SYSTEM CHARACTERIZATION REPORT

Combined Sewer Management Permit Compliance

Joint Meeting of Essex and Union Counties

Elizabeth City, Union County, New Jersey

NJPDES Permit No. NJ0024741

Original Submission:

June 27, 2018

CDM Smith

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Section 1

Introduction

This document constitutes the *System Characterization Report* (SCR) developed by the Joint Meeting of Essex and Union Counties (JMEUC) for the required "Characterization Monitoring and Modeling of the Combined Sewer System" under Part IV Section G.1 of JMEUC's New Jersey Pollutant Discharge Elimination System (NJPDES) permit action (Permit No. NJ0024741) issued for Combined Sewer Management (CSM). This permit was issued by the New Jersey Department of Environmental Protection (NJDEP) on October 9, 2015 and superseded the CSM permit originally issued on March 12, 2015. NJDEP issued CSM permits in 2015 to all NJPDES permittees who own or operate combined sewer systems, or who treat combined sewage from these systems, with the intent to address combined sewer overflow (CSO) impacts on receiving waterbodies.

The JMEUC does not own or operate a combined sewer system, nor does it own or operate any CSO outfalls, but does treat flow from the combined sewer system owned and operated by the City of Elizabeth. NJDEP therefore issued individual CSM permits to both the JMEUC and Elizabeth; the Elizabeth permit (Permit No. NJ0108782) was issued by NJDEP on October 7, 2015 and superseded the original CSM permit issued on March 12, 2015. Under the requirements of their respective CSM permits, the JMEUC and Elizabeth have prepared separate SCR documents, but have coordinated closely in the development of these separate reports and both permittees have cross-certified the other permittee's report (see Sections 1.5 and 1.6 below).

The JMEUC is a member of the NJ CSO Group, and has also coordinated closely with the Group during the preparation of this SCR, including the development of the Typical Year precipitation record used to characterize system performance (see Section 6). The NJ CSO Group was originally formed to bring together utilities and municipalities that own combined sewers in Northern New Jersey, who all have the common interest of coordinating their activities and responses to local regulatory issues like the pathogen Total Maximum Daily Load (TMDL) program. The group was expanded to facilitate compliance with the NJPDES requirements established in the 2015 CSM permits and the JMEUC has been an active participant in the CSM permit compliance efforts of the Group.

This report documents that the JMEUC has developed a thorough understanding of its wastewater collection and treatment systems, including the systems' responses to precipitation events of varying duration ant intensity, and the capacity of these systems to capture and treat flows from the Elizabeth combined sewer system. The objective of the SCR is to provide the JMEUC and Elizabeth with a comprehensive and empirical understanding of the physical nature and hydraulic performance of their respective systems for use in optimizing the performance of these systems and in the development of CSO control alternatives for the Elizabeth combined sewer system.

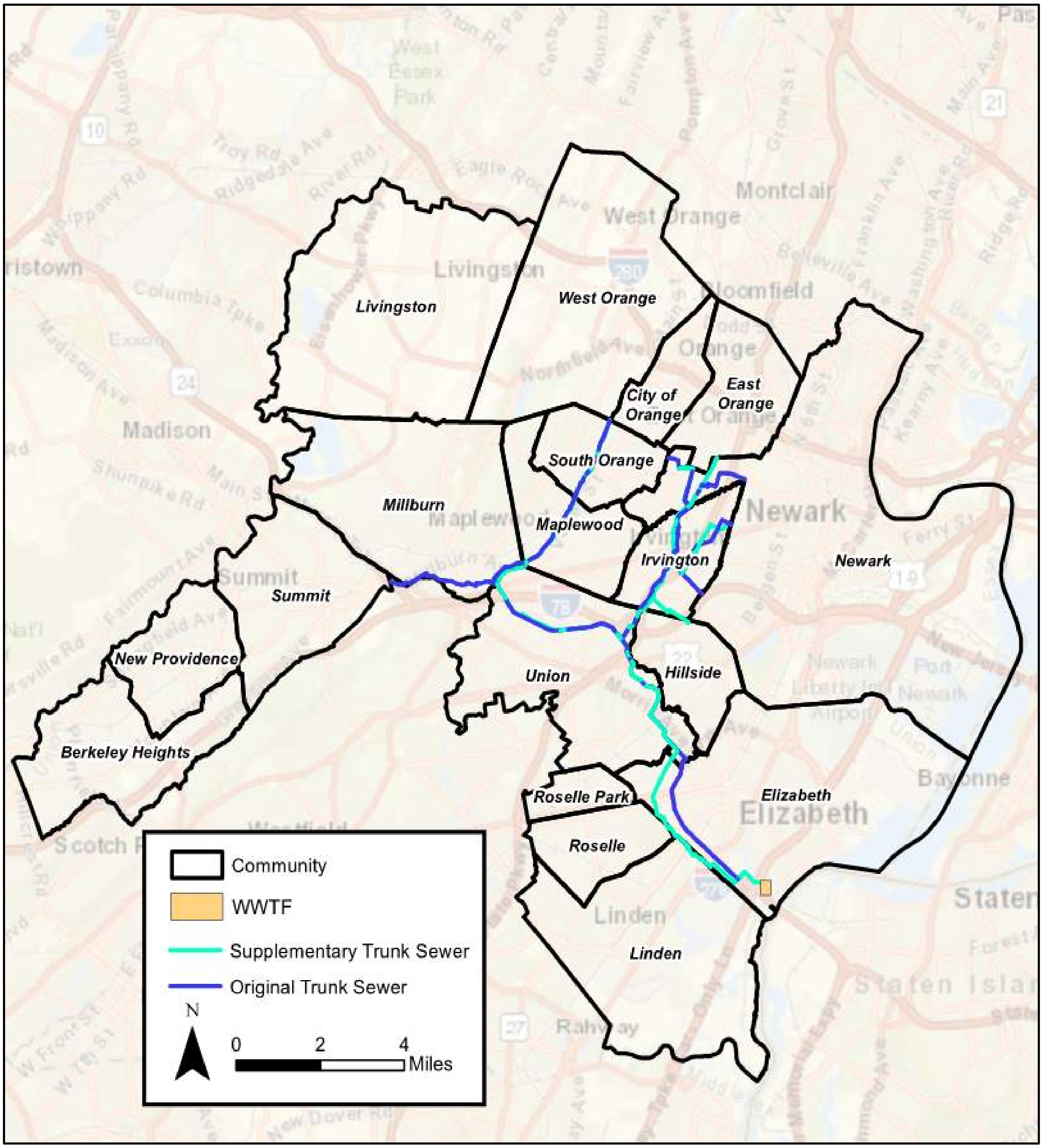

Figure 1-1 Municipalities Served by the JMEUC

1.1 Regulatory Context and Objectives

1.1.1 USEPA Combined Sewer Overflow Control Policy

USEPA's CSO Control Policy (Policy) was issued in April of 1994[1-1] to elaborate on the 1989 National CSO Control Strategy and to expedite compliance with the requirements of the Clean Water Act (CWA). The Policy provided guidance to municipal permittees with CSOs, to the state agencies issuing National Pollution Discharge Elimination permits (e.g. NJDEP and NJPDES permits) and to state and interstate water quality standards authorities (e.g. the Delaware River Basin Commission). The Policy establishes a framework for the coordination, planning, selection and implementation of CSO controls required for permittee compliance with the Clean Water Act (CWA).

The Policy includes three major activities required of municipalities with CSO related permits:

- ***System Characterization*** – The identification of current combined sewer system assets and current performance characteristics;
- ***Implementation of the Nine Minimum Controls***[1-2] – identified in the Policy to ensure that the current combined sewer system is being optimized and property maintained; and
- ***Development of a Long-Term Control Plan (LTCP)*** – The analysis and selection of long term capital and institutional improvements to the combined sewer system that once fully implemented will result in compliance with the CWA.

The Policy includes provisions for public and stakeholder involvement (e.g. the CSO Supplemental Committees), the assessment of affordability (rate-payer impacts) and financial capability (permittee ability to finance the long-term controls) as a driver of implementation schedules and two CSO control alternatives. The "presumption" approach is premised on the presumption that the achievement of certain performance standards, e.g. the capture of at least 85% of wet weather flows (WWF) during a typical year would result in CWA compliance subject to post-implementation verification. Under the "demonstration" approach, permittees demonstrate that their proposed controls do not cause or contribute to a violation of receiving stream water quality standards.

1.1.2 New Jersey Pollution Discharge Elimination System (NJPDES) Permit Requirements

Under Section 1311 of the CWA, all point source discharges to the waters of the United States must be permitted. USEPA Region II has delegated permitting authority in New Jersey to the New Jersey Department of Environmental Protection (NJDEP). The permits are reissued on a nominal

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1-1 59 FR 18688 et seq.

1-2 The nine minimum controls include: 1) proper operation and regular maintenance; 2) maximizing the use of the collection system for storage where feasible; 3) review and modification of the Industrial Pretreatment Program to minimize CSO impacts; 4) maximization of flow to the wastewater treatment plant; 5) the prohibition of CSOs during dry weather; 6) control of solids and floatables (addressed by NJDEP's requirement of screening or other facilities in the late 2000s); 7) pollution prevention; 8) public notification; and 9) monitoring CSO impacts and controls. 59 FR 18691.

five-year cycle. All twenty-one New Jersey municipalities and municipal authorities with combined sewer systems were issued new permits in 2015 that set forth requirements for the completion of the system characterization and the development of LTCPs on the following schedule:

- Submittal of the System Characterization Report to NJDEP – July 1, 2018;
- (LTCP Report 1) Development & Evaluation of CSO Control Alternatives – July 1, 2019; and
- (LTCP Report 2) Selection and Implementation of Alternatives – July 2020.

The System Characterization Reports are to be updates to and to utilize where applicable, previous system inventories and evaluations such as the Long Term Control Plan, Cost and Performance Analysis Report completed for the JMEUC in March 2007. This report was developed in response to the 2005 NJPDES permit action containing provisions for addressing long-term CSO requirements in accordance with the 1994 U.S.EPA CSO Control Policy, with final NJDPES permit action in February 2006 requiring the JMEUC to develop a LTCP. This was an individual permit, and followed two rounds of general permits beginning with the Master General Permit (MGP) effective March 1, 1995 for system characterization and minimum technology (Nine Minimum) controls, and a second MGP in 2004 for the LTCP requirements.

1.2 Combined Sewer System and Service Area Overview

The JMEUC owns and operates a wastewater treatment facility which treats wastewater collected in a 65 square mile service area in northern New Jersey. The JMEUC trunk sewer system collects wastewater from this service area, which includes eleven member (owner) communities and four customer communities. Owner communities include all or some parts of East Orange, Hillside, Irvington, Maplewood, Millburn, Newark, Roselle Park, South Orange, Summit, Union, and West Orange. The City of Elizabeth and portions of Livingston, Orange, and New Providence are currently served as customers by the JMEUC. Small portions of two neighboring communities, Berkeley Heights and Linden are also served. See Section 9 of this report for details on the institutional arrangements. Figure 1-1 depicts the locations of trunk sewer system, communities served, and the wastewater treatment facility.

The JMEUC service area is dominated by separate sanitary sewer areas, with the only confirmed combined sewer area in the system located within the City of Elizabeth. The JMEUC has coordinated with Elizabeth, and will continue to coordinate with Elizabeth, to identify portions of Roselle Park and possibly other adjoining towns that flow into Elizabeth that may also be combined, or have their storm sewers connected into Elizabeth's combined or separate sanitary sewers. Similarly, the JMEUC has identified New Jersey Department of Transportation (NJDOT) catch basin connections into the sanitary and/or combined sewer systems in JMEUC's service area.

Separate sanitary sewers owned by each JMEUC member community and the separate sewer areas in the customer communities provide local sewer service, and the largely combined sewer system in Elizabeth provides local sewer service for that community. The JMEUC trunk sewers capture flows from these local sewer systems and provide regional conveyance of all flows to the Edward P. Decker Secondary Wastewater Treatment Facility (WWTF) located in Elizabeth, New

Jersey. The JMEUC trunk sewer system totals roughly 43 miles in length, and was developed as a network of twin conduits, referred to as the "Original" and "Supplementary" sewers, aligned more or less in parallel for the full length of the system. The Original Trunk Sewer system was constructed in the early 1900's, and the much larger Supplementary Trunk Sewer in the 1930's.

The Elizabeth sewer system is owned by the City of Elizabeth and the majority of the system routes wastewater to the Trenton Avenue Pump Station (TAPS), where it is pumped via force main a distance of roughly 1000 feet into the JMEUC system, at a point roughly 1300 feet upstream of the WWTF. There is also a small area (Elmora) in Elizabeth with combined sewers draining directly to the JMEUC trunk sewers.

The JMEUC WWTF is a conventional activated sludge plant rated for an average flow of 85 mgd. The preliminary treatment consists of mechanical coarse screens followed by mechanical fine screens followed by gravity grit chambers. From the grit chambers, the wastewater flows to four rectangular primary clarifiers. The primary clarifier effluent is conveyed to four aeration tanks by five low lift pumps. The aeration tanks are equipped with mechanical aerators. From the aeration tanks, the mixed liquor flows to four circular secondary clarifiers. The secondary effluent is then disinfected using sodium hypochlorite, and then dechlorinated with sodium bisulfite. The treated wastewater is then discharged to the Arthur Kill through two outfall conduits into the Arthur Kill, just below Newark Bay, with an emergency bypass outfall into the Elizabeth River just above the confluence with the Arthur Kill. Section 8 of this report further describes the processes and evaluates the capacities of the facility's existing treatment processes

1.3 Previous Studies

This report has been developed in accordance with the System Characterization Work Plan developed by the JMEUC and approved by NJDEP. The Work Plan was submitted to NJDEP in December 2015, comments were received from DEP in April 2016, and a final Work Plan was submitted to DEP in June 2016. Final approval was received from NJDEP on August 4, 2016. In that letter, DEP requested a detailed listing of previous studies and reports that are stored on the JMEUC FTP site. That information was provided in a letter to DEP dated September 1, 2016. The final Work Plan, DEP approval letter of August 4, 2016, and the September 1, 2016 letter from the JMEUC with the detailed listing of previous reports are provided in Appendix A of this report.

In addition to the reports listed in Appendix A, there are several other previous studies of significance to this System Characterization Report:

- Long Term Control Plan, Cost and Performance Analysis Report completed by CDM for the JMEUC in March 2007

- Final Report of the JMEUC Trunk Interceptor Hydraulic Modeling Evaluations completed by CDM Smith in July 2016

The JMEUC has available significant data describing the design, construction and operation of the physical system that is the subject of this System Characterization Report. The data sources that were used in preparation of this System Characterization Report include:

- Design drawings for the Original and Supplementary Trunk Sewers (see drawing index in Appendix B).
- Geodatabase of trunk sewer networks including manholes and conduits owned by the JMEUC.
- Flow monitoring data – see Section 4.2.1 and Appendix C.
- Rainfall monitoring data – see Section 4.2.2 and Appendix D.
- Tidal data (Sandy Hook EDT NAVD88 hourly time series)
- WWTF data:
  - Design hydraulic profile of treatment process train
  - Design drawings of WWTF
  - Effluent flow rate data
  - Effluent concentration data (fecal coliform bacteria)
- Inflow and Infiltration Investigation plates (Killam, 1979)
- NJ State GIS
  - Municipal boundary
- American Community Survey 2011-2015 5-year population data

1.4 Organization of Report

This Introduction section (Section 1) is followed by:

Section 2 – Description of Combined and Separate Sewer Systems and Treatment Facilities

Section 3 – Receiving Waterbodies

Section 4 – Sewer System Monitoring and Modeling

Section 5 – Receiving Waterbody Monitoring and Modeling

Section 6 – Rainfall Analysis and Typical Annual Hydrologic Record

Section 7 – Characterization of System Performance – JMEUC Sewer System

Section 8 – Characterization of System Performance – Wastewater Treatment Plant

Section 9 – Institutional Arrangements

Section 10 – Conclusions

Appendices

Appendix A – JMEUC System Characterization Work Plan, NJDEP Approval Letter, and JMEUC Letter of September 1, 2016

Appendix B – Drawing Index Listing of Design Drawings for the Original and Supplementary Trunk Sewers

Appendix C – Flow Monitoring Data

Appendix D – Rainfall Monitoring Data

Appendix E – JMEUC Trunk Interceptor Hydraulic Modeling Evaluations

Appendix F – Flow Monitoring Site Reports Generated by ADS

Appendix G – Baseline Merged Model Calibration and Validation Plots

Appendix H – Baseline Merged Model Scatter Plots

Appendix I – August 2017 Presentation to NJDEP on Calibration and Validation Events

Appendix J – Summary of Calibrated RTK and IA Parameters for Modeled Subcatchments

Appendix K – JMEUC Procedure for Storm Flow Operations

Appendix L – 2017 JMEUC Annual Report

Appendix M – JMEUC Rules and Regulations

Appendix N – Typical Year Report and NJDEP Approval Letter

1.5 Joint Meeting of Essex and Union Counties – Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate 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 purposely, knowingly, recklessly, or negligently submitting false information.

6/26/18

Samuel T. McGhee — Date

Executive Director, Joint Meeting of Essex and Union Counties

1.6 City of Elizabeth – Certification

Without prejudice to any objections timely made to permit conditions, I certify under penalty of law that this document and all attachments were prepared either: (a) under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted; or (b) as part of a cooperative effort by members of a hydraulically connected system, as is required under the NJPDES Permit, to provide the information requested. 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 purposely, knowingly, recklessly, or negligently submitting false information.

6/26/2018

Daniel Loomis, P.E.
City Engineer, City of Elizabeth

Date

Section 2

Description of the Combined Sewer System Collection and Treatment Facilities

The Edward P. Decker Secondary Wastewater Treatment Facility (WWTF) in Elizabeth, New Jersey is owned and operated by the JMEUC and serves the entire area addressed in this report. The WWTF's service area consists of eleven-member communities along with four customer communities. The service area includes both separate sanitary sewer systems and combined sewer systems. Flow from upstream communities is conveyed to the WWTF via two trunk sewers (Original and Supplementary) owned and operated by the JMEUC. In the downstream portion of the collection system, the Original and Supplementary Trunk Sewers come together at a junction (herein called Junction J16) at the intersection of Bayway Avenue and Pulaski Street. A twin barrel trunk sewer (the North Barrel and South Barrel) exits J16 with flow being split relatively equally between the two barrels before reaching the WWTF. In addition to member and customer communities flows, flow is received from catch basin connections into the JMEUC trunk sewers from the New Jersey Department of Transportation (NJDOT) drainage system along Elmora Avenue and Bayway between Westfield and Brunswick Avenues in the downstream portion of the JMEUC's service area within Elizabeth. The extents of the JMEUC service area are indicated in Figure 2-1.

This section of the report describes the sewer service areas, the physical characteristics of the sewer systems in these areas, pump stations and other special structures, and the JMEUC WWTF.

2.1 Combined and Separate Sanitary Sewer Areas

As noted above, the JMEUC service area includes both combined sewer and separate sanitary sewer areas. These service areas are relatively distinct and therefore are described individually below.

2.1.1 Combined Sewer Service Area Description

The combined sewer area contributing flow to the JMEUC trunk sewers is limited to the City of Elizabeth. The significant majority of combined flow from Elizabeth enters the North Barrel of the twin barrel trunk sewer via the TAPS, at the force main connection located roughly 1,300 feet upstream of the WWTF. Additionally, there are pockets of combined sewer areas within Elizabeth, mostly in the Elmora area, which drain directly to the trunk sewer system. The majority of this flow enters the Original Trunk Sewer at various connections in the downstream portion of the collection system, just upstream of the TAPS (Figure 2-2) force main connection point.

In total, the combined sewer area serves an estimated 128,640 residents based on the latest available estimate from the United States Census Bureau. Of these 128,640 residents, 119,140, or 93%, are serviced by a portion of the Elizabeth collection system which drains to the TAPS, while the remaining 7% (9,500) are serviced directly by the JMEUC trunk sewers. Approximately 7,168 acres in the City of Elizabeth is in the Joint Meeting service area, and 95% of the City of Elizabeth's service area (6800 acres) eventually drains to the TAPS, while the remaining 5% (368 acres) drains directly to the JMEUC trunks sewers. Figure 2-2 shows a sewer system map of the City of Elizabeth's combined sewer system.

A detailed description of the combined sewer areas contributing flow to the JMEUC WWTF and land uses in these areas can be found in the City of Elizabeth's CSO System Characterization Report (June 2018).

2.1.2 Separate Sanitary Sewer Service Area Description

The eleven member communities of the JMEUC along with the customer communities of Livingston, Orange, and New Providence (along with small portions of Berkeley Heights and Linden) are all serviced by separate sanitary sewer systems which are owned and operated by each individual community. These systems are tributary to the Original and Supplementary Trunk Sewers owned and operated by the JMEUC, which collect and convey flows from these communities to the WWTF. The total population of the separated sewer service area is estimated to be 327,313 based on American Community Survey 2011-2015 5-year estimates, while the total sewered area of these communities (excluding large parks and other significant open spaces) is estimated to be 29,780 acres or 46.5 square miles. Table 2-1 provides a summary of the land use within the separate sewer area served by the JMEUC.

Table 2-1 Land Use Summary for the Separate Sanitary Sewer Areas Served by the JMEUC

Land Use Type	% of Separate Sewer Service Area
Residential - Medium Density	32.98%
Residential - High Density	24.60%
Commercial	14.65%
Residential - Light Density	9.81%
Wooded Area/Marsh	6.49%
Recreational/Open Area	4.91%
Industrial/Military	3.45%
Transportation/Utilities	3.12%

Over two-thirds of the JMEUC separate sanitary sewer service area is made up of residential property, of which most is either medium or high-density housing. Commercially developed land makes up the next highest land use percentage (15%), while the remaining areas are evenly distributed among wooded, recreational, industrial, and transportation land uses. Population estimates and sewered areas are broken down by community in Table 2-2. Figure 1-1 in Section 1 shows the locations of the communities which make up the separate sewer portion of the JMEUC collection system, along with their locations relative to the JMEUC trunk sewers.

Table 2-2 Separated Sewer Communities Served by the JMEUC

Member Community (see footnotes below)	Estimated Population Serviced by the JMEUC	Sewered Area (acres)
East Orange [1]	17,247	570
Hillside	20,415	1,570
Irvington	55,774	1,870
Maplewood	23,156	1,890
Millburn and Livingston	17,322	3,840
Newark[1]	44,284	1,210
Roselle Park [2]	11,735	680
South Orange	16,257	1,670
Summit [3]	31,978	5,700
Union	53,871	5,140
West Orange [4]	40,743	5,440

[1] Population and area values include only the portion of the community serviced by JMEUC. Remainder of community is serviced by Passaic Valley Sewerage Commission.
[2]Population and area values include only the portion of the community serviced by JMEUC. Remainder of community is serviced by Rahway Valley Sewerage Commission.
[3]Population and area values include the customer community of New Providence and portion of Berkeley Heights serviced by the JMEUC.
[4]Population and area values include Customer Community of City of Orange.

2.2 Combined Sewer System

Figure 2-2 shows Elizabeth's combined sewer system and drainage areas along with CSO outfall locations. The Elizabeth combined sewer system consists of a network of sewers collecting both stormwater and wastewater generated in the City of Elizabeth. Flows from this sewer network are captured by two interceptor sewers; the easterly interceptor which serves the eastern and southern portions of the City and the westerly interceptor which serves the western portion of the City. All flow captured by the two interceptors drains to the TAPS, where it is pumped via a 48-inch force main into the North Barrel of the twin barrel trunk sewer as noted above.

In total, there are 29 CSO outfalls located upstream of the TAPS that relieve the City of Elizabeth combined sewer system during wet weather. Of these 29 outfalls:

- 21 outfalls discharge to Elizabeth River,
- 4 outfalls discharge to the Arthur Kill,
- 4 outfalls discharge to Newark Bay, including two via the Great Ditch and one via the Peripheral Ditch.

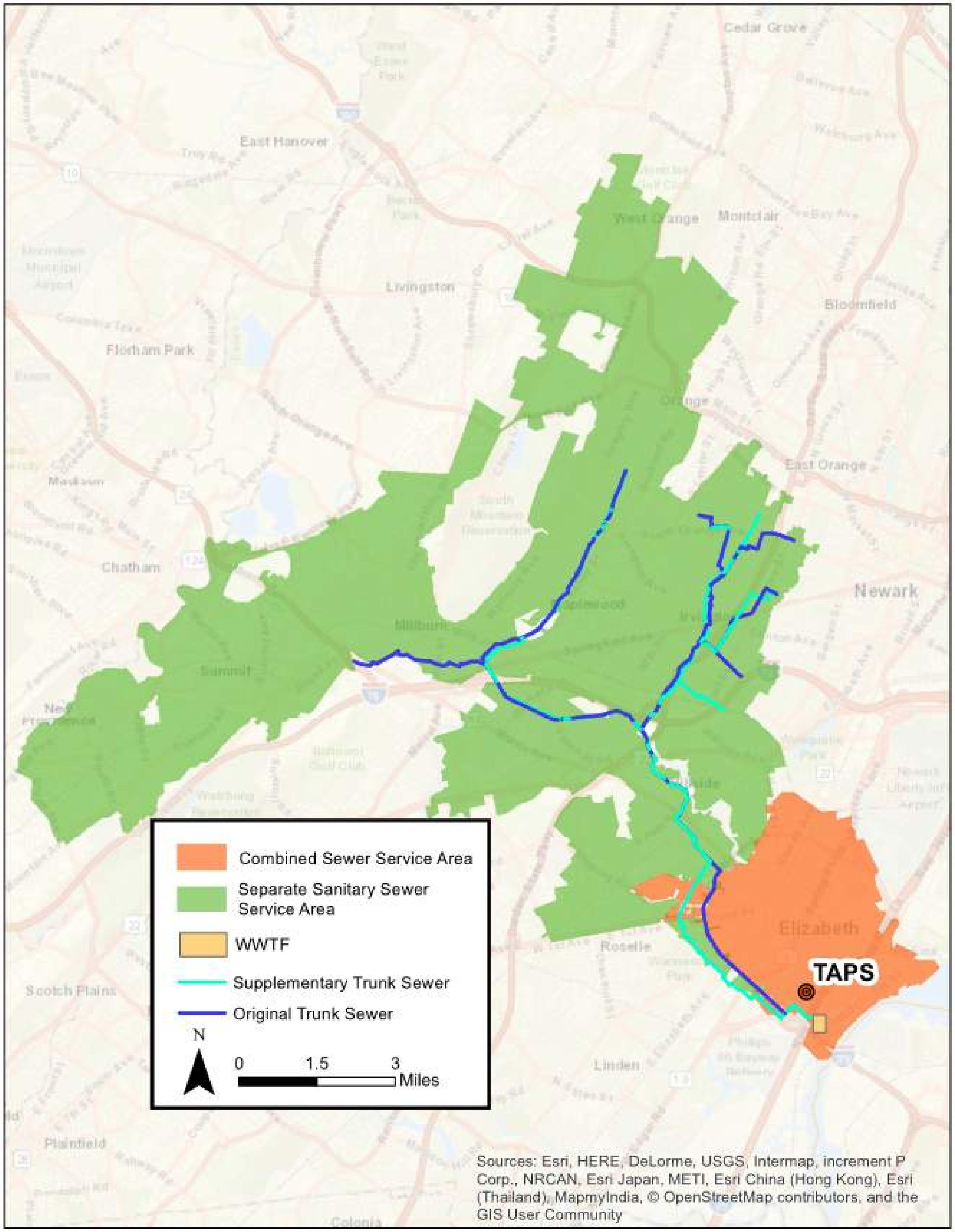

Figure 2-1 JMEUC Service Area

Figure 2-2 - Overview of City of Elizabeth Sewer System and Drainage Area

Source: City of Elizabeth CSO System Characterization Report; June 2018

Legend

- Significant Industrial Users
- JMEUC Treatment Plant
- Pumping Station
- CSO Discharge
- Regulator
- Elizabeth City Hall
- Trunk Sewer Alignments
- CSO Outfall
- Force Main Alignment
- Siphon Main
- Combined Sewer Main
- Seperated Sanitary Sewer Main
- Storm Water Sewer Main (CSS)
- Edge Of Pavement

Interceptor Alignment

- Easterly Interceptor
- Westerly Interceptor
- JMEUC Trunk Sewer
- Municipal Boundary
- Water Bodies
- Regulator Basin

Sewer System Drainage Types

- Combined Sewer System
- Seperated Sewer System
- No Contributing Flow

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MOTT MACDONALD
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Iselin, New Jersey 08830-4112

CITY OF ELIZABETH
UNION COUNTY, NEW JERSEY
CSO LONG TERM CONTROL PROGRAM
SYSTEM CHARACTERIZATION REPORT
PLATE A
SEWER SYSTEM OVERALL MAP

Designed	Drawn	Checked	Approved	Date
AG	RJL	AG	AG	5/30/2018

Peak discharge from the TAPS to the JMEUC system is currently limited to 36 mgd by contractual agreement between the City of Elizabeth and the JMEUC. Inflows to the TAPS exceeding 36 mgd are only observed during wet weather events, as the observed average dry weather flow (ADWF) entering the TAPS is typically around 15 mgd. Based on population estimates and hydraulic model results, the estimated ADWF from the Elmora 368-acre combined sewer area is around two mgd, a significant majority of which drains directly to the Original JMEUC Trunk Sewer.

Along with the combined sewer area in the City of Elizabeth, there are also NJDOT catch basin connections to the Original Trunk Sewer which collect storm water along Elmora Avenue and Bayway between Westfield Avenue and Brunswick Avenue. Figure 2-3 shows the locations of these catch basin connections in more detail.

Additional details pertaining to the City of Elizabeth's service area and collection system can be found in the City of Elizabeth's CSO System Characterization Report (June 2018).

2.3 Separate Sanitary Sewer System

Other than the City of Elizabeth, all other communities serviced by the JMEUC have separate sanitary sewer systems which tie into the Original and Supplementary Trunk Sewers owned and operated by the JMEUC. The JMEUC does not own or operate any portion of member or customer community collection systems upstream of the two trunk sewers. The JMEUC trunk sewer system includes the Original Trunk Sewer constructed in the early 1900's and the Supplementary Trunk Sewer constructed in the 1930's. They generally run parallel to one another throughout the service area. In the downstream portion of the collection system, the Original and Supplementary Trunk Sewers come together at junction J16 at the intersection of Bayway Avenue and Pulaski Street. A twin barrel trunk sewer (the North Barrel and South Barrel) exit J16 with flow being split relatively evenly between the two barrels. Together, the total length of the trunk sewers owned and operated by the JMEUC is approximately 43 miles.

There are approximately 900 manholes which serve as access points to the trunk sewers from the tributary collection systems. The diameters of the trunk sewers range in size from 10" in the most upstream portions of the system in Newark and Irvington, to 81" in the downstream portion of the Supplementary Trunk Sewer. Figure 2-4 through Figure 2-7 shows the trunk sewer network and associated pipe shapes and sizes. All pipes within the trunk sewer network are circular except the twin barrel trunk sewer in the downstream portion of the system and a short stretch of rectangular pipe making up the Original Trunk Sewer, as indicated in Figure 2-6.

All flow within the JMEUC trunk sewers is conveyed downstream via gravity, although four pump stations are present immediately upstream of the trunk sewer network. Three of the pump stations convey separated wastewater flows to the trunk sewer system, while the TAPS conveys combined flows from the City of Elizabeth to the North Barrel of the twin barrel trunk sewer (see description above). Details pertaining to these pump stations are included in Section 2.4. There are no constructed relief points to the receiving waters within the trunk sewer system.

There are a total of 18 cross connections (relief sewers) and 16 junctions throughout the trunk sewer network which divert and distribute flow among the two trunk sewers to maximize conveyance capacity of the system during WWF

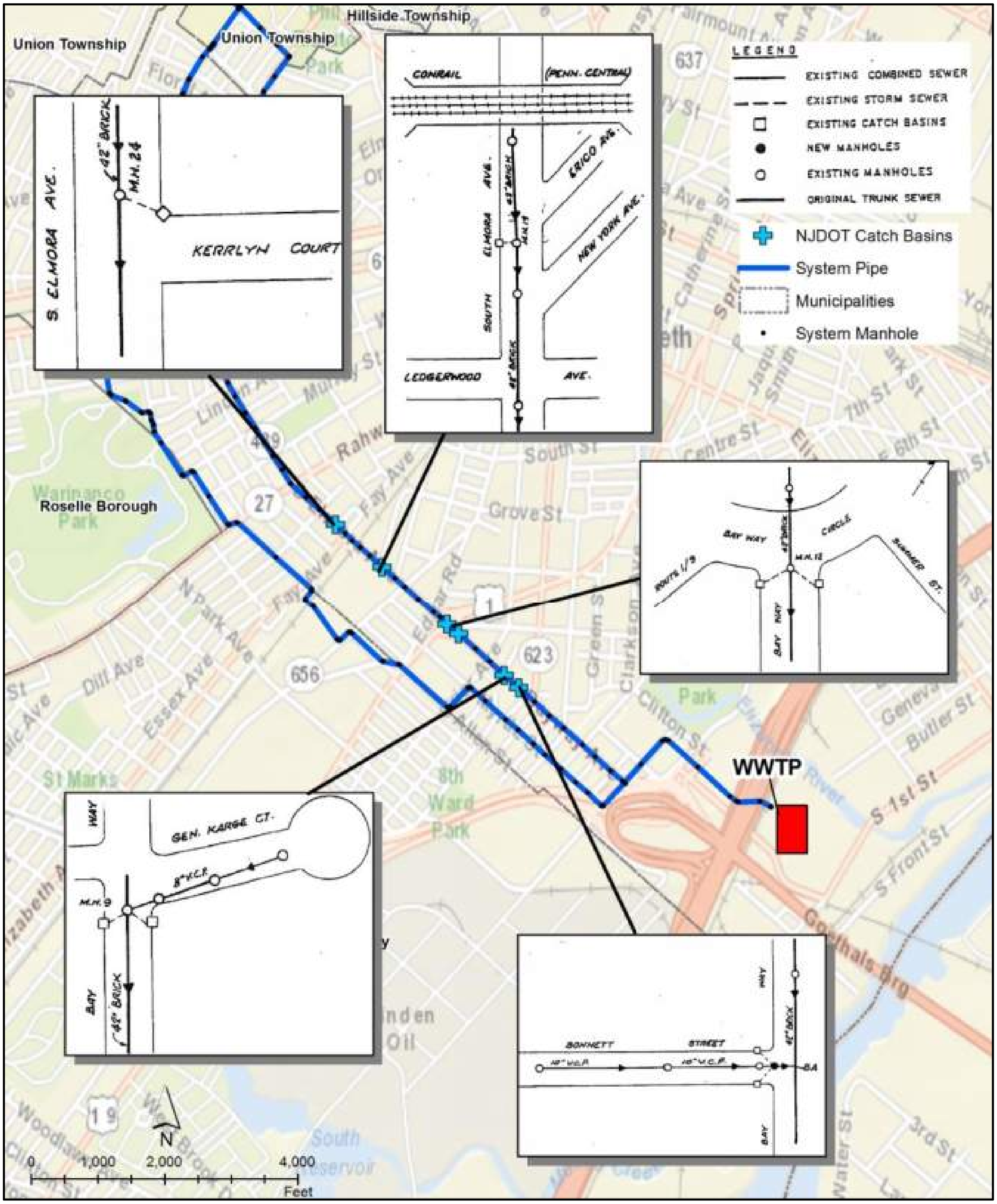


Figure 2-3 NJDOT Catch Basin Connections to the JMEUC Original Trunk Sewer

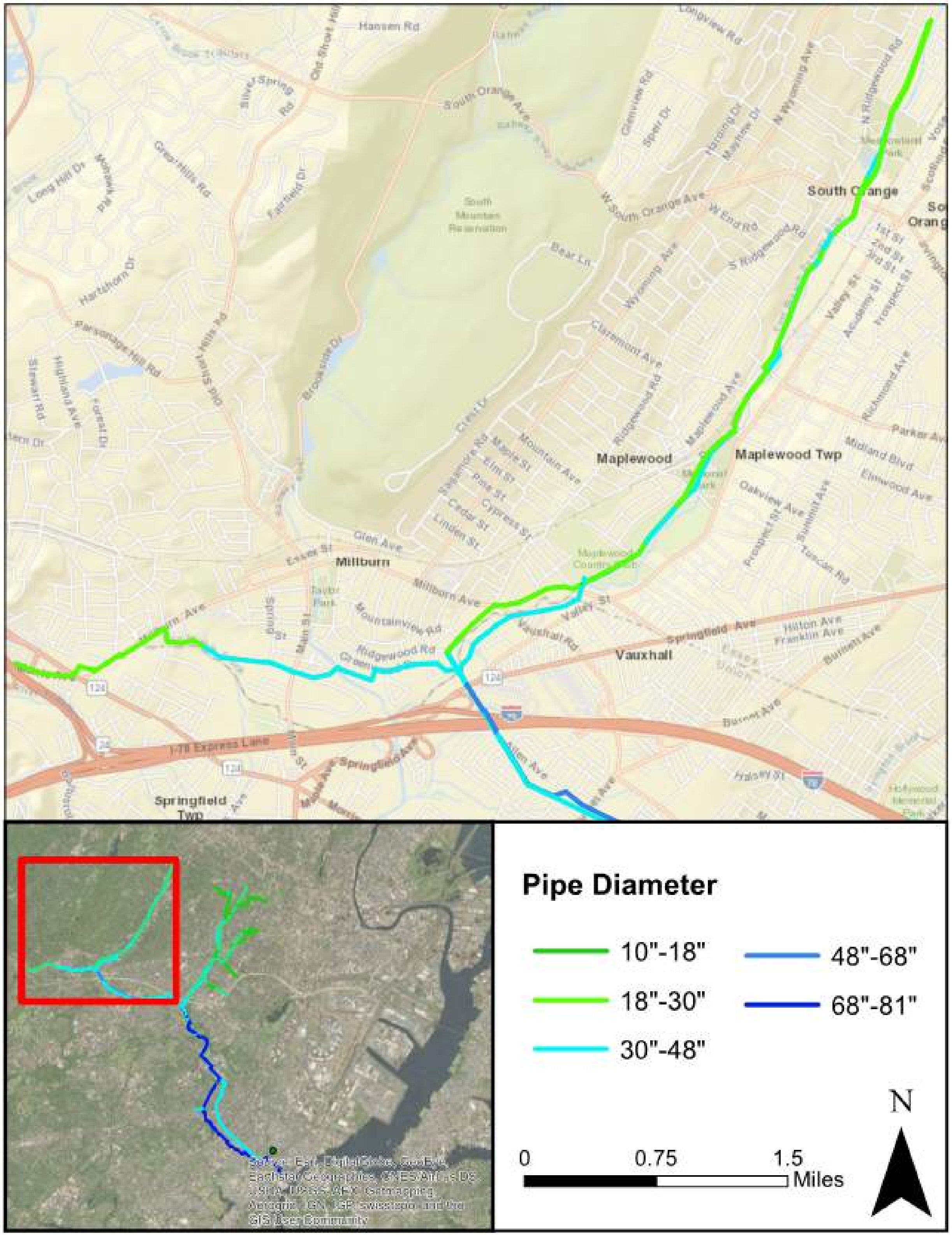


Figure 2-4 JMEUC Trunk Sewer Pipe Sizes and Shapes – Northwest Portion of Service Area

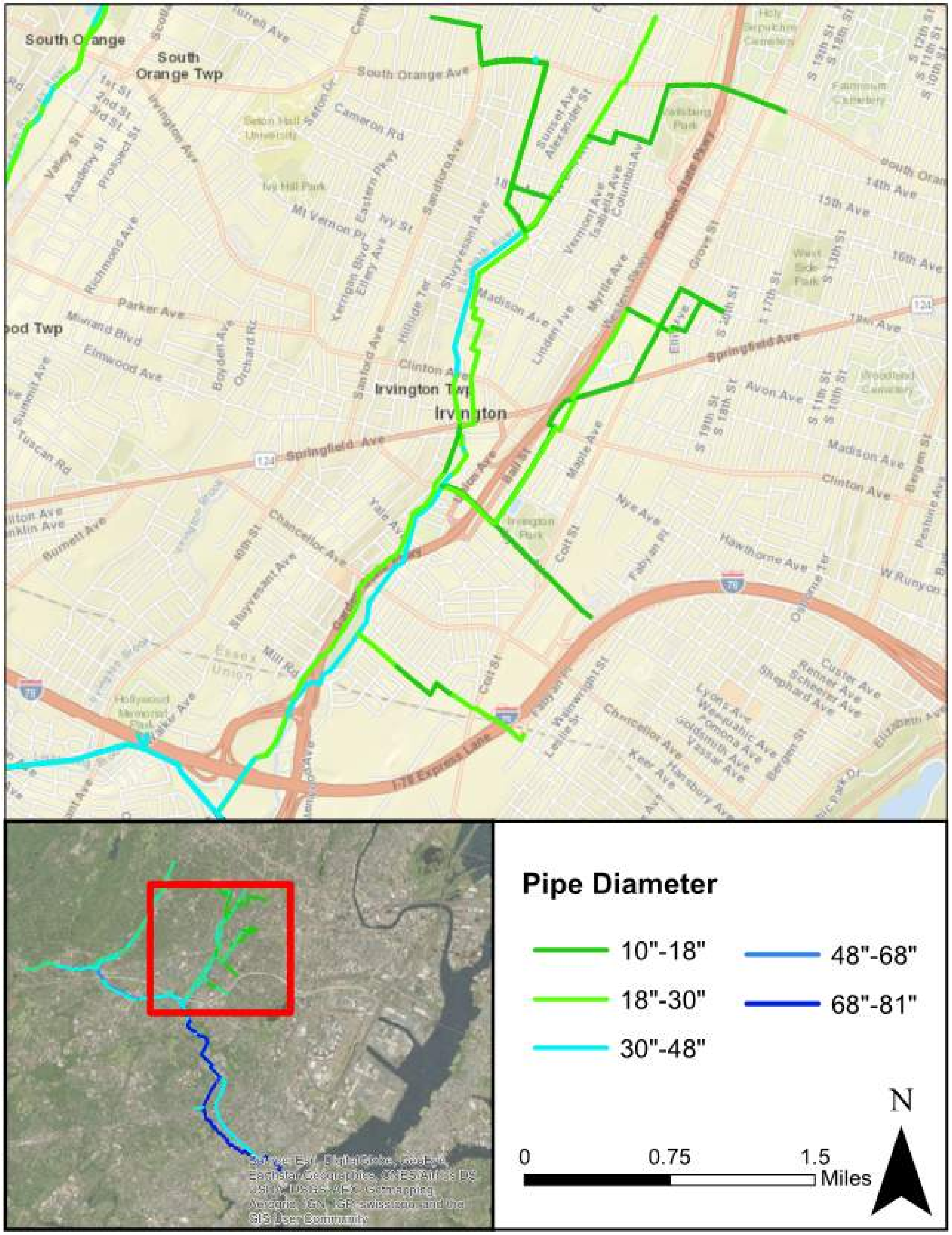


Figure 2-5 JMEUC Trunk Sewer Pipe Sizes and Shapes – Northern Portion of Service Area

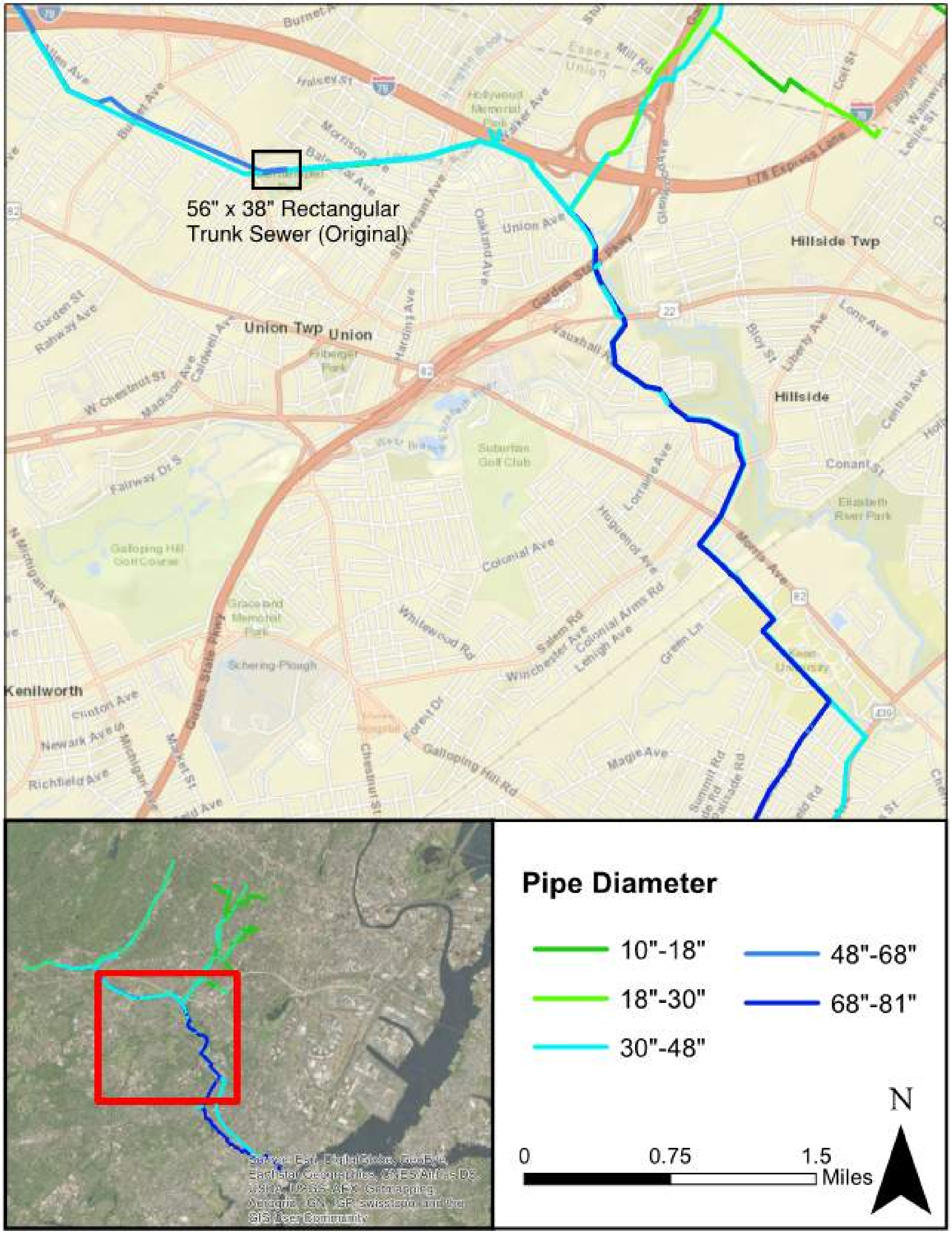


Figure 2-6 JMEUC Trunk Sewer Pipe Sizes and Shapes – Central Portion of Service Area

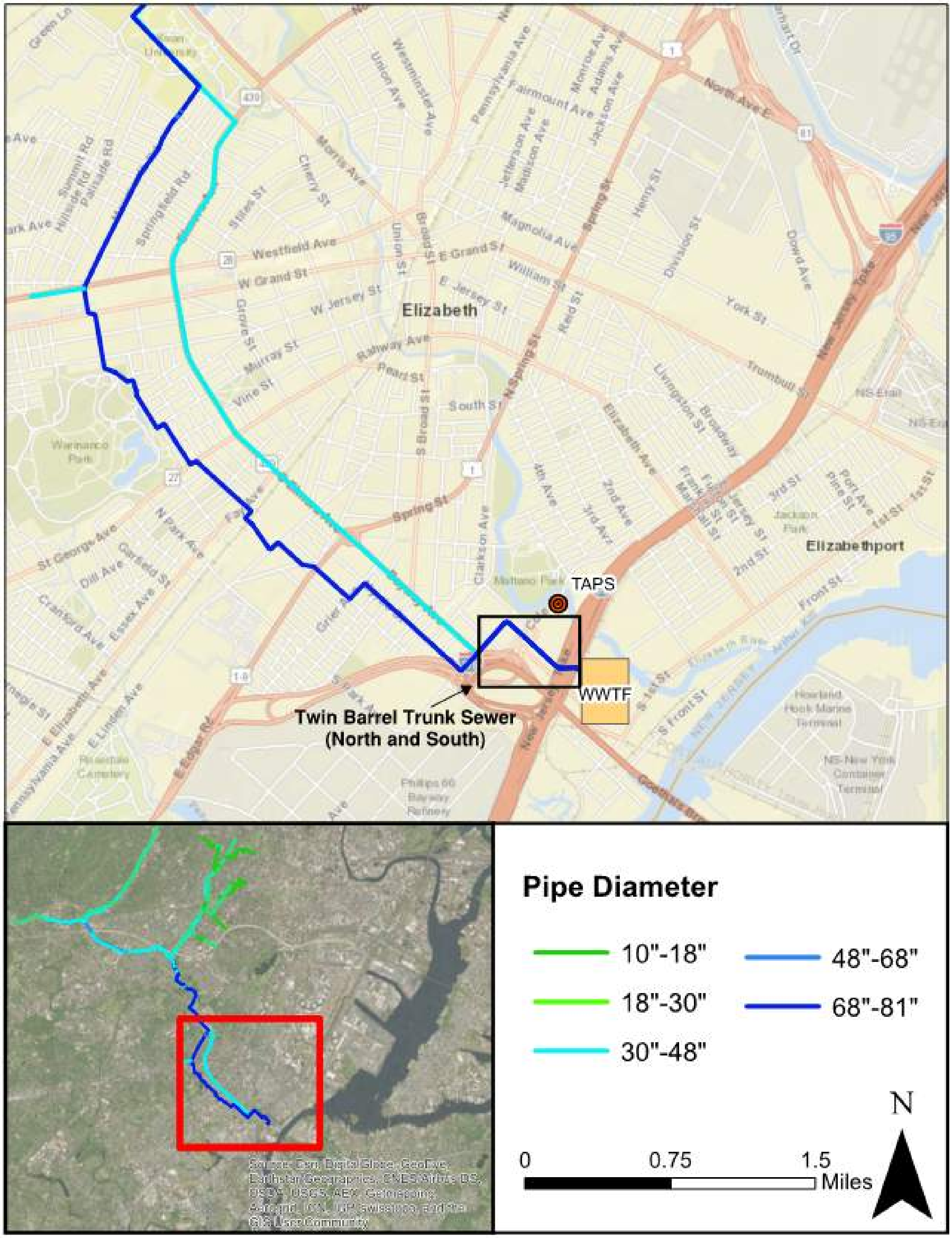


Figure 2-7 JMEUC Trunk Sewer Pipe Sizes and Shapes – Southeast Portion of Service Area

These connections and junctions balance flow and head in the system, thereby avoiding the overloading of one trunk while capacity may be available in the other. Details pertaining to these cross connections and junctions are included in Section 2.5.

The trunk sewer network also includes two inoperable venturi meters and four areas of depressed pipe segments below stream/river crossings. Details pertaining to these structures are also found in Section 2.5.

Historically, the JMEUC has not observed issues with sewer system overflows or flooding and hydraulic modeling results have indicated no measurable flooding in the JMEUC system during typical year rainfall (see Section 7).

2.4 Pump Stations and Force Mains

Including the TAPS, there are four pump stations immediately upstream of the JMEUC trunk sewer network. These pump stations are described below. Information pertaining to pump stations in the City of Elizabeth's collection system upstream of the TAPS can be found in the City of Elizabeth's CSO System Characterization Report (June 2018).

2.4.1 New Providence Pump Station

The New Providence Pump Station services the customer community of New Providence in the northwestern portion of the JMEUC service area. Flows are conveyed via force main to the member community of Summit. Flows from Summit subsequently enter the Original Trunk Sewer at the most northwest end of the JMEUC collection system. DWF through the New Providence Pump Station is typically around 1.5 mgd.

2.4.2 Cherry Lane Pump Station

The Cherry Lane Pump Station services a portion of the member community of West Orange in the northwestern portion of the JMEUC service area. Flows are conveyed via force main to the community of Millburn where they subsequently enter the Original Trunk Sewer. DWF through the Cherry Lane Pump Station is typically around 0.5 mgd.

2.4.3 Pump Station

The Hillside Pump Station services approximately 80% of the member community of Hillside in the southeast portion of the JMEUC service area. Flows are conveyed via force main to the Original Trunk Sewer. DWF through the Hillside Pump Station is typically around 2.5 mgd according to flow monitoring data used in model development and calibration (Section 4).

2.4.4 Trenton Avenue Pump Station (TAPS)

The TAPS is located in the most southeastern portion of the JMEUC service area and services the majority of the City of Elizabeth. Flows are conveyed via a 48-inch force main approximately 1,000 feet in length and enter the North Barrel of the twin barrel trunk sewer roughly 1,300 feet upstream of the WWTF. ADWF through the TAPS is typically around 15 mgd. Although the maximum pumping capacity of the TAPS has been estimated at 55 mgd, discharge from the TAPS to the North Barrel is contractually capped at 36 mgd, historically limiting the amount of WWF that can be discharged to the JMEUC trunk sewer system from the City of Elizabeth.

2.5 Other Flow Controls / Structures

2.5.1 Cross Connections and Junctions

Flow control structures within the JMEUC trunk sewer network are limited to various cross connections (relief sewers) and junction points between the Original and Supplementary Trunk Sewers. In total, there are 18 cross connections and 16 junctions which redistribute flow among the Original and Supplementary Trunk Sewers to maximize capacity of the collection system.

Cross connections and junctions were differentiated based on how they were represented in the hydraulic model. Structures were defined as cross connections if they connected Original and Supplementary Trunk Sewers via a pipe, while junctions were defined as structures where flows from Original and Supplementary Trunk Sewers come together at a common point.

Figure 2-8 through Figure 2-11 show the locations of these cross connections and junctions. For naming convention purposes, cross connections were given the prefix “CC”, followed by number, while junctions were given the prefix “J”, followed by a number. Additional information pertaining to the hydraulics and distribution of flow through these cross connections and junctions is included in Section 7.

2.5.2 Venturi Meters and Stream Crossings

In addition to the cross connections and junctions between the two trunk sewers, the collection system also includes other notable or special structures. Two inoperable venturi meters (one at the Union Avenue Junction Chamber and the other along Monmouth Road at the border of the City of Elizabeth and Union) are not currently used to measure flows, but they are still able to convey flows via inverted siphons. Additionally, both venturi meters have bypass structures which add additional localized capacity and allow for some flow to bypass the inverted siphons. There are also four areas of depressed pipe segments under stream/river crossings that can impact the hydraulic conditions in the trunk sewers.

The locations of the venturi meters and depressed pipe segments are indicated in Figure 2-12. A construction drawing showing the venturi meter located immediately upstream of the Union Avenue Junction Chamber is included in Figure 2-13, while Figure 2-14 shows profile and cross-sectional views of the depressed pipe located near Vauxhall Road. The three other depressed pipes within the system have a similar configuration to the one shown in Figure 2-14, with the pipe maintaining its slope, transitioning in cross-sectional shape from circular to rectangular and then back to circular.

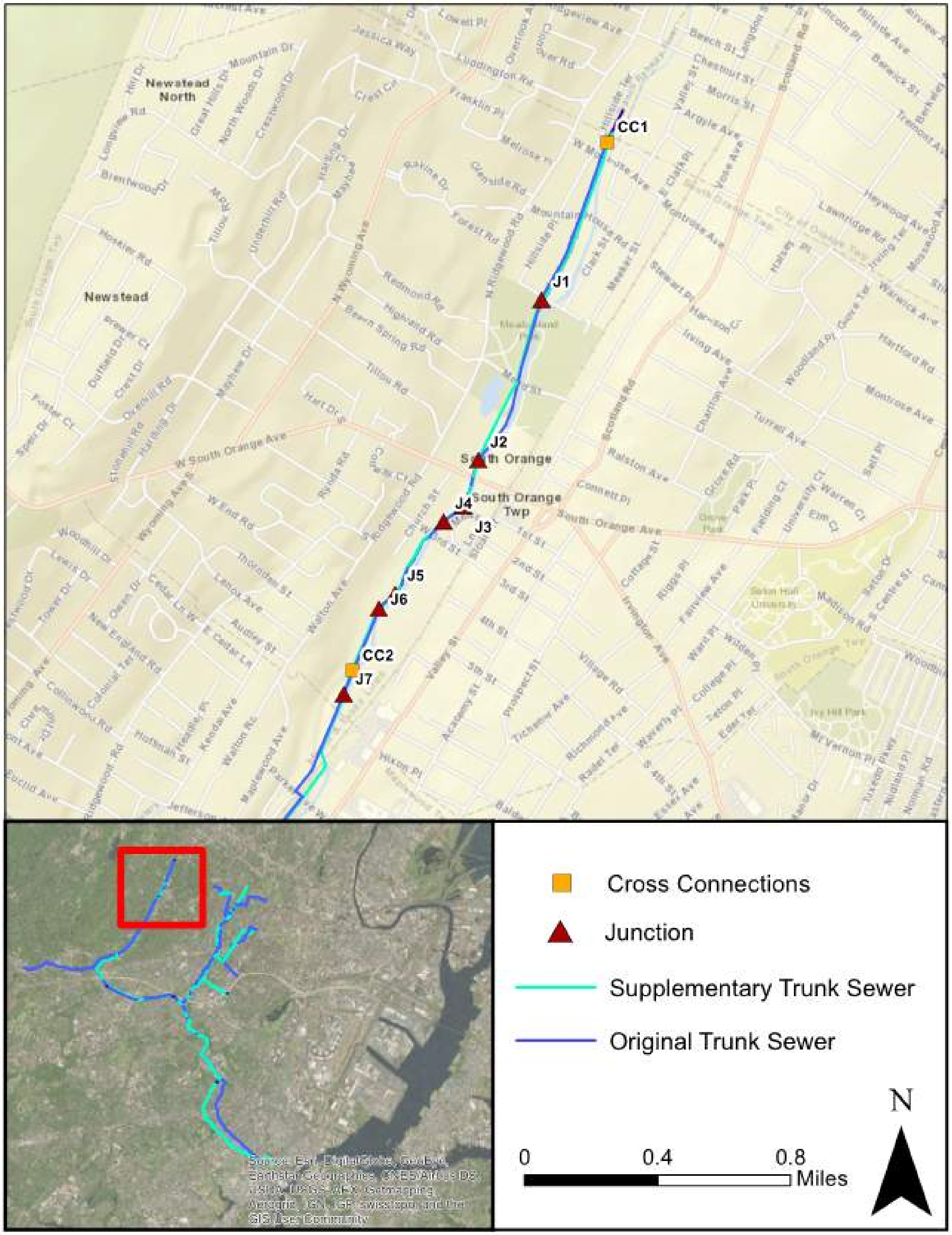


Figure 2-8 Locations of Cross Connections and Junctions between Original and Supplementary Trunk Sewers – Northwest Portion of Service Area

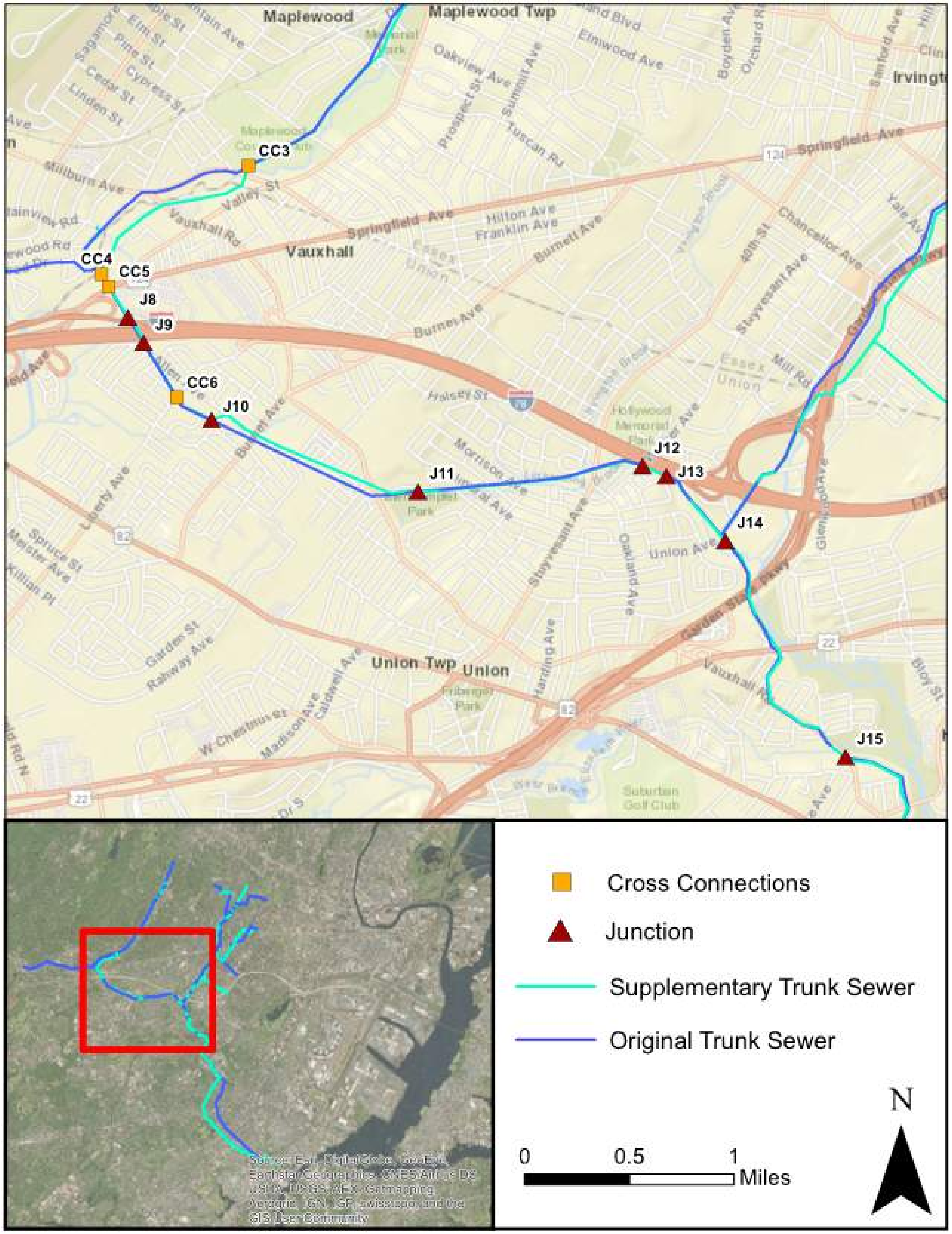


Figure 2-9 Locations of Cross Connections and Junctions between Original and Supplementary Trunk Sewers – North-Central Portion of Service Area

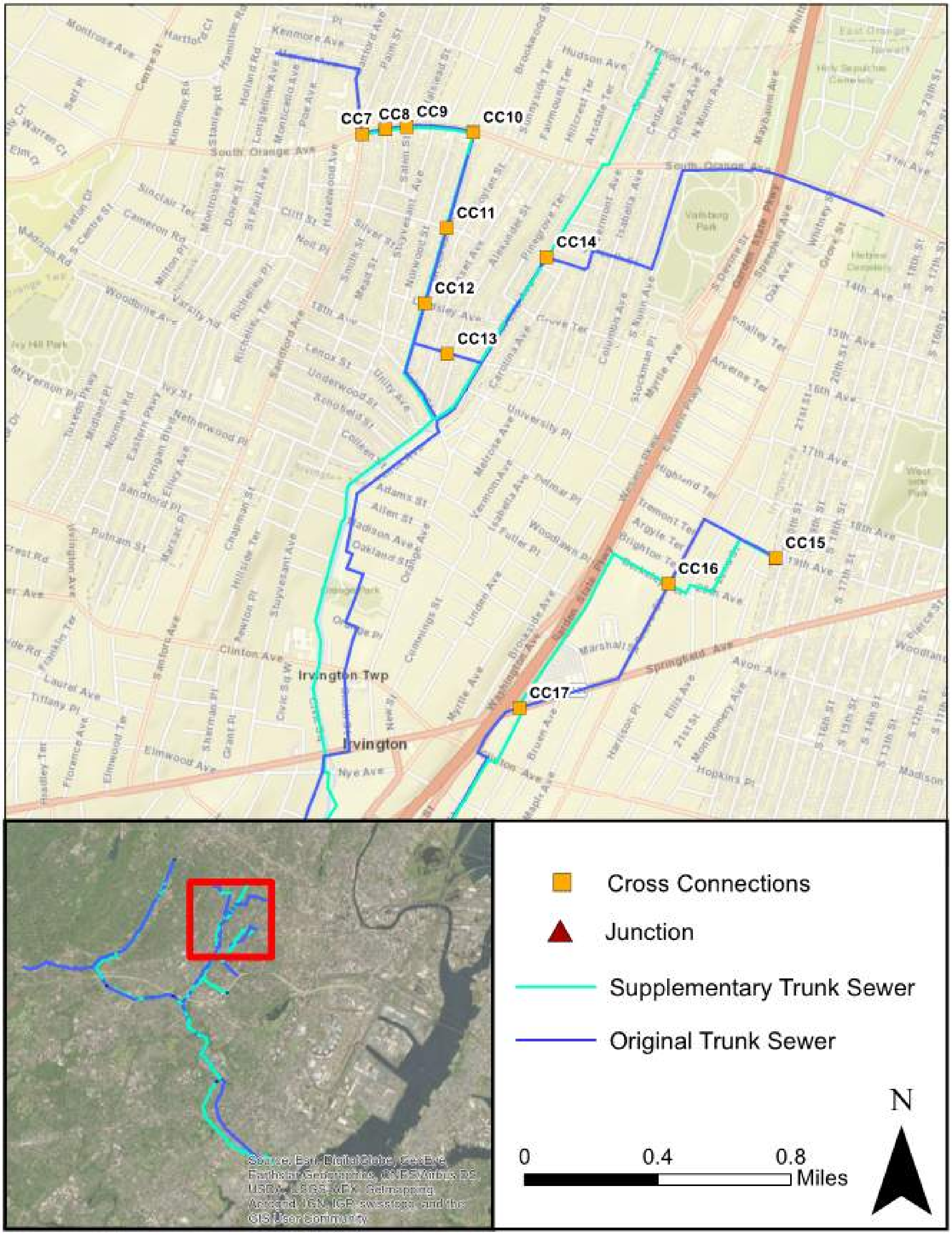


Figure 2-10 Locations of Cross Connections and Junctions between Original and Supplementary Trunk Sewers – Northern Portion of Service Area

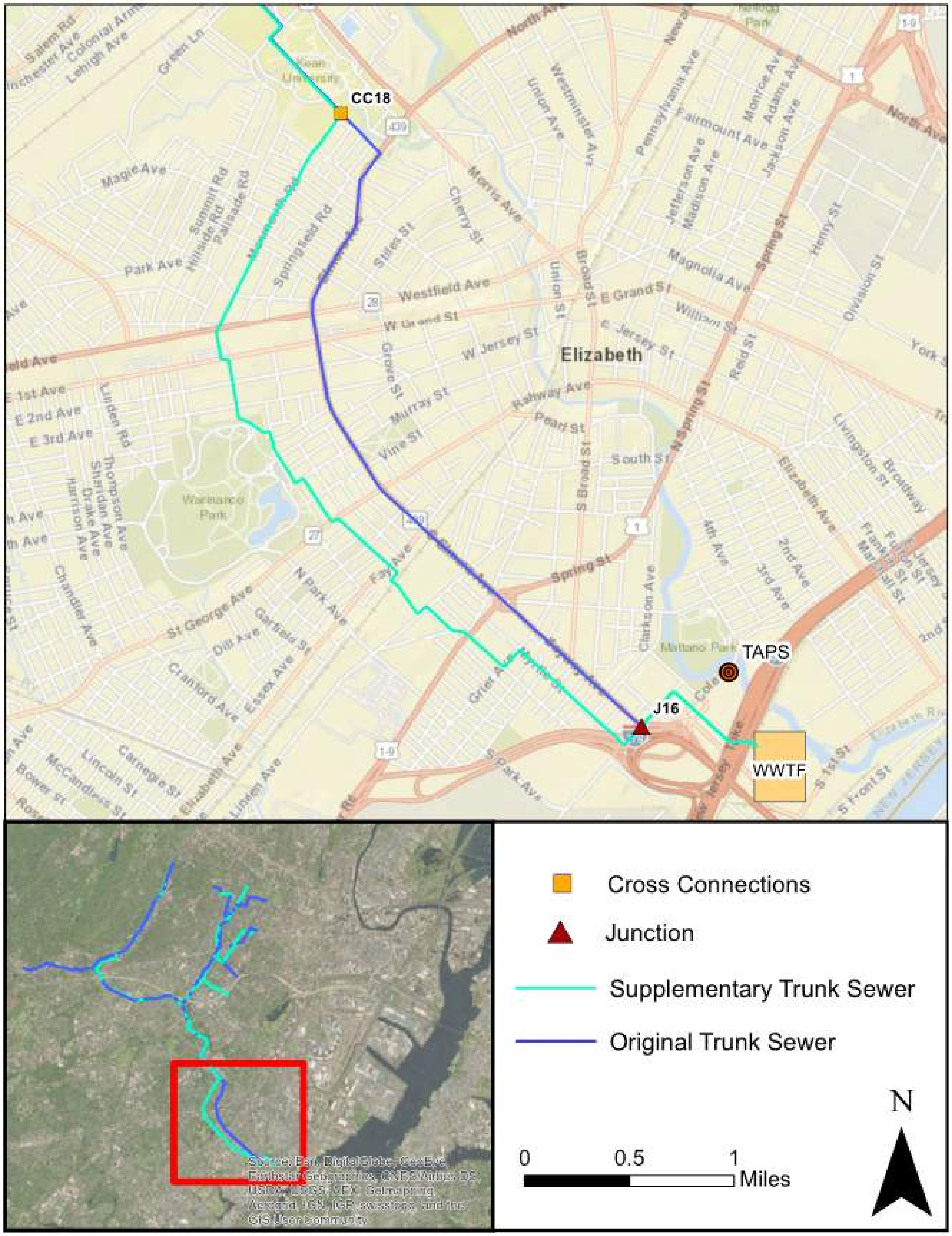


Figure 2-11 Locations of Cross Connections and Junctions between Original and Supplementary Trunk Sewers – Southeast Portion of Service Area

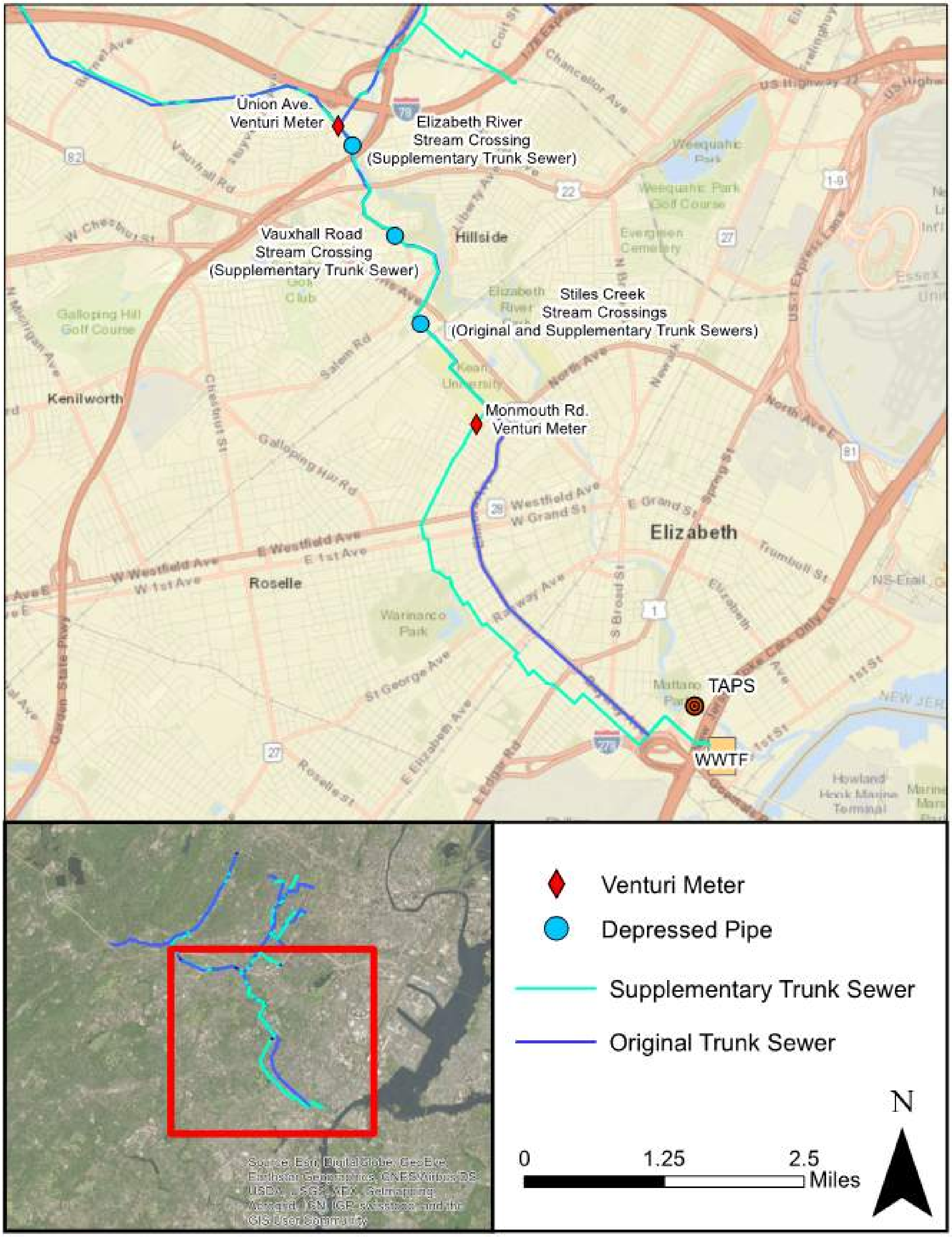


Figure 2-12 Locations of Venturi Meters and Depressed Pipes within the JMEUC Trunk Sewer System

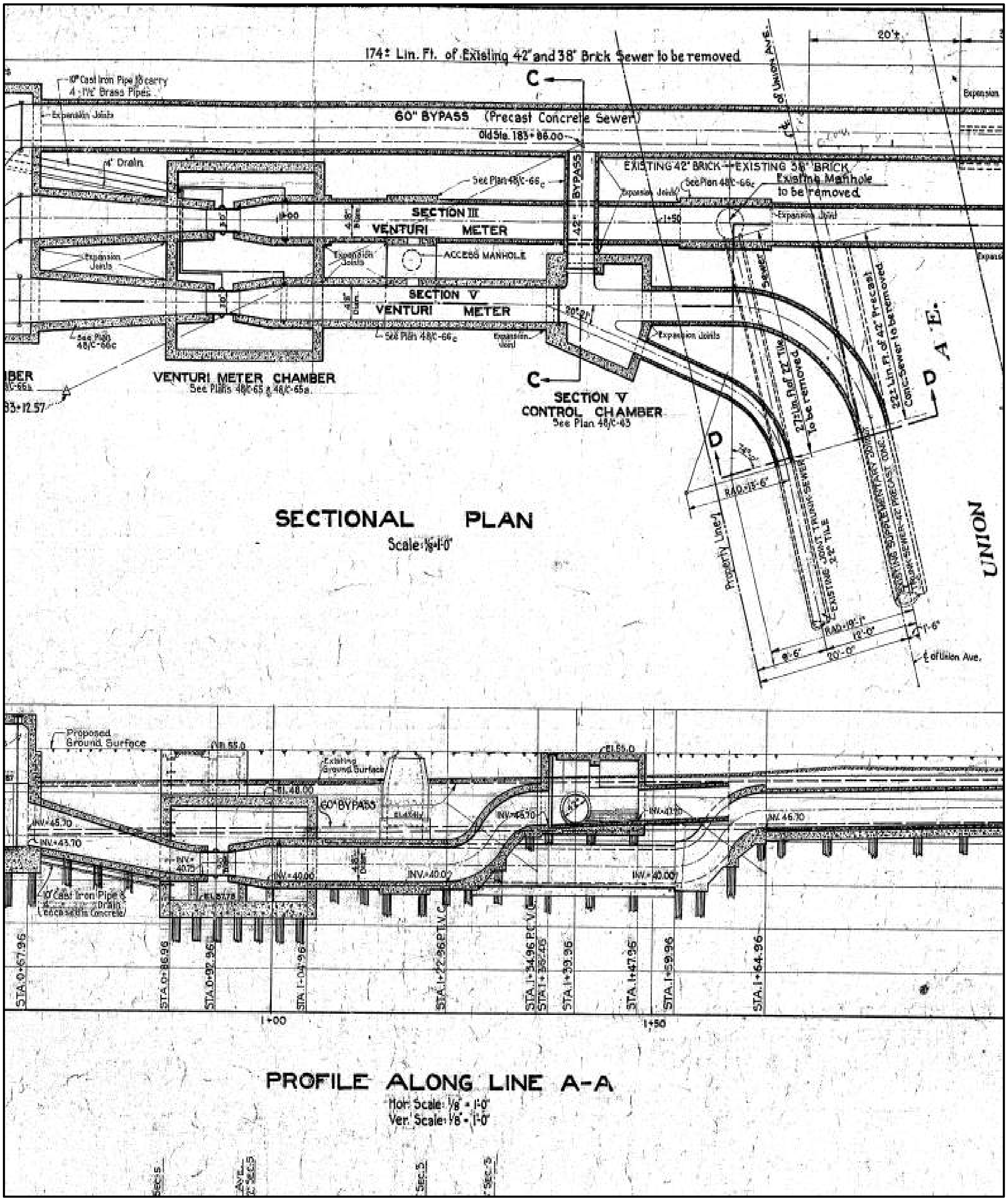


Figure 2-13 Construction Drawings of Union Avenue Venturi Meter

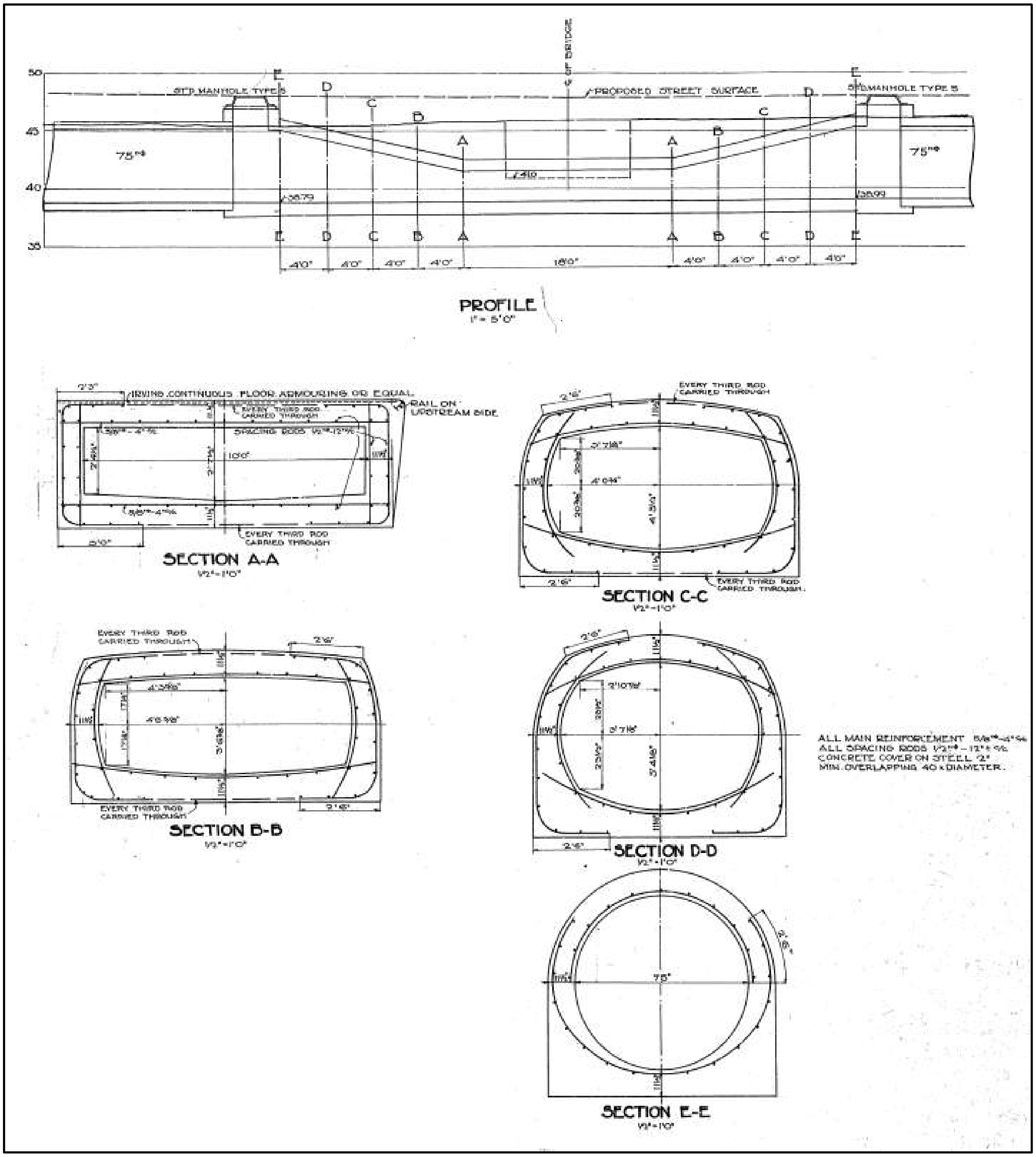


Figure 2-14 Profile and Cross-Sectional Views of the Depressed Pipe Located at Vauxhall Road

2.6 Edward P. Decker Secondary Wastewater Treatment Facility

The Edward P. Decker Secondary Wastewater Treatment Facility (WWTF) has a rated peak hydraulic capacity of 180 mgd, although flows reaching 220 mgd may be processed during significant wet weather events. Peak discharge from the WWTF is limited by mean sea level (MSL), with rated capacity of the WWTF dropping to 120 mgd when tides exceed eight feet above MSL (corresponding to 13-year recurrence interval). Average daily influent flows at the WWTF are around 85 mgd. Additional information about the WWTF is provided in Section 8, and Figure 8-1 shows the general WWTF layout.

2.6.1 Preliminary Treatment

Flows from the Original and Supplementary Trunk Sewers enter the headworks of the WWTF and are diverted to one of two paired sets of coarse and fine screens. No pumping of the influent is required at the headworks of the WWTF. Flow passes by gravity first through the coarse screens and then through the fine screens. The coarse screens have 3.5-inch clear openings while the fine screens have 0.75 inch clear openings. When both sets of screens are on-line flow is typically split evenly between the paired sets of screens. Effluent flow from the fine screen enters four grit channels, each measuring 9.5 feet wide by seven feet deep by 57 feet long.

2.6.2 Primary Treatment

Flow exiting the individual grit channels is combined at a downstream flume which routes flow to a collection channel immediately upstream of four primary settling tanks (PSTs). The four PSTs have identical geometries (200 feet long by 75 feet wide by 13.8 feet deep). During DWF conditions only two of the four PSTs are on-line. A third PST is brought on-line during WWF when flows measured directly upstream of secondary treatment exceed 100 mgd. The fourth PST is only brought on-line in emergency situations such as power failure.

The four PSTs have effluent weir lengths of 75 feet each, with effluent flow entering a collection channel before flowing to the primary effluent chamber. Under normal operating conditions, flow exits the primary effluent chamber and enters a six foot by 10 foot box-shaped conduit which conveys flow to the Main Sewage Pumps wet well. The wet well feeds five low lift pumps, all equipped with variable frequency drives. Two pumps are normally in operation at all times, and their pumping rate controlled by the water level of the wet well. When flows discharging from the wet well exceed 100 mgd, a third and occasionally fourth pump are turned on manually to maintain the water level in the wet well. Collectively the five wet well pumps have a capacity of over 200 mgd, enough to maintain proper water levels in the plant during extreme wet weather events.

The primary effluent chamber also has two emergency overflows (one discharging to the Arthur Kill and the other discharging to the Elizabeth River). Activation of these overflows is controlled by the primary effluent chamber water level and by gates in the chamber which are normally closed. These emergency overflows have not activated in many years and any activation of these overflows would most likely be due to downstream mechanical issues as opposed to insufficient downstream capacity.

2.6.3 Secondary Treatment and Disinfection

The WWTF has four aeration tanks, each with a volume of 3.97 million gallons (15.89 million gallons total). Each aeration tank has eight surface aerators rated at 100 horsepower and two-speed operation capable of providing a maximum of 2,360 lb/hour of oxygen per tank. Effluent flows from the aeration tanks enter four final settling tanks (FSTs), each having a diameter of 180 feet and a depth of 15 feet. FST effluent flows are disinfected with sodium hypochlorite in a chlorine contact tank capable of treating a peak hour flow of 73 mgd at the required contact time of 20 minutes. The disinfected effluent is then dechlorinated with sodium bisulfate before being discharged to the Arthur Kill through two outfall conduits. Section 8 of this report further describes the treatment train at the WWTF and describes the capacities of each of the existing treatment processes.

Section 3
Receiving Waterbodies

The JMEUC and the City of Elizabeth are both members of the NJ CSO Group. The Passaic Valley Sewerage Commission (PVSC) is conducting extensive receiving waterbody investigations on behalf of the Group, in support of the October 2015 Combined Sewer Management permits issued to each of the Group's members. A brief summary description of the receiving waterbodies is provided here, and the reader is directed to the City of Elizabeth System Characterization Report (June 2018) and the PVSC Baseline Compliance Monitoring Report (June 2018) for additional information.

3.1 Identification and Description of CSO Receiving Waters

As noted previously, the JMEUC does not own or operate any CSO outfalls. The City of Elizabeth combined sewer system has 29 CSO outfall points which are permitted to discharge to the following waterbodies (the City of Elizabeth System Characterization Report; June 2018):

- 21 outfalls discharge to the Elizabeth River; upstream of Broad Street this waterbody is classified as Fresh Water FW2 and downstream of Broad Street it is Saline Estuary SE3;
- Four outfalls discharge to the Arthur Kill (Saline Estuary SE3); and
- Four outfalls discharges to Newark Bay (Saline Estuary SE3), including two via the Great Ditch and one via the Peripheral Ditch.

The reader is directed to the City of Elizabeth System Characterization Report (June 2018) for more detailed information about the CSO receiving waterbodies.

Treated wastewater from the WWTF is discharged through two outfall conduits into the Arthur Kill, just below Newark Bay, with an emergency bypass outfall into the Elizabeth River just above the confluence with the Arthur Kill. The Arthur Kill and the lower Elizabeth River are both tidal waterbodies classified as Saline Estuary SE3.

3.2 Current Water Quality Conditions

There has been extensive investigation of water quality conditions in the subject waterbodies conducted prior to and as part of the current efforts under the October 2015 Combined Sewer Management permits issued by NJDEP to the individual members of the NJ CSO Group. The reader is directed to the PVSC Baseline Compliance Monitoring Report, prepared on behalf of the Group, for further information about current water quality conditions in the subject waterbodies.

3.3 Identification, Evaluation and Prioritization of Environmentally Sensitive Areas

There has been a detailed investigation of the subject waterbodies relative to the established criteria used to designate Sensitive Areas as defined in the U.S.EPA CSO Control Policy and reiterated in the NJDEP Combined Sewer Management permit issued in October 2015 to the JMEUC. This work has been performed by PVSC on behalf of the NJ CSO Group, as part of the current efforts under the October 2015 Combined Sewer Management permits issued by NJDEP to the individual members of the Group. The reader is directed to the PVSC Consideration of Sensitive Areas Report (June 2018), for further information about Sensitive Areas in the subject waterbodies. The City of Elizabeth System Characterization Report (June 2018) also addresses this subject and further information is available in that report.

Section 4

Sewer System Monitoring and Modeling

4.1 Background

The JMEUC began the effort to develop the current hydraulic model of their trunk sewer system in 2012 using InfoWorks® ICM modeling software (Innovyze®). The model was calibrated and validated using the JMEUC's permanent flow meter data for four storms that occurred between June 2014 and June 2015. These efforts were documented in a previous report (JMEUC Trunk Interceptor Hydraulic Modeling Evaluations; July 2016 – see Appendix E). This model is referred to as the Preliminary Model in this report.

To comply with Part IV Section G.1 "Characterization Monitoring and Modeling of the Combined Sewer System" of JMEUC's NJPDES Combined Sewer Management Permit (Number NJ0024741), the Preliminary Model was significantly refined and further calibrated and validated with more recent storm events between October 2015 to May 2017. This current model reflects the system condition in 2015, which has been established by the JMEUC as the baseline condition for purposes of characterization of the JMEUC system. The current model is therefore referred to as the Baseline JMEUC Model, and enables better understanding of the current JMEUC collection system hydrology and hydraulics.

The Baseline JMEUC Model includes the flow from the TAPS as a boundary inflow, using a time series that corresponds to the simulation period (e.g. a typical year time series of flow from TAPS was generated for that period using the Elizabeth Model). In order to support system-wide simulation of the entire JMEUC service area, including the combined sewer system in the City of Elizabeth, the Baseline JMEUC Model was merged with the baseline condition model of the Elizabeth combined sewer system (developed by Mott MacDonald on behalf of the City of Elizabeth). The modeling teams working on behalf of the JMEUC and the City of Elizabeth coordinated the effort to create the merged model, and both teams have their own version of this merged model in hand to support their respective system characterizations (as documented in the independent reports submitted by the JMEUC and the City of Elizabeth) and forthcoming joint development of the LTCP. The JMEUC's version of the merged model is referred to in this report as the Baseline Merged Model. Its development is discussed in Section 4.3.3.

Both the Baseline JMEUC Model and Baseline Merged Model, and variations of these models incorporating various planning scenarios, will subsequently be used in the development of the LTCP to identify impacts on the JMEUC conveyance and treatment facilities associated with potential alternatives to eliminate or reduce CSO impacts from the City of Elizabeth combined sewer system. While the Baseline Merged Model has the advantage of including all elements of the City of Elizabeth combined sewer system, the merged model is much larger and more complex, requiring roughly five hours of computational runtime for the typical year simulation (versus less than one hour for the Baseline JMEUC Model). Therefore, simulations that do not require the detailed representation of the City of Elizabeth combined sewer system (e.g. evaluations of the hydraulic grade line in the JMEUC trunk sewers during storm flows) can be performed much more efficiently with the Baseline JMEUC Model (or a planning variation of this model). On the other hand, for example, simulations performed to evaluate changes in CSO discharge at the outfalls in the City of Elizabeth under planning scenarios that involve increased conveyance and treatment in the JMEUC system, would require use of a planning variation of the Baseline Merged Model.

This section documents flow and rainfall monitoring data used to support development of the Baseline JMEUC Model, as well as the model updates and calibration and validation efforts. The details of these analyses were presented to NJDEP during quarterly status update meetings and for further information the reader is directed to the presentations used during the meetings included in Appendix I.

4.2 Sewer System Monitoring

Flows in the JMEUC trunk sewer system and rainfall within the JMEUC service area have been monitored by the JMEUC for many years. This section describes the current flow and rainfall monitoring facilities, and the data collected by them that have been used to support the model calibration and validation efforts undertaken to support the JMEUC System Characterization Report.

4.2.1 Sewer Flow Monitoring

4.2.1.1 JMEUC's Permanent Meters

Since 1991, the JMEUC has had permanent area-velocity flow meters installed in or upstream of the JMEUC trunk sewer system for various operational purposes. The original flow meters installed were the ADS Quadrascan units. These flow meters were upgraded to ISCO 2100 Series meters before being replaced by ADS FlowShark Triton model flow meters which are the meters currently in use today. In late 2013, ADS Environmental Services, Inc. (ADS) was contracted to maintain these meters on a regular basis. Data quality since that time has been excellent.

A total of 32 permanent flow meters measure either incoming flow from upstream communities or flow within the trunk sewer system. Figure 4-1 through Figure 4-4 show the locations of the 32 flow meters in map format (to scale) and Figure 4-5 provides a schematic view which depicts the relative location of the flow meters and their connectivity. Table 4-1 summarizes the individual meters and the community or communities which are tributary to each meter location. Appendix F includes site reports generated by ADS for each flow meter in the JMEUC collection system and Appendix C includes flow monitor data that was used for model calibration and validation.

Table 4-1 JMEUC Flow Meter Summary

Flow Meter	Location Relative to JMEUC trunk sewers	Communities Contributing Flow to Metershed
JM04	Upstream	Roselle Park
JM10	Upstream	Newark
JM12	Upstream	Newark
JM13	Upstream	East Orange
JM14	Upstream	East Orange
JM15	Upstream	South Orange
JM16	Upstream	Irvington
JM19	Upstream	Newark
JM20	Upstream	Maplewood
JM21	Upstream	Maplewood
JM22	Upstream	Maplewood
JM24	Upstream	New Providence, Summit, Berkeley Heights
JM29	Upstream	West Orange, City of Orange, Livingston
JM30	Upstream	West Orange, City of Orange, Livingston
JM34	Upstream	Hillside
JM05	Supplementary	Union
JM05A	Original	Union
JM06	Original	Hillside
JM09	Original	Irvington
JM09A	Supplementary	Irvington
JM17	Original	Newark
JM18	Supplementary	Newark
JM25	Supplementary	Maplewood
JM26	Original	Maplewood
JM27	Original	South Orange
JM28	Supplementary	South Orange
JM31	Upstream	Maplewood
JM32C	Original	Millburn
JM32D	Supplementary	Millburn
JM32E	Original	Millburn
JMS1	Original	All Communities
JMS1A	Supplementary	All Communities

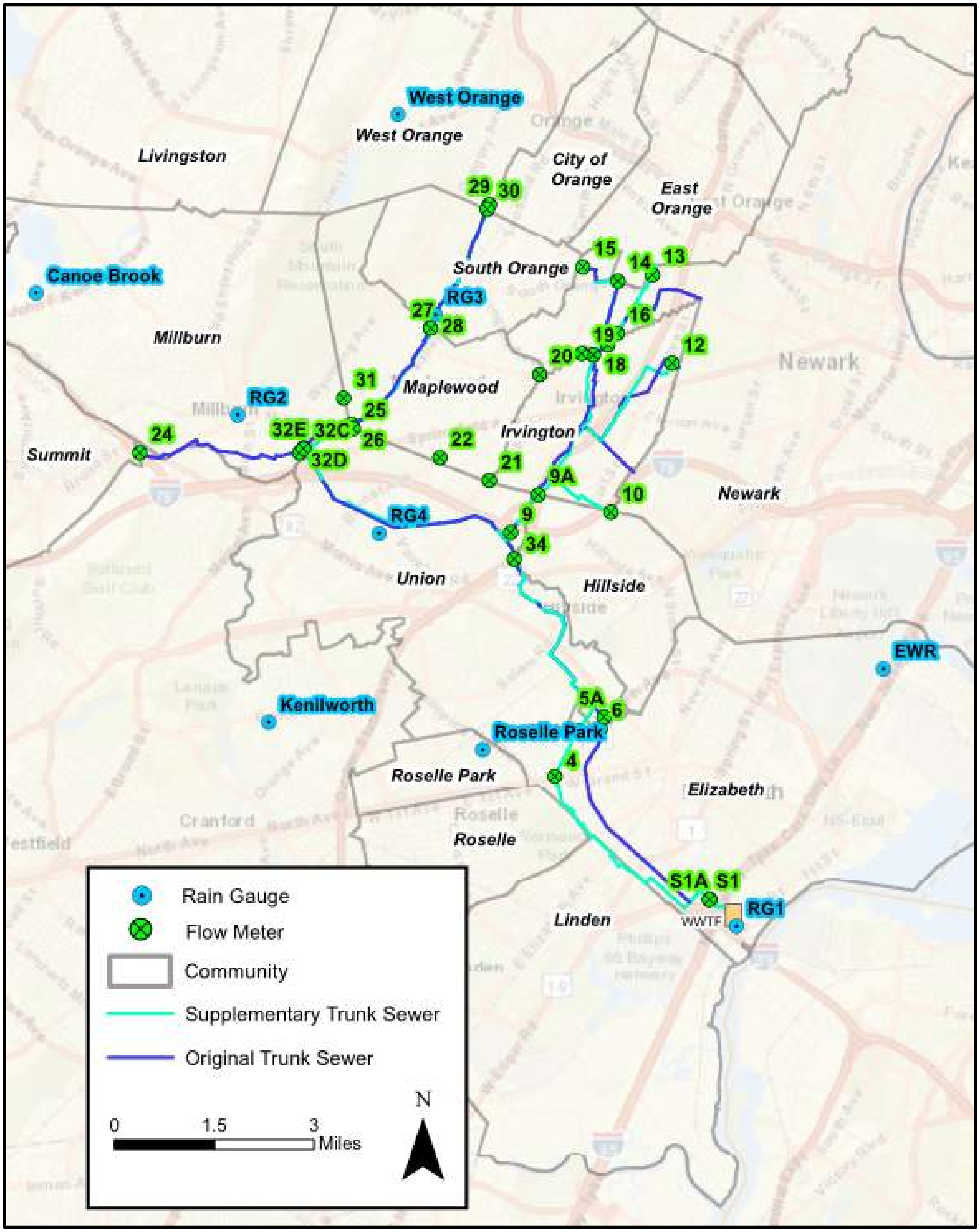


Figure 4-1 Flow Meter and Rain Gauge Locations – Entire Service Area

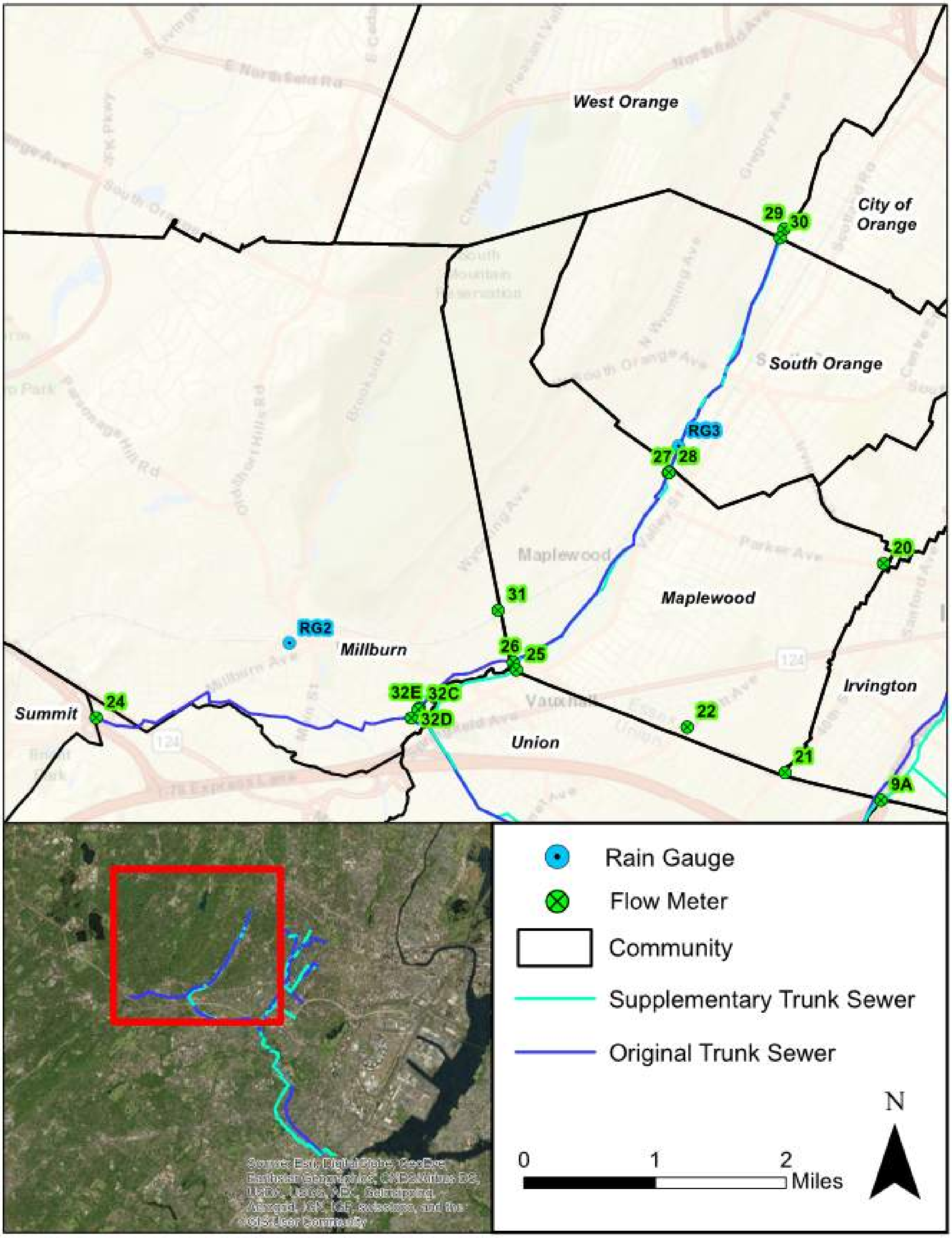


Figure 4-2 Flow Meter and Rain Gauge Locations – Northwest Service Area

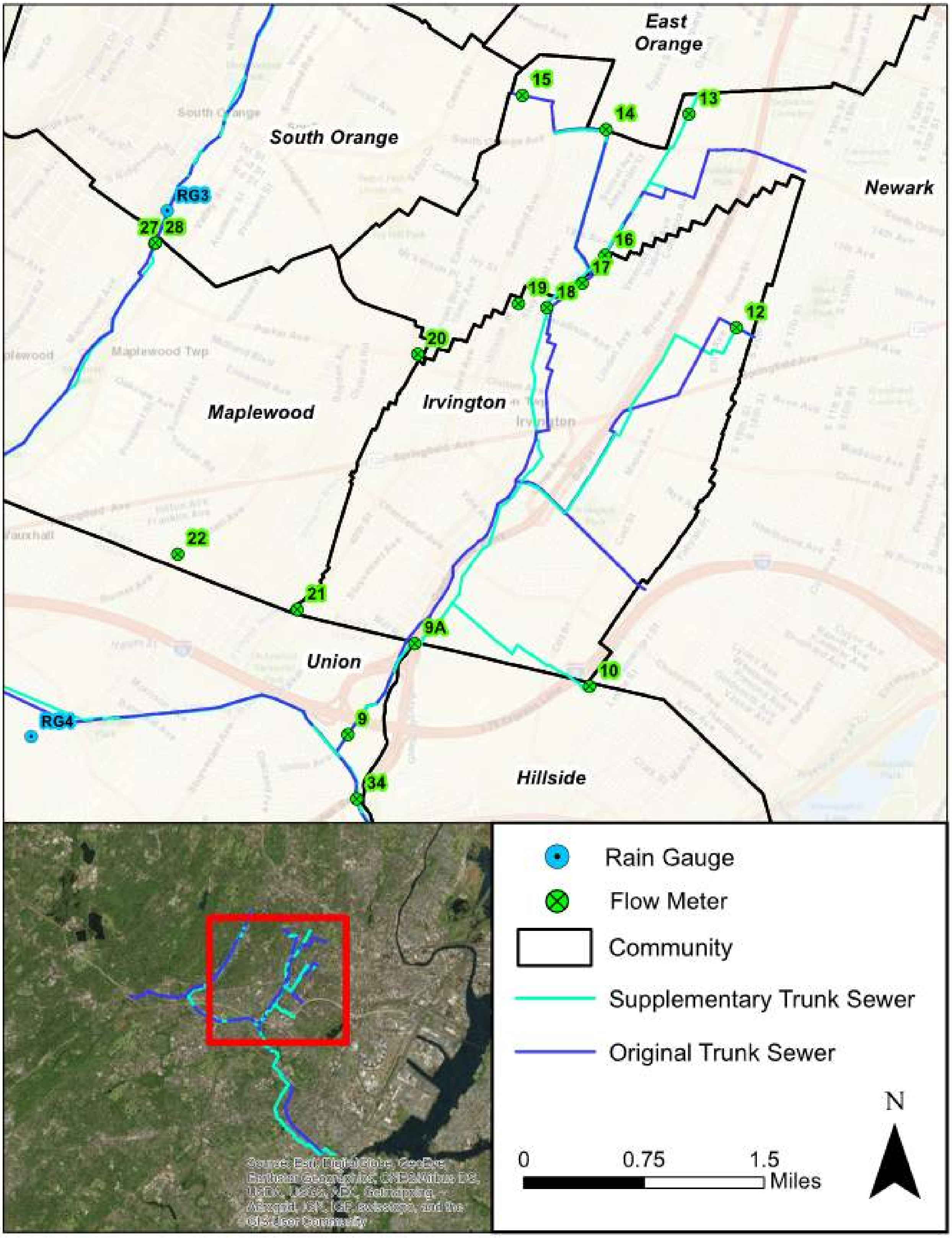


Figure 4-3 Flow Meter and Rain Gauge Locations – Northern Service Area

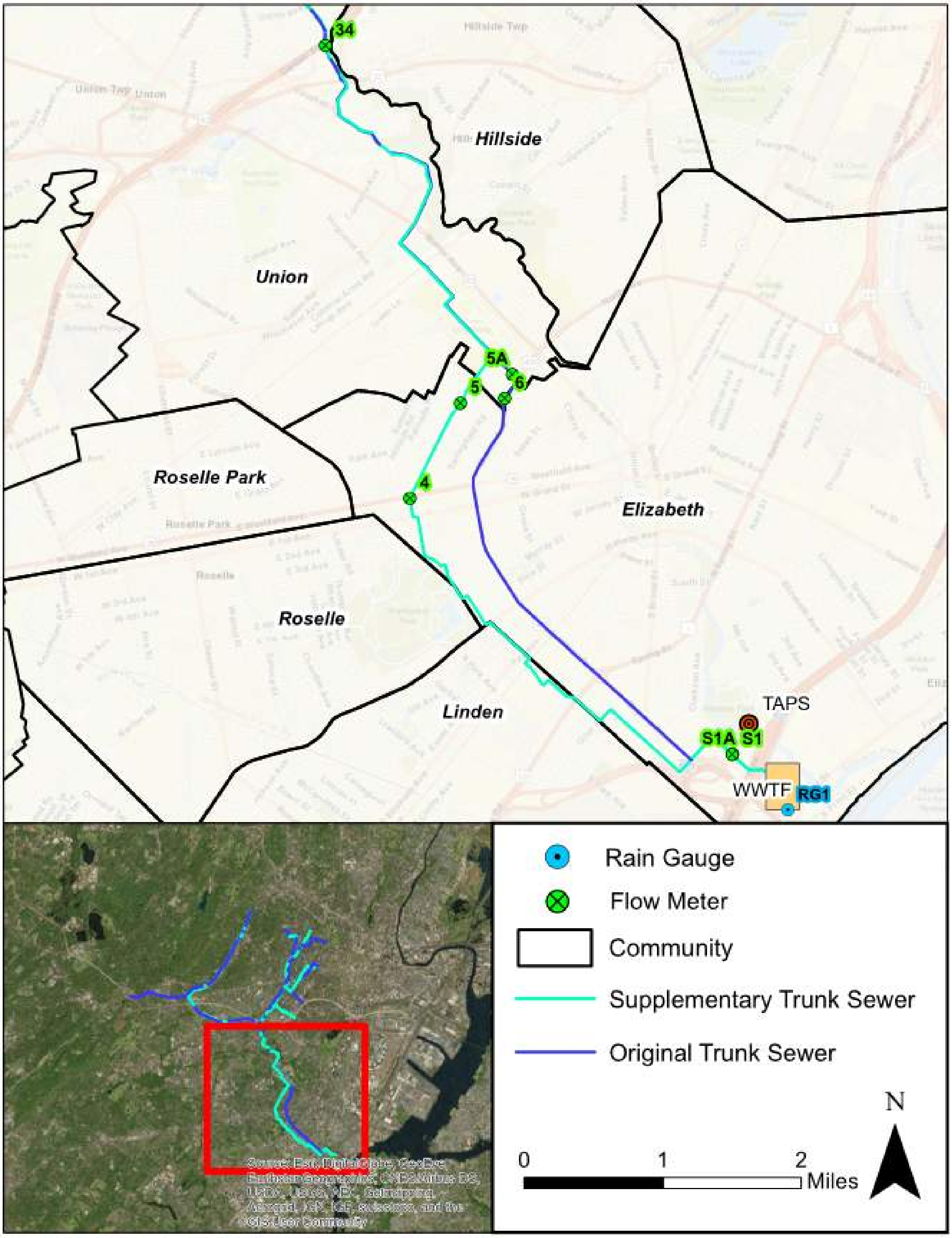


Figure 4-4 Flow Meter and Rain Gauge Locations – Central and Southeast Service Area

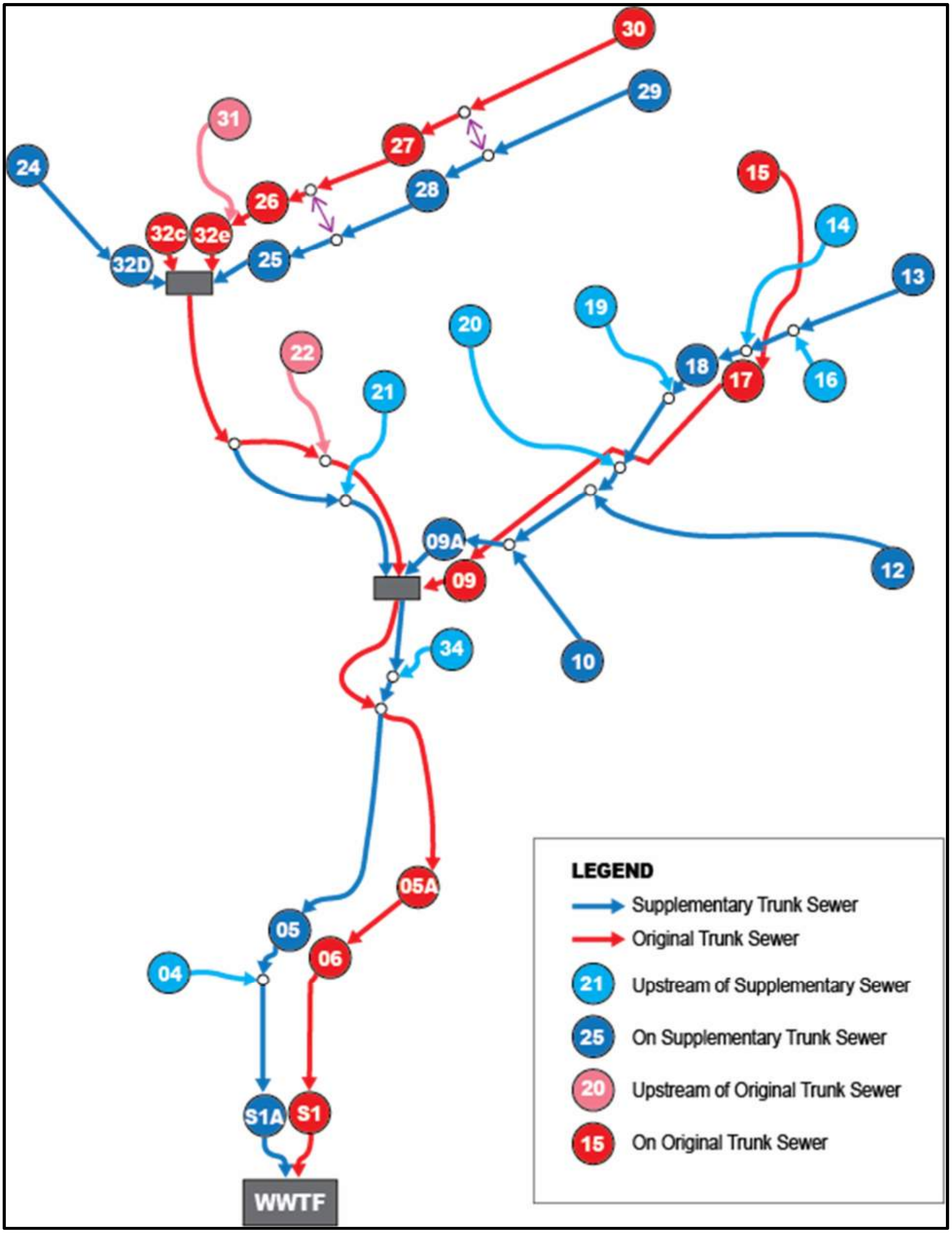


Figure 4-5 JMEUC Flow Meter Connectivity

This most recent model calibration and validation focused on data collected during the 20-month period from October 1, 2015 through June 1, 2017. The use of more than one year of observed data allows for the incorporation of seasonality in flow conditions, caused by seasonal changes in base groundwater levels and rainfall-derived inflow and infiltration (RDII), into the hydraulic model. The JMEUC's permanent meters measure both depth and velocity from which flow is calculated. Data quality has generally been very good since late 2014. Occasional dropouts of either depth or velocity sensors were mostly resolved quickly and did not have any significant impact on model calibration and validation. Shifts in metered depth and velocity were observed at JM05A, JM09, and JM32C during the monitoring period. It was concluded (through review of adjacent flow meter data) that these shifts were due to meter issues as opposed to changes in hydraulics of the system. Any calibration events affected by data quality issues are indicated in time series plots found in Appendix G.

4.2.1.2 The City of Elizabeth Data

The TAPS pumped flow rate is recorded in circular (paper) chart format. Time series for significant storm events during the calibration period were developed by digitizing the circular chart data. Figure 4-6 shows an example of the circular chart data and its digitized time series. A significant level of effort is required to generate digital time series data from circular paper charts, therefore other means were used for the remainder of the JMEUC calibration period.

The City of Elizabeth deployed 40 flow meters from August 22 to December 21, 2015 for system characterization. Two flow meters, M-32 and M-35, directly upstream of the TAPS provided relevant flow information during dry and wet weather condition. To develop a model input time series that closely approximates TAPS pumped flow, the observed flow at M-32 and M-35 was summed for the period of October 1 through December 21, 2015. The flow during dry weather was then extrapolated through the remainder of the JMEUC calibration period (December 22, 2015 – June 1, 2017) while the WWF was filled in with the digitized circular chart data as noted above.

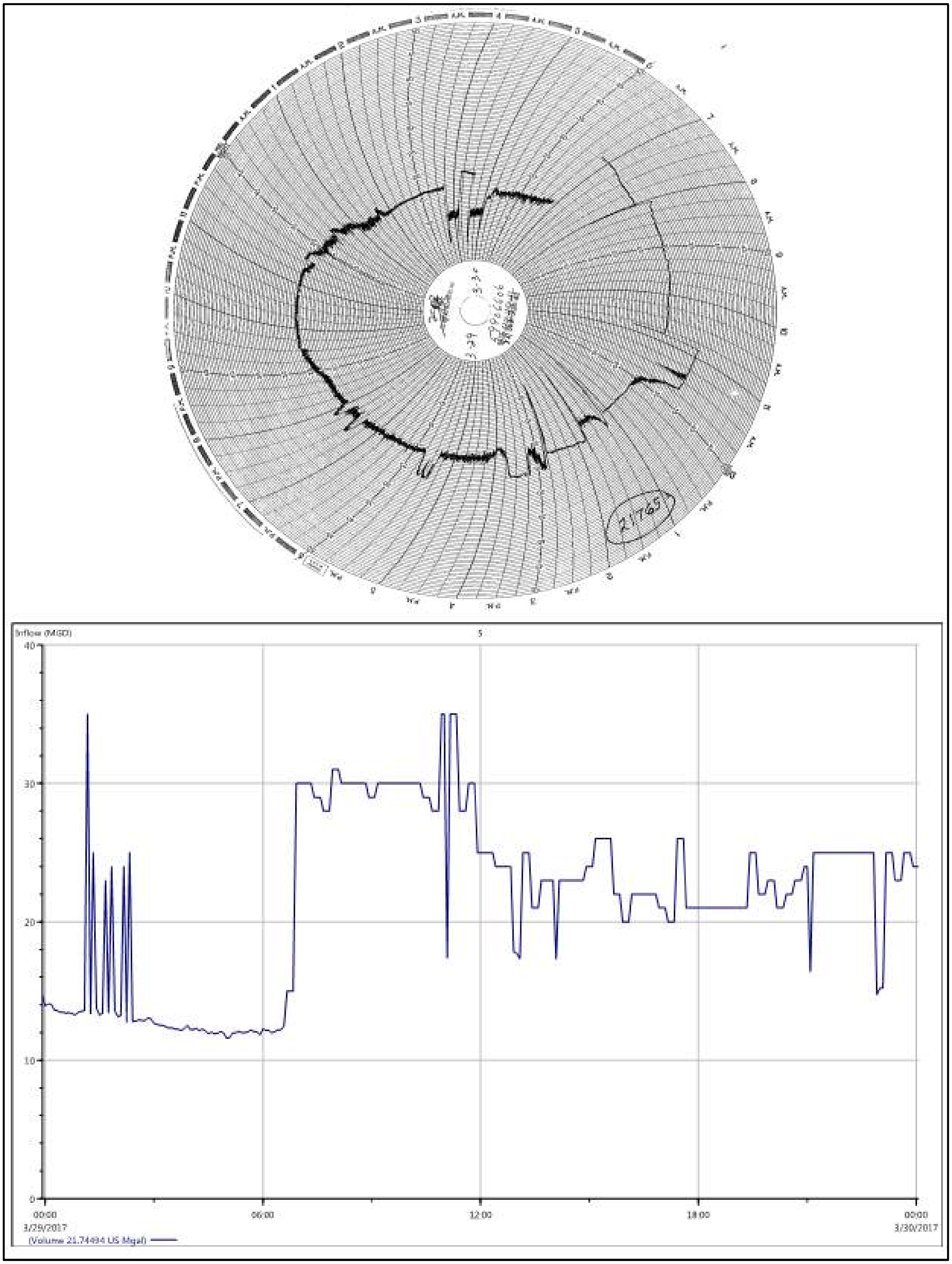


Figure 4-6 Example of Circular Chart Data and Digitized Time Series for 3/29/17 – 3/30/17

4.2.2 Rainfall Monitoring

4.2.2.1 JMEUC Rain Gauges

The JMEUC has owned and operated a tipping bucket rain gauge at the WWTF since 1991. In 2014, three more tipping bucket rain gauges were installed by ADS to better capture the spatial variation of rainfall over the 65 square mile JMEUC service area. These four gauges are listed in Table 4-2 and their locations can be seen in Figure 4-1 through Figure 4-4. They are maintained by ADS and record precipitation data in 15-minute intervals.

Table 4-2 Rain gauges maintained by ADS within the JMEUC service area

Rain Gauge	Location
RG4	Union Township DPW
RG3	South Orange DPW
RG2	Millburn DPW
RG1	WWTF

4.2.2.2 Regional Gauges

The Liberty International Airport, Newark NJ rain gauge (COOP286026), a National Weather Service (NWS) gauge, is located roughly five miles to the east of the JMEUC service area. Precipitation data with different intervals are available at this gauge including high quality daily data, quality controlled hourly data, and raw 1-minute data.

A USGS gauge at Canoe Brook (CHMN4) records precipitation data in 15-minute intervals. Limited quality control is provided at this gauge.

Three other Citizen Weather Observer Program (CWOP) gauges were also found in and around the JMEUC service area. They are West Orange (EW1297), Roselle Park (EW6780), and Kenilworth (EW5816). The precipitation data at these gauges were recorded at different intervals ranging from 5-minute to 15-minute. Quality control of these datasets is limited.

The locations of all the above rain gauges can be seen in They provide good coverage of the JMEUC service area. Three JMEUC rain gauges (RG2, RG3, and RG4) were used for model calibration and validation. Rain gauges were assigned to modeled subcatchments based on proximity. Tabular time series rainfall data captured by these rain gauges during the data collection period is included in Appendix D. The five regional gauges and JMEUC RG1 were used for quality control of the three gauges used in calibration through identifying data gap, spatial variability, and outliers of each recorded event.

4.2.3 Selection of Calibration Validation Events

Extensive review of rainfall data collected at the four JMEUC rain gauges during October 1, 2015 to June 1, 2017 was conducted to select events for model calibration and validation. First, monthly cumulative rainfall from all nine gauges were compared to identify data gaps and abnormalities (see details in August 2017 Presentation in Appendix I).   Then a list of storms (total volume > 0.3”) were identified for each JMEUC gauge using 6-hour inter-event time to distinguish individual events. A total of 72 events during the 20-month period were identified. Finally, the following criteria were applied to help select individual events for calibration and validation.

- Avoid winter season (December - February) due to potential snowpack/snowmelt effects;
- Avoid events with significant spatial variability;
- Prefer events with significant hydrological responses at all or most flow meters;
- Prefer periods with good data capture at the JMEUC rain gauges and flow monitors; and
- Prefer events in different seasons with a wide variety of rainfall duration and intensity.

Table 4-3 lists the events chosen for calibration and validation in chronological order.

Table 4-3 Calibration and Validation Event Summary

Start Date	Duration [1] (hours)	Peak Intensity[1] (in/hr)	Rainfall Depth[1] (in)	Average Return Interval[2] (ARI)	Event Used For
10/28/15	19 – 25	0.72 – 0.96	1.79 – 2.01	1-month to 3-month	Calibration
7/25/16	2.5 – 6.75	2.00 – 3.12	1.13 – 1.28	~ 2-year	Calibration
11/15/16	7 – 7.25	0.60 – 0.84	1.41 – 1.49	3-month to 1-year	Calibration
11/29/16	12 – 12.25	0.60 – 0.80	2.00 – 2.26	6-month to 1-year	Calibration
11/30/16	17.75 – 23	0.40 – 0.72	1.05 – 1.4	> 1-month	Calibration
03/31/17	27 – 29.5	0.28 – 0.32	1.84 – 2.08	6-month for 24-hour duration	Validation[3]
4/4/2017	11 -15.25	0.6 – 0.68	1.04 -1.07	3-month to 6-month	Validation[4]
05/05/17	8.75 – 9	0.76 – 1.08	1.62 – 1.89	6-month to 1-year	Validation

[1]Range of values recorded at rain gauges RG2, RG3, and RG4

[2]Average return interval was identified based on long term rainfall statistics at Newark International Airport (COOP286026)

[3]RG4 data was questionable and was substituted with RG1 data

[4]RG4 data was questionable and was substituted with RG2 data

The above selection process was discussed with NJDEP during the quarterly update meeting on August 1, 2017 and was documented in the presentation prepared for this meeting (see Appendix I).

4.3 Sewer System Modeling

The Preliminary Model of the JMEUC trunk sewer system includes the Original and Supplementary Trunk Sewers, the twin barrel trunk sewer immediately upstream of the WWTF, and 35 subcatchments covering the entire JMEUC service area, except for the City of Elizabeth. The flows from the City of Elizabeth were represented by two inflow time series, with one representing inflow from the TAPS and the other representing inflow from the Elmora area. The downstream boundary of the Preliminary Model hydraulic network was the headworks of the WWTF, with a constant head used to represent the water level during normal operational condition.

The Preliminary Model was used as the basis for the Baseline JMEUC Model, as noted above. Model updates and refinements, along with the calibration and validation modeling approach and results are documented in this section. These details can also be found in the presentations of quarterly NJDEP status update meetings (Appendix I).

The Baseline Model is in InfoWorks® ICM 8.5 software with vertical datum of NAVD88 and coordinate system of NAD 1983 New Jersey state plane coordinate system (US feet).

4.3.1 Model Extent and Refinement

4.3.1.1 Hydraulic Network and Refinement

The modeled trunk sewer network in the Preliminary Model was largely developed using the JMEUC's GIS data and these sewer network data were migrated into the Baseline JMEUC Model. Record drawings and field investigations were used to supplement and resolve any questionable GIS data. The model does not include the sewer networks of communities upstream of the trunk sewers, but does include the sewersheds for these sewer service areas. Where an upstream flow meter is located immediately upstream from the trunk sewer, a "dummy" pipe was included in the Preliminary Model to facilitate calibration of the model at this meter. Under the current modeling effort, critical areas/structures of the trunk sewer system were refined, and the individual elements of the JMEUC WWTF treatment train were added to the model.

Critical structures reviewed included key junctions, cross connections, depressed pipes at stream crossings, and venturi meters. Based on record drawings and metered hydraulics, refinements were made to the following modeled trunk sewer elements:

- Union Avenue Junction Chamber (Junction J14) and venturi meter
  - Updated to the inverts of incoming and outgoing pipes at the junction chamber
  - Updated to the inverts of the venturi meter
  - Addition of 42" bypass pipe that was not included previously (see Figure 2-13 for record drawing)
  - Applied high head loss curve at the venturi meter to simulate energy losses associated with an inverted siphon
- Kean University Junction Chamber (Cross Connection CC18 upstream of meter JM05 and JM05A)
  - Updated cross connection upstream invert based on record drawings
  - Added sluice gate (not included in Baseline Model) to represent a gate installed in 2007 which controls flow entering the Original Trunk Sewer
- Monmouth Road Venturi Meter (upstream of meter JM05)
  - Applied high head loss curve at the venturi meter to simulate energy losses associated with an inverted siphon
- Depressed pipe sections crossing Elizabeth River, Stiles Creek, and Vauxhall Road
  - Added high head loss curve at depressed pipes to simulate energy losses associated with turbulence caused by rapidly changing pipe geometries

- Springfield Avenue crossing the trunk sewers
  - Removed 24" cross connection based on field verification
- Maple Place in Irvington where Elizabeth River crossing the Garden State Parkway
  - Removed cross connection between the two trunk sewers based on client's input
- Update to the double barrel of the downstream section of the trunk sewers
  - Removal of previously modeled cross connections not physically present between the North Barrel and South Barrel of the twin barrel trunk sewer immediately upstream of JMS1 and JMS1A

In addition to refinements to critical hydraulic structures, the WWTF preliminary and primary (including primary effluent pumping) treatment trains were also added to the downstream end of the model. Specific additions included fine and coarse screens, four grit chambers and an influent flume, four primary settling tanks, and a primary effluent chamber and pump. These processes were modeled using a variety of hydraulic structures including weirs, pumps, gates, screens, and storage units. Control rules were added to simulate WWF operations. The downstream boundary of the model is a fixed water surface elevation which was set equal to normal water level in the aeration tanks which are located immediately downstream of the primary effluent pumps.

To create an accurate representation of plant hydraulics, plant record drawings, the WWTF Standard Operating Procedure for Storm Flow Operation, and the 2007 LTCP were referenced. The inclusion of the WWTF treatment processes in the Baseline Model will provide significantly better support of CSO control alternatives evaluations related to plant capacity and potential increases in WWF delivered to the plant. The plant hydraulics were calibrated based on historic hydraulic grade line (HGL) profiles and input from WWTF operators (See Section 4.3.2.3 for details).

4.3.1.2 Subcatchments and Refinement

Modeled subcatchments representing separate sanitary sewer areas were refined through re-delineation of sewershed boundaries to exclude any significant unsewered areas such as golf courses, parks, streams, etc. This enables an accurate estimate of the sewered area of each subcatchment, which is important when determining the magnitude of RDII in a separate sanitary sewer system. The Preliminary Model, municipality boundary maps, municipality sewer maps, and GIS orthophoto background layer were used as sources for the update. This process increased the number of subcatchments from 35 in the Preliminary Model to 38 in the Baseline JMEUC Model.

The resolution of the subcatchments generally corresponds to that of the flow meters. For example, for the upstream meter JM24, one subcatchment was delineated which represents sewered area in Summit, New Providence, and Berkeley Heights which contribute flow to meter JM24. Within the Baseline Model, there are thirteen subcatchments representing the sewered areas of thirteen upstream meters. Because they are located far upstream of the JMEUC trunk sewer, sewershed areas for meters JM31, JM19, and JM20 were not explicitly modeled, rather their contributing areas were incorporated into the next respective downstream meter subcatchment.

For meters located on the trunk sewers, subcatchments were delineated to represent the incremental areas between two adjacent meters. For example, Subcatchment 28 encompasses the area between meter JM29 and JM28 which contributes flow to meter JM28. There are twenty-five subcatchments representing the incremental areas of sixteen flow meters. The contributing area (Township of Union) to meter JM05 and JM5A was broken down into nine subcatchments in the model due to the large geographic area and multiple connection points along the trunk sewers. Both meter JM9A and JM17 had two subcatchments associated with each meter due to specific system configuration.

Other than the separate sanitary sewer areas, one subcatchment was developed to represent the combined sewer area of Elmora in the City of Elizabeth which drains directly to the JMEUC trunk sewers (mostly into the Original Trunk Sewer). GIS of the City of Elizabeth's sewer system was used to delineate this simplified catchment which aggregated multiple smaller areas. The subcatchment representing the drainage contribution from DOT catch basins along Bayway was delineated using drawings from JMEUC's field investigations. Flows from these two subcatchments contribute flow to both JMS1 and JMS1A flow meters because the two trunk sewers flow to Junction J16 at Bayway Avenue and Pulaski St. At this junction, the two trunk sewers transition to a twin barrel trunk sewer which extends to the WWTF. Meters JMS1 and JMS1A are located in the North and South Barrel, downstream of this junction. The combined flow entering the North Barrel of the twin barrel trunk sewer through the TAPS was not explicitly modeled as a subcatchment, rather an inflow time series which discharges to a point directly upstream of meter JMS1 (See Section 4.2.1).

Table 4-4 provides a summary of the 38 modeled subcatchments and Figure 4-7 shows their locations.

Table 4-4 Summary of Modeled Subcatchments

Subcatchment	System Type	Associated Flow Meter(s) [1]	Population	Contributing Area (Acres)
Elmora	Combined	JMS1, JMS1A	9250	351
DOT	Combined	JMS1, JMS1A	0	12
05A	Separate	JM5, JM5A	1942	208
05C	Separate	JM5, JM5A	5299	503
05D	Separate	JM5, JM5A	2675	180
05E	Separate	JM5, JM5A	7939	1016
05H	Separate	JM5, JM5A	9050	724
05I	Separate	JM5, JM5A	17,277	1664
05J	Separate	JM5, JM5A	2839	342
05K	Separate	JM5, JM5A	6090	474
05L	Separate	JM5, JM5A	760	33
17	Separate	JM17	10,751	285
17E	Separate	JM17	3651	184
4	Separate	JM04	11,735	746
6	Separate	JM06	18,515	1294
10	Separate	JM10	5214	192
12	Separate	JM12	2474	79
13	Separate	JM13	6657	218
14	Separate	JM14	10,590	348
15	Separate	JM15	1827	161
16	Separate	JM16	2714	79
18	Separate	JM18	22,194	467
21	Separate	JM21	8065	505
22	Separate	JM22	3815	228
24	Separate	JM24	31,978	5702
25	Separate	JM25	6060	526
26/31	Separate	JM26	5216	635
27	Separate	JM27	6614	517
28	Separate	JM28	7816	1152
29	Separate	JM29	35,489	5029
32C	Separate	JM32C, JM32E	6379	1308
32D	Separate	JM32D	7032	2002
32E	Separate	JM32C, JM32E	3911	534
34	Separate	JM34	1900	272
9	Separate	JM9	1901	547
9A	Separate	JM9A	50,479	1247
9A-Up	Separate	JM9A	680	26
30	Separate	JM30	5254	414

[1]Represents the closest downstream flow meter to each subcatchment load point in model. More than one flow meter listed indicates a cross connection or junction present between the flow meter location and the subcatchment load point which distributes flow to the meters listed.

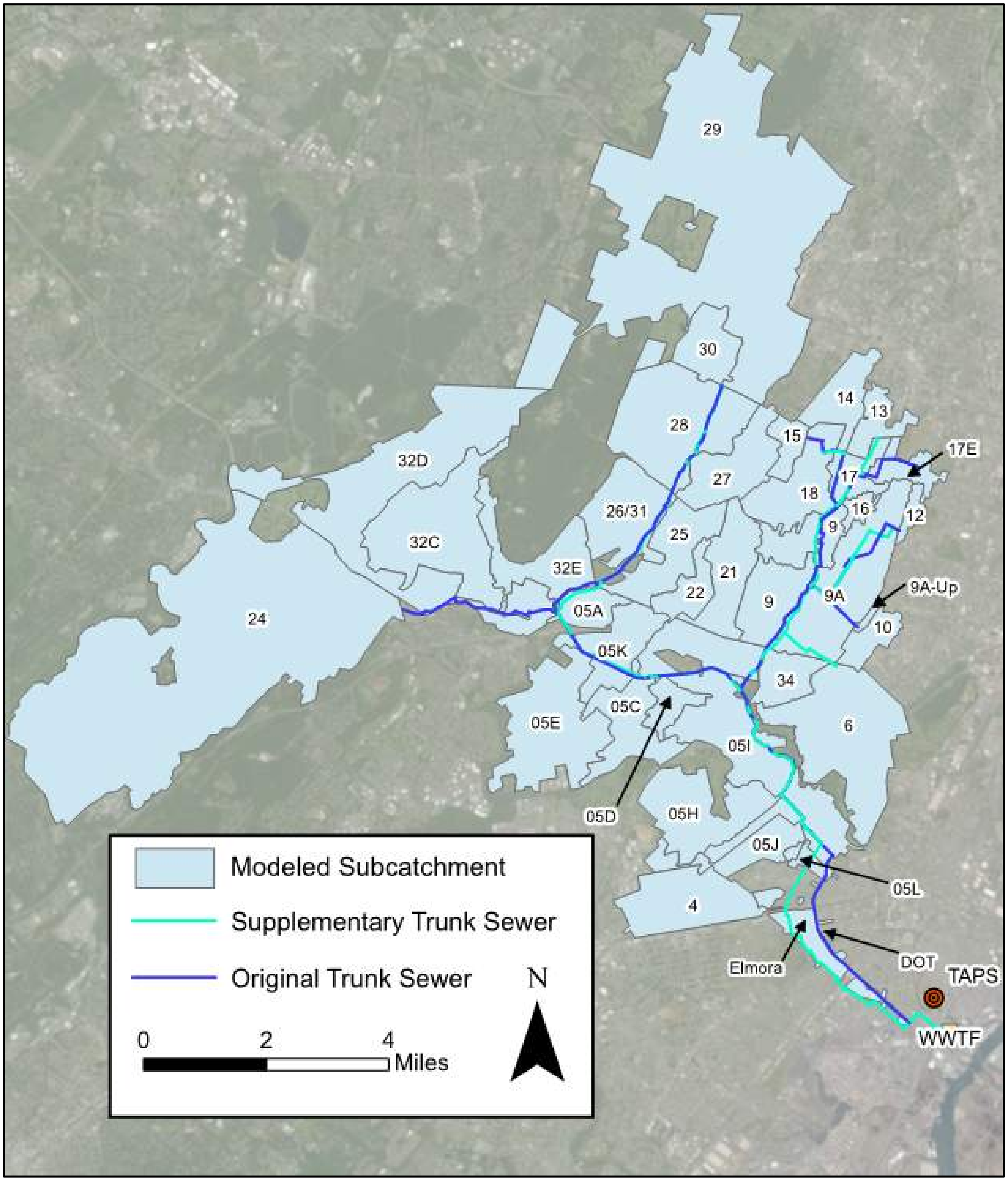


Figure 4-7 Modeled Subcatchments within the JMEUC Service Area

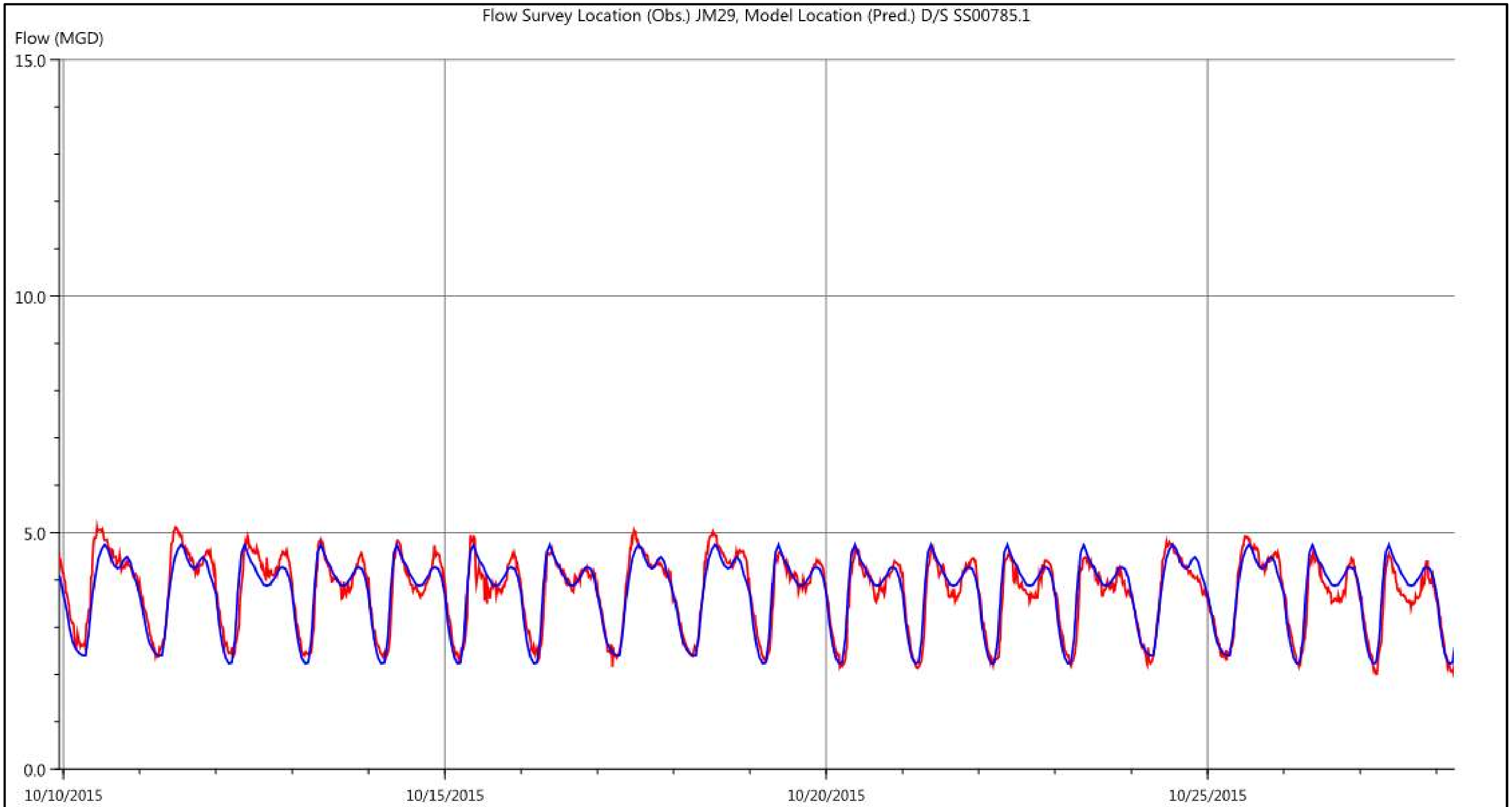
4.3.1.3 Dry Weather Flow Development and Modeling Approach

There are two components in dry weather flow (DWF) in sewers; sanitary flow and base groundwater infiltration (GWI). DWF in the Preliminary Model was updated for the Baseline JMEUC Model using base flow and trade flow in InfoWorks® ICM to model these two components respectively.

Dry periods (at least one week without rain in any summer month June through October) during the calibration period were selected for calibration of DWF. Data from the 29 meters used in calibration were extracted for this dry period and average values of sanitary flow and base GWI (for this period) were disaggregated using the assumption that GWI makes up 80% of the minimum nighttime flows. Average flow from each incremental area between two meters was calculated by subtracting the upstream flow from downstream flow. Continuity was checked to ensure that the calculated incremental flows were larger than zero and of reasonable value.

Once the average incremental sanitary flow for each of the 29 meters were finalized, the unit flow rate (gallons per capita per day) was calculated by using population estimates (American Community Survey 2011-2015 five-year data). The water usage rate and population at each meter was then entered into InfoWorks® ICM to generate the average sanitary flow. Weekday and weekend diurnal patterns were also developed for each meter with a contributing subcatchment and entered into InfoWorks® ICM. An example of the developed DWF using data for meter JM29 is included in Figure 4-8.

Trade flow in InfoWorks® ICM was used to represent base GWI in the model. Data from the entire calibration period along with the disaggregated average base GWI values were used to develop a monthly pattern to represent the seasonal variation in base GWI at each meter. The seasonal patterns and average base GWI values were then incorporated into InfoWorks® ICM and later calibrated to better represent the recorded data at each meter.



	Flow		
	Min (MGD)	Max (MGD)	Volume (US Mgal)
Observed	2.010	5.117	68.533
Simulated>	2.233	4.749	68.440

Figure 4-8 Calibrated DWF at Meter JM29 During Extended Dry Period in October 2015

4.3.1.4 Wet Weather Flow Development and Modeling Approach

The Baseline JMEUC Model includes subcatchments that represent both separate sanitary sewer areas and combined sewer areas; the substantial majority of the subcatchments are separate sanitary sewer areas. Different approaches were used to model the wet weather responses of these different areas.

For subcatchments representing separate sanitary sewer areas, RDII was modeled using RTK methodology. The RTK method is a widely used approach, endorsed by U.S.EPA and applied for sewer modeling purposes for more than 30 years (see Review of Sewer Design Criteria and RDII Prediction Methods; EPA/600/R-08/010; U.S.EPA Office of Research and Development; January 2008). RTK methodology decomposes the observed rainfall response of a separate sanitary sewer area into three distinct unit hydrographs representing fast (inflow), medium (inflow and infiltration), and slow (infiltration) responses.

Each unit hydrograph is defined by three parameters, R, T, and K. R represents the fraction of rainfall entering the collection system; T represents the time to peak; and K represents the ratio of the time of recession to the time to peak. When the three unit hydrographs are summed together, a composite unit hydrograph is generated which represents the overall response to observed rainfall from a separate sanitary sewer area. Figure 4-9 illustrates the RTK methodology.

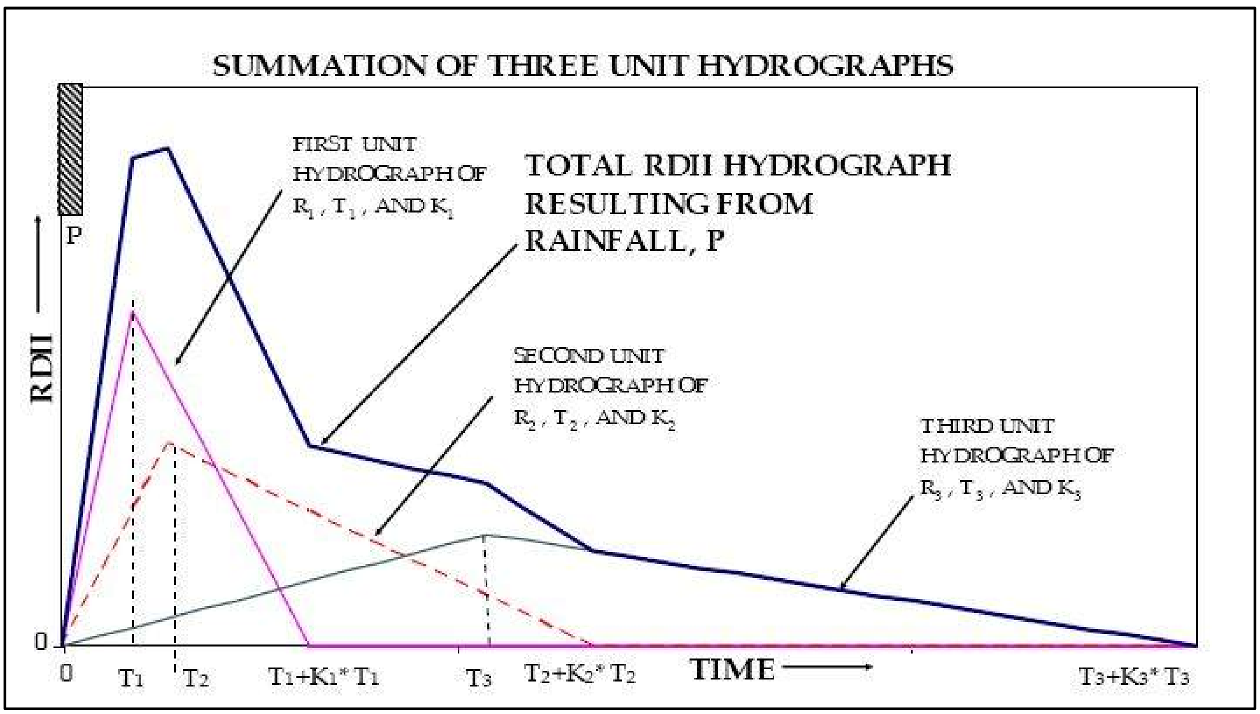


Figure 4-9 RTK Methodology in Graphical Format

The RTK methodology uses initial abstraction (IA) to account for the rainfall threshold that must be exceeded before an RDII response occurs. IA is determined by two parameters commonly used in sewer modeling software; IA depth and IA depth recovery rate. IA depth represents the amount of precipitation that must fall on a separate sanitary sewer area before an RDII response is observed in the system. The IA recovery rate represents how fast the IA depth is recovered after a rainfall event. IA can therefore be thought of as analogous to representing depression storage and evaporation in surface hydrology.

Seasonally-varied RTK capability only became available in InfoWorks® ICM with the release of InfoWorks® ICM Version 8. The constant RTK values for every modeled subcatchment in the Preliminary Model were updated to monthly RTK parameters (including IA) to incorporate observed seasonality of the rainfall response. U.S.EPA's Sanitary Sewer Overflow Analysis and Planning (SSOAP) Toolbox (see Computer Tools for Sanitary Sewer System Capacity Analysis and Planning; EPA/600/R-07/111; U.S.EPA Office of Research and Development; October 2007) was used to analyze metered data during the calibration period and develop initial RTK parameters. These values were later refined through calibration as described in Section 4.3.2.2.

To model the rainfall runoff response of combined sewer areas in the Baseline JMEUC Model, USEPA's SWMM 5 nonlinear reservoir algorithm was used. This algorithm represents a combined sewer area as a nonlinear reservoir where surface runoff rate is a function of water depth in the reservoir, subcatchment/reservoir slope and width, as well as overland surface roughness. The water depth in the reservoir must exceed the depth of depression storage before any surface runoff occurs. Along with surface runoff, outflow from the reservoir can also occur through infiltration and evaporation. For the two subcatchments representing the combined service areas (Elmora area in the City of Elizabeth and DOT drainage along Bayway), subcatchment slope, area, and percent impervious were determined using NJDEP 2012 land use and topographic data. Other model parameters such as subcatchment width, infiltration, and depression storage were left at their default values and later calibrated to reproduce metered flow at JMS1 and JMS1A.

4.3.2 Model Calibration and Validation

As is common practice in sewer system modeling, calibration and validation of the Baseline JMEUC Model focused on DWF parameters first, followed by the various and more complex WWF parameters.

4.3.2.1 Dry Weather Flow Calibration

To account for seasonality in base GWI, the average base GWI value and monthly pattern for each subcatchment were incorporated into the Baseline JMEUC Model as described in Section 4.3.1.3. Initial values were adjusted in an upstream to downstream manner during calibration. Seasonal variation in base GWI was observed to varying degrees at all flow meter locations over the course of the calibration period. Figure 4-10 shows the normalized monthly GWI patterns for all 38 modeled subcatchments.

As expected, Figure 4-10 shows GWI is generally above average in the winter/spring months January through May, and generally below average in the summer/fall months July through November, with transitional periods (near average) in June and December. This figure also shows base GWI is typically at its highest in March and lowest in August and September, with the range of variability in normalized GWI extending as high as almost twice the average and as low as about one-fifth of average. Subcatchment 27, representing a portion of South Orange, showed the highest normalized GWI variability (0.19-1.90) while Subcatchment 9A, representing a large portion of

Irvington, showed the lowest GWI variability (0.94-1.04). Figure 4-11 and Figure 4-12 show the simulated base flow and trade flow from these subcatchments over the course of 2016.

Preliminary calibration of depth and velocity under dry weather conditions at downstream flow meters was also completed via adjustments to Manning friction loss and minor loss coefficients to ensure the hydraulic conditions during relatively low flow were well captured in the Baseline JMEUC Model. Depth and velocity calibration was not necessary at upstream flow meters because these meters are not located on the JMEUC trunk sewers and are thus outside the extent of the modeled pipe network.

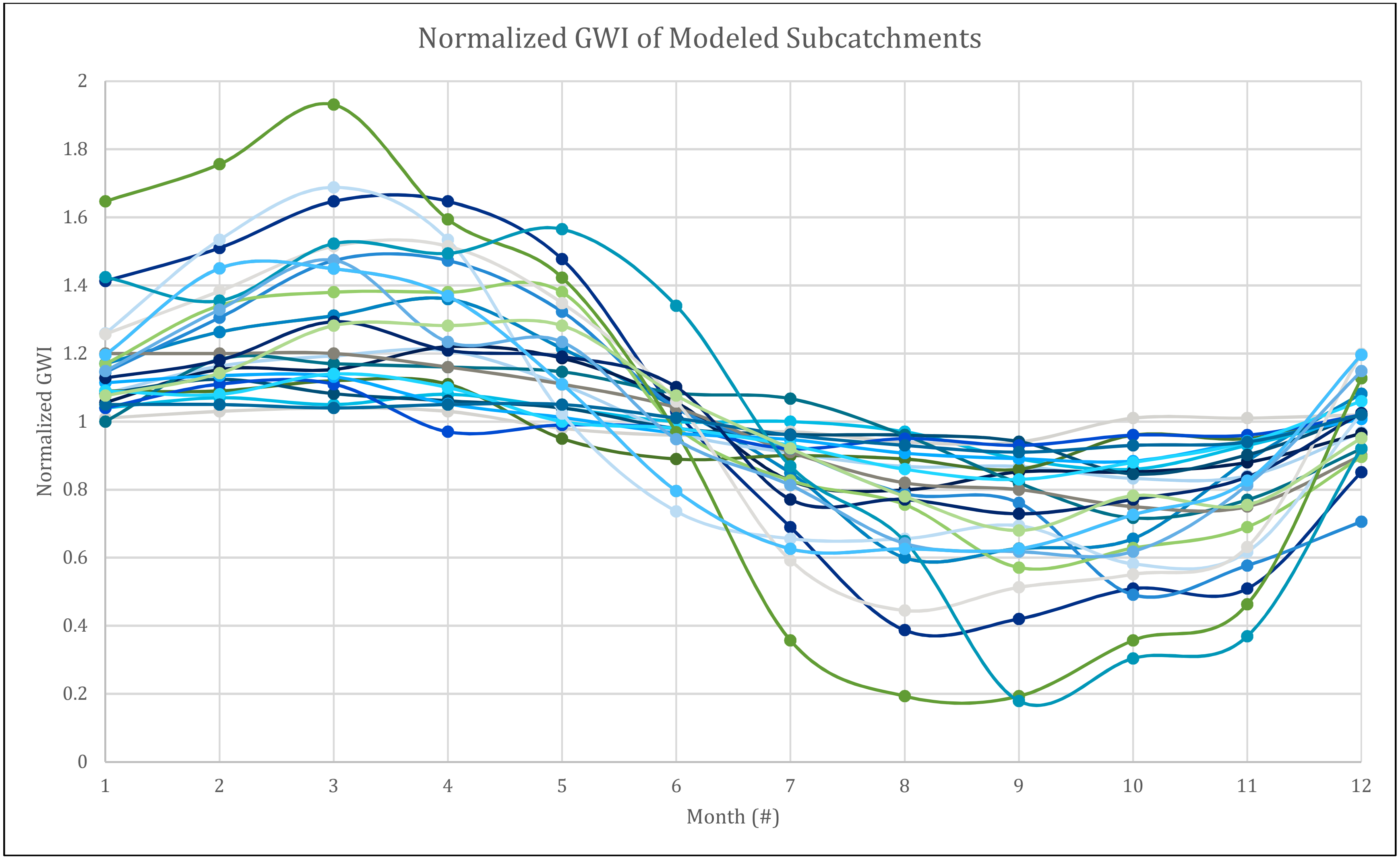


Figure 4-10 Normalized GWI Patterns of Modeled Subcatchments

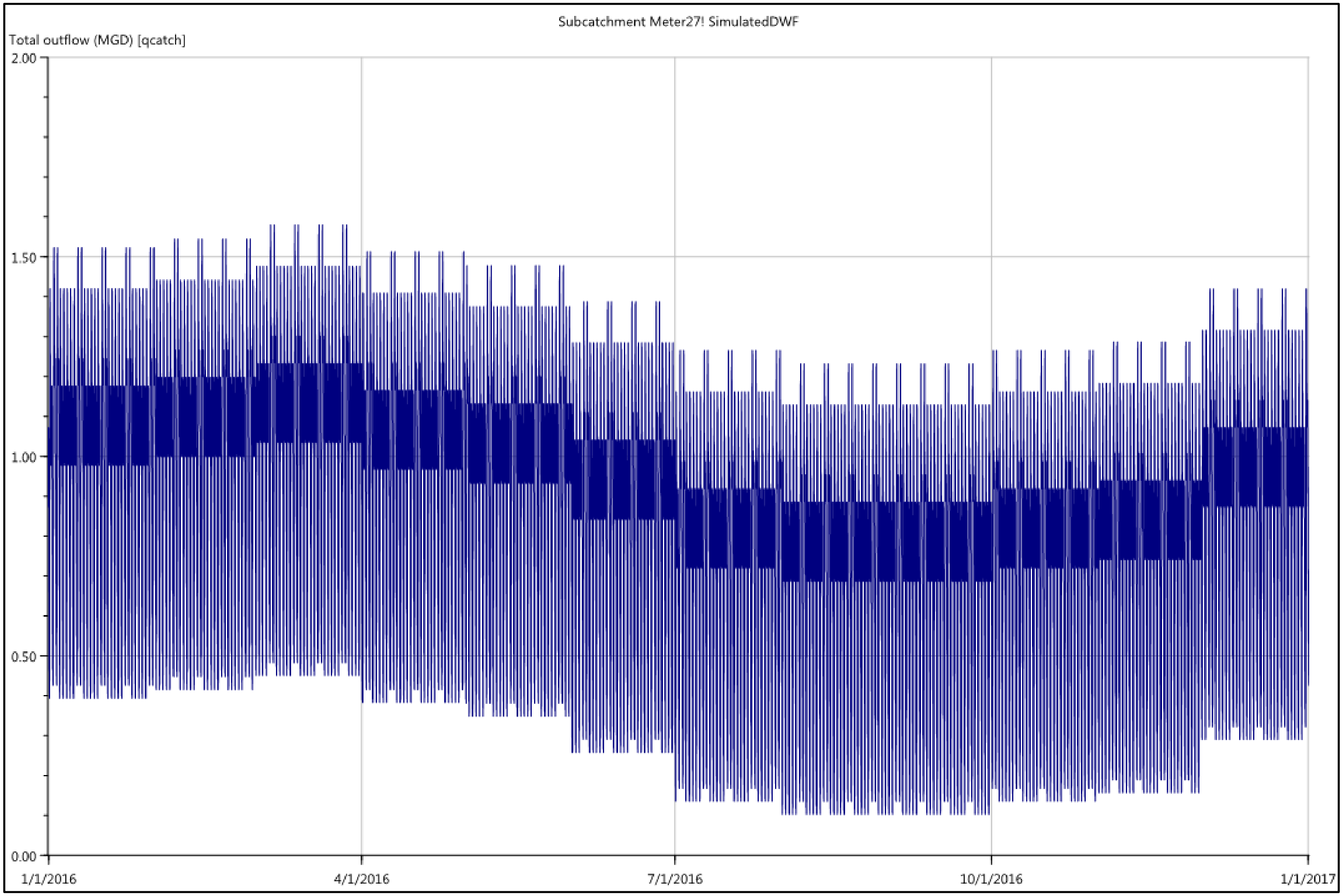


Figure 4-11 Simulated Dry Weather Flow for Subcatchment 27 during 2016 Model Simulation

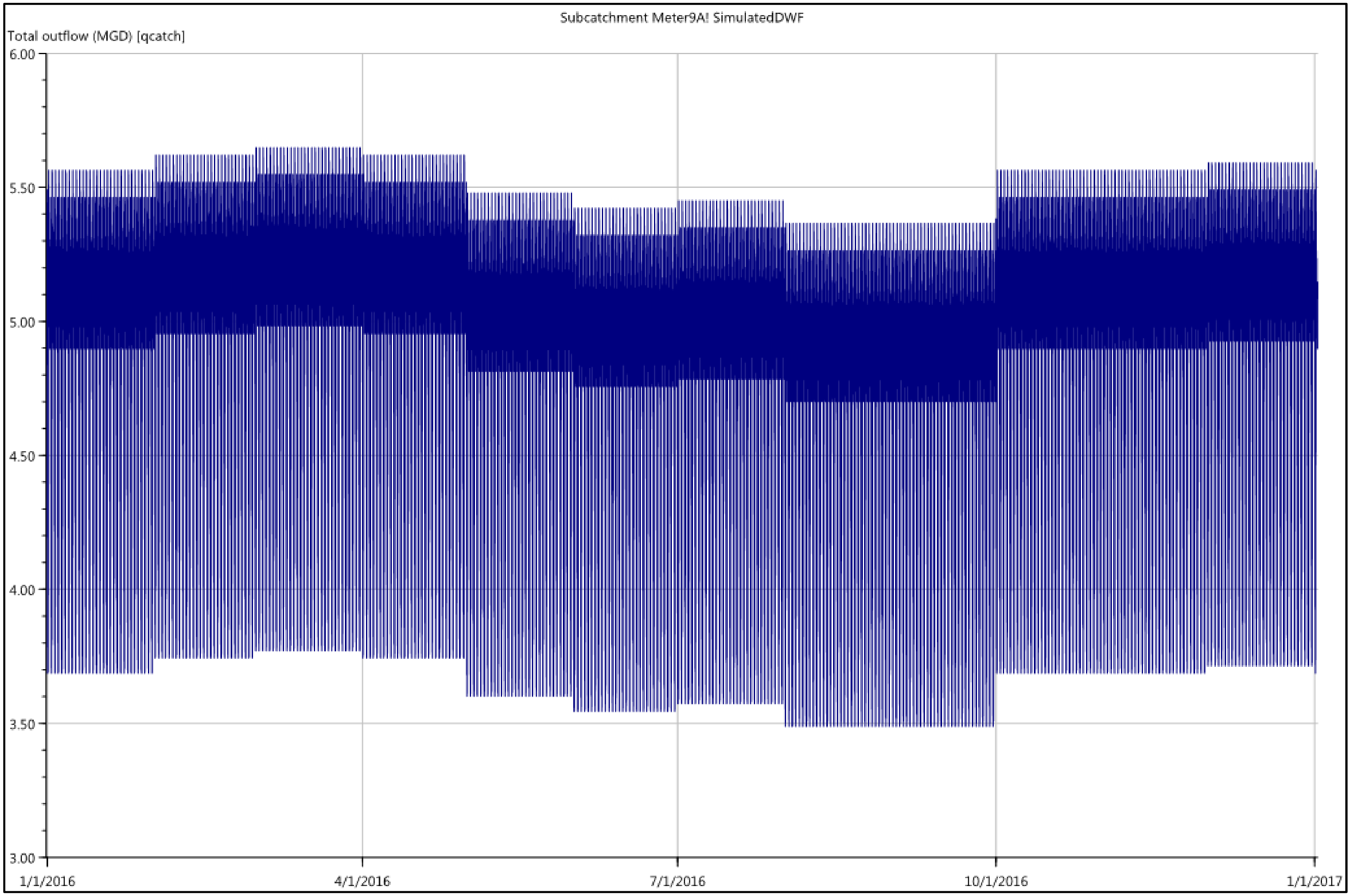


Figure 4-12 Simulated Dry Weather Flow for Subcatchment 9A during 2016 Model Simulation

4.3.2.2 Wet Weather Calibration and Validation

As discussed in Section 4.3.1.4, RTK methodology was used to model RDII for the subcatchments representing separate sewer areas serviced by the JMEUC and initial values for monthly varied RTK and IA parameters were developed using USEPA's SSOAP toolbox. The model was calibrated in an upstream to downstream direction to ensure continuity was satisfied among flow meters. All upstream flow meters (i.e. those not on the Original or Supplementary Trunk Sewers) were calibrated first prior to calibration of downstream meters. The initial RTK and IA parameter values were fine-tuned in an iterative manner to match metered WWF in each season during the calibration period. Care was taken to remove any bias (consistent over or under prediction) in the modeled RDII response of subcatchments over the course of the calibration period. A summary of calibrated RTK and IA parameters for modeled subcatchments is included in Appendix J.

It should be noted that use of larger than typical IA depths in the hydraulic model was required to calibrate the model for spring 2016, an unusually dry period, during which minimal RDII responses were recorded in the system. Correspondingly large R values had to be used to offset the large IA depths in order to calibrate the model during wet seasons such as spring 2017 where significant RDII responses were recorded. This approach enables the hydraulic model to be well calibrated over the entire 18 months of the calibration period, as the use of both large IA depths and large R values provides an excellent representation of the physical system response to wet weather over the wide range of observed meteorological conditions.

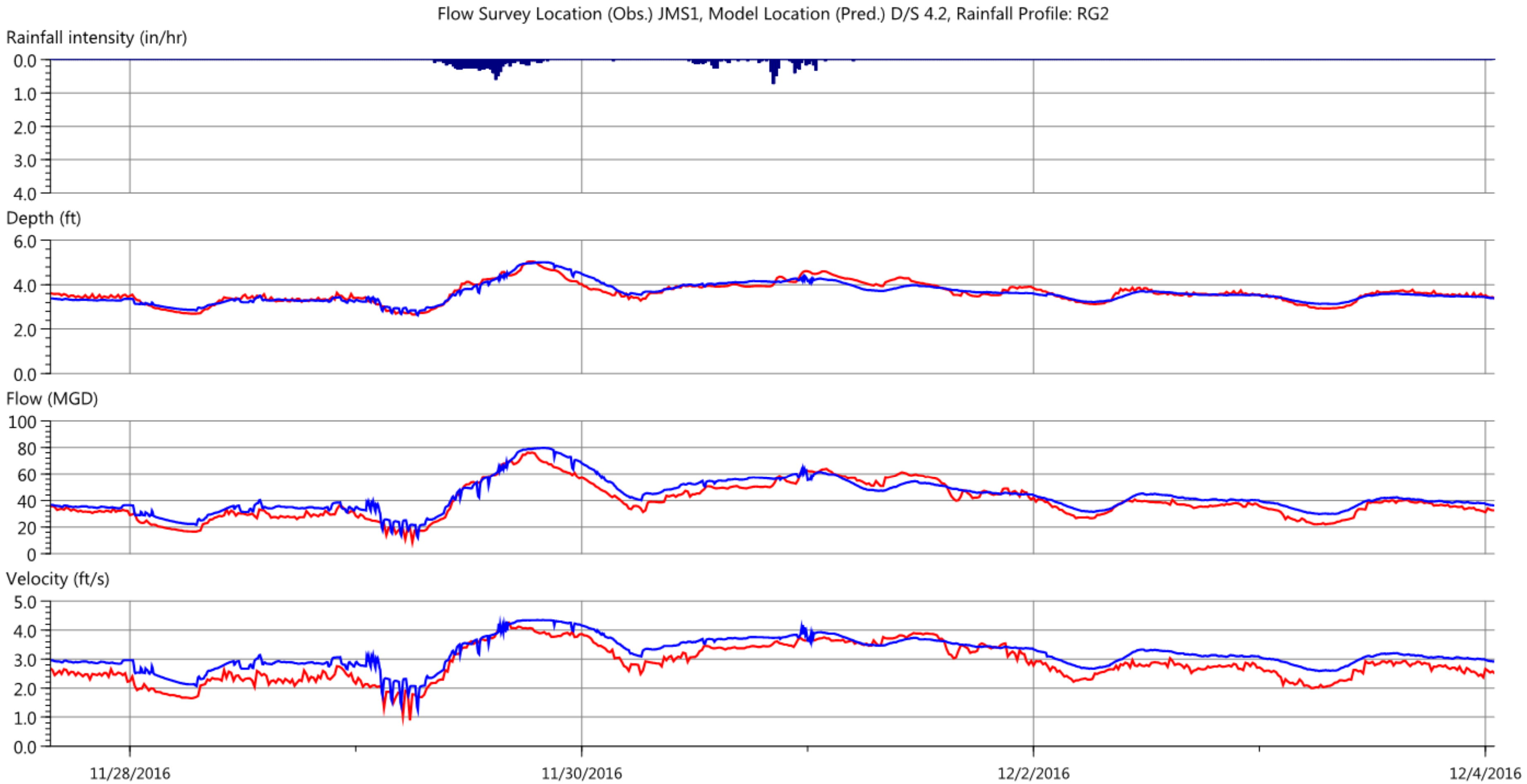
For the Elmora and DOT subcatchments representing combined sewer areas, subcatchment width, infiltration, and depression storage were set at the default values, as flow balance using the metered data showed negligible impact from these areas.

For upstream flow meters, no calibration of system hydraulics was necessary as these flow meters are located at the upstream boundary of the JMEUC trunk sewer network. For downstream meters, hydrologic and hydraulic calibration was conducted in parallel, as cross connections in the immediate vicinity of flow meter locations had a direct impact on simulated flows. Key updates and parameter adjustments during hydraulic calibration for WWF conditions included:

- Refinements to pipe roughness (Manning's n) and minor loss coefficients near flow meter locations,
- Adjustments to the inverts of junctions and cross connections located near meters based on record drawings,
- Addition of custom headloss curves at Flow Meters JM18, JM26, JM32E, JM5A, and JM6 to replicate back water conditions observed during WWF,
- Updates to the Kean University Junction Chamber (Cross Connection CC18) to replicate the gate which splits flow directly upstream of JM5 and JM5A, and
- Removal of previously modeled cross connections not physically present between the North and South Barrels of the twin barrel trunk sewer immediately upstream of JMS1 and JMS1A.

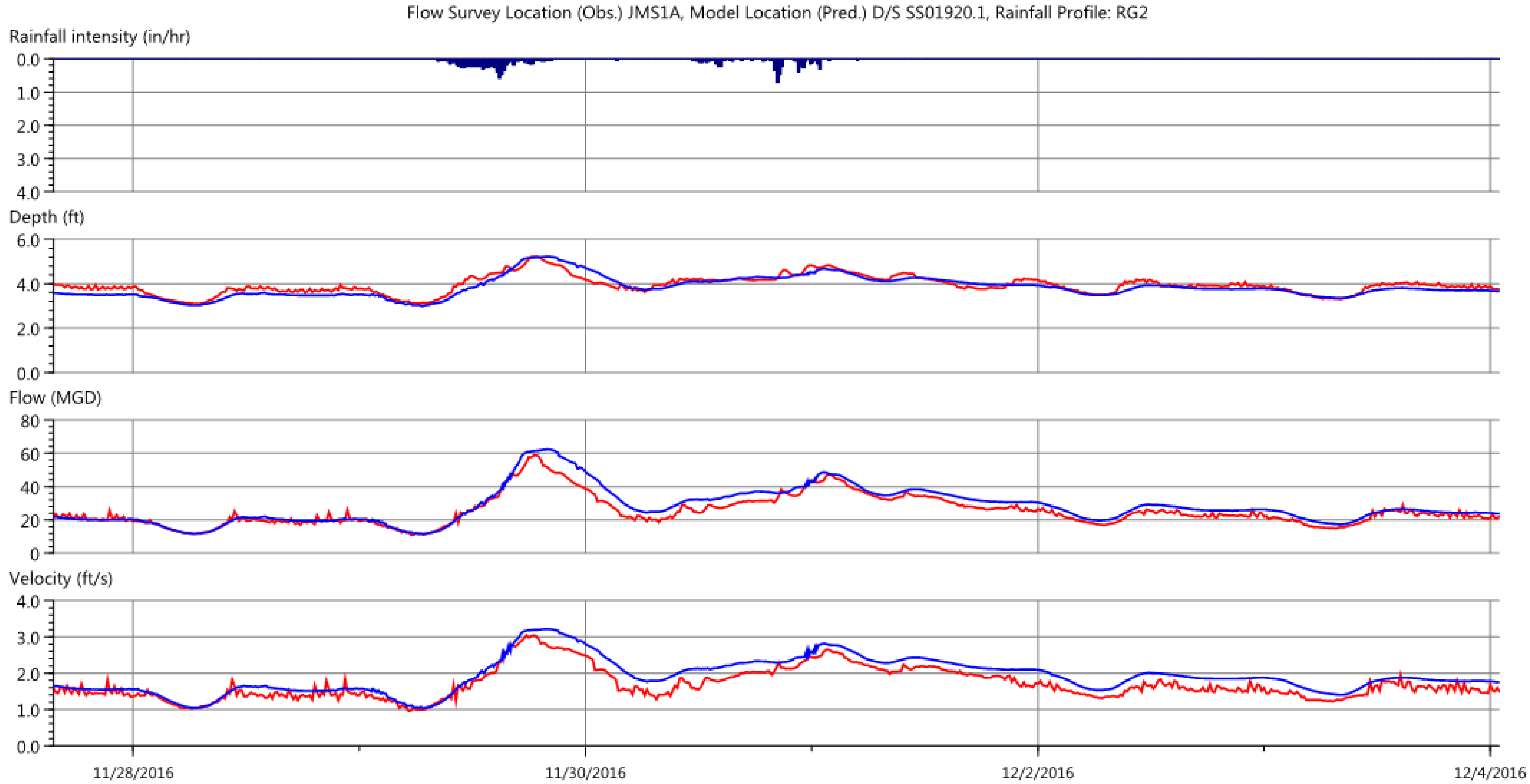
Calibration results are presented in two formats; time series plots of simulated and metered flow, and scatter plots comparing wet weather event volume, peak flow, peak depth, and peak velocity between simulated and metered data. The time series plots depict event-specific agreement of all metrics, including agreement for peak timing and hydrograph shape, while the scatter plots depict overall agreement for the indicated metrics and reveal any prediction bias.

Figure 4-13 and Figure 4-14 show examples of calibration time series plots at JMS1 and JMS1A (directly upstream of the WWTF) for depth, flow, and velocity and Figure 4-15 and Figure 4-16 shows scatter plots at these meter locations for all 72 events identified during the calibration period.



	Rainfall			Depth		Flow			Velocity	
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (ft)	Max (ft)	Min (MGD)	Max (MGD)	Volume (US Mgal)	Min (ft/s)	Max (ft/s)
Rain	3.560	0.720	0.023							
Observed				2.648	5.039	8.786	76.252	252.045	0.890	4.260
Simulated>				2.625	5.010	12.074	79.698	275.419	1.256	4.344

Figure 4-13 Calibration Time Series Plots at Meter JMS1 for the 11/29-30/16 Calibration Event



	Rainfall			Depth		Flow			Velocity	
	Depth (in)	Peak (in/hr)	Average (in/hr)	Min (ft)	Max (ft)	Min (MGD)	Max (MGD)	Volume (US Mgal)	Min (ft/s)	Max (ft/s)
Rain	3.560	0.720	0.023							
Observed				3.101	5.235	10.941	58.866	161.635	0.950	3.050
Simulated>				2.990	5.227	11.337	62.334	178.535	1.021	3.220

Figure 4-14 Calibration Time Series Plots at Meter JMS1A for the 11/29-30/16 Calibration Event

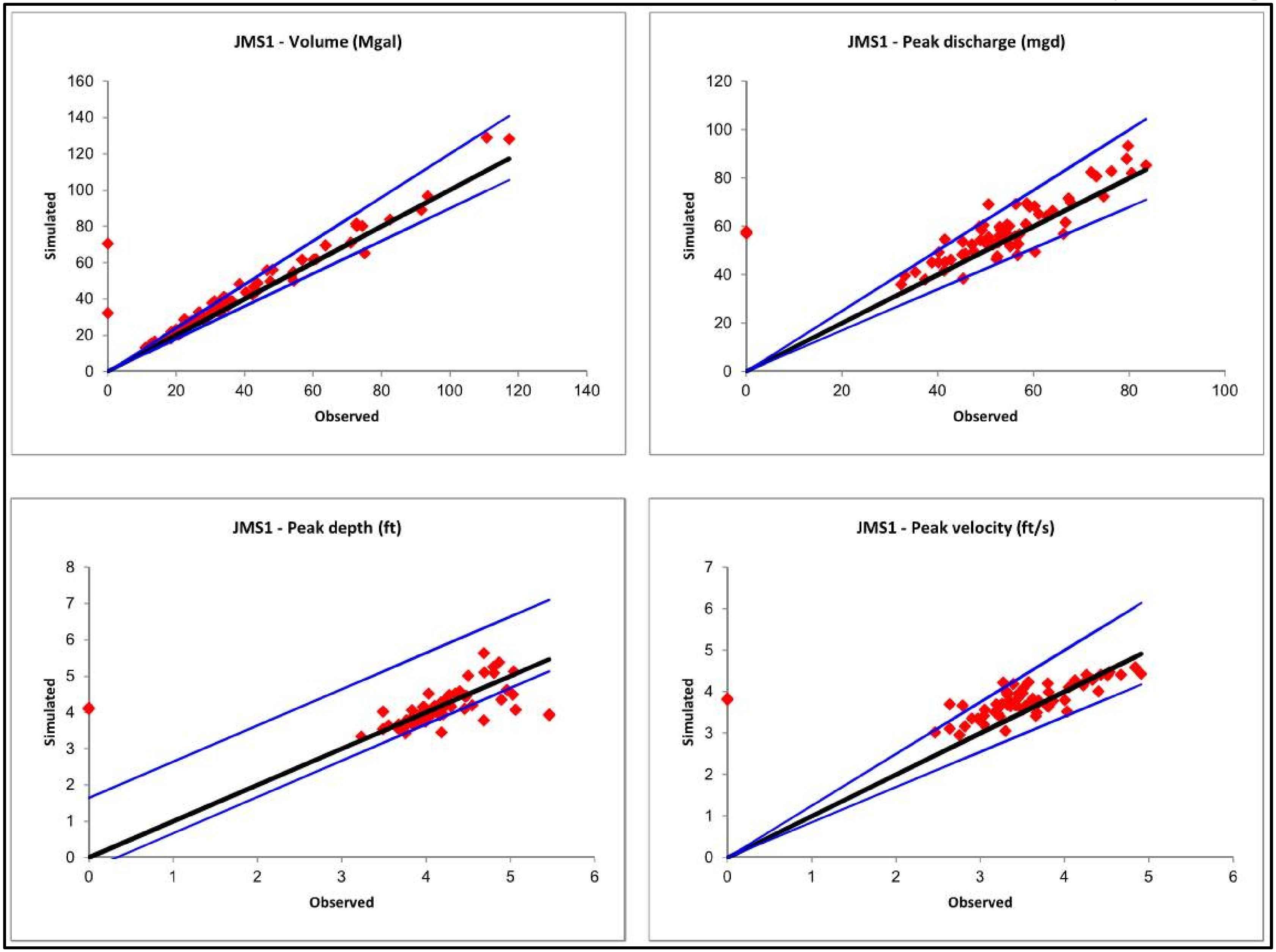


Figure 4-15 Scatter Plots Showing a Comparison of Observed and Simulated Data at Meter JMS1 for the 72 Rainfall Events Identified during the Calibration Period

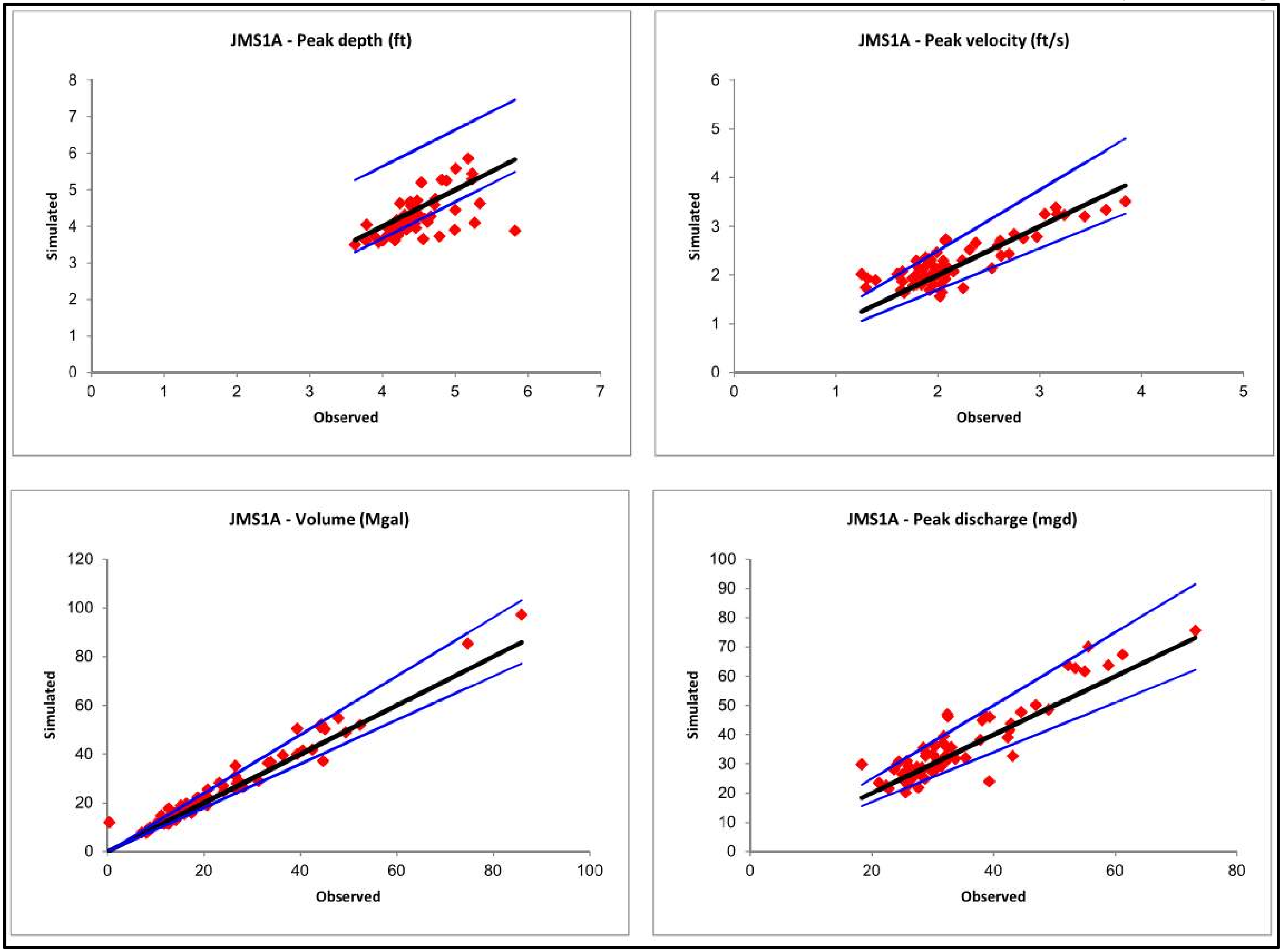


Figure 4-16 Scatter Plots Showing a Comparison of Observed and Simulated Data at Meter JMS1A for the 72 Rainfall Events Identified during the Calibration Period

Time series plots for all calibration and validation events of all meters are included in Appendix G. Scatter plots for all meters are included in Appendix H. As shown in these plots, the model successfully captured the wet weather conditions at all 29 meters.

4.3.2.3 Calibration of Modeled WWTF Processes

Elimination and/or reduction of CSO volumes in the City of Elizabeth may involve an increase in allowable discharge from the TAPS to the JMEUC trunk sewer system. This increase in discharge would lead to an increase in peak flows to be processed at the WWTF. Inclusion of the preliminary and primary treatment processes and pumping to secondary in the Baseline JMEUC Model allows for explicit simulation of plant hydraulics under increased flow rate scenarios. An accurate representation of the current WWTF is necessary to determine the extent of any hydraulic impact resulting from future additional flows.

To create an accurate representation of plant hydraulics, plant record drawings, the WWTF's SOP, and the 2007 LTCP were referenced. A hydraulic profile showing design normal and high water levels through the WWTF was available to calibrate the hydraulic model elements representing the WWTF. Observed headloss through the coarse and fine screens (0.2 feet during DWF) was also known, and input from WWTF personnel was used to confirm model results. Modeled headloss through the screens was calibrated by adjusting the effective width of the screens in the model. The model was able closely predict both normal and high water levels through preliminary and primary treatment, with no adjustments necessary to any of the geometries of the WWTF's modeled elements. Table 4-5 shows simulated water levels through the WWTF compared to the water levels either indicated on the hydraulic profile or identified by WWTF personnel.

Table 4-5 WWTF Calibration Summary [1]

Location	Normal Water Level (ft)[2]		High Water Level (ft)[3]	
	Calibration Values	Model Results	Calibration Values	Model Results
Headworks[4]	4.44	4.49	5.09	5.53
Grit Chamber[4]	4.33	4.25	4.77	4.71
PST[4]	4.15	4.13	4.38	4.28
Wet Well[5]	0.47	0.39	2.29	1.82

[1]Vertical datum = NAVD88

[2]Water level during DWF

[3]High water levels indicated on hydraulic profile were not associated with a specific WWTF inflow. Simulated water levels are from 11/29/16 (6-month to 1-year return period) storm

[4]Calibration Values from hydraulic profile

[5]Calibration Values from WWTF personnel. The normal water level is the control level of the wet well (assumed to be maintained during DWF) and the high water level is the water level when additional pumps are turned on in the wet well to maintain the level during wet weather.

The WWTF SOP and input from WWTF personnel were used as a basis for control rule implementation in the model. Control rules added to the model were reviewed by WWTF personnel to ensure the rules accurately simulated WWTF operations during WWF.

Calibration results indicate that the model is able to accurately replicate the current hydraulics of the WWTF. As CSO reduction alternatives are further explored and more calibration data for wet weather conditions at the WWTF becomes available, additional refinements to the modeled WWTF processes may be possible and will be explored as needed.

4.3.3 Baseline Merged Model

After model refinement and calibration and validation were completed for both the Baseline JMEUC Model and the City of Elizabeth's combined sewer system model, the two models were "merged" together to create a connected, standalone model of the entire JMEUC service area (the Baseline Merged Model) through the following steps. First, the City of Elizabeth model was imported into the Baseline JMEUC Model. Overlapping and duplicate model elements were checked for and redundant elements were removed when necessary. Following this, the discharge from the TAPS from the City of Elizabeth model was connected to the North Barrel of the twin barrel trunk sewer in the Baseline JMEUC Model. The finalized hydraulic network of the Baseline Merged Model is shown in Figure 4-17.

Figure 4-17 Hydraulic Network of the Baseline Merged Model

The City of Elizabeth model included a downstream portion of the Original Trunk Sewer and twin barrel trunk sewer just upstream of the WWTF. The City of Elizabeth model also included three small (12 acres or less) subcatchments representing combined areas within the City of Elizabeth which drained to the Original Trunk Sewer. The duplicate pipes from the City of Elizabeth model were removed from the Baseline Merged Model, while the three small catchments were connected to the Original Trunk Sewer in the Baseline Merged Model following field verification of their connectivity to the system. The additional flow generated from these modeled subcatchments was determined to be insignificant relative to the incoming flow from upstream communities and had negligible impact on model calibration results at surrounding flow meters locations.

To connect the TAPS to the North Barrel of the twin barrel trunk sewer in the Baseline Merged Model, the downstream invert of the force main in the City of Elizabeth model was adjusted (from

2.48' to 2.07') to match the invert of the connection point found in the Baseline JMEUC Model. This adjustment had negligible impact on the TAPS performance and simulated discharge from the TAPS remained capped at 36 mgd.

After the model merge was complete, quality control (QC) was performed by comparing the simulated calibration and validation events (Table 4-3) between the Baseline JMEUC Model and Baseline Merged Model. The main difference between the two models is that TAPS effluent flow changes from an hourly inflow time series interpreted from circular charts to being dynamically simulated in the City of Elizabeth's portion of the model. This only resulted in differences in the very downstream portions of the JMEUC trunk sewer system, i.e. at meter locations JMS1 and JMS1A directly downstream of the TAPS. Figure 4-18 shows simulated flow values for the 3/31/2017 and 4/4/2017 validation events for the Baseline JMEUC Model and Baseline Merged Model at meter locations JMS1 and JMS1A, along with observed flow data at these locations during this time period. The changes in the Baseline Merged Model generally improved the calibration agreement at these two meters versus the previous agreement with the Baseline JMEUC Model. Other calibration and validation events at these locations showed similar improvements.

The Baseline Merged Model has been used to support system characterization for both the JMEUC trunk sewer system and the City of Elizabeth's combined sewer system (detailed in Section 7), and will be used for alternative development in the forthcoming phase of the LTCP.

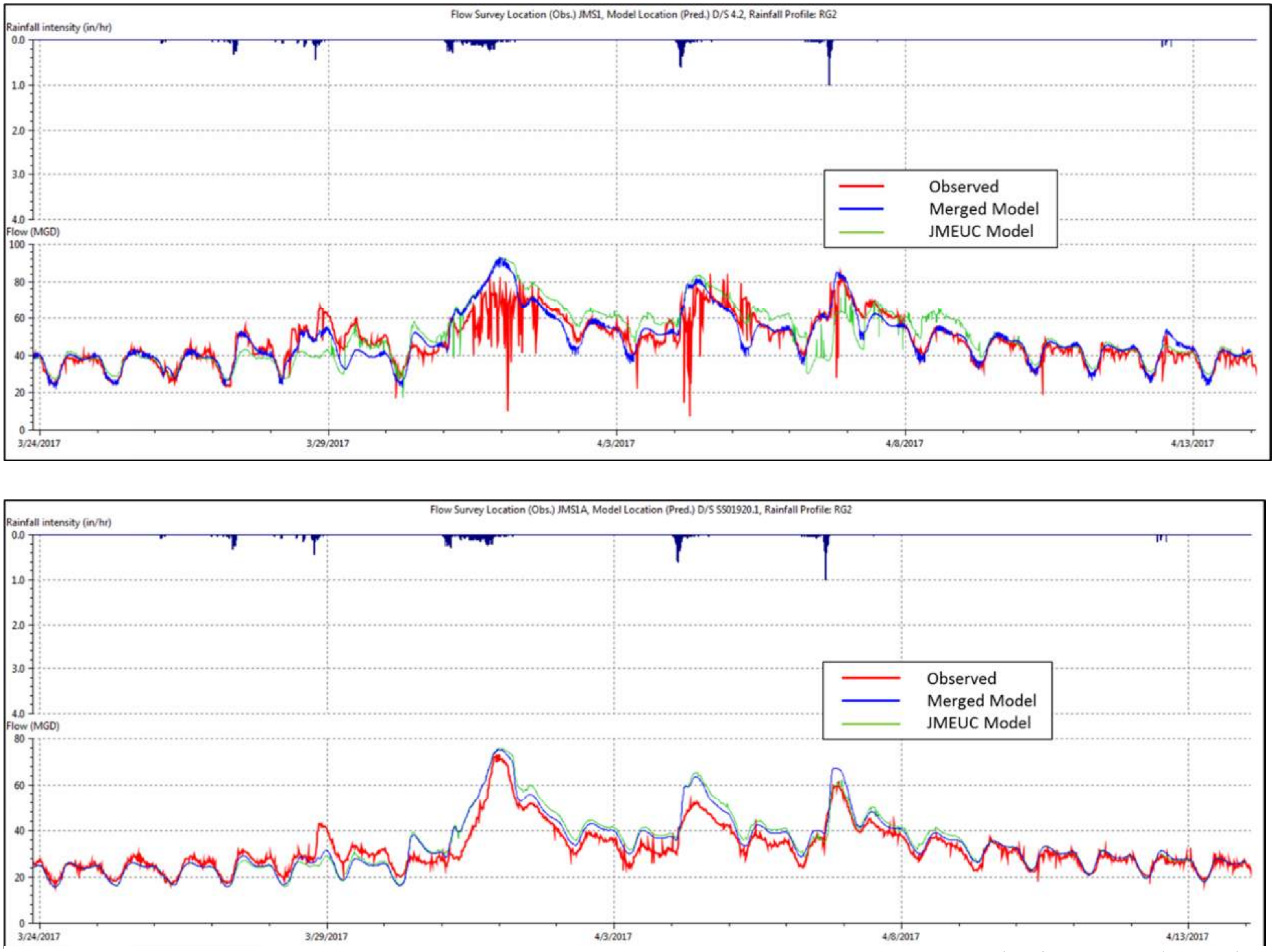


Figure 4-18 Comparison of Simulated Flow from Baseline JMEUC Model and Baseline Merged Model at JMS1 (Top) and JMS1A (Bottom)

Section 5

Receiving Waterbody Monitoring and Modeling

The JMEUC and the City of Elizabeth are both members of the NJ CSO Group. PVSC is conducting extensive receiving waterbody investigations on behalf of the Group, in support of the October 2015 Combined Sewer Management permits issued to each of the Group's members. The reader is directed to the PVSC Baseline Compliance Monitoring Report (June 2018) for additional information.

Section 6

Rainfall Analysis and Typical Annual Hydrologic Record

There has been extensive investigation of long term hydrologic data performed by PVSC as part of their current efforts under the October 2015 Combined Sewer Management permit issued to them by NJDEP. This investigation has been conducted for the purpose of selecting a typical year precipitation record for use in their CSO LTCP development process and is documented in the Typical Hydrologic Year Report (May 2, 2018) submitted by PVSC to NJDEP and subsequently approved by NJDEP in their May 31, 2018 approval letter (see Appendix N for the Typical Hydrologic Year Report from PVSC and the NJDEP Approval Letter).

As noted earlier in this report, the JMEUC and the City of Elizabeth are both members of the NJ CSO Group. PVSC has shared with the Group their information on the typical year rainfall analysis, recognizing that individual members of the Group would likely want to coordinate on the use of a common typical year precipitation record for purposes of their individual CSO LTCPs. There is also a need for the Group to coordinate on a common typical year for generating land-side loads from CSOs and plant effluent discharges for the water quality modeling of the CSO receiving waterbodies being performed by the PVSC team on behalf of the Group.

After the extensive investigation by PVSC, their report recommends use of the calendar year 2004 as the typical hydrologic year, specifically use of the unadjusted hourly precipitation record at the Liberty International Airport, Newark, NJ for this annual period. The JMEUC and the City of Elizabeth both reviewed the report, certified their approval of the report, and thereby accepted the selected typical year as proposed by PVSC on behalf of the NJ CSO Group members for use in the LTCP development process.

The reader is directed to the PVSC Typical Hydrologic Year Report (Appendix N) and the PVSC System Characterization Report for further information about the selection of the typical year precipitation record and the supporting analysis.

Section 7

Characterization of System Performance – JMEUC Sewer System

The JMEUC and the City of Elizabeth are both characterizing their respective sewer systems under the current NJDEP CSO permit process. As described in Section 2, the two systems are connected primarily through a 48-inch force main connecting the TAPS to the North Barrel of the twin barrel trunk sewer owned and operated by the JMEUC. As described in Section 4, both the JMEUC and the City of Elizabeth have independently built and applied models of their respective systems, and shared these models to enable each to have in hand a merged model of both systems. These merged models have been used for system characterization, and will continue to be used in the next phases of the LTCP process for evaluation and selection of CSO control alternatives.

The JMEUC Merged Model, as described in Section 4, has been applied by JMEUC's modeling team to characterize the performance of the JMEUC sewer system, and the results of that effort are documented in this section of the report. The reader is directed to the City of Elizabeth System Characterization Report for information describing the performance of the City of Elizabeth combined sewer system.

7.1 Sewer System Performance During Dry Weather

7.1.1 Base Groundwater Infiltration

Flow during dry weather is made up of sanitary flow from residential, commercial and industrial service connections and base groundwater infiltration into the sewer system (both the public sewers and private laterals). Sanitary flow in residential areas exhibits a diurnal pattern which usually peaks in the morning. Base groundwater infiltration (GWI) often exhibits seasonal patterns, as the groundwater table typically rises in spring and falls in late summer and autumn. As such, the highest DWF typically occur in spring. This behavior is seen in the flow monitoring data and the Baseline JMEUC Model was calibrated to properly simulate this seasonal variability in GWI.

The Baseline Merged Model simulation of 2004 typical year showed that the highest DWF rates were in March. Figure 7-1 illustrates the base groundwater infiltration portion of the DWF at the WWTF (primary effluent) to demonstrate the seasonality (red line). The JMEUC system experiences some level of base groundwater infiltration, much like most sewer systems in the northeast U.S. In this case we see a roughly 10 mgd deviation from the high GWI period in the typical year (March thru May) versus the low GWI period (August thru October), i.e. a roughly 20% variation in DWF seasonally.

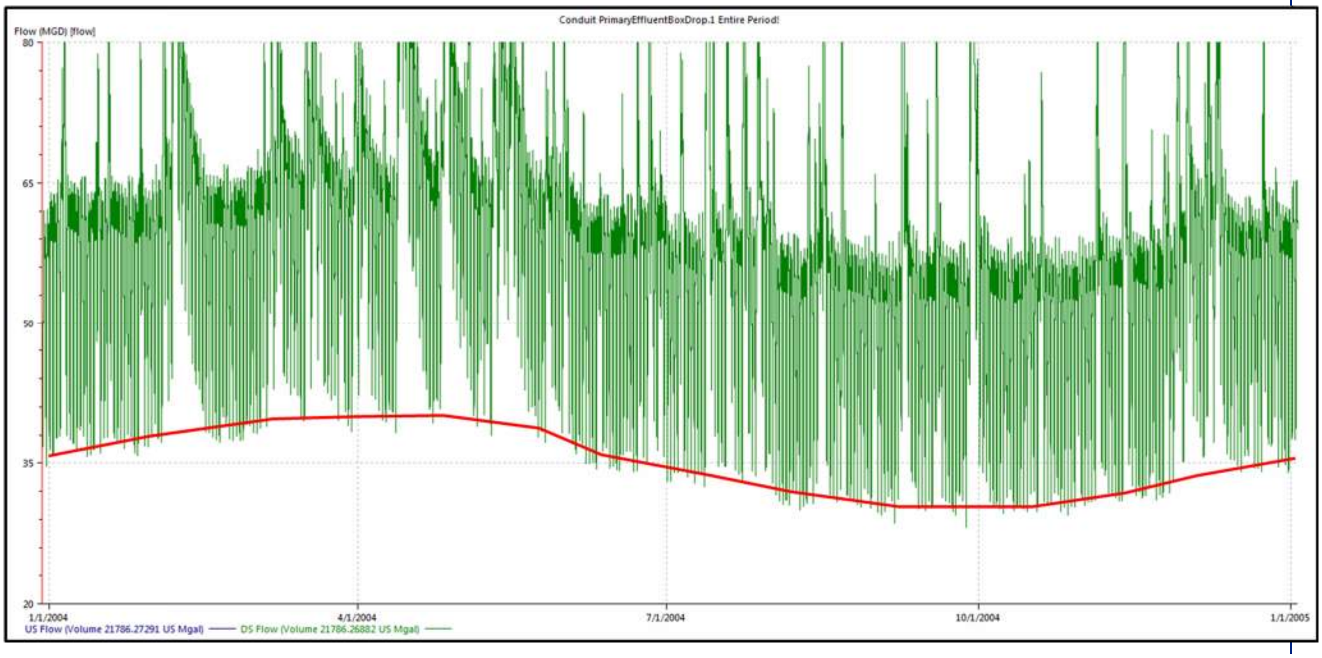


Figure 7-1 Seasonal Trend in Base Groundwater Infiltration at WWTF (Primary Effluent)

7.1.2 System Capacity for Dry Weather Flow

The JMEUC trunk sewers generally have ample capacity to convey DWF. Figure 7-2 shows the percentage of full pipe capacity required to convey peak DWF. This is the peak flow rate during the highest seasonal period (March 2004) in the typical year. As the figure shows, a significant majority of the system conveys peak DWF with less than 50% of pipe full capacity occupied. There are, however, a few locations that were identified during simulations of the system for the typical year that bear further discussion and are addressed below. In two of these cases, the model predicted surcharge conditions in one or more modeled pipes. Surcharge is defined to occur when the hydraulic grade line (HGL) exceeds the crown of the pipe.

Figure 7-2 illustrates surcharge conditions of the JMEUC trunk sewer system during DWF. Model simulations of the JMEUC system showed abundant capacity during March 2004 with only one short segment near meter JM14 predicted to experience surcharged conditions (Figure 7-2, Segment "2"). Figure 7-3 and Figure 7-4 display the peak HGLs through the Original and Supplementary Trunk Sewers in this area, as well as across cross connection (CC10) which suggests the slope of the cross-connection pipe is limiting the extent of relief from the Original Trunk Sewer to the Supplementary Trunk Sewer during peak DWF conditions. This causes slight surcharge in the Original Trunk Sewer and un-used capacity in the Supplementary Trunk Sewer through this segment.

It should be noted that Segment "1" also exhibits simulated surcharge conditions during dry weather, however this surcharging is caused by the model resolution in the pipe network. The model extent (upstream boundary) ends at a point which has a very large contributing area upstream, and as a result relatively high flows are loaded instantaneously into the modeled pipe network at this location (rather than being routed). This is a fairly common modeling anomaly, and because no observed surcharge in this segment during dry weather is seen in the meter data, the simulated surcharge is not considered real and is neglected.

Segment "3," just upstream of the WWTF, is predicted to exceed 75% pipe full capacity in portions of the North Barrel of the twin barrel trunk sewer during peak DWF, however this condition is largely due to TAPS inflows and only occurs during peak DWF.

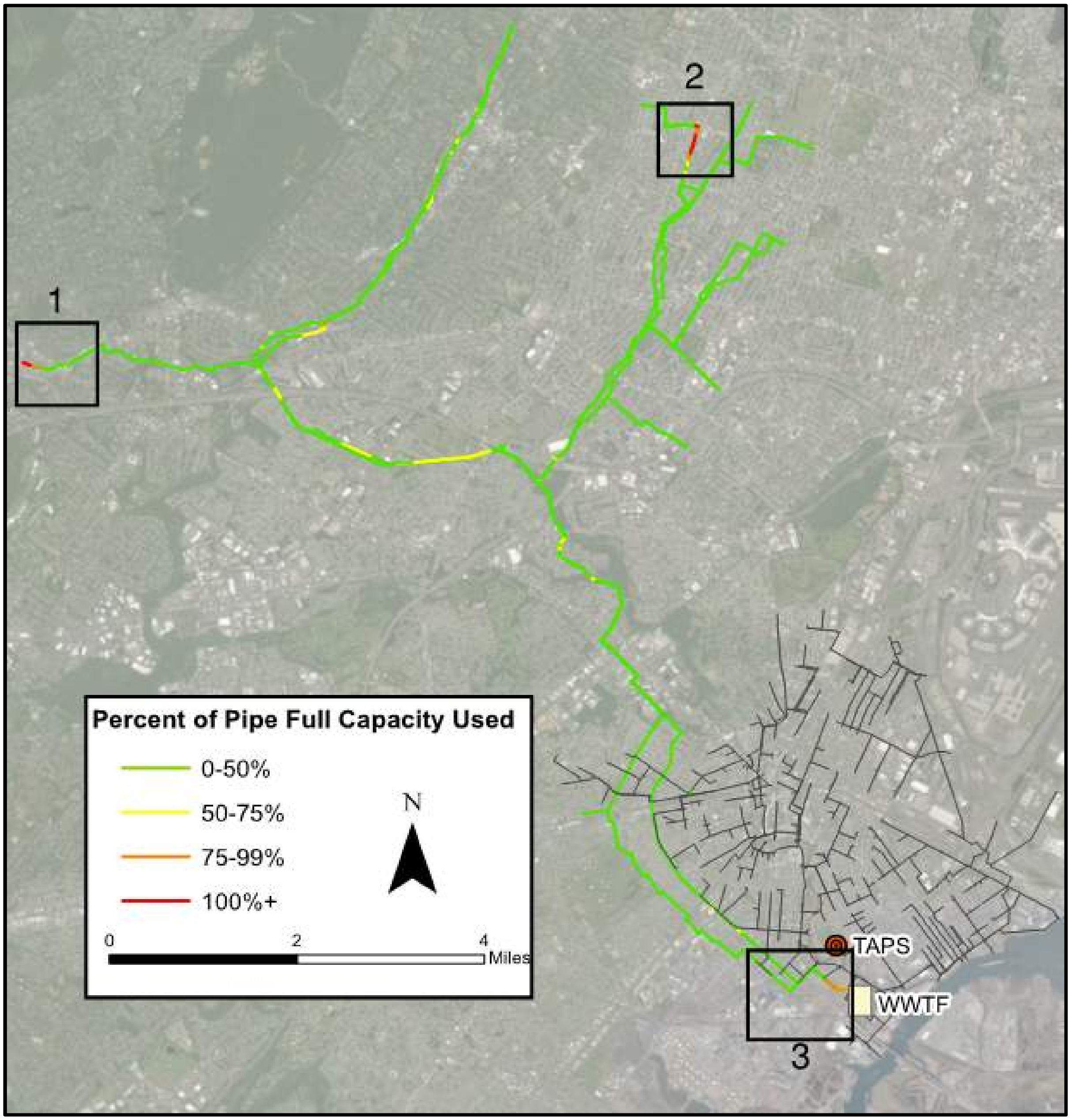


Figure 7-2 JMEUC Trunk Sewer Capacity During Dry Weather

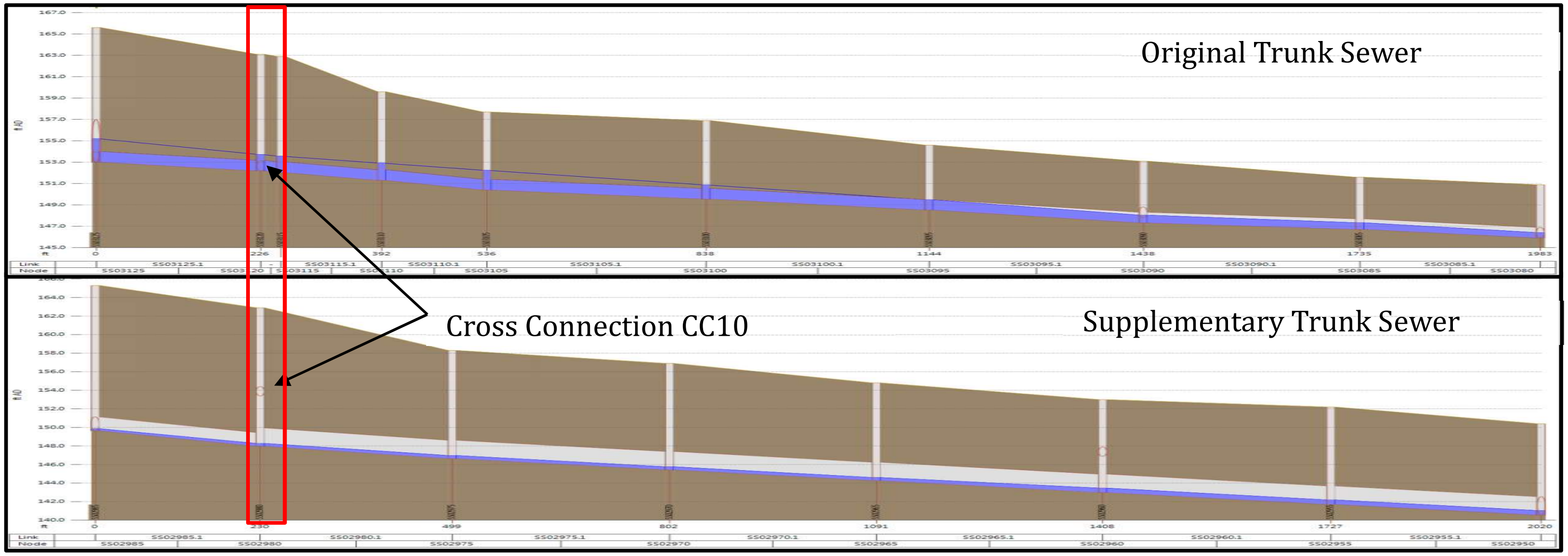


Figure 7-3 Peak HGL of Surcharged Segments #2 during Dry Weather – Trunk Sewers

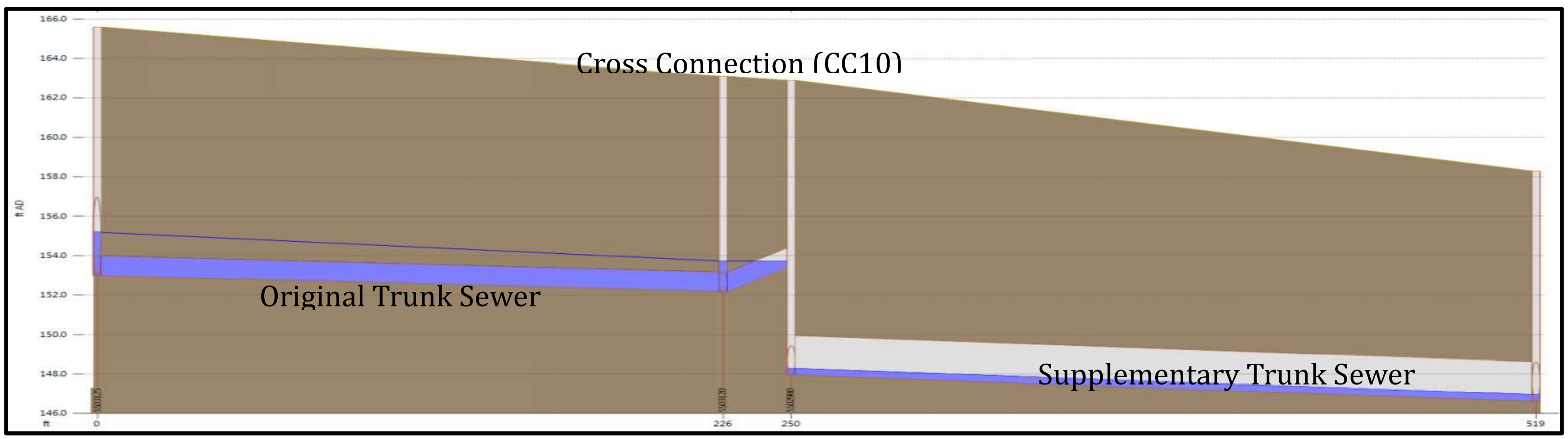


Figure 7-4 Peak HGL of Surcharged Segments #2 during Dry Weather – Cross Connection

7.1.3 Flow Balance Conditions in the JMEUC Parallel Trunk Sewers

As described in Section 2.5, there are 18 cross connections and 16 junctions throughout the trunk sewer network which divert and distribute flow among the Original and Supplementary Trunk Sewers to maximize total conveyance capacity of the system. Some cross connections are active during DWF while others only activate during WWF. Table 7-1 summarizes the activation status of the cross connections during DWF as well as the flow distribution at each junction during DWF. The naming convention of these structures is generally in an upstream to downstream direction (i.e. CC1 is the most upstream cross connection and CC18 is the most downstream cross connection). Structure locations relative to meter locations and other structures are shown in Figure 7-5.

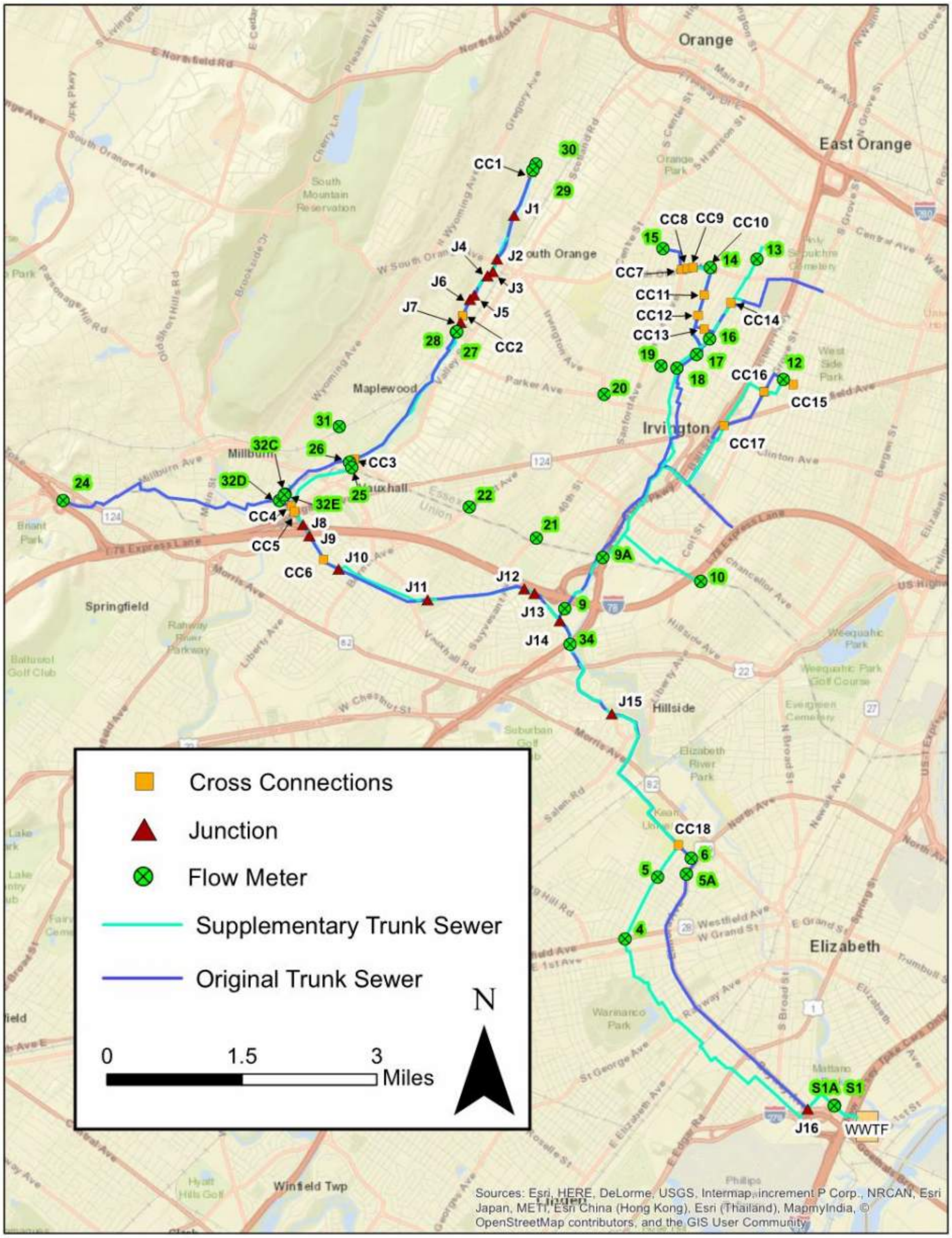


Figure 7-5 Locations of Modeled Junctions and Cross Connections

Table 7-1 Dry Weather Flow Distribution at Junctions and Cross Connections

Structure	Active During ADWF[1]	ADWF Inflow to Structure (mgd)[2]	ADWF Outflow to Original Trunk Sewer (mgd)[2]	ADWF Outflow to Supplementary Trunk Sewer (mgd)[2]
CC1	No	5.1	0.34	4.76
J1	Yes	5.1	1.07	4.03
J2	Yes	5.1	1.77	3.33
J3	Yes	5.1	0.21	4.89
J4	No	5.1	0	5.1
J5	Yes	5.1	2.53	2.57
J6	Yes	5.1	0.15	4.95
CC2	No	5.1	0.15	4.95
J7	Yes	5.1	0.15	4.95
CC3	Yes	7.57	1.88	6.63
CC4	Yes	16.66	11.62	5.04
CC5	Yes	16.66	12.27	4.58
J8	Yes	16.85	11.47	5.38
J9	Yes	16.85	2.99	13.86
CC6	No	16.85	3.8	13.86
J10	Yes	17.66	7.72	9.94
J11	Yes	18.19	8.35	9.84
J12	Yes	18.89	9.42	10.42
J13	Yes	19.84	6.73	13.11
J14	No	32.1	0	32.1
J15	No	32.74	0	32.74
CC7	Yes	0.32	0.12	0.2
CC8	No	0.32	0.12	0.2
CC9	No	0.32	0.12	0.2
CC10	Yes	1.74	1.42	0.32

Notes:

[1]Cross Connections considered active during ADWF if hydraulic model predicted any flow through cross connection during DWF periods.

[2]Flow rates based on hydraulic model simulation of high base groundwater table season (February 1 through May 31). This simulation only included dry weather flow without applying any rainfall.

[3]Activation of junction is defined as any time flow is predicted to discharge to both Original and Supplementary Trunk Sewers.

[4]CC13 connects two separate branches of Original Trunk Sewer - See Figure 2-10

[5]At J16 the Original Trunk Sewer and the Supplementary Trunk Sewer join and form the twin barrel trunk sewer (referred to as the North Barrel and South Barrel) that flows to the WWTF.

Table 7-1 Dry Weather Flow Distribution at Junctions and Cross Connections (Continued)

Structure	Active During ADWF[1]	ADWF Inflow to Structure (mgd) [2]	ADWF Outflow to Original Trunk Sewer (mgd)[2]	ADWF Outflow to Supplementary Trunk Sewer (mgd)[2]
CC11	Yes	1.74	0.89	0.85
CC12	Yes	1.74	0.34	1.4
CC13 [4]	Yes	NA[4]	NA[4]	NA[4]
CC14	Yes	0.72	0.09	0.63
CC15	No	0.28	0	0.28
CC16	No	0.28	0	0.28
CC17	No	0.28	0	0.28
CC18	Yes	35.39	1.94	33.45
J16 [5]	Yes	42.96	20.96	22

Notes:

[1]Cross Connections considered active during ADWF if hydraulic model predicted any flow through cross connection during DWF periods.

[2]Flow rates based on hydraulic model simulation of high base groundwater table season (February 1 through May 31). This simulation only included dry weather flow without applying any rainfall.

[3]Activation of junction is defined as any time flow is predicted to discharge to both Original and Supplementary Trunk Sewers.

[4]CC13 connects two separate branches of Original Trunk Sewer - See Figure 2-10

[5]At J16 the Original Trunk Sewer and the Supplementary Trunk Sewer join and form the twin barrel trunk sewer (referred to as the North Barrel and South Barrel) that flows to the WWTF.

Eight of the 18 cross connections were not predicted by the model to activate during DWF, while five of the 16 junctions were predicted to divert all DWF into the Supplementary Trunk Sewer to potentially free up capacity in the Original Trunk Sewer for WWF.

7.2 Sewer System Performance During Wet Weather

The Typical Hydrological Year Report (May 2, 2018) submitted by PVSC to NJDEP, discussed in Section 6, defined the typical year precipitation record for use in this system characterization. The JMEUC Merged Model was used to simulate the wet weather response of the JMEUC sewer system to this typical year record. The typical year was developed with a particular emphasis on generating average annual CSO statistics (e.g. overflow frequencies, volumes and pollutant loads) for the NJ CSO Group combined sewer systems, including the City of Elizabeth system. However, for characterization of the JMEUC trunk sewer system, the focus of the analysis was on the impact of the largest events in the typical year on the trunk sewer system and the ability of the system to handle those largest events.

In the Typical Hydrological Year Report, the largest rainfall events were summarized in tabular format (reproduced here as Table 7-2). The 9/28/2004 event produced the highest recorded rainfall depth and the second highest simulated peak flow rate through the WWTF. This event was used to evaluate the impact an increase in peak discharge from the TAPS would have on the JMEUC collection system and WWTF (Section 7.3.2) along with potential infiltration and inflow

(I/I) reduction in upstream separate sewer communities which contribute flow to the JMEUC (Section 7.3.1). The 4/12/2004 event was a long duration event occurring during the spring when the RDII response of the system is typically at its highest. This event was also used to evaluate the effects of any potential I/I reduction in upstream separate sewer communities that contribute flow to the JMEUC (Section 7.3.1).

Table 7-2 Largest 20 Rainfall Events by Depth in 2004

Rank	Event Start	Duration, hr	Total Depth, in	Max Intensity, in/hr	Avg Intensity, in/hr	ARI
1	9/28/2004 1:00	28	3.68	0.53	0.13	2-yr
2	9/8/2004 4:00	25	2.21	0.63	0.09	1-yr
3	7/12/2004 9:00	27	1.99	0.32	0.07	
4	4/12/2004 17:00	30	1.67	0.25	0.06	
5	4/25/2004 14:00	35	1.67	0.25	0.05	
6	7/23/2004 10:00	24	1.66	0.33	0.07	
7	2/6/2004 5:00	33	1.63	0.33	0.05	
8	7/18/2004 16:00	14	1.6	0.64	0.11	
9	11/28/2004 2:00	12	1.5	0.85	0.13	
10	7/27/2004 15:00	18	1.45	0.41	0.08	
11	9/17/2004 22:00	12	1.44	1.25	0.12	1-yr
12	6/25/2004 17:00	5	1.39	0.4	0.28	
13	11/12/2004 7:00	23	1.08	0.1	0.05	
14	5/12/2004 16:00	2	1.08	0.99	0.54	
15	11/4/2004 14:00	16	1.03	0.2	0.06	
16	7/5/2004 3:00	12	1	0.69	0.08	
17	12/1/2004 4:00	10	1	0.18	0.1	
18	8/16/2004 0:00	21	0.94	0.6	0.04	
19	8/21/2004 14:00	3	0.84	0.81	0.28	
20	12/6/2004 12:00	39	0.83	0.2	0.02	

Source: PVSC Typical Hydrological Year Report (May 2, 2018)

This section discusses the JMEUC system response predicted during WWF, including RDII from different communities, flow balance between the Original and Supplementary Trunk Sewers, and characterization of inflow from the TAPS.

7.2.1 Rainfall-Derived Inflow/Infiltration (RDII)

Other than the City of Elizabeth, which has a combined sewer system, all other member communities and customer communities have separate sanitary sewers. Although storm runoff is not intended to be collected in sanitary sewers, some RDII still enters the sewer pipes during and immediately after rainfall. RDII has been quantified and compared across the different communities to identify the areas that contribute significant RDII from both a volumetric standpoint and in terms of the rate of RDII (either absolute peak rates or relative rates using the ratio of RDII to typical DWF).

A set of calibration/validation events occurring in late March 2017 and early April 2017 were used in the analysis. These events were selected for the following reasons:

- These events generated both high inflow and infiltration responses (Figure 7-6);
- These events were spaced closely together temporally, which typically generates high RDII responses; and
- Two of these events were model validation events, further ensuring the accuracy of the model to quantify RDII.

RDII is quantified by peak flow rates and event volumes. The period used in this analysis began on March 19, 2017 and extended through April 19, 2017. Absolute flow rates and volumes can be calculated for specific locations, but it is often useful to calculate unit RDII characteristics, where RDII rates and volumes are normalized using DWF. Unit RDII is quantified in two ways. One way is to divide the overall peak flow rate by the ADWF rate. The other way is to divide the overall event volume by the volume of DWF (excluding the RDII portion of flow) for the same period. Unit RDII characteristics take into account the geographic area and population of the service area, as DWF correlates closely to area and population.

Table 7-3 and Table 7-4 present the total RDII and unit RDII flow rates and volumes based on modeled metersheds, while Figure 7-8 through Figure 7-11 present the same information in map format using different colors to indicate the level of simulated RDII originating from upstream communities. The metersheds used here are mostly consistent with modeled sewersheds with two exceptions. One is Meter 05/05A which aggregates all modeled sewersheds in this group (i.e. those labeled "05A-L"). The other exception is Meter29/30. Because there are multiple cross connections inside West Orange upstream from these two meter locations, which are outside of the Baseline Model extent, it is not possible to accurately quantify RDII individually for these two metersheds and total flow from the two meters was instead used.

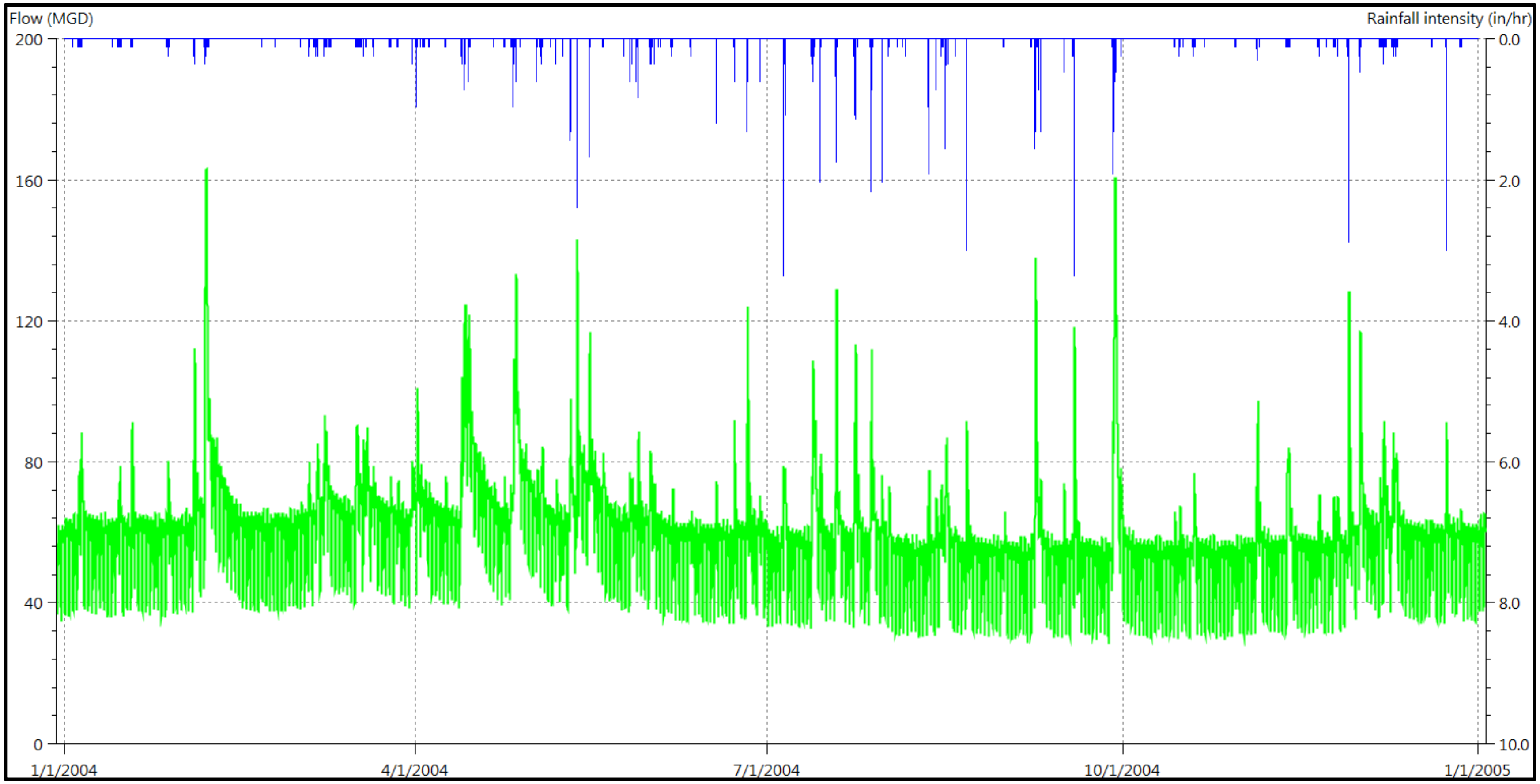


Figure 7-6 Simulated WWTF Inflow vs. Rainfall During Typical Year (2004)

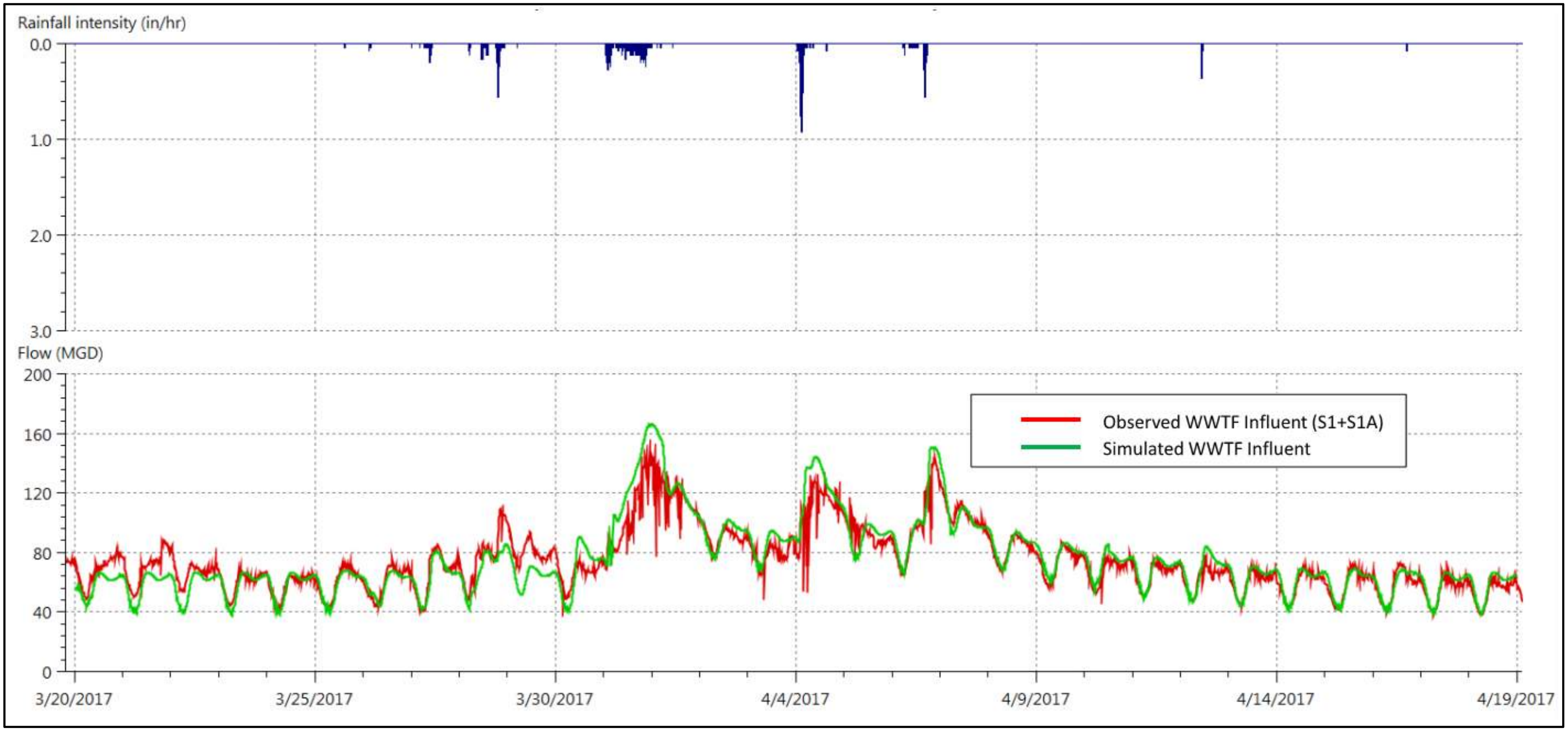


Figure 7-7 Primary Effluent at JMEUC's the WWTF during March and April 2017

Table 7-3 RDII Peak Flow Rate and Event Volume by Metershed

Metershed	Simulated Peak RDII Rate - March/April 2017		Simulated Total RDII Volume - March/April 2017	
	Peak Flow (mgd)	Rank	Volume (MG)	Rank
Meter05/05A	33.95	1	313.34	1
Meter9A/9A-Up	26.67	2	165.04	4
Meter24	14.38	3	181.58	3
Meter29/30	14.04	4	191.82	2
Meter04	10.14	5	73.47	7
Meter32D	7.63	6	64.9	9
Meter28	7.14	7	72.49	8
Meter9	6.95	8	52.68	10
Meter06	6.89	9	105.53	5
Meter32C	4.01	10	32.73	14
Meter18	3.99	11	74.67	6
Meter26/31	3.78	12	36.7	13
Meter13	3.05	13	24.41	18
Meter21	2.9	14	30.84	15
Meter17/17E	2.8	15	17.54	21
Meter27	2.67	16	45.55	12
Meter14	2.63	17	46.4	11
Meter34	2.6	18	20.8	19
Meter25	2.28	19	26.42	17
Meter10	2.23	20	20.59	20
Meter32E	2.21	21	29.92	16
Meter22	2.01	22	12.85	24
Meter16	1.56	23	12.97	23
Meter15	1.21	24	13.79	22
Meter12	0.93	25	9.74	25

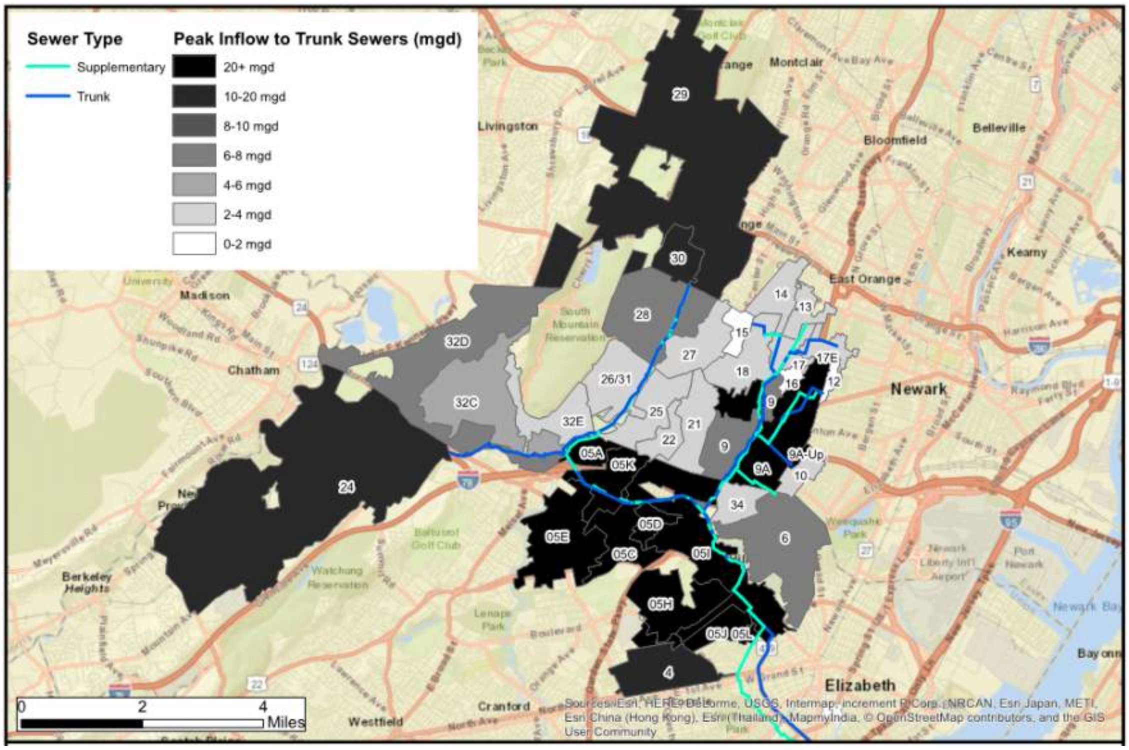


Figure 7-8 Simulated Peak RDII Flow Rate (March 19 – April 19, 2017)

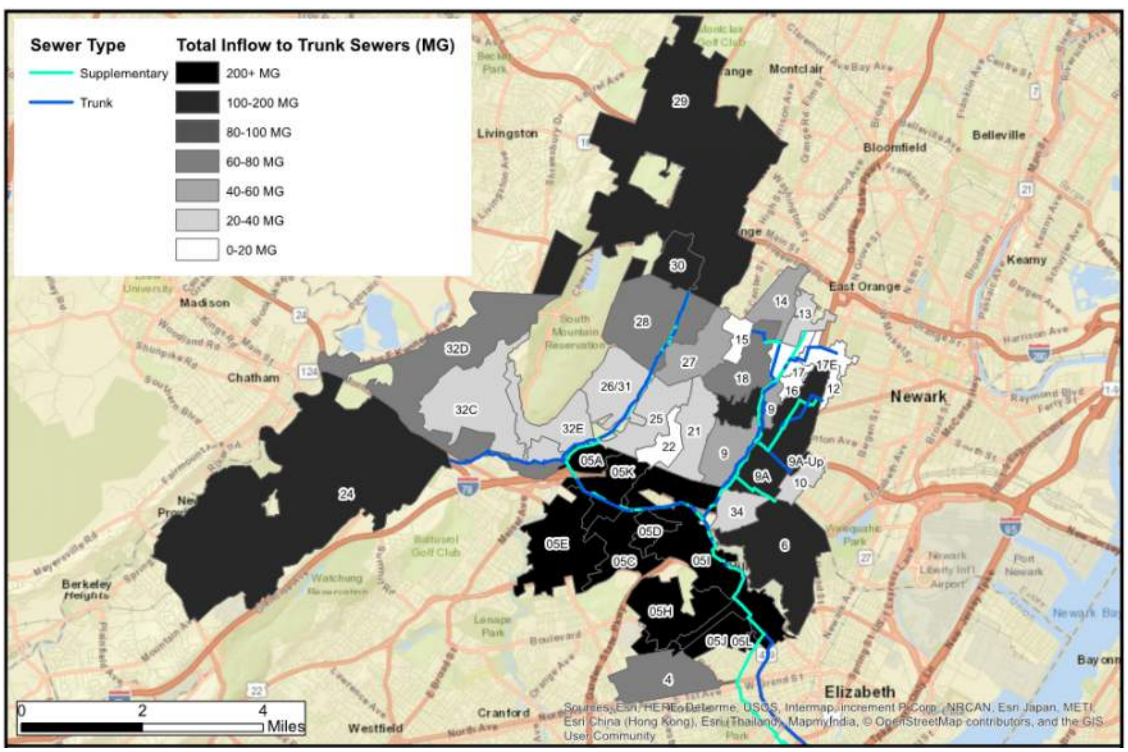


Figure 7-9 Simulated RDII Volume (March 19 – April 19, 2017)

Table 7-4 Unit RDII Peak Flow Rate and Event Volume by Metershed

Metershed	Simulated Peak WWF/ADWF		Simulated Volume WWF/DWF	
	Peaking Factor	Rank	Volume Ratio	Rank
Meter04	7.46	1	1.744	2
Meter22	7.11	2	1.464	7
Meter17/17E	6.97	3	1.411	9
Meter05/05A	6.79	4	2.02	1
Meter32C	5.66	5	1.491	4
Meter16	5.47	6	1.462	8
Meter9	5.42	7	1.325	12
Meter9A/9A-Up	5.36	8	1.071	22
Meter13	5.32	9	1.372	10
Meter28	4.83	10	1.581	3
Meter32D	4.68	11	1.283	14
Meter21	4.32	12	1.483	5
Meter10	4.15	13	1.234	17
Meter34	4.11	14	1.061	24
Meter26/31	3.94	15	1.237	16
Meter15	3.71	16	1.361	11
Meter12	3.23	17	1.089	21
Meter24	3.21	18	1.308	13
Meter25	3.03	19	1.134	20
Meter29/30	2.71	20	1.194	18
Meter32E	2.69	21	1.172	19
Meter27	2.68	22	1.475	6
Meter06	2.55	23	1.258	15
Meter14	1.84	24	1.049	25
Meter18	1.77	25	1.068	23

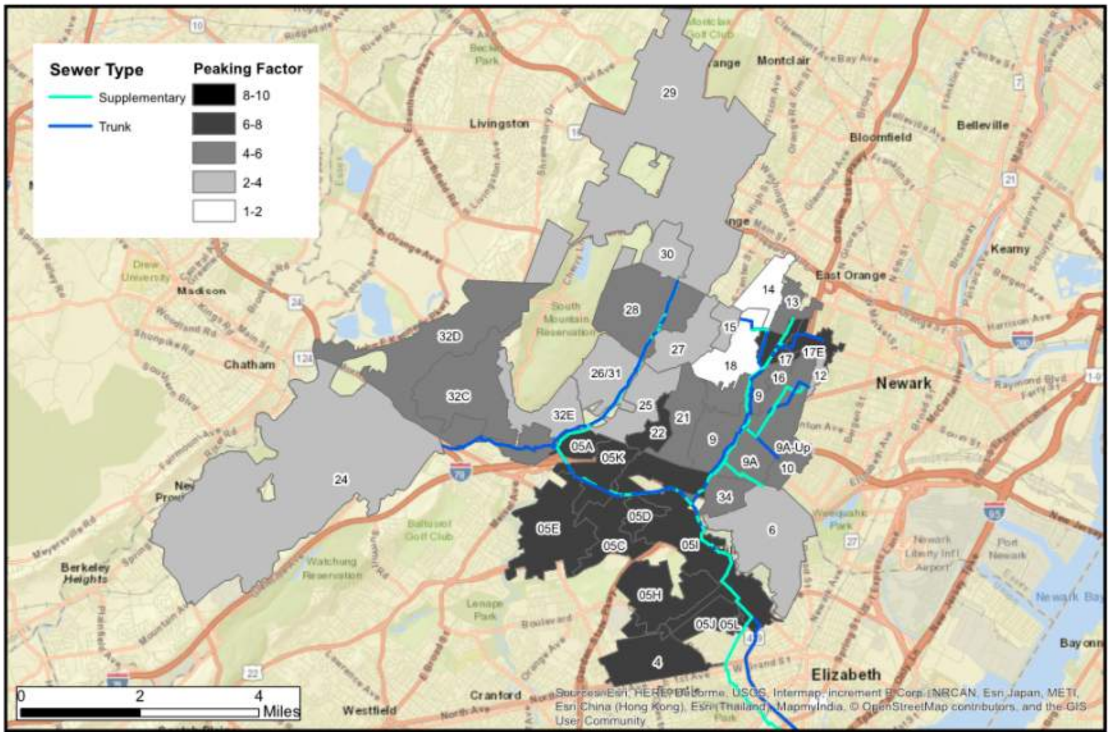


Figure 7-10 Unit RDII Peak Flow Rate (March 19 – April 19, 2017)

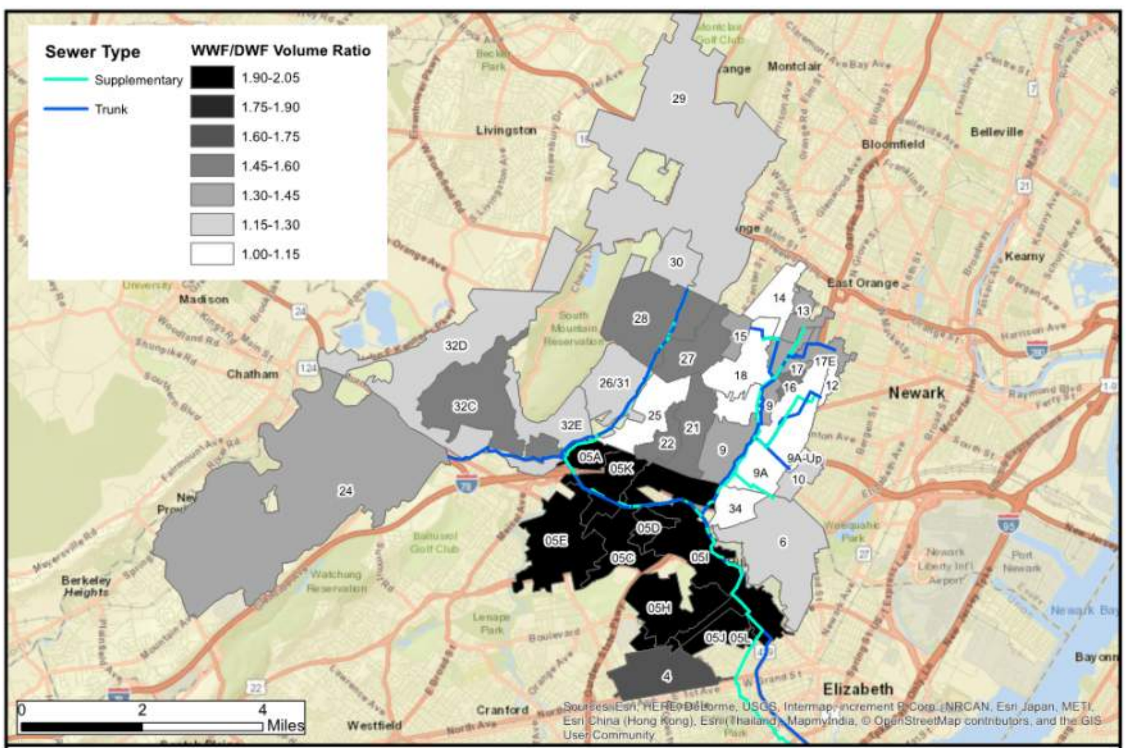


Figure 7-11 Unit RDII Volume (March 19 – April 19, 2017)

Figure 7-8 and Figure 7-9 demonstrate the variation in total RDII from different metersheds across the study area. The ones with the highest total RDII are those in Union (Metersheds 5A-L), Irvington (Metershed 9A), Summit and New Providence (Metershed 24), West Orange (Metershed 29/30), and Roselle Park (Metershed 04). Although Hillside Township (Metershed 06) is not one of the highest ranked metersheds by RDII peak flow rate, its RDII volume is the 5th highest.

When RDII is normalized by the size of the area or population served (Figure 7-10 and Figure 7-11), Union (Metershed 05) and Roselle Park (Metershed 04) have some of the highest unit RDII levels. A small part of Maplewood (Metershed 22) and Newark (Metershed 17/17E) also show high unit RDII levels.

The areas with high RDII rates and volumes, and those with high unit RDII levels, may be considered for RDII reduction as alternatives during the LTCP alternatives evaluation process.

7.2.2 System Capacity and Flow Balance in the JMEUC Parallel Trunk Sewers During Wet Weather

During the largest events in the typical year, isolated areas within the JMEUC system are predicted to experience surcharge conditions (as defined in Section 7.1.2). Surcharging during wet weather is common in sanitary sewer systems across the U.S., as the occurrence of RDII is ubiquitous in sanitary sewer systems and frequently increases flow rates to levels exceeding full pipe capacity. Surcharging is not in itself problematic, as the elevated hydraulic head that occurs during surcharging can increase flow rates through the surcharged sewers. However, if surcharged HGLs reach the elevation of the manhole rim, flooding (discharge of flow to the surface) can occur. It should be noted that at no locations in the JMEUC trunk sewer network was measurable flooding simulated to occur during the typical year. (At two locations the maximum simulated HGL was observed to reach the rim elevation but in both cases for only one or a few time steps and reported flooding volumes were 0.00 MG).

For analysis purposes, eight different segments were identified as shown in Figure 7-12. The maximum predicted surcharge during the typical year most often occurred during the 9/28/2004 event, although for Segments #2, #6, and #8 the highest surcharge levels are predicted during the 5/12/2004 event.

The duration of surcharging in the segments shown on Figure 7-12 varies significantly for the different reaches in the pipe network; some segments only experience brief surcharging during one specific event in the typical year while other segments were surcharged for longer periods over multiple events. And, as noted in Section 7.1.2, one segment surcharges during DWF. The specific durations of surcharging during the typical year are reported below in Table 7-5 for each segment.

With the exception of Segment 1, each segment identified on Figure 7-12 includes two pipe reaches, one in the Original Trunk Sewer and one in the Supplementary Trunk Sewer (Segment 1 does not include a Supplementary Trunk Sewer reach). As noted in Section 7.1.2 (and in this section below), simulated surcharging in Segment 1 is neglected. Of the 14 individual pipe reaches in Segments 2 through 8, two do not surcharge in the typical year while nine surcharge for a total duration of 24 hours or less during the typical year. Of the remaining three sewer reaches, one (the Original Trunk Sewer in Segment 2) surcharges during DWF, although not continuously (the longest continuous surcharge period is 43 hours at this reach). Surcharging at the other two reaches occurs for a total duration of 1% or less of the typical year. The surcharge conditions in each of the segments identified in Figure 7-12 are discussed individually in this section.

Table 7-5 Duration of Simulated Surcharging in the JMEUC Trunk Sewers for the Typical Year

Segment	Trunk Sewer	Most Significant Surcharge Location (JMEUC Pipe ID) [1]	Total Hours Surcharged During Typical Year	Longest Time Continuously Surcharged (hours)	Event Causing Longest Continuous Surcharging
1	Supplementary [2]	NA	NA	NA	NA
	Original	SS04345	see Note 5	--	--
2	Supplementary [3]	NA	NA	NA	NA
	Original [4]	SS02920	6729.5 (280 days)	42.92	2/6/2004
3	Supplementary	SS01695	14.58	8.33	2/6/2004
	Original	SS05155	97.08	16.58	9/28/2004
4	Supplementary	SS05125	32.58	8.75	9/28/2004
	Original	SS04515	23.00	14.25	9/28/2004
5	Supplementary	SS04565	24.08	13.17	9/28/2004
	Original	SS03775	8.83	8.83	9/28/2004
6	Supplementary	SS00125	1.33	0.75	5/12/2004
	Original [3]	NA	NA	NA	NA
7	Supplementary	SS04620	1.58	0.92	2/6/2004
	Original	SS03255	16.17	8.08	2/6/2004
8	Supplementary	SS04550	1.92	1.88	5/12/2004
	Original	SS00025	10.58	5.67	9/28/2004

Notes:
[1] Significance based on total hours surcharged during typical year.
[2] No parallel Supplementary Trunk Sewer present.
[3] No surcharging occurred during the typical year simulations.
[4] Surcharged during DWF conditions; see Section 7.1.2
[5] Modeled surcharge at this segment is neglected - see Sections 7.1.2 and 7.2.2 discussions of this segment

Surcharge in Segment #1 is not real and is a relatively common modeling anomaly associated with the limited model extent, as explained in Section 7.1.2. Segments #2 through #8 experience surcharging during the typical year simulations due to a variety of hydraulic restrictions as described below.

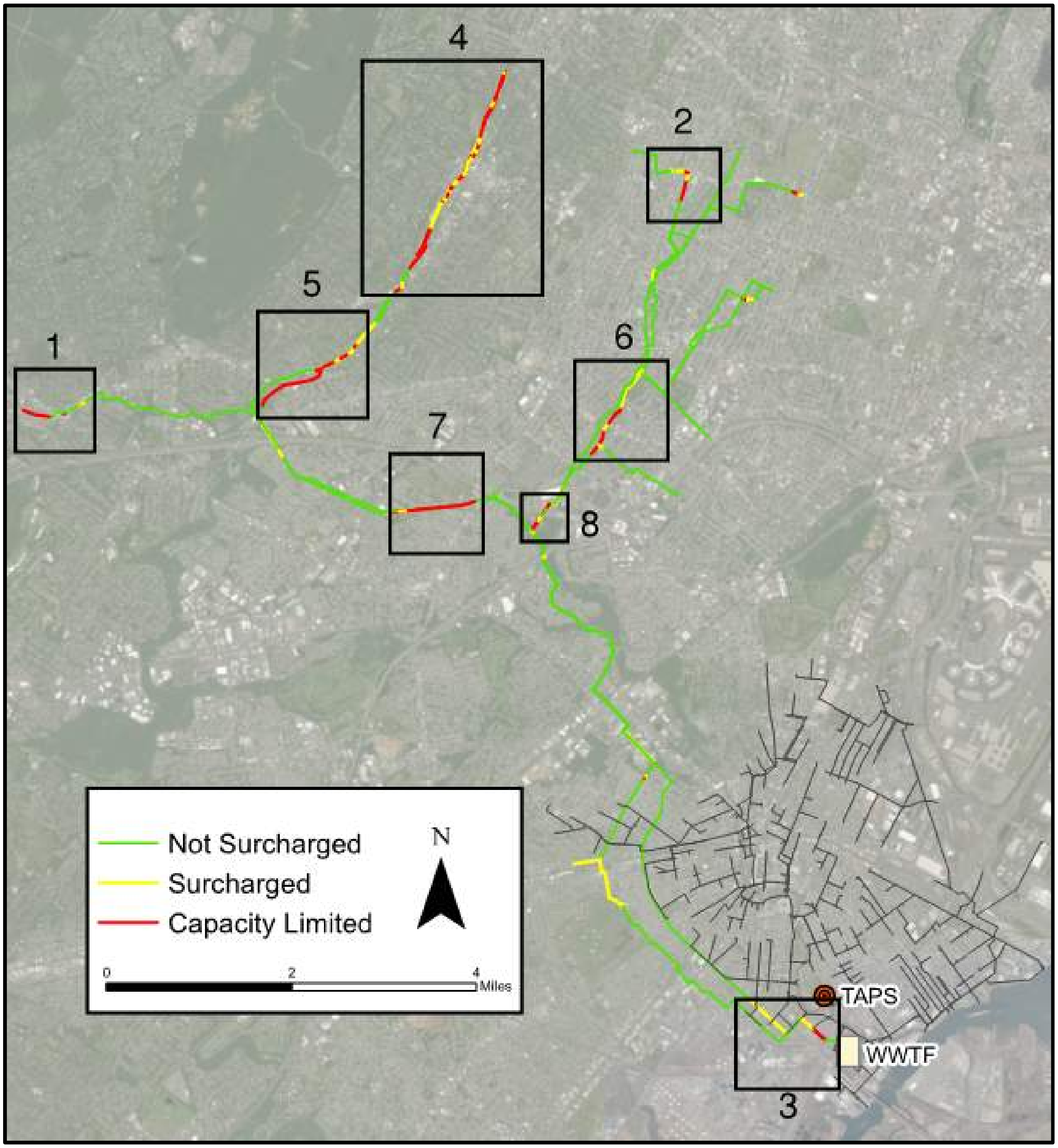


Figure 7-12 Peak Surcharge Condition During 2004 Typical Year

Surcharge levels in the Original Trunk Sewer in Segment #2 are highest during the 5/12/2004 event, but as noted earlier, this segment surcharges during DWF, therefore some level of surcharging is common at this location. Similar to the predicted hydraulics during DWF, the high offset of cross connection CC10 on the Supplementary Trunk Sewer limits flow diversion from the Original Trunk Sewer to alleviate surcharging, as indicated in Figure 7-13 . The Original Trunk Sewer segment directly upstream of the cross connection seems to be the most capacity limited, as shown in Figure 7-13. While surcharging here is common, no flooding is predicted, as the upstream extent of surcharging is limited to only a few (3) sewer segments and there is ample surcharge depth available in this reach.

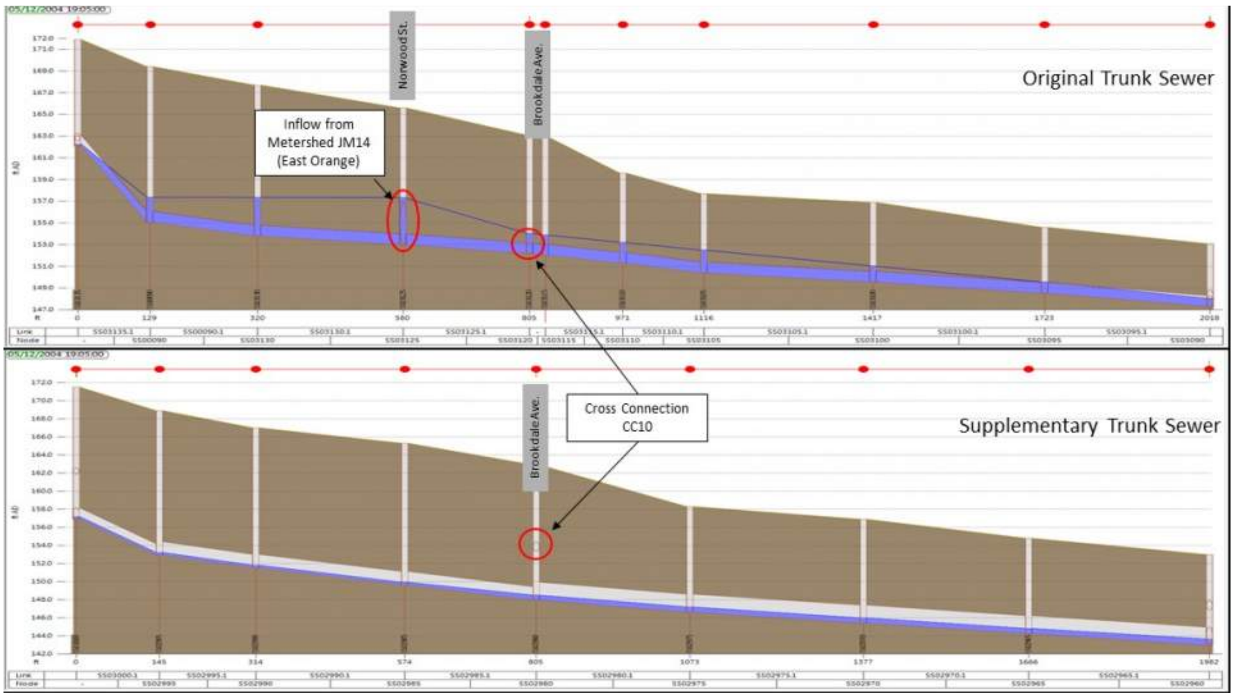


Figure 7-13 Peak HGL in Segment #2

Segment #3 is located directly upstream of the WWTF headworks (Figure 7-14). The North Barrel of the twin barrel trunk sewer is predicted to surcharge during the 9/28/2004 event. Surcharging at this location is largely due to inflow from the TAPS. Simulation results indicate that the HGLs between the North and South Barrels of the twin barrel trunk sewer are well balanced. The section of the Original Trunk Sewer upstream from J16 is not capacity limited, rather it is surcharging due to backwater in the twin barrel trunk sewer.

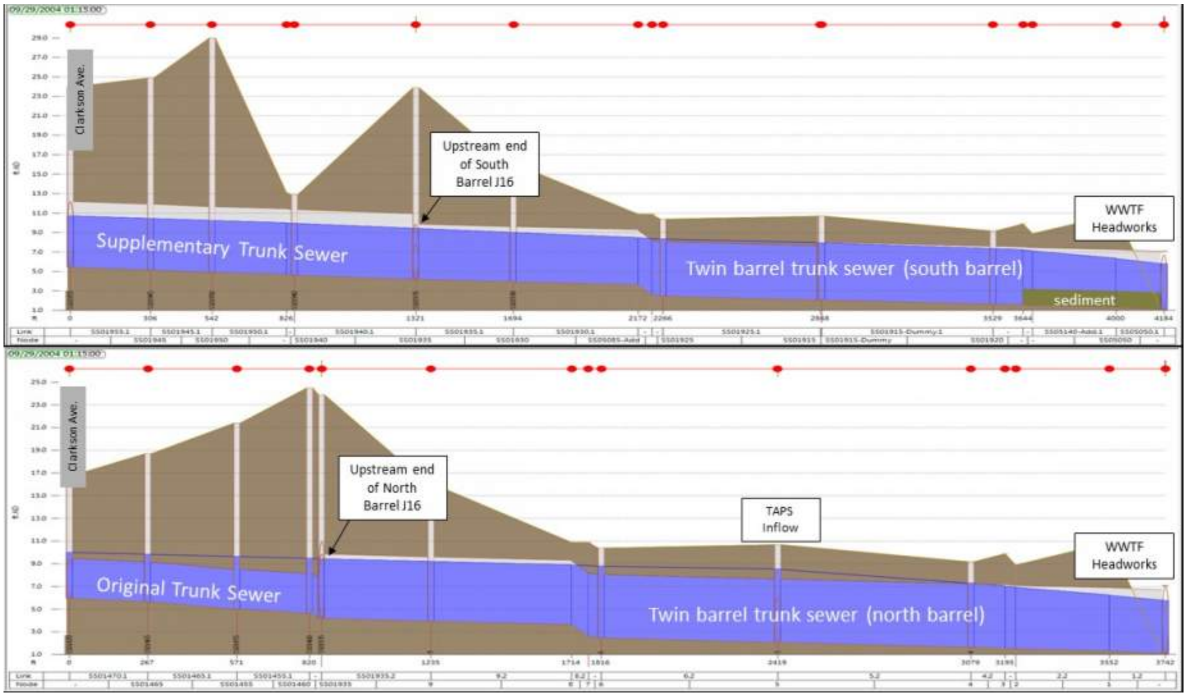


Figure 7-14 Peak HGL in Segment #3

Segment #4 extends from meter locations JM29 and JM30 downstream to a point just below meter locations JM27 and JM28, where pipe slopes become steeper and surcharging is predicted to subside (Figure 7-15). Peak HGLs during the typical year were predicted to occur during the 9/28/2004 event and capacity limitations in both the Original and Supplementary Trunk Sewers extending roughly 1000 feet between Walton Road and Valley Street in South Orange (behind the Stop & Shop) were predicted. The HGL is predicted to reach one manhole rim elevation along the Original Trunk Sewer, however this level is reached at only four model reporting time steps (at five minute intervals) during the typical year and the simulated flooding volume is zero (0.00 MG).

Segment #5 is located near JM25 and JM26 (Figure 7-16) and the distribution of flow through the Original and Supplementary Trunk Sewers in this segment is largely controlled by Cross Connection CC3. The flow in the trunk sewers is well balanced through CC3, which alleviates potential surcharging in the Original Trunk Sewer. This cross connection does cause mild surcharging of the Supplementary Trunk Sewer during large rainfall events due to differences in trunk sewer elevations, as indicated in Figure 7-16.

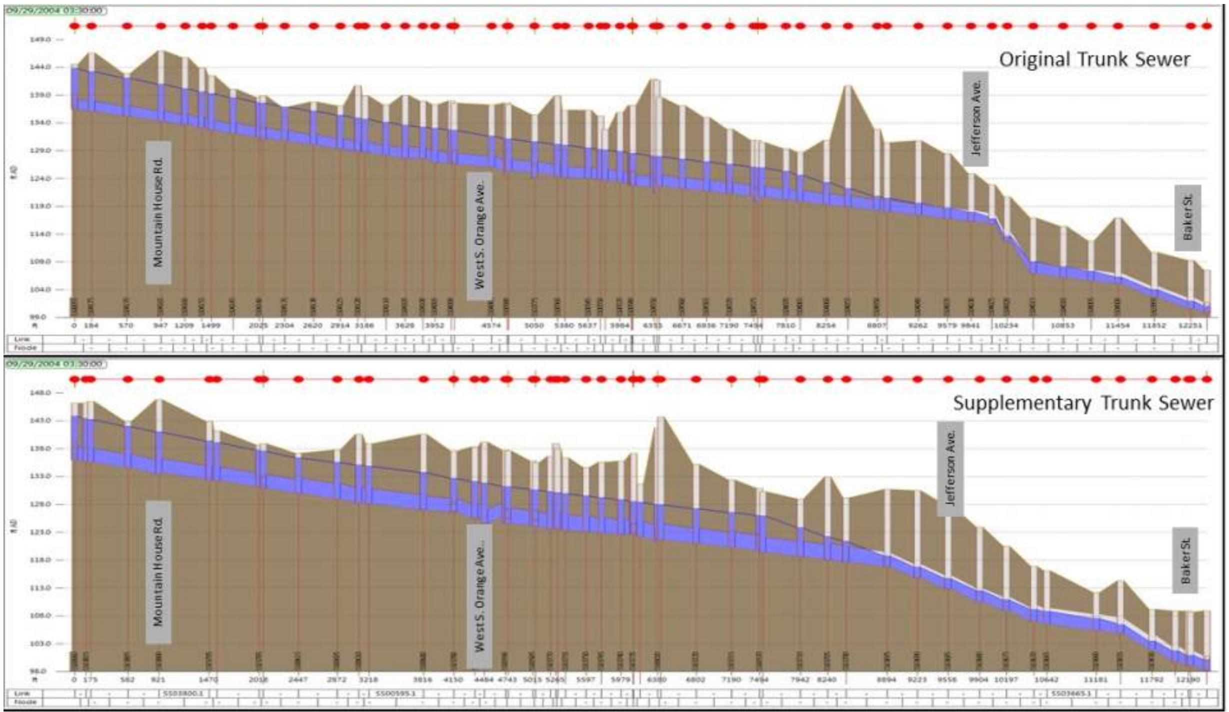


Figure 7-15 Peak HGL in Segment #4

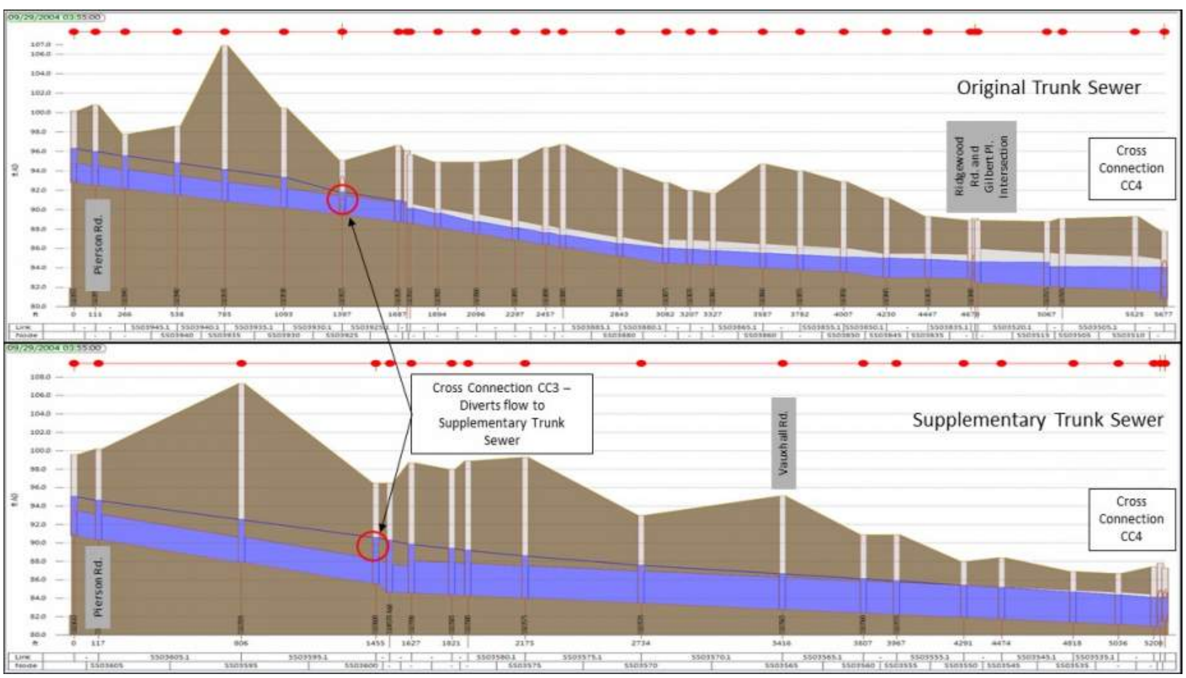


Figure 7-16 Peak HGL in Segment #5

There are no cross connections or junctions present along Segment #6. The nearest upstream connection between the Original and Supplementary Trunk Sewers is CC12, located roughly 5000 feet upstream of this segment. This segment shows the most disparity between HGLs within the trunk sewers, with the Original Trunk Sewer predicted to have ample capacity during all WWF periods in the typical year, while the Supplementary Trunk Sewer is predicted to surcharge (Figure 7-17) during the largest events.

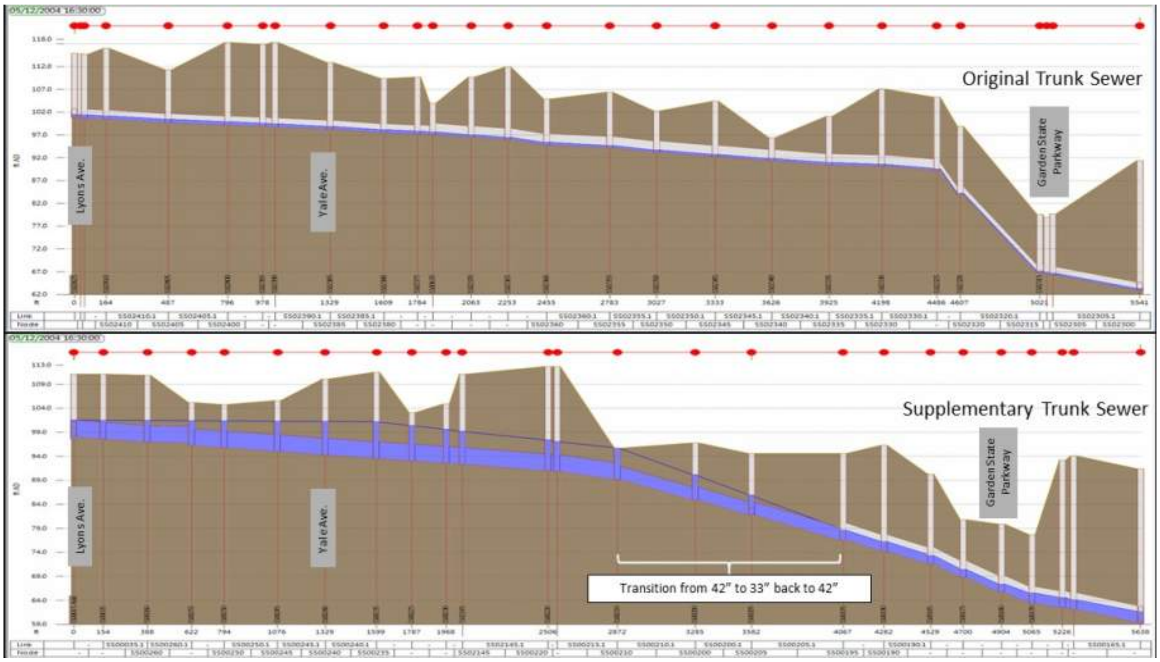


Figure 7-17 Peak HGL in Segment #6

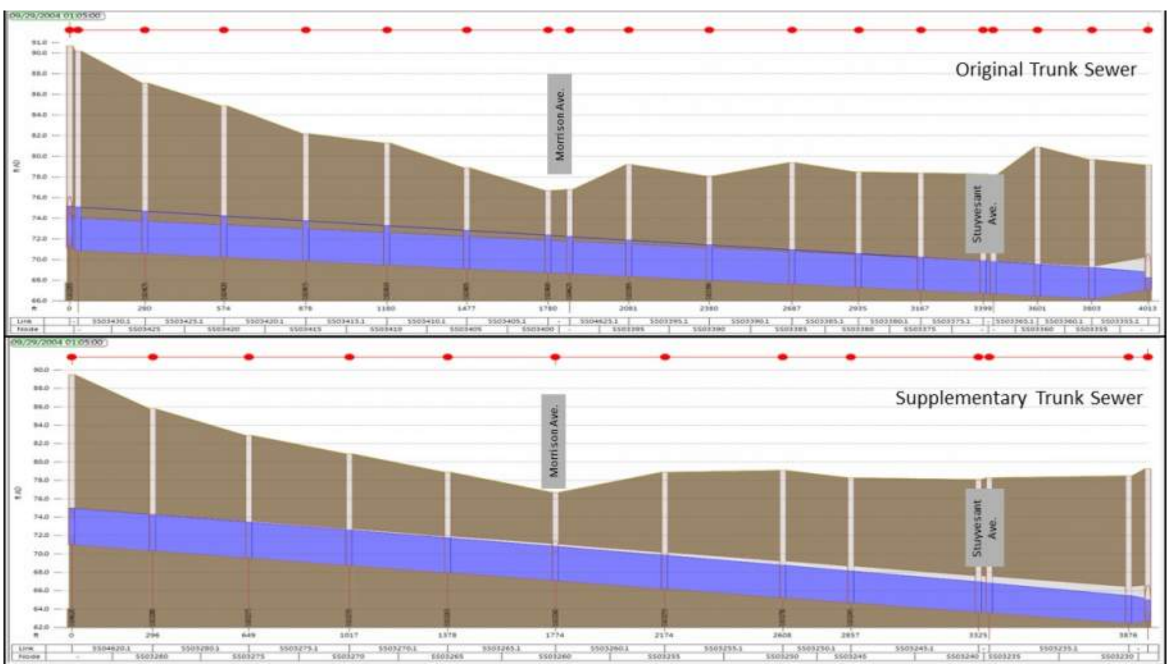


Figure 7-18 Peak HGL in Segment #7

A transitional pipe section from 42-inch to 33-inch and then back to 42-inch in the Supplementary Trunk Sewer under the Garden State Chancellor Park in Irvington is capacity limited and causes the majority of predicted surcharging in this stretch of the Supplementary Trunk Sewer. At the upstream end of this transitional pipe section the HGL is predicted to reach one manhole rim elevation along the Original Trunk Sewer, however this level is reached at only one model reporting time step (at five minute intervals) during the typical year and the simulated flooding volume is zero (0.00 MG). Segment #7 is between J11 and J12. The Original Trunk Sewer through this segment is predicted to experience slight surcharging during the 9/28/2004 event due to its smaller pipe diameter (Figure 7-18), but this surcharging is insignificant. Simulations show that flow is well balanced between the Original and Supplementary Trunk Sewers in this area.

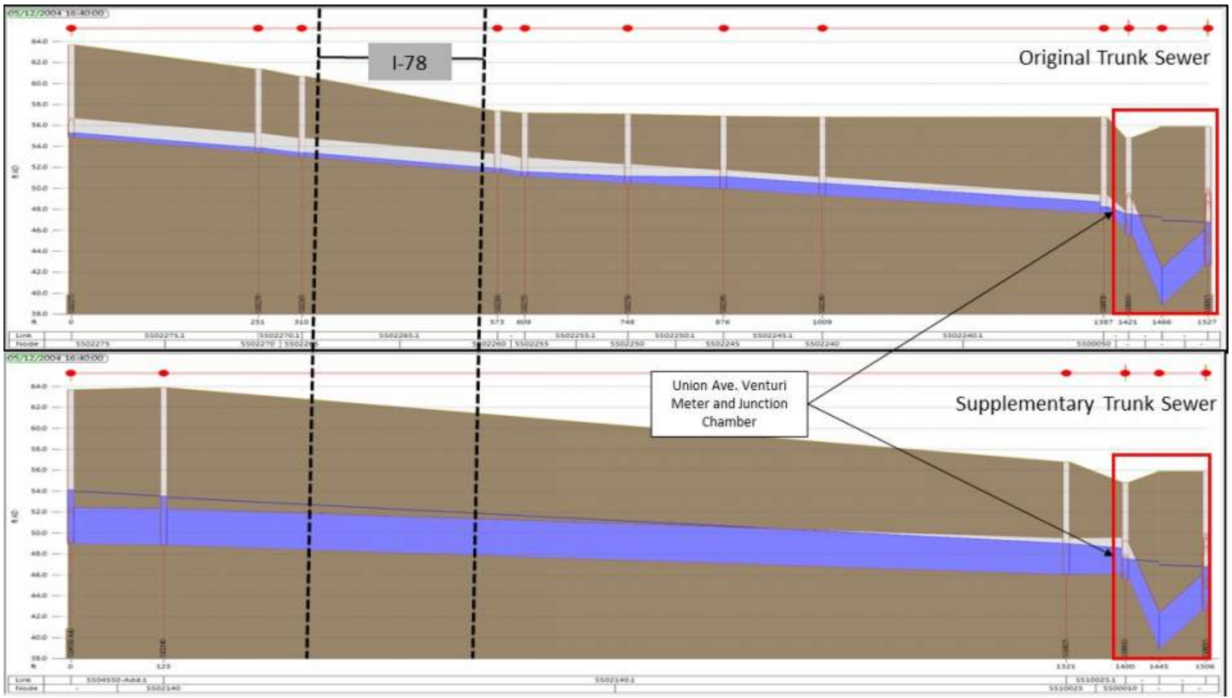


Figure 7-19 Peak HGL in Segment #8

Segment #8 is located directly upstream of the Union Avenue Junction Chamber (Figure 7-19). There are no cross connections or junctions present between Segments #6 and Segments #8 and as a result most predicted flow in this part of the system passes through the Supplementary Trunk Sewer, which shows peak surcharging during the 5/12/2004 event. This surcharging is mild (roughly two feet) and there is ample vertical relief in this area (roughly 12 feet from pipe crown), therefore this surcharging is not problematic.

With the exception of the segments described above, the JMEUC system shows minimal surcharging during the 2004 typical year and flows between the Original and Supplementary Trunk Sewers are generally well balanced through cross connections and junctions located throughout the system. Table 7-6 summarizes the predicted wet weather activation frequency of cross connections and junctions during the typical year (for those not active during DWF; if a cross connection or junction is active during DWF, wet weather activation is logically assumed during all WWF events).

All junctions are predicted to activate for one or more events during the typical year. Five cross connections are predicted to not activate during the typical year, and there is no simulated surcharge observed in the vicinity of these cross connections.

Table 7-6 Flow Balance between the Trunk Sewers through Junctions and Cross Connections during Wet Weather

Structure	Active During ADWF[1,2,3]	Number of Activations during typical year (2004) [4]	Structure	Active During ADWF[1,2,3]	Number of Activations during typical year (2004) [4]
CC1	No	22	J12	Yes	-
J1	Yes	-	J13	Yes	-
J2	Yes	-	J14	No	4
J3	Yes	-	J15	No	28
J4	No	23	CC7	Yes	-
J5	Yes	-	CC8	No	0
J6	Yes	-	CC9	No	0
CC2	No	9	CC10	Yes	-
J7	Yes	-	CC11	Yes	-
CC3	Yes	-	CC12	Yes	-
CC4	Yes	-	CC13 [5]	Yes	-
CC5	Yes	-	CC14	Yes	-
J8	Yes	-	CC15	No	23
J9	Yes	-	CC16	No	0
CC6	No	0	CC17	No	0
J10	Yes	-	CC18	Yes	-
J11	Yes	-	J16 [6]	Yes	-

Notes:

1. Cross Connections considered active if hydraulic model predicted any flow through cross connection during DWF.
2. Based on hydraulic model simulation of high base groundwater table season (February 1 through May 31). This simulation only included dry weather flow without applying any rainfall.
3. Activation of junction is defined as any time flow is predicted to discharge to both Original and Supplementary Trunk Sewers.
4. The number of activations during the typical year is not applicable to any junction which activates in dry weather and is annotated with "-".
5. CC13 connects two branches of the Original Trunk Sewer - See Figure 2-10
6. At J16 the Original Trunk Sewer and the Supplementary Trunk Sewer join and form the twin barrel trunk sewer (referred to as the North Barrel and South Barrel) that flows to the WWTF.

The Union Avenue Junction (J14), is an important junction within the system given its location and function. During DWF, the junction diverts all flow into the Supplementary Trunk Sewer, freeing up all available capacity in the Original Trunk Sewer. During the typical year simulation, there are only four events which generate sufficiently high flow levels in the junction to cause activation of the downstream Original Trunk Sewer. Overall, the trunk sewers downstream of J14 have ample capacity during the typical year simulation and neither experience surcharging.

The Kean University Cross Connection (CC18) is another important flow control feature in the JMEUC system. It consists of a 42-inch cross connection and a flow control gate immediately downstream of the cross connection on the Original Trunk Sewer. The gate is exercised regularly but is generally maintained in a fixed position and is used to control flow into the Original Trunk Sewer downstream of CC18. During DWF, all upstream flow entering CC18 enters via the Supplementary Trunk Sewer. The flow level in the Supplementary Trunk Sewer downstream of CC18 is sufficiently high to allow flow through the gate and into the Original Trunk Sewer downstream. During wet weather, a portion of WWF enters from the Original Trunk Sewer at J15. This flow is conveyed downstream where it is split at the flow control gate immediately downstream of CC18. As much as 50% or more of inflow from the Original Trunk Sewer is diverted through CC18 to the Supplementary Trunk Sewer during the largest events in the typical year, while the remaining flow passes through the gate into the Original Trunk Sewer. CC18 is the last connection point in the trunk sewer system until the start of the twin barrel trunk sewer into the WWTF.

7.2.3 Combined Sewer Flow from the City of Elizabeth

The City of Elizabeth is a densely populated urban area with high levels of impervious cover. The typical peak runoff response from similar urban areas is often very fast, usually much less than an hour after the rainfall peak. Moreover, the City of Elizabeth sewer service area is located immediately northeast of the WWTF, and the TAPS discharge connects to the JMEUC trunk sewer system immediately (roughly 1300 feet) upstream of the headworks. Combined flow from the City of Elizabeth therefore reaches the WWTF very quickly. In contrast, the large separate sanitary sewer area serviced by the WWTF stretches over 65 square miles, and the trunk sewer collects flow from local sewer systems that tie into the trunk sewers as much as roughly 16 miles from the plant.

The peak rainfall response time of the separate sewer service area has a travel time on the order of 2.5 hours. The TAPS time to peak is around 30 minutes after a rainfall event begins. Figure 7-20 illustrates this difference in travel time between TAPS inflow and the flow from the separate sanitary sewer portions of the JMEUC service area. As a result, flow at the WWTF headworks is also observed to peak roughly 2.5 hours after the start of a rainfall event. The difference in peak timing could enable additional flow from TAPS to be pumped during this roughly two-hour window before the peak of the upstream flow reaches the plant, thereby increasing the flow delivered from TAPS without increasing the peak flow rate at the WWTF from the event. Additionally, evaluation of the JMEUC trunk sewers and WWTF have shown that these facilities have sufficient capacity to accept additional flow during and after the peak flow rate is reached (i.e. can accommodate higher peak flow rates), further increasing the combined sewer flow from TAPS treated at the WWTF during wet weather. This opportunity will be evaluated in the forthcoming evaluation of CSO control alternatives, and further information is provided below in Section 7.3.2.

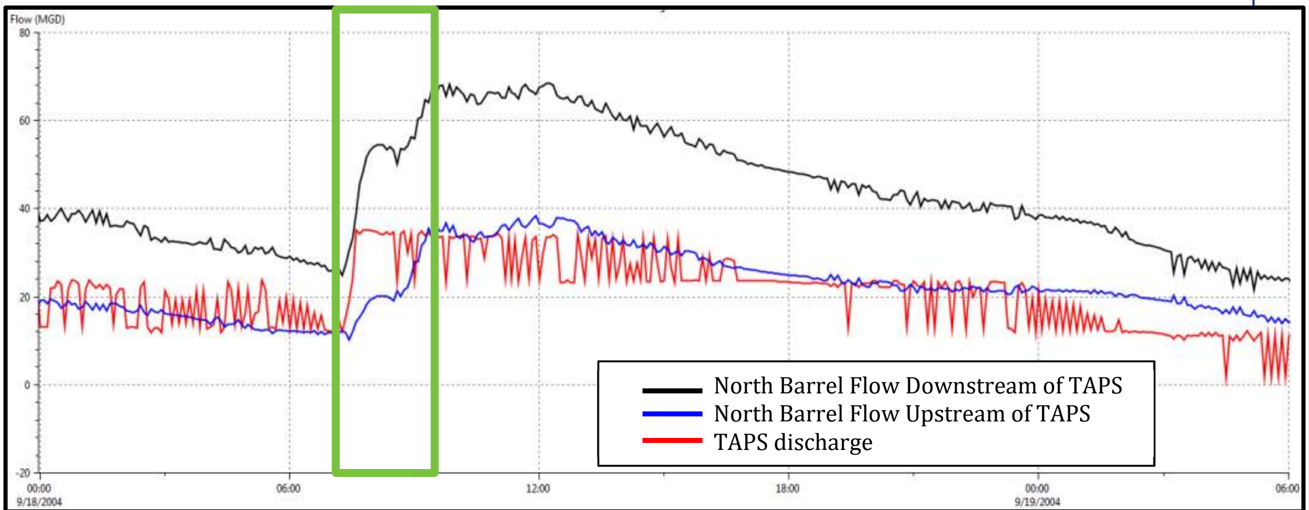


Figure 7-20 Peak flow timing for the Elizabeth combined sewer system and for the upstream sanitary sewer portions of the JMEUC trunk sewer system

7.3 Characterization of Key System Impacts

The combined sewer flow from the City of Elizabeth and the separate sewer response from the remaining (sanitary sewer) portions of the JMEUC service area are two distinctive wet weather inflow sources to the system. This section explores individually the impacts to the system and at the WWTF from potential changes in each. Further analysis will be part of the alternatives evaluation in the next phase of the LTCP.

7.3.1 Impact of RDII Reduction

The potential impact of RDII reduction in separate sewer areas upstream of the trunk sewers was evaluated. For evaluation purposes, the wet weather system response was simulated using a 50% reduction in the RDII parameters. This level of reduction is considered the maximum attainable RDII reduction system-wide across the JMEUC system. In other words, higher levels of reduction may be possible in certain smaller areas, but national experience has shown that a system-wide reduction exceeding 50% is extremely unlikely for a system of this size, especially considering that relatively significant RDII reductions have already been achieved (see Section 9.3.1).

This RDII reduction scenario was implemented in the Baseline Merged Model by reducing the unit hydrograph values of R1, R2, and R3 by 50%. The resulting flows at the WWTF for the 4/12/2004 and 9/28/2004 events are presented in Figure 7-22 and Figure 7-23. In both events, a system-wide 50% reduction in RDII produced a 15% to 20% reduction in peak flow rate and a 12% to 14% reduction in RDII volume.

Maximum system surcharge was also evaluated under the same RDII reduction scenario. As shown in Figure 7-21, all wet weather surcharge in the 2004 typical year is eliminated through RDII reduction. Only two small sections within the system remain surcharged in the simulations, which is consistent with Segments #1 and #2 shown in the dry weather condition system surcharging map (see Figure 7-2).

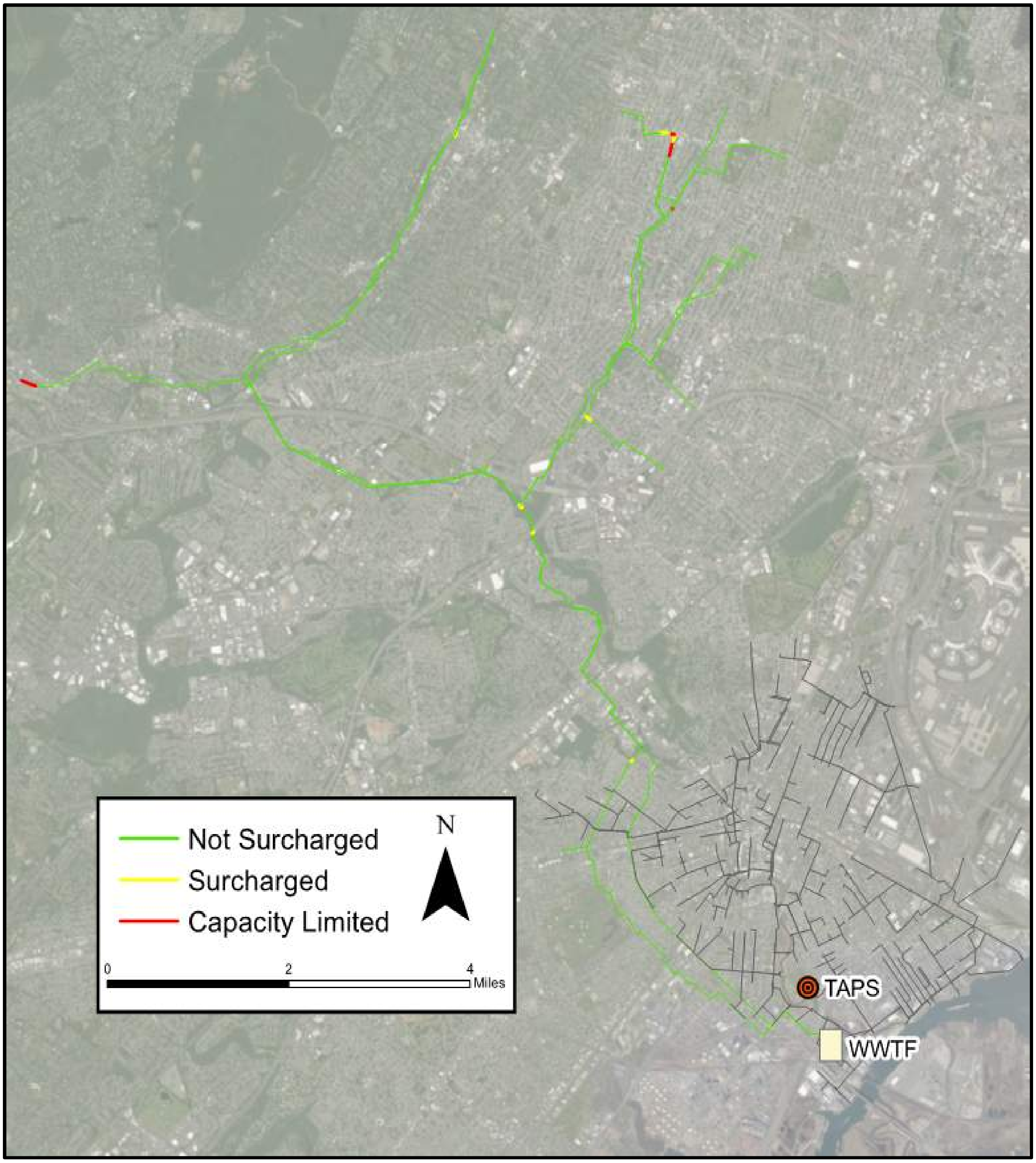


Figure 7-21 Maximum Surcharge State in 2004 Typical Year with System Wide 50% RDII Reduction

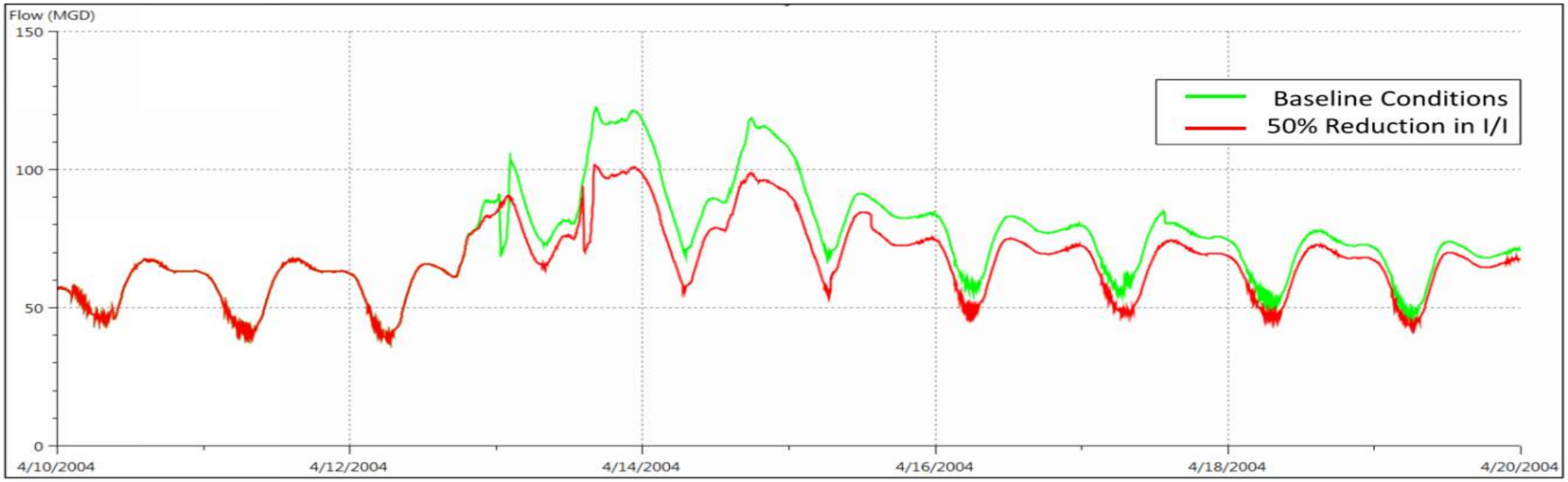


Figure 7-22 Comparison of Simulated WWTF (Primary Effluent) Flow Rate with 50% System Wide RDII Reduction (April 2004)

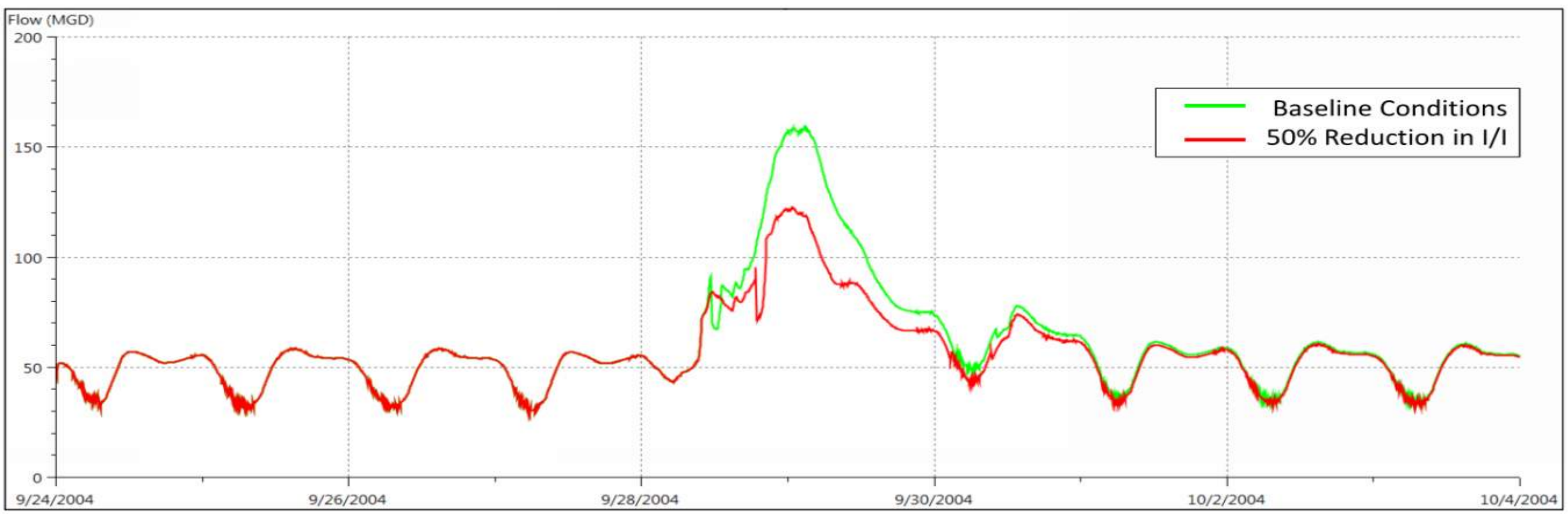


Figure 7-23 Comparison of Simulated WWTF (Primary Effluent) Flow Rate with 50% System Wide RDII Reduction (September 2004)

7.3.2 Impact of Increased Flow from TAPS

Currently, the TAPS is being operated during wet weather with a maximum pumping rate at the contractual peak flow limit of 36 mgd. Previous studies of the pump station capacity (the City of Elizabeth CSO Long Term Control Plan – Cost & Performance Analysis Report, Volume 1; March 2007; pg.6) suggested that the existing pumps at the TAPS have a total capacity of 55 mgd (peak pumping rate). The impact of this additional flow on system capacity and performance, without any other modifications to the existing system, has been initially explored. Additional evaluations may be performed as part of the forthcoming evaluation of alternative CSO controls in the next phase of the LTCP process. This may include the potential use of real time controls (RTCs) to take advantage of the peak timing difference and coordinate the concurrent operations of the TAPS and WWTF facilities to maximize WWF capture for treatment.

To increase the simulated pump capacity from 36 to 55 mgd in the model, modifications were made to the City of Elizabeth portion of the merged model by increasing pump capacity as well as enlarging gates at the TAPS headworks. The simulated peak flow from TAPS before and after the modifications are shown in Figure 7-24 for the 9/28/2004 event. Figure 7-25 demonstrates the differences in simulated flow at the WWTF (using the primary effluent flow rate) resulting from an increase in TAPS discharge to 55 mgd.

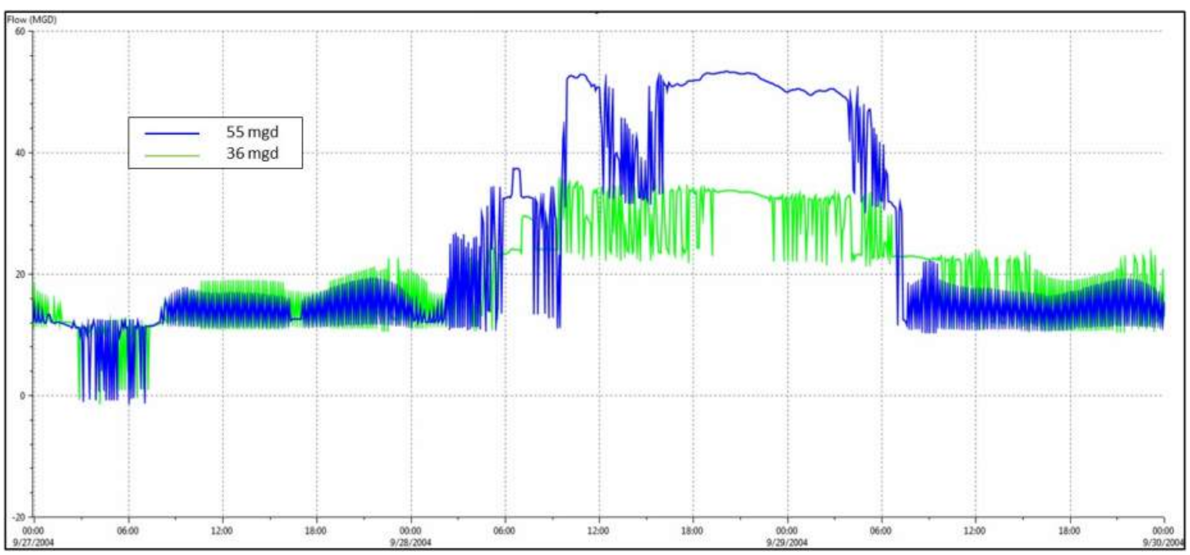


Figure 7-24 Comparison of Simulated TAPS Discharge at Higher Pumping Rate

The additional 19 mgd in peak flow rate from TAPS increases the HGL in both barrels of the twin barrel trunk sewer. Simulations have shown this HGL increase extends roughly one mile upstream in both the Original and Supplementary Trunk Sewers, as can be seen in Figure 7-26. Downstream of the TAPS, the effect of additional flow is only seen at the headworks of the WWTF. The HGL through the primary treatment train of the WWTF is largely controlled by the primary settling tank effluent weirs, which have ample length to pass the additional TAPS flow without a significant increase in HGL through the WWTF.

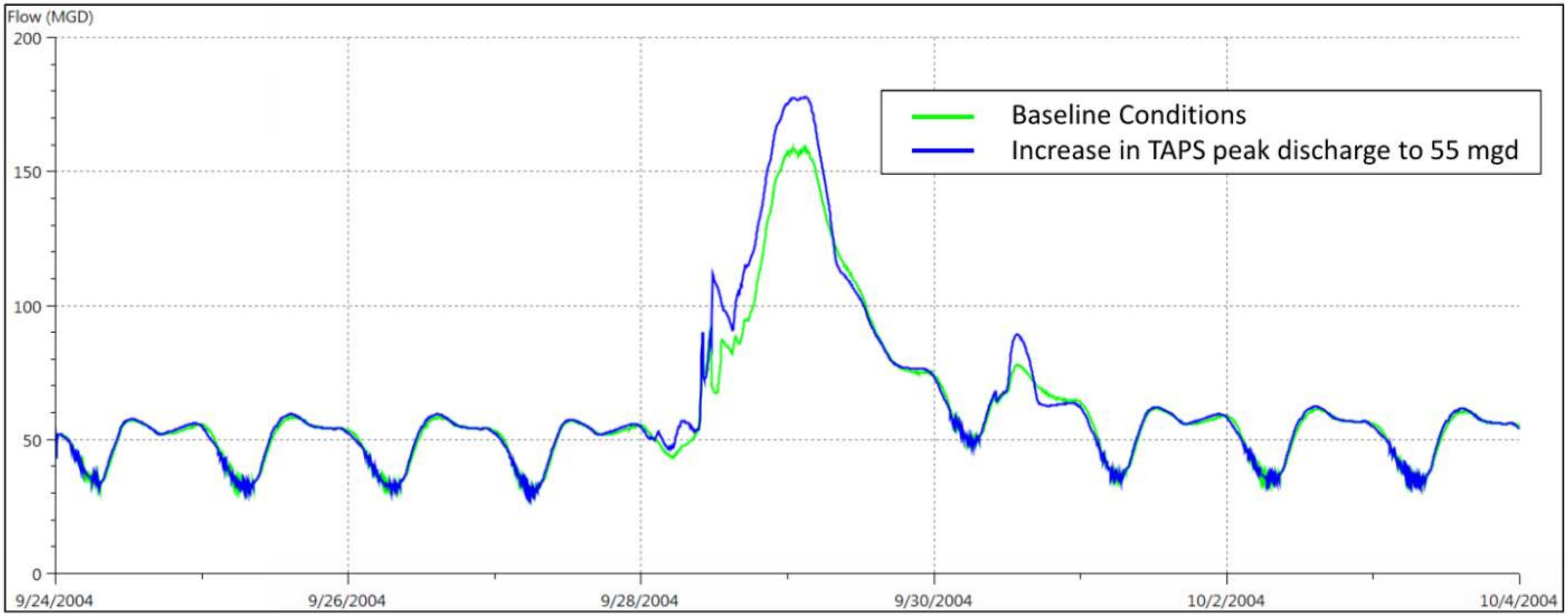


Figure 7-25 Simulated WWTF (Primary Effluent) Flow Rate with Increased TAPS Discharges

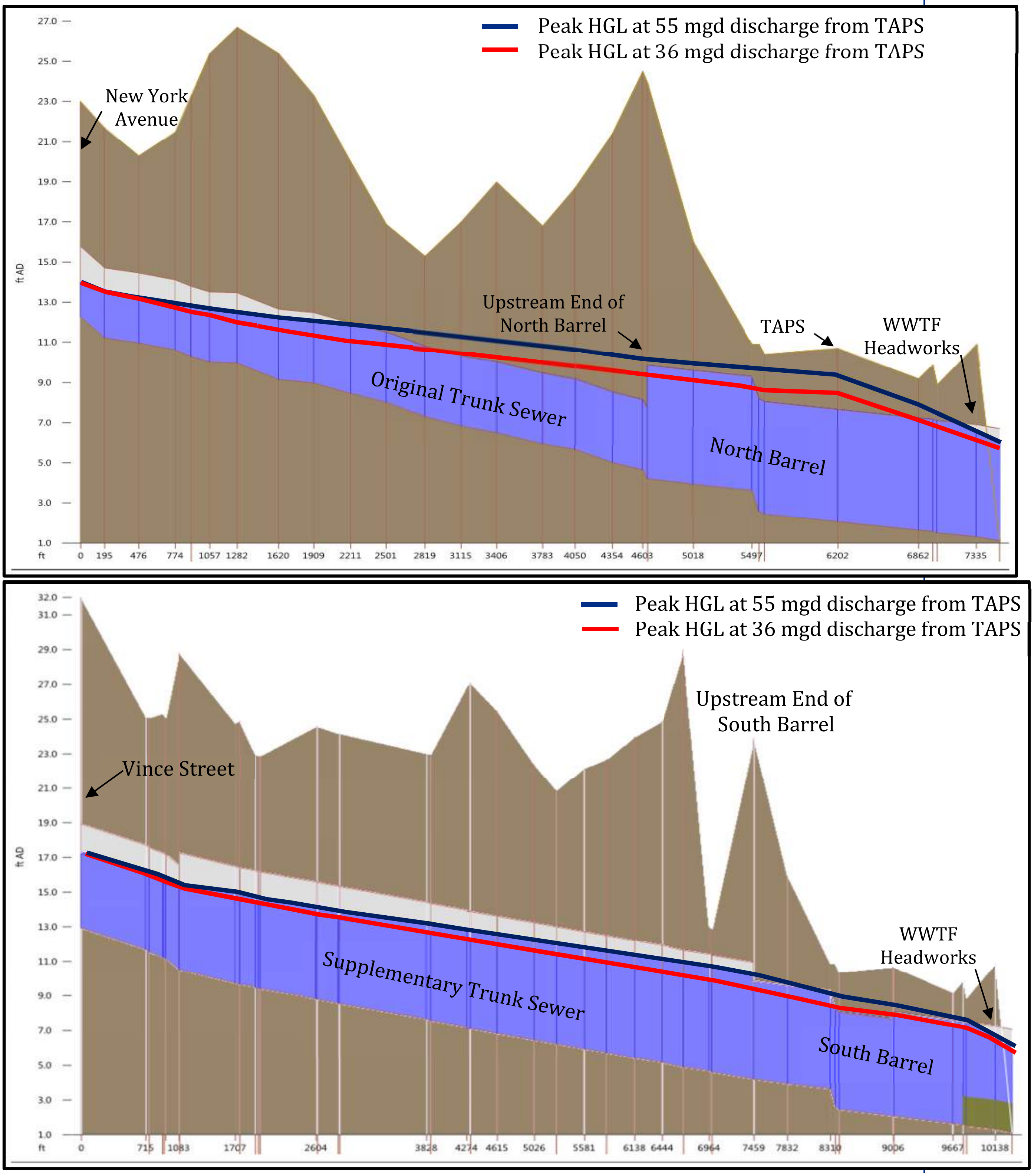


Figure 7-26 Comparison of Peak HGL along the Trunk Sewers (September 28, 2004 Storm)

Section 8

Characterization of System Performance – Wastewater Treatment Plant

The JMEUC owns and operates the Edward P. Decker Secondary Wastewater Treatment Facility (WWTF) located in the City of Elizabeth, New Jersey. The WWTF is an 85 MGD activated sludge treatment facility owned by a partnership of eleven municipalities, which has also served four customer municipalities, since 1898. The secondary treatment process effluent discharges into the Arthur Kill, a tidally influenced surface waterway.

Historically, the plant has always been operated as a conventional aeration process, but it may also be operated in a step aeration mode. The raw wastewater enters the plant headworks by gravity and passes through influent screens (both coarse and fine mechanically-cleaned screens) and then flows through four parallel grit chambers. After grit removal flow is gravity fed to four primary settling tanks, two of which are continuously in service while the third is reserved for use during high-rate (wet weather) flow conditions and the fourth is held in reserve for emergency storage during power failure.

The primary treatment process effluent flows by gravity to the main pumping facility, where the wastewater is pumped to four parallel, dual-pass surface aeration tanks. From aeration, the wastewater is gravity fed to four secondary clarifiers that have been equipped with Stamford Baffles. The wastewater is then disinfected with sodium hypochlorite, and dechlorinated with sodium bisulfite prior to discharge into the Arthur Kill.

The primary sludge is screened to remove grit and other large solids. The waste activated sludge (WAS) is pumped to four thickener tanks; the partially thickened WAS is thickened further using gravity belt thickeners. The screened primary sludge and thickened WAS is pumped to four primary digesters, where anaerobic digestion is used to stabilize the sludge. From the digesters the sludge is pumped through screens to remove debris prior to two sludge storage tanks and then on to the dewatering facility where it is dewatered using three centrifuges. After dewatering, the sludge is loaded into trucks for composting and land application.

Table 8-1 presents the NJPDES permit limits for the JMEUC WWTF. The next section of this report provides more detailed information about the individual plant processes and the characteristics of each unit in the treatment train. Figure 8-1depicts the layout of the JMEUC WWTF.

Table 8-1 NJPDES Permit Limits for the JMEUC WWTF

Parameter	Effluent Limitation		
	Percent Removal	Concentration	Mass Loading[1]
5-day Carbonaceous Biological Oxygen Demand ($cBOD_5$), monthly average	85%	25 mg/l	7,100 kg/day
$cBOD_5$, weekly average	---	40 mg/l	11,355 kg/day
Total Suspended Solids (TSS), monthly average	85%	30 mg/l	8,519 kg/day
TSS, weekly average	---	45 mg/l	12,779 kg/day
Oil & Grease, monthly average	---	10 mg/l	---
Oil & Grease, weekly average	---	15 mg/l	---
pH	---	6.0 to 9.0 SU	---
Fecal Coliform, Monthly Geometric Average	---	200/100 ml	---
Fecal Coliform, Weekly Geometric Average	---	400/100 ml	---
Chlorine Produced Oxidants, Monthly Average	---	0.062 mg/l	17.6 kg/day
Chlorine Produced Oxidants, Daily Maximum	---	0.088 mg/l	25.0 kg/day
Dissolved Oxygen, Minimum Weekly Average	---	4.0 mg/l	---
Nickel, Total Recoverable, Daily Maximum	---	0.02 mg/l	5.8 kg/day
Silver, Total Recoverable, Daily Maximum	---	0.01 mg/l	2.8 kg/day
Zinc, Total Recoverable, Monthly average	---	0.39 mg/l	128 kg/day
Zinc, Total Recoverable, Daily Maximum	---	0.78 mg/l	236 kg/day
Lead, Total Recoverable, Monthly Average	---	0.13 mg/l	36.9 kg/day
Lead, Total Recoverable, Daily Maximum	---	0.24 mg/l	68.1 kg/day
Copper, Total Recoverable, Daily Maximum	---	45.8 ug/l	13 kg/day
Mercury, Total (as Hg), Monthly average	---	0.40 ug/l	114 g/day

Notes:
[1] – Effluent mass loading values based on a flow rate of 75 mgd.

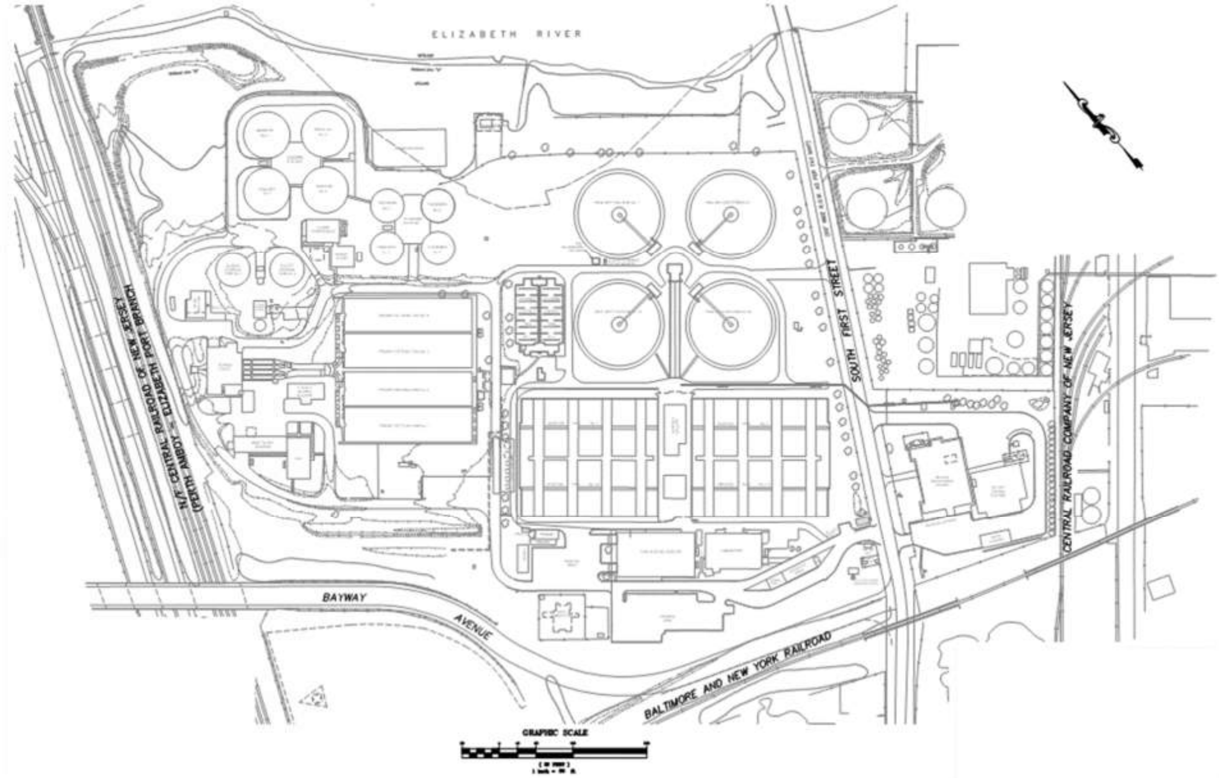


Figure 8-1 Plant Layout - JMEUC Wastewater Treatment Facility

8.1 Existing Hydraulic Capacity and Treatment Performance

Table 8-2 presents the existing average influent and effluent data for the JMEUC facility. These data were taken from the JMEUC March 2007 *Long Term Control Plan, Cost and Performance Analysis Report* and are used here as plant influent and effluent conditions have not changed significantly since that time.

Table 8-2 Existing Average Influent and Effluent Data

Parameter	Average Influent	Average Effluent
Flow, mgd	66.5	66.5
Temperature, degrees Celsius	18.6	NA
Total Suspended Solids (TSS), mg/L	155	13.6
Volatile Suspended Solids (VSS), mg/L	84.8	NA
Biochemical Oxygen Demand (BOD), mg/L	190.1	15.9
Carbonaceous Biochemical Oxygen Demand (cBOD), mg/L	161.7	9.8
Ammonia (NH_3), mg/L	16.1	16.9

Flows at the WWTF increase significantly during wet weather. Table 8-3 presents the existing average wet weather influent and effluent data for the JMEUC facility. As with Table 8-2 above, these data were taken from the JMEUC March 2007 *Long Term Control Plan, Cost and Performance*

Analysis Report and are used here as plant influent and effluent conditions during wet weather have also not changed significantly since that time.

Table 8-3 Existing Average Wet Weather Influent and Effluent Data

Parameter	Wet Weather Average Influent	Wet Weather Average Effluent
Flow, mgd	126	126
Temperature, degrees Celsius	18.6	NA
Total Suspended Solids (TSS), mg/L	104	25.5
Volatile Suspended Solids (VSS), mg/L	81.2	20.0
Biochemical Oxygen Demand (BOD), mg/L	96.1	21.3
Carbonaceous Biochemical Oxygen Demand (cBOD), mg/L	78.6	15.3
Ammonia (NH_3), mg/L	7.9	9.9

The JMEUC facility continues to meet the existing effluent permit limits, even with the large wet weather events.

During development of the 2007 CSO Long Term Control Plan, each unit process in the liquid treatment train was evaluated to determine its capacity. The physical WWTF facilities and plant influent flow conditions have not changed significantly since that time and the results of this evaluation are therefore considered valid and presented below.

8.1.1 Preliminary Treatment

Preliminary treatment consists of coarse mechanical bar screens followed by fine mechanical bar screens followed by long rectangular gravity grit tanks. The screens are installed in two 12 foot wide parallel influent channels which split into four 9.5 foot wide channels for grit removal.

Coarse screens have 3.5 inch clear openings, and fine screens have 0.75 inch clear openings. The hydraulic capacity of clean screens is 220 mgd with 0.2 feet of combined head loss. Grit channels are 9.5 feet wide by seven feet deep by 57 feet long and have a hydraulic capacity of over 220 mgd. The channel geometry is unconventional, however based on fall velocities of coarse sand (medium grit) approximately 70 percent removal of medium grit can be expected at 220 mgd.

8.1.2 Primary Settling Tanks (PSTs)

There are four rectangular PSTs; each 200 feet long, by 75 feet wide by 13.8 feet deep. Based on the recommended peak hour hydraulic loading rate of primary clarifiers from 10 State Standards of 1,500 to 3,000 gallon per day per square foot, the primary settling tanks (PSTs) should be able to treat between 126 to 252 mgd. However, based on facility data, with three units in service, the PSTs perform poorly at hydraulic loading rates at the higher end of the recommended range. Therefore, a hydraulic loading rate of 1,500 gallons per day per square foot (gpd/sq. ft.) was used to determine the capacity of the PSTs. Based on this hydraulic loading rate, with all four units in service, the facility has primary treatment capacity of 126 mgd. However, experience during periods of higher peak flow rates has shown that the PSTs are capable of performing adequately at rates well above this theoretical capacity.

8.1.3 Aeration Capacity

There are four aeration tanks, each with a volume of approximately 3.97 million gallons (total volume of 15.89 million gallons). Each aeration tank has eight surface aerators rated at 100 horsepower and are capable of providing a maximum of 2,360 lb/hour of oxygen per tank. Two of the four aeration tanks aerators are two speed manual operation. In 2015 the aerators in two aeration tanks were upgraded to operate via variable frequency driven 100 horsepower motors and remotely from programmable logic controllers (PLCs) based on dissolved oxygen concentrations in the aeration tanks. Based on NJAC regulations of 38 lbs of cBOD per 1,000 cubic feet of volume; the four aeration tanks can treat a maximum of 80,712 lb/day of cBOD. The facility re-rating report (Hazen and Sawyer, P.C., June 1990) indicates that the existing aeration tanks are capable of treating 180 mgd.

Effluent flows from the aeration tanks enter four final settling tanks (FSTs), each having a diameter of 180 feet and a depth of 15 feet. FST effluent flows are disinfected with sodium hypochlorite in a chlorine contact tank capable of treating a peak hour flow of 73 mgd at the required contact time of 20 minutes. The disinfected effluent is then dechlorinated with sodium bisulfate before being discharged to the Arthur Kill through two outfall conduits.

8.1.4 Final Settling Tanks (FSTs)

There are four FSTs, each with a diameter of 180 feet and depth of 15 feet. Based on the recommended peak hour hydraulic loading rate of secondary clarifiers from 10 State Standards of 1,200 gpd/sq. ft., the FSTs can adequately treat 122 mgd. However, experience during periods of higher peak flow rates has shown that the FSTs are capable of performing adequately at rates well above this theoretical capacity

8.1.5 Chlorine Contact Tanks

Based on the required contact time at peak hour flow rate of 20 minutes from N.J.A.C. 7:14A-23.23(c), the existing chlorine contact tank volume is sufficient to treat a peak hour flow of 73 mgd. At this capacity, the plant can consistently achieve the permit limits for bacteria (fecal coliform; see Table 8-1).

8.1.6 Hydraulic Capacity

In addition to treatment process limitations, the plant was evaluated for hydraulic limitations. Though the plant is hydraulically rated for 180 to 220 mgd based on the tide elevation at the outfall, some known hydraulic problems exist at high WWF's. The relationship between tidal conditions and plant performance has been studied extensively, and this information is presented in Section 8.2.

8.1.6.1 Final Settling Tanks (FSTs)

FST Nos. 2 and 2A are significantly farther from the post chlorination chamber than the other two final settling tanks. During high flow events, this can cause the secondary effluent to backup into FST Nos. 2 and 2A effluent troughs, flooding the weirs. This problem has been observed to occur at flows greater than 180 mgd, when tides exceed six feet above mean sea level (msl).

8.1.6.2 Outfall – High/Low Tide

The JMEUC facility discharges to the Arthur Kill, a tidal water body through a twin-barrel outfall structure. Each barrel is a 7’3” (width) by 6’3” (height) box-shaped conduit. The twin-barrel outfall was originally designed with one barrel designated for secondary effluent and the second barrel for primary effluent. The flow rate of the facility is limited at high tide due to the weir elevation of the chlorine contact tanks and FSTs. At tide elevations greater than eight feet above mean sea level, the facility can only discharge 120 mgd. A value of eight feet above sea level corresponds to a 13-year storm. At tides less than six feet above mean sea level (corresponding to a one year recurrence interval), the hydraulic capacity of the facility is 180 mgd. The mean high tide for the Arthur Kill is approximately 2.5 feet above mean sea level. Therefore, the hydraulic capacity of the facility actually decreases during large wet weather events due to the tidal elevation of the Arthur Kill (see Section 8.2).

8.1.7 Current Solids Handling

The facility has 1.2 mgd of primary sludge pumping capacity, 24 mgd of waste sludge pumping capacity, and 33 mgd of return sludge pumping capacity. Primary and waste activated sludge (WAS) are thickened using four gravity thickeners. From the gravity thickeners the sludge is pumped to two of three existing gravity belt thickeners. The thickened sludge is then fed to four primary anaerobic digesters. From the four primary digesters the sludge is transferred through screening devices to two sludge storage tanks before being pumped to the dewatering facility. At the dewatering facility, digested sludge is dewatered by centrifuge. The centrifuge cake is hauled offsite for pathogen and vector attraction reduction in accordance with USEPA 503 Regulations via composting; the composted material is ultimately land applied as a fertilizer and soil conditioner.

8.1.7.1 Gravity Thickeners

There are four gravity thickeners, each with a diameter of 65 feet and side water depth of 10 feet. Based on the recommended (M&E, Wastewater Engineering, 2003) maximum hydraulic loading rate of gravity thickeners processing combined waste and primary sludge of 300 gpd/sq ft and a maximum solids loading rate of 16 lb/sq ft/d, the gravity thickeners can adequately treat 3.98 mgd and 212,400 lb/d of sludge.

8.1.7.2 Gravity Belt Thickeners

There are three two-meter gravity belt thickeners used for thickening WAS and primary sludge prior to digestion. Based on the recommended (M&E, Wastewater Engineering, 2003) maximum hydraulic loading rate of gravity thickeners of 200 gpm/meter, each GBT can process 0.576 mgd of sludge. Based on a conservative maximum solids loading rate of 900 lb/hr/meter the GBTs can process 129,600 lb/d of sludge.

8.1.7.3 Primary Digesters

There are four primary digesters, each with a diameter of 95 ft and side water depth of 33.5 ft. Based on a solids retention time of 17 days and a loading rate of 200 lb volatile suspended solids (VSS)/1000 cu ft/d, the primary digesters can adequately treat a maximum month sludge flow of 0.42 mgd of sludge and 190,000 lb/d of VSS.

8.1.8 Electric Service Capacity

Additional treatment capacity generally requires additional power. The current peak demand load for the JMEUC facility is approximately 3,900 kilowatts (KW). The assumed power factor is 88 percent and the peak kilovolt-ampere (KVA) demand of 4,400 KVA. New proposed loads will be connected to the 5KV transformers that serve the main switchgear. These transformers have a maximum rating of 5,250 KVA using forced air cooling. Under normal operating conditions the facility is powered by both utility services and both main transformers. There is a power take-off at the 26 KV bus for the Dewatering and Drying Facilities. These take-offs do not burden the main transformers. Switching provisions are provided that allow one utility service to power both main transformers. As a result the only time the facility relies on a single main transformer is if a main transformer fails or during periods of maintenance. The primary source of power to the treatment plant is from four co-generators of 800 kW capacity each. Three units are normally on line at any given time fueled by either digester gas or natural gas.

After reviewing the number and size of the transformers connected to the facility and the number and size of the main pumps, it was assumed that the power system diversity was 65 percent. As such, it was assumed the main transformers carry approximately 2,800 KVA. For a safety margin, the assumed load was increased by 25 percent and it was assumed that the peak load on a single transformer can be as high as 3,500 KVA. In addition, it is not recommended that the facility be operated for long periods of time at 5,250 KVA. Therefore, it is not recommended that the facility be operated at more than 90 percent of the forced air cooled rating and the total connected load should be limited to 4,700 KVA. It is assumed that there is 1,200 KVA of spare capacity within a transformer. Options that have operating loads of 1,200 KVA or less will utilize the spare capacity in the transformer. There are means available (power factor correction) that will free up transformer capacity and allow the load to grow to 1,350 KVA.

8.1.9 Land Availability

Limited space is available for expansion at the JMEUC facility site. Though some unused land exists on the JMEUC property southwest of the primary clarifiers, northwest of the sludge storage tanks and northwest of the final settling takes, much of the remaining property is either in the flood plain or classified as Wetlands. Therefore, it may be necessary to purchase more land near the existing facility in order to implement any LTCP alternatives that would involve providing additional treatment capacity at the WWTF.

8.2 Limitations on Treatment Capacity

8.2.1 Historical By-Pass Operations

The JMEUC serves 15 municipalities, and is therefore subject to a variety of waste streams, i.e. sanitary, industrial and storm flows, as well as a variety of weather related and environmental factors. Historically, wet weather has impacted the hydraulic load of the plant, necessitating controlled bypasses to deal with these elevated flows. When the influent flow reached 120 mgd, the secondary treatment bypass conduit to the Arthur Kill was utilized to allow excess flow to be discharged following primary treatment and disinfection. These controlled bypasses were implemented based on the USEPA's CSO Guidance for Nine Minimum Controls, and the original secondary biological treatment design capacity of 120 mgd.

During wet weather events resulting in flows greater than 120 mgd, if operators observed significant solids loss from the secondary clarifiers a controlled bypass was implemented to avoid biomass washout and minimized any damage to facility equipment. In a roughly three-year period during 2001-2004, there were 10 controlled by-pass events that were implemented under the USEPA's CSO Guidance for Nine Minimum Controls. In response to the proposed EPA blending policy in 2005, and a desire to better manage WWF's, the JMEUC studied a variety of hydraulic, process control and maintenance options to reduce the need for bypasses, and to ensure that any future bypasses would meet or exceed the proposed blending policy.

These 2005 studies took into account the following issues:

- Hydraulic constraints of the plant, including tidal fluctuations of the Arthur Kill.
- Biological treatment capacity of the plant utilizing ten years of monitoring data.
- Impact of Stamford Baffles on effluent quality during WWF.

8.2.2 Short Term Actions Implemented to Address Storm-flow Bypass Issues

In order to reduce the number of bypass events during WWF, the JMEUC instituted a new operational protocol in 2005 to utilize existing processes and tankage to better handle the overwhelming hydraulic load imposed during wet weather. The protocol is implemented when the flow exceeds 100 mgd and the solids begin to build-up in the secondary clarifiers. The protocol involves putting online the reserve primary settling basin for use as a surge tank.

Additionally, the aerators in the second pass of each aeration tank are shut down to store solids and reduce solids loading on the secondary clarifiers. These actions were employed successfully during storm events in 2005, without violating the discharge permit.

8.2.3 Long-Term Actions to Address Stormflow Bypasses

Hydraulic studies were performed during 2005 and determined that the hydraulic capacity of the JMEUC WWTF is impacted by the tidal fluctuation of the Arthur Kill. These studies indicate the majority of the bypass events that occurred prior to the new WWF protocol was instituted, were performed prematurely. Figure 8-2 shows the flow capacity of the plant as a function of tidal elevation. The Arthur Kill can reach a critical elevation of +6 ft, and at this elevation the plant can hydraulically convey 180 mgd through secondary treatment. Above this critical elevation, the hydraulic capacity of the plant is reduced. The maximum tide and critical tide levels are highlighted in red, and the corresponding plant flow rate is highlighted in yellow.

Hydraulically the plant was considered able to handle WWF of 180 mgd, before emergency storage, bypass or blending was needed. In addition, flow balance was performed on the plant to determine the fraction of total influent flow that would need to be bypassed as a function of the hydraulic capacity of the entire plant based on the Arthur Kill tidal elevation. Figure 8-3 is an example of one of the flow balance curves. These curves can be used in conjunction with a remote tide elevation monitor located near the outfall to determine the amount of flow the plant should be able to hydraulically handle during specific wet weather events.

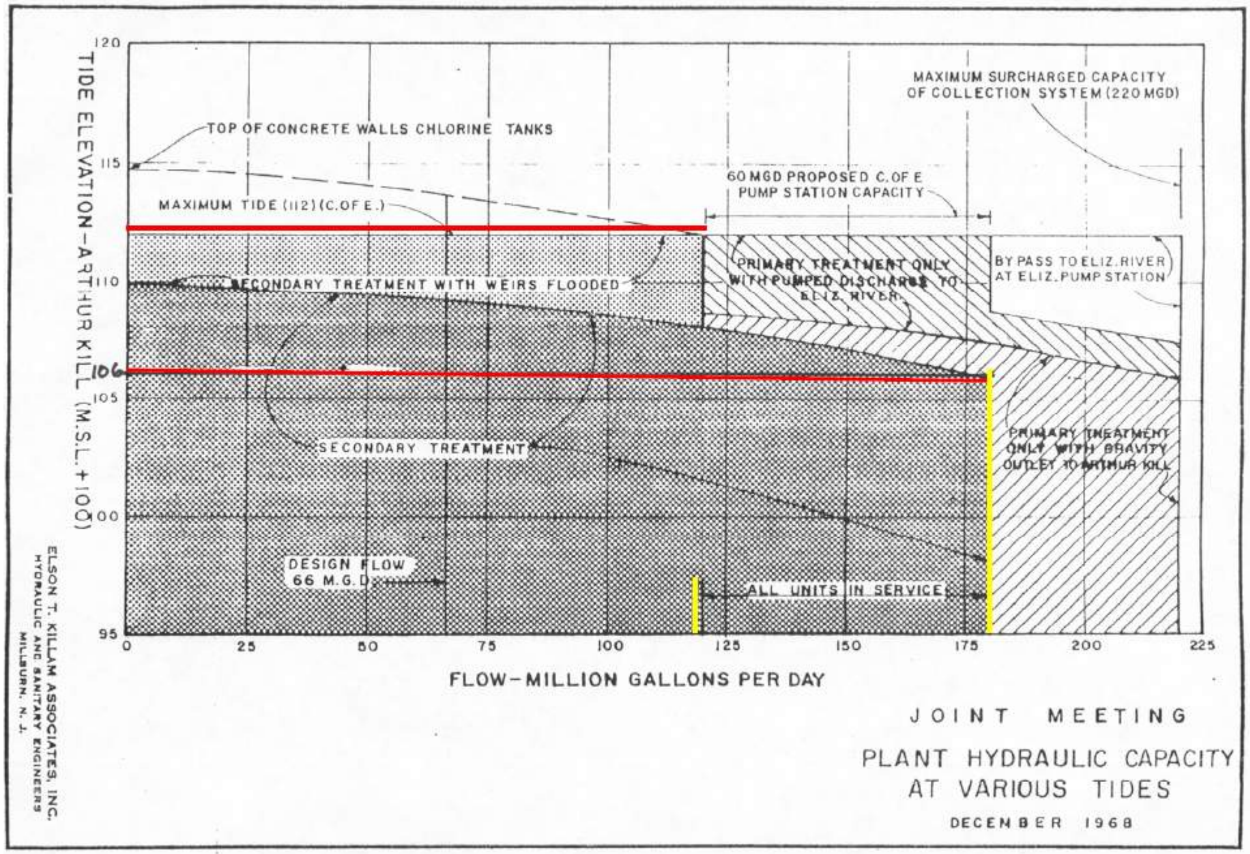


Figure 8-2 Flow and Plant Operation as a Function of Receiving Water Tidal Elevation

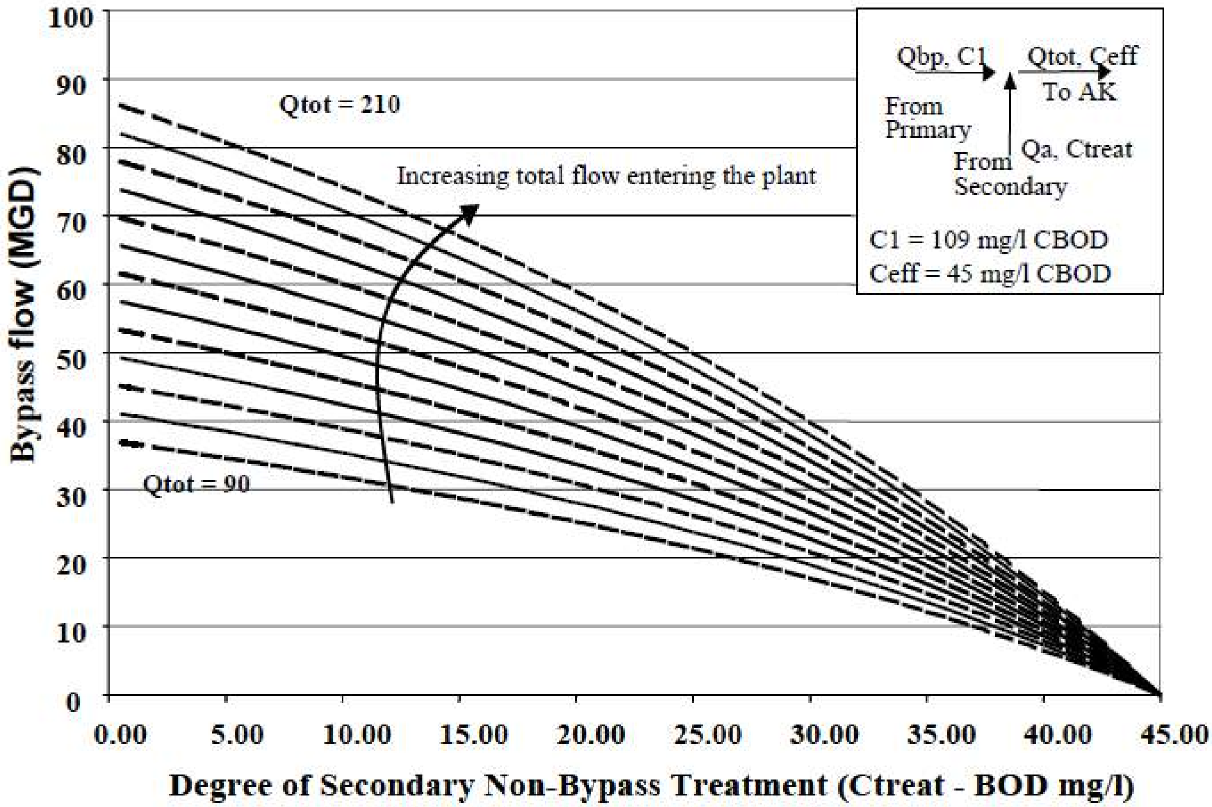


Figure 8-3 Bypass and Total Flow Balance for 45 mg/L CBOD Effluent Concentration

Although the JMEUC plant can hydraulically handle 180 mgd, a computer model of the treatment process (BIOWIN®) was used during the 2005 studies to determine the biological treatment capacity of the system and the resulting solids loadings on the secondary clarifiers. The purpose was to determine the maximum flow that could be treated, while still meeting the effluent concentrations of 45 mg/L CBOD and 45 mg/L TSS. The model was calibrated using data provided by the JMEUC. Partial results of the modeling effort are shown in Figure 8-4.

The model indicated that the plant could treat in excess of 200 mgd and still meet the 45mg/L CBOD (excluding effluent TSS), even when operating under the new storm flow protocol. However, under high flow conditions the solids loading capacity of the secondary clarifiers becomes the controlling factor. Typical clarifiers would allow only about 115 mgd under the storm flow protocol, while the clarifiers equipped with Stamford baffles (assuming 25% increase in capacity per industry literature) can handle approximately 140 mgd. This indicates that the storm protocol would allow the plant to handle at least 140 mgd prior to implementing a bypass.

Similarly, the hydraulic surface loading on the clarifiers also becomes limiting at flows greater than 150 mgd. Other biological modeling results showed that solids loading became a less controlling factor when influent BOD is diluted and/or step aeration is implemented prior. These numbers are conservative, as the model uses BOD and not CBOD, and the increase in capacity provided by Stamford Baffles was found to be significantly greater than 25% under peak flow conditions.

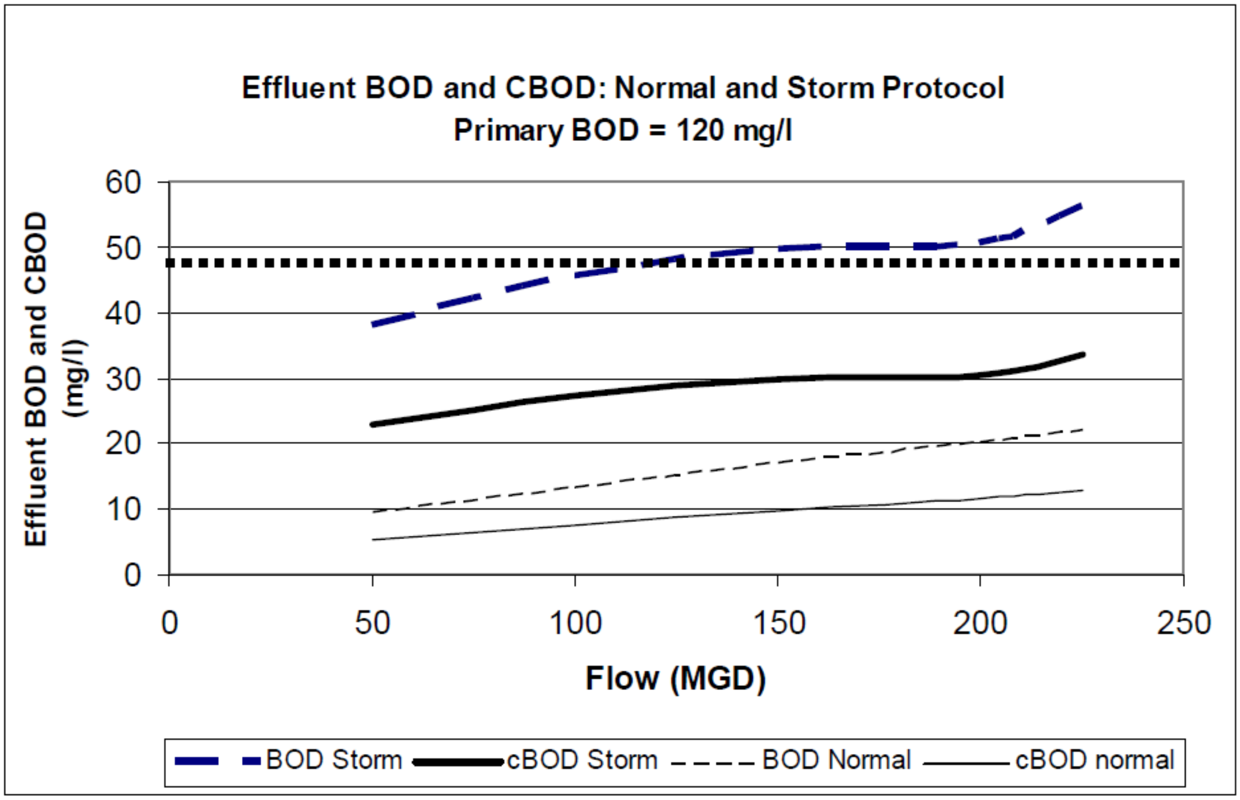


Figure 8-4 Effluent BOD and CBOD Concentrations During Normal and Storm Flow Protocols

The end result of the 2005 studies was the establishment of a technically sound and cost effective wet weather management plan for WWTF operation that incorporates the hydraulic and treatment limitations of the existing plant to eliminate the great majority of bypass events. WWTF performance since 2005 has shown that the plant processes can successfully operate during wet weather events under the current sewer system flows and conditions, effectively eliminating the need to bypass secondary treatment and continue to meet effluent discharge limitations.

8.2.4 Current Wet Weather Plant Operations

The JMEUC maintains a detailed written procedure for wet weather plant operations (Procedure for Storm Flow Operation – November 26, 2013; see Appendix K), which is only briefly summarized here. This procedure uses flow rate measured at the point immediately downstream of the Main Sewage Pumps before flow enters the aeration basins as the critical metric for operating decisions; references to "plant flow rate" refer to this measurement. It should be noted that this flow rate includes recirculation flow that is returned to secondary treatment, therefore this rate is 7-10 mgd higher than final effluent discharge rates.

The objectives of the procedure are to ensure that:

- All flow entering the plant headworks passes through screening,
- All primary effluent passes through secondary treatment,

- Bypassing of flow around secondary treatment is prevented,
- Solids washout from the final setting tanks does not occur; and
- An on-site spill condition is prevented.

Plant operation proceeds under normal operating procedures until plant flow rate reaches 100 mgd, at which point the storm flow operating procedures are invoked and the third PST is put into operation. Once the third PST is online, a third Main Sewage Pump is turned on to increase flow through secondary treatment. If necessary during the event, a fourth Main Sewage Pump will be turned on to further increase flow through secondary treatment.

At a plant flow rate of 120 mgd, additional gates controlling flow to secondary treatment are opened. Constant and extensive monitoring of the water levels in the various process tanks is undertaken to ensure that the plant is properly operated under the high flow conditions. If the weirs on the FSTs become submerged, or washout from the FSTs begin, then additional steps are taken to protect plant processes. At no point in the procedure is the secondary bypass gate to be opened without the direct order from one of four specifically identified senior JMEUC officials.

Section 9

Institutional Arrangements

The JMEUC was created by a special act of the New Jersey Legislature in 1898. Since its formation, the original six members have expanded to eleven members, and now also serves four customer communities. One of those customers is the City of Elizabeth, the largest municipality served by the JMEUC and the only combined sewer community in the JMEUC service area.

9.1 Roles and Responsibilities

9.1.1 Ownership of the Sewer Systems and Wastewater Treatment Facilities

The JMEUC owns and controls the WWTF and the trunk sewers that capture flow from the member and customer communities for delivery to and treatment at the WWTF. The member and customer communities own and control their respective sewer systems. These systems are upstream of and flow into the JMEUC trunk sewer system.

Flows into the JMEUC trunk sewers are closely monitored by the JMEUC, and costs to operate and maintain the JMEUC trunk sewers and WWTF facility are apportioned to the members and customers according to flow and pollutant loads (BOD and TSS). In the case of the members, costs are apportioned as required by the 1926 Contract of the JMEUC, under a user charge system established in 1978 pursuant to the construction grant for WWTF upgrades required under the Clean Water Act of 1972 (PL 92-500), as described below.

In the case of customer municipalities tributary to the member communities, costs are passed on to the customer by the member receiving the flow. For the City of Elizabeth, where flow is discharged directly to the JMEUC, there is a service agreement between the two parties. As noted earlier, the City of Elizabeth is a combined sewer community, and the terms of the agreement have direct impact on the performance of the City of Elizabeth combined sewer system, and could be important in process of planning CSO controls, thus the City of Elizabeth agreement is described in detail below.

9.2 Financial and Legal Controls

This section addresses the financial and legal controls available to the JMEUC that can be exercised by the JMEUC to control the wastewater flows during both dry and wet weather conditions that are delivered to the JMEUC WWTF. Because the only combined sewer system in the JMEUC service area is the City of Elizabeth, this section is divided into two sub-sections: one for the City of Elizabeth, and a second for the other communities served by the JMEUC.

9.3 The City of Elizabeth

Wastewater flows delivered to the JMEUC from the City of Elizabeth are controlled in a legal (as opposed to technical) manner by three legal agreements between the two parties. The original agreement was made in 1930, later expanded upon in 1981, and clarified in 2016. The key elements of these agreements, for purposes of this report, are as follows:

- 1930 contract – Established the flow limits that can be delivered to the JMEUC from the TAPS as 18 mgd during dry weather, and a peak flow rate of 36 mgd during wet weather.
- 1981 settlement agreement – Established the method of cost sharing by which the City of Elizabeth compensates the JMEUC for wastewater conveyance and treatment.
- 2016 settlement agreement – Summarizes and clarifies the 1981 settlement agreement.

These three agreements remain in force today and together constitute the entire understanding between the two parties as to their legal relationships.

9.4 Member and Other Customer Communities

The 1926 Contract of the Joint Meeting defines capacity limits on flow (in mgd) that can be discharged to the JMEUC by each member. Article X of the 1926 Contract established the requirement to apportion the costs to operate the JMEUC among the members. In 1978 the current method to do this was established, with a user charge system to apportion costs. The method used to calculate the cost contribution of each member under this user charge system is based on both flow and pollutant loads to apportion treatment costs. Under the current cost allocation roughly one-third of the basis is flow, and roughly two-thirds is pollutant load (allocated between BOD and TSS). Under the cost allocation method other costs are also assigned, including industrial flows and loads (which are distinguished from Domestic & Commercial) and I/I flows. An estimated allocation of cost is assigned to each member for each cost category.

I/I levels (in units of gallons per day) in each community have been tracked since 1982 and are updated annually to reflect I/I reduction projects completed each year. The JMEUC maintains a database of these I/I reduction projects completed by its members and documents the I/I benefits (as flow removed in gallons per day) in the JMEUC annual assessment reports.

Operating costs for the JMEUC are allocated to each member community with a calculation that includes I/I rates estimated for each community. Removal of both infiltration and inflow is estimated individually for each community annually based on the I/I reduction projects completed in the previous year. As a result of this process, cost allocations for I/I are updated annually. This method of cost allocation provides a strong incentive to each member community to address and reduce I/I in their respective sewer systems.

The JMEUC has also promulgated and published Rules and Regulations (current version dated June 17, 2010) that control the use of the sewers by the member and customer communities. This document controls many aspects of sewer system access, use and operations, including an offset program to implement I/I reduction, described in further detail below.

9.5 Implementation of the Nine Minimum Controls

The U.S.EPA's Combined Sewer Overflow Control Policy establishes nine broad operation and maintenance and minor construction best practices intended to ensure that a municipal permittee's combined sewer system is being optimized. The requirement to fully implement these nine CSO control measures is incorporated into Section F of the NJPDES Combined Sewer Management permits.

The JMEUC reports to NJDEP on a quarterly basis their progress with implementation of the Nine Minimum Controls (NMCs). As indicated on those reports, only three of the nine NMC provisions in Section F of the CSO permit apply to the JMEUC; specifically F.1 (operation and maintenance), F.4 (maximization of flow for treatment) and F.7 (pollution prevention).

The JMEUC has an ongoing O&M program for the interceptor sewer system, and has established standard operating procedures for flow maximization at the plant. These programs are well documented and the status reported to NJDEP quarterly in the progress reports. This section of the report will focus on I/I reduction measures under F1 and F.7.

The CSO permit requirements to address I/I reduction are included in Section F.1.h.ii, F.1.j.xii, and F.7.c; also under G.4.e.iv. The Section G requirement is for I/I control to be evaluated as a CSO control alternative in the LTCP, in the next phase of the CSO control program. As noted above, in this report I/I reduction measures under F.1 and F.7 are addressed. These permit requirements are summarized here as:

- **F.1.h.ii**: Review JMEUC rules, ordinances, and/or sewer use agreements and develop a schedule to require "customer municipalities" (in this case assumed to apply to both member and customer communities) to identify I/I and reduce it to meet the regulatory (N.J.A.C.) definitions of non-excessive infiltration and non-excessive inflow.
- **F.1.j.xii**: Ensure that JMEUC standard operating procedures address I/I reduction strategies as defined above.
- **F.7.c**: Similar to F.1.h.ii above, develop a schedule for revisions to rules, ordinances, and/or sewer use agreements.

The JMEUC understands that NJDEP is currently planning to amend the permit provisions of the CSO permittees under Sections F.1.h and F.7.c, but this report will nonetheless address the current rules and agreements as they relate to I/I reduction. The JMEUC also has an active I/I reduction program that addresses the requirements under F.1.j.xii, as described below.

9.5.1 JMEUC I/I Reduction Program

The JMEUC encourages its member municipalities to reduce I/I and provides significant resources to them in support of this program. This has been a decades long effort to address sources of I/I related to the age and condition of the collection system. The JMEUC member municipalities developed a phased approach to identify areas and specific sources of I/I through development of Sewer System Evaluation Survey (SSES) studies. The SSES reports were organized by community (a unique study was conducted for each member) and provided to the communities for their use in addressing I/I. A detailed listing of these reports and associated maps was submitted to NJDEP on September 1, 2016 as requested pursuant to NJDEP approval of the revised System Characterization Work Plan and is included as Appendix A of this report.

The first phase (Phase I) of the multi-decade I/I reduction effort was a field survey initiated by The JMEUC to identify portions of the service area contributing apparent excessive infiltration.

These areas were then evaluated in detail by each member municipality in a two-part second phase of studies. In the late 1970s Phase II-A investigations were conducted by member municipalities for which each sewer segment within their respective collections systems was analyzed to confirm segments where excessive infiltration was evident. This effort mapped the locations where further detailed field surveys were recommended for each member municipality.

Phase II-B followed, in which municipalities completed a detailed investigation of the specific sources of I/I in the areas identified as having excessive infiltration. Phase II-B information was summarized in a series of reports completed in 1983 that provided a value of I/I identified in gallons per day. Following Phase II-B, municipalities completed projects to reduce a portion of the I/I in their system, which was reported in the 1988 SSES-III reports.

In 1994, the SSES evaluations were updated with exhaustive field investigations and a comprehensive set of detailed data regarding sources of I/I in each member municipality. These reports included a balance of I/I (expressed as a flow rate in gallons per day) that was the product of Phase IIB and Phase III efforts. Table 9-1 displays the I/I flow rates determined in the SSES reports, and shows the reductions in I/I that were achieved in each municipality between 1983 and 1994.

The cost allocation process for I/I, described above, provides a strong incentive for communities to address and reduce I/I levels in the local sewer systems. This incentive, together with the resources provided by the JMEUC, has produced significant reductions in I/I. The SSES data on Table 9-1 has been summed to show the system-wide I/I reductions achieved. The way in which I/I flows were assigned as either infiltration or inflow may have influenced the results, as the table indicates significantly greater reduction in infiltration than in inflow. According to the most recent annual report, the *Assessment for the Year 2018* (see Appendix L), it is estimated for 2017 that infiltration has been reduced by 40% and inflow has been reduced by 34% relative to the base year of 1982 (these figures are based on estimated volumes of I/I and are not adjusted for differences in rainfall). These more recent data agree closely on the level of infiltration reduction, and the significantly greater inflow reduction may reflect additional I/I reductions achieved since 1994.

The JMEUC maintains an active Public Outreach Program (see www.jmeuc.com for more information) which addresses a number of topics, including the JMEUC Program to Eliminate Storm Water Inflow. The JMEUC also requires all new sewer connections to the JMEUC system to implement an I/I removal project, in which each new unit (gallon) of flow to be delivered will be offset by three gallons of I/I removal in an existing portion of the sewer system. This 3:1 I/I offset program was established by formal resolution of the JMEUC authorizing the Executive Director to implement the program (Resolution No. R-091/04 dated September 30, 2004).

Table 9-1 -Summary of SSES Data for JMEUC Member Municipalities (1983-1994)

Municipality	Infiltration (gpd)			Inflow (gpd)		
	Identified[1]	Removed[2]	Balance[3]	Identified[1]	Removed[2]	Balance[3]
East Orange	69,910	16,420	53,490	3,007,440	-	3,007,440
Hillside	77,155	46,032	31,123	1,185,120	-	1,185,120
Irvington	1,112,840	318,646	794,194	8,612,640	792,000	7,820,640
Maplewood	388,000	189,593	198,407	5,449,680	-	5,449,680
Millburn	190,695	39,369	151,326	2,729,520	288,000	2,441,520
Newark	232,125	12,370	219,755	1,959,840	-	1,959,840
Roselle Park	104,750	41,040	63,710	1,576,080	-	1,576,080
South Orange	409,810	326,970	82,840	2,183,760	-	2,183,760
Summit	170,515	80,461	90,054	3,651,120	-	3,651,120
Union	327,560	91,114	236,446	14,534,640	-	14,534,640
West Orange	248,755	95,964	152,791	7,097,040	352,440	6,744,600
Total	3,332,115	1,257,979	2,074,136	51,986,880	1,432,440	50,554,440
Percent reduction		38%			3%	

[1] Values reported in SSES-IIB (1983) Report

[2] Values reported in SSES-III (1988) Report

[3] Values reported in SSES Review (1994) Report

9.5.2 JMEUC Rules and Regulations

The JMEUC Rules and Regulations (dated June 17, 2010) are published on the JMEUC website (also included here as Appendix M), and include an I/I reduction requirement for any site remediation project that will discharge groundwater to the JMEUC system. The proposed discharger must reduce two units (gallons) of I/I for each gallon of groundwater discharged. This 2:1 offset is required for the life of the site remediation discharge.

Section 10
Conclusions

The key findings from the study of the JMEUC trunk sewers and WWTF completed in developing this System Characterization Report are presented below. The findings are organized into three areas:

(1) the ability of the JMEUC system to capture and convey flow for treatment from the entire JMEUC service area, as determined by the hydraulic performance of the system;

(2) the impacts on the hydraulic performance of the system attributable to RDII that is generated in the tributary sewer systems serving the member and customer municipalities; and

(3) the implications of the key findings from this study on the direction for the forthcoming Development and Evaluation of Alternatives Report that will be prepared and submitted cooperatively with the City of Elizabeth to address CSO impacts from the City of Elizabeth's combined sewer system.

10.1 Hydraulic Performance of the JMEUC Trunk Sewers and WWTF

During the development of the JMEUC System Characterization Report, the hydraulic performance of the JMEUC trunk sewers and WWTF has been studied in significant detail using a sophisticated computer model built and calibrated/validated using the InfoWorks ICM® software and the extensive body of JMEUC flow monitoring data. Both the JMEUC and the City of Elizabeth developed models of their respective sewer systems using this software, and model datasets were exchanged and coordinated during the project. This enabled both parties to generate and apply merged models, which integrate both model networks into a single model, to simulate the wet weather performance of the entire system.

After completing the extensive model calibration/validation process, modeling of the system was performed with the JMEUC Merged Model using the established typical year precipitation record (see Section 6) to characterize hydraulic performance. The simulations of the system focused on the largest events in the typical year record, as it is these events that most stress the hydraulic performance of the system.

The JMEUC trunk sewer network is relatively unique in its configuration, as virtually the entire network is comprised of two parallel and interconnected conduits. This characteristic and its impact on system performance and hydraulic capacities was investigated thoroughly in the model simulations. Key findings of these investigations are:

- The distribution of WWF in the trunk sewer system is well balanced. The location and configuration of the various interconnections between the two parallel sewers enables the full hydraulic capacity of both conduits to be used to convey flow.

- During the largest events in the typical year, the trunk sewer system experiences limited surcharging in several reaches within the trunk sewer network, but no measurable flooding was simulated at any location in the system. This finding demonstrates that system capacity is adequate to fully capture and convey for treatment all WWF currently delivered to the system during the typical year.

- A significant majority of the combined sewer flow delivered to the JMEUC system during wet weather is the flow pumped by the City of Elizabeth's TAPS. The peak flow rate delivered by TAPS is currently capped at 36 mgd by contractual agreement between the City and JMEUC. The actual hydraulic capacity of the pump station has been estimated at 55 mgd, and model simulations were performed at both peak pumping rates. These simulations showed that the existing JMEUC trunk sewers and WWTF have sufficient hydraulic capacity to handle peak flow from TAPS at not only the current peak rate of 36 mgd, but also at this higher rate of 55 mgd.

10.2 Rainfall-Derived Infiltration/Inflow (RDII) Impacts on System Performance

An extensive flow monitoring investigation was performed to characterize RDII entering the JMEUC trunk sewer system from the local sewer systems serving the various member and customer communities. This investigation was supported by the JMEUC network of 32 flow monitors located throughout the trunk sewer system. These monitoring sites are located at or near the connection points from the local sewer systems and at key points on the trunk sewers. They are equipped with modern area/velocity flow monitors capable of providing flow level and velocity data with good accuracy at 15-minute intervals, and flow rate information derived from those measurements. Flow data has been collected at these sites for more than 20 years, and data for a period of 20 months during 2015 through 2017 collected using the current flow monitoring equipment was used for this investigation.

The large, high-quality flow monitoring dataset enabled both seasonally-varied groundwater infiltration and rainfall-derived (event driven) I/I to be characterized. This information was then used to calibrate and validate the InfoWorks ICM® model of the system for use in simulating the response of the system to the typical year precipitation record and the largest events during that record. Key findings of the I/I investigations are:

- While some seasonal variability in groundwater infiltration (GWI) was seen in the data, it was relatively modest in magnitude. The expected variability in GWI rates from the spring high to the autumn low in the typical year is roughly 10 mgd, or +/- 10% of average DWF.

- RDII rates, while not unusually high in the context of similar older sewer systems nationally, are high enough to stress the JMEUC trunk sewer network during wet weather. The simulated RDII rates for the largest events in the typical year were found to cause surcharging at various locations across the JMEUC trunk sewer system, as noted above in Section 10.1.

- Although the I/I investigations to support this System Characterization Report did not include field inspection of the JMEUC trunk sewers to characterize I/I into these sewers, the findings of past studies and the current flow monitoring data suggest that the significant majority of I/I into the system is generated in the local sewer systems, not I/I directly into the JMEUC trunk sewers.

- In terms of the peak RDII flow rates and RDII volumes, the highest levels were found to be delivered to the JMEUC system from the municipalities of Union, Irvington, Summit and New Providence, and West Orange.
- In terms of unit RDII rates and volumes, where WWF's are normalized to DWF to characterize relative RDII levels, the highest levels were found to be delivered to the JMEUC system from the municipalities of Union and Roselle Park.
- The JMEUC policies and procedures encourage RDII levels in the local sewer systems to be reduced as technically and economically feasible and have done so for roughly 40 years (see Section 9). These efforts have achieved 30 to 40% reductions in RDII across the JMEUC service area over that period. Although some additional RDII reductions are probably economically achievable at specific locations in the system, it is not likely that additional system-wide reductions in RDII can be economically achieved at a level sufficient to support significant CSO reduction.
- For purposes of testing the impact of RDII on sewer systems, it is often useful to simulate the hydraulic performance of the system without RDII flows. In this case, rather than eliminating all RDII flows in the simulations, an additional 50% RDII reduction system wide was used. As noted above, this level of RDII reduction may be considered infeasible, but more reasonable than complete RDII elimination as a hypothetical scenario for system evaluation purposes. Under this scenario, system surcharging during the typical year was eliminated. This indicates that in any localized areas where significant additional RDII reduction may be feasible, system surcharging could be eliminated for the typical year (and significantly reduced for larger events).

10.3 Direction for the Development and Evaluation of Alternatives Report

Under the NJPDES Combined Sewer Management permits issued to both the JMEUC and the City of Elizabeth, the next phase of the LTCP process requires the preparation of the Development and Evaluation of Alternatives Report (DEAR). As noted above this report will be a cooperative effort of the City of Elizabeth and the JMEUC, and will identify feasible approaches for control of CSOs from the City's combined sewer system, develop planning-level project descriptions and costs, and evaluate the benefits of these alternative CSO control projects to support the development of the LTCP in the final phase of the process.

The findings of the JMEUC System Characterization Report provide useful insights for the development and evaluation of alternatives for control of the City of Elizabeth CSOs. Those insights are summarized here:

- RDII levels during the typical year, and the hydraulic capacity of the JMEUC trunk sewers and WWTF to accommodate these WWF's, do not impede the ability to capture existing combined sewer flows from the City of Elizabeth at current contract limits. In fact, the JMEUC system has sufficient capacity to accept these flows at higher rates up to and including the current hydraulic capacity of the TAPS.

- Significant RDII reduction has already been achieved across the JMEUC sanitary sewer service area, and significant additional reduction at a system-wide scale is likely not feasible. Given this, and given that current RDII levels are not impeding the capture of combined sewer flow from the City of Elizabeth at either the current contractual limits nor at the current hydraulic capacity of the TAPS, it is expected that system-wide RDII reduction as a CSO control alternative may be of limited effectiveness.

- Although surcharging of the JMEUC trunk sewers was found to not be excessive or problematic (i.e. does not cause measurable flooding) during the typical year, during larger events (e.g. the 5-year, 10-year or larger storms) it may be problematic. While significant system-wide RDII reduction may not be feasible for CSO control, local RDII reduction projects may be effective for any areas where downstream surcharging may be problematic during large storm events, as noted above in Section 10.2. However, these projects would be outside the scope of CSO control and will not be pursued during the DEAR.

- Simulations of the JMEUC trunk sewers and WWTF indicate that higher flows can be pumped into the system from TAPS for conveyance to and treatment at the JMEUC WWTF. This would enable greater delivery of combined sewer flows for treatment during wet weather, to the extent that the interceptor sewers in the City of Elizabeth can capture and deliver those flows to TAPS. Potentially significant reductions in CSO discharges at the outfalls in the City of Elizabeth combined sewer system may be possible with this approach and it should be evaluated during the DEAR.

- The wet weather performance of the JMEUC WWTF has been extensively evaluated under previous studies and operational experience, and shown to be able to handle wet weather flows of 180 mgd or higher and meet effluent permit limits. The higher flows delivered to the WWTF by increasing the peak TAPS pumping rate from 36 to 55 mgd during wet weather are not expected to be problematic for the WWTF, although this would be evaluated further in the DEAR. This evaluation could include the use of real-time controls to enable the WWTF to control TAPS pumping rates if necessary to maintain proper plant operations and to take advantage of difference in the peak timing of flows from the separate and combined sewer systems.

- The above approach would evaluate the performance of the existing JMEUC trunk sewers and facilities at the WWTF with the potential flows that could be delivered to this system if constrained only by the physical limitations of the existing pumping, force main and trunk sewer capacities. JMEUC and the City agree that additional scenarios that include expanded pumping and force main capacities should also be considered during the DEAR.

- Additional scenarios that would use expanded pumping and force main capacities to deliver higher peak flows to the WWTF would need to evaluate the ability of the WWTF to provide treatment at those higher peak flow rates. Both U.S.EPA and NJDEP have indicated renewed interest in considering blending as a means to increase the treatment of WWF, and this approach is also fully consistent with the objectives of the U.S.EPA CSO Control Policy. JMEUC and the City agree that blending, and potentially other wet weather treatment approaches at the JMEUC WWTF, perhaps with physical (as opposed to purely operational) modifications, should be considered in the DEAR.

Appendix A

JMEUC System Characterization Work Plan, NJDEP Approval Letter, and JMEUC Letter of September 1, 2016

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix B

Drawing Index Listing of Design Drawings for the Original and Supplementary Trunk Sewers

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix C

Flow Monitoring Data

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix D

Rainfall Monitoring Data

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix E

JMEUC Trunk Interceptor Hydraulic Modeling Evaluations

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix F

Flow Monitoring Site Reports Generated by ADS

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix G

Baseline Merged Model Calibration and Validation Plots

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix H

Baseline Merged Model Scatter Plots

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix I

Baseline Merged Model Scatter Plots

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix J

Summary of Calibrated RTK and IA Parameters for Modeled Subcatchments

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix K

JMEUC Procedure for Storm Flow Operations

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix L

2017 JMEUC Annual Report

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix M

JMEUC Rules and Regulations

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

Appendix N

Typical Year Report and NJDEP Approval Letter

Report appendix files not included here due to file size limitations. Appendix files available separately and can be downloaded from FTP site; contact CDM Smith for instructions.

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