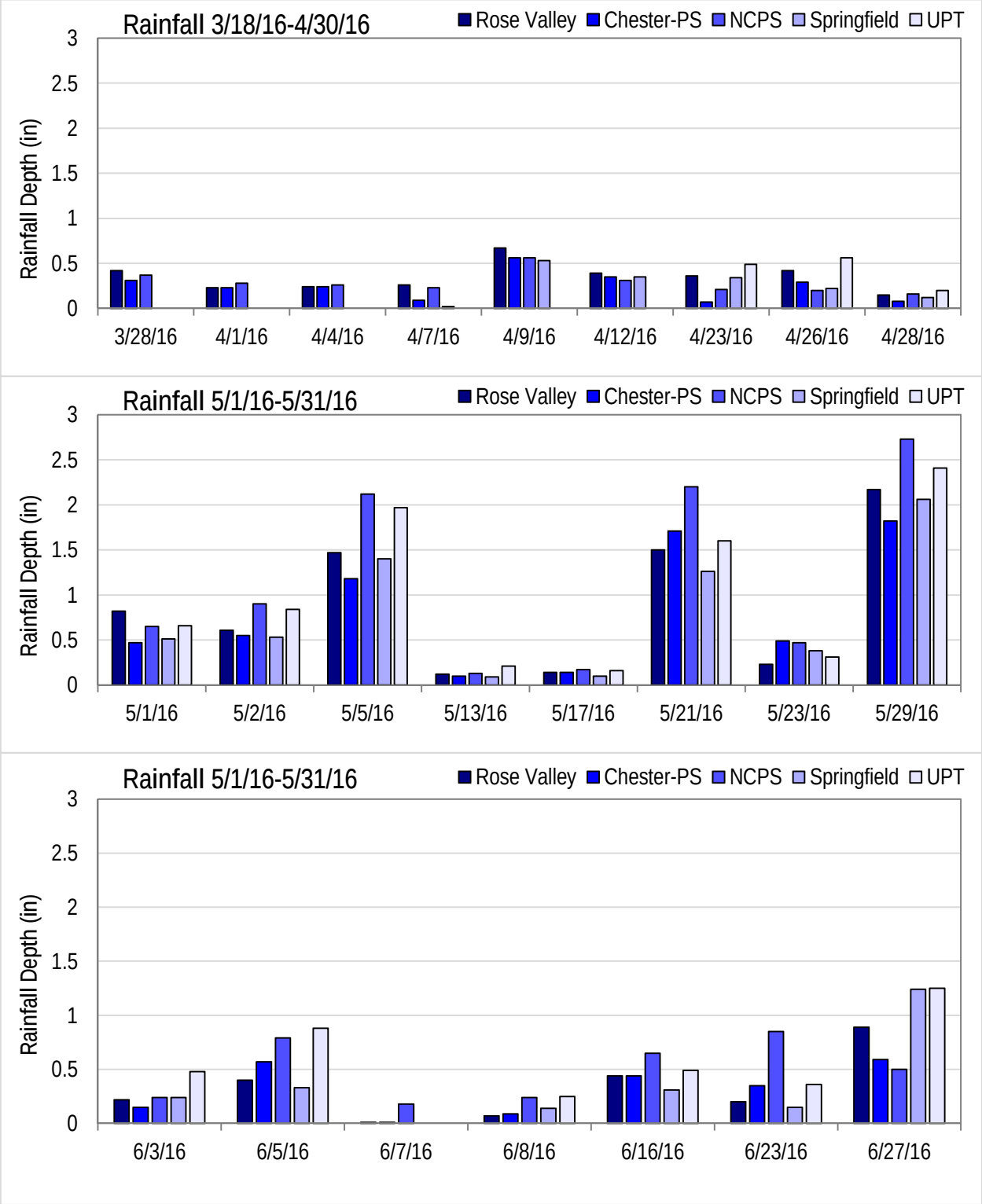
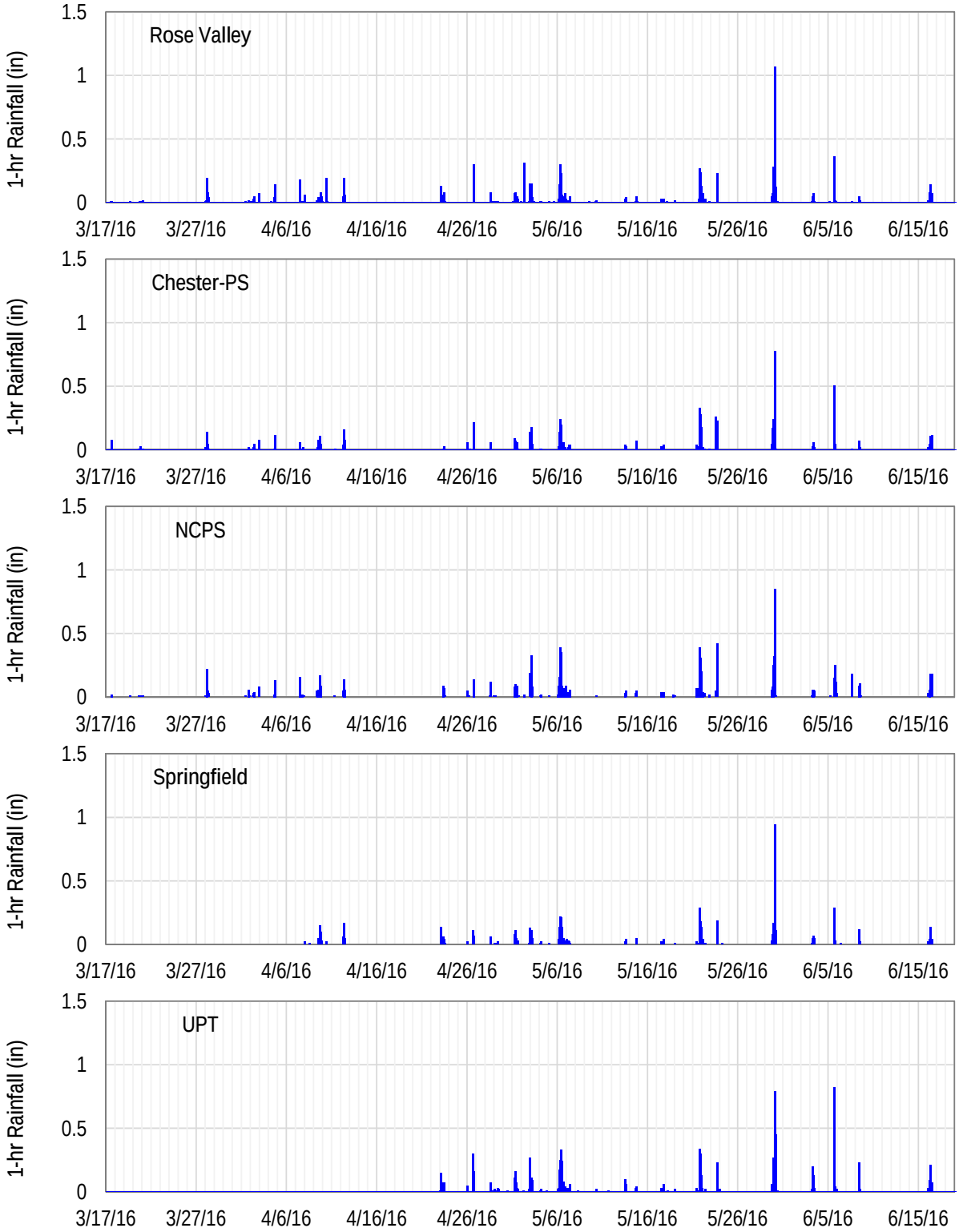


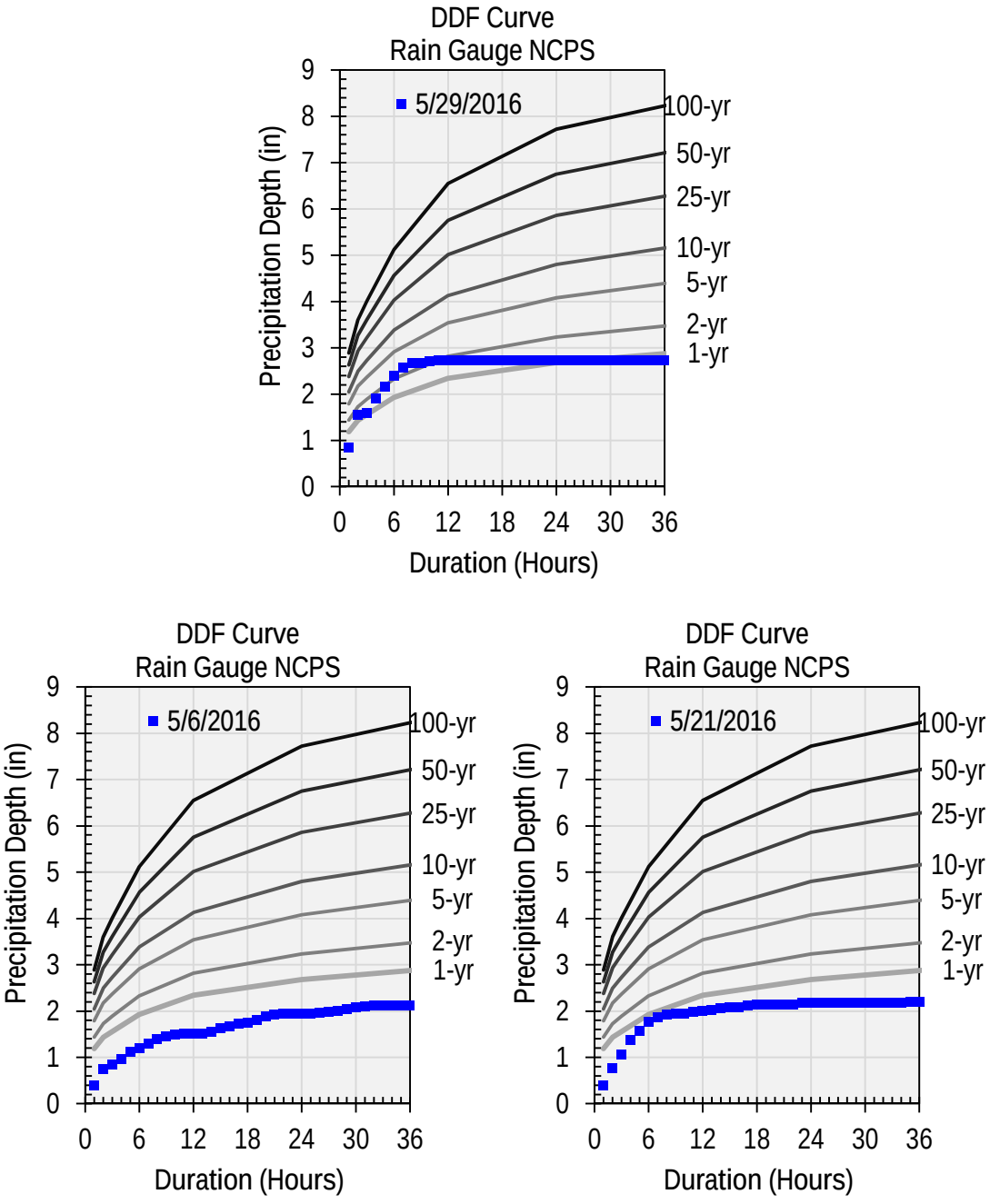
Figure 3: Hourly Rainfall Profile



2.3.1 Rainfall Return Frequency

Rain gauge RG_NCPS was selected for return frequency analysis because it recorded the maximum rainfall amount from the five newly installed gauges. For the three storm events greater than 1 inch, the 5/29/16 storm has a return frequency of 2-years, the 5/21/16 storm is close to 1-year, and the 5/6/16 storm is less than 1-year event **(Figure 4**).

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



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 5**. **Figure 6** 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 7**.

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.

In total, 38 additional flow meters have been installed. Details of the newly 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
Side-1	1571	US	36	Concrete	No	3
Side-2	2135	US	8	Clay	Yes	3

Figure 5: Existing and Newly Installed Flow Meter Locations

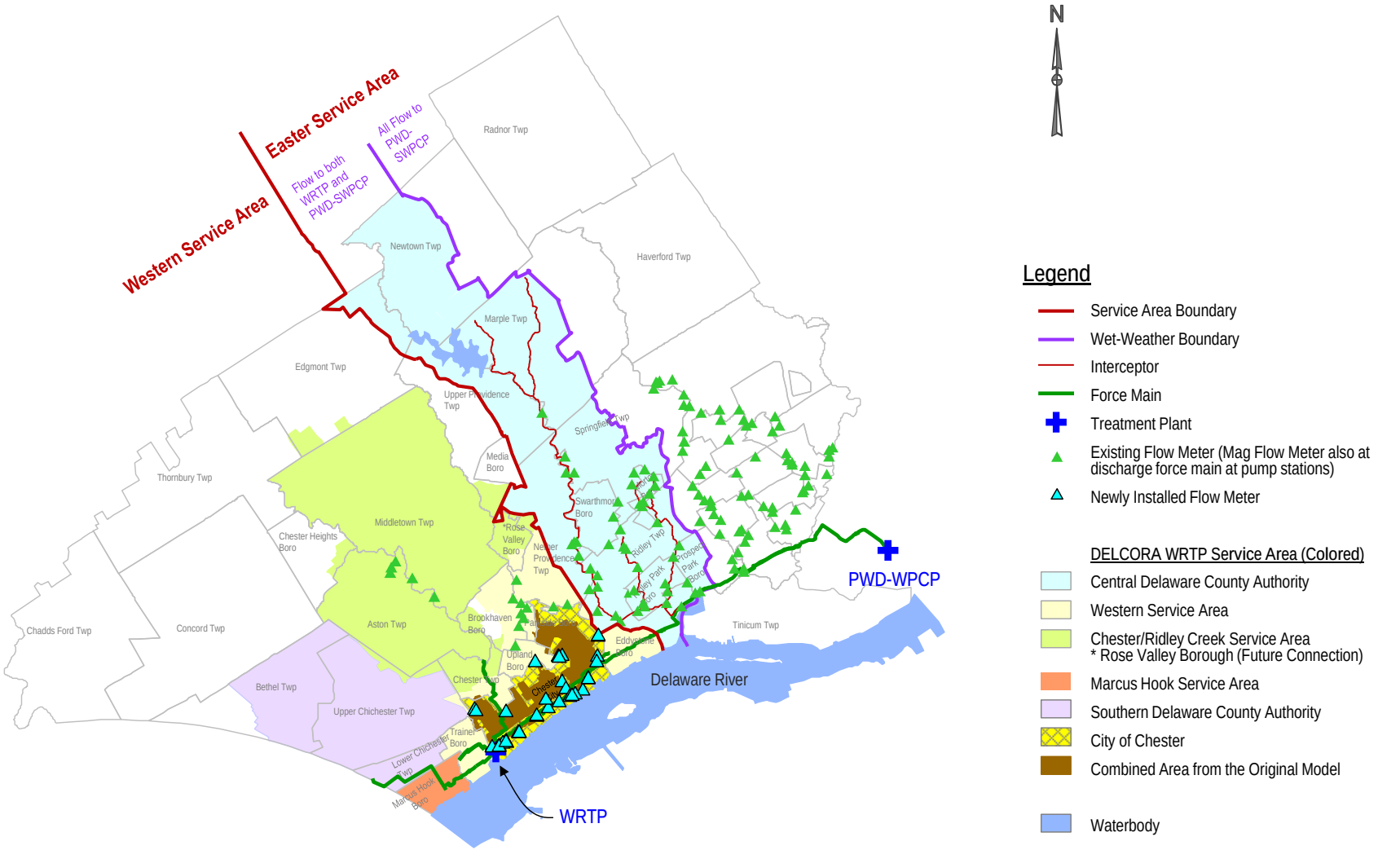


Figure 6: Newly Installed Flow Meter Locations

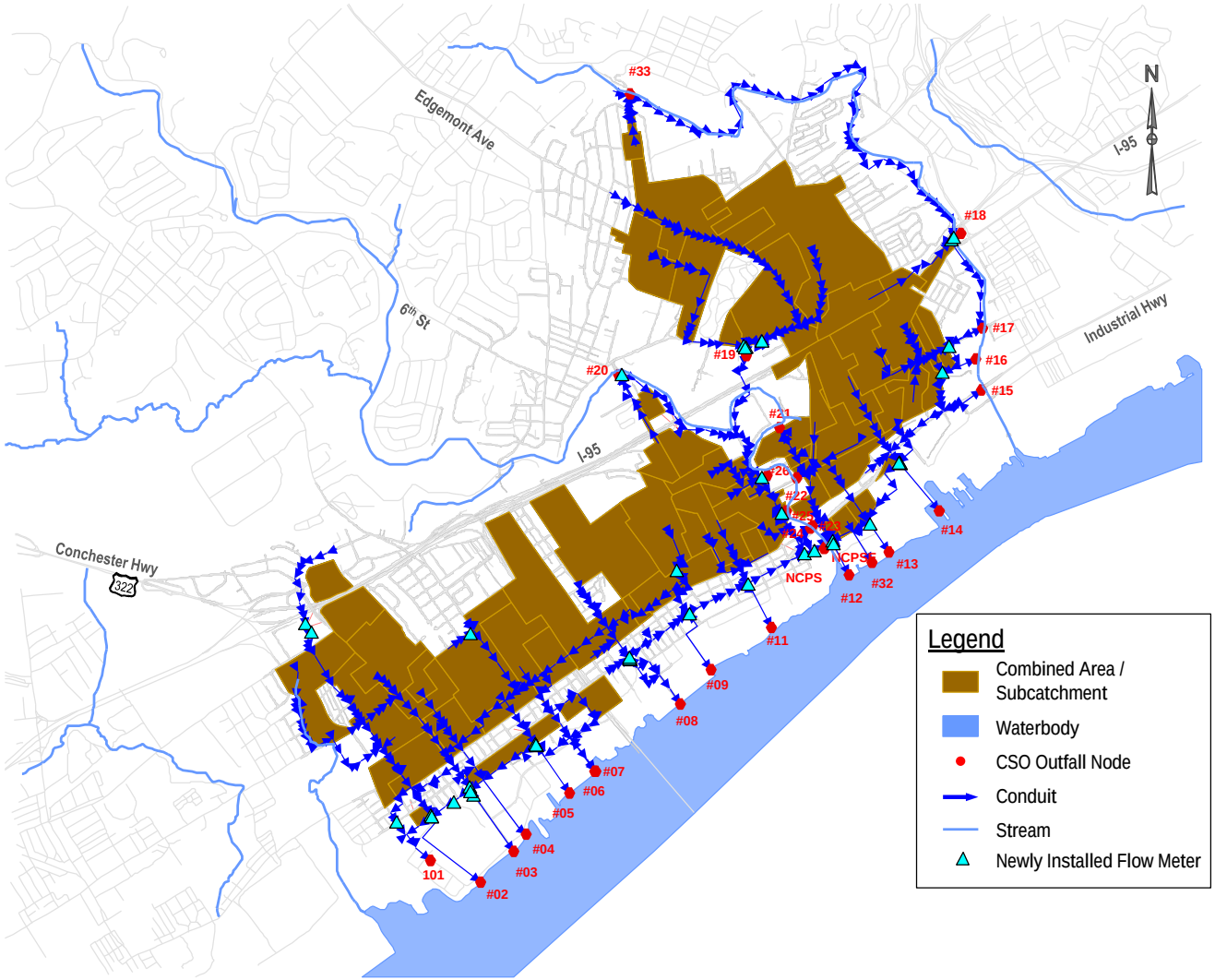
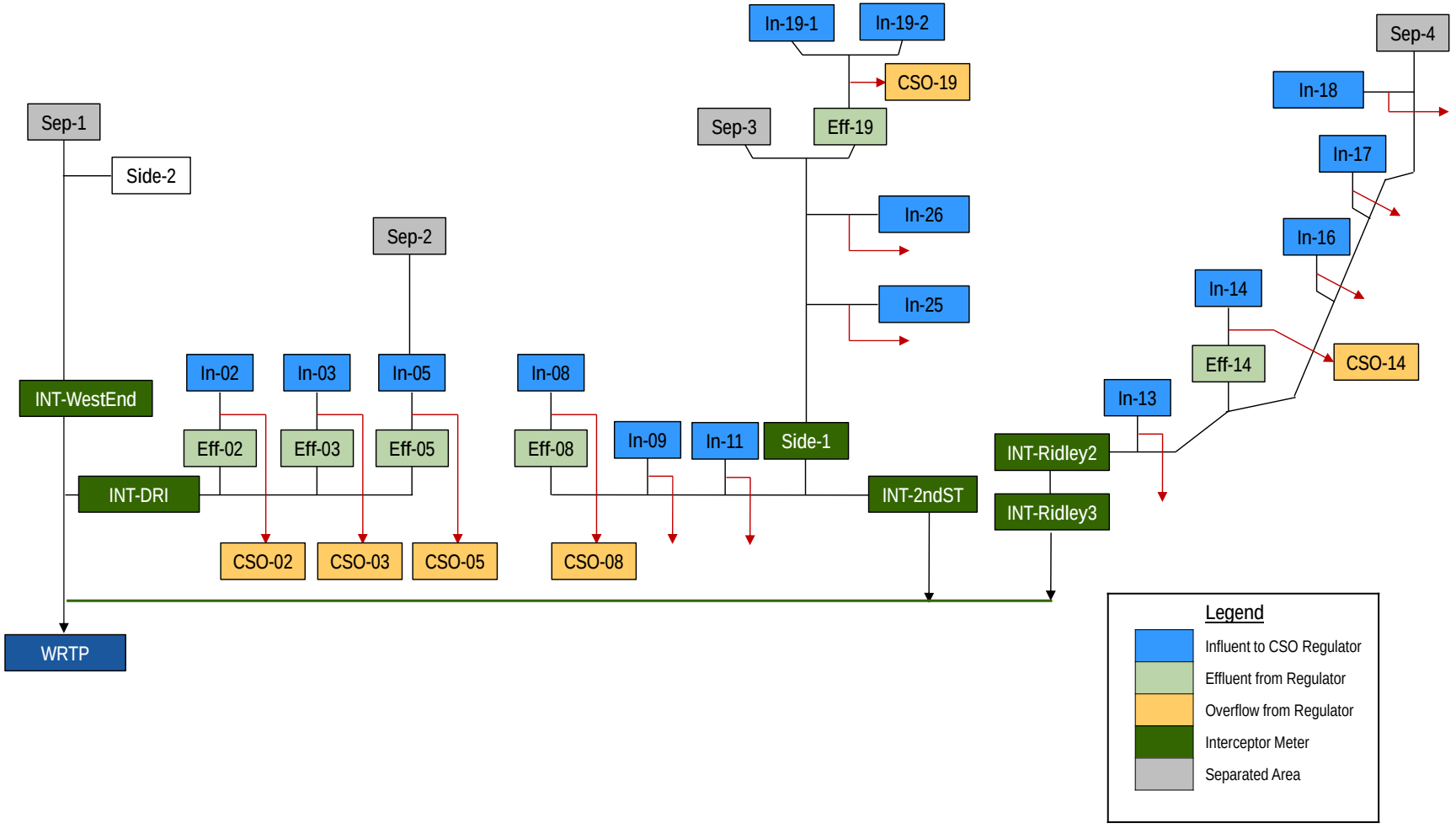


Figure 7: Flow Monitoring Schematic



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. 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 8**. 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 9** 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 11 to 88 and average at 40. The hourly peaking factor for the interceptor is between 3.8 and 6.8 with an average of 4.4. The hourly peaking factor is between 3.6 and 6.4 for the separated area, with an average of 5.0.

A detailed hydrograph and scattergraph for each flow monitoring site is shown in **Figure 10** to **Figure 47**, 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) 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	8.13	0.30	27.1	Free flow most of the time
Eff-02	1.70	0.30	5.6	Surcharged under common conditions
CSO-02	8.36	0.00		Free flow most of the time
In-03	9.48	0.24	39.2	Free flow most of the time
Eff-02	2.67	0.23	11.7	Surcharged under large storms
CSO-03	8.00	0.00		Free flow most of the time
In-05	13.01	0.65	20.2	Backwater observed
Eff-05	2.65	0.63	4.2	Severely surcharged under common conditions
CSO-05	11.60	0.00		Free flow most of the time, backwater observed
In-08	34.47	0.74	46.6	Free flow most of the time
Eff-08	8.80	0.85	10.3	Free flow most of the time, backwater during large storms
CSO-08	35.12	0.00		Free flow most of the time
In-09	8.60	0.11	79.6	Free flow most of the time
In-10	6.52	0.18	36.8	Free flow most of the time
In-11	11.75	0.22	53.6	Free flow most of the time
In-13	9.35	0.24	39.7	Free flow most of the time
In-14	13.03	0.28	47.2	Backwater observed
Eff-14	3.69	0.29	12.9	Free flow mostly, backwater and surcharge during large storms
CSO-14	10.53	0.00		Free flow most of the time
In-16	4.38	0.40	10.9	Backwater observed
In-17	3.09	0.12	24.9	Backwater observed
In-18	6.79	0.08	87.3	Free flow most of the time
In-19-1	11.61	0.65	17.8	Free flow most of the time
In-19-2	9.58	0.69	13.9	Free flow most of the time
Eff-19	3.21	1.41	2.3	Free flow most of the time
CSO-19	18.13	0.00		Free flow most of the time
In-25	4.70	0.06	74.8	Free flow mostly, backwater observed
In-26	7.56	0.30	25.4	Free flow mostly
INT-2nd St	13.04	3.76	3.5	Free flow mostly
INT-DRI	4.26	1.40	3.0	Severe surcharge observed
INT-Ridley 2	15.73	3.29	4.8	Free flow mostly, backwater observed
INT-Ridley 3	17.02	3.59	4.7	Free flow mostly, backwater observed
INT-WEI	9.54	1.41	6.8	Free flow mostly, backwater observed
Sep-1	0.73	0.15	5.0	Free flow mostly
Sep-2	0.75	0.12	6.4	Free flow mostly
Sep-3	1.62	0.45	3.6	Free flow mostly
Side-1	11.34	2.42	4.7	Free flow mostly
Side-2	0.72	0.24	3.0	Free flow mostly

Figure 8: Dry Weather Flow Balance Schematic

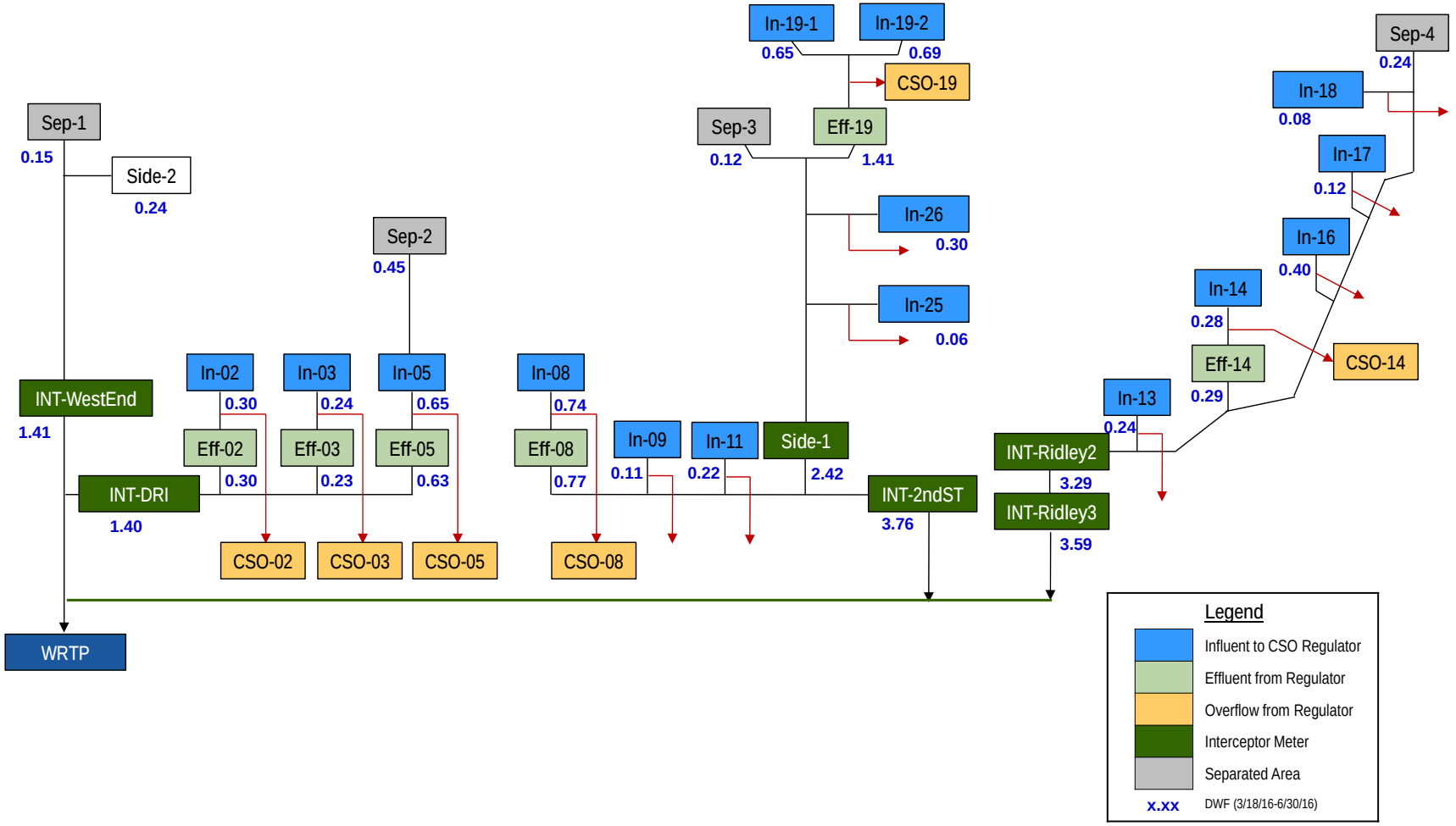


Figure 9: Flow Hydrograph In-08 and Eff-08

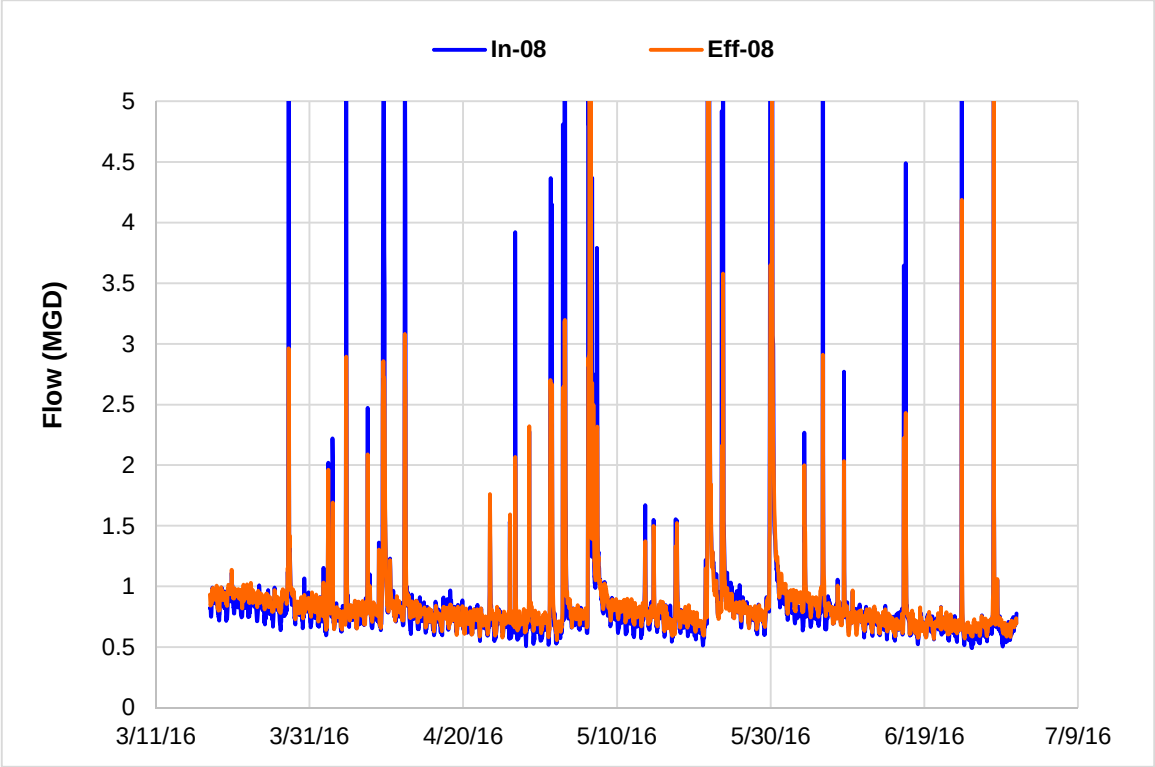
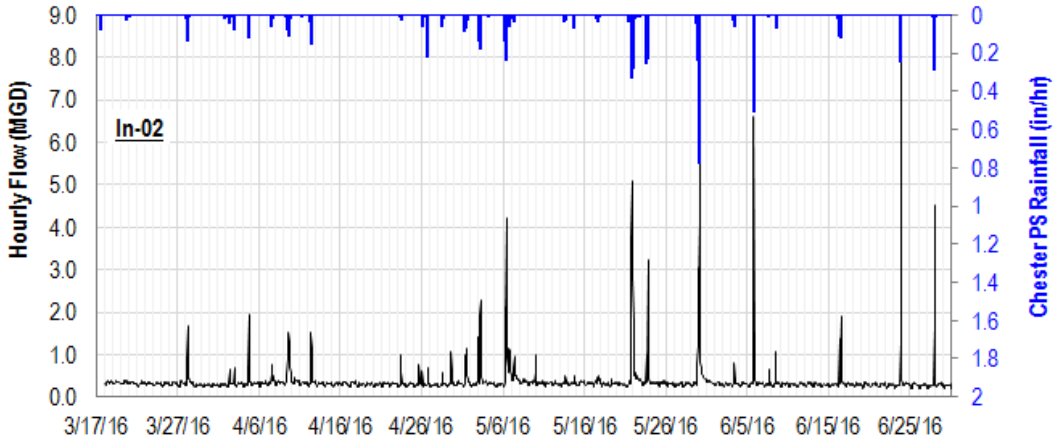
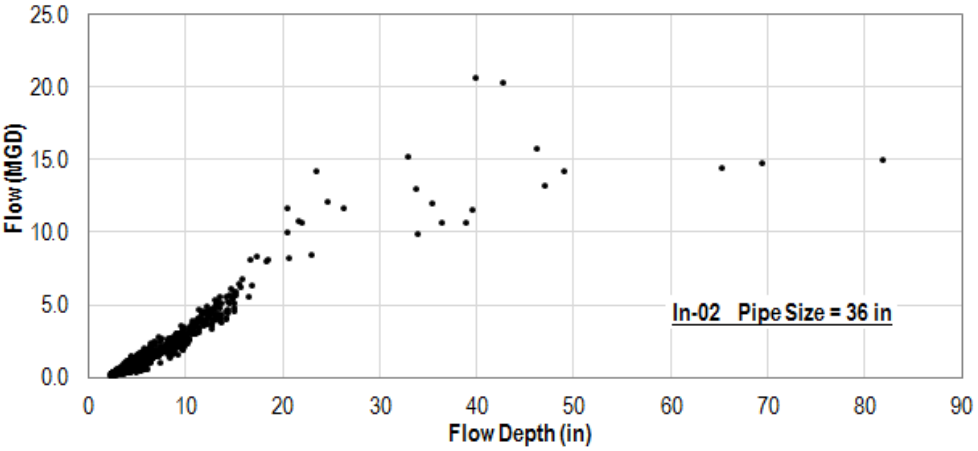


Figure 10: Flow Monitoring Data, In-02

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#02 Influent , Effluent and Overflow

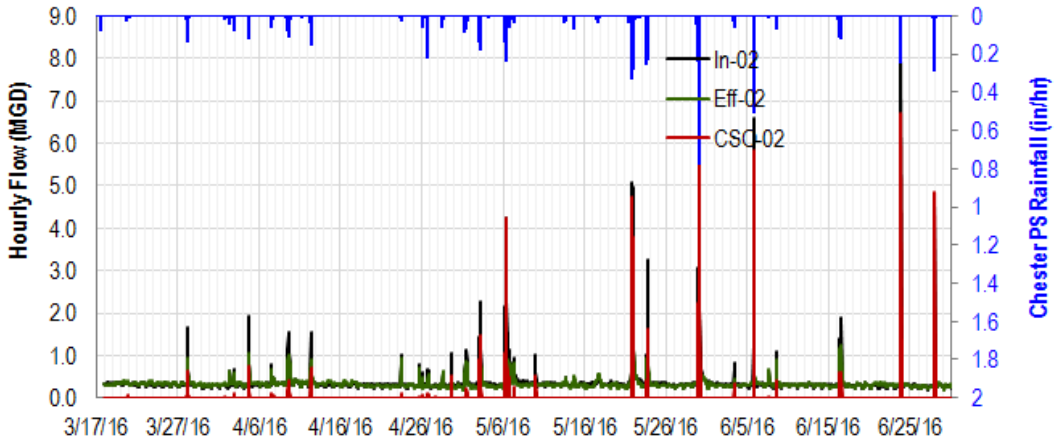
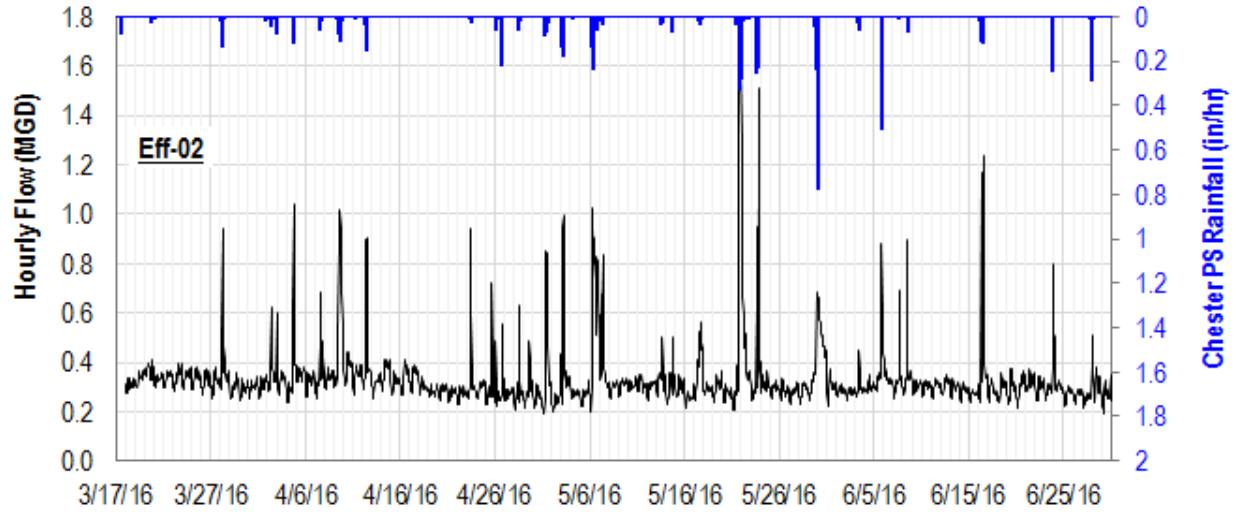


Figure 11: Flow Monitoring Data, EFF-02

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

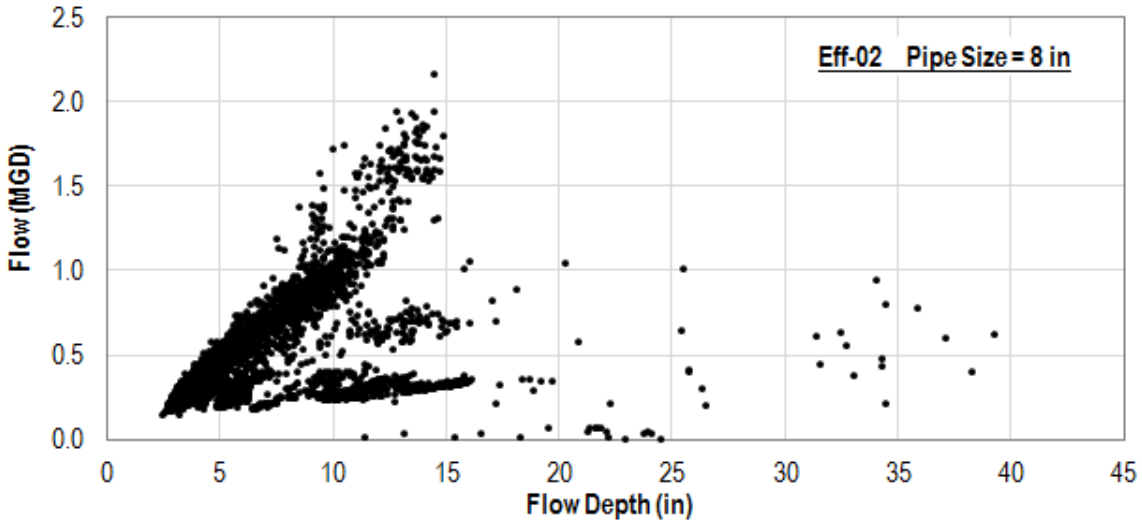
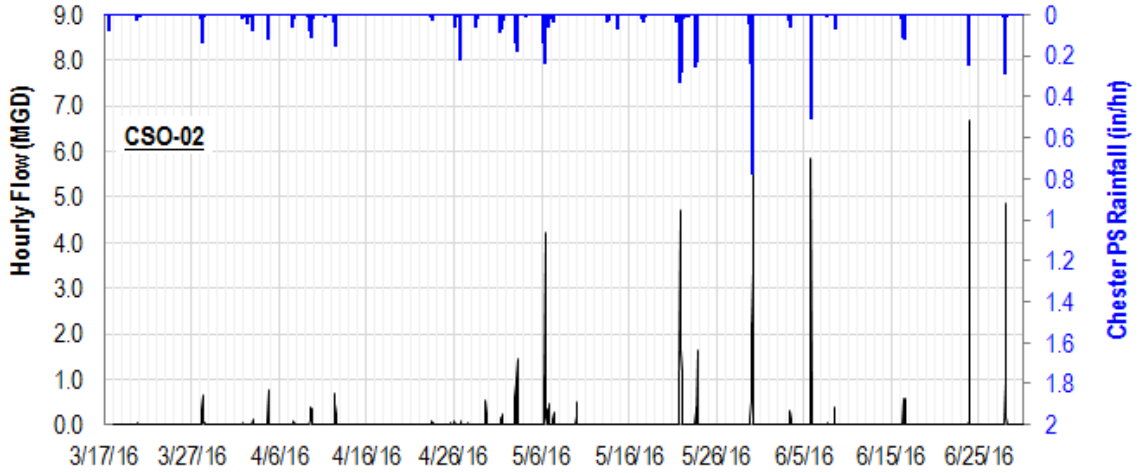


Figure 12: Flow Monitoring Data, CSO-02

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

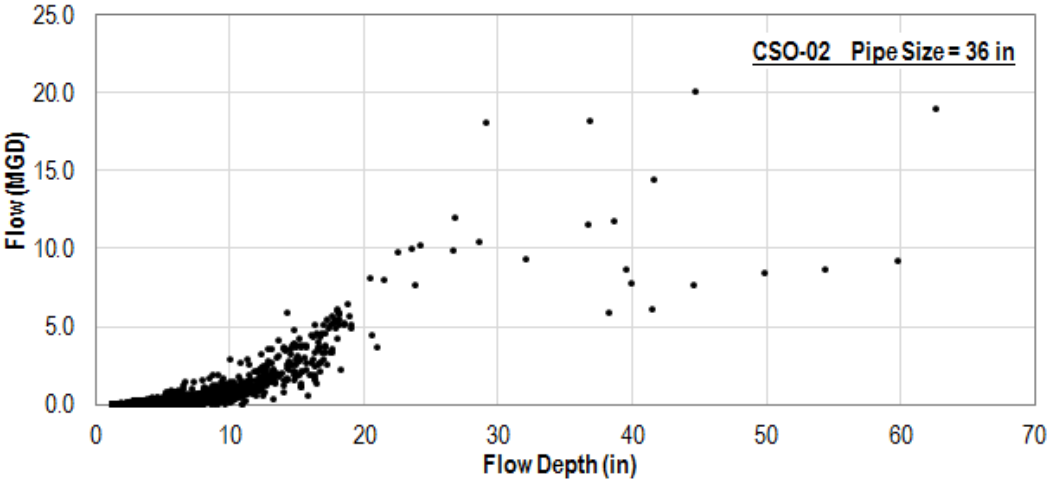
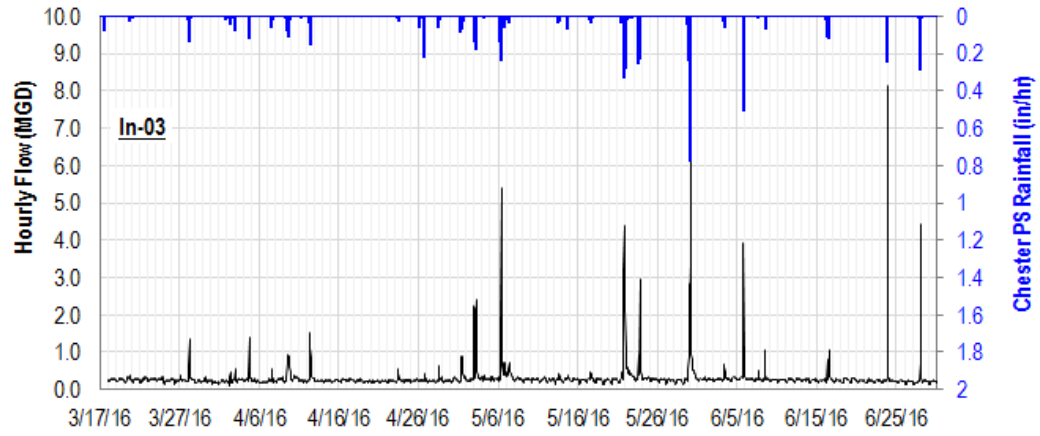
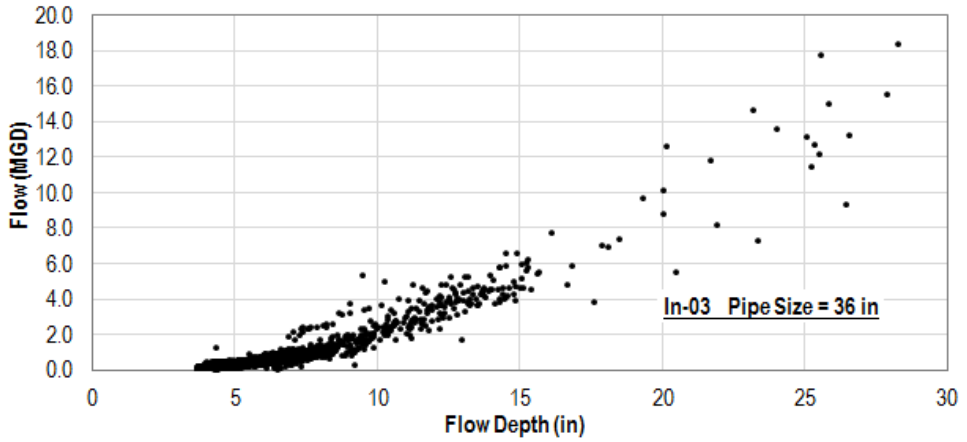


Figure 13: Flow Monitoring Data, IN-03

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#03 Influent , Effluent and Overflow

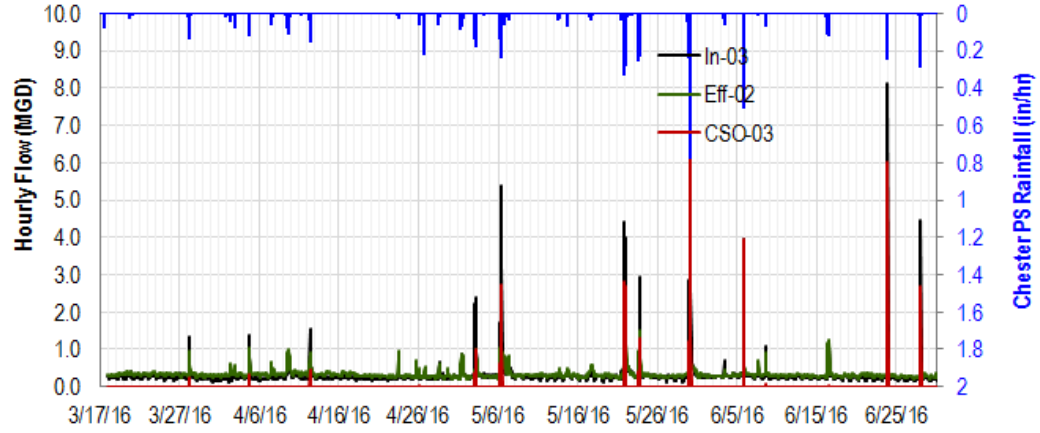


Figure 14: Flow Monitoring Data, Eff-03

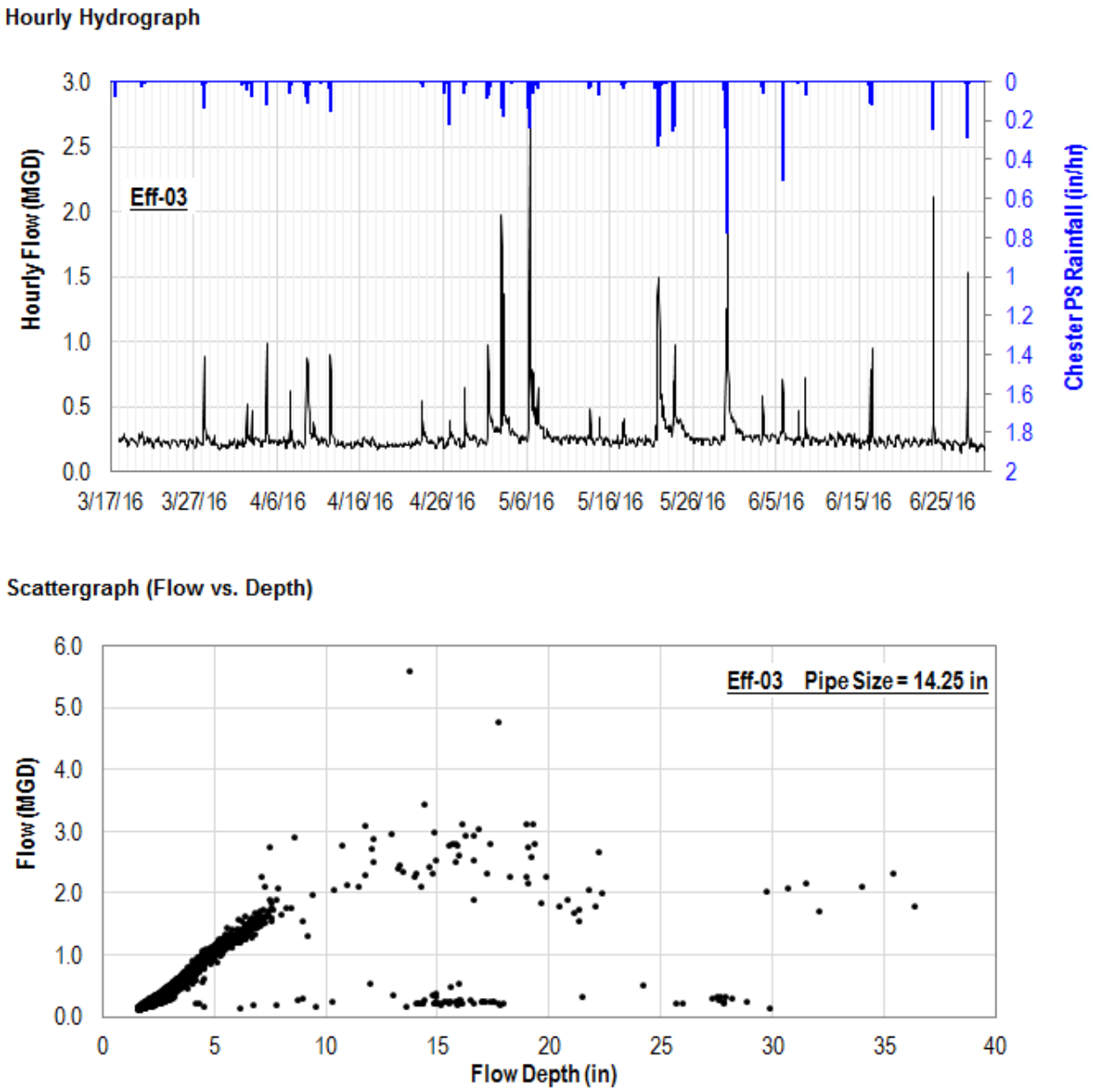
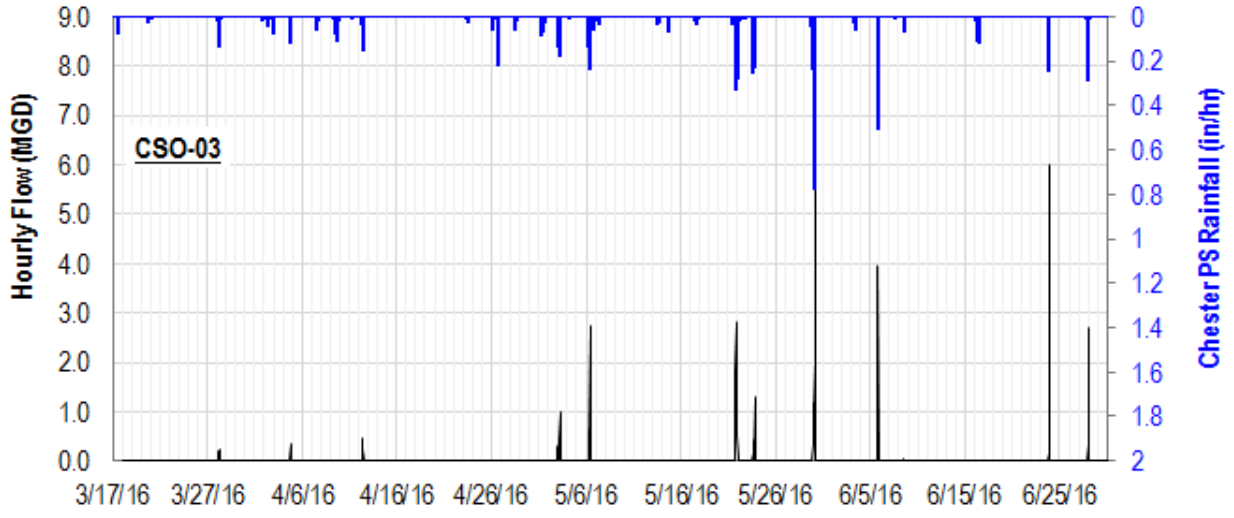


Figure 15: Flow Monitoring Data, CSO-03

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

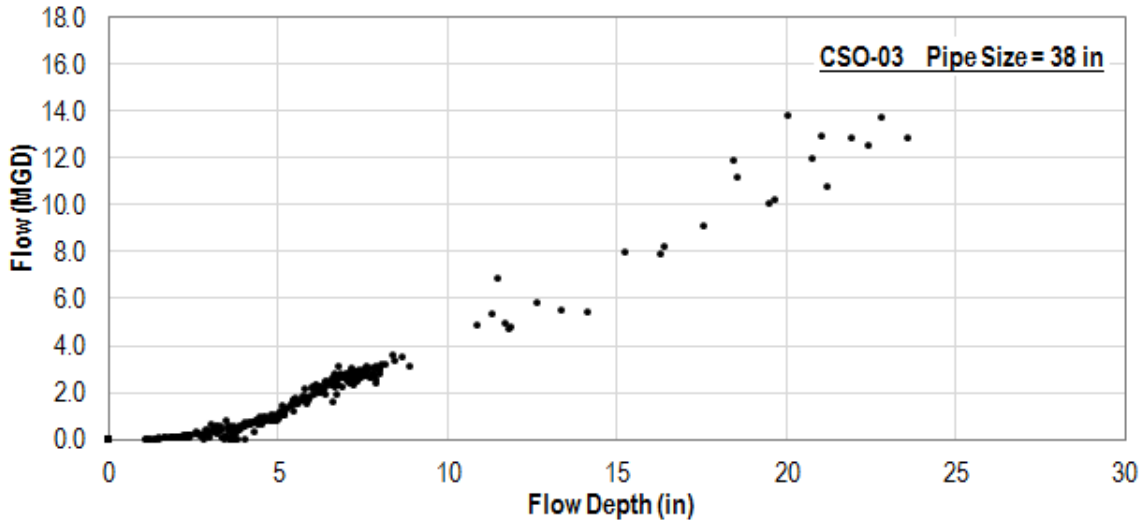
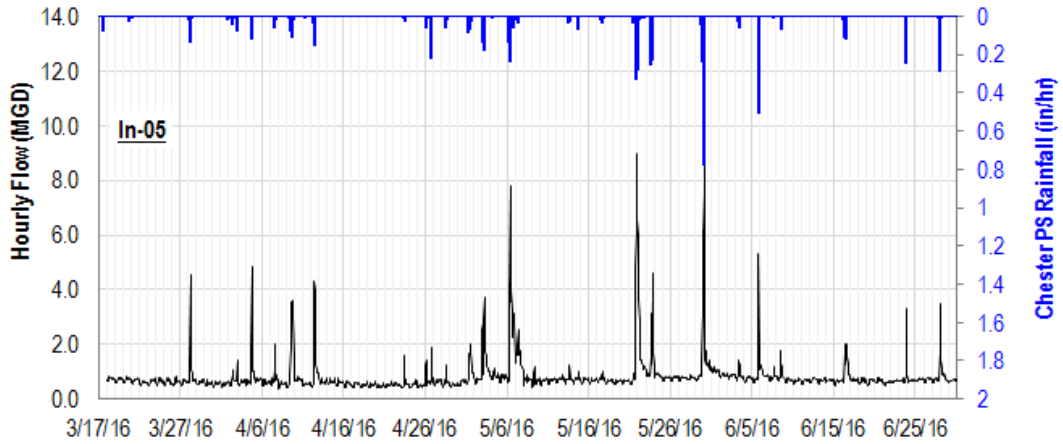
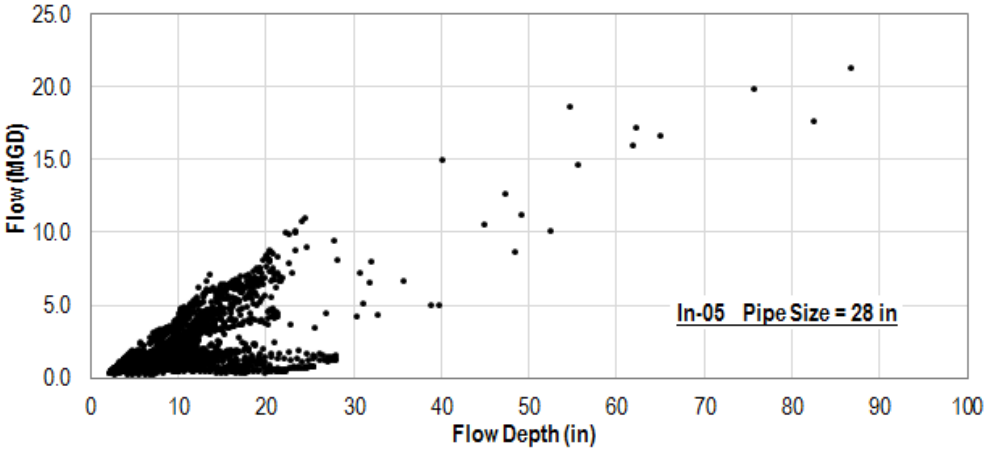


Figure 16: Flow Monitoring Data, IN-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#03 Influent , Effluent and Overflow

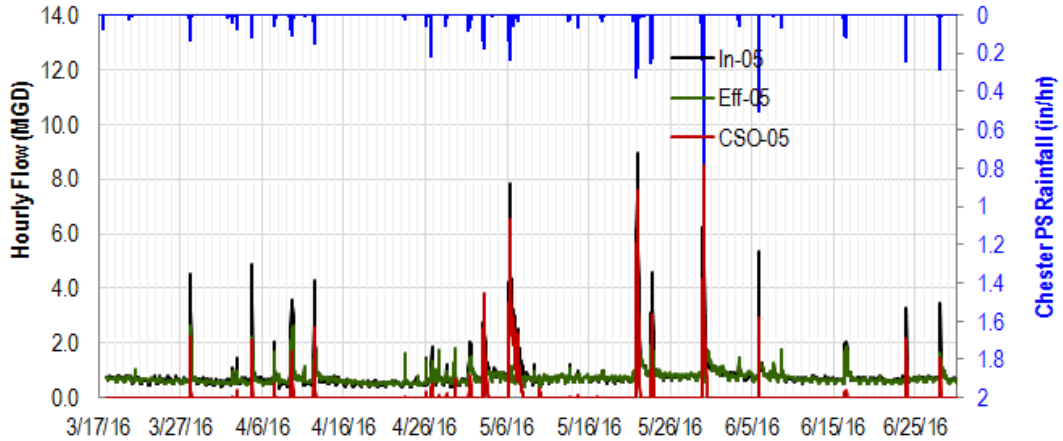
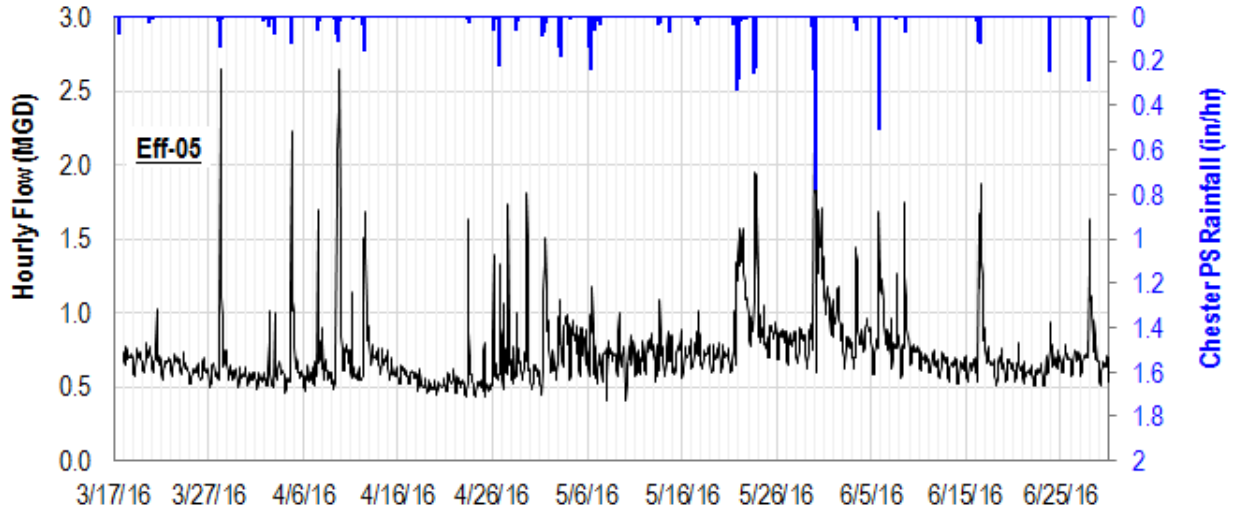


Figure 17: Flow Monitoring Data, Eff-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

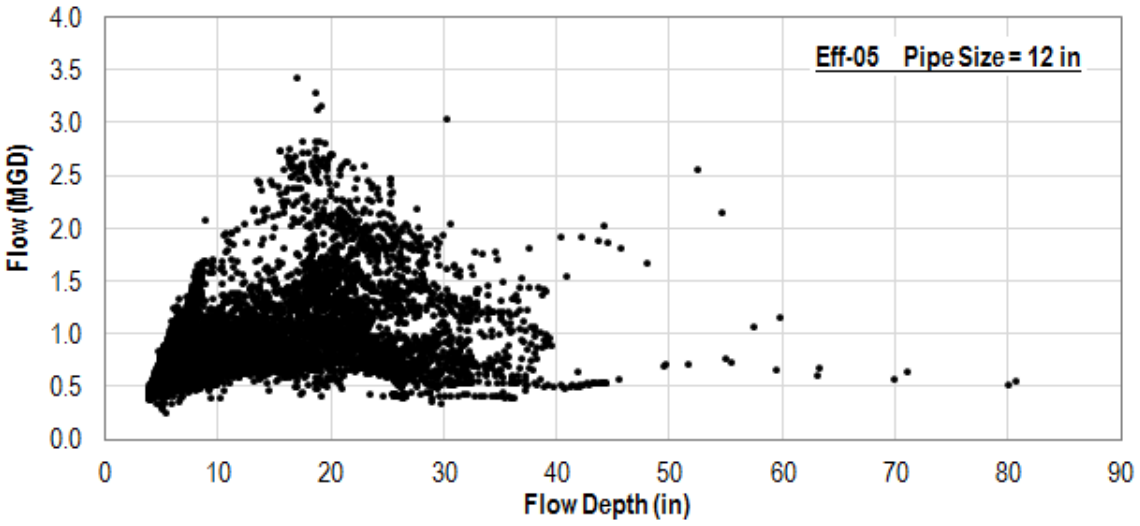


Figure 18: Flow Monitoring Data, CSO-05

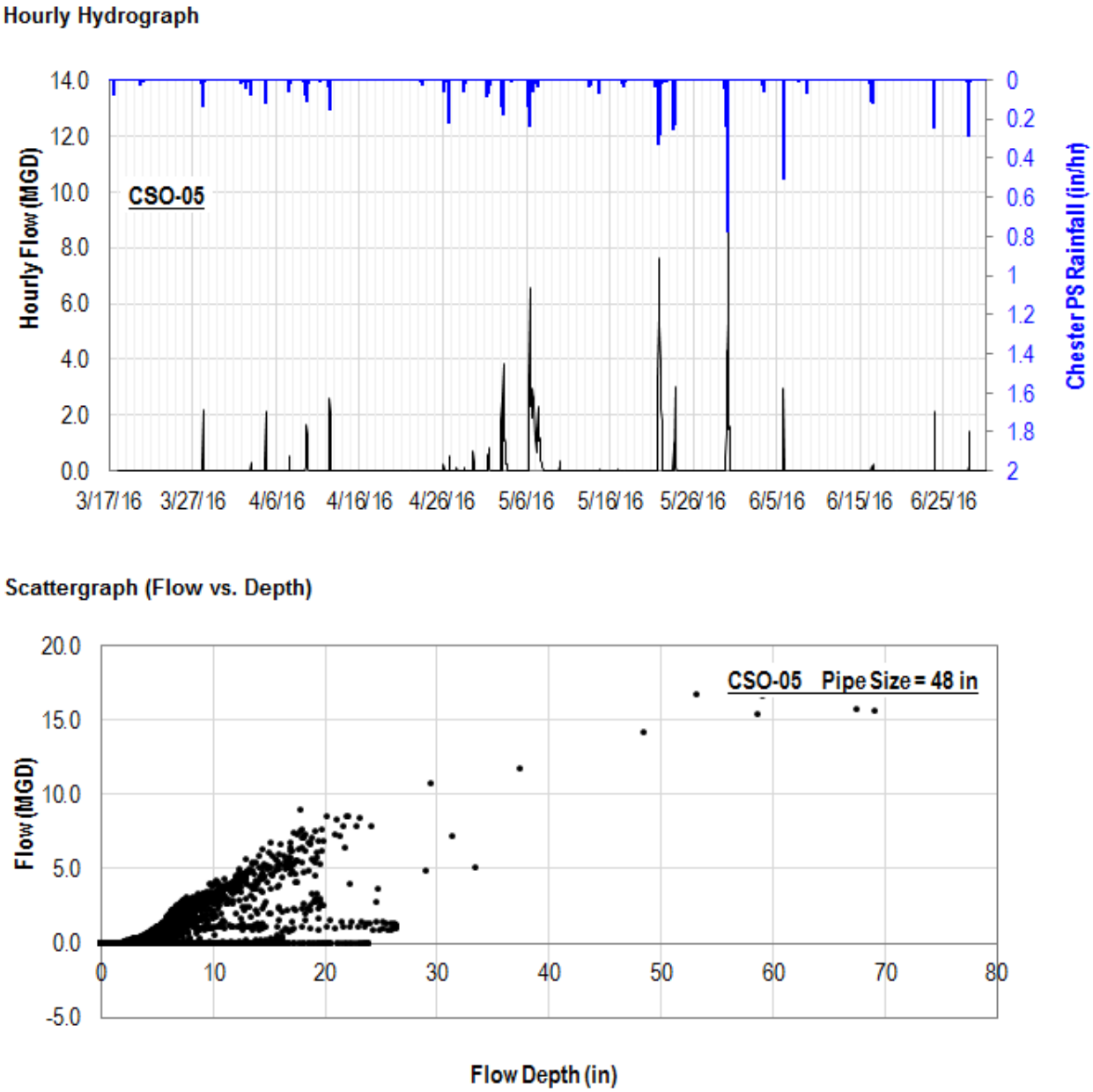
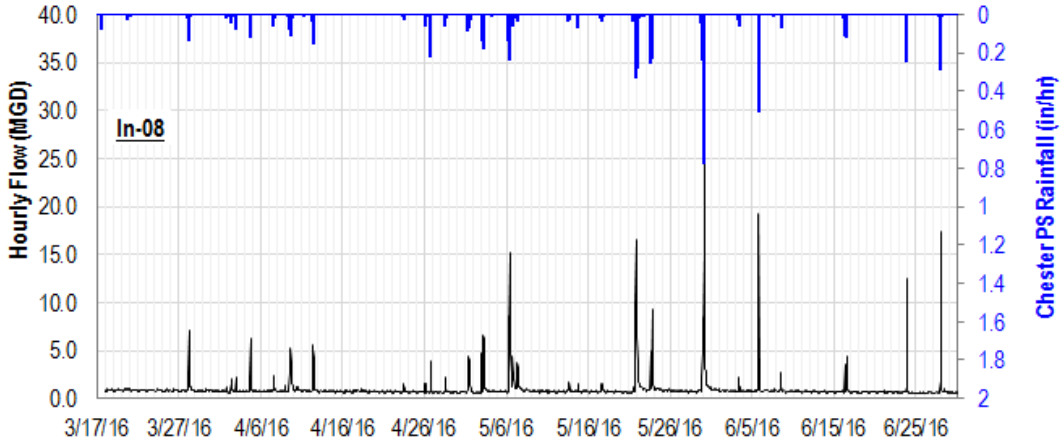
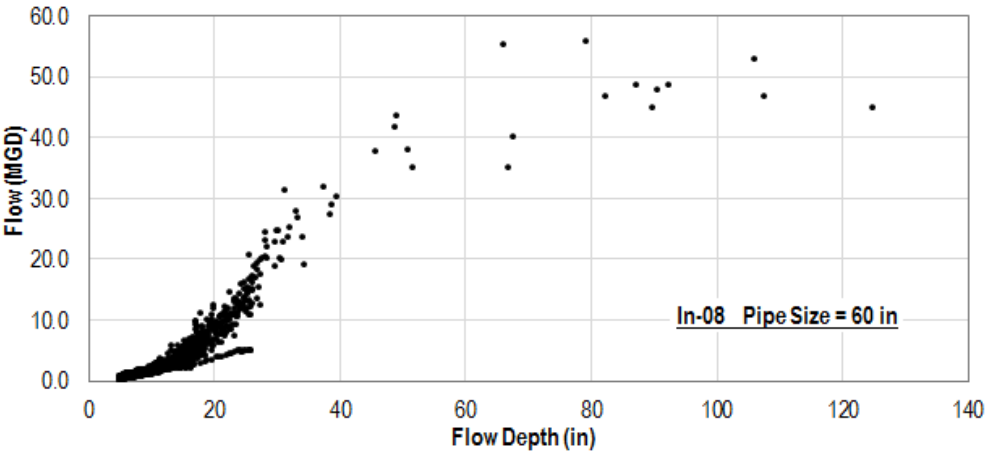


Figure 19: Flow Monitoring Data, IN-08

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#03 Influent , Effluent and Overflow

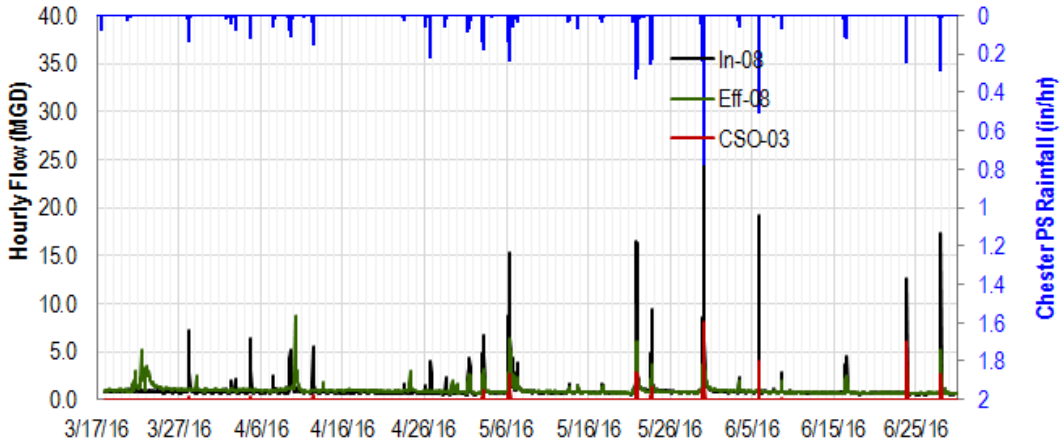
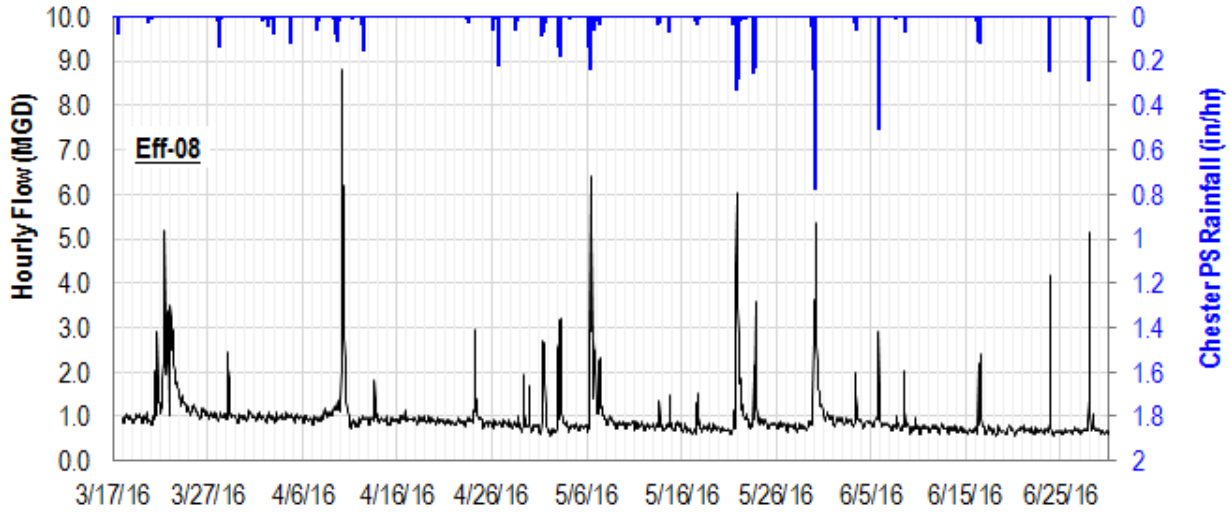


Figure 20: Flow Monitoring Data, Eff-08

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

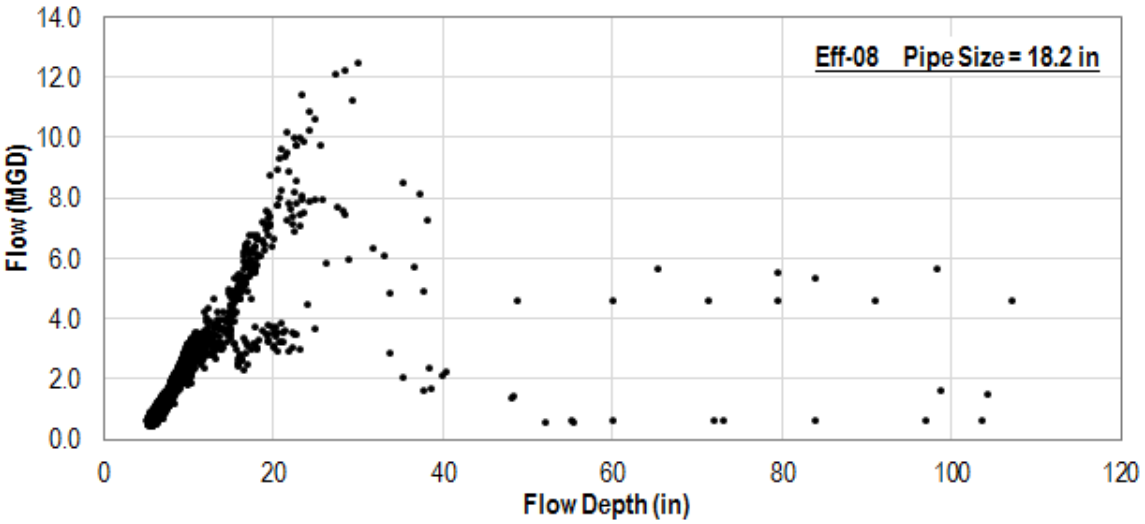


Figure 21: Flow Monitoring Data, CSO-08

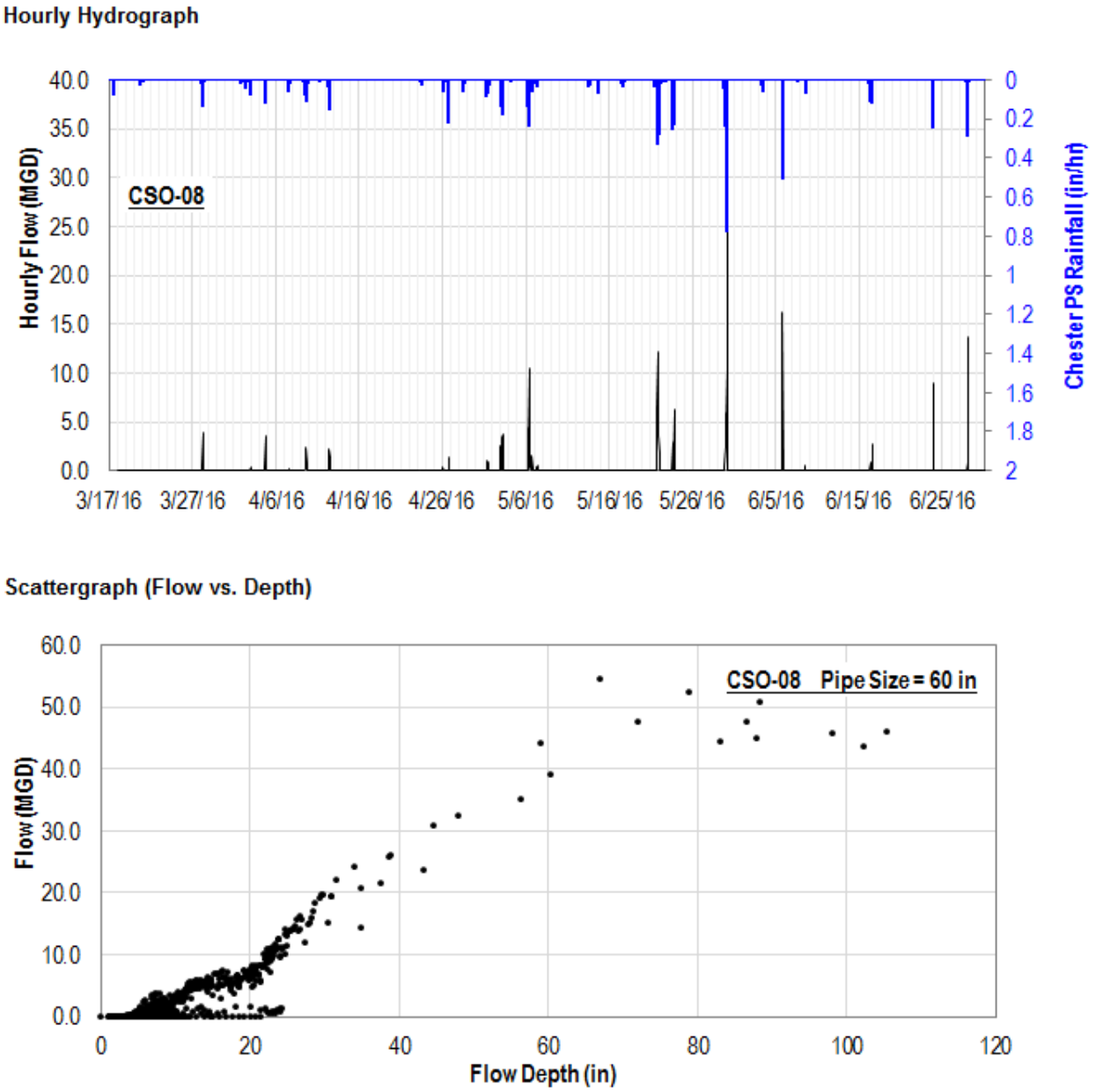


Figure 22: Flow Monitoring Data, In-09

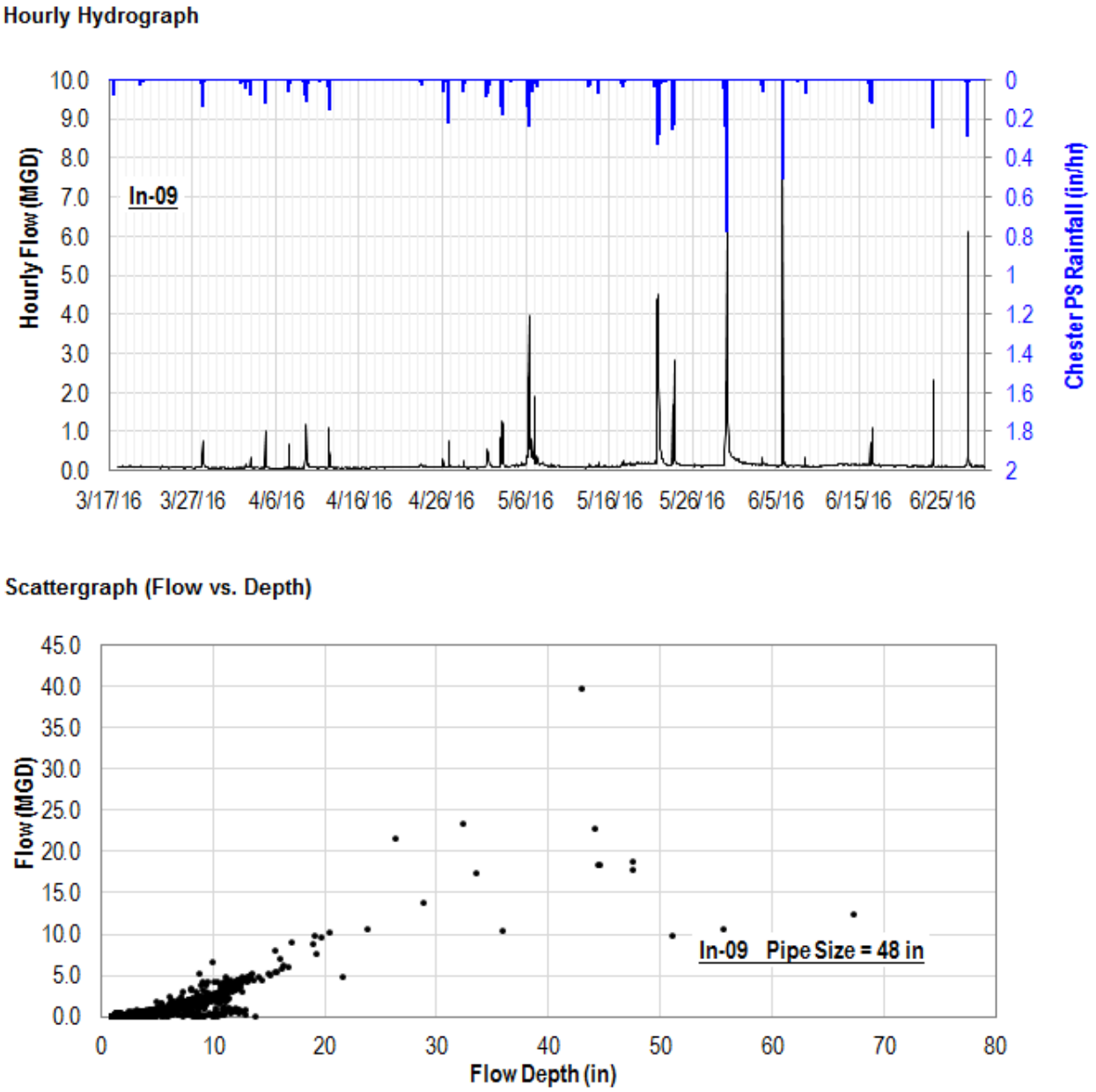


Figure 23: Flow Monitoring Data, In-10

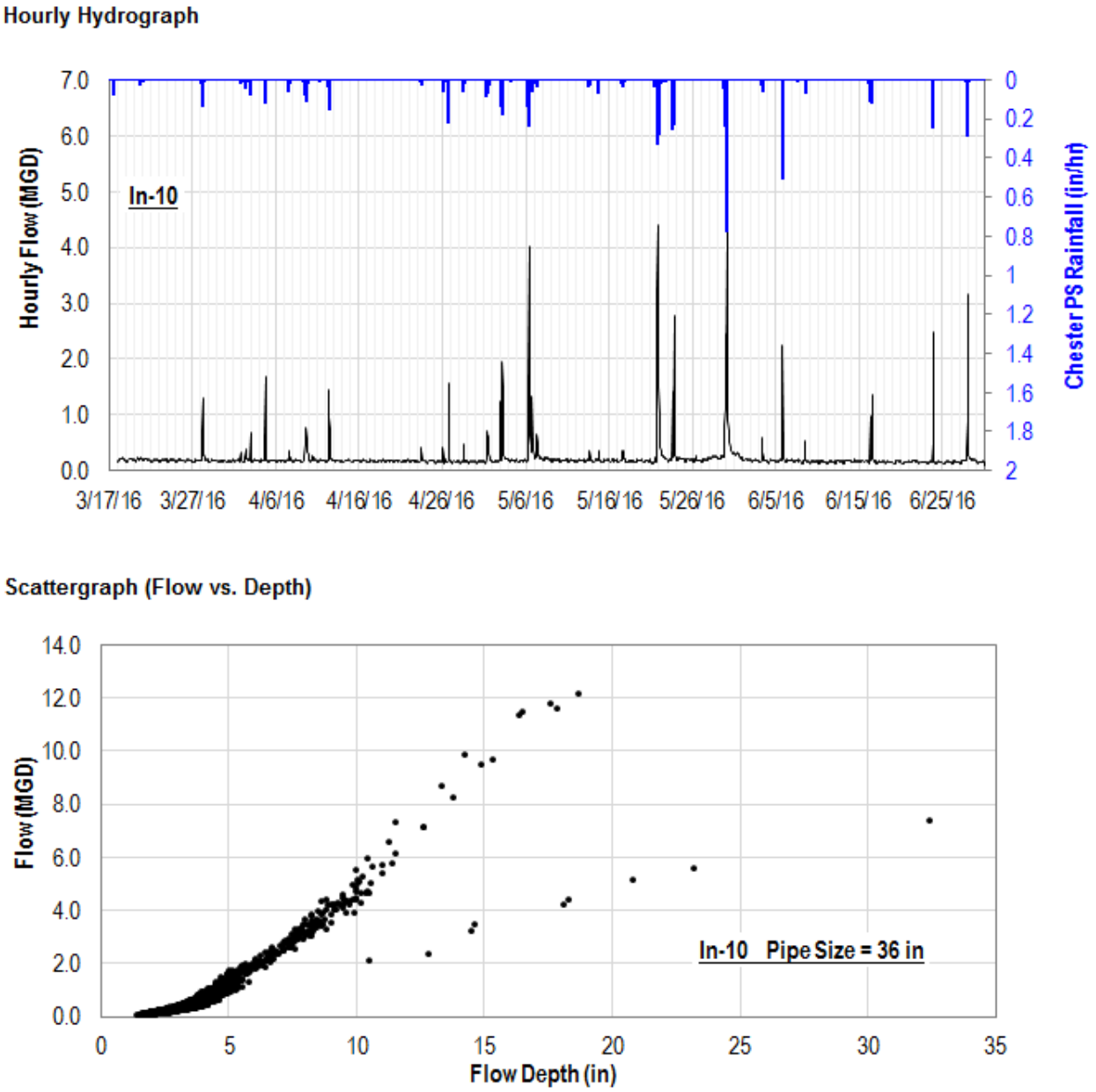


Figure 24: Flow Monitoring Data, In-11

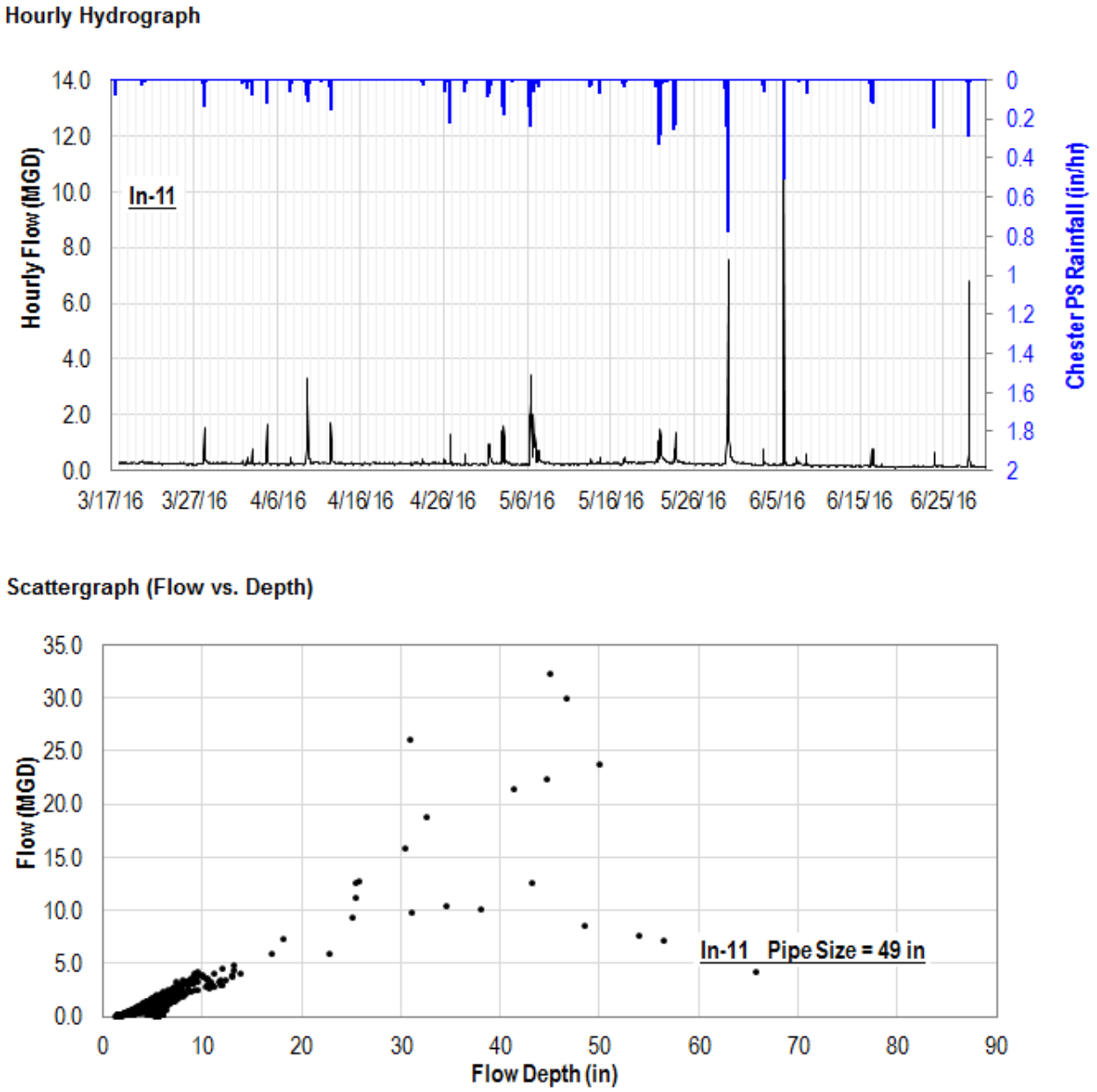
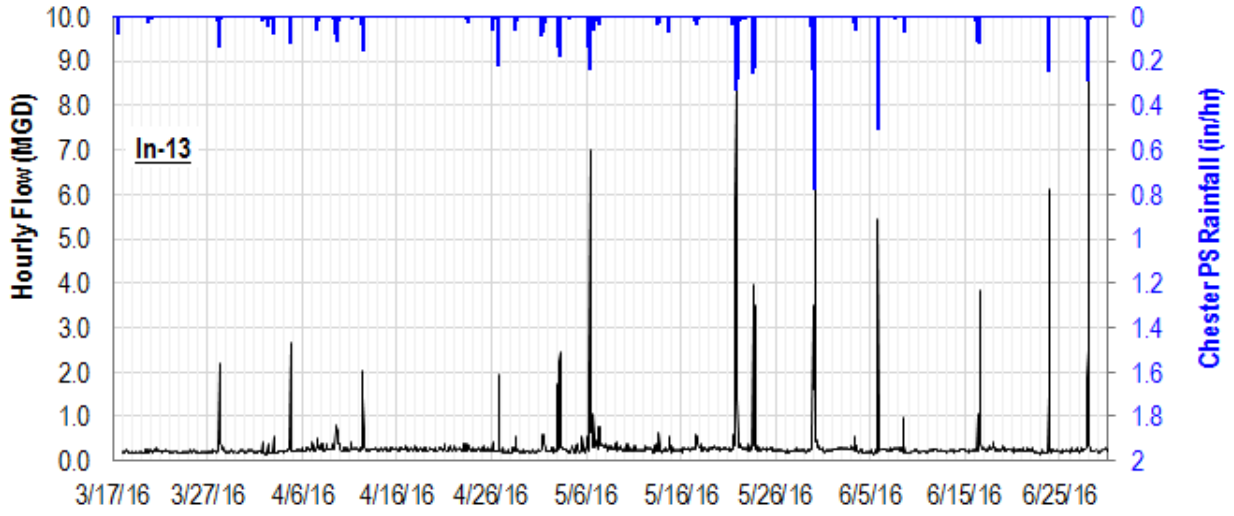


Figure 25: Flow Monitoring Data, In-13

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

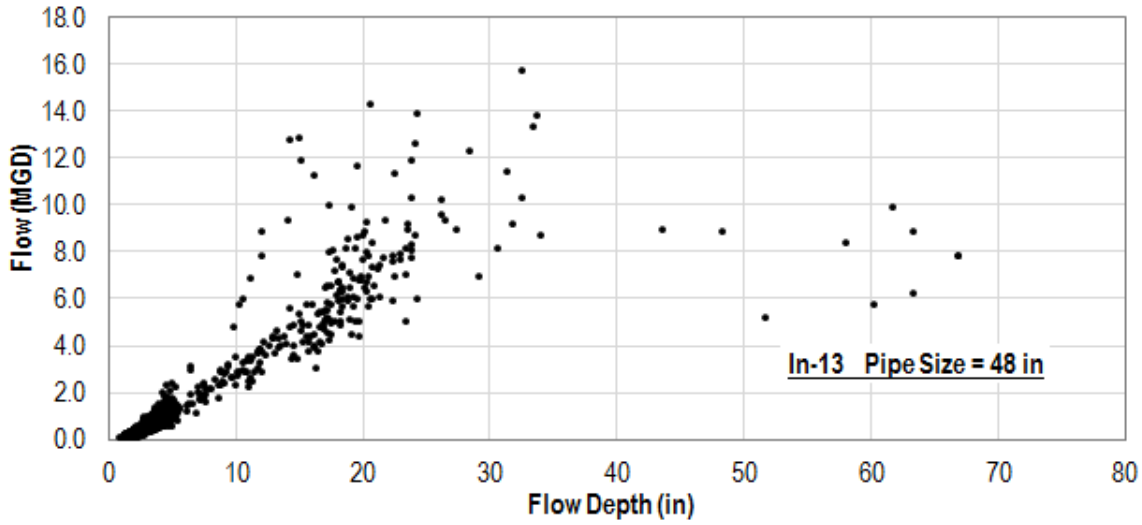
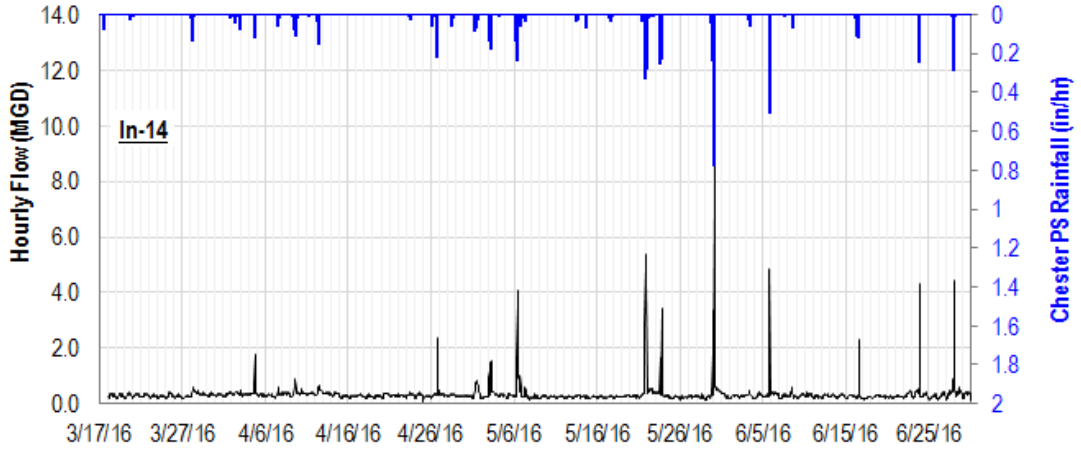
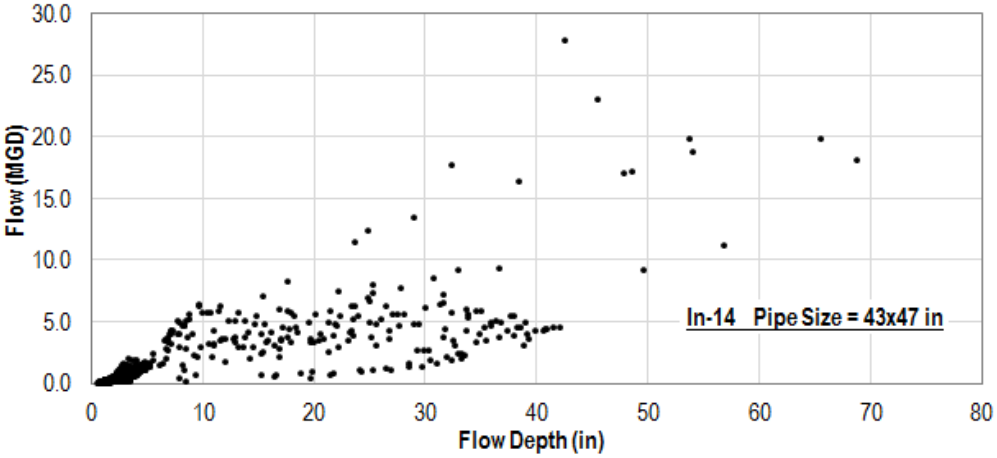


Figure 26: Flow Monitoring Data, In-14

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#03 Influent , Effluent and Overflow

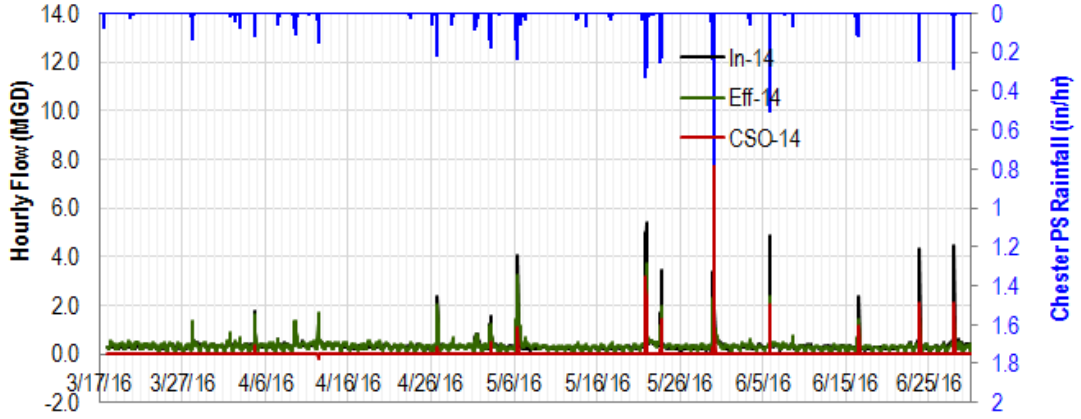
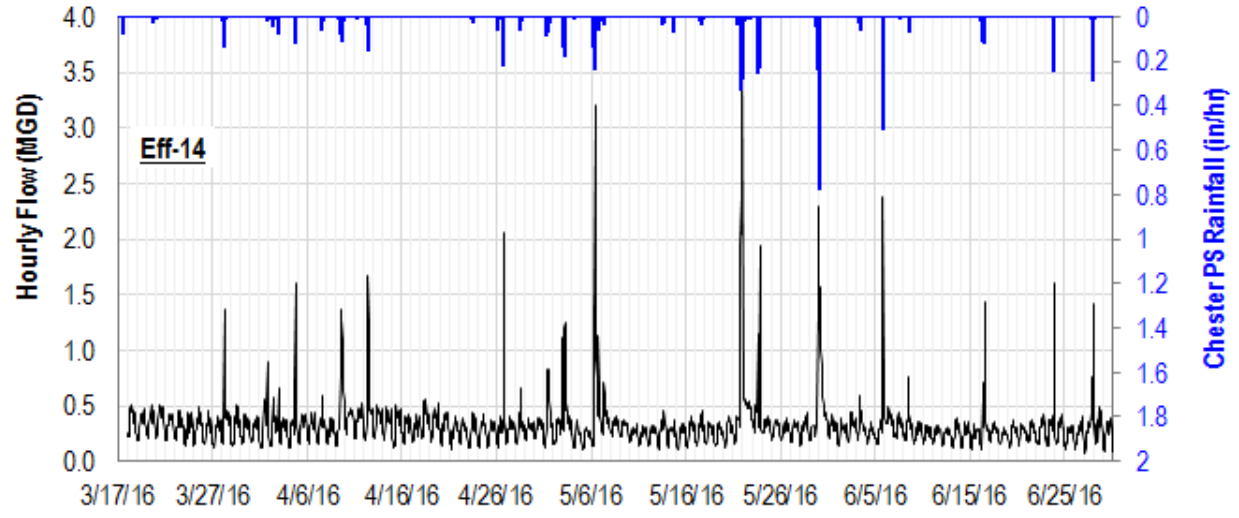


Figure 27: Flow Monitoring Data, Eff-14

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

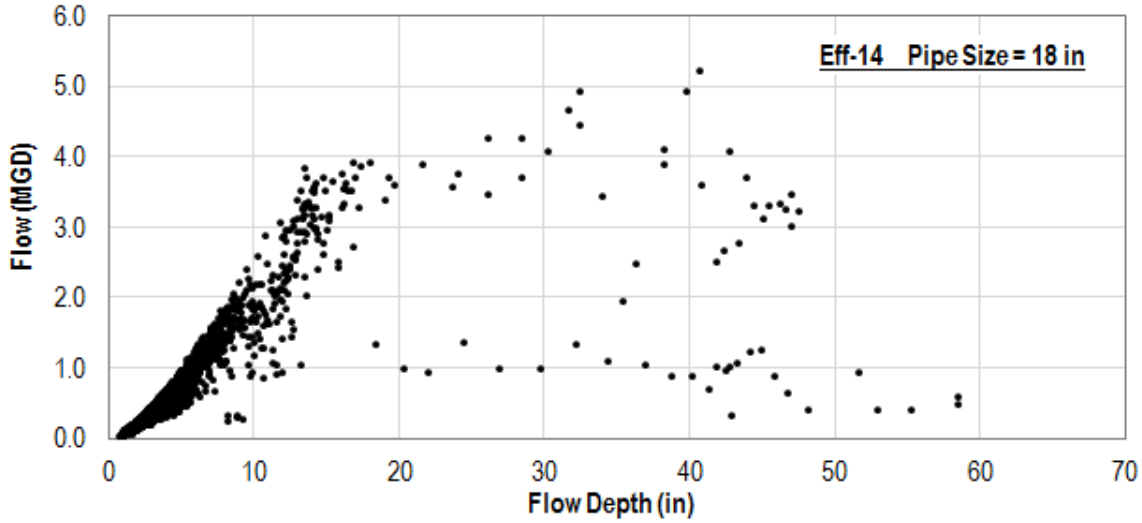


Figure 28: Flow Monitoring Data, CSO-14

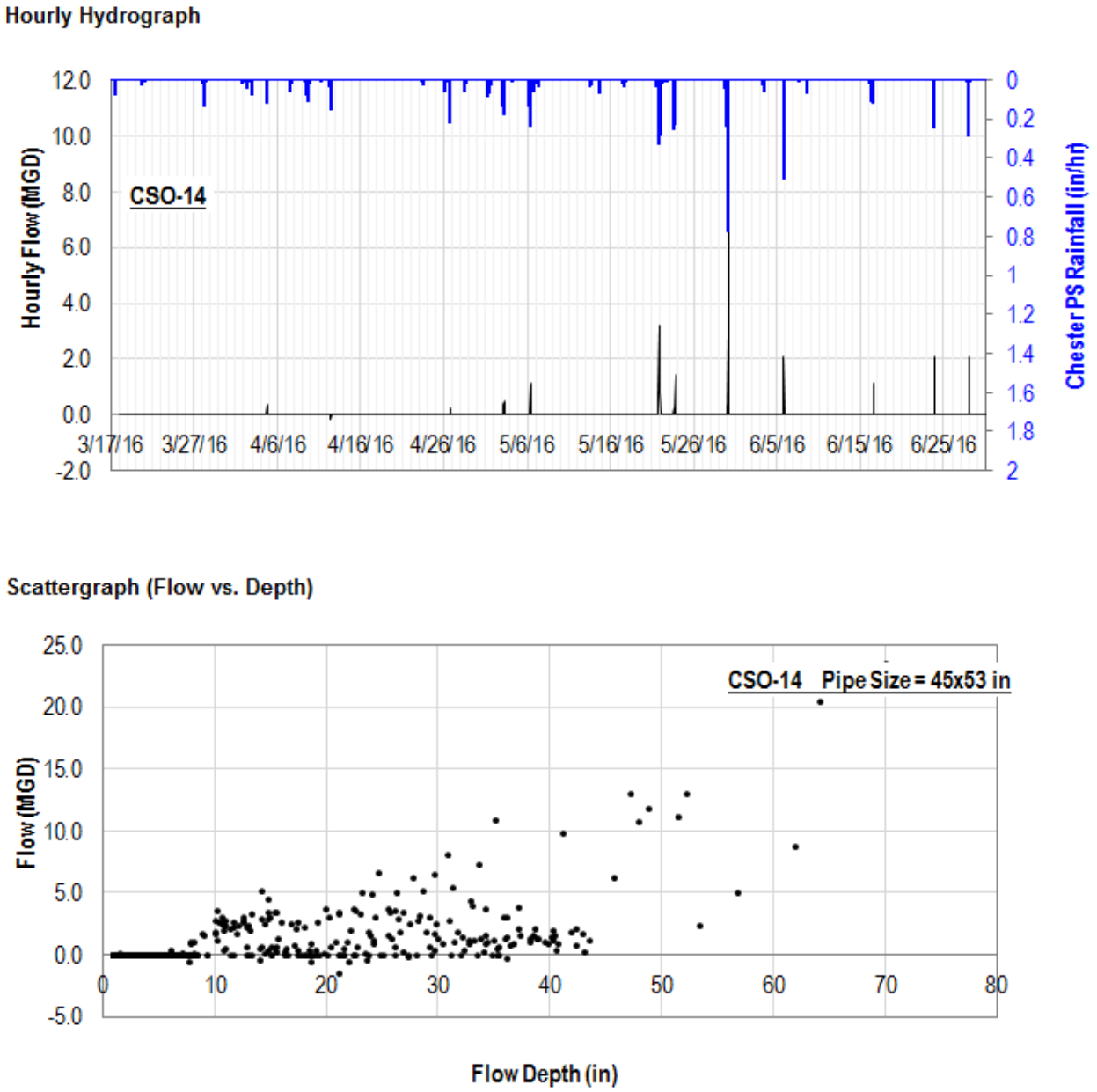
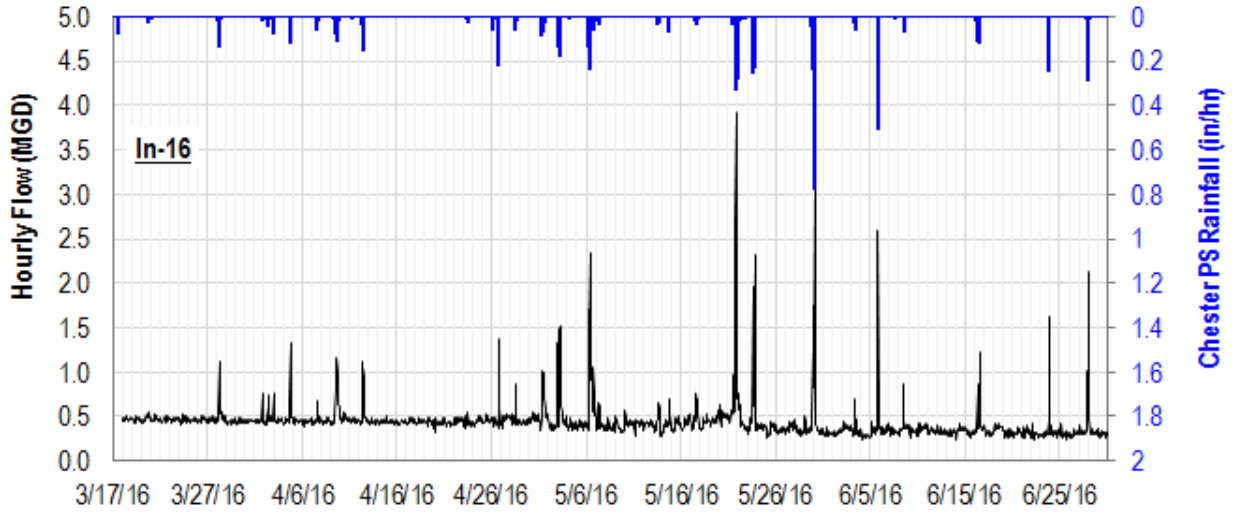


Figure 29: Flow Monitoring Data, In-16

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

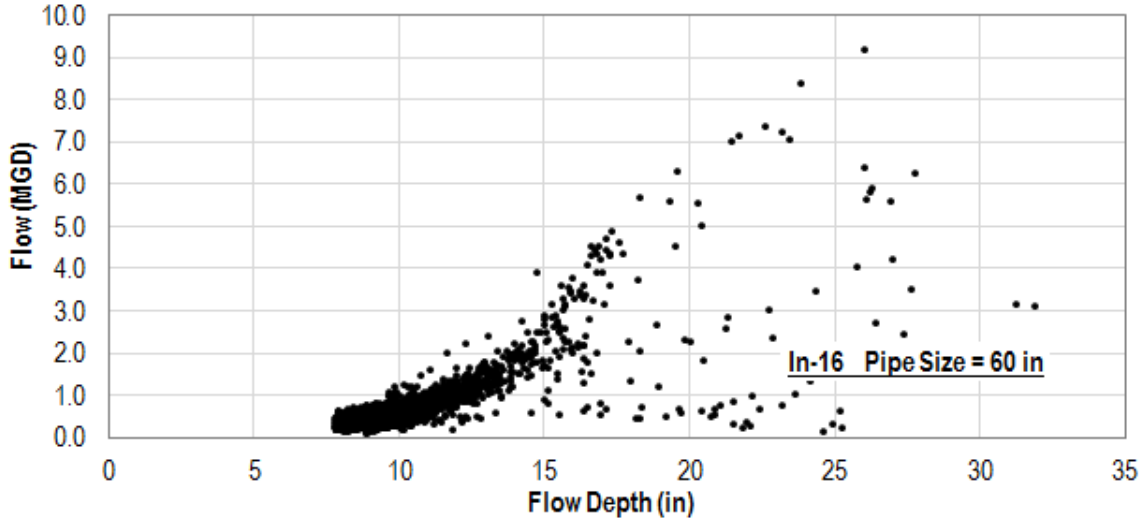


Figure 30: Flow Monitoring Data, In-17

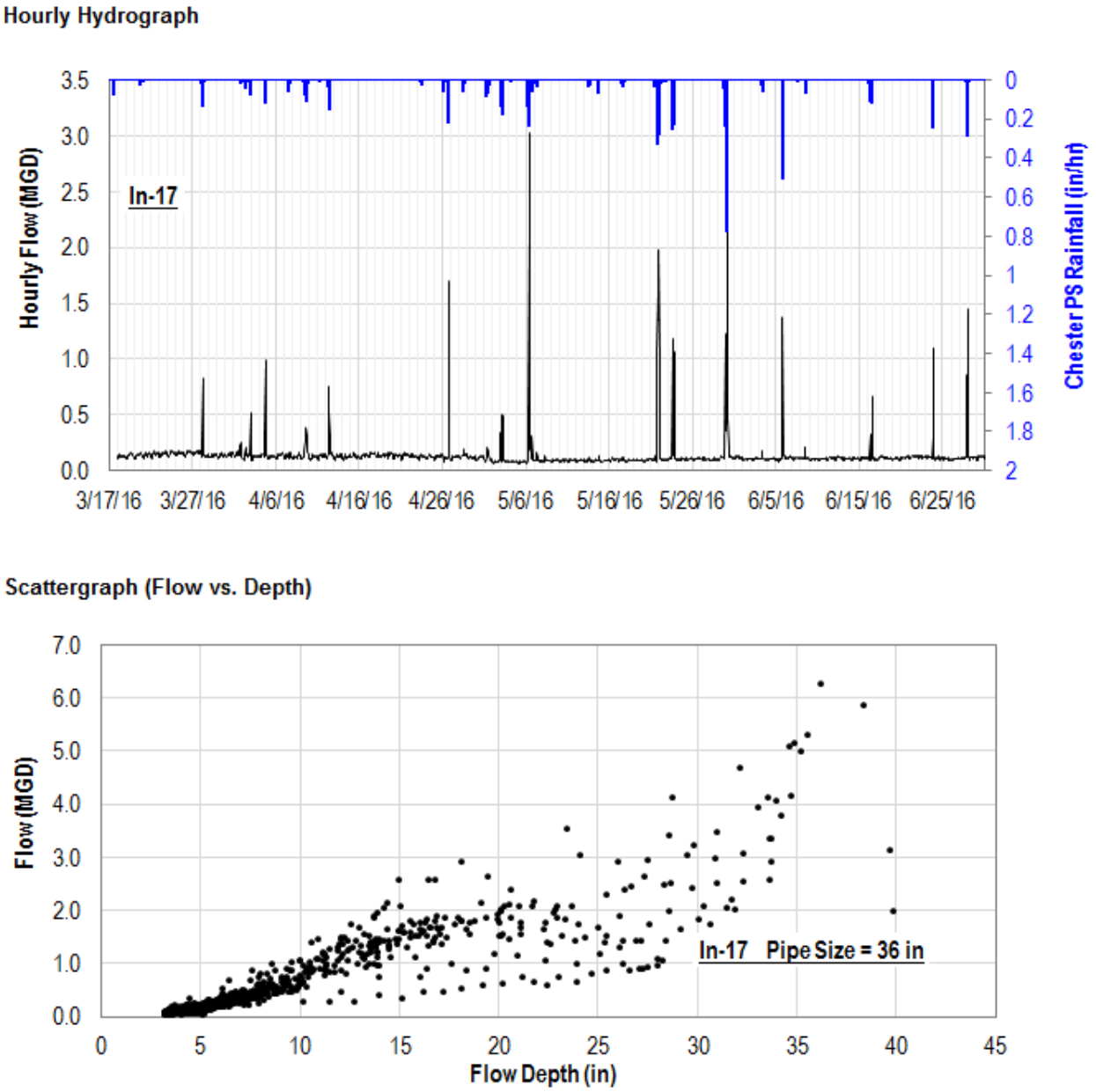


Figure 31: Flow Monitoring Data, In-18

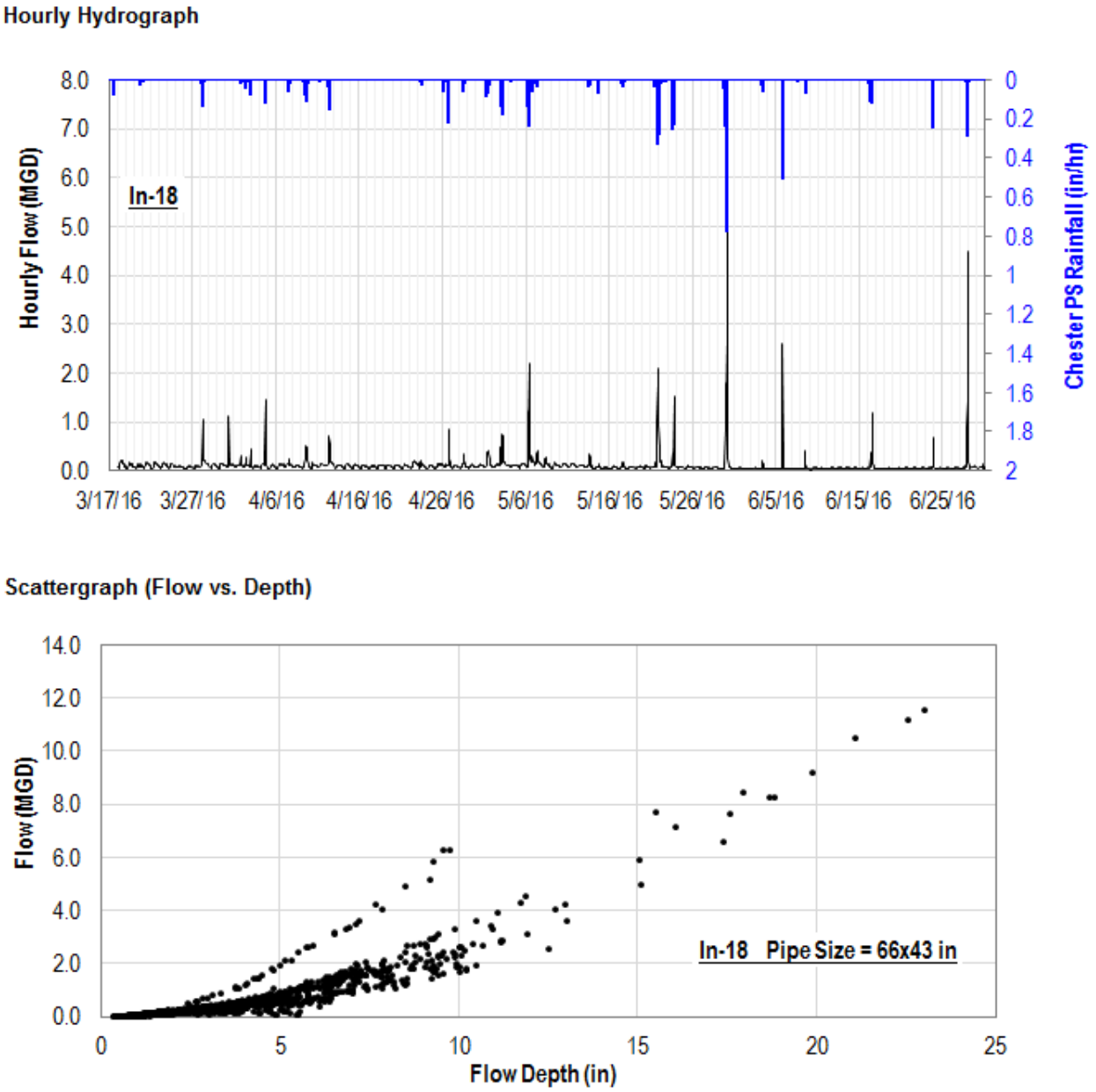
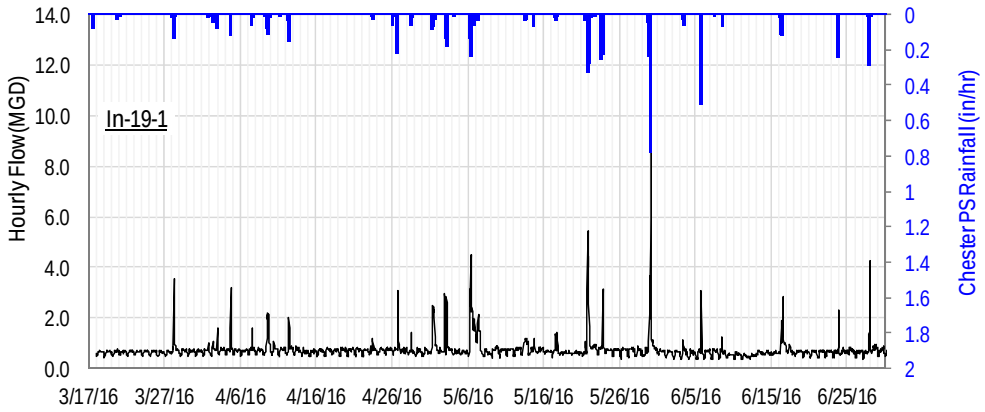
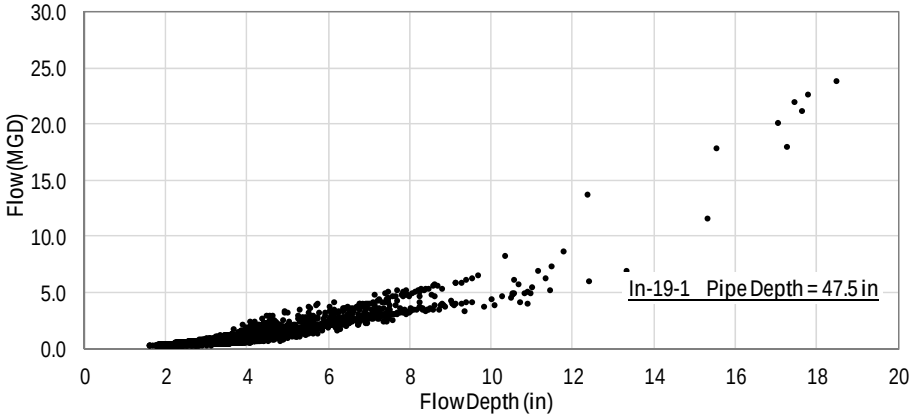


Figure 32: Flow Monitoring Data, In-19-1

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#19 Influent , Effluent and Overflow

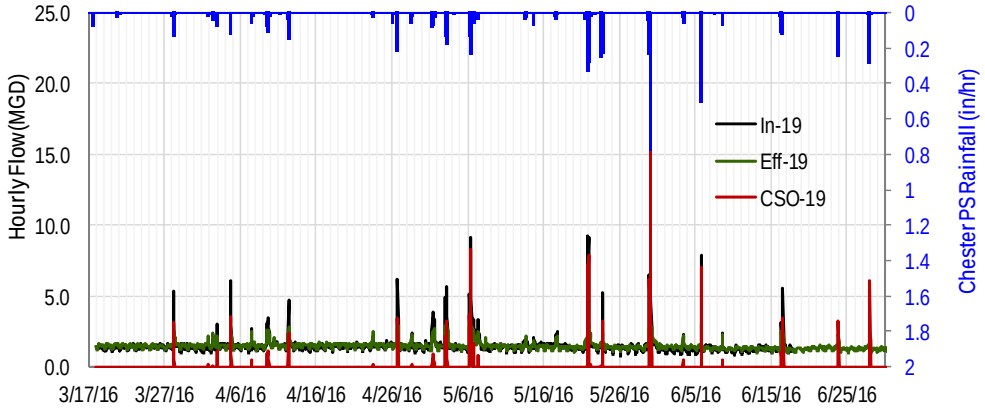


Figure 33: Flow Monitoring Data, In-19-2

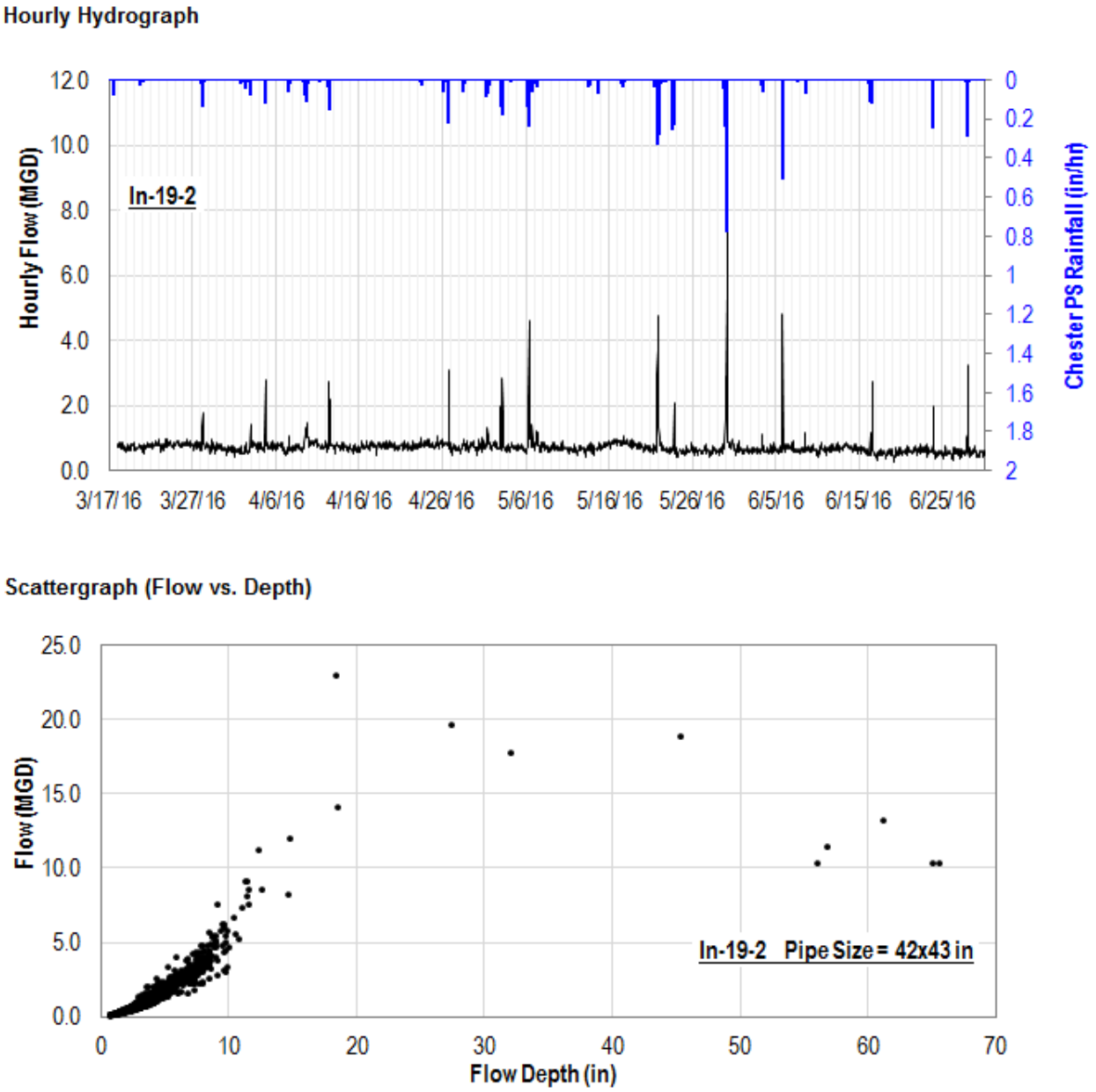


Figure 34: Flow Monitoring Data, Eff-19

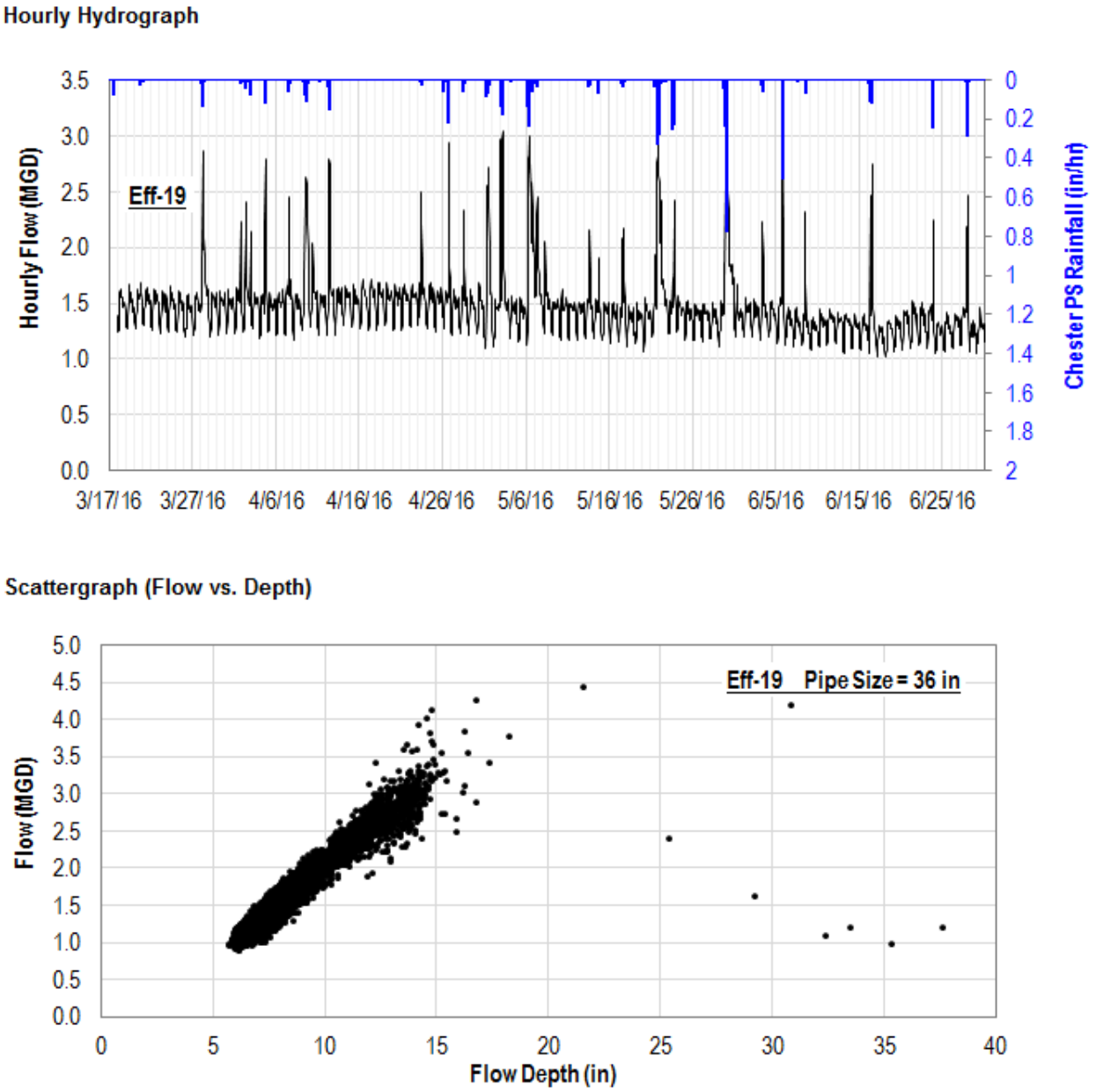
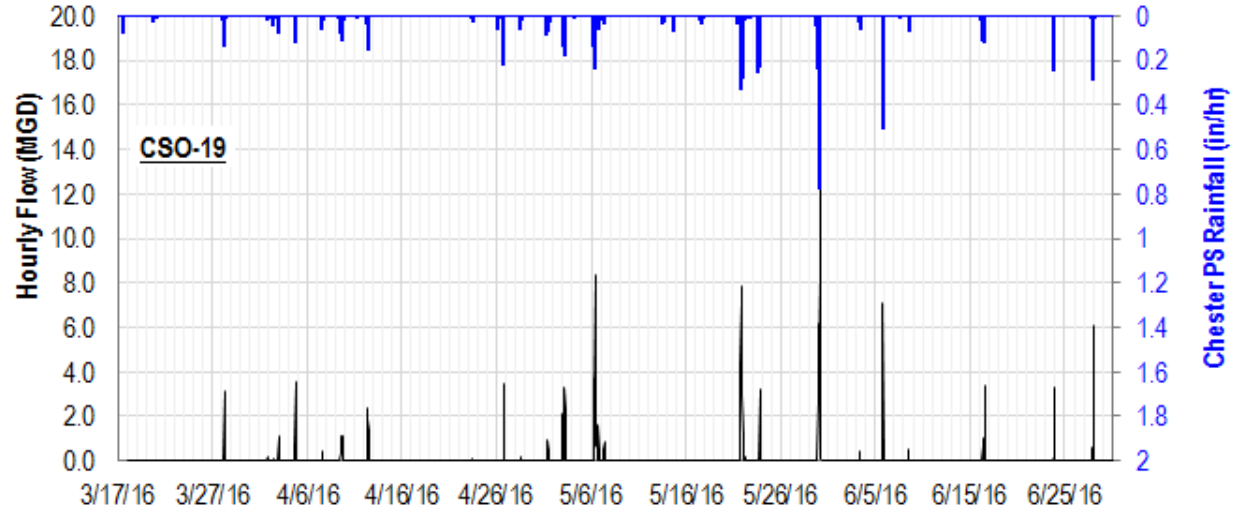


Figure 35: Flow Monitoring Data, CSO-19



Scattergraph (Flow vs. Depth)

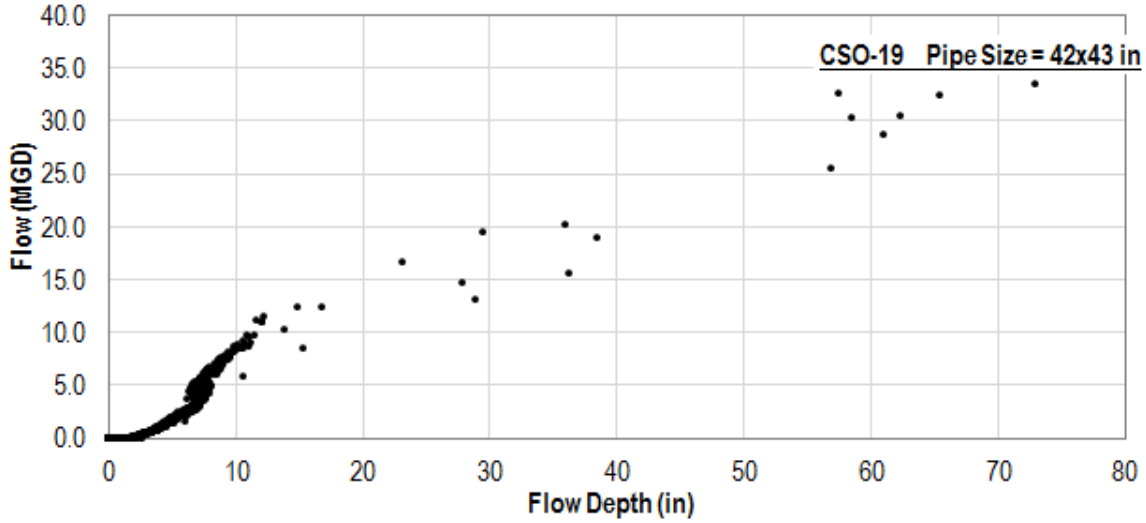


Figure 36: Flow Monitoring Data, In-25

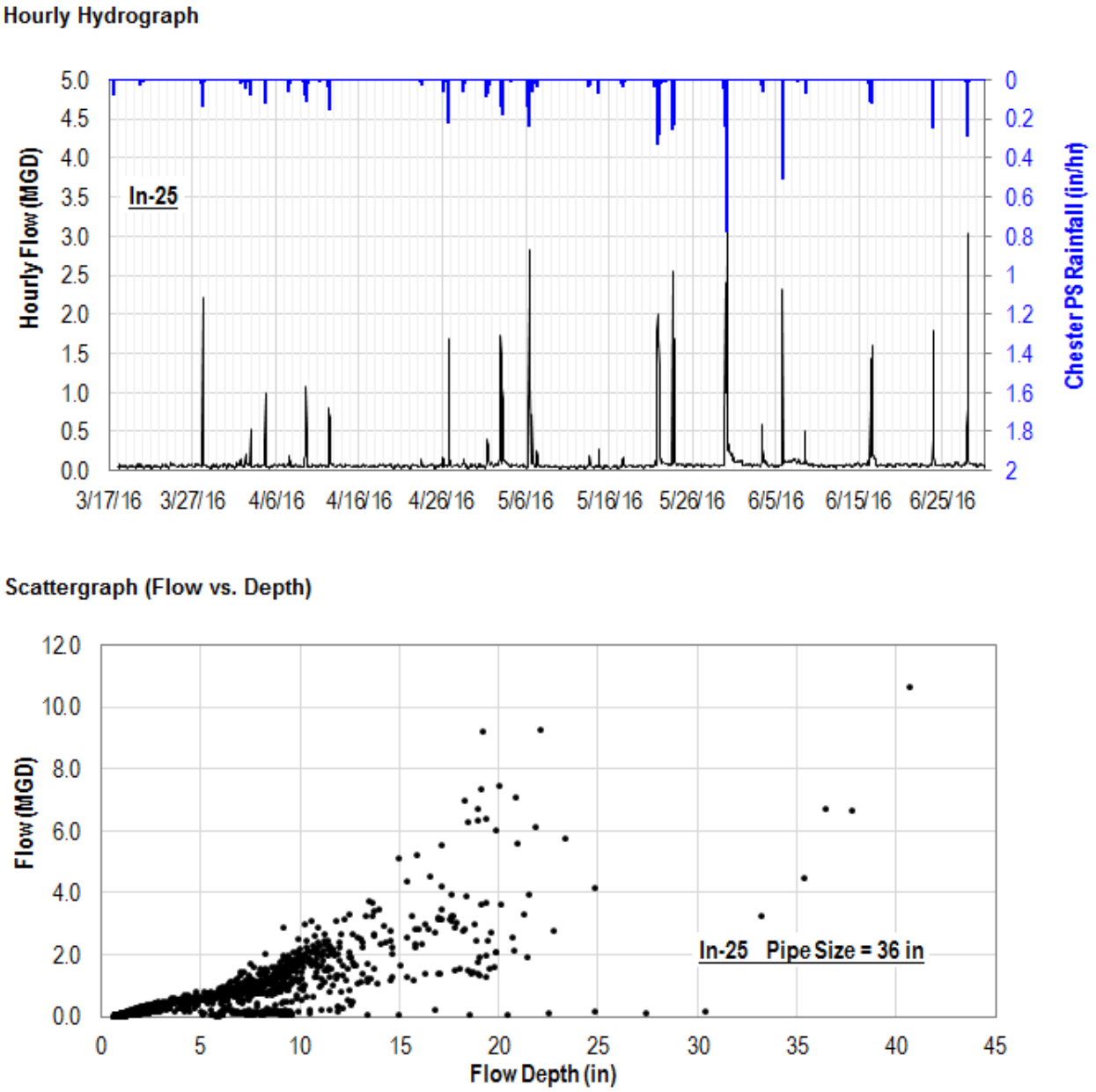
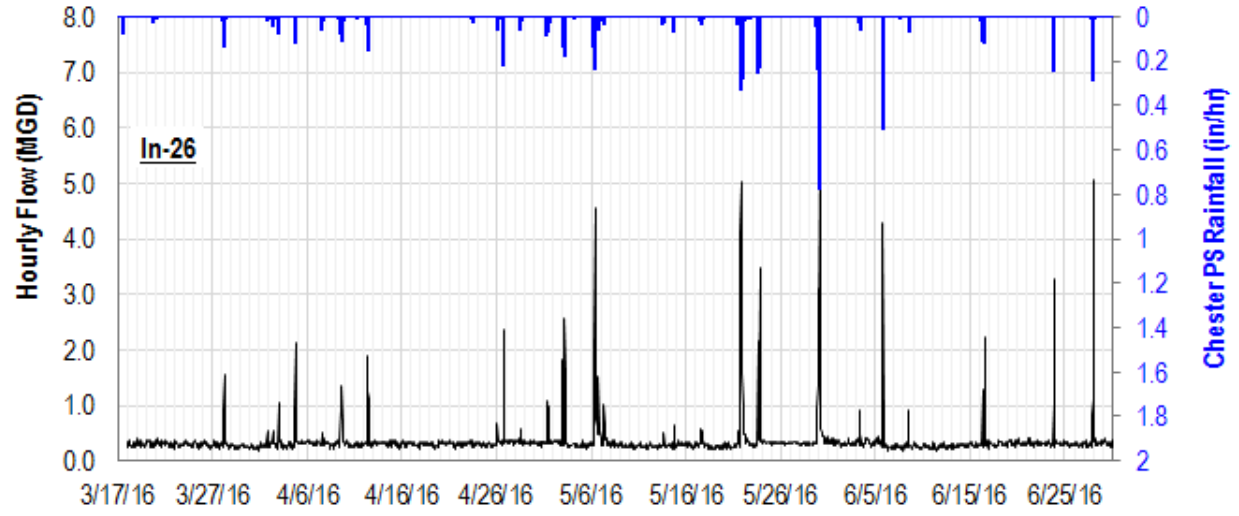


Figure 37: Flow Monitoring Data, In-26

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

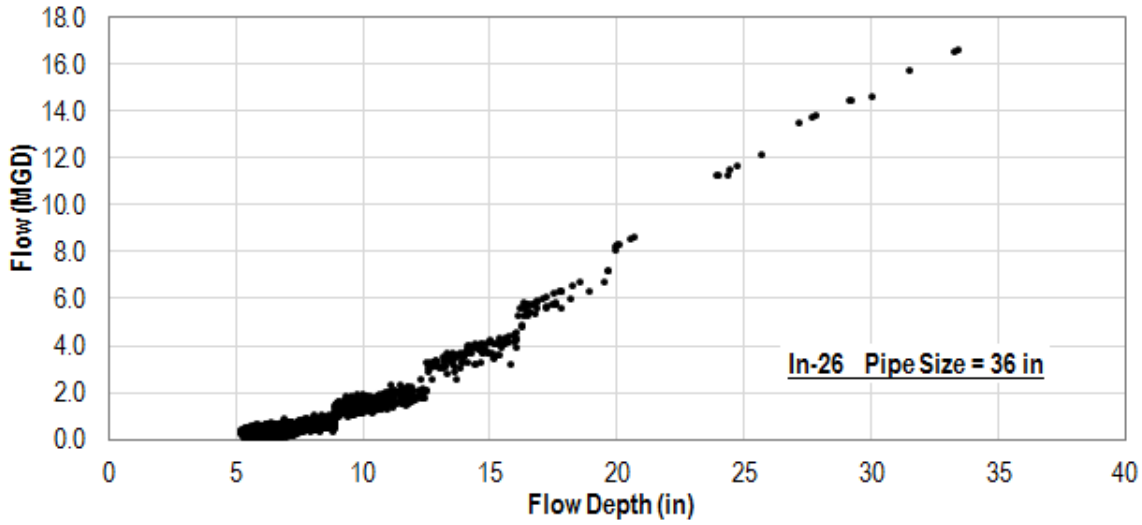
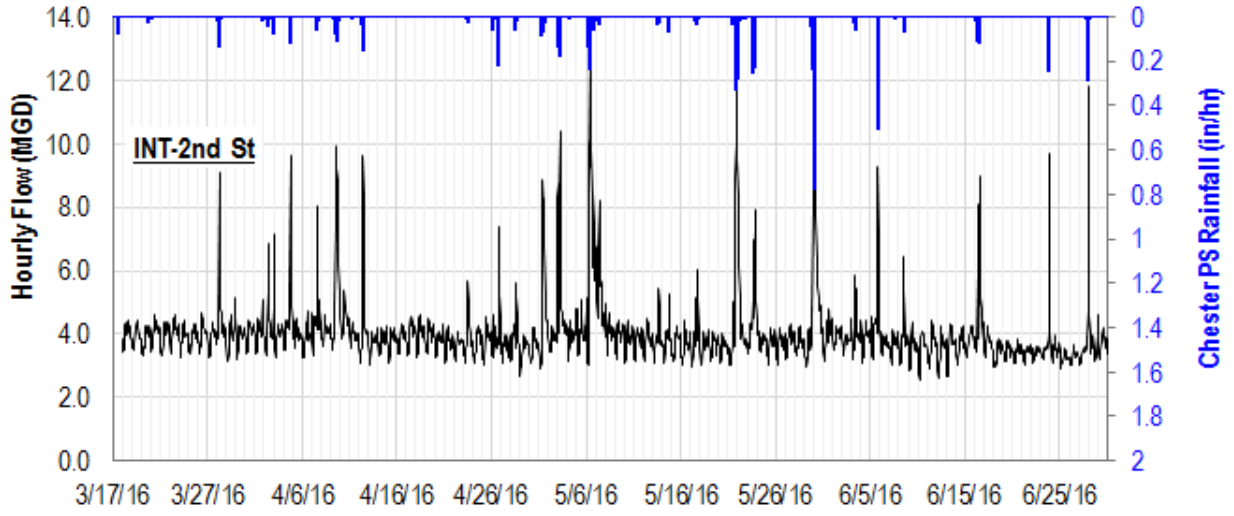


Figure 38: Flow Monitoring Data, INT-2nd St.

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

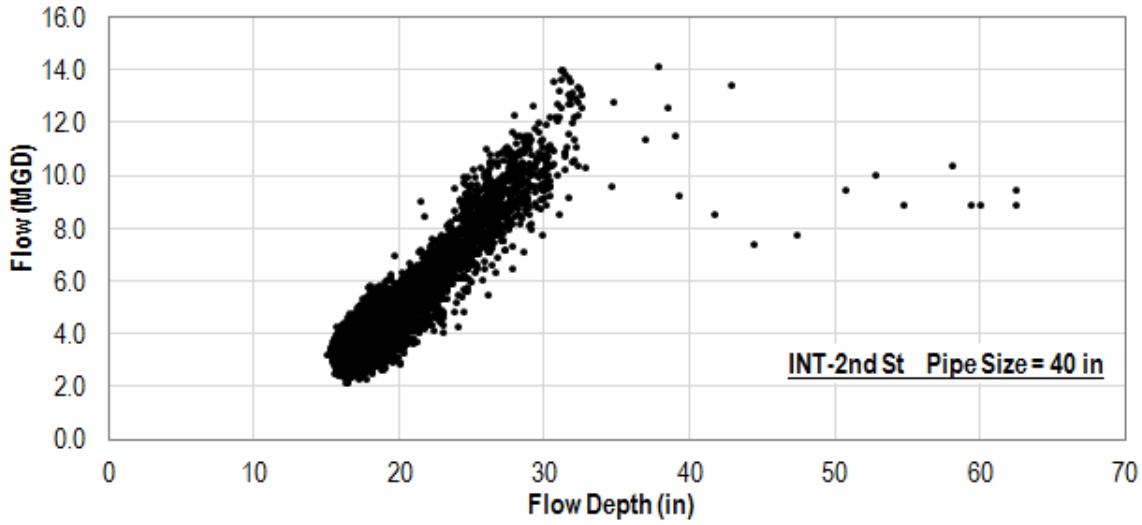


Figure 39: Flow Monitoring Data, INT-DRI

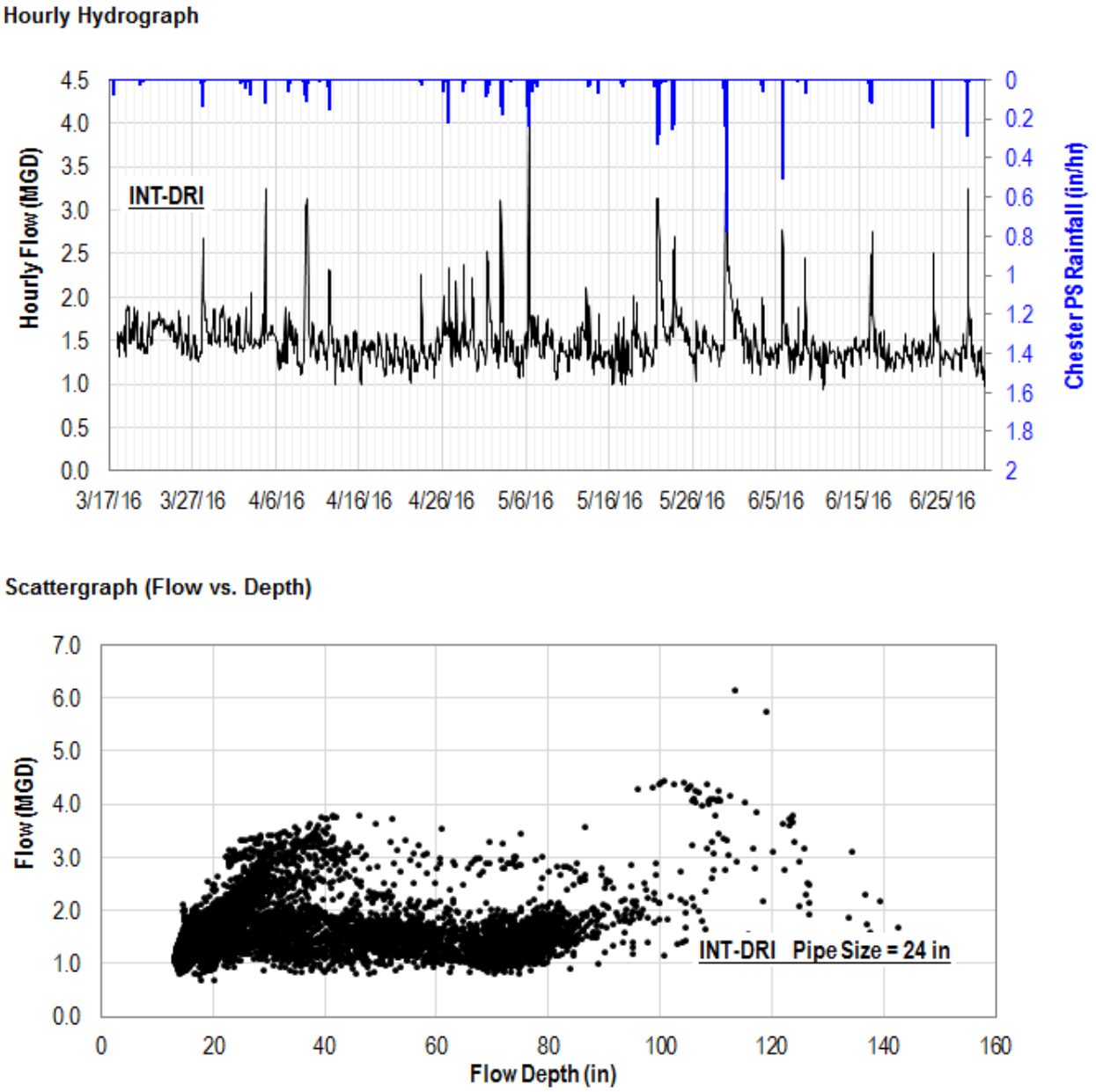


Figure 40: Flow Monitoring Data, INT-Ridley 2

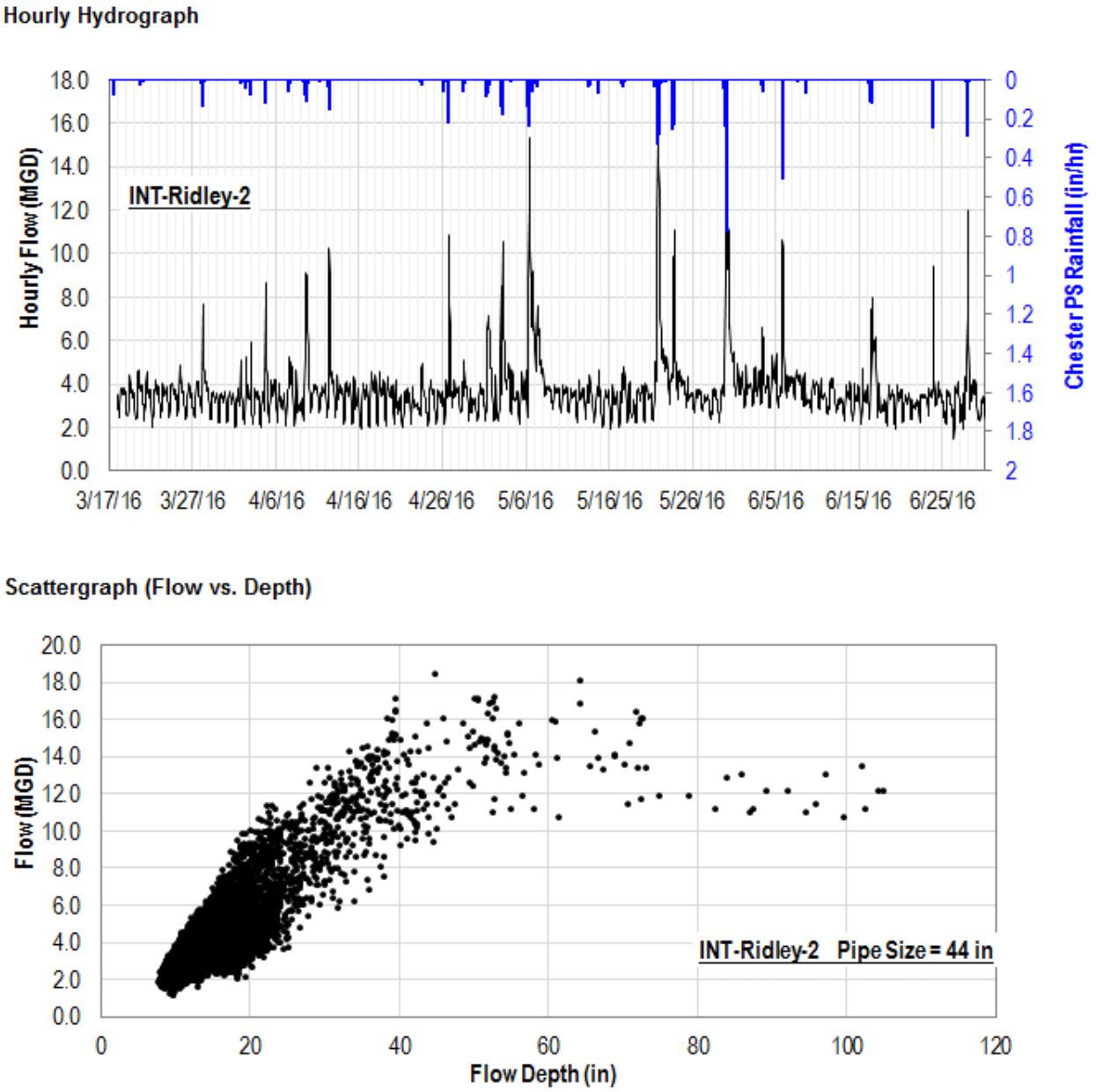


Figure 41: Flow Monitoring Data, INT-Ridley 3

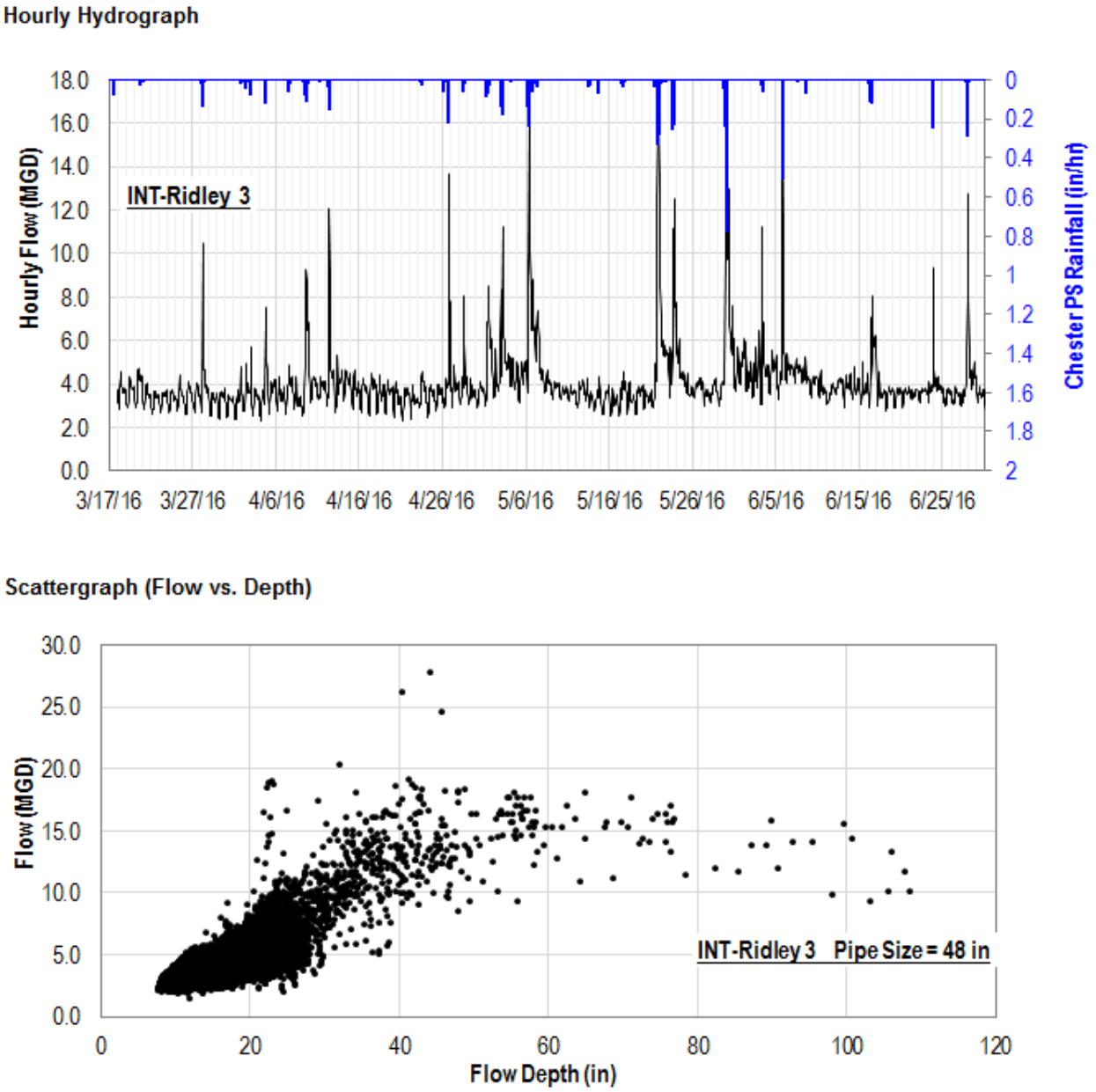


Figure 42: Flow Monitoring Data, INT-WEI

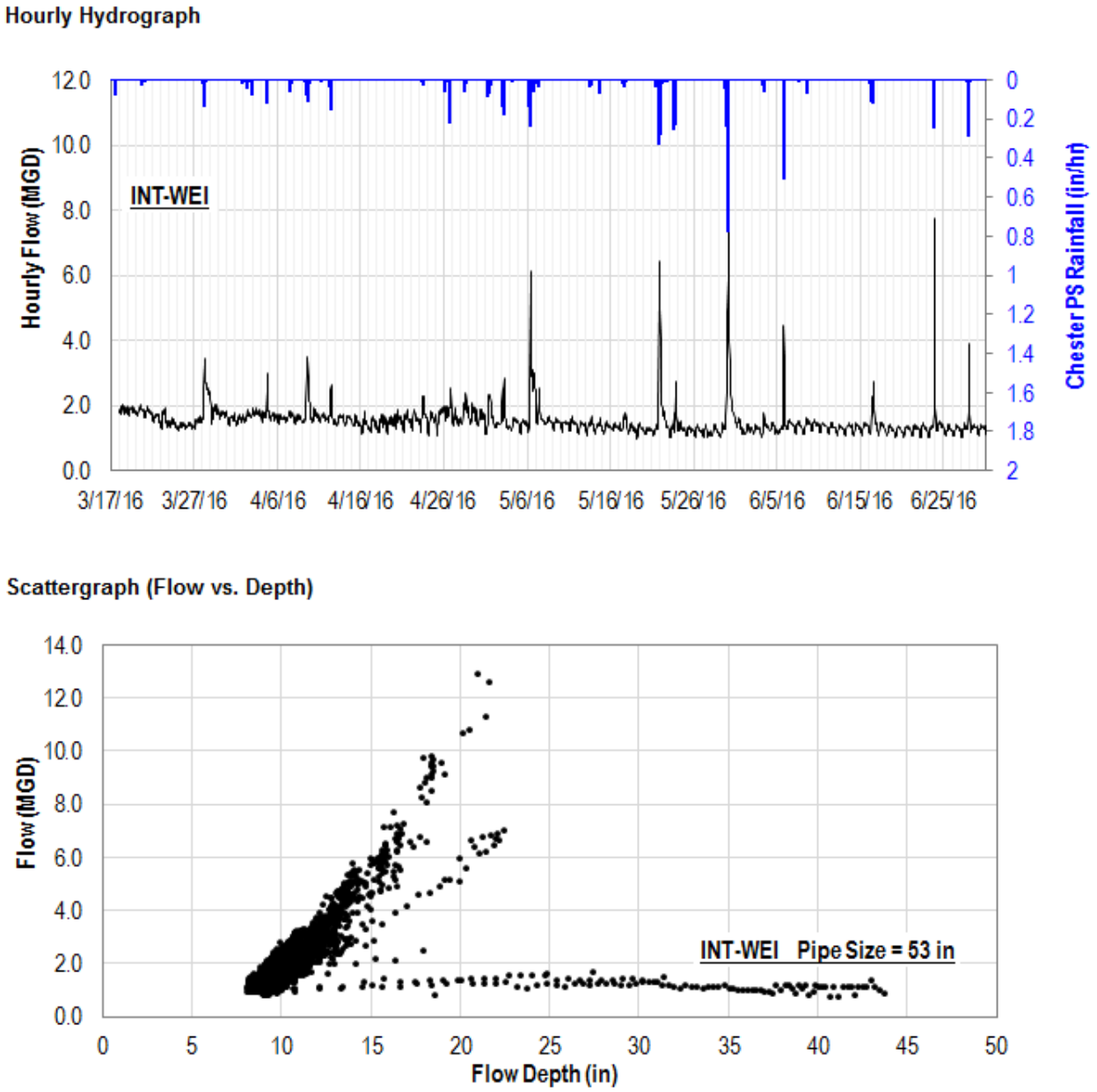


Figure 43: Flow Monitoring Data, 1-Sep

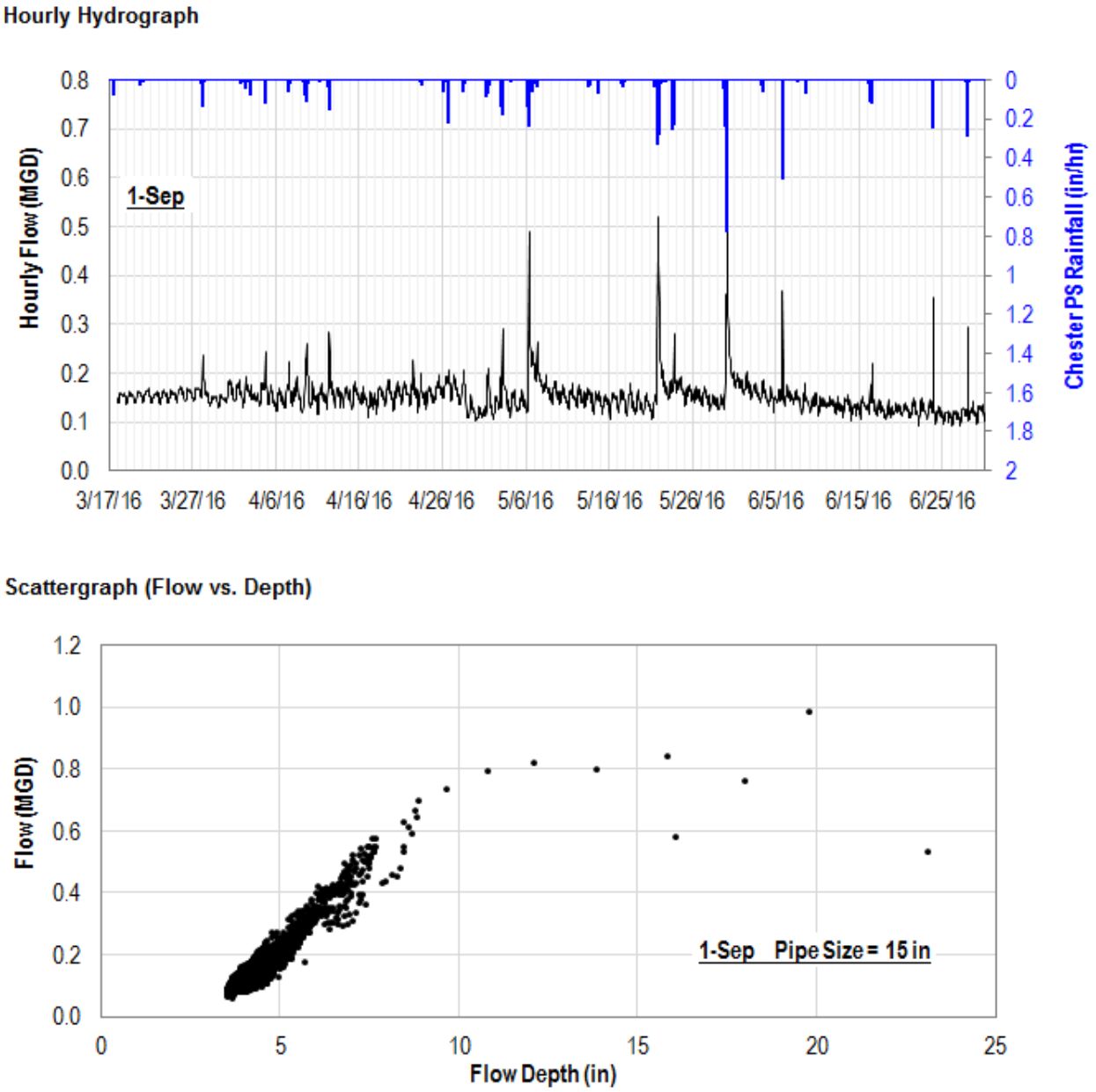
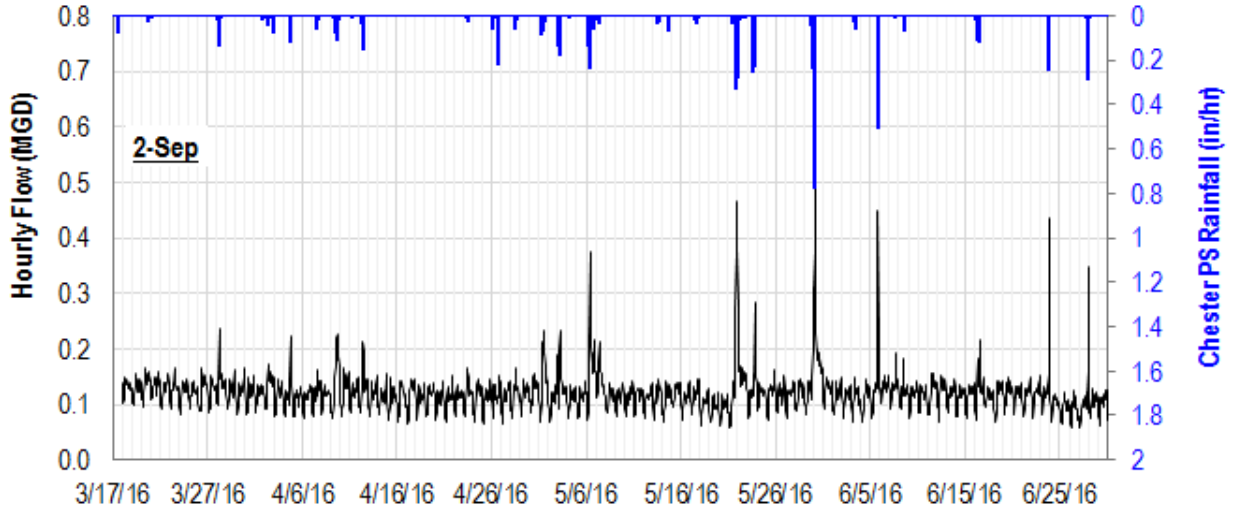


Figure 44: Flow Monitoring Data, 2-Sep

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

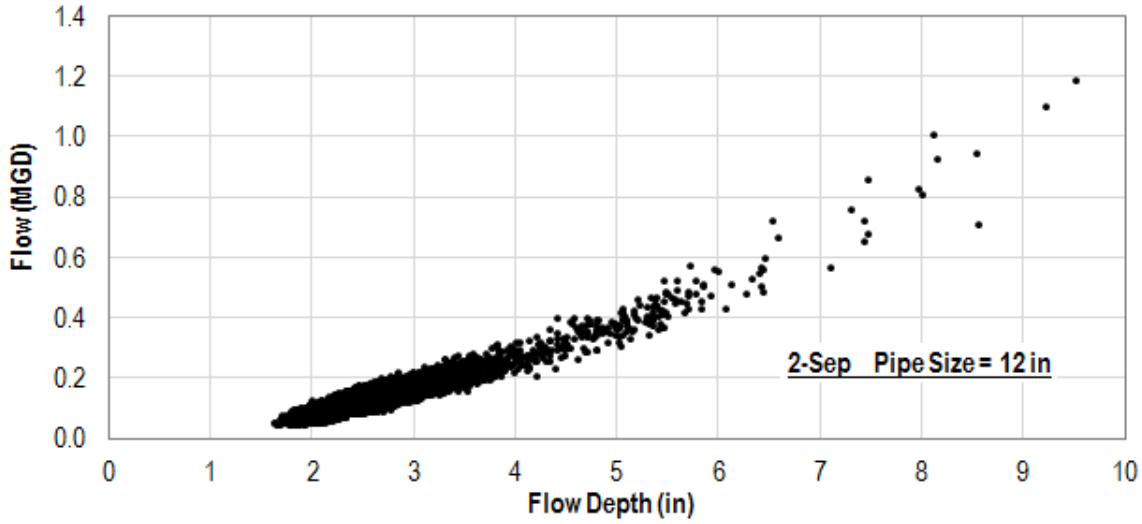
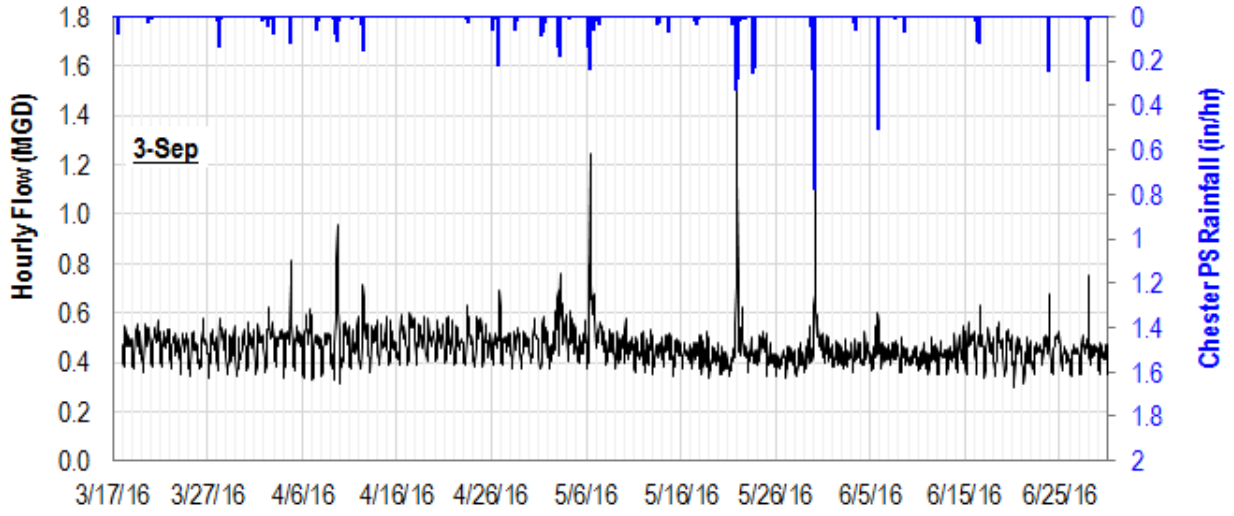


Figure 45: Flow Monitoring Data, 3-Sep

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

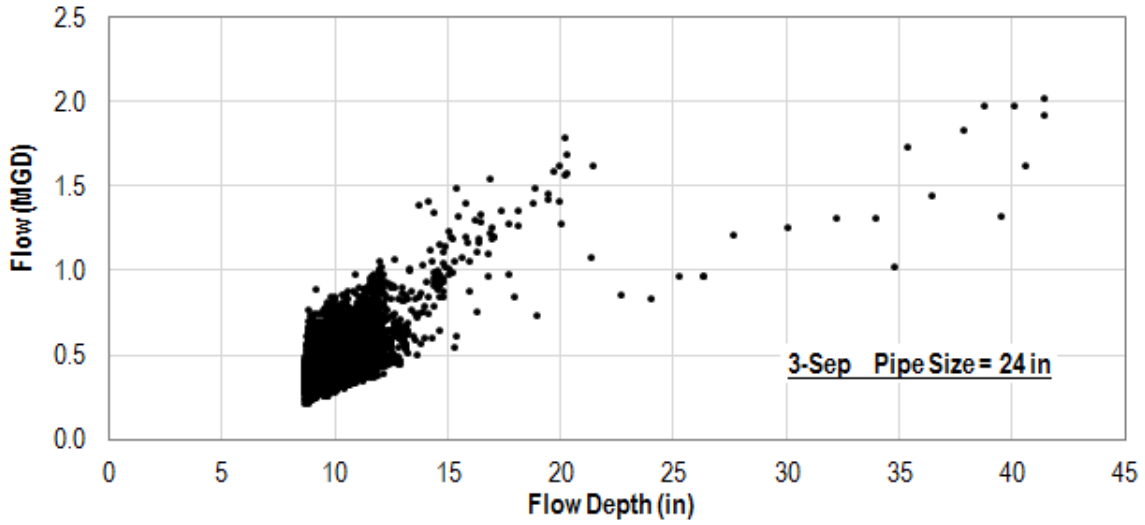


Figure 46: Flow Monitoring Data, Side 1

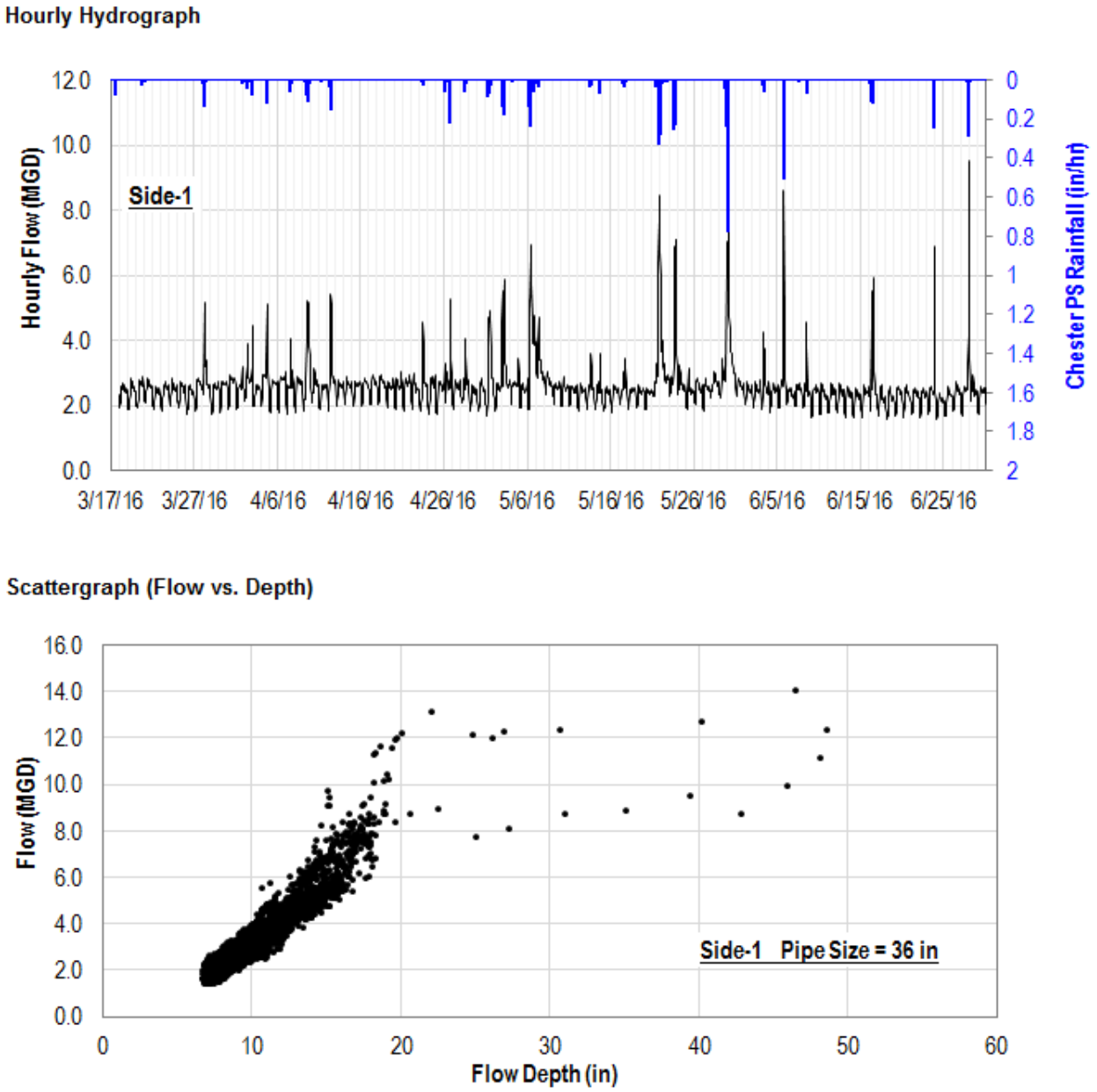
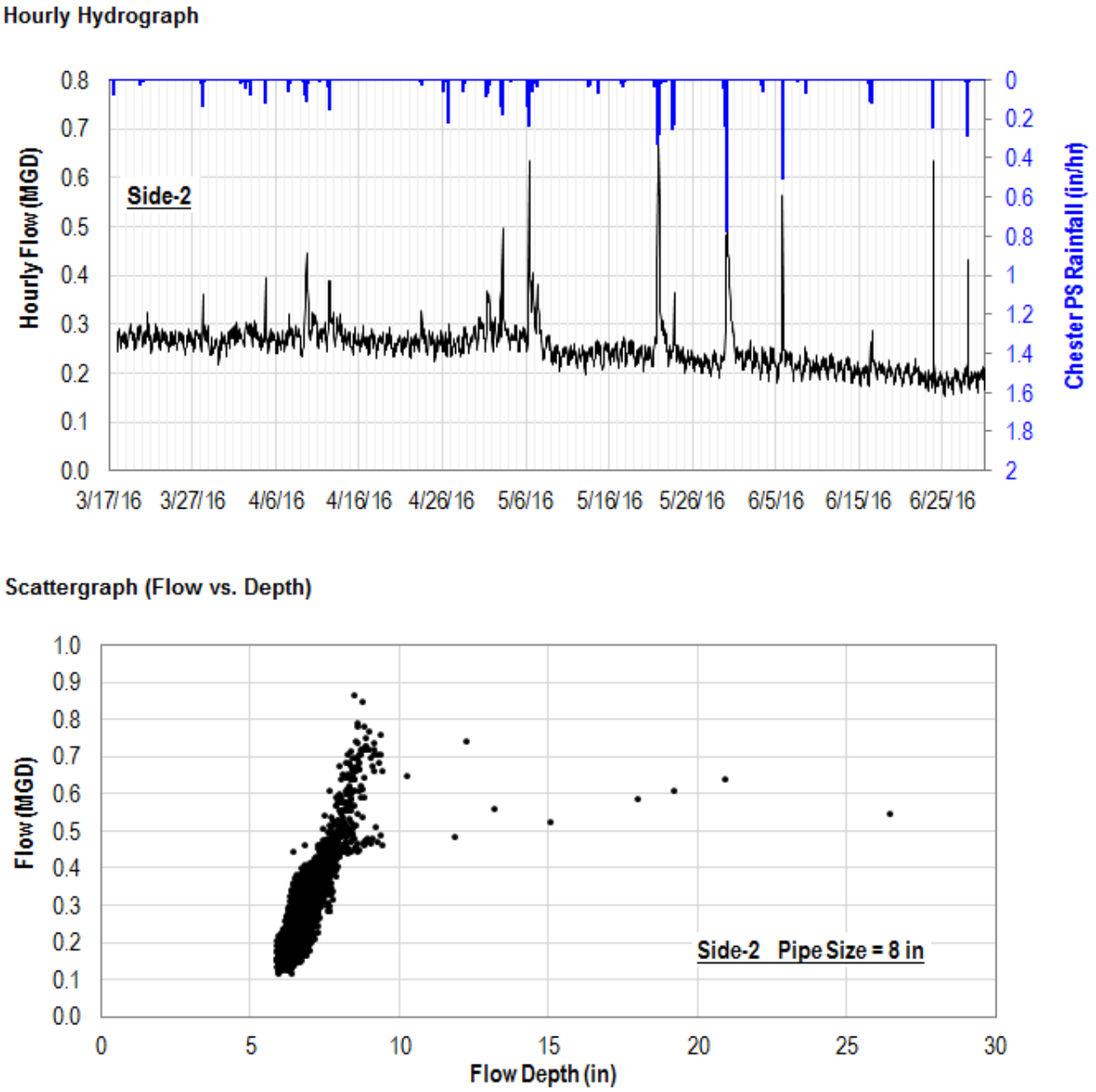


Figure 47: Flow Monitoring Data, Side-2



Greeley and Hansen LLC
1700 Market Street, Suite 2130
Philadelphia, PA 19103
(215) 563-3460
www.greeley-hansen.com

GREELEY AND HANSEN

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

Rainfall and Flow Monitoring Quarterly Report No. 2

(July 1, 2016 to September 30, 2016)

(Final)

October 2016

GREELEY AND HANSEN

REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Rainfall and Flow Monitoring Report No. 2.

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	10/21/16 Date
DELCORA ENGINEERING		
Director of Engineering	Signature	10/26/16 Date
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	Signature	10/21/16 Date

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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 July 1, 2016 to September 30, 2016.

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 26 rainfall events during reporting period. **Table 2** lists rainfall events with total precipitation greater than 0.1 inch.

Figure 1: Rain Gauge Locations

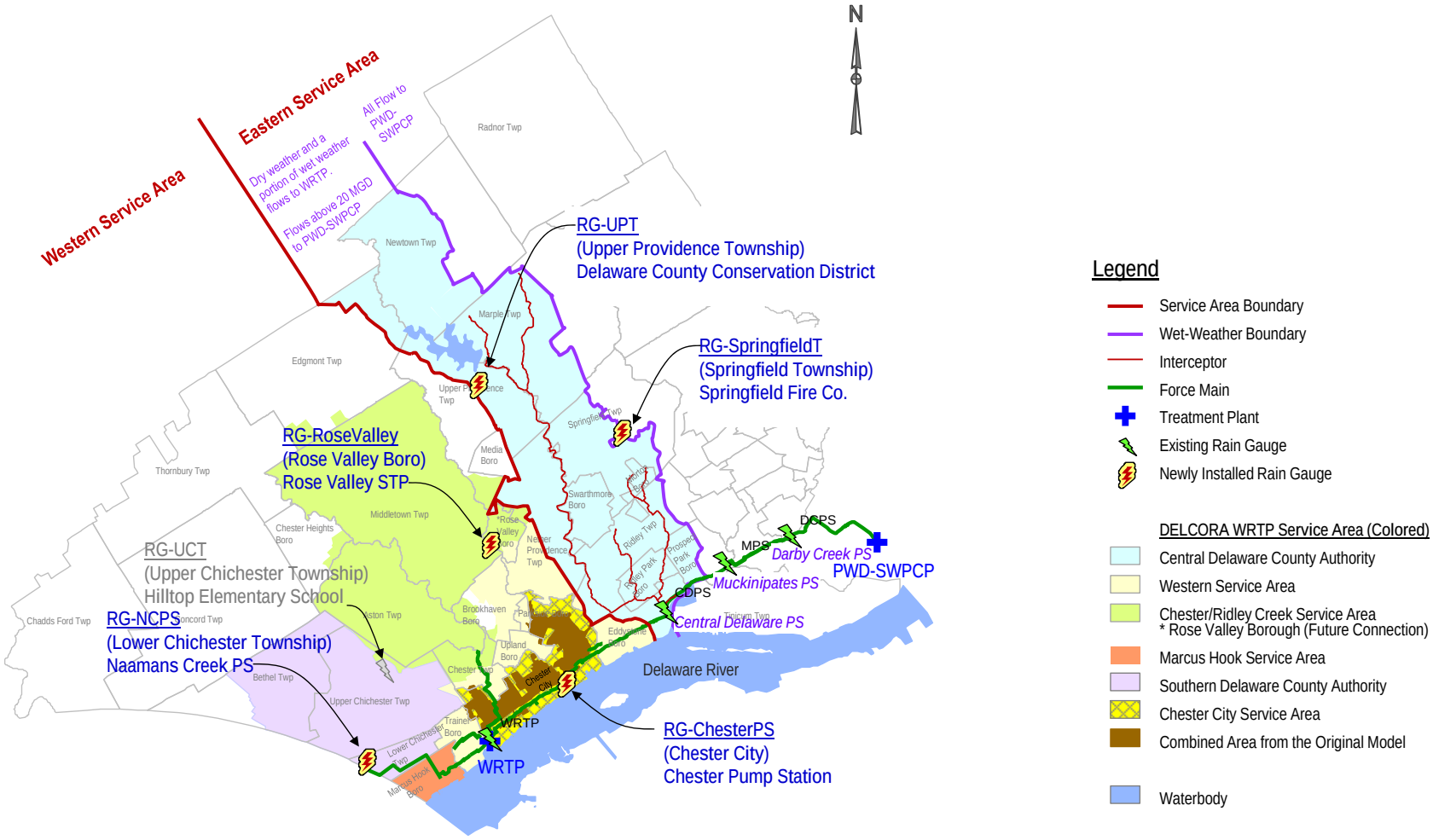


Figure 2 shows rainfall amounts at each rain gauge in each month for July, August and September. It is obvious that rainfall in the area has significant spatial and temporal variance. As an example, during this reporting period, the rain gauge at the Chester Pump Station (Chester PS) recorded a total rainfall of 8.371 inches while the gauge at the Upper Providence Township (UPT) recorded 14.74 inches. **Figure 3** shows the 1-hour rainfall profile for all of the 5 rain gauges.

Table 2: Rainfall Event Summary, 7/1/16 - 9/30/16

	Rain Event Starting Time	Rose Valley	Chester-PS	NCPS	Springfield	UPT
1	7/1/2016 13:40	0.19	0	0	0.12	0.01
2	7/4/2016 14:55	0.44	0.45	0.88	0.46	0.66
3	7/9/2016 16:00	0.25	0.03	0.3	0.1	0.21
4	7/13/2016 9:45	0.35	0.14	0.12	0.66	0.8
5	7/18/2016 15:40	0.21	0.37	0.53	0.19	0.16
6	7/23/2016 16:55	0.23	0.09	0.26	0	0
7	7/25/2016 4:35	1.46	1.05	1.71	2.18	2.97
8	7/28/2016 14:25	0.42	1.26	1.63	0.35	0.55
9	7/30/2016 16:45	0.35	0.27	0.48	0.3	1.1
10	8/11/2016 8:30	0.09	0.04	0	0.31	0.02
11	8/17/2016 0:55	0.23	0.17	0.09	0.25	0.07
12	8/17/2016 22:40	0.31	0.3	0.43	0.22	0.29
13	8/18/2016 22:25	0.29	0.21	0.18	0.13	0.19
14	8/21/2016 14:05	0.45	0.36	0.41	0.57	1.17
15	8/31/2016 19:50	0.27	0.18	0.27	0.26	0.21
16	9/19/2016 6:15	1.69	0.96	1.65	1.33	2.63
17	9/27/2016 3:40	0.13	0.13	0.15	0.12	0.12
18	9/28/2016 11:55	2.55	2.36	3.65	2.09	3.58
	Subtotal (7/1/16-9/30/16)	**9.91**	**8.37**	**12.74**	**9.64**	**14.74**

Figure 2: Rainfall Event Summary, 7/1/16 - 9/30/16

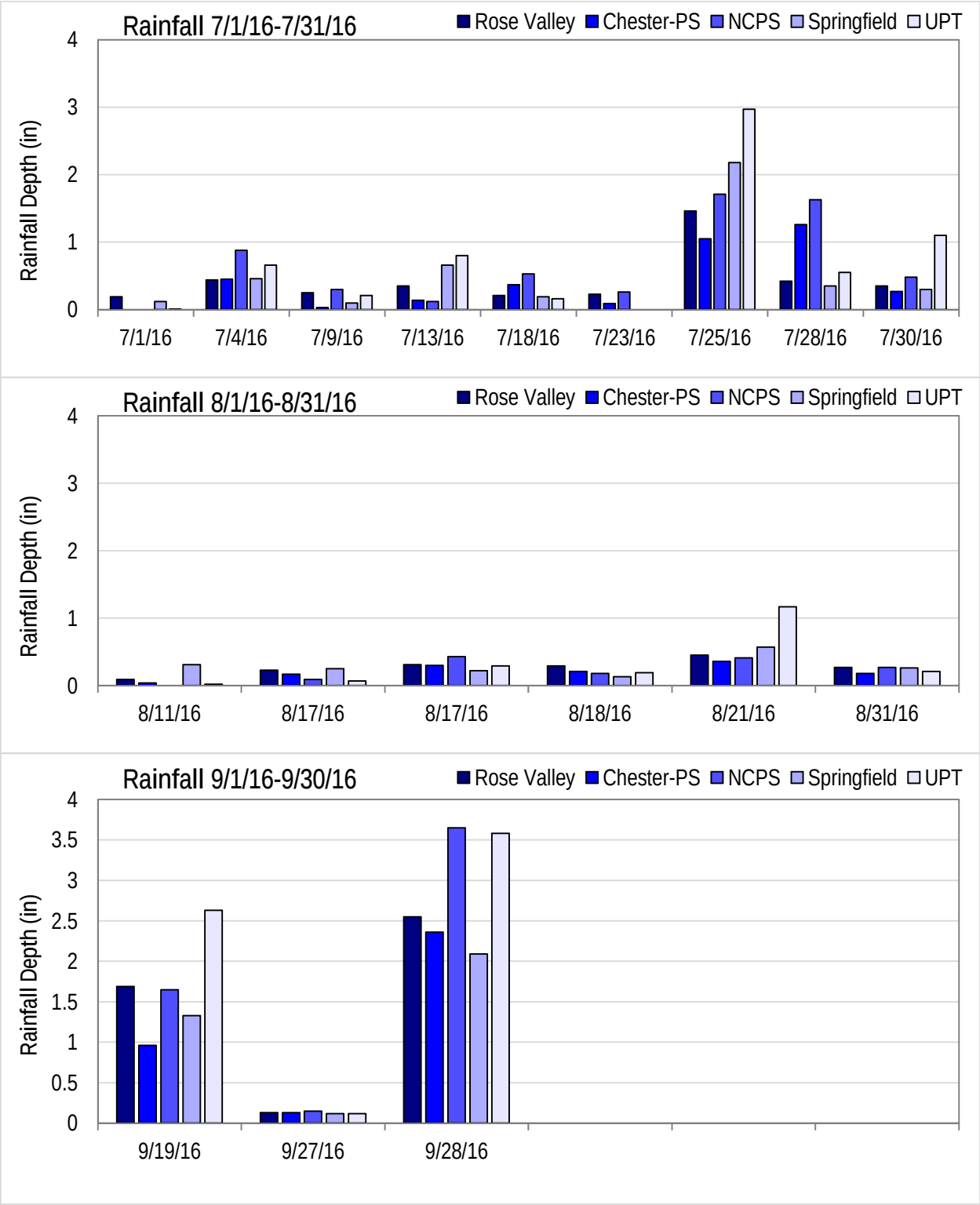
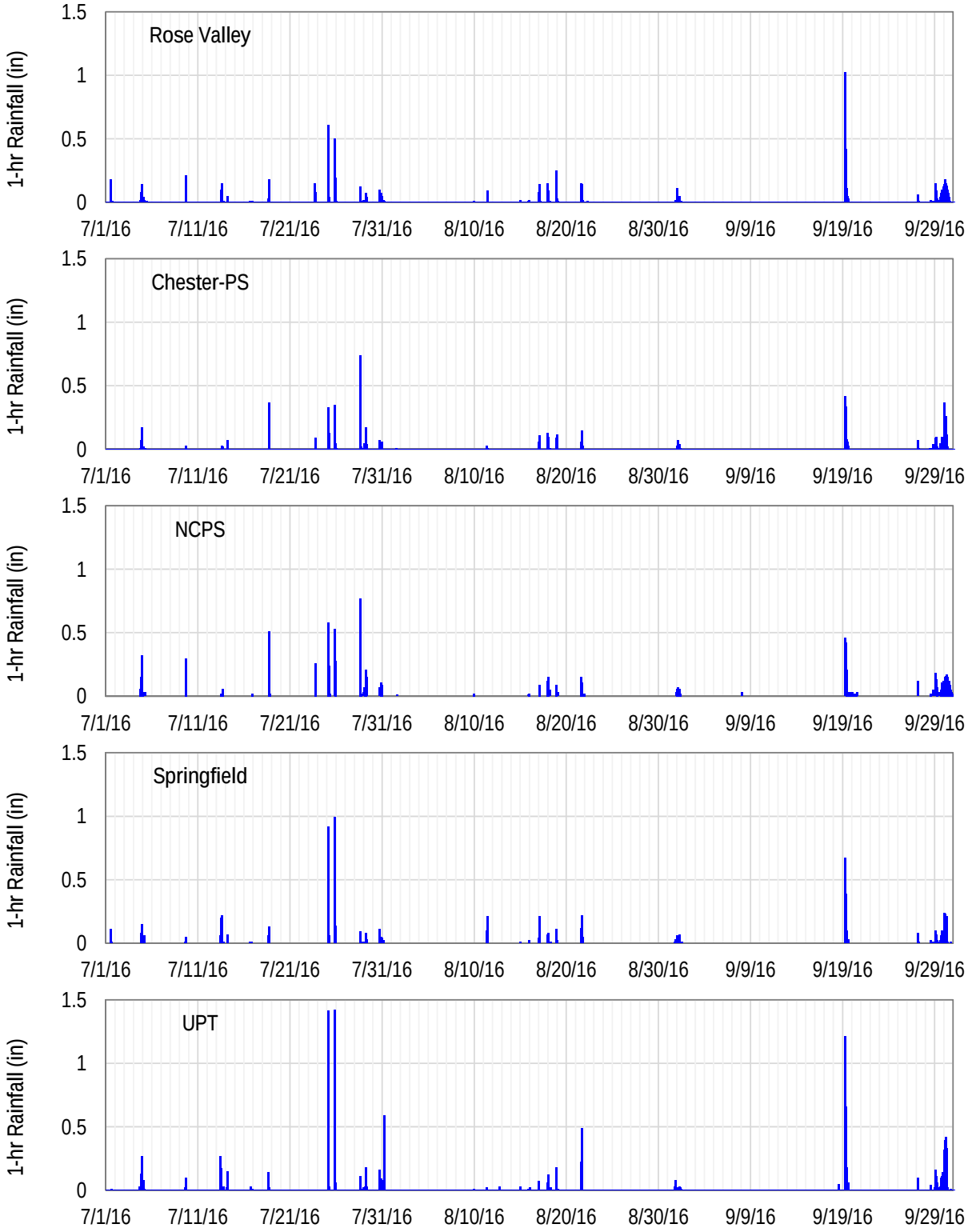


Figure 3: Hourly Rainfall Profile



2.3.1 Rainfall Return Frequency

Rainfall return frequency was analyzed for rain gauges RG_NCPS and RG_UPT because they recorded 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. Three storms were recorded with total precipitation volumes greater than 1 inch. The 9/28/16 storm has a return frequency of 2-year, and the other two events (7/28/16 and 9/19/16) are less than 1-year events.

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

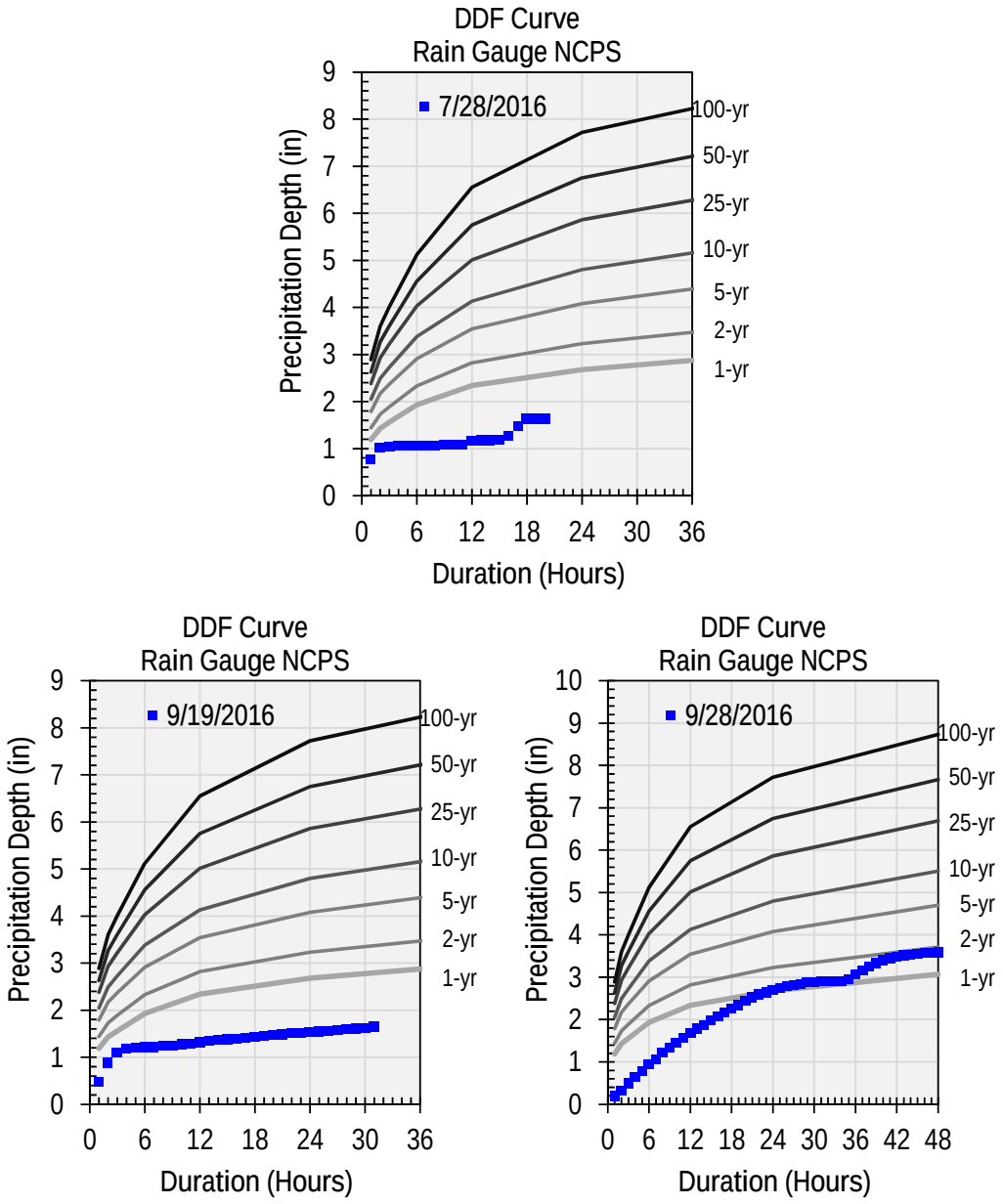


Figure 5 shows Duration-Depth-Frequency (DDF) plot for RG_UPT. Six storms were recorded with a total precipitation volume greater than 1 inch. Both short storms in 7/25/16 storm have return frequencies close to 2-year, the other storm in 9/19/2016 is a 5-year storm, the storm in 9/28/2016 is a 2-year storm, and the other two events (7/30/16 and 8/21/16) are less than 1-year events.

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

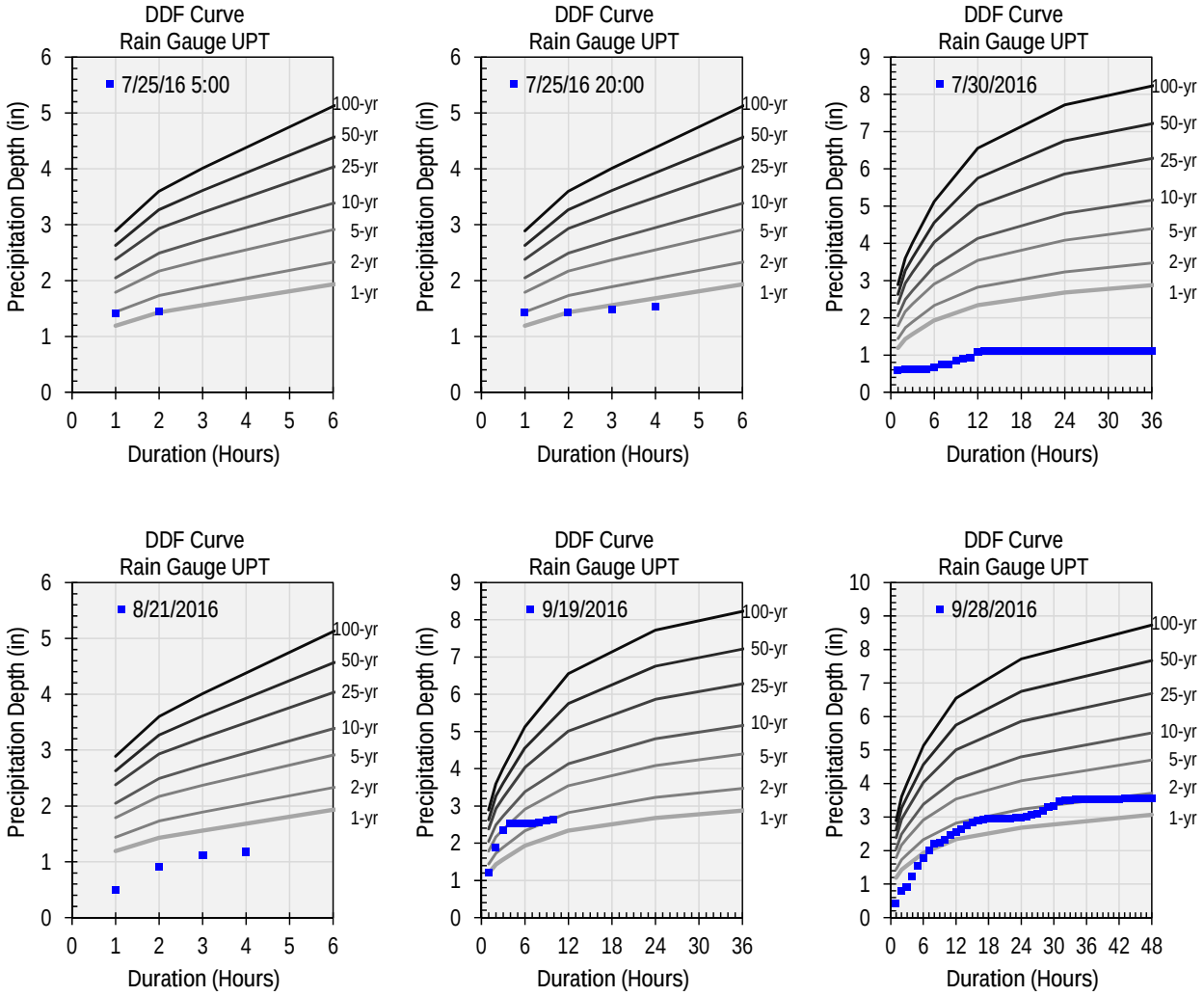
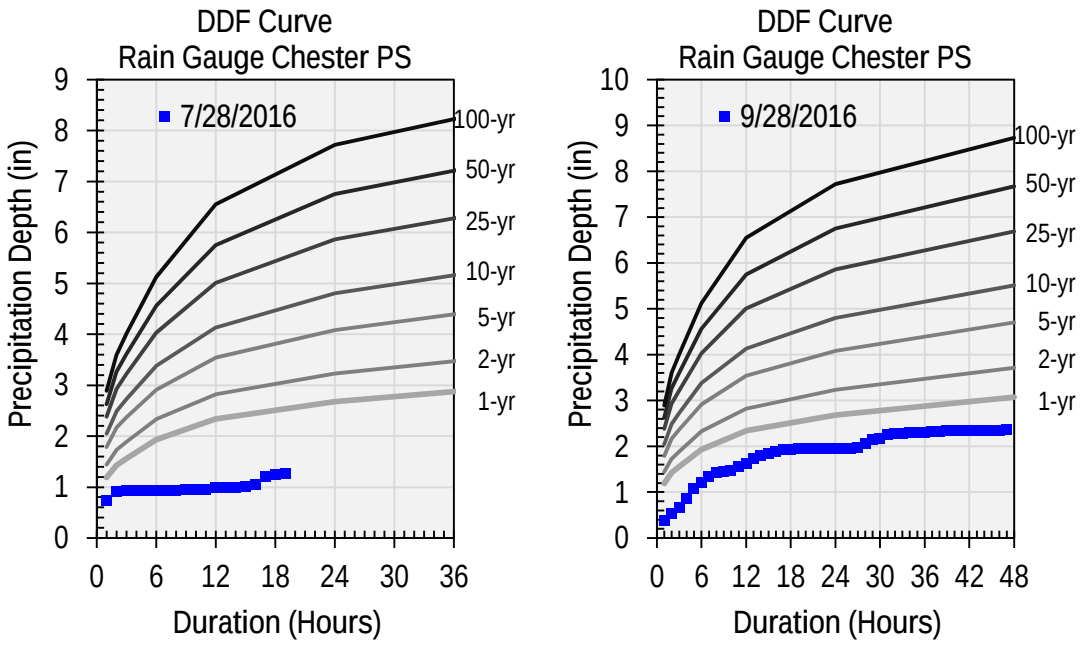


Figure 6 shows Duration-Depth-Frequency (DDF) plot for RG_ChesterPS. Two storms were recorded with a total precipitation volume greater than 1 inch. Both of them (7/28/16 and 9/28/16) are less than 1-year events.

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



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 7**. **Figure 8** 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 9**.

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 7: Existing and Newly Installed Flow Meter Locations

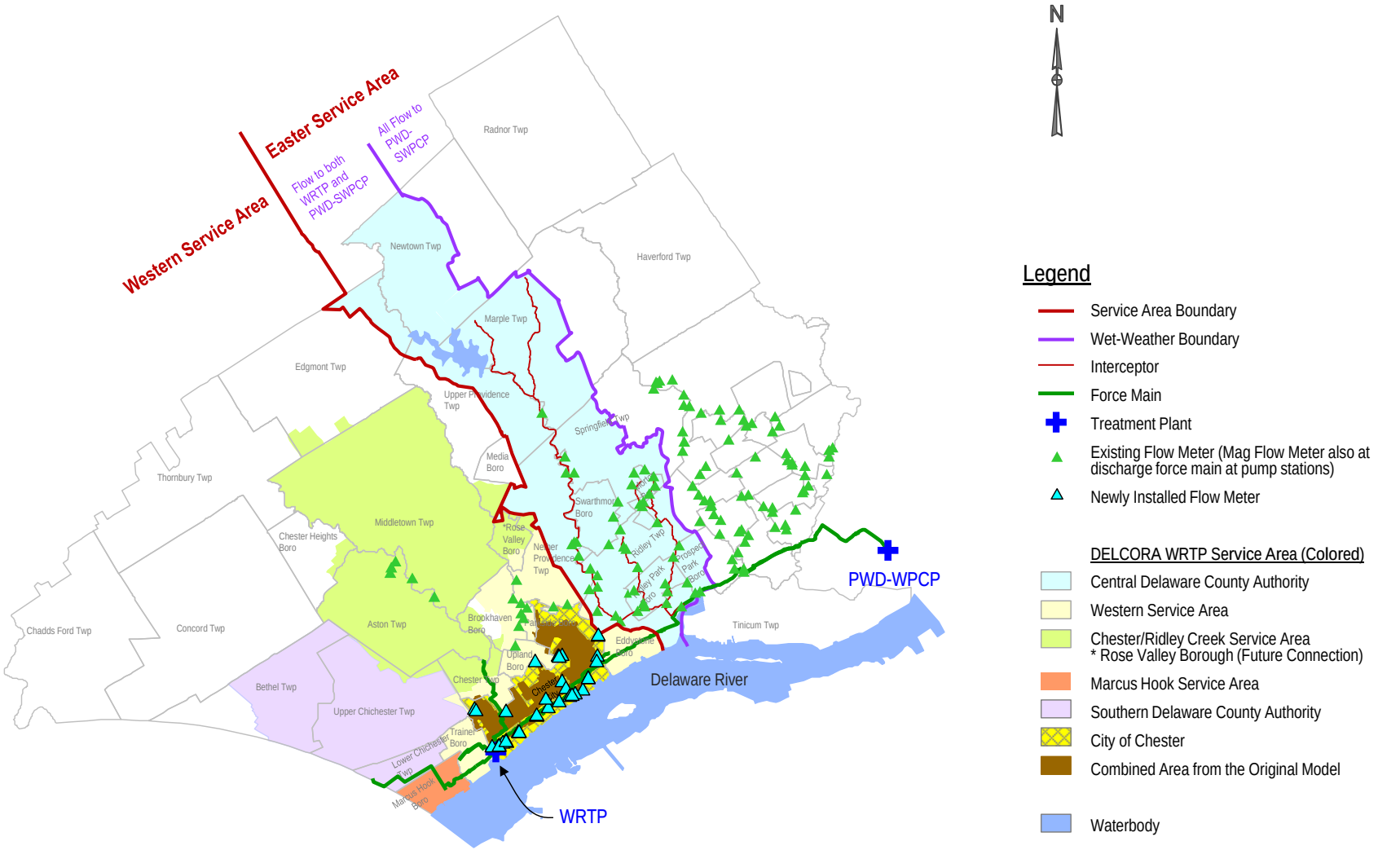


Figure 8: Newly Installed Flow Meter Locations

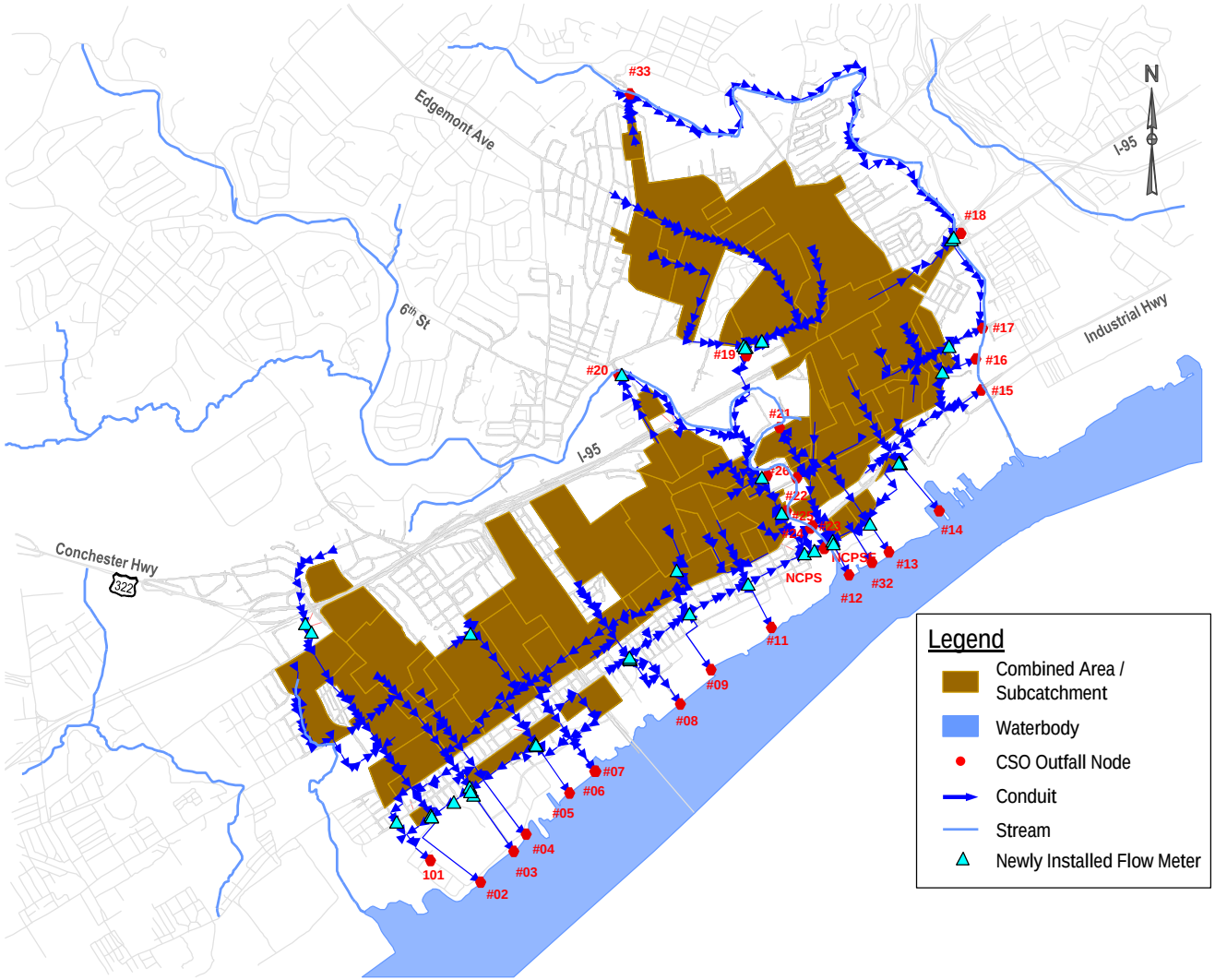
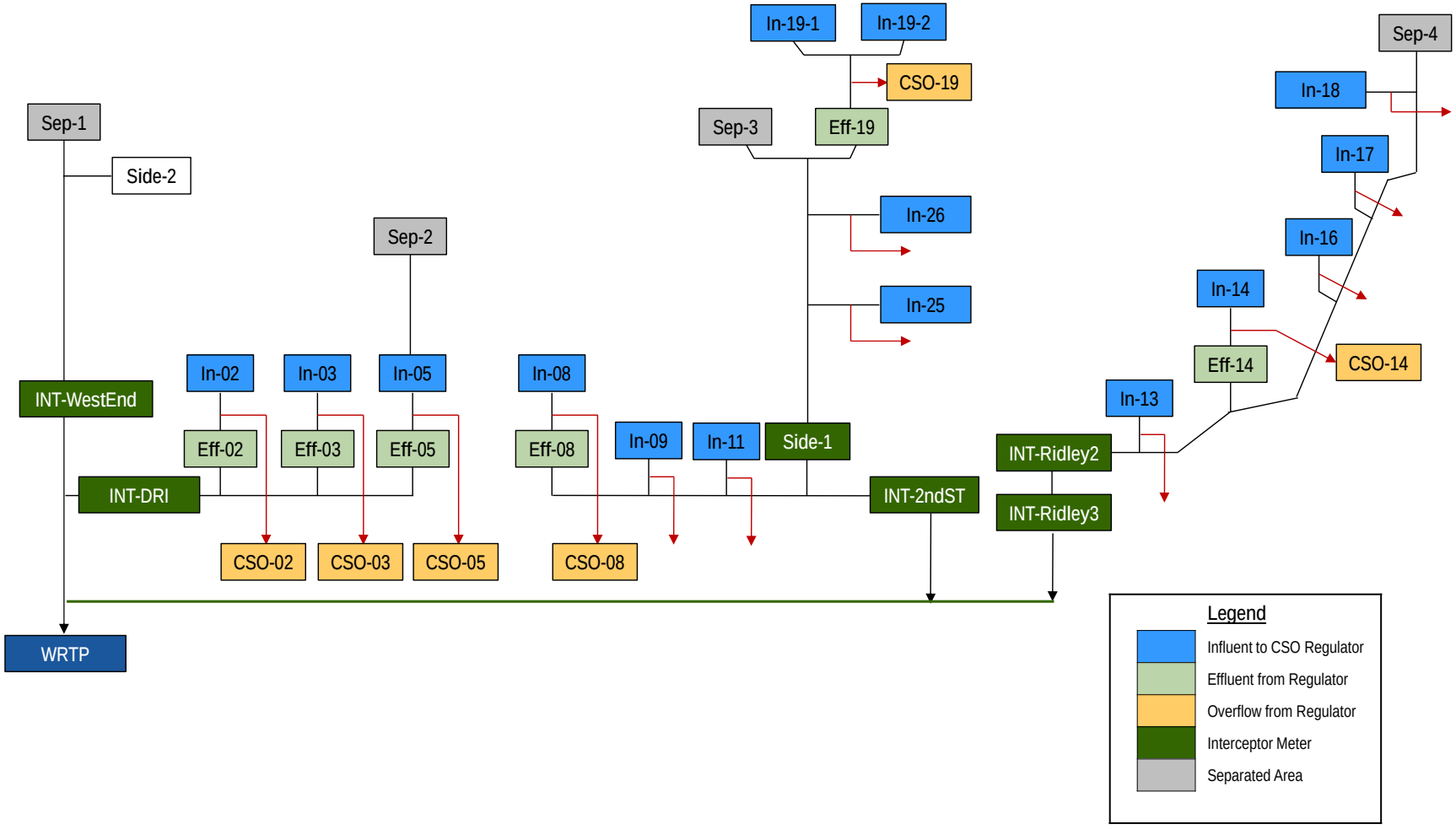


Figure 9: Flow Monitoring Schematic



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 10**. 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 11** 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 9 to 85 and average at 39. The hourly peaking factor for the interceptor is between 2.8 and 8.5 with an average of 4.6. The hourly peaking factor is between 2.9 and 5.5 for the separated area, with an average of 4.1.

A detailed hydrograph and scattergraph for each flow monitoring site is shown in **Figure 12** to **Figure 50**, 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) 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	6.25	0.29	21.7	Free flow most of the time
Eff-02	1.19	0.26	4.5	Surcharged under common conditions
CSO-02	5.01	0.04		Free flow most of the time
In-03	9.46	0.28	33.6	Free flow most of the time
Eff-03	1.52	0.24	6.2	Surcharged under large storms
CSO-03	8.85	0.03		Free flow most of the time
In-05	22.65	0.86	26.4	Backwater observed
Eff-05	2.30	0.75	3.1	Severely surcharged under common conditions
CSO-05	18.83	0.10		Free flow most of the time, backwater observed
In-08	21.99	0.80	27.5	Free flow most of the time
Eff-08	5.21	0.69	7.5	Free flow most of the time, backwater during large storms
CSO-08	22.36	0.11		Free flow most of the time
In-09	7.09	0.13	53.8	Free flow most of the time
In-10	4.55	0.18	25.6	Free flow most of the time
In-11	9.04	0.22	41.2	Free flow most of the time, backwater during large storms
In-13	28.52	0.34	82.8	Free flow most of the time, backwater during large storms
In-14	14.44	0.43	34.0	Backwater observed
Eff-14	4.22	0.38	11.0	Free flow mostly, backwater and surcharge during large storms
CSO-14	11.33	0.03		Free flow most of the time
In-16	12.95	0.33	38.7	Free flow most of the time, backwater during large storms
In-17	6.90	0.17	41.2	Backwater observed
In-18	10.05	0.16	61.7	Free flow most of the time
In-19-1	6.24	0.69	9.1	Free flow most of the time
In-19-2	11.62	0.57	20.2	Free flow most of the time
Eff-19	4.02	1.27	3.2	Free flow most of the time
CSO-19	10.72	0.07		Free flow most of the time
In-25	12.55	0.15	84.7	Free flow mostly, backwater observed
In-26	5.80	0.36	16.1	Free flow mostly
INT-2nd St	18.15	3.59	5.1	Free flow mostly, backwater during large storms
INT-DRI	4.08	1.46	2.8	Severe surcharge observed
INT-Ridley 2	14.26	3.11	4.6	Free flow mostly, backwater observed
INT-Ridley 3	13.94	3.35	4.2	Free flow mostly, backwater observed
INT-WEI	11.34	1.34	8.5	Free flow mostly, backwater observed
Sep-1	0.65	0.12	5.5	Free flow mostly
Sep-2	0.54	0.11	4.8	Free flow mostly
Sep-3	1.26	0.43	2.9	Free flow mostly
Sep-4	4.29	1.35	3.2	Free flow mostly
Side-1	8.44	2.35	3.6	Free flow mostly
Side-2	0.68	0.21	3.2	Free flow mostly

Figure 10: Dry Weather Flow Balance Schematic

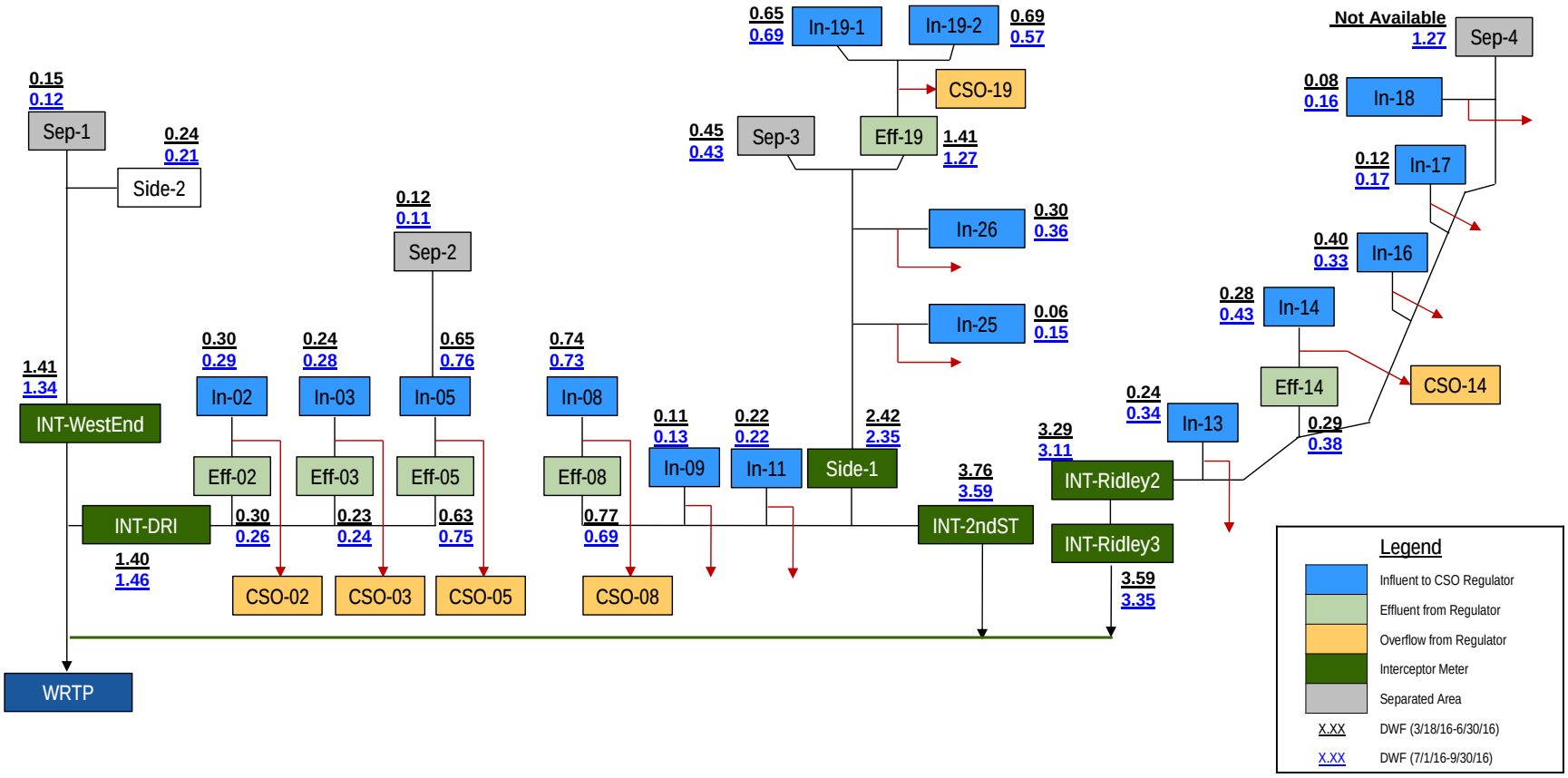


Figure 11: Flow Hydrograph In-08 and Eff-08

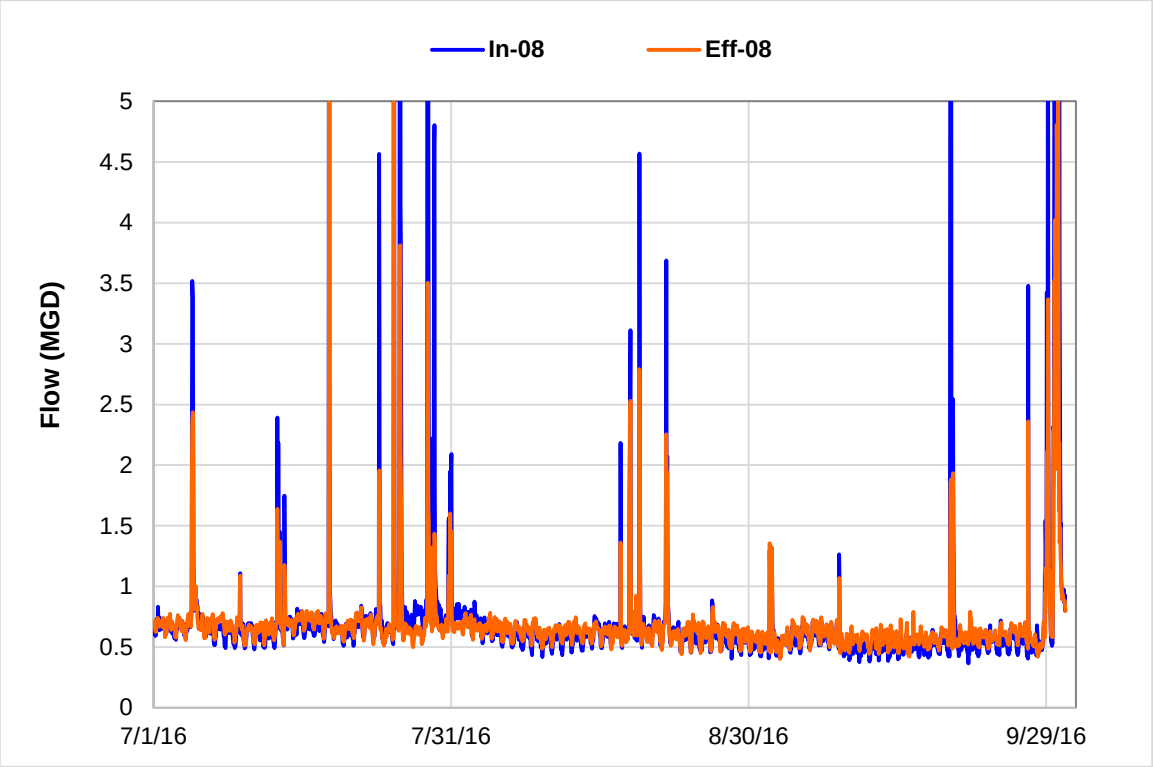
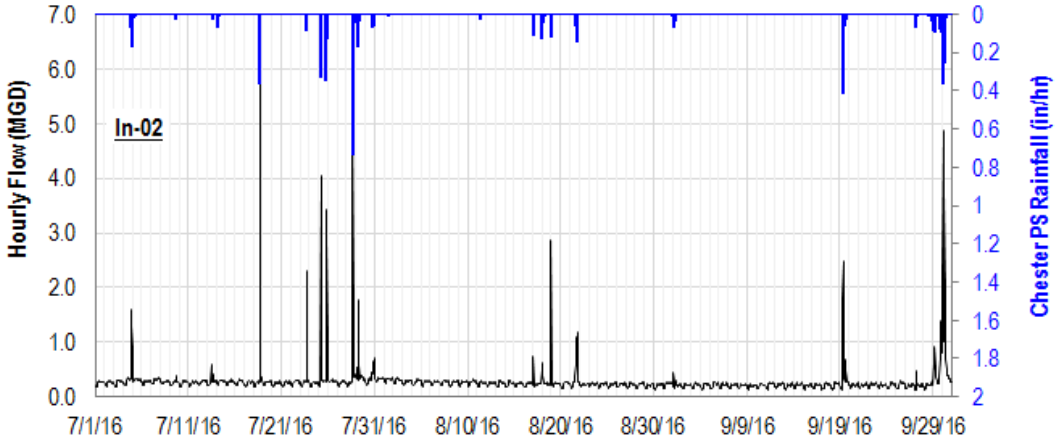
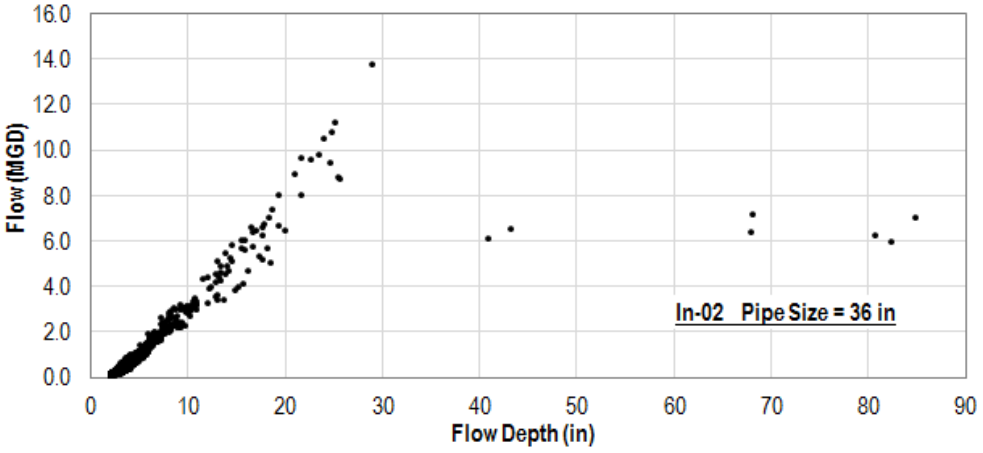


Figure 12: Flow Monitoring Data, In-02

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#02 Influent , Effluent and Overflow

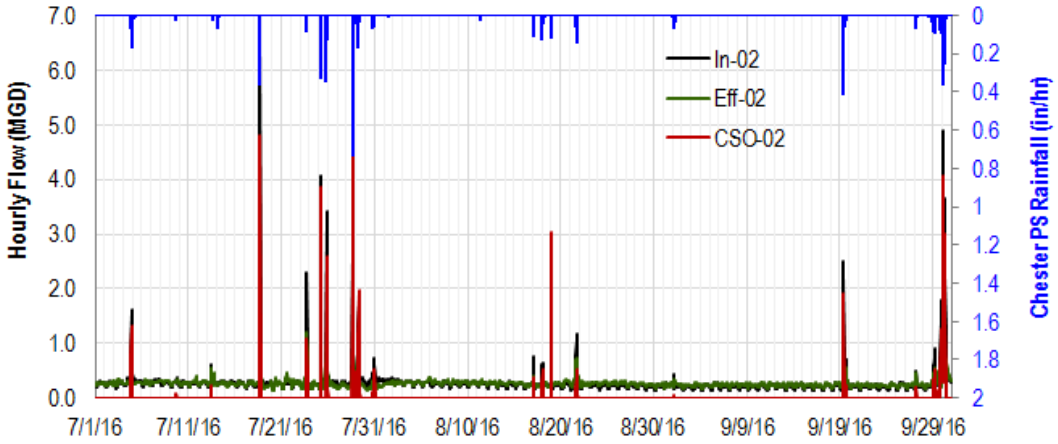


Figure 13: Flow Monitoring Data, EFF-02

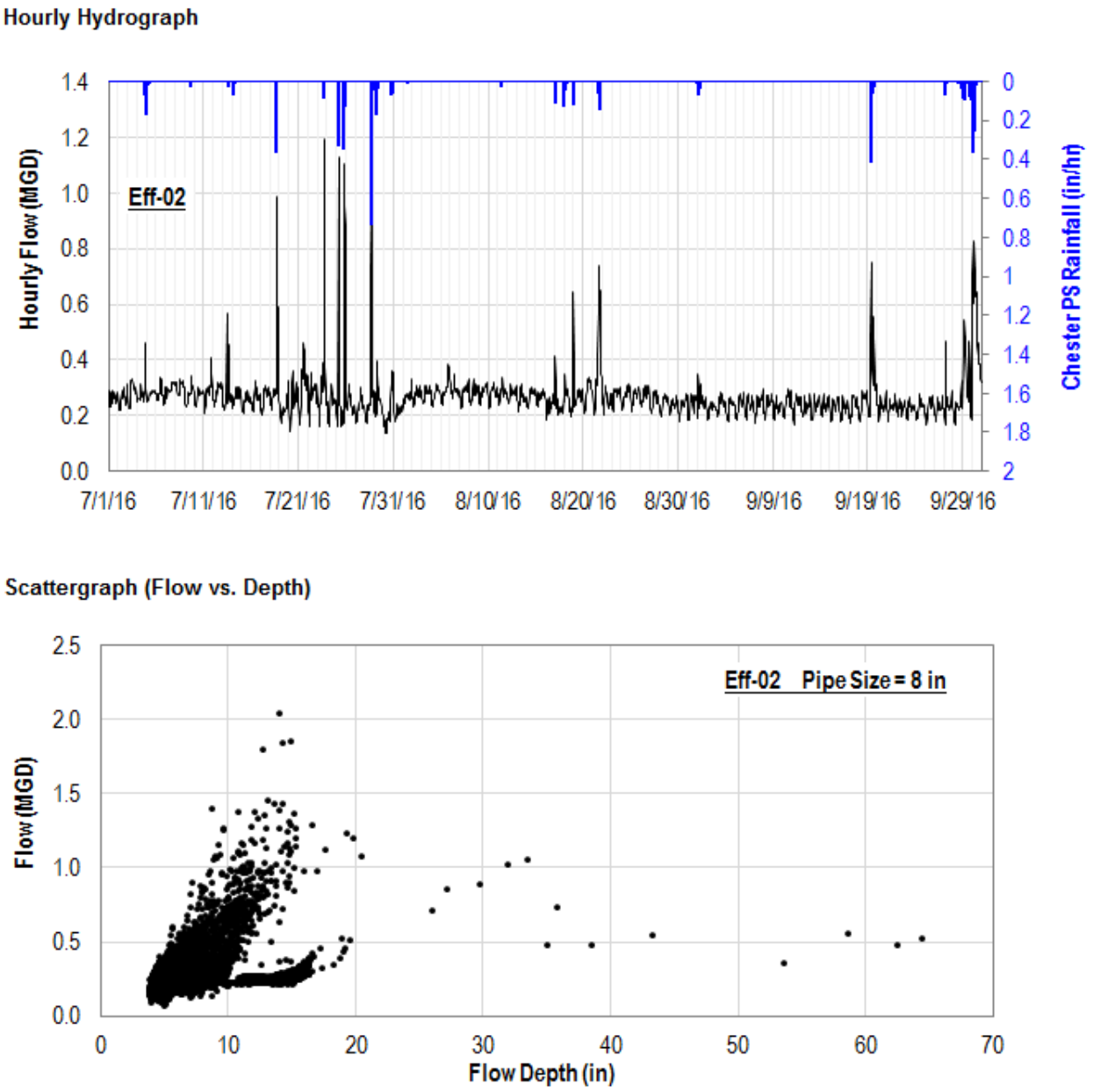


Figure 14: Flow Monitoring Data, CSO-02

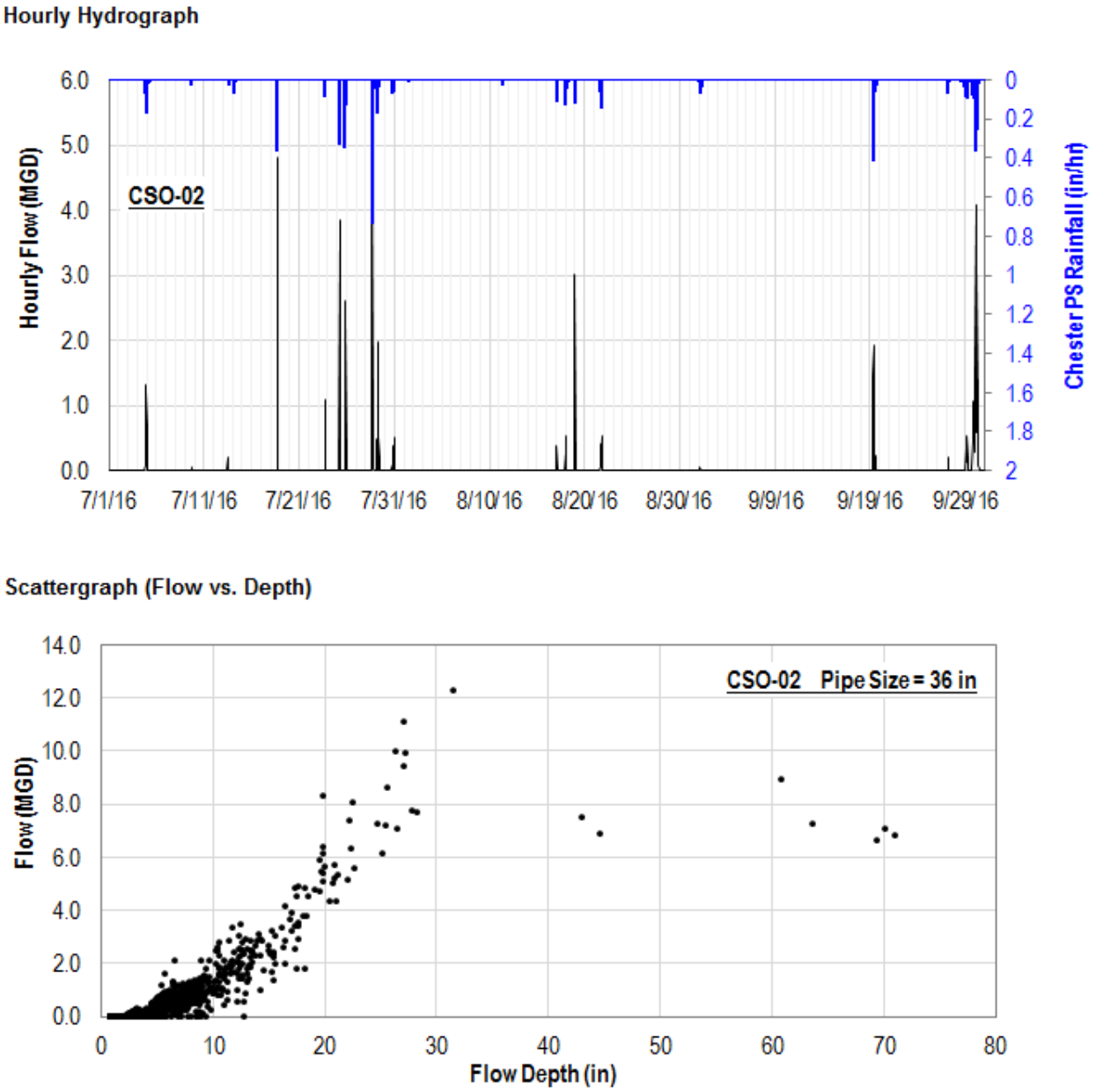
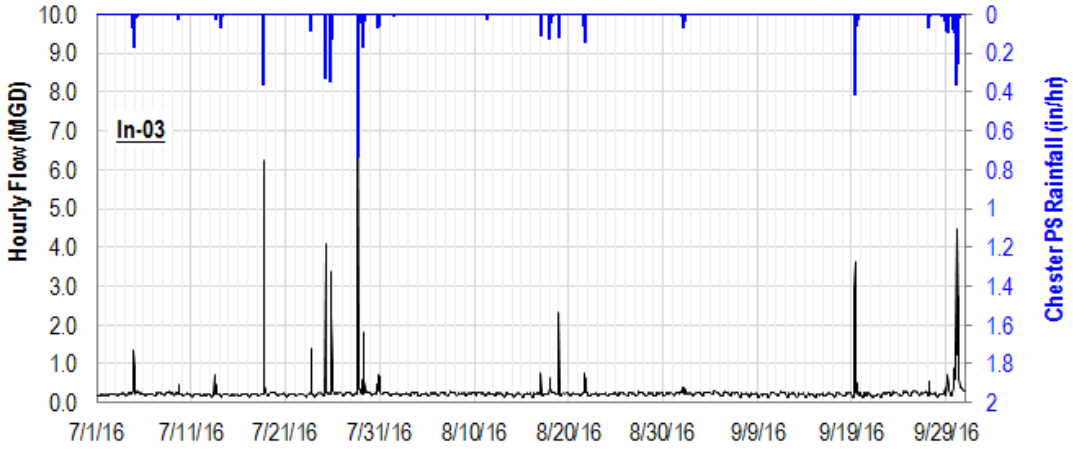
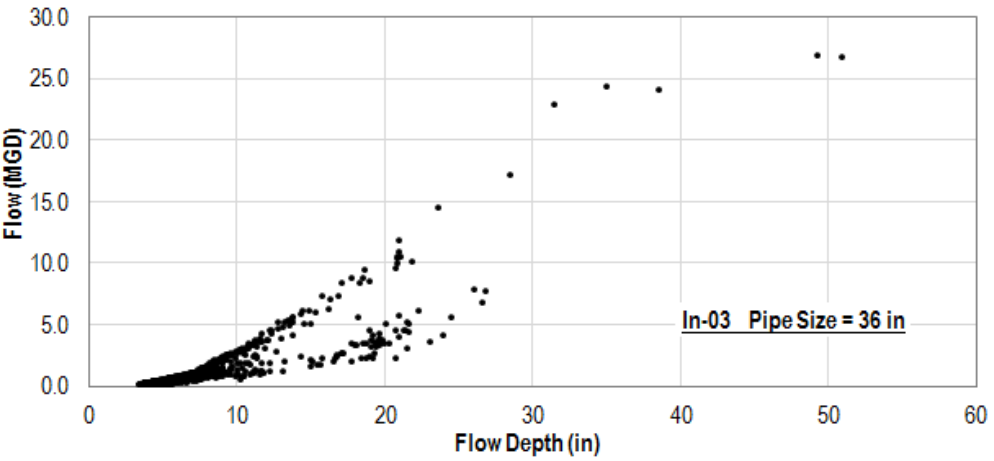


Figure 15: Flow Monitoring Data, IN-03

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#03 Influent , Effluent and Overflow

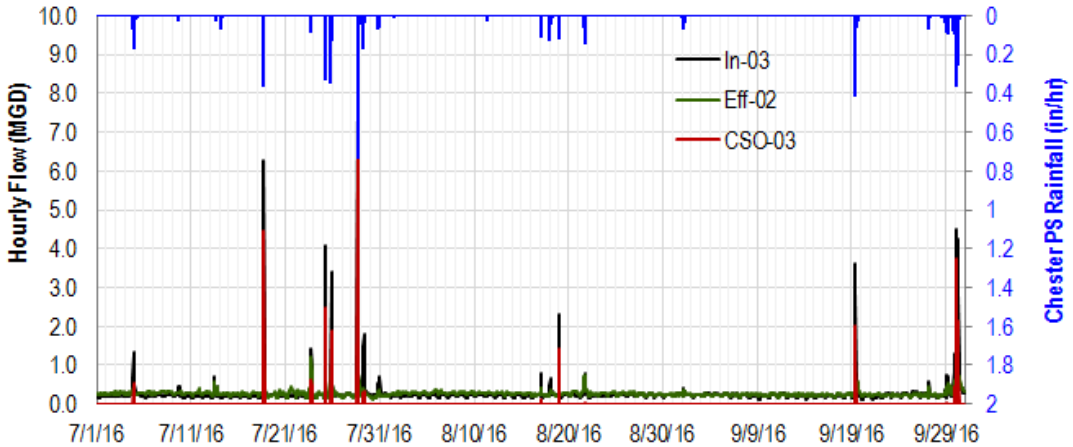
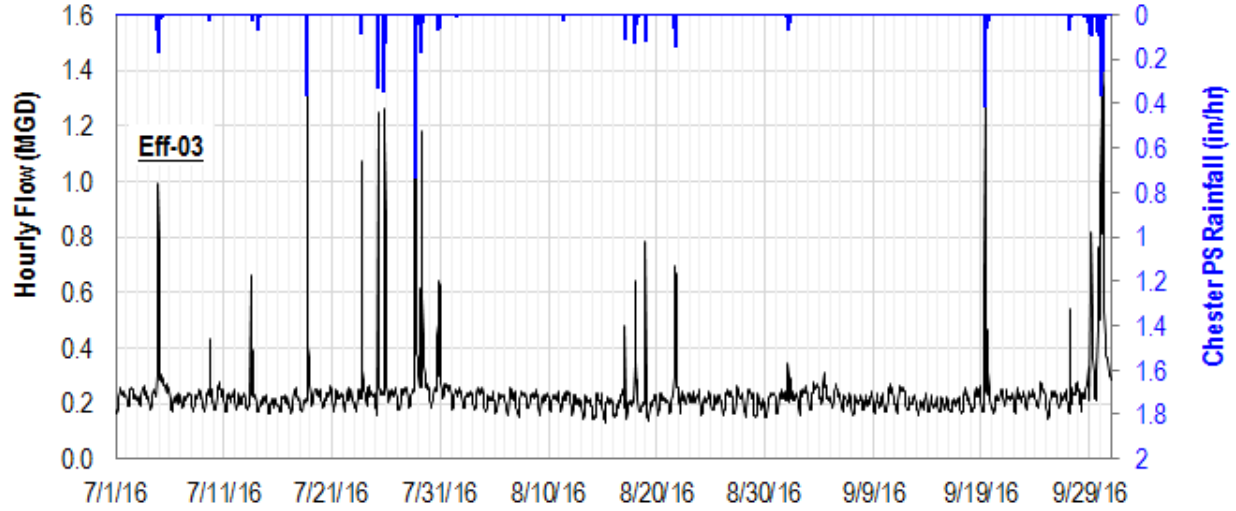


Figure 16: Flow Monitoring Data, Eff-03

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

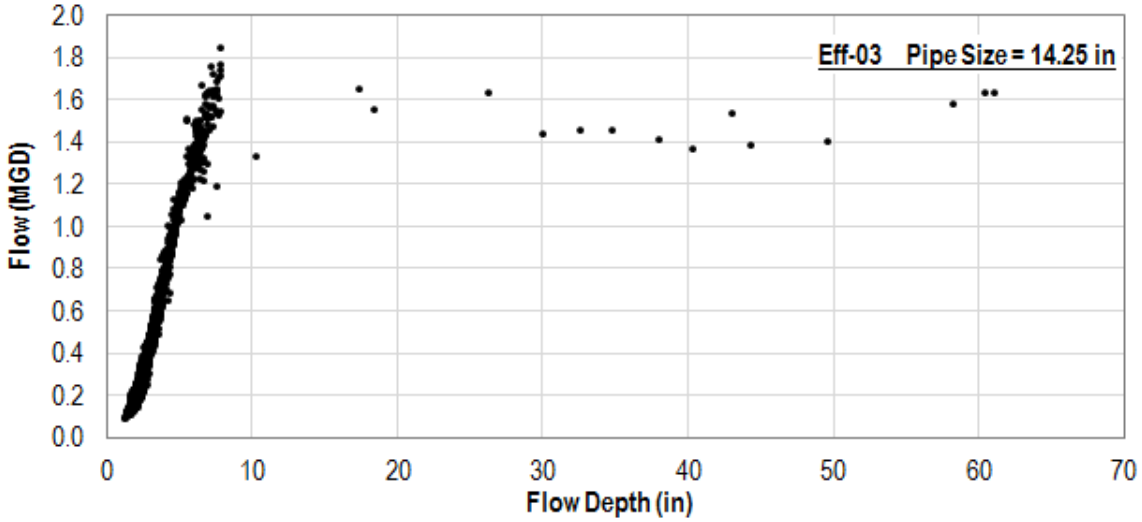
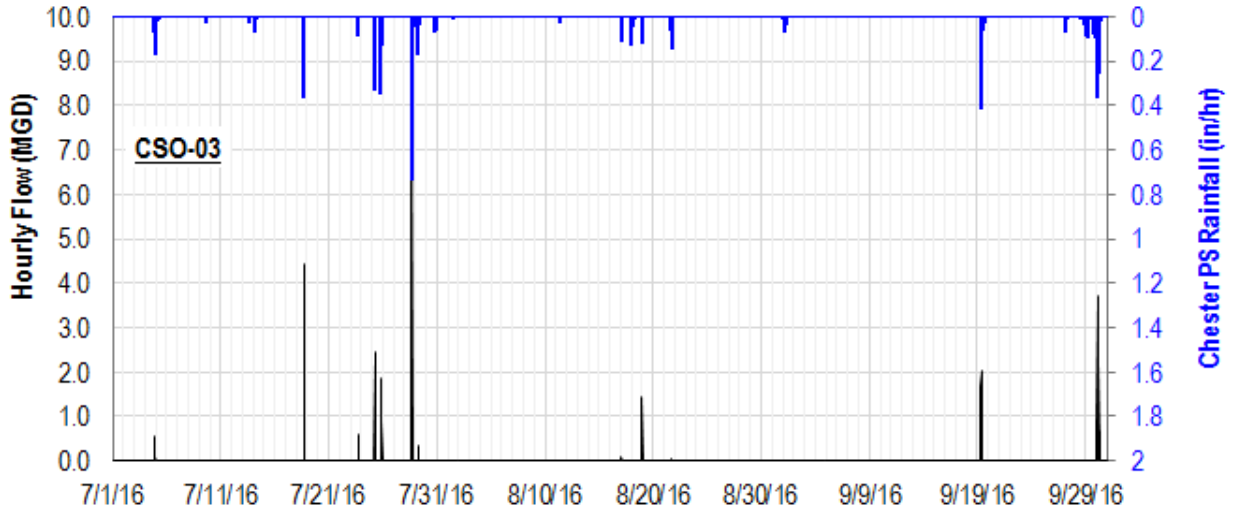


Figure 17: Flow Monitoring Data, CSO-03

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

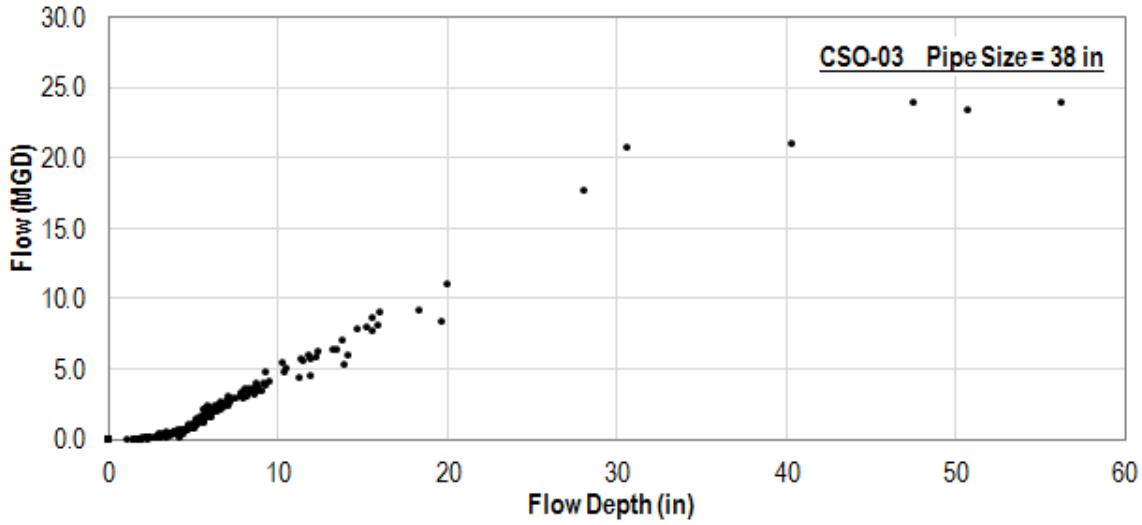
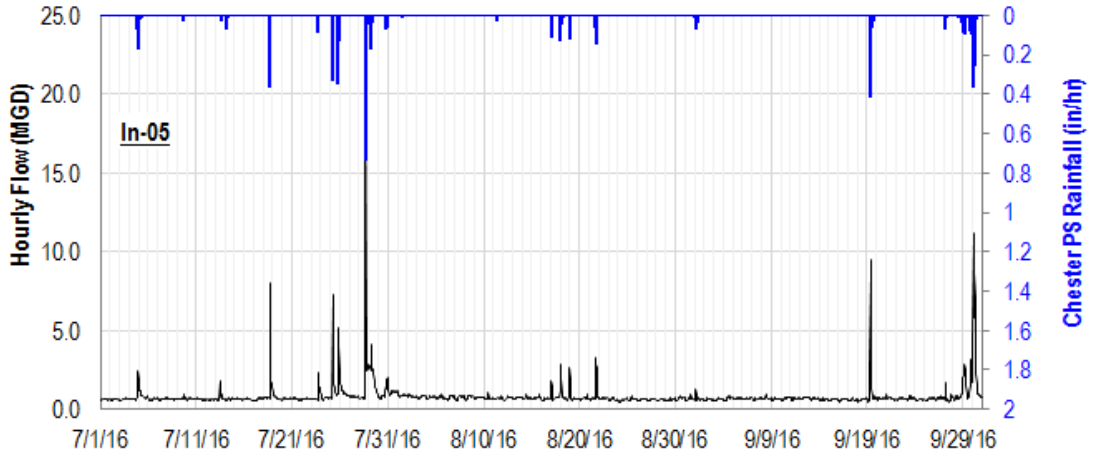
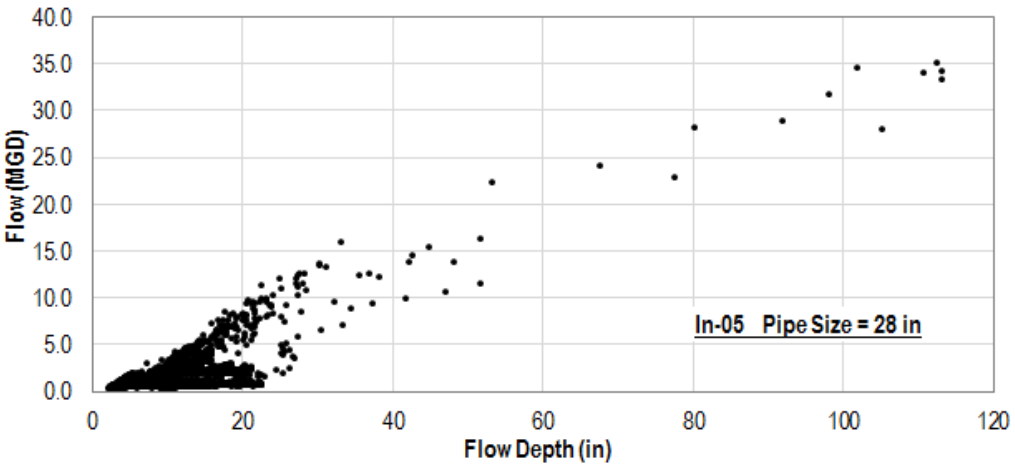


Figure 18: Flow Monitoring Data, IN-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#05 Influent , Effluent and Overflow

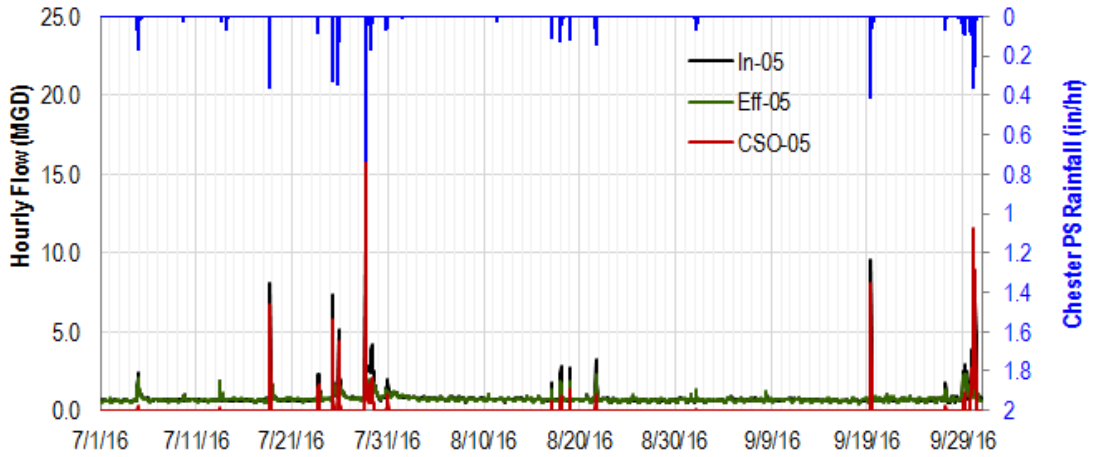
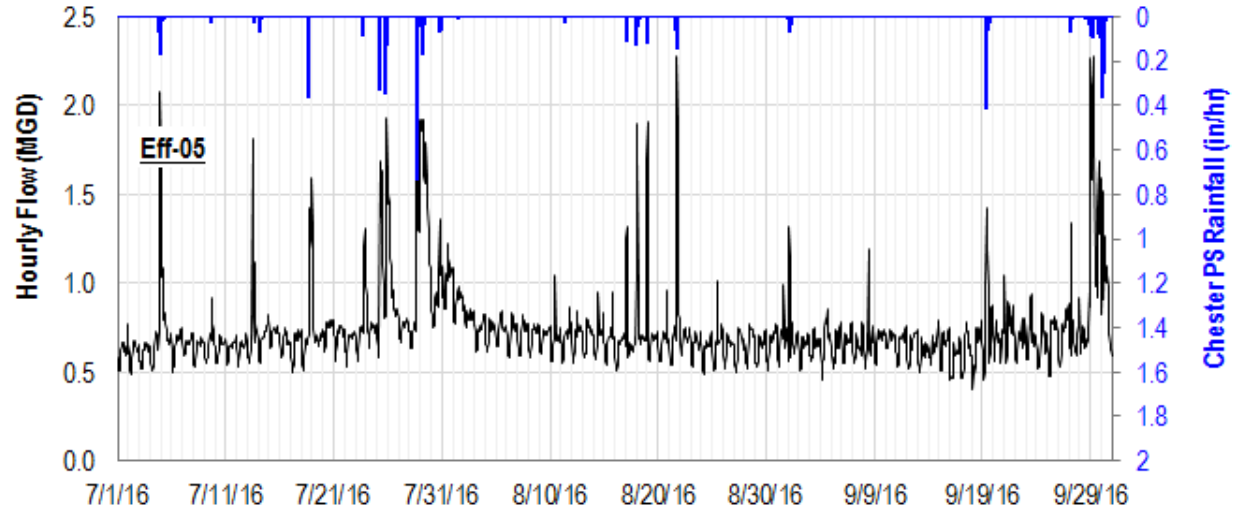


Figure 19: Flow Monitoring Data, Eff-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

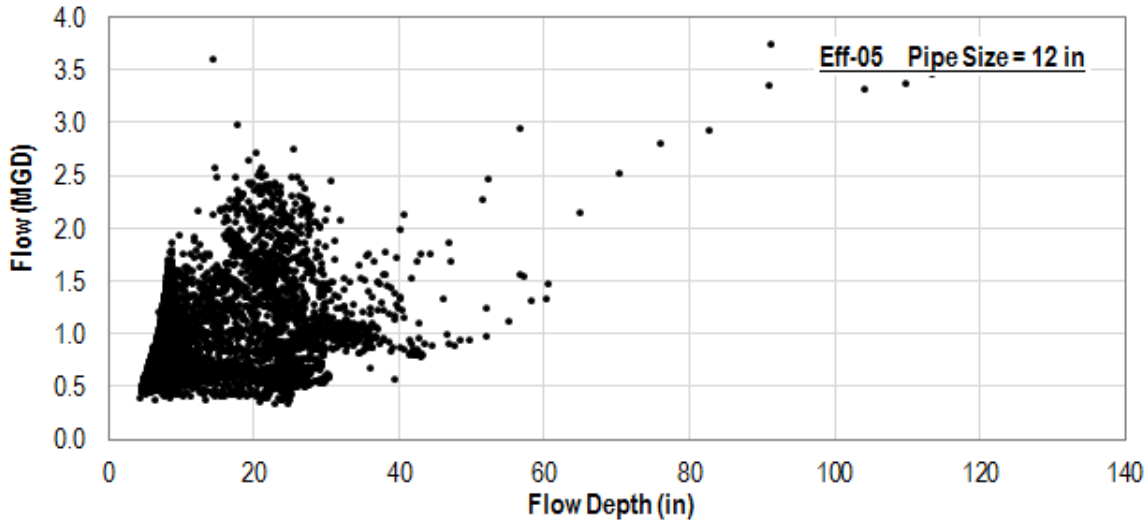
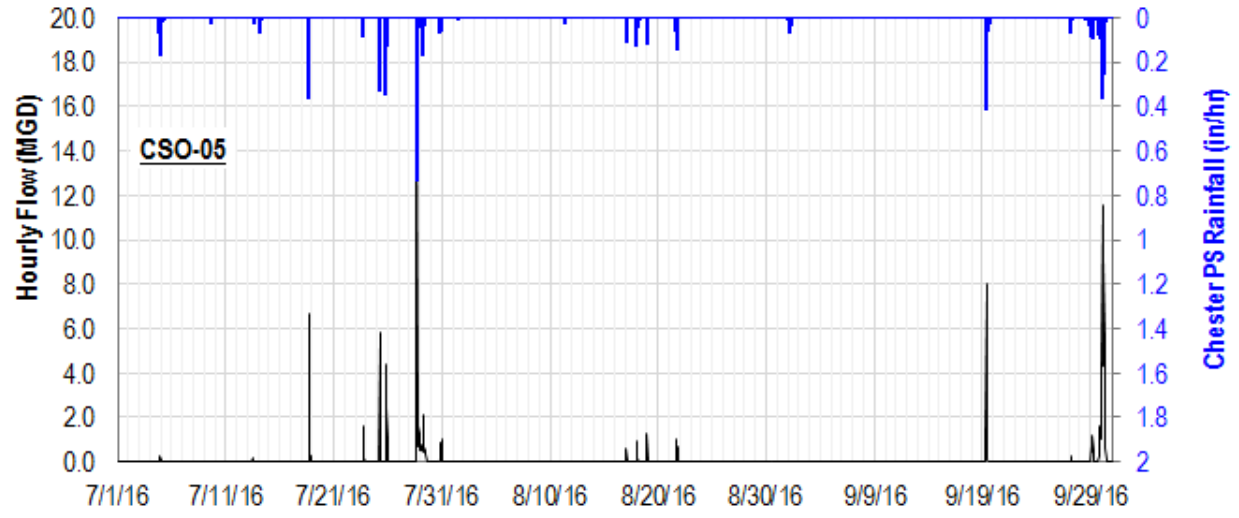


Figure 20: Flow Monitoring Data, CSO-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

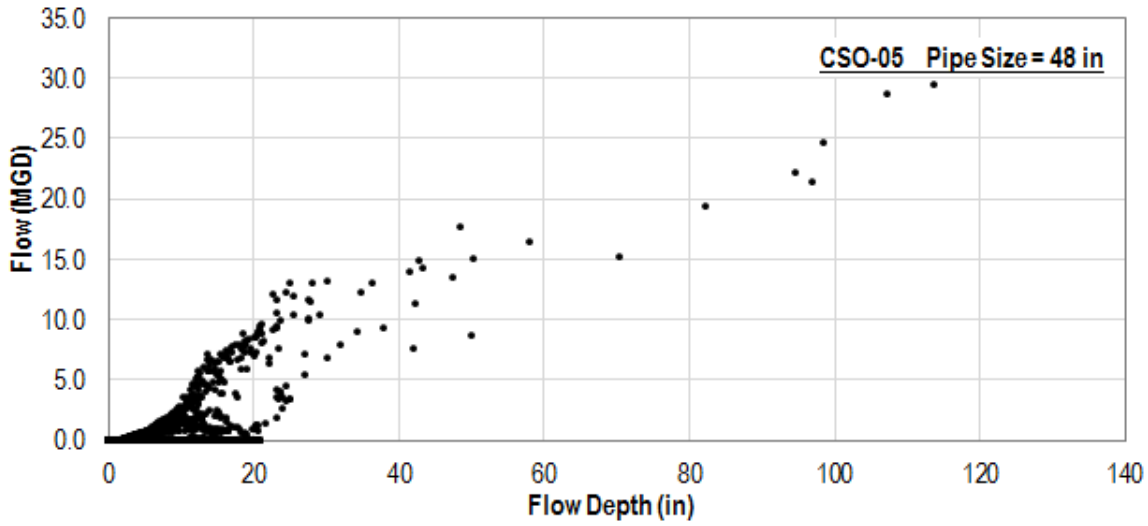
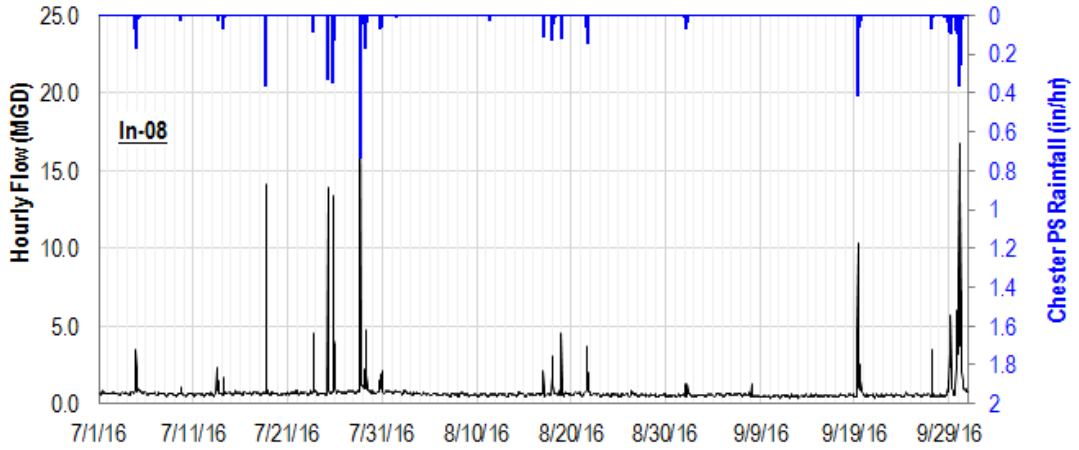
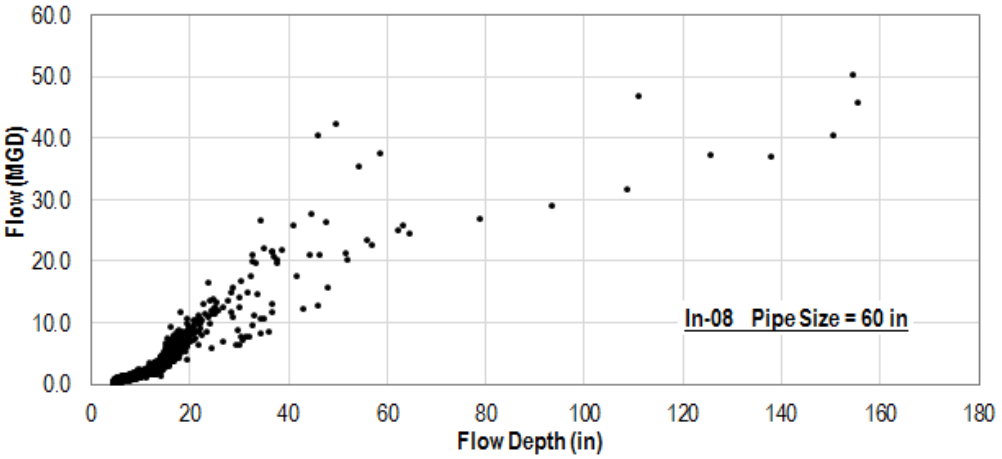


Figure 21: Flow Monitoring Data, IN-08

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#08 Influent , Effluent and Overflow

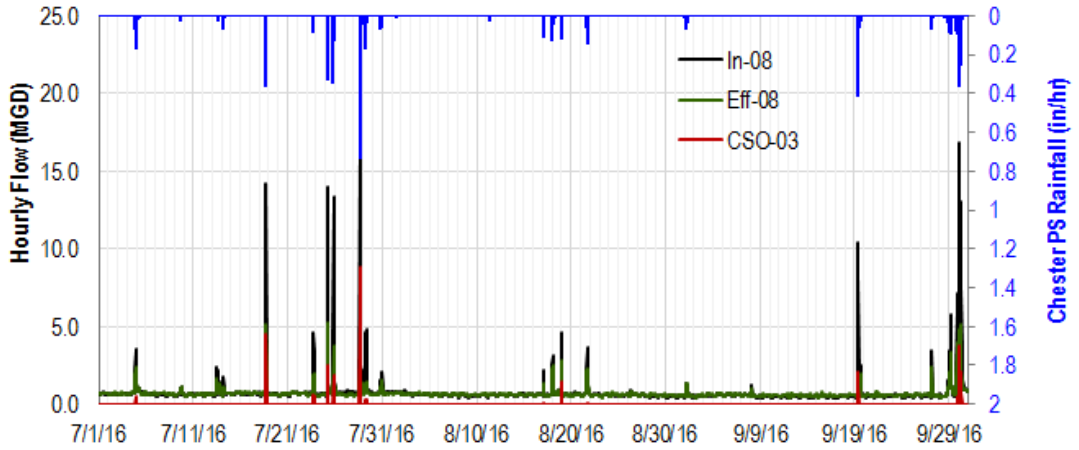


Figure 22: Flow Monitoring Data, Eff-08

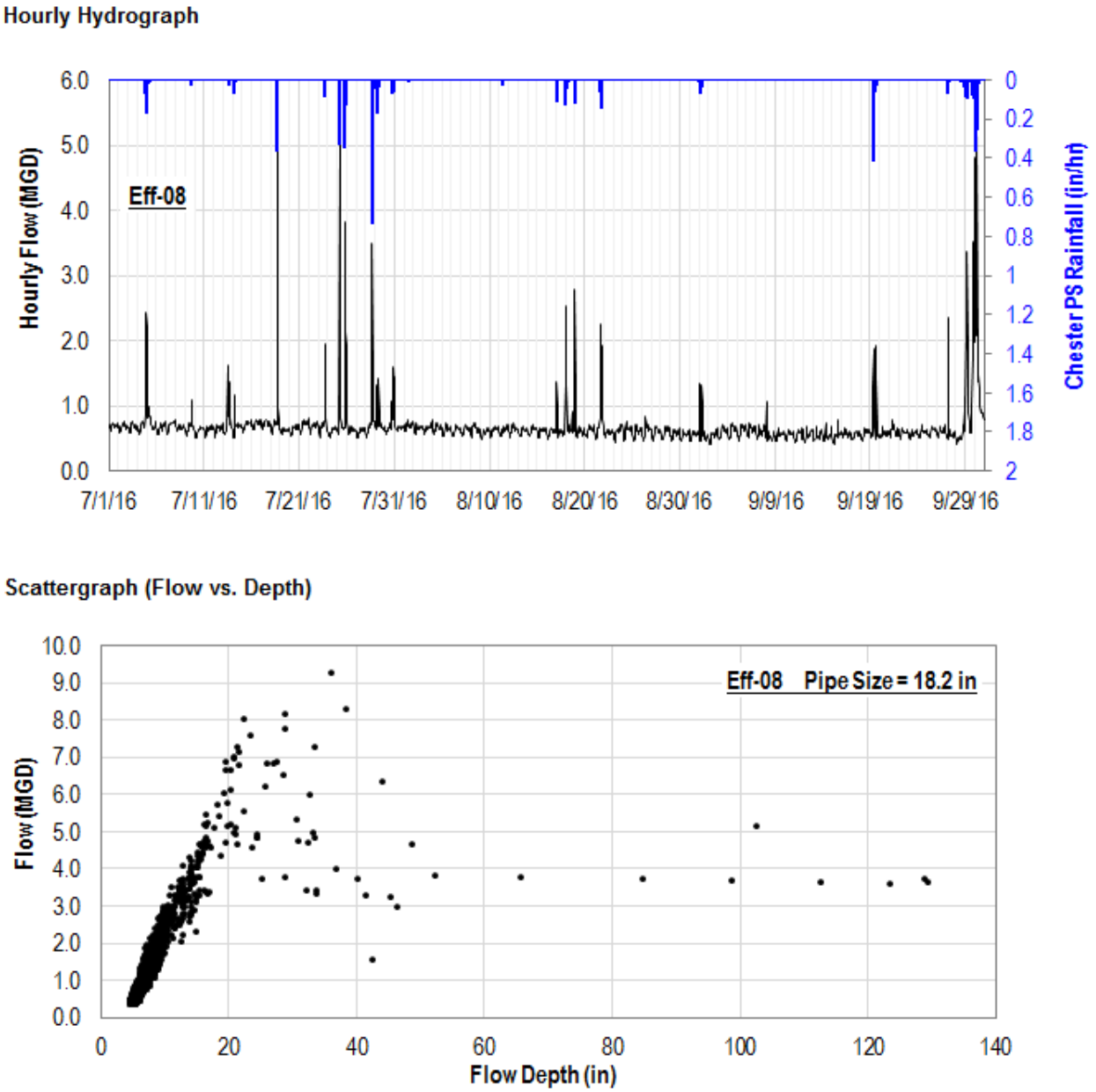


Figure 23: Flow Monitoring Data, CSO-08

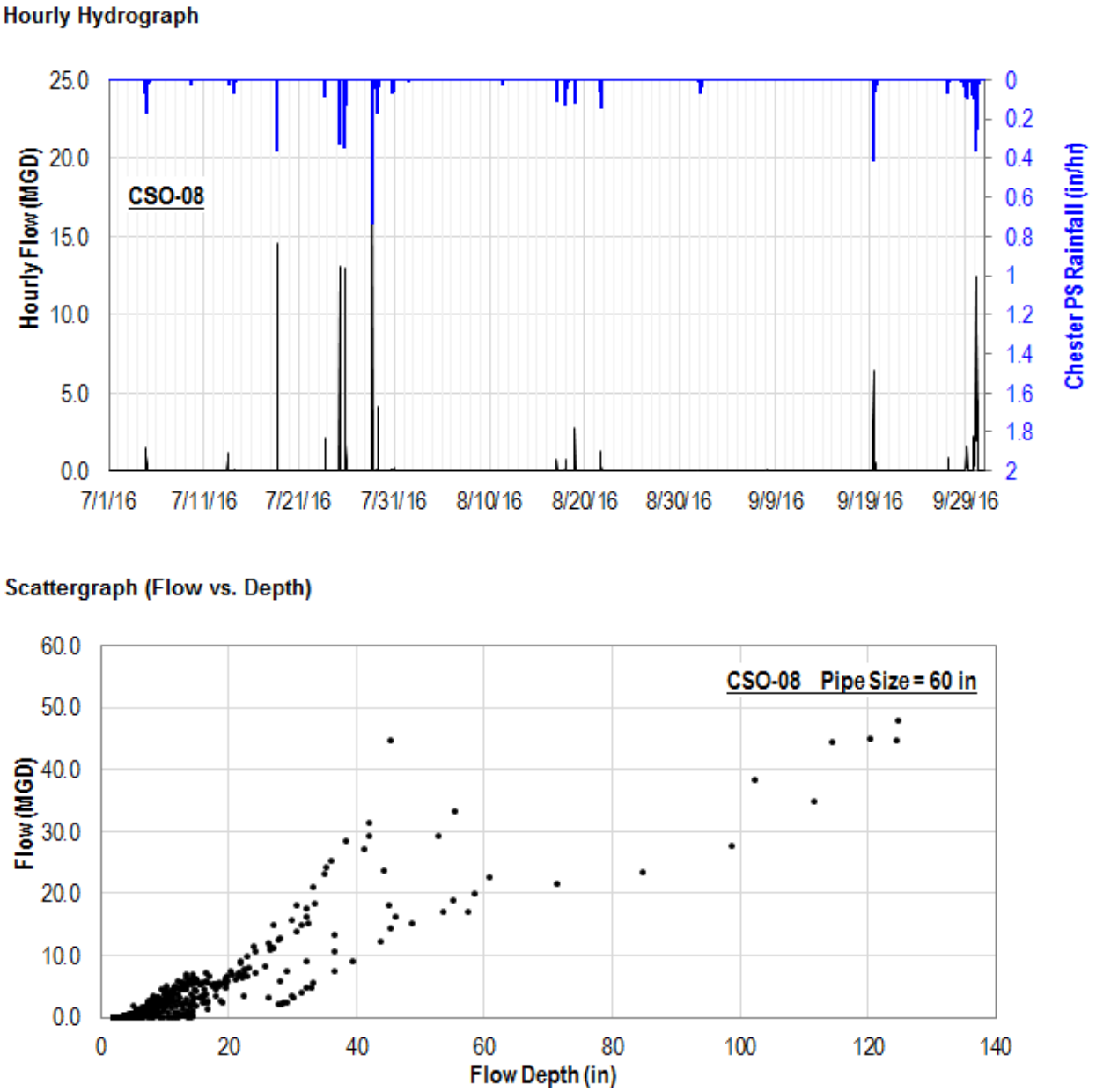
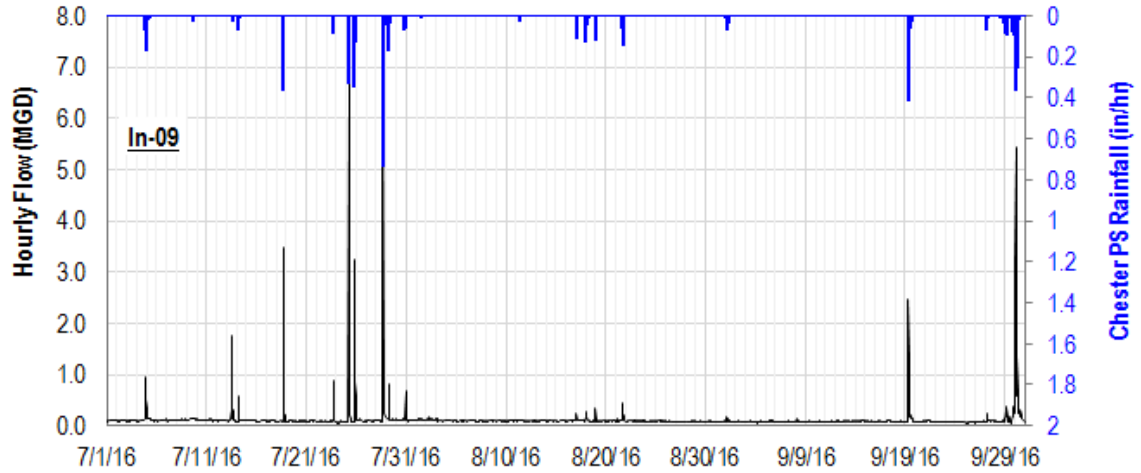


Figure 24: Flow Monitoring Data, In-09

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

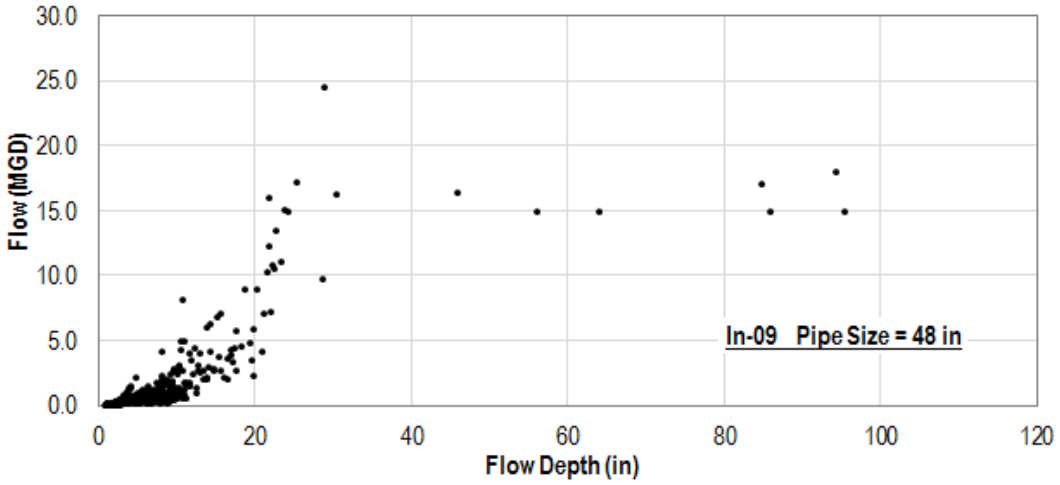
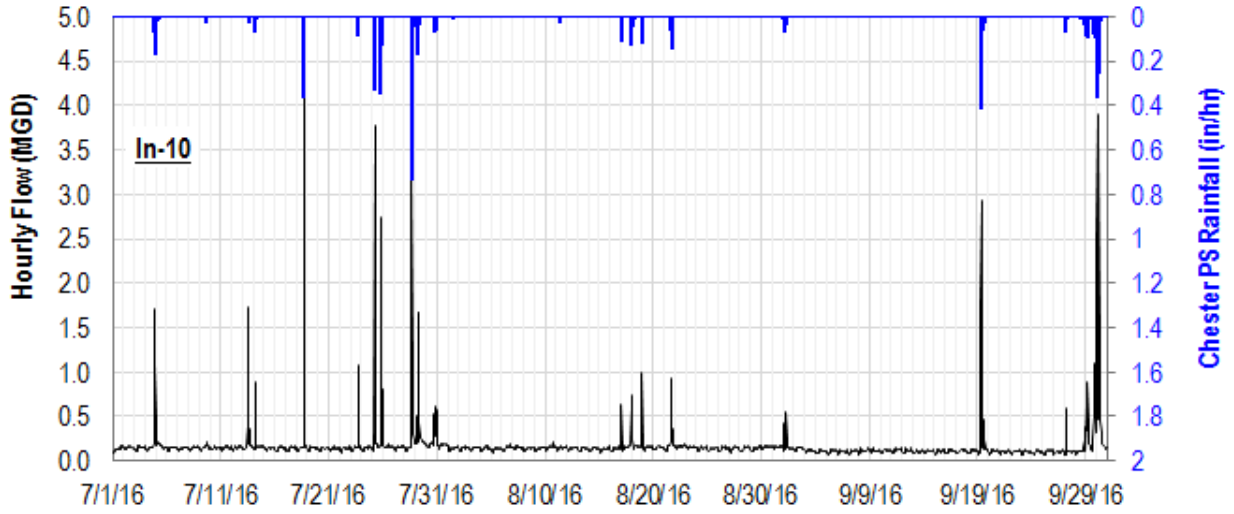


Figure 25: Flow Monitoring Data, In-10

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

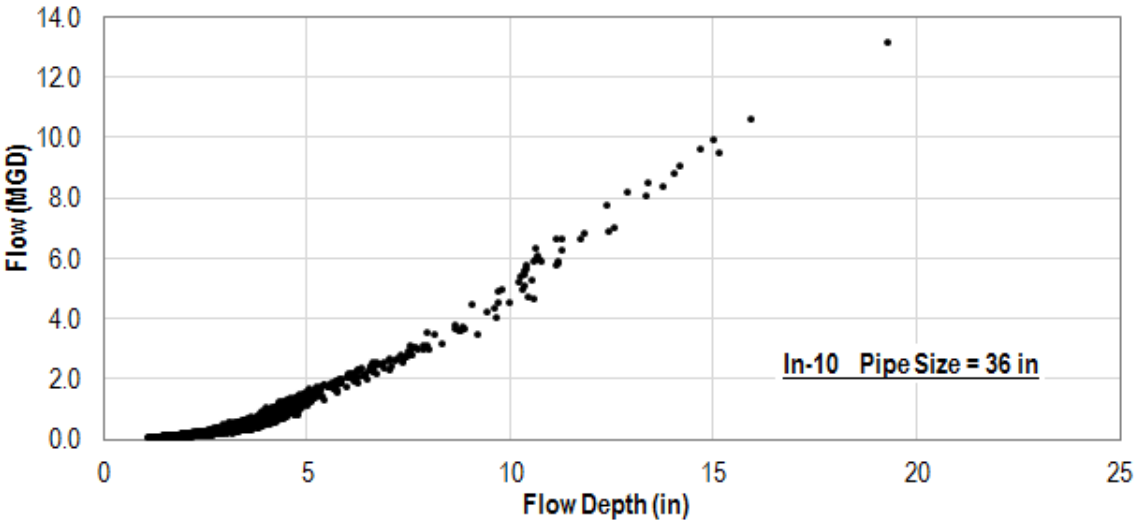


Figure 26: Flow Monitoring Data, In-11

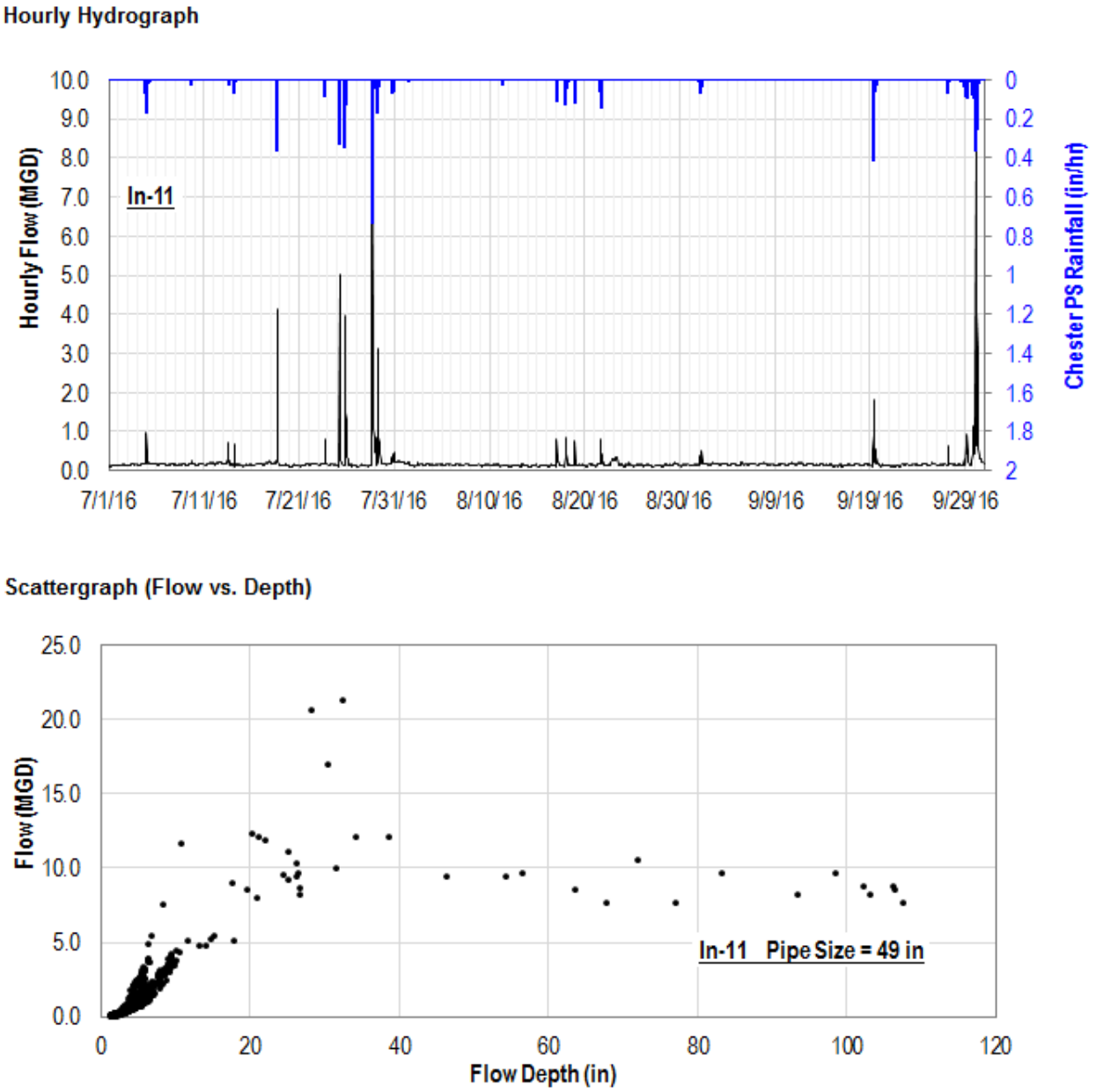


Figure 27: Flow Monitoring Data, In-13

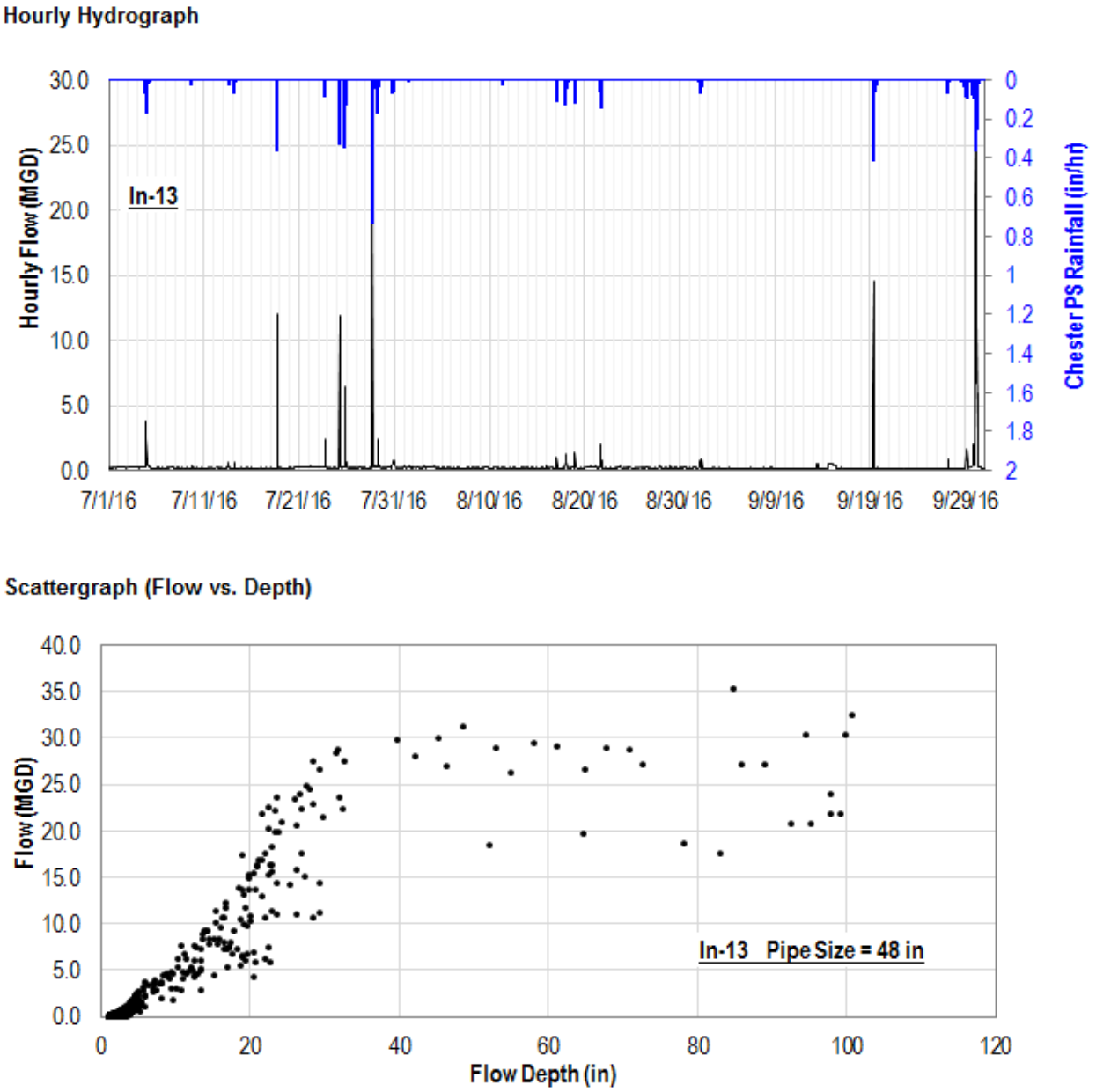
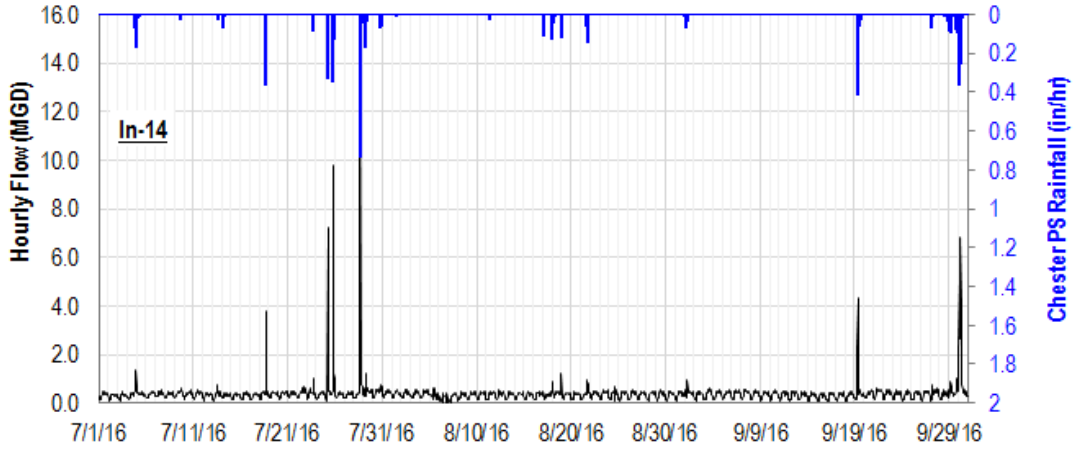
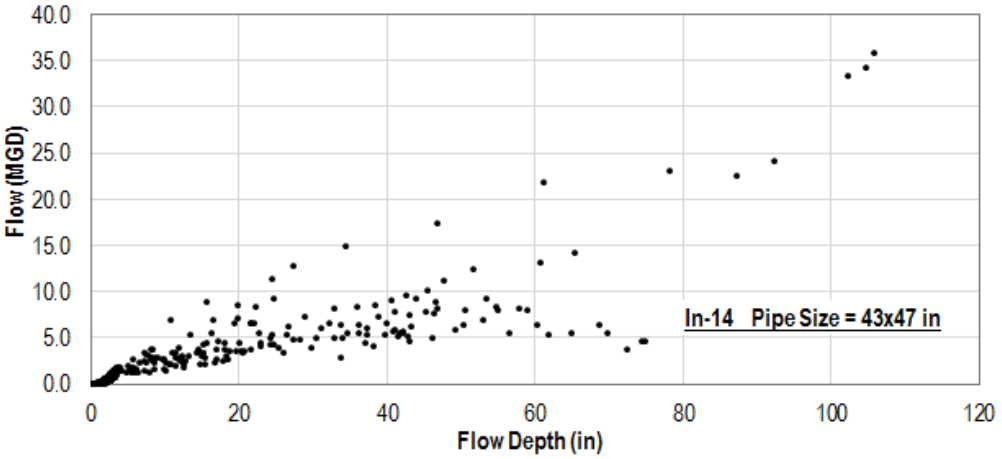


Figure 28: Flow Monitoring Data, In-14

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#14 Influent , Effluent and Overflow

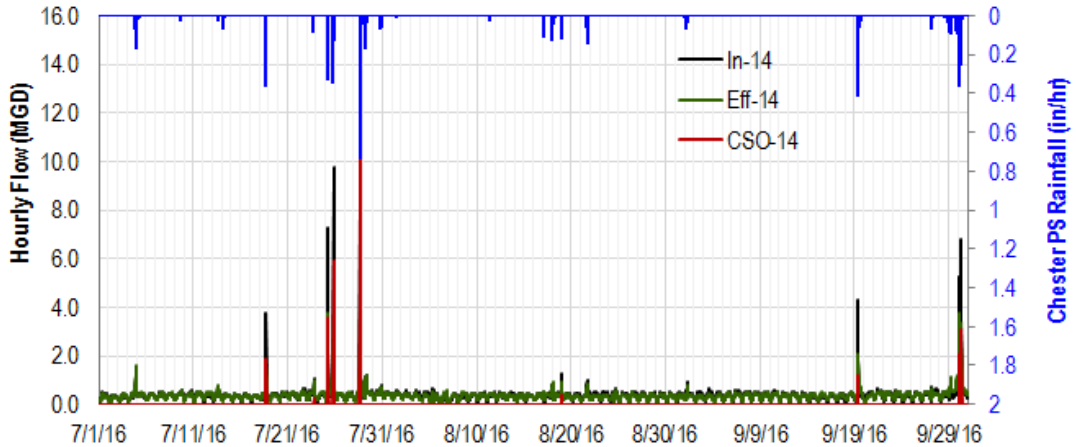
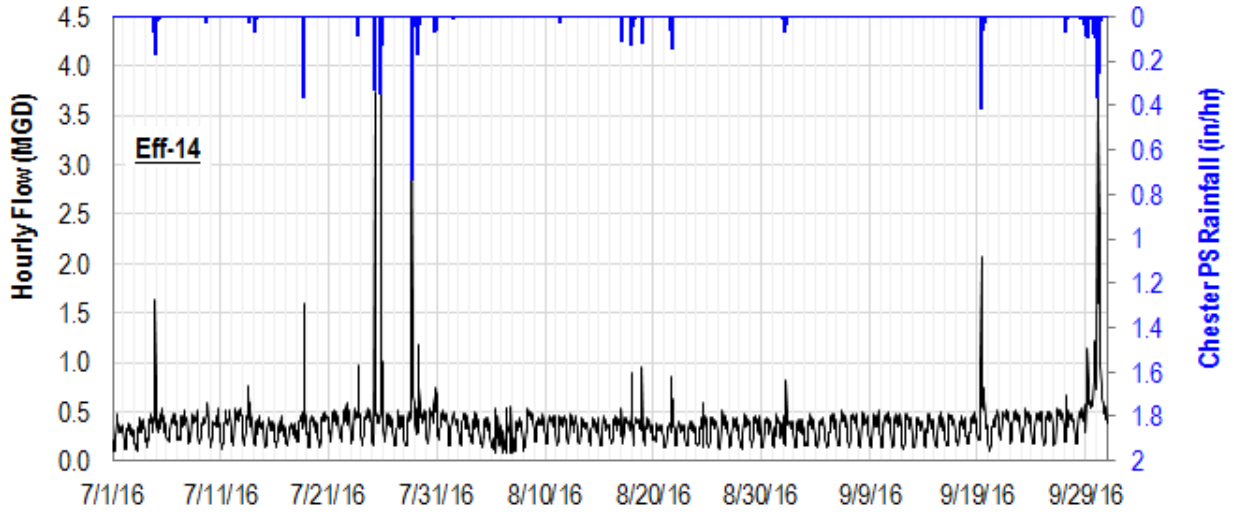


Figure 29: Flow Monitoring Data, Eff-14

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

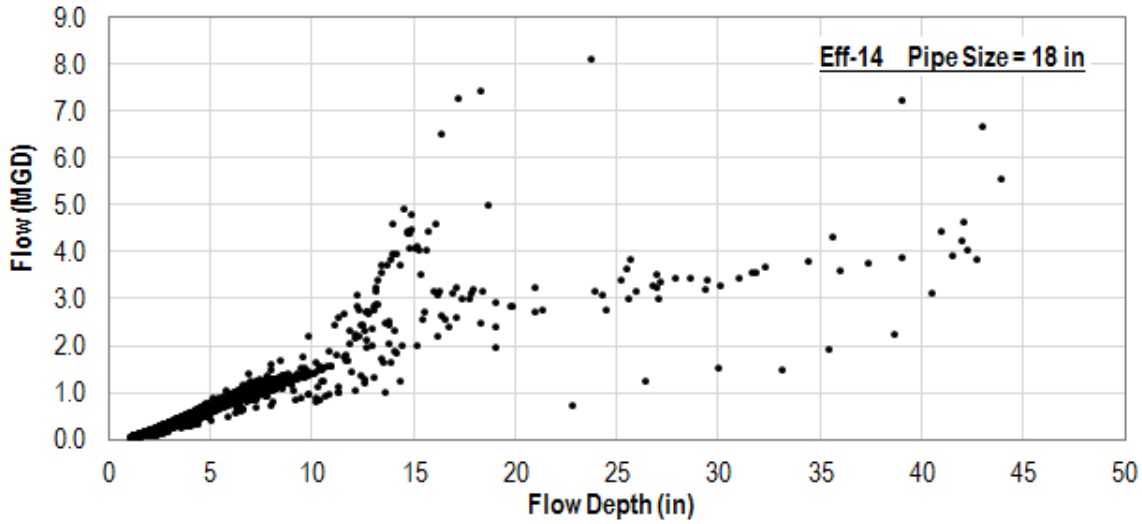


Figure 30: Flow Monitoring Data, CSO-14

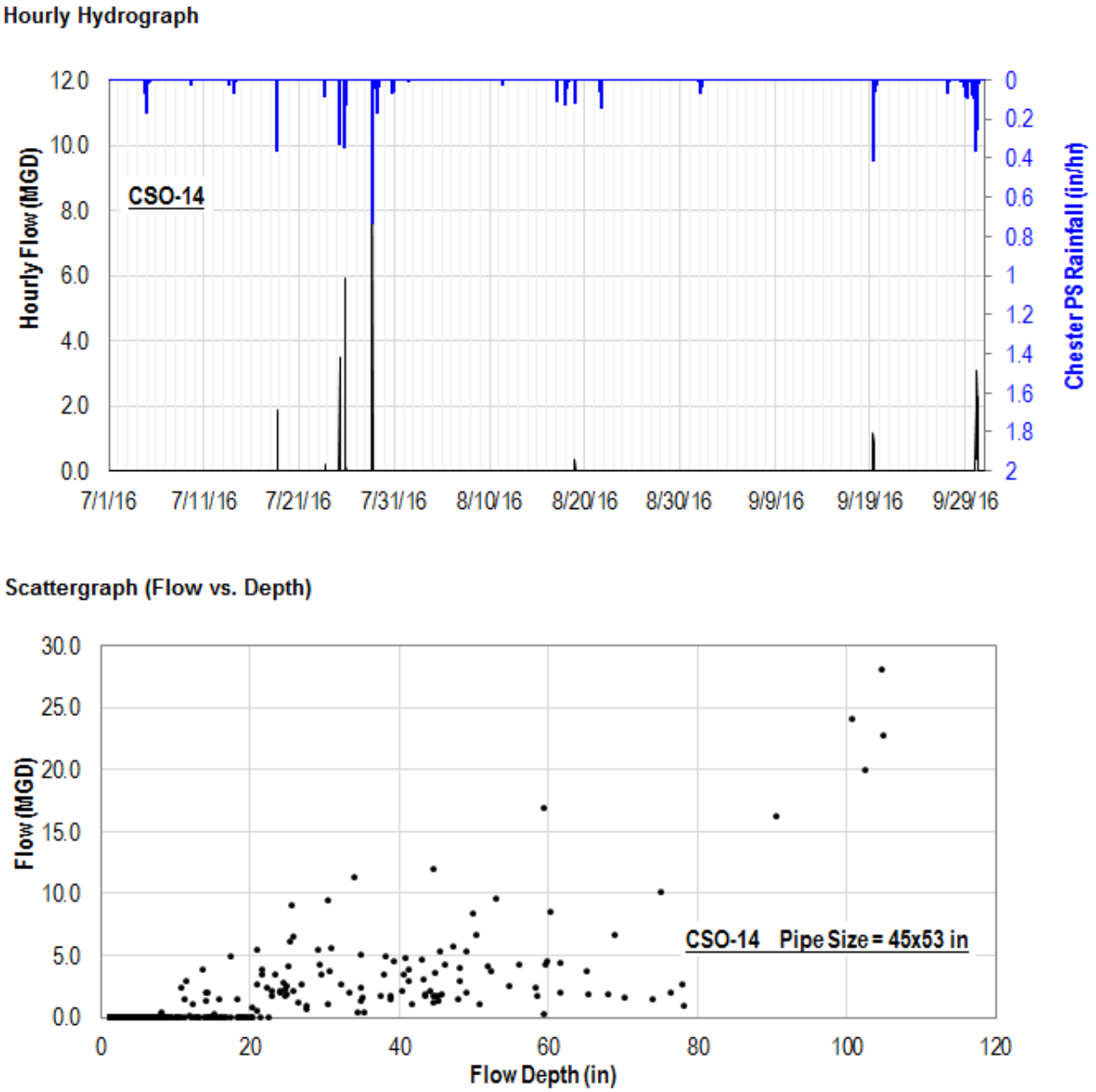


Figure 31: Flow Monitoring Data, In-16

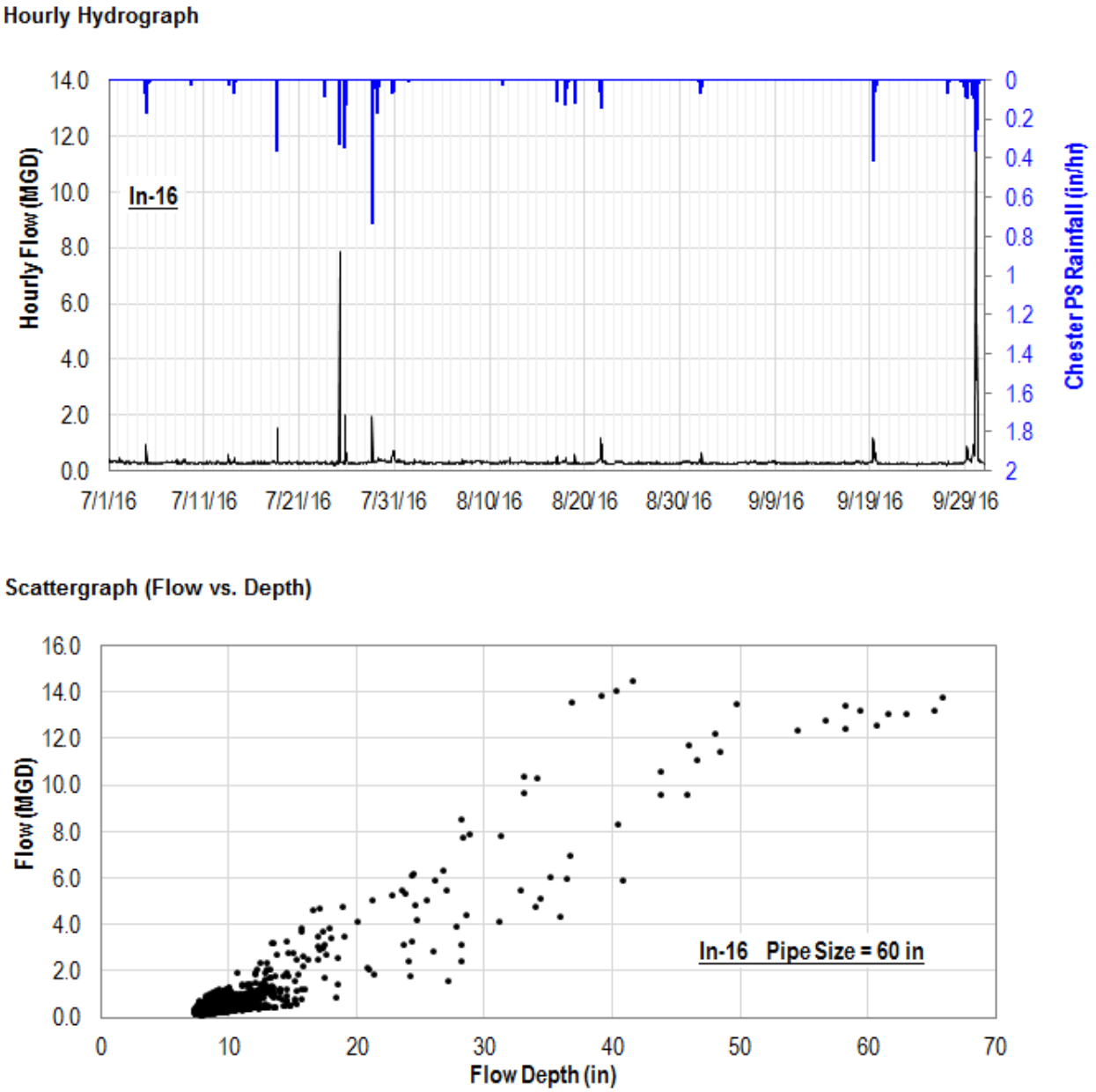


Figure 32: Flow Monitoring Data, In-17

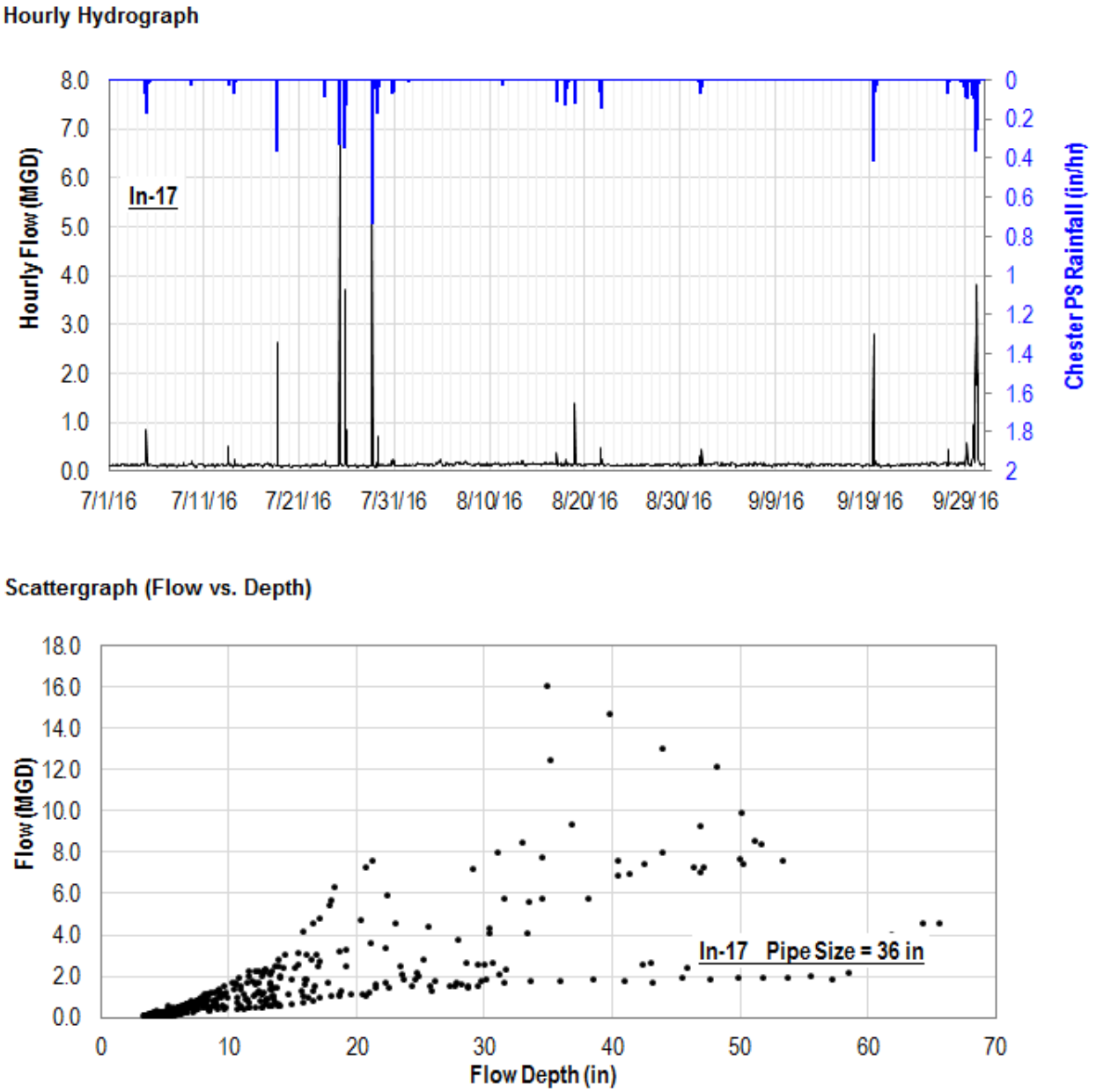


Figure 33: Flow Monitoring Data, In-18

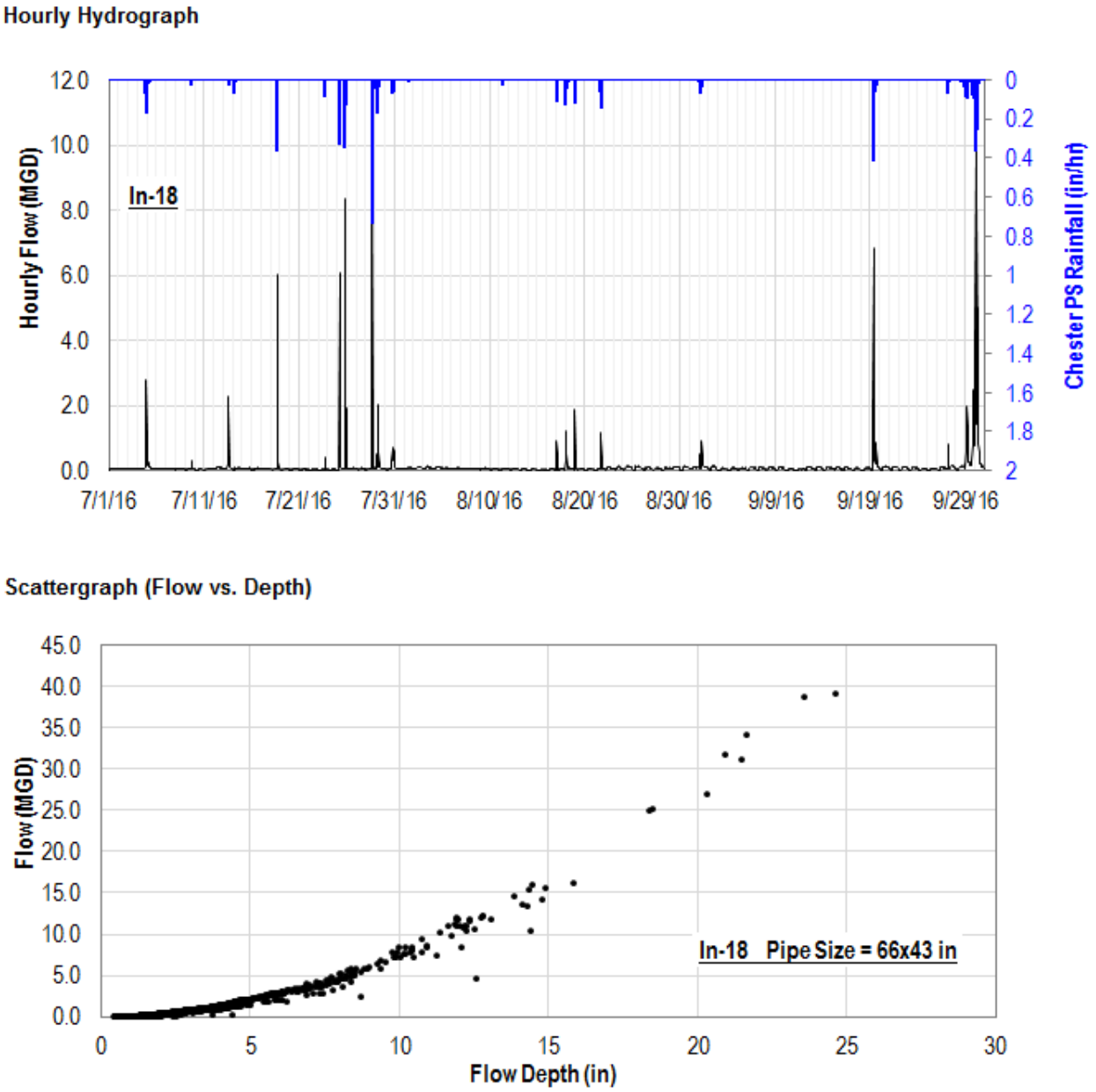
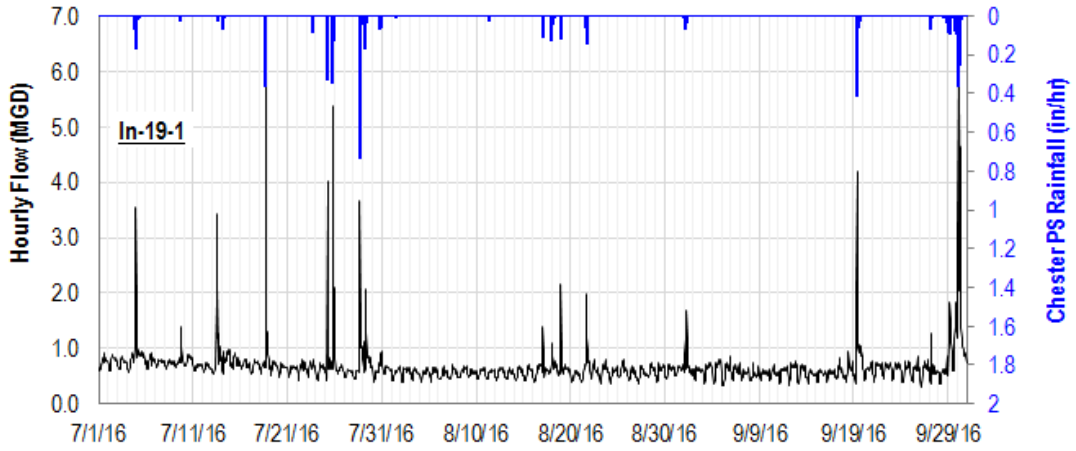
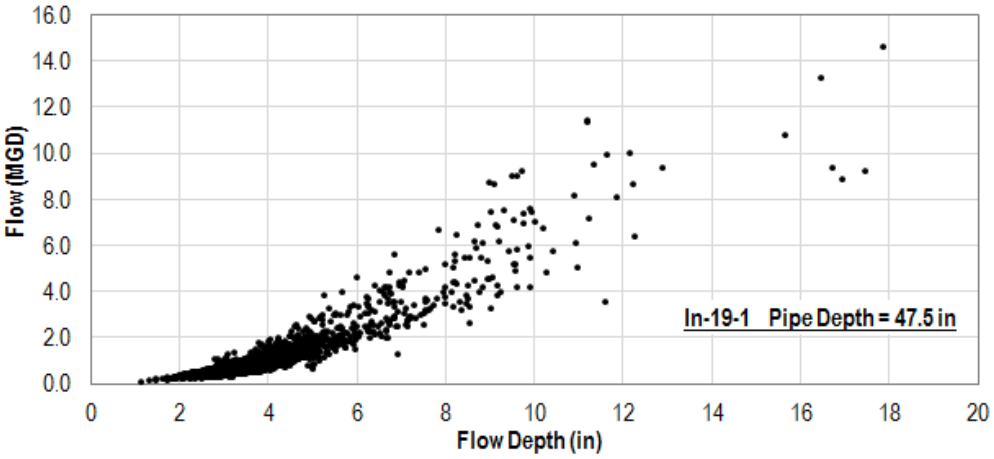


Figure 34: Flow Monitoring Data, In-19-1

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#19 Influent , Effluent and Overflow

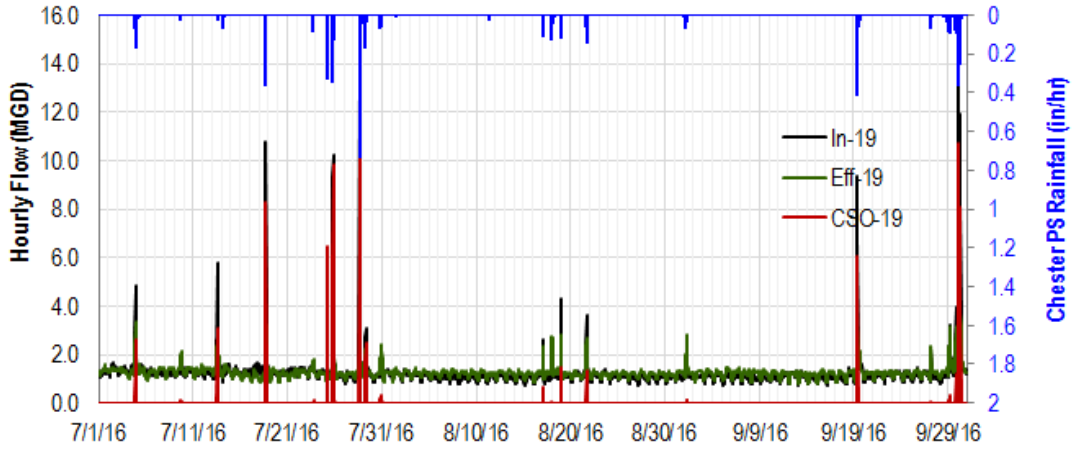


Figure 35: Flow Monitoring Data, In-19-2

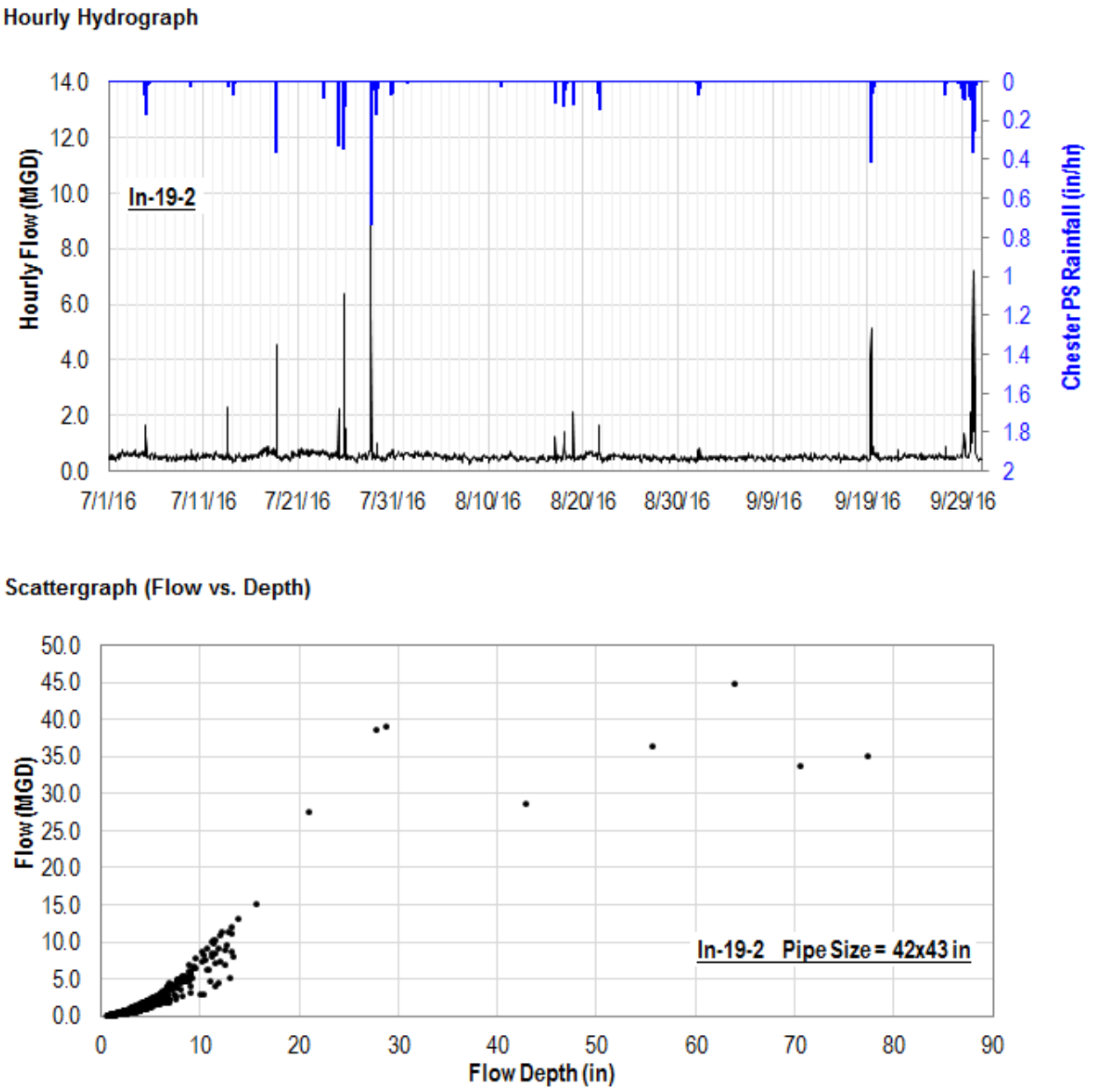
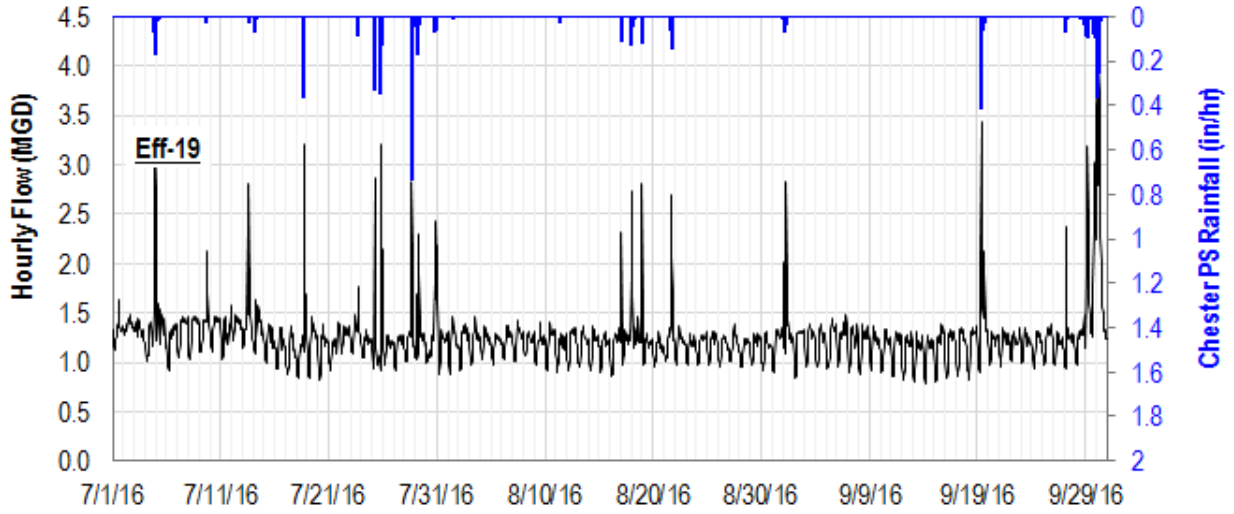


Figure 36: Flow Monitoring Data, Eff-19

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

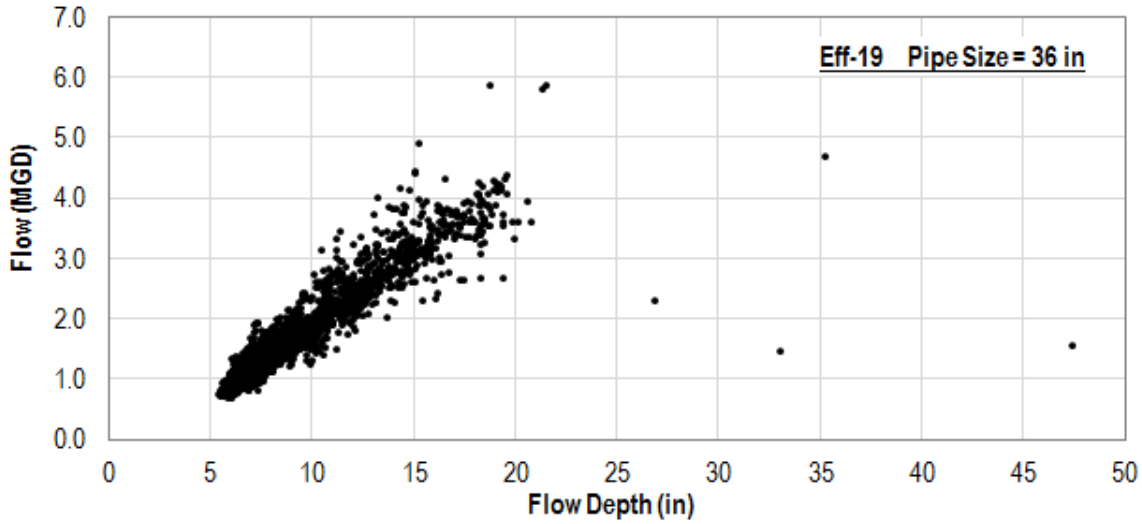
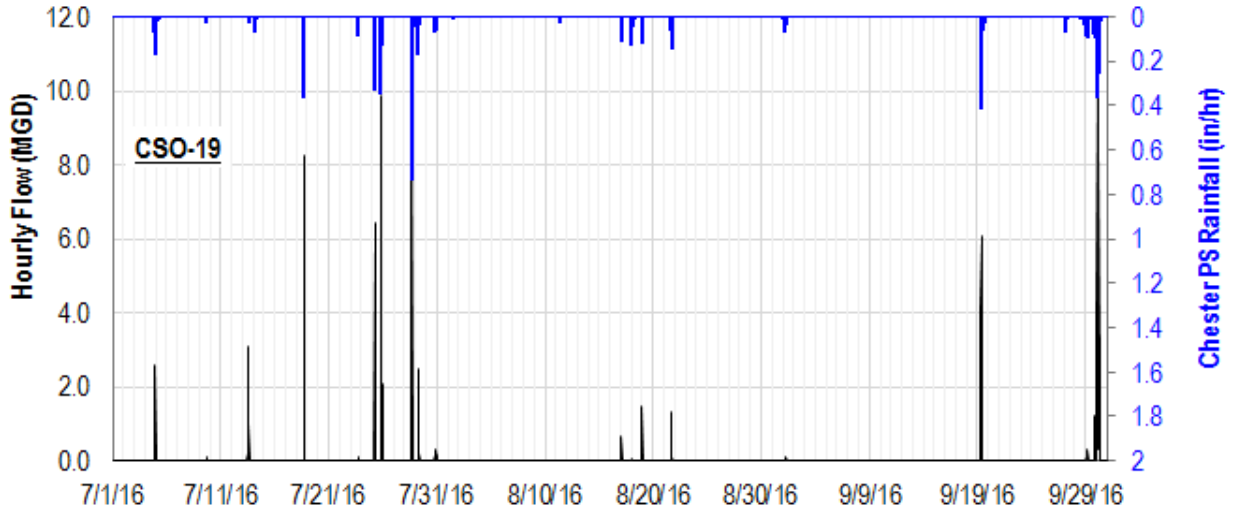


Figure 37: Flow Monitoring Data, CSO-19

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

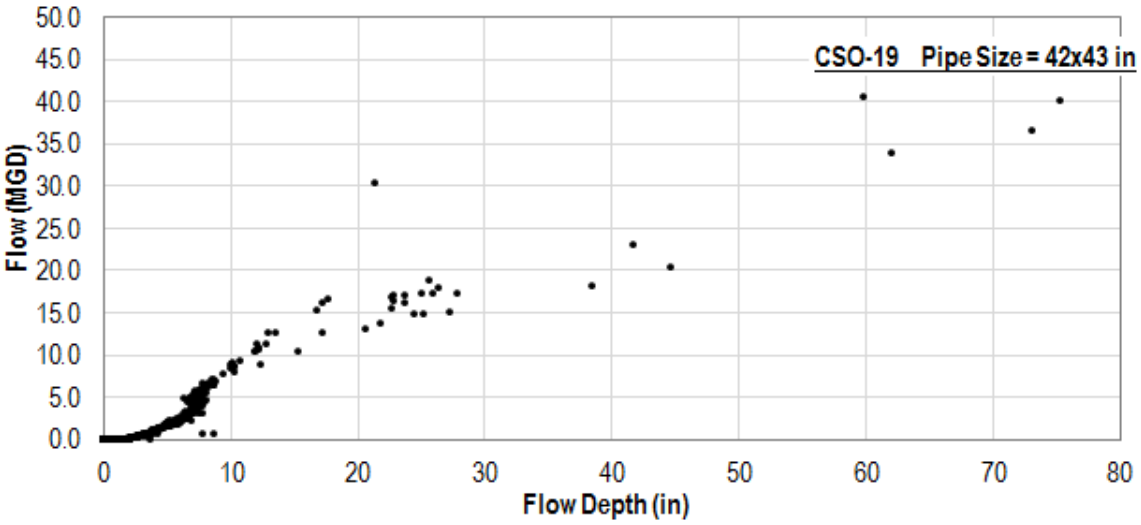


Figure 38: Flow Monitoring Data, In-25

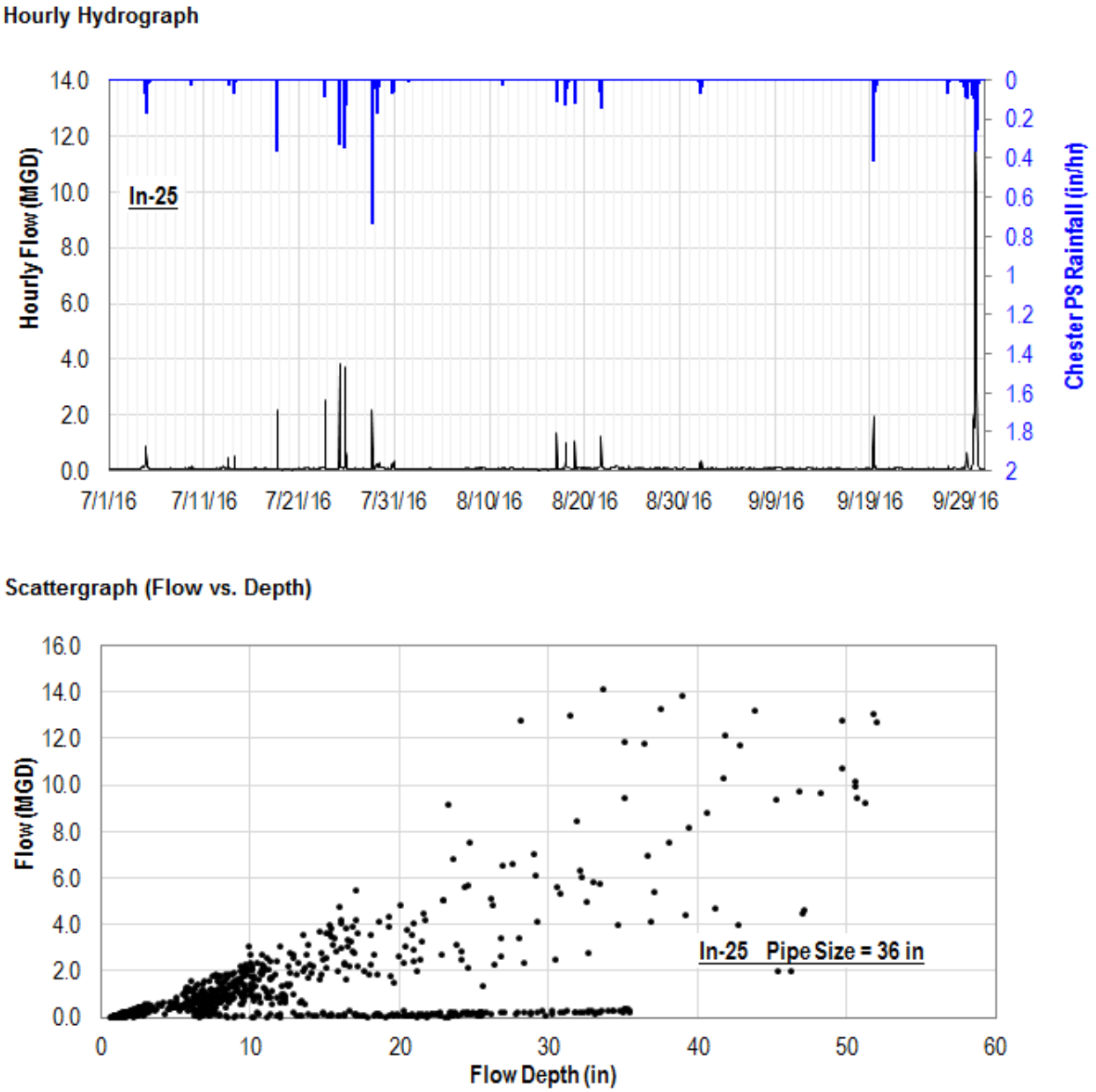
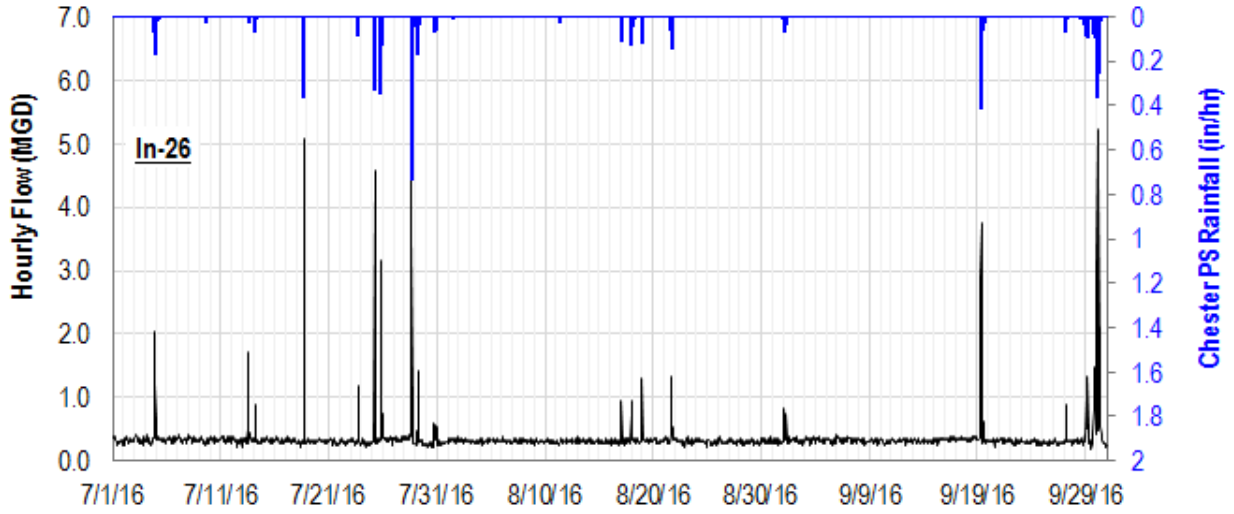


Figure 39: Flow Monitoring Data, In-26

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

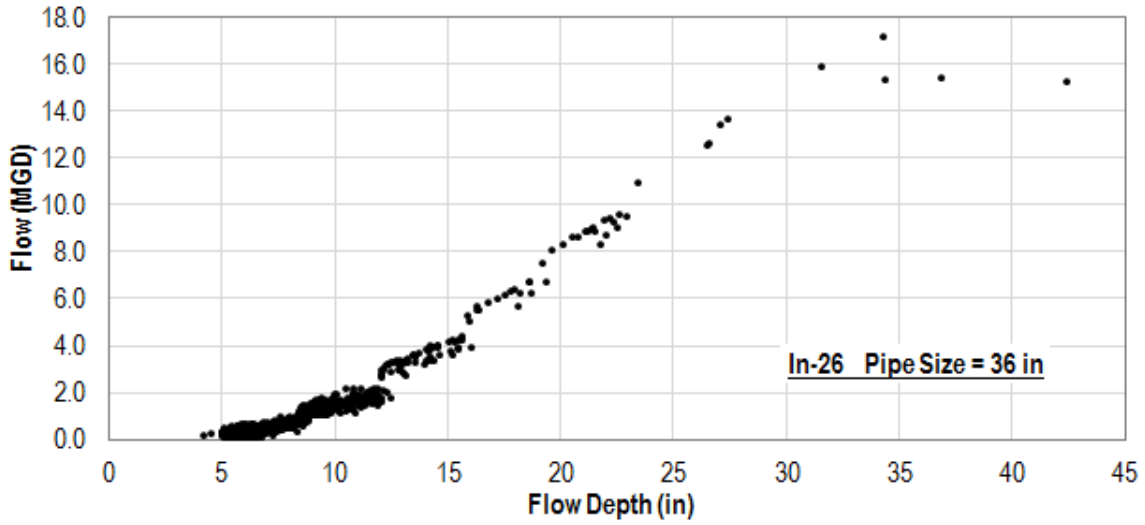
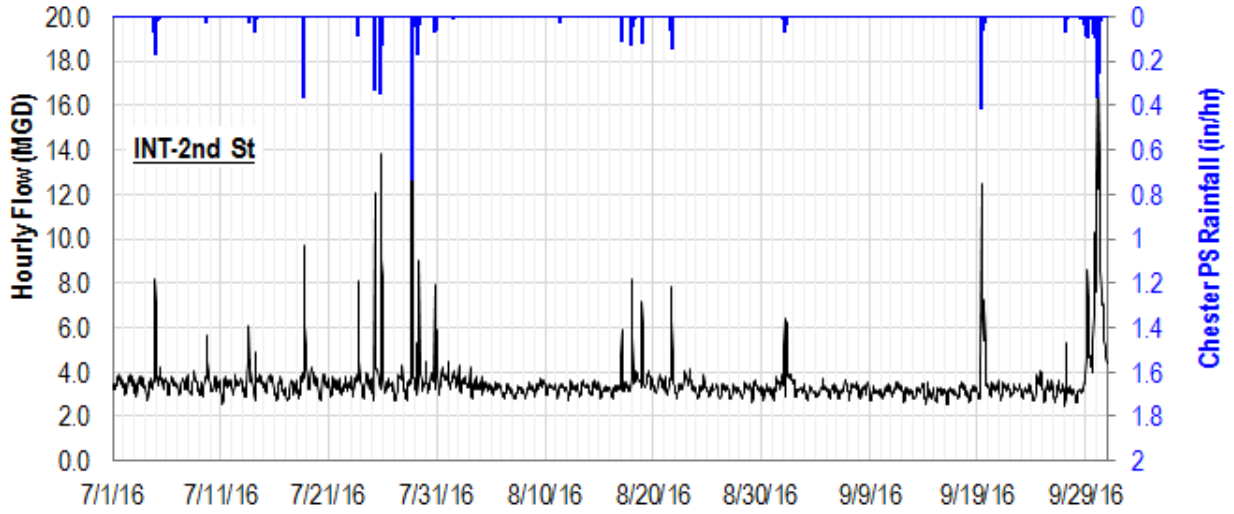


Figure 40: Flow Monitoring Data, INT-2nd St

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

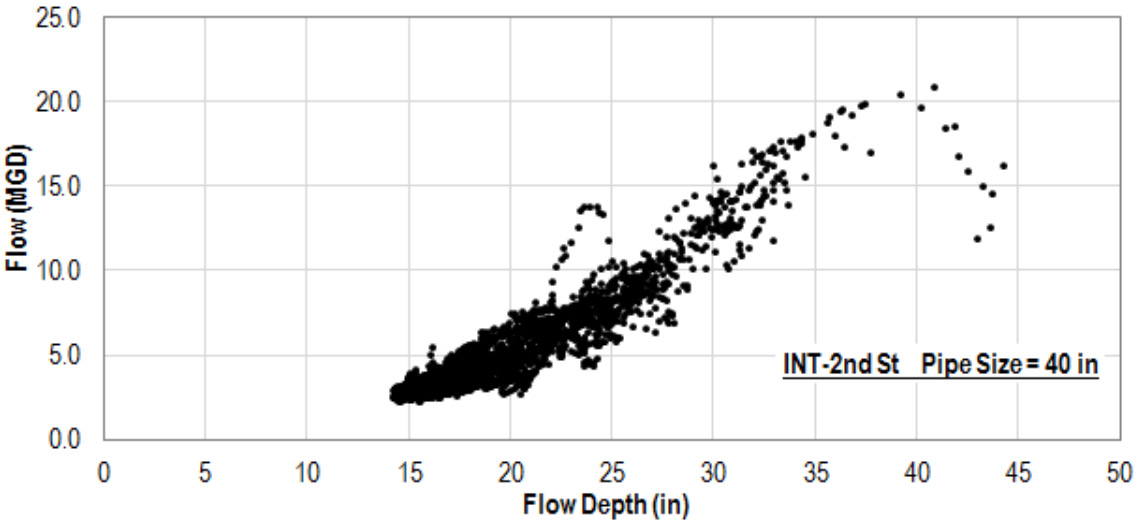


Figure 41: Flow Monitoring Data, INT-DRI

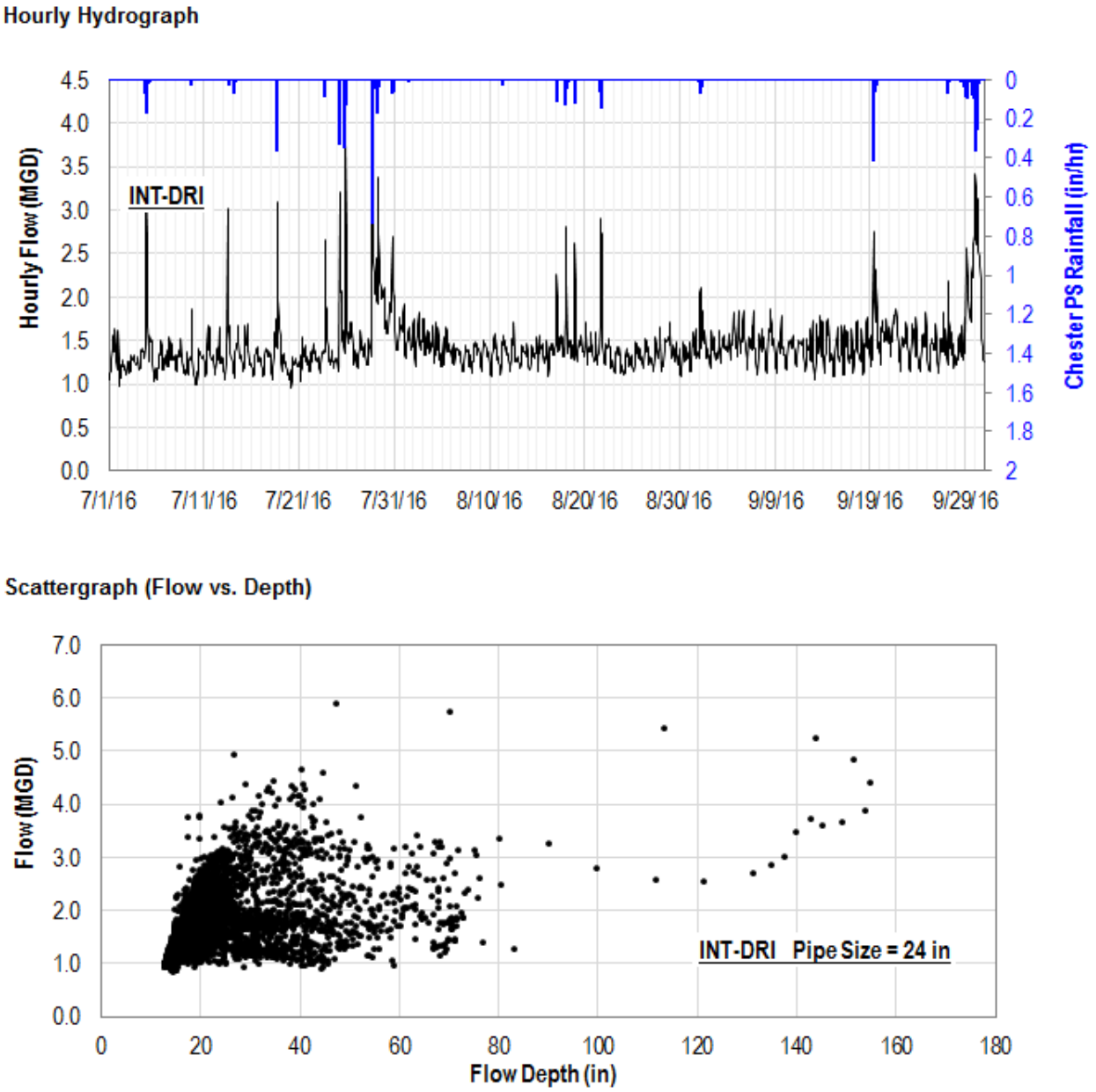


Figure 42: Flow Monitoring Data, INT-Ridley 2

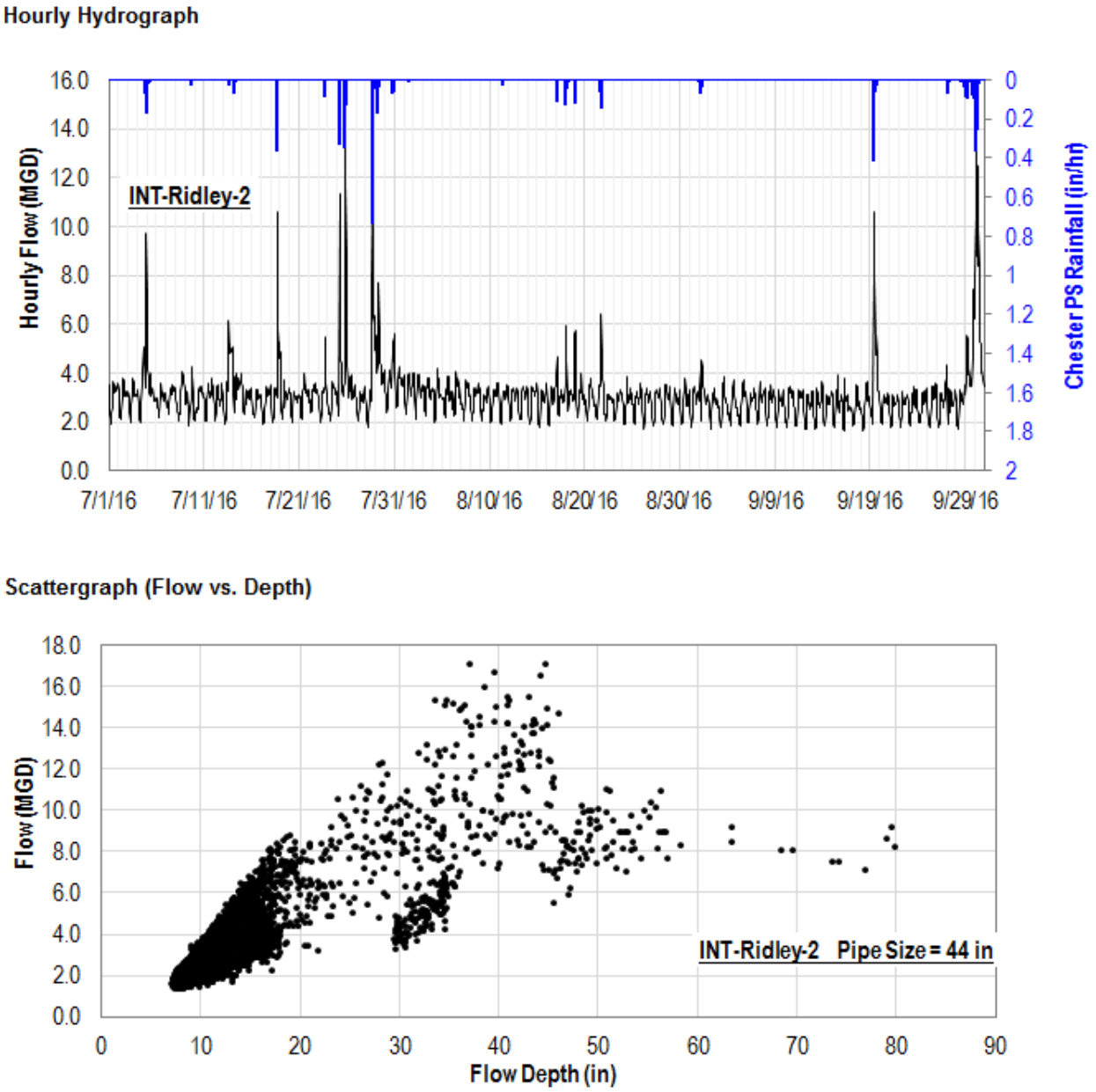


Figure 43: Flow Monitoring Data, INT-Ridley 3

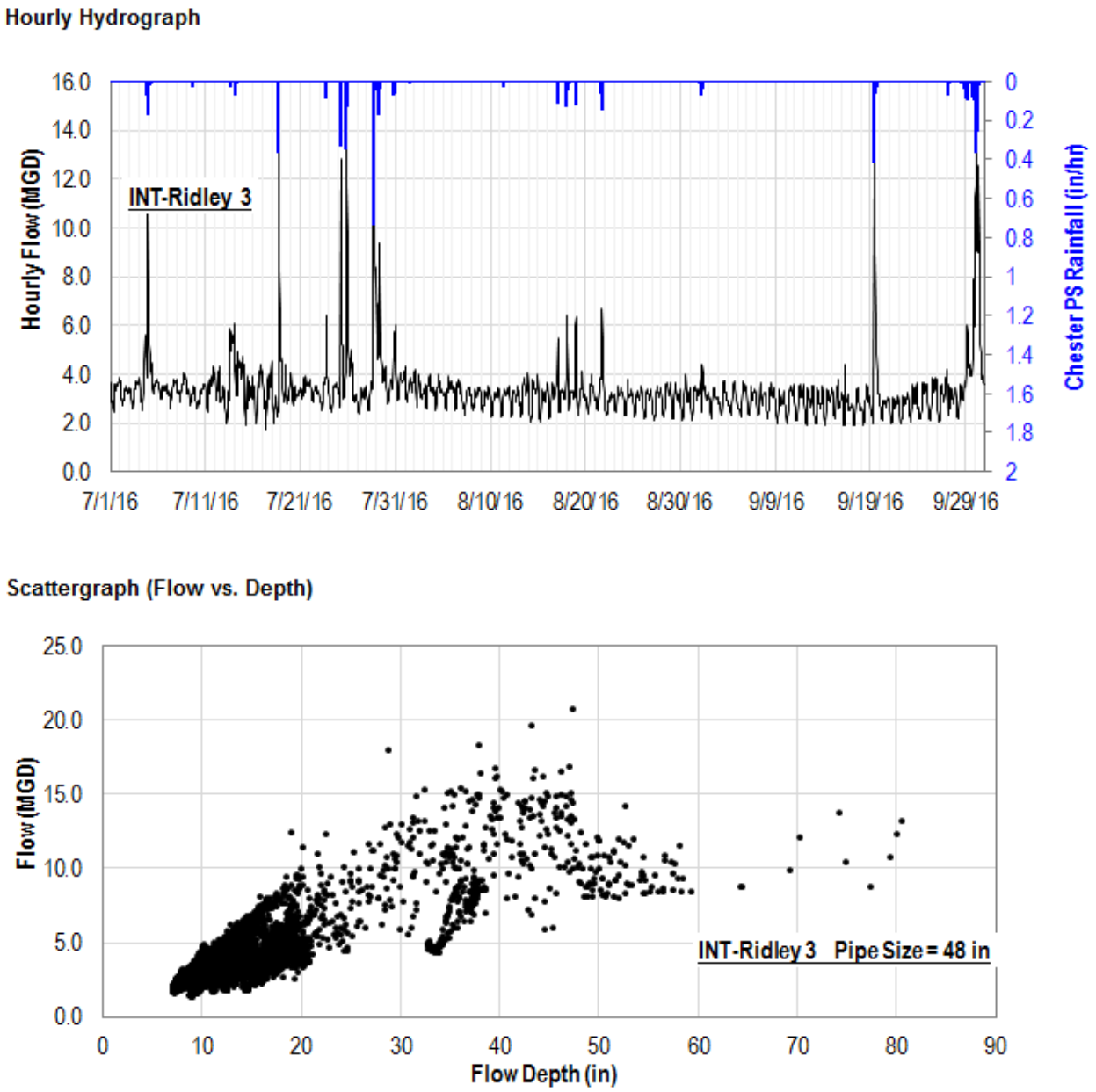
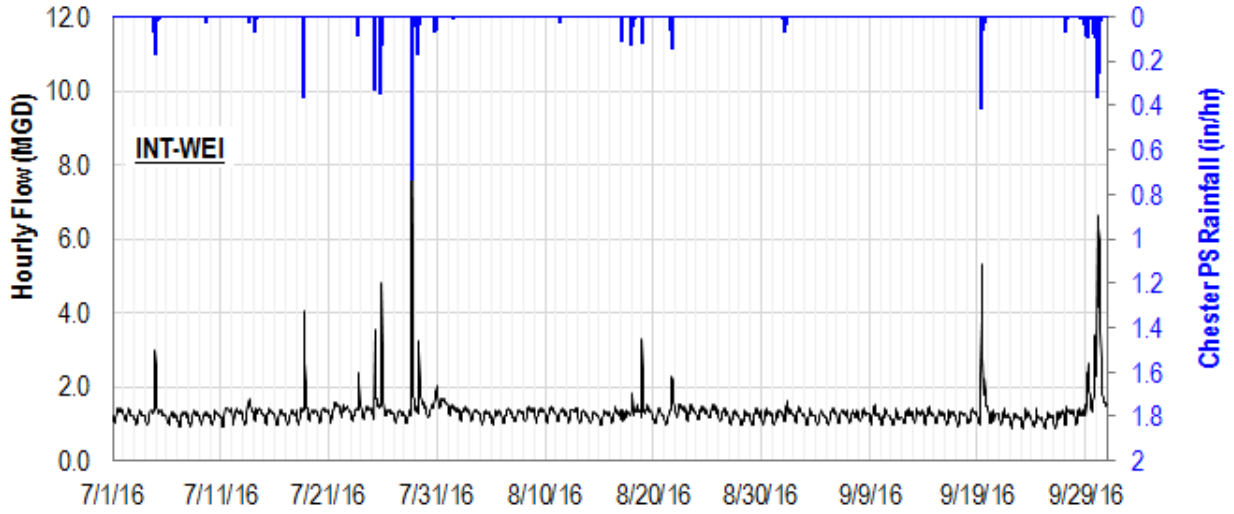


Figure 44: Flow Monitoring Data, INT-WEI

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

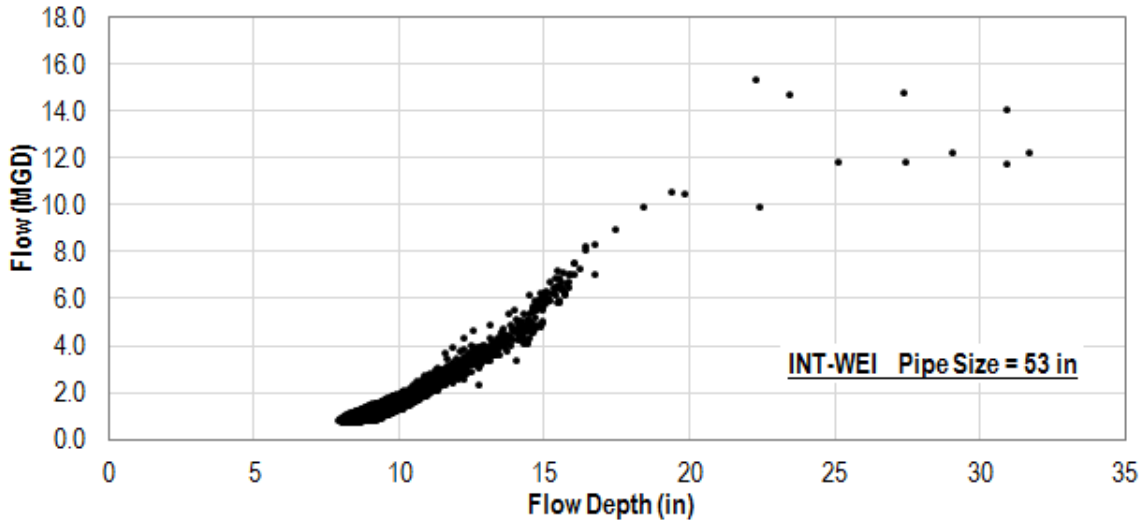


Figure 45: Flow Monitoring Data, Sep-1

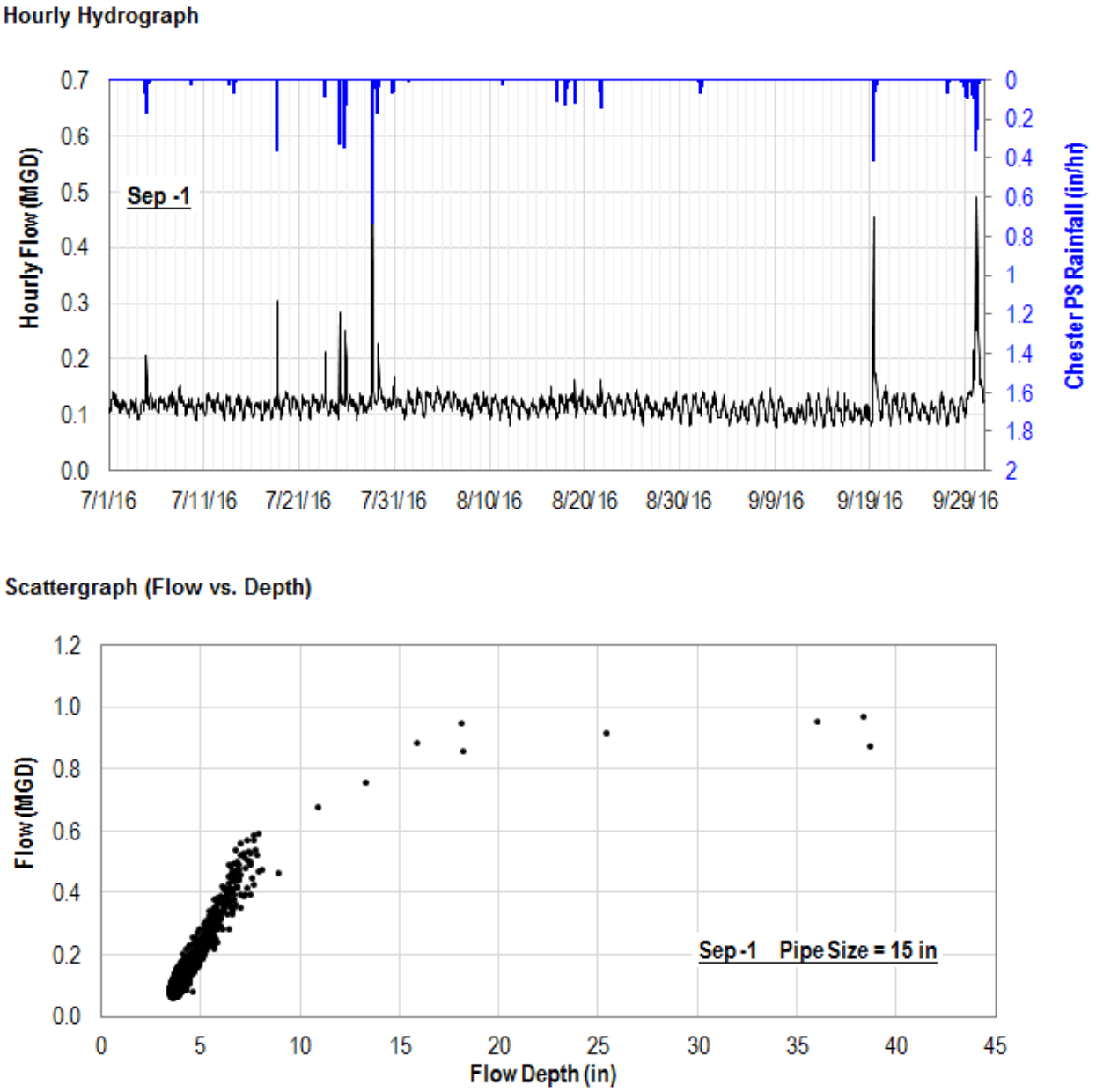
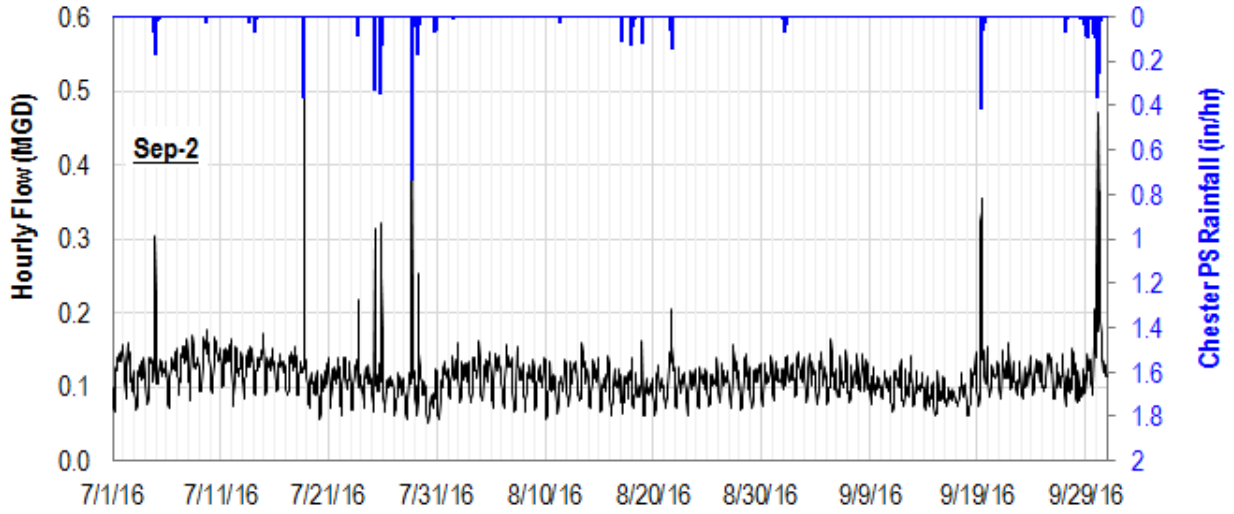


Figure 46: Flow Monitoring Data, Sep-2

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

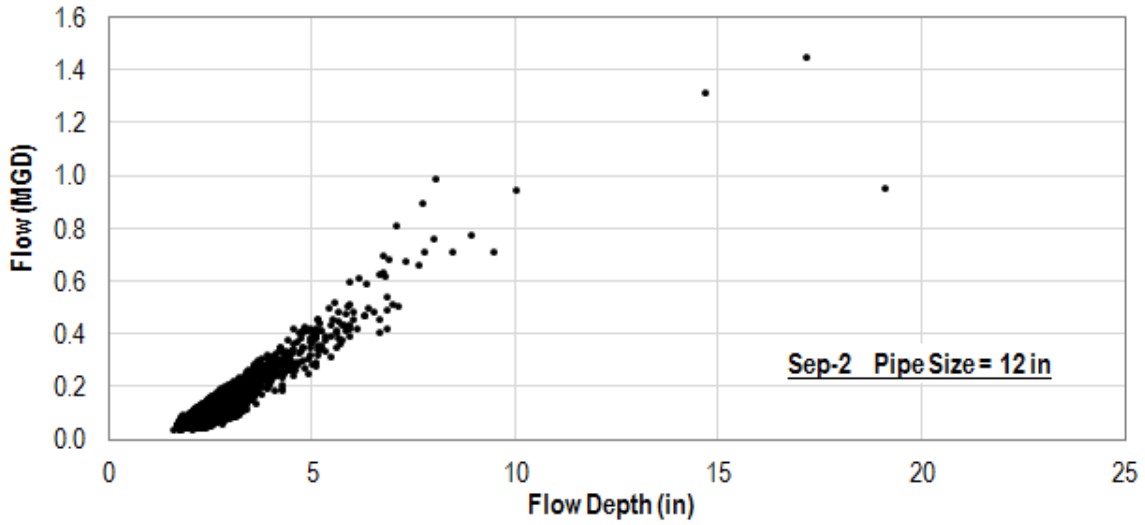


Figure 47: Flow Monitoring Data, Sep-3

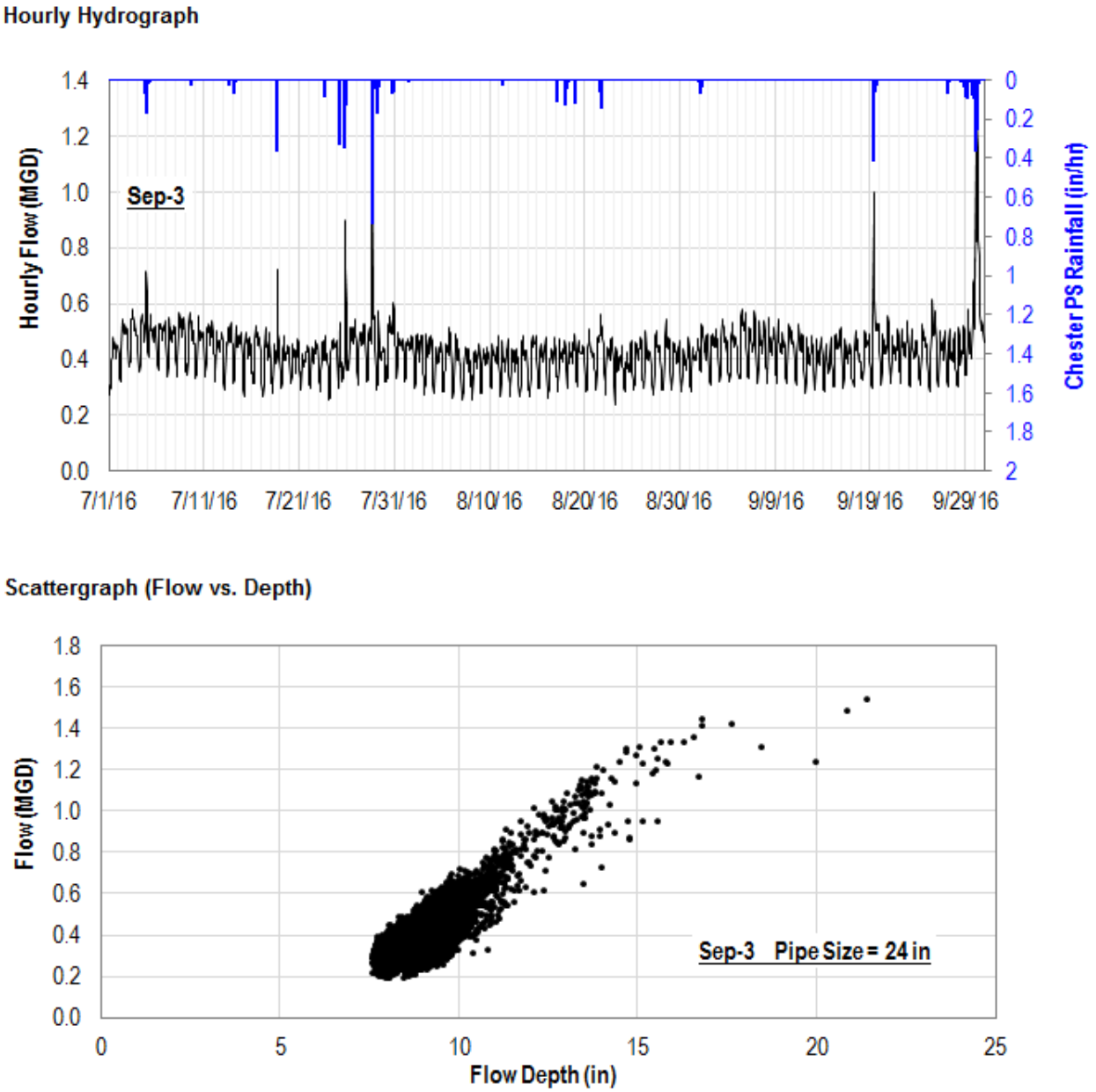
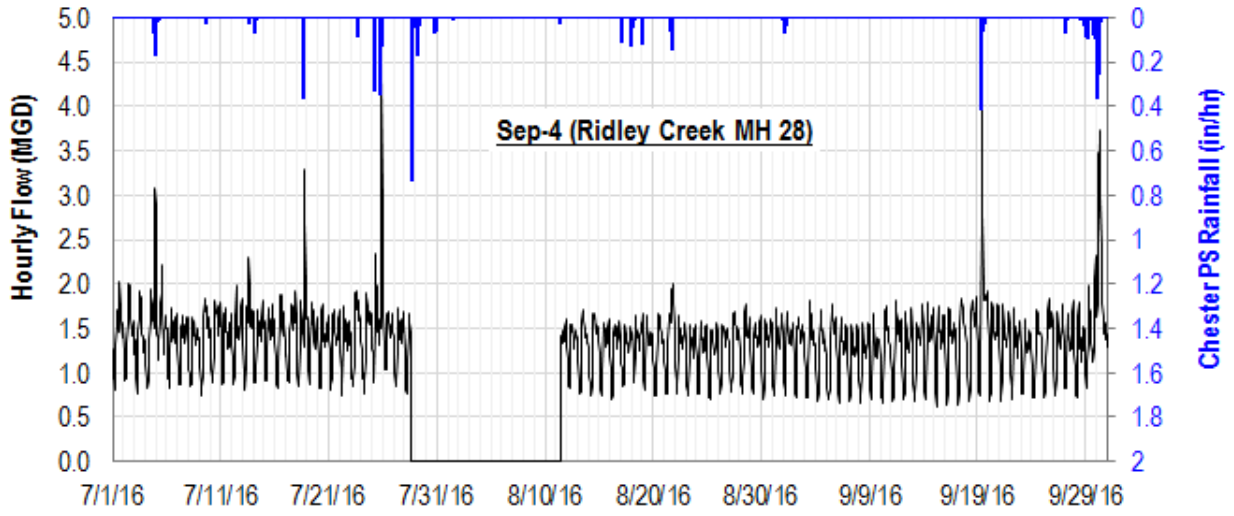


Figure 48: Flow Monitoring Data, Sep-4

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

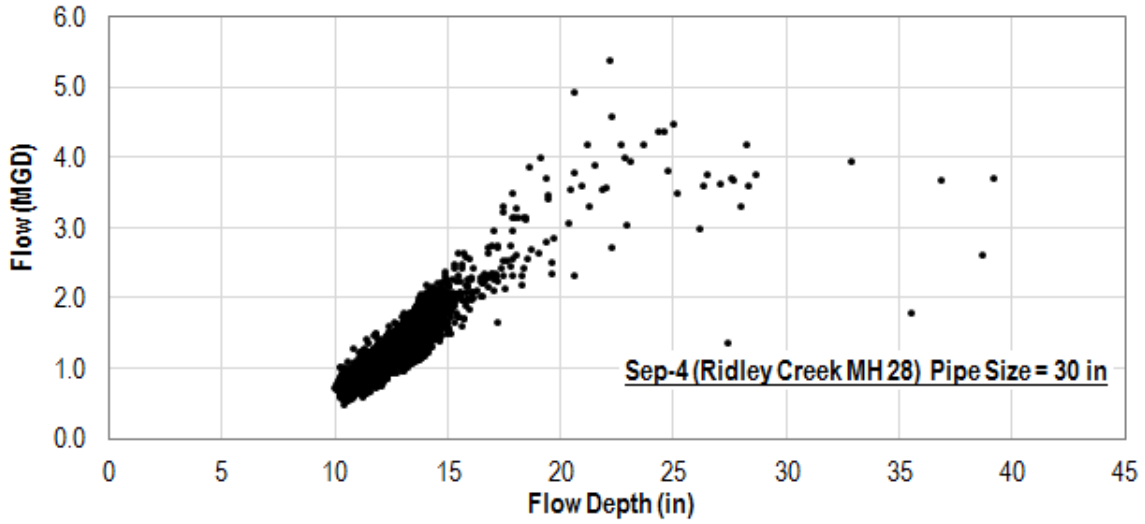
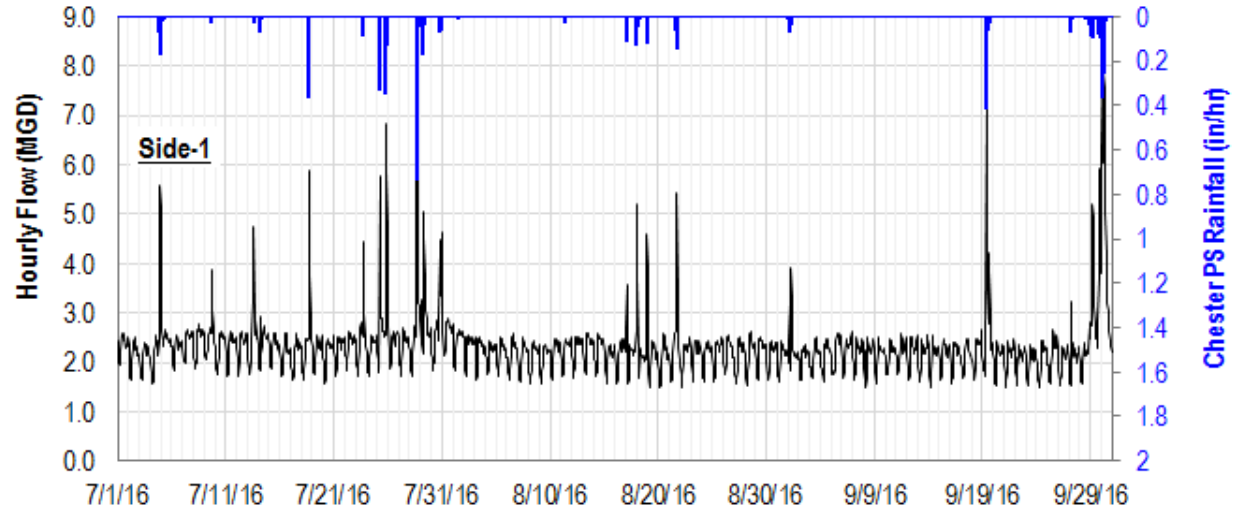


Figure 49: Flow Monitoring Data, Side-1

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

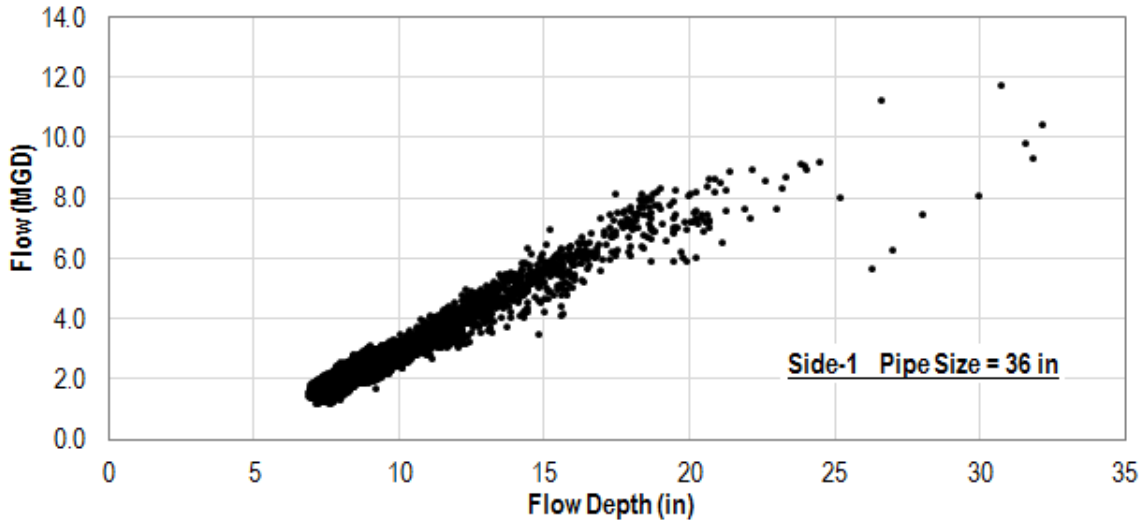
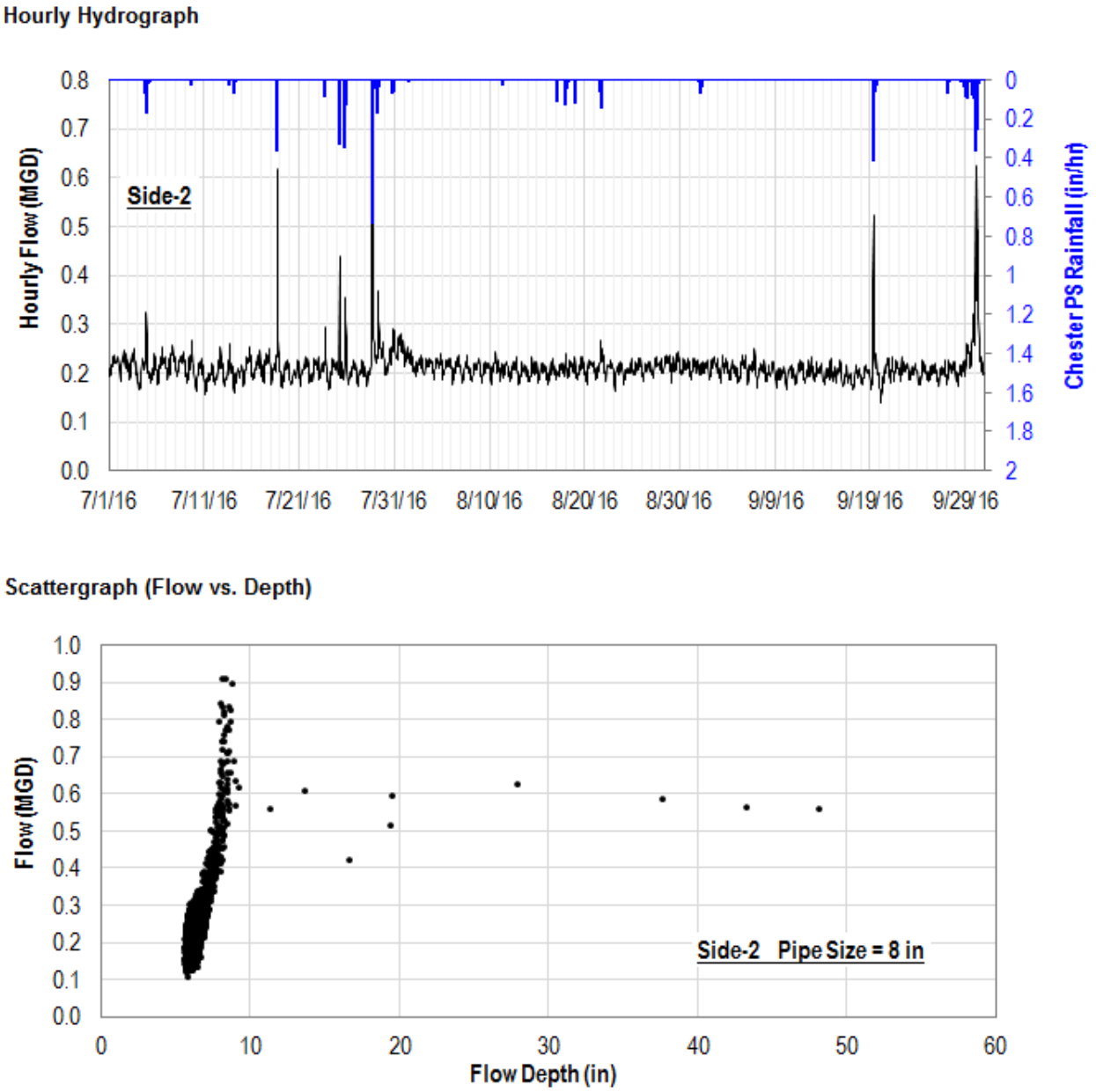


Figure 50: Flow Monitoring Data, Side-2



Greeley and Hansen LLC
1700 Market Street, Suite 2130
Philadelphia, PA 19103
(215) 563-3460
www.greeley-hansen.com

GREELEY AND HANSEN

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

Rainfall and Flow Monitoring Quarterly Report No. 3

(October 01, 2016 to December 31, 2016)

Final

January 2017

GREELEY AND HANSEN

REPORT SIGNATURE COVER SHEET

Signature of this cover signifies agreement with the content of the DELCORA Rainfall and Flow Monitoring Quarterly Report No. 3.

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	1/25/17 Date
DELCORA ENGINEERING		
Director of Engineering	Signature	1/25/17 Date
DELCORA OPERATIONS AND MAINTENANCE		
Director of Operation and Maintenance	Signature	1/25/17 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 October 1, 2016 to December 31, 2016.

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 17 rainfall events during reporting period. **Table 2** lists all 13 rainfall events with total precipitation greater than 0.1 inch.

Figure 1: Rain Gauge Locations

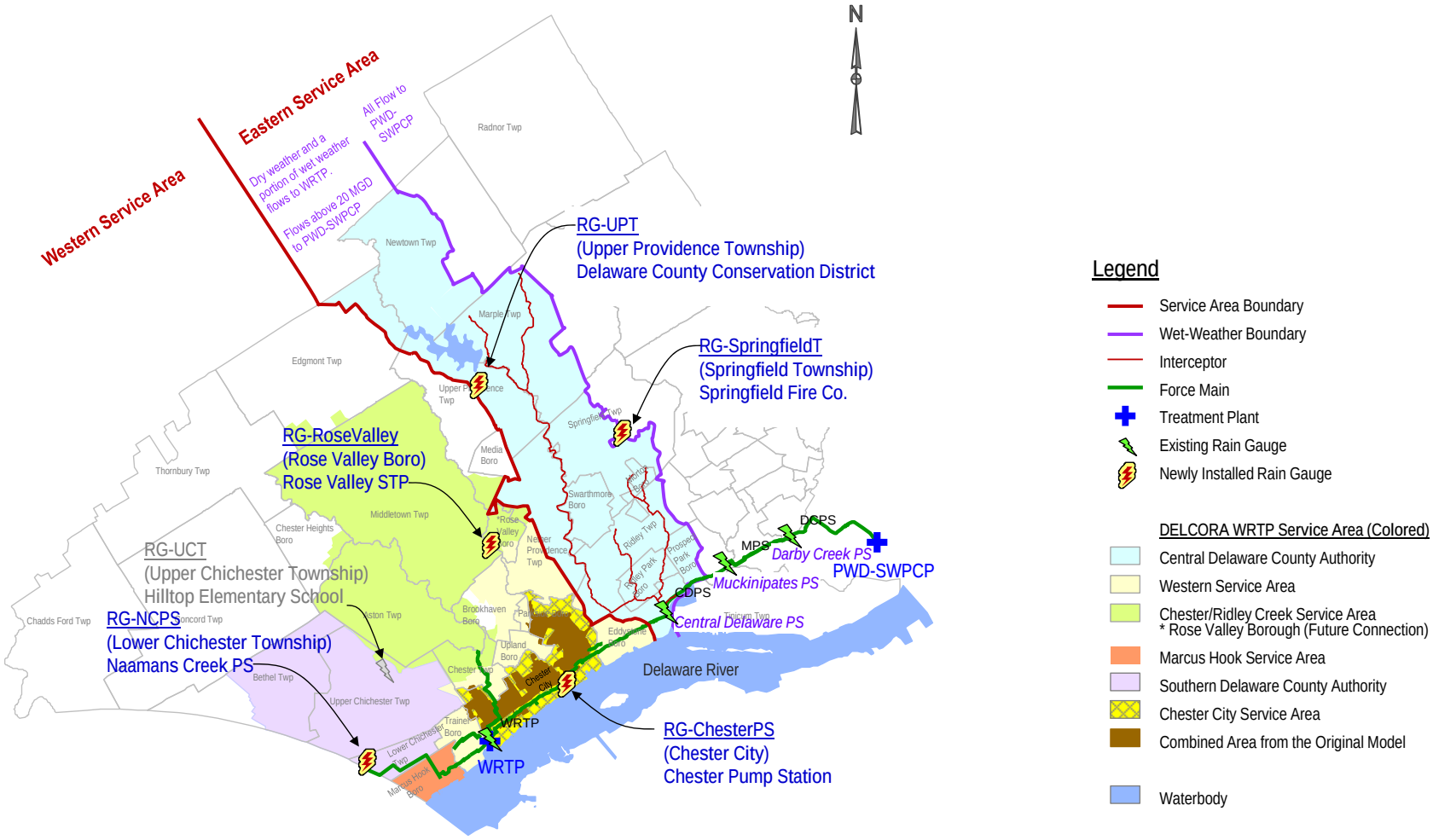


Figure 2 shows rainfall amounts at each rain gauge in each month for October, November and December. It is obvious that rainfall in the area has significant spatial and temporal variance. As an example, during this reporting period, the rain gauge at the Chester Pump Station (Chester PS) recorded a total rainfall of 6.65 inches while the gauge at the Upper Providence Township (UPT) recorded 8.52 inches. **Figure 3** shows the 1-hour rainfall profile for all of the 5 rain gauges.

Table 2: Rainfall Event Summary, 10/1/16 - 12/31/16

	Rain Event Starting Time	Rose Valley	Chester-PS	NCPS	Springfield	UPT
1	10/8/2016 13:25	0.91	1	1.1	0.82	1.05
2	10/21/2016 20:55	0.24	0.2	0.2	0.24	0.36
3	10/27/2016 8:30	0.45	0.54	0.71	0.32	0.43
4	10/30/2016 17:45	0.25	0.23	0.21	0.37	0.65
5	11/9/2016 7:25	0.26	0.23	0.31	0.29	0.33
6	11/19/2016 20:25	0.08	0.03	0.17	0.06	0.14
7	11/29/2016 5:30	1.74	1.84	2.13	2.39	2.37
8	12/5/2016 0:25	0.14	0.12	0.12	0.14	0.14
9	12/6/2016 13:35	0.8	0.69	0.22	0.92	0.99
10	12/12/2016 1:05	0.57	0.39	0.46	0.47	0.68
11	12/17/2016 7:20	0.82	0.79	0.89	0.85	0.61
12	12/24/2016 4:35	0.44	0.36	0.53	0.43	0.51
13	12/29/2016 6:30	0.31	0.23	0.28	0.25	0.26
	Subtotal (10/1/16-12/31/16)	**7.01**	**6.65**	**7.33**	**7.55**	**8.52**

Figure 2: Rainfall Event Summary, 10/1/16 - 12/31/16

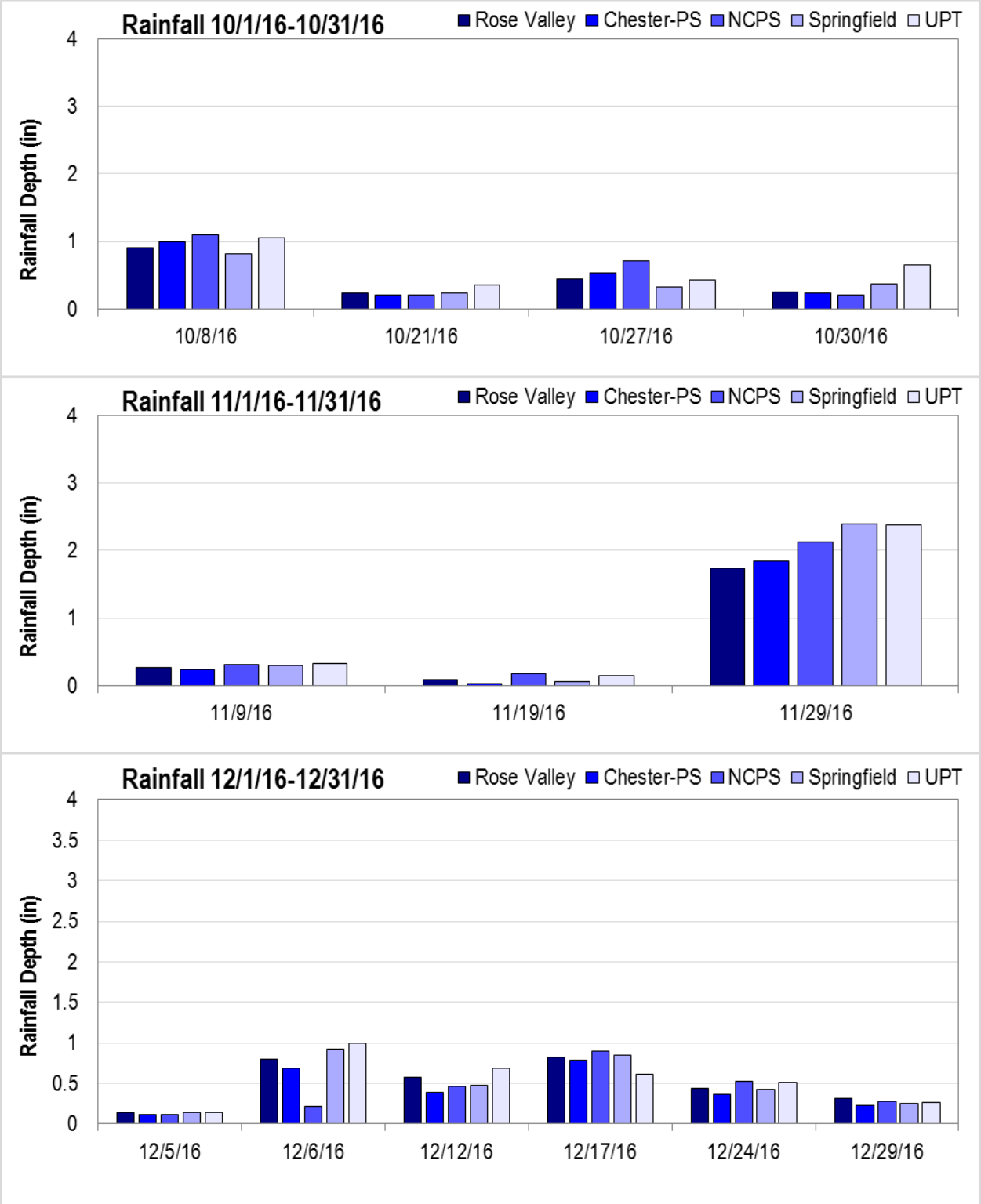
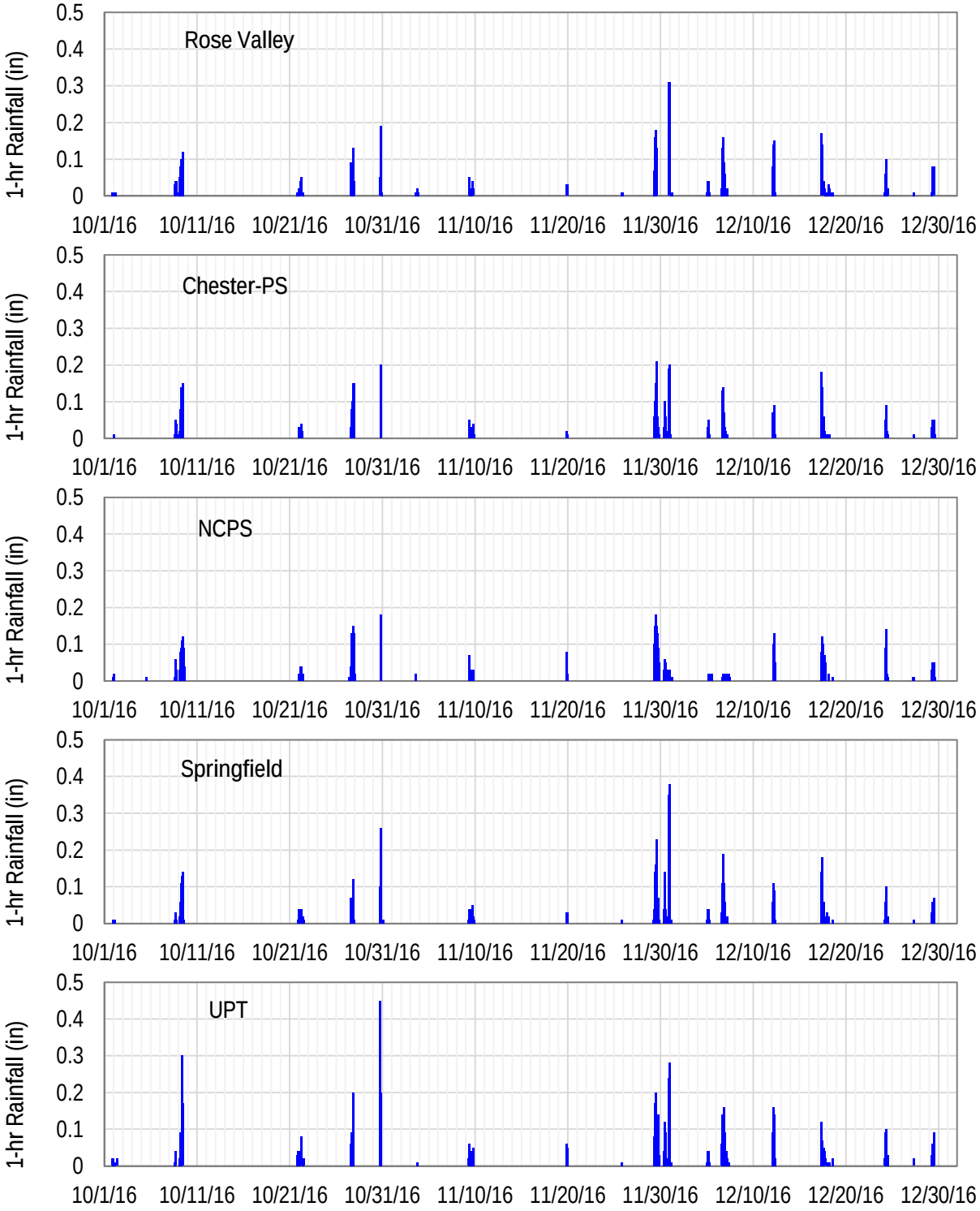


Figure 3: Hourly Rainfall Profile



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. Two storms were recorded with total precipitation volumes greater than 1 inch. Both events (10/8/17 and 11/29/17) are less than 1-year events.

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

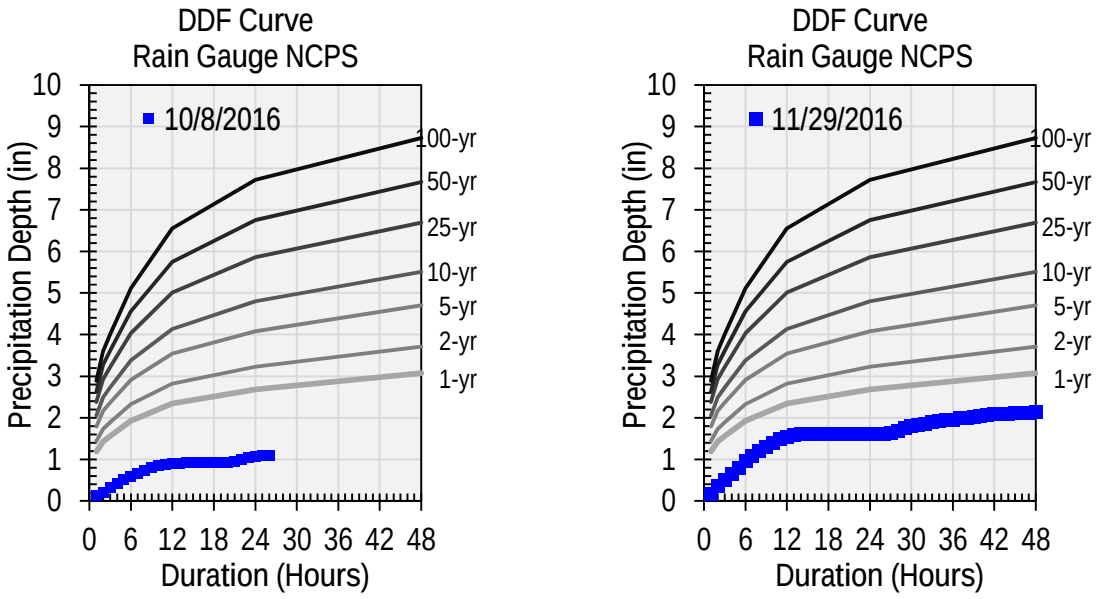


Figure 5 shows Duration-Depth-Frequency (DDF) plot for RG_UPT. Two storms were recorded with total precipitation volumes greater than 1 inch. Both events (10/8/17 and 11/29/17) are less than 1-year events.

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

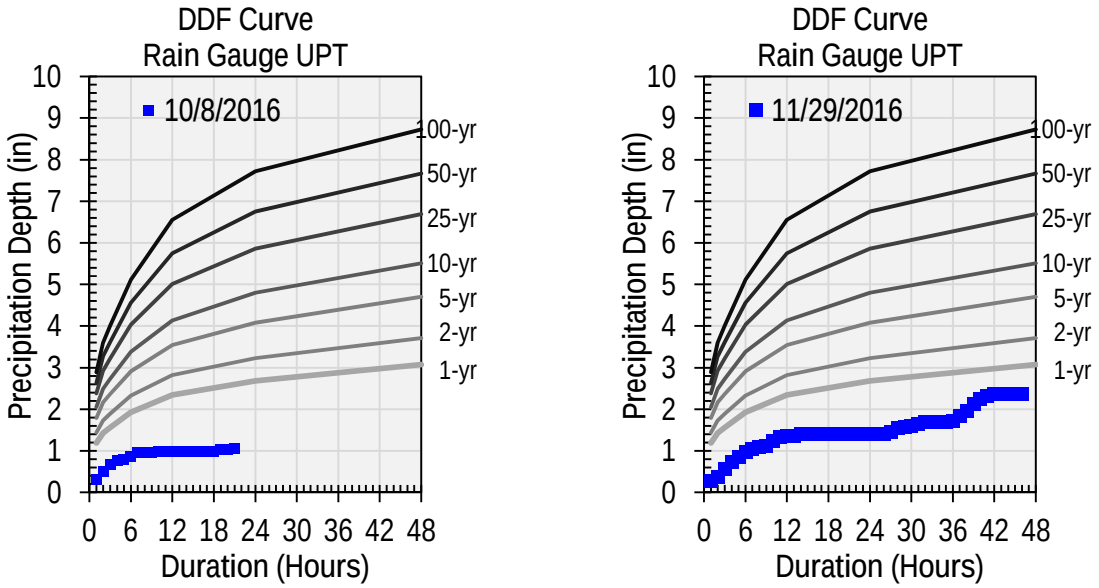
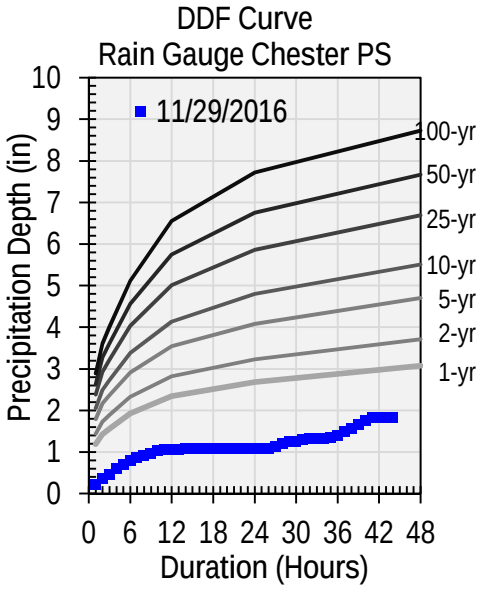


Figure 6 shows Duration-Depth-Frequency (DDF) plot for RG_ChesterPS. Only one storm (11/29/17) was recorded with a total precipitation volume greater than 1 inch. It is less than a 1-year event.

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



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 7**. **Figure 8** 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 9**.

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 7: Existing and Newly Installed Flow Meter Locations

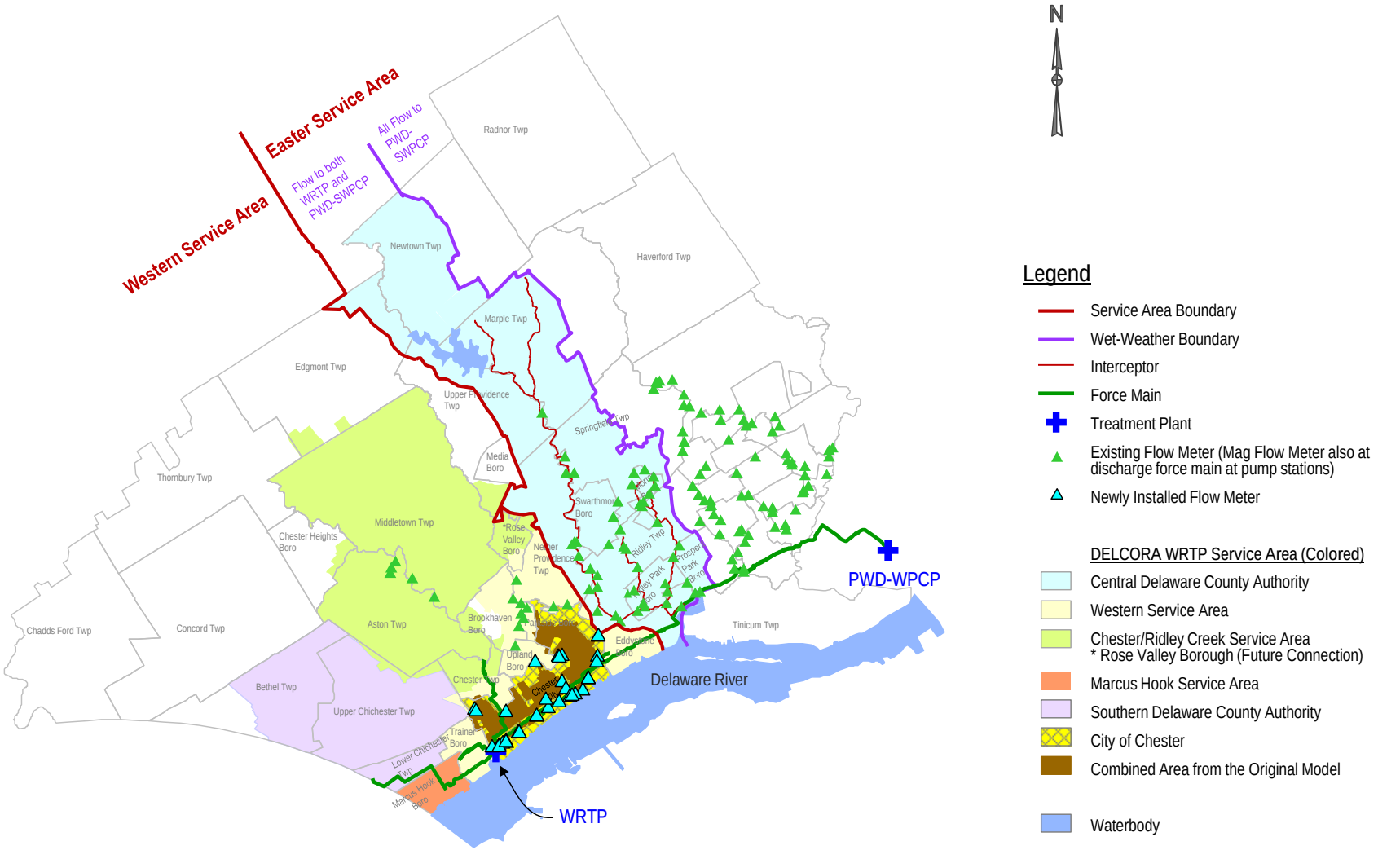


Figure 8: Newly Installed Flow Meter Locations

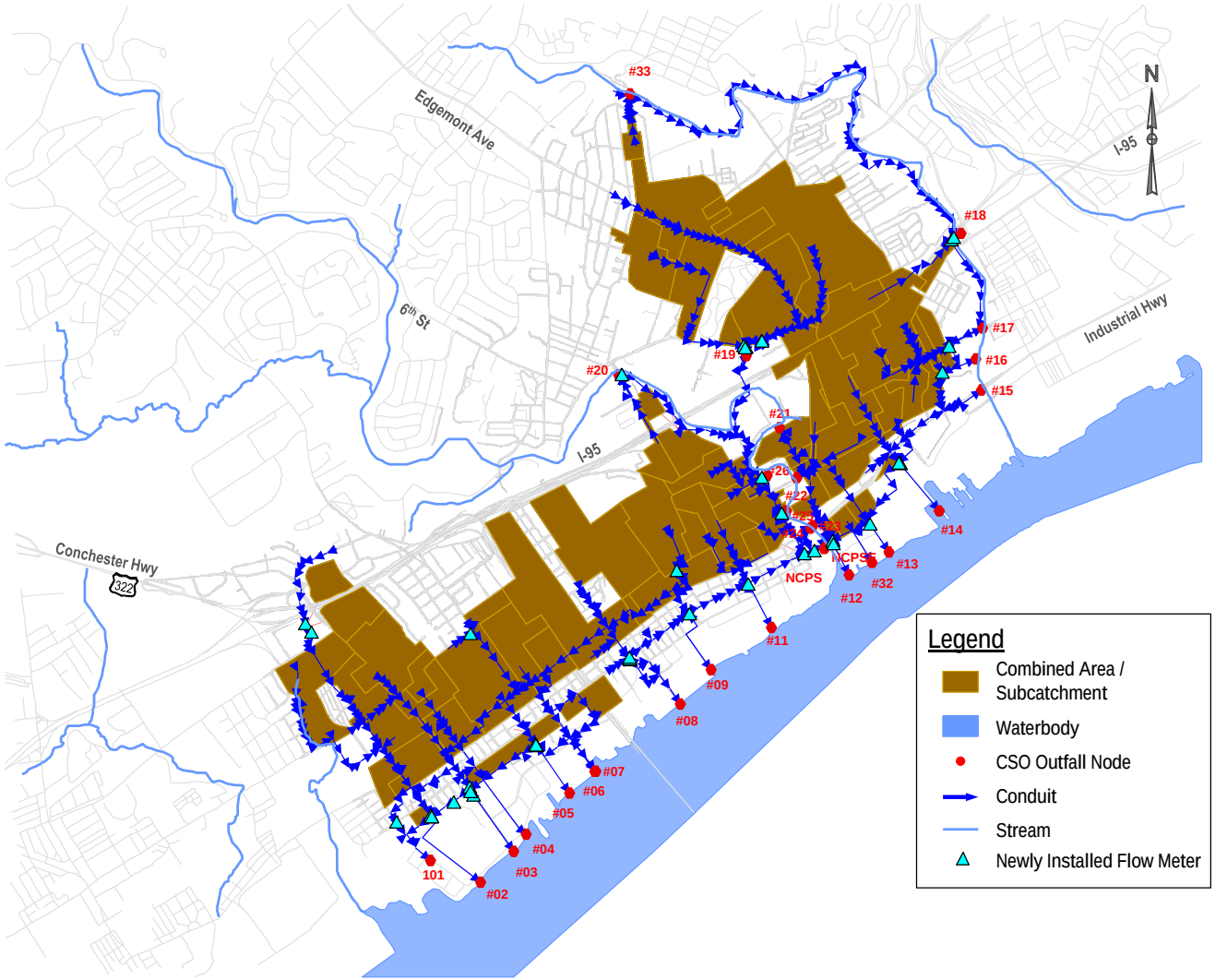
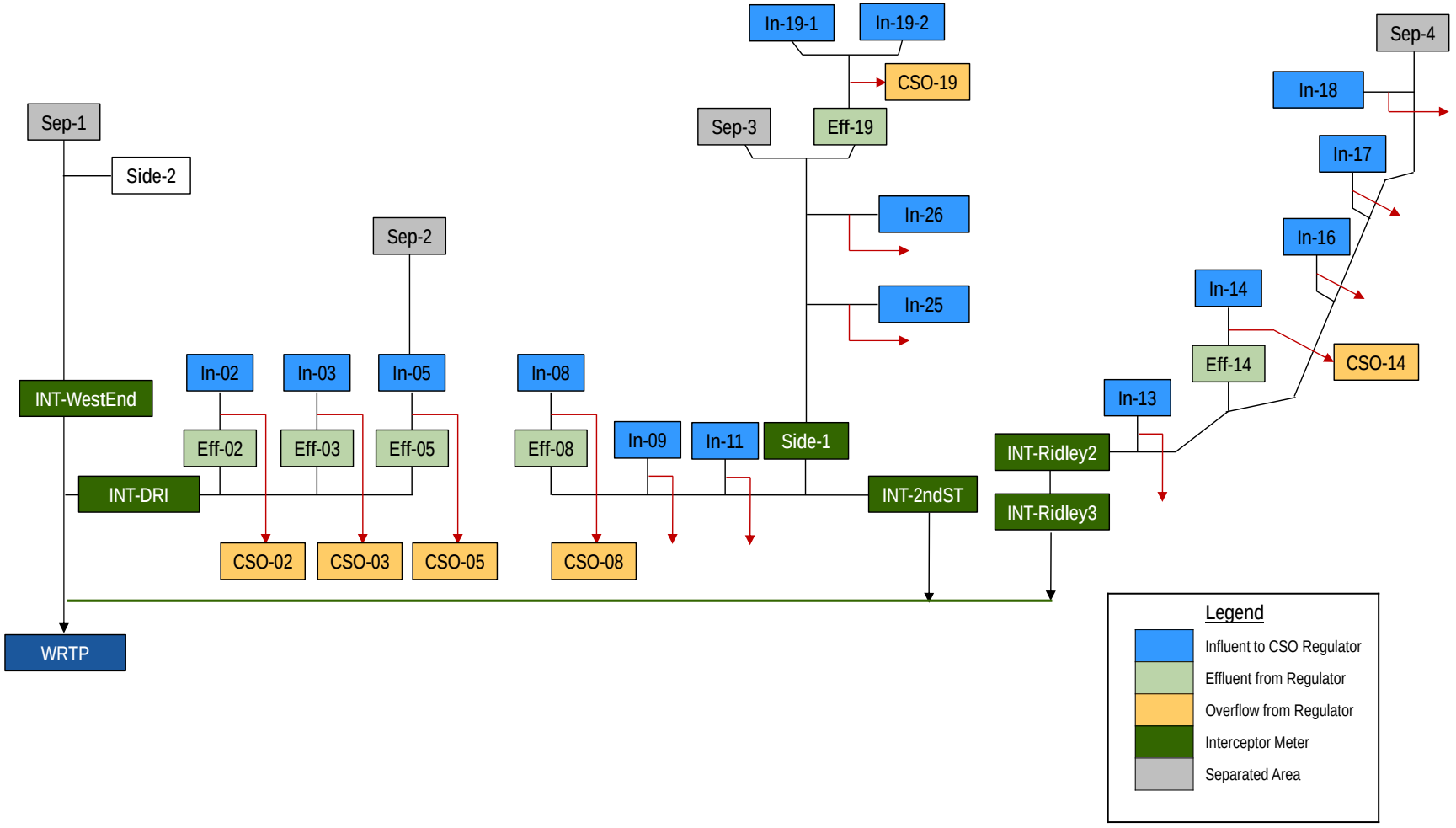


Figure 9: Flow Monitoring Schematic



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 10**. 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 11** 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 12** to **Figure 50**, 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	6.25	0.29	21.7	Free flow most of the time
Eff-02	1.19	0.26	4.5	Surcharged under common conditions
CSO-02	5.01	0.04		Free flow most of the time
In-03	9.46	0.28	33.6	Free flow most of the time
Eff-03	1.52	0.24	6.2	Surcharged under large storms
CSO-03	8.85	0.03		Free flow most of the time
In-05	22.65	0.86	26.4	Backwater observed
Eff-05	2.30	0.75	3.1	Severely surcharged under common conditions
CSO-05	18.83	0.10		Free flow most of the time, backwater observed
In-08	21.99	0.80	27.5	Free flow most of the time
Eff-08	5.21	0.69	7.5	Free flow most of the time
CSO-08	22.36	0.11		Free flow most of the time
In-09	7.09	0.13	53.8	Free flow most of the time
In-10	4.55	0.18	25.6	Free flow most of the time
In-11	9.04	0.22	41.2	Free flow most of the time
In-13	28.52	0.34	82.8	Free flow most of the time, backwater during large storms
In-14	14.44	0.43	34.0	Backwater observed
Eff-14	4.22	0.38	11.0	Free flow mostly, backwater and surcharge during large storms
CSO-14	11.33	0.03		Free flow most of the time
In-16	12.95	0.33	38.7	Free flow most of the time, backwater during large storms
In-17	6.90	0.17	41.2	Backwater observed
In-18	10.05	0.16	61.7	Free flow most of the time
In-19-1	6.24	0.69	9.1	Free flow most of the time
In-19-2	11.62	0.57	20.2	Free flow most of the time
Eff-19	4.02	1.27	3.2	Free flow most of the time
CSO-19	10.72	0.07		Free flow most of the time
In-25	12.55	0.15	84.7	Free flow mostly, backwater observed
In-26	5.80	0.36	16.1	Free flow mostly
INT-2nd St	18.15	3.59	5.1	Free flow mostly, surcharge and backwater during large storms
INT-DRI	4.08	1.46	2.8	Severe surcharge and backwater observed
INT-Ridley 2	14.26	3.11	4.6	Free flow mostly, surcharge and backwater observed
INT-Ridley 3	13.94	3.35	4.2	Free flow mostly, surcharge and backwater observed
INT-WEI	11.34	1.34	8.5	Free flow mostly
Sep-1	0.65	0.12	5.5	Free flow mostly
Sep-2	0.54	0.11	4.8	Free flow mostly
Sep-3	1.26	0.43	2.9	Free flow mostly
Sep-4	4.29	1.35	3.2	Free flow mostly
Side-1	8.44	2.35	3.6	Free flow mostly, surcharge and backwater observed
Side-2	0.68	0.21	3.2	Free flow mostly

Figure 10: Dry Weather Flow Balance Schematic

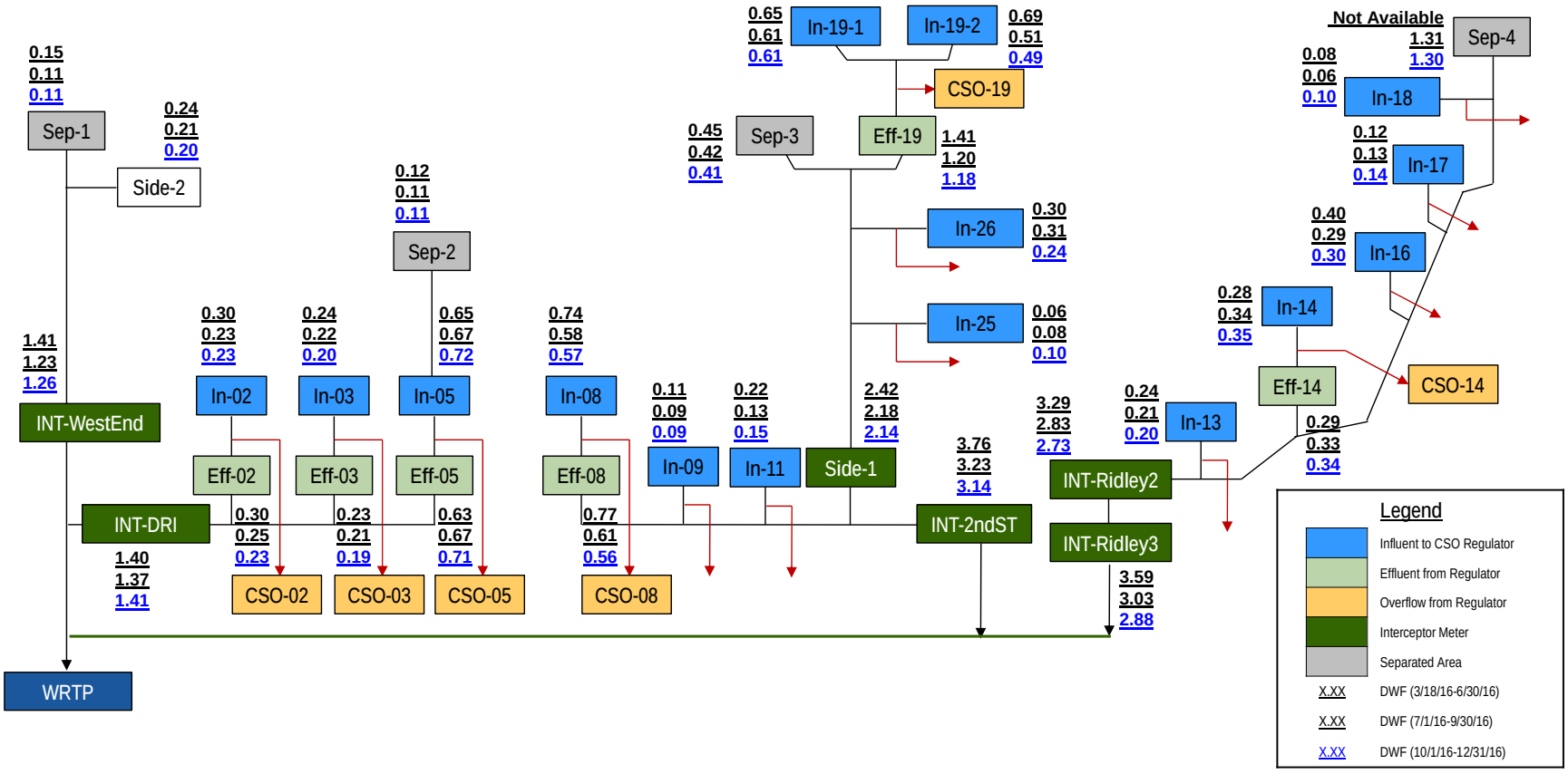


Figure 11: Flow Hydrograph In-08 and Eff-08

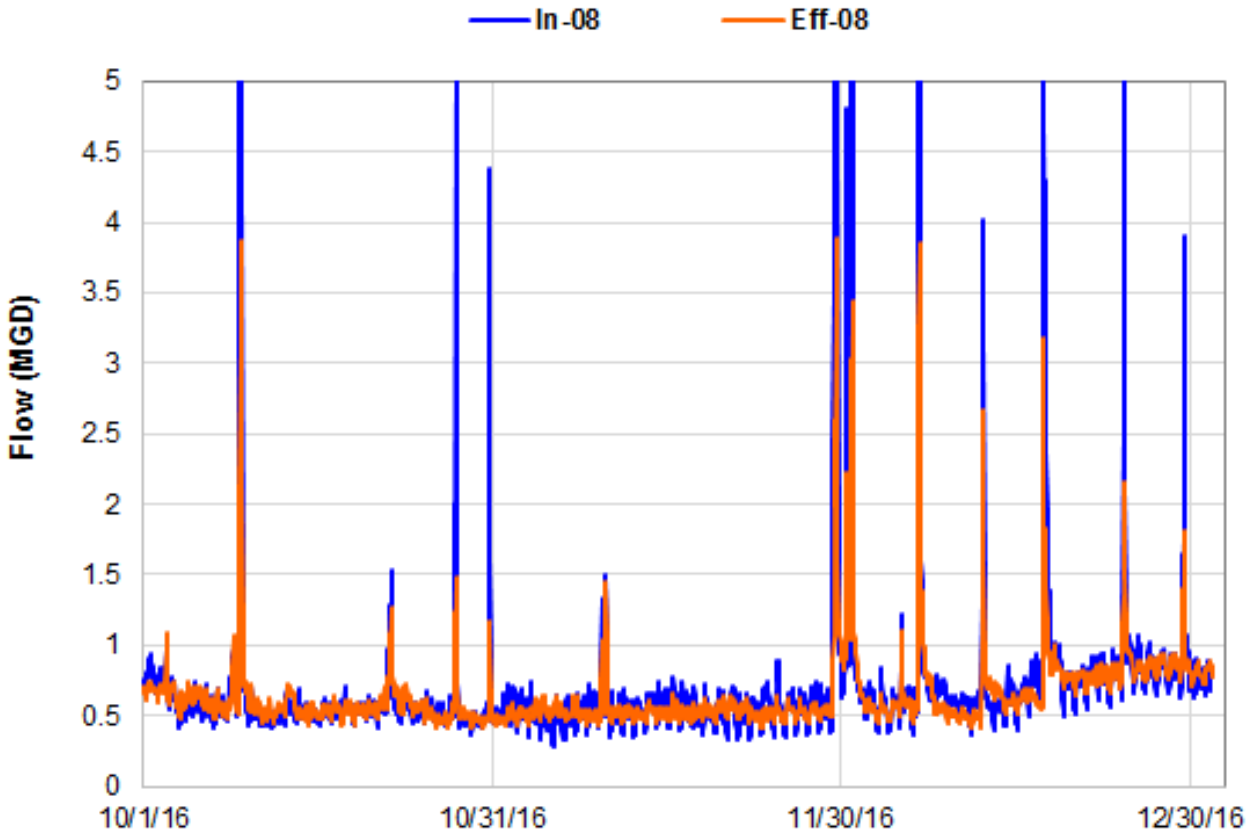
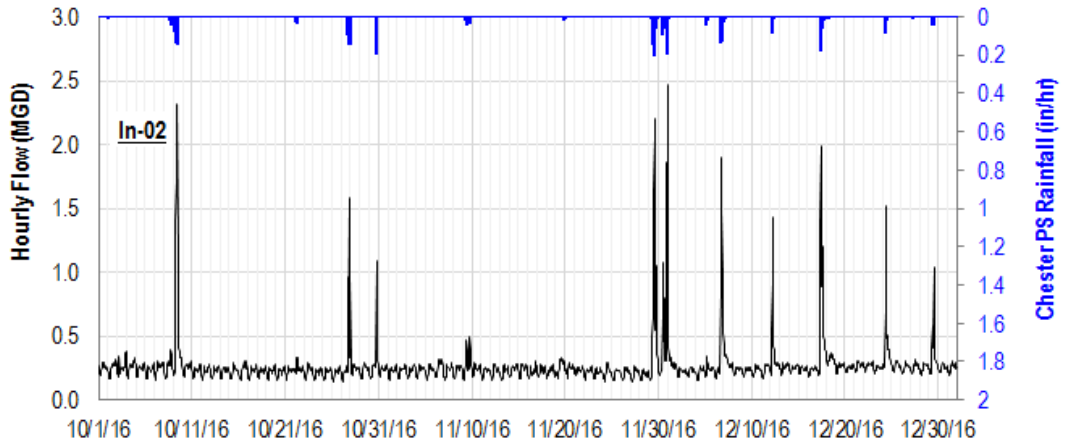
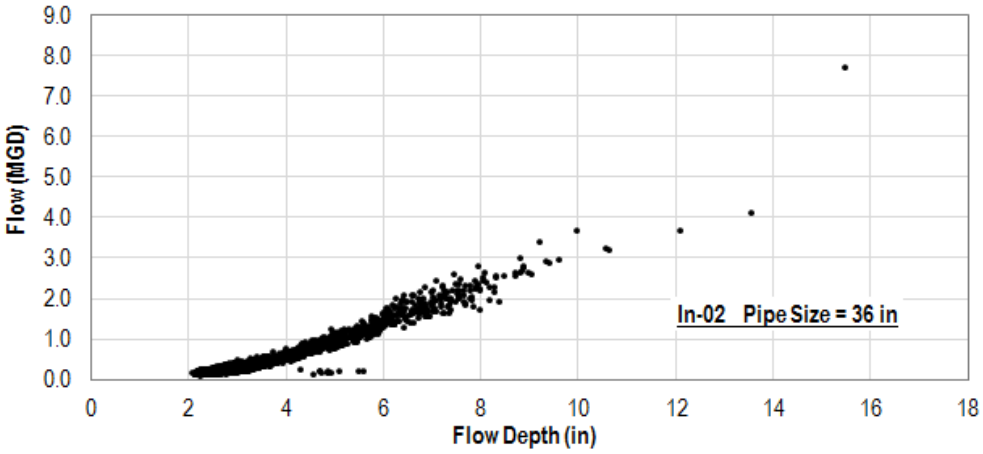


Figure 12: Flow Monitoring Data, In-02

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#02 Influent , Effluent and Overflow

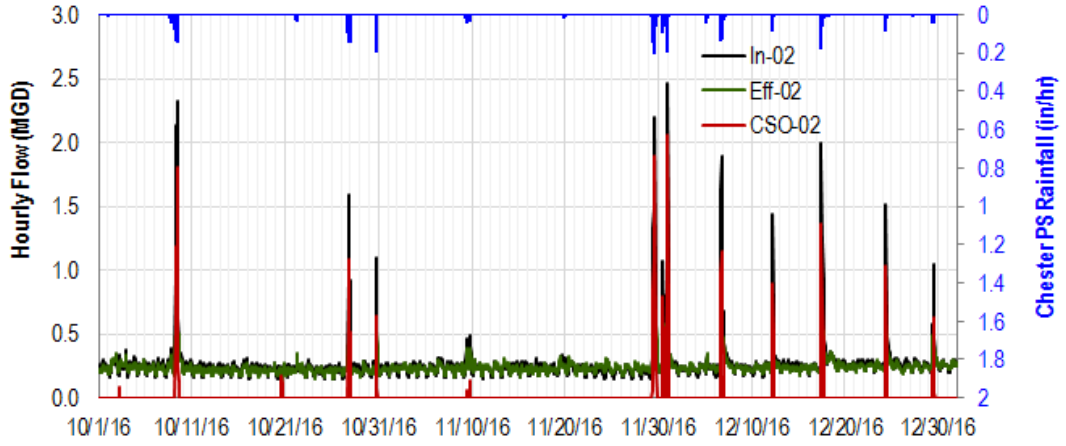


Figure 13: Flow Monitoring Data, EFF-02

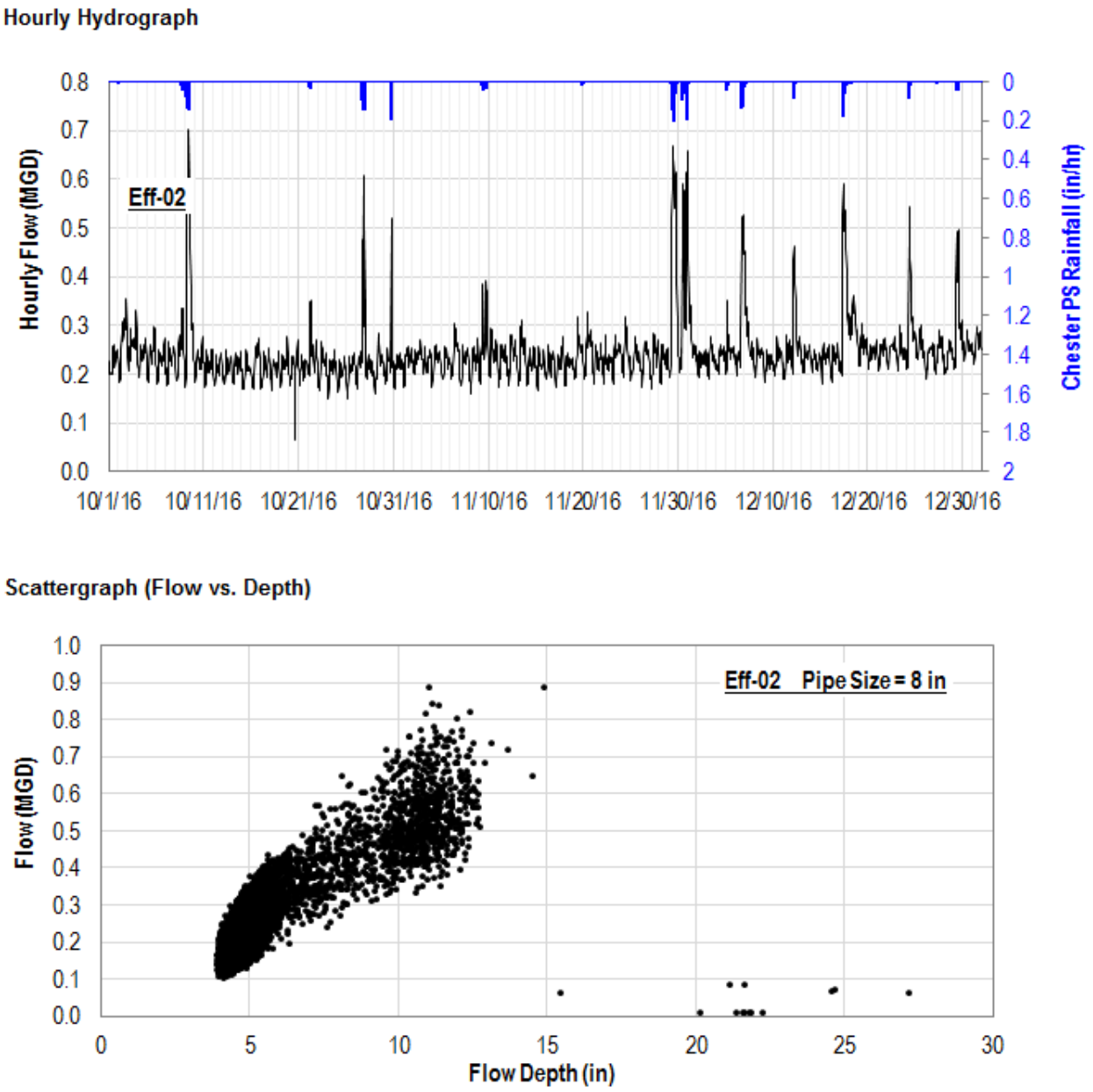
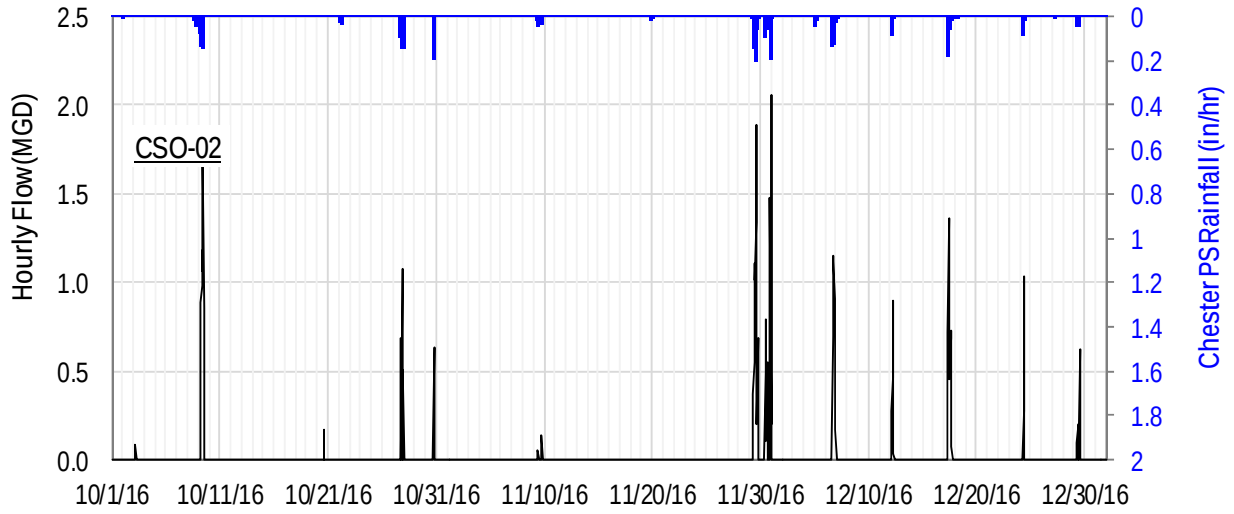


Figure 14: Flow Monitoring Data, CSO-02

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

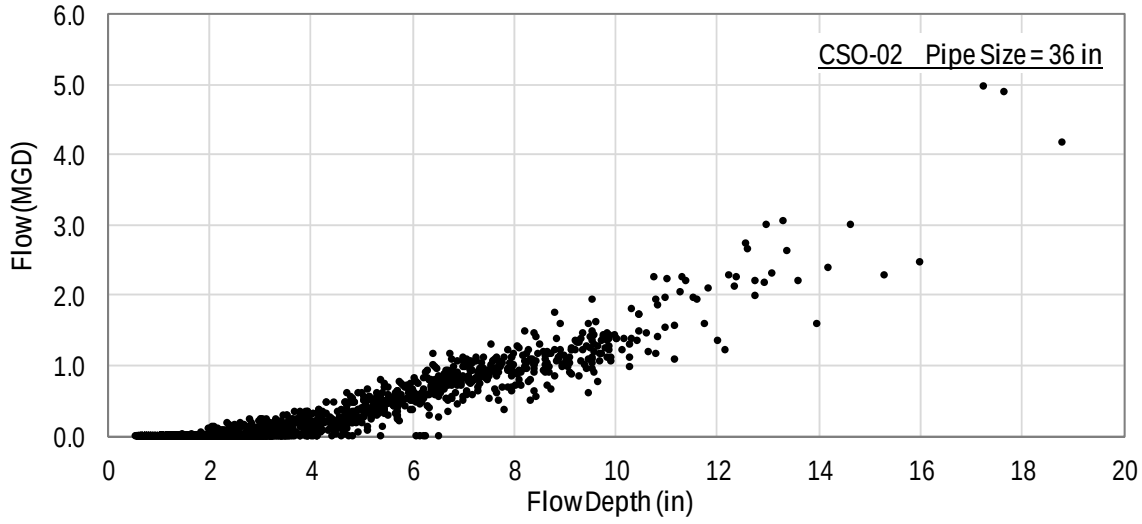
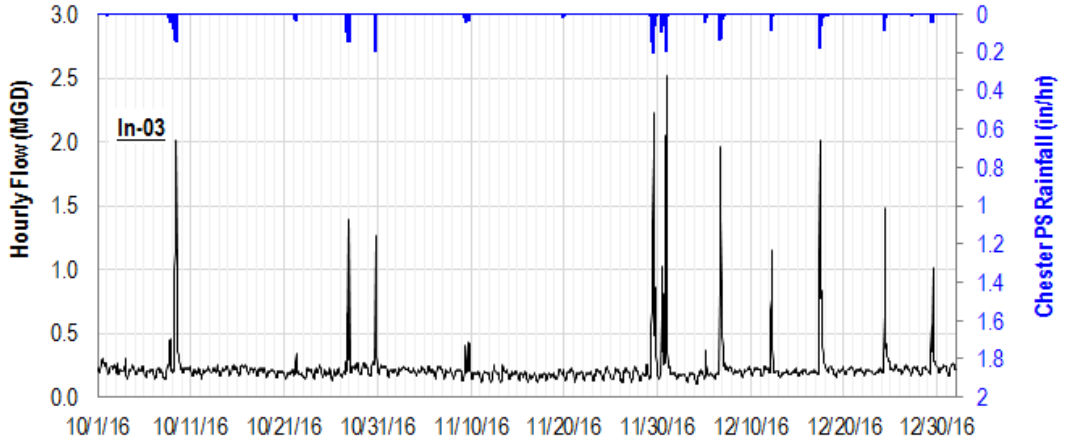
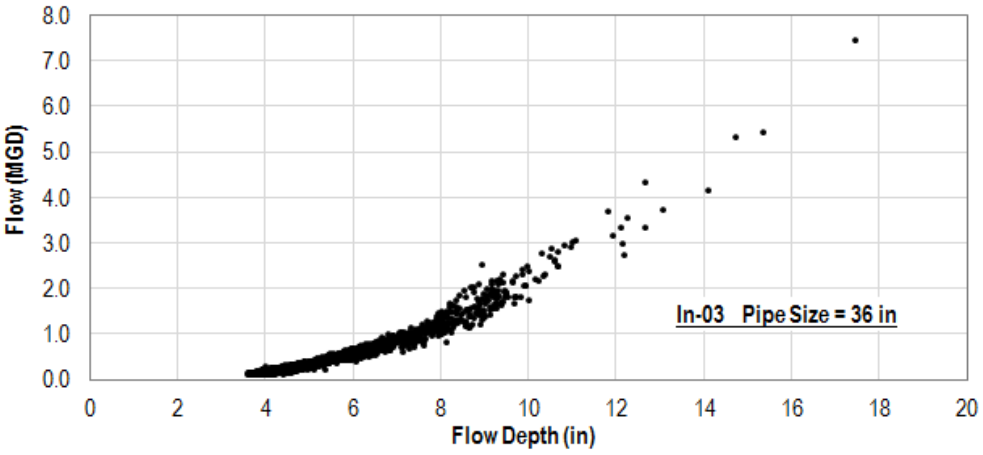


Figure 15: Flow Monitoring Data, IN-03

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#03 Influent , Effluent and Overflow

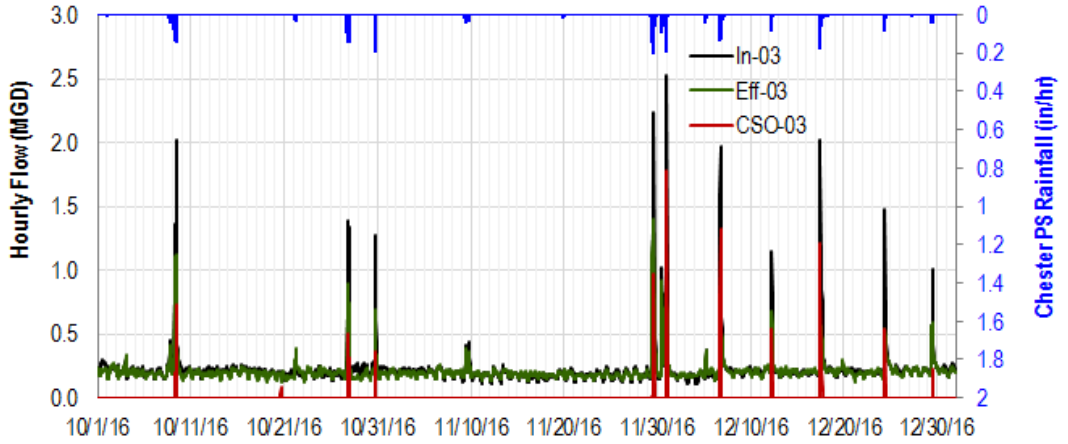


Figure 16: Flow Monitoring Data, Eff-03

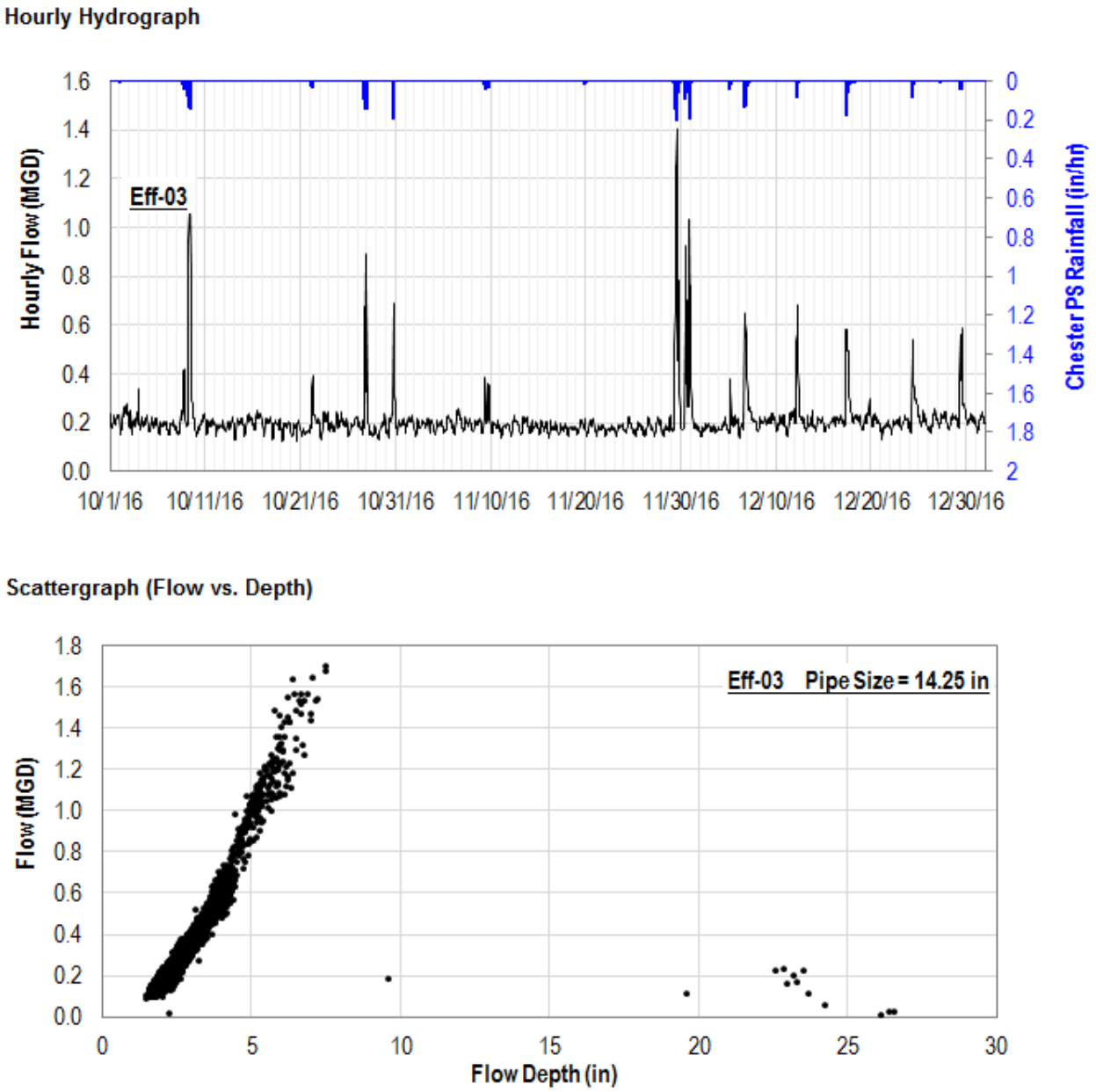


Figure 17: Flow Monitoring Data, CSO-03

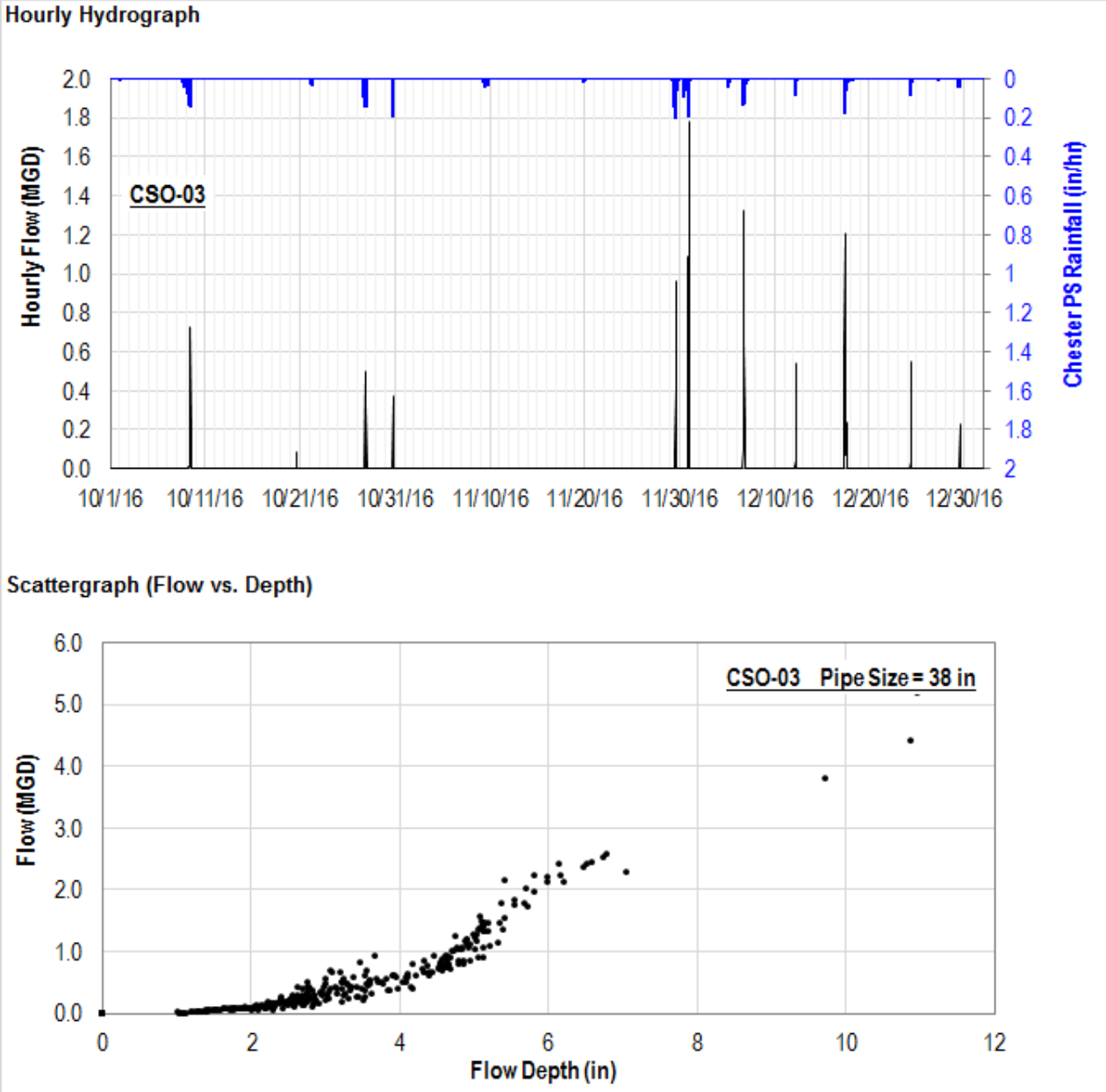
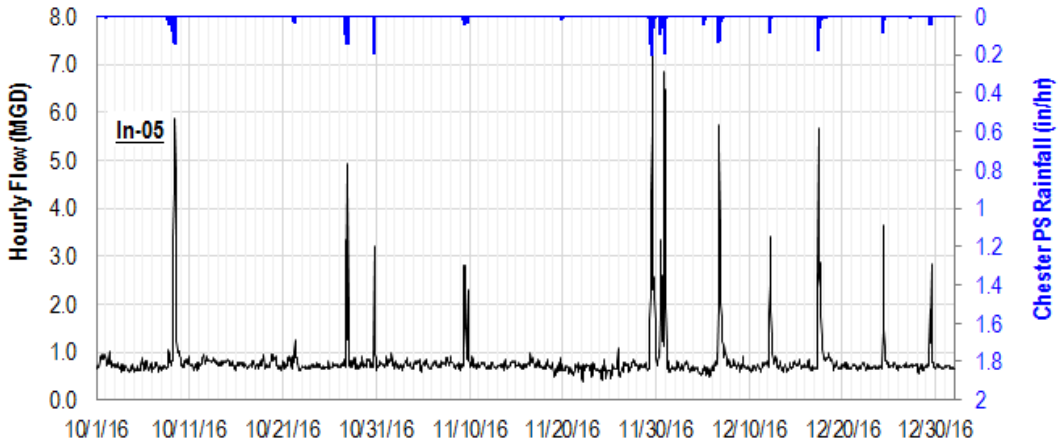
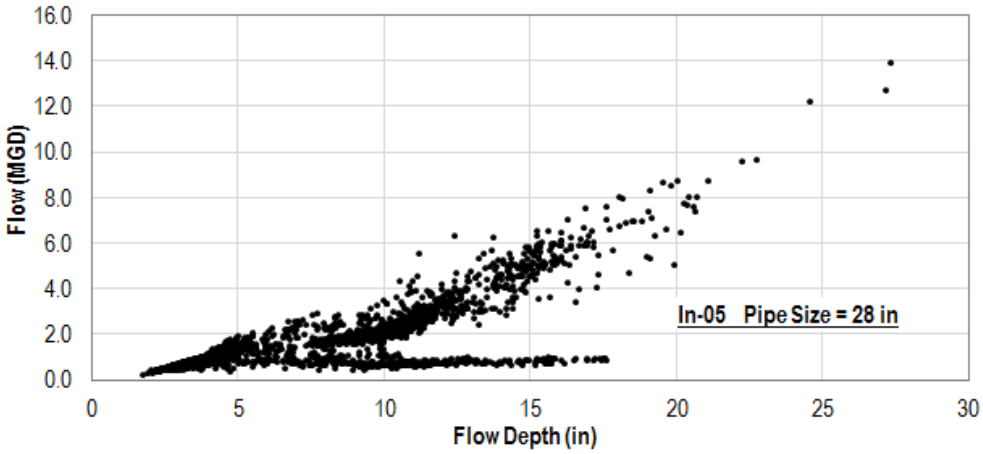


Figure 18: Flow Monitoring Data, IN-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#05 Influent , Effluent and Overflow

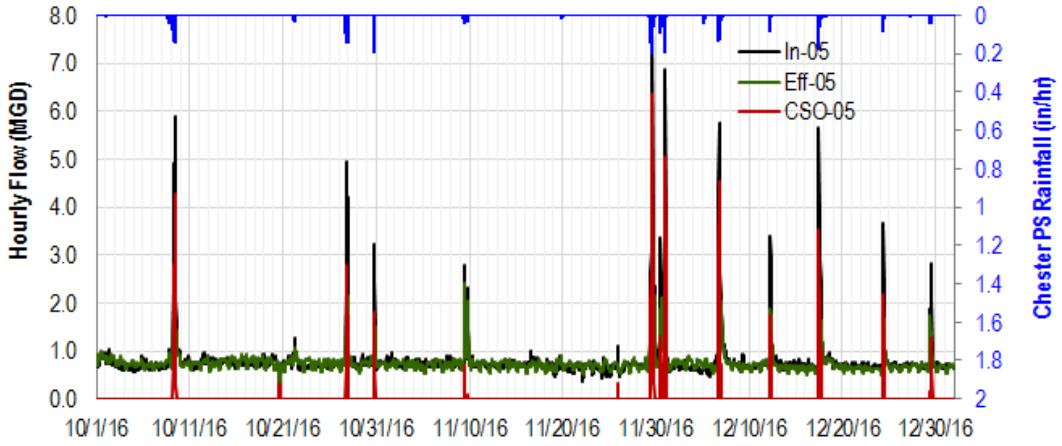
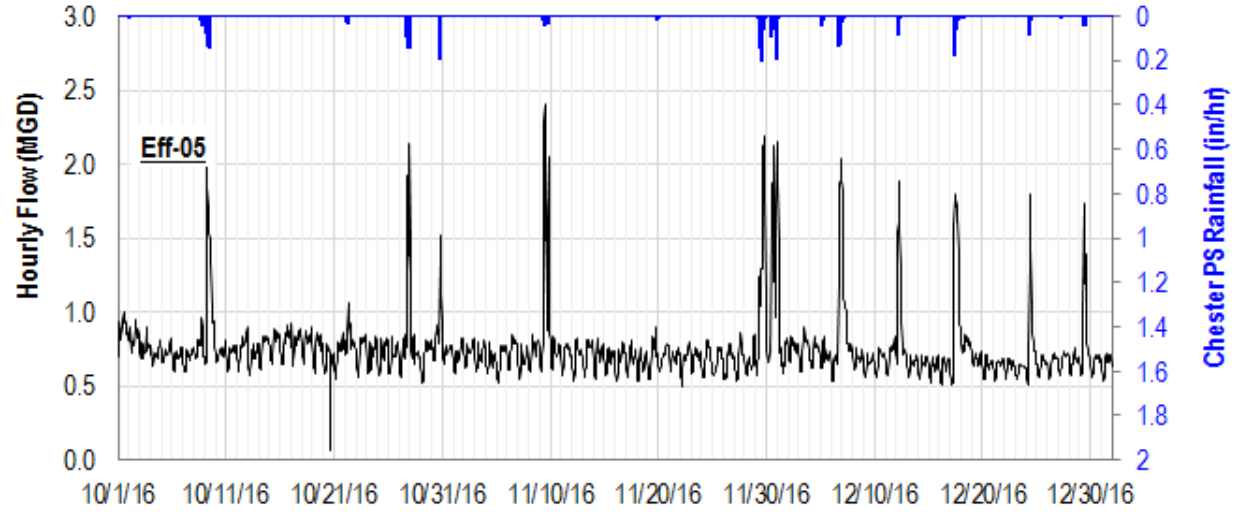


Figure 19: Flow Monitoring Data, Eff-05

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

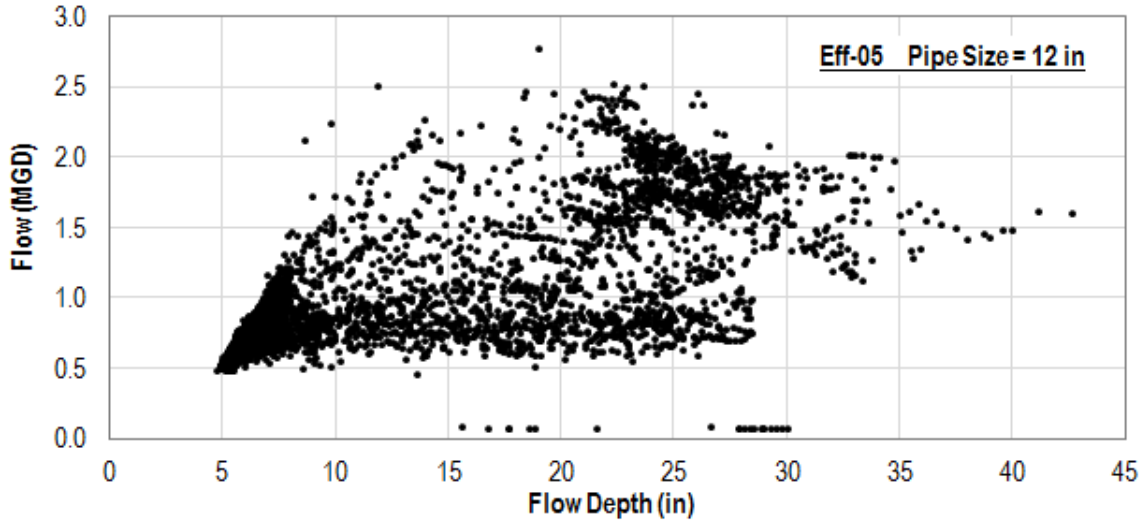


Figure 20: Flow Monitoring Data, CSO-05

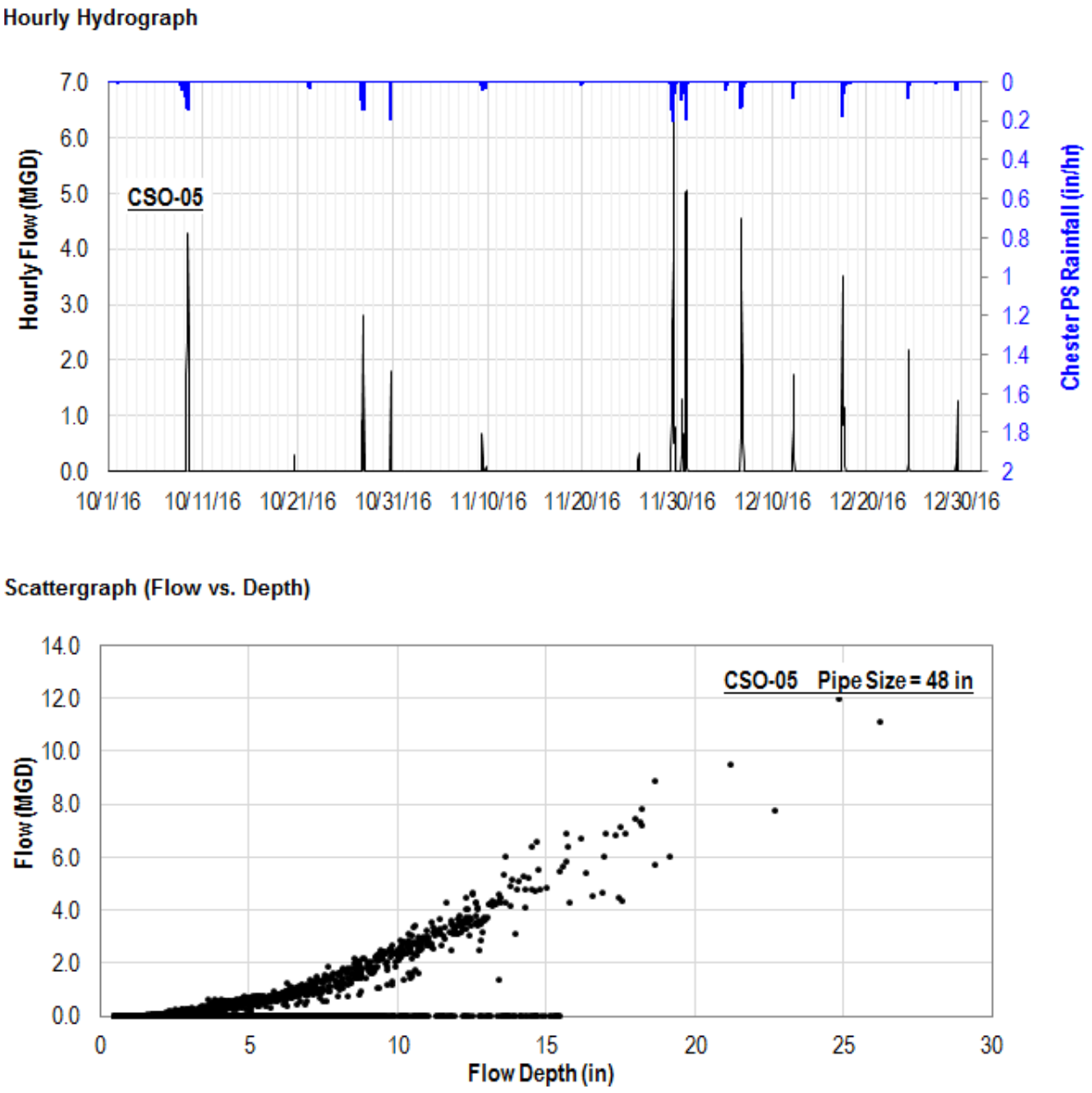


Figure 21: Flow Monitoring Data, IN-08

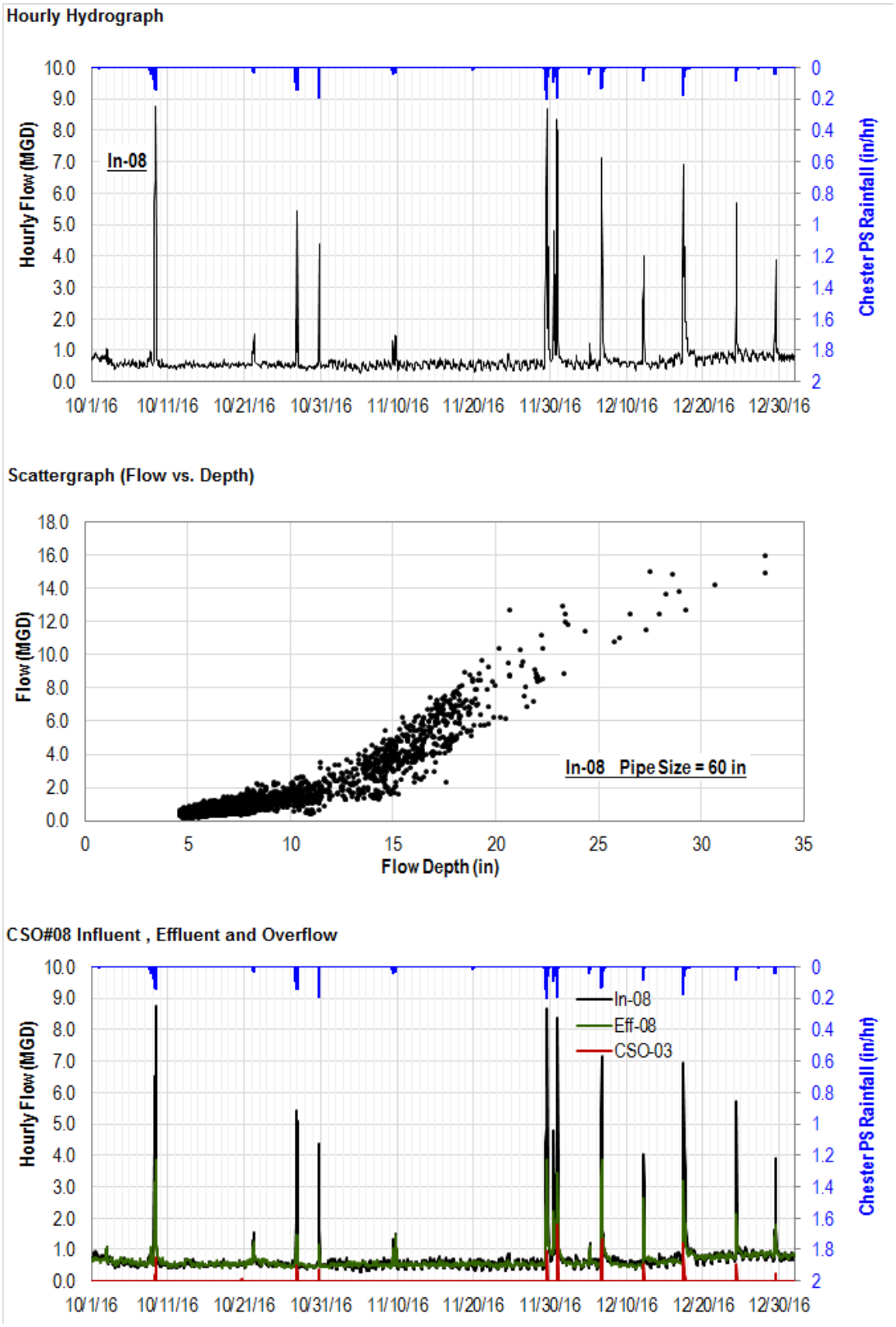
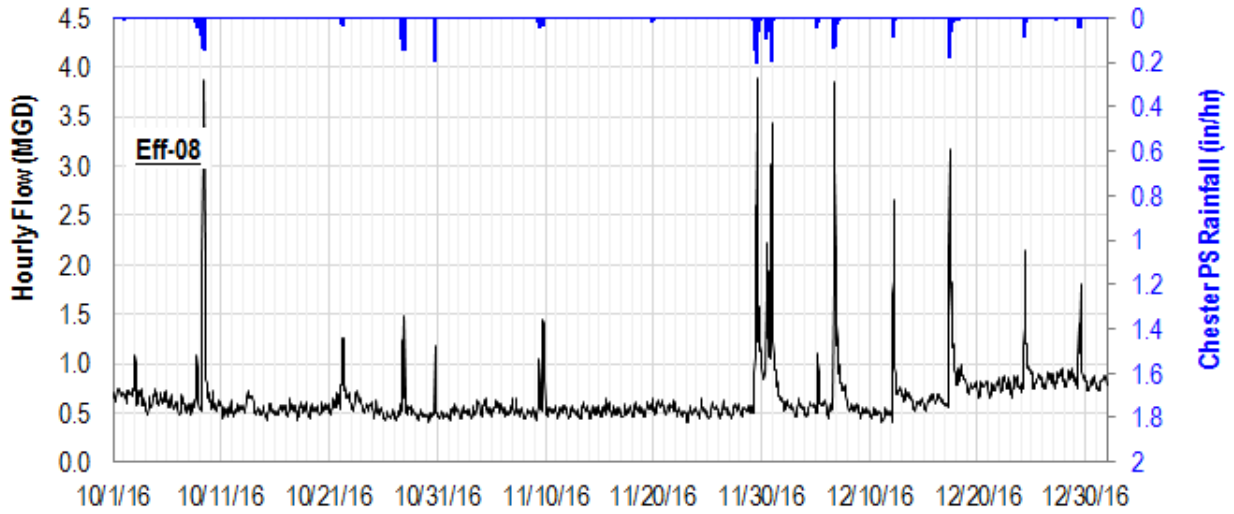


Figure 22: Flow Monitoring Data, Eff-08

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

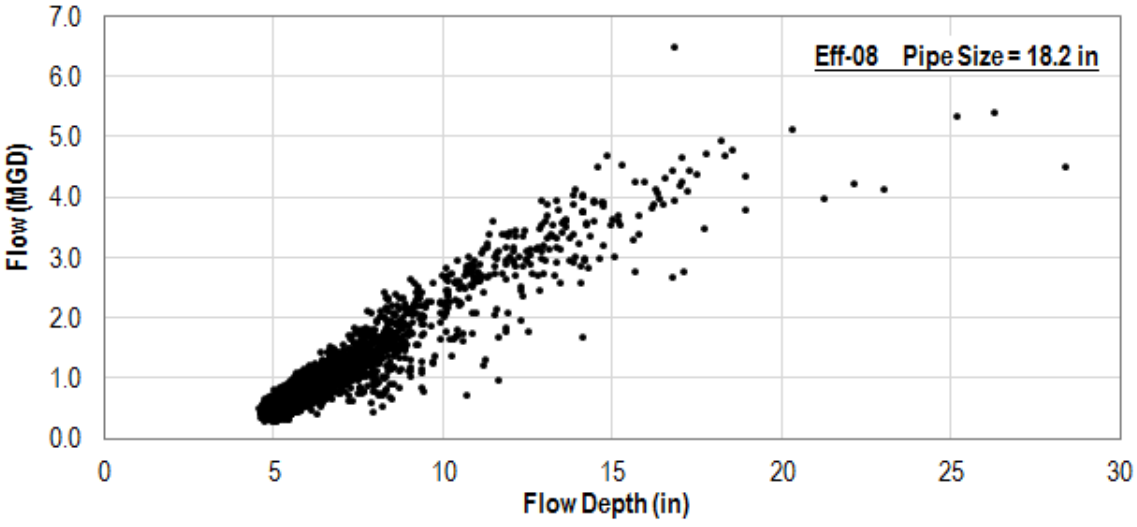


Figure 23: Flow Monitoring Data, CSO-08

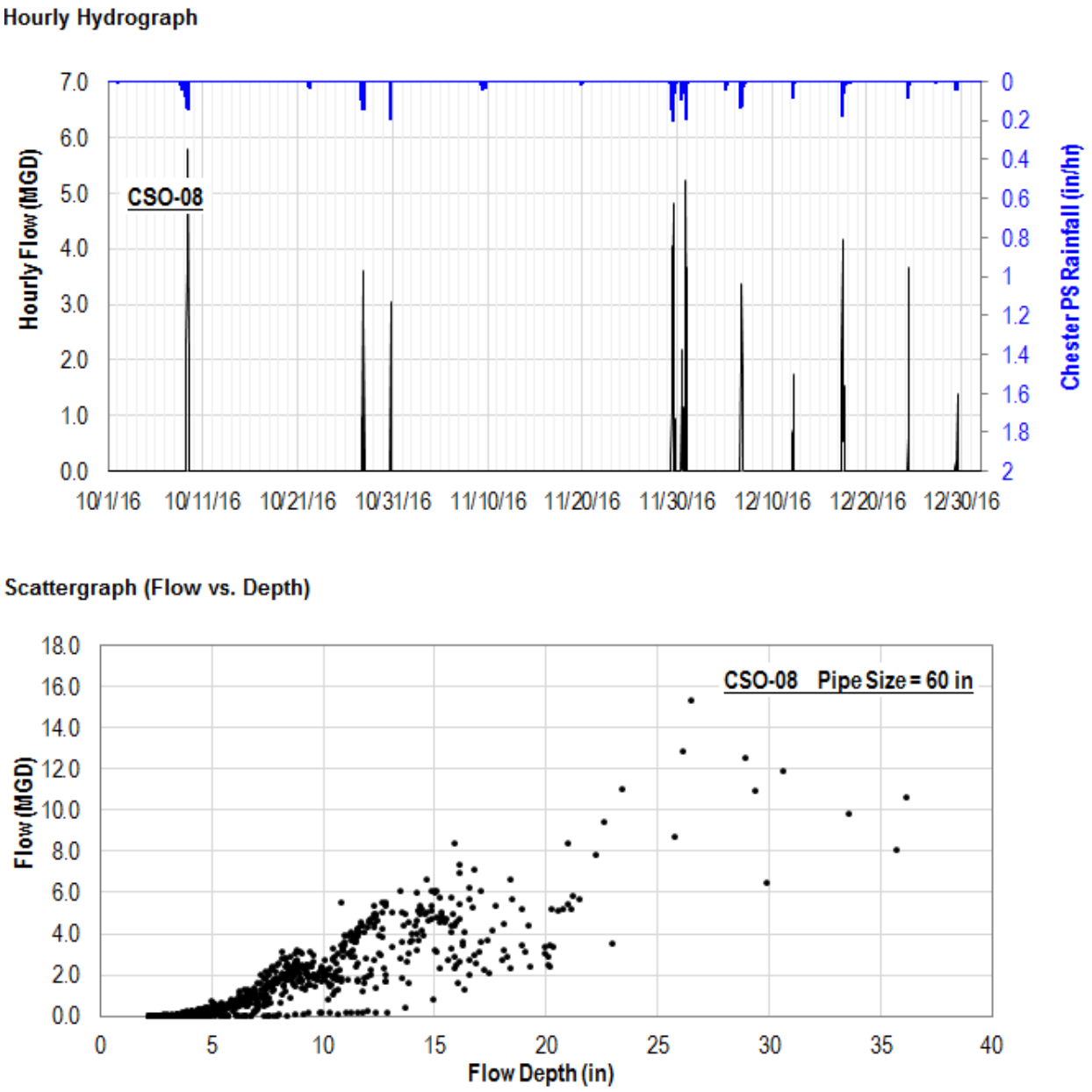


Figure 24: Flow Monitoring Data, In-09

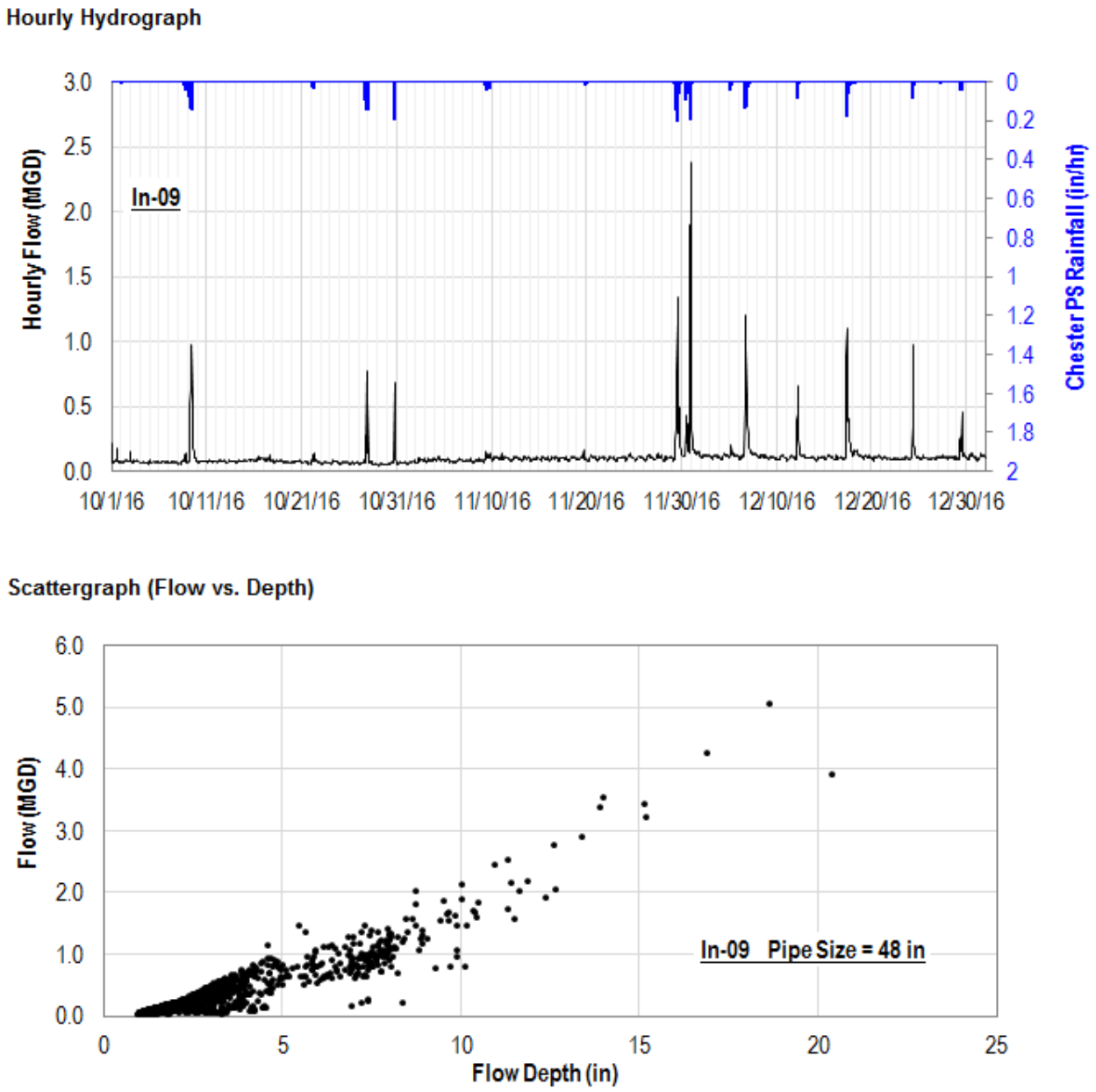


Figure 25: Flow Monitoring Data, In-10

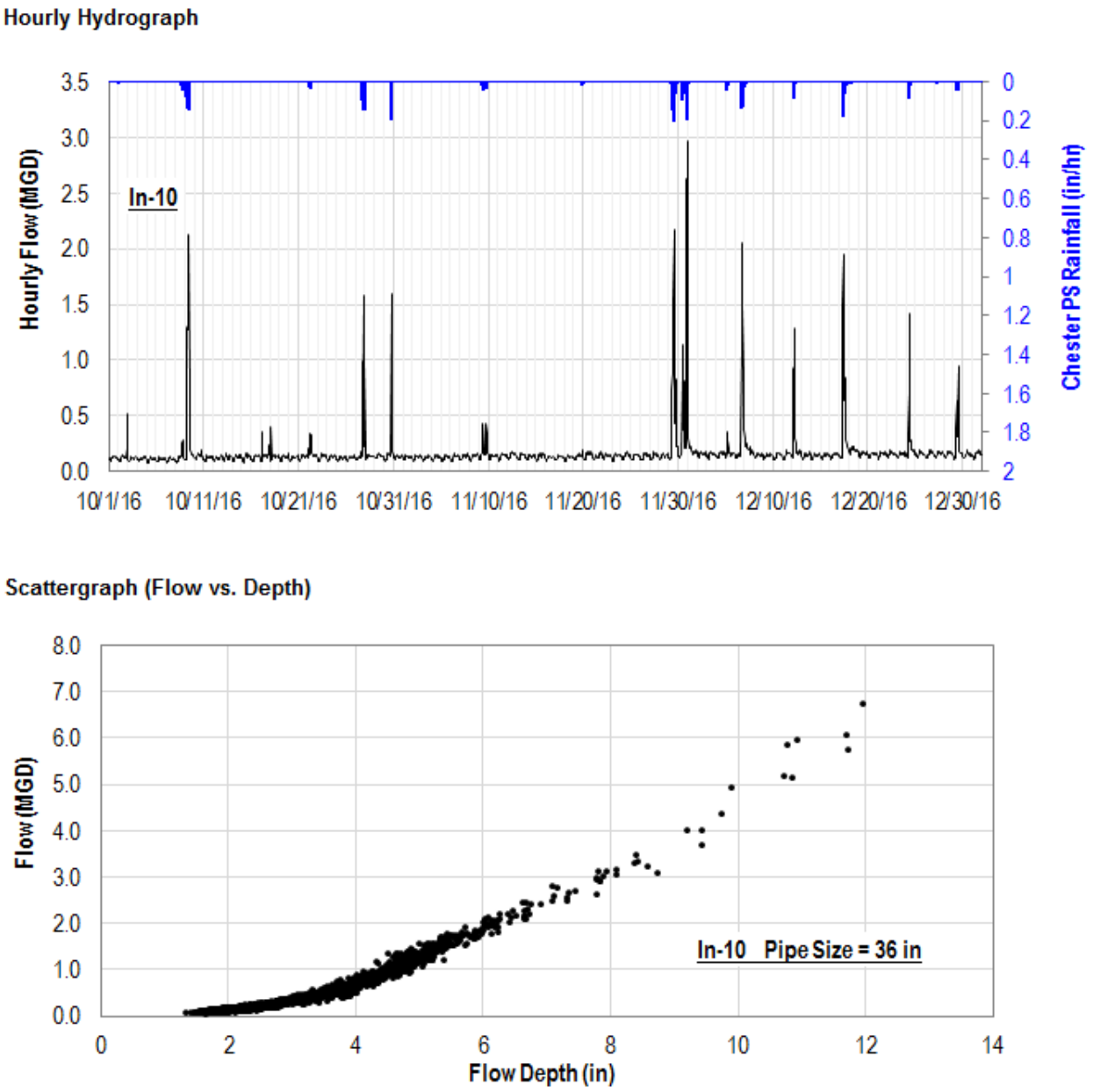


Figure 26: Flow Monitoring Data, In-11

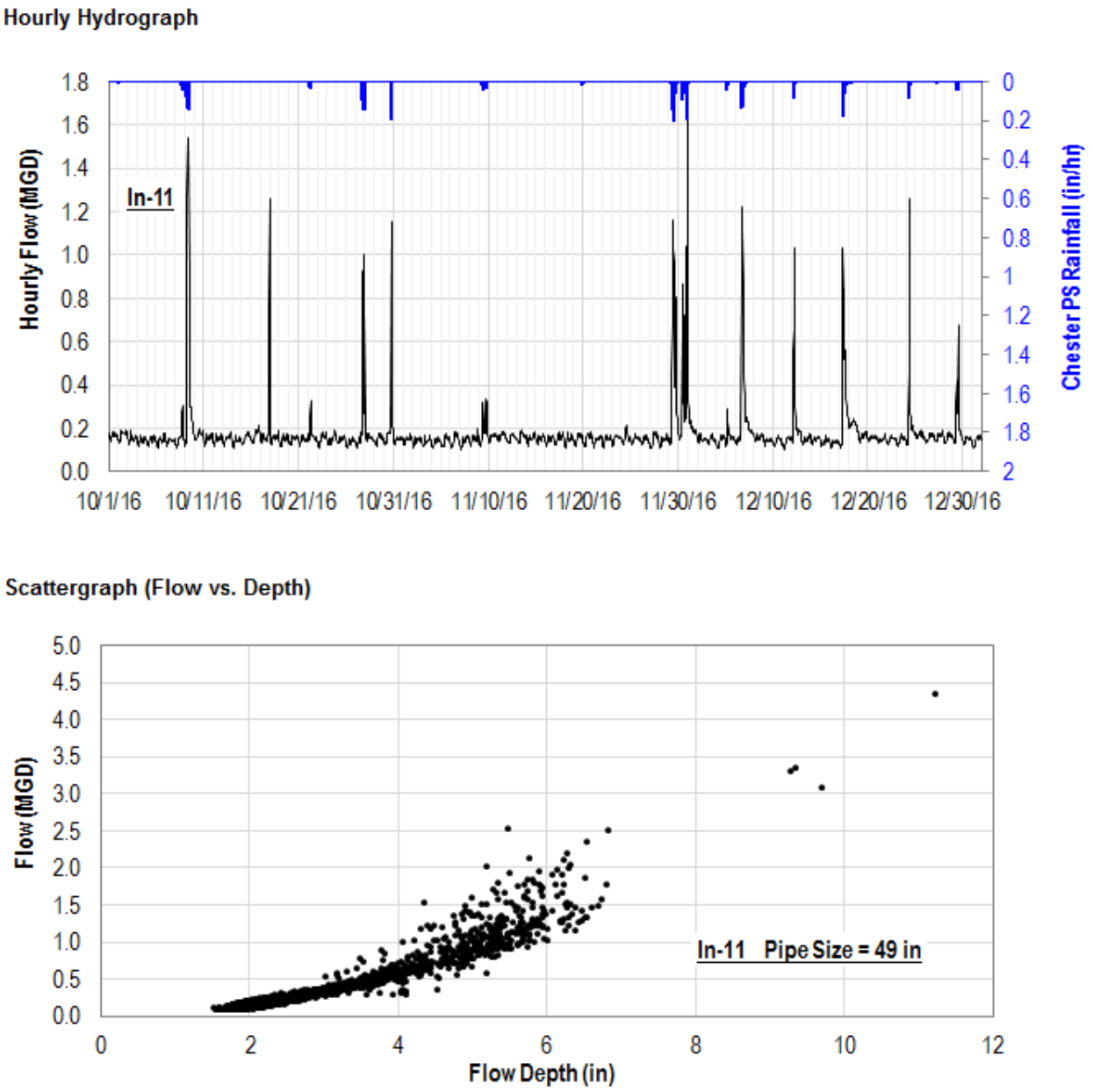


Figure 27: Flow Monitoring Data, In-13

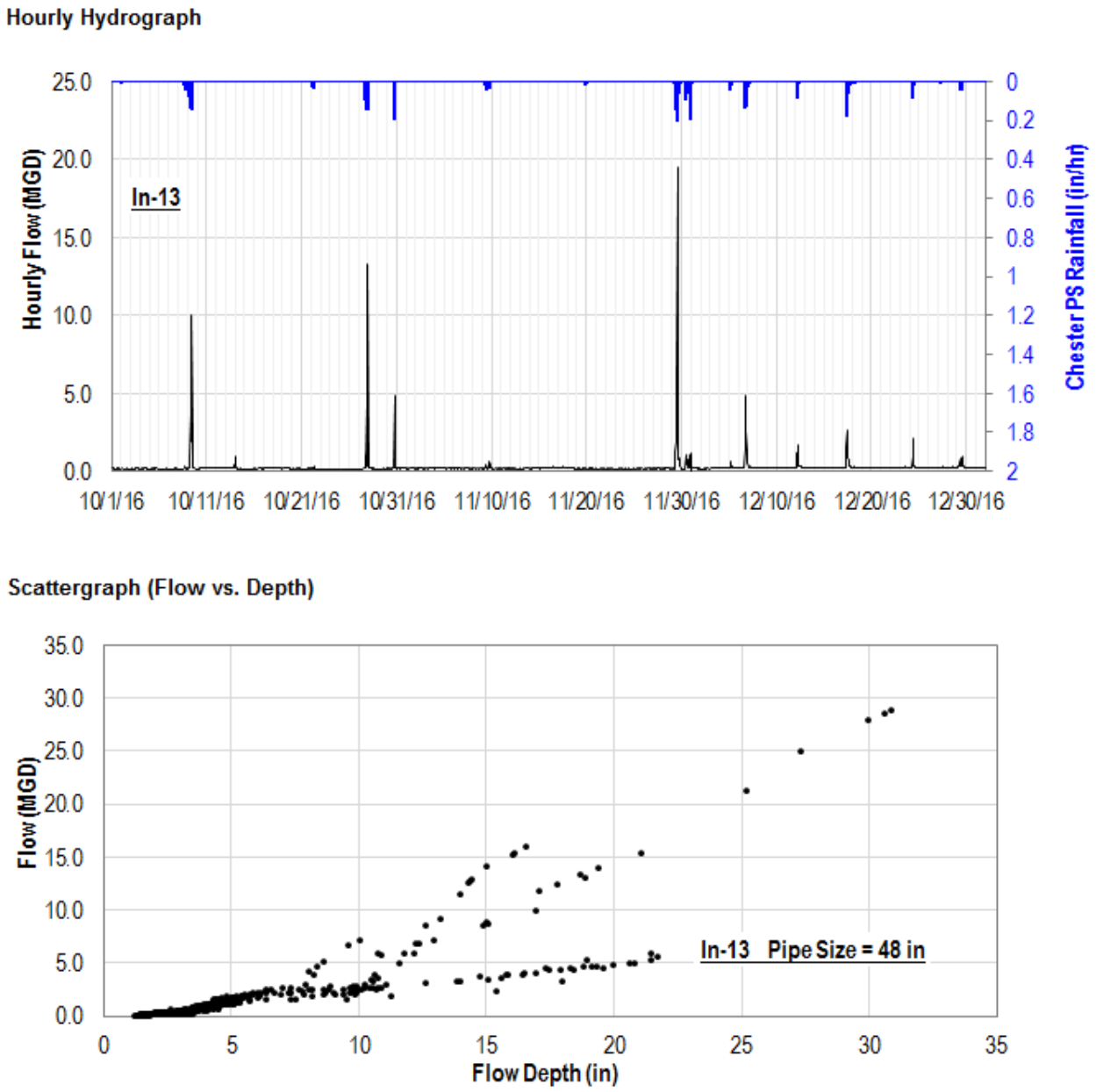
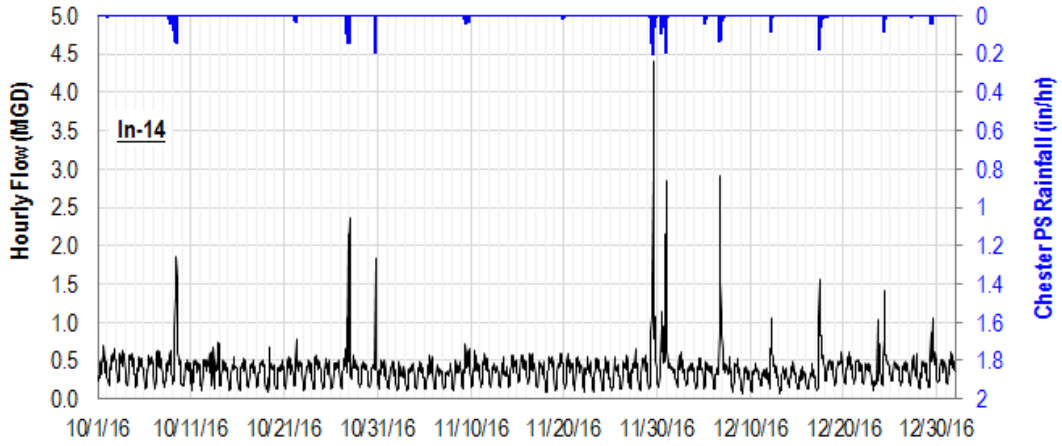
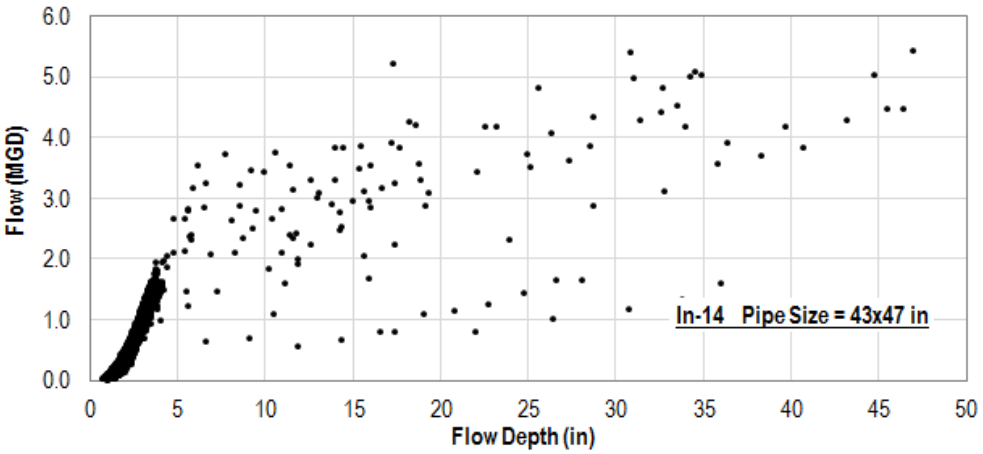


Figure 28: Flow Monitoring Data, In-14

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#14 Influent , Effluent and Overflow

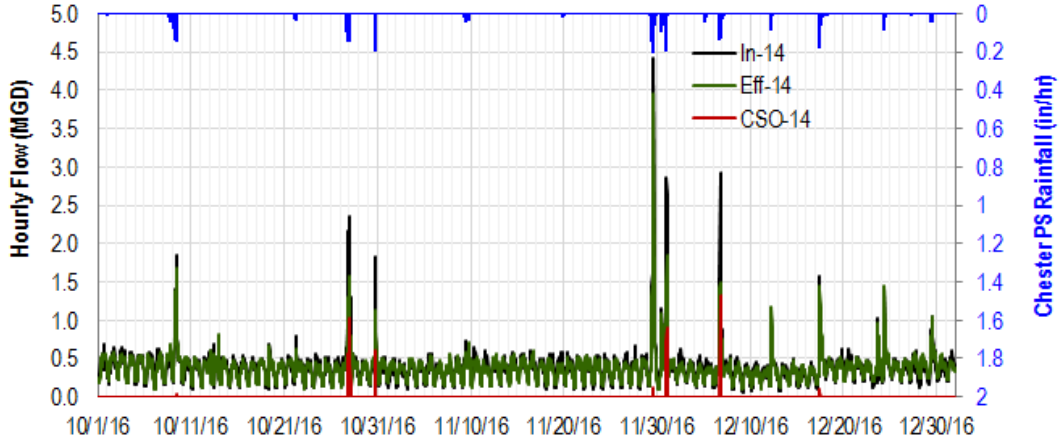
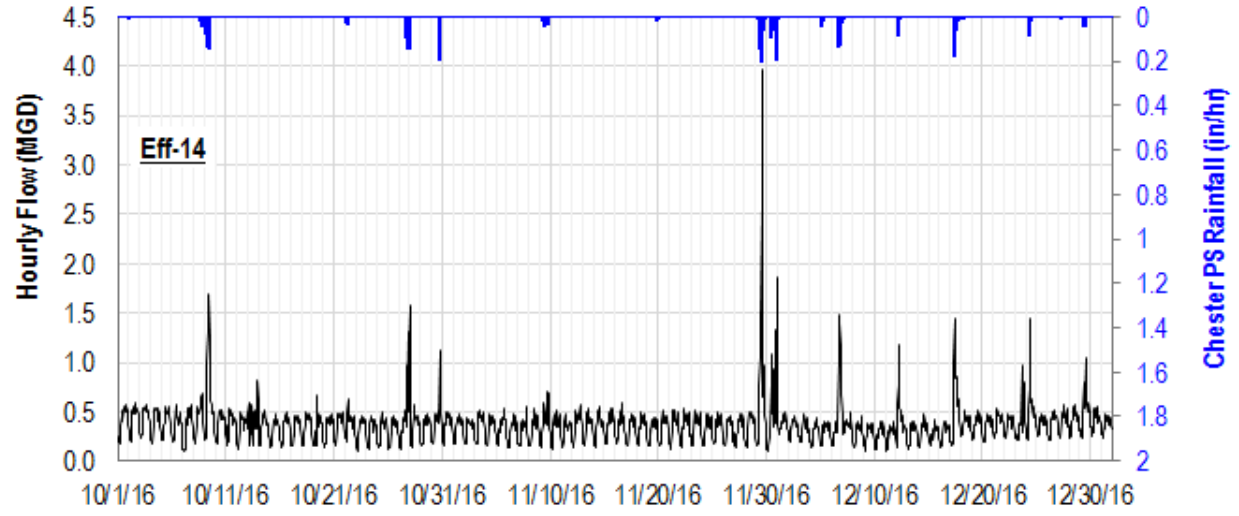


Figure 29: Flow Monitoring Data, Eff-14

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

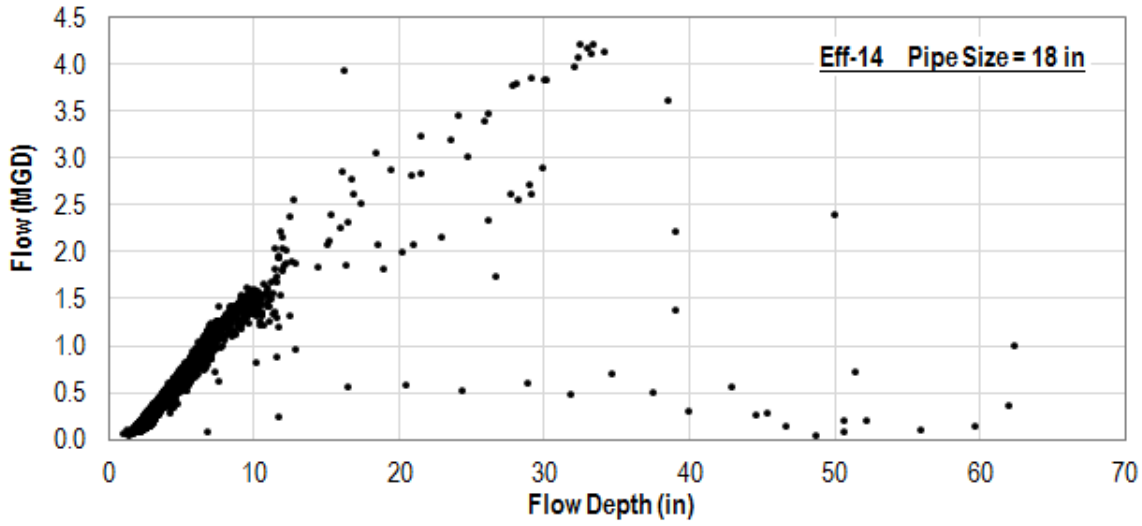
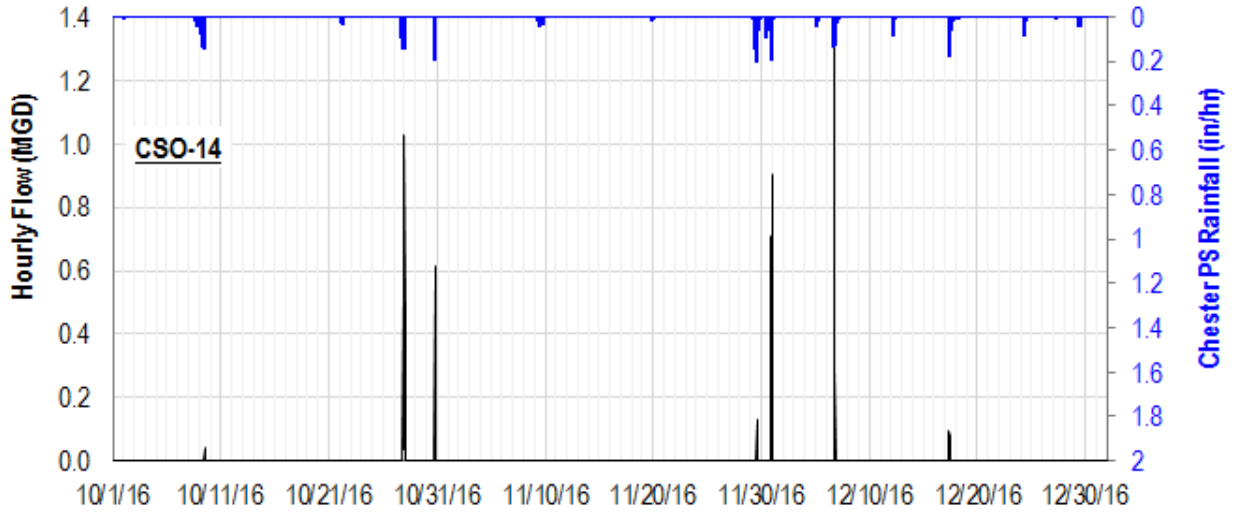


Figure 30: Flow Monitoring Data, CSO-14

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

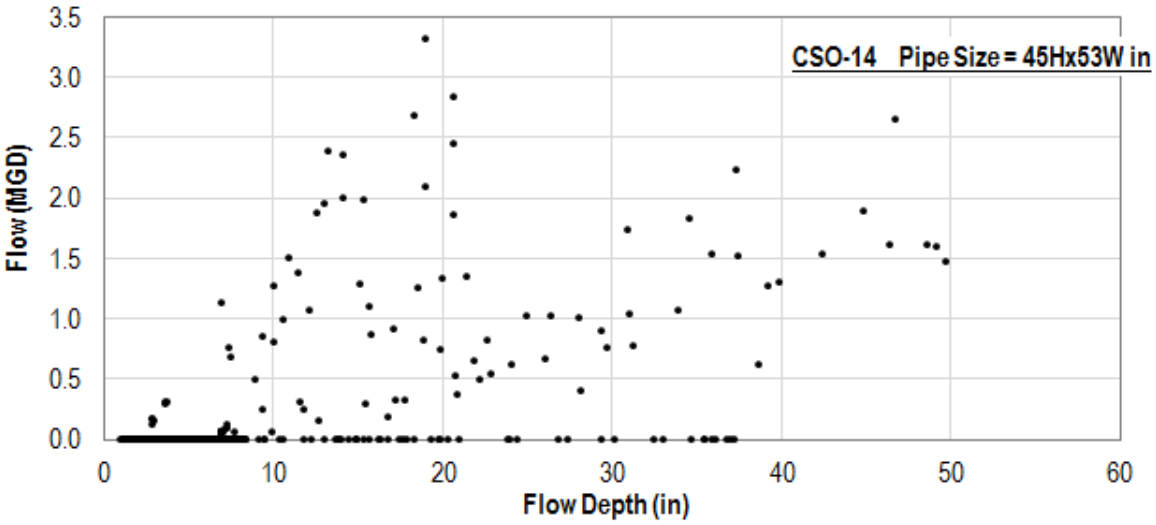


Figure 31: Flow Monitoring Data, In-16

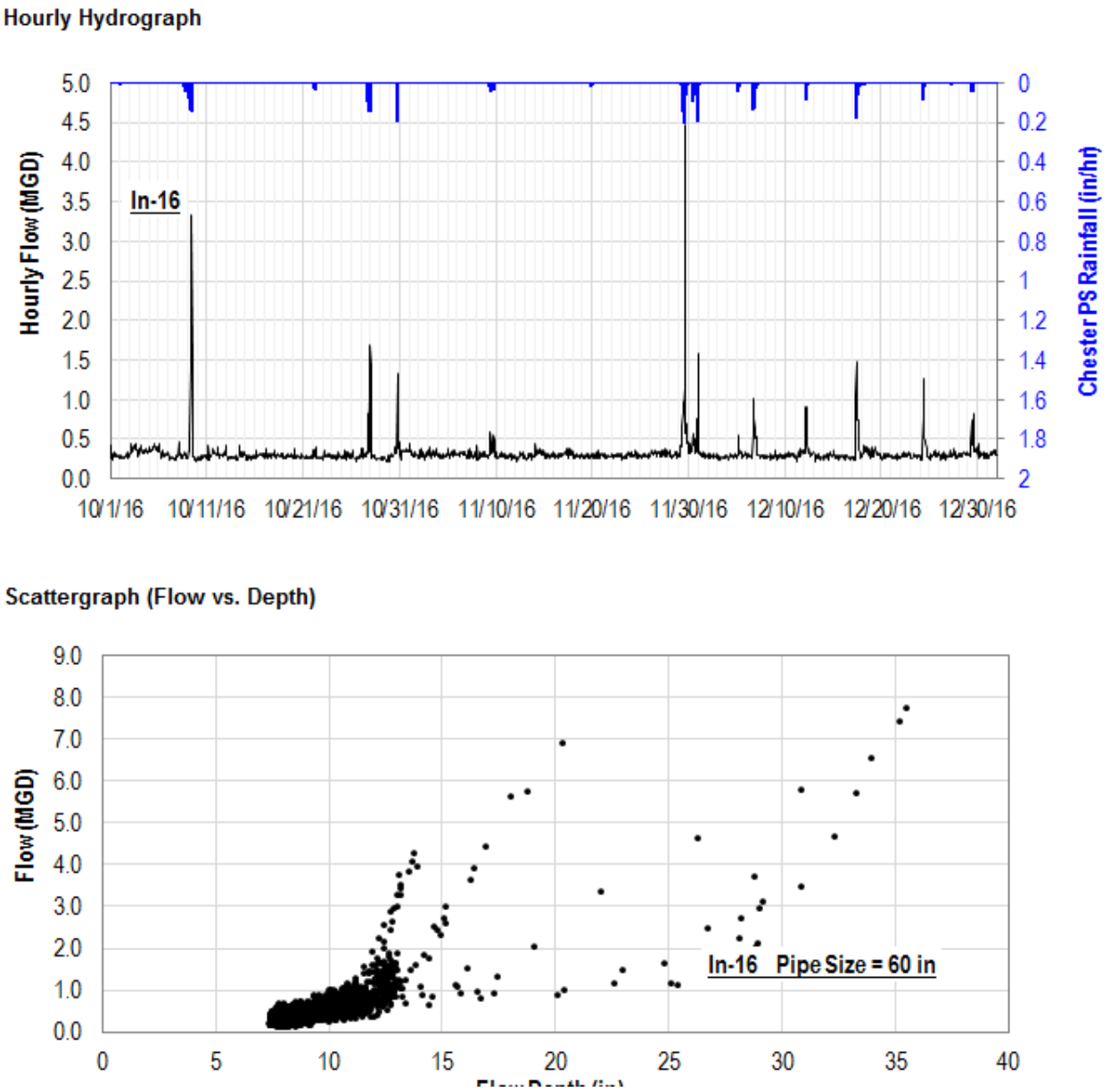


Figure 32: Flow Monitoring Data, In-17

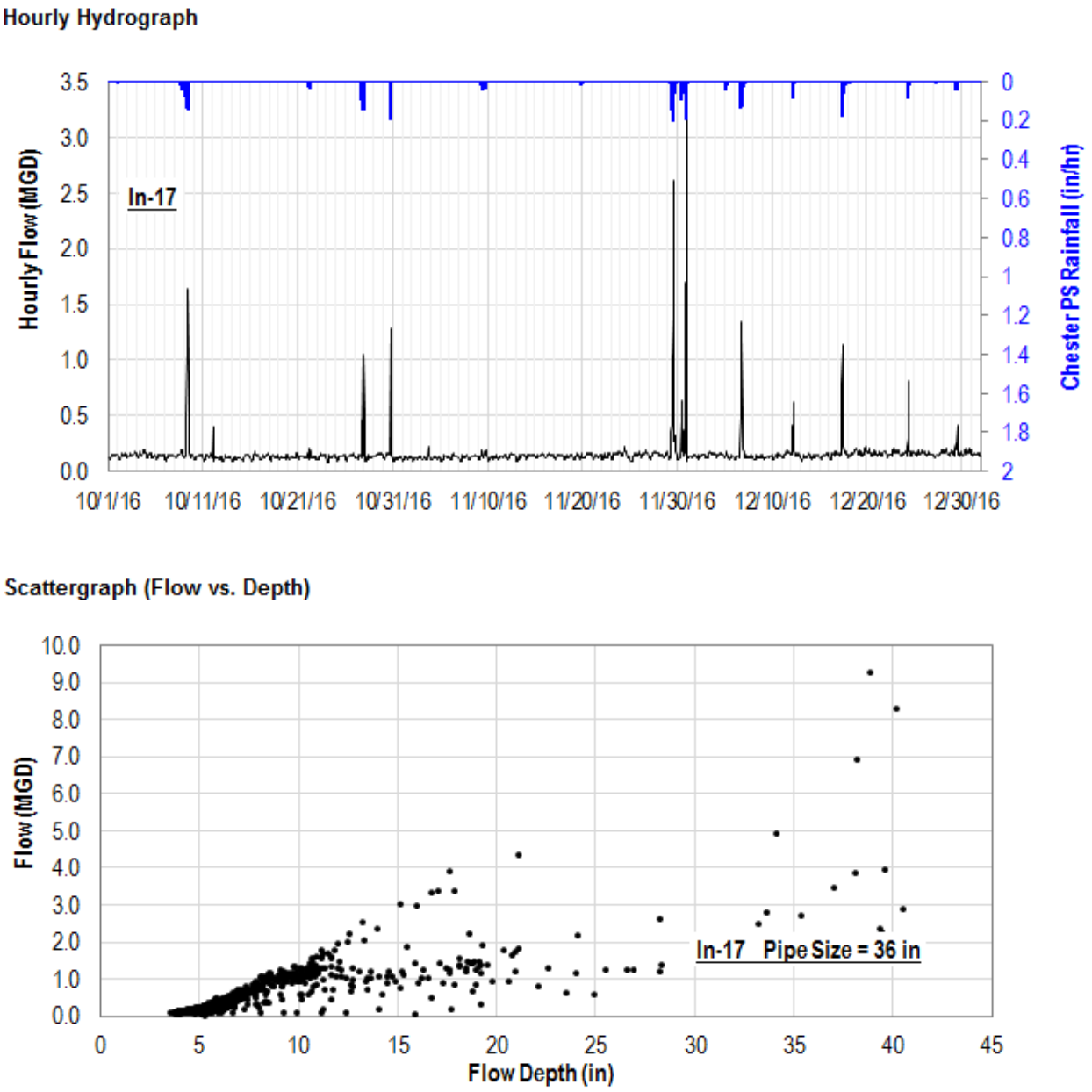


Figure 33: Flow Monitoring Data, In-18

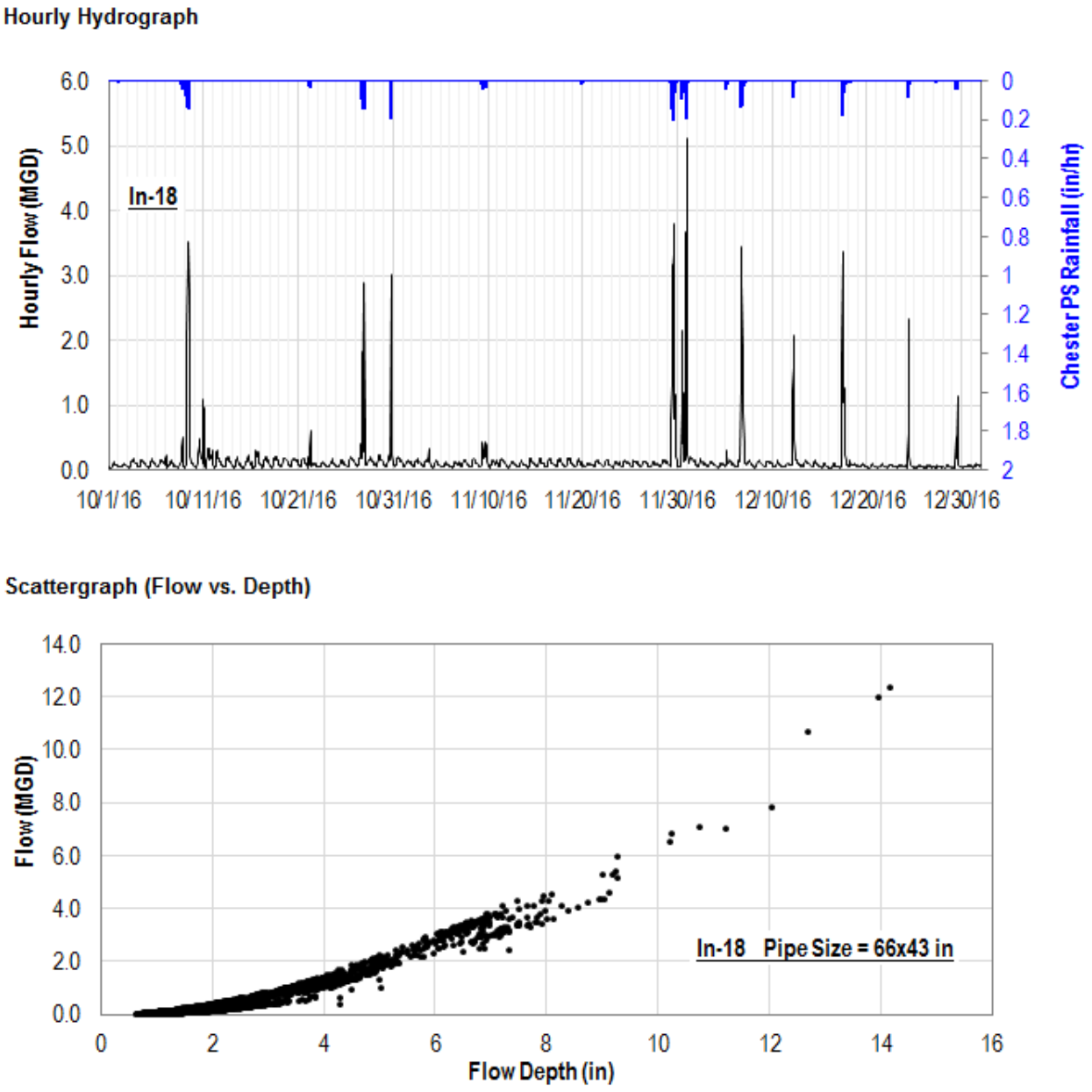
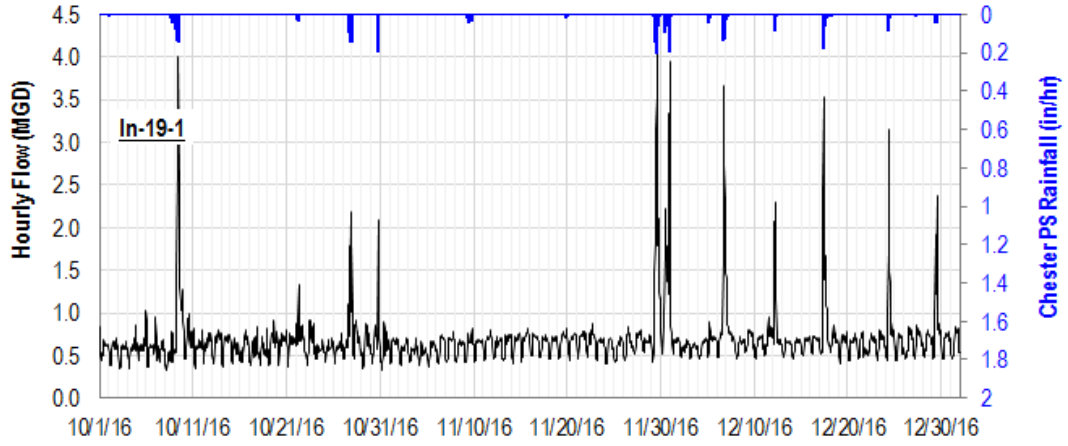
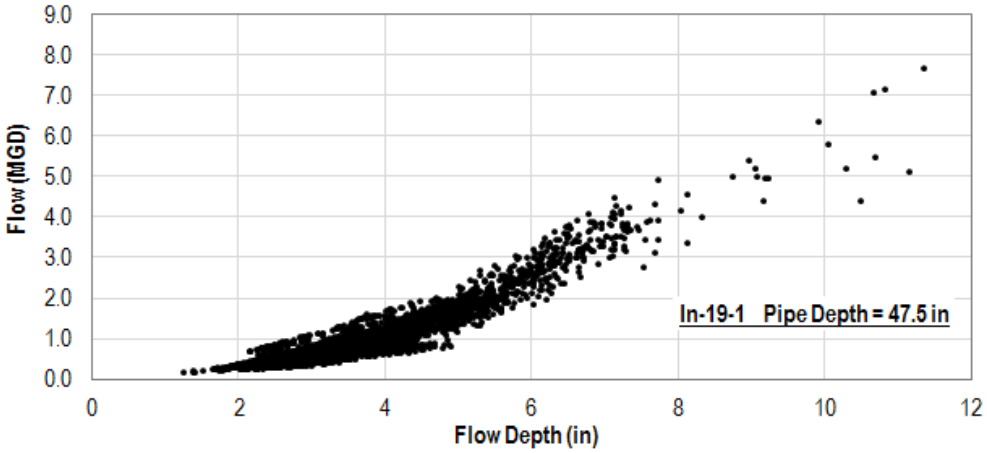


Figure 34: Flow Monitoring Data, In-19-1

Hourly Hydrograph



Scattergraph (Flow vs. Depth)



CSO#19 Influent , Effluent and Overflow

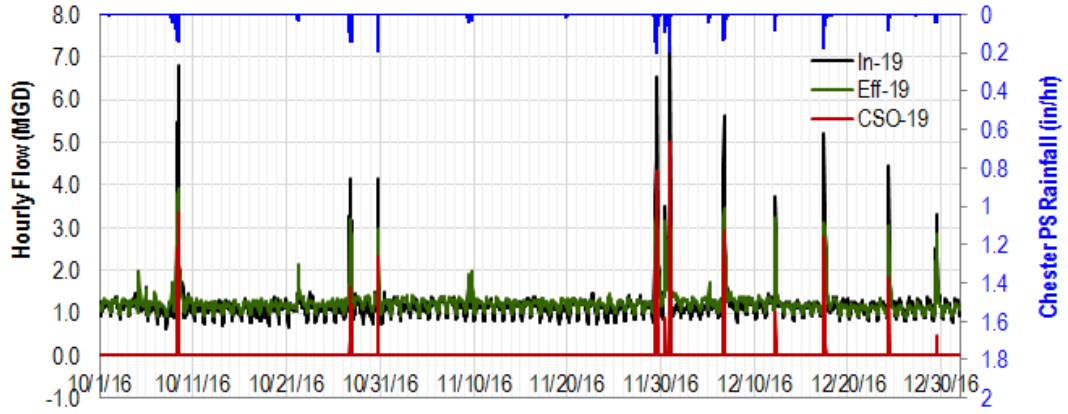
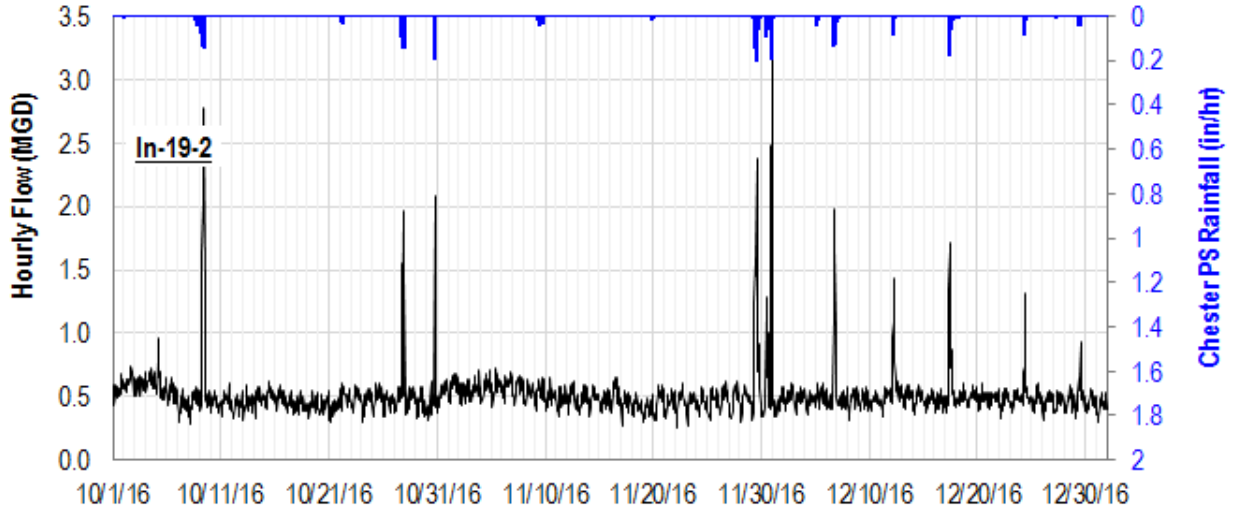


Figure 35: Flow Monitoring Data, In-19-2

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

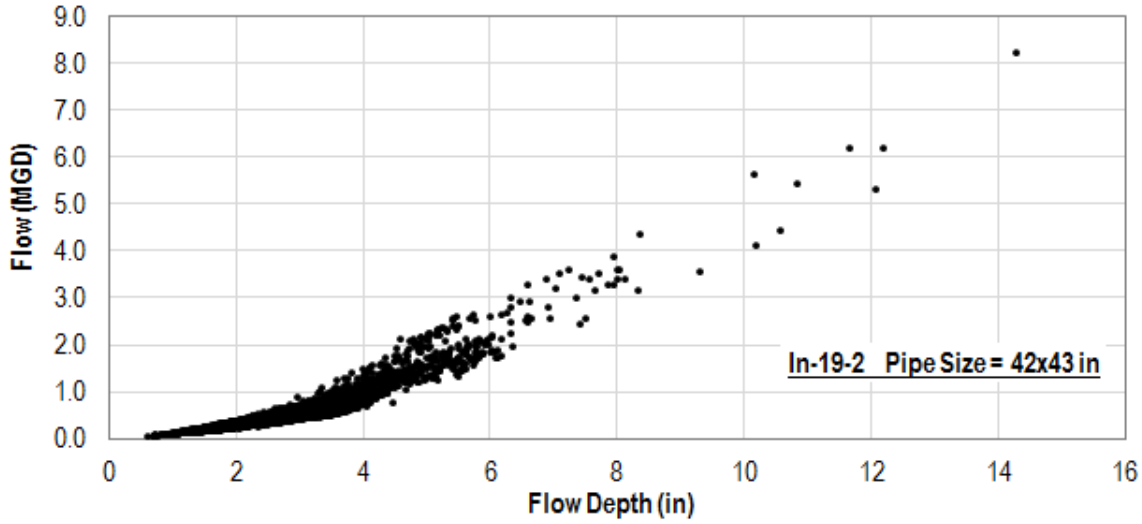


Figure 36: Flow Monitoring Data, Eff-19

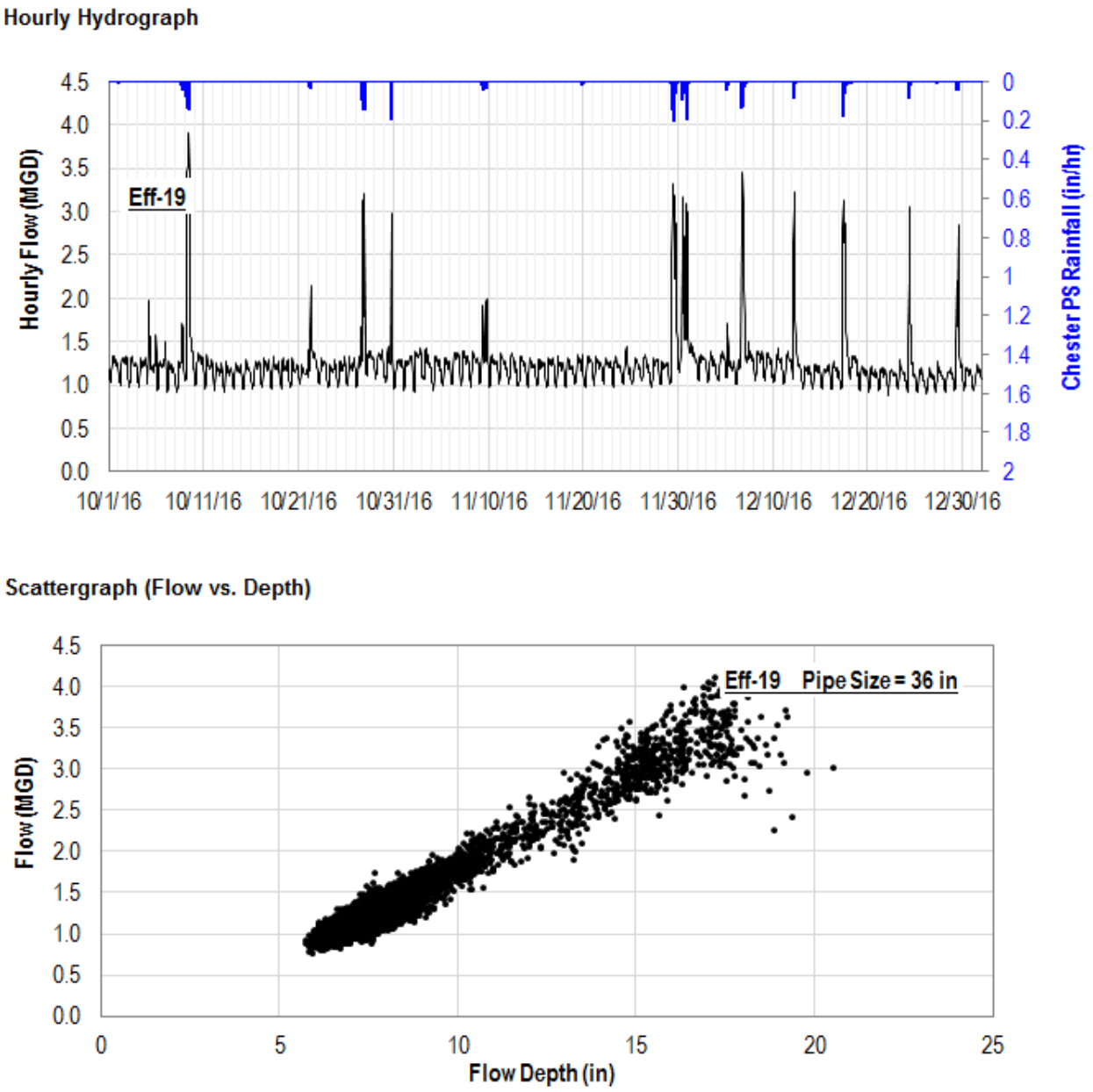


Figure 37: Flow Monitoring Data, CSO-19

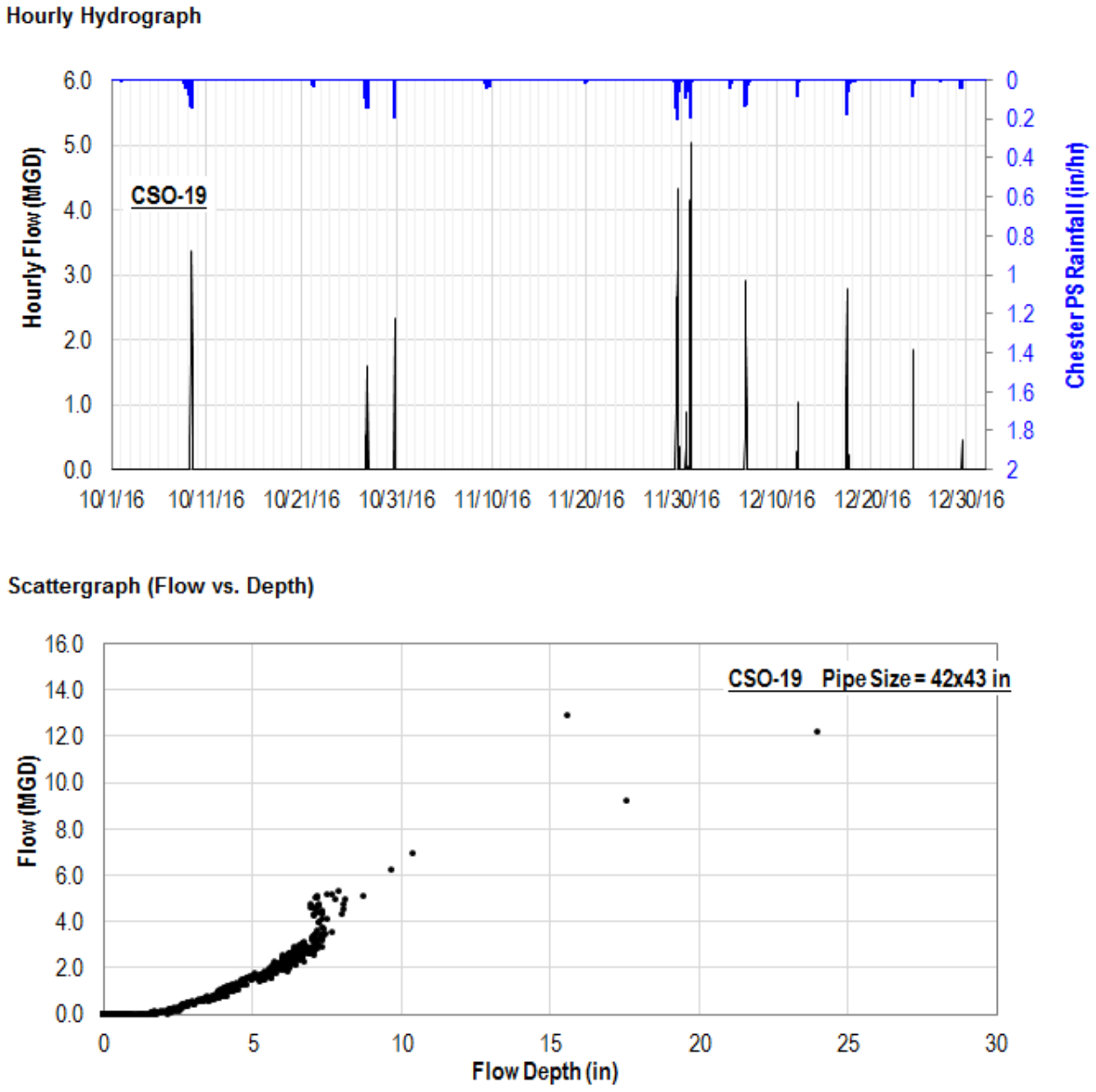


Figure 38: Flow Monitoring Data, In-25

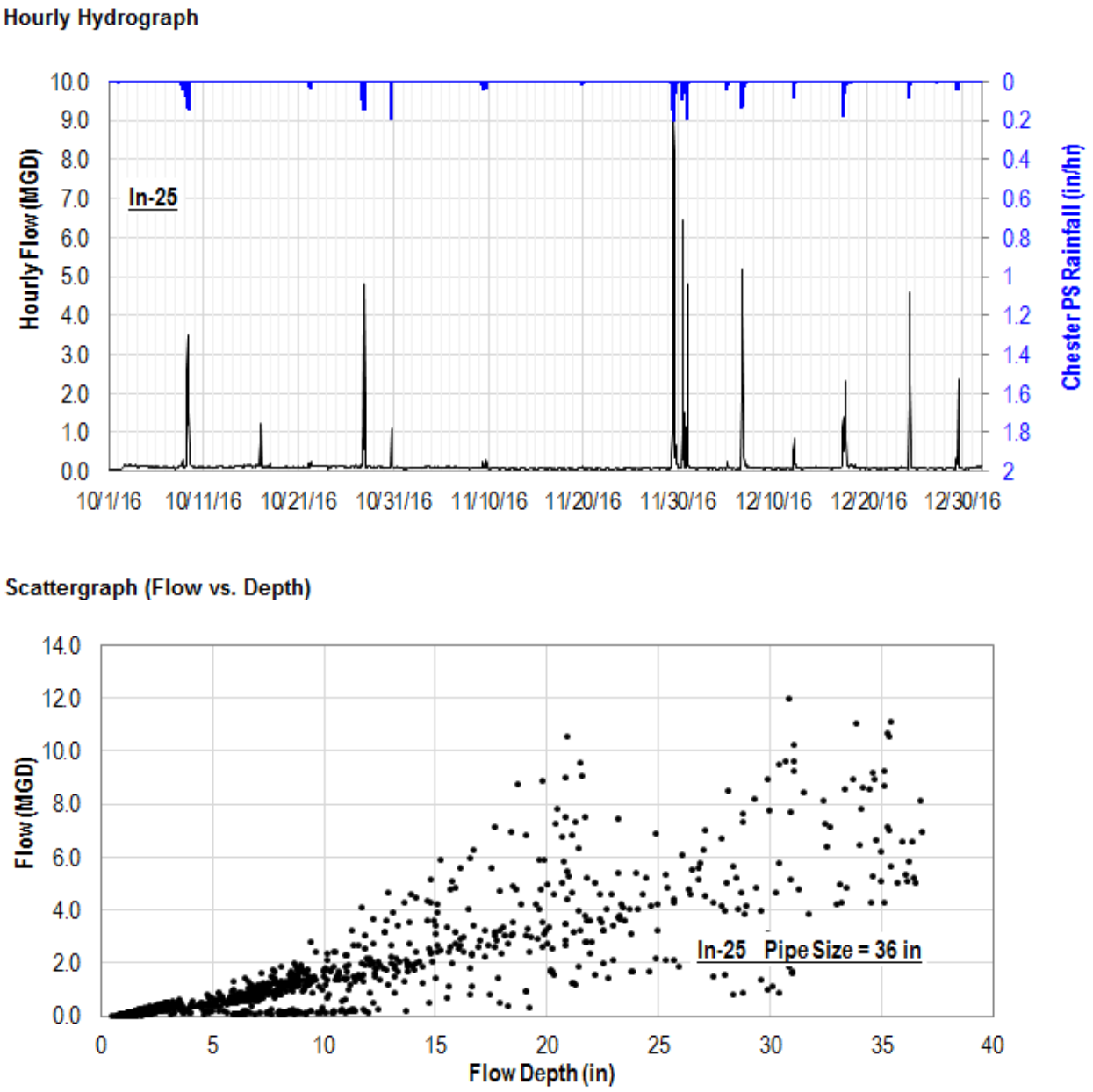
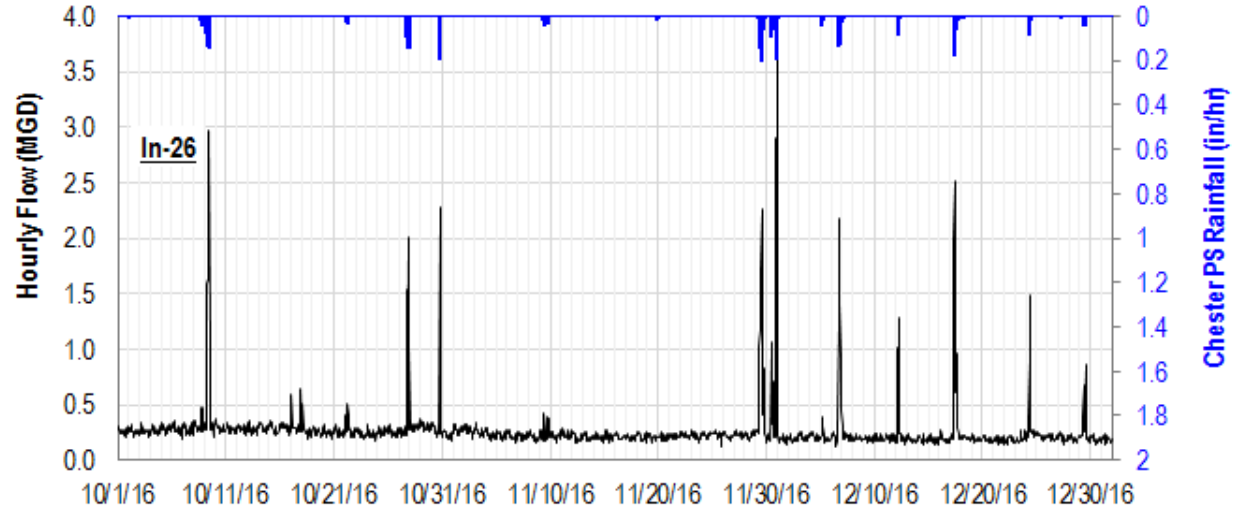


Figure 39: Flow Monitoring Data, In-26

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

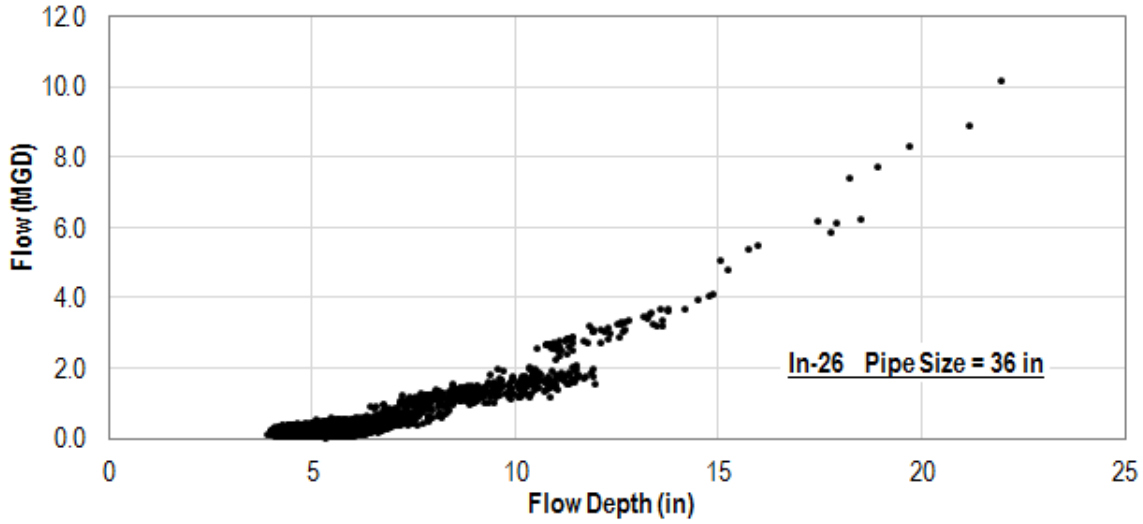


Figure 40: Flow Monitoring Data, INT-2nd St

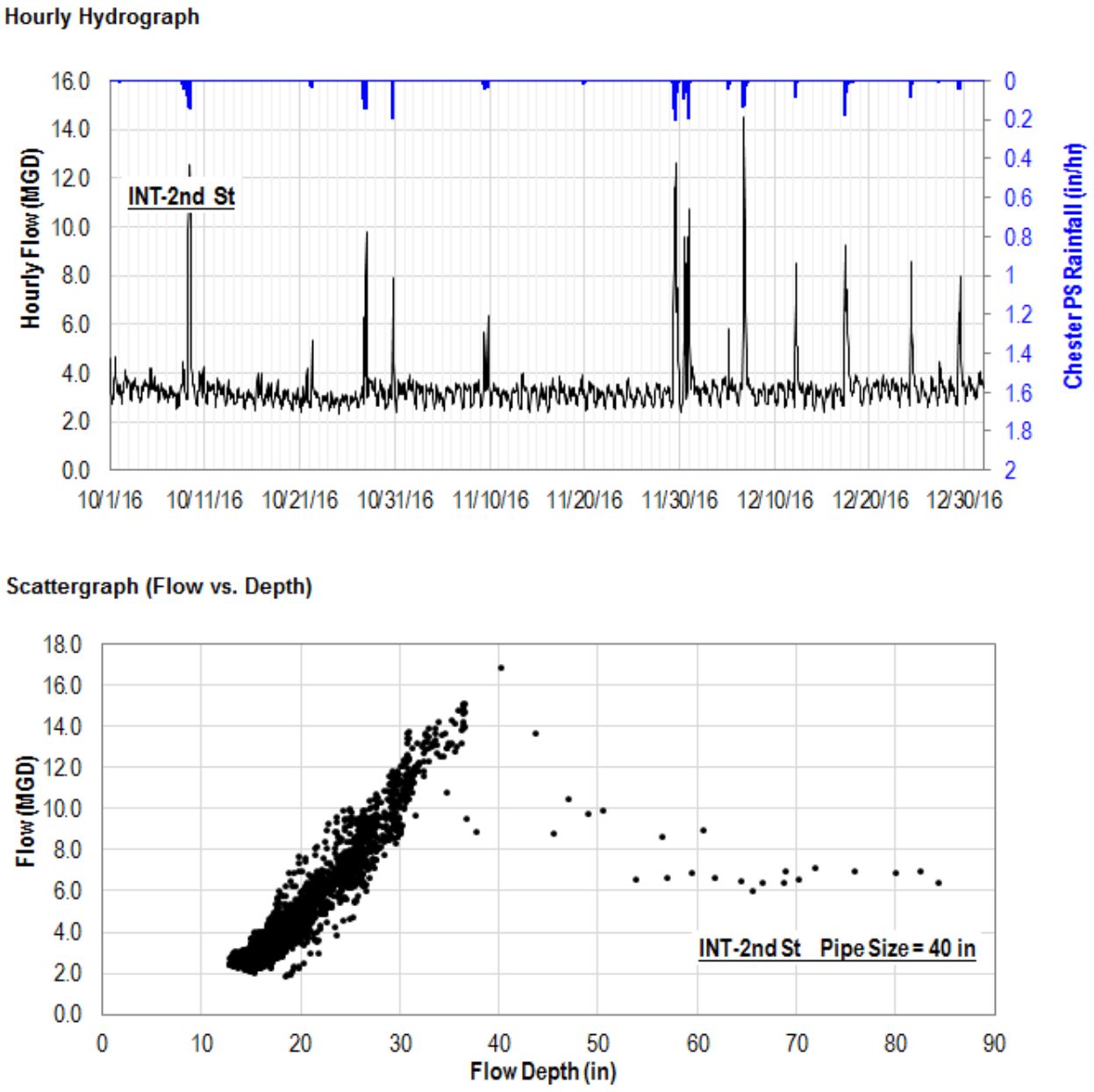
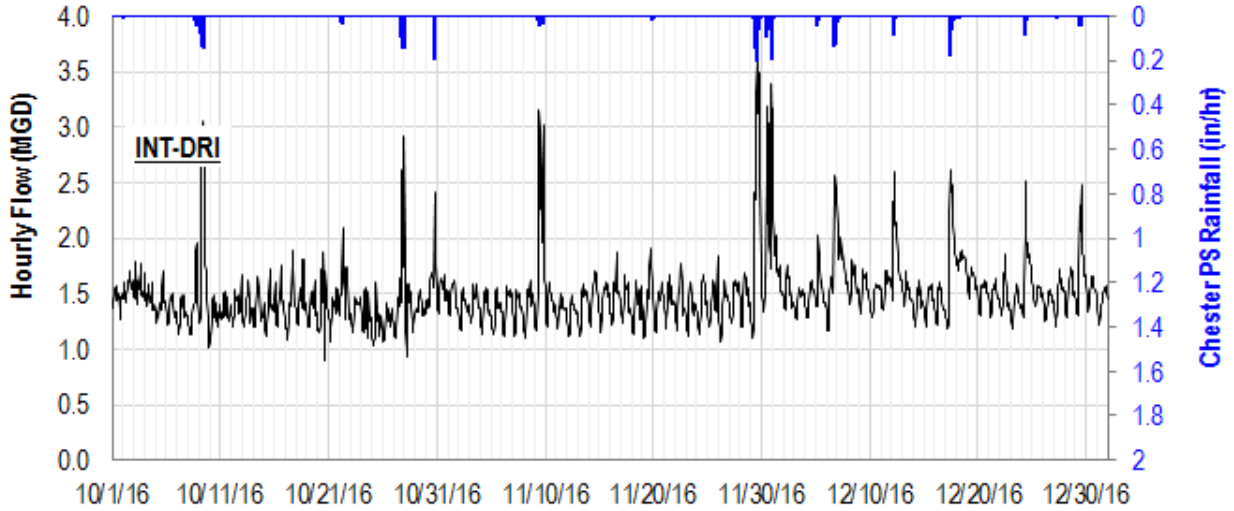


Figure 41: Flow Monitoring Data, INT-DRI

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

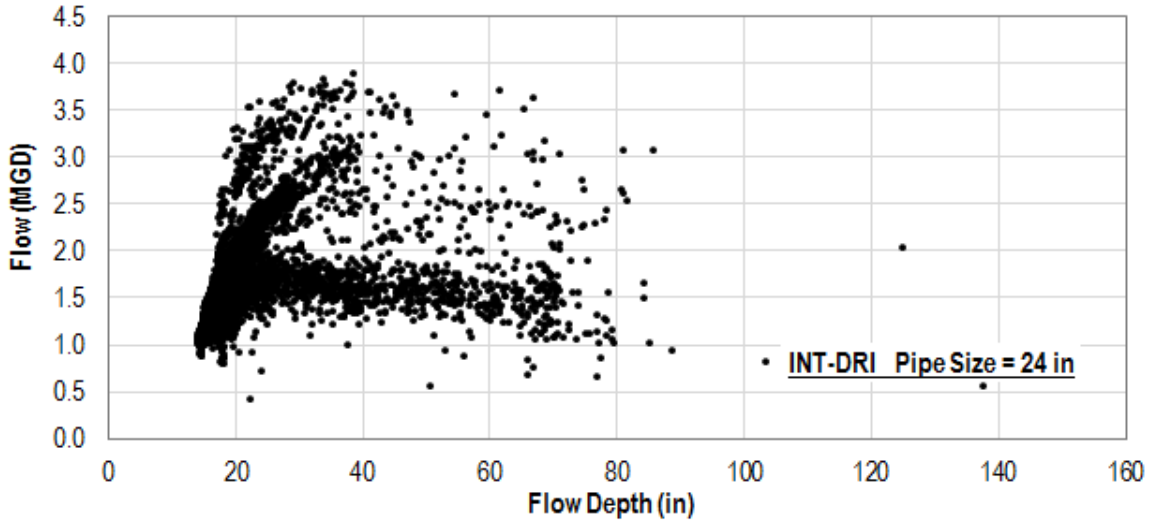
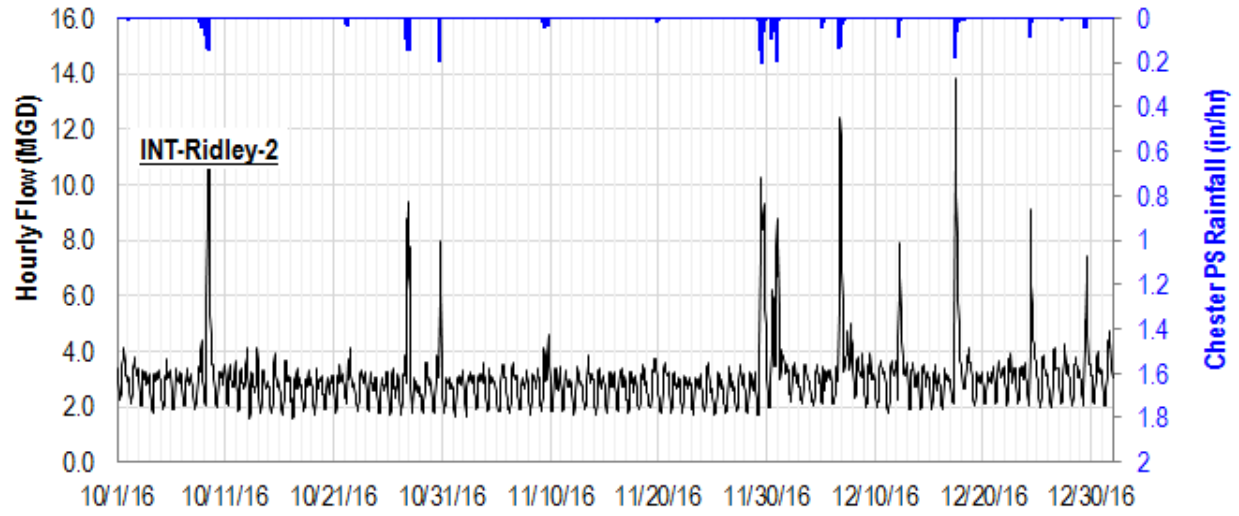


Figure 42: Flow Monitoring Data, INT-Ridley 2

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

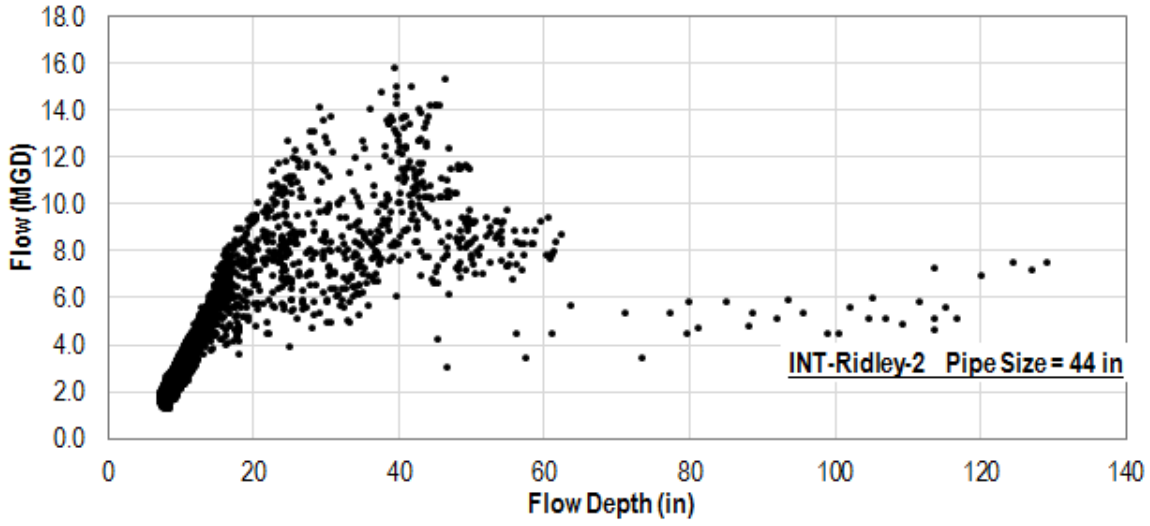


Figure 43: Flow Monitoring Data, INT-Ridley 3

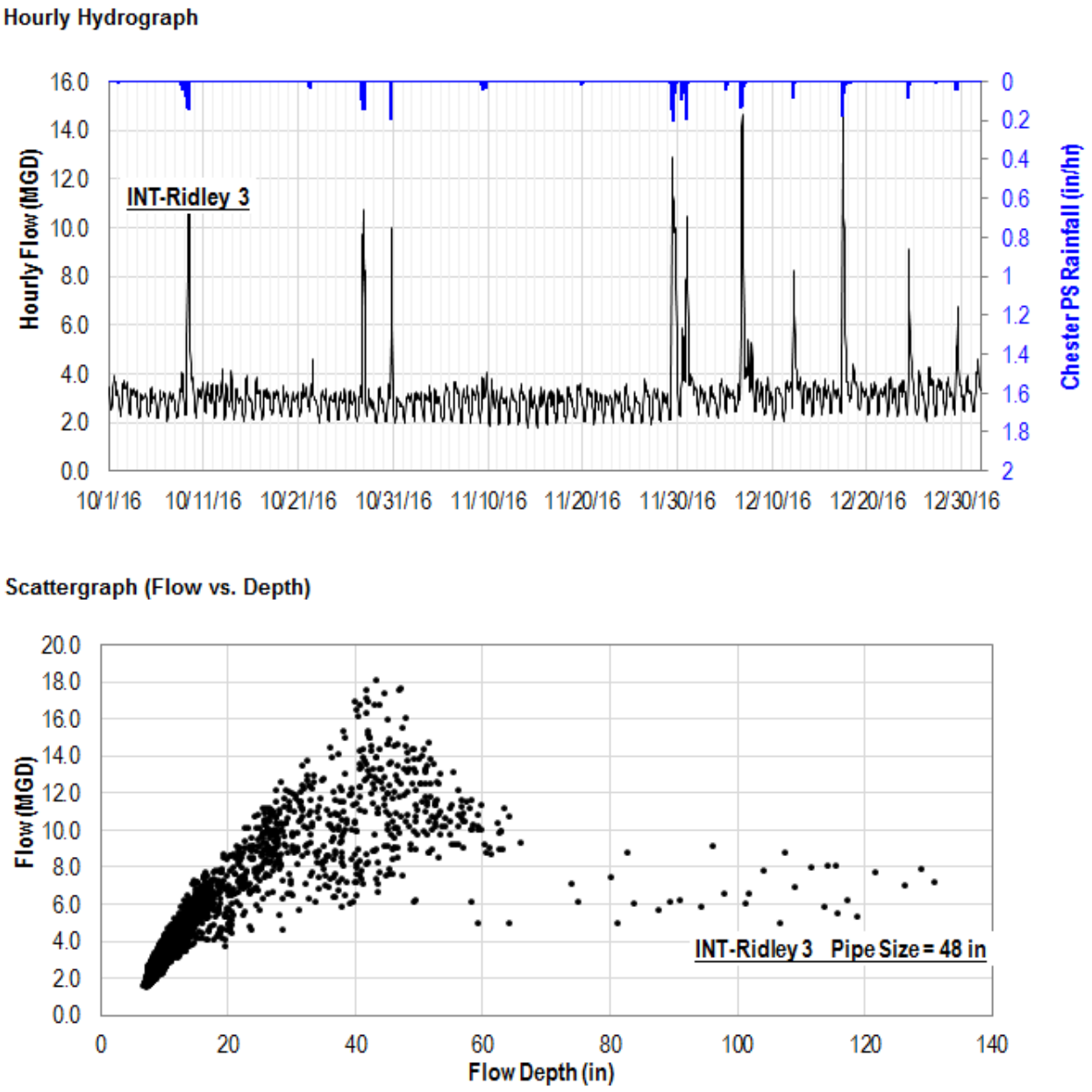


Figure 44: Flow Monitoring Data, INT-WEI

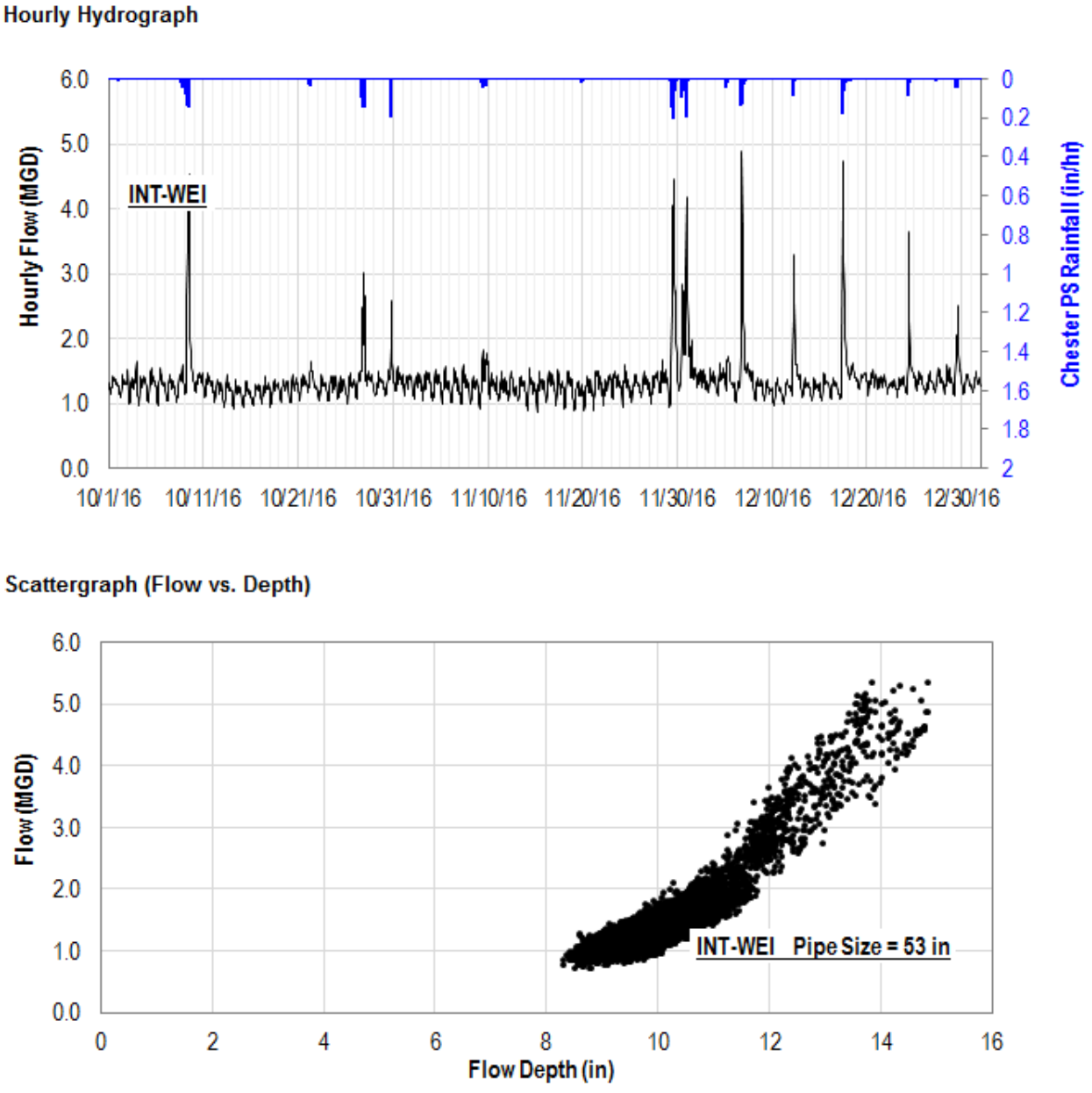
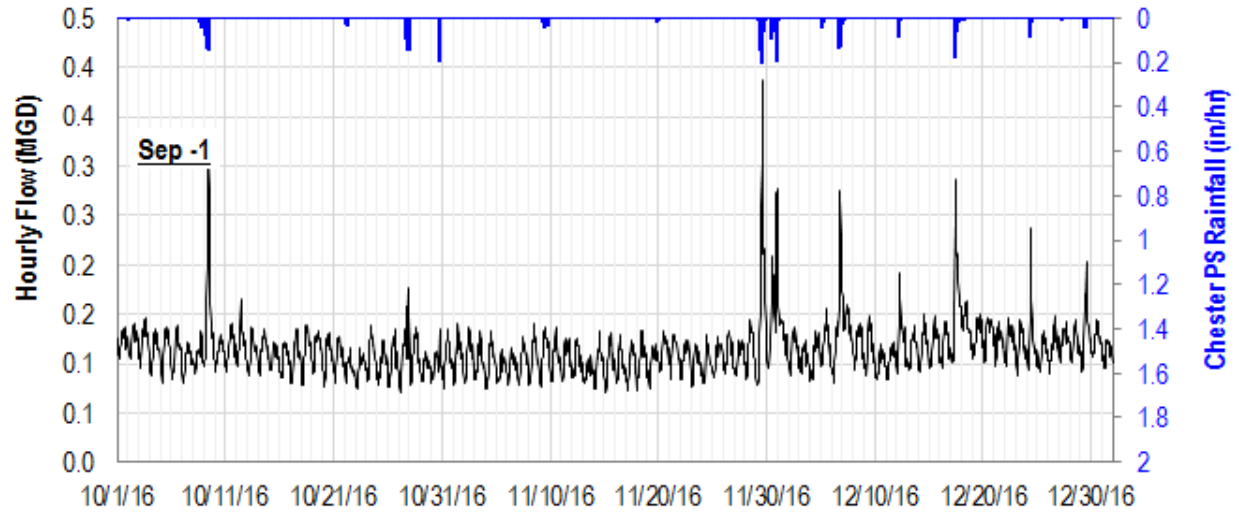


Figure 45: Flow Monitoring Data, Sep-1

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

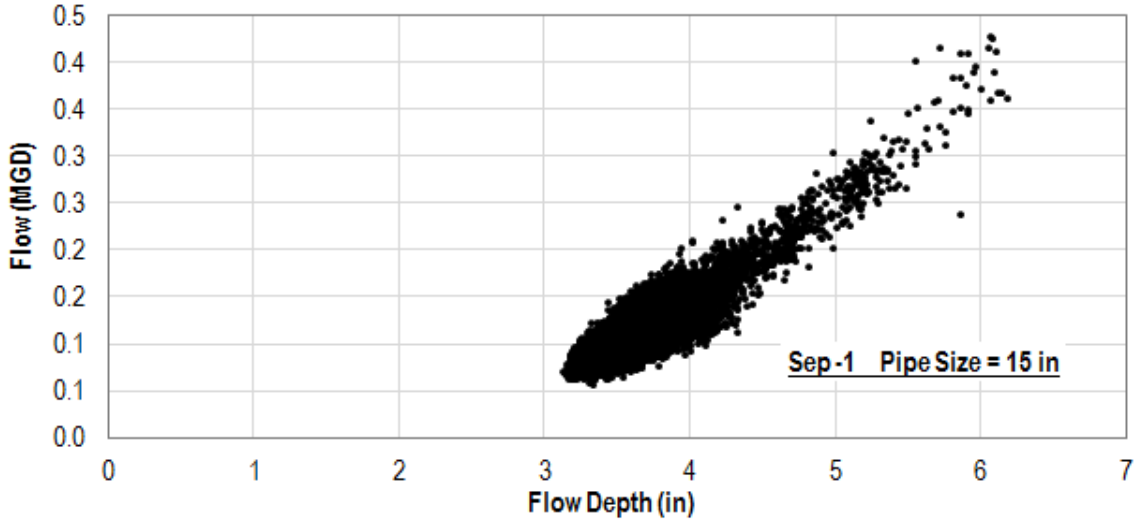


Figure 46: Flow Monitoring Data, Sep-2

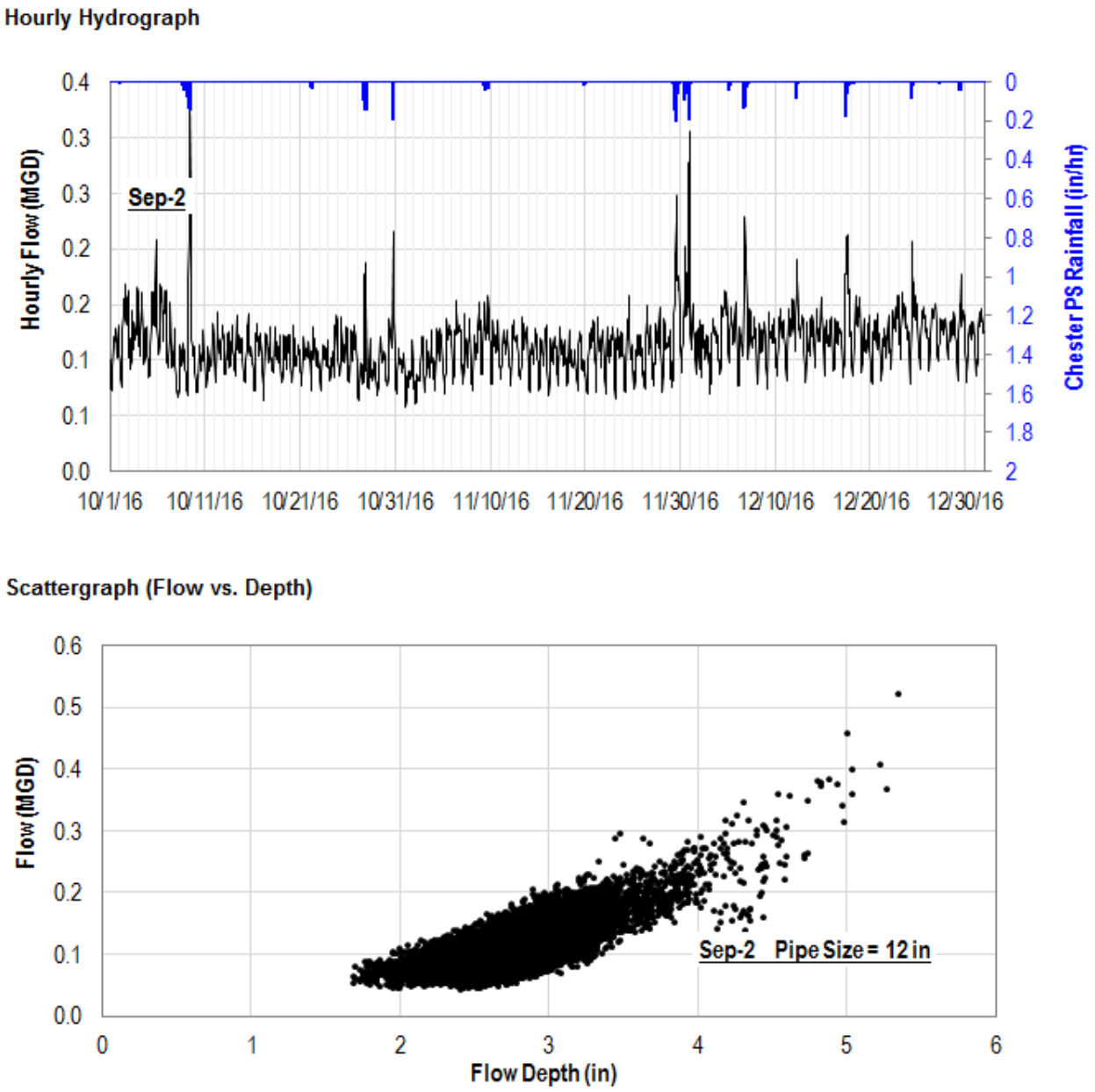


Figure 47: Flow Monitoring Data, Sep-3

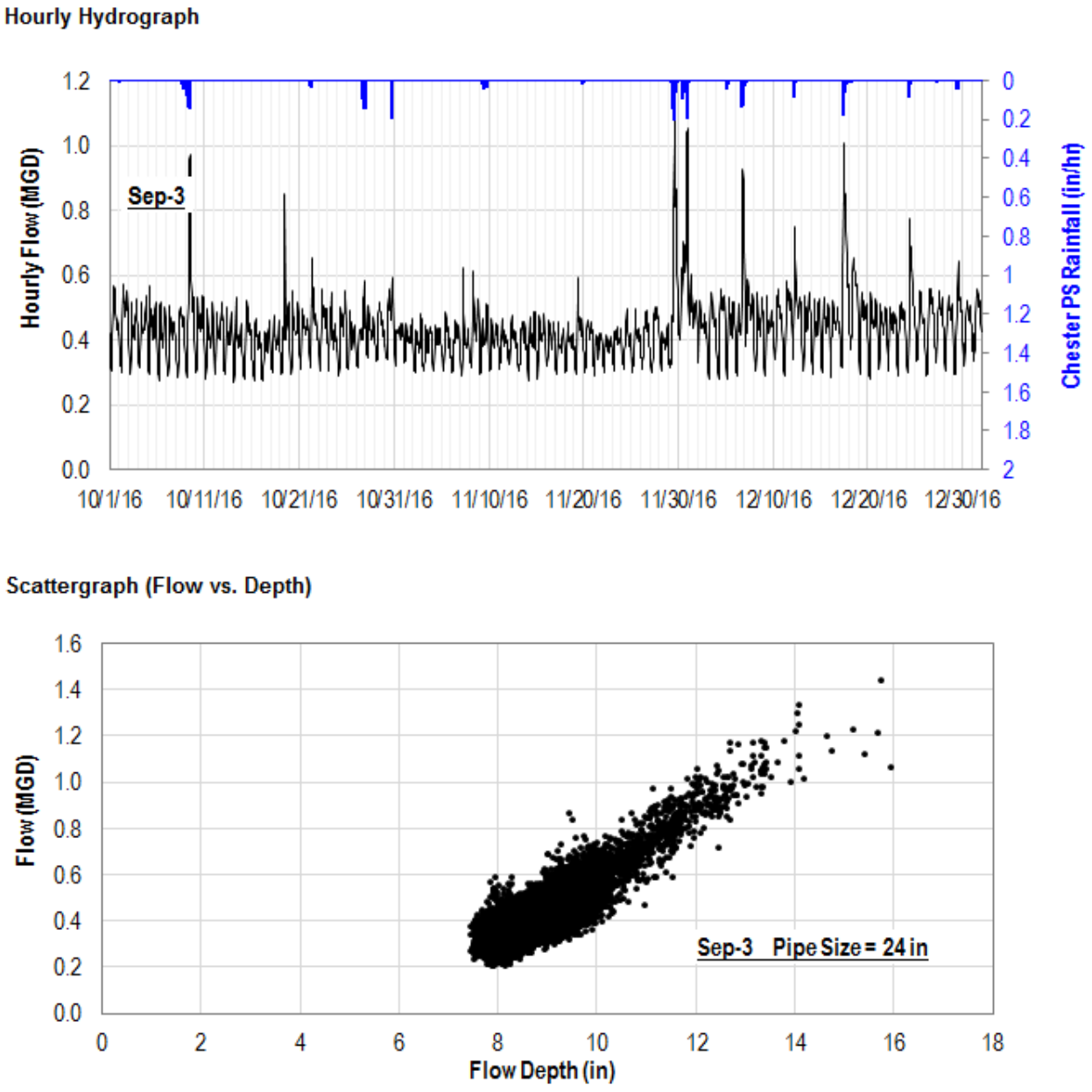
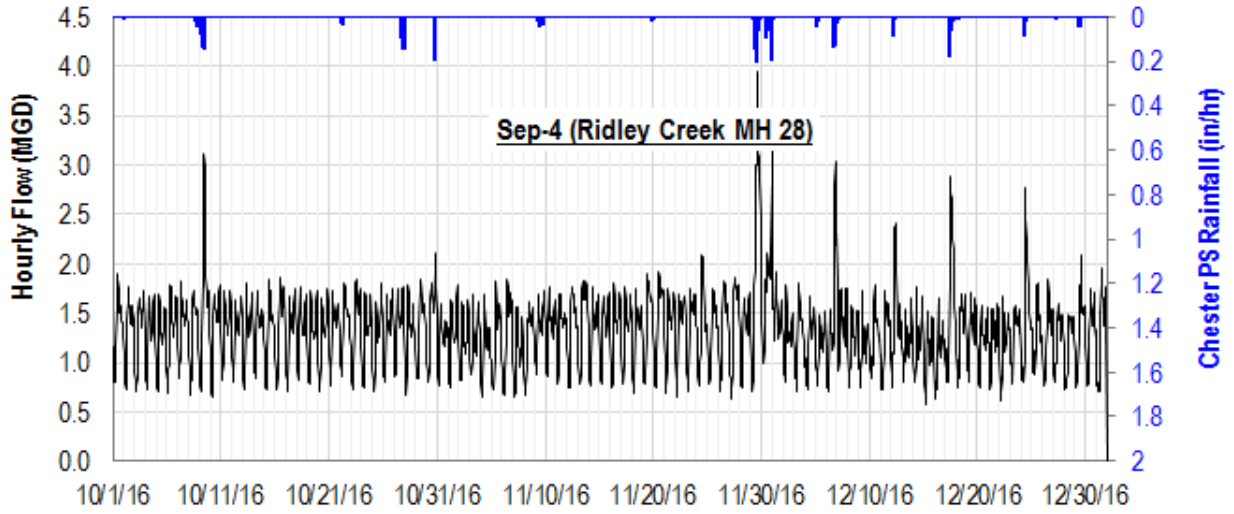


Figure 48: Flow Monitoring Data, Sep-4

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

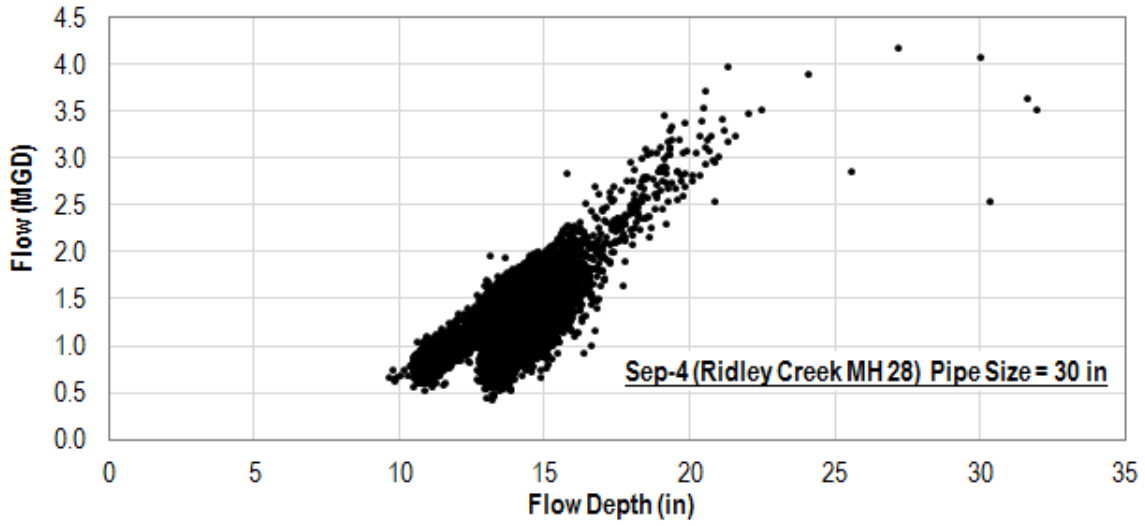
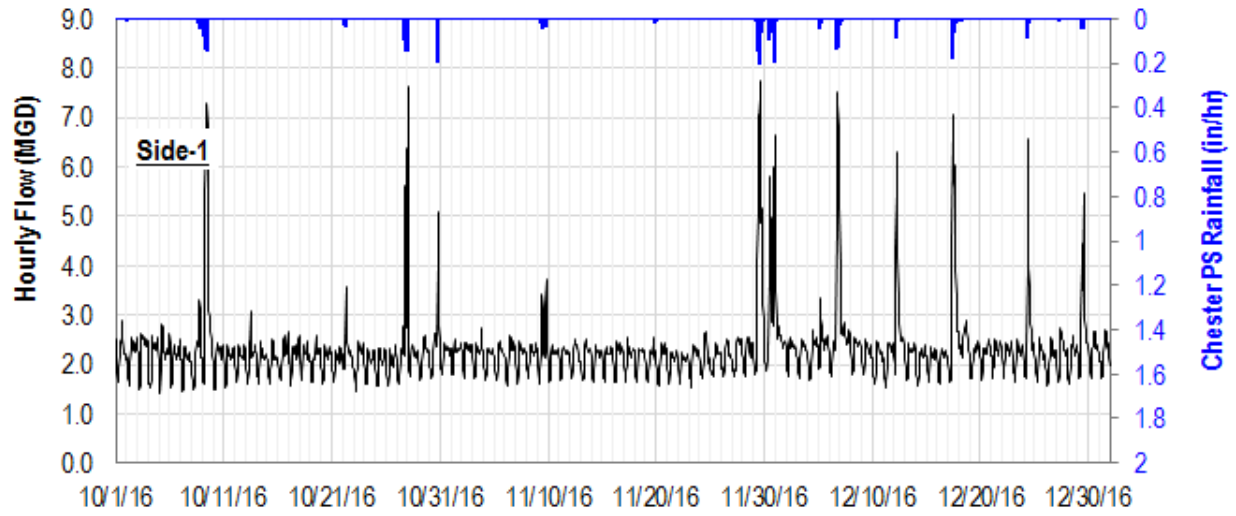


Figure 49: Flow Monitoring Data, Side-1

Hourly Hydrograph



Scattergraph (Flow vs. Depth)

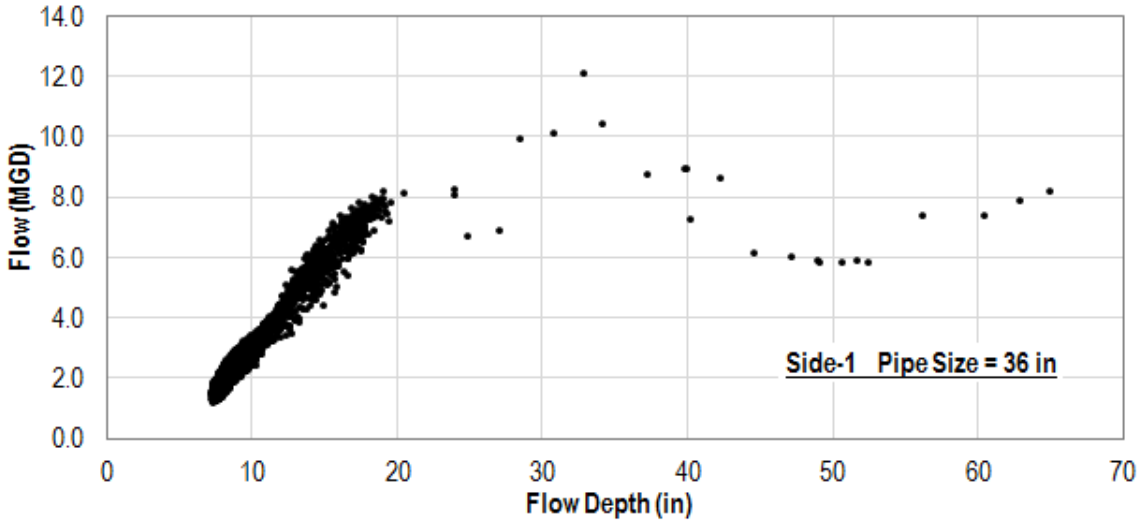
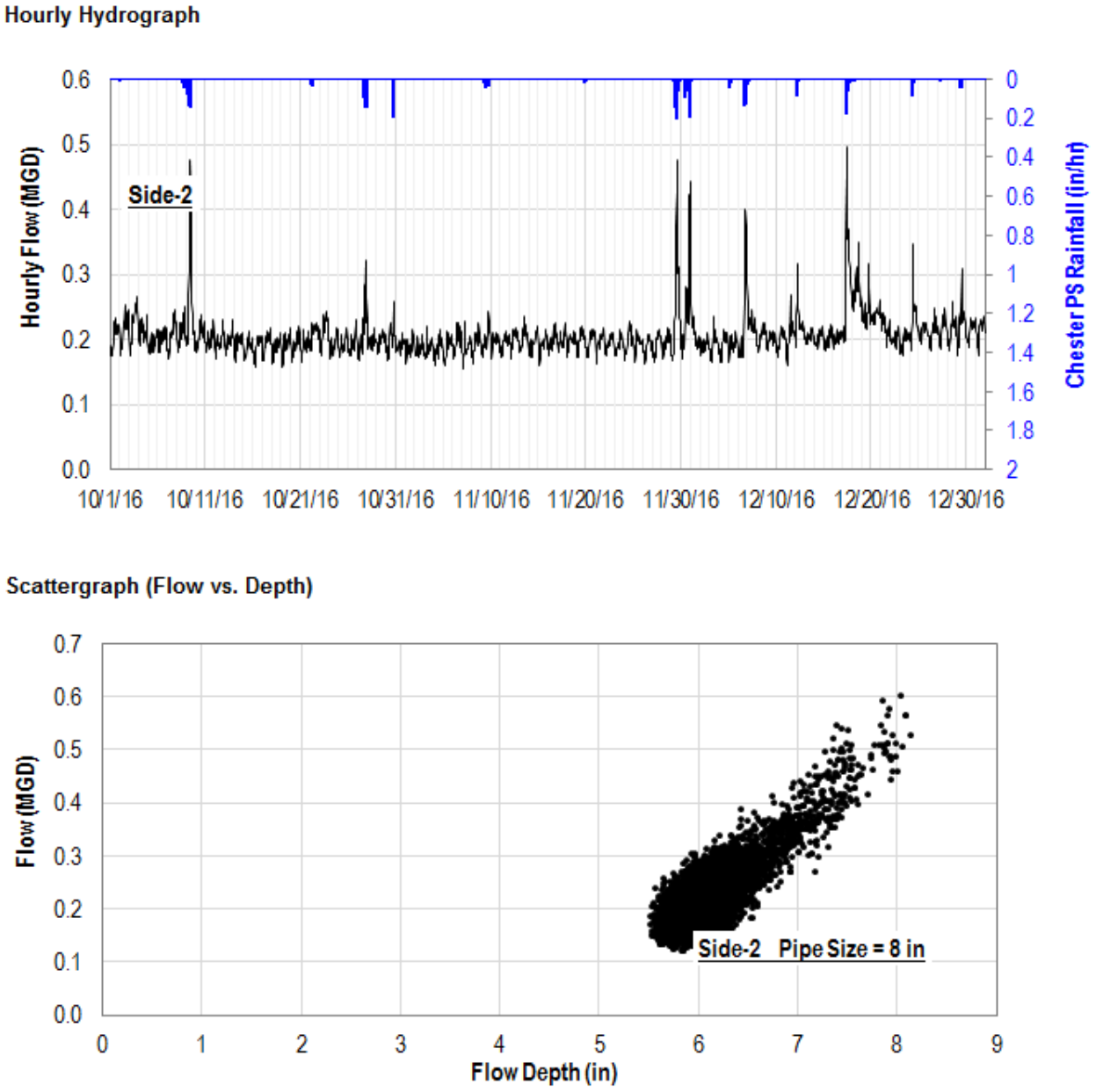


Figure 50: Flow Monitoring Data, Side-2



Greeley and Hansen LLC
1700 Market Street, Suite 2130
Philadelphia, PA 19103
(215) 563-3460
www.greeley-hansen.com

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

Rainfall and Flow Monitoring Quarterly Report No. 4

(January 1, 2017 to April 1, 2017)

Final

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