ONEIDA COUNTY DEPARTMENT OF WATER QUALITY & WATER POLLUTION CONTROL

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(315) 798-5656 wpc@ocgov.net FAX 724-9812

Anthony J. Picente, Jr.
County Executive

Steven P. Devan, P.E.
Commissioner

April 24, 2018

Gregg Townsend, P.E.
Regional Engineer
NYS Department of Environmental Conservation
317 Washington Street
Watertown, NY 13601

UNITED PARCEL SERVICE

Carol Lamb-Lafay, P.E.
Director – Bureau of Water Permits
Division of Water
NYS Department of Environmental Conservation
625 Broadway, 4th Floor
Albany, NY 12233

Re: Oneida County Sewer District
Quarterly Progress Report – 1st Quarter 2018

Consent Order No. R6-20060823-67

Dear Mr. Townsend and Ms. Lamb-Lafay:

On behalf of Oneida County, I am providing for your review and comment Oneida County's Quarterly Progress Report for the 1st Quarter – 2018 as required per Section XIII – Reporting Requirements of the Consent Order. This document summarizes the status and progress of work completed between January 1, 2018 and March 31, 2018 in support of Consent Order compliance requirements.

Please feel free to contact me should you have any questions or need additional information.

Sincerely,

THE ONEIDA COUNTY DEPARTMENT OF
WATER QUALITY & WATER POLLUTION CONTROL

Steven P. Devan, P.E.
Commissioner

Enclosure: Quarterly Progress Report – 1st Quarter 2018

ecc: Anthony J. Picente, Jr. - Oneida County Executive
Peter M. Rayhill, Esq. – Oneida County Attorney
Karl E. Schrantz, P.E. – O'Brien & Gere Engineers, Inc.
Howard LeFever, P.E. – GHD Consulting Services, Inc.
Judy Drabicki, - NYSDEC
Joseph DiMura, P.E. - NYSDEC
Thomas Vigneault, P.E. - NYSDEC
Richard Coriale, P.E. – NYSDEC
Michael O'Neil, P.E. - NYSEFC

SANITARY SEWER COLLECTION SYSTEM
QUARTERLY PROGRESS REPORT
1ST QUARTER – 2018
ONEIDA COUNTY SEWER DISTRICT

NYSDEC Consent Order R620060823-67

Prepared for

Oneida County Department of Water Quality
& Water Pollution Control

Steven P. Devan, P.E., Commissioner
51 Leland Avenue
Utica, NY 13502

April 24, 2018

Cazenovia, NY   Syracuse, NY   Utica, NY

Sanitary Sewer Collection System
Quarterly Progress Report
1st Quarter - 2018
Oneida County Sewer District
NYSDEC Consent Order R620060823-67

Prepared for:

Oneida County Department of Water Quality &
Water Pollution Control

Prepared by:

O'Brien & Gere Engineers, Inc.
101 First Street
4th Floor
Utica, NY 13501

April 24, 2018

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1.0 INTRODUCTION

1.1 HISTORICAL BACKGROUND

The Oneida County Sewer District (District) was formed in 1965 through an act by the former Oneida County Board of Supervisors. It is administered by Oneida County through the Oneida County Department of Water Quality and Water Pollution Control (WQ&WPC), which is responsible for the operation of the District's facilities and personnel. District facilities include 45-miles of interceptor sewers, the Sauquoit Creek Pumping Station (SCPS), the Barnes Avenue Pumping Station, and the Water Pollution Control Plant (WPCP). The District services 15 municipalities, nine of which are within the SCPS Basin. These municipalities own and operate their own collection systems.

1.2 PURPOSE

The New York State Department of Environmental Conservation (NYSDEC) and Oneida County (County) entered a Consent Order (No. R620060823-67) due to sanitary sewer overflows (SSO) at the SCPS. In addition to the required mitigation of those SSOs, the Consent Order, with an effective date of December 12, 2011, requires the submission of Quarterly Progress Reports. The intent of this Quarterly Progress Report is to summarize the work that has been undertaken by the County between January 1, 2018 and March 31, 2018 (1st Quarter of 2018) in support of the Consent Order compliance requirements.

2.0 ENGINEERING INVESTIGATIONS AND EVALUATIONS

During the 1st Quarter of 2018, the County completed the following tasks related to engineering investigations and evaluations.

2.1 COLLECTION SYSTEM

2.1.1 Manhole Inspections

The manhole inspection program was completed in 2012. There were no additional manhole inspections completed during the 1st Quarter of 2018.

2.1.2 Sanitary Sewer Televising

There are approximately 216-miles of sanitary sewer within the SCPS basin (30-miles of District interceptor sewer plus 186-miles of municipal sewer). In 2011, the County contracted with a firm (National Water Main Cleaning Co.) to perform closed circuit televising (CCTV) of these sanitary sewers. Televising data was collected electronically in the field using the nationally standardized Pipe Assessment and Certification Program (PACP) and incorporated into the County's data management software.

The 2011 initial televising contract resulted in approximately 79%, or 171-miles, of the 216-miles of sewers being televised. The remaining 21%, or 47-miles of sewers, were not inspected at that time due to: heavy debris in quantities beyond the scope of the contractual cleaning effort; small diameter pipe inhibiting effective CCTV inspections; lack of easement access to manholes and sewers; and buried manholes. These obstacles are primarily maintenance related and are being addressed through the District-wide Capacity, Management, Operations, and Maintenance (CMOM) program currently in various stages of implementation. Efforts are being made to CCTV and inspect additional sewers as a component of current and future sewer rehabilitation contracts.

During the 1st Quarter 2018, additional televising was not performed; however, including the original CCTV contract, and subsequent CMOM and rehabilitation related CCTV, a total of approximately 193-miles of sewer, or 89% of the total sewers in the SCPS basin have been televised.

2.1.3 Dye Testing

The dye testing program was completed in 2012. There was no additional dye testing performed during 1st Quarter 2018.

2.2 TREATMENT FACILITIES

Investigations, evaluations and designs have been completed. The WPCP, SCPS and New Force Main are in various stages of bid evaluation and construction. Table 2.1 summarizes how the work has been segregated, and the status of each of the various planned construction contracts. Note: Contract numbers identified for the work at the WPCP and the SCPS/Force Main (C-1 through C-8), do not correlate to the sanitary sewer rehabilitation contracts (Contracts 2-14).

Table 2.1

Oneida County Sewer District										
Summary of Contracts 1Q 2018										
Water Pollution Control Plant and Sauquoit Creek Pumping Station/Force Main										
Contract No.	**Title of Contract**	**Components of System Addressed**	**Status of Design**	**Status of DEC Review**	**Status of other Agency Reviews**	**Estimated Advertisement**	**Estimated [1] Construction Start**	**Construction Progress**	**Estimated Construction Complete**
1	Incinerator No. 2 Demolition	Demolition of Incinerator No. 2	Final	Approved	n/a	Bidding occurred during 1Q 2016; however, due to the outcome of bids, the demolition was added to Contract 2 by addendum on May 25, 2016.			
2	WPCP Solids Handling Upgrades	2 new egg-shaped digesters, 1 secondary digester w/gas holding cover, new waste activated sludge pumps, refurbish 4 gravity thickeners, new stand-by lime stabilization system, 2 new belt filter presses	Final	Approved	n/a	Advertised April 4, 2016	Notice to Proceed September 27, 2016	Demo of Incinerator No. 2 complete. Lime stabilization building and equipment installation complete, waiting for final electrical, instrumentation & startup. Erection of steel tanks (Primary digesters) is complete, mech. equipment install on-going. Secondary Digester tank complete, mech. equipment and cover install on-going. Mechanical installation of New Belt Filter Presses, Gravity Belt Thickeners and Sludge Blend Tanks on-going. Installation of new Gravity Thickeners is complete and equipment field tested.	April 2019
3A	Electrical Equipment Pre-Purchase (Digester 15kV)	Pre-purchase of major electrical components such as switch gears, transformers, and supporting power distribution equipment	Final	n/a	n/a	April 2017	Equipment delivery October 2017	Equipment has been installed and tested. Training has been provided to the Owner.	n/a
4	Sauquoit Creek Force Main Upgrades	New 48-inch force main and rehabilitation of the existing force main, new flow metering and flow control vaults	Final	Approved	Approved	Advertised December 15, 2017	May 2018	Bids received in March 2018. Contracts being prepared for exectuion by the County and the apparent low bidder.	December 2020

Table 2.1

Oneida County Sewer District									
Summary of Contracts 1Q 2018									
Water Pollution Control Plant and Sauquoit Creek Pumping Station/Force Main									
Contract No.	Title of Contract	Components of System Addressed	Status of Design	Status of DEC Review	Status of other Agency Reviews	Estimated Advertisement	Estimated (1) Construction Start	Construction Progress	Estimated Construction Complete
5	Sauquoit Creek Pumping Station Upgrades	Replacement of existing pump station mechanical screen contained in a new screen building, 2 screenings washer/compactors and conveyor; replacement of existing standby generator capable of operating the station to pump peak flow during a power outage; electrical/HVAC upgrades; flow distribution structure at the WPCP	Final	Approved	n/a	November 2016	July 2017	General: General Contractor assisted local agencies over the course of several days with the Jan 2018 ice jam break up and ice debris removal. New Screenings Building: concrete poured for base slab and foundation walls; new emergency generator installed for April startup; testing of new electrical service transformer and assoc. cables; installed electrical conduits and wiring; on-going HVAC and plumbing; Existing Building: preparing to relocate existing boiler and install new second boiler; on-going electrical wiring/lighting replacements; began demo of existing plumbing to allow layout of new plumbing modifications	January 2019
5.1	Barnes Avenue Pumping Station Upgrades	Relocation of pumping station to south side of CSX Railroad right-of-way; new, smaller, sustainable pumping station sized to accommodate actual flow rates	0%	n/a	n/a	December 2018	May 2019	n/a	January 2020
6	WPCP Headworks Upgrades	New screening facility and pump station dedicated to sanitary flows from North Utica & Starch Factory Creek Interceptors; repurpose existing raw waste building for combined flow from City of Utica; new grit removal facilities; remodeling of the administrative building including new laboratory, control room, offices, training room, etc.	Final	Approved	Pending National Grid approval, Stage A submitted in February 2016	March 2017	September 2017	On-going foundation and concrete work for Influent Bldg, Grit Bldg No. 2, and Grit Bldg No. 3; installation of miscellaneous yard piping; on-going asbestos abatement and interior renovations in Administration Bldg.	May 2020
7	WPCP Primary Treatment Upgrade/Disinfection	New rectangular primary settling tanks to replace existing circular tanks; new high rate disinfection system for wet weather combined sewer flows; new HRD outfall	Final	Submitted December 9, 2016	n/a	Advertised November 28, 2017	May 2018	Bids received in February 2018. Notice of Award issued to apparent low bidder and contracts being prepared for execution.	December 2021
8	WPCP Secondary Treatment Process Upgrades	Replacement of existing blowers with more efficient units, replacement of existing aeration tank diffusers, refurbishment of the existing final settling tanks	30%	Estimated submittal December 2018	n/a	January 2019	May 2019	n/a	December 2021

* - Estimated construction start = Notice to Proceed

3.0 MANAGEMENT PROGRAMS

3.1 COMPUTERIZED MANAGEMENT AND MAINTENANCE SYSTEM

The County purchased a Computerized Management and Maintenance System (CMMS) software system (Lucity) in 2009. This software is used to manage the sewer system data (mapping, inspections, etc.) obtained to date by the County. At the same time that the software was acquired, the County invested in computer hardware upgrades to support the CMMS. The County's Geographic Information System (GIS) Coordinator manages the system.

The County continues to utilize the CMMS for tracking and documenting sewer rehabilitation work, and uploading and managing new PACP data provided by the County's CCTV and sewer rehabilitation contractors on a regular basis.

The Consultant Team utilizes the CMMS in support of the sanitary sewer rehabilitation design efforts to identify defects and develop rehabilitation methodologies.

The County continues to maximize the use of its current CMMS software. At the same time, the County, with the assistance of the Consultant Team, continues to assess ways to optimize the CMMS with the long term expanded asset management needs for the wastewater system. As a result, the County has begun to explore potential alternative software. It is anticipated this research of alternative software systems will continue as opportunities become available.

3.2 FLOW MONITORING PROGRAM AND HYDRAULIC MODEL

In 2010, a hydrologic (HSPF) and hydraulic (SWMM) model of the sewer collection system tributary to Sauquoit Creek Pumping Station (SCPS) was developed in order to evaluate control methods for reducing sanitary sewer overflow (SSO) at SCPS. This effort included the analysis of data from 30+ flow meters collected over a period of nine months during 2008. The model was calibrated to the flow meter data and then used to simulate flow conditions for a typical year. The results from the simulations were used to evaluate engineering alternatives. Since then, I/I removal projects have been completed in the collection system.

The County worked closely with the Dormitory Authority of the State of New York (DASNY) to secure an $950,000 Economic Development Assistance Program (EDAP) funding allocation to support the extensive flow monitoring program proposed by the County, and approved by NYSDEC on August 24, 2012.

The EDAP funds were ultimately made available by DASNY to the County in March 2014. Procurement of the flow monitoring equipment was advertised in June 2014. Contract was awarded in September 2014 to ADS Environmental Services, LLC (ADS). In 2015, ADS completed the installation of 63 flow meters and five rain gauges within the collection system, at the same approximate locations the meters were installed in 2008. Two of the meters were installed to monitor flow to the County's Barnes Ave Pumping Station. Two others monitor flow in two of the City of Utica's combined sewers to aid in hydraulic model calibration and confirmation. The flow meters and rain gauges have been consistently collecting flow data since their installation.

To further support the Consent Order flow data documentation and assessment requirements, the County's consultants began the calibration of an update to the original 2010 hydraulic model in June 2017 (completed in December 2017) utilizing 2015-2016 flow meter and rain gauge data (County rain gauges and National Weather Service gauges were used). Typical year simulations were run on both the old and new calibrated models. The results of the "pre-rehabilitation" and "post-rehabilitation" models were statistically compared and used to evaluate the effectiveness of the I/I removal projects upstream of the SCPS. The comparison showed that the I/I reduction projects completed through May 2017, have reduced the average annual SSO volume at the SCPS by 24 percent. Technical Memorandum, I/I Reduction Analysis – Sauquoit Creek Pump Station, dated December 19, 2017 which summarizes the evaluation and findings of the hydraulic model calibrations is included in Appendix A.

3.3 PRIVATE PROPERTY INFLOW AND INFILTRATION REDUCTION PROGRAM

The document titled "Preliminary Planning Document – Private Property Inflow and Infiltration Reduction Program" was submitted to NYSDEC on June 29, 2012 as required by Schedule A - Section B.2 of the Consent Order. The County, working through the Steering Committee, created a working group of appropriate private property inflow and infiltration (PPII)-oriented community representatives to map out a phased implementation plan.

The full Steering Committee convened on January 25, 2018. County Executive Anthony Picente, Jr. was in attendance encouraging the group to continue implementing and working collaboratively on CMOM and PPII programs at the municipal level. He provided an update to the Committee regarding the rate increase that residents will see in April 2018. Status of progress on the various construction projects at the WPCP, SCPS, and sanitary sewer rehabilitation, as well as 2017 community outreach efforts, was provided by the consultant team.

In support of a potential future pilot project to address private property I/I, lateral CCTV has, and continues to be, performed in select locations during the on-going sewer rehabilitation projects. CCTV data is received from the sewer rehabilitation contractor and reviewed for completeness.

3.4 CAPACITY, MANAGEMENT, OPERATIONS AND MAINTENANCE PROGRAM

The document titled "Preliminary Planning Document – Proposed CMOM Framework – Sauquoit Creek Pumping Station Basin Communities" was submitted to NYSDEC on June 29, 2012 as required by Schedule A – Section B.3 of the Consent Order. The County, working through the Steering Committee, created a working group of appropriate CMOM-oriented community representatives to map out a phased implementation plan.

The full Steering Committee met on January 25,2018. A summary of topics discussed can be found above in Section 3.3.

Fats, Oils, and Grease (FOG) Program: OCSD and Oneida County Department of Health (OCDOH) are collaborating on the implementation of the Fats, Oils, and Grease (FOG) program. OCSD, OCDOH, Oneida County Department of Planning, and consultants held a work session on March 16, 2018 to discuss and confirm some of the inspection components that need to be finalized prior to inspections beginning in summer 2018. Inspectors will verify that Food Service Establishments (FSEs) are in compliance with the local and County sewer use ordinance in not releasing fat-laden wash water or cooking oils to the sanitary sewer system. Inspectors will look for evidence that FSEs are utilizing best management practices, tracking grease trap maintenance and keeping grease hauling records. Information on each FSE will be entered in the County CMMS Lucity so that it can be associated with the growing collection system database.

Easement Maintenance: The County advanced a small easement maintenance contract involving cutting of trees and vegetation along the Deerfield East Interceptor Sewer easement located east of Leland Avenue, between the Canal and NYS Thruway. The easement was overgrown and required re-establishment for future inspection and maintenance of the interceptor sewer. Work was done using low ground pressure forestry equipment and hand tools. The work was completed prior to March 31 and did not involve grading and/or filling.

Sauquoit Creek Interceptor Sewer Stabilization (Victoria Drive): The County submitted a Joint Application for Permit to NYSDEC and Army Corps of Engineers on March 27, 2018. The Project will repair/stabilize a section of 24-inch interceptor sewer exposed in Sauquoit Creek between Victoria Drive (Utica) and NYS Route 8 (New Hartford). The planned work will include stream bank stabilization along with grade control at the immediate downstream limits to help mitigate the existing water elevation drop, and re-establish aquatic biota passage through the reach.

4.0 SCHEDULE/MILESTONE DATES

4.1 APPROVED SCHEDULE

The following table represents the approved schedule as defined by the Consent Order (note that there were no changes to this schedule during the 1st Quarter of 2018):

Description	Consent Order, Schedule "A" Date	Status
Engineering Investigations and Evaluations		
Dye Testing and Storm Sewer Report	June 30, 2012	Complete, Submitted June 29, 2012
Manhole Evaluation Report – Phase II	June 30, 2012	Complete, Submitted June 29, 2012
SCPS Evaluation Report	August 31, 2012	Complete, Approved November 28, 2012
WPCP Evaluation Report	August 31, 2012	Complete, Approved November 28, 2012
Treatment System Supplement (Report)	60 days after approval of WPCP Evaluation Report	Complete, Submitted January 25, 2013
Sewer CCTV Inspection Report – Phase II	April 30, 2013	Complete, Submitted April 25, 2013
Sewer CCTV Inspection Report – Phase III	April 30, 2014	Complete, Submitted April 29, 2014
Collection System Supplement (Report)	May 31, 2014 (extension granted to July 1, 2014)	Complete, Submitted June 30, 2014 Approved December 18, 2014
Management Programs		
Flow Monitoring Program	March 31, 2012	Complete, Approved August 24, 2012
Private Property I/I Reduction Program	June 30, 2012	Complete, Submitted June 29, 2012
CMOM Program	June 30, 2012	Complete, Submitted June 29, 2012
PPII Reduction Program Implementation	May 31, 2013	Began implementation in 4th Quarter 2012
CMOM Implementation	May 31, 2013	Began implementation in 4th Quarter 2012
Asset Management Plan	December 31, 2021	In development
Remedial Measures		
Semi-Permanent Alternative-Construction	December 31, 2016	Technical language for a proposed modification to Consent Order addressing this item has been tentatively agreed to and is being finalized between NYSDEC and the County.

Description	Consent Order, Schedule "A" Date	Status
SSO Mitigation-Consent Order Compliance	December 31, 2021	In progress
Reporting		
Annual Work Plan	January 31, Annually	Submitted annually
Quarterly Progress Report	Quarterly	Submitted quarterly

Note: I/I – Inflow and Infiltration

4.2 MILESTONES

During the 1st Quarter of 2018, the following milestone dates were met:

- Continuing to make progress toward compliance milestones.
- The original Schedule "A" date for the completion of construction of the Semi-Permanent Alternative was December 31, 2016. A formal request was submitted to the NYSDEC in September 2016 to eliminate the Semi-Permanent Alternative and to modify the December 31, 2016 Consent Order interim milestone date. The Semi-Permanent Alternative was found to no longer provide the value originally anticipated due to enhancements to the project construction schedule at the WPCP, and the benefits seen from the progression of sewer rehabilitation contracts. During subsequent conversations with the Regional Water Engineer, the request was made to provide the dollar equivalents in sewer rehabilitation contracts for the planned savings that would be realized from the Semi-Permanent Alternative. Through continued dialog with the Regional Water Engineer, conceptual consensus was reached during the 1st Quarter of 2018 on the technical terms of a modification to the Consent Order. Specific wording of the Consent Order Modification is currently being discussed, and it is anticipated that this will be formalized between the County and NYSDEC in the 2nd Quarter 2018.

5.0 SEWER REHABILITATION

Sewer rehabilitation work financed under CWSRF Project No. C6-6070-08-00, C6-6070-08-10, and C6-6071-02-00 continued to progress. Projects are being tracked by contract number. The rehabilitation contracts are being undertaken in order to reduce the amount of inflow and infiltration entering the system due to defects in interceptor sewers, mainline sewers, lateral connections and manhole structures. Work under these sewer rehabilitation contracts typically includes: a mix of cured-in-place-pipe (CIPP) lining; pipe joint and lateral grouting; open cut repairs; spot repairs; manhole repairs/replacement; and supplemental CCTV inspections. The status and details of the rehabilitation contracts to date are presented in Table 5.1.

Oneida County Sewer District

Summary of Contracts 1Q 2018

Sewer Rehabilitation Contracts

Contract No.*	Title of Contract	Project Location/Description	CWSRF Project No.	Status of Design	Status of DEC/EFC/COUNTY Review	Miles of Rehabilitation[(2)]	Estimated I/I Reduction (gal/day)	Current Contract Amount [(1)]	Contractor	Contract Status
2	Sanitary Sewer Manhole Rehabilitation - Phase 2	District-wide: Rehabilitation of approximately 1,278 sanitary sewer manholes	C6-6070-08-00	Final	Approved	47	5,411,910	$ 1,529,131.73	Green Mountain Pipeline Services	Project Complete; Closed Out
3	Sanitary Sewer Mainline Rehabilitation - Phase 1	Villages of New York Mills, Oriskany, New Hartford, Whitesboro, and Yorkville; Towns of New Hartford and Whitestown	C6-6070-08-00	Final	Approved	13	1,503,360	$ 1,916,428.54	Insituform	Project Complete; Closed Out
4	Sewer Separation - Clinton/Henderson Street, NY Mills	NY Mills: Storm/Sanitary sewer separation	C6-6070-08-00	Final	Approved	2	264,000	$ 155,007.51	JJ Lane Construction	Project Complete; Closed Out
5	Sewer Repairs and Rehabilitation	Villages of Whitesboro, New Hartford, Yorkville, New York Mills: Storm/Sanitary sewer repairs and rehabilitation; manhole replacement and UV-CIPP lining.	C6-6070-08-00	Final	Approved	1	120,000	$ 411,841.66	Central Paving	Project Complete; Closed Out
6	Sanitary Sewer Mainline Rehabilitation - Phase 2	Villages of New Hartford and Clayville; Towns of New Hartford and Paris; City of Utica	C6-6070-08-00	Final	Approved	15	1,130,000	$ 2,086,525.00	Green Mountain Pipeline Services	Project Complete; Closed out
7	Sanitary Sewer Mainline Rehabilitation - Phase 3	Towns of New Hartford and Whitestown: Glenhaven area (HHI-1 and WHN-31), the area west of the Whitesboro Parkway School and south of Clinton Street area (WHN-33), and Kellogg Road area (NHD-18)	C6-6070-08-00	Final	Approved	13	630,000	$ 2,060,644.00	Green Mountain Pipeline Services	Project Complete; Closed out
8	Sanitary Sewer Mainline Rehabilitation - Phase 4	Town of New Hartford: Paris Road area (NHD-23)	C6-6070-08-00	Final	Approved	14	249,000	$ 1,143,410.78	National Water Main Cleaning Co.	Project Complete: Closed Out
10	Sanitary Sewer Mainline Rehabilitation - Phase 5	Town of Whitestown and Village of Whitesboro: area west of Henderson St., north of Mud Creek, south of Clinton St. and east of Clinton Rd; and areas of V. of Whitesboro that have not been previously rehabbed	C6-6070-08-10	Final	Approved	17	1,120,000	$ 3,429,370.00	Green Mountain Pipeline Services	- Project was shut down until end of February due to winter weather conditions. Post rehab CCTV initiated in March 2018. - Punchlist completion will occur in Spring 2018.

Table 5.1

Oneida County Sewer District

Summary of Contracts 1Q 2018

Sewer Rehabilitation Contracts

Contract No.*	Title of Contract	Project Location/Description	CWSRF Project No.	Status of Design	Status of DEC/EFC/COUNTY Review	Miles of Rehabilitation(2)	Estimated I/I Reduction (gal/day)	Current Contract Amount (1)	Contractor	Contract Status
11	Sanitary Sewer Mainline Rehabilitation - Phase 6	Town of New Hartford/Hamlet of Washington Mills: Chapman Rd, Higby Rd., and Mohawk St. as well as side streets in T. of New Hartford (NHD-20)	C6-6070-08-10	Final	Approved	7	260,640	$ 632,029.26	National Water Main Cleaning Co.	Project Complete; Closed Out
12(3)	Sewer Rehabilitation Project	Village of Yorkville: areas of the Village not previously rehabbed (YKV-1)	C6-6071-02-00	Final	Approved	11	824,832	$ 3,552,280.00	National Water Main Cleaning Co.	Project under construction; Completion delayed due to winter weather conditions, remobilization expected in Spring 2018. Possible rehab scope increase due to funds availability.
13	Sanitary Sewer Mainline Rehabilitation - Phase 8	Town of New Hartford: residential subdivisions along Routes 12B and Merritt Place, situated south of Route 5B and Seneca Turnpike, and north of Sherrill Brook Park (NHD-6)	C6-6070-08-10	Final	Approved	5	280,000	$ 802,838.50	National Water Main Cleaning Co.	Project is under construction; Minor punchlist items completed in non-traffic areas. Most work complete. Balance of punchlist items will be completed in Spring 2018. Certificate of Substantial Completion issued.
14	Sanitary Sewer Mainline Rehabilitation - Phase 9	Town of New Hartford: Commercial district along Seneca Turnpike surrounding Sangertown Square Shopping Mall, south to a residential area situated between Seneca Turnpike and Clinton Rd., and a small residential area south of Clinton Rd. along Merritt Place (NHD-9)	C6-6070-08-10	Final	Approved	7	360,000	$ 995,407.25	National Water Main Cleaning Co.	Project is under construction. Project was temporarilly shut down until mid-March due to winter weather conditions. Project is proceeding.
16	Sanitary Sewer Mainline Rehabilitation - Phase 10	Town of Whitestown: Residential area along Westmoreland Rd. and West St., south of the NYS Thruway, and north of Clinton Rd. (WHN-34, WHN-35, WHN-12 & WHN-36)	C6-6070-08-10	Final	Approved	3	270,000	$ 386,042.00	National Water Main Cleaning Co.	Notice of Award was issued on March 30, 2018. Contract is being prepared for execution in 2Q 2018.

* - Contract 9 - Flow Monitoring Contract

(1) - Values are subject to change upon submission of final contractor close-out documentation. Some entries are contract bid amounts and will be updated when project closes out.

(2)- In order to estimate the manhole repairs in equivalent miles, the following calculation was used:
In the April 2012, Engineering Report, Sauquoit Creek Pumping Station Basin – Phase I-Mainline Pipe Rehabilitation – Contract No. 3, the length of line to be rehabilitated was 13-miles, and the corresponding flow to be removed is 1,503,360 gal/day, which calculates to 116,000 gpd/mile. Using the same 116,000 gpd/mile figure for Contract No. 2, an estimated 5,411,910 gal/day divided by 116,000 gpd/mile, is equivalent to 47-miles of rehabilitated sewers.

(3) - formerly Contract 12 - Sanitary Sewer Mainline Rehabilitation - Phase 7. Financed by the Village of Yorkville.

BOLD - Value represents the Engineers estimate

6.0 ASSESSMENT OF REHABILITATION EFFECTIVENESS

See Section 3.2 above for a discussion of the status of flow monitoring and hydraulic model update. Based on the completed work, and using estimated values of inflow and infiltration (I/I) removals provided in the Offset Plan and/or the approved Basis of Design engineering reports for the respective projects, the estimated reductions in I/I for each rehabilitation contract are shown in Table 5.1.

7.0 COMPLETED CAPITAL PROJECTS/FACILITY UPGRADES

Status of all capital projects and facility upgrades is provided in Table 2.1 and Table 5.1.

8.0 I/I OFFSET PROJECTS/NEW FLOWS

During the 1st Quarter of 2018, new additions and subtractions to the I/I Offset Credit Bank were not recorded by the County. All amounts are reported in gallons per day (gpd) after the application of the 5:1 offset ratio.

Community	Starting Balance	Credits Added	Location	Credits Used	Ending Balance
Town of New Hartford	1,587,181	0		0	1,587,181
Town of Paris	253,064	0		0	253,064
Town of Whitestown	854,274	0		0	854,274
Village of Clayville	59,069	0		0	59,069
Village of New Hartford	278,004	0		0	278,004
Village of New York Mills	166,523	0		0	166,523
Village of Oriskany	103,466	0		0	103,466
Village of Whitesboro	163,599	0		0	163,599
Village of Yorkville	160,282	0		0	160,282
Oneida County Business Park	43,027	0		0	43,027
Oneida County Sewer District	24,710	0		0	24,710
Totals	**3,693,199**			**0**	**3,693,199**

9.0 KEY PERSONNEL CHANGES

Key personnel changes, as they relate to the SSO Mitigation/Consent Order compliance project, are interpreted to be those staff members whose addition to or deletion from the project would be viewed by the County to either add resources, or be a detriment to progress. Project staff includes County, satellite community, and Consultant Team personnel. The following is a summary of changes.

9.1 COUNTY STAFF

During the 1st Quarter of 2018, there were no changes of key personnel to report.

9.2 SATELLITE COMMUNITY STAFF

During the 1st Quarter of 2018:

Village of New Hartford – Timothy Hughes, Public Works Superintendent, retired. Thomas Hughes was appointed as the new Public Works Superintendent and Steering Committee representative.

Town of Schuyler – Donald Sroka, Highway Superintendent, passed away unexpectedly in January 2018. Phillip Johnson has been appointed interim Highway Superintendent and Steering Committee representative.

9.3 CONSULTANT TEAM STAFF

During the 1st Quarter of 2018, there were no changes of key personnel to report.

10.0 ADMINISTRATIVE ITEMS

10.1 WORK AUTHORIZATIONS

New work orders were not authorized during the 1st Quarter of 2018.

10.2 PROJECT FINANCING

The following listing is from the CWSRF 2018 Final Intended Use Plan (IUP), issued in December 2017 for the County:

CWSRF PROJECT #	PROJECT NAME	TOTAL IUP AMOUNT
C6-6070-08-00 (Long-term financed)	I/I CORR [9 CONTRIBUTING COMMUNITIES] Phase 1 and 2a	(1)$10,078,438 (includes $4M Principal Forgiveness)
C6-6070-08-10 (Balance of unexpended funds from Original C6-6070-08-00 financing)	I/I CORR [9 CONTRIBUTING COMMUNITIES] Phase 1 and 2a	$11,721,562
C6-6070-08-01 (Multi-year)	I/I CORR [SSO - 9 Contributing Communities] Phase 2b, 3, 4, 5, & 6	$28,400,000
C6-6070-08-02 (Long-term financed)	FM, PS REHAB [DESIGN AND PERMITTING PHASE] Phase 5a	(1)$2,524,071
C6-6070-08-03 (Multi-year)	I/I CORR [SSO Phase 4]	$7,663,000
C6-6070-08-04 (Annual List - Short-term financed)	FM Rehab, PS Rehab [CONSTRUCTION PHASE] Phases 5b	$97,000,000
C6-6070-08-04 (Annual List - Short-term financed)	FM Rehab, PS Rehab [CONSTRUCTION PHASE] Phase 5b	$15,000,000
	Water Infrastructure Grant	$5,000,000
C6-6070-08-05 (Annual List)	STP UP (Phases 6a)	$43,000,000
C6-6070-08-06 (Long-term financed)	STP UP [SOLIDS HANDLING SYSTEMS DESIGN AND CONSTRUCTION]	$35,000,000
C6-6070-08-15 (Multi-year)	STP UP	$87,000,000

(1) - CWSRF Project Financing has closed, is no longer listed in IUP, but reflect the amount Oneida County is now repaying.

10.2.1 STP UP [Phase 6a] (CWSRF No. C6-6070-08-05 and C6-6070-08-15) - $130 Million

Bond authorization to increase the financing amount to $160 million was approved by the Oneida County Board of Legislators on November 22, 2017. The County began the preparation of an application for CWSRF financing in the 1st Quarter of 2018. Application will be submitted in the 2nd Quarter of 2018.

Appendix A

Technical Memorandum No. 1 I/I Reduction Analysis – Sauquoit Creek Pumping Station

Technical Memorandum

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Andover, MA 01810
T: 978-794-0336

Prepared for: Oneida County Sewer District

Project Title: Hydraulic Model Update

Project No: 150778

Technical Memorandum No. 1

Subject: I/I Reduction Analysis – Sauquoit Creek Pump Station

Date: December 19, 2017

To: Karl Schrantz, P.E.

From: Matthew Davis, P.E.

Copy to: Robert Winn, P.E.

Prepared by: Matthew Davis, P.E.____________________

Reviewed by: Robert Winn, P.E.______________________

Limitations:

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Executive Summary

The Sauquoit Creek Pump Station (SCPS) experiences sanitary sewer overflows (SSOs) during significant rainfall events. In 2012 Oneida County completed an *SSO Mitigation Plan* to address the SSOs at the SCPS. The *Plan* recommended a series of I/I reduction projects to reduce SSOs at the pump station. Many of those projects have now been completed.

This Study was performed to evaluate the effectiveness of the I/I reduction projects in reducing SSO volumes at the SCPS. In support of this effort, Oneida County deployed a network of flow meters and rain gauges in the system to monitor rainfall and flow rates from 2015 through 2017. This Study used this information, along with rain gauge and flow meter data collected in 2008 and hydrologic and hydraulic modeling tools to estimate the effectiveness of the I/I reduction projects. This Study found that the I/I reduction projects have reduced the average annual SSO volume at the SCPS by approximately 24 percent.

Section 1: Introduction

Oneida County completed the development of an *SSO Mitigation Plan (Plan)* in 2012. A major focus of the *Plan* was reducing SSOs at the SCPS. To this end, the *Plan* recommended a series of I/I reduction projects upstream of the pump station. Many I/I reduction projects have now been completed and the goal of this Study was to evaluate the reduction in SSOs that have been achieved at the SCPS due to these efforts.

This Study was tasked with characterizing SSOs at the SCPS for the "pre-rehabilitation" and the "post-rehabilitation" flow conditions, where the pre-rehabilitation conditions correspond to conditions before the completion of the *Plan* and the post-rehabilitation conditions correspond to current conditions with multiple I/I reduction projects having been completed.

For the purposes of this Study, "characterizing" the flows is primarily a matter of determining the SSO volumes at the SCPS. By comparing the SSOs before and after the I/I reduction projects were completed, it is possible to determine the SSO reductions achieved by those projects. Unfortunately, conclusions cannot be drawn by directly comparing the SSOs measured at the SCPS during the pre-rehabilitation and post-rehabilitation periods. The hydrologic conditions during these two periods of time were different. Different amounts of rain fell. The rainfall intensities were also different. In addition, there were a host of other factors which impact I/I like antecedent soil moisture conditions, snow pack and evapotranspiration. Directly comparing SSOs from the pre- and post-rehabilitation period would be like comparing apples and oranges.

In order to evaluate the SSOs reductions at the SCPS, it is necessary to estimate the SSOs for the pre- and post-rehabilitation conditions under the same hydrologic conditions. It is a best practice within the engineering community to use hydrologic and hydraulic models to perform this type of analysis. The typical approach, which is the approach utilized by this Study, is to calibrate a hydrologic and hydraulic model to pre-rehabilitation conditions, and then calibrate another hydrologic and hydraulic model to the post-rehabilitation condition. Once the models are well-calibrated, they can be expected to simulate conditions with reasonable accuracy outside of their calibration period. The two models are then used to simulate flows using the exact same set of hydrologic conditions. This approach makes it possible to directly compare the SSOs at the SCPS for the same hydrologic conditions before and after the I/I reduction projects were completed.

As mentioned, the approach used by this Study relied upon a hydrologic and hydraulic model, but it is important to emphasize that the most important component of the model was the hydrology. Since this Study was focused on SSOs at the SCPS, only the pump station and the pipes going into and out of it were modeled. As a result, the hydraulics were modeled in a straightforward manner. The hydrology, however, was much more complicated. Several flow meters were located on the gravity sewers upstream of the pump station and the flows from these meters were summed together and routed through the pump station. The flows measured by the flow meters result from a host of complicated interactions between the watershed and the sewer system. The goal of a hydrologic model is to accurately simulate these processes.

SSOs are most likely to occur at the SCPS during the winter and spring time. From 2011-2015, nearly 60 percent of the SSO volume occurred during the months of January through April. It is clear from the flow meter record that the groundwater has an important influence on I/I in the system during this time of year. Snow melt is also important. In order to accurately simulate the hydrology of the system, it is important to simulate these processes.

The *Plan* relied primarily on the HSPF hydrologic model to simulate the flow of water through the watershed. It was coupled with another model called CAPE which converted the watershed flows into I/I and then exported the I/I to SWMM which was used solely for its hydraulic modeling capabilities. HSPF was used because it is one of the most respected watershed models available and is adept at simulating snow melt, surface runoff, groundwater flow and interflow. For this Study, however, it was decided to try and use the SWMM model to simulate both the hydrology and hydraulics. This approach was taken for several reasons. First, the use of multiple models makes it difficult for other parties to reuse and modify the models. Secondly, SWMM has a hydrologic model which mods snowmelt and the groundwater. Unfortunately, in spite of extensive efforts to calibrate the SWMM models to the flows entering the SCPS, the SWMM models were unable to adequately simulate some of the winter/springtime conditions which lead to SSOs. In the end, a different approach was taken which proved to be more straight forward. It also provided greater accuracy. However, SWMM was still used to model the hydraulics of the SCPS.

The hydrology was simulated using a two-fold approach:

- **Infiltration** was simulated with a function that transforms Mohawk River stage data into sewer infiltration.
- **Inflow** was simulated using three unit hydrographs, which is the same process that SWMM uses to simulate rainfall dependent I/I.

Since the process used to simulate inflow is well-described in the *Stormwater Management Model Reference Manual, Volume 1 – Hydrology (Revised)* it will not be detailed here. However, the use of Mohawk River stage data to estimate infiltration is described in Section 2.

The hydrologic modeling utilized rainfall, flow meter and river stage data. The data is presented and discussed in Section 3. The calibration of the hydrologic models to pre- and post-rehabilitation conditions is discussed in Section 4. In Section 5, the pre- and post-rehabilitation models are used to simulate SSOs from 2008 through 2017. The data from these model runs was used to estimate the reduction in SSOs achieved by the I/I reduction projects upstream of the SCPS.

Due to the large number of figures and tables in this TM, they have been placed at the end of the document.

Section 2: Methodology

As discussed in Section 1, hydrologic and hydraulic models representing pre- and post-rehabilitation conditions were developed for the SCPS. The models were calibrated to measured flow meter data (see Section 3). After the models were calibrated, the models were used to simulate the performance of the SCPS from 2008 through 2017. For convenience, these ten-year simulations are referred to as *long-term simulations* in this TM. The ten years of SSOs estimated by the pre- and post-rehabilitation models were then compared to estimate the SSO reductions achieved by the upstream I/I reduction projects.

Hydraulic Model

SWMM was used for hydraulic modeling of the SCPS. The capacity of the pumping system to s that pump flow to the WWTF was assumed to be 15 MGD. The capacity of the pumping system to pump SSOs to the Mohawk River was assumed to be 22.5 MGD. Flows from the hydrologic model were inserted at the upstream end of a gravity sewer that discharges to the pump station. The same hydraulic model was used for both pre- and post-rehabilitation models. As a result, when the term 'pre-rehabilitation' or 'post-rehabilitation' model is used in this TM, it is used primarily to make a distinction between the hydrologic models.

Hydrologic Model

This Study originally used the SWMM to simulate the hydrology, but despite extensive efforts to calibrate the model, it was found to be incapable of simulating some of the hydrologic processes which lead to SSOs during the winter and springtime. Both snow accumulation/melt and groundwater were included in the SWMM model, but the model could not accurately simulate some periods of elevated flow which appear to be related to groundwater dynamics. The flows during these periods share some of the characteristics of both inflow and infiltration. Whereas inflow typically has a short-term, low volume response and groundwater infiltration typically has a long-term, high volume response, the flows that SWMM was having difficulty simulating were somewhere in between. They had a medium-term response coupled with significant volumes. These flows bear similarities to a type of groundwater flow referred to as interflow. Unfortunately, SWMM does not have the ability to simulate interflow. Due to this shortcoming, the SWMM hydrology model was eventually abandoned and a different approach was adopted.

Infiltration Model

Infiltration was modeled with a function that transforms a continuous record of Mohawk River stage data into sewer infiltration flows. The rationale behind this approach is that the Mohawk River stage data is well-correlated to flows entering the SCPS. It is important to note that this Study is not suggesting that the Mohawk River is directly discharging to the sewer system. Rather, this approach is suggesting that river stage is a good surrogate measurement of groundwater and interflow processes taking place in the watershed that contribute to I/I.

A generalized function was used to transform the river stage data to infiltration as shown in Equation 2-1.

Equation 2-1

$$H_i = Ar_i + B$$

where H_i is the infiltration at timestep i, A is the river stage scaling factor, r_i is the river stage at timestep i, and B is the offset factor. Both A and B are constant value which are calibrated to measured flow data. The river stage data used by the model is discussed in Section 3.

It is assumed that the hydrology and hydraulics of the Mohawk River have not changed significantly from 2008 through 2017.

Inflow Model

Inflow was modeled using the unit hydrograph method. Three unit hydrographs were used, making it identical to the approach used by SWMM for modeling rainfall dependent I/I. In SWMM the process is referred to as RTK. Since this process is described in detail in the *Stormwater Management Model Reference Manual, Volume 1 – Hydrology (Revised)*, it will not be detailed here.

The unit hydrograph method uses rainfall data to simulate inflow. The rainfall data used in the analysis is discussed in Section 3. The dynamics of snow accumulation and snow melt were not incorporated into the inflow analysis. As will be shown in Section 4, it did not seem necessary. The calibrations were able to achieve a good fit to the measured data without explicitly accounting for snow accumulation and melt. It is likely that the flows simulated by the infiltration model are adequately accounting for these dynamics as the river depth is influenced significantly by snow melt in the spring.

Model Scenarios

The hydrologic model was calibrated to pre- and post-rehabilitation conditions. The pre-rehabilitation model was calibrated to data collected from March 2008 through September 2008. The post-rehabilitation model was calibrated to data collected from February 2015 through May 2017. However, I/I reduction projects were being performed during this time, resulting in changes to the hydrologic conditions. As a result, two different post-rehabilitation models were calibrated. Post-rehabilitation Model 1 was calibrated to data from February 2015 through June 2016. Post-rehabilitation Model 2 was calibrated to data collected from July 2016 through May 2017. The calibration periods for the hydrologic models is summarized in Table 2-1.

Long-Term Simulations

After the models were calibrated, they were used to simulate flows over a ten-year period lasting from 2008 through 2017. This period was chosen because it overlaps with the pre- and post-rehabilitation periods. It is also a period of time for which both river stage and rainfall data were available. After the long-term simulations were completed, the average annual simulated SSO volume at the SCPS for each of the different models was determined and compared in order to determine the SSO reductions achieved by the I/I reduction projects.

The ten years included in the long-term simulations represent a wide range of meteorological conditions. Some years were wetter than others. Some years had more snow than others. By calculating the average annual SSO volume from the ten years of simulated flows it is possible to get a reasonable estimate of the average annual SSO volume at the SCPS. Clearly, it would be ideal to simulate an even longer period of time. This would lead to a better estimate of the true annual average. However, the length of the simulation period is limited by the availability of river stage data for the Mohawk River. Currently only 10 years of river stage data are available, but this is sufficient to develop a reasonable estimate of the average annual SSO volumes.

The SSO Mitigation *Plan* estimated SSOs at the SCPS for “typical year” conditions. The year 1986 was chosen as the typical year based on the annual rainfall total and the size and distribution of the storms that occurred during that year. Since river stage data is not available for 1986, this Study did not simulate the typical year. Rather, it performed long-term simulations to determine the average annual SSO volume over a ten-year period.

Both the average annual and typical year SSO volumes are useful metrics; however, the average annual SSO metric is preferred as it provides a better assessment of average conditions. While sound engineering judgement was taken in selecting 1986 as the typical year, there was no rigorous methodology available for determining which year had the most "typical" conditions. There are too many factors to consider such as rainfall, temperature, wind speed, antecedent soil moisture conditions, etc. In contrast, calculating averages from long-term simulations provides a rigorous assessment of average conditions.

Section 3: Source Data

The hydrologic model requires continuous records of rainfall and Mohawk River stage data. It also requires flow meter data during the calibration process. These data sources are described in this Section.

Rain Gauge Data

Rain gauges were deployed from March 2008 through September 2008 and from February 2015 through May 2017. The locations of the rain gauge locations are shown in Figure 3-1. The monthly rainfall totals measured at the wastewater treatment *Plan*ts are shown in Table 3-1.

The quality of the rain gauge data was evaluated by comparing it with a National Weather Service (NWS) rain gauge in Rome, NY (KRME) and Albany, NY (KALB). These NWS rain gauges are Tier I rain gauges and receive routine maintenance and upkeep. The processed data from these rain gauges is considered to be of high quality. Double mass plots were developed for each local rain gauge by plotting its cumulative rainfall against the cumulative rainfall of the KRME rain gauge for the same time period. In general, the data should fall on a 45-degree line if the two gauges are in perfect agreement. Aberrations from the 45-degree line can be helpful in identifying periods of time when the local rain gauges may not have been functioning properly. In general, the local rain gauge data appeared to be of high quality.

The rain gauges deployed in the County are not heated which means that precipitation falling in the form of snow may not have been measured accurately. This was a concern because of the need to have good rainfall data to accurately model winter time conditions. The aforementioned NWS rain gauges are heated, so the double mass plots were reviewed to determine if the local rain gauges deviated from the NWS gauge during the winter time. Fortunately, the plots did not show any significant deviation, indicating that the local rain gauges were able to measure winter time precipitation even though they were not heated.

The Paris Department of Public Works (DPW) rain gauge was used to calibrate the hydrologic models. Figure 3-2 presents time-series plots of the Paris DPW rain gauge data by year. For the long-term simulation which spanned from 2008 through 2017, the data from the Paris Department of Public Works rain gauge was supplemented with data from the KRME rain gauge.

Flow Meter Data

The flows into the SCPS are measured in the gravity sewers upstream of the pump station. In 2008, the flows were measured by flow meters at sites SCI-4, WOI-1 and YKV-1. In 2015, flows meters were deployed at five sites. These sites included two of the sites which were monitored during 2008, SCI-4 and WOI-1; and three meters were deployed in the Yorkville Interceptor at sites YKV1A, YKV1B and YKV2.

In order to simplify data management, a composite record of flows into the pump station was created for both monitoring periods by adding the data from each of the monitoring periods together. There are some periods in the record when one or more of the flow meters was missing flows. During these periods, zero values were assigned to the composite flow record.

The individual flow meter data for the years 2008, 2015, 2016 and 2017 are shown in Figures 3-6, 3-7, 3-8 and 3-9, respectively. The composite flows into the SCPS for the years 2008, 2015, 2016 and 2017 are shown in Figures 3-10, 3-11, 3-12 and 3-13, respectively.

River Stage Data

The hydrologic model uses river stage data from the Mohawk River to estimate sewer infiltration. In order to calibrate the hydrologic models, river stage data is needed for the 2008 and 2015 through 2017 flow/rainfall monitoring periods.

USGS operates multiple river gauges on the Mohawk River. One of the gauges (USGS 013426020) is close by, only about two miles east of Utica. Unfortunately, this gauge has been collecting data only since 2014. Data from 2008 is not available. The next downstream river gauge (USGS 01347000) is located about 20 miles downstream of Utica near Little Falls, NY. River stage data is available at this site beginning in late 2007. Initial test calibrations were performed using both gauges. The Utica gauge’s stage data is very well-correlated to the flows to the SCPS. This gauge would be the ideal choice if its record extended back to 2008. Surprisingly, even though it is 20 miles downstream, the stage data at the Little Fall gauge is also well correlated with the flows to the SCPS. Since the Little Fall gauge has data covering both calibration periods, it was used for calibration. It was also used for the long-term simulations. A sample of the Little Falls River stage data is shown in Figure 3-14 for the year 2015.

SSO Volumes

When flows into the SCPS exceed the capacity of the station to pump flows to the Wastewater Treatment *Plan*t, the excess flow is pumped to the Mohawk River. Since the flow is discharged untreated, these discharges are considered SSOs. A flow meter measures SSO discharges to the River and records daily totals. For convenience, this flow meter will be referred to as the SCPS totalizer. The total annual SSOs from 1999 through 2017 are presented in Table 3-2. The average annual SSO volume during this period of time was 266 MG.

Section 4: Calibration

One pre-rehabilitation and two post-rehabilitation models were calibrated during the periods of time shown in Table 2-1. The models were calibrated using the rainfall, river stage and flow meter data discussed in Section 3.

The hydrologic model calculates the total flow as the sum of base flow, infiltration and inflow. Each of these flow components was calibrated as follows:

- Base flow calibration - The base flow was calculated by multiplying the average daily base flow by an hourly variation pattern which accounts for variation in sanitary sewage generation throughout the day. An analysis of dry weather flow determined that the base flow was 3.14 MGD. While the base flow is comprised primarily of sanitary flow, it also includes some base infiltration; however, the base flow analysis was performed during the driest time of the year when base infiltration is at its minimum. An hourly variation pattern for the base flow was developed. The base flow was the same for the 2008 and 2015-2017 flow monitoring periods.

- Infiltration calibration - The infiltration was calibrated by adjusting the river stage scaling and offset factors (see Section 3).
- Inflow calibration - The inflow was calibrated by adjusting the parameters for three unit hydrographs.

Pre-Rehabilitation Model

The Pre-Rehabilitation Model was calibrated to data measured from March 2008 through September 2008. The calibrated model flows are plotted against the measured flows in Figure 4-1. Table 4-1 provides a summary of the peak flows and volumes for the rainfall events during the calibration period with rainfall totals exceeding 0.25 inches. Figure 4-2 contains a scatterplot of the measured versus simulated peak flow during the rain events. It also contains a scatterplot of the measured versus simulated volume during the rain events. The solid blue line indicates a perfect match and the dashed green lines indicate errors of 10 and 20 percent.

Table 4-2 provides a summary of SSOs by month at the SCPS. It includes SSO data as measured by the SCPS totalizer, SSOs as predicted by the hydraulic model routing the flow meter data and SSOs predicted by the hydrologic and hydraulic model. Since the flow meter data collected in 2008 is considered to be of high quality, the SSOs predicted by the hydraulic model routing the flow meter data is assumed to be the most accurate estimate of the SSOs. The SSOs measured by the SCPS totalizer show similar trends but are different in magnitude. The reason for the difference is unknown. The SSOs predicted by the hydrologic and hydraulic model differed from the SSOs predicted by the hydraulic model routing the flow meter data by 156 percent over the course of the calibration period, but this is primarily due to the model overpredicting for the event in April. For the other months, the difference in the total SSO volume was less than 10 percent. The overprediction in April was related to high water levels in the Mohawk River. The river stage data looks unusual during this period of time and does not seem to be well-correlated with rainfall, and it is suspected that the river gauge may not have been functioning properly. This analysis suggests that the calibrated model can provide reasonably accurate estimates of SSOs at the SCPS for pre-rehabilitation conditions.

Post-Rehabilitation Model 1

The Pre-Rehabilitation Model was calibrated to data measured from February 2015 through June 2016. The calibrated model flows are plotted against the measured flows in Figure 4-3. Table 4-3 provides a summary of the peak flows and volumes for the rainfall events during the calibration period with rainfall totals exceeding 0.25 inches. Figure 4-4 contains a scatterplot of the measured versus simulated peak flow during the rain events. It also contains a scatterplot of the measured versus simulated volume during the rain events. The solid blue line indicates a perfect match and the dashed green lines indicate errors of 10 and 20 percent.

Table 4-4 provides a summary of SSOs by month at the SCPS. It includes SSO data as measured by the SCPS totalizer, SSOs as predicted by the hydraulic model routing the flow meter data and SSOs predicted by the hydrologic and hydraulic model. Since the flow meter data measured from 2015 through 16 is considered to be of high quality, the SSOs predicted by the hydraulic model routing the flow meter data is assumed to be the most accurate estimate of the SSOs. The SSOs measured by the totalizer show similar trends but are different in magnitude. The reason for the difference is unknown. The SSOs predicted by the hydrologic and hydraulic model were 24 percent lower than the SSOs predicted by the hydraulic model routing the flow meter data.

Post-Rehabilitation Model 2

The Pre-Rehabilitation Model was calibrated to data measured from July 2016 through May 2017. The calibrated model flows are plotted against the measured flows in Figure 4-5. Table 4-5 provides a summary of the peak flows and volumes for the rainfall events during the calibration period with rainfall totals exceeding 0.25 inches. Figure 4-6 contains a scatterplot of the measured versus simulated peak flow during the rain events. It also contains a scatterplot of the measured versus simulated volume during the rain events. The solid blue line indicates a perfect match and the dashed green lines indicate errors of 10 and 20 percent.

Table 4-6 provides a summary of SSOs by month at the SCPS. It includes SSO data as measured by the SCPS totalizer, SSOs as predicted by the hydraulic model routing the flow meter data and SSOs predicted by the hydrologic and hydraulic model. Since the flow meter data collected from 2016 through 2017 is considered to be of high quality, the SSOs predicted by the hydraulic model routing the flow meter data is assumed to be the most accurate estimate of the SSOs. The SSOs measured by the totalizer show similar trends but are different in magnitude. The reason for the difference is unknown. The SSOs predicted by the hydrologic and hydraulic model were 22 percent higher than the SSOs predicted by the hydraulic model routing the flow meter data.

Section 5: Long-Term Simulation

Long-term simulations were performed using the calibrated models. The simulations were performed from January 1, 2008 through December 17, 2017. The SCPS SSO volume for each year is shown in Table 5-1.

The average annual SSO volume predicted by the Pre-Rehabilitation, Post-Rehabilitation 1, and Post-Rehabilitation 2 Models were 250, 229 and 191 MG/yr, respectively. The SSO volumes estimated by the Post-Rehabilitation Model 1 are 8 percent lower than the SSO volumes predicted by the Pre-Rehabilitation Model. This is equivalent to saying that the I/I reduction projects completed from 2008 through June 2016 reduced SSO volumes at the SCPS by approximately 8 percent. The SSO volumes predicted by the Post-Rehabilitation Model 2 are 24 percent lower than the SSO volumes predicted by the Pre-Rehabilitation Model. This is equivalent to saying that the I/I reduction projects completed from 2008 through May 2017 reduced the SSO volumes at the SCPS by approximately 24 percent.

Conclusions

The I/I reduction projects have been effective in reducing the SSOs at the SCPS. The I/I reduction projects completed through June 2016 appear to have reduced the average annual SSO volume at the SCPS by about 8 percent. The I/I reduction projects that were completed from July 2016 through May 2017 appear to have reduced the average annual SSO volume at the SCPS by approximately an additional 16 percent, bringing the total reduction to 24%.

TABLES

Table 2-1. Calibration Periods for the Hydrologic Models	
Model Name	**Calibration Period**
Pre-rehabilitation	March 2008 – September 2008
Post-rehabilitation 1	February 2015 – June 2016
Post-rehabilitation 2	July 2016 – May 2017

Table 3-1. Monthly Rainfall Totals				
Month	**Rainfall (in)**			
	2008	**2015**	**2016**	**2017**
January			1.36	3.71
February		0.24	3.97	1.87
March	2.27	1.16	2.71	3.28
April	2.85	3.52	2.48	5.37
May	2.15	1.85	2.47	6.86
June	4.35	4.96	4.54	
July	5.77	2.16	3.75	
August	4.09	2.84	4.71	
September	1.67	4.63	2.21	
October		3.45	6.1	
November		1.1	3.09	
December		4.98	3.02	

Table 3-2. Annual SSO Discharges Measured at the SCPS	
Year	Annual SSO Volume (MG)
1999	85
2000	422
2001	327
2002	302
2003	398
2004	228
2005	273
2006	307
2007	405
2008	387
2009	169
2010	N/A
2011	511
2012	70
2013	378
2014	163
2015	69
2016	85
2017	207
Average	266

Table 4-1. Rain Events Summary for the Pre-Rehabilitation Model

	Rainfall		Peak Flow (MGD)			Volumes (MG)			Ranking		
Rain start	Duration (hr)	Total (in)	Measured	Simulated	Error	Measured	Simulated	Vol Error	Total Rainfall	Measured Peak Flow	Measured Volume
3/7/2008 17:00	29	1.34	33.9	30.8	-9%	26.3	21.9	-17%	4	2	11
3/14/2008 20:00	12	0.33	18.2	18.2	0%	39.5	40.7	3%	20	8	8
3/19/2008 5:00	24	1	29.7	28.4	-4%	97.6	91.4	-6%	8	3	1
3/27/2008 20:00	14	0.65	15.1	19.1	27%	45.4	52.4	15%	11	11	5
3/31/2008 6:00	39	0.48	28.7	30.8	7%	89.2	87.8	-2%	15	4	2
4/4/2008 3:00	26	0.63	19.7	24.2	23%	22.9	30.9	35%	12	7	12
4/11/2008 8:00	24	0.32	20.5	26.6	30%	58.7	87.6	49%	21	6	4
4/28/2008 5:00	29	1.24	17.6	18.7	6%	68.2	77.2	13%	6	9	3
5/4/2008 0:00	5	0.5	13.4	14.3	7%	5.6	5.7	2%	13	13	15
6/6/2008 1:00	9	1.82	36.2	31.2	-14%	36.0	37.0	3%	2	1	9
6/14/2008 15:00	6	0.29	8.6	7.9	-8%	1.7	1.6	-10%	22	21	17
6/16/2008 6:00	20	1.47	9.8	13.9	42%	9.6	10.7	12%	3	17	14
6/18/2008 18:00	2	0.49	8.9	9.9	12%	2.1	2.1	1%	14	20	16
6/22/2008 10:00	2	0.43	9.2	10.5	14%	1.1	1.1	3%	17	18	19
7/9/2008 12:00	6	0.26	7.1	7.2	1%	0.0	0.0	0%	23	23	23
7/13/2008 10:00	15	1.13	16.6	12.4	-25%	39.6	41.0	4%	7	10	7
7/20/2008 19:00	14	0.78	11.2	11.9	6%	0.5	0.3	-35%	10	15	22
7/22/2008 16:00	2	0.45	14.8	9.8	-34%	0.6	0.3	-49%	16	12	21
7/23/2008 7:00	31	3.15	25.4	23.4	-8%	27.7	33.4	21%	1	5	10
8/2/2008 10:00	8	0.37	12.6	12.0	-5%	1.0	0.7	-31%	19	14	20
9/6/2008 4:00	20	1.25	8.9	11.8	33%	12.8	17.2	35%	5	19	13
9/9/2008 8:00	3	0.84	7.8	12.9	66%	1.3	1.9	49%	9	22	18

9/12/2008 14:00	12	0.39	11.1	8.9	-20%	43.2	44.1	2%	18	16	6

Table 4-2. Monthly SSO Summary for the Pre-Rehabilitation Model Calibration Period

Period	SSO Volume (MG)		
	SCPS Totalizer	Flow Meter Data Routed through Hydraulic Model	Hydrologic + Hydraulic Model
March-08	129	89.5	91.6
April-08	44	37.9	106.2
May-08	0	0.0	0.0
June-08	6	5.7	7.0
July-08	1	2.1	3.2
August-08	1	0.0	2.7
September-08	0	0.0	0.0
Total	181	135.3	210.6

Table 4-3. Rain Events Summary for the Post-Rehabilitation Model 1												
	Rainfall		Peak Flow (MGD)			Volumes (MG)			Ranking		
Rain start	Duration (hr)	Total (in)	Measured	Simulated	Error	Measured	Simulated	Vol Error	Total Rainfall	Measured Peak Flow	Meas-ured Volume
7/1/2016 14:00	1	0.33	9.3	0.0	0%	0.0	0.0	0%	31	35	39
7/8/2016 15:00	39	1.03	9.0	13.3	48%	24.2	25.7	6%	10	37	26
7/14/2016 12:00	13	0.8	11.7	10.4	-11%	8.7	8.9	2%	15	27	33
7/15/2016 15:00	2	0.29	8.7	10.5	22%	5.4	6.4	20%	34	38	35
8/11/2016 13:00	3	0.47	7.1	7.3	3%	0.3	0.3	-11%	27	39	38
8/12/2016 13:00	7	0.27	9.2	7.1	-22%	5.9	5.1	-13%	38	36	34
8/13/2016 14:00	8	2.28	22.1	18.5	-16%	22.5	25.8	15%	1	7	27
8/16/2016 8:00	24	0.85	15.4	10.5	-31%	27.2	22.8	-16%	14	23	24
8/21/2016 13:00	4	0.65	13.1	9.6	-27%	30.2	28.2	-6%	20	25	20
10/27/2016 12:00	21	0.76	11.7	11.2	-5%	59.3	55.3	-7%	17	28	11
11/2/2016 22:00	27	1.08	20.1	16.1	-20%	49.0	47.0	-4%	8	14	16
11/15/2016 16:00	15	0.56	10.8	9.8	-9%	33.6	32.1	-4%	23	33	19
11/19/2016 20:00	27	0.39	11.4	9.8	-14%	164.2	148.9	-9%	30	31	1
12/5/2016 12:00	13	0.33	11.2	14.6	30%	40.5	39.0	-4%	31	32	17
12/18/2016 3:00	10	0.28	18.0	18.0	0%	29.5	34.8	18%	36	21	22
12/26/2016 17:00	11	0.28	19.3	17.0	-12%	50.1	49.3	-2%	36	16	15
12/31/2016 12:00	24	0.49	13.1	13.2	1%	4.2	3.9	-8%	26	26	36
1/3/2017 12:00	26	0.73	22.5	18.4	-18%	75.0	65.6	-12%	19	6	6
1/12/2017 2:00	23	0.4	22.9	22.9	0%	50.2	55.5	11%	29	5	14
1/17/2017 12:00	46	0.53	20.3	16.5	-18%	96.9	85.4	-12%	24	12	3
1/23/2017 21:00	20	1.32	20.3	19.3	-5%	113.1	92.7	-18%	5	13	2
2/7/2017 16:00	16	1.14	21.2	17.5	-18%	61.7	59.4	-4%	7	10	9

Table 4-3. Rain Events Summary for the Post-Rehabilitation Model 1

	Rainfall		Peak Flow (MGD)			Volumes (MG)			Ranking		
Rain start	Duration (hr)	Total (in)	Measured	Simulated	Error	Measured	Simulated	Vol Error	Total Rainfall	Measured Peak Flow	Meas-ured Volume
2/15/2017 11:00	3	0.29	11.6	12.9	11%	11.6	12.8	11%	34	30	32
2/25/2017 13:00	9	0.95	28.4	33.5	18%	58.1	69.9	20%	11	4	12
3/7/2017 2:00	28	0.89	18.4	16.9	-8%	62.0	64.9	5%	12	20	8
3/17/2017 11:00	2	0.26	10.7	11.9	11%	0.4	0.4	-2%	39	34	37
3/25/2017 2:00	13	0.42	18.4	13.5	-27%	29.9	24.1	-19%	28	19	21
3/27/2017 0:00	9	0.33	21.3	15.7	-26%	80.1	70.0	-13%	31	9	5
3/30/2017 21:00	36	1.66	34.5	28.5	-17%	82.0	74.7	-9%	2	3	4
4/4/2017 0:00	27	1.5	37.5	35.4	-6%	61.4	65.3	6%	4	1	10
4/6/2017 7:00	44	1.25	35.1	34.5	-2%	62.8	66.5	6%	6	2	7
4/19/2017 13:00	10	0.76	15.4	16.5	7%	17.9	21.6	20%	17	22	29
4/20/2017 22:00	16	0.89	21.5	24.2	12%	54.8	64.7	18%	12	8	13
5/1/2017 19:00	22	0.78	18.7	17.9	-4%	36.5	41.8	15%	16	18	18
5/4/2017 17:00	21	1.05	20.5	21.6	6%	20.2	21.0	4%	9	11	28
5/6/2017 1:00	51	0.64	18.9	23.8	26%	26.7	32.0	20%	21	17	25
5/13/2017 7:00	15	0.57	15.3	14.1	-7%	27.5	28.5	4%	22	24	23
5/21/2017 20:00	19	0.53	11.7	12.0	2%	15.5	15.4	-1%	24	29	30
5/29/2017 4:00	18	1.53	20.1	20.4	1%	11.8	11.8	0%	3	15	31

Table 4-4. Monthly SSO Summary for the Post-Rehabilitation Model 1 Calibration Period			
	SSO Volume (MG)		
Period	SCPS Total-izer	Flow Meter Data Routed through Hydraulic Model	Hydrologic + Hy-draulic Model
March-15	2.8	8.8	0
April-15	32.9	92.2	76
May-15	0.4	1.1	3
June-15	4.2	7.6	14
July-15	0	2.0	3
August-15	0	0.8	1
September-15	0.3	1.0	7
October-15	0	2.0	4
November-15	0	0.0	0
December-15	11.1	31.7	15
January-16	2.4	11.7	8
February-16	36.4	62.6	29
March-16	0	3.2	6
April-16	45	15.5	15
May-16	0	0.1	0
June-16	0	0.6	1
Total	135.5	241.0	182.6

Table 4-5. Rain Events Summary for the Post-Rehabilitation Model 2											
	Rainfall		Peak Flow (MGD)			Volumes (MG)			Ranking		
Rain start	Duration (hr)	Total (in)	Measured	Simulated	Error	Measured	Simulated	Vol Error	Total Rainfall	Measured Peak Flow	Measured Volume
7/1/2016 14:00	1	0.33	9.3	0.0	0%	0.0	0.0	0%	31	35	39
7/8/2016 15:00	39	1.03	9.0	13.3	48%	24.2	25.7	6%	10	37	26
7/14/2016 12:00	13	0.8	11.7	10.4	-11%	8.7	8.9	2%	15	27	33
7/15/2016 15:00	2	0.29	8.7	10.5	22%	5.4	6.4	20%	34	38	35
8/11/2016 13:00	3	0.47	7.1	7.3	3%	0.3	0.3	-11%	27	39	38
8/12/2016 13:00	7	0.27	9.2	7.1	-22%	5.9	5.1	-13%	38	36	34
8/13/2016 14:00	8	2.28	22.1	18.5	-16%	22.5	25.8	15%	1	7	27
8/16/2016 8:00	24	0.85	15.4	10.5	-31%	27.2	22.8	-16%	14	23	24
8/21/2016 13:00	4	0.65	13.1	9.6	-27%	30.2	28.2	-6%	20	25	20
10/27/2016 12:00	21	0.76	11.7	11.2	-5%	59.3	55.3	-7%	17	28	11
11/2/2016 22:00	27	1.08	20.1	16.1	-20%	49.0	47.0	-4%	8	14	16
11/15/2016 16:00	15	0.56	10.8	9.8	-9%	33.6	32.1	-4%	23	33	19
11/19/2016 20:00	27	0.39	11.4	9.8	-14%	164.2	148.9	-9%	30	31	1
12/5/2016 12:00	13	0.33	11.2	14.6	30%	40.5	39.0	-4%	31	32	17
12/18/2016 3:00	10	0.28	18.0	18.0	0%	29.5	34.8	18%	36	21	22
12/26/2016 17:00	11	0.28	19.3	17.0	-12%	50.1	49.3	-2%	36	16	15
12/31/2016 12:00	24	0.49	13.1	13.2	1%	4.2	3.9	-8%	26	26	36
1/3/2017 12:00	26	0.73	22.5	18.4	-18%	75.0	65.6	-12%	19	6	6
1/12/2017 2:00	23	0.4	22.9	22.9	0%	50.2	55.5	11%	29	5	14
1/17/2017 12:00	46	0.53	20.3	16.5	-18%	96.9	85.4	-12%	24	12	3
1/23/2017 21:00	20	1.32	20.3	19.3	-5%	113.1	92.7	-18%	5	13	2
2/7/2017 16:00	16	1.14	21.2	17.5	-18%	61.7	59.4	-4%	7	10	9
2/15/2017 11:00	3	0.29	11.6	12.9	11%	11.6	12.8	11%	34	30	32

Table 4-5. Rain Events Summary for the Post-Rehabilitation Model 2

	Rainfall		Peak Flow (MGD)			Volumes (MG)			Ranking		
Rain start	Duration (hr)	Total (in)	Measured	Simulated	Error	Measured	Simulated	Vol Error	Total Rainfall	Measured Peak Flow	Measured Volume
2/25/2017 13:00	9	0.95	28.4	33.5	18%	58.1	69.9	20%	11	4	12
3/7/2017 2:00	28	0.89	18.4	16.9	-8%	62.0	64.9	5%	12	20	8
3/17/2017 11:00	2	0.26	10.7	11.9	11%	0.4	0.4	-2%	39	34	37
3/25/2017 2:00	13	0.42	18.4	13.5	-27%	29.9	24.1	-19%	28	19	21
3/27/2017 0:00	9	0.33	21.3	15.7	-26%	80.1	70.0	-13%	31	9	5
3/30/2017 21:00	36	1.66	34.5	28.5	-17%	82.0	74.7	-9%	2	3	4
4/4/2017 0:00	27	1.5	37.5	35.4	-6%	61.4	65.3	6%	4	1	10
4/6/2017 7:00	44	1.25	35.1	34.5	-2%	62.8	66.5	6%	6	2	7
4/19/2017 13:00	10	0.76	15.4	16.5	7%	17.9	21.6	20%	17	22	29
4/20/2017 22:00	16	0.89	21.5	24.2	12%	54.8	64.7	18%	12	8	13
5/1/2017 19:00	22	0.78	18.7	17.9	-4%	36.5	41.8	15%	16	18	18
5/4/2017 17:00	21	1.05	20.5	21.6	6%	20.2	21.0	4%	9	11	28
5/6/2017 1:00	51	0.64	18.9	23.8	26%	26.7	32.0	20%	21	17	25
5/13/2017 7:00	15	0.57	15.3	14.1	-7%	27.5	28.5	4%	22	24	23
5/21/2017 20:00	19	0.53	11.7	12.0	2%	15.5	15.4	-1%	24	29	30
5/29/2017 4:00	18	1.53	20.1	20.4	1%	11.8	11.8	0%	3	15	31

Table 4-6. Monthly SSO Summary for the Post-Rehabilitation Model 2 Calibration Period			
	SSO Volume (MG)		
Period	SCPS Totalizer	Flow Meter Data Routed through Hydraulic Model	Hydrologic + Hydraulic Model
July-16	0.2	0.0	0.0
August-16	0	0.9	0.6
September-16	0	0.0	0.0
October-16	0.9	0.0	0.6
November-16	0	1.2	0.1
December-16	0.3	2.7	6.1
January-17	11.4	35.0	14.8
February-17	8.2	16.8	31.1
March-17	25	36.8	30.0
April-17	87.4	94.4	131.1
May-17	1.9	8.4	26.9
Total	135.3	196.2	241.3

Table 5-1. Annual SSO Volumes from Long-Term Simulations			
	SSO Volume (MG)		
Year	Pre-Rehabilitation Model	Post-Rehabilitation Model 1	Post-Rehabilitation Model 2
2008	370	335	279
2009	160	148	119
2010	247	232	189
2011	451	422	362
2012	72	69	48
2013	349	329	277
2014	234	206	178
2015	144	132	100
2016	81	77	51
2017	390	340	307
Average	250	229	191
Percent Reduction from Pre-Rehabilitation Model Average		8%	24%

FIGURES

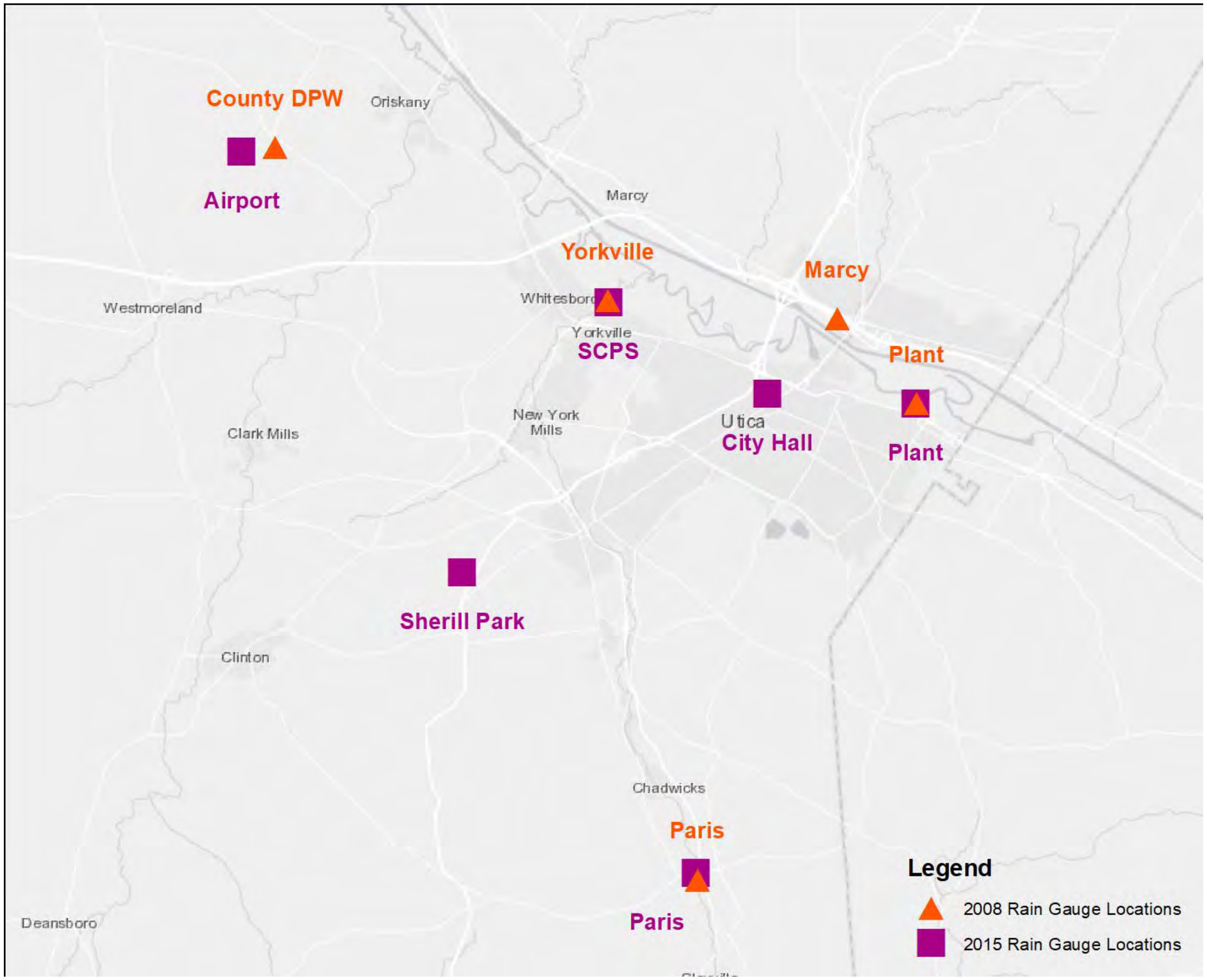

Figure 3-1. Rain Gauge Locations

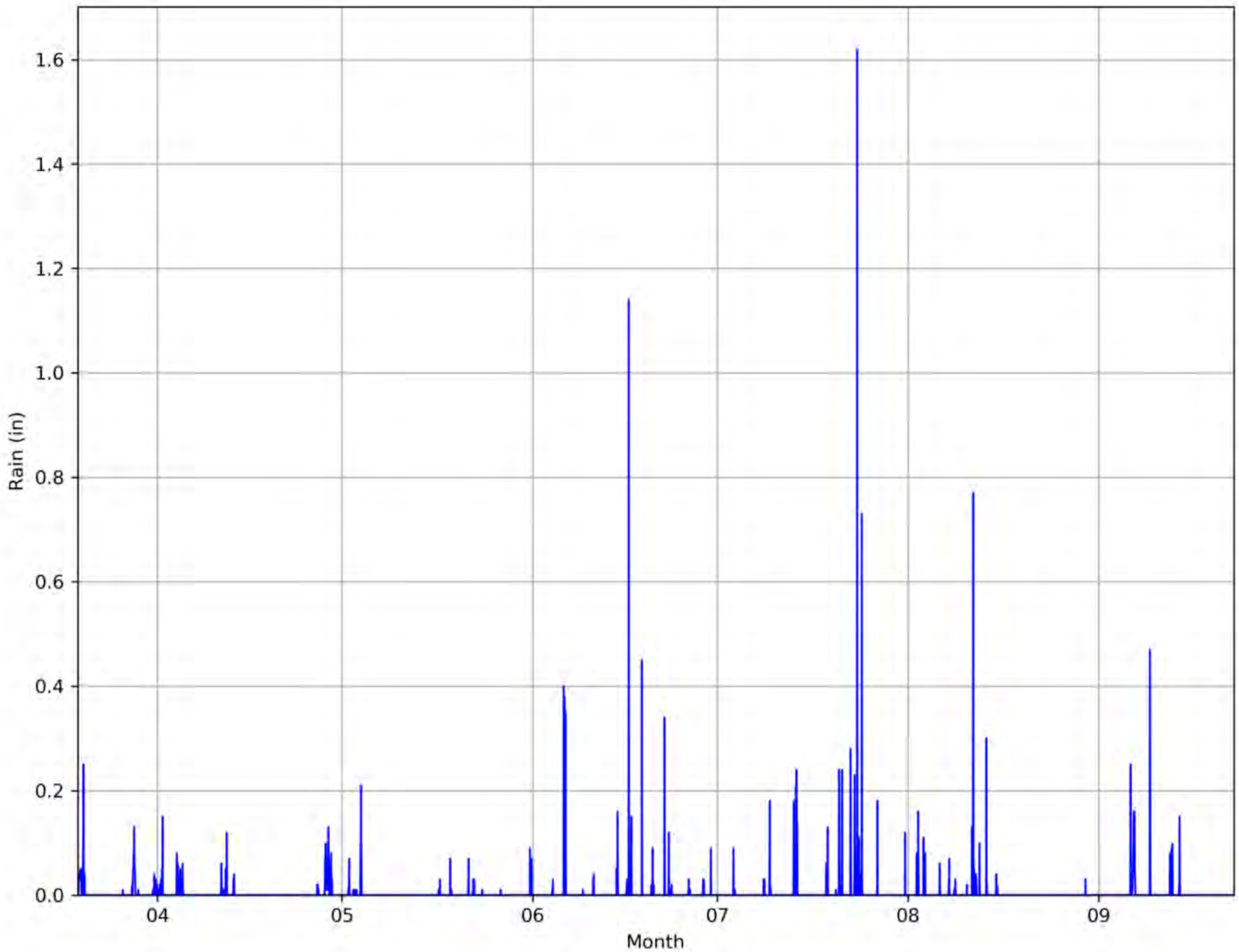

Figure 3-2. Paris DPW Rain Gauge Data (2008)

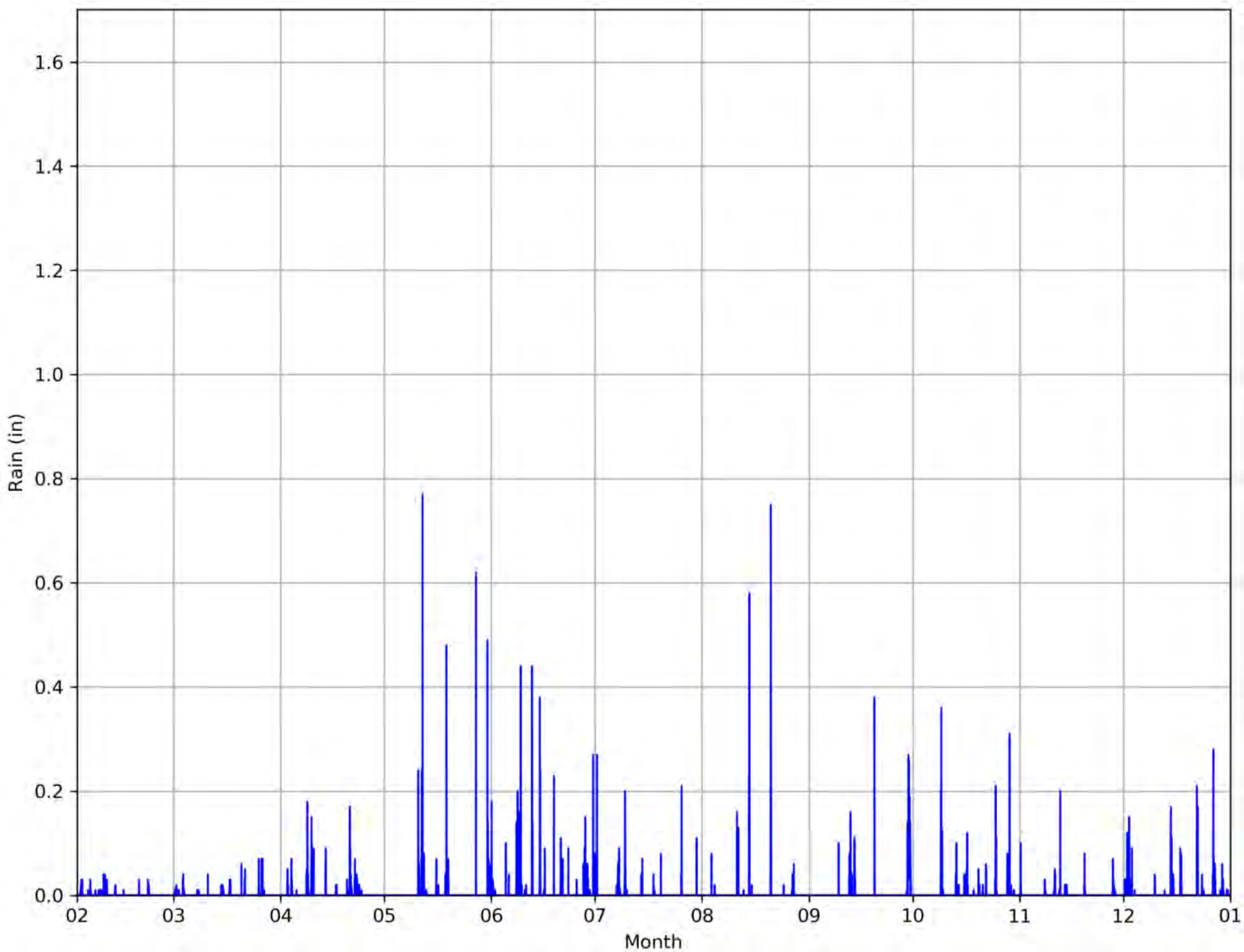

Figure 3-3. Paris DPW Rain Gauge Data (2015)

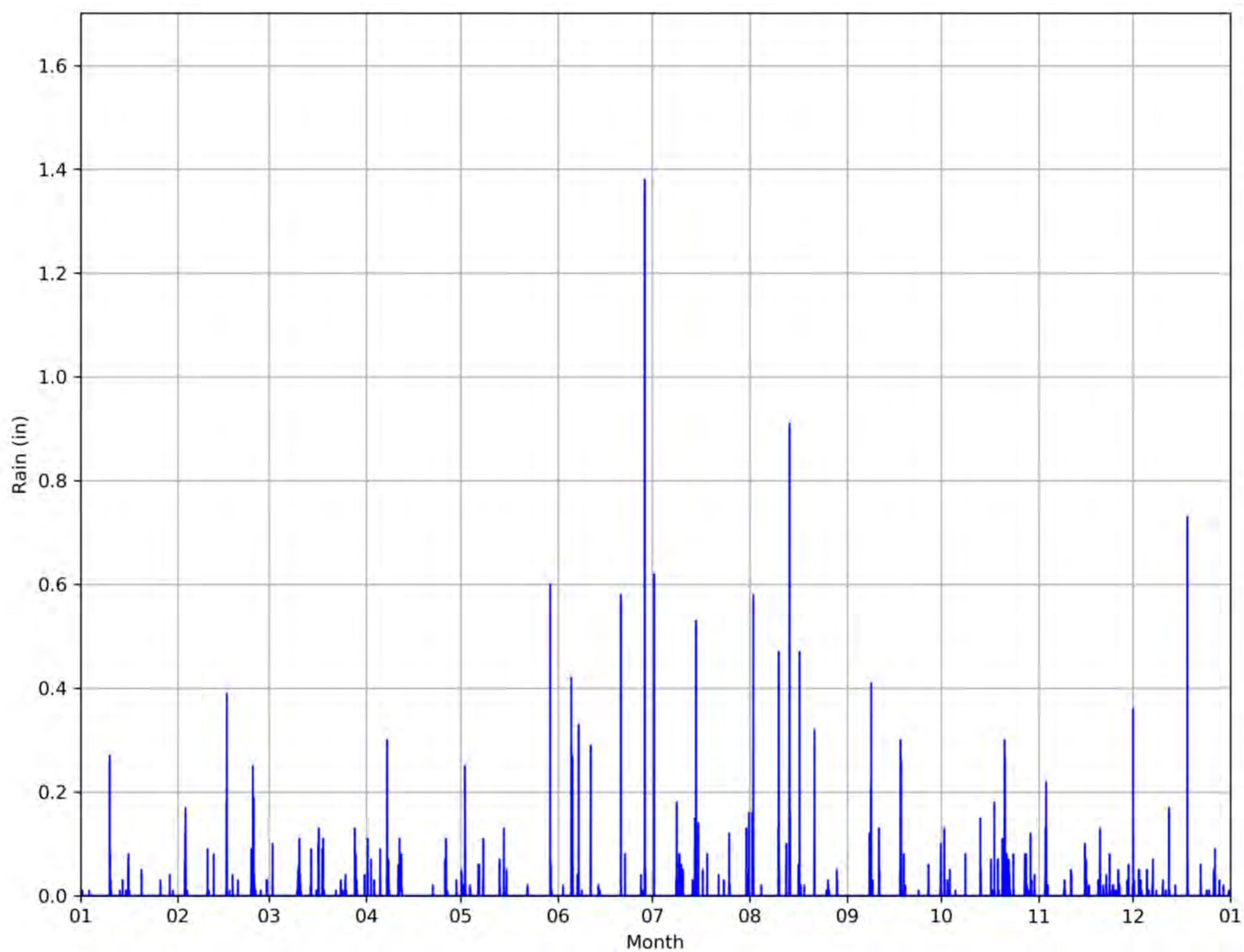

Figure 3-4. Paris DPW Rain Gauge Data (2016)

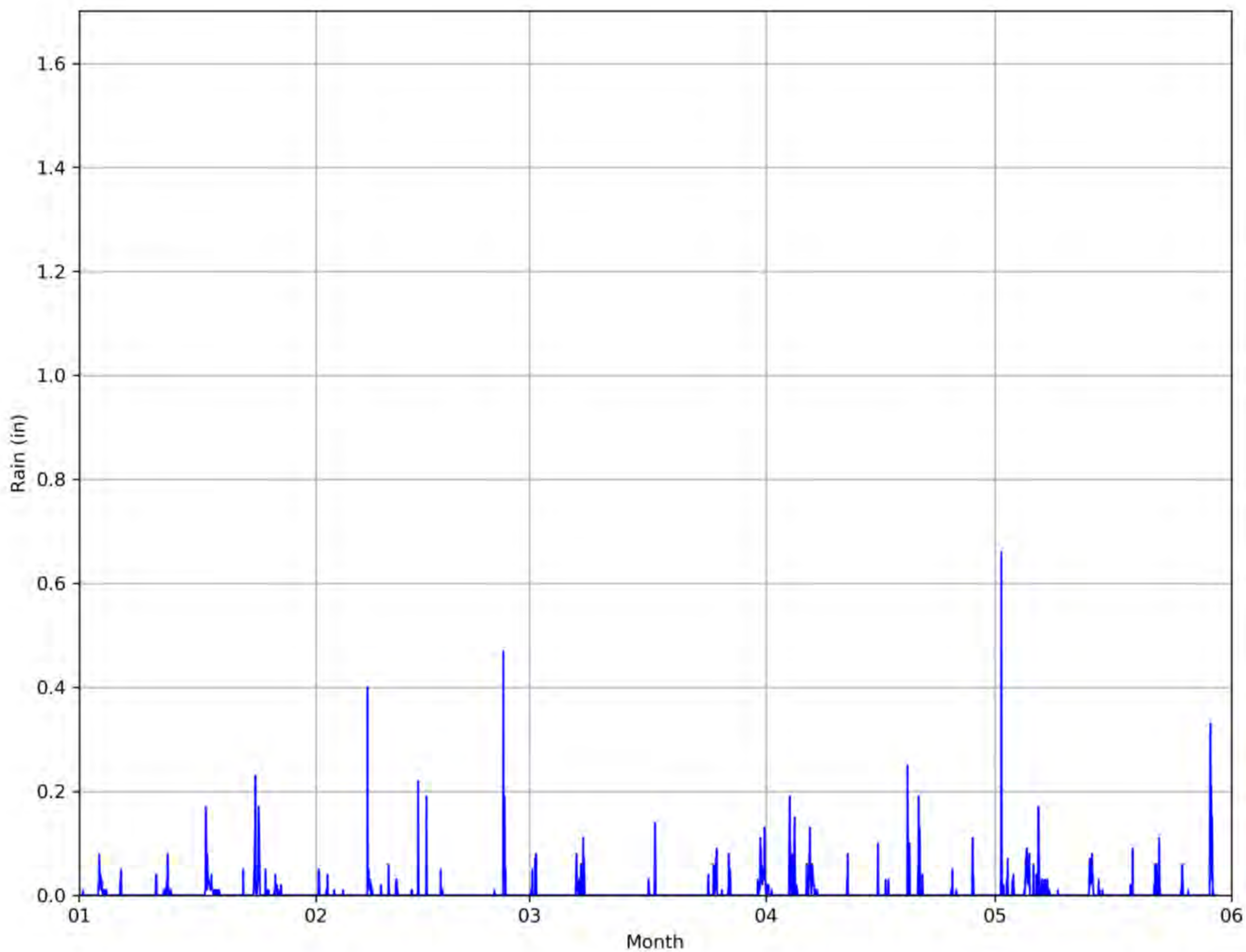

Figure 3-5. Paris DPW Rain Gauge Data (2017)

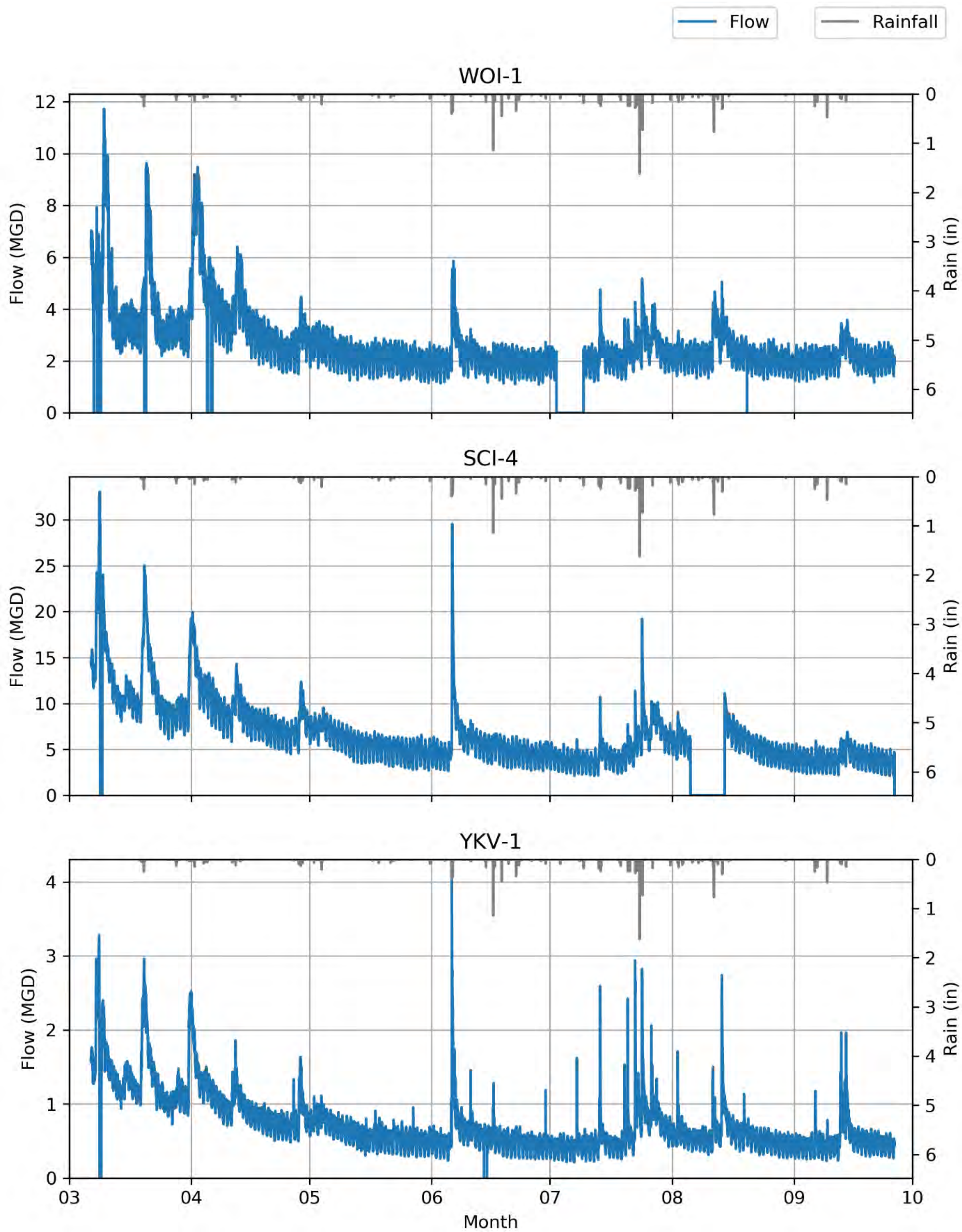

Figure 3-6. Flow Meter Data upstream of the SCPS during 2008

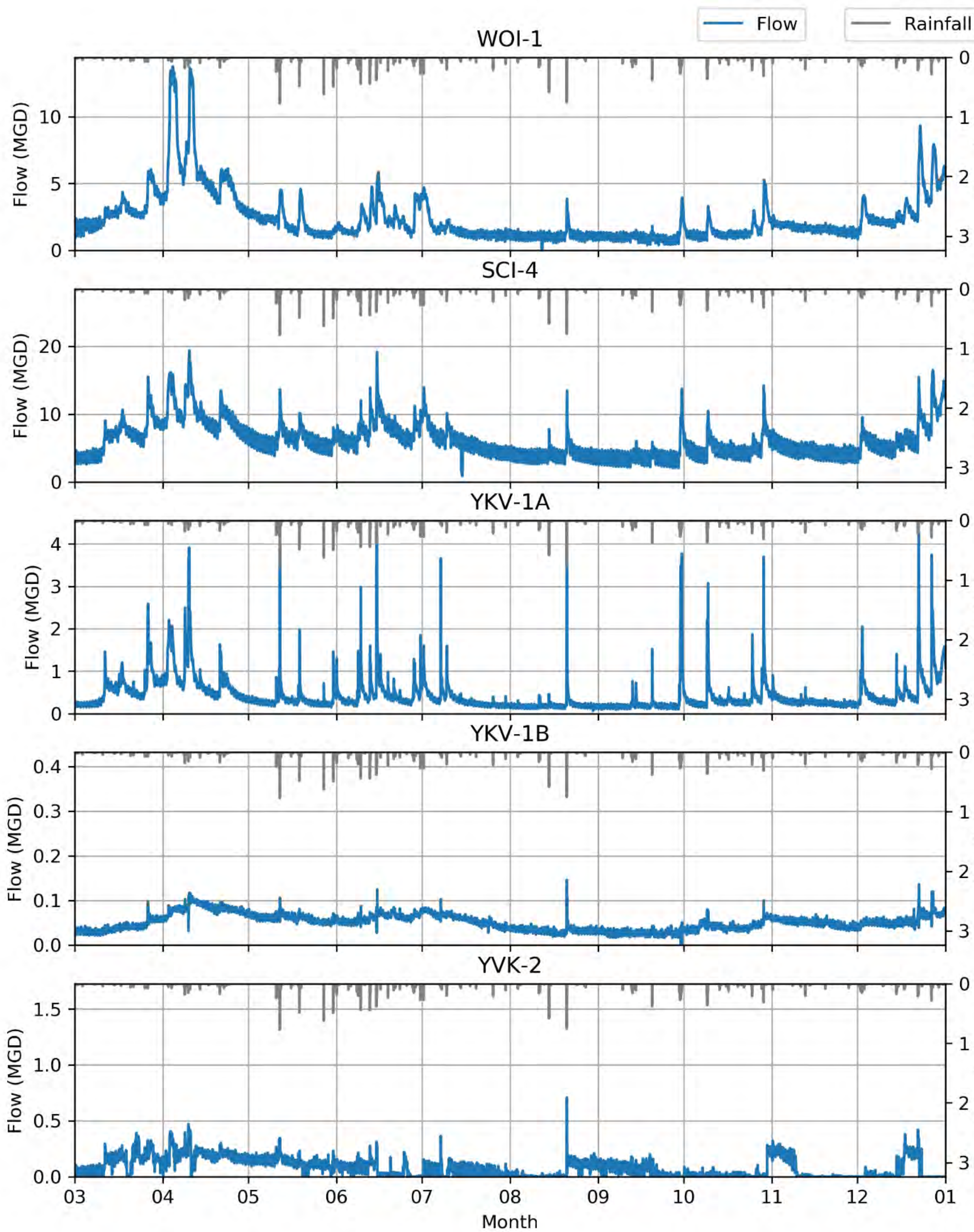

Figure 3-7. Flow Meter Data upstream of the SCPS during 2015

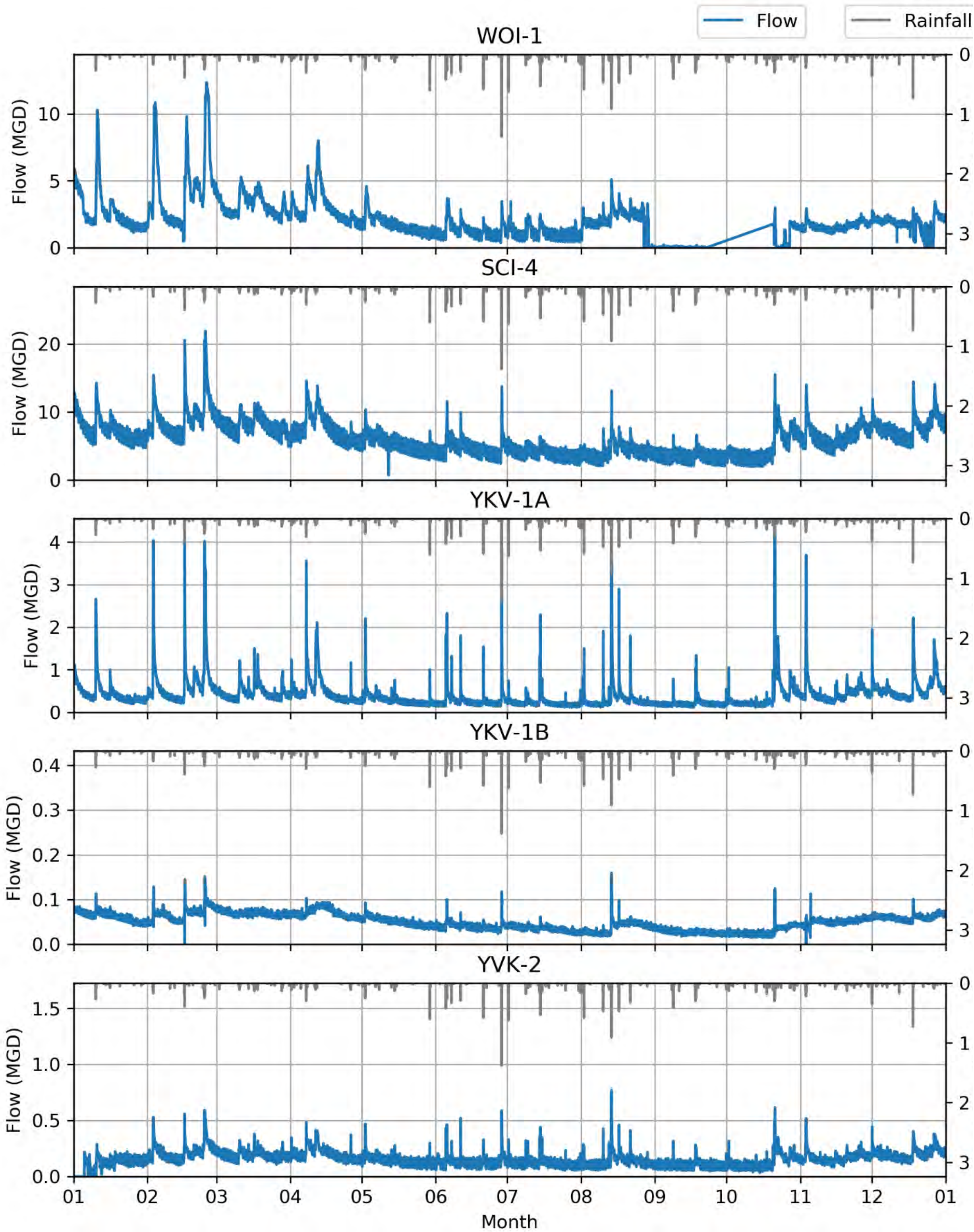

Figure 3-8. Flow Meter Data upstream of the SCPS during 2016

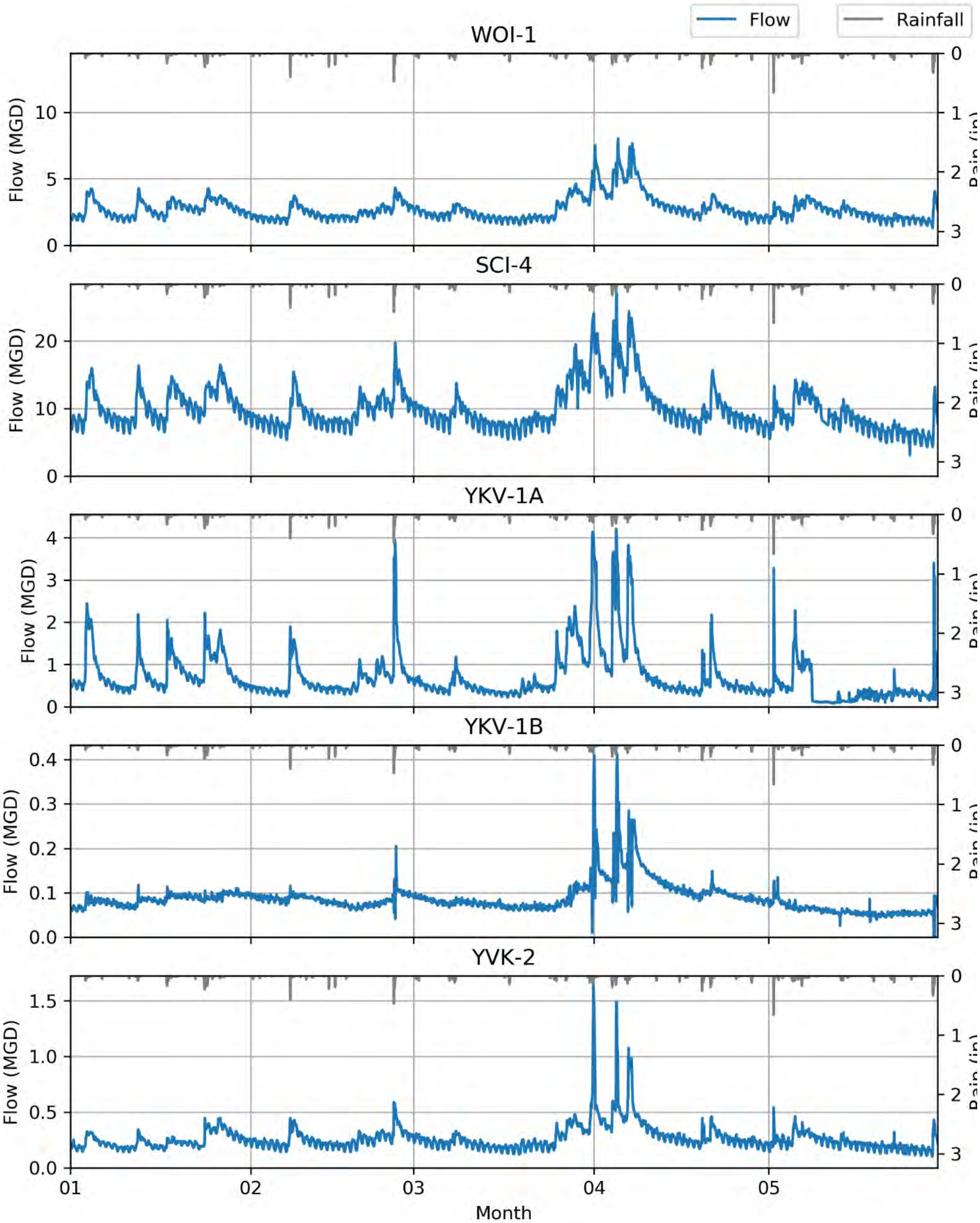

Figure 3-9. Flow Meter Data upstream of the SCPS during 2017

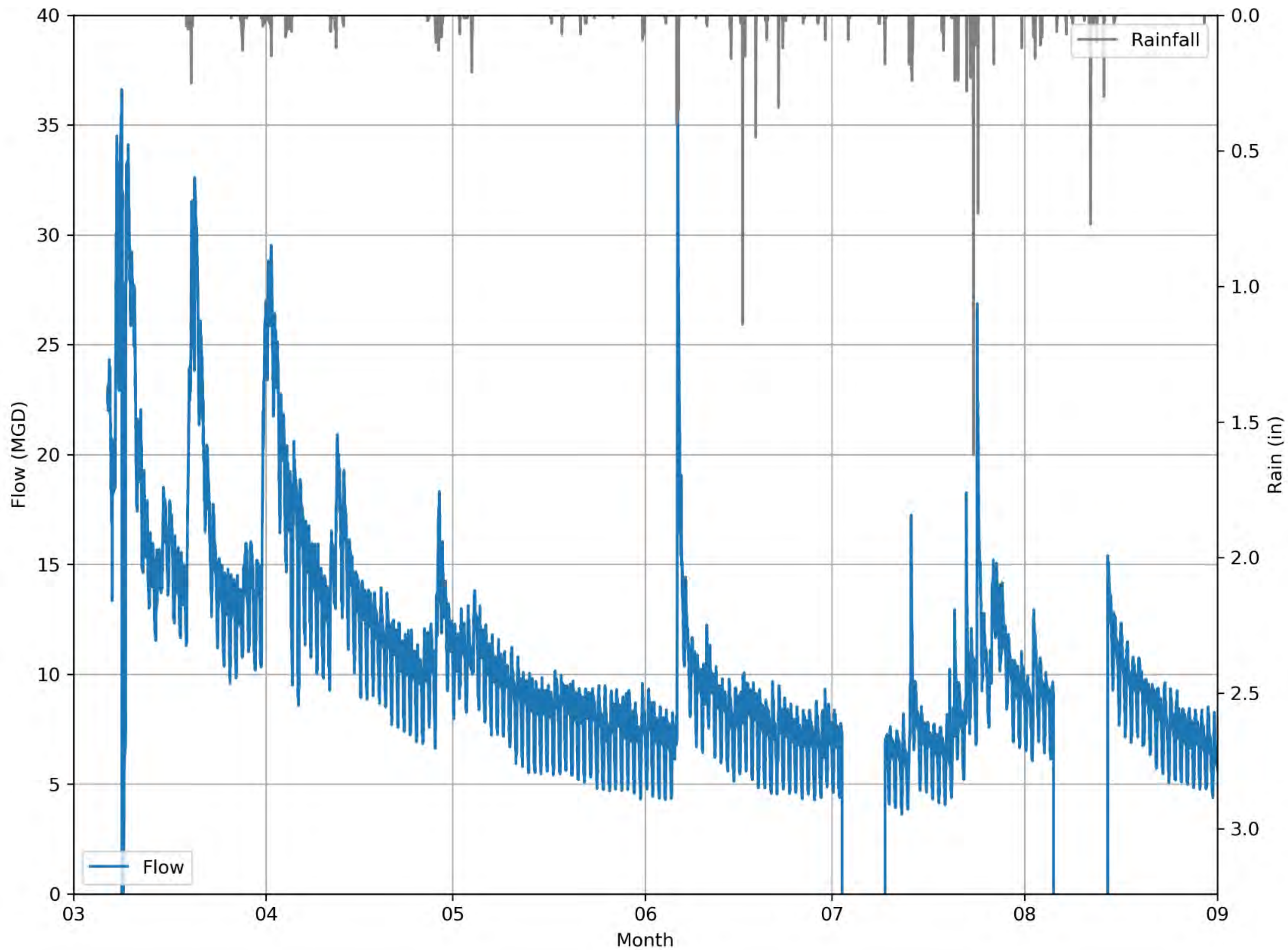

Figure 3-10. Total Flow into the SCPS during 2008

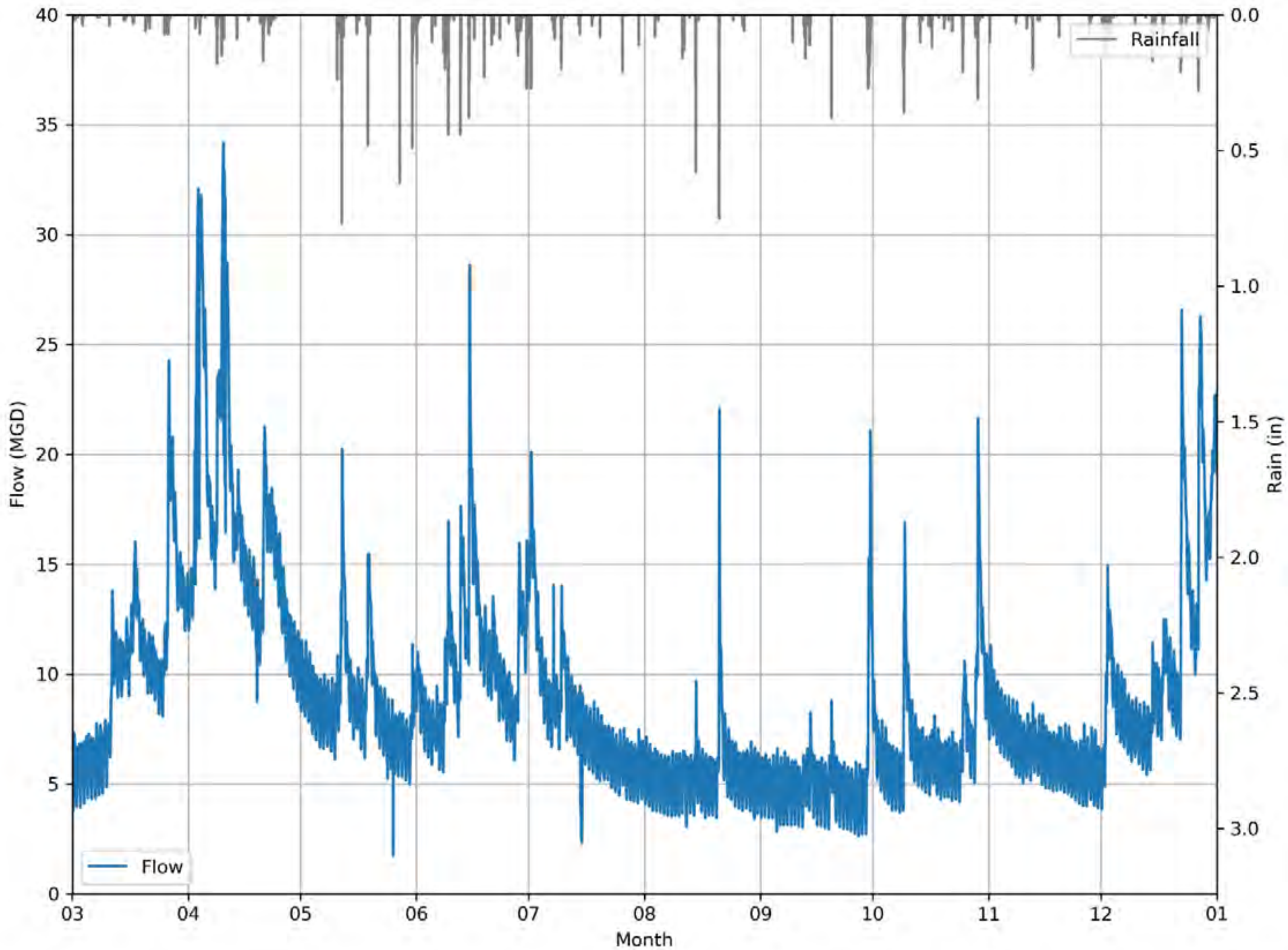

Figure 3-11. Total Flow into the SCPS during 2015

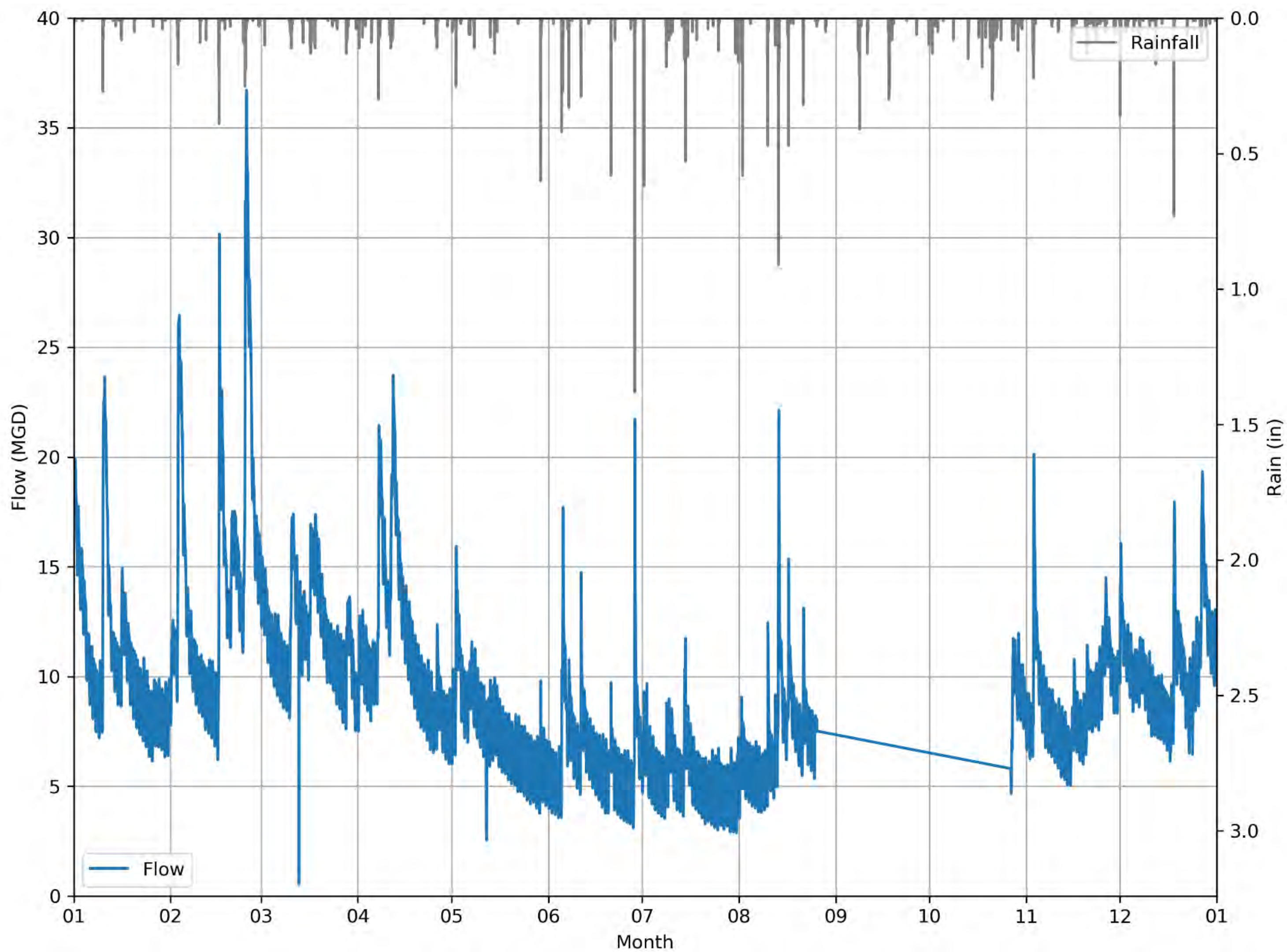

Figure 3-12. Total Flow into the SCPS during 2016

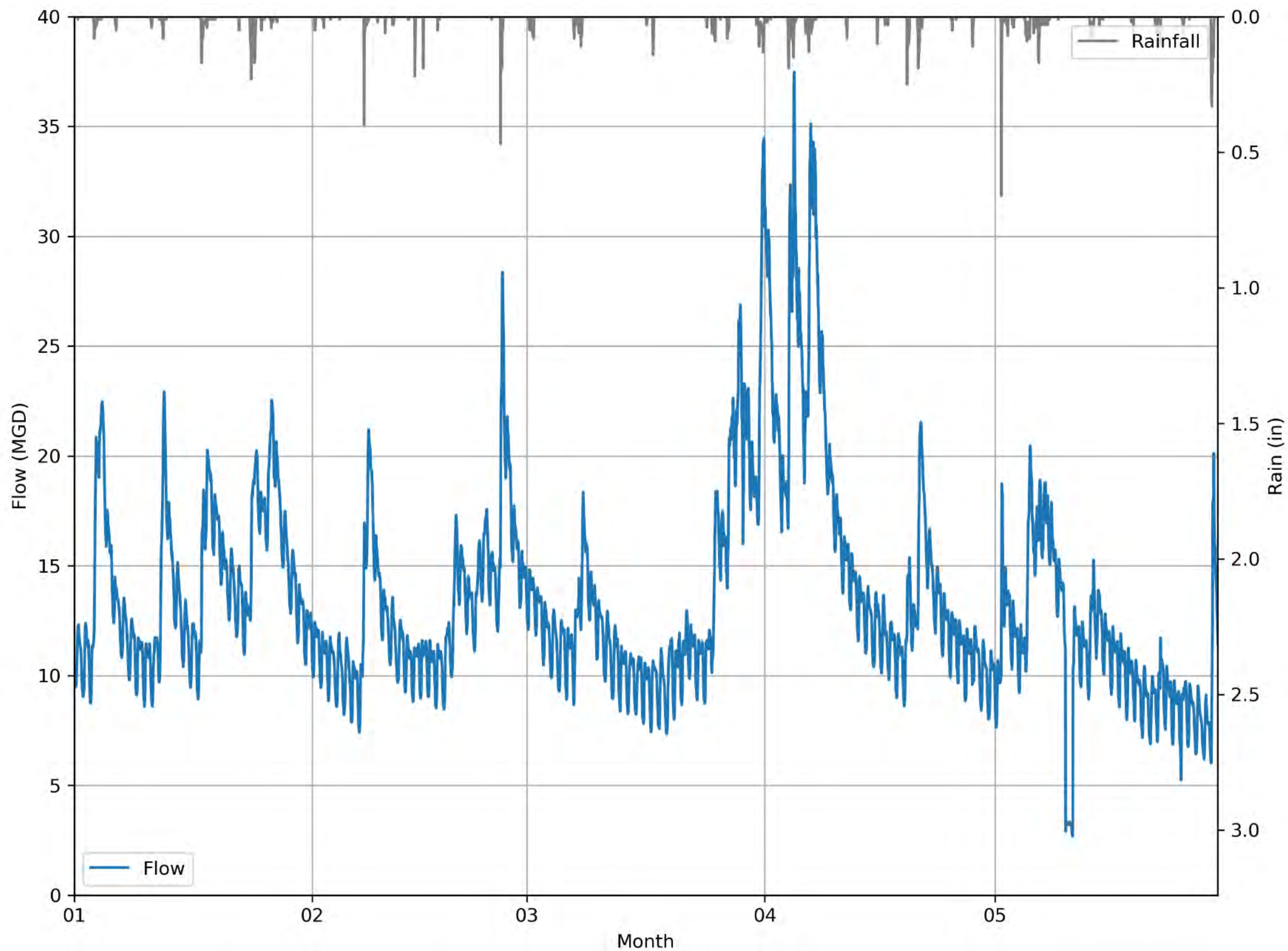

Figure 3-13. Total Flow into the SCPS during 2017

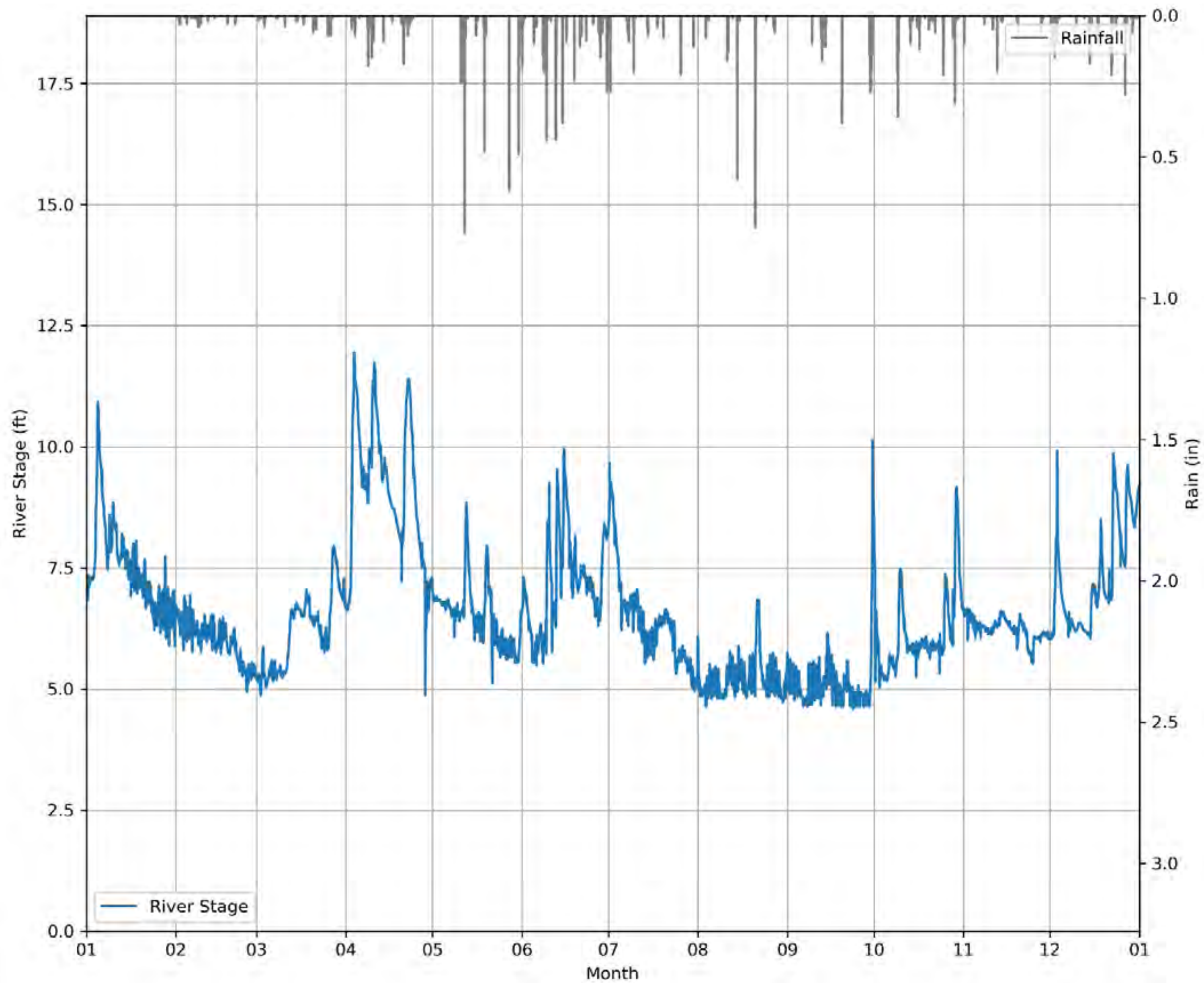

Figure 3-14. Mohawk River Stage Data for 2015

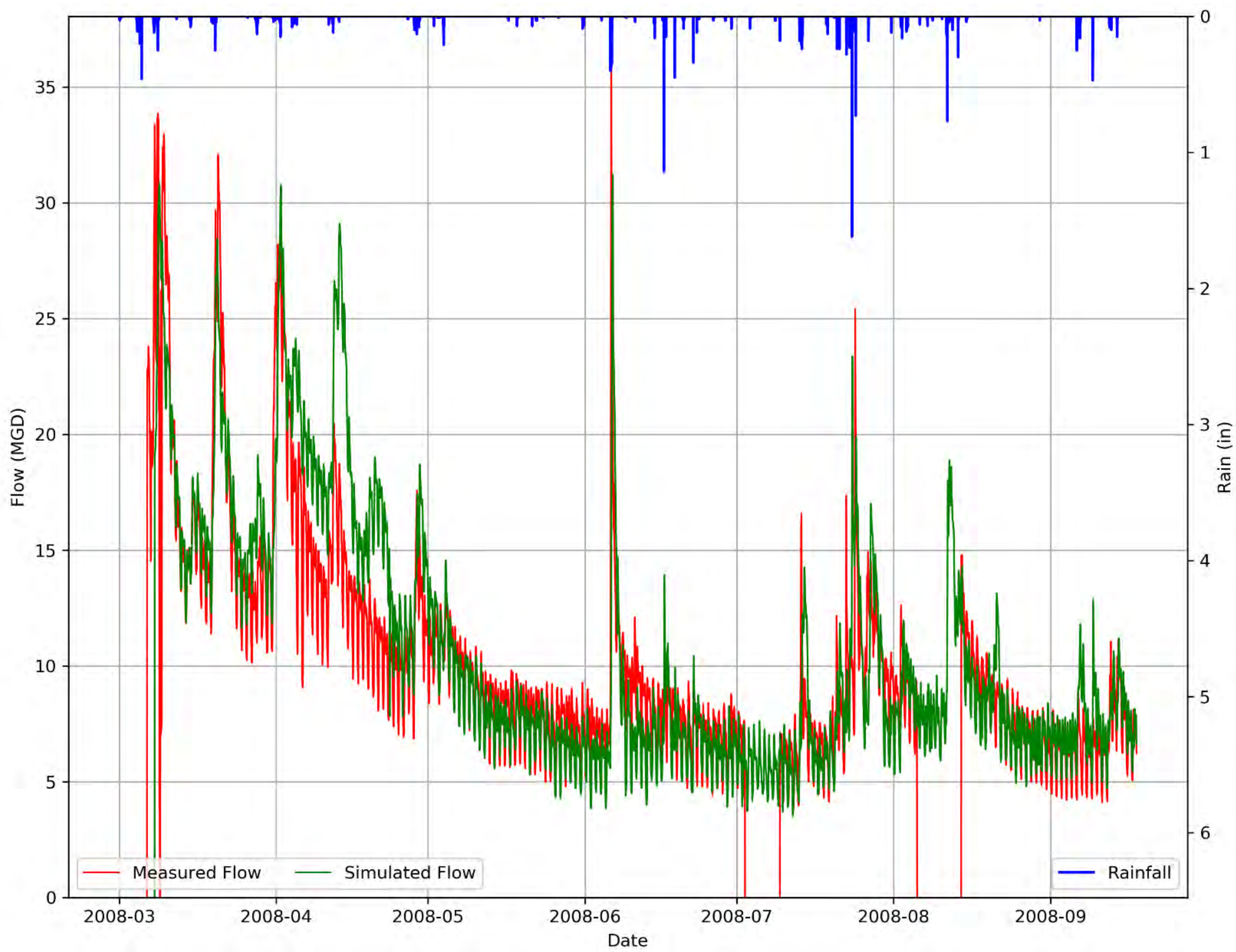

Figure 4-1. Calibrated Pre-Rehabilitation Model

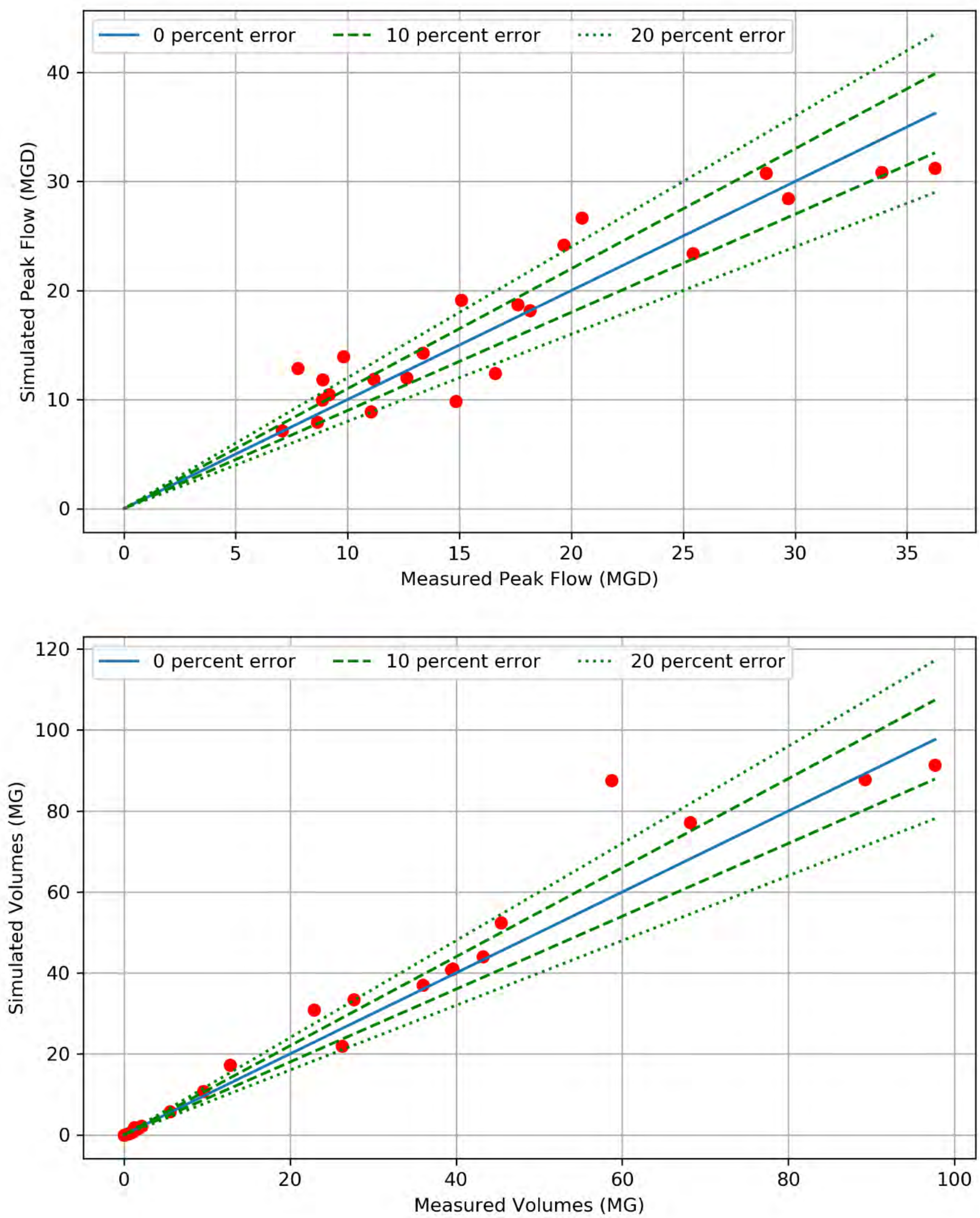

Figure 4-2. Pre-Rehabilitation Model Calibration Results for Rain Events

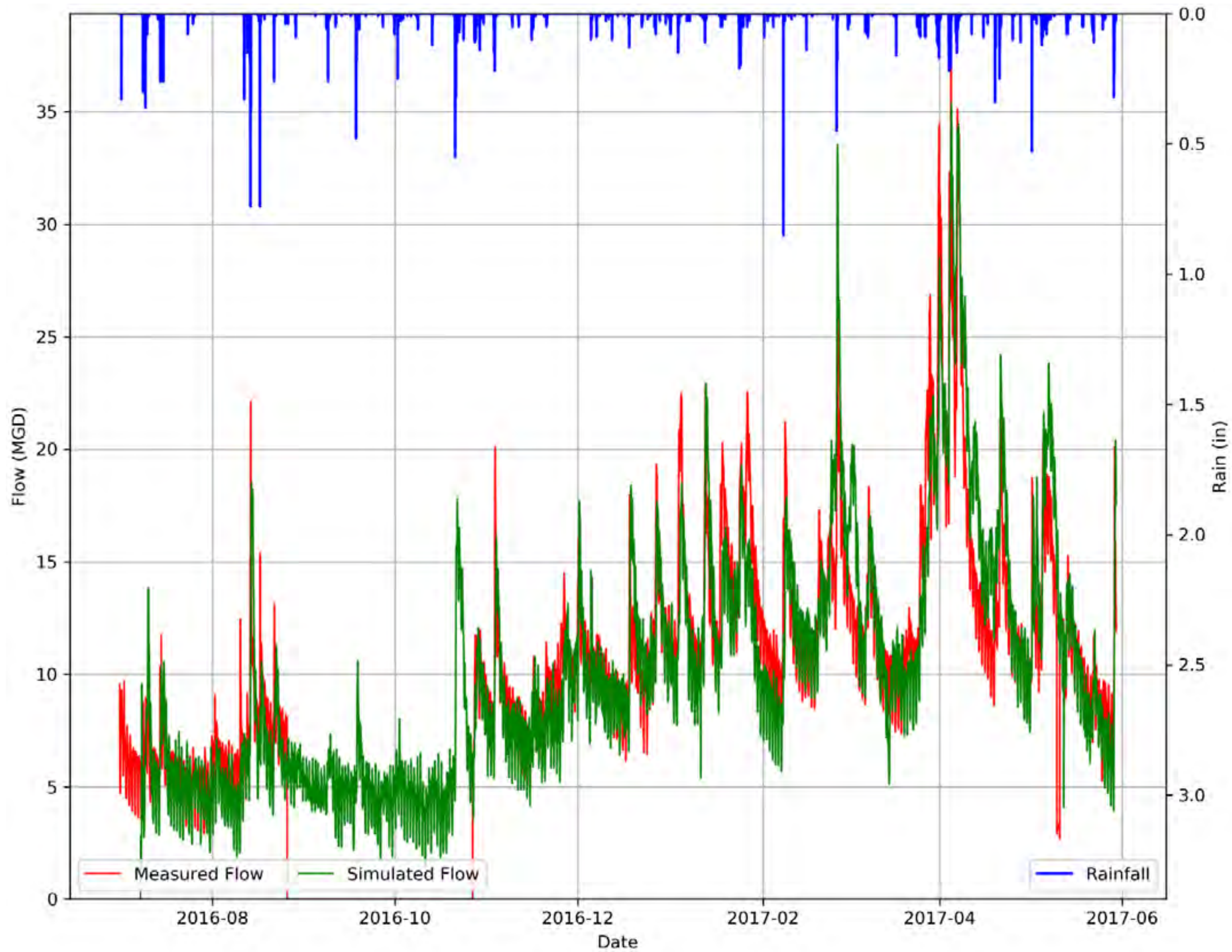

Figure 4-3. Calibrated Post-Rehabilitation Model 1

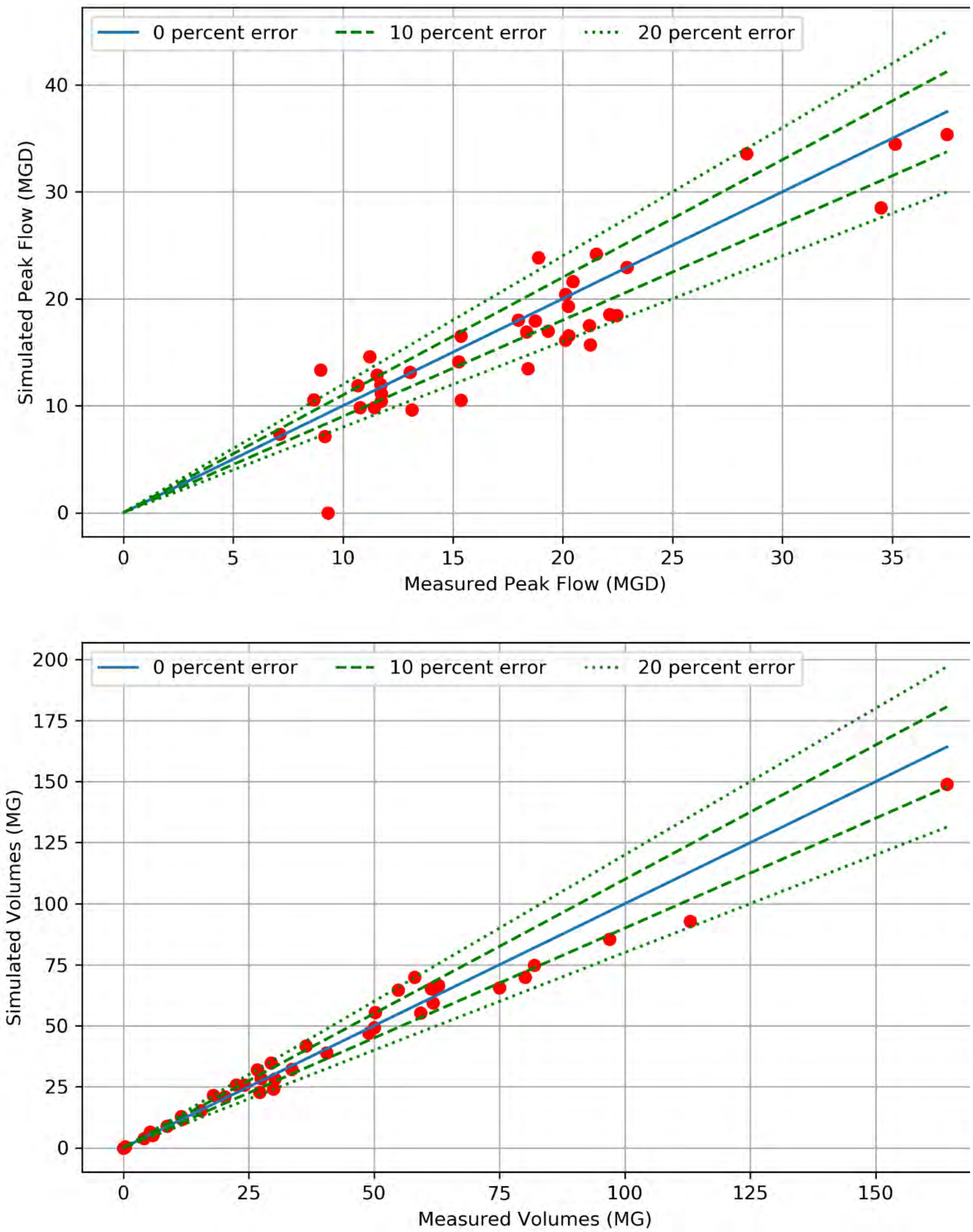

Figure 4-4. Post-Rehabilitation Model 1 Calibration Results for Rain Events

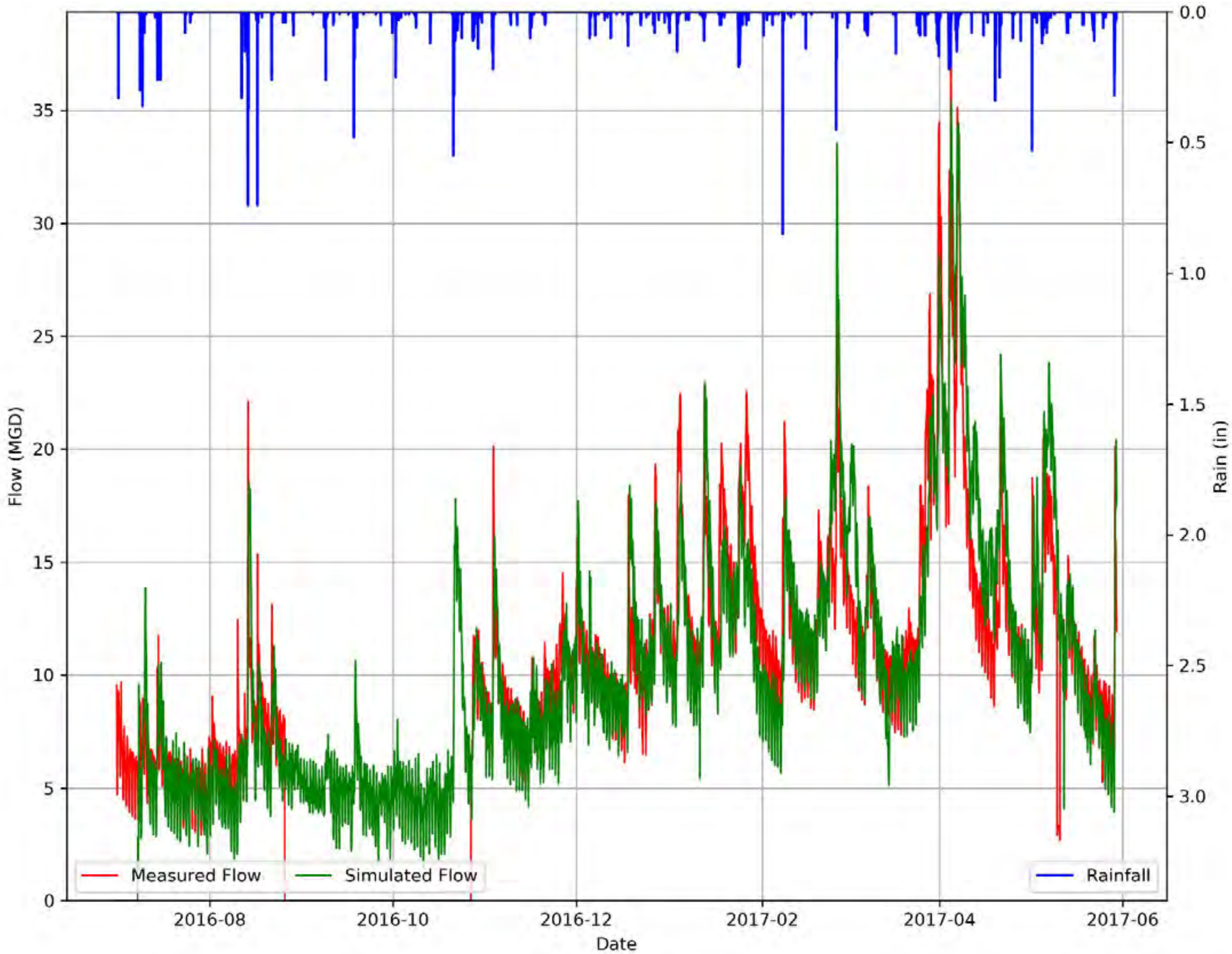

Figure 4-5. Calibrated Post-Rehabilitation Model 2

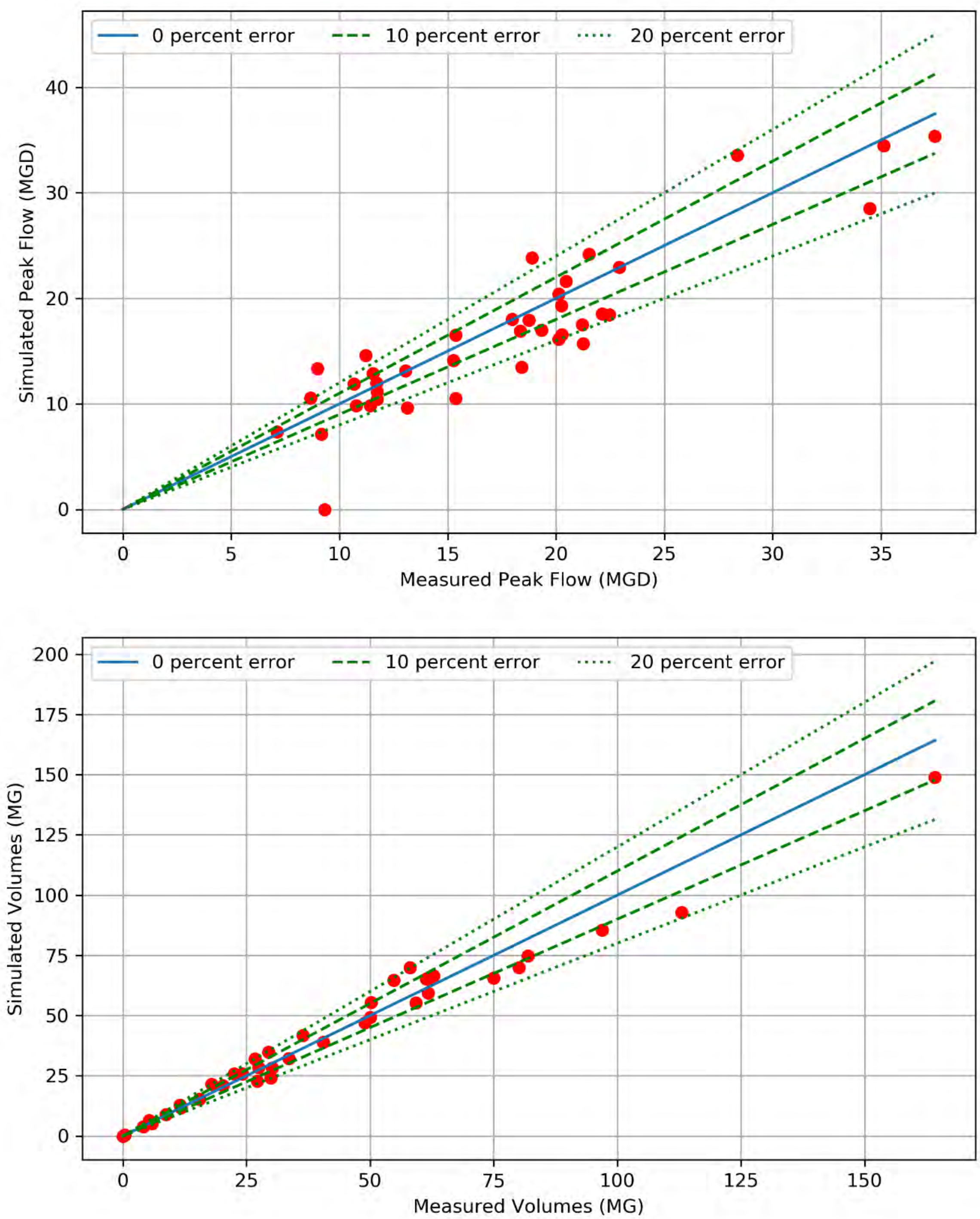

Figure 4-6. Post-Rehabilitation Model 2 Calibration Results for Rain Events

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