City of Fullerton Sewer Master Plan
Final Report

Prepared by:

RMC
Water and Environment

October 2009

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Acknowledgements

CITY OF FULLERTON

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<u>**List of Acronyms**</u>

BWF	Base Wastewater Flow
CCTV	Closed-Circuit Television
CDR	Center for Demographic Research
CIP	Capital Improvement Program
CRP	Capital Replacement Program
d/D	Depth over Diameter
DU	Dwelling Unit
FTC	Fullerton Transportation Center
GWI	Groundwater Infiltration
I/I	Infiltration and Inflow
mgd	Million Gallons per Day
OCSD	Orange County Sanitation District
PACP	Pipeline Assessment and Certification Program
PDWF	Peak Dry Weather Flow
PWWF	Peak Wet Weather Flow
RDI/I	Rainfall Dependent Infiltration and Inflow
SSMP	Sewer System Management Plan
TAZ	Traffic Analysis Zone
VCP	Vitrified Clay Pipe
WWPF	Wet Weather Peaking Factor

Executive Summary

In May of 2008, the City of Fullerton (City) retained RMC Water Environment, Inc. (RMC) to assist City staff in the preparation of this Sewer Master Plan (Master Plan). The main objectives of the Master Plan were to:

- Conduct a capacity assessment of the City's sewer system under existing and future flow conditions using a fully-dynamic hydraulic model, and formulate capital improvement projects to address identified deficiencies
- Characterize the structural condition of the City's sewers based on available inspection data, and estimate planning-level costs for repair, rehabilitation, and replacement of sewers over the next 20 years.

The focus of this Master Plan was to identify system deficiencies in regards to capacity and structural condition, and to develop a 20-year Capital Improvement Program (CIP) which addresses these deficiencies. A dynamic hydraulic model of the City's major sewers was created to assess the capacity of the City's major sewers under existing conditions, to verify capacity of the existing sewer system to accommodate future development and zone changes, and to identify improvement projects needed to provide capacity through the year 2035 (buildout). The model includes the Orange County Sanitation District (OCSD) trunk sewers in the City as well as the City's major sewers, although improvement projects were developed only for City sewers. The Master Plan also focused on condition assessment by characterizing sewers by age, analyzing video inspections completed for approximately 60% of the City's sewer system, and extrapolating the results to create a system-wide Capital Replacement Program (CRP). An infiltration/inflow study was also performed to identify areas with high I/I and to recommend potential I/I control options.

Following initial data research, scoping, and setup of project management systems, the project team concentrated on developing the data needed to conduct the study. Key data development tasks for the capacity analysis included extracting sewer attributes from previous modeling studies, compiling rainfall and flow data from major wet weather events in 2005, and obtaining and integrating data on land use, population and water consumption from various sources for use in estimating current and future wastewater flows. Development tasks for the CRP included assembling video inspection results into a master database and reviewing costs of recent rehabilitation projects for use in cost estimating.

The analysis phase of the project consisted of calibrating a dynamic hydraulic model such that it accurately simulated monitored flows under both dry and wet weather conditions, followed by the application of the model to identify capacity deficiencies under existing and future conditions, including a wet weather design storm event derived from historical data. CIP projects to address the capacity deficiencies were developed and prioritized, and planning-level cost estimates were developed. The project team also used the model to quantify infiltration and inflow (I/I) throughout the sewer system. For the CRP, video inspections were reviewed for consistency with PACP standards and the inspection findings were used to estimate the mileage of sewers within particular age ranges requiring rehabilitation, repair, and re-inspection over the next 20 years, and the associated planning-level budgetary requirements.

The model results show that the capacity of major sewers is adequate under existing dry weather flow conditions. Under existing wet weather design event conditions, some of the main trunks in the system are full or surcharging. It is important to note that these results are not for an actual storm that occurred, but rather a 10-year return period design event. City staff state that a rain-induced overflow has never occurred in the system. Nevertheless, these results indicate that portions of the system may be heavily surcharged or overflowing during design wet weather conditions.

As dry weather flow increases in the future as a result of development and redevelopment, a few additional capacity deficiencies will occur and need to be addressed.

A list of all of the recommended capacity improvement projects is provided in **Table ES-1**. Projects were prioritized based on a number of factors and the priorities were used to phase the projects out over the next 20 years.

Table ES-2 lists the breakdown of annual CIP costs over the next 20 years. The total estimated capital cost of the 20-Year CIP is approximately $63M. Included in that total is an estimated $46M CRP covering the inspection, repair, and rehabilitation/replacement of sewers. The estimated capital cost of the capacity improvement projects is $20M. The total CIP is $3M less than the sum of the capacity improvement projects and the CRP due to overlap between capacity projects and rehabilitation projects.

Table ES-1: Prioritized CIP Projects

Project ID	Location	Length	Priority	Estimated Cost	Credit to CRP Budget
1A	W Bastanchury Road, Morellia Pl, from N Euclid St to Arbolado Dr	10,440'	High	$4,525,000	$705,000
1B	W Bastanchury Road, from N Euclid St to Warburton Way	3,860'	High	$1,807,000	$328,000
1C	W Bastanchury Rd and Hughes Dr	1,610'	High	$724,000	$135,000
2	N Euclid St from Rosecrans Ave to Bastanchury Rd	1,440'	Medium	$1,305,000	$0
3	N Euclid St from W Malvern Ave to W Commonwealth Ave	2,030'	Medium	$787,000	$463,000
4	W Valencia Dr from S Euclid St to S Woods Ave	1,190'	Medium	$435,000	$0
5	Evergreen Ave and Laurel Ave from Maple Ave to Lark Ellen Dr	820'	Low	$391,000	$0
6	Arroyo Drive from Ramona Dr to W Malvern Ave	1,420'	Low	$104,000	$0
7A	W Malvern from Arroyo Drive to N Basque Ave	970'	Medium	$399,000	$221,000
7B	N Basque Ave from W Malvern Ave to Gregory Ave	1,710'	Medium	$646,000	$390,000
7C	Gregory Ave from N Wanda Dr to N Basque Ave	3,840'	Medium	$2,684,000	$0
8	Johnson Pl from Carhart Ave to N Stephens Ave	250'	Low	$114,000	$0
9	W Valencia Dr & S Basque Ave from S Brookhurst Rd to W Elm Ave	3,680'	Low	$1,495,000	$0
10	Nutwood Ave from State College Blvd to Ruby Dr	3,880'	Low	$3,167,000	$0
11	By W Valley View Dr and N Euclid St	970'	Low	$331,000	$220,000
12	Conejo Lane from Sunrise Lane to Camino Centroloma	880'	Low	$463,000	$0
13	E Bastanchury Rd from Amberleaf St to Puente St	580'	Low	$363,000	$0
TOTAL				**$19,740,000**	**$2,462,000**

Table ES-2: 20-Year CIP Annual Costs

Year		Rehab.	Spot Repair	Inspections	Re-Inspections	Capacity Projects	Total Capital Cost[1]
1	2009	$1,152,000	$467,000	$382,000	$0	$1,178,000	$3,178,000
2	2010	$1,152,000	$467,000	$382,000	$0	$1,178,000	$3,178,000
3	2011	$2,274,000	$1,160,000	$0	$53,000	$1,178,000	$4,664,000
4	2012	$2,274,000	$1,160,000	$0	$53,000	$1,178,000	$4,664,000
5	2013	$2,274,000	$1,160,000	$0	$121,000	$1,178,000	$4,732,000
6	2014	$1,122,000	$693,000	$0	$135,000	$1,036,000	$2,987,000
7	2015	$1,122,000	$693,000	$0	$135,000	$1,036,000	$2,987,000
8	2016	$1,122,000	$693,000	$0	$169,000	$1,036,000	$3,021,000
9	2017	$1,122,000	$693,000	$0	$169,000	$1,036,000	$3,021,000
10	2018	$1,122,000	$693,000	$0	$101,000	$1,036,000	$2,953,000
11	2019	$1,122,000	$693,000	$0	$101,000	$621,000	$2,537,000
12	2020	$1,122,000	$693,000	$0	$169,000	$621,000	$2,605,000
13	2021	$1,201,000	$769,000	$0	$124,000	$621,000	$2,715,000
14	2022	$1,201,000	$769,000	$0	$124,000	$621,000	$2,715,000
15	2023	$1,201,000	$769,000	$0	$124,000	$621,000	$2,715,000
16	2024	$1,201,000	$769,000	$0	$124,000	$621,000	$2,715,000
17	2025	$1,201,000	$769,000	$0	$56,000	$621,000	$2,647,000
18	2026	$1,201,000	$769,000	$0	$299,000	$621,000	$2,889,000
19	2027	$1,201,000	$769,000	$0	$367,000	$621,000	$2,957,000
20	2028	$1,201,000	$769,000	$0	$367,000	$621,000	$2,957,000
TOTAL		**$26,588,000**	**$15,417,000**	**$764,000**	**$2,791,000**	**$17,280,000**	**$62,837,000**

[1]Total cost accounts for project overlap between capacity projects and rehabilitation projects.

Chapter 1 Introduction

This introductory chapter provides background information on the scope and objectives of the Fullerton Sewer Master Plan, the City's sewer system and service area, and the contents and organization of the Master Plan report.

1.1 Background and Study Objectives

In May of 2008, the City of Fullerton (City) retained RMC Water Environment, Inc. (RMC) to assist City staff in the preparation of this Sewer Master Plan (Master Plan).

The main objectives of the Master Plan were to:

- Conduct a capacity assessment of the City's sewer system under existing and future flow conditions using a fully-dynamic hydraulic model, and formulate capital improvement projects to address identified deficiencies
- Characterize the structural condition of the City's sewers based on available inspection data, and estimate planning-level costs for repair, rehabilitation, and replacement of sewers over the next 20 years.

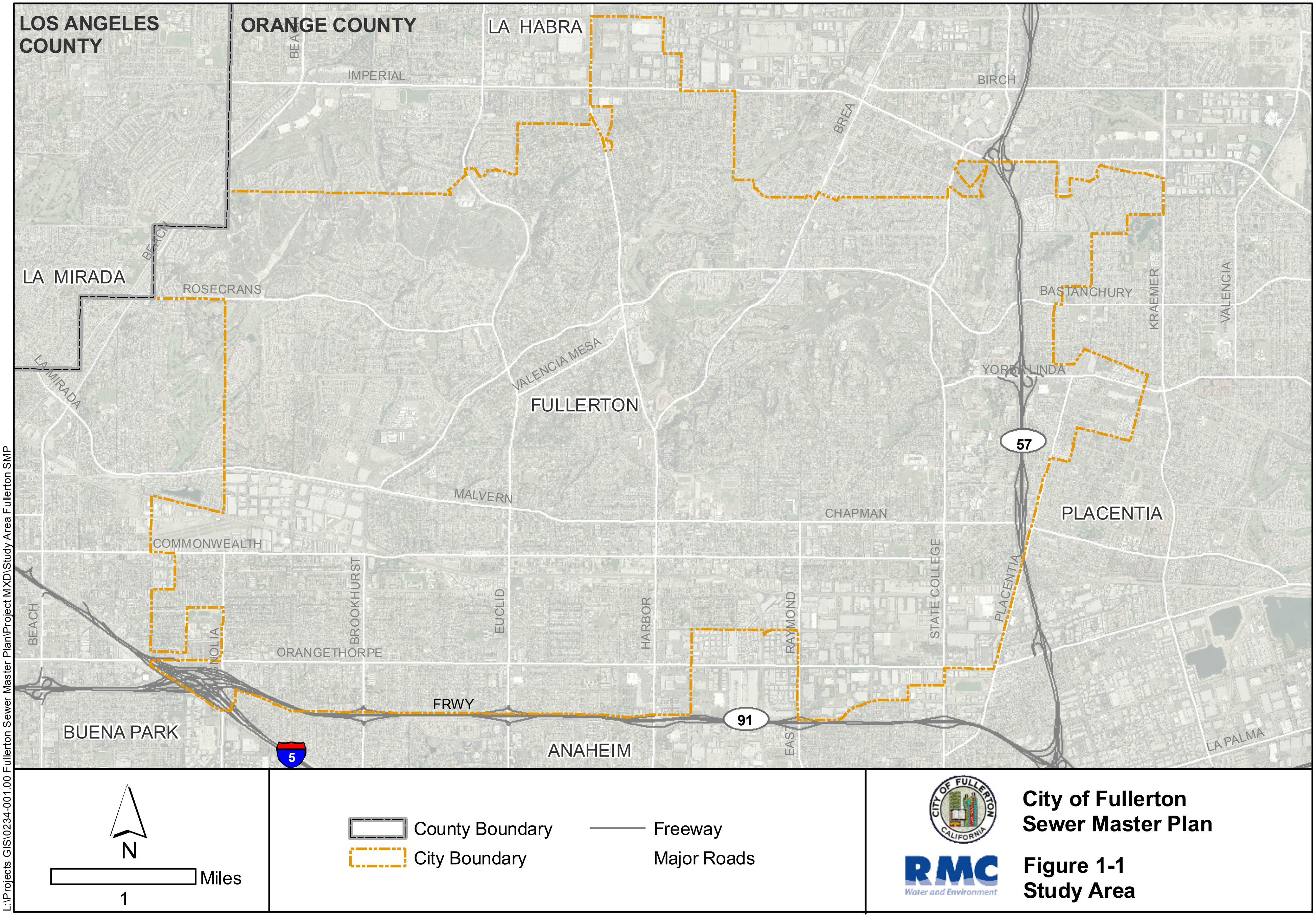
1.2 Study Area

The study area for this Master Plan is defined by Fullerton's City boundary. **Figure 1-1** illustrates the boundaries of the study area, which covers approximately 22 square miles.

1.3 Existing Sewer System

The City's system operates entirely by gravity and discharges to several of Orange County Sanitation District's (OCSD) trunk lines. The following statistics relate to the city-owned portion of the sewer system:

- The estimated total length of the City's sewer system is 330 miles, including 2.7 miles of privately-owned sewers. Also included in the system are 36 inverted siphons.
- **Figure 1-2** shows the City's sewer system.
- **Figure 1-3** and **Figure 1-4** give the range of diameters and materials represented in the City's system. Diameters range between 6 inches and 39 inches, with 81% of the City's sewers being 6 or 8 inches in diameter. Siphons range from 6 to 36 inches in diameter.
- **Figure 1-5** illustrates the construction dates of the City's sewers. The oldest sewers in the system were constructed in 1921, with the average age of all sewers being 44 years. A large portion of the sewers (41%) were constructed before 1958 and are over 50 years old. As part of the Master Plan effort, the City extracted sewer construction dates from as-built drawings for the entire sewer system and input them to the City's GIS database.
- 99% of the sewers are constructed of vitrified clay pipe (VCP).



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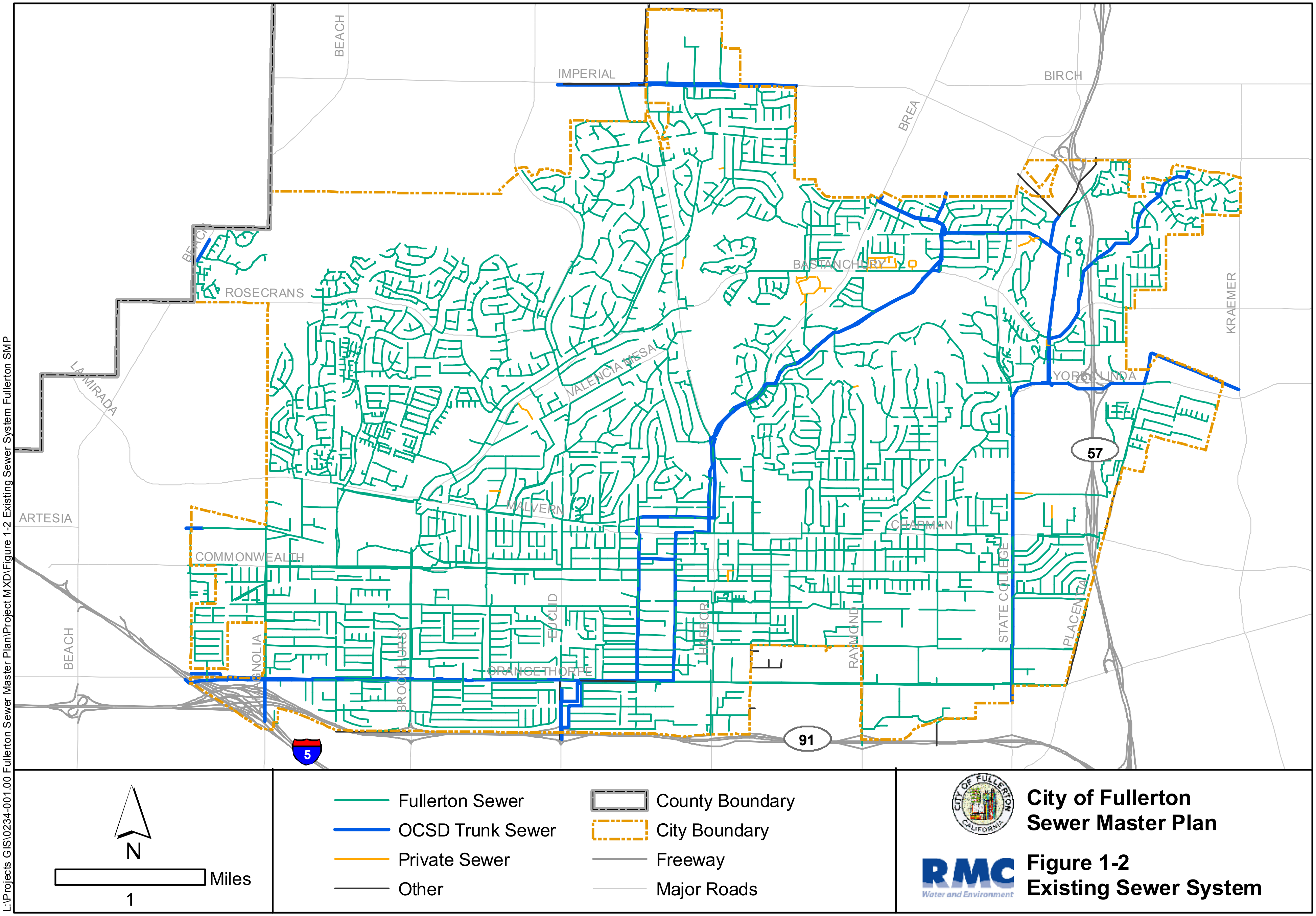
City of Fullerton
Sewer Master Plan

Figure 1-1
Study Area



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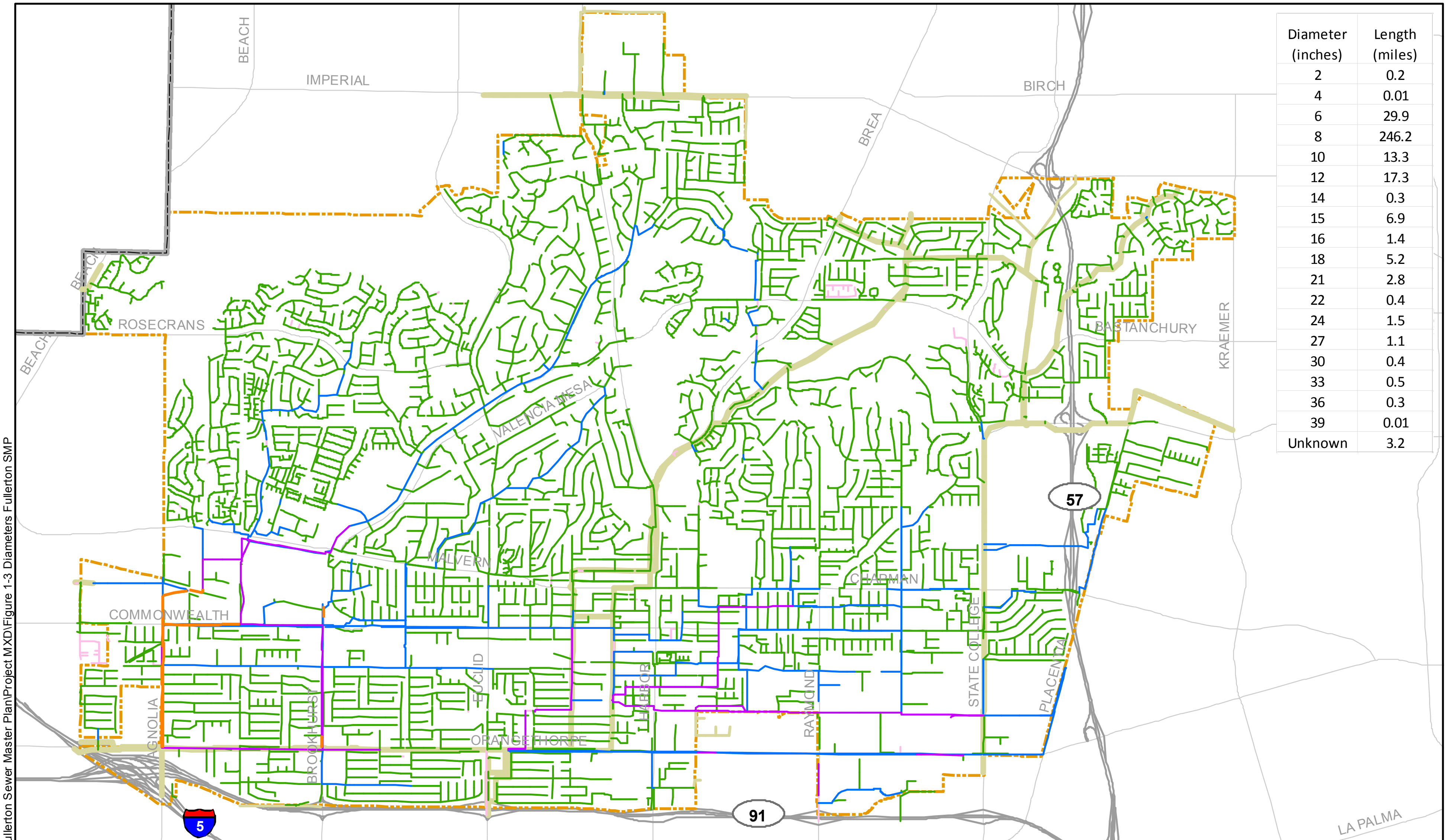

Diameter (inches)	Length (miles)
2	0.2
4	0.01
6	29.9
8	246.2
10	13.3
12	17.3
14	0.3
15	6.9
16	1.4
18	5.2
21	2.8
22	0.4
24	1.5
27	1.1
30	0.4
33	0.5
36	0.3
39	0.01
Unknown	3.2

N

Miles
1

Diameters

- 2" - 8"
- 10" - 15"
- 16" - 24"
- 27" - 36"
- Unknown
- OCSD Trunk Sewer
- Other Cities Sewer
- County Boundary
- City Boundary

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City of Fullerton Sewer Master Plan

Figure 1-3 Sewer Pipe Diameters

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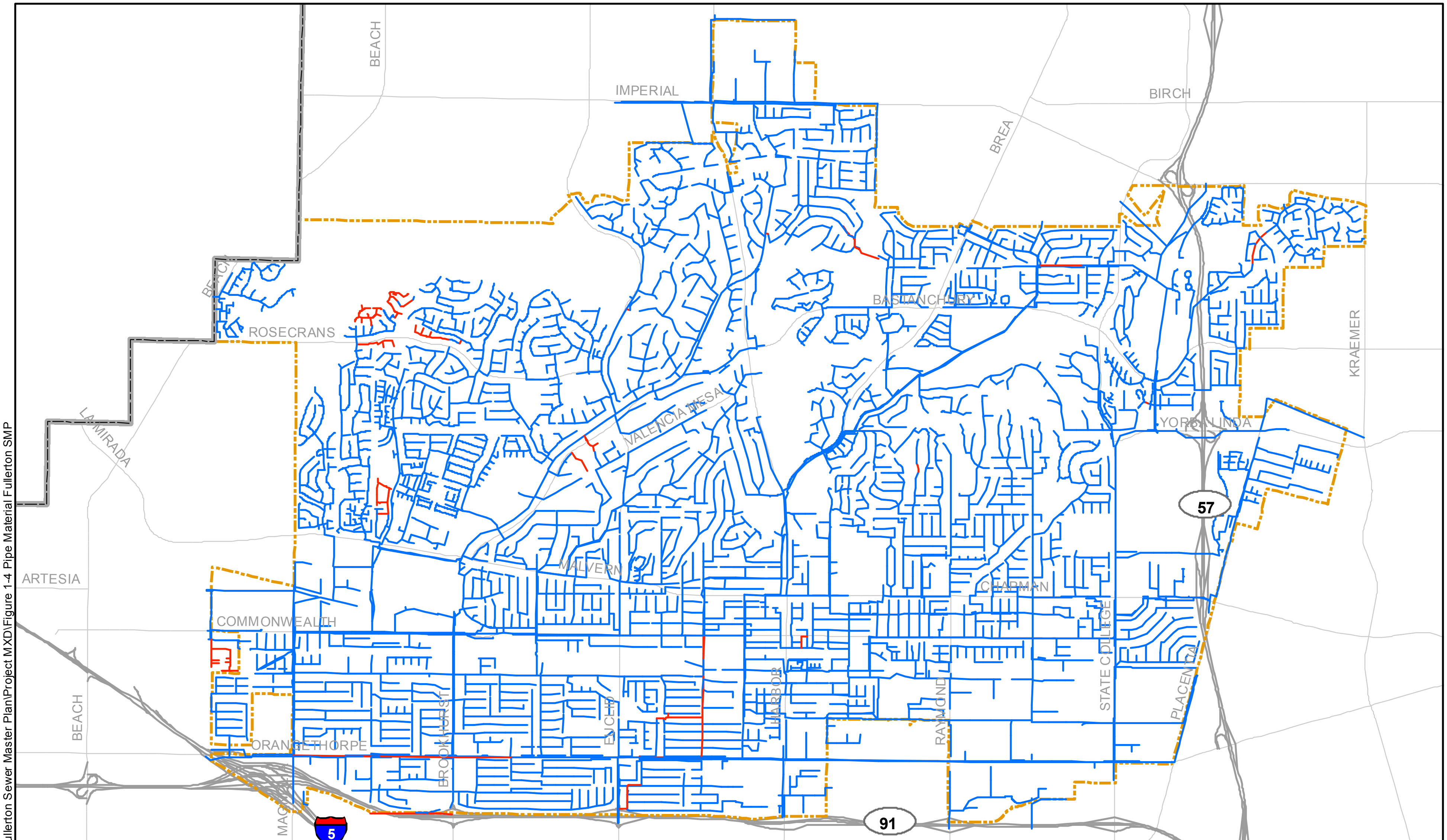

N

Miles

1

Material

VCP

Other

County Boundary

City Boundary

City of Fullerton
Sewer Master Plan

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Figure 1-4
Pipe Material

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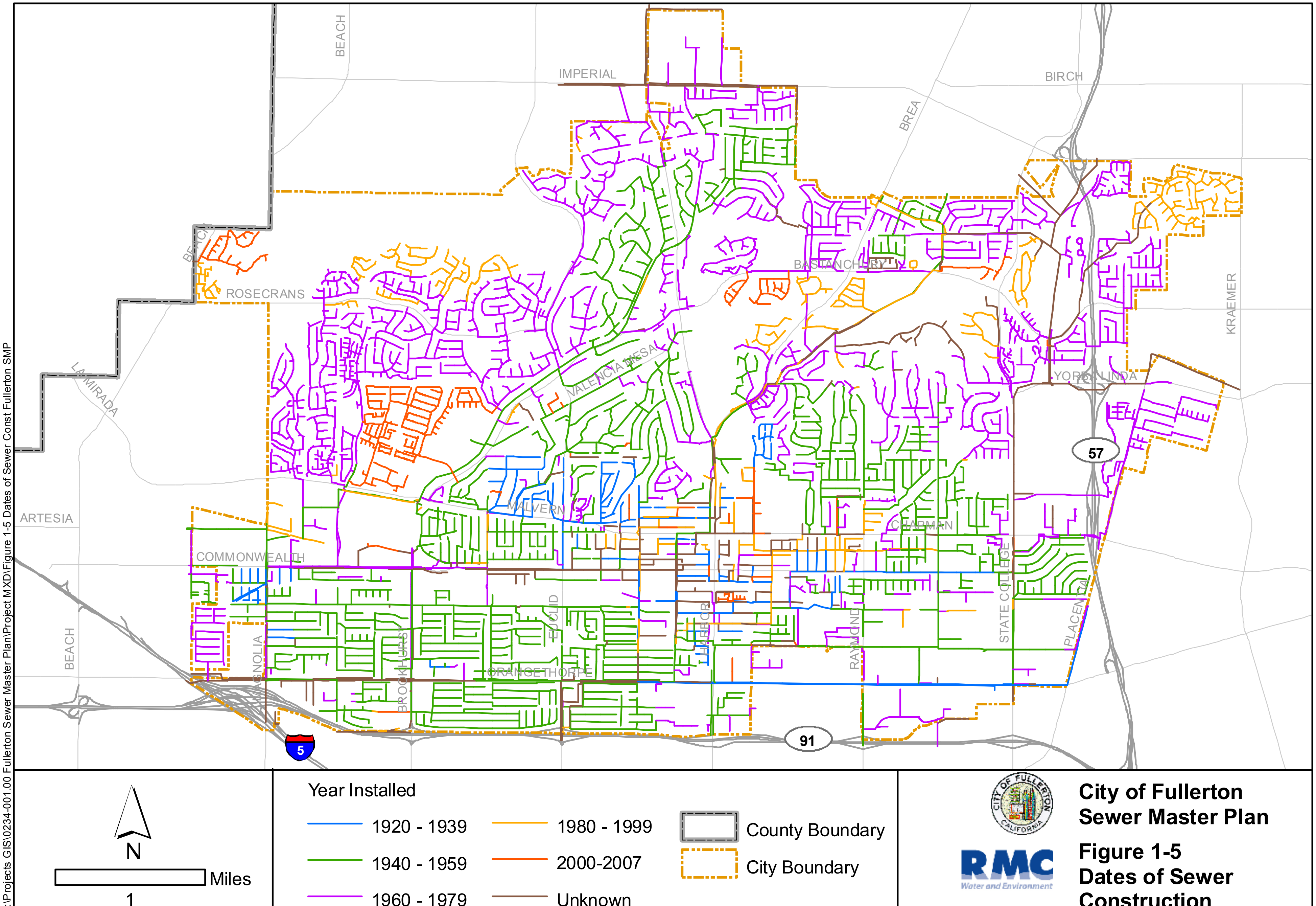

City of Fullerton
Sewer Master Plan

Figure 1-5
Dates of Sewer Construction

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1.4 Scope of Study

The focus of this Master Plan was to identify system deficiencies in regards to capacity and structural condition, and to develop a 20-year Capital Improvement Program (CIP) which addresses these deficiencies. A dynamic hydraulic model of the City's major sewers was created to assess the capacity of the City's major sewers under existing conditions, to verify capacity of the existing sewer system to accommodate future development and zone changes, and to identify improvement projects needed to provide capacity through the year 2035 (buildout). The model includes the OCSD trunk sewers in the City as well as the City's major sewers, although improvement projects were developed only for City sewers. The Master Plan also focused on condition assessment by characterizing sewers by age, analyzing video inspections completed for approximately 60% of the City's sewer system, and extrapolating the results to create a system-wide Capital Replacement Program (CRP). An infiltration/inflow study was also performed to identify areas with excessive I/I and to recommend potential I/I control options.

Following initial data research, scoping, and setup of project management systems, the project team concentrated on developing the data needed to conduct the study. Key data development tasks for the capacity analysis included extracting sewer attributes from previous modeling studies, compiling rainfall and flow data from major wet weather events in 2005, and obtaining and integrating data on land use, population and water consumption from various sources for use in estimating current and future wastewater flows. Development tasks for the CRP included assembling video inspection results into a master database and reviewing costs of recent rehabilitation projects for use in cost estimating.

The analysis phase of the project consisted of calibrating a dynamic hydraulic model such that it accurately simulated monitored flows under both dry and wet weather conditions, followed by the application of the model to identify capacity deficiencies under existing and future conditions, including a wet weather design storm event derived from historical data. CIP projects to address the capacity deficiencies were developed and prioritized, and planning-level cost estimates were developed. The project team also used the model to quantify infiltration and inflow (I/I) throughout the sewer system. For the CRP, video inspections were reviewed for consistency with PACP standards and the inspection findings were used to estimate the mileage of sewers within particular age ranges requiring rehabilitation, repair, and re-inspection over the next 20 years, and the associated planning-level budgetary requirements.

1.5 Report Organization

This section describes the contents of each of the eight chapters and the appendices of this Master Plan.

Chapter 1 - Introduction

This introductory chapter provides information on the scope and objectives of the City of Fullerton Sewer Master Plan, the City's sewer system and service area, and the contents and organization of the Master Plan report.

Chapter 2 - Existing and Future Dry Weather Flow

This chapter presents the methodology used to determine existing and future dry weather wastewater flows for the Master Plan. Data sources are documented, followed by a step-by-step description of the procedure used to estimate dry weather flows for the various planning scenarios (existing, 2015, and 2035). The resulting total City flows are presented for each of the scenarios.

Chapter 3 - Hydraulic Model Building and Calibration

This chapter documents the procedures used to build and calibrate the InfoSWMM™ hydraulic model used for the Master Plan. The objective of this chapter is to provide an overview of the model development process and the results of model calibration under dry and wet weather flow conditions.

Chapter 4 – Sewer System Capacity Analysis

The calibrated hydraulic model was used to identify any capacity deficiencies in the system for both dry and wet weather flows under existing and future conditions. This chapter presents the criteria that were used to identify potential hydraulic capacity deficiencies, including the design storm that was used to evaluate wet weather capacity. The results of the model analysis are then summarized.

Chapter 5 – Recommended Capacity Improvement Projects

This chapter presents the capacity-related projects that are recommended for inclusion in the City's capital improvement program (CIP) based on the findings of the hydraulic analysis. Each project is documented with a general description, plan map, hydraulic profile, project details and considerations, planning-level capital cost estimate, and relative priority ranking.

Chapter 6 – Infiltration and Inflow (I/I) Analysis

This chapter identifies areas in the City which have the highest I/I and considers the impact that I/I has on CIP costs. This is followed by a discussion of methods for finding and reducing I/I that may be appropriate for the City. Finally, estimates of potential costs and benefits of I/I reduction in specific areas are presented.

Chapter 7 – Capital Replacement Program

This chapter presents the recommended 20-year Capital Replacement Program (CRP) based on characteristics of the City's sewer system and results of sewer video inspections performed up to September 2008. The program is presented as a system-wide rehabilitation, repair, and re-inspection schedule for the next 20 years.

Chapter 8 – 20-Year Capital Improvement Program

This chapter outlines the City's 20-Year Capital Improvement Program (CIP). The program includes capacity projects defined from the hydraulic modeling analysis, the system-wide capital replacement program (CRP) defined using recent video inspections, and rehabilitation projects listed in the City's current CIP. Project prioritization and an implementation strategy are also provided.

Appendix A – Fullerton Transportation Center (FTC) Sewer Study

Appendix A is a technical memorandum that was prepared as part of this master plan contract to assess the impact of FTC redevelopment on wastewater flows and sewer system capacity.

Appendix B – Model Subcatchment Map

Appendix B is a D-size map showing the model subcatchments and their respective IDs. This map can be used as a reference when reviewing the model results.

Appendix C – Dry Weather Flow Calibration Plots

Appendix C shows dry weather calibration plots of modeled vs. metered flow, velocity, and depth for all of the meters.

Appendix D - Wet Weather Flow Calibration Plots

Appendix D shows wet weather calibration plots of modeled vs. metered flow, velocity, and depth for all of the meters.

Chapter 2 Existing and Future Dry Weather Flow

This chapter presents the methodology used to determine existing and future dry weather wastewater flows for the Master Plan. Data sources are documented, followed by a step-by-step description of the procedure used to estimate dry weather flows for the existing (2008), near-term (2015) and long-term (2035) planning scenarios. The resulting total City flows are presented for each of the scenarios.

Residential and non-residential dry weather wastewater flows within the City were estimated using information compiled at the parcel level (approximately 29,800 parcels) and then aggregated into 288 subcatchments (load points in the hydraulic model). Flows from 61 subcatchments located outside the City's boundary were extracted from an existing model of the OCSD system. While most of these areas are not tributary to any of the City's sewers, they are tributary to OCSD trunk lines which were included in the model. Further details of the procedure used to estimate and distribute these values are described below.

2.1 Data Sources

A number of data sources were used in the process of estimating dry weather wastewater flows, most notable of which are water billing data provided by the City, TAZ-level population and employment projections prepared jointly by the Center for Demographic Research-Cal State Fullerton (CDR) and the City, and flow assumptions extracted from OCSD's hydraulic model. **Table 2-1** briefly describes these data sources and how they were used in this study.

2.2 Existing (2008) Dry Weather Flow

2.2.1 Existing Flows within City Limits

Existing residential and non-residential flow was estimated based on water billing data provided by the City. Metered water use during the winter months most closely approximates wastewater generation, since outdoor water use is at a minimum. Therefore, meter readings taken in the winter of 2007-2008 were used as the basis for estimating residential and non-residential flow.

Each water billing record in the City's database is assigned a rate type which characterizes the land use type or how the water is used. Accounts coded with a rate type of 13 or 15 are strictly for fire lines or irrigation; they do not contribute wastewater to the sewers and were therefore not included in the analysis. The remaining accounts were assigned to either a residential (1, 2, 3, 11, 12, 16, 17) or non-residential rate type (4, 5, 8, 10) and geocoded to their associated parcels. A list of septic users was obtained from the City to ensure that water billing records associated with those parcels were excluded from the study. For future scenarios, it was assumed that the 25 parcels with septic tanks would remain on septic (i.e. not connect to the sewer system).

The total residential and non-residential flow for each model subcatchment was calculated by summing the winter water usage and/or calculated flow for each of the parcels within that subcatchment. A sewer return rate (percentage of winter water use that enters the sewer system) was used to account for irrigation and consumption. Return rates were finalized during model calibration (see Chapter 3), but are listed here for reference:

- Non-residential parcels = 100%
- Small residential parcels (land use types other than R1) = 95%
- Larger residential parcels (R1) = 75%
- Parcels located within meter basins FUL02, FUL03, FUL04, FUL06, FOC018 = 50%

Table 2-1: Data Sources for Wastewater Flow Estimates and Projections

Data	Source	Description	Geographic Level	Use
Water Billing Data	City	Bimonthly water billing data for all customers, winter 2007-2008	City	• Estimate existing wastewater flow from residential and non-residential customers • Identify large dischargers
OCSD Industrial Permit Flows	OCSD	Permitted and actual wastewater flows from major dischargers	Parcels	• Estimate existing and future flows from large dischargers
Basin 11 Sewer Study	City	Measured sewer return rate	City Basin 11	• Used to calculate wastewater flow from water billing data and subtract from OCSD modeled flow when splitting OCSD sewer subcatchments (outside of City boundary only)
OCSD Model Data	OCSD	Existing and future population and employment figures	Modeled area	• Estimate wastewater flow for areas outside City but tributary to modeled network
Development Activity Maps	City	Quarterly updates on locations of current and future planned development	City	• Assign future developments to appropriate subcatchments
TAZ population and employment projections	City/CDR	Population and employment projections	TAZ	• Assign future developments to appropriate planning scenario • Calculate future flow based on population and employment projections • Define near-term and long-term planning scenarios

2.2.2 Existing Flows from Outside City Boundary

A different approach for estimating flow was required outside the City boundary, where water meter records were not readily available. For these areas, population and employment data from OCSD model subcatchments were used. Residential flow was calculated using a unit flow factor of 75 gallons per capita per day, while non-residential flow was calculated using a unit flow factor of 25 gallons per employee per day. These flow factors were determined as part of the 2006 OCSD model calibration.

In some cases, the OCSD model subcatchments overlapped with the City model subcatchments. To avoid double-counting flow in these areas, it was necessary to trim the OCSD subcatchments, calculate the flow from the trimmed area using water billing data, and then subtract that flow from the OCSD flows.

Although nearly all these flows discharge directly to sewers owned by OCSD, some discharge to the City's sewers. Flows from the following cities were found to discharge to the City's sewer system:

- Placentia: approximately 0.6 mgd
- Anaheim: approximately 0.2 mgd
- Brea: approximately 0.1 mgd

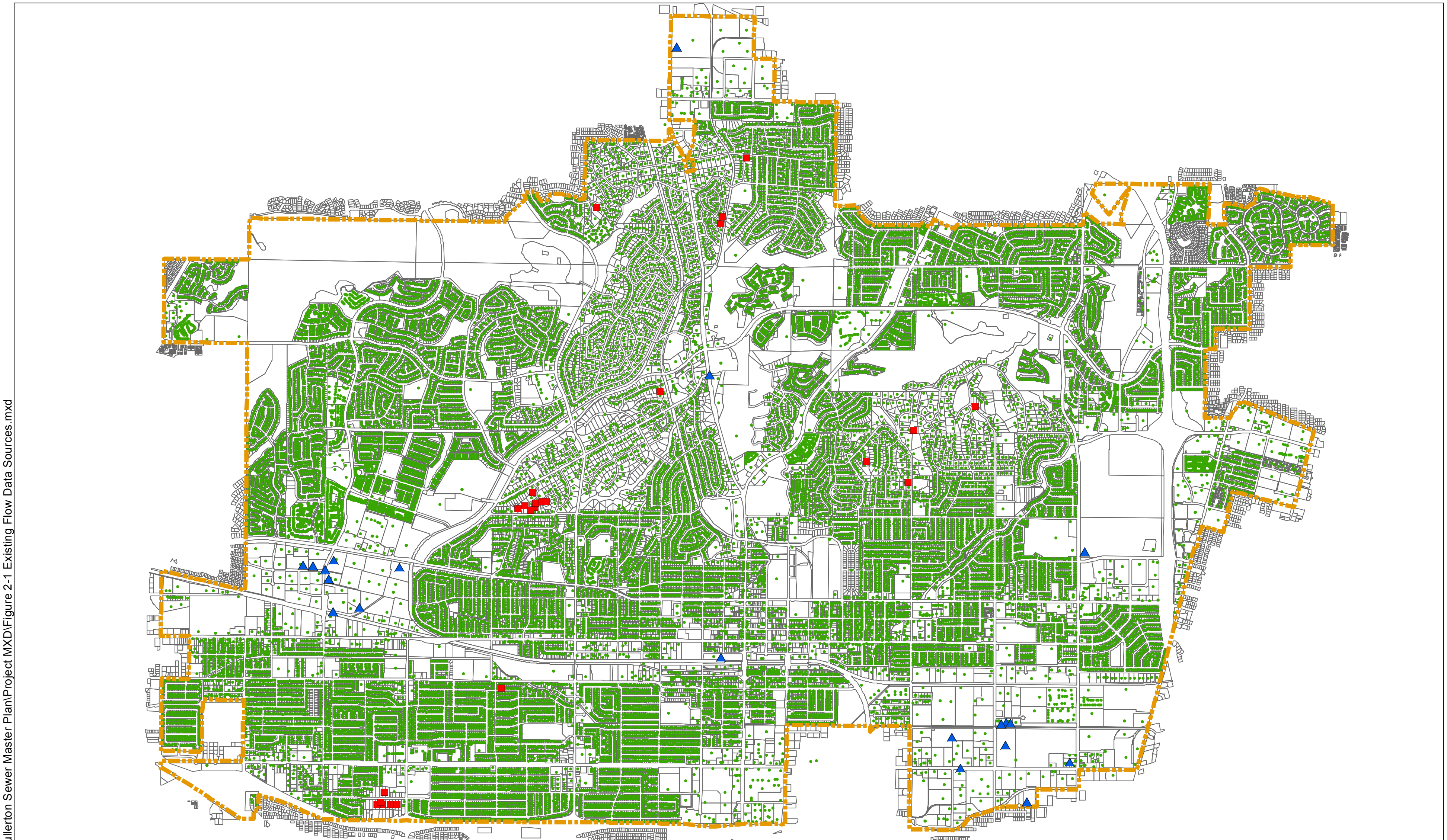
2.2.3 Existing Large Discharger Flows

Non-residential dischargers that contribute more than 5,000 gallons per day of wastewater flow to the City's sewers, referred to as large dischargers, were identified based on water billing records and permit information from OCSD's Source Control Division. The goal was to get a more accurate estimate of actual wastewater flow and hours of discharge for each individual large discharger rather than using a generalized wastewater return rate as was done for the nearly 30,000 other customers. **Table 2-2** lists the large dischargers identified for inclusion in the model, and their actual average daily wastewater flow as reported by OCSD's Source Control Division. These values were used in place of water billing data for these customers.

Table 2-2: Wastewater Flow Estimates for Large Dischargers

Name	Address	Sewer Flow (mgd)
St. Jude Medical Center	101 E. Valencia Mesa Drive	0.065
Kryler Corp	1217 E Ash Ave	0.008
Santana Services	1224 E Ash Ave	0.005
Winonics, inc.	1257 South State College	0.050
World Citrus West inc.	130 W Santa Fe Ave	0.020
Nelco Products, inc.	1411 E. Orangethorpe Ave	0.020
Johnson Controls Battery Group	1550 E Kimberly Ave	0.010
Weidemann Water Conditioners	1702 E. Rosslynn Avenue	0.030
Orange County Metal Processing	1711 E. Kimberly	0.028
PCA Industries LLC	1726 E Rosslynn Ave	0.055
St. Hart Container, Amcor manufacturing site	1901 E Rosslynn Ave	0.005
Fullerton Cultured Specialties	1901 Via Burton	0.090
Raytheon Company	1910 West Malvern Ave	0.029
Kimberly-Clark Worldwide, inc.	2001 E. Orangethorpe Ave	1.100
Samco Metal Products	2007 Raymer Ave	0.005
Western Yarn Dyeing, inc.	2011 Raymer Ave	0.038
Vista Paint Corp	2020 E. Orangethorpe Ave	0.005
Y2K Textile	2051 Raymer Ave	0.400
Pulmuone Wildwood, inc.	2315 Moore Ave	0.070
Van Law Food Products, inc.	2325 Moore Ave	0.025
Scientific Spray Finishes inc	315 S Richman Ave	0.005
Appliance Distribution	331 S Hale Ave	0.005
TT Electronics Technology	4200 Bonita Pl	0.005
Spiveco, inc; Caran Precision	4275 N Palm St	0.005
Beckman Coulter, inc.	4300 N. Harbor Boulevard	0.018
Cargill inc.	550 N Gilbert St	0.030
Cargill inc.	600 N Gilbert St	0.015
Dae Shin USA, inc.	610 N Gilbert St	0.765
Alcoa Global Fasteners, inc.	800 S. State College Blvd.	0.057

Figure 2-1 illustrates the location of the large dischargers as well as the parcels on septic tanks and the parcels for which water billing records were used to estimate wastewater flows.



N

Miles

1

Water Billing Records

Large Dischargers

Septic Tanks

Parcels

City Boundary

City of Fullerton
Sewer Master Plan

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Figure 2-1
Existing Flow
Data Sources

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2.3 Future Dry Weather Flow

Future dry weather flows for near-term (2015) and long-term (2035) scenarios were developed for analysis in this study. This section outlines the methodology used to calculate future flows. It is noted that recent government campaigns promoting water conservation and water-saving improvements to plumbing fixtures could actually result in a reduction in flow in the coming years. For this reason, it can be said that the flow assumptions in this report are conservative.

2.3.1 Future Flows within City Limits

Future flows on redeveloping or vacant parcels were estimated based on the CDR's population and employment projections by Traffic Analysis Zone (TAZ). These projections, which included extensive input from the City's planning department, show increases in population and employment which correspond directly to specific development projects. The projections also include a standard minimum increase in population and employment due to infill, densification, and/or household size increases throughout the City. **Figure 2-2** shows the TAZ boundaries and development project locations within the City.

The following method was used in this study to distribute the TAZ projections to the underlying model subcatchments. First, each TAZ was assigned a standard growth rate for each scenario. Standard growth rates for each scenario were estimated from TAZs that had no specific planned development:

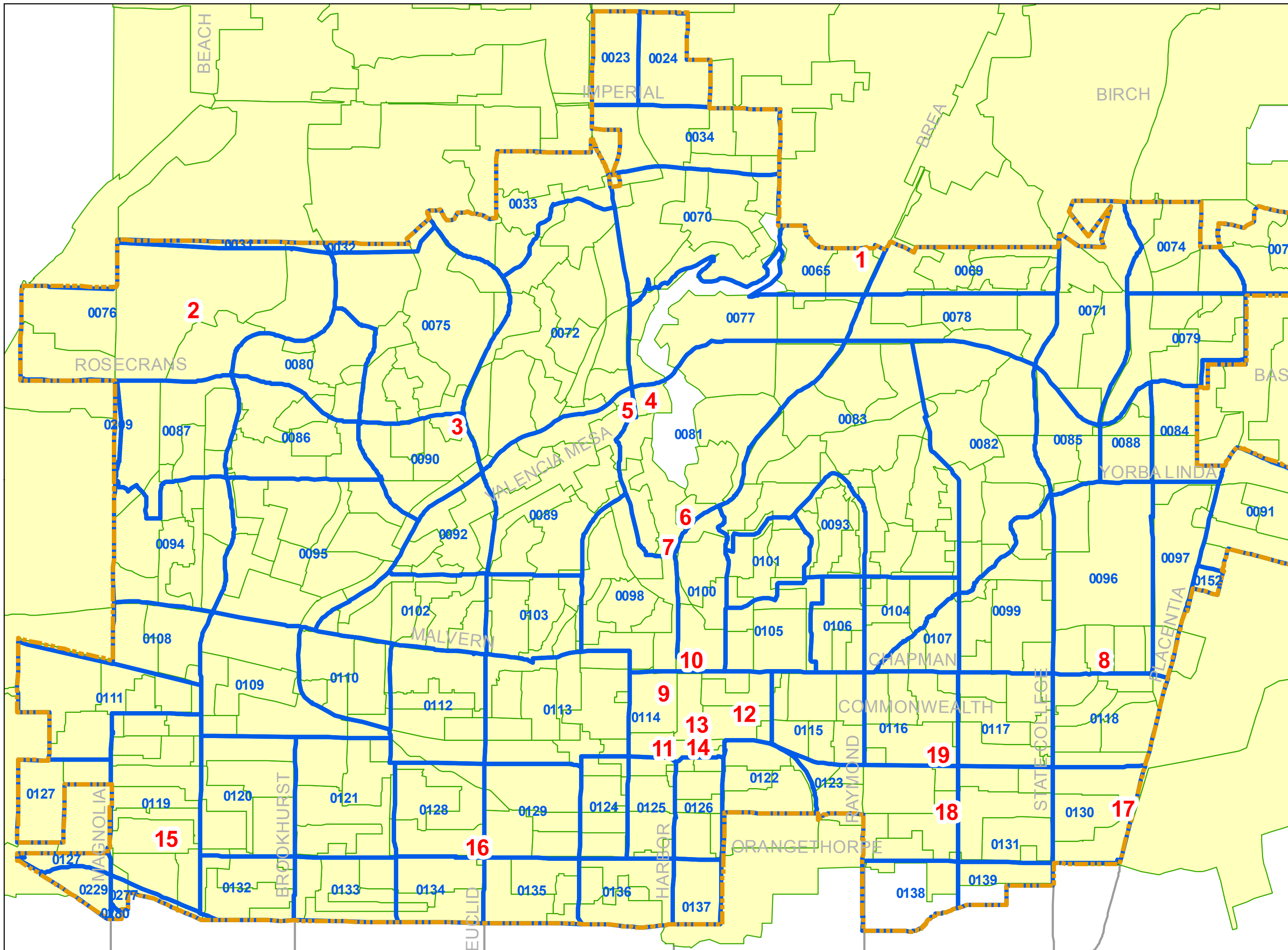
- Residential 2008 to 2015 = 8%
- Residential 2016 to 2035 = 3%
- Non-residential 2008 to 2015 = 4%
- Non-residential 2016 to 2035 = 2%

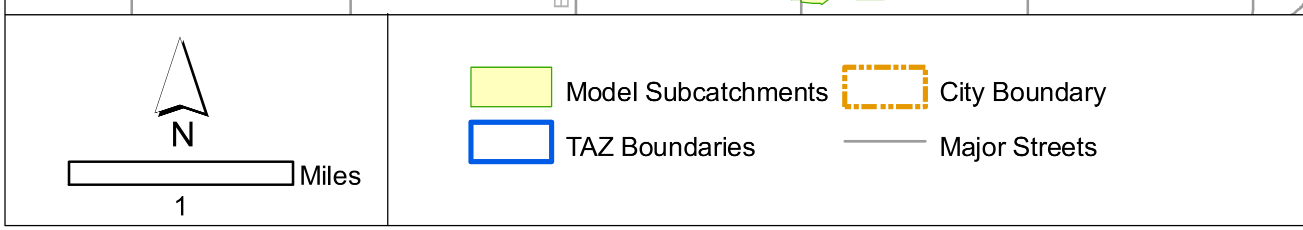
The resulting increases in population and employment were distributed to the underlying subcatchments within each TAZ using an area-weighted method. In other words, the ratio of a subcatchment's population and employment increase to the TAZ's population and employment increase was equivalent to the ratio of the subcatchment's area to the total area of all subcatchments within that TAZ.

Second, any growth projected on top of standard growth was assumed to be related to specific development projects located within that TAZ, as identified in the City's Development Activity Maps. Project-specific growth was applied directly to the subcatchment(s) in which planned development will occur.

Figure 2-2 illustrates how assigning project-specific population and employment growth at the subcatchment level provides a higher level of detail than distributing the growth throughout the TAZ, which covers a broader area than a subcatchment. The following is a list of all planned developments that were included in the study:

- Amerige Court
- Fox Theater
- Fullerton Campus Village
- Fullerton Transportation Center
- Harbor Medical Investors
- Home Depot/Sams Club
- Jacaranda Senior Developments
- Newcastle Development
- Nicklett Apartments
- Orangethorpe Plaza
- Providence Center/St. Jude Plaza
- Sai Power Development
- SOCO Walk
- University Heights
- West Coyote Hills
- World Citrus





1 Sai Power Development
TR 17117, PRJ 06-00287

2 West Coyote Hills
TR 15671, 15672, 15673
PRJ 03-00075

3 Jacaranda Senior Apartments
TR 17131, PRJ 03-00365

4 St Jude Medical Center Specific Plan
PRJ 04-00319

5 Providence Center/St Jude Plaza
PM 2006-248/2007-133
PRJ 04-00919/06-00291

6 University Heights
TR 16834, PRJ 04-00859

7 Harbor Medical Investors
PRJ 06-00586

8 Fullerton Campus Village
TR 17162 PRJ 07-00344

9 Amerige Court
10 Fox Theatre
11 World Citrus

12 Newcastle Development
PRJ 05-00753

13 Fullerton Transportation Center
CIP 42930

14 SOCO Walk
TR 16583 PRJ 03-00864

15 Nicklett Apartments
PRJ 08-00054

16 Orangethorpe Plaza
PRJ 06-00452

City of Fullerton
Sewer Master Plan

Figure 2-2
TAZ Boundaries and Planned Development

Unit flow factors of 75 gal/cap/d and 25 gal/emp/d were used to calculate flow from the population and employment projections, respectively. These factors come from the OCSD model calibration, which used flow data from the City of Fullerton to determine an area-specific unit factor.

For developed parcels which have no plan for redevelopment, the same water billing data was assumed to characterize dry weather flow in the future.

One of these development projects, the Fullerton Transportation Center (FTC), was updated during the course of the Master Plan and required further study. Housing unit (residential use) and square footage (commercial use) projections were provided by the City, from which RMC developed a methodology for calculating wastewater flow. It was assumed that the FTC would be constructed entirely between 2015 and 2035. These updated flows were used in place of the TAZ projections. The estimation of flows for the FTC is fully documented in the *Fullerton Transportation Center Sewer Study (June 2009)* included as **Appendix A** of this Master Plan.

2.3.2 Future Flows from Outside City Boundary

A similar approach to that used to estimate existing flows from outside the City boundary was used for future flow estimation. Population and employment projections from the OCSD model had been developed for the following planning scenarios: 2010, 2020, and 2030. For the purposes of this study it was assumed that the OCSD 2020 projections correlated to the City's 2015 projections, and the OCSD 2030 projections correlated to the City's 2035 projections.

2.3.3 Future Large Discharger Flows

All existing flows from large dischargers was assumed to remain the same in future scenarios, with the exception of St. Jude Medical Center. The St. Jude Medical Center is currently planning to expand several wings of its hospital, a project which will require a new sewer connection on Bastanchury Rd. in addition to their existing connection on Valencia Mesa. Future flows were estimated using a flow factor of 300 gpd/1000ft^2 for medical buildings (City of Los Angeles Bureau of Engineering *Sewer Design Manual*). The flows to each sewer line are shown in **Table 2-3**.

Table 2-3: St. Jude Medical Center Flows

	Existing (2008)	2015	2035
Flow to Bastanchury Line (mgd)	0.065	0.125	0.125
Flow to Valencia Mesa Line (mgd)	---	0.033	0.128
Total Average Flow (mgd)	0.065	0.158	0.253

2.4 Dry Weather Flow Summary

Table 2-4 summarizes the existing and future residential and non-residential dry weather flow estimates for the City of Fullerton. These values exclude flow from outside of the City limits.

Table 2-4: City of Fullerton Dry Weather Flow Summary

	Existing (2008)	2015	2035
Residential Flow (mgd)	10.85	13.10	14.43
Non-Residential Flow (mgd)	3.74	4.20	4.31
Large Discharger Flow (mgd)	2.96	3.06	3.15
Total Average Dry Weather Flow (mgd)	17.55	20.36	21.89

Chapter 3 Hydraulic Model Building and Calibration

This chapter documents the procedures used to build and calibrate the InfoSWMM™ hydraulic model used for the Master Plan. The objective of this documentation is to provide an overview of the model development process, including steps taken to calibrate the model to dry and wet weather conditions.

This chapter covers the following topics:

- Terminology
- Model Software
- Data Sources
- Model Building
- Model Calibration

3.1 Terminology

Network refers to the representation of the physical facilities being modeled. The primary components of the modeled network are pipes and manholes.

Nodes are primarily manholes, but also include outfalls (discharge points from the modeled system) and breaks (changes in slope or diameter without a structure). Breaks are used to model inverted siphons. The primary data associated with nodes are manhole invert and ground elevations.

Pipes are connections between nodes. The primary data associated with pipes are upstream and downstream node IDs, pipe length, diameter, roughness factor, and upstream and downstream invert elevations.

Subcatchments are areas that contribute flow to the modeled sewer network. Data associated with subcatchments include sanitary flow, infiltration/inflow (I/I) parameters, and the node at which the flow from the subcatchment enters the modeled system.

Model loads are the flows associated with load manholes. Components of model loads are residential and commercial base flow, groundwater infiltration (GWI), and rainfall-dependent I/I (RDI/I). As a sum, they represent the total wastewater flow applied to the model.

Models are the combination of a modeled network, its associated subcatchments and loads, and other data files (e.g., rainfall, diurnal curves, inflows from other areas, etc.) that comprise a specific model scenario.

3.2 Model Software

The City, in conjunction with RMC, selected InfoSWMM™ (MWHSoft) to be used for the capacity analysis. InfoSWMM uses the EPA's SWMM hydraulic engine, which provides a fully-dynamic solution for modeling stormwater and sanitary sewer systems. The program has an ArcGIS-based model interface. RMC agreed to use its own InfoSWMM license to perform the modeling analysis.

3.3 Data Sources

The following paragraphs describe the sources of data that were used to construct the model.

OCSD Model. OCSD developed a model of their trunk sewer system in 2005 using InfoWorks™ software. As the extent of the City rests entirely within OCSD's service area, this model contains information such as diurnal profiles and wet weather parameters that were useful for the calibration of the City's model. In addition, the City's sewer model was integrated with the OCSD model to create a fully-connected network which models the effects of OCSD trunk sewer hydraulics on the City's sewer system.

Sewer GIS Layers. GIS layers of sewer manholes and sewer mains were provided by the City. The layers provide the location, unique ID, pipe length and pipe diameter for all sewer structures within the City's jurisdiction, including structures owned and maintained by OCSD. Pipe slopes and manhole depths were available for most City structures, and found to be highly accurate.

1974 Model Database. Data from a modeling study conducted in 1974 were compiled by the City. The database contains information that is missing from the GIS layers, mainly manhole invert elevations, manhole ground elevations, and pipe invert elevations. The database references old manhole IDs, which needed to be translated into the current manhole IDs for use in the model.

As-built drawings research. Both RMC and the City performed as-built drawing research to fill in data gaps found in the GIS layers and 1974 model database. This research resulted in the addition of 11 inverted siphons to the model, as well as any updates to the sewer system following the completion of the 1974 modeling study.

Parcel, billing and TAZ data. Water billing records, measured during a two-month period in the winter of 2007-2008, were the primary source of sanitary flow data for the model. Future flows were estimated using population and employment projections provided by Traffic Analysis Zone (TAZ). The procedure for processing these data is described in **Chapter 2**.

Flow monitoring data. Initial model results are compared to flow monitoring data during model calibration. As part of an iterative process, model parameters are adjusted until a good fit to the flow data is achieved. Three sets of flow monitoring data, all obtained from meters installed and maintained by ADS Environmental Services, were evaluated for the dry and wet weather calibration.

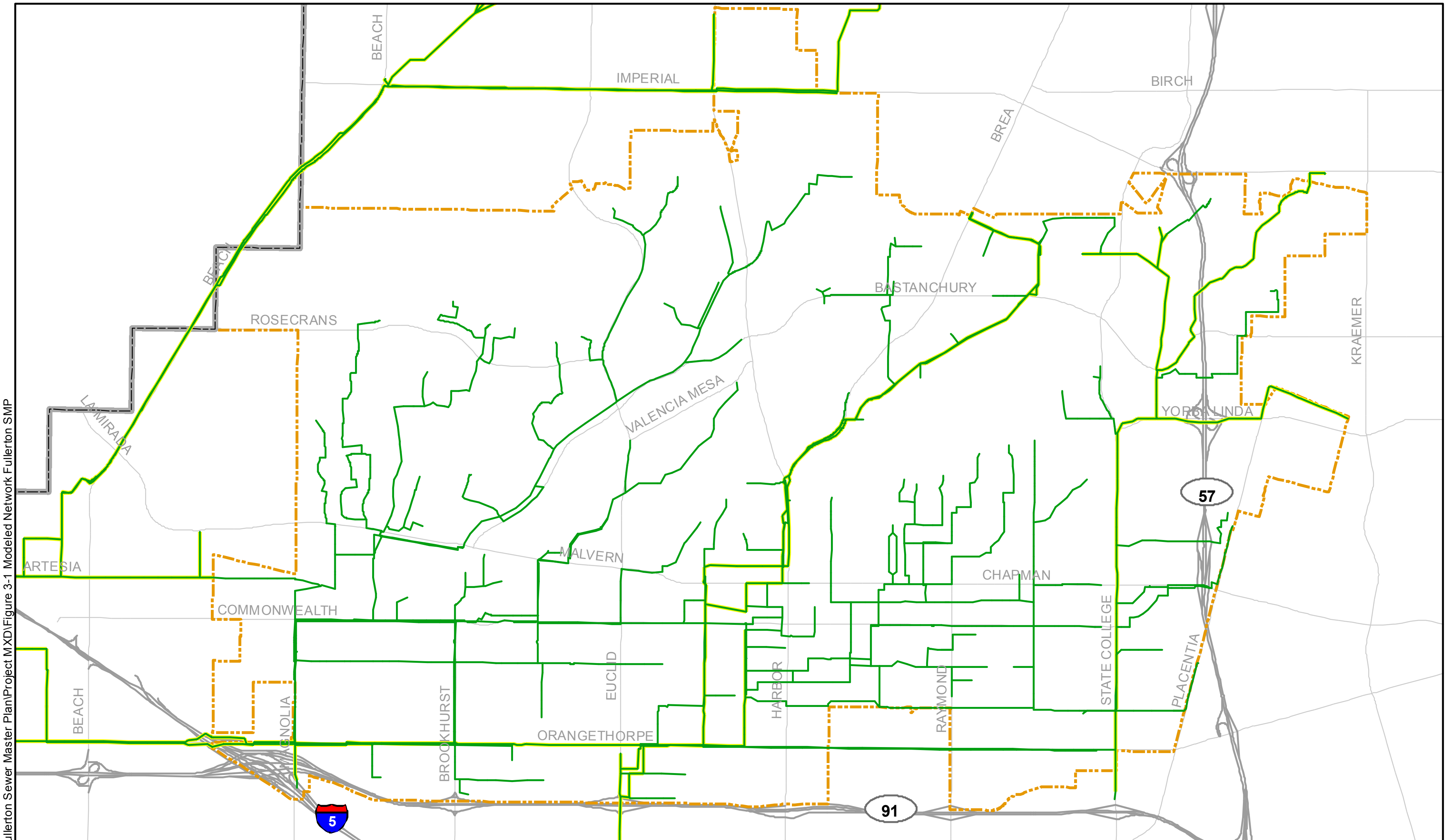
3.4 Model Building

This section describes how the model network was defined, and the steps that went into building an accurate and comprehensive model.

3.4.1 Network Definition

The modeled network includes all pipes 10-inch and larger in diameter, any 6 to 8-inch lines conveying flow from areas larger than 40 acres, and all OCSD trunk sewer lines located within the City. In total, the network includes 80 miles (24% of total system length) of City sewers and 51 miles of OCSD trunk sewers. It includes 30 miles of 6 and 8-inch sewers. The model network has 6 model outfalls (endpoints), all of which connect to OCSD's sewer system. The model network is shown in **Figure 3-1**.

The City's total area was divided into 288 subcatchments with an overall average of 40 acres per subcatchment. In order to model all of the flow in the OCSD trunk lines, an additional 61 subcatchments covering portions of the cities of La Habra, Brea, Placentia, and Anaheim were included. Model subcatchments are shown in **Appendix B.**



N

Miles
1

Modeled Sewer
OCSD Trunk Sewer
County Boundary
City Boundary

City of Fullerton
Sewer Master Plan

RMC Water and Environment

Figure 3-1
Modeled Network

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\Figure 3-1 Modeled Network Fullerton SMP

3.4.2 Data Validation

Once the model network was defined, a data validation procedure was followed to fill in missing information and create a fully-connected network.

The data validation process included the following steps:

- Establish a logical numbering system for all model components. Manholes were named as they are on City Atlas maps, for example, “7-13” where 7 is the manhole number and 13 is the reference sewer atlas page. Pipes were named using the upstream manhole name followed by a unique suffix integer, for example, “7-13.1”. For flow splits where there are two pipes with the same upstream manhole, example names would be “7-13.1” and “7-13.2”. Subcatchments were named using a three-digit sequential number, for example, “FULL_001”. Subcatchments imported from the OCSD model were named according to their load node and preceded by the letter “R”, for example, “R_EUB0640-0000”.
- Check the modeled network for connectivity, i.e., verify upstream/downstream manholes were identified and correct for each pipe and all links were present between manholes in the network.
- Populate manhole and pipe attribute data. Use diameter and length data from the GIS layers. Use manhole invert and rim data from the 1974 model database. Perform as-built drawing research to populate attributes for post-1974 sewers. For pipes which did not have data from these sources, infer invert elevations from GIS slope data and ground elevations from GIS manhole depths.
- Plot pipe profiles of the modeled network to visually check for missing or suspect data. Examples of missing or suspect data include missing invert or ground elevations, negative pipe slopes, or abrupt inclines/declines in pipe inverts or diameters. Where appropriate, make inferences (i.e., interpolate between known points, use pipe slope to calculate inverts, add manhole depth to invert elevation to get ground elevations) to populate missing data or adjust suspect data.
- Add siphons. Siphons were incorporated into the model network using siphon as-built plans (i.e., inverts, diameter, single/double siphon). Nodes were added as breaks to model the downward, upward, and horizontal legs of inverted siphons.
- Incorporate drop manholes. In general, pipe inverts were assumed to be the same as the inverts of the manholes it connected. This was due to the inability to associate upstream and downstream pipe invert data from the 1974 database with the correct pipe in the GIS. However, an effort was made to identify drop manholes and populate the model database with the correct elevations. Invert elevations of incoming/outgoing pipes were adjusted if the invert difference was equal or greater than 0.5 feet. The lowest incoming/outgoing pipe invert was used for the invert of the manhole.
- Modify weirs. Over 20 weir/diversion structures exist in the OCSD sewer system within Fullerton. Weir heights and settings were adjusted according to weir information provided in the OCSD modeling documentation. Correct weir operation was essential for modeling the OCSD system, and required several model modifications when converting from Infoworks to InfoSWMM.
- Datum adjustment. The entire OCSD network was decreased by 7.995 feet to match the vertical datum of the City. All connections between the City and OCSD modeled lines were checked for continuity. If elevations were missing at the City connection to the OCSD model, invert elevations were inferred by matching pipe crowns where pipe size increased by 0.5’ or greater.
- Model Loads. Assign model loading nodes to all of the subcatchments. **Appendix B** shows the modeled subcatchments and IDs.
- Populate global parameters which are required by the model, such as manhole diameters (assumed to be 4 feet) and Manning’s ‘n’ (assumed to be 0.013 for all gravity sewers).

3.5 Model Calibration

Model calibration is the process of comparing model-computed flows to observed (monitored) flows and adjusting various model parameters until the model is accurately simulating flows in the sewer system. The model was calibrated for both dry and wet weather conditions.

3.5.1 Flow Monitoring Data

The main objective of flow monitoring data is to characterize dry weather flow and wet weather flow response to rainfall in different parts of the sewer system.

The following sets of flow monitoring data were evaluated for the dry and wet weather calibration:

1. 18 meters and 3 raingauges installed by ADS Environmental Services for the City as part of the "Wastewater Collection System Infiltration and Inflow Study", January 13, 2005 to February 23, 2005.
2. 6 meters installed by ADS Environmental Services for the City as part of a dry weather temporary flow monitoring study, June 27, 2007 to July 3, 2007.
3. 28 long-term meters installed by ADS Environmental Services for OCSD, May 2002 to April 2005.

32 meters (sets one and two plus eight meters from set three) were considered for the dry weather calibration and 46 meters (sets one and three) were used for the wet weather calibration. The locations of flow meters and raingauges used in the calibration are shown in **Figure 3-2**.

Although much of the flow monitoring data (2005) and the water billing data (2008) were three years apart, it was not anticipated to effect the calibration. Quarterly redevelopment maps prepared by the City indicated that no major redevelopment had been constructed between these years.

3.5.2 Dry Weather Calibration

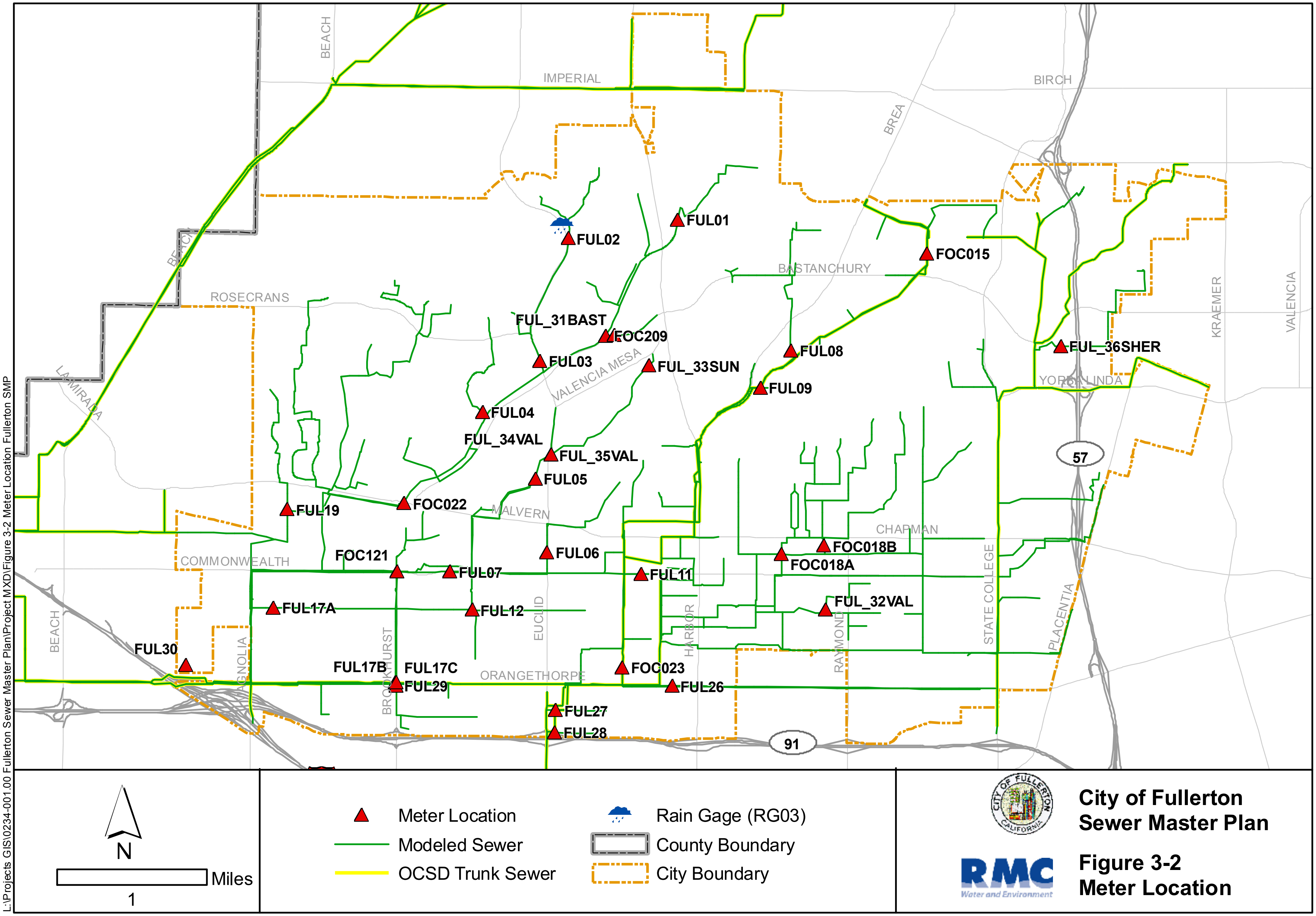
In domestic wastewater systems, dry weather flow (DWF) varies throughout the day, peaking early in the morning in upstream sewers and later and less sharply in larger downstream sewers due to flow travel time and attenuation. Typical peak hourly flow from residential areas tends to be 1.5 to 2 times the average flow. DWF patterns in commercial and industrial areas depend on specific land use types but are typically characterized by a more uniform flow that lasts throughout working hours. For both residential and non-residential areas, there are also differences between weekday and weekend diurnal flow patterns.

When a dynamic analysis of the sewer system is conducted, the peak flows are determined by routing the individual diurnal DWF hydrographs for all of the model subcatchments through the sewer system using the hydraulic model. The model attenuates flow based on hydraulic storage and routing computations, which results in lower peaking factors as flow proceeds downstream.

The 5-day dry period from January 15 -19, 2005, was used as the dry weather calibration period for comparing flow data to the model results. This period consisted of a Saturday, Sunday and three weekdays, during which a majority of the meters showed consistent readings. Data from meters FOC18B, FOC209, FUL02, FUL04, and FUL28 either had missing data, drifting or strange peaks before or during the dry weather event. For these meters, data was used from another dry time period: January 29-February 2 (Saturday to Wednesday).

The most important step in the dry weather calibration was to determine the correct sewer return rate (ratio of water consumption to wastewater generation) throughout the City. Based on land use type and geographic location, return rates were found to vary between 50% and 100%:

- Non-residential parcels = 100%
- Small residential parcels (land use types other than R1) = 95%
- Larger residential parcels (R1) = 75%
- Parcels located within meter basins FUL02, FUL03, FUL04, FUL06, FOC018 = 50%



City of Fullerton
Sewer Master Plan

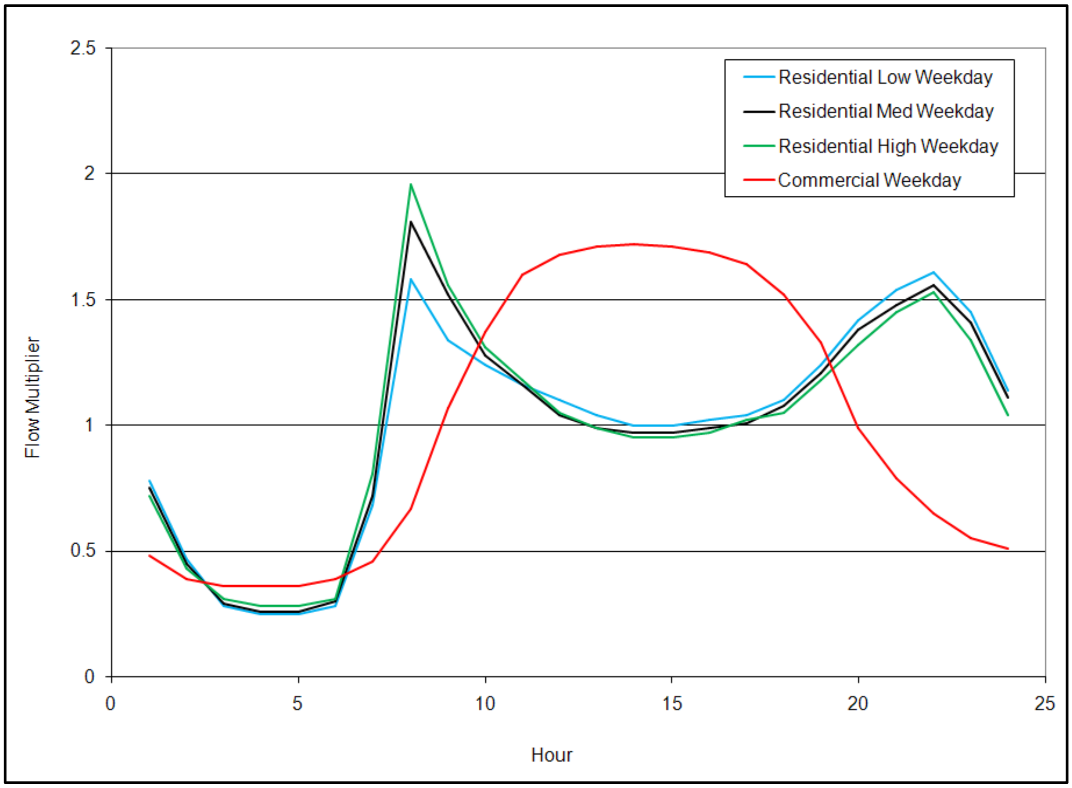
Figure 3-2
Meter Location

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\Figure 3-2 Meter Location Fullerton SMP

Large discharger flows came directly from wastewater flow estimates provided by OCSD and were therefore assigned a return rate of 100%. Flows from outside the City boundary were taken directly from the OCSD model.

The second step was to create diurnal curves for the model which calibrated well to those observed at meter locations. The diurnal curves used in the OCSD model were used as the starting point, and were modified as needed for the City's model. The OCSD model included three residential diurnal curves, one commercial curve and one industrial curve, applied based on land use characteristics. For residential areas, different curves were applied to subcatchments based on income levels (low, medium, and high). Different curves were defined for weekend and weekday conditions. The final weekday calibrated curves that were used in the City's model are shown in **Figure 3-3**.

Figure 3-3: Diurnal Curves



Finally, groundwater infiltration (GWI) was added when the observed dry weather hydrographs were greater than the simulated hydrographs by a relatively constant value throughout the day. The additional flow seen at the meter was distributed to subcatchments within the meter basin on an area-weighted basis (gal/day/acre). GWI was applied to the following meter basins:

- FUL01 = 0.03 mgd
- FUL08 = 0.08 mgd
- FUL09 = 0.01 mgd

Tables 3-1 and 3-2 compare the model vs. metered dry weather flow (average and peak, respectively) at each of the meter locations. **Appendix C** shows plots of modeled vs. metered flow for all of the meters.

The model calibration resulted in a good match between modeled and metered average flow, within 20 percent for 27 of the 31 meters. The total measured flow at all the meters was within 2 percent of the

Table 3-1: DWF Calibration Results
Average Metered Flow vs. Average Modeled Flow

Meter	Meter Avg Flow (mgd)	Model Avg. Flow (mgd)	Percent Difference
FOC015	1.147	1.263	10%
FOC018A	0.155	0.179	15%
FOC018B	0.192	0.171	-11%
FOC022	1.264	1.354	7%
FOC023	3.154	3.524	12%
FOC121	0.822	0.739	-10%
FOC209	0.589	0.452	-23%
FUL01	0.217	0.210	-3%
FUL02	0.082	0.069	-16%
FUL03	0.205	0.203	-1%
FUL04	0.132	0.127	-4%
FUL05	0.198	0.212	7%
FUL06	0.137	0.132	-3%
FUL07	0.200	0.155	-22%
FUL08	0.425	0.398	-7%
FUL09	0.083	0.069	-16%
FUL11	0.307	0.323	5%
FUL12	0.351	0.311	-11%
FUL17A	0.158	0.151	-4%
FUL17B	0.335	0.318	-5%
FUL17C	0.172	0.186	8%
FUL19	0.139	0.167	20%
FUL26	0.268	0.259	-3%
FUL28	0.155	0.158	2%
FUL29	0.164	0.149	-9%
FUL_31BAST	0.251	0.202	-19%
FUL_32VAL	0.154	0.101	-35%
FUL_33SUN	0.061	0.054	-11%
FUL_34VAL	0.144	0.142	-2%
FUL_35VAL	0.057	0.070	23%
FUL_36SHER	0.101	0.124	23%
TOTAL	**11.823**	**12.097**	**2%**

Table 3-2: DWF Calibration Results
Peak Metered Flow vs. Peak Modeled Flow

Meter	Meter Peak Flow (mgd)	Model Peak Flow (mgd)	Percent Difference
FOC015	1.877	1.958	4%
FOC018A	0.335	0.294	-12%
FOC018B	0.380	0.309	-19%
FOC022	2.397	2.124	-11%
FOC023	5.344	5.457	2%
FOC121	1.580	1.161	-27%
FOC209	0.974	0.766	-21%
FUL01	0.389	0.375	-4%
FUL02	0.164	0.125	-24%
FUL03	0.371	0.319	-14%
FUL04	0.297	0.242	-19%
FUL05	0.366	0.342	-7%
FUL06	0.256	0.213	-17%
FUL07	0.337	0.318	-6%
FUL08	0.800	0.606	-24%
FUL09	0.161	0.136	-16%
FUL11	0.518	0.514	-1%
FUL12	0.612	0.500	-18%
FUL17A	0.301	0.249	-17%
FUL17B	0.610	0.503	-18%
FUL17C	0.319	0.290	-9%
FUL19	0.306	0.302	-1%
FUL26	0.515	0.411	-20%
FUL28	0.307	0.250	-19%
FUL29	0.358	0.247	-31%
FUL_31BAST	0.569	0.288	-49%
FUL_32VAL	0.382	0.159	-58%
FUL_33SUN	0.149	0.088	-41%
FUL_34VAL	0.288	0.224	-22%
FUL_35VAL	0.142	0.125	-12%
FUL_36SHER	0.222	0.224	1%
TOTAL	**21.626**	**19.119**	**-12%**

total modeled flow, indicating the total flows in the model are accurate. Peak flows were within 20 percent for 23 of the 31 meters. Inspection of the comparison graphs displayed in **Appendix C** indicates that the model simulates dry weather flow conditions in the system very well.

Meters which were more than 20 percent different from the modeled flows were analyzed extensively to determine the reason for the difference. Meters FUL_32VAL, FUL_35VAL, and FUL_36SHER were from the 2007 dry weather monitoring study. These meters were only installed for one week, meaning that it was not possible to review a large dataset and pick data that appeared to be most representative of the total dataset. Therefore the average and peak flows from the meter data may not be very accurate. This situation can be observed on day four of Meter FUL_32VAL's data, when flows are much higher than those on other days of that week.

Looking at the FUL_35VAL comparison plots, the model actually appears to very accurately represent flows from this area. The reason for the poor matching percentage is that the meter data is very spiky, which would lower the calculated average flow from the meter.

Upstream of Meter FUL07, there were many apparent flow splits (manholes 57-19, 14-23, 46-23, and 59-17) which were resolved as best as possible. However, it is possible that one or more of the splits are still not modeled to accurately depict field conditions. This potentially affects flows in the City lines located on Commonwealth, but mainly only affects the OCSD trunks.

3.5.3 Wet Weather Calibration

During wet weather calibration, parameters are adjusted to accurately simulate the volume and timing of rainfall dependent infiltration and inflow (RDI/I) for a historical storm. The storm occurring from February 17-23, 2005 was selected for calibration due to its large size, significant RDI/I response, and the availability of extensive flow monitoring data. During this storm, approximately 7.5 inches of rainfall fell on the City, with a peak rainfall rate of 1.6 inches/hour.

A review of two rainfall data sources was conducted to determine which should be used for calibration: 1) gauge-adjusted radar rainfall data for 2-kilometer square pixels obtained for the *OCSD Strategic Plan Update (2006)* and 2) raingauge data collected at three sites by ADS as part of the *Wastewater Collection System Infiltration and Inflow Study (2005)*. Radar rainfall data is typically used in lieu of raingauge data to represent rainfall over large areas because it accounts for spatial variation in a rainfall event throughout the coverage area without having to install a large number of raingauges. For this study, given the relatively small size of the study area, the available raingauge data was considered to more accurately represent average rainfall in the City than the radar data for the entire OCSD service area. Data from raingauge RG03 was chosen for use during the calibration because it was located in the area of the City which had the highest RDI/I, thereby resulting in the most accurate calibration for sewers most affected by RDI/I. **Figure 3-4** shows a plot of 15-minute data for the rainfall event as measured by raingauge RG03.

Data from 24 meters installed in the winter of 2005 were used for the calibration, 18 of which were installed on City sewers. The six meters installed in the summer of 2007 were intended to capture dry weather flow only and were not used in the wet weather calibration.

InfoSWMM simulates RDI/I as a fraction of rainfall and distributes it over time using three triangular synthetic hydrographs. Each of the triangular hydrographs has its own characteristic parameters, namely time to peak (T), recession constant (K), and fraction of an effective rainfall volume allocated to the triangle (R). Each of the three hydrographs represent different components of RDI/I. The first triangle represents rapidly responding (short-term, or "fast") components, such as direct inflow. The third triangle represents long-term or "slow" runoff components which can take up to a day to enter the sewer system. The second triangle represents infiltration with an intermediate or "medium" time response. The total unit hydrograph is the aggregation of the three triangular hydrographs. The technique is illustrated in **Figure 3-5**.

Figure 3-4: February 17-23, 2005 Rainfall Event

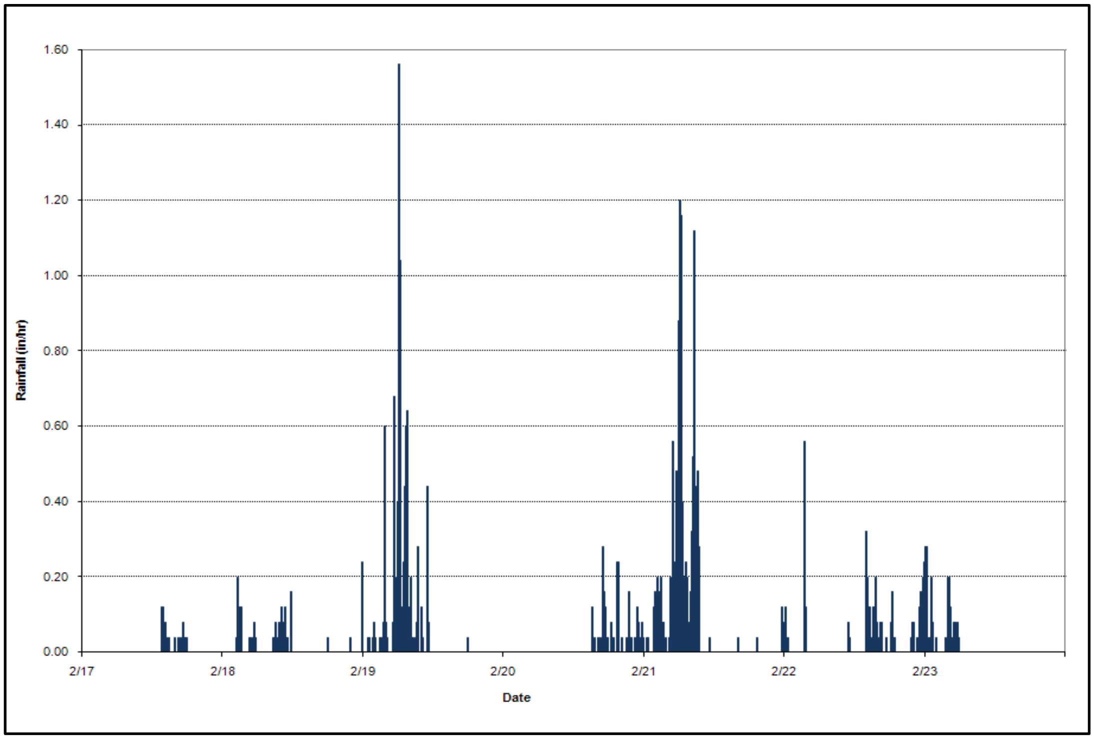
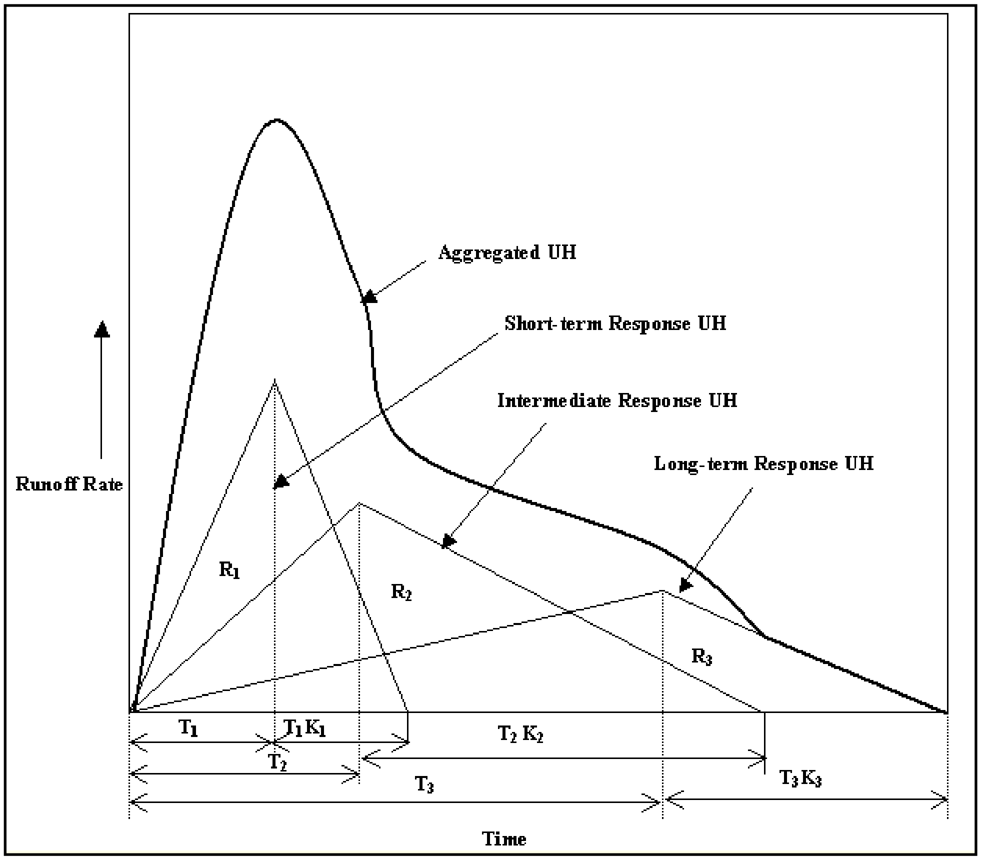


Figure 3-5: InfoSWMM Wet Weather Hydrograph



It is noted that the wet weather period actually has two storm events: one occurring February 19th and the other occurring on the 21st. In a typical design storm condition, soils are saturated and the amount of infiltration entering the sewer system is at a maximum. This condition is represented best by the second storm, which follows closely after the first storm has saturated the soils. Therefore, when refining RTK values for the calibration, greater emphasis was placed on matching the second storm because it was more representative of a typical design storm condition.

The unit hydrograph parameters were independently calibrated for each of the City meters used in the wet weather calibration. For areas of the City that were not metered or that drained directly to OCSD trunks, the parameters were derived from the calibration parameters in the OCSD InfoWorks model.

Table 3-3 lists the calibrated parameters for each meter basin. The results show that Meters FUL01, FUL05, FOC023 and FOC121 have the highest R-values, a finding which is discussed in detail in ADS's 2005 report. Many of the meters had a significantly high "fast" component, with peaks occurring within 15 to 30 minutes of the rainfall. A high "fast" component indicates that there may be sources of direct inflow in the City (although sources other than direct inflow can also account for "fast" RDI/I).

Appendix D shows plots of model vs. metered flow for the 2005 calibration storm. **Table 3-4** compares the model vs. metered wet weather flow at each of the meter locations. The model calibration resulted in a good match between modeled and metered peak flow, within 20 percent for 23 of the 25 meters. As stated above, results were compared for the second storm of the event period.

Table 3-3: WWF Calibration Parameters

Meter	R-value (%)	Fast (%)	Medium (%)	Slow (%)
FOC015	4.3	0.21	1.06	2.98
FOC018	2.5	0.75	1.00	0.75
FOC022	4.0	2.00	0.80	1.20
FOC023	8.0	2.40	4.00	1.60
FOC121	8.0	4.00	1.60	2.40
FOC209	6.0	0.30	2.70	3.00
FUL01	12.0	1.20	6.00	4.80
FUL02	7.0	2.80	2.10	2.10
FUL03	2.8	1.96	0.56	0.28
FUL04	4.0	2.00	1.20	0.80
FUL05	8.0	3.20	2.40	2.40
FUL06	3.0	2.10	0.45	0.45
FUL07	1.2	0.60	0.24	0.36
FUL08	4.0	2.80	0.60	0.60
FUL09	3.0	2.40	0.30	0.30
FUL11	5.0	3.50	0.50	1.00
FUL12	4.0	2.80	0.80	0.40
FUL17	0.2	0.01	0.09	0.10
FUL 19	1.0	0.40	0.30	0.30
FUL 26	3.0	2.40	0.30	0.30
FUL 27	0.0	0.00	0.00	0.00
FUL 28	3.0	1.80	0.60	0.60
FUL 29	4.5	2.25	1.35	0.90
FUL30	0.9	0.04	0.39	0.43

Table 3-4: WWF Calibration Results
Peak Metered Flow vs. Peak Modeled Flow

Meter	Meter Peak Flow (mgd)	Model Peak Flow (mgd)	Percent Difference
FOC015	2.934	2.995	2%
FOC018A	0.989	0.918	-7%
FOC018B	0.837	0.727	-13%
FOC022	5.745	5.466	-5%
FOC023	12.660	12.559	-1%
FOC121	3.616	2.890	-20%
FOC209	2.237	2.167	-3%
FUL01	1.602	1.493	-7%
FUL02	0.840	0.918	9%
FUL03	1.642	1.687	3%
FUL04	0.761	0.909	19%
FUL05	1.918	1.766	-8%
FUL06	0.835	0.773	-7%
FUL07	1.099	1.071	-3%
FUL08	1.574	1.910	21%
FUL09	0.577	0.540	-6%
FUL11	1.040	1.096	5%
FUL12	1.518	1.602	6%
FUL17A	0.323	0.329	2%
FUL17B	1.161	0.974	-16%
FUL17C	0.470	0.502	7%
FUL19	0.367	0.372	1%
FUL26	0.789	0.626	-21%
FUL28	0.437	0.525	20%
FUL29	0.778	0.888	14%
TOTAL	**46.749**	**45.703**	**-2%**

Chapter 4 Sewer System Capacity Analysis

The calibrated hydraulic model was used to identify any capacity deficiencies in the system for both dry and wet weather flows under existing and future conditions. This chapter presents the criteria that were used to identify potential hydraulic capacity deficiencies, including the design storm that was used to evaluate wet weather capacity. The results of the model analysis are then summarized. Improvement projects formulated from these deficiencies are detailed in **Chapter 5**.

It is noted that although the OCSD trunks were modeled and the results shown on capacity figures in this chapter, they are not listed as deficiencies to be addressed in this Master Plan.

4.1 Design Storm

The use of wet weather design events as the basis for sewer capacity evaluation is a well-accepted practice. The approach is to first calibrate the model to match wet weather flows from observed storm(s), and then apply a design event to identify and size improvement projects. The design event may be synthesized from rainfall statistics, or may be an actual historical rainfall event of appropriate duration and intensity. Other considerations for the design event include the spatial variation of the rainfall and the timing of the storm relative to the diurnal sanitary flow pattern.

Selection of a design rainfall event is typically based on an allowable level of risk, often expressed as the return period. It is recognized that while wet weather overflows are highly undesirable, it is not cost-effective to provide capacity for the largest possible event. Regulatory agencies have not adopted standard criteria for return periods, so each agency must choose a target return period based on desired level of service, impacts of overflow events, and cost. Choosing to maintain a high level of service to its customers, the City has decided to use a 10-year return period for analysis of wet weather capacity.

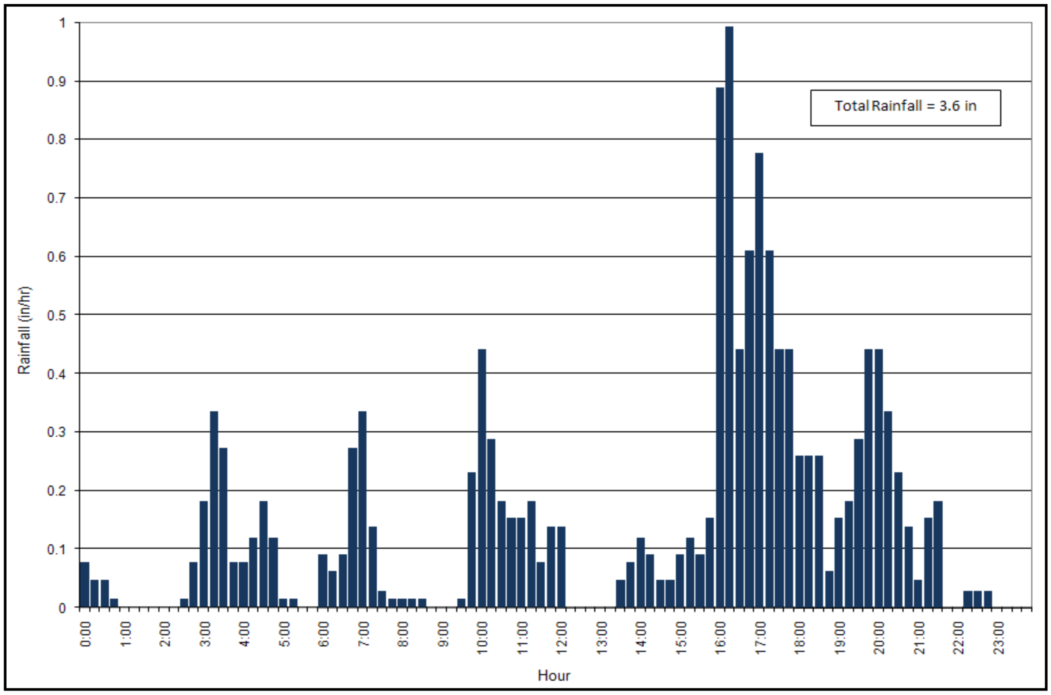
For the *OCSD Strategic Plan Update* (April 2006), a 10-year design storm was developed for the OCSD service area, which incorporates the City of Fullerton. The storm had the following characteristics:

- Based on an actual storm occurring on January 9, 2005, in the same season as the storm used to calibrate the model for this report
- Estimated to be a 5-year storm according to a DDF (depth-duration-frequency) analysis of historical and radar rainfall
- Rainfall scaled up by 20% to be equivalent to a 10-yr storm
- Peaked between 4 and 6pm, which coincides with above-average but not peak dry weather flow
- Resulting peak flows approximately 10% lower than those occurring during the calibration event

This storm was determined to be appropriate for adoption as the City's design storm. The design storm hyetograph is shown in **Figure 4-1**. It is noted that the magnitude of the wet weather calibration event (in terms of resulting peak wet weather flow) was similar to that of the design event, meaning that the design storm analysis is a sensible approach for identifying and sizing sewer projects.

For future scenarios, the sewer system's response to rainfall will be assumed to remain the same on a per-acre basis as determined in the wet weather flow calibration. This implies that I/I will neither increase due to deterioration of existing sewers nor decrease due to sewer rehabilitation or replacement, and that new sewers and laterals will generate similar I/I as existing sewers. Of course, increases in dry weather flow due to new development and redevelopment will be added to the model at the appropriate locations, as described in **Chapter 2**.

Figure 4-1: 10-Year Design Storm Hyetograph



4.2 Sewer Deficiency Criteria

Sewer deficiency criteria are used to determine when the capacity of a sewer is exceeded to the extent that a relief sewer or larger replacement sewer is required. These are sometimes called "trigger" criteria in that they trigger the need for a project. These criteria often differ from criteria that are applied to determine the size of a new sewer, which are typically more conservative.

It is important that the sewer deficiency criteria be coordinated with the peak design flow criteria. For example, if the peak design flow considers only peak dry weather flow and little or no I/I, the deficiency criteria should be conservative (e.g., require pipes to flow less than full to allow capacity for I/I). On the other hand, if the peak design flow includes I/I from an infrequent storm event, it is appropriate to allow the sewers to flow full or even surcharged to some extent, since the peak flows will be infrequent and brief in duration.

Since the peak wet weather design flow includes RDI/I from a 10-year return period event, the City considers it acceptable to allow surcharging of up to two feet over the pipe crown before a capacity relief project is triggered, provided the hydraulic grade line remains at least five feet below the ground surface. Deficiencies were identified based on existing, 2015, and 2035 conditions. More information about the definition of these scenarios is presented in **Chapter 2**.

4.3 Dry Weather Flow Analysis

Although the deficiency criteria are based on peak wet weather flow, it is important to confirm that the system has adequate capacity to convey dry weather flows. The system was assessed under dry weather conditions using the same criteria as under wet weather; that is, surcharging of up to two feet was allowed provide the hydraulic grade line remains five feet below the ground. Areas identified as being deficient under dry weather flow will have a higher priority in the 20-year CIP than those identified under wet weather flow.

The calibrated model was run for dry weather flows under existing, 2015, and 2035 conditions.

Figure 4-2, **Figure 4-3**, and **Figure 4-4** present the maximum depth-to-diameter (d/D) results for these scenarios.

Under existing dry weather flow conditions, all pipes have adequate capacity (according to the sewer deficiency criteria) to convey peak dry weather flows.

Under 2015 and 2035 dry weather flow conditions, the model predicts that development east of California State University - Fullerton causes the following line to be deficient:

- Nutwood Ave between State College Blvd and Ruby Dr (10")

Other sewers which show up as red are surcharged but do not exceed the trigger criteria for this Master Plan.

4.4 Wet Weather Flow Analysis

The calibrated model was run for design wet weather flows under existing, 2015, and 2035 conditions. **Figure 4-5**, **Figure 4-6,** and **Figure 4-7** present the maximum depth-to-diameter (d/D) results for these scenarios.

The results show that under existing wet weather design event conditions, some of the main trunks in the system are full or surcharging. It is important to note that these results are not for an actual storm that occurred, but rather a 10-year return period design event, during which flows are approximately 20% higher than the January 9, 2005 storm. City staff state that a rain-induced overflow has never occurred in the system. Nevertheless, these results indicate that portions of the system may be heavily surcharged or overflowing during design wet weather conditions.

Under existing conditions, the model predicts that the following lines are deficient:

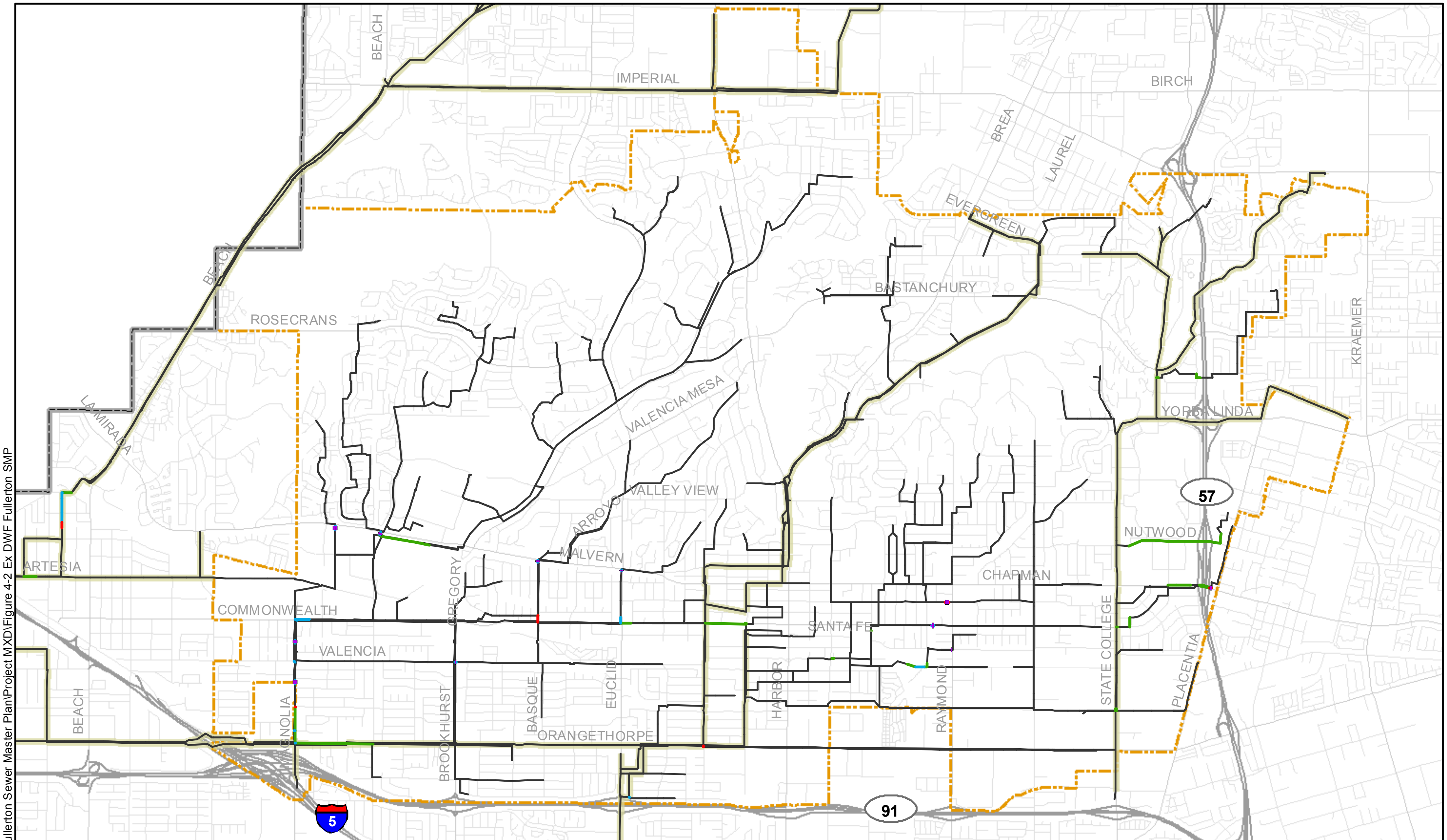
- W Bastanchury Road and Morellia Pl between N Euclid St and Arbolado Dr (8"- 10")
- N Euclid St from Rosecrans Ave to Bastanchury Rd (8")
- N Euclid St between W Malvern Ave and W Commonwealth Ave (8"- 10")
- W Valencia Dr between S Euclid St and S Woods Ave (8")
- Evergreen Ave and Laurel Ave between Maple Ave and Lark Ellen Dr (8")
- Arroyo Drive between Ramona Dr and W Malvern Ave (6")
- W Malvern between Arroyo Drive and N Basque Ave (8"- 10")
- N Basque Ave between W Malvern Ave and Gregory Ave (10" - 12")
- Gregory Ave between N Wanda Dr and N Basque Ave (15" – 18")
- Johnson Pl between Carhart Ave and N Stephens Ave (6")
- W Valencia Dr & S Basque Ave from S Brookhurst Rd to W Elm Ave (8" - 12")
- E Bastanchury Rd from Amberleaf St to Puente St (8" deep sewer)

For future flow conditions, additional deficiencies are caused by development and redevelopment of West Coyote Hills, St. Jude Medical Center, and the Fullerton Transportation Center. In addition to those lines mentioned above, the following lines are predicted to be deficient:

- W Valley View Dr and N Euclid St (10")
- Conejo Lane from Sunrise Lane to Camino Centroloma (10")
- Alley north of Santa Fe Ave between S Harbor Blvd and S Highland Ave (12")

It is noted that the deficient pipe in the alley north of Santa Fe Ave was assumed to be replaced by a new 12 to 15-inch pipe on Santa Fe Ave that is currently under design, as documented in the *Fullerton*

Transportation Center Sewer Study, (June 2009). The sewer under design has adequate capacity to convey flows in the area, including those from the Fullerton Transportation Center. This new sewer was assumed to be built for the purposes of this Master Plan, and is therefore not included in the recommended capacity improvement projects described in **Chapter 5**.



N

Miles 1

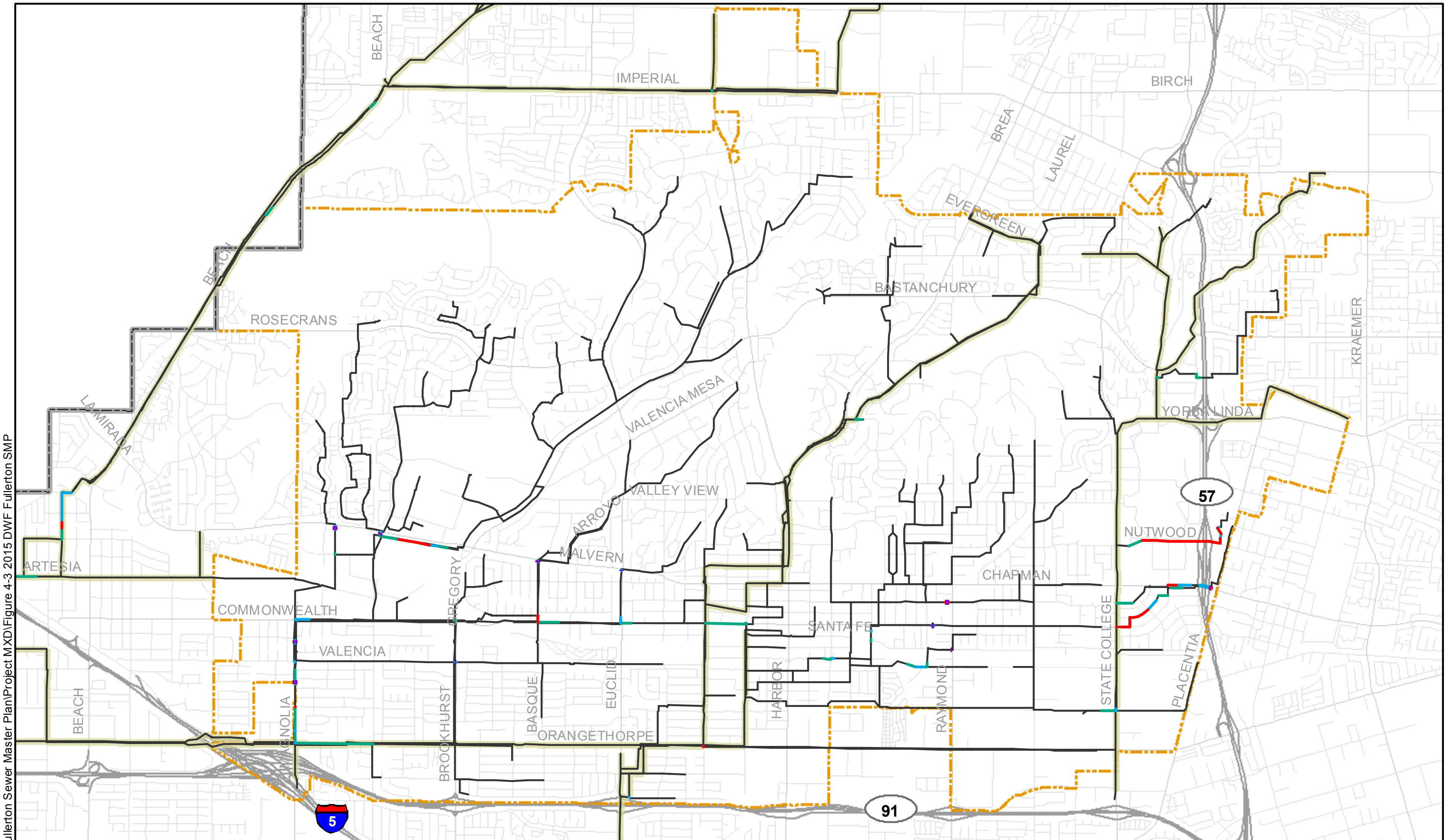
Maximum Depth to Diameter Ratio (d/D)

- Less than 75%
- 75% - 100%
- Surcharge: Flow Backup
- Surcharge: Capacity Limitation
- Siphon
- OCSD Sewer
- County Boundary
- City Boundary

City of Fullerton
Sewer Master Plan

Figure 4-2
Existing Dry Weather Capacity Analysis

RMC Water and Environment



N

Miles

1

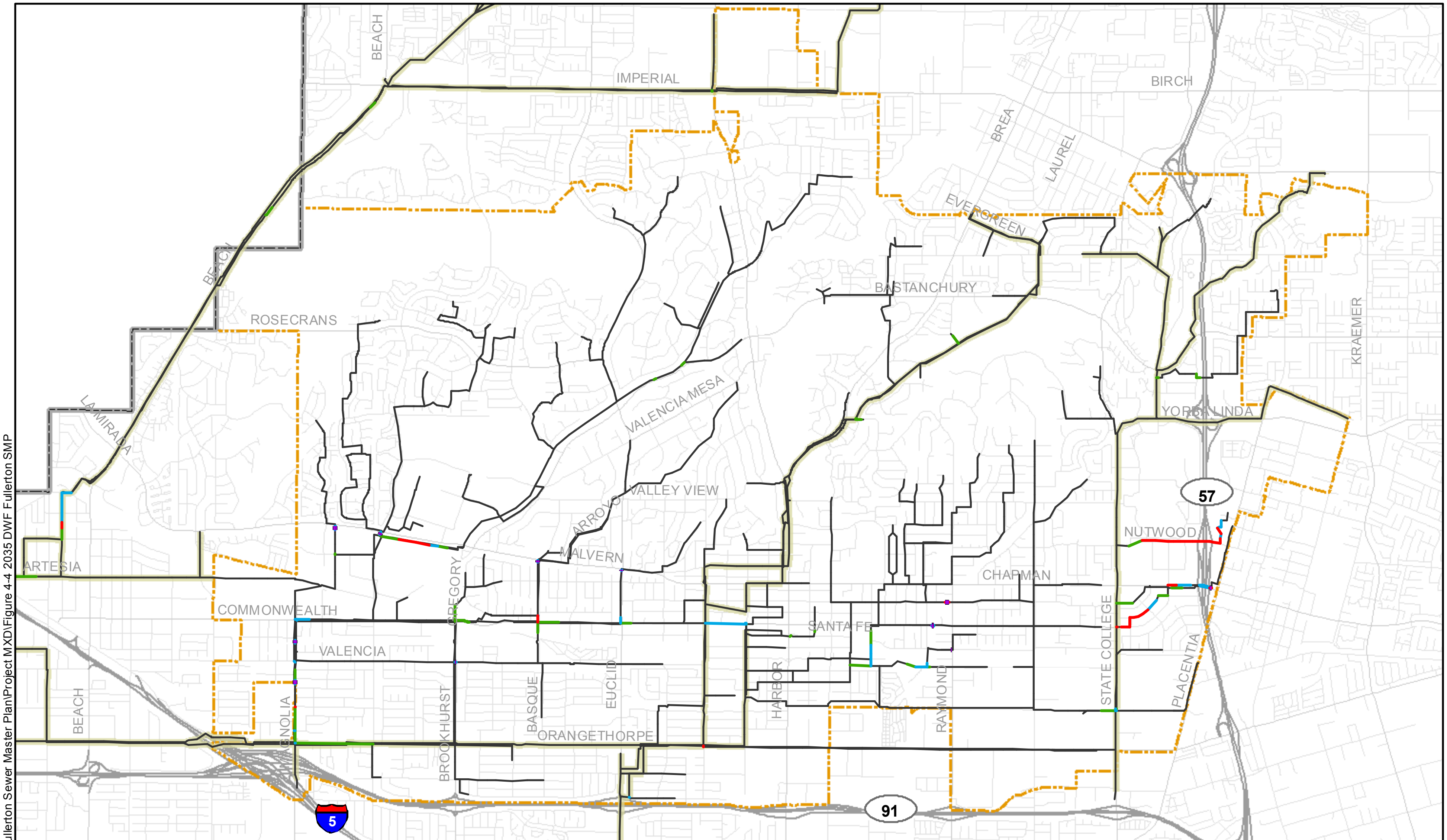
Maximum Diameter Ratio (d/D)

- Less than 75%
- 75% - 100%
- Surcharge: Flow Backup
- Surcharge: Capacity Limitation
- Siphon
- OCSD Sewer
- County Boundary
- City Boundary

City of Fullerton
Sewer Master Plan

RMC Water and Environment

Figure 4-3
2015 Dry Weather Capacity Analysis



N

Miles

1

Maximum Depth to Diameter Ratio (d/D)

- Less than 75%
- 75% - 100%
- Surcharge: Flow Backup
- Surcharge: Capacity Limitation
- Siphon
- OCSD Sewer
- County Boundary
- City Boundary

City of Fullerton
Sewer Master Plan

RMC Water and Environment

Figure 4-4
2035 Dry Weather Capacity Analysis

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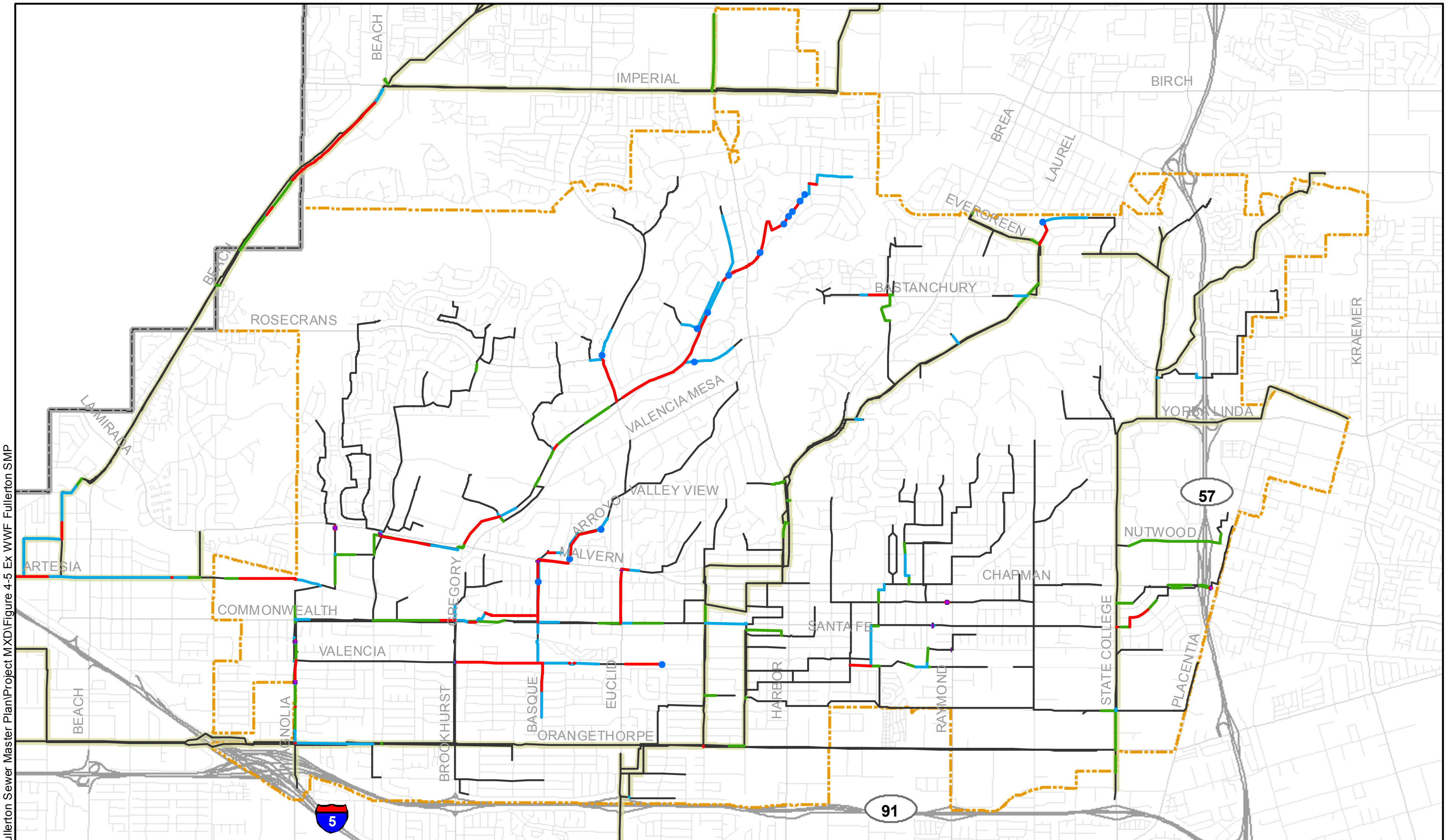


Maximum Depth to Diameter Ratio (d/D)

Less than 75%

75% - 100%

Surcharge: Flow Backup

Surcharge: Capacity Limitation

MH Overflow

Siphon

OCSD Sewer

County Boundary

City Boundary

N

Miles

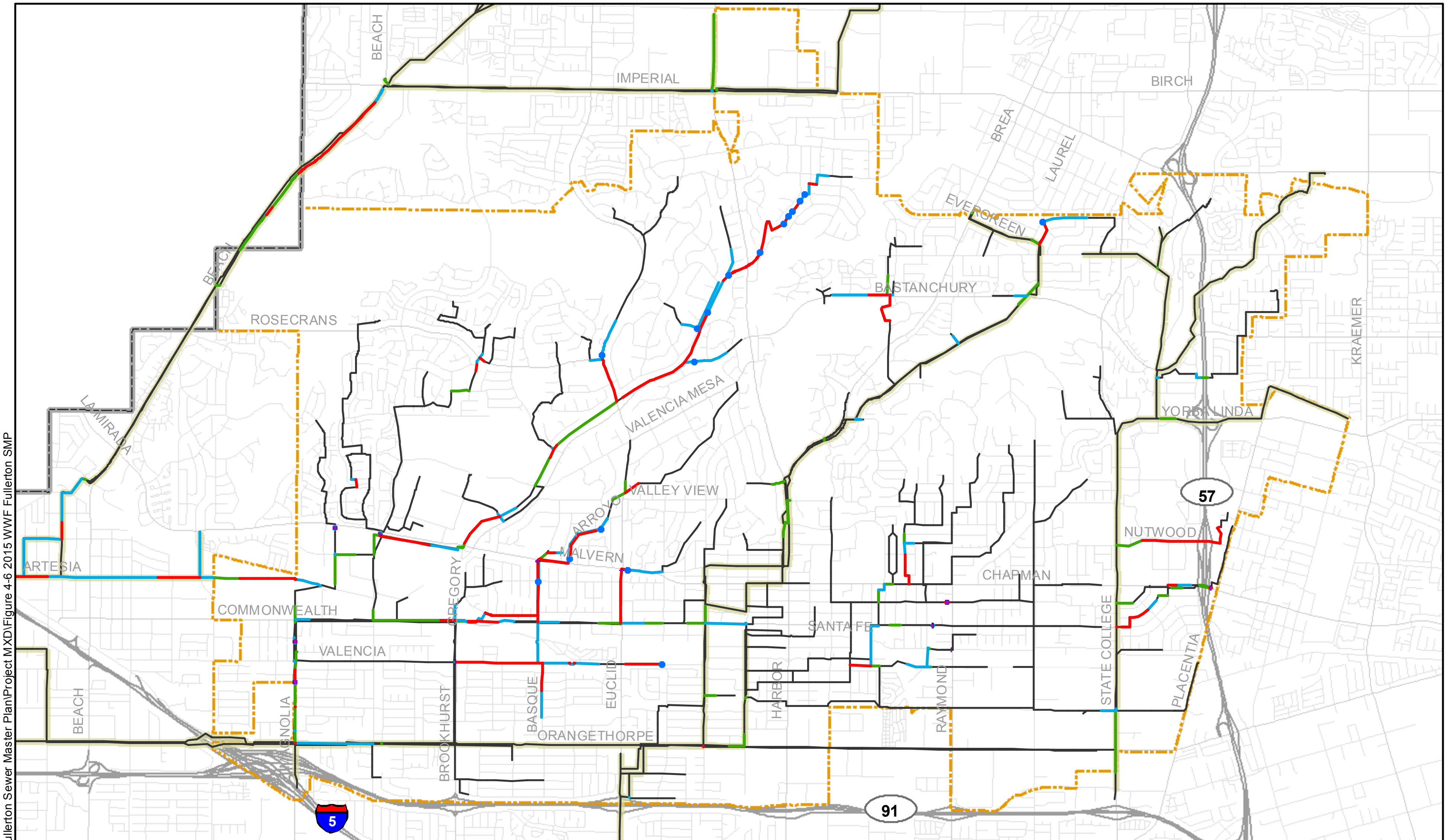
1

City of Fullerton
Sewer Master Plan

RMC Water and Environment

Figure 4-5
Existing Wet Weather Capacity Analysis

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\Figure 4-5 Ex WWF Fullerton SMP



N

Miles
1

Maximum Depth to Diameter Ratio (d/D)

- Less than 75%
- 75% - 100%
- Surcharge: Flow Backup
- Surcharge: Capacity Limitation
- MH Overflow
- Siphon
- OCSD Sewer
- County Boundary
- City Boundary

City of Fullerton
Sewer Master Plan

RMC Water and Environment

Figure 4-6
2015 Wet Weather Capacity Analysis

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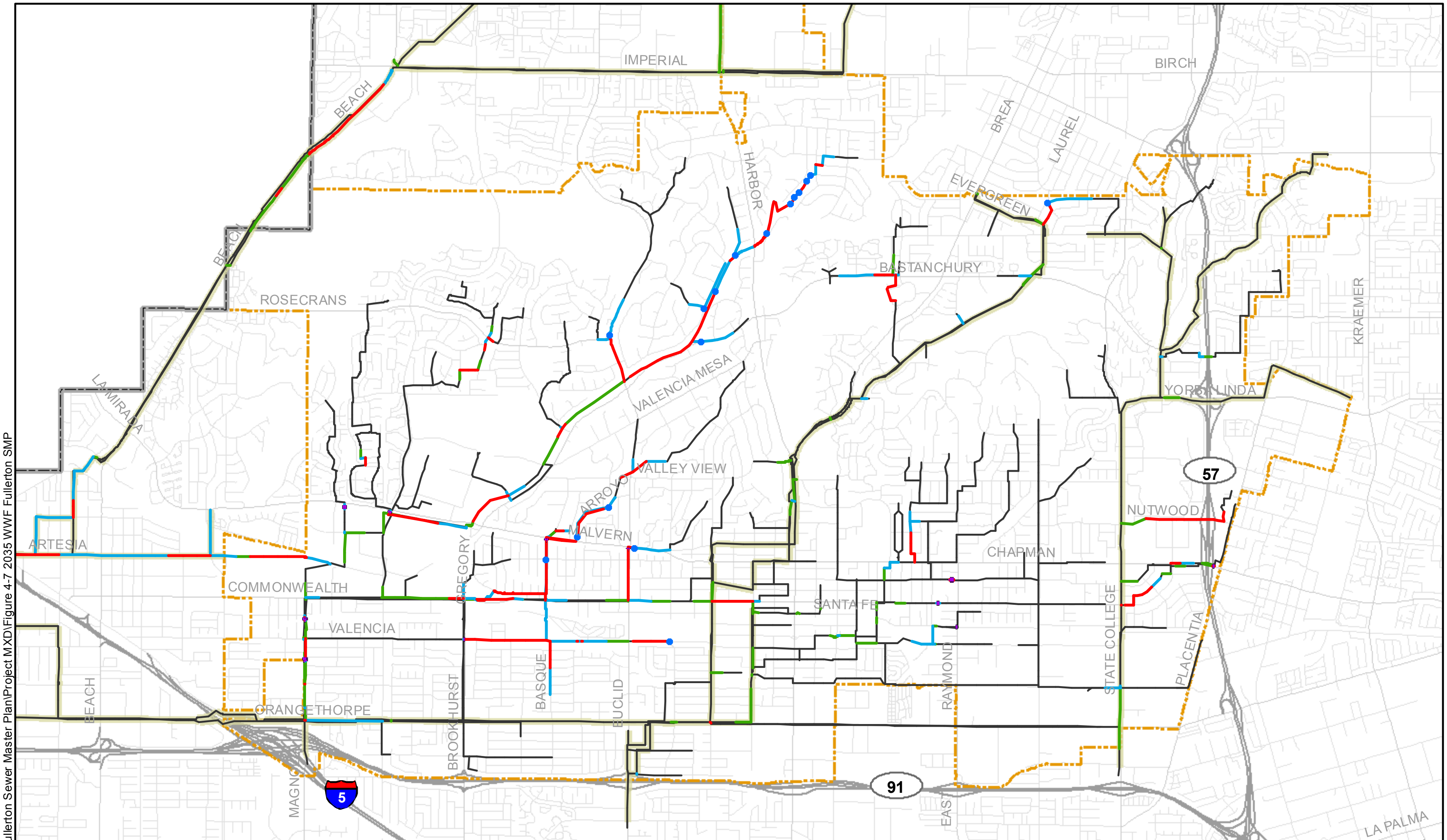


N

Miles

1

Maximum Depth to Diameter Ratio (d/D)

- Less than 75%
- 75% - 100%
- Surcharge: Flow Backup
- Surcharge: Capacity Limitation

- MH Overflow
- Siphon
- OCSD Sewer
- County Boundary
- City Boundary

City of Fullerton
Sewer Master Plan

RMC Water and Environment

Figure 4-7
2035 Wet Weather Capacity Analysis

Chapter 5 Recommended Capacity Improvement Projects

This chapter presents the capacity-driven sewer projects that are recommended for inclusion in the City's capital improvement program (CIP), based on the findings of the capacity analysis. Each project is documented with a general description, plan map, hydraulic profile, project details and considerations, planning-level capital cost estimate, and relative priority ranking. An implementation strategy is discussed in **Chapter 8**.

5.1 Capacity Projects

Capacity improvement projects were developed to correct the hydraulic capacity deficiencies identified in **Chapter 4**. Potential alternatives were developed in consultation with City staff and verified using the hydraulic model.

5.1.1 Sizing Criteria for Master Planning

For new projects identified as part of this Master Plan, replacement of existing pipes was assumed (except where specifically noted) and the replacement pipes were sized to convey 2035 peak wet weather flows without surcharging. Model runs with all capacity projects in place were made to measure the impact of increased capacity from upstream projects on peak flows in pipes downstream from those projects. In some cases, additional projects were identified to convey the increased flow. Existing pipe slopes and depths were preserved for new sewers. As these projects are implemented, consideration should be given to alternatives to replacement along the same alignment.

5.1.2 Cost Criteria for Master Planning

This section summarizes the methodology used to develop the base cost criteria for developing preliminary opinions of probable construction costs for the capacity improvement projects. All costs presented in this section have been adjusted to an Engineering News Record (ENR) construction cost index of 9410.65, which represents the average 2008 ENR cost index for the Los Angeles Area.

Planning level cost estimates were developed using the equation outlined in **Table 5-1.**

Table 5-1: Project Cost Estimate Assumptions

Project Costs Equation	Assumptions
Facility Raw Construction Cost (cost includes contractor overhead & profit)	See Table 5-2
+ Mobilization, Demobilization, Bonding, Insurance, Permits, NPDES permit compliance, Site security, Traffic Control, Staging area/Yard rental.	20% of Facility Raw Construction Cost
=Construction Cost Sub-Total	-
+ Pre-Design Construction Contingency	20% of Construction Cost Sub-Total
= Total Construction Cost	-
+ Engineering, Survey, Environmental, Construction management, Engineering services during construction, Legal, Administration, Financial	30% of Total Construction Cost
= Total Capital Cost	-

Construction costs are for the installation of gravity sewer pipelines. The basis for these costs is described below.

Baseline pipeline construction costs were developed for open cut gravity sewer trunks and trenchless pipe construction. Unit cost criteria and cost factors were developed for each of the cost components shown in the equation above based on a combination of recent bid results, construction experience, and construction unit price guides (RS Means 2008). Raw construction costs were developed based on the unit costs presented in **Table 5-2**.

Table 5-2: Project Unit Cost Assumptions

Item	Description/Assumptions	Unit Cost [1]
Open-Cut Gravity Sewer Trunks for pipe sizes in **paved roadway**: 8", 10", 12", 15", 18", 21", 24" DIA. ▪ <10' depth ▪ 10'-15' depth ▪ 15'-20' depth ▪ >20' depth	Assumes VCP for all pipe sizes; ¾ CY excavator with trench box; Additional shoring; Resurfacing; Hauling excess spoils; Saw-Cutting; Bedding/Backfill /Compaction. Assumes native soil for backfill outside pipe zone 12" above pipe OD. Does not include costs for: Traffic Control; Dewatering	- - - - - $100 - $135 /LF $120 - $170 /LF $150 - $230 /LF $220 - $270 /LF
Open-Cut Gravity Sewer Trunks for pipe sizes in **easements**: 8", 10", 12", 15", 18", 21", 24" DIA. ▪ <10' depth ▪ 10'-15' depth ▪ 15'-20' depth ▪ >20' depth	Assumes VCP for all pipe sizes; ¾ CY excavator with trench box; Additional shoring; Hauling excess spoils; Bedding/Backfill /Compaction. Assumes native soil for backfill outside pipe zone 12" above pipe OD. Does not include costs for: Traffic Control; Dewatering; Resurfacing; Saw-Cutting.	- - - - - $80 - $130 /LF $110 - $150 /LF $140 - $210 /LF $200 - $260 /LF
Structures ▪ New Manhole; 15' depth ▪ New Manhole; >15' depth ▪ Connect to Existing Manhole ▪ Clean-Out	Assumes installation of a new Type I precast manhole 60" DIA. New clean-outs are assumed to be installed along the mainlines. As these mainlines are new open-cut installation, the costs of clean-outs is negligible.	- $5,000 /EA $8,000 /EA $1,000 /EA $0 / EA
Lateral Service Connections	Assumes lateral connection every on pipe up through 12" DIA (existing and new). Cost is for reconnecting lateral only and does not include replacing any lateral pipe.	$500 /EA
Demolition & Removal ▪ of Existing Pipe ▪ of Existing Manholes	Assumes selective demolition of small sewer pipe (up to 12") or large sewer pipe (up to 24") and selective demolition of precast manholes at 20' depth.	- $25 - $35 /LF $4,200 /EA
Trenchless Construction	Assumes trenchless bore & jack construction for a 36" DIA pipe with a 64" DIA casing under drainage channel.	$1,170 /LF +$101,190 /EA (jacking pit) +$59,080 /EA (receiving pit)
Land & Right-of-Way ▪ Railroad Right-of-Way Access	Assumes all project facilities will be constructed in City right-of-way except along railroad right-of-ways and easements. Costs for railroad permitting assume one railroad employee will be required to be onsite while working within railroad right-of-way. Assumes 1 worker at $100/hour and assumes a construction progress rate of 200 LF of installed pipe per day.	- $100 /hour

Item	Description/Assumptions	Unit Cost [1]
Overhead & Profit	Already included in facility construction costs.	$0
Bypass Pumping	Assumes equipment & labor for bypassing 200 LF of pipe for one day.	$30 /LF
Mobilization, Demobilization, Bonding, Insurance, Permits, NPDES permit compliance, Site security, Traffic Control, Staging area/Yard rental.	20% of Facility Raw Construction Cost	20%
Pre-Design Construction Contingency	20% of Construction Cost Sub-Total	20%
Engineering, Survey, Environmental, Construction management, Engineering services during construction, Legal, Administration, Financial	30% of Total Construction Cost	30%

(1) Values have been rounded to nearest whole dollar value.

Baseline unit pipe construction costs were developed for gravity trunk sewers ranging from 8 to 24 inches in diameter for four depth-of-cover ranges: less than 10 feet, 10 to 15 feet, 15 to 20 feet and greater than 20 feet. These unit costs are presented in **Table 5-2**. Pipe material is assumed to VCP (clay pipe).

The baseline pipe construction costs include the following assumptions:

- Vertical trench walls to reduce utility conflicts and construction impact.
- Trench box shoring is assumed for all construction alignments; however additional shoring is included due to the depth of the majority of the pipelines and uncertainty of utilities in the area. The specific type of shoring used will depend upon the trench depths, soil conditions, conflicting utilities, and groundwater levels. For purposes of this master plan, additional shoring is included at $4 to $5 per vertical square foot for solid shoring depending on trench depths.
- Select imported backfill in the pipe zone and native backfill above the pipe zone to the pavement structural base. It is assumed that the spoils may be hauled to local disposal site. Backfill would be compacted to 90 percent to within 2 feet of the ground surface. Pipe installation and trench detailed quantities is based on City of Fullerton Standard Drawings 312 and 313.
- An average construction installation, new alignment and rehabilitation, of 200 linear feet of pipe per day.
- Temporary pavement or trench plates to be placed over the excavated areas in traveled roadways at the end of each day.
- Sales tax of 8.25 percent on all raw materials.
- It was acknowledged that some projects involving upsizing of existing pipes could potentially be done less expensively and with less disruption by pipe bursting rather than removal and replacement of the existing pipe. However, because it is not known at the planning stage whether pipe bursting would be feasible based on site conditions, open-cut pipe replacement was assumed when developing costs for all such projects.

A few specific construction assumptions of note include the following:

- **Lateral Service Connections:** It is assumed there will be lateral service connections on pipelines up through 12 inches in diameter based on knowledge of the City system and experience. A lump sum cost of $500 per lateral connection is assumed. This cost assumes only reconnection of the lateral; it does not include any replacement of the lateral pipeline. The locations of laterals was based on aerial imagery of pipeline alignments and experience.

- **Manholes:** It is assumed that new manholes will be constructed in place of rehabilitating existing manholes along capacity-deficient sewer pipelines. Costs for manholes will include demolition and removal of existing manholes along with costs for constructing a new manhole in its place. Capacity-deficient sewer pipelines that connect to only the upstream or downstream manholes, those manholes will not be removed. Costs for coring into the manhole for the upsized pipeline will be included.
- **Dewatering:** It is assumed dewatering will not be required for all alignments based on a typical groundwater depth of over 100 feet.
- **Bypass Pumping:** Bypass pumping will be required for all demolition of existing pipelines to reroute flow temporarily. A linear foot cost of $30 is assumed based on equipment and labor for 200 feet of bypass pumping a day.
- **Trenchless Construction:** It was assumed that all crossing of creeks, drainage channels, major arterials (including highways), and railroads would require trenchless construction (bore-and-jack). Additional permitting costs for accessing railroad right-of-way are included as part of trenchless construction as-needed.
- **Geotechnial:** As the majority of the construction alignments are along existing alignments and/or along major roads, it is assumed no hard rock or cobbles will be encountered. For purposes of this master plan, there is no contingency for unexpected geologic conditions.

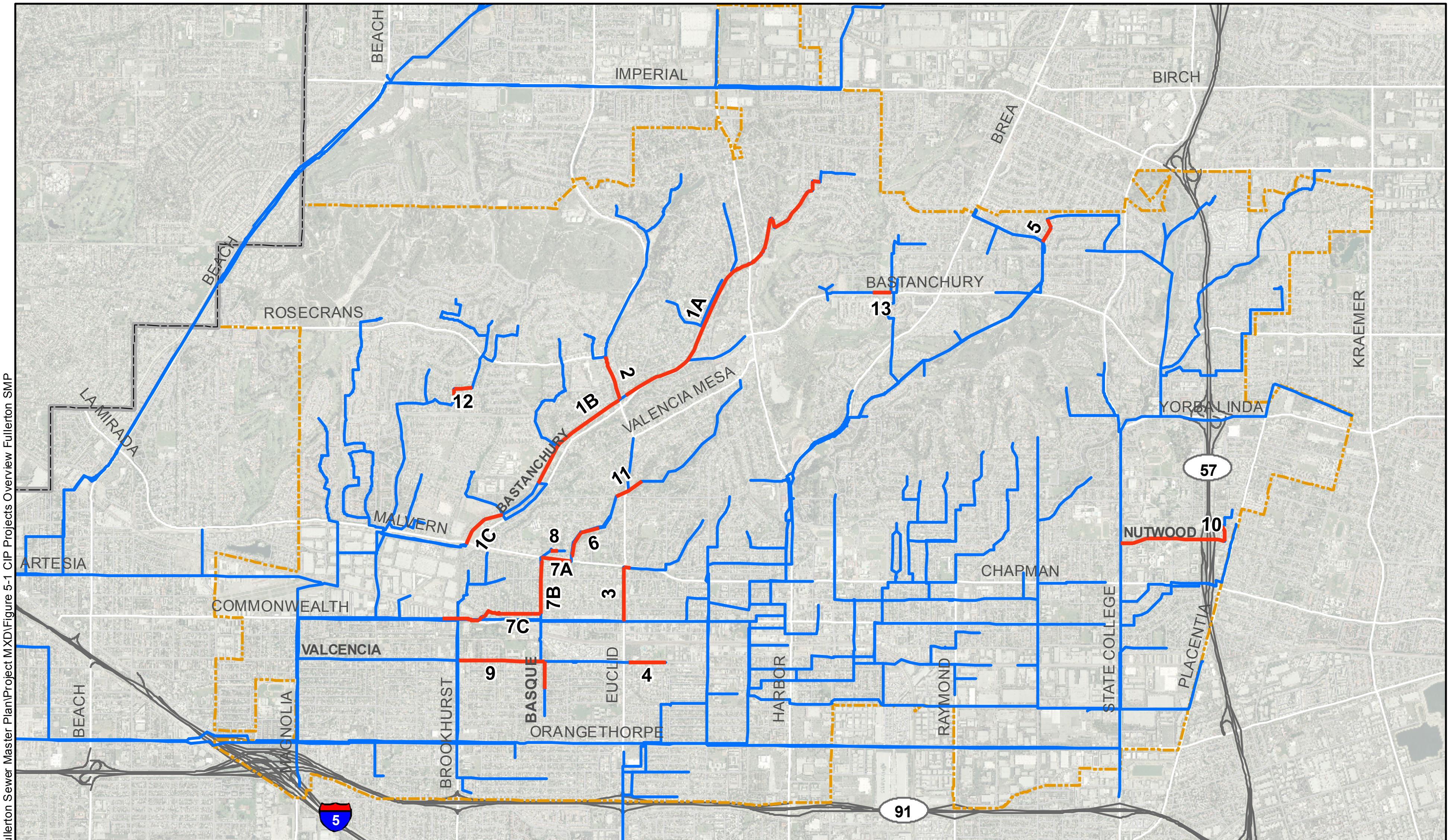
A standard cost estimating spreadsheet was developed and used for estimating the cost of all improvement projects. The spreadsheet also includes a summary description of the project, including location, proposed facilities, manhole references, project priority, estimated cost, and a brief discussion of any project specific considerations, assumptions, and possible alternatives. Also included in the spreadsheet are the *Trench Section Quantity Calculations* used to calculate the linear foot cost per diameter pipe and depth of pipe.

5.1.3 Project Identification and Ranking

The recommended projects are described at the end of this chapter. Project descriptions are each contained on a single page and consist of a summary project description, cost estimate, priority, and a discussion of project issues. The projects are in numerical order based on the project numbers shown in **Figure 5-1**. The project description page is followed by plan and profile views.

Initially, projects were ranked based on two factors. First, the project was ranked according to the planning scenario during which the project was triggered (projects triggered during dry weather flow of a particular planning scenario were given higher priority than those during wet weather flow). Within each trigger scenario group, projects were then ranked based on the freeboard depth (distance between the estimated maximum water depth and the ground surface).

Figure 5-1 shows an overview of the project locations within the City, and **Table 5-3** lists the proposed capacity improvement projects in ranked order. It is noted that although a ranking order was defined based on hydraulic deficiencies, it is not necessarily recommended that projects be constructed in ranking order. Some projects are related to each other and must therefore be constructed as part of a group or in sequence. **Chapter 8** discusses project sequencing and how the projects could be implemented in conjunction with the Capital Replacement Program presented in **Chapter 7**.



N

Miles

1

1 CIP Project

Modeled Sewer

County Boundary

City Boundary

Freeway

Street

City of Fullerton
Sewer Master Plan

RMC
Water and Environment

Figure 5-1
CIP Projects Overview

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\Figure 5-1 CIP Projects Overview_Fullerton SMP

Table 5-3: List of Ranked Capacity-Related Capital Improvement Projects

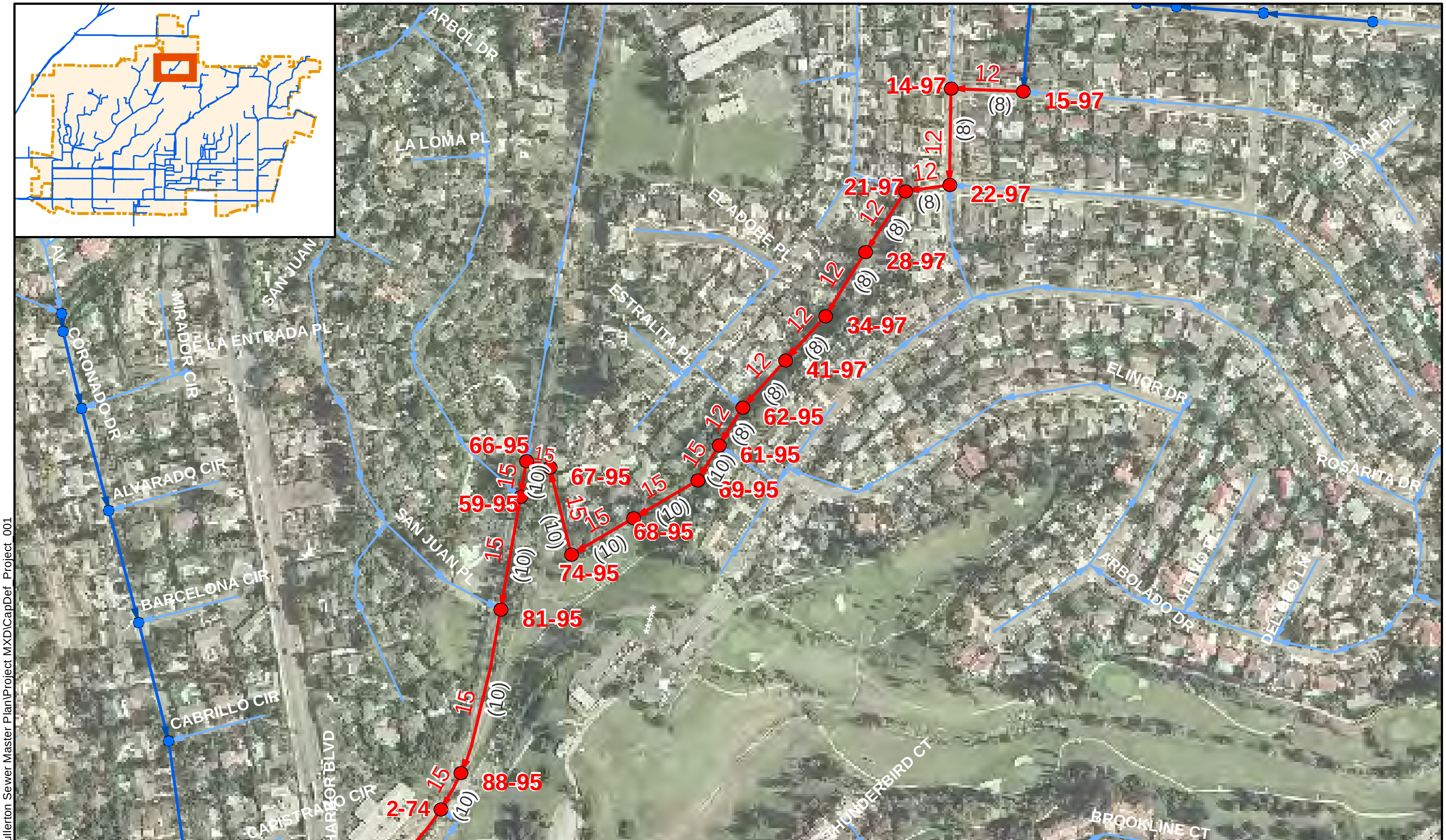
Project ID	Location	US MH	DS MH	Length	Existing Diameter	Trigger Scenario	Existing Worst Condition	2015 Worst Condition	2035 Worst Condition	Freeboard at Trigger Scenario	Solution	Estimated Cost
1A	W Bastanchury Road, Morellia Pl, from N Euclid St to Arbolado Dr	15-97	72-69	10,440'	8", 10"	Ex. WWF	Multiple Overflows	Multiple Overflows (WWF)	Multiple Overflows (WWF)	0	Replace 15-97 to 61-95 (8") with 12" (L=2303'); Replace 61-95 to 72-69 (10") with 15" (L= 8136')	$4,525,000
2	N Euclid St from Rosecrans Ave to Bastanchury Rd	28-69	71-69	1,440'	8"	Ex. WWF	Multiple Overflows	Multiple Overflows (WWF)	Multiple Overflows (WWF)	0	Replace 28-69 to 71-69 (8") with 10" (L=1443')	$1,305,000
3	N Euclid St from W Malvern Ave to W Commonwealth Ave	102-46	57-19	2,030'	8", 10"	Ex. WWF	Overflow	Overflow (WWF)	Overflow (WWF)	0	Replace 90-44 to 57-19 (10") with 12" (L=1665'); Replace 102-46 to 91-44 (8") with 12" (L=232'), add another 8" siphon (L=103')	$787,000
4	W Valencia Dr from S Euclid St to S Woods Ave	8-22	1-22	1,190'	8"	Ex. WWF	Overflow	Overflow (WWF)	Overflow (WWF)	0	Replace 8-22 to 1-22 (8") with 10" (L=1193')	$435,000
5	Evergreen Ave and Laurel Ave from Maple Ave to Lark Ellen Dr	26-100	EUB0880-0005	820'	8"	Ex. WWF	Overflow	Overflow (WWF)	Overflow (WWF)	0	Replace 3-100 to 36-100 (8") with 12" (L =560'); Reconnect 36-100 to EUB0920-0000 (12" diversion; L=260');	$391,000
6	Arroyo Drive from Ramona Dr to W Malvern Ave	45-44	73-44	1,420'	6"	Ex. WWF	Overflow	Overflow (WWF)	Overflow (WWF)	0	Place 1' weir at 26-44 to divert flow from 6" (west pipe) to the 10" (south pipe)	$104,000
7B	N Basque Ave from W Malvern Ave to Gregory Ave	82-42	58-17	1,710'	10", 12"	Ex. WWF	Overflow	Overflow (WWF)	Overflow (WWF)	0	Replace existing 12" pipe with 18"; Retain existing 10" pipe and lateral connections (L=1721')	$646,000
7A	W Malvern from Arroyo Drive to N Basque Ave	78-44	66-42	970'	8", 10"	Ex. WWF	3.8' of surcharge	3.9' of surcharge (WWF)	3.9' of surcharge (WWF)	0.5'	Replace north 8" with a 15" (L=951'); Retain south existing 8"; Replace 68-42 to 66-42 (10") with 15" (L=22')	$399,000
8	Johnson Pl from Carhart Ave to N Stephens Ave	66-44	64-44	250'	6"	Ex. WWF	3.0' of surcharge	3.0' of surcharge (WWF)	3.0' of surcharge (WWF)	2.5'	Replace 66-44 to 64-44 (6") with 8" (L=250')	$114,000
1C	W Bastanchury Rd and Hughes Dr	10-42	28-42	1,610'	15", 18"	Ex. WWF	4.8' of surcharge	5.6' of surcharge (WWF)	5.9' of surcharge (WWF)	2.7'	Replace 10-42 to 9-42 (15") with 18" (L=590'); Replace 9-42 to 28-42 (18") with 21" (L=1018')	$724,000
9	W Valencia Dr & S Basque Ave from S Brookhurst Rd to W Elm Ave	29-20	91-17A	3,680'	8", 12"	Ex. WWF	4.2' of surcharge	4.9' of surcharge (WWF)	5.1' of surcharge (WWF)	2.9'	Replace 1-20 to 91-17A (12") with 15" (L=2791'); Replace 1-20 to 29-20 (8") with 10" (L=890')	$1,495,000
7C	Gregory Ave from N Wanda Dr to N Basque Ave	58-17	22-15	3,840'	15", 18"	Ex. WWF	1.2' of surcharge	1.4' of surcharge (WWF)	1.5' of surcharge (WWF)	4.5'	Replace 58-17 to 29-15A (15") with 18" (L=2906'); Replace 29-15A to 22-15 (18") with 21" (L=932')	$2,684,000
1B	W Bastanchury Road, from N Euclid St to Warburton Way	71-69	12-41	3,860'	15"	Ex. WWF	11.0' of surcharge	12.4' of surcharge (WWF)	13.3' of surcharge (WWF)	6.4'	Replace 71-69 to 12-41 (15") with 18" (L=3860')	$1,807,000
13	E Bastanchury Rd from Amberleaf St to Puente St	46-76	36-78	580'	8"	Ex. WWF	2.3' of surcharge	2.5' of surcharge (WWF)	2.5' of surcharge (WWF)	23.4'	Replace 46-76 to 36-78 (8") with 10" (L=574')	$363,000
10	Nutwood Ave from State College Blvd to Ruby Dr	12-60	NHP0545-0000	3,880'	10"	2015 WWF		1.4' of surcharge (DWF) 1.6' of surcharge (WWF)	1.6' of surcharge (DWF) 2.3' of surcharge (WWF)	3.9'	Replace from 12-60 to OCSD trunk (10") with 12" (L=3880')	$3,167,000
11	By W Valley View Dr and N Euclid St	50-45	8-44	970'	10"	2035 WWF			1.9' of surcharge (WWF)	3.0'	Replace from 50-45 to 8-44 (10") with 12" (L=970'); 12" segment will be between 10" pipes.	$331,000
12	Conejo Lane from Sunrise Lane to Camino Centroloma	62-67	123-65	880'	10"	2035 WWF			0.8' of surcharge (WWF)	4.8'	Replace 62-67 to 123-65 (10") with 12" (L=878'); 12" segment will be between 10" pipes.	$463,000

5.2 Capacity Improvement Project Descriptions

The following pages contain detailed information about the proposed capacity projects. Project descriptions are each contained on a single page and consist of a summary project description, cost estimate, priority, and a discussion of project issues. The project description page is followed by plan and profile views.

The plan views include the new pipe sizes and show all streets and sewers in the project vicinity. The existing pipe sizes are also indicated in parentheses if the new pipe is intended to replace the existing pipe (and not if the new pipe is intended to run parallel to an existing pipe that is to remain in service).

The profiles illustrate the invert and crown of the proposed sewer (black lines filled with blue), the ground surface (green line) based on rim elevations at all manholes, and the maximum hydraulic gradeline (red line). Profiles are provided for two scenarios. The first profile shows deficient pipe sections for the scenario that triggered the project. The second shows the proposed capacity project under 2035 peak wet weather flow.



N

0 150 300 450 600 Feet

Manhole on CIP Project Pipe

Manhole on Modeled Pipe

12 New Pipe Diameter

(8) Existing Pipe Diameter

Modeled Sewer

Unmodeled Sewer

Street

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City of Fullerton
Sewer Master Plan

RMC Water and Environment

Capital Improvement Program: Project 1A (1 of 3)

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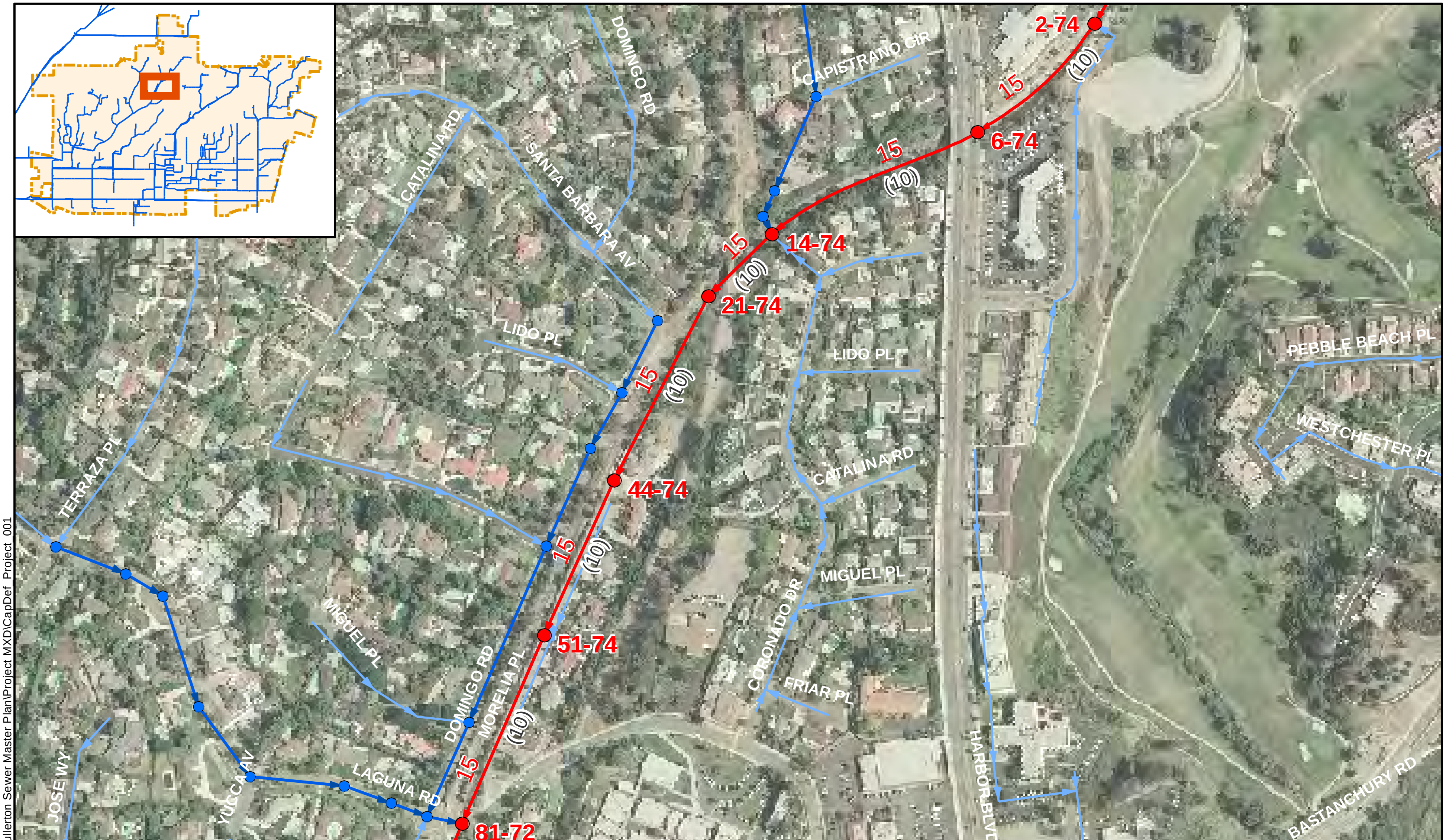

N

Feet

0 150 300 450 600

Manhole on CIP Project Pipe

Manhole on Modeled Pipe

12 New Pipe Diameter

(8) Existing Pipe Diameter

Modeled Sewer

Unmodeled Sewer

Street

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City of Fullerton
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Capital Improvement Program: Project 1A (2 of 3)

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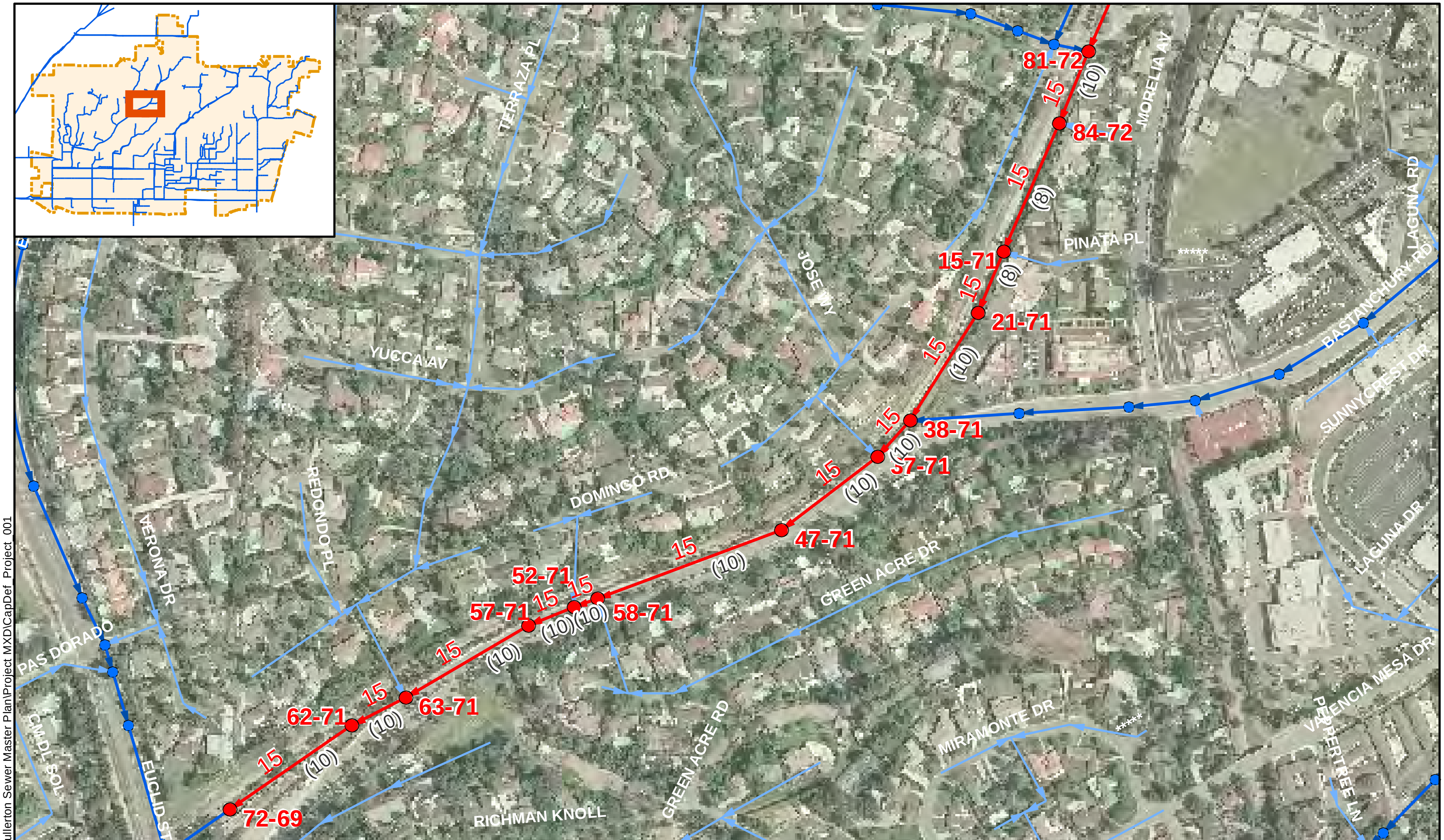

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N

0 150 300 450 600 Feet

- Manhole on CIP Project Pipe
- Manhole on Modeled Pipe
- 12 New Pipe Diameter
- (8) Existing Pipe Diameter
- Modeled Sewer
- Unmodeled Sewer
- Street

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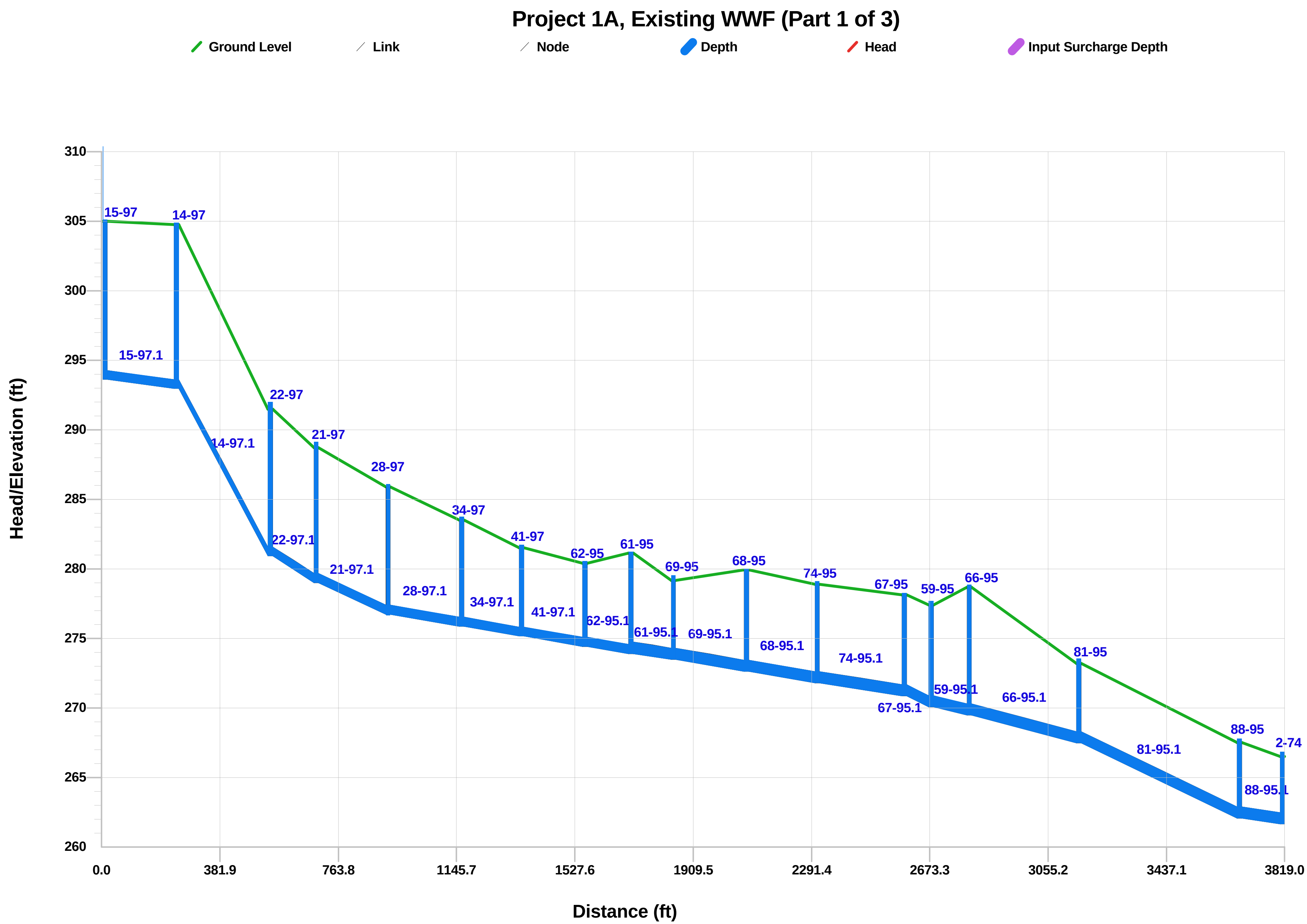
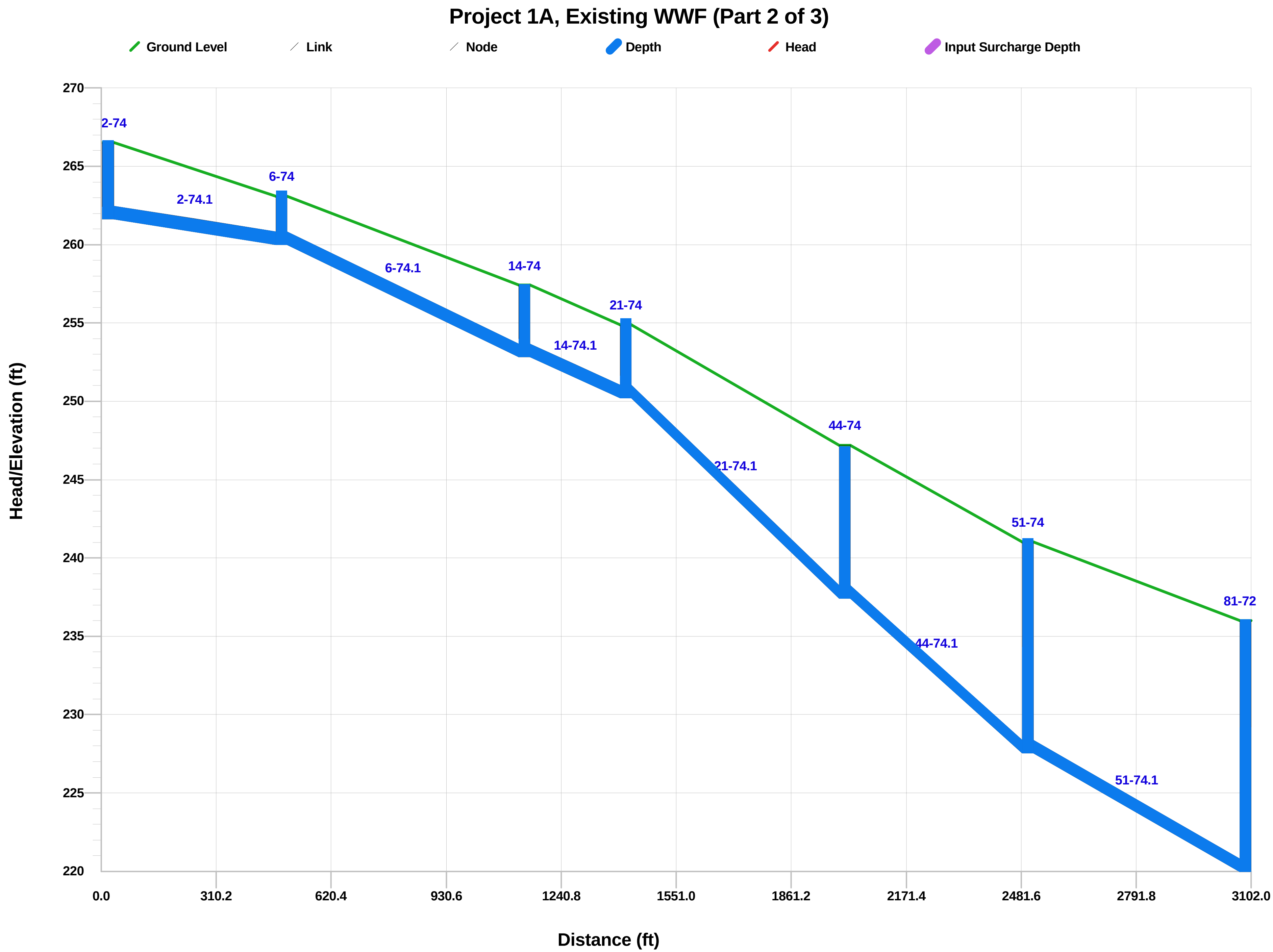
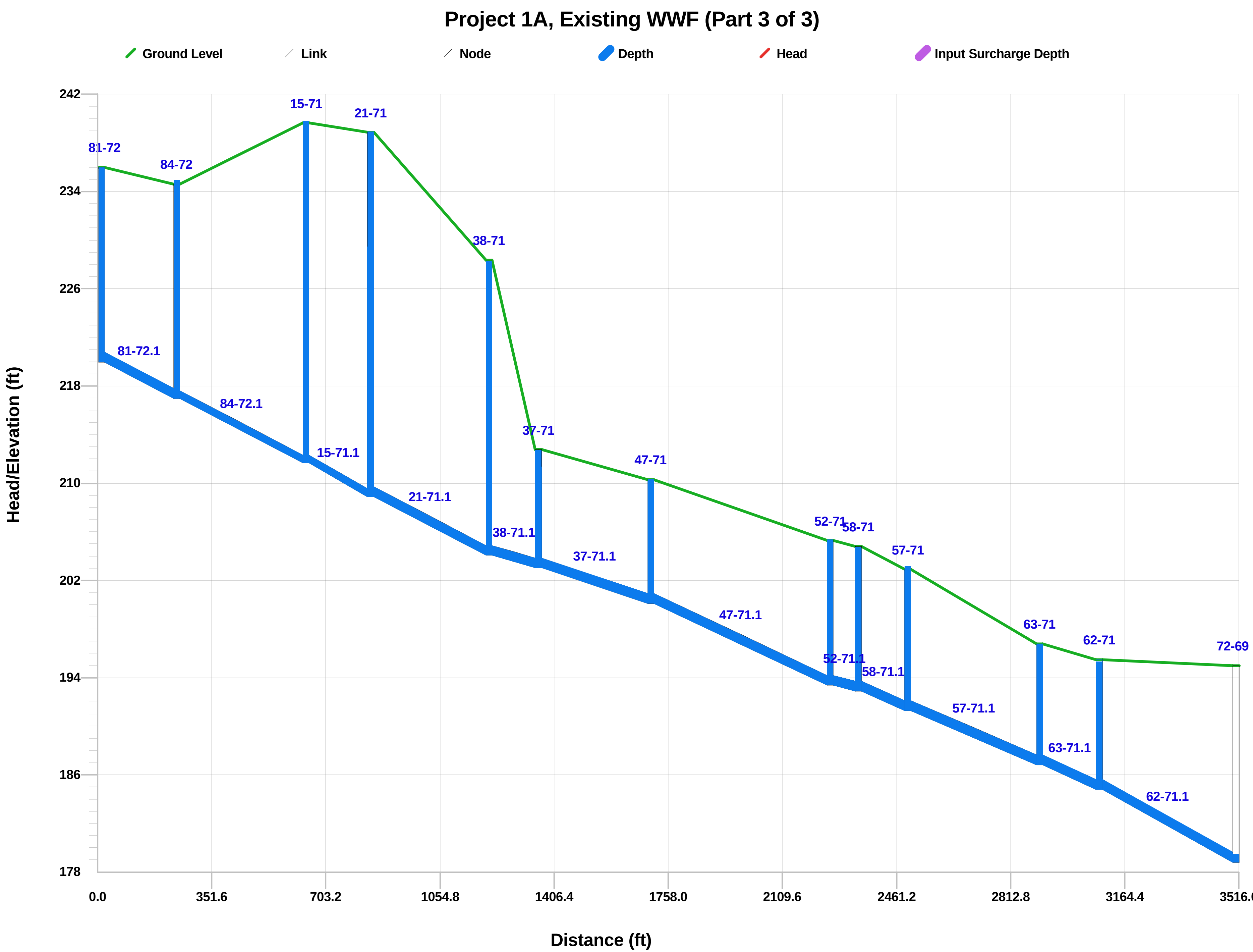
Capital Improvement Program: Project 1A (3 of 3)



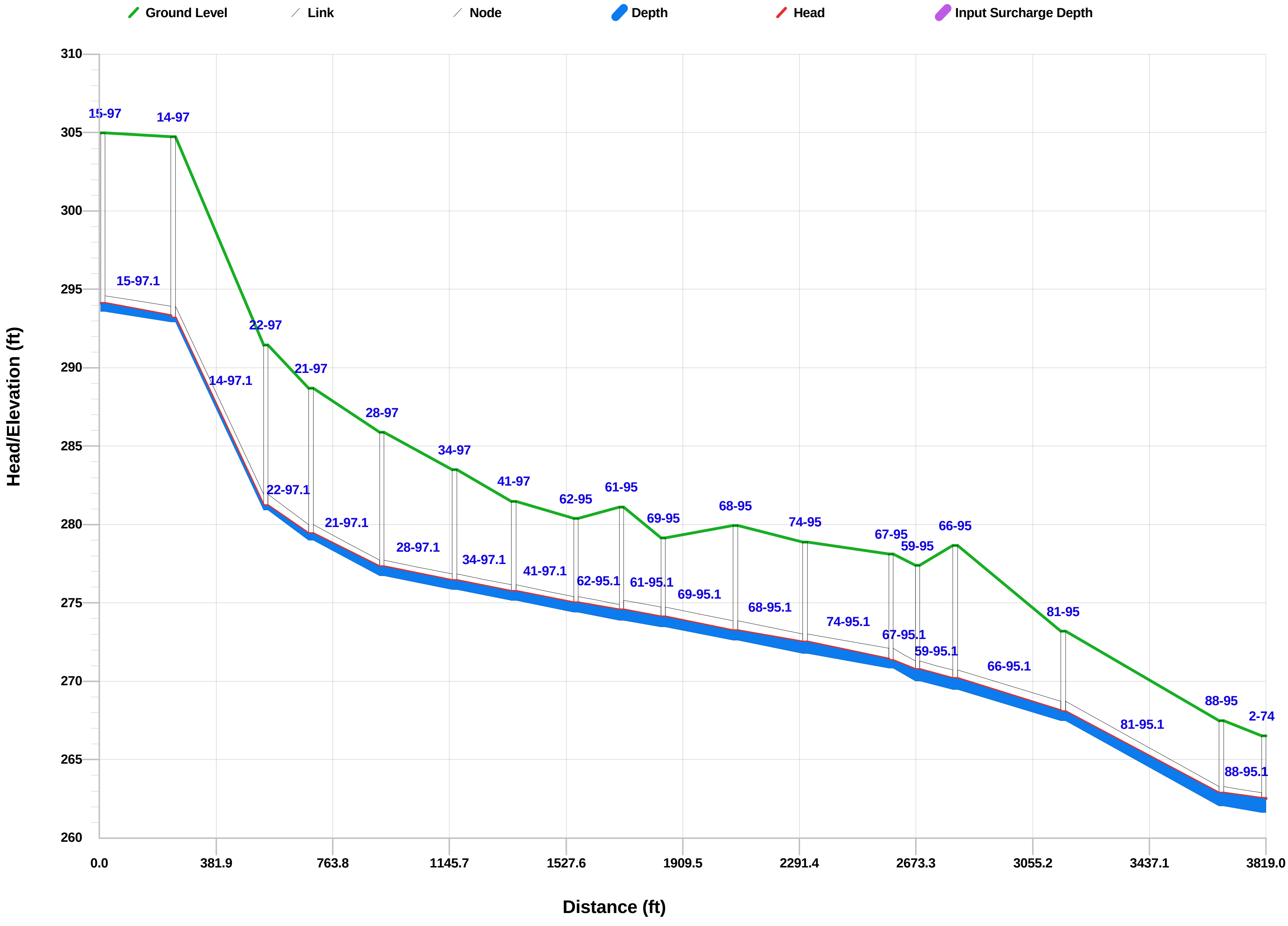
Project 1A, Existing WWF (Part 1 of 3)
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
310
305
300
295
290
285
280
275
270
265
260
Distance (ft)
0.0
381.9
763.8
1145.7
1527.6
1909.5
2291.4
2673.3
3055.2
3437.1
3819.0
15-97
14-97
15-97.1
22-97
21-97
14-97.1
28-97
34-97
41-97
62-95
61-95
69-95
68-95
74-95
67-95
59-95
66-95
81-95
88-95
2-74
22-97.1
21-97.1
28-97.1
34-97.1
41-97.1
62-95.1
61-95.1
69-95.1
68-95.1
74-95.1
59-95.1
66-95.1
67-95.1
81-95.1
88-95.1

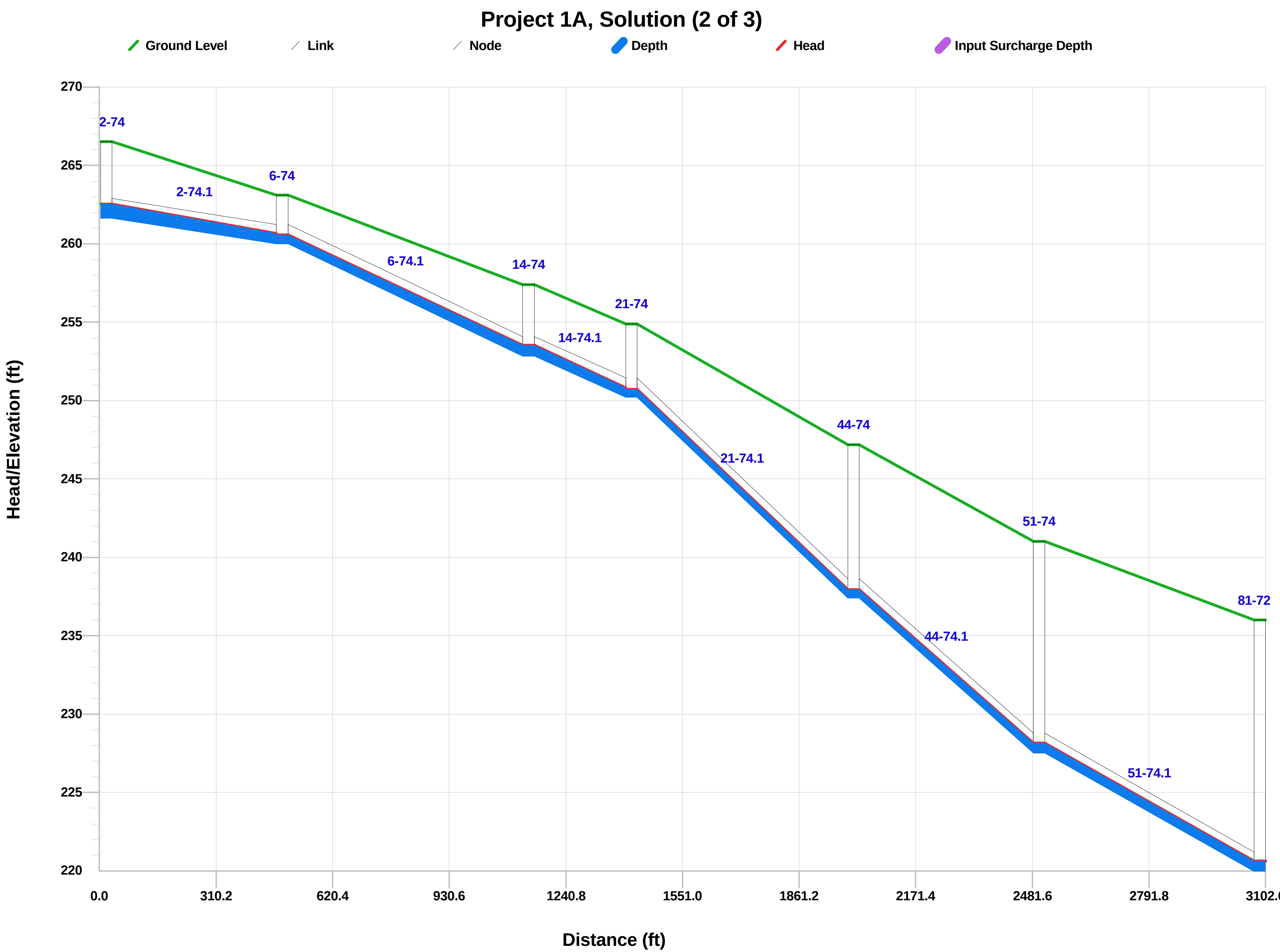

Project 1A, Existing WWF (Part 2 of 3)
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
270
265
260
255
250
245
240
235
230
225
220
0.0
310.2
620.4
930.6
1240.8
1551.0
1861.2
2171.4
2481.6
2791.8
3102.0
2-74
2-74.1
6-74
6-74.1
14-74
14-74.1
21-74
21-74.1
44-74
44-74.1
51-74
51-74.1
81-72



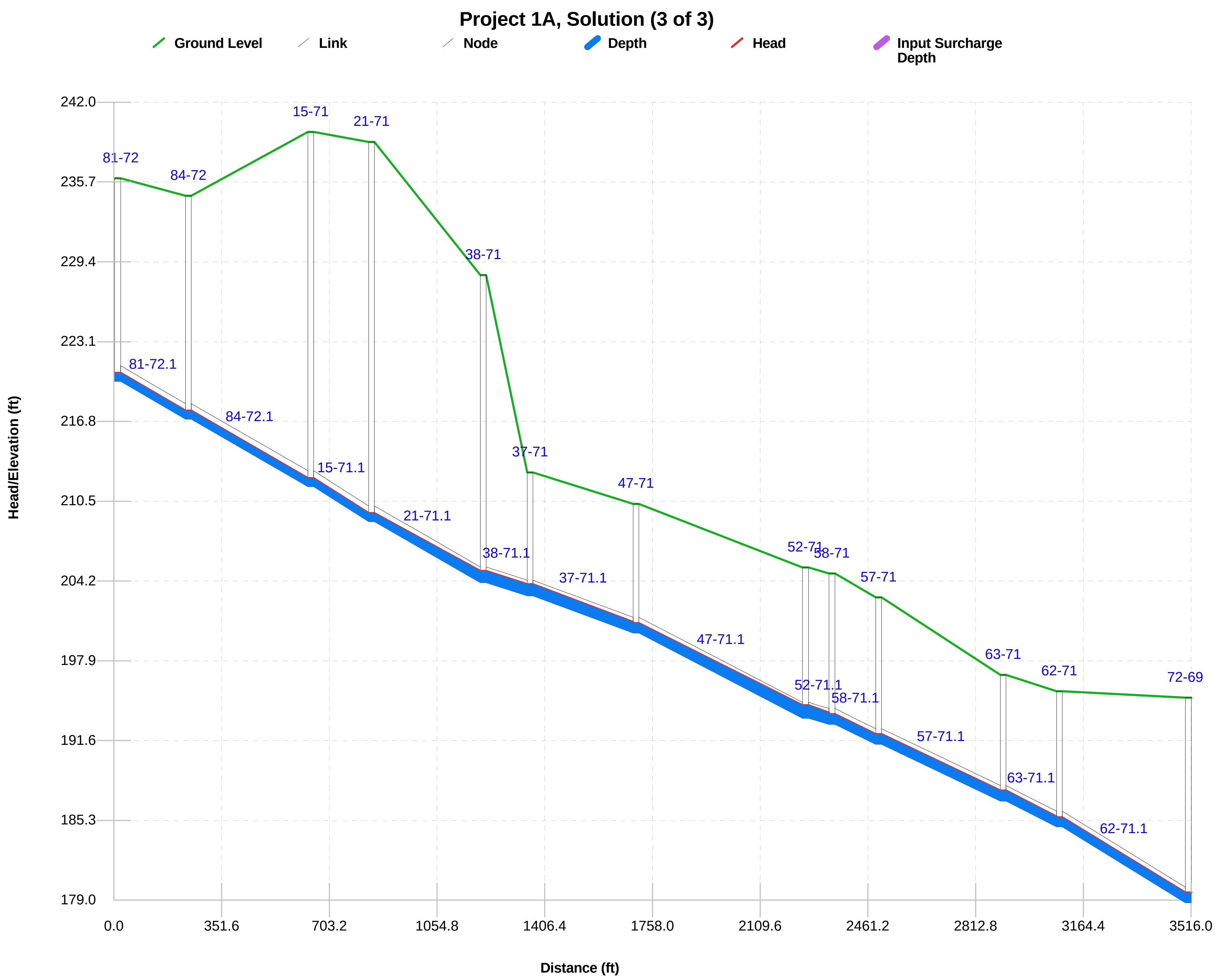
Project 1A, Existing WWF (Part 3 of 3)
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
242
234
226
218
210
202
194
186
178
0.0
351.6
703.2
1054.8
1406.4
1758.0
2109.6
2461.2
2812.8
3164.4
3516.0
81-72
84-72
15-71
21-71
38-71
37-71
47-71
52-71
58-71
57-71
63-71
62-71
72-69
81-72.1
84-72.1
15-71.1
21-71.1
38-71.1
37-71.1
47-71.1
52-71.1
58-71.1
57-71.1
63-71.1
62-71.1

Project 1A, Solution (1 of 3)





Project 1A, Solution (2 of 3)
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
270
265
260
255
250
245
240
235
230
225
220
0.0
310.2
620.4
930.6
1240.8
1551.0
1861.2
2171.4
2481.6
2791.8
3102.0
Distance (ft)
2-74
2-74.1
6-74
6-74.1
14-74
14-74.1
21-74
21-74.1
44-74
44-74.1
51-74
51-74.1
81-72



Project 1A, Solution (3 of 3)
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
242.0
235.7
229.4
223.1
216.8
210.5
204.2
197.9
191.6
185.3
179.0
0.0
351.6
703.2
1054.8
1406.4
1758.0
2109.6
2461.2
2812.8
3164.4
3516.0
81-72
84-72
15-71
21-71
38-71
37-71
47-71
52-71
58-71
57-71
63-71
62-71
72-69
81-72.1
84-72.1
15-71.1
21-71.1
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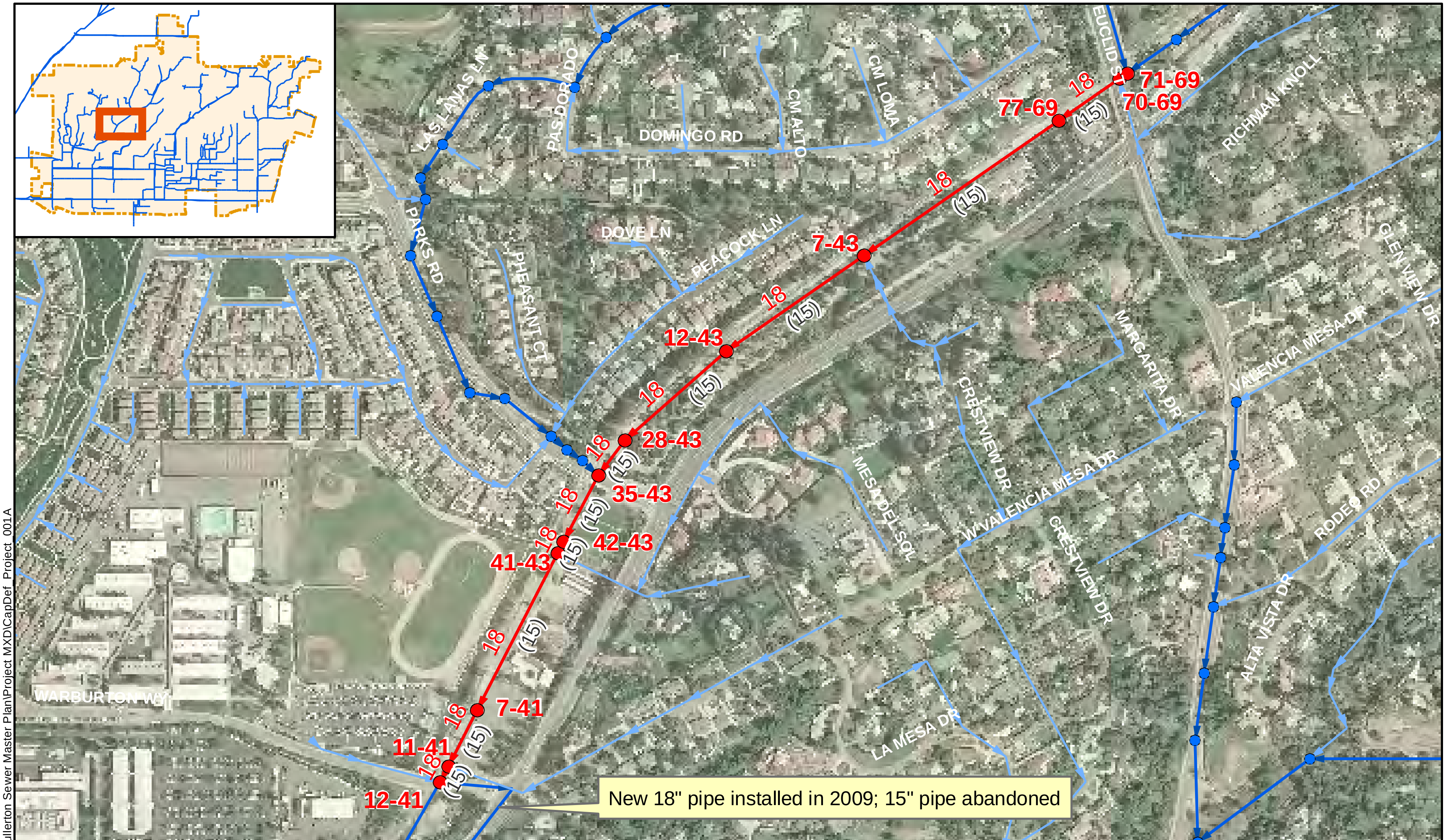
52-71.1
58-71.1
57-71.1
63-71.1
62-71.1



N

Feet

0 175 350 525 700

- Manhole on CIP Project Pipe
- Manhole on Modeled Pipe
- 12 New Pipe Diameter
- (8) Existing Pipe Diameter
- Modeled Sewer
- Unmodeled Sewer
- Street

City of Fullerton
Sewer Master Plan

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Capital Improvement Program: Project 1B

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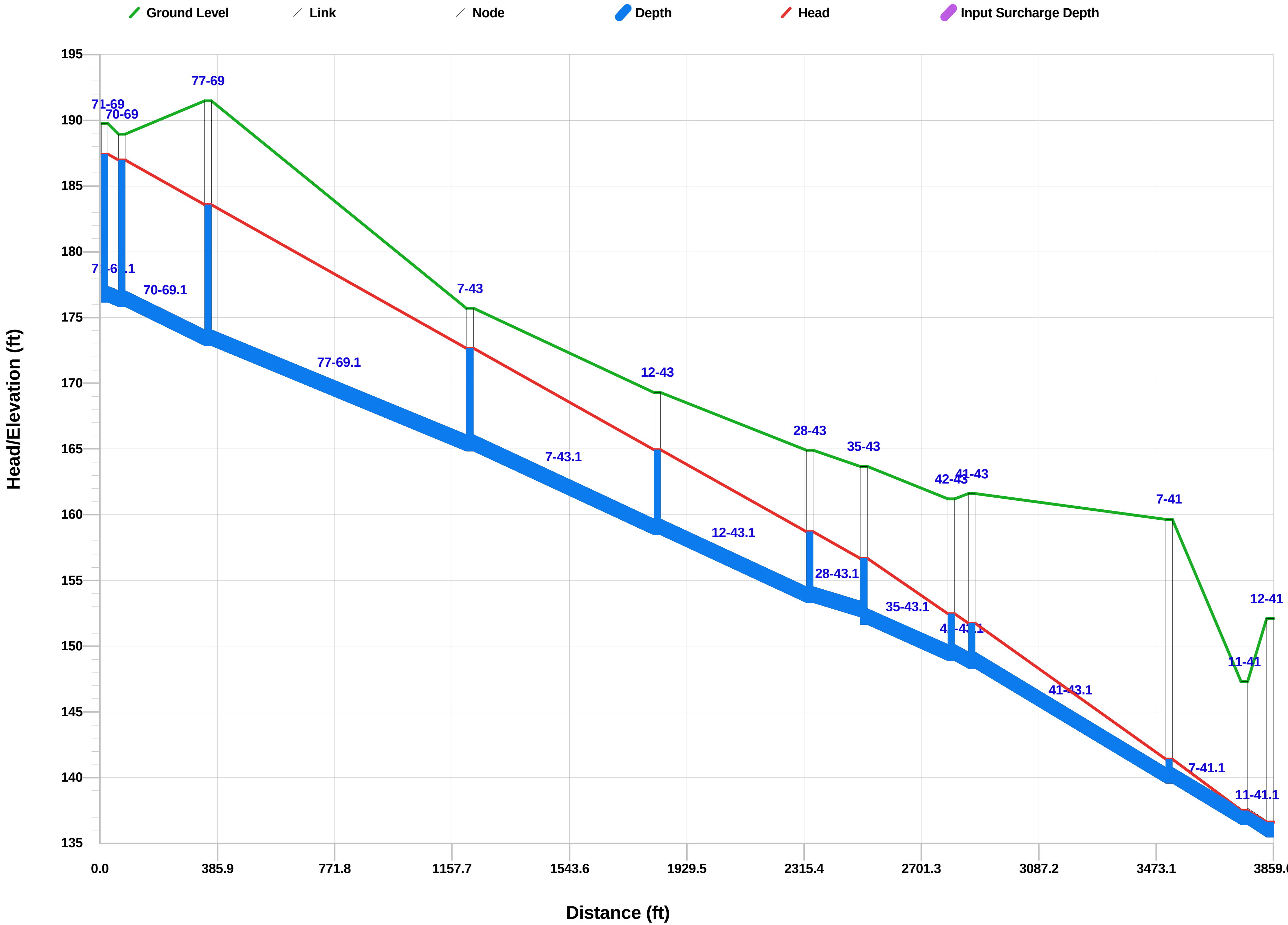
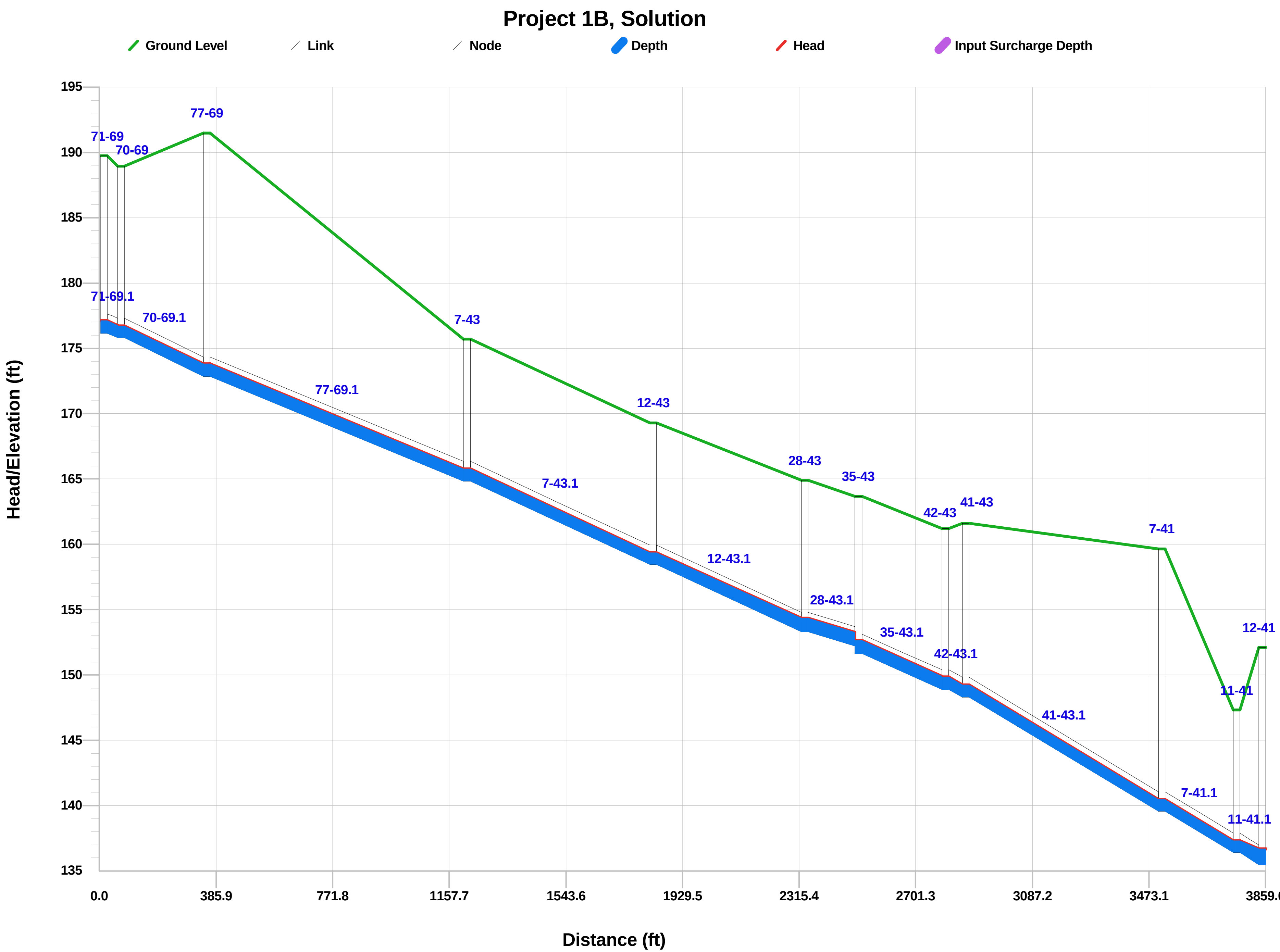
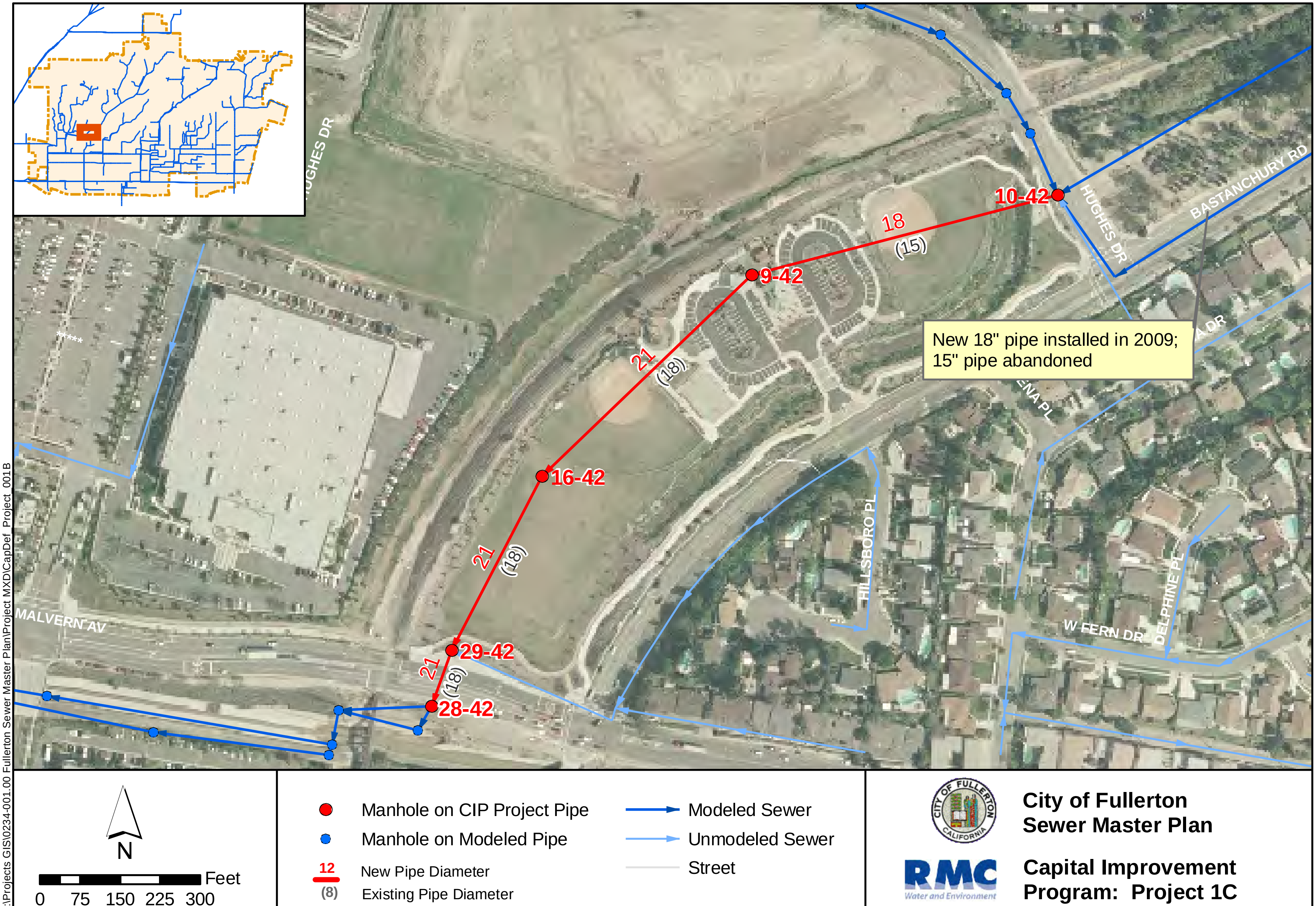
Project 1B, 2035 WWF (after Project 1A built)





Project 1B, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
195
190
185
180
175
170
165
160
155
150
145
140
135
0.0
385.9
771.8
1157.7
1543.6
1929.5
2315.4
2701.3
3087.2
3473.1
3859.0
71-69
70-69
77-69
7-43
12-43
28-43
35-43
42-43
41-43
7-41
11-41
12-41
71-69.1
70-69.1
77-69.1
7-43.1
12-43.1
28-43.1
35-43.1
42-43.1
41-43.1
7-41.1
11-41.1



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Sewer Master Plan

Capital Improvement
Program: Project 1C

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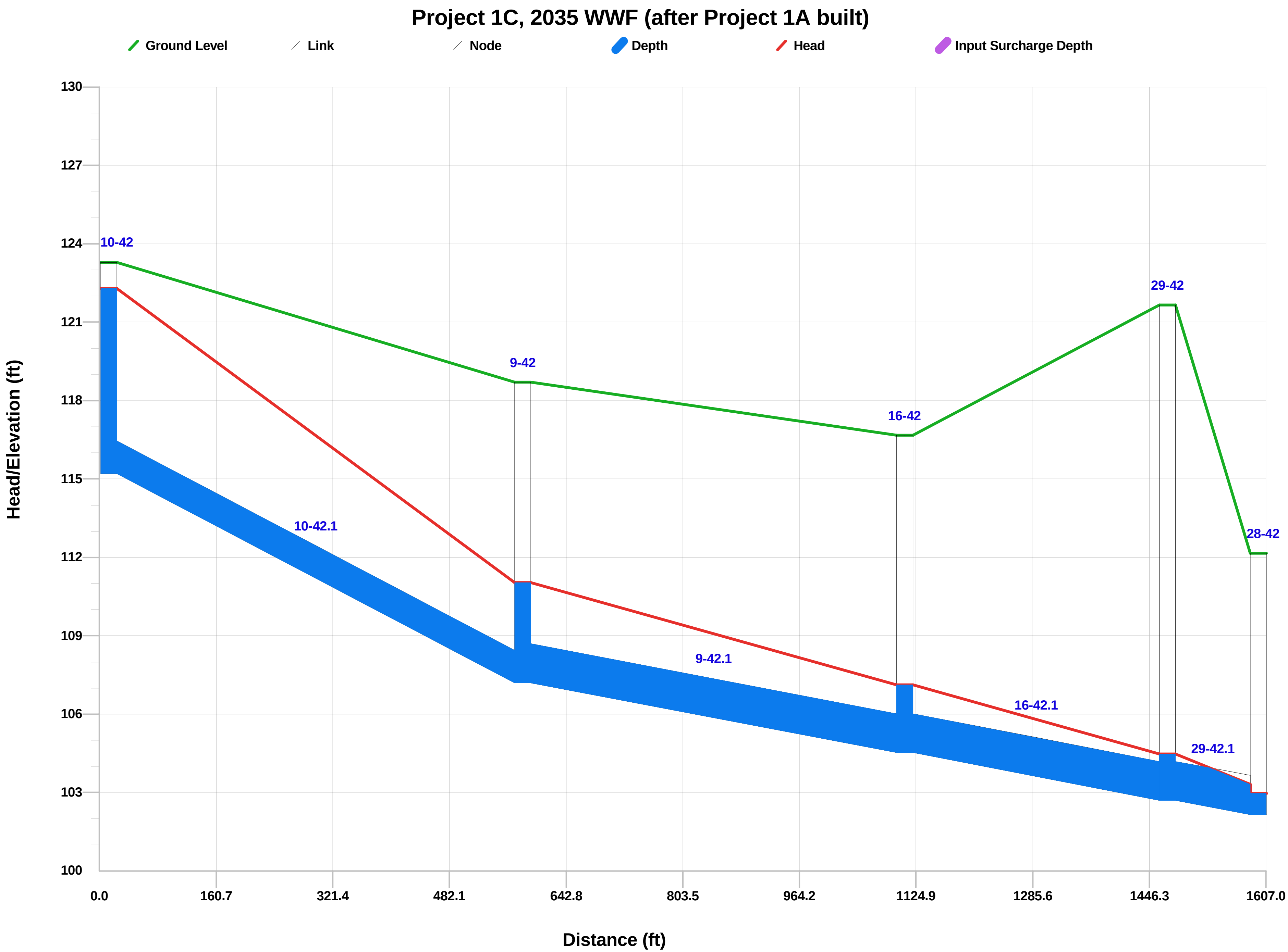
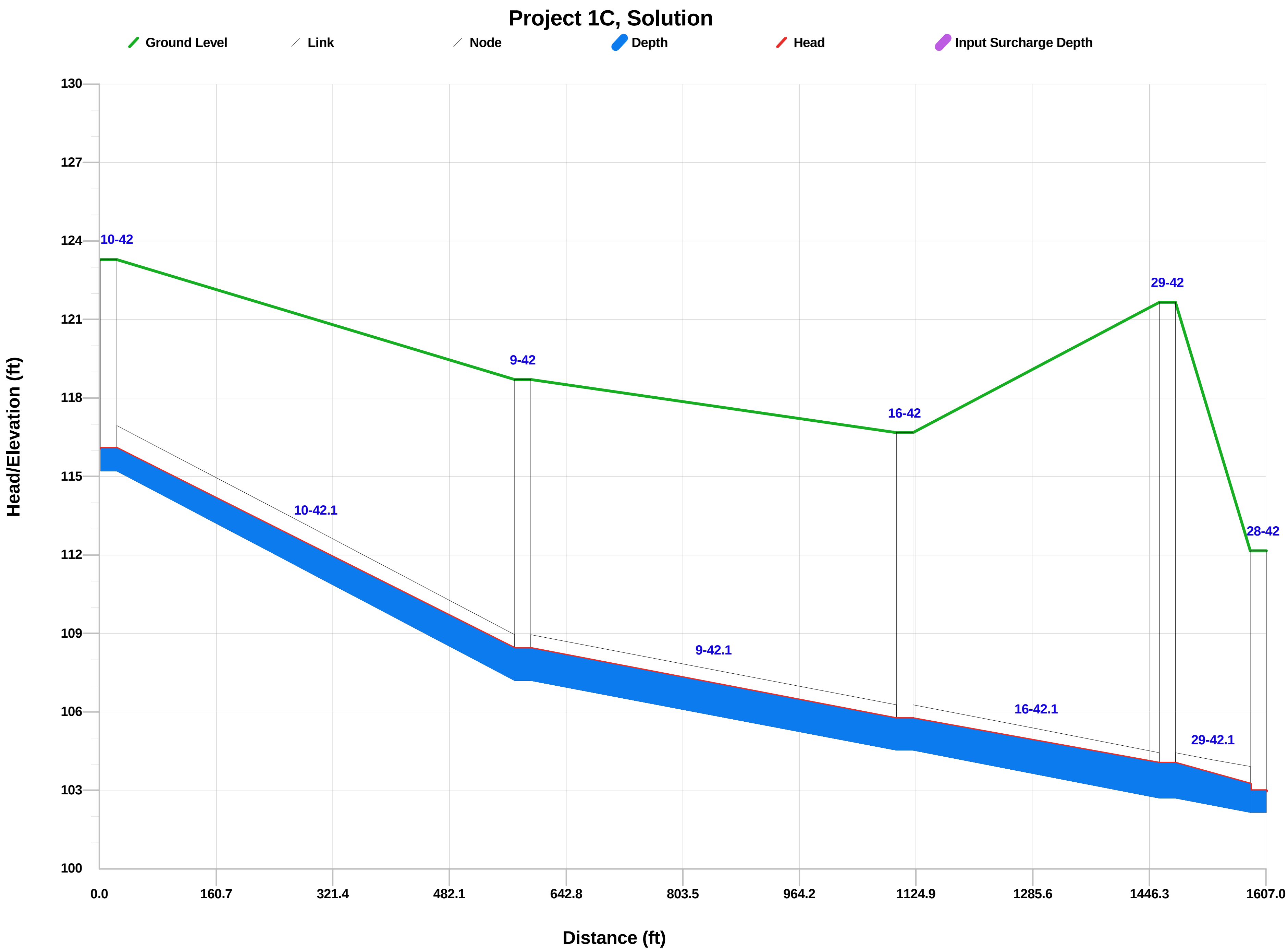
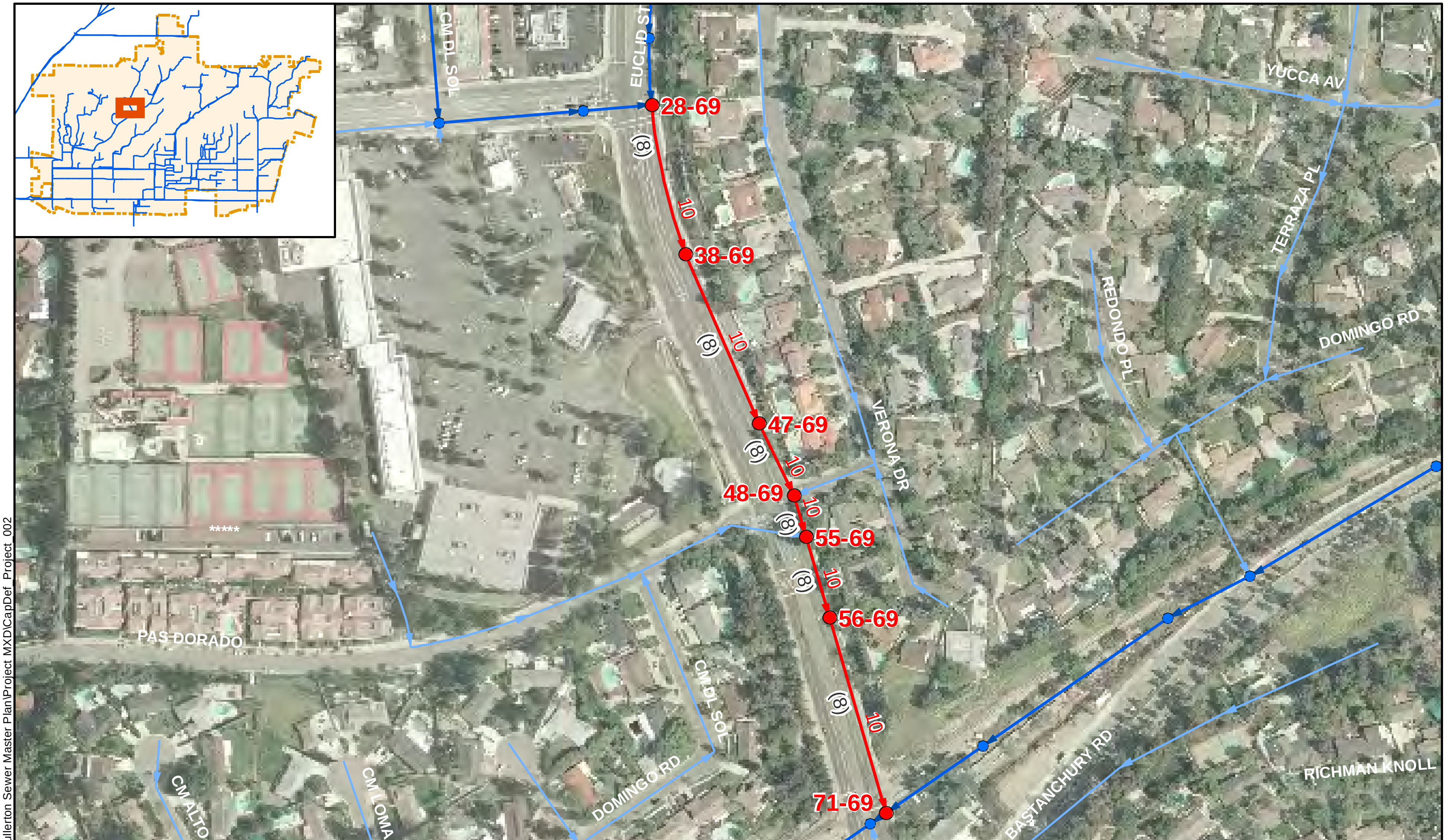


Project 1C, 2035 WWF (after Project 1A built)
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
130
127
124
121
118
115
112
109
106
103
100
10-42
9-42
16-42
29-42
28-42
10-42.1
9-42.1
16-42.1
29-42.1
0.0
160.7
321.4
482.1
642.8
803.5
964.2
1124.9
1285.6
1446.3
1607.0
Distance (ft)



Project 1C, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
130
127
124
121
118
115
112
109
106
103
100
Head/Elevation (ft)
10-42
9-42
16-42
29-42
28-42
10-42.1
9-42.1
16-42.1
29-42.1
0.0
160.7
321.4
482.1
642.8
803.5
964.2
1124.9
1285.6
1446.3
1607.0
Distance (ft)



N

Feet
0 100 200 300 400

Manhole on CIP Project Pipe
Manhole on Modeled Pipe
12 New Pipe Diameter
(8) Existing Pipe Diameter

Modeled Sewer
Unmodeled Sewer
Street

City of Fullerton
Sewer Master Plan

RMC Water and Environment

Capital Improvement Program: Project 2

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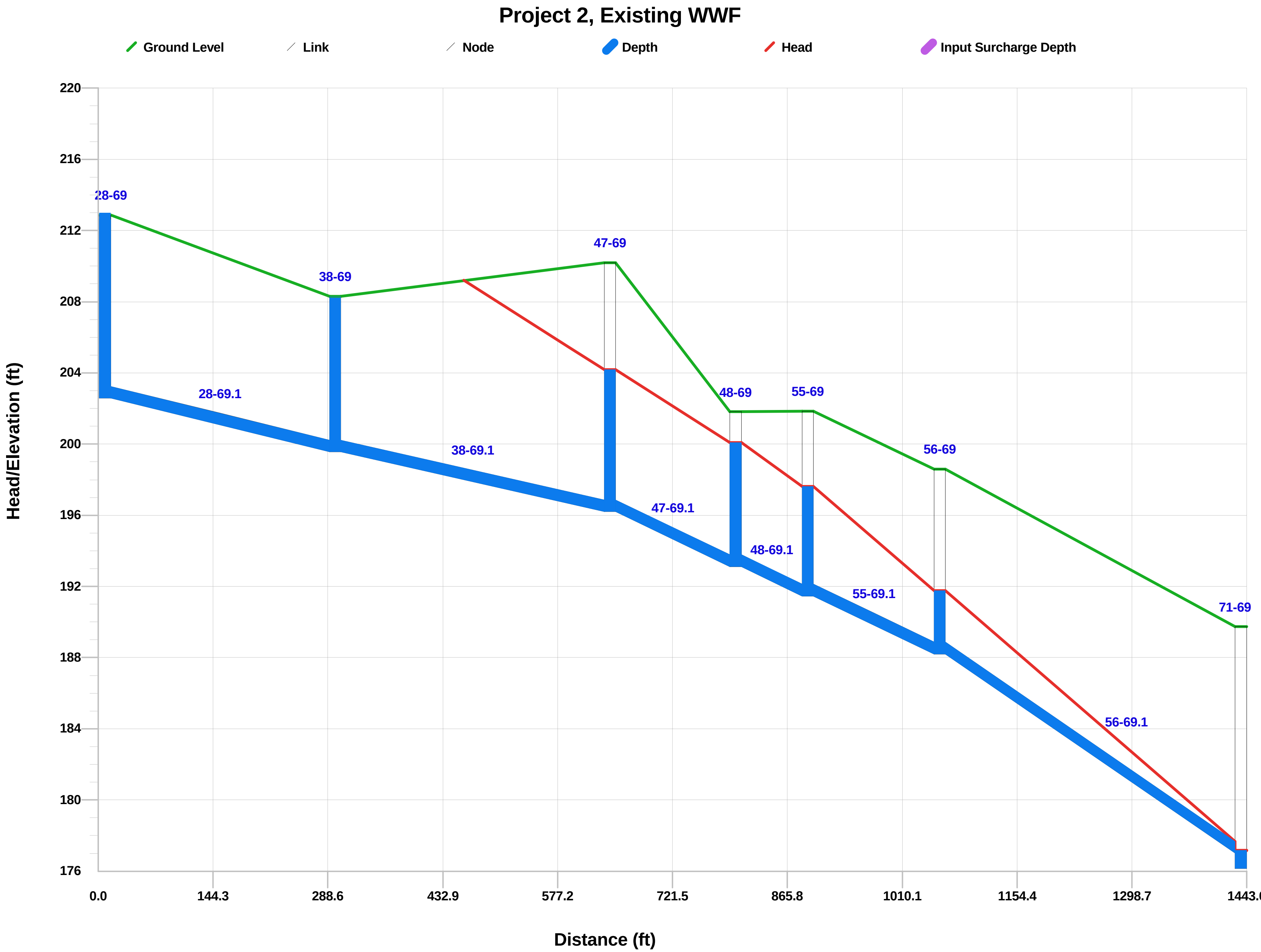
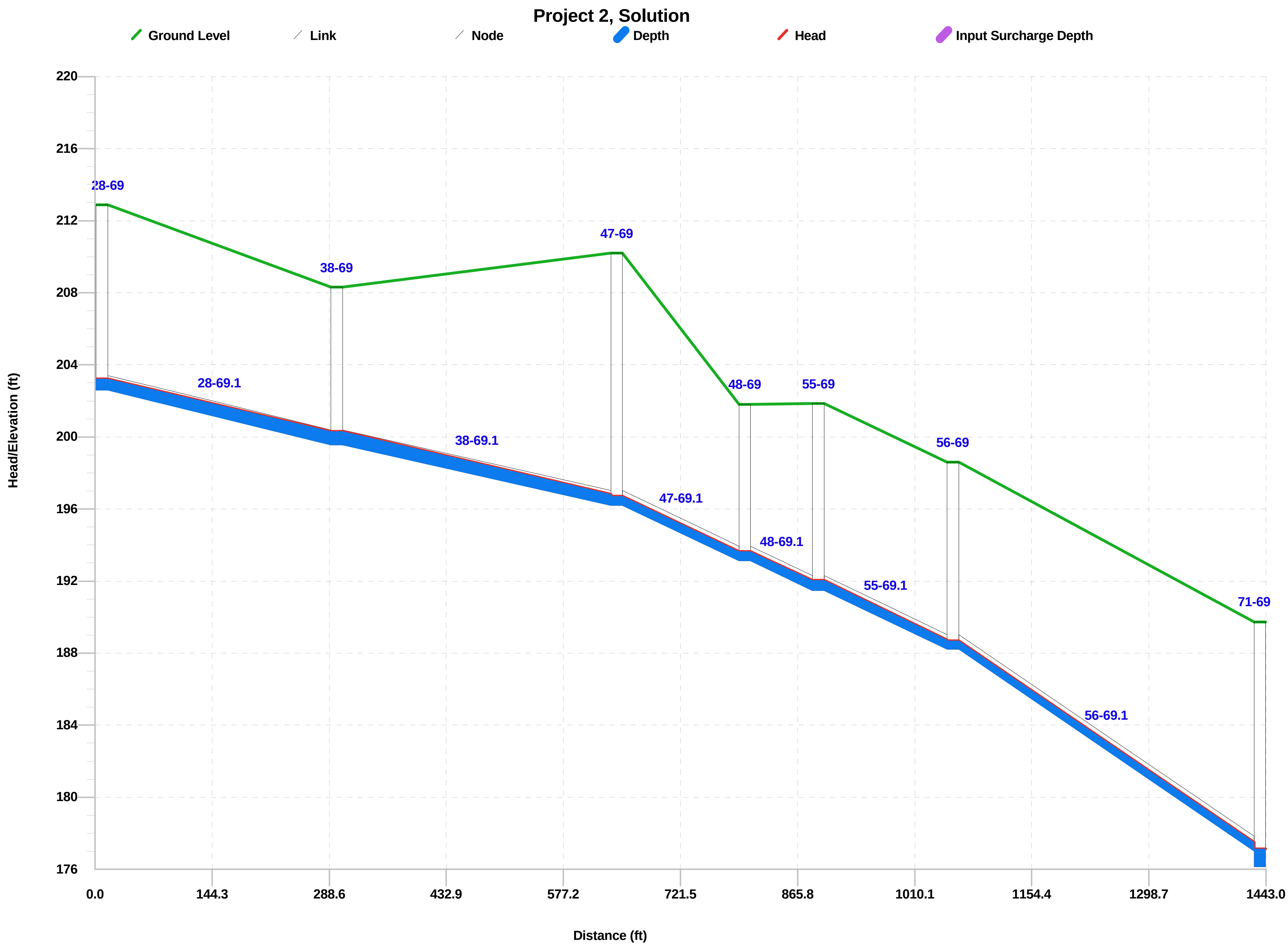

Project 2, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
220
216
212
208
204
200
196
192
188
184
180
176
Distance (ft)
0.0
144.3
288.6
432.9
577.2
721.5
865.8
1010.1
1154.4
1298.7
1443.0
28-69
38-69
47-69
48-69
55-69
56-69
71-69
28-69.1
38-69.1
47-69.1
48-69.1
55-69.1
56-69.1


Project 2, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
220
216
212
208
204
200
196
192
188
184
180
176
0.0
144.3
288.6
432.9
577.2
721.5
865.8
1010.1
1154.4
1298.7
1443.0
28-69
38-69
47-69
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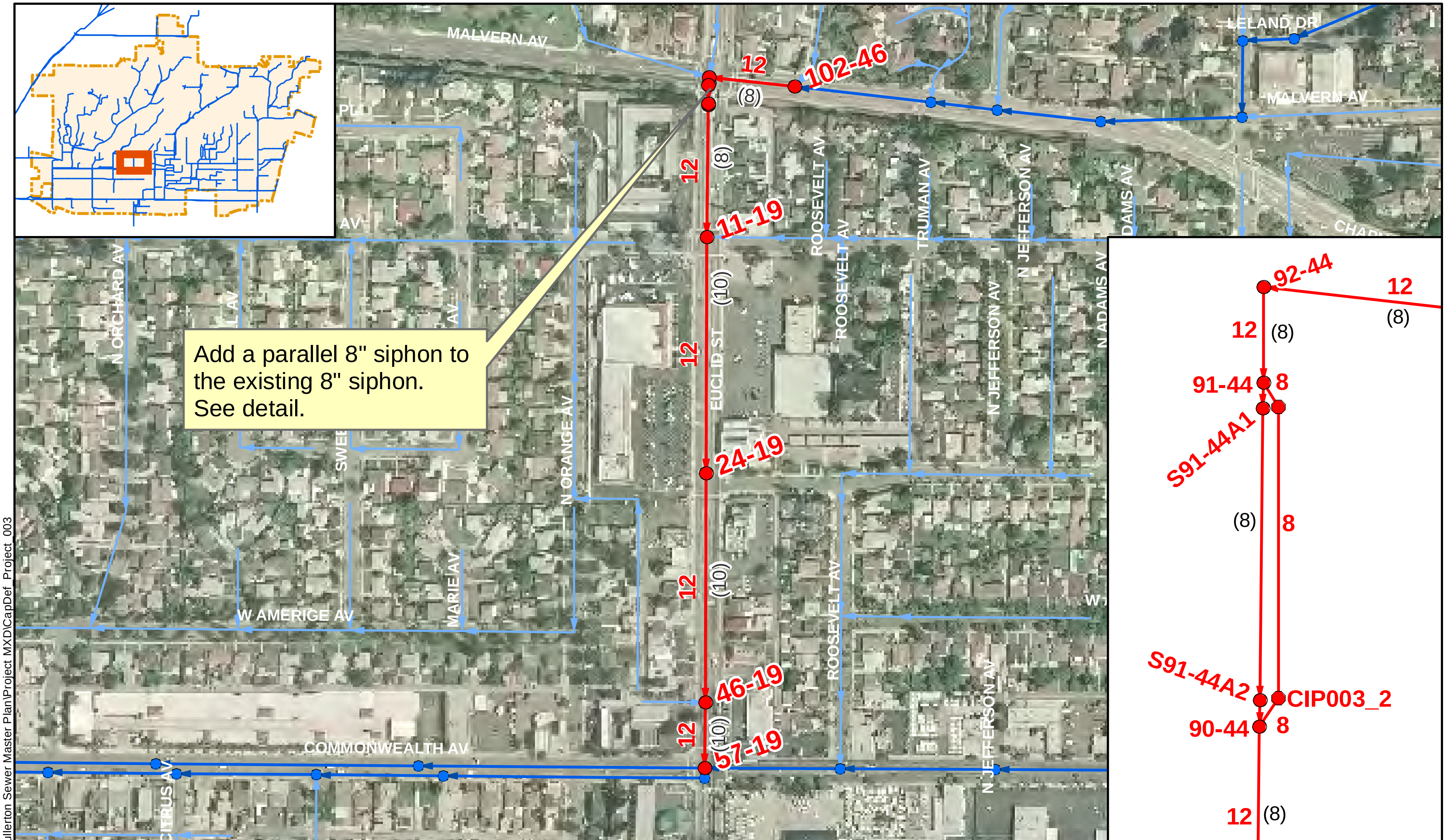
55-69.1
56-69.1



N

0 150 300 450 600 Feet

●	Manhole on CIP Project Pipe
●	Manhole on Modeled Pipe
12	New Pipe Diameter
(8)	Existing Pipe Diameter
→	Modeled Sewer
→	Unmodeled Sewer
—	Street

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Capital Improvement Program: Project 3

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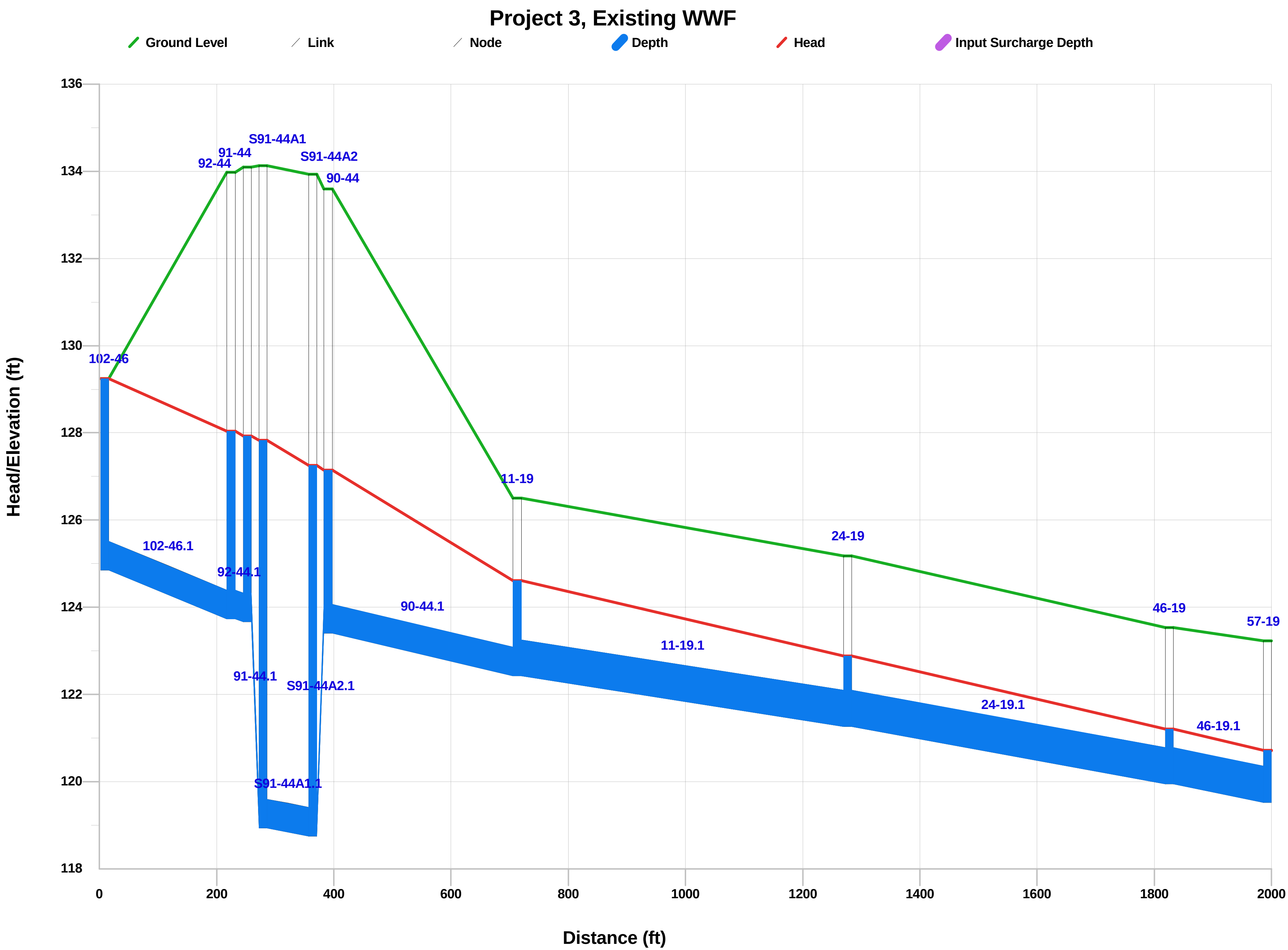
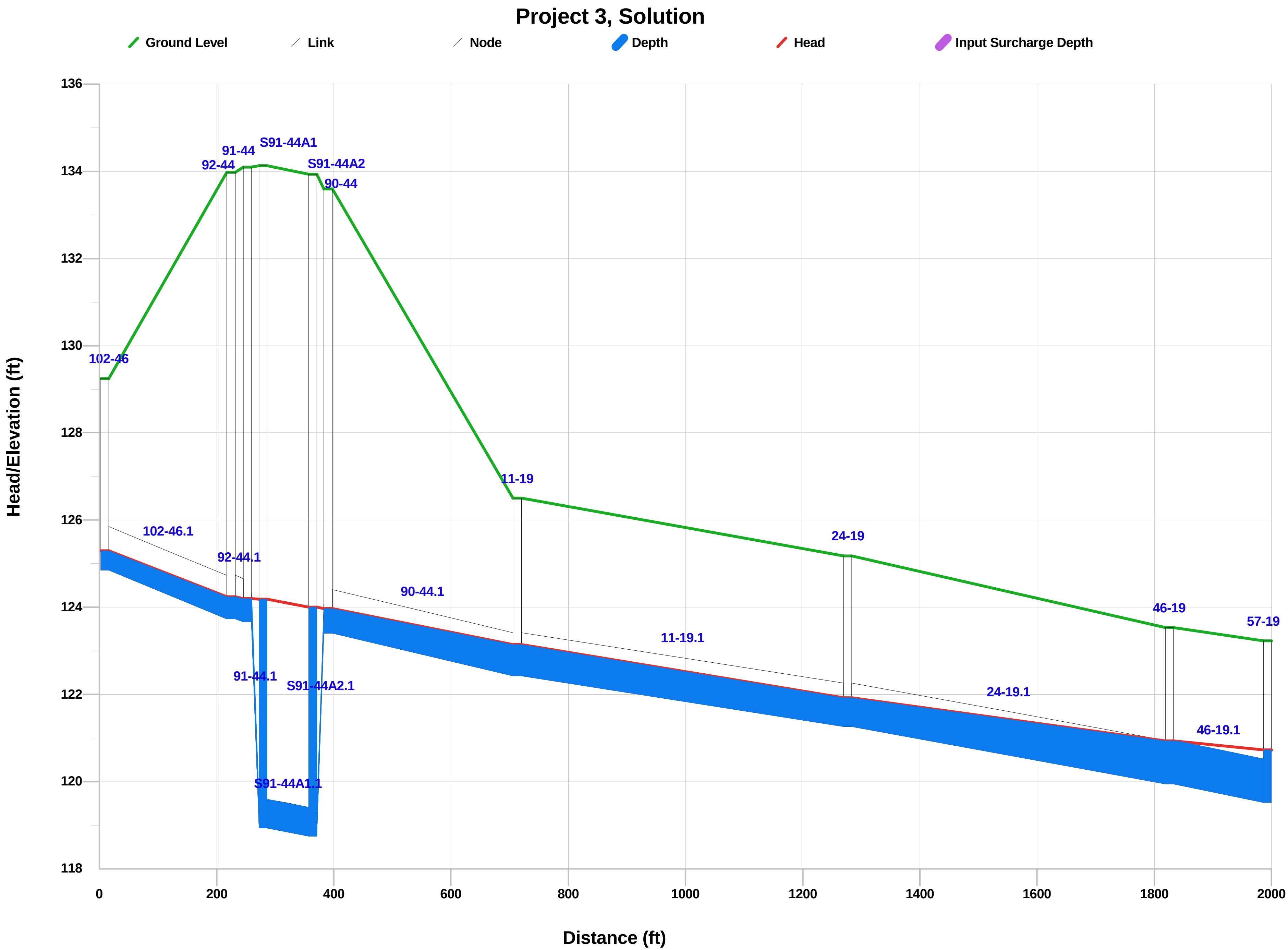
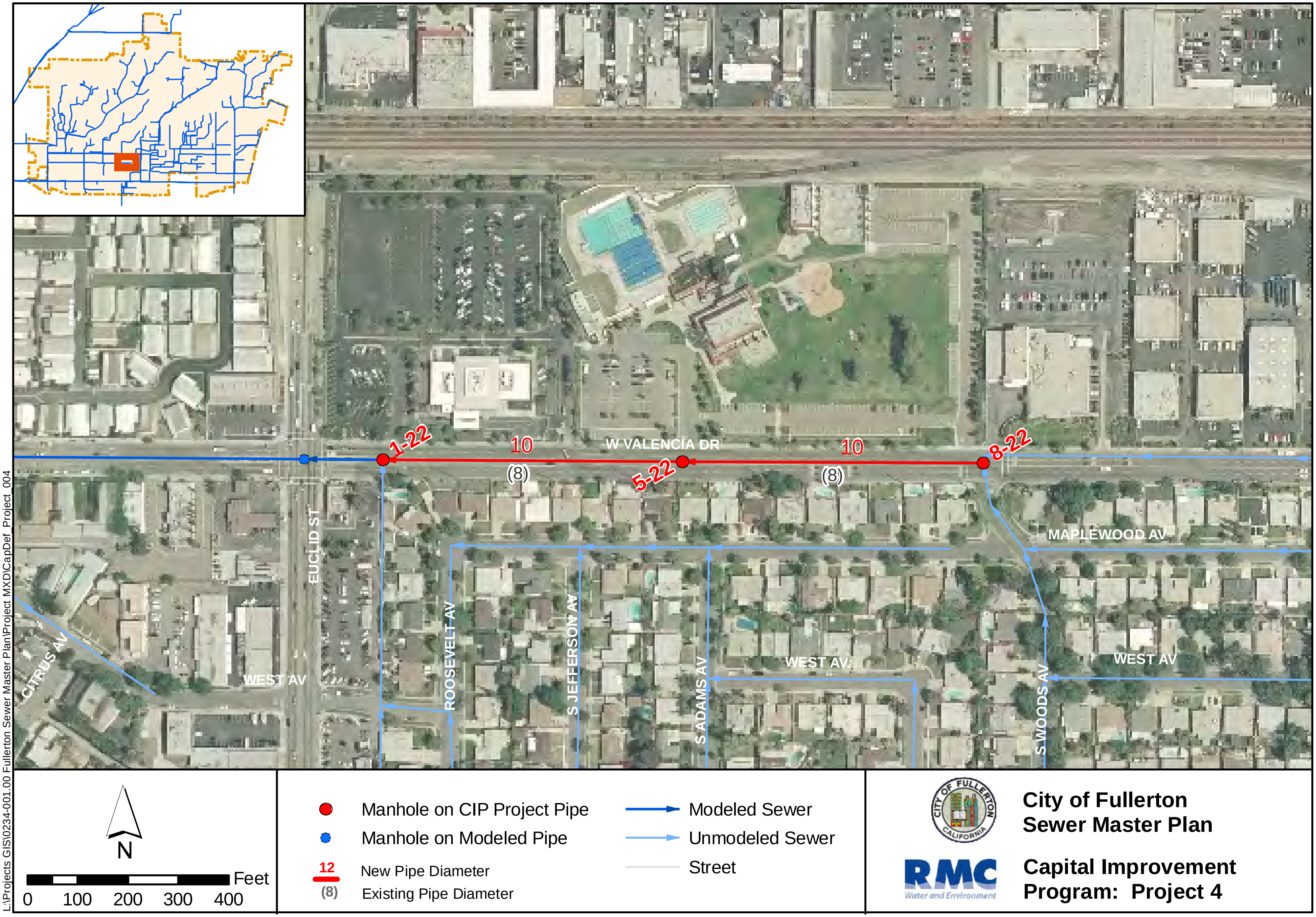

Project 3, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
136
134
132
130
128
126
124
122
120
118
0
200
400
600
800
1000
1200
1400
1600
1800
2000
102-46
92-44
91-44
S91-44A1
S91-44A2
90-44
11-19
24-19
46-19
57-19
102-46.1
92-44.1
91-44.1
S91-44A2.1
S91-44A1.1
90-44.1
11-19.1
24-19.1
46-19.1

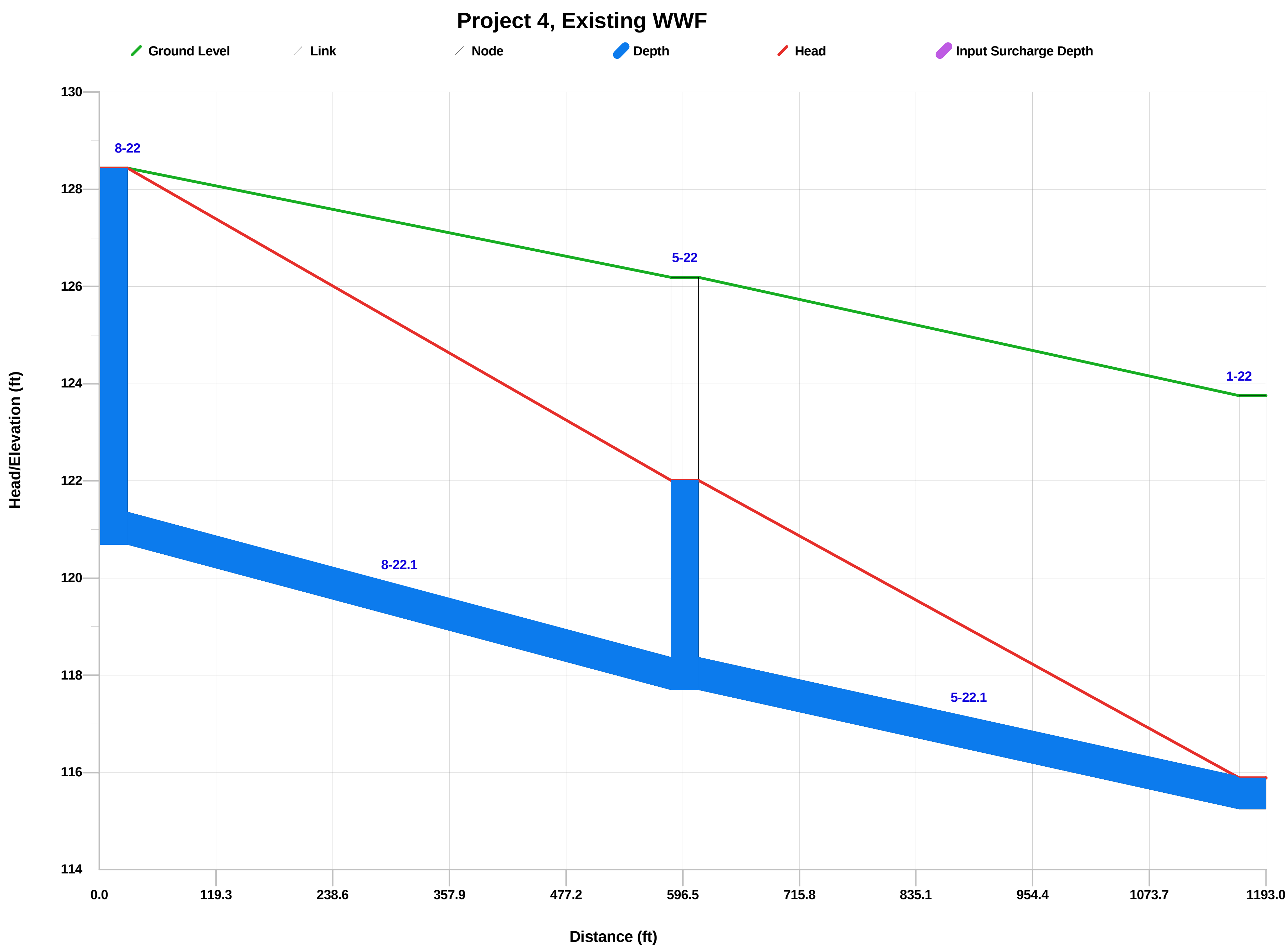

Project 3, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
136
134
132
130
128
126
124
122
120
118
0
200
400
600
800
1000
1200
1400
1600
1800
2000
102-46
92-44
91-44
S91-44A1
S91-44A2
90-44
11-19
24-19
46-19
57-19
102-46.1
92-44.1
90-44.1
11-19.1
91-44.1
S91-44A2.1
24-19.1
46-19.1
S91-44A1.1



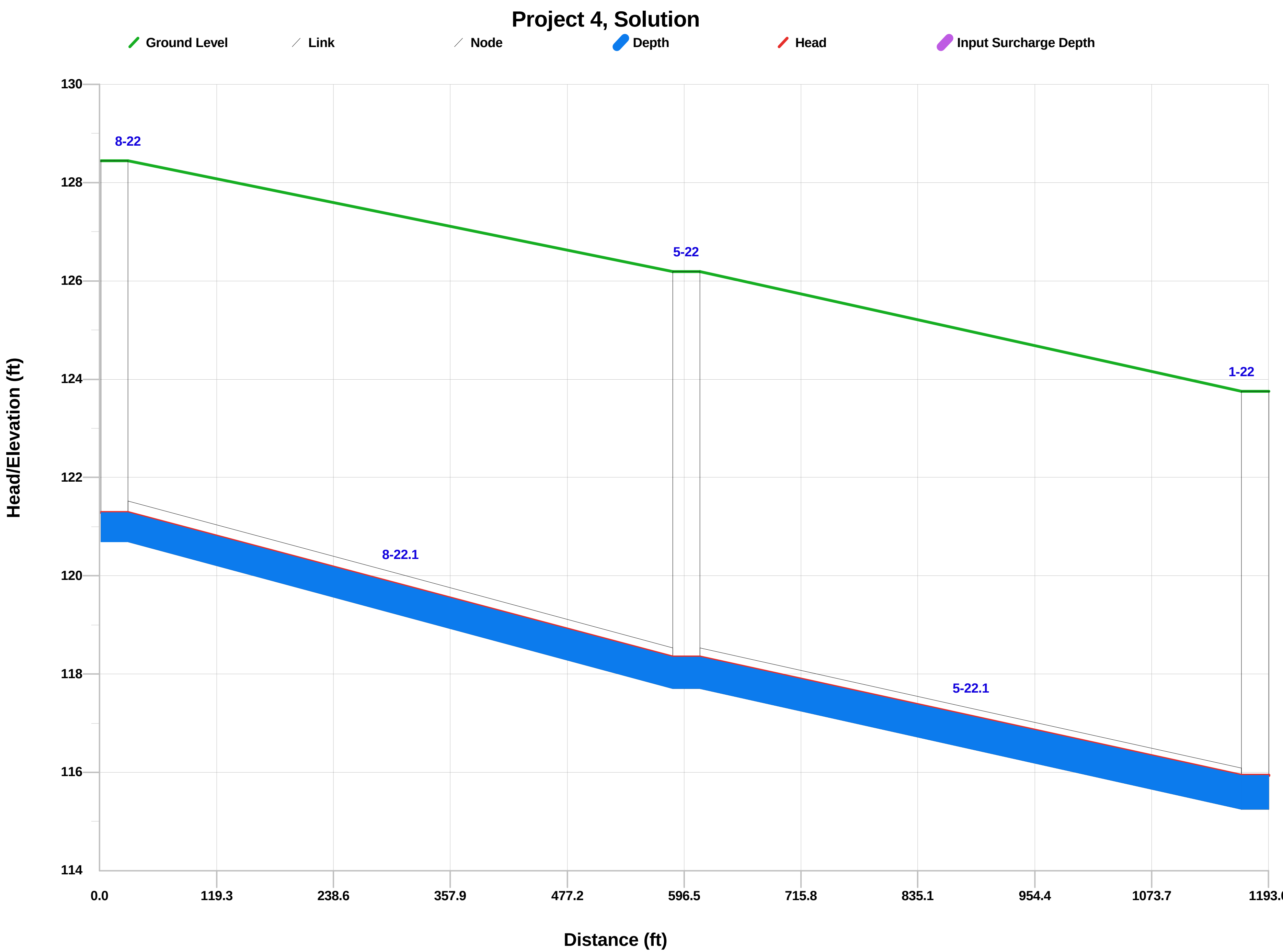
City of Fullerton Sewer Master Plan

Capital Improvement Program: Project 4

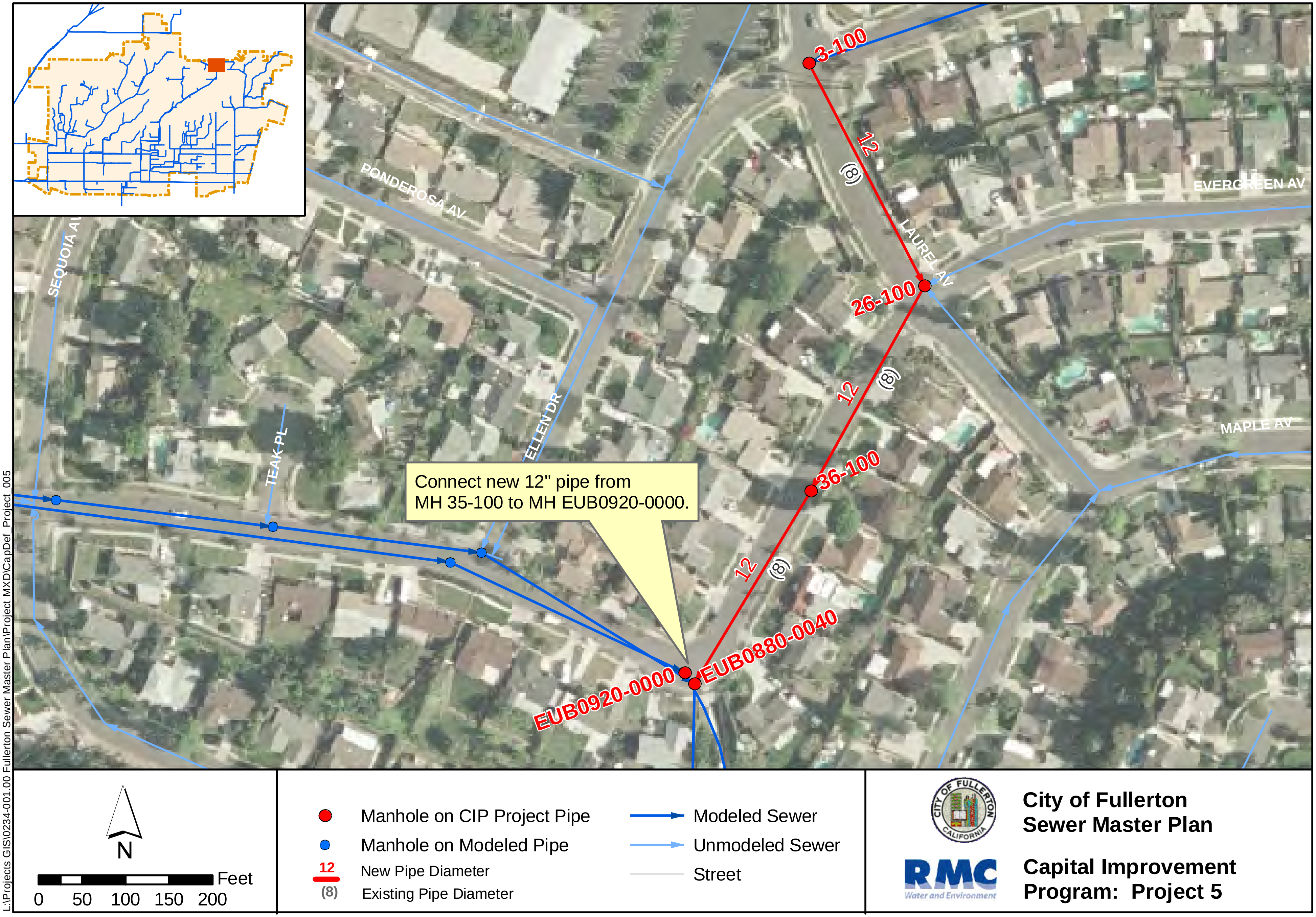
L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_004



Project 4, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
130
128
126
124
122
120
118
116
114
Head/Elevation (ft)
8-22
5-22
1-22
8-22.1
5-22.1
0.0
119.3
238.6
357.9
477.2
596.5
715.8
835.1
954.4
1073.7
1193.0
Distance (ft)



Project 4, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
130
128
126
124
122
120
118
116
114
8-22
5-22
1-22
8-22.1
5-22.1
0.0
119.3
238.6
357.9
477.2
596.5
715.8
835.1
954.4
1073.7
1193.0
Distance (ft)



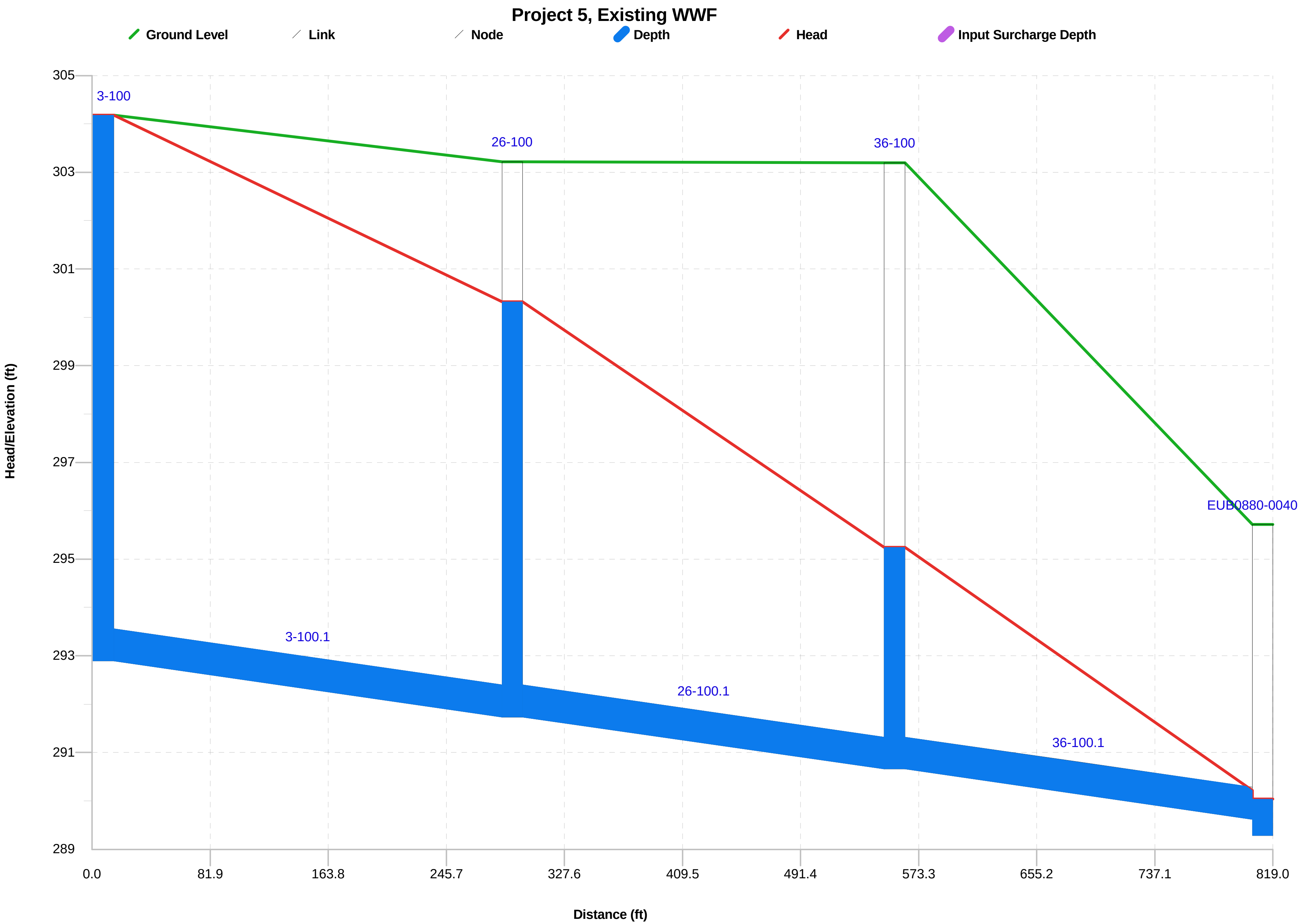
Manhole on CIP Project Pipe
Manhole on Modeled Pipe
12 New Pipe Diameter
(8) Existing Pipe Diameter
Modeled Sewer
Unmodeled Sewer
Street

City of Fullerton
Sewer Master Plan

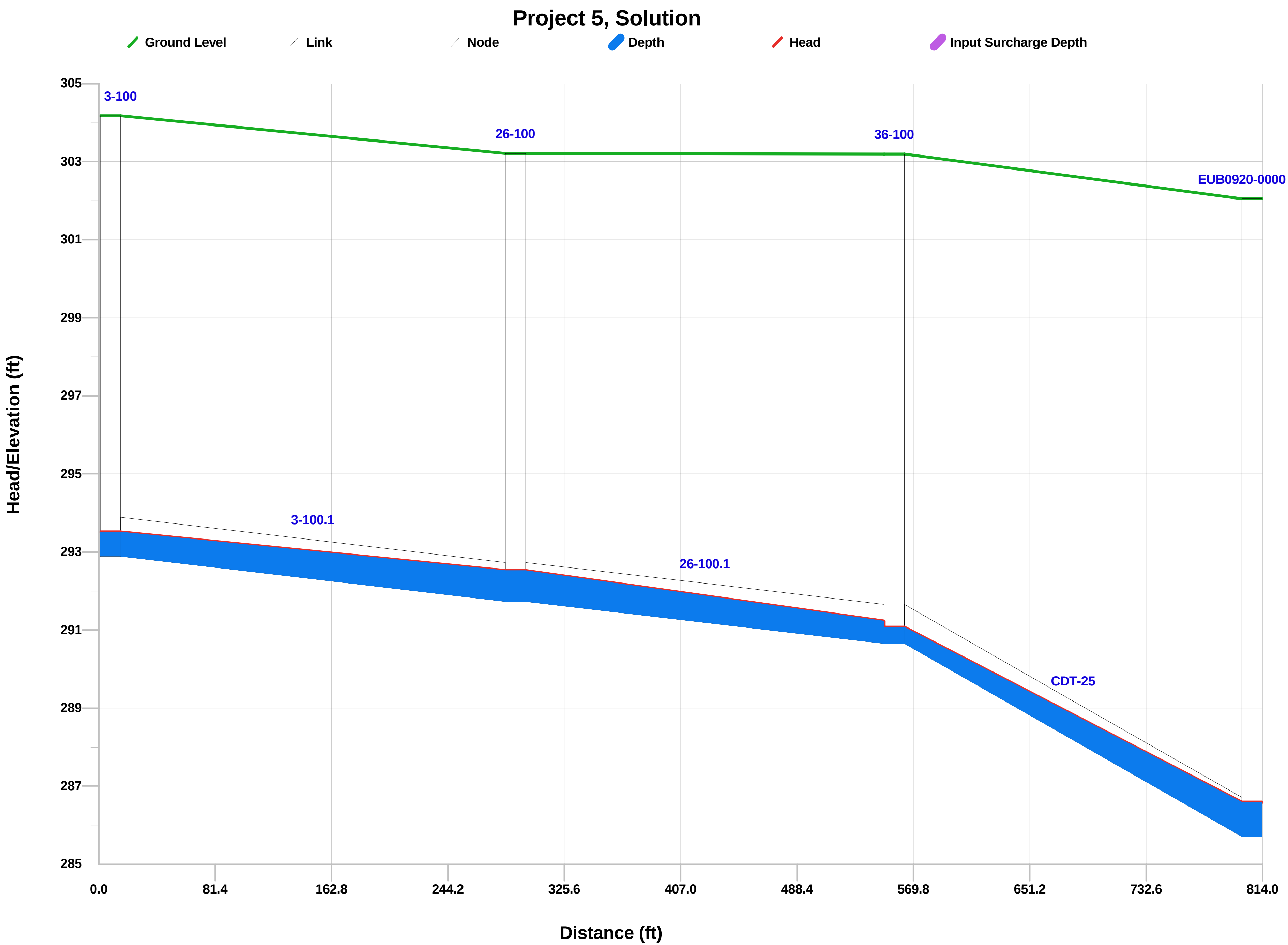
RMC Water and Environment

Capital Improvement Program: Project 5

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_005



Project 5, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
305
303
301
299
297
295
293
291
289
3-100
26-100
36-100
EUB0880-0040
3-100.1
26-100.1
36-100.1
0.0
81.9
163.8
245.7
327.6
409.5
491.4
573.3
655.2
737.1
819.0
Distance (ft)



Project 5, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
305
303
301
299
297
295
293
291
289
287
285
3-100
26-100
36-100
EUB0920-0000
3-100.1
26-100.1
CDT-25
0.0
81.4
162.8
244.2
325.6
407.0
488.4
569.8
651.2
732.6
814.0
Distance (ft)

N

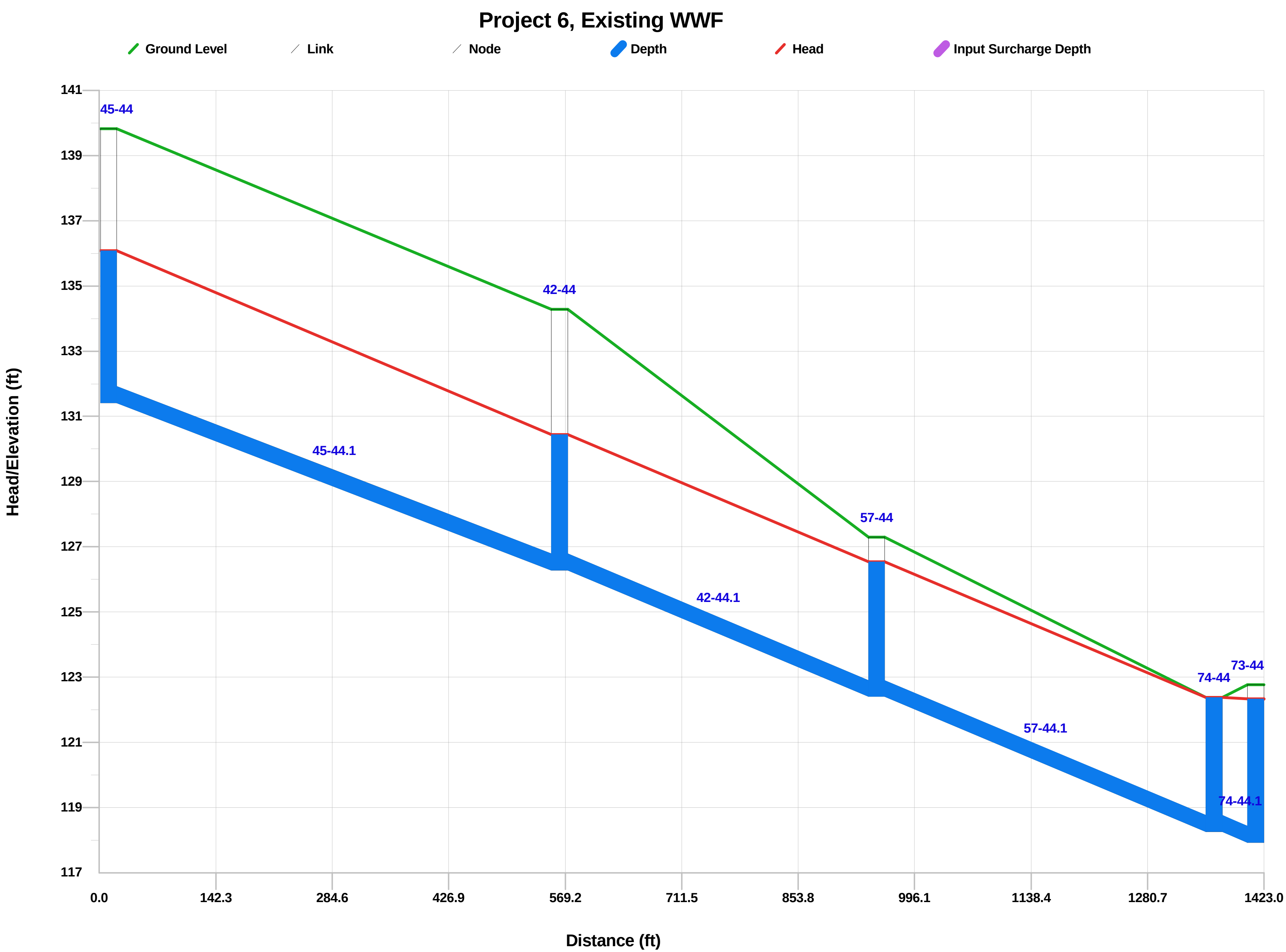
0 100 200 300 400 Feet

- Manhole on CIP Project Pipe
- Manhole on Modeled Pipe
- 12 New Pipe Diameter
- (8) Existing Pipe Diameter
- Modeled Sewer
- Unmodeled Sewer
- Street

City of Fullerton
Sewer Master Plan

Capital Improvement Program: Project 6

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_006



Project 6, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
141
139
137
135
133
131
129
127
125
123
121
119
117
45-44
45-44.1
42-44
42-44.1
57-44
57-44.1
74-44
73-44
74-44.1
0.0
142.3
284.6
426.9
569.2
711.5
853.8
996.1
1138.4
1280.7
1423.0
Distance (ft)

Project 6, Solution

N

0 75 150 225 300 Feet

Manhole on CIP Project Pipe

Manhole on Modeled Pipe

12 New Pipe Diameter

(8) Existing Pipe Diameter

Modeled Sewer

Unmodeled Sewer

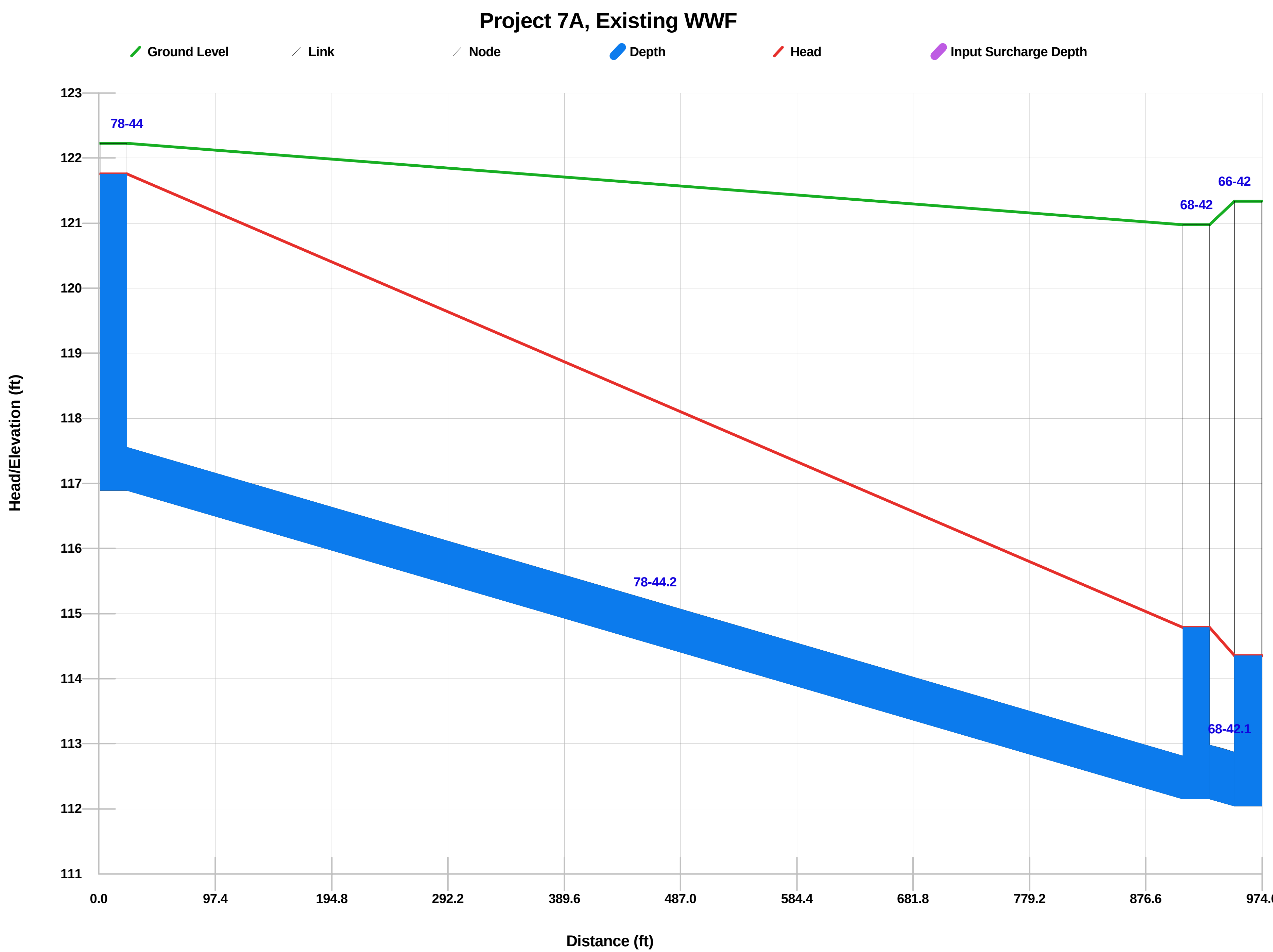
Street

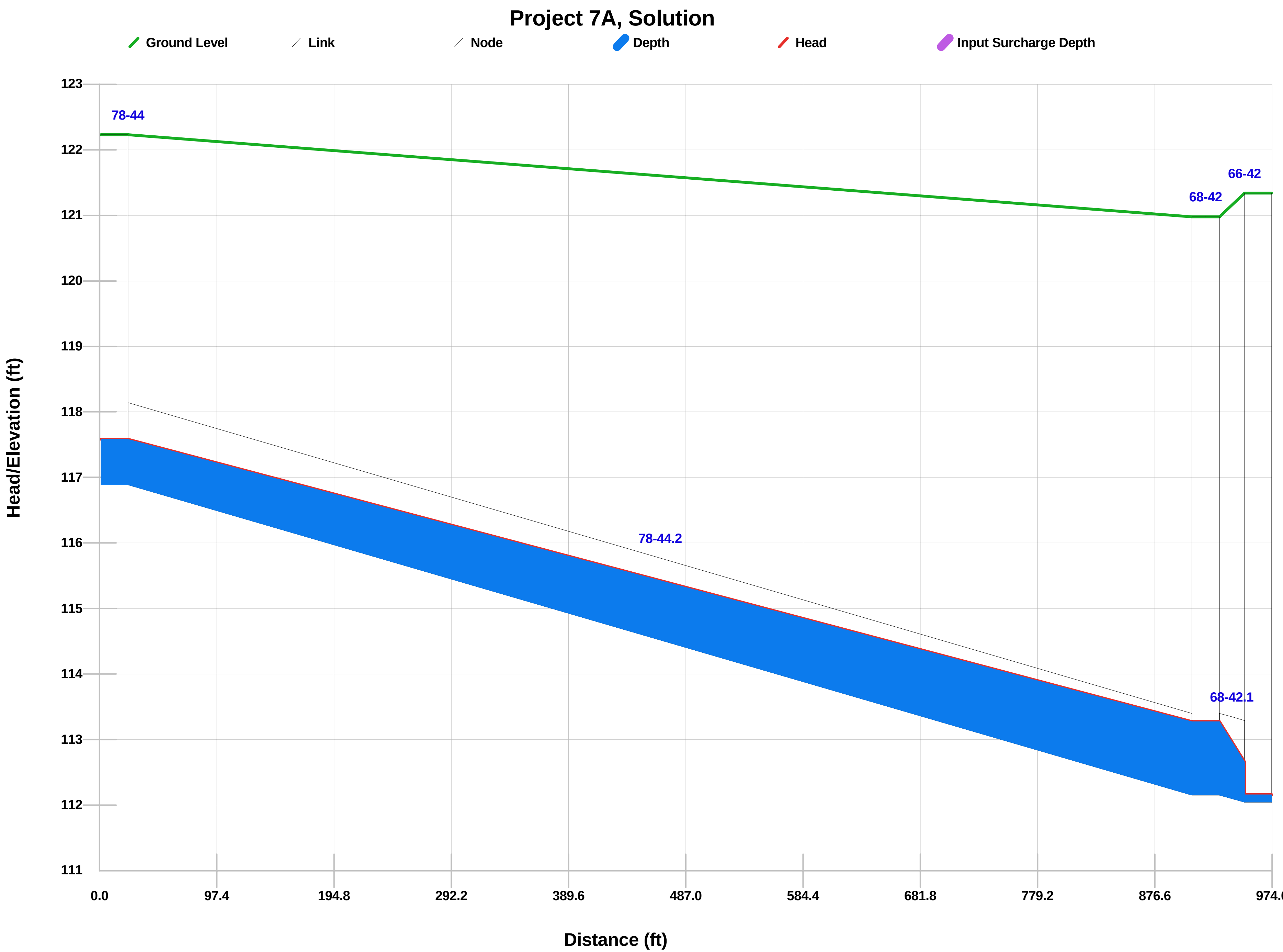
City of Fullerton
Sewer Master Plan

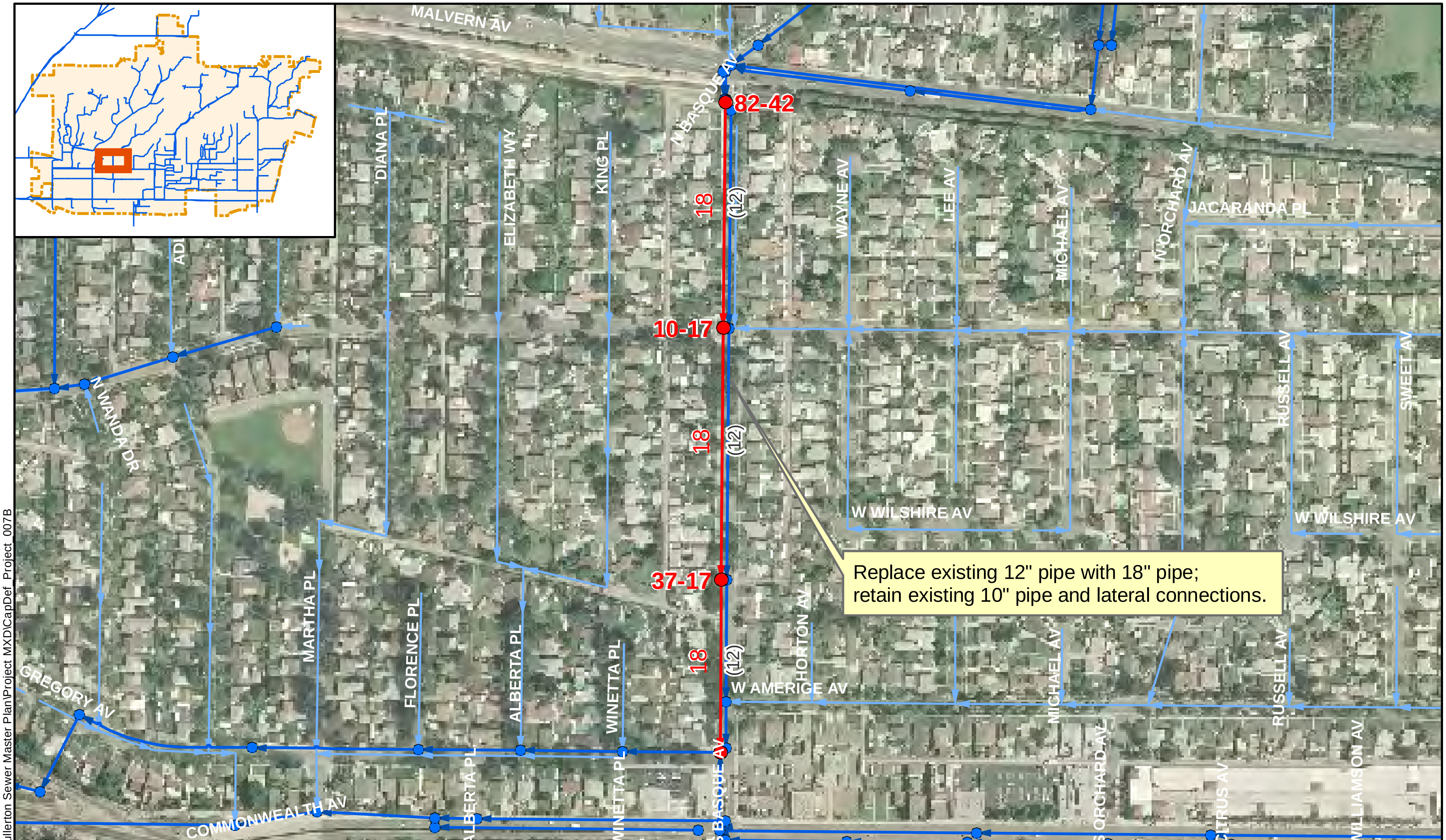
RMC Water and Environment

Capital Improvement Program: Project 7A

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_007A


Project 7A, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
123
122
121
120
119
118
117
116
115
114
113
112
111
0.0
97.4
194.8
292.2
389.6
487.0
584.4
681.8
779.2
876.6
974.0
78-44
68-42
66-42
78-44.2
68-42.1


Project 7A, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
123
122
121
120
119
118
117
116
115
114
113
112
111
Head/Elevation (ft)
78-44
78-44.2
68-42
66-42
68-42.1
0.0
97.4
194.8
292.2
389.6
487.0
584.4
681.8
779.2
876.6
974.0
Distance (ft)



Manhole on CIP Project Pipe

Manhole on Modeled Pipe

12 New Pipe Diameter

(8) Existing Pipe Diameter

Modeled Sewer

Unmodeled Sewer

Street

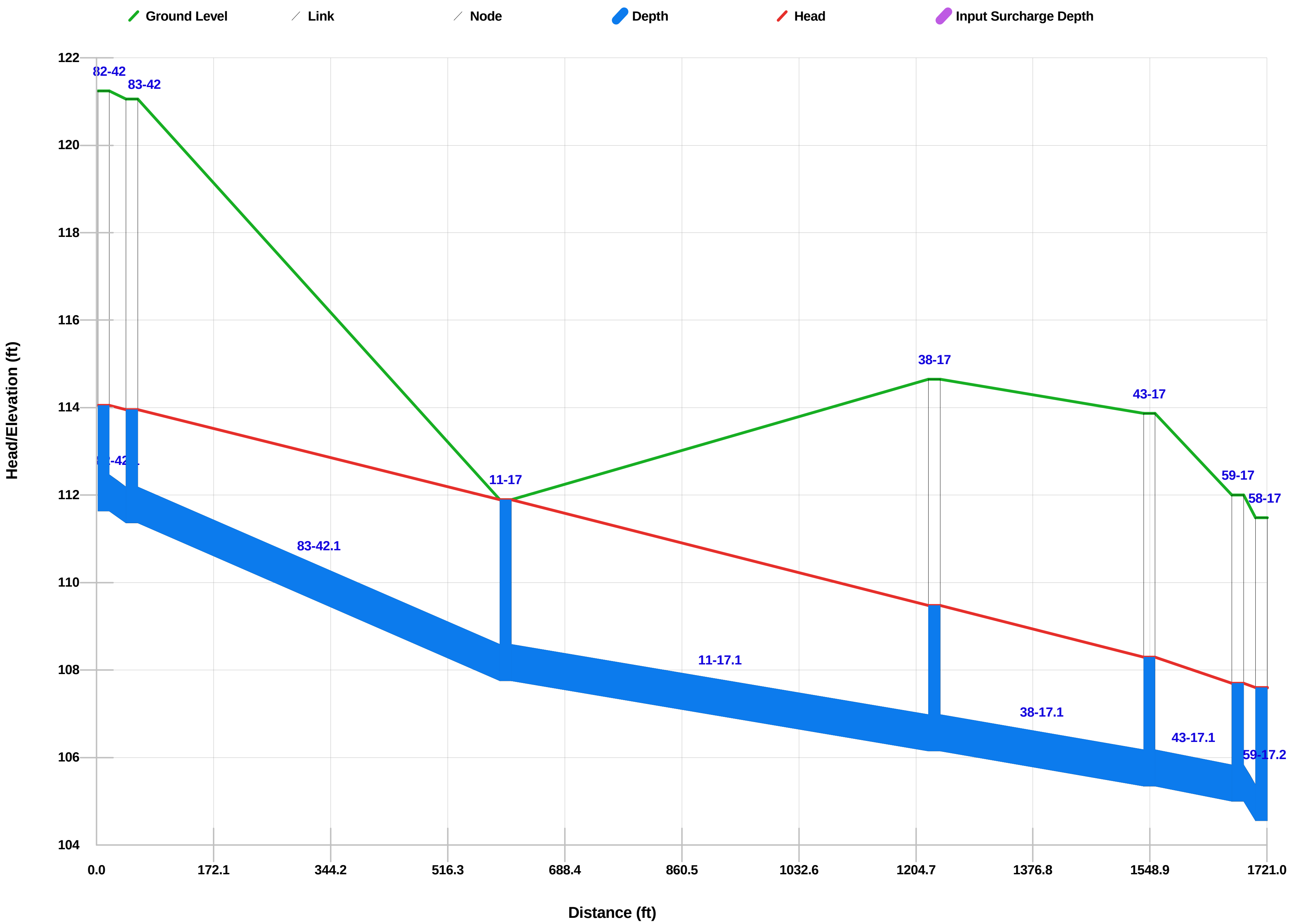
City of Fullerton
Sewer Master Plan

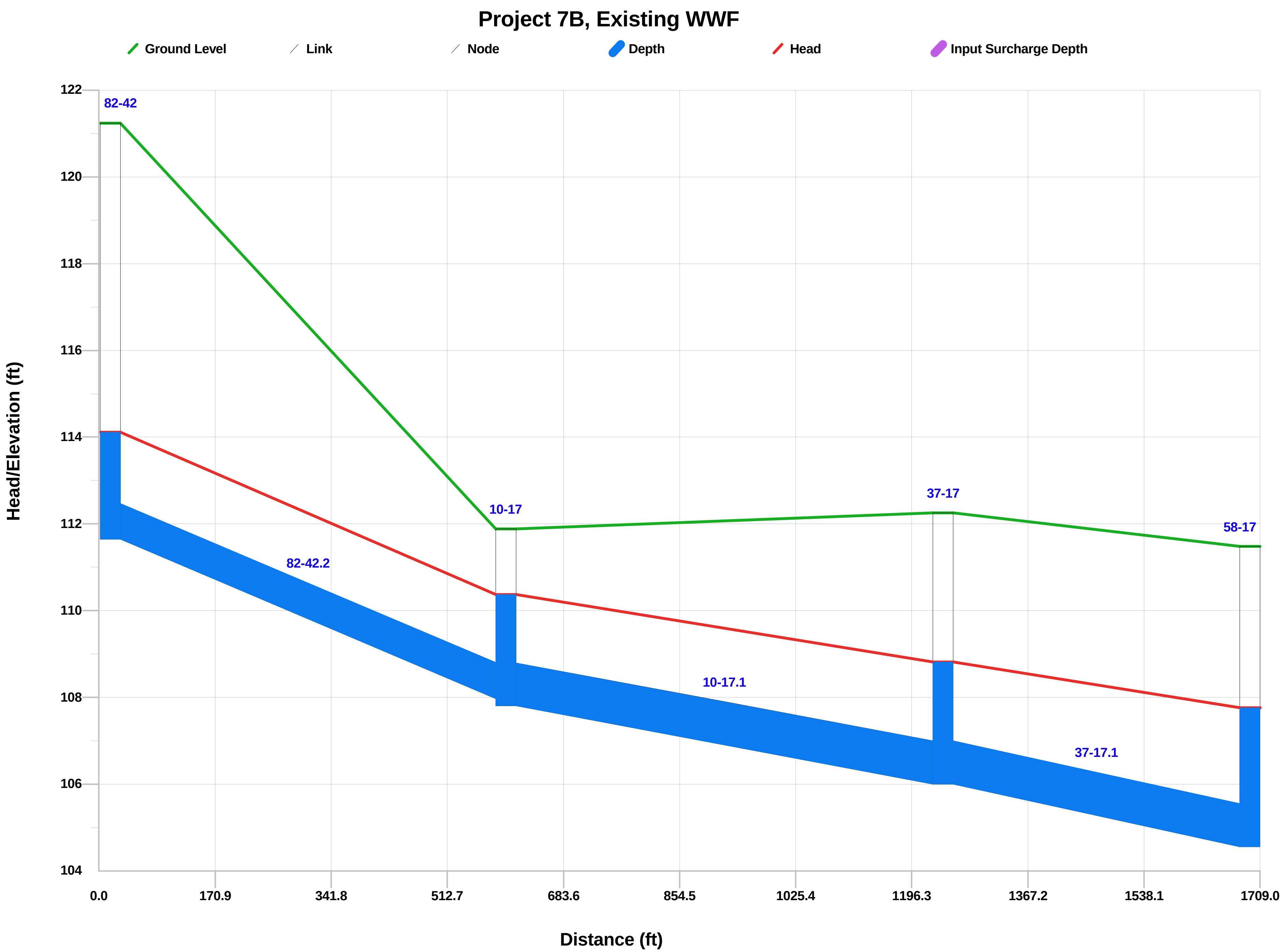
RMC Water and Environment

Capital Improvement Program: Project 7B

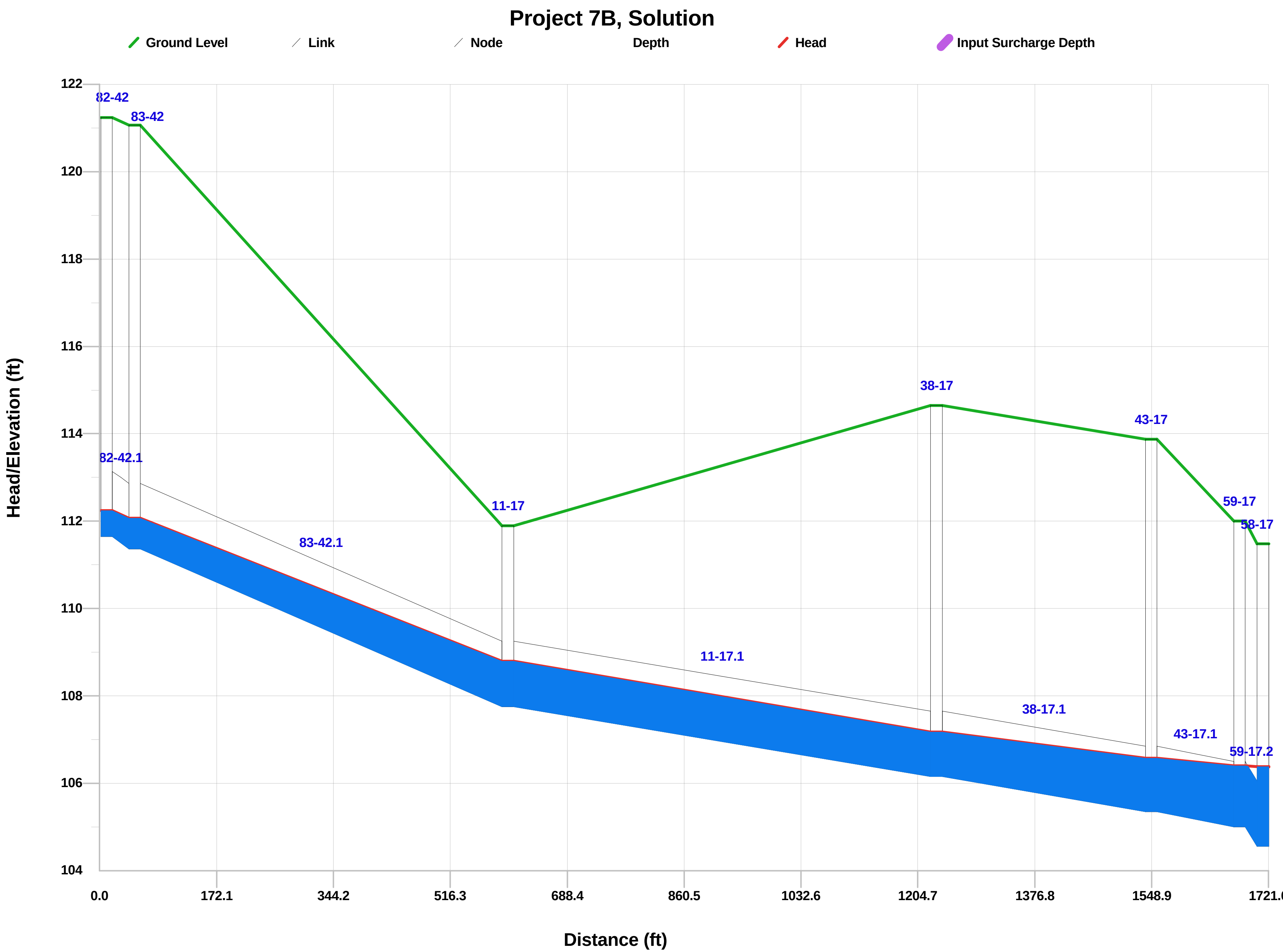
L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_007B

Project 7B, Existing WWF

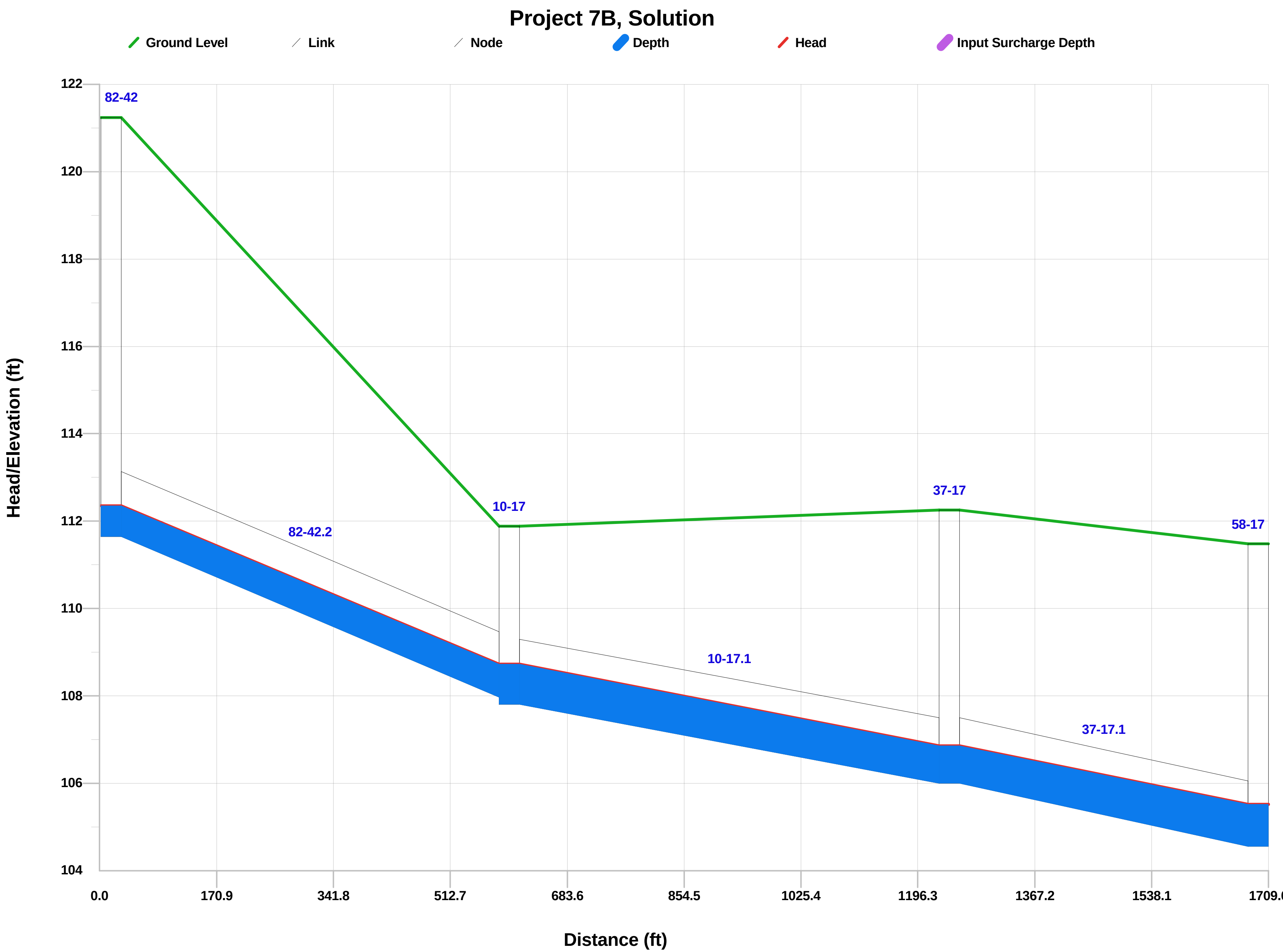




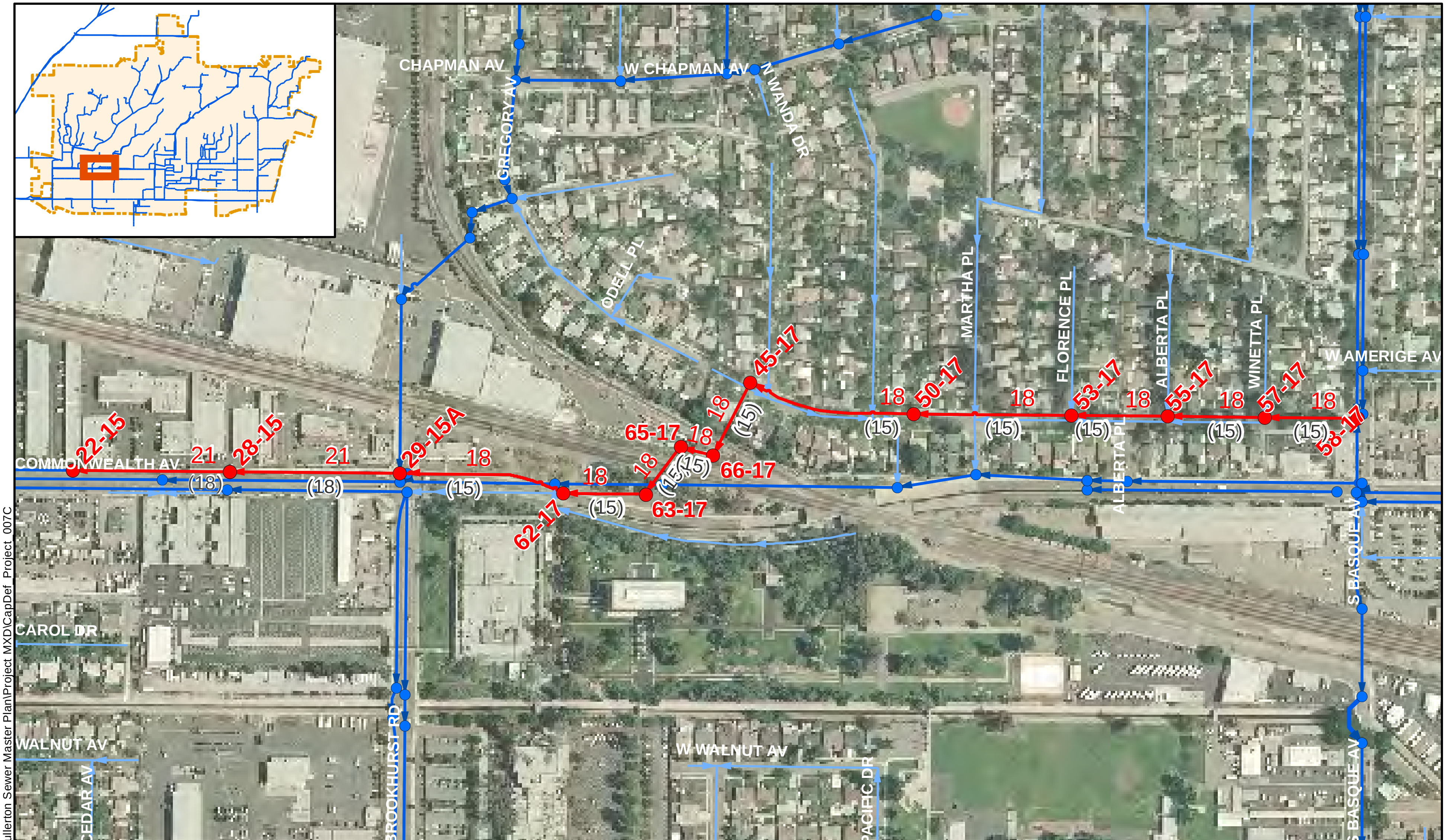
Project 7B, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
122
120
118
116
114
112
110
108
106
104
82-42
10-17
37-17
58-17
82-42.2
10-17.1
37-17.1
0.0
170.9
341.8
512.7
683.6
854.5
1025.4
1196.3
1367.2
1538.1
1709.0
Distance (ft)



Project 7B, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
122
120
118
116
114
112
110
108
106
104
0.0
172.1
344.2
516.3
688.4
860.5
1032.6
1204.7
1376.8
1548.9
1721.0
82-42
83-42
82-42.1
83-42.1
11-17
11-17.1
38-17
38-17.1
43-17
43-17.1
59-17
58-17
59-17.2



Project 7B, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
122
120
118
116
114
112
110
108
106
104
82-42
82-42.2
10-17
10-17.1
37-17
37-17.1
58-17
0.0
170.9
341.8
512.7
683.6
854.5
1025.4
1196.3
1367.2
1538.1
1709.0
Distance (ft)



Manhole on CIP Project	Modeled Sewer
Manhole on Modeled Pipe	Unmodeled Sewer
12 New Pipe Diameter	Street
(8) Existing Pipe Diameter	

N

Feet

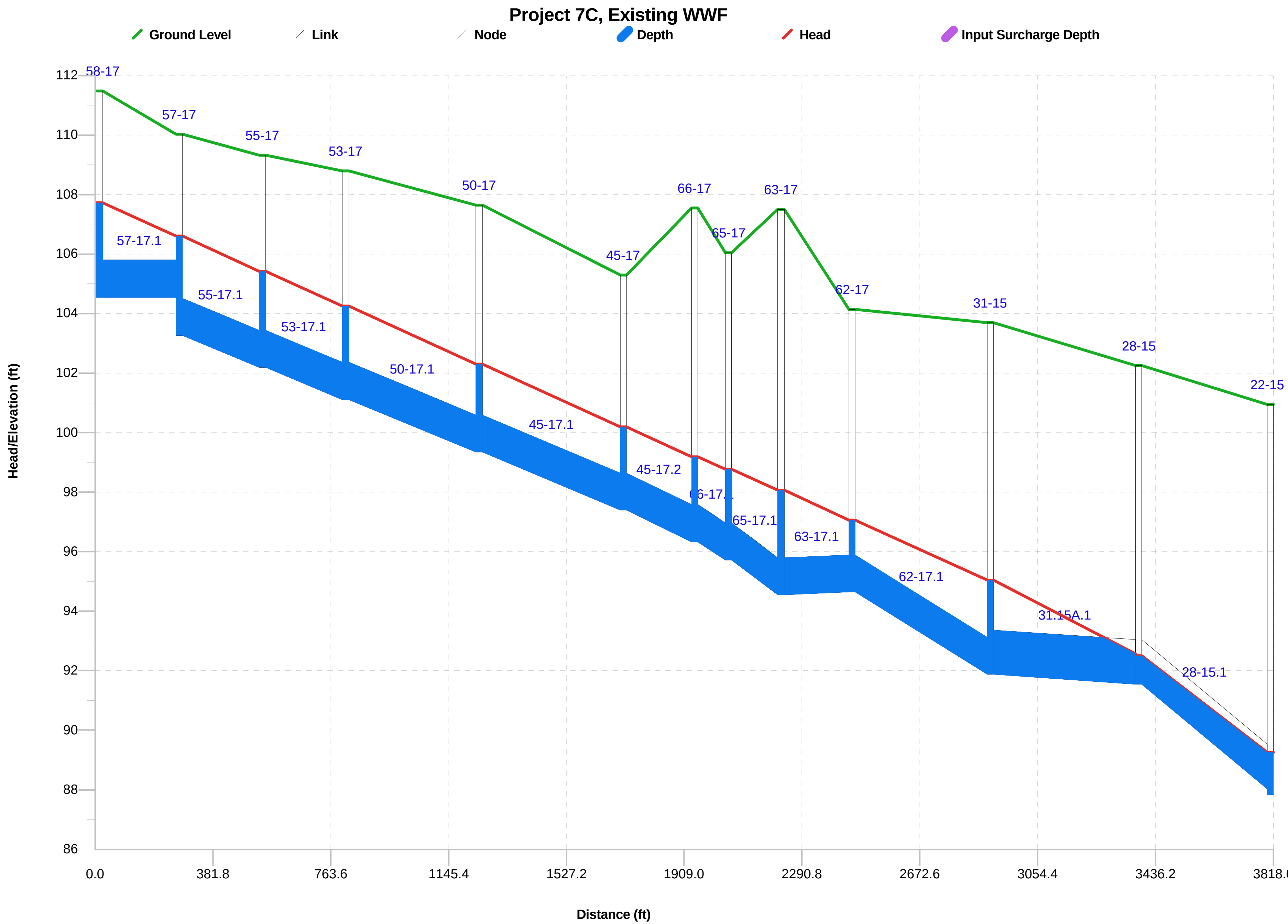
0 150 300 450 600

City of Fullerton
Sewer Master Plan

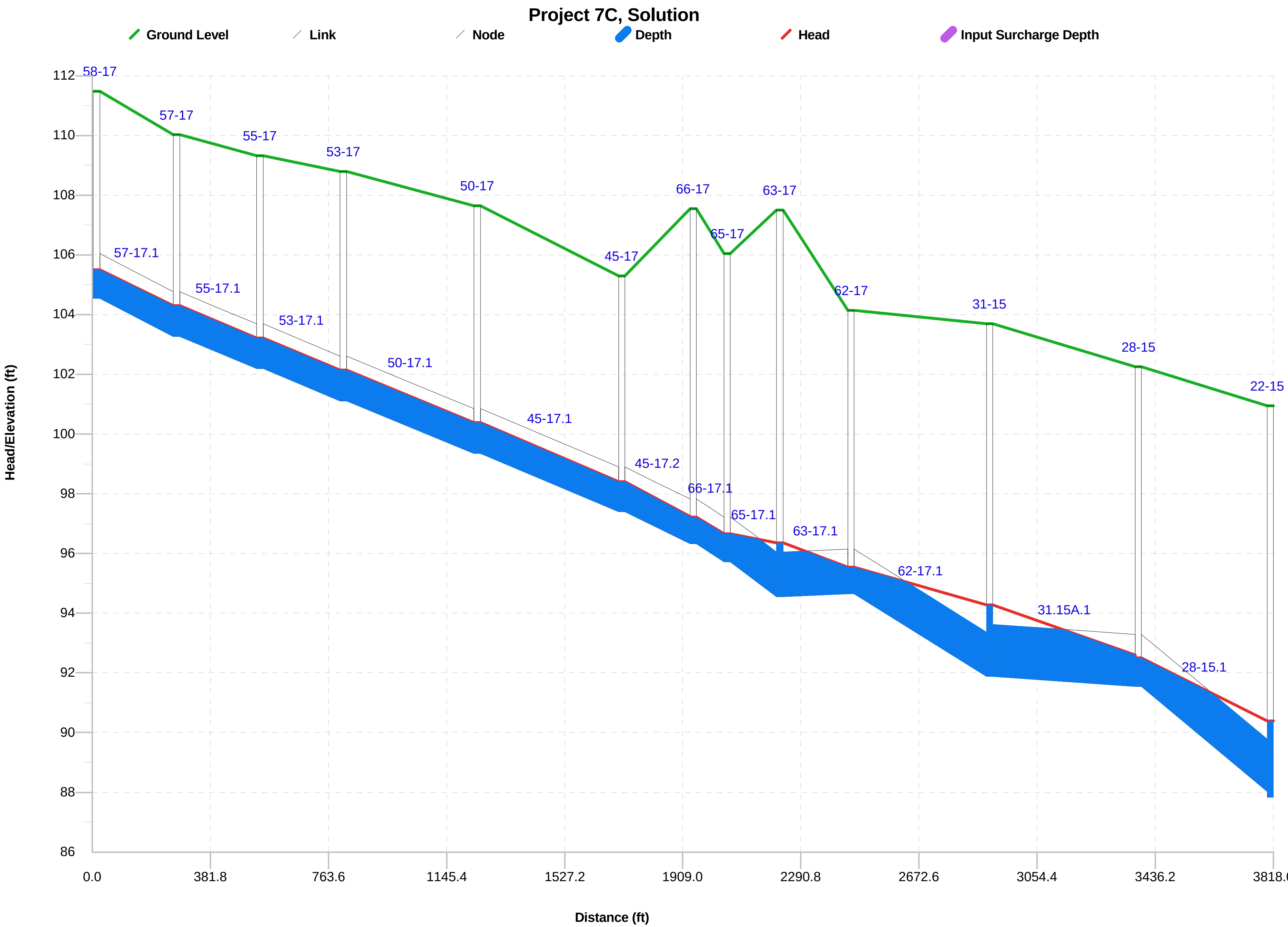
RMC Water and Environment

Capital Improvement Program: Project 7C

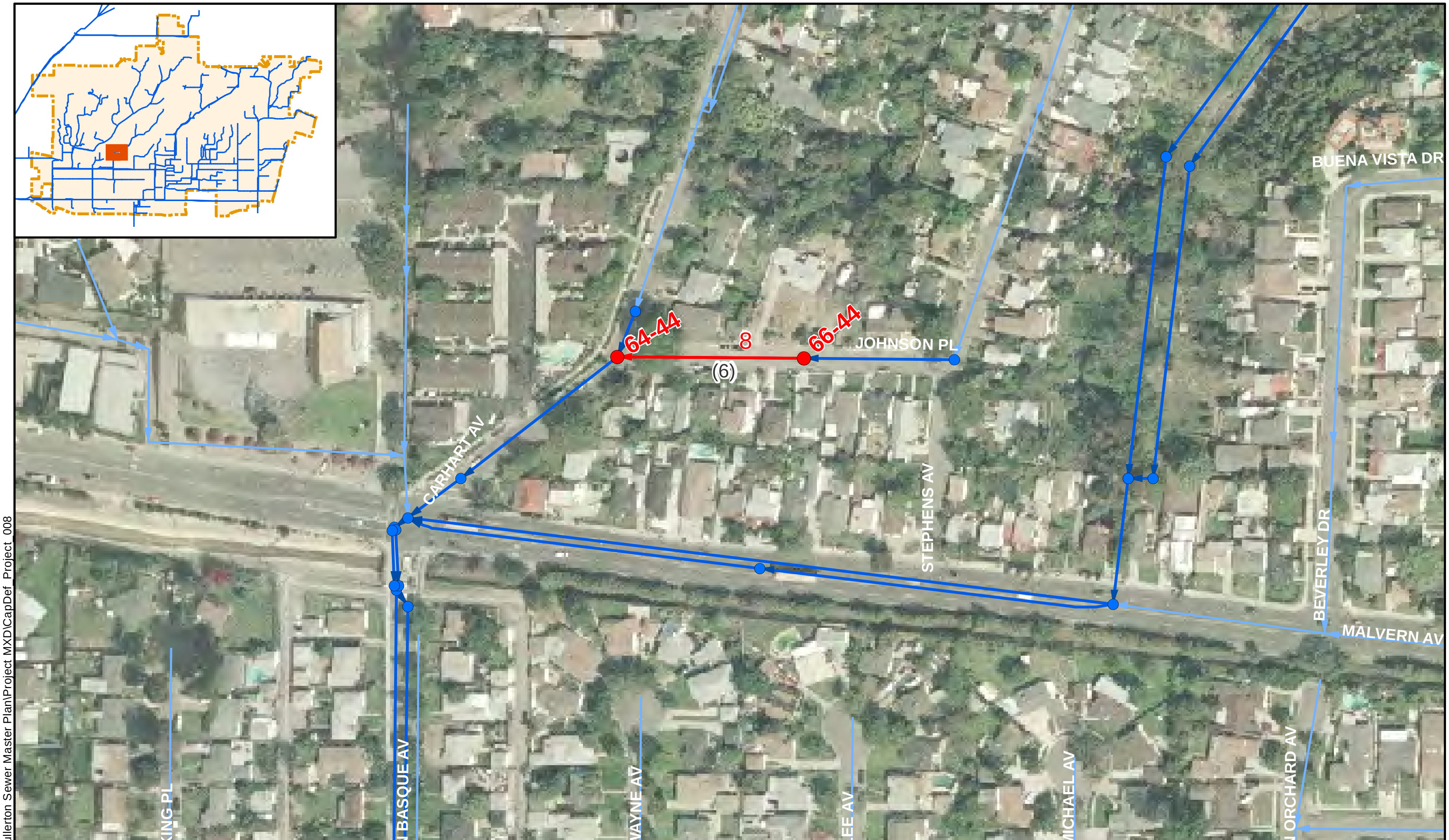
L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_007C



Project 7C, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
112
110
108
106
104
102
100
98
96
94
92
90
88
86
0.0
381.8
763.6
1145.4
1527.2
1909.0
2290.8
2672.6
3054.4
3436.2
3818.0
58-17
57-17
55-17
53-17
50-17
66-17
63-17
65-17
45-17
62-17
31-15
28-15
22-15
57-17.1
55-17.1
53-17.1
50-17.1
45-17.1
45-17.2
66-17.1
65-17.1
63-17.1
62-17.1
31.15A.1
28-15.1



Project 7C, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
112
110
108
106
104
102
100
98
96
94
92
90
88
86
0.0
381.8
763.6
1145.4
1527.2
1909.0
2290.8
2672.6
3054.4
3436.2
3818.0
58-17
57-17
55-17
53-17
50-17
45-17
66-17
65-17
63-17
62-17
31-15
28-15
22-15
57-17.1
55-17.1
53-17.1
50-17.1
45-17.1
45-17.2
66-17.1
65-17.1
63-17.1
62-17.1
31.15A.1
28-15.1



N

0 75 150 225 300 Feet

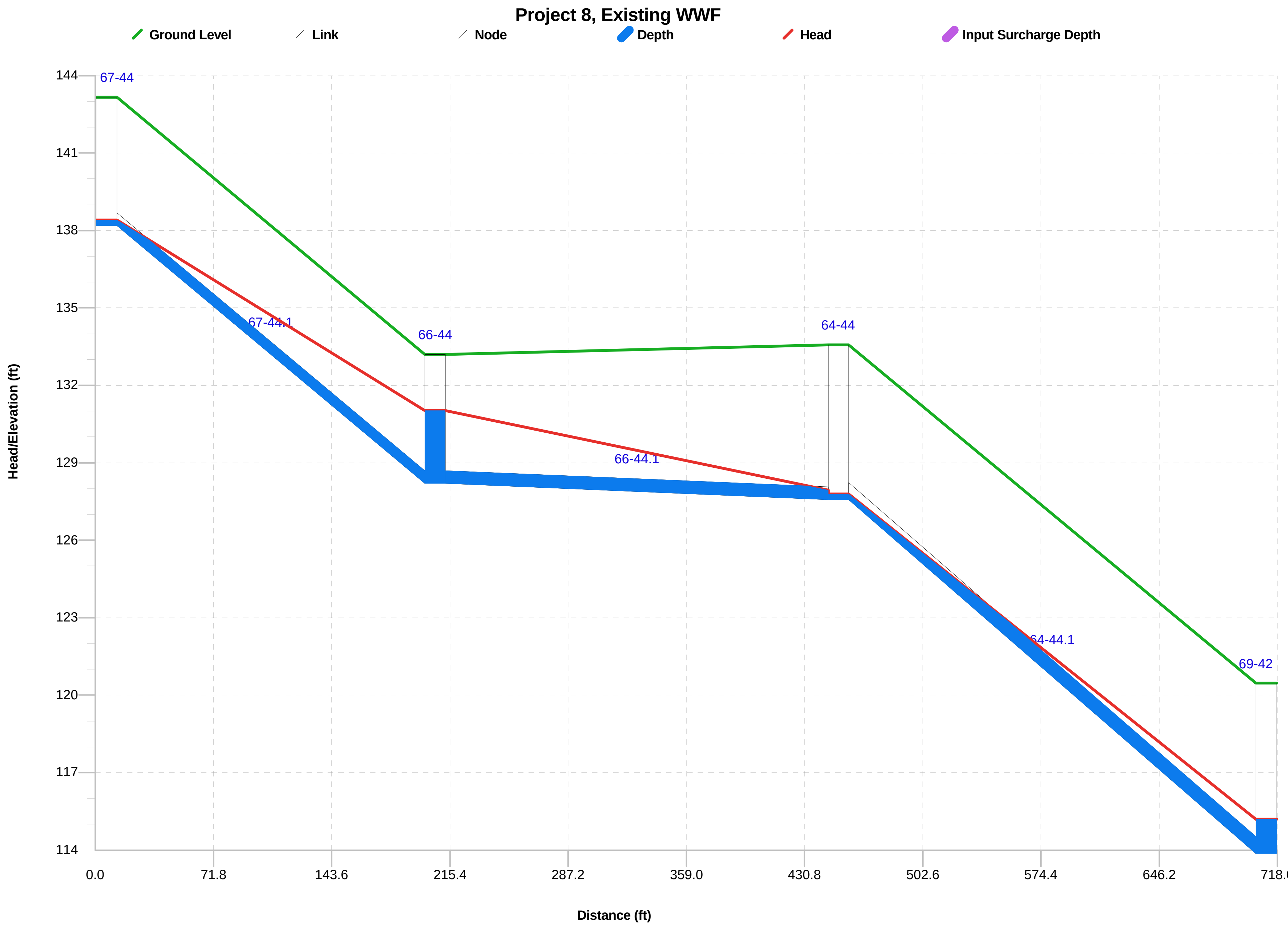
Manhole on CIP Project	Modeled Sewer
Manhole on Modeled Pipe	Unmodeled Sewer
12 New Pipe Diameter	Street
(8) Existing Pipe Diameter	

City of Fullerton
Sewer Master Plan

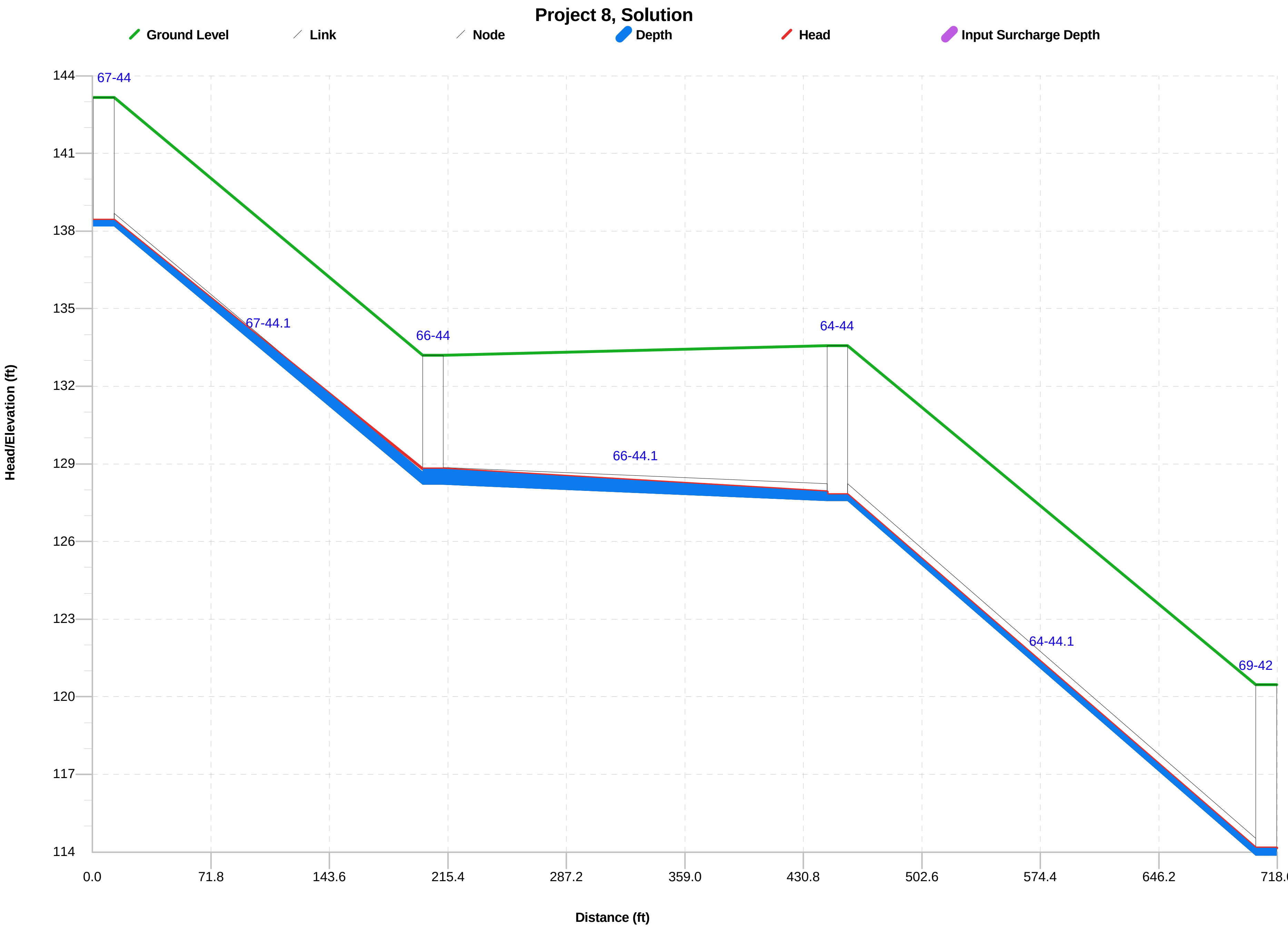
RMC Water and Environment

Capital Improvement Program: Project 8

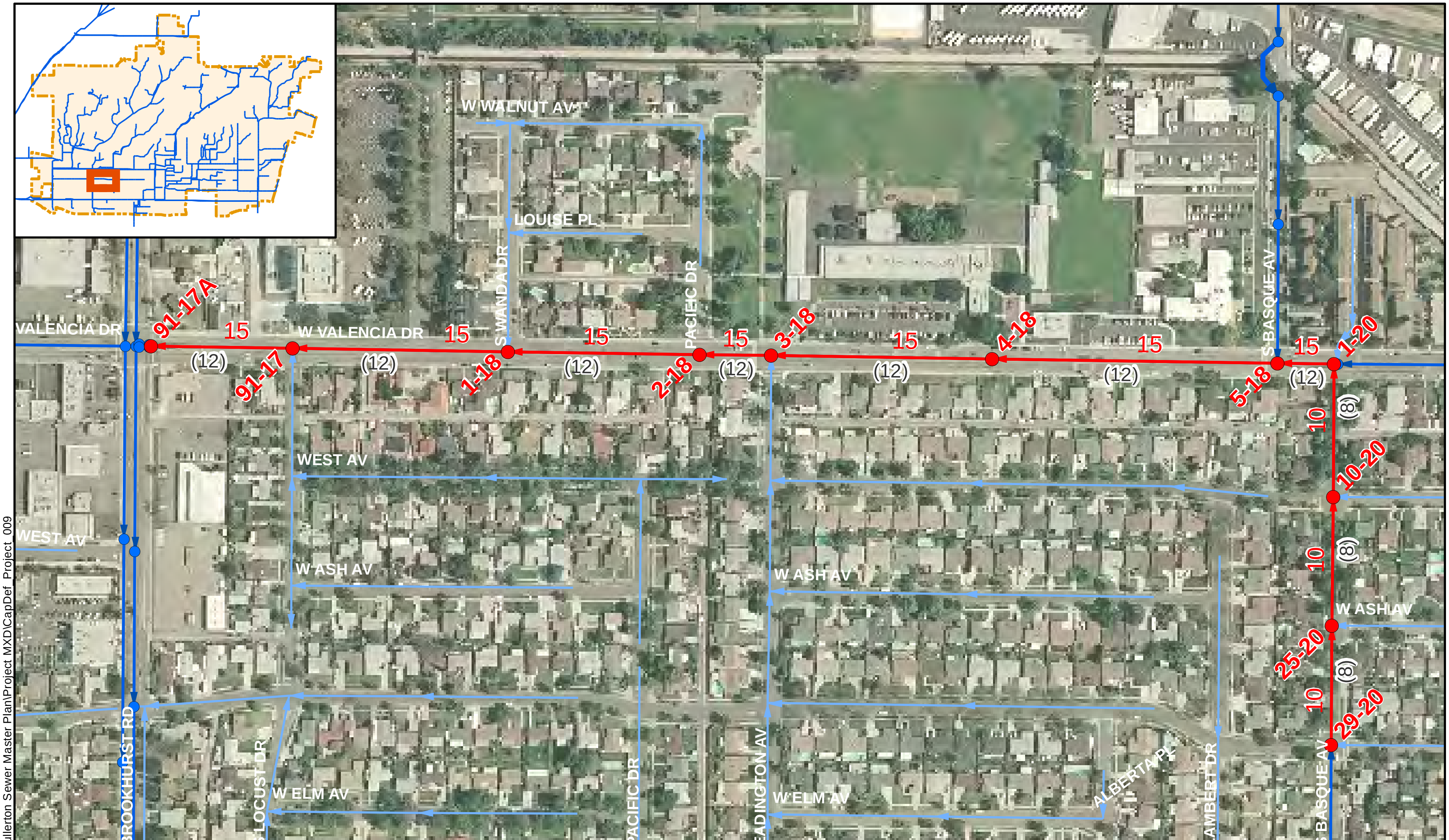
L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_008



Project 8, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
144
141
138
135
132
129
126
123
120
117
114
0.0
71.8
143.6
215.4
287.2
359.0
430.8
502.6
574.4
646.2
718.0
67-44
67-44.1
66-44
66-44.1
64-44
64-44.1
69-42



Project 8, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
144
141
138
135
132
129
126
123
120
117
114
67-44
67-44.1
66-44
66-44.1
64-44
64-44.1
69-42
0.0
71.8
143.6
215.4
287.2
359.0
430.8
502.6
574.4
646.2
718.0
Distance (ft)



N

0 125 250 375 500 Feet

●	Manhole on CIP Project Pipe	→	Modeled Sewer
●	Manhole on Modeled Pipe	→	Unmodeled Sewer
12	New Pipe Diameter	—	Street
(8)	Existing Pipe Diameter		

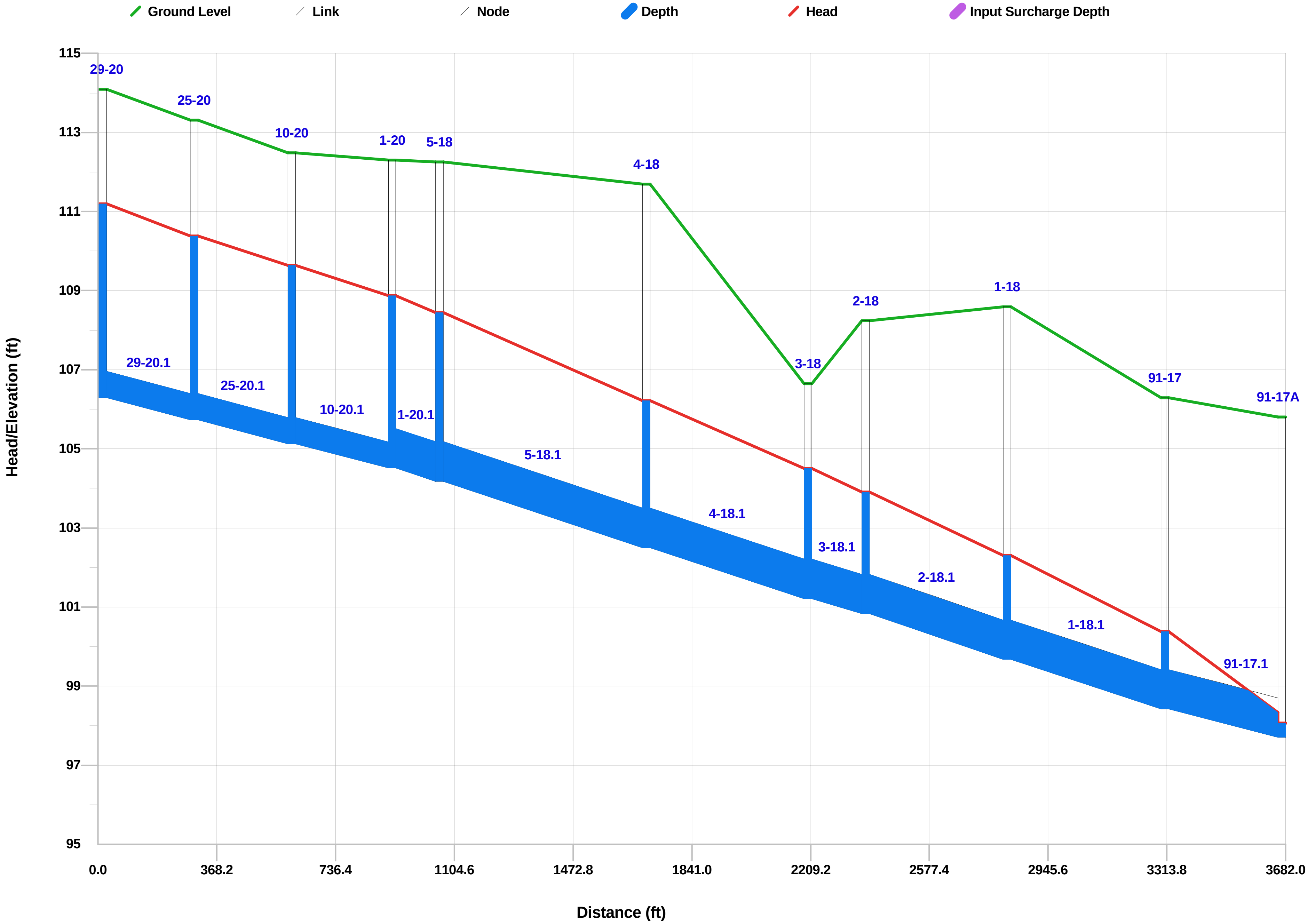
City of Fullerton
Sewer Master Plan

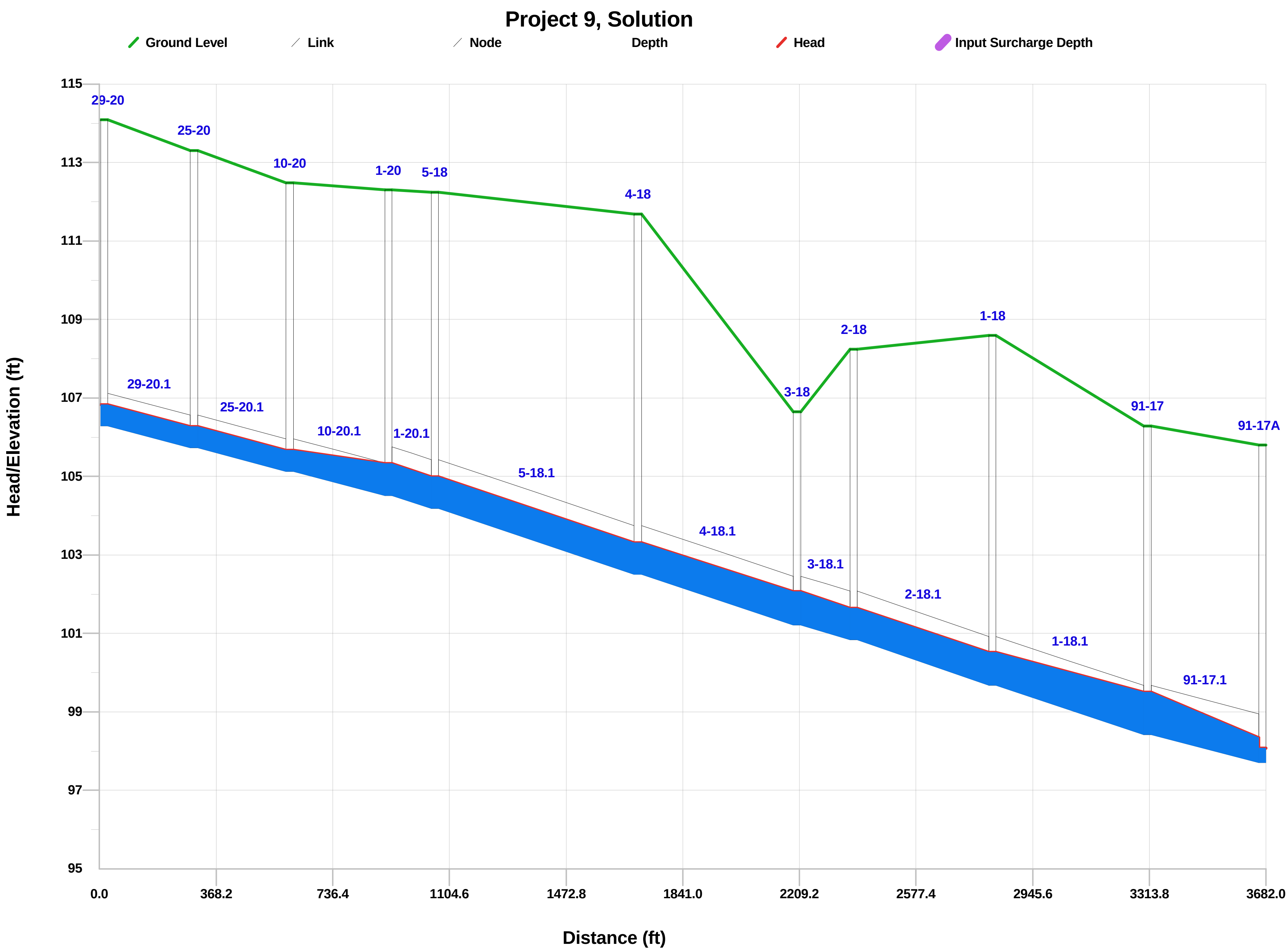
RMC Water and Environment

Capital Improvement Program: Project 9

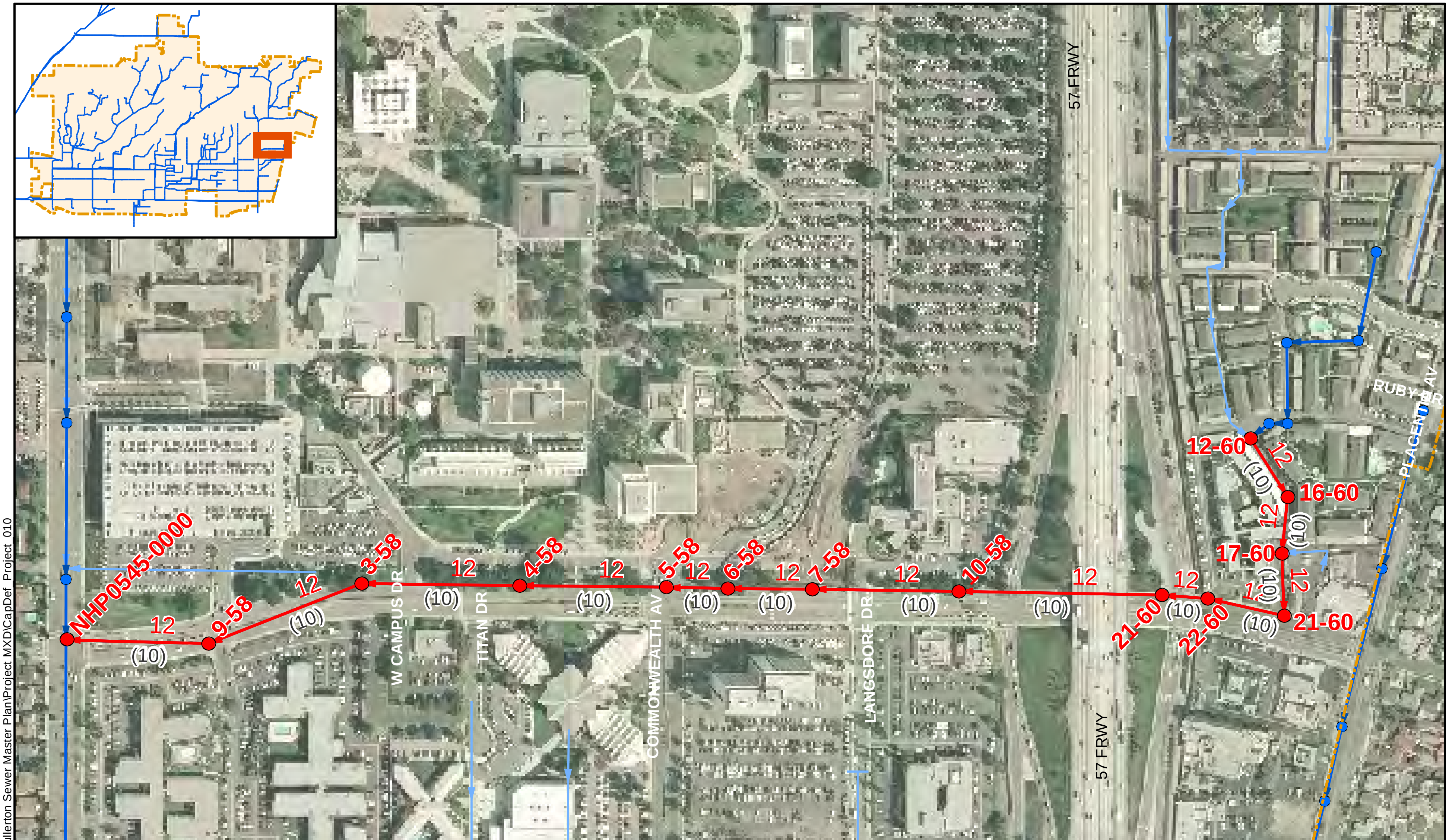
L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_009

Project 9, Existing WWF





Project 9, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
Distance (ft)
115
113
111
109
107
105
103
101
99
97
95
0.0
368.2
736.4
1104.6
1472.8
1841.0
2209.2
2577.4
2945.6
3313.8
3682.0
29-20
25-20
10-20
1-20
5-18
4-18
3-18
2-18
1-18
91-17
91-17A
29-20.1
25-20.1
10-20.1
1-20.1
5-18.1
4-18.1
3-18.1
2-18.1
1-18.1
91-17.1



N

0 150 300 450 600 Feet

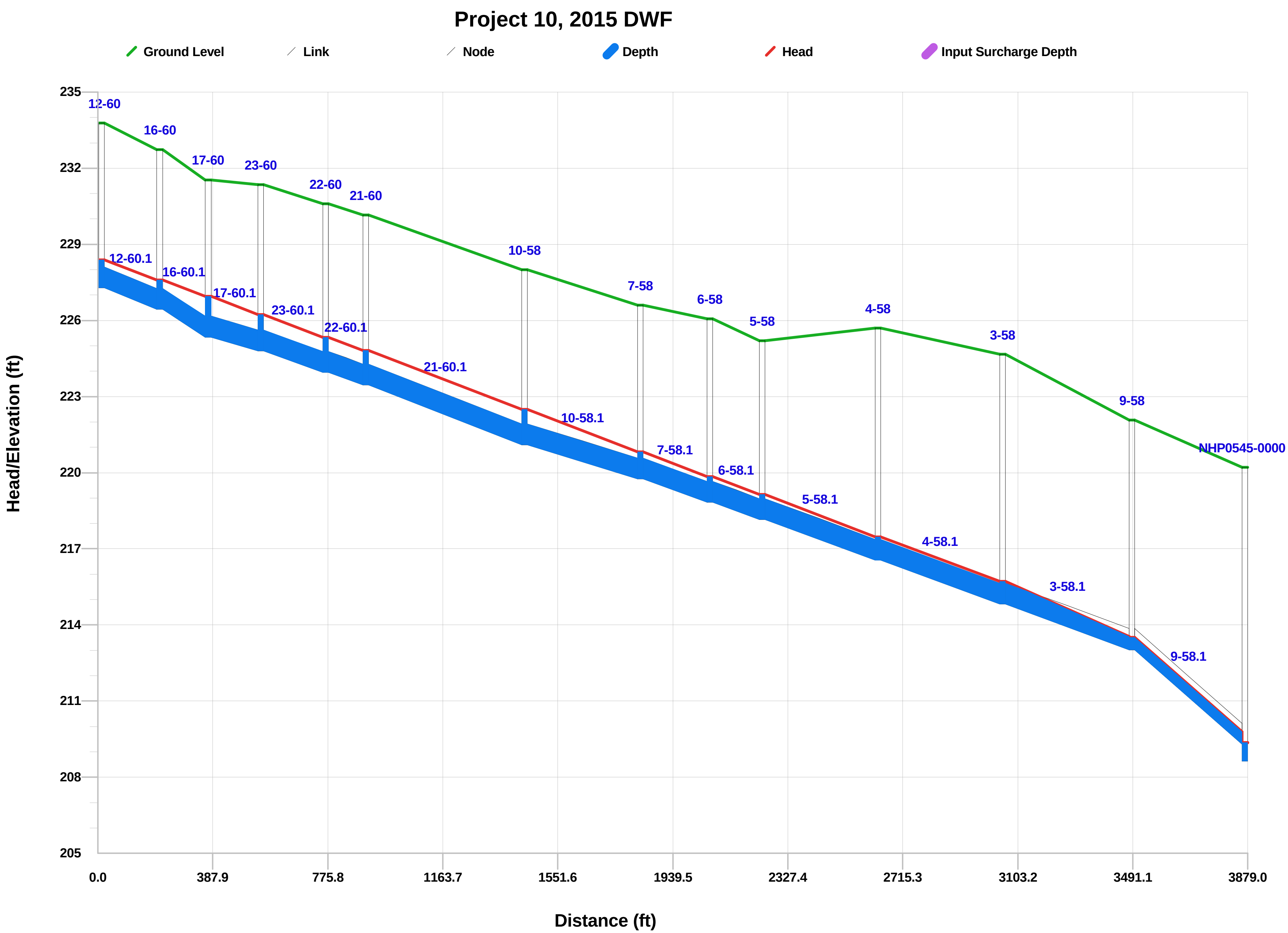
Manhole on CIP Project Pipe	Modeled Sewer
Manhole on Modeled Pipe	Unmodeled Sewer
12 New Pipe Diameter	Street
(8) Existing Pipe Diameter	

City of Fullerton
Sewer Master Plan

RMC Water and Environment

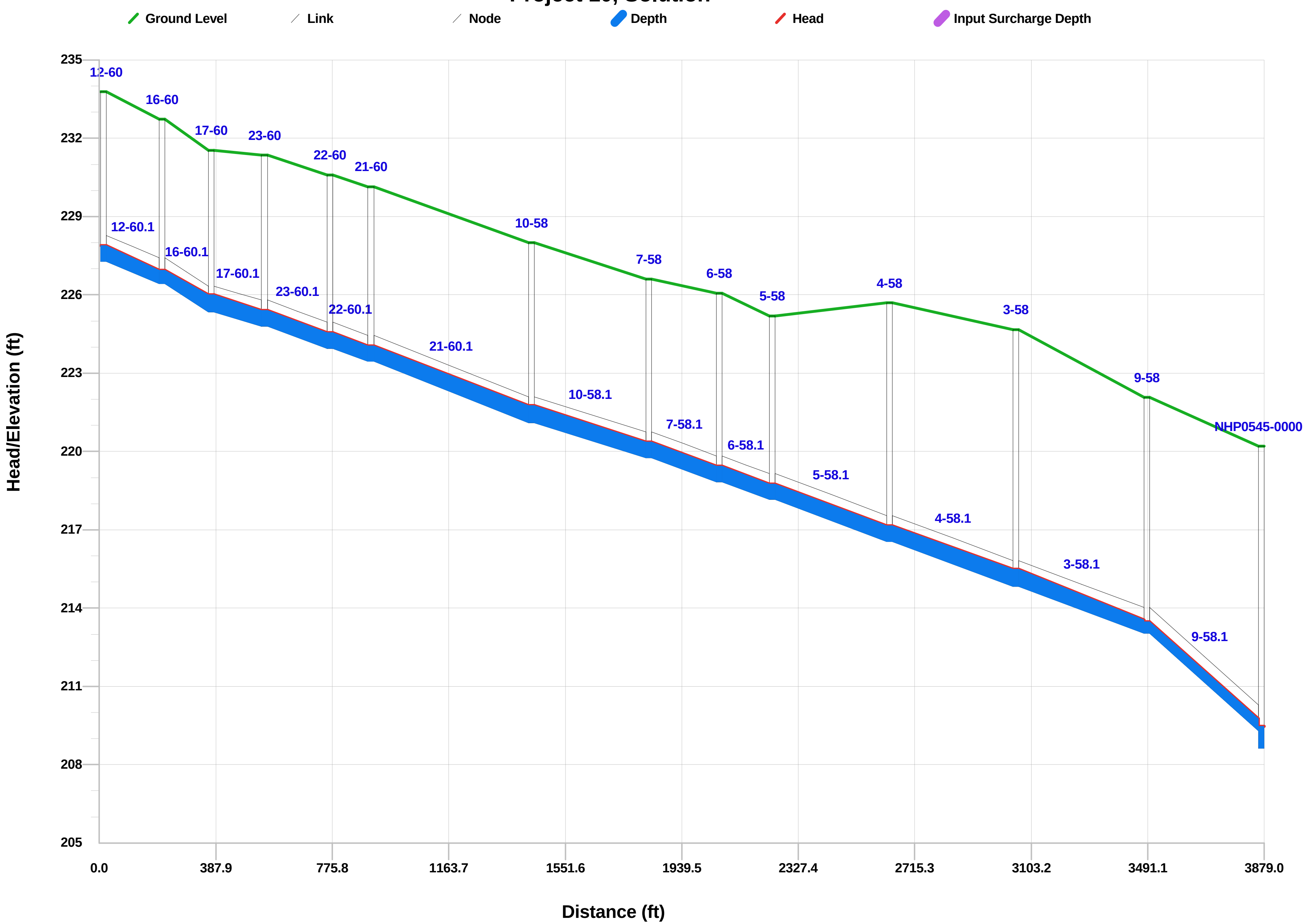
Capital Improvement Program: Project 10

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_010



Project 10, 2015 DWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
235
232
229
226
223
220
217
214
211
208
205
Distance (ft)
0.0
387.9
775.8
1163.7
1551.6
1939.5
2327.4
2715.3
3103.2
3491.1
3879.0
12-60
16-60
17-60
23-60
22-60
21-60
10-58
7-58
6-58
5-58
4-58
3-58
9-58
NHP0545-0000
12-60.1
16-60.1
17-60.1
23-60.1
22-60.1
21-60.1
10-58.1
7-58.1
6-58.1
5-58.1
4-58.1
3-58.1
9-58.1

Project 10, Solution



N

0 75 150 225 300 Feet

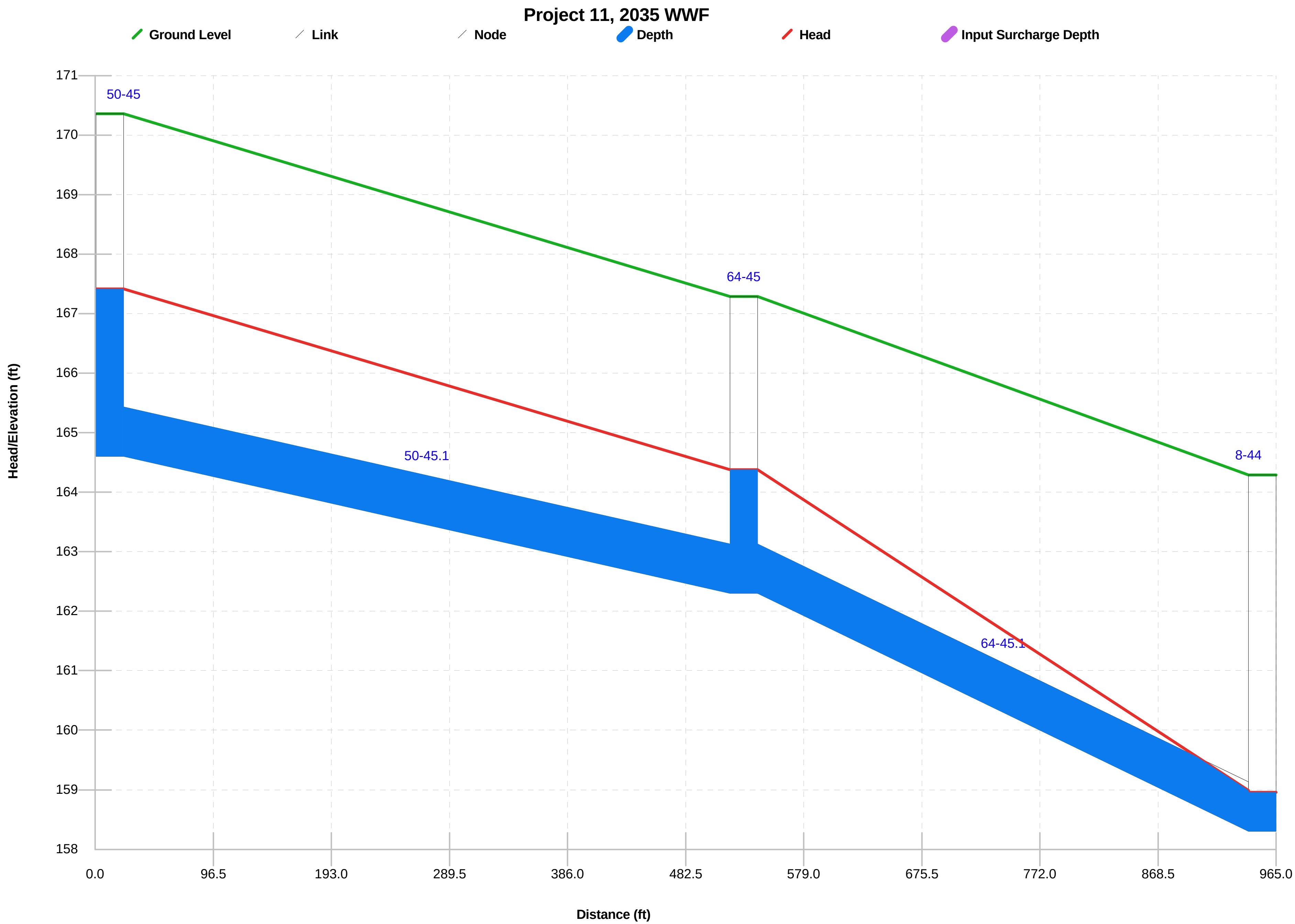
- Manhole on CIP Project Pipe
- Manhole on Modeled Pipe
- 12 New Pipe Diameter
- (8) Existing Pipe Diameter
- Modeled Sewer
- Unmodeled Sewer
- Street

City of Fullerton
Sewer Master Plan

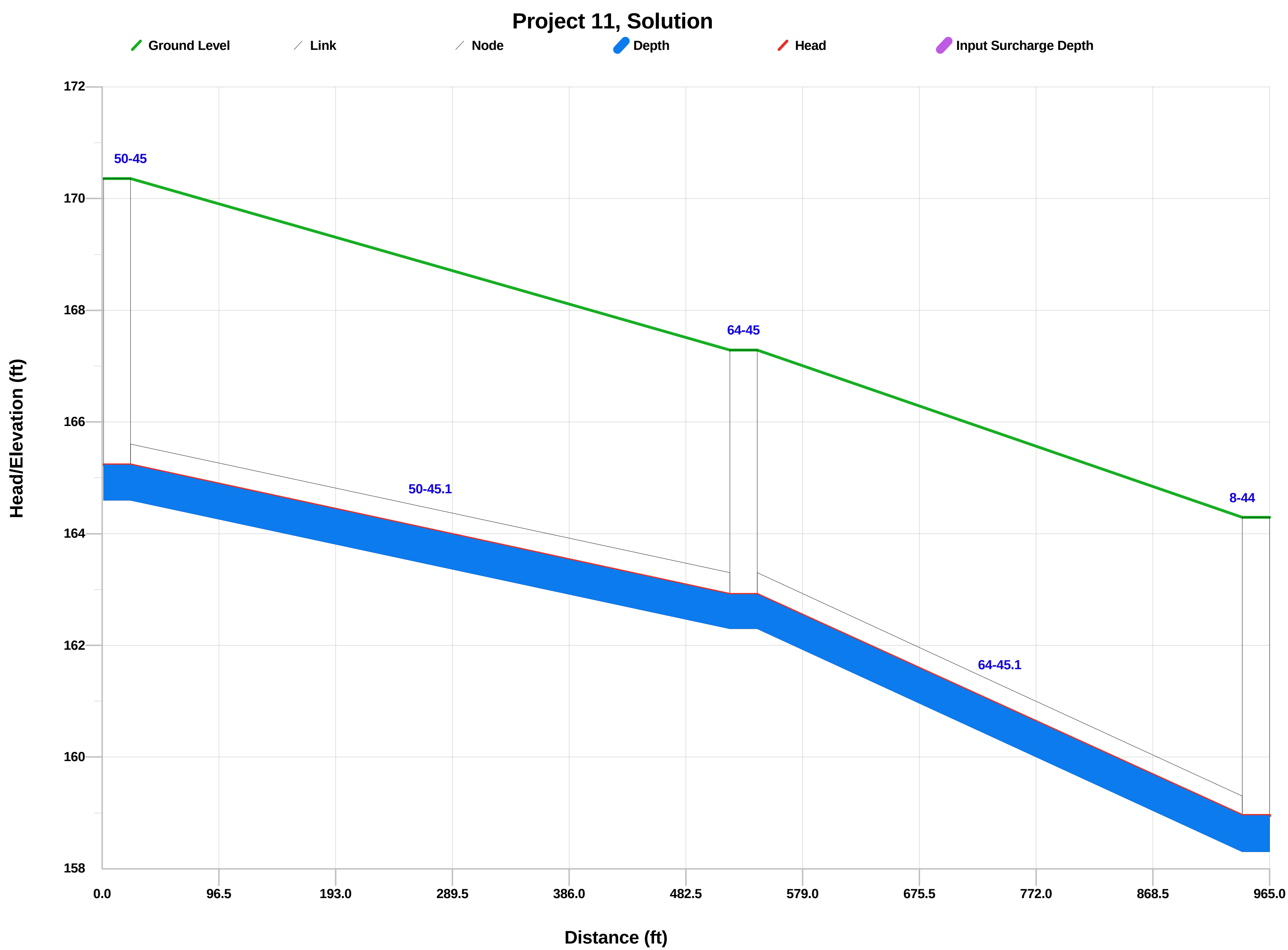
RMC Water and Environment

Capital Improvement Program: Project 11

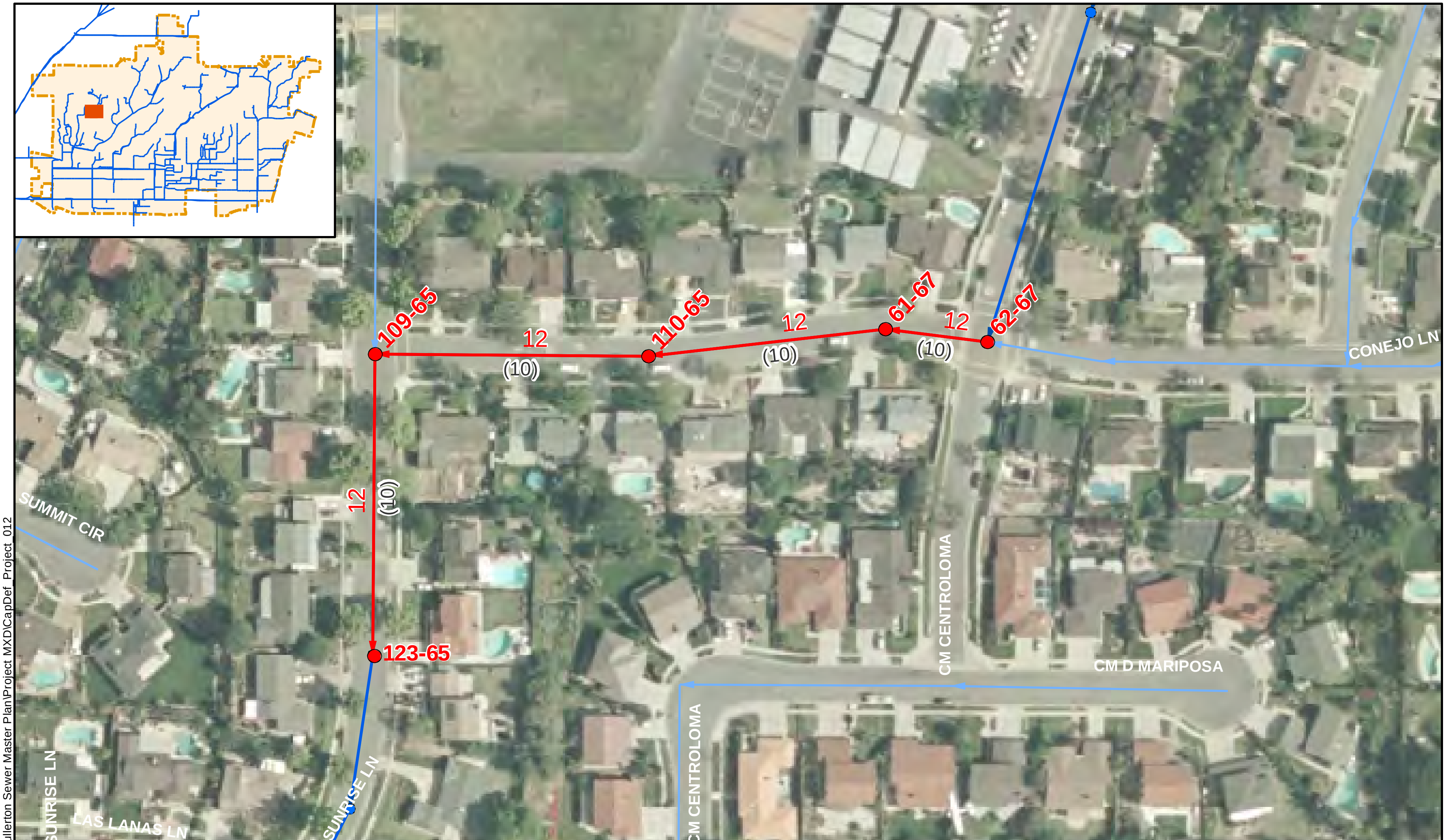
L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_011



Project 11, 2035 WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
171
170
169
168
167
166
165
164
163
162
161
160
159
158
50-45
64-45
8-44
50-45.1
64-45.1
0.0
96.5
193.0
289.5
386.0
482.5
579.0
675.5
772.0
868.5
965.0
Distance (ft)



Project 11, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
172
170
168
166
164
162
160
158
50-45
64-45
8-44
50-45.1
64-45.1
0.0
96.5
193.0
289.5
386.0
482.5
579.0
675.5
772.0
868.5
965.0
Distance (ft)



N

0 50 100 150 200 Feet

Manhole on CIP Project Pipe

Manhole on Modeled Pipe

12 New Pipe Diameter

(8) Existing Pipe Diameter

Modeled Sewer

Unmodeled Sewer

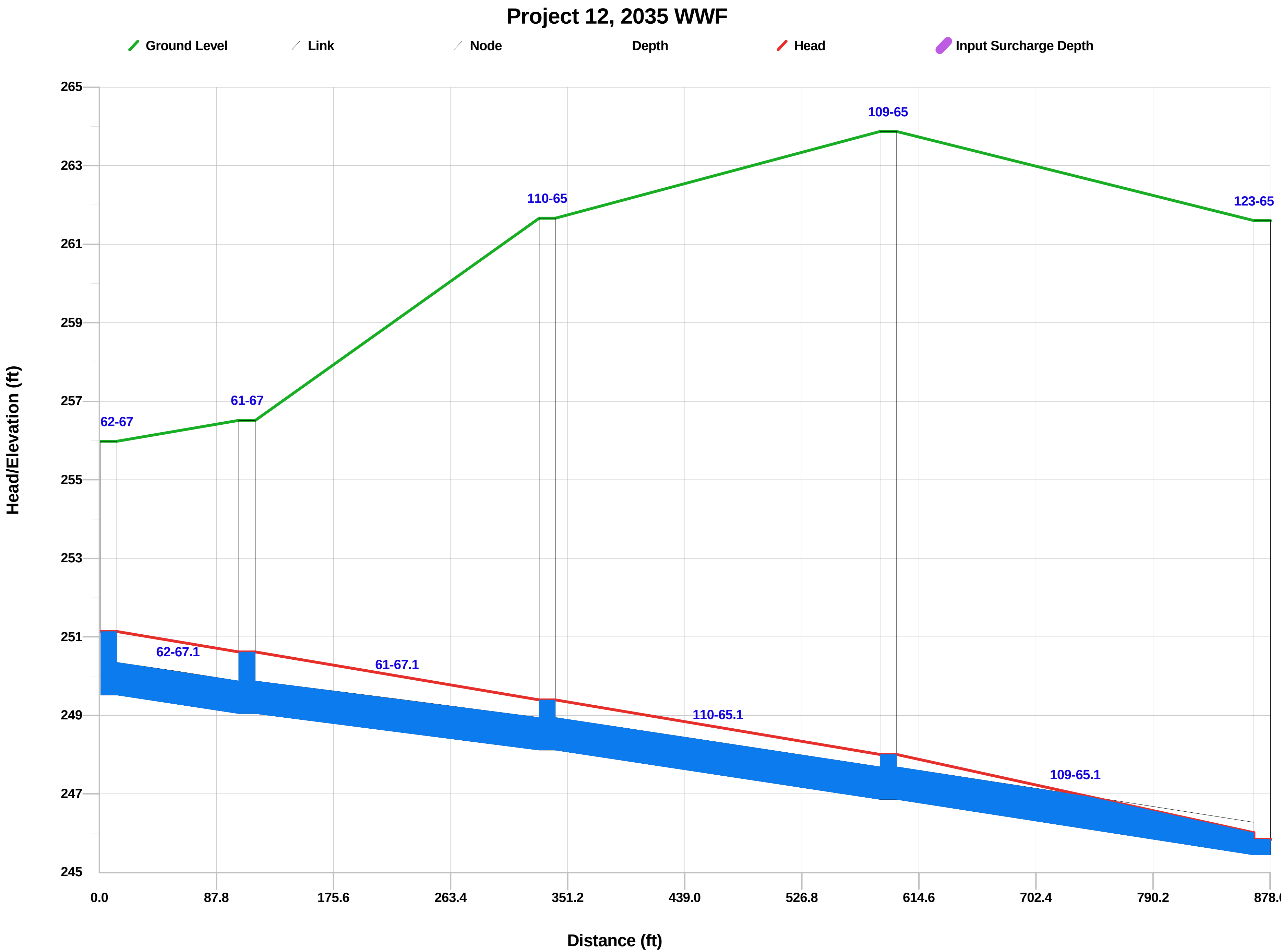
Street

City of Fullerton
Sewer Master Plan

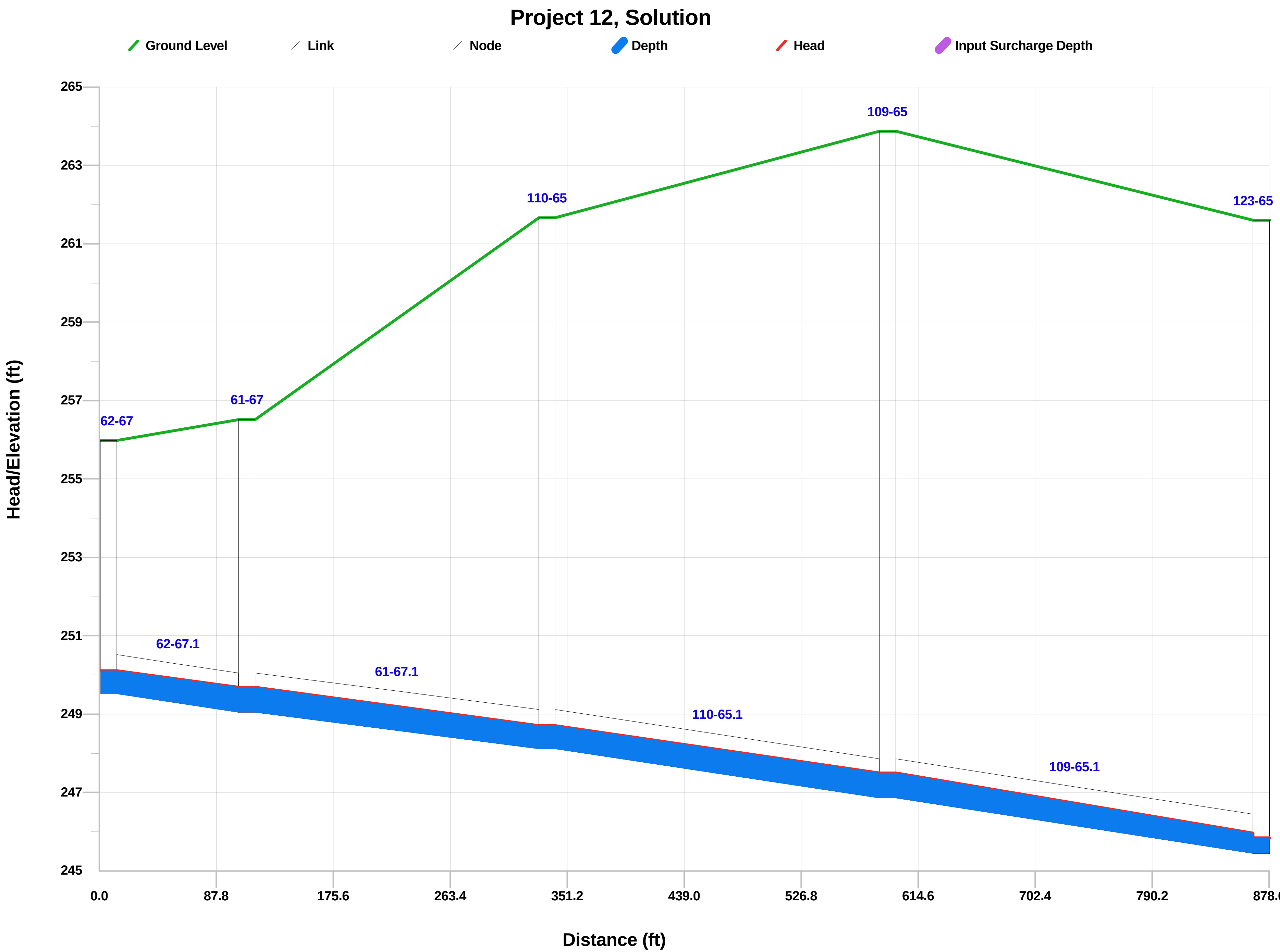
RMC Water and Environment

Capital Improvement Program: Project 12

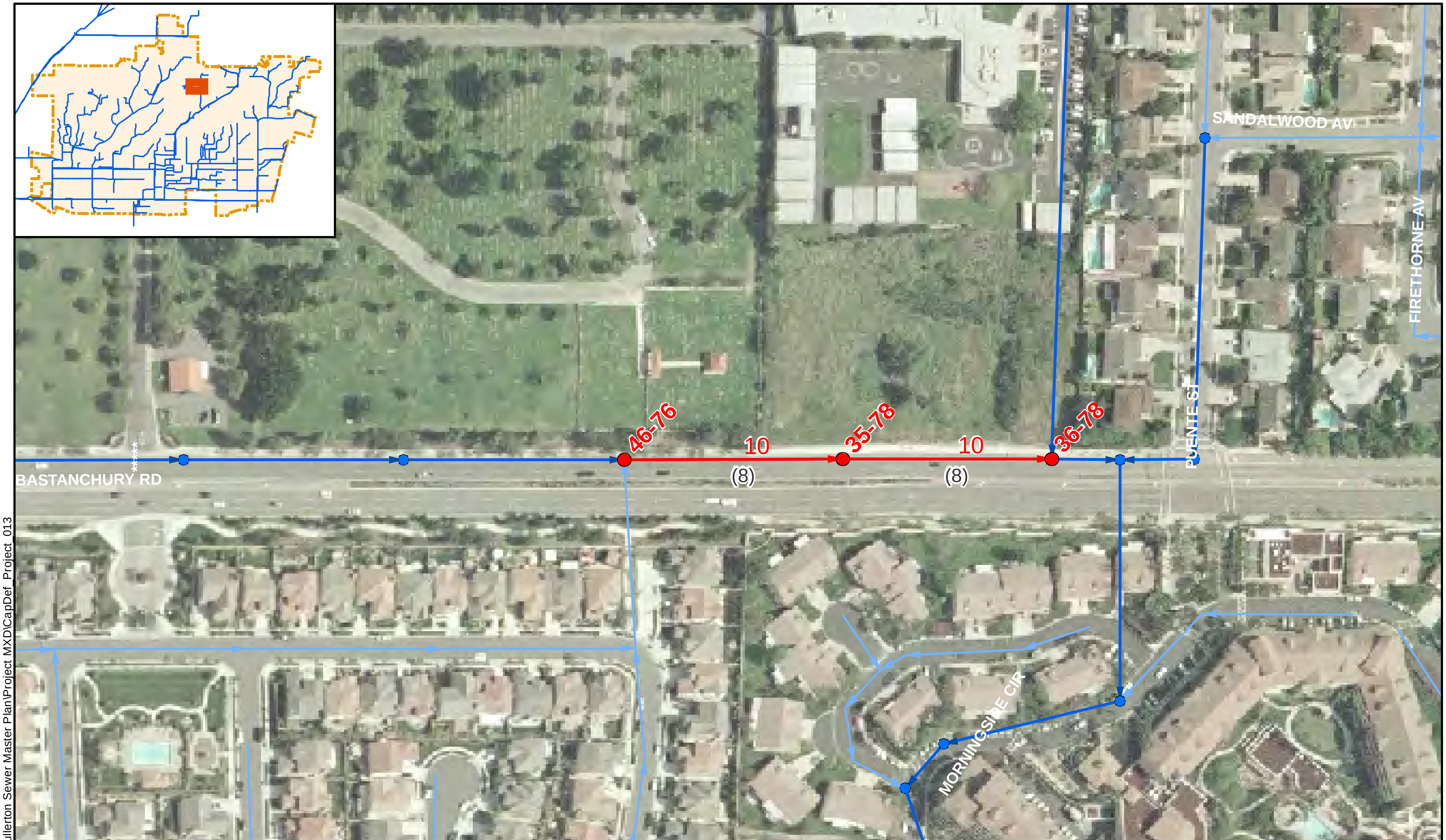
L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\CapDef_Project_012



Project 12, 2035 WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
265
263
261
259
257
255
253
251
249
247
245
62-67
61-67
110-65
109-65
123-65
62-67.1
61-67.1
110-65.1
109-65.1
0.0
87.8
175.6
263.4
351.2
439.0
526.8
614.6
702.4
790.2
878.0
Distance (ft)



Project 12, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
265
263
261
259
257
255
253
251
249
247
245
Head/Elevation (ft)
62-67
61-67
110-65
109-65
123-65
62-67.1
61-67.1
110-65.1
109-65.1
0.0
87.8
175.6
263.4
351.2
439.0
526.8
614.6
702.4
790.2
878.0
Distance (ft)



N

0 75 150 225 300 Feet

Manhole on CIP Project Pipe

Manhole on Modeled Pipe

12 New Pipe Diameter

(8) Existing Pipe Diameter

Modeled Sewer

Unmodeled Sewer

Street

City of Fullerton
Sewer Master Plan

RMC Water and Environment

Capital Improvement Program: Project 13

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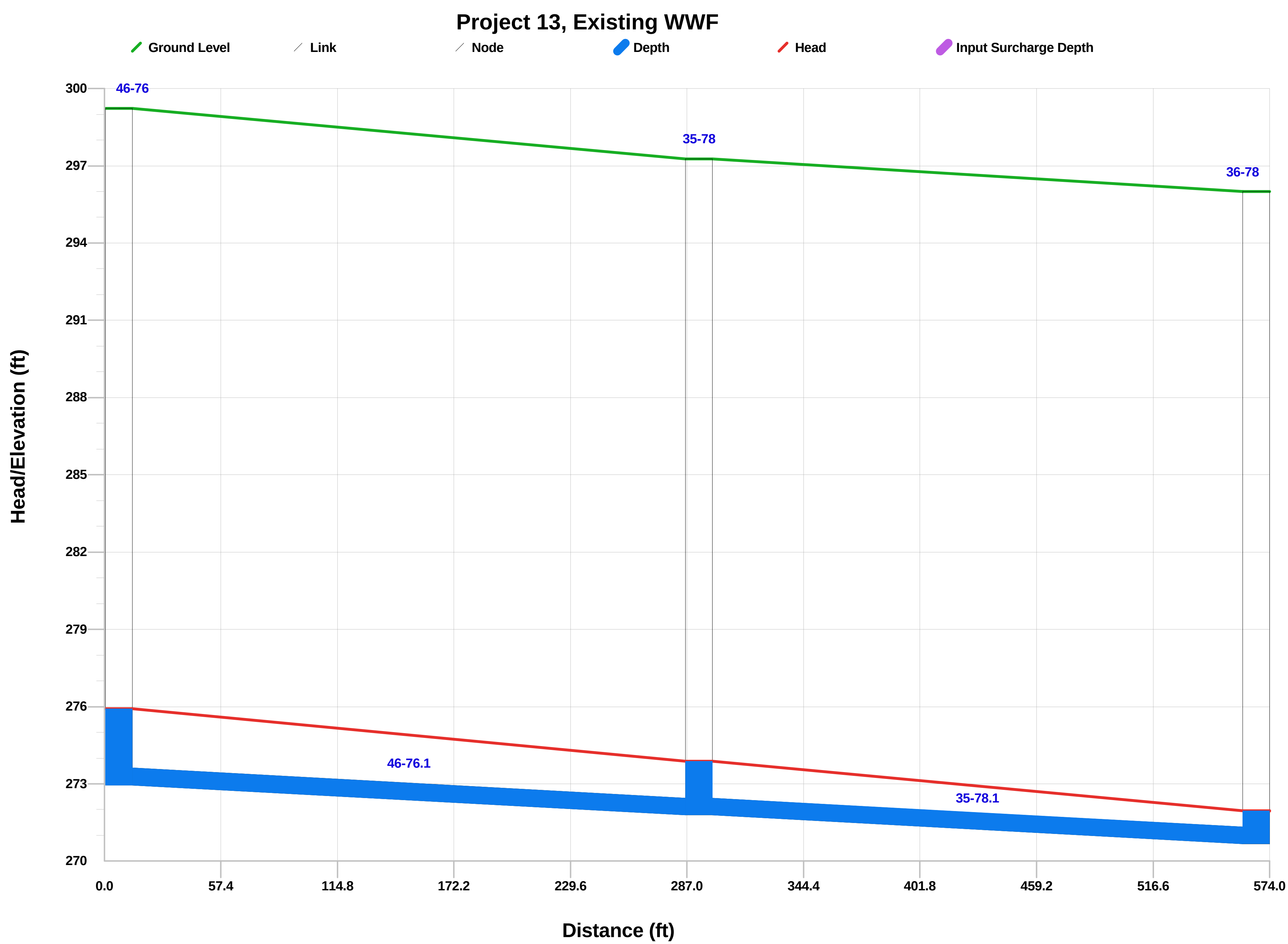
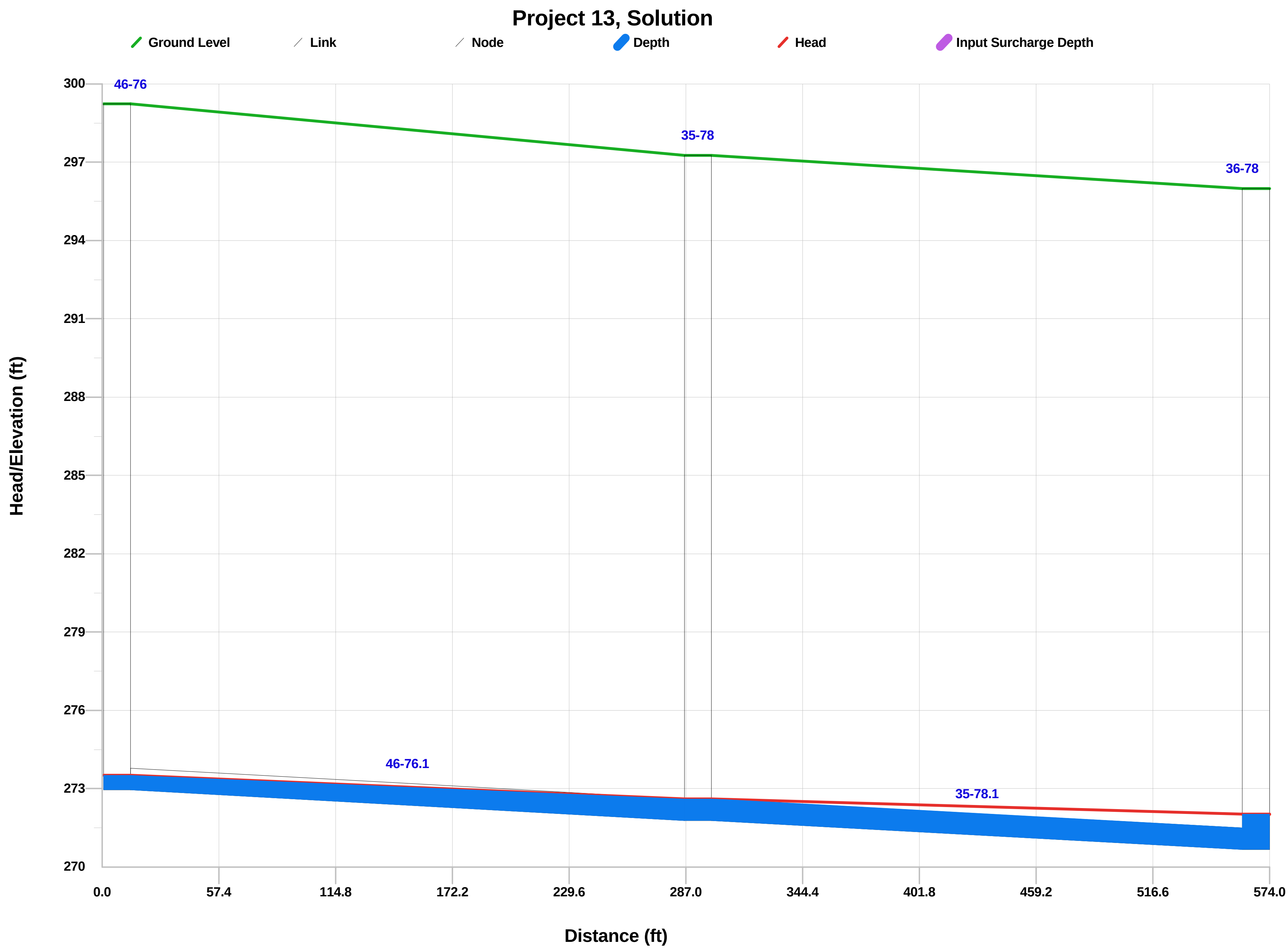


Project 13, Existing WWF
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
300
297
294
291
288
285
282
279
276
273
270
46-76
35-78
36-78
46-76.1
35-78.1
0.0
57.4
114.8
172.2
229.6
287.0
344.4
401.8
459.2
516.6
574.0
Distance (ft)


Project 13, Solution
Ground Level
Link
Node
Depth
Head
Input Surcharge Depth
Head/Elevation (ft)
300
297
294
291
288
285
282
279
276
273
270
46-76
35-78
36-78
46-76.1
35-78.1
0.0
57.4
114.8
172.2
229.6
287.0
344.4
401.8
459.2
516.6
574.0
Distance (ft)

Chapter 6 Infiltration and Inflow (I/I) Analysis

Infiltration and inflow (I/I) utilizes capacity within the sewer system that would otherwise be available for growth. In addition, I/I contributes to the need for and cost of the CIP projects identified in this report. This chapter identifies areas in the City which have the highest I/I and considers the impact that I/I has on CIP costs. This is followed by a discussion of methods for finding and reducing I/I that may be appropriate for the City. Finally, estimates of potential costs and benefits of I/I reduction in specific areas are presented.

6.1 Wet Weather Flow Analysis and I/I Characterization

6.1.1 Previous I/I Study

In 2005, the City contracted ADS to conduct the *Wastewater Collection System Infiltration and Inflow Study*. As part of the study, ADS monitored flow from 26 basins identified as having high I/I according to OCSD's long-term flow monitoring program. The results of the flow monitoring were then used to quantify I/I from each of the basins.

The flow analysis in this section is similar to the ADS study, except that it uses the results of a design storm model simulation to quantify I/I from the basins. The findings of this analysis are developed further in Section 6.2, which uses the design storm simulations to explore I/I control options.

6.1.2 General I/I Characteristics

There are two basic types of I/I: rainfall-dependent I/I (RDI/I) and groundwater infiltration (GWI). RDI/I occurs during and immediately following rain events, and results from either direct inflow of rain water (e.g. illegal connections of roof leaders or other types of storm drains, runoff entering through manhole covers) or from infiltration through temporarily wet soils and into defects in laterals, mains, and manholes. GWI is more persistent infiltration that occurs when groundwater levels are permanently or seasonally above leaky or defective pipes.

To varying degrees, I/I is present in every sewer system, and the City's system is no exception. The flow monitoring data and results of the model calibration indicate that parts of the City's system experience very quick and significant levels of RDI/I following rainfall events, but does not experience a significant amount of GWI. This conclusion is supported by observed average and minimum flows that are consistent with normal sanitary flow quantities and patterns. Furthermore, significantly elevated levels of GWI do not persist during entire wet weather seasons, as the flow levels return to normal dry weather levels shortly after isolated rainfall events.

6.1.3 Meter Basin Analysis

As described in Chapter 3, RDI/I was modeled using temporary flow monitoring data for the 2005 wet weather season. The percentage of the total rainfall entering the City's sewer system was calibrated through a series of model iterations. The speed of the wet weather response was also determined and ranged from a spiky, quick response to a more gradual and drawn out response. Each meter basin had different contributing percentages and response profiles.

To better quantify the relative peak flows from each basin that result from design storm conditions combining the effects of RDI/I and average dry weather flow (ADWF), wet weather peaking factors (WWPF) were calculated for each basin:

$$WWPF = \frac{ModeledPeakWWF}{ADWF}$$

The WWPFs for all the metered basins are listed in **Table 6-1**. Many of the basins show WWPFs greater than 5:1, including basins FUL01, FUL02, FUL03, FUL04, FUL05, FUL06, FUL07, and FUL09. **Figure 6-1** illustrates the basins with the highest peak I/I.

Basins with the highest I/I are generally sewered with pipes constructed before 1960, as shown in **Figure 1-5**. This suggests that pipes may be deteriorated such that a high level of infiltration is entering the system through cracks and other defects. In addition, some of the major sewers appear to be located in creek beds, for instance upstream of Bastanchury Rd and in Hiltscher Park. In these areas, high water tables will exacerbate infiltration through pipe defects.

The actual shape of the RDI/I hydrograph is of interest because it may indicate whether the RDI/I is the result of direct inflow versus infiltration. **Appendix C** shows the wet weather calibration hydrographs. Hydrographs which have gradual peaks and a medium response are indicative of infiltration originating from throughout the basin. Conversely, hydrographs with a spiky and very quick response may be indicative of direct inflow, possibly originating from improper storm connections to the sewer system. The hydrographs with the highest peak I/I have both characteristics, indicating that both direct inflow and infiltration are influencing the system's wet weather response. However, hydrograph shapes alone do not provide conclusive proof of the existence of direct inflow sources.

6.2 I/I Reduction Program Options

There are many "best management practices" for reducing I/I that are implemented by high-performing public sewer system agencies. These practices include source detection activities such as wet weather flow monitoring and flow isolation, smoke testing, and video inspections that aim to identify specific sources of I/I so that the most effective I/I reduction strategies can be implemented. I/I reduction strategies include inflow elimination, sewer main rehabilitation/replacement, and lateral rehabilitation/replacement policies and programs.

The City has initiated some of these strategies. The results of the 2005 flow monitoring study were used to define a smoke testing program for basins FUL01, FUL02, FUL05, and FUL06. The program found numerous missing lateral caps and some drain spout connections, all of which were corrected. The effectiveness of these repairs is yet to be determined.

This section focuses on the practices that may be most appropriate for implementation by the City.

6.2.1 Flow Monitoring, Smoke Testing, and Inflow Elimination

Follow-up wet weather flow monitoring in basins targeted by the smoke testing program could be performed to estimate the effectiveness of the corrections made following the testing program. The objective would be to determine if repairs had reduced wet weather peaking factors enough to eliminate the need for capacity improvement projects. If so, those projects could be removed from the capital improvement program, and smoke testing and corrections could be performed in other high-I/I basins such as FUL03 and FUL04. One limitation of wet weather flow monitoring is the risk that little or no useful information would be obtained due to lack of rainfall during the monitoring period. In addition, any comparisons to the pre-correction flows must consider differences in antecedent and storm rainfall between the two monitoring periods.

The cost of temporary flow monitoring is about $100 per meter per day for typical wet weather programs of 6 to 8 weeks in duration. The cost for smoke testing is about $1-2 per foot of sewer. Costs for inflow elimination depend on the nature of the inflow sources, but are generally very low. Inflow elimination projects are generally considered to be cost-effective.

6.2.2 Sewer Inspection and Rehabilitation

The City is currently in the process of performing video inspections of its entire sewer system. Video inspection is typically performed to assess the condition of sewers and identify structural defects that need

Table 6-1: Wet Weather Flow Peaking Factors for Meter Basins

Meter Basin	Model Ave BWF (MGD)	Model Peak WWF (MGD)	WWPF
FOC011	2.8	8.8	3.1
FOC013	6.8	10.2	1.5
FOC015	1.3	2.9	2.3
FOC018A	0.2	0.8	4.5
FOC018B	0.2	0.6	3.2
FOC019	3.7	11.7	3.1
FOC020	3.3	10.0	3.0
FOC021	2.2	5.9	2.7
FOC022	1.4	5.2	3.9
FOC023	3.5	11.4	3.2
FOC024	4.2	7.5	1.8
FOC031	0.7	2.7	4.1
FOC038	8.0	13.4	1.7
FOC121	0.7	2.7	3.7
FOC125	10.5	17.4	1.7
FOC178	5.6	13.8	2.5
FOC209	0.5	2.1	4.7
FUL01	0.2	1.4	6.9
FUL02	0.1	0.7	9.6
FUL03	0.2	1.4	7.1
FUL04	0.1	0.6	5.0
FUL05	0.2	1.4	6.6
FUL06	0.1	0.8	5.8
FUL07	0.2	1.1	6.8
FUL08	0.4	1.5	3.9
FUL09	0.1	0.4	5.4
FUL11	0.3	1.1	3.3
FUL12	0.3	1.4	4.5
FUL17A	0.2	0.3	2.1
FUL17B	0.3	1.0	3.0
FUL17C	0.2	0.5	2.6
FUL19	0.2	0.3	1.8
FUL26	0.3	0.6	2.5
FUL27	0.1	0.2	1.6
FUL28	0.2	0.5	2.9
FUL29	0.1	0.6	4.3

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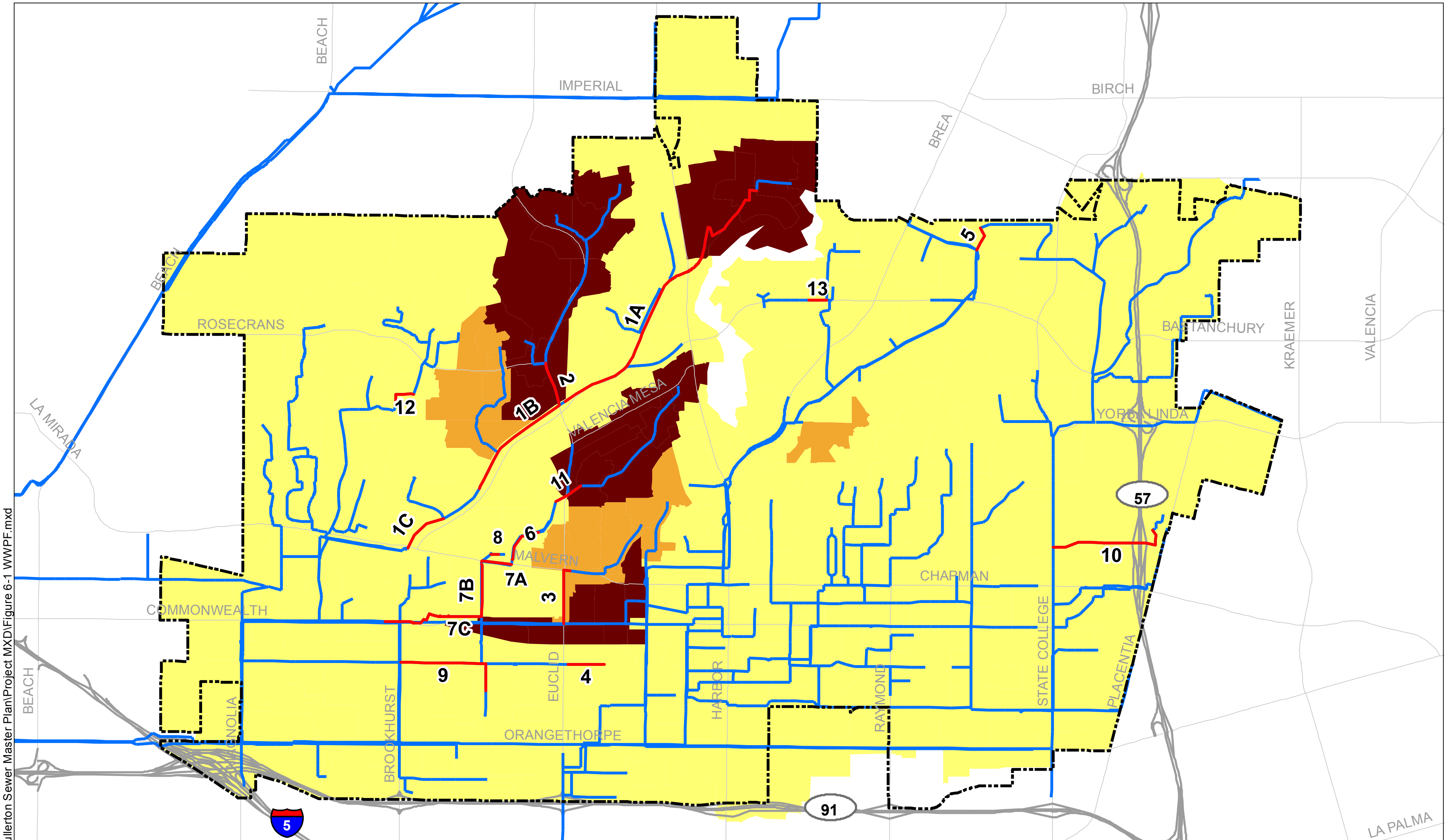


N

Miles

1

Wet Weather Peaking Factor by Basin

less than 5

5 to 6.5

greater than 6.5

CIP Project

Modeled Sewer

City Boundary

CITY OF FULLERTON CALIFORNIA

City of Fullerton
Sewer Master Plan

RMC Water and Environment

Figure 6-1
Wet Weather Peaking Factors by Basin

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\Figure 6-1 WWPF.mxd to be corrected through spot repairs or complete manhole-to-manhole rehabilitation in the form of lining, pipe bursting, or traditional dig and replace methods. These structural defects can contribute to I/I, so structural condition can provide an indication of sources of I/I from the publicly-owned sewer mains. However, visual observation of active I/I is not feasible since the significant RDI/I sources in the City are generally active for only short periods during rainfall events. Furthermore, the consensus in the industry is that it is not possible to achieve significant reductions in I/I (excluding direct inflow sources) through targeted spot repairs or rehabilitation/replacements of isolated pipe segments. What is required is to comprehensively address entire subbasins of contiguous pipes, essentially renovating entire neighborhoods.

Since video inspections are useful for identifying structural defects, and the City intends to inspect its entire sewer system over the next several years for this purpose, one approach would be to place high priority on inspecting the basins that have been identified as having high I/I (Basins FUL01, FUL02, FUL03, FUL04, FUL05, FUL06, FUL07, and FUL09). Once those basins have been inspected and sewer conditions assessed, consideration could be given to comprehensively rehabilitating entire basins that are in the worst condition, rather than rehabilitating individual pipe segments or performing spot repairs. This comprehensive rehabilitation approach, while potentially more costly than a structural repair approach, should have added benefits in term of I/I reduction.

If wet weather flow monitoring is also performed in those basins, the results of the flow monitoring program could be used in conjunction with the results of the condition assessment to prioritize areas for comprehensive rehabilitation.

6.2.3 Potential Costs and Benefits of Comprehensive Rehabilitation

The benefit to the City of reducing I/I by comprehensive rehabilitation would be primarily the cost savings that would be achieved by eliminating the need to construct relief sewers. As shown in Figure 5-1, the basins with the highest peak I/I are upstream of several of the identified capacity improvement projects. Therefore, a preliminary analysis was performed to compare the potential cost savings to the potential cost of I/I reduction.

The amount of I/I reduction that can be achieved from comprehensive inspection and rehabilitation of sewer mains is estimated to range from 20 to 40 percent. Although conditions and results vary from city to city, studies have shown that rehabilitation programs that include lateral rehabilitation are more successful in reducing I/I than programs than address only the mains. The I/I reduction rates in **Table 6-2** are rough estimates of what can be achieved based on a review of past studies.

Table 6-2: I/I Reduction Rates

Components to be Rehabilitated	I/I Reduction Rate
Sewer mains only	20% - 40%
Upper laterals only	20% - 40%
Upper and lower laterals	30% - 50%
Mains and lower laterals	45% - 65%

Using the calibrated hydraulic model, I/I was reduced by 30% in basins with high peak I/I (Basins FUL01, FUL02, FUL03, FUL04, FUL05, FUL06, FUL07, FUL09) to determine if I/I reduction through rehabilitation of sewer mains (without lateral rehabilitation) would eliminate any of the required future capacity improvement projects. The results showed that Projects 1B, 1C and 11 could be eliminated. The basins upstream of Projects 1B and 1C are FUL01, FUL02, FUL03 and FUL04. The basin upstream of Project 11 is FUL05.

A planning-level construction cost for rehabilitation of mains (not including laterals) is $175 per foot (based on mostly lining or pipe bursting of 8-inch sewer mains). Assuming a 30% allowance for engineering, design, and administration, the total capital cost would be $228 per foot. **Table 6-3** compares the cost for rehabilitation (by basin) to the CIP project cost.

Table 6-3: Rehabilitation Costs by CIP Project

CIP Project	Upstream Basins	Upstream Sewers (mi)	Rehabilitation Costs ($M)	CIP Project Capital Cost ($M)
1B, 1C	FUL01, FUL02, FUL03, FUL04	20.8	$25.0	$2.5
11	FUL05	6.2	$7.5	$0.3
Total	**---**	**27**	**$32.5**	**$2.8**

It is clear from these estimates that the capital costs for CIP Projects 1B, 1C, and 11 are more than an order of magnitude less than the cost of the rehabilitation work needed to eliminate these projects. Thus, rehabilitation cannot be justified solely on this basis. However, comprehensive rehabilitation of these sewers would have other benefits in terms of improving service levels, reducing maintenance costs, and reducing the risks of blockages and overflows. Based on this analysis, I/I reduction through comprehensive rehabilitation is not considered a cost-effective alternative to construction of capacity improvement projects.

Chapter 7 Capital Replacement Program

This chapter presents the recommended 20-year Capital Replacement Program (CRP) covering the inspection, rehabilitation, replacement, and repair of the gravity sewer system. The program is defined in terms of annual mileages and costs, rather than by specific sewer reaches, and is based on characteristics of the City's sewer system and results of sewer video inspections performed up to September 2008.

For the purposes of the CRP, sewer "rehabilitation" is defined to include all manhole-to-manhole projects, including open cut replacement, lining, or pipe bursting. "Spot repair" is defined as the replacement or sectional lining of damaged pipe segments, typically only a few feet long.

7.1 Sewer System Characteristics

The City owns and operates a wastewater collection system consisting of approximately 330 miles of gravity sewers, including 2.7 miles of private sewers. The City has a significant number of older sewers dating as far back as the 1920's, with the average age being 44 years. 99% of the City's sewers are constructed of clay pipe, with pipes ranging in size from 6 to 48 inches. The City's sewers discharge to trunk sewers owned and operated by Orange County Sanitation District. The characteristics of the City's sewer system are summarized in **Table 7-1**.

Table 7-1: Sewer System Characteristics

Characteristic	Value
Total Length	330 miles
Range of Pipe Sizes	6 to 39-inch diameter; 79% is 8-inch diameter
Material of Construction	99% of sewers are constructed of clay pipe
Age	Average age is 44 years; oldest sewer was installed in 1921; 59% installed after 1958

Due to the uniformity of the sewers in terms of pipe materials, the year of construction is the most significant characteristic that can be used as an indicator of pipe condition and rehabilitation requirements. Besides the fact that older pipe has had a longer period in which to deteriorate, there are also differences in the pipe and joint materials that were commonly used during different historical periods in the evolution of clay pipe. Based on information provided by the National Clay Pipe Institute[1], there have been three generations of clay sewer pipe:

- **Generation 1 -** Clay pipe manufactured before 1950 consists of short sections with joints every two to three feet. When compared with modern clay pipe, it has relatively thin walls and is only partially fired. This pipe is commonly referred to as "terra cotta" pipe. The joints are rigid and typically consist of cement mortar. The fragile nature of the pipes resulted in damage during construction and subsequent damage from earth movement and loss of support due to migration of fine soil particles and nearby underground construction. The cement mortar joints tend to deteriorate due to microbial-induced corrosion and cracking due to soil movement. Roots exploit the cracks and failed joints to gain access to water and nutrients and thereby cause further damage to the pipe.
- **Generation 2 -** Clay pipe manufactured between 1950 and 1958 consists of longer sections with joints every five to six feet. The pipe walls are thicker and the clay is fired to a greater extent. This pipe is commonly referred to as vitrified clay pipe. The joints are rigid and typically consist

[1] Adapted from National Clay Pipe Institute Chronology prepared by John Butler, dated August 23, 2005.

of cement mortar. Sewers of this generation are less susceptible to damage during construction, but they are problematic due to the durability of the joints, as described above for terra cotta pipe.

- **Generation 3 -** Clay pipe manufactured after 1958 was also vitrified clay pipe but was designed with flexible joints made of polyvinyl chloride and, later, synthetic rubber (polyurethane). Sewers of this generation perform better than previous generations and are less susceptible to joint deterioration and root invasion. They are expected to have longer useful lives than pipes of previous generations.

About 14 percent of the City's sewers are Generation 1 sewers built prior to 1950 (pipes with unknown age are assumed to be in this category). More prevalent (27 percent) are Generation 2 sewers built between 1950 and 1958, which are of some concern due to their rigid joints and the fact that those pipes are now over 50 years old. The Generation 3 sewers, which make up 59 percent of the City's system, would be expected to be in good condition and to remain so for many more years.

Although pipe material, clay pipe generation, and age are factors that are typically indicative of the condition and remaining useful life of sewers, actual current structural condition can only be determined through internal video inspections. Therefore, CRP recommendations are based primarily on video inspection findings, but the clay pipe generation has been used to extrapolate the findings to uninspected sewers. The clay pipe generation has also been used to enhance the decision matrix for long-term rehabilitation.

7.2 Condition Assessment Methodology

Identifying and prioritizing capital replacement projects requires obtaining accurate information on the structural condition of the sewer system. Current industry best practices for sewer system management call for conducting a baseline inspection of the entire system, typically over a 5- to 10-year period, as a basis for assessing its overall structural condition. The results of the baseline inspection also serve to determine the frequency and priority for the next round of inspections and provide data with which to assess long-term trends in sewer condition.

Video inspection using closed circuit television (CCTV) is the basic method used to assess sewer condition. This section provides guidelines for video inspection and condition assessment, including establishing standardized observation codes, data documentation procedures, condition grading, and criteria for using the results to make CRP decisions. The application of this methodology to the City's baseline inspections is described in **Section 7.3**.

7.2.1 Video Inspection Specifications

Effective use of video inspection data requires that the data recorded be consistent, complete, and of high quality; and that it is captured in a format that can be readily accessed for analysis. Current industry best practice is to use Pipeline Assessment and Certification Program (PACP) standards developed by the National Association of Sewer Service Companies (NASSCO), which specifies observation codes and grades to be applied to all structural and maintenance-related defects. The City has already adopted PACP standards and operator certification requirements for its video inspections.

Before using inspection data to design the 20-year CRP, RMC reviewed a subset of the City's inspection videos for consistency with the PACP standards. Data for 18 of the City's worst sewers was included in the subset. The review concluded that inspection data was consistent with PACP standards, with the following exceptions:

- There is not a beginning and end recorded for continuous defects.
- When roots should be listed as root balls (due to flow being limited by more than 50%), they are listed as roots medium.

- At some locations where "crack – circumferential" or "fracture – circumferential" are noted at joints, roots are also present and not noted.
- Roots were often not reported.

The City is aware of these findings and has already instructed operators to correct their methodology. Regardless, the inconsistencies are all related to maintenance defects, not structural defects, so the inspection data is valid for characterizing the structural condition of the sewers, which is the basis for the capital replacement program.

7.2.2 Condition Grading and Rating

Under the PACP standard, all structural defects are assigned a condition grade of 1 to 5. The grades are defined generally as follows, although more specific definitions apply to each defect type:

- 5 – Immediate: Defects require immediate attention.
- 4 – Poor: Severe defects that are likely to become Grade 5 defects within the next five years.
- 3 – Fair: Moderate defects that will continue to deteriorate.
- 2 – Good: Defects that have not begun to deteriorate.
- 1 – Excellent: Minor defects.

The grades for individual defects observed on a manhole-to-manhole pipe segment can be combined in various ways to determine an overall structural condition rating for the pipe. The PACP manual suggests several formulas for this purpose, including summing the grades of all defects or averaging the grades. Some investigators divide the sum of the grades by the length of the pipe to get a per-foot grade density. While such formulas may be useful for screening pipes in terms of overall condition, they are not particularly useful for deciding which pipes require immediate attention. What is most important in such decisions is the presence of major defects (Grade 4 and 5 defects), and the number of such defects. For example, a single Grade 5 defect in a pipe requires action, while five Grade 1 defects do not, even though they both sum to 5. The number of Grade 4 or 5 defects is significant since it helps determine whether point repair(s) or manhole-to-manhole rehabilitation (e.g., lining, pipe bursting) or replacement would be most appropriate.

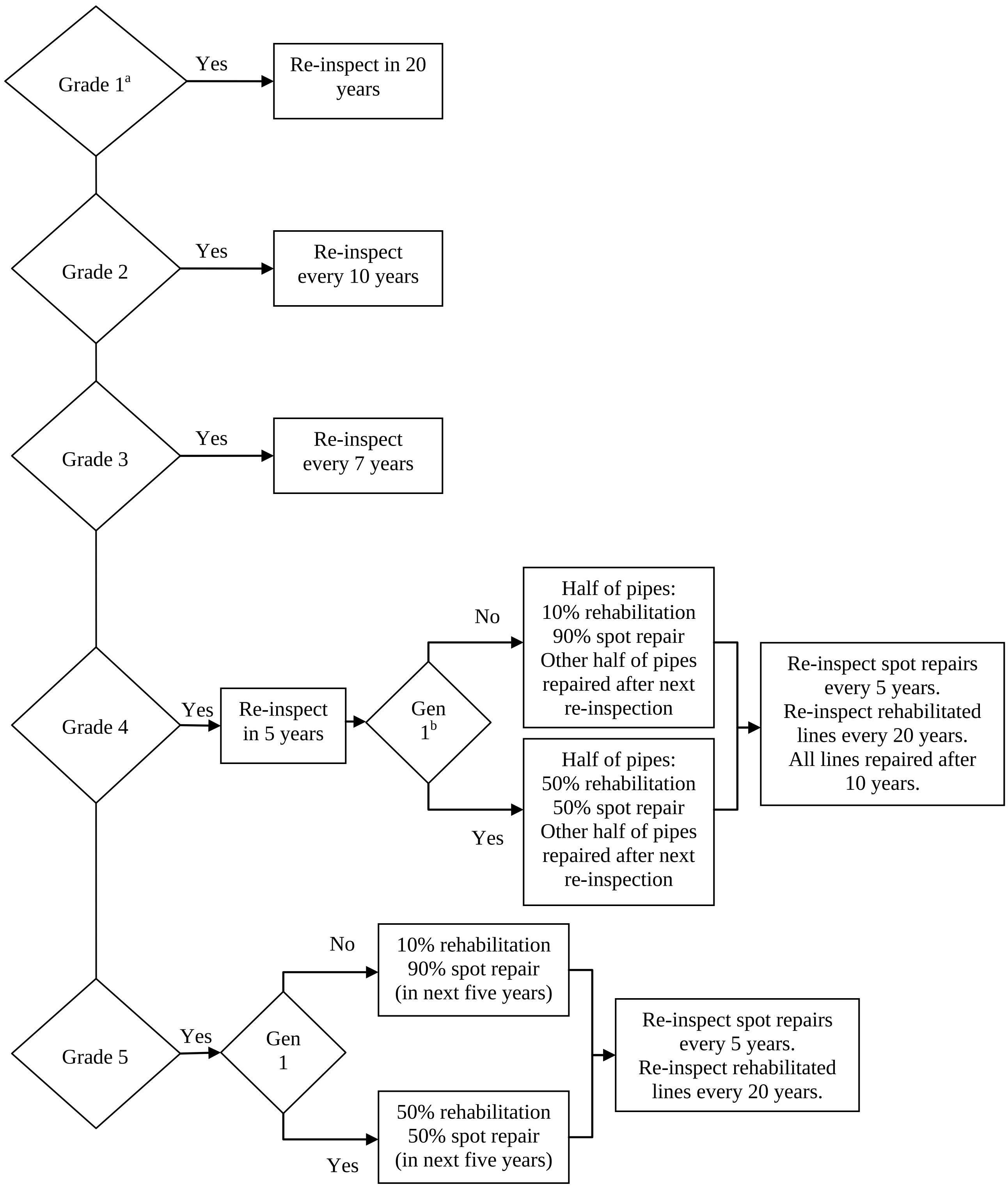
Because it provides the best overall rating method for the purposes of decision making, the PACP Quick Structural Rating (QSR) is recommended as the City's primary rating system for condition assessment. The rating is a four-digit code that indicates the number of defects having the two highest grades. For example, a QSR of 5132 indicates the worst defect was a Grade 5 defect (of which there was only one occurrence), and the next worst defect was Grade 3 (of which there were 2 occurrences). As another example, a QSR of 3412 indicates no Grade 4 or 5 defects, four Grade 3 defects, no Grade 2 defects, and two Grade 1 defects.

7.2.3 Rehabilitation Decision Criteria

The QSR provides the basic information needed to decide which renewal/replacement action is appropriate, and/or when the pipe should be re-inspected. The recommended decision criteria and actions are illustrated in **Figure 7-1**, which also includes assumptions made in the development of the CRP. Basically, if the worst structural defect is less than Grade 5, the pipe is scheduled for re-inspection only, with the timing based on condition. The better the condition (as indicated by the grade of the worst defect), the farther in the future the re-inspection can occur, since the risk of a failure prior to re-inspection is small. With Grade 4 defects, the assumption is that there is a low risk of that defect turning into a Grade 5 defect and failing within 5 years.

For pipes with Grade 5 defects, immediate action is required. "Immediate" action is assumed to mean within the next 5 years, and preferably within two years. The decision on whether to implement a point

Figure 7-1: Rehabilitation Decision Criteria Based on the Worst Grade of All Structural Defects



[a] Grades 1-5: Indicates severity of structural defects (Grade 5 = worst defects)
[b] Gen 1: Indicates Generation 1 clay pipes built prior to 1950

repair or a manhole-to-manhole rehabilitation or replacement is partly an economic decision (it is generally less costly to rehabilitate an entire pipe than to perform point repairs if there are more than two repairs for every 100 feet of pipe), but may also involve a number of other considerations, including whether adjacent pipes need rehabilitation, whether the pipe needs additional capacity, and the specific nature of the defects. For the purposes of developing this CRP, it was assumed that for Generation 1 pipes with Grade 5 defects, half would be rehabilitated and half would be spot repaired over the next five years. For Generation 2 and 3 pipes, only 10 percent would be rehabilitated and 90 percent would be spot repaired over the next five years (assume two spot repairs per typical 250-foot manhole-to-manhole section). These assumptions reflect the fact that the older Generation 1 pipes generally have more defects and also are more difficult to successfully spot repair than newer pipes.

Figure 7-1 also includes assumptions about rehabilitation and repair of the pipes with Grade 4 defects, after they are re-inspected in five years. It has been assumed that half of those pipes will have developed Grade 5 defects by that time, and will need to be rehabilitated or repaired within the following five years. It is further assumed that the other half of the pipes will have developed Grade 5 defects by the subsequent re-inspection after another five years. These assumptions are made for the purposes of budgetary planning only, and detailed assessments of individual pipe reaches must be performed based on past and future inspection results in order to determine the appropriate actions for any specific pipe.

Pipes requiring rehabilitation should be prioritized if the work will need to be performed over multiple years due to practical considerations and/or financial constraints. In setting priorities, the goal is to minimize risk. In this context, risk includes both the likelihood of a failure and the consequences of that failure. The likelihood of a failure is based on the number and grade of defects (e.g., a Grade 5 defect has a greater likelihood of causing a pipe failure than a Grade 4 defect). The consequence of a failure is more subjective, and depends on the characteristics of the pipe and the land uses in the area. These characteristics include:

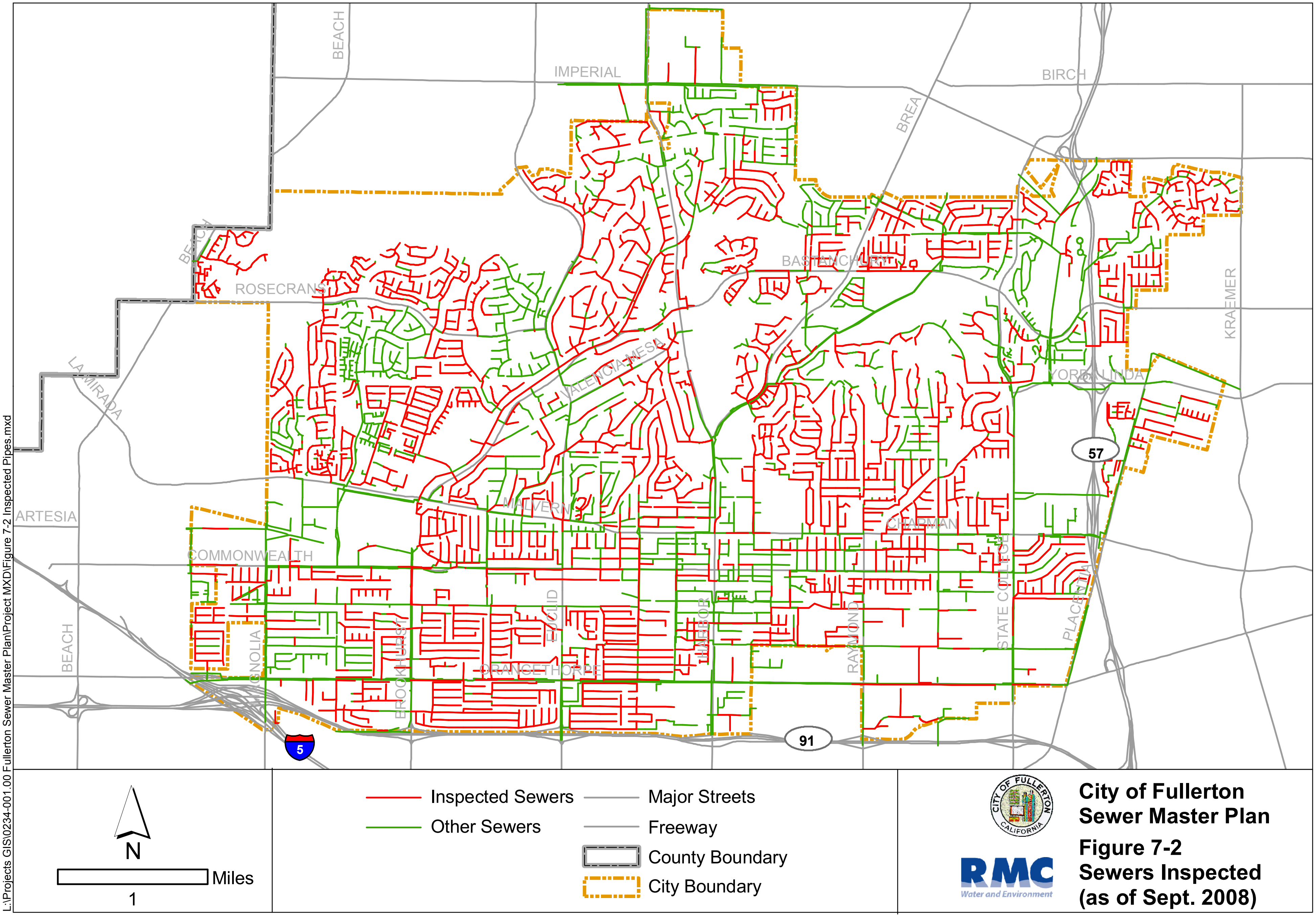
- Pipe size, as an indicator of flow rate. The failure of a large pipe (as opposed to a small pipe) that triggers a partial or total blockage is more likely to cause a significant overflow with a high impact.
- Traffic volume. A spill in a high-traffic street will create a greater impact than one on a low-traffic street.
- Proximity to open channels. A spill near an open channel is more likely to reach the channel before it can be contained in the street or in a storm drain.
- Sensitive land uses. Spills near schools, businesses, and environmentally sensitive habitats, for example, will have a greater impact than spills in a typical residential neighborhood.

Some agencies have assigned quantitative weights to these and other characteristics to compute impact scores which are combined with the likelihood scores to compute an overall risk score for each defective pipe. Such a quantitative approach may be justified to help prioritize a large number of defects that will be addressed over a multi-year period. The City should consider the potential consequences of each identified defect when prioritizing rehabilitation projects.

7.3 Baseline Inspection and Condition Assessment Program

The City has been conducting video inspections of its sewer system since November of 2005. As of September 2008, the City had produced inspection data for 198 miles of sewers, and plans to complete their baseline inspections by the end of 2010. **Figure 7-2** highlights the sewers inspected as of September 2008, which comprises approximately 60% of the entire system.

Although different operators performed the inspections, all were confirmed to have complied with PACP standards. Also, the databases produced in both projects included manhole identifiers that allowed the



City of Fullerton Sewer Master Plan

Figure 7-2 Sewers Inspected (as of Sept. 2008)

RMC Water and Environment

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\Figure 7-2 Inspected Pipes.mxd inspection results to be linked to the City's GIS for analysis. The findings from these inspections provide a sound basis for a preliminary assessment of the condition of the City's sewers.

Table 7-2 summarizes the inspections results in terms of the highest observed grade of structural defects in each pipe. Five percent of the inspected pipes (by length) had Grade 5 structural defects, and 14 percent had Grade 4 structural defects. Over half of the inspected pipes had only minor or no defects (Grades 0 and 1).

When the pipes are grouped by Generation, important trends are apparent. 37 percent of the inspected Generation 1 pipes (by length) had Grade 4 or 5 structural defects, while only 26 percent of Generation 2 pipes and 9 percent of Generation 3 pipes had such defects. This supports the conclusion that Generation 1 pipes are in the worst condition, followed by Generation 2 pipes. Generation 3 pipes are in relatively good condition. **Figure 7-3** highlights the inspected sewers based on the highest observed grade of structural defects in each pipe.

Table 7-3 is an extrapolation of the inspection results to the entire system. In extrapolating the results, all pipes built per Generation were assumed to be in the same condition as the inspected pipes built in that Generation. The amount of pipe inspected from each Generation was adequate to make this extrapolation reasonable. For example, 40 percent of the Generation 1 sewers were inspected, and 72 and 59 percent of the Generation 2 and 3 sewers were inspected, respectively.

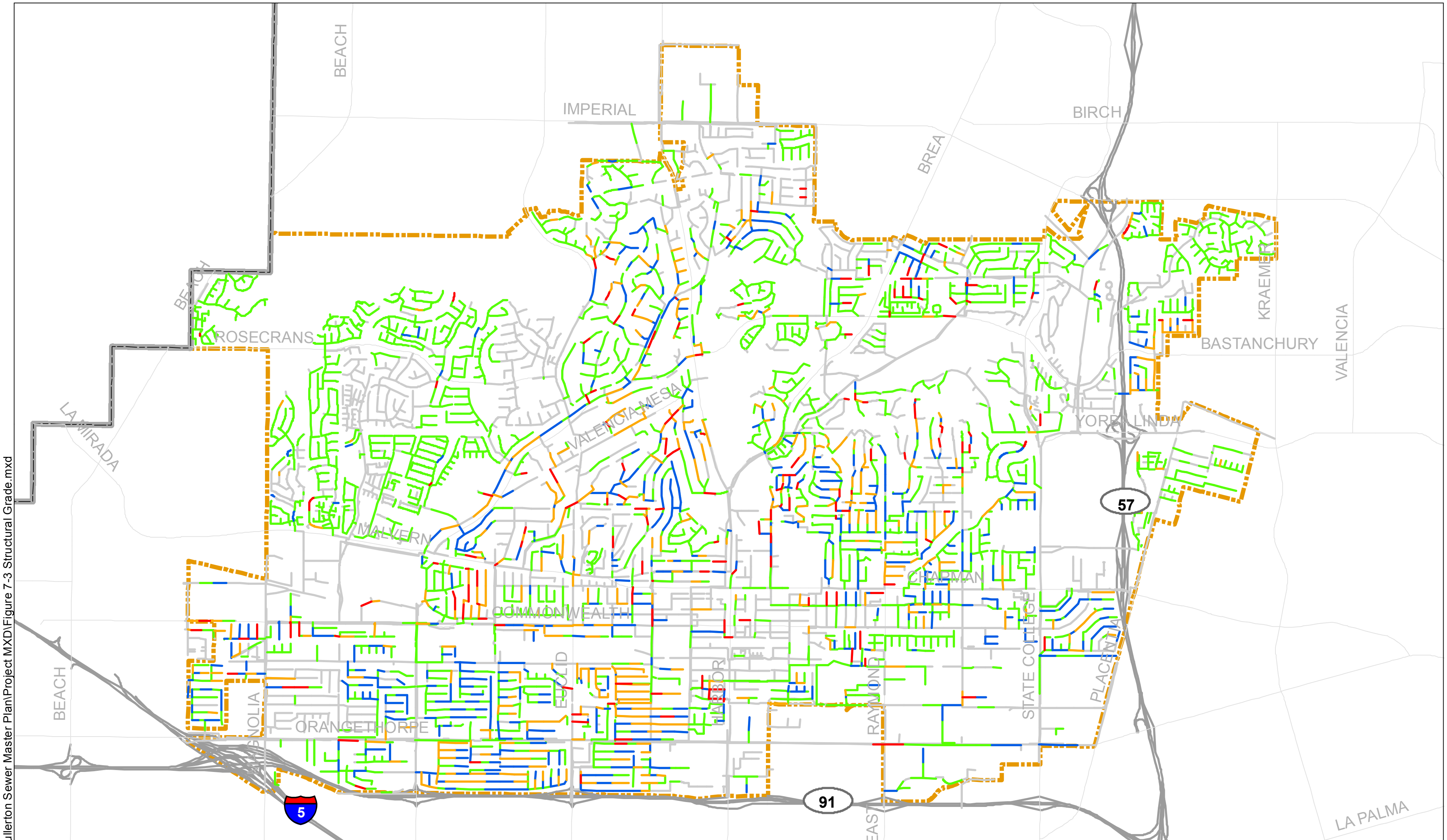
The 19 percent of pipes with Grade 4 and 5 defects will comprise the first wave of rehabilitation and repair projects as they are addressed over the next ten years. The 18 percent of pipes with Grade 3 defects will eventually comprise a new wave of rehabilitation costs when they deteriorate to Grade 5, some potentially within the next 20 years.

Table 7-2: Summary of Structural Grades (Inspected Pipes)

Pipe Generation	No Defects (Miles)	Grade 1 Defects (Miles)	Grade 2 Defects (Miles)	Grade 3 Defects (Miles)	Grade 4 Defects (Miles)	Grade 5 Defects (Miles)	Total Inspected (Miles)
1	6.0	1.0	1.7	4.6	4.8	3.1	21.2
2	14.7	5.3	10.8	21.9	16.2	2.5	71.4
3	70.7	6.4	8.7	9.9	6.5	3.4	105.6
Total (Miles)	91.4	12.7	21.2	36.4	27.5	9.0	198.2
% of Inspected Pipes	*46%*	*6%*	*11%*	*18%*	*14%*	*5%*	*100%*

Table 7-3: Summary of Structural Grades (Extrapolation to Entire System)

Pipe Generation	No Defects (Miles)	Grade 1 Defects (Miles)	Grade 2 Defects (Miles)	Grade 3 Defects (Miles)	Grade 4 Defects (Miles)	Grade 5 Defects (Miles)	Total System (Miles)
1	15.0	2.5	4.3	11.5	12.0	7.8	53.0
2	20.4	7.4	15.0	30.4	22.5	3.5	99.1
3	118.9	10.8	14.6	16.7	10.9	5.7	177.6
Total (Miles)	154.3	20.6	33.9	58.5	45.4	16.9	329.7
% of All Pipes	*47%*	*6%*	*10%*	*18%*	*14%*	*5%*	*100%*



N

Miles

1

Grade for Inspected Pipes

No Defects, Grade 1, or Grade 2

Grade 3

Grade 4

Grade 5

Sewers Not Inspected

Major Streets

Freeway

County Boundary

City Boundary

City of Fullerton Sewer Master Plan

RMC Water and Environment

Figure 7-3 Highest Structural Grade of Inspected Sewers

L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\Figure 7-3 Structural Grade.mxd

7.4 Projected 20-Year Inspection and Rehabilitation Requirements

The above-described generalized outcome model can be used to estimate the annual sewer rehabilitation, repair and re-inspection requirements for a 20-year CRP. The program assumes that the City's baseline inspection program would be completed in 2010, and that re-inspections would commence in the following year. Rehabilitation is assumed to start in 2009, which is Year 1 of the 20-year CRP. Baseline inspections started in 2005, which means that pipes scheduled for re-inspection after 20 years would be re-inspected starting in Year 18.

Re-inspections should be performed based on the intervals presented in **Figure 7-1**, which considers the results of the initial inspection (maximum grade of defects observed). In general, pipes having more severe defects get inspected more often. The first two years of the program would be spent completing the baseline inspection program. In Year 3, Grade 4 re-inspections begin. Re-inspections of Grade 3 pipes begin in Year 5, followed by Grade 2 re-inspections in Year 8. The inspection cycle starts anew in Year 18, when 175 miles of Grade 1 pipes and pipes with no defects are re-inspected over the next 5 years.

The schedule for rehabilitation and repairing pipes puts priority on Grade 4 and 5 pipes. Grade 5 pipes are completed by Year 5, while Grade 4 pipes are completed by Year 12. For the remaining years, it is forecasted that a number of pipes currently with Grade 3 defects will deteriorate to Grade 4 or 5 and will therefore require repair. Because it is largely unknown what percentage of Grade 3 pipes will deteriorate and when, it was assumed that the rates of rehabilitation and spot repair in the 13 to 20-year timeframe would be similar to those estimated for years 6 to 12 of the program. The actual requirements will depend on the findings of subsequent re-inspections.

The annual inspection and rehabilitation requirements corresponding to the recommended 20-year CRP are presented in **Table 7-4**. The requirements are based on the extrapolated structural grades for the entire system shown in **Table 7-3**.

The program is anticipated to result in an average of about 1.1 miles per year of manhole-to-manhole rehabilitation projects and about 4 miles per year of spot repairs (or about 168 spot repairs, assuming two per typical pipe length of 250 feet). That corresponds to an annual rehabilitation rate of about 0.3 percent of the sewer system (nearly a 300-year cycle). With spot repairs included, the annual rate increases to about 1.6 percent (64-year cycle). Over the first five years of the program, the annual rehabilitation rate would be 0.5 percent (200-year cycle), and 1.8 percent (55-year cycle) with spot repairs included.

It should be noted that since September 2008 (date of the last set of inspection data used for this analysis), the City has developed projects to repair or rehabilitate approximately 71,000 feet (13.5 miles) of pipe as part of their existing Capital Improvement Program (CIP). It is expected that many of these projects will address pipes included in the 20-year CRP. As these repairs are completed, pipes listed as Grade 4 or 5 as of September 2008 may be changed to a pipe with no defects. It will be of the utmost importance to maintain an up-to-date database of each pipe's current structural condition and its corresponding re-inspection schedule. The list should be linked to the City's maintenance management system for cross-reference when defining repair projects and scheduling re-inspections.

These rehabilitation and repair estimates are based on a sampling of sewer conditions as they exist today, and are considered to be most accurate over the next 5 to 10 years, and less accurate for years 10 to 20. The City should expect that sewers will continue to deteriorate over time, so that the estimates presented here will need to be continuously updated based on the findings of ongoing future inspections and assessments.

Table 7-4 : Projected Annual Inspection and Rehabilitation Requirements in Miles

		Generation 1				Generation 2				Generation 3				Total*			
Program Year	Actual Year	Rehabilitate	Spot Repair	Inspect	Re-Inspect	Rehabilitate	Spot Repair	Inspect	Re-Inspect	Rehabilitate	Spot Repair	Inspect	Re-Inspect	Rehabilitate	Spot Repair	Inspect	Re-Inspect
1	2009	0.8	0.8	15.9	---	0.1	0.6	13.9	---	0.1	1.0	36.0	---	1.0	2.4	65.8	---
2	2010	0.8	0.8	15.9	---	0.1	0.6	13.9	---	0.1	1.0	36.0	---	1.0	2.4	65.8	---
3	2011	1.4	1.4	---	2.4	0.3	2.6	---	4.5	0.2	2.0	---	2.2	1.9	6.0	---	9.1
4	2012	1.4	1.4	---	2.4	0.3	2.6	---	4.5	0.2	2.0	---	2.2	1.9	6.0	---	9.1
5	2013	1.4	1.4	---	4.7	0.3	2.6	---	10.6	0.2	2.0	---	5.5	1.9	6.0	---	20.8
6	2014	0.6	0.6	---	5.5	0.2	2.0	---	11.2	0.1	1.0	---	6.5	0.9	3.6	---	23.2
7	2015	0.6	0.6	---	5.5	0.2	2.0	---	11.2	0.1	1.0	---	6.5	0.9	3.6	---	23.2
8	2016	0.6	0.6	---	5.7	0.2	2.0	---	14.0	0.1	1.0	---	9.4	0.9	3.6	---	29.1
9	2017	0.6	0.6	---	5.7	0.2	2.0	---	14.0	0.1	1.0	---	9.4	0.9	3.6	---	29.1
10	2018	0.6	0.6	---	3.4	0.2	2.0	---	7.9	0.1	1.0	---	6.0	0.9	3.6	---	17.4
11	2019	0.6	0.6	---	3.4	0.2	2.0	---	7.9	0.1	1.0	---	6.0	0.9	3.6	---	17.4
12	2020	0.6	0.6	---	5.7	0.2	2.0	---	14.0	0.1	1.0	---	9.4	0.9	3.6	---	29.1
13	2021	---	---	---	4.3	---	---	---	10.8	---	---	---	6.3	1.0	4.0	---	21.4
14	2022	---	---	---	4.3	---	---	---	10.8	---	---	---	6.3	1.0	4.0	---	21.4
15	2023	---	---	---	4.3	---	---	---	10.8	---	---	---	6.3	1.0	4.0	---	21.4
16	2024	---	---	---	4.3	---	---	---	10.8	---	---	---	6.3	1.0	4.0	---	21.4
17	2025	---	---	---	2.0	---	---	---	4.7	---	---	---	3.0	1.0	4.0	---	9.6
18	2026	---	---	---	6.3	---	---	---	13.2	---	---	---	31.9	1.0	4.0	---	51.4
19	2027	---	---	---	8.6	---	---	---	19.3	---	---	---	35.2	1.0	4.0	---	63.1
20	2028	---	---	---	8.6	---	---	---	19.3	---	---	---	35.2	1.0	4.0	---	63.1

* The Generations of pipes to be rehabilitated and spot repaired between Years 13 and 20 are unknown.

7.5 Projected Capital Costs

Planning-level construction and capital costs were estimated for inspection, rehabilitation, and spot repair using the unit costs shown in **Table 7-5**. These unit costs were based on recent project bids provided by the City and are intended to represent a long-term average cost of many projects. The inspection costs cover the cost of hiring a contractor to perform the inspections, but do not include capital costs for reviewing the inspection results and determining the appropriate action for each pipe segment, which is assumed to be performed by City staff.

The basic unit cost for rehabilitation of $175 per foot is based on the following assumptions:

- A very high percentage of projects will be on small diameter (8-inch) pipes in streets with low traffic and favorable soil and groundwater conditions.
- 6-inch diameter pipes will be replaced with 8-inch diameter pipes.
- Cut and cover pipe replacement as well as trenchless technologies such as pipe bursting and CIPP will be applied as determined by local conditions. The unit cost assumes projects will be 80 percent pipe bursting and 20 percent open cut replacement.
- Most manholes will not need to be replaced - minor repair and benching will be adequate.
- The projects will be over a mile in length, allowing for economies of scale.
- Laterals will be reconnected, but neither upper nor lower laterals will be replaced.

Standard engineering costs for these projects were applied to construction costs to compute design and construction engineering costs.

Table 7-5: Unit Costs for Video Inspection, Rehabilitation, and Spot Repairs

Item Description	Spot Repair (cost per repair)	Rehabilitation (cost per LF)	Video Inspection (cost per LF)
Construction Cost	$3,500	$175	$1.10
Legal/Administrative (5% of construction cost)	$175	$9	
Design (10% of construction cost)	$350	$18	
Engineering Services during Construction (10% of construction cost)	$350	$18	
Environmental/Permitting (5% of construction cost)	$175	$9	
Total Capital Cost	$4,550	$228	$1.10

The cost per spot repair was converted to a cost of $36 per linear foot, assuming two spot repairs per typical 250-foot manhole-to-manhole section. The unit costs from **Table 7-5** were applied to the projected inspection and rehabilitation program requirements from **Table 7-4.** The resulting annual capital costs are shown in **Table 7-6**. Note that the costs are all in 2008 dollars and have not been escalated for future price inflation.

The annual capital cost requirements are only as accurate as the projections of rehabilitation and repair requirements, specifically the percentages of Grade 4 and 5 pipes. As the program proceeds, the projections that were based initially on inspection of 60 percent of the sewers should be revised. Capital cost projections should be updated to reflect the latest findings and actual unit costs from early projects.

Table 7-6: Annual Inspection, Rehabilitation, and Repair Costs

Year		Rehabilitation	Spot Repair	Inspections	Re-Inspections	Total Capital Cost
1	2009	$1,152,000	$467,000	$382,000	$0	$2,001,000
2	2010	$1,152,000	$467,000	$382,000	$0	$2,001,000
3	2011	$2,274,000	$1,160,000	$0	$53,000	$3,487,000
4	2012	$2,274,000	$1,160,000	$0	$53,000	$3,487,000
5	2013	$2,274,000	$1,160,000	$0	$121,000	$3,555,000
6	2014	$1,122,000	$693,000	$0	$135,000	$1,950,000
7	2015	$1,122,000	$693,000	$0	$135,000	$1,950,000
8	2016	$1,122,000	$693,000	$0	$169,000	$1,984,000
9	2017	$1,122,000	$693,000	$0	$169,000	$1,984,000
10	2018	$1,122,000	$693,000	$0	$101,000	$1,916,000
11	2019	$1,122,000	$693,000	$0	$101,000	$1,916,000
12	2020	$1,122,000	$693,000	$0	$169,000	$1,984,000
13	2021	$1,201,000	$769,000	$0	$124,000	$2,094,000
14	2022	$1,201,000	$769,000	$0	$124,000	$2,094,000
15	2023	$1,201,000	$769,000	$0	$124,000	$2,094,000
16	2024	$1,201,000	$769,000	$0	$124,000	$2,094,000
17	2025	$1,201,000	$769,000	$0	$56,000	$2,026,000
18	2026	$1,201,000	$769,000	$0	$299,000	$2,269,000
19	2027	$1,201,000	$769,000	$0	$367,000	$2,337,000
20	2028	$1,201,000	$769,000	$0	$367,000	$2,337,000
	TOTAL	**$26,588,000**	**$15,417,000**	**$764,000**	**$2,791,000**	**$45,560,000**

Chapter 8 20-Year Capital Improvement Program

This chapter outlines the City's 20-Year Capital Improvement Program (CIP). The program includes capacity projects defined from an in-depth hydraulic modeling analysis and the system-wide capital replacement program (CRP) defined using recent video inspections. These projects comprise a proactive program to replace or rehabilitate sewers to ensure adequate hydraulic capacity and structural integrity over the next 20 years. Project prioritization, groupings, and an implementation strategy are also provided.

8.1 Capacity Project Implementation

Each of the specific projects defined in the capacity analysis were prioritized using a risk-based methodology that considers both the likelihood and consequences of failure. A project's likelihood of failure , was determined from both modeling results (freeboard depth, existing vs. future deficiency, and confidence in findings) and video inspection results (number of Grade 4 and 5 defects). Projects that have not yet been inspected were evaluated based on their year of construction. A project's consequence of failure may be related to its location near sensitive areas such as creekbeds or to its size that would result in high-volume overflows in the case of failure. Projects with high likelihood and consequences of failure present the highest risk and are the most critical projects to implement.

Each project was assigned to one of three implementation phases, based on its priority. These phases are defined as follows:

- High-priority projects: to be implemented immediately and completed within 5 years
- Medium-priority projects: to be completed within a 5 to 10 year period
- Low-priority projects: to be completed within a 10 to 20 year period

Table 8-1 lists projects by priority. A discussion follows about how each project was prioritized, and identifies any potential issues that should be considered during further planning and design phases. The column "Credit to CRP Budget" is the estimated cost for upsizing sewers that also have Grade 4 and Grade 5 structural defects, and are thus included in the capital replacement program as rehabilitation or repair projects. This credit avoids double-counting of capital costs.

Projects 1A, 1B, and 1C (High Priority). These three projects collectively upsize most of the line on Bastanchury Rd. Of all the projects defined in this Master Plan, these projects are the most critical and should be addressed immediately.

- Flow monitoring performed in 2005 showed that the line was surcharging heavily at Meter FUL01 during storm events. Modeling of the system with the proposed CIP projects in place showed that freeing up the upstream bottleneck known as Project 1A resulted in increased flows downstream. These increased flows caused an additional bottleneck, known as Project 1B. In this same way, Project 1C was identified. Therefore, all three of these projects will be necessary to provide adequate capacity for wet weather flows. In terms of sequencing, the most downstream project should be constructed first, Project 1C, followed by Project 1B, and finally 1A.
- Approximately 14,000 feet, or almost the entire length of these projects, have been inspected. Over 5,000 feet of pipe were assigned Grade 4 and 5 defects. The City acknowledges that the line is in poor condition.
- Because it will be necessary to upsize this line due to capacity limitations, the costs associated with repairing or rehabilitating the Grade 4 and 5 defect pipes can be subtracted from the required CRP budget. The credit to the CRP budget is estimated to be $1,168,000.

Table 8-1: Prioritized CIP Projects

Project ID	Location	Length	Priority	Estimated Cost	Credit to CRP Budget
1A	W Bastanchury Road, Morellia Pl, from N Euclid St to Arbolado Dr	10,440'	High	$4,525,000	$705,000
1B	W Bastanchury Road, from N Euclid St to Warburton Way	3,860'	High	$1,807,000	$328,000
1C	W Bastanchury Rd and Hughes Dr	1,610'	High	$724,000	$135,000
2	N Euclid St from Rosecrans Ave to Bastanchury Rd	1,440'	Medium	$1,305,000	$0
3	N Euclid St from W Malvern Ave to W Commonwealth Ave	2,030'	Medium	$787,000	$463,000
4	W Valencia Dr from S Euclid St to S Woods Ave	1,190'	Medium	$435,000	$0
5	Evergreen Ave and Laurel Ave from Maple Ave to Lark Ellen Dr	820'	Low	$391,000	$0
6	Arroyo Drive from Ramona Dr to W Malvern Ave	1,420'	Low	$104,000	$0
7A	W Malvern from Arroyo Drive to N Basque Ave	970'	Medium	$399,000	$221,000
7B	N Basque Ave from W Malvern Ave to Gregory Ave	1,710'	Medium	$646,000	$390,000
7C	Gregory Ave from N Wanda Dr to N Basque Ave	3,840'	Medium	$2,684,000	$0
8	Johnson Pl from Carhart Ave to N Stephens Ave	250'	Low	$114,000	$0
9	W Valencia Dr & S Basque Ave from S Brookhurst Rd to W Elm Ave	3,680'	Low	$1,495,000	$0
10	Nutwood Ave from State College Blvd to Ruby Dr	3,880'	Low	$3,167,000	$0
11	By W Valley View Dr and N Euclid St	970'	Low	$331,000	$220,000
12	Conejo Lane from Sunrise Lane to Camino Centroloma	880'	Low	$463,000	$0
13	E Bastanchury Rd from Amberleaf St to Puente St	580'	Low	$363,000	$0
TOTAL				**$19,740,000**	**$2,462,000**

- The line is a major conveyor of flow with diameters ranging in size from 8” to 18”.
- The line is located in a creekbed and should be relocated if possible. A viable alternative would be to construct a new line on Bastanchury Rd, rather than upsize the line in its current alignment. In addition to being in a sensitive habitat, it is known that it will not be possible to upsize the line in-place between manholes 10-42 and 9-42 due to existing utilities.

Projects 2, 3, and 4 (Medium Priority). These projects are grouped together because they all have overflows predicted during the Existing WWF scenario.

- All of the lines had meters installed on them during the 2005 storms, and all recorded surcharging.
- None of the lines have been inspected. The pipes associated with Projects 2 and 4 were constructed between 1954 and 1960 and are assumed to be in acceptable condition.
- The pipes associated with Project 3 were constructed in 1924 and are assumed to be in poor condition.
- The lines are 8” to 10” in diameter and are considered to be major conveyors of flow.

Project 5 (Low Priority). This project is located at the connection point to OCSD’s Old Fullerton-Brea Trunk Sewer.

- In OCSD’s *2006 Strategic Plan Update*, Project EUB-1 was identified to address a capacity deficiency in the Old Fullerton-Brea Trunk Sewer. The project called for upsizing the Old Fullerton-Brea Trunk Sewer from 12” to 15”, or alternatively moving the connection point of the City’s 8” sewer on Evergreen Ave. (i.e., this Project 5 sewer) from manhole EUB0880-0040 (Old Fullerton-Brea Trunk Sewer) to manhole EUB0920-0000 (Fullerton-Brea Interceptor). Since this 8” sewer has now been identified as being undersized to convey local wet weather flows, it is recommended to upsize the line and move its connection point to manhole EUB0920-0000, thereby also resolving the deficiency in OCSD’s Old Fullerton-Brea Trunk Sewer.
- It has been confirmed that the capacity deficiency is a result of local wet weather flows and not flow backup from the OCSD trunk sewer. However, there was no meter installed on this line to verify the predicted surcharging and overflow.
- The line was inspected and found to be in good condition.

Project 6 (Low Priority). This project calls for constructing a weir to balance flow in parallel 6” and 10” lines. The flow split is just downstream of FUL05, so there is a high degrees of confidence about the total flow, but not about how flow is split between the 6” and 10” lines. It is possible that more flow goes to the 10” than is predicted. Flows should be monitored more in these lines to verify that the project is necessary.

Projects 7A, 7B, and 7C (Medium Priority). These projects would collectively upsize most of the line along the Arroyo Easement and which carries flow from Hiltscher Park. This line has been historically suspected by the City of having a capacity limitation.

- Projects 7A and 7B are along streets that have parallel lines, both of which were found to be deficient in model simulations. The recommended solution is to replace the larger line and retain the smaller line with its existing lateral connections.
- Looking at the hydraulic profile of Project 7B, it would be helpful to confirm the ground elevation at manhole 11-17, which looks much lower than surrounding manhole elevations. If this ground elevation is actually higher, it may eliminate the prediction of an overflow for Project 7B, thereby lessening the priority of the project somewhat. But in the end, the project would still be required.
- In the future, the line will carry additional flow from the expanding St. Jude Medical Center.

- The lines and parallel lines associated with Projects 7A and 7B were constructed in 1927 and 1941, respectively, and are assumed to be in poor condition. If the lines parallel to these projects are kept in service, it would be necessary to rehabilitate these lines as needed.
- Meter FOC121 is located just downstream of Project 7C.
- The line associated with Project 7C was constructed in 1979 and is assumed to be in good condition.
- Project 7C is a shallow sewer.
- In terms of project sequencing, Projects 7A and 7B should be constructed first, followed by Project 7C.
- The line is a major conveyor of flow with diameters ranging in size from 8” to 18”.

Project 8 (Low Priority). This project addresses a flat pipe located between two steep pipe sections on Johnson Pl.

- This project is located on a small 6” collector sewer.
- The sewer is at a higher risk for overflows due to it being a shallow sewer (6 feet deep).
- The line was inspected and found to be in good condition.
- There was no meter installed on this line to verify that flows exceed pipe capacity.

Project 9 (Low Priority). This project is located on Valencia Dr. between Brookhurst St. and Basque Ave.

- The project is downstream of Meter FUL12, which recorded surcharging during storms of 2005.
- In between Meter FUL12 and the project location, there is a line that connects from the north. In the model, no flow is in the line connecting from the north into manhole 5-18. If there is flow in this line, then the limitation could be worse than predicted. More research is required to confirm the magnitude of this deficiency.
- The line is 8” to 12” in diameter.
- The line has not been inspected. It was constructed between 1953 and 1955, so is assumed to be in acceptable condition.

Projects 10, 11, and 12 (Low Priority). These projects are attributed to planned growth.

- Until this growth occurs, they are considered to be low priority. It will be important to track development as it occurs to determine the need for these projects.
- Project 11 pipes were all inspected and found to have Grade 4 and 5 defects. Project 10 and 12 pipes have not been inspected. Both lines were constructed in 1962 and are therefore assumed to be in acceptable condition.
- The deficient lines are all 10” in diameter.

Project 13 (Low Priority). This project is located on a deep sewer (greater than 25 feet deep). It is classified as low priority because there is very little risk of an overflow. The line was constructed in 1976 and is assumed to be in acceptable condition.

8.2 Overall 20-Year CIP

Table 8-2 lists the total combined annual capital costs for the CRP and capacity-related projects. The sum of the CRP plus the capacity improvement project costs is $62.8M (after applying the CRP credits to the capacity project costs to avoid double-counting), which equates to $3.1M/year over a 20-year period. The annual costs in the early years are higher than this average (up to $4.7M), in order to complete all the high-priority capacity projects and address all the Grade 5 structural defects in the first five years. Thereafter, the annual costs range from $2.5M to $3.0M.

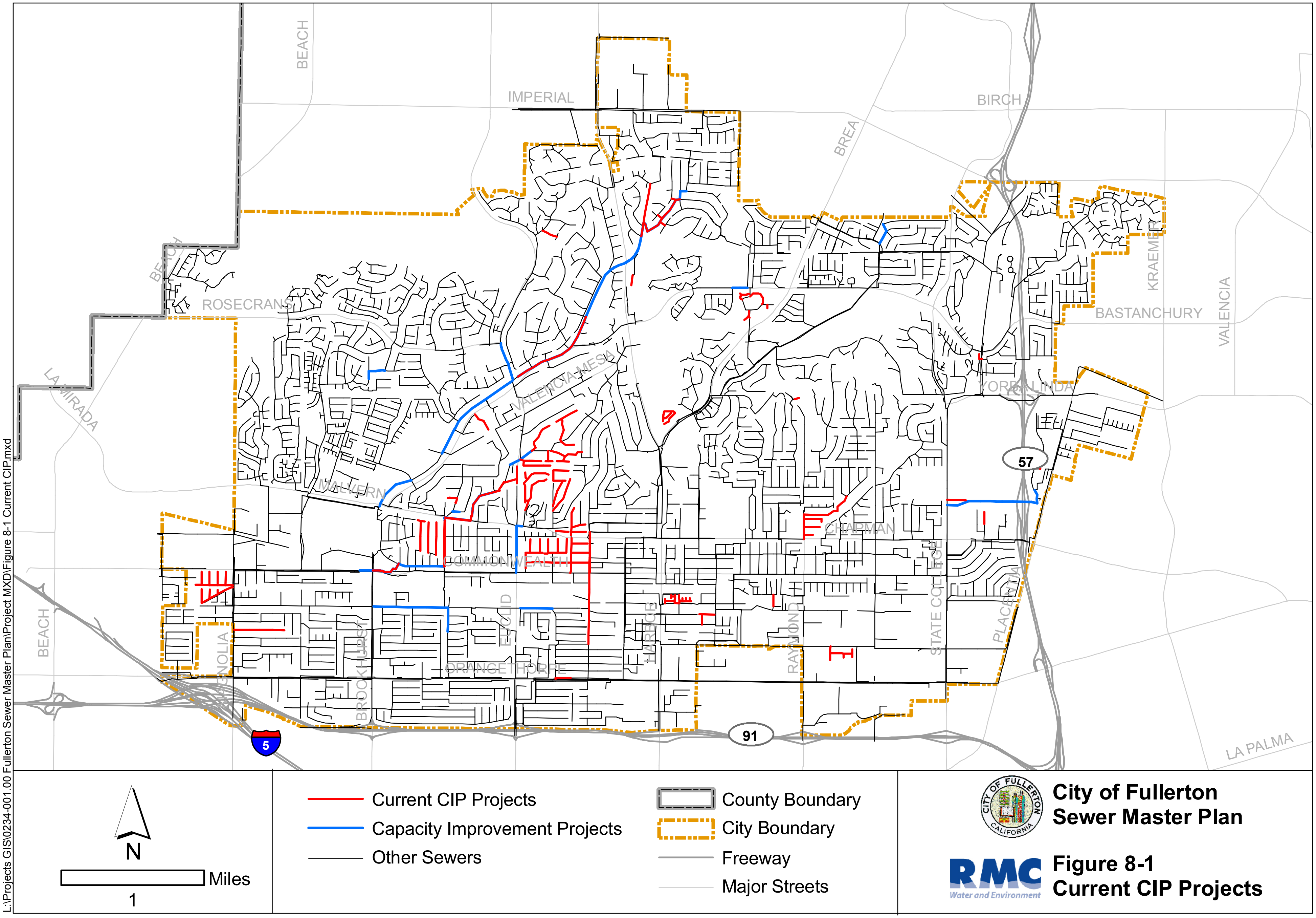
Table 8-2: 20-Year CIP Annual Costs

Year		Rehab.	Spot Repair	Inspections	Re-Inspections	Capacity Projects	Total Capital Cost[1]
1	2009	$1,152,000	$467,000	$382,000	$0	$1,178,000	$3,178,000
2	2010	$1,152,000	$467,000	$382,000	$0	$1,178,000	$3,178,000
3	2011	$2,274,000	$1,160,000	$0	$53,000	$1,178,000	$4,664,000
4	2012	$2,274,000	$1,160,000	$0	$53,000	$1,178,000	$4,664,000
5	2013	$2,274,000	$1,160,000	$0	$121,000	$1,178,000	$4,732,000
6	2014	$1,122,000	$693,000	$0	$135,000	$1,036,000	$2,987,000
7	2015	$1,122,000	$693,000	$0	$135,000	$1,036,000	$2,987,000
8	2016	$1,122,000	$693,000	$0	$169,000	$1,036,000	$3,021,000
9	2017	$1,122,000	$693,000	$0	$169,000	$1,036,000	$3,021,000
10	2018	$1,122,000	$693,000	$0	$101,000	$1,036,000	$2,953,000
11	2019	$1,122,000	$693,000	$0	$101,000	$621,000	$2,537,000
12	2020	$1,122,000	$693,000	$0	$169,000	$621,000	$2,605,000
13	2021	$1,201,000	$769,000	$0	$124,000	$621,000	$2,715,000
14	2022	$1,201,000	$769,000	$0	$124,000	$621,000	$2,715,000
15	2023	$1,201,000	$769,000	$0	$124,000	$621,000	$2,715,000
16	2024	$1,201,000	$769,000	$0	$124,000	$621,000	$2,715,000
17	2025	$1,201,000	$769,000	$0	$56,000	$621,000	$2,647,000
18	2026	$1,201,000	$769,000	$0	$299,000	$621,000	$2,889,000
19	2027	$1,201,000	$769,000	$0	$367,000	$621,000	$2,957,000
20	2028	$1,201,000	$769,000	$0	$367,000	$621,000	$2,957,000
TOTAL		**$26,588,000**	**$15,417,000**	**$764,000**	**$2,791,000**	**$17,280,000**	**$62,837,000**

[1]Total cost accounts for project overlap between capacity projects and rehabilitation projects.

The City currently budgets about $5.2M per year for all sewer CIP projects. If this budget level is maintained in the future, the City should be able to accelerate some of the lower-priority capacity projects and also perform more CRP projects. In particular, a higher percentage of the CRP projects could be performed as rehabilitation/replacement projects rather than spot repairs, providing a more permanent solution. Also, the additional funds could be productively used to package together rehabilitation/replacement projects having lower priority (e.g., Grade 4 defects) with adjacent projects having higher priority (e.g., Grade 5 defects).

The City's current CRP projects are shown in **Figure 8-1**.Those projects should be evaluated in terms of the priority criteria established in this Master Plan and the highest priority projects should be implemented along with the high-priority capacity projects.



L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\Figure 8-1 Current CIP.mxd

Appendix A - Fullerton Transportation Center Sewer Study

Technical Memorandum

RMC Water and Environment

City of Fullerton Sewer Master Plan

Subject: **Fullerton Transportation Center Sewer Study**

Prepared For: Yelena Voronel, Thuy Nguyen

Prepared by: Alison Hill

Reviewed by: Paul Giguere

Date: June 18, 2009

Reference: 0234-001.00

The Fullerton Transportation Center (FTC) Sewer Study was conducted to assess the impact of FTC redevelopment on wastewater flows and sewer system capacity. The study documents the assumptions made for estimating wastewater flows from proposed development, presents the results of simulations of sewer system capacity performed using a hydraulic model, and recommends an improvement project to convey future flows. The findings of the study will be incorporated into an Environmental Impact Report (EIR) prepared as part of the FTC planning process.

This report covers the following topics:

- Scope of Study
- Study Area
- Flow Estimation
- Hydraulic Modeling Results

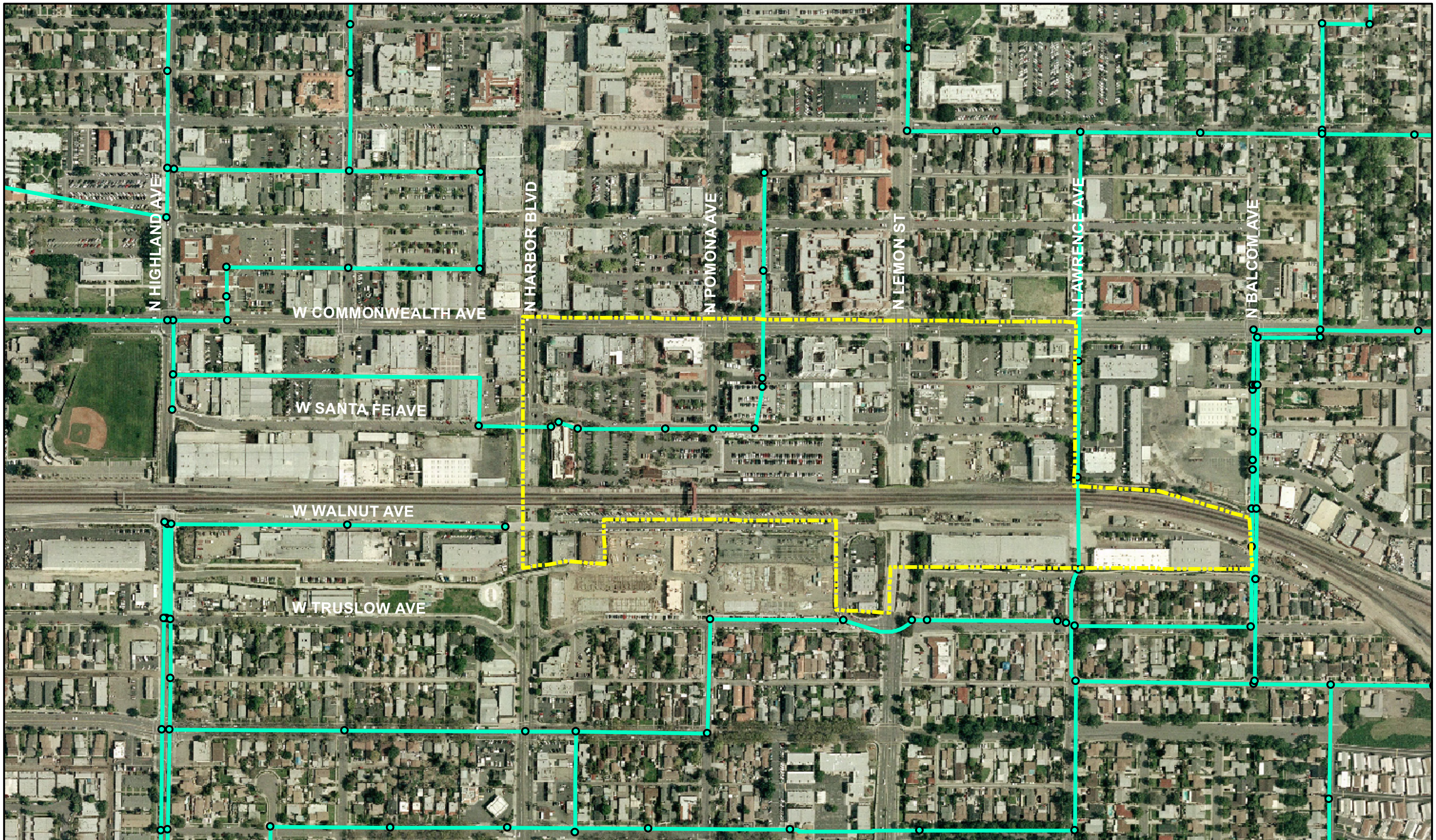
1 Scope of Study

This study involved updating the InfoSWMM™ (MWHSoft) model that was built and calibrated in 2008 as part of the City of Fullerton Sewer Master Plan (Master Plan) to include wastewater flows anticipated from the proposed FTC plan. The increased flows were added to future model scenarios and the results evaluated to determine if any capacity deficiencies would be caused by the FTC development.

Unless otherwise described in this report, all assumptions made as part of the Master Plan apply to this sewer study as well.

2 Study Area

The Fullerton Transportation Center study area covers approximately 44 acres of Fullerton's historic downtown core. The area includes a railroad line and transit center, industry and warehouse space, commercial properties, and one multi-story residential building. Sewer lines on Santa Fe Ave (12"), Truslow Ave (12") and Walnut Ave (10") were modeled as the major conveyors of wastewater from the FTC. Smaller sewers conveying flow from the FTC were not included in the study because it was assumed that these sewers would be replaced as part of the redevelopment process. **Figure 1** illustrates the extents of the FTC study area.



N

Miles

0.1

Existing Major Sewer

FTC Boundary

Fullerton Transportation Center Sewer Study

RMC Water and Environment

Figure 1
Study Area

3 Flow Estimation

As part of the Master Plan model building process (completed in 2008), existing residential and non-residential flows were estimated based on parcel-level water billing data. Future flows were estimated based on the Center for Demographic Research's (CDR) population and employment projections by Traffic Analysis Zone (TAZ). Completed in 2006, CDR's projections included an increase of 863 residents and 563 employees (equivalent to 0.08 mgd) relating to the FTC project.

For this study, the City's planning department provided updated details on the proposed FTC development by parcel group. A spreadsheet was provided listing the proposed square footages and number of dwelling units by type of use, as well as the existing development "to remain" and "to be demolished" for each parcel within the FTC. **Appendix A** is the FTC spreadsheet, and **Appendix B** is a site plan identifying each parcel.

The FTC spreadsheet lists figures for both a "high residential" scenario and a "high office" scenario. Based on the unit flow factor assumptions used for this study, the "high residential" scenario would produce more wastewater and was therefore the scenario analyzed in this study. Project phasing was not considered; all development was assumed to occur by 2035, which corresponds to the long-term scenario analyzed in the Master Plan.

The following steps were taken to convert the development information in the FTC spreadsheet into wastewater flow estimates:

- "Proposed" development. An alternate to the approach used in the Master Plan for calculating flow from new development was required because the Master Plan approach was based on population and employment projections, while the FTC plan is quantified in terms of dwelling units and square footages. Unit flow factors for non-residential development in the FTC plan were adopted from the City of Los Angeles (Bureau of Engineering *Sewer Design Manual, Part F,* Table F229):
    - Office and retail = 100 gpd / 1000 sq. ft.
    - Hotels = 150 gpd/room

  For FTC residential development, the wastewater flow from each dwelling unit was based on a household size of 2.93 (City's average household size recommended by the City's planning department for this study), and a per-capita unit flow rate of 75 gallons per day (calibrated unit flow rate used in the Master Plan).
- Development "to demolish". For the Master Plan, existing wastewater flows were computed from water billing data that had been geo-referenced to individual parcels. The flow from FTC parcels which were marked for demolition was removed by subtracting the wastewater flow calculated from the water billing data.
- Development "to remain". No change to the Master Plan flow was necessary. Flow from these parcels is already represented in the model using actual water billing data.
- The new incremental FTC flows were spatially assigned to the appropriate model basins.
- Previous estimates of FTC flow based on CDR population and employment projections by TAZ were removed from the model.

The total projected increase in average dry weather flow from the FTC is 0.37 mgd.

Peak dry weather flow was calculated based on calibrated curves of diurnal flow variation throughout the day. Several curves were used to represent residential and non-residential land use, weekdays and weekends, low-income and high-income areas. Curves were assigned to flows from smaller sewer basins (about 40 acres in size) that were routed dynamically through the hydraulic model.

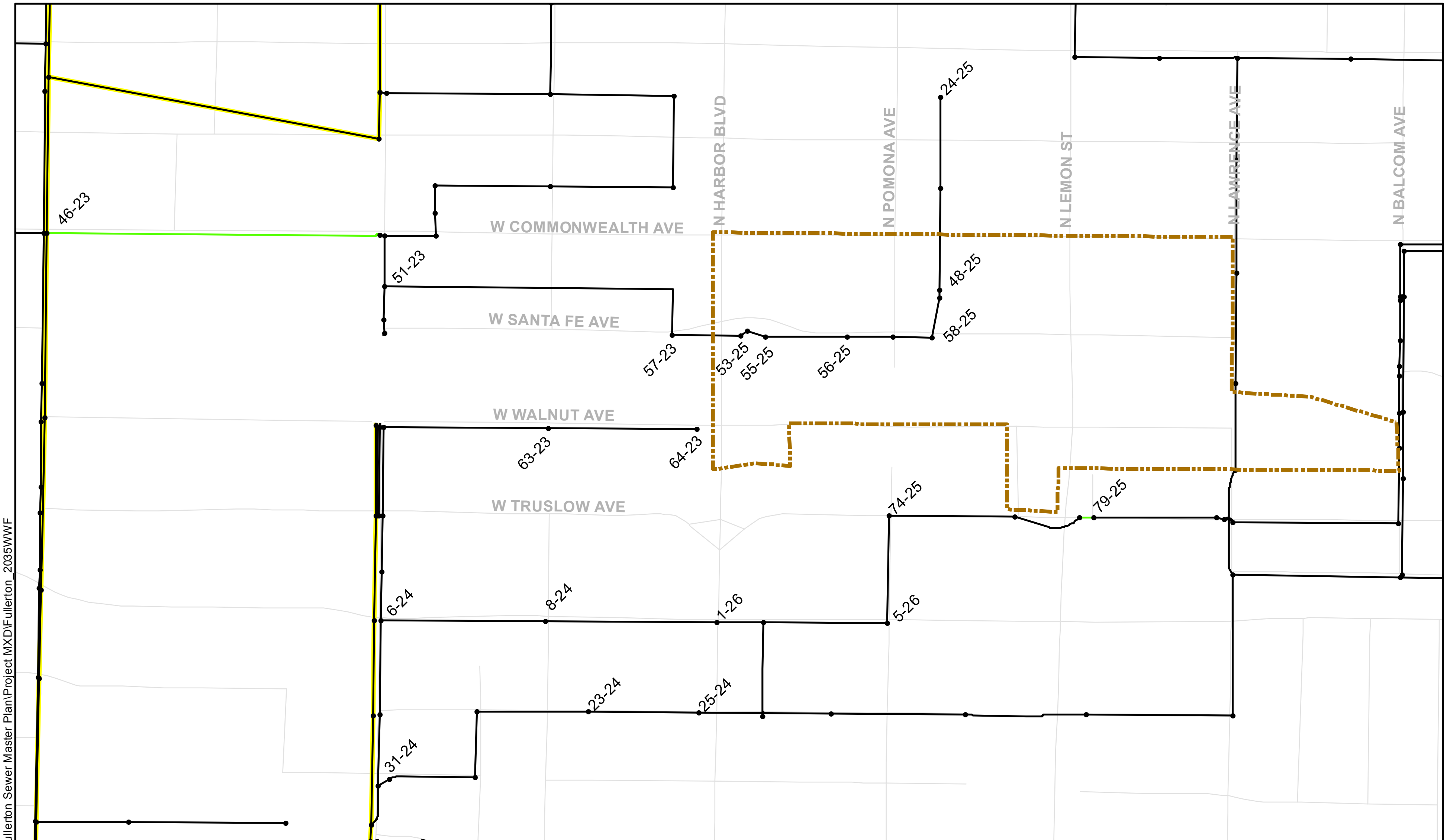
The existing sewer system's modeled response to wet weather flow was calibrated using flow meter data from a storm occurring in February of 2005. "Design" flows were then estimated by simulating the system's response to a larger, 10-year storm. For the FTC area, which is within Basin 11 of the 2005 metering study, the maximum peaking factor during the design storm was approximately 3.3 (ratio of peak wet weather flow to average dry weather flow). No change to the Master Plan model was made to either increase or decrease wet weather flow from the FTC area.

4 Hydraulic Modeling Results

Simulation results for 2035 dry and wet weather flow conditions are presented in **Figures 2 and 3**. The maximum depth to diameter ratio (d/D) for major sewers accepting the proposed FTC flow was 84% during dry weather conditions. During wet weather conditions, about 2.8 feet of surcharging is predicted at manhole 57-23, which exceeds the two feet of surcharge allowed by the project trigger criteria established for the Master Plan. The surcharging is due to a capacity limitation in the 12" line located in the alley just north of Santa Fe Ave between Harbor Ave and Highland Ave. It is noted that without the increased FTC flows, this line would have sufficient capacity under 2035 peak wet weather conditions.

A project is currently in design to divert flows from the alley to a new 12 to 15-inch diameter line on Santa Fe Ave and Highland Ave. This project was initiated because the alley line is in poor condition, difficult to access for maintenance, and undersized to convey flow from the Fullerton Transportation Center (as determined by the *City of Fullerton Basin 11 Sewer Study, PBS&J, 2007*). The 2009 design-level cost estimate provided by the City is $586,000 (includes 30% markup for engineering, contract administration and contingency costs). **Figure 4** shows the location of the proposed pipeline.

The City's proposed Highland/Santa Fe project was analyzed using the hydraulic model and found to be sufficient to convey flows from the FTC (see **Figure 5**). The 2035 peak wet weather flow in the proposed pipeline, which includes the existing and proposed FTC flows, is 1.2 mgd. It is estimated that new FTC development accounts for 0.44 mgd or 37% of the total peak flow in the pipe.



N

0.1 Miles

Maximum Depth to Diameter Ratio (d/D)

- less than 75%
- 75% - 100%
- Surcharge: Flow Backup
- Surcharge: Capacity Limitation

- Modeled Manholes
- OCSD Sewer
- FTC Boundary

RMC Water and Environment

Fullerton Transit Center
Sewer Study

Figure 2
2035 Dry Weather
Capacity Analysis

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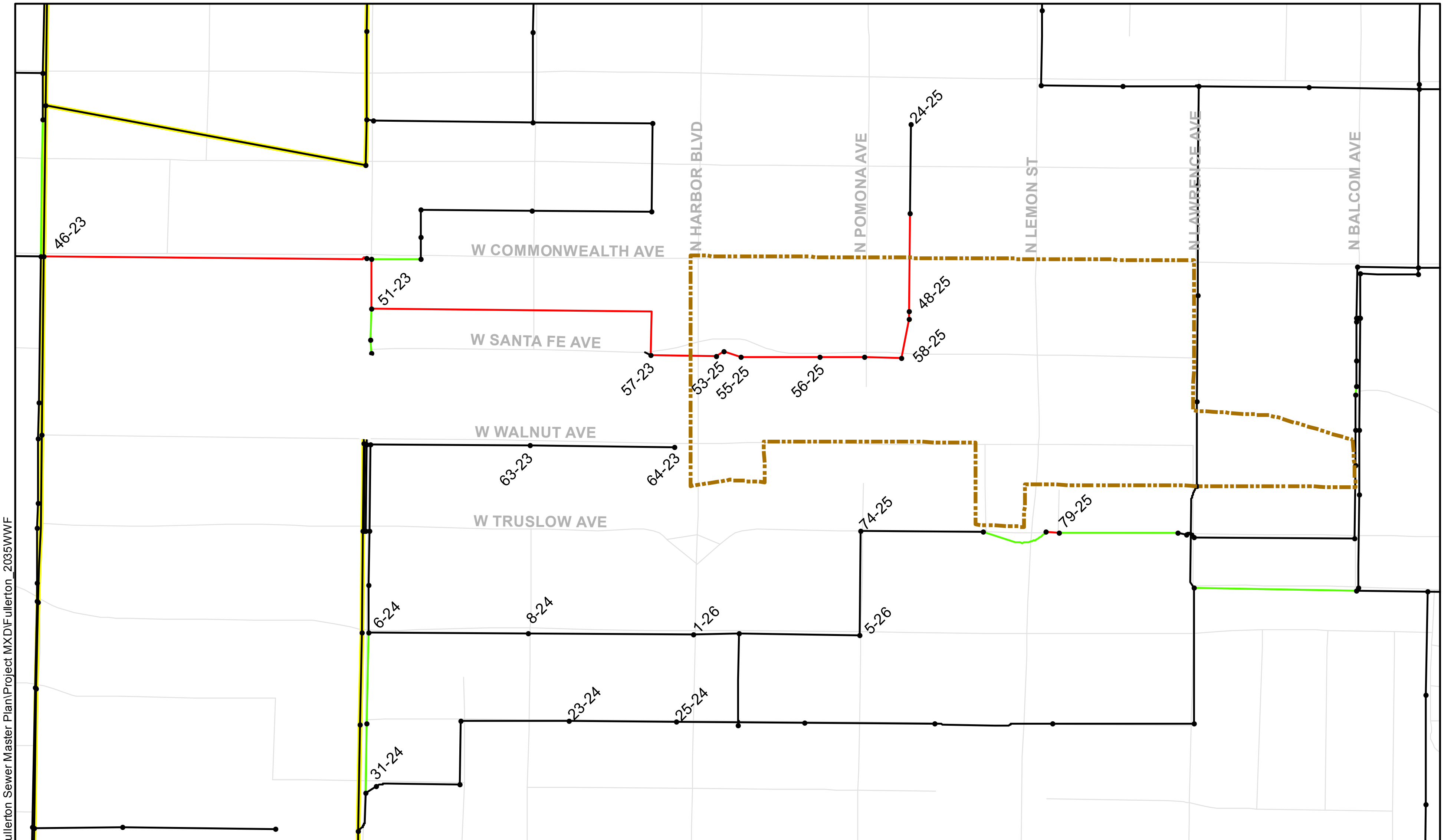


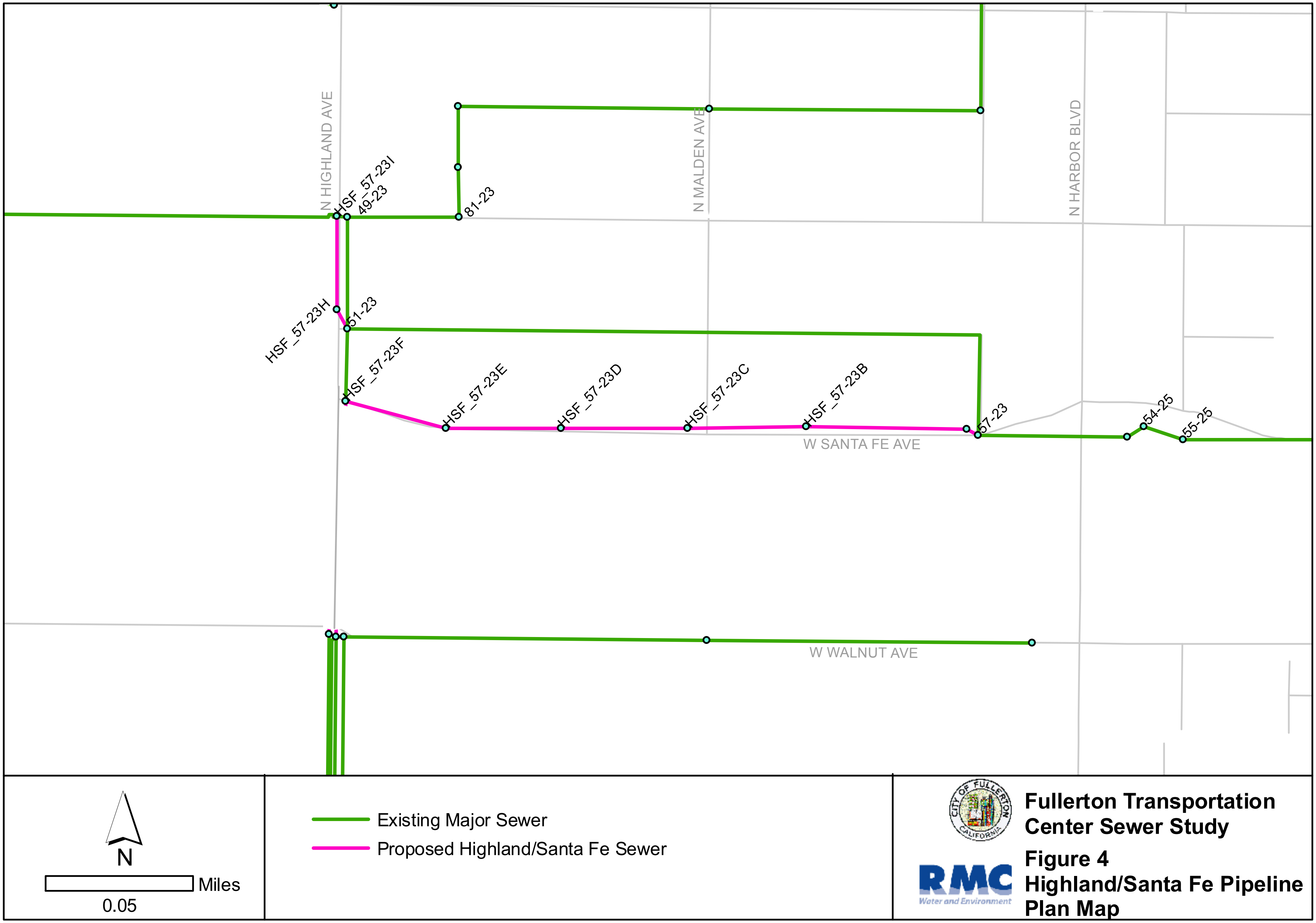
Maximum Depth-to-Diameter (d/D) Ratio

- less than 75%
- 75% - 100%
- Surcharge: Flow Backup
- Surcharge: Capacity Limitation
- Modeled Manholes
- OCSD Sewer
- FTC Boundary

Fullerton Transit Center Sewer Study

Figure 3
2035 Wet Weather Capacity Analysis

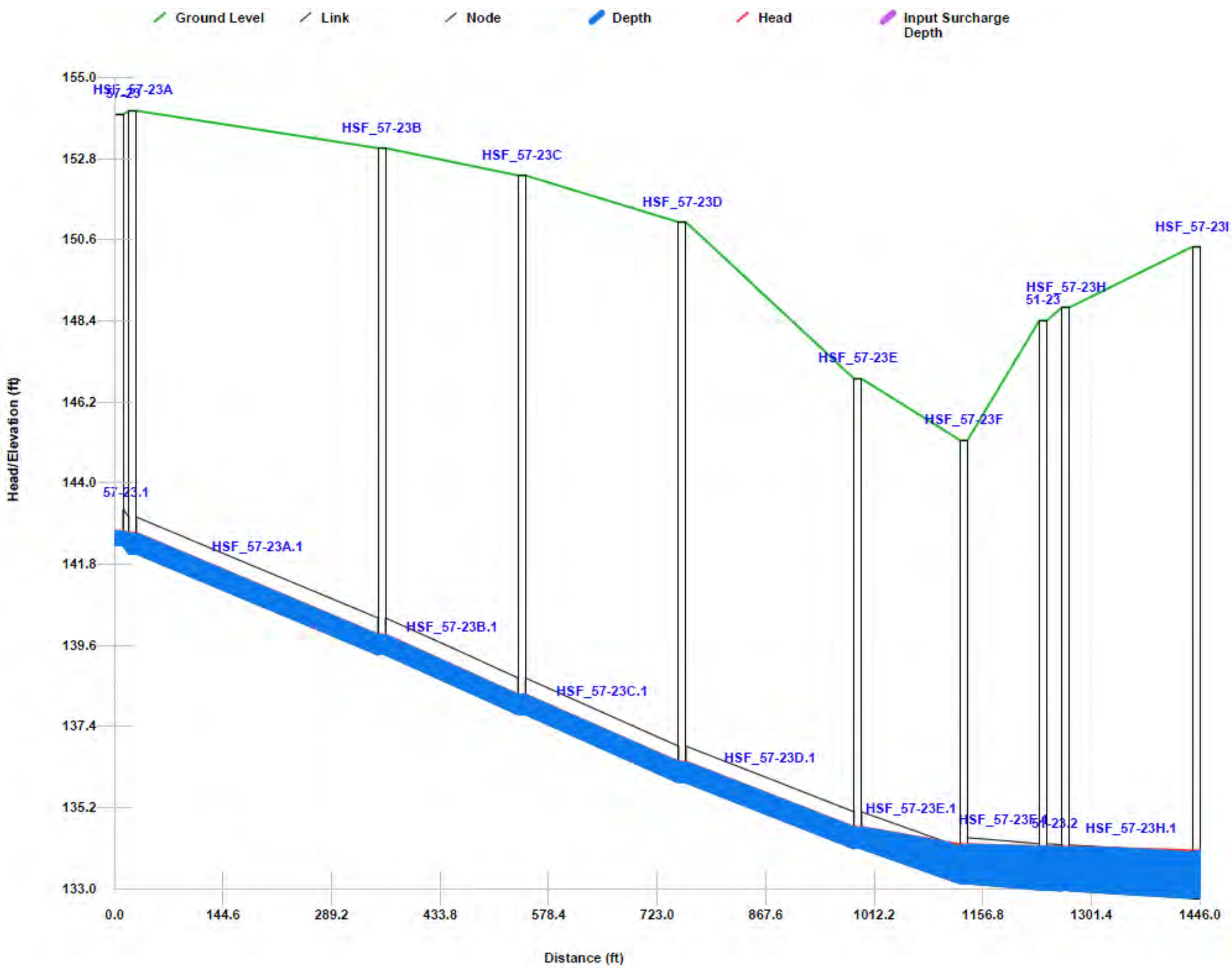
L:\Projects GIS\0234-001.00 Fullerton Sewer Master Plan\Project MXD\Fullerton_2035WWF



Fullerton Transportation Center Sewer Study

Figure 4
Highland/Santa Fe Pipeline Plan Map

Figure 5. Proposed Highland/Santa Fe Pipe Hydraulic Profile at 2035 Peak Wet Weather Flow



Appendix A - FTC Planning Spreadsheet

FULLERTON TRANSPORTATION CENTER
Program Summary by Building
WORKING DRAFT
May 7, 2009

Building No.	PROPOSED SQUARE FOOTAGE (BY USE) General Retail	Low Office**	High Office*	Hotel	Hotel Rooms	Low Residential *	High Residential**	Low DUs *	High DUs **	TOTAL S.F. (Office Intensive)	TOTAL S.F. (Residential Intensive)	# of Stories	Max. Building Height (Ft.)
WEST PARCELS													
W1-I				120,000	*120*					120,000	120,000	5	70
W1-II	2,000					*28,575*	*28,575*	*25*	*25*	30,575	30,575	1 to 3	70
W1-III	15,000	25,000	25,000							40,000	40,000	3	45
W2-I	12,000		12,000			45,750	57,750	44	*55*	69,750	69,750	5	70
W3-I	13,000		13,000			44,750	57,750	43	*55*	70,750	70,750	5	70
W4-I													
W4-II	10,000	24,000	24,000							34,000	34,000	3	50
W4-III													
CENTRAL PARCELS													
C1-I	2,000					36,750	36,750	*35*	*35*	38,750	38,750	6	80
C1-II						26,250	26,250	*25*	*25*	26,250	26,250	6	80
C1-III													
C1-IV	5,000					52,500	52,500	*50*	*50*	57,500	57,500	6	80
C2-I	15,000		11,000			146,500	157,500	*140*	*150*	172,500	172,500	9	100
C3-I						157,500	157,500	*150*	*150*	157,500	157,500	9	100
C4-I	15,000		15,000			79,500	94,500	*76*	*90*	109,500	109,500	6	80
C4-II	Included in C4-1												
EAST PARCELS													
E1-I	3,500					52,500	52,500	*50*	*50*	56,000	56,000	6	80
E1-II	4,000					57,750	57,750	*55*	*55*	61,750	61,750	6	80
E1-III	3,500					52,500	52,500	*50*	*50*	56,000	56,000	6	80
E2-I						84,000	84,000	*80*	*80*	84,000	84,000	9	100
E2-II						63,000	63,000	*60*	*60*	63,000	63,000	9	100
E2-III						84,000	84,000	*80*	*80*	84,000	84,000	9	100
E3-I						42,000	42,000	*40*	*40*	42,000	42,000	6	80
E3-II						31,500	31,500	*30*	*30*	31,500	31,500	6	80
E3-III						52,500	52,500	*50*	*50*	52,500	52,500	6	80
SOUTHEAST PARCELS													
S1-I						5,250	5,250	*5*	*5*	5,250	5,250	3	35
S1-II						5,250	5,250	*5*	*5*	5,250	5,250	3	35
S2-I						63,000	63,000	*60*	*60*	63,000	63,000	5	55
S2-II						63,000	63,000	*60*	*60*	63,000	63,000	5	55
S2-III						63,000	63,000	*60*	*60*	63,000	63,000	5	55
S3-I						63,000	63,000	*60*	*60*	63,000	63,000	5	55
S3-II						63,000	63,000	*60*	*60*	63,000	63,000	5	55
S3-III						42,000	42,000	*40*	*40*	42,000	42,000	5	55
SOUTHWEST PARCELS													
B1-I						84000	84000	*80*	*80*	84,000	84,000	9	100
TOTAL :	**100,000**	**49,000**	**100,000**	**120,000**		**1,589,325**	**1,640,325**	**1,511**	**1,560**	**1,909,325**	**1,909,325**		

Building No.	Assessor Parcel No.'s	Unique Existing Buidlings	EXISTING S.F. TO REMAIN (BY USE) Retail	Office	Residential	No. of Units / Rooms	Restaurant	Public Structure	TOTAL SQUARE FOOTAGE (Sq. Ft.)	# of Stories	Appox. Ex. Max. Height (Ft.)
W1-I	033-031-44, 45, 27		0	0	0	0	0	0	0		
W1-II	033-031-04, 05, 19, 25, 36	Existing Building Cluster	0	1,500	0	0	23,500	17,850	42,850		
W1-III	033-031-46		0	0	0	0	0	0	0		
W2-I	033-031-39		0	0	0	0	0	0	0		
W3-I	033-031-23		0	0	0	0	0	0	0		
W4-I	033-030-13	Existing "Spaghetti Factory"	0	0	0	0	14,940	0	14,940		
W4-II	033-030-14		0	0	0	0	0	0	0		
W4-III	033-030-17	Existing Train Depot	0	0	0	0	0	6,850	6,850		
C1-I	033-032-01	Existing Post Office	0	0	0	0	0	6,000	6,000		
C1-II	033-032-05, 06, 07		0	0	0	0	0	0	0		
C1-III	033-032-29	Existing SRO	0	0	49,400	137	0	0	49,400		
C1-IV	033-032-11, 26		0	0	0	0	0	0	0		
C2-I	033-032-28, 27, 17		0	0	0	0	0	0	0		
C3-I	033-032-18, 19, 20		0	0	0	0	0	0	0		
C4-I	033-030-17		0	0	0	0	0	0	0		
C4-II	033-030-12		0	0	0	0	0	0	0		
E1-I	033-091-23, 21		0	0	0	0	0	0	0		
E1-II	033-091-24, 25		0	0	0	0	0	0	0		
E1-III	033-091-28, 29		0	0	0	0	0	0	0		
E2-I	033-091-27		0	0	0	0	0	0	0		
E2-II	033-091-18		0	0	0	0	0	0	0		
E2-III	033-091-17, 10	Existing Lakeman Chassis	0	0	0	0	0	0	0		
E3-I	033-092-08		0	0	0	0	0	0	0		
E3-II	033-092-07		0	0	0	0	0	0	0		
E3-III	033-092-05		0	0	0	0	0	0	0		
S1-I	033-045-04		0	0	0	0	0	0	0		
S1-II	(inc. in 033-045-04)		-	-	-	-	-	-	-	-	-
S2-I	033-092-18		0	0	0	0	0	0	0		
S2-II	(inc. in 033-092-18)		-	-	-	-	-	-	-	-	-
S2-III	(inc. in 033-092-18)		-	-	-	-	-	-	-	-	-
S3-I	033-0143-36		0	0	0	0	0	0	0		
S3-II	033-0143-37, 30		0	0	0	0	0	0	0		
S3-III	(inc. in 033-0143-37, 30)		-	-	-	-	-	-	-	-	-
B1-I	033-041-31, 33	Existing Ice House	0	6,634	0	0	0	9,520	16,154		
TOTAL :			**0**	**8,134**	**49,400**	**137**	**38,440**	**40,220**	**136,194**		

Building No.	EXISTING S.F. TO BE DEMOLISHED (BY USE) Retail	Office	Residential	No. of Units / Rooms	Restaurant	Public Structure	Warehouse / Storage	Industrial	TOTAL SQUARE FOOTAGE (Sq. Ft.)
W1-I	0	0	0	0	7,693	0	0	0	7,693
W1-II	0	0	0	0	0	0	0	0	0
W1-III	0	5,080	0	0	0	0	0	0	5,080
W2-I	0	0	0	0	0	0	0	0	0
W3-I	0	0	0	0	0	0	0	0	0
W4-I	0	0	0	0	0	0	0	0	0
W4-II	0	0	0	0	0	0	0	0	0
W4-III	0	0	0	0	0	0	0	0	0
C1-I	0	0	0	0	0	0	0	0	0
C1-II	0	5,600	0	0	0	0	0	0	5,600
C1-III	0	0	0	0	0	0	0	0	0
C1-IV	800	7,250	0	0	0	0	0	0	8,050
C2-I	0	0	0	0	0	0	3,800	0	3,800
C3-I	0	0	1,015	1	0	0	5,064	23,885	29,964
C4-I	0	0	0	0	0	0	0	0	0
C4-II	0	0	0	0	0	0	0	5,500	5,500
E1-I	0	4,360	0	0	2,548	11,000	0	0	17,908
E1-II	0	8,554	0	0	0	0	0	0	8,554
E1-III	0	7,873	0	0	0	0	0	0	7,873
E2-I	0	0	0	0	0	0	7,068	0	7,068
E2-II	0	0	0	0	0	0	0	0	0
E2-III	0	0	0	0	0	0	0	8,280	8,280
E3-I	0	720	0	0	0	0	5,100	0	5,820
E3-II	0	0	0	0	0	0	1,600	0	1,600
E3-III	0	0	0	0	0	0	0	10,712	10,712
S1-I	0	0	0	0	0	0	0	7,648	7,648
S1-II	-	-	-	-	-	-	-	-	-
S2-I	0	0	0	0	0	0	52,573	0	52,573
S2-II	-	-	-	-	-	-	-	-	-
S2-III	-	-	-	-	-	-	-	-	-
S3-I	0	0	0	0	0	0	17,150	2,000	19,150
S3-II	0	0	0	0	0	0	18,975	0	18,975
S3-III	-	-	-	-	-	-	-	-	-
B1-I	0	0	0	0	0	0	0	0	0
TOTAL :	**800**	**39,437**	**1,015**	**1**	**10,241**	**11,000**	**111,330**	**58,025**	**231,848**

NOTE 1: Phase 1 Projects highlighted in Yellow

NOTE 2: Refer to attached map for Building Nos.

NOTE 3: Building height does not include parapet, architectural roof features, or mechanical equipment roof elements.

NOTE 4: Properties with historic structures highted in purple

NOTE 5: Form based code allows flexible use of buildings. Anticipated maximum combinations are as follows:
* High Residential Scenario : Maximum 1,560 Dus and Maximum 49,000 sf Office
** High Office Scenario : Maximum 1,511 Dwellings and Maximum 100,000 sf Office
Both scenarios have a max. total square footage of: 1,909,325
Office to Residential equivalency : 1,050 sf office = 1 dwelling

Appendix B - FTC Parcel Map

DRAFT REGULATING SITE PLAN FOR THE FULLERTON TRANSPORTATION CENTER SPECIFIC PLAN

NOTE: IN-PROGRESS DRAWING

BUILDING LOCATIONS, USES & HEIGHTS MAY VARY

Prepared by JOHNSON FAIN
Revised May 07, 2009

Appendix B - Model Subcatchment Map

N

Miles

1

Subcatchments

Fullerton

OCSD

Load Manhole

Modeled Sewer

County Boundary

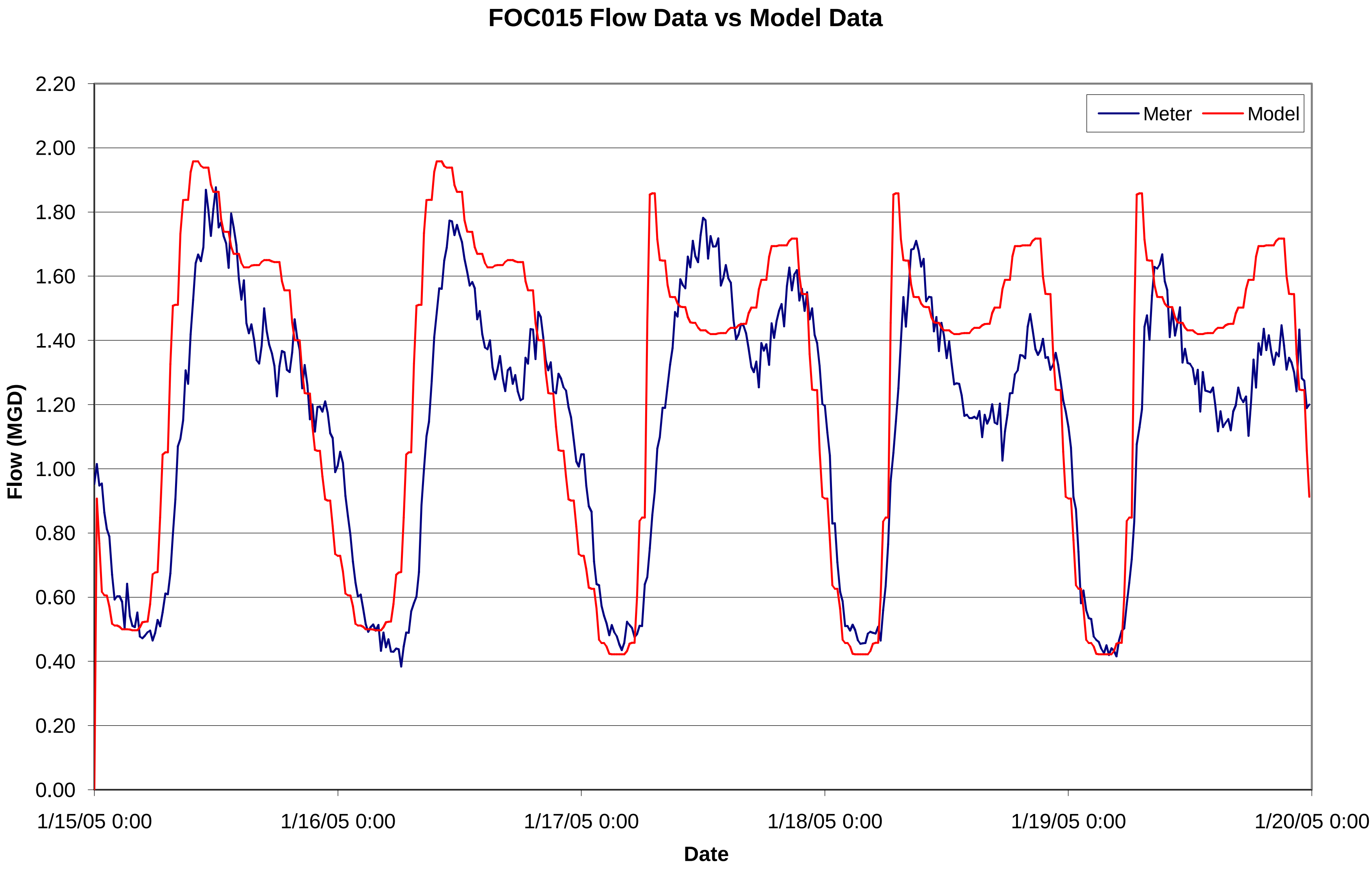
City Boundary

City of Fullerton
Sewer Master Plan

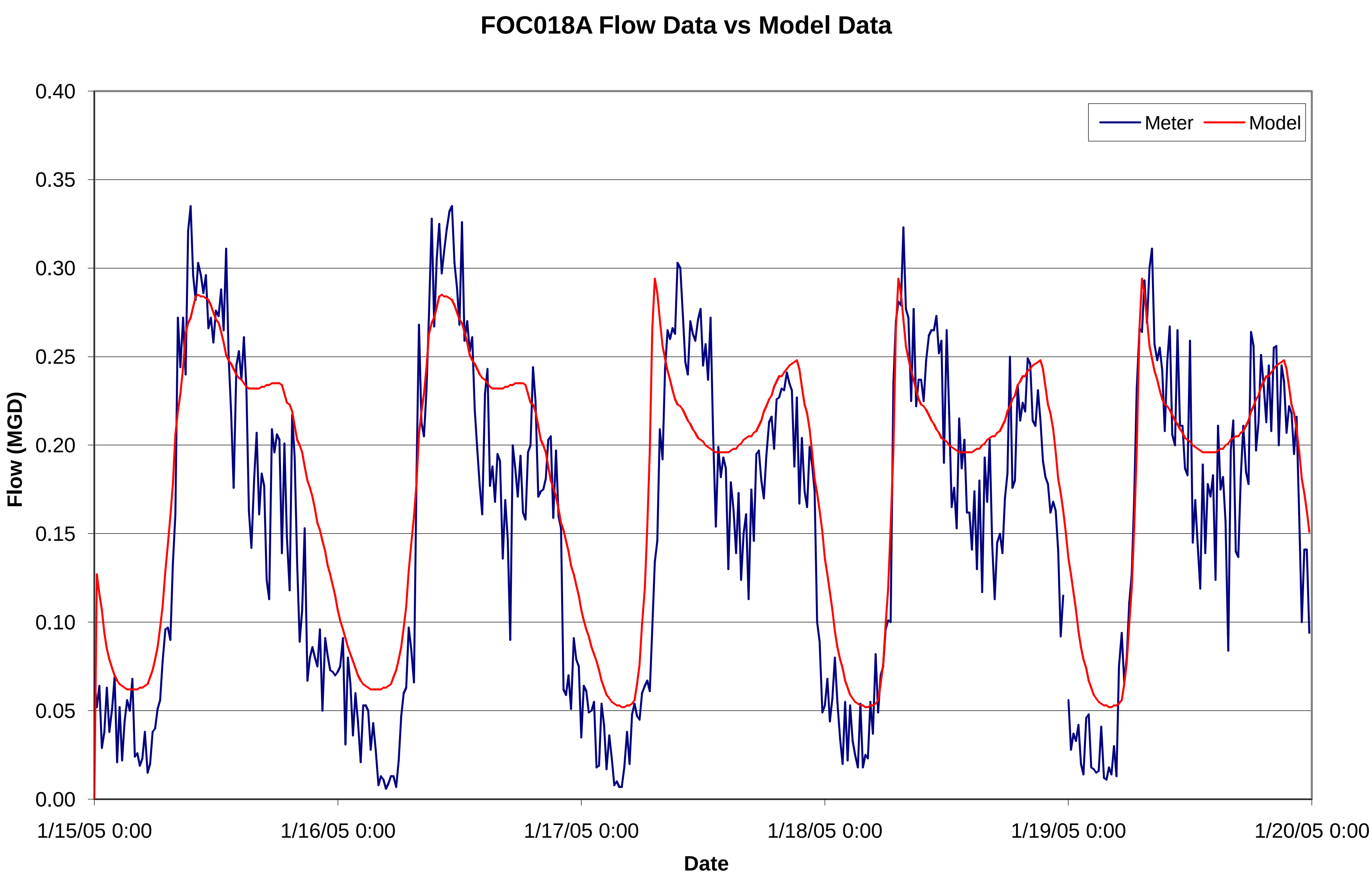
RMC

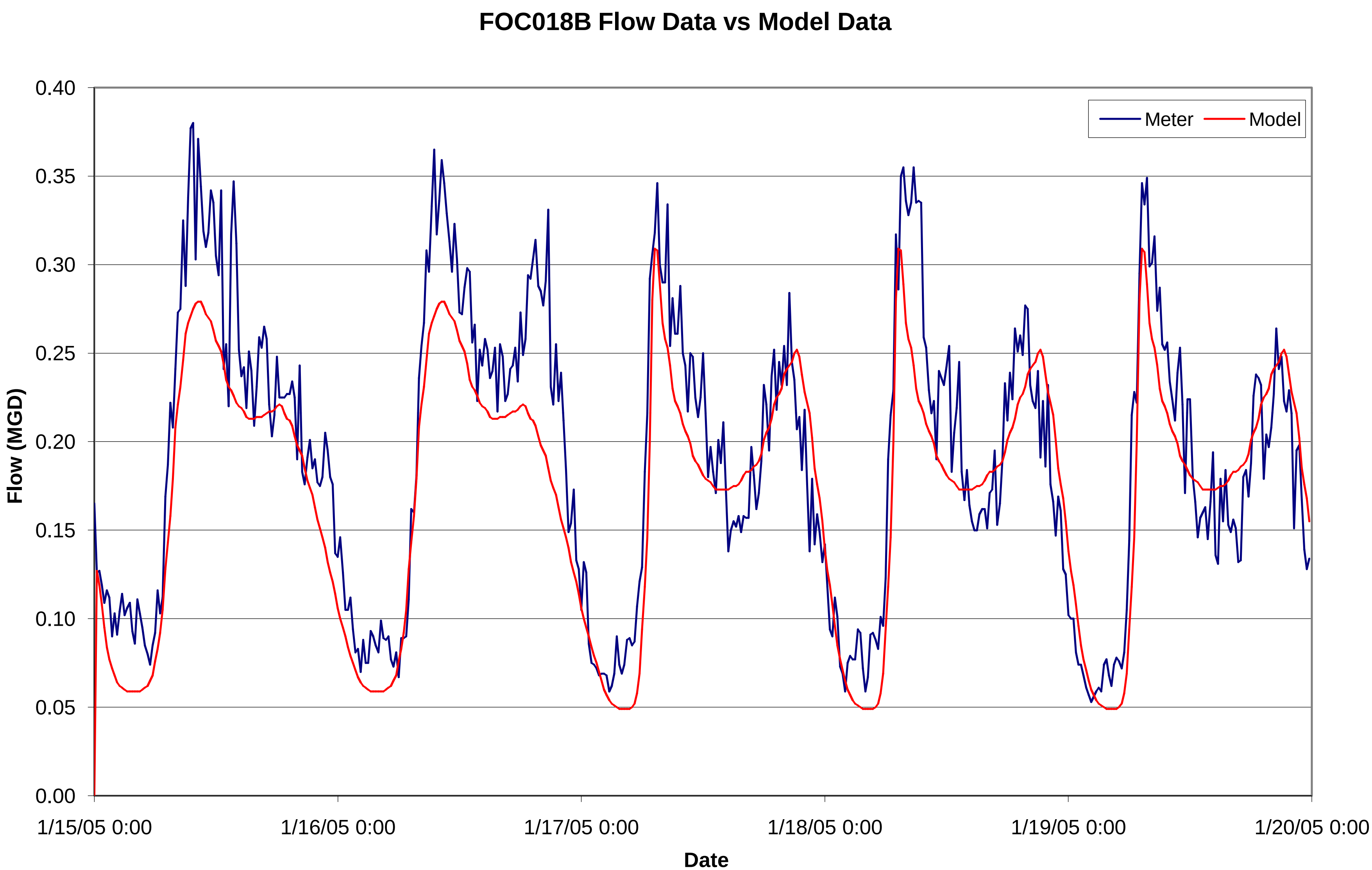
Modeled
Subcatchments

Appendix C - Dry Weather Calibration Plots

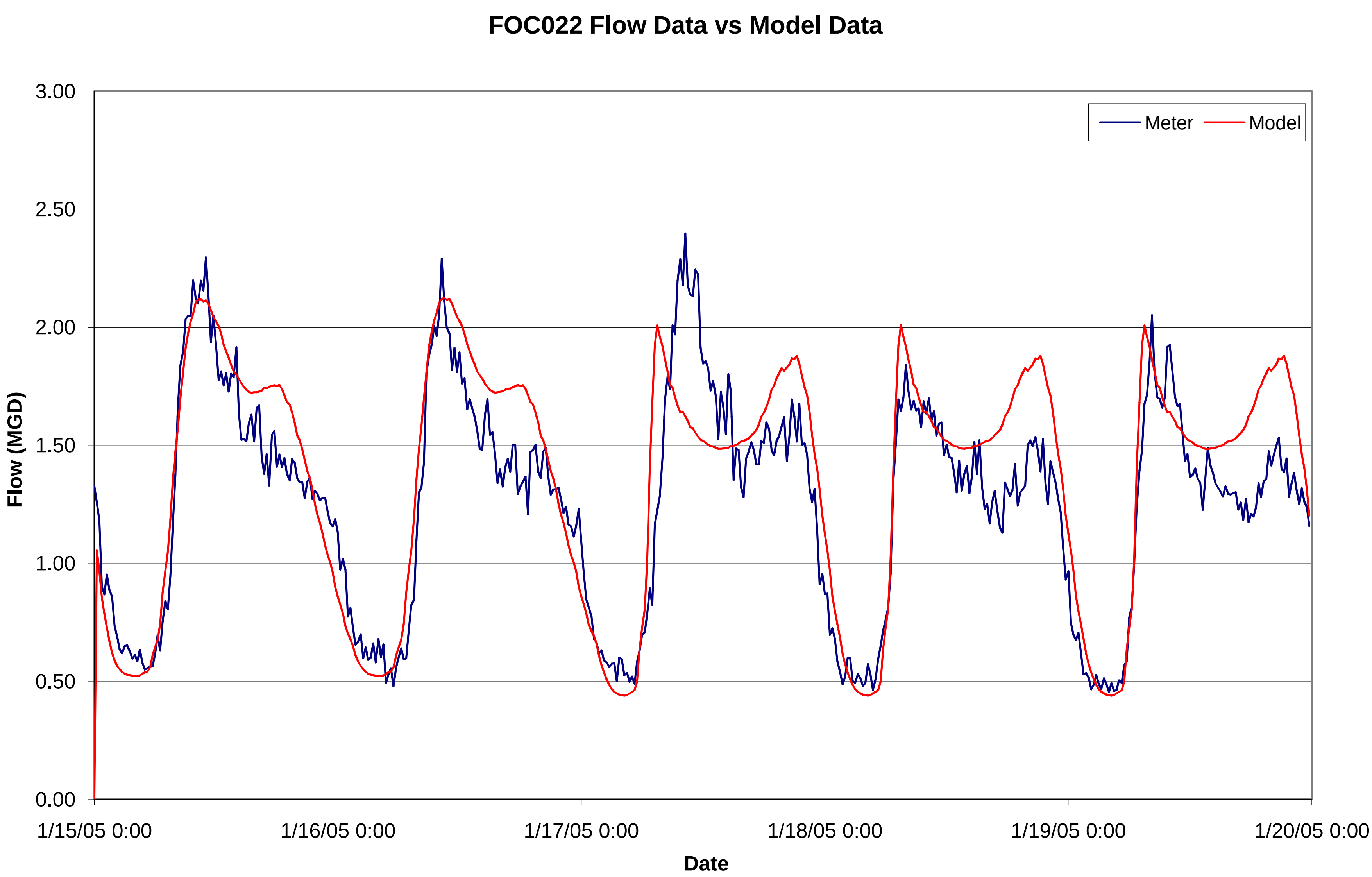


FOC015 Flow Data vs Model Data
Meter
Model
Flow (MGD)
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

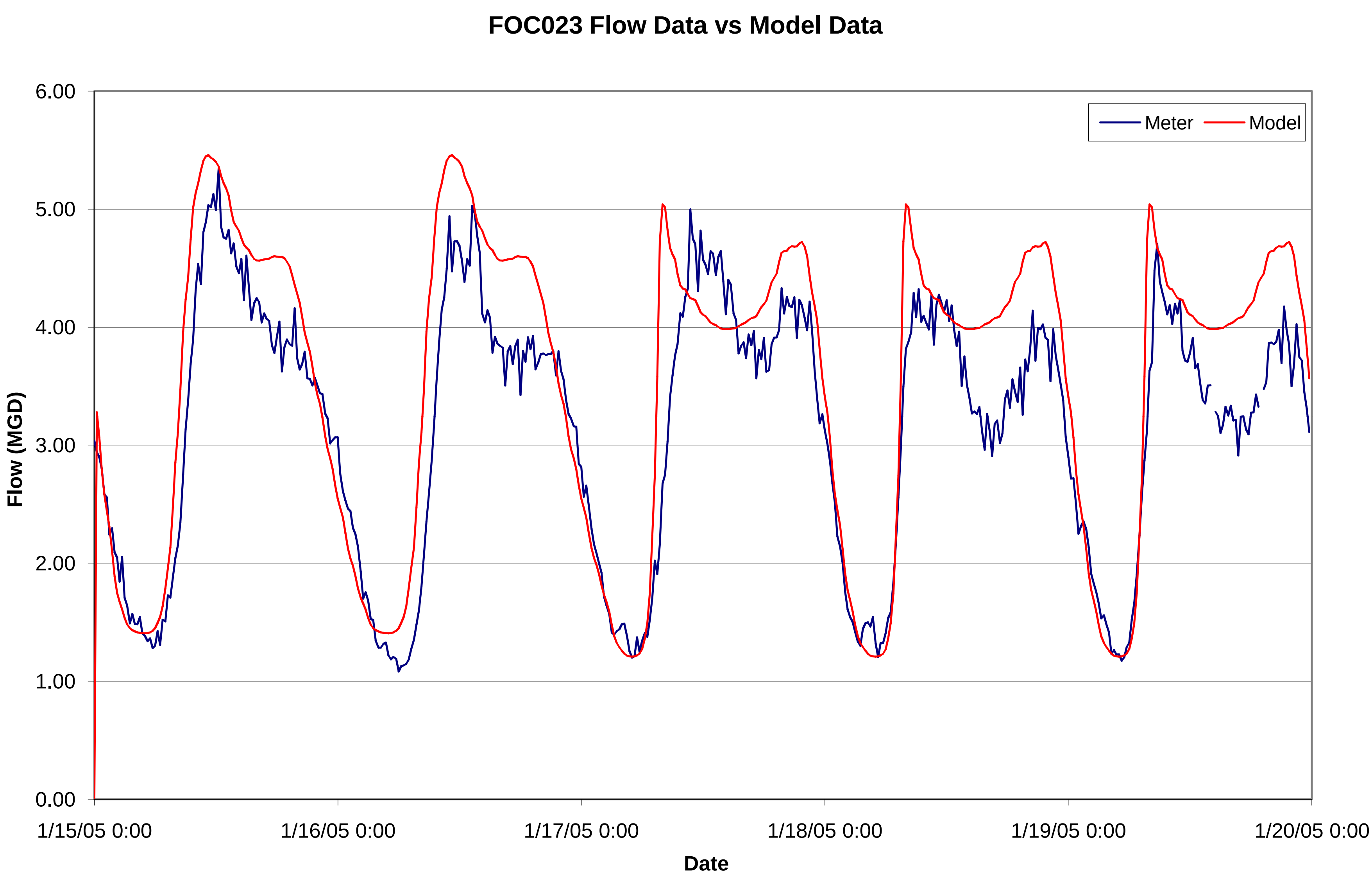

FOC018A Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

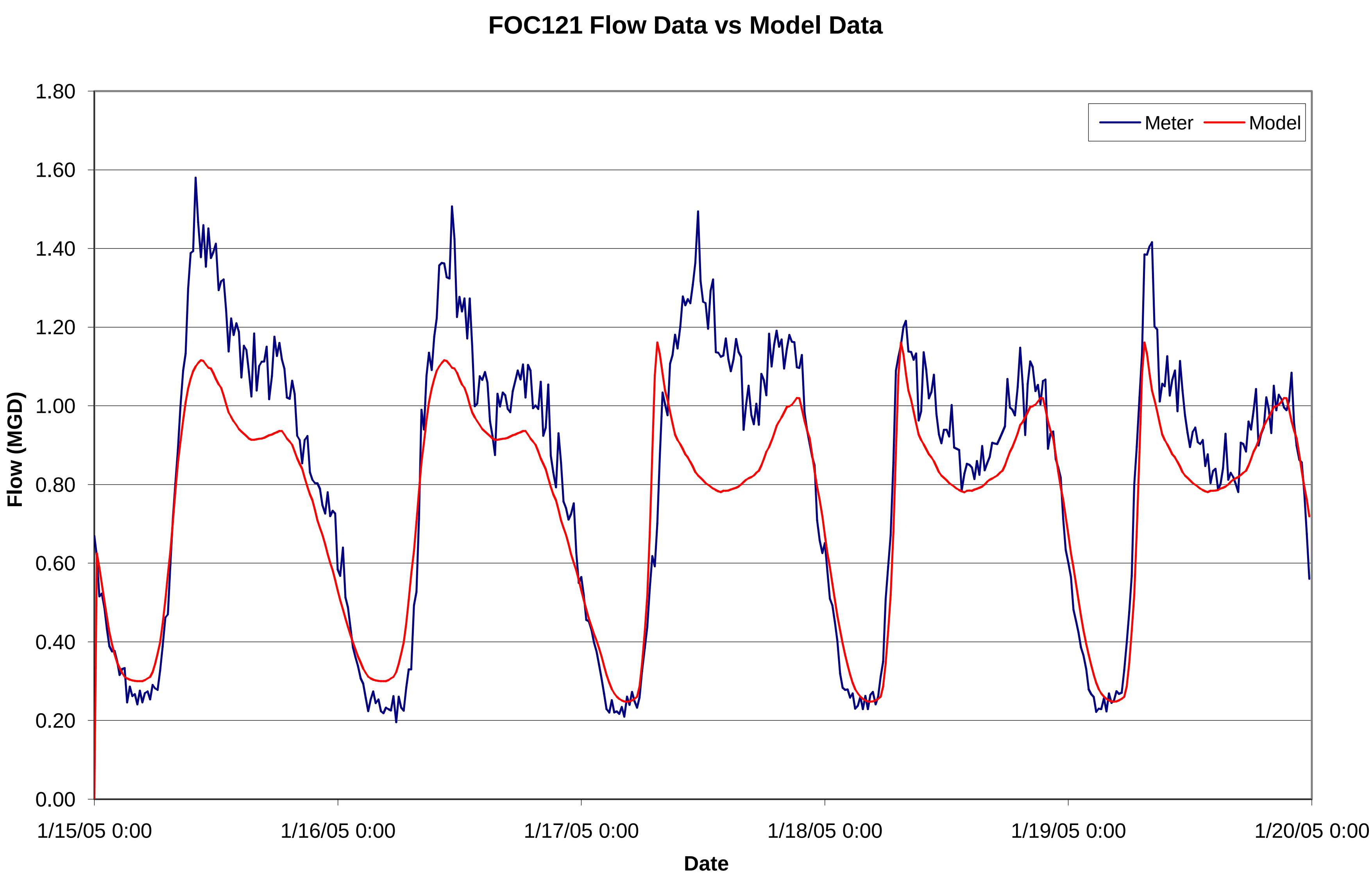


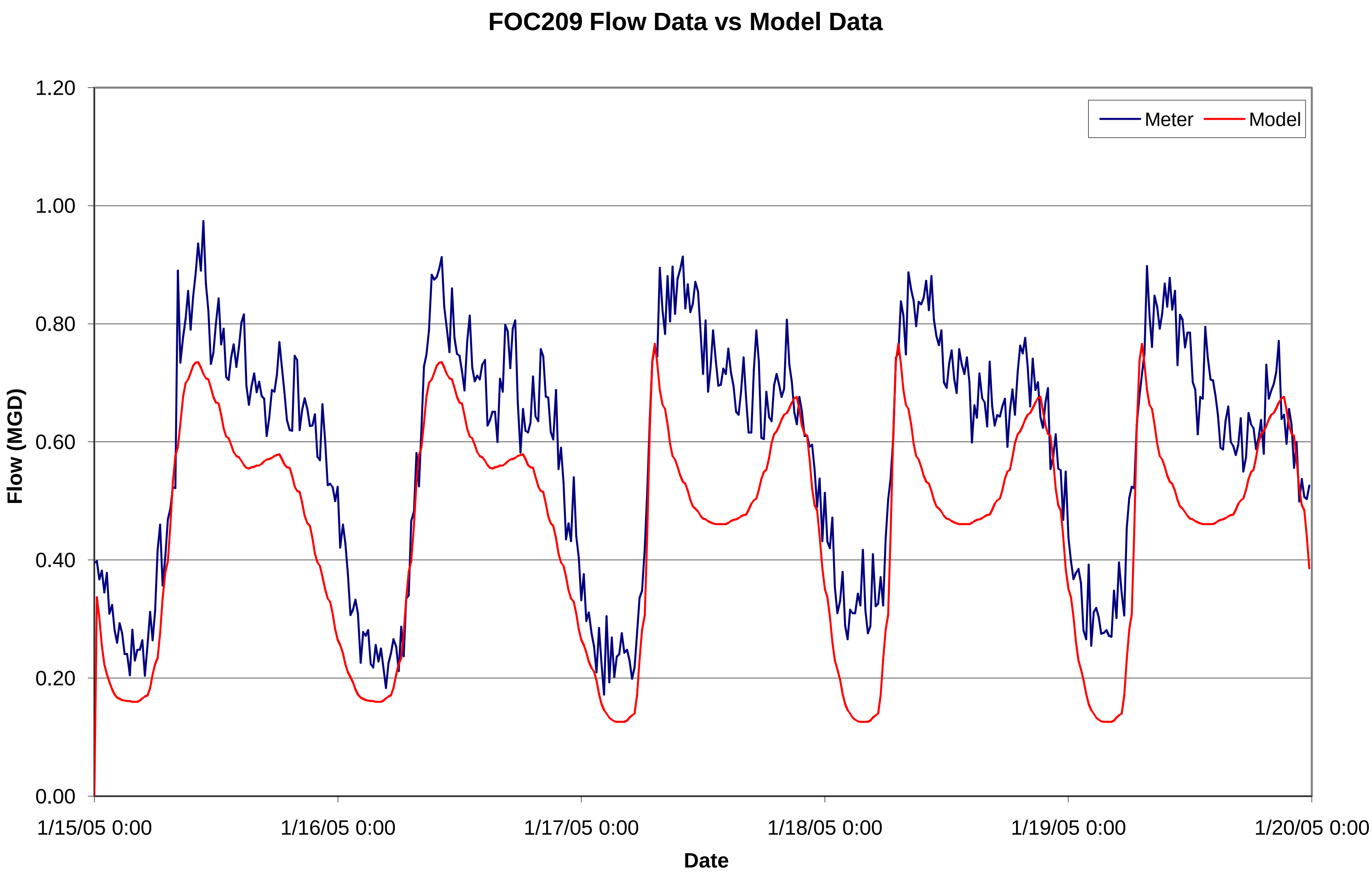
FOC018B Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date



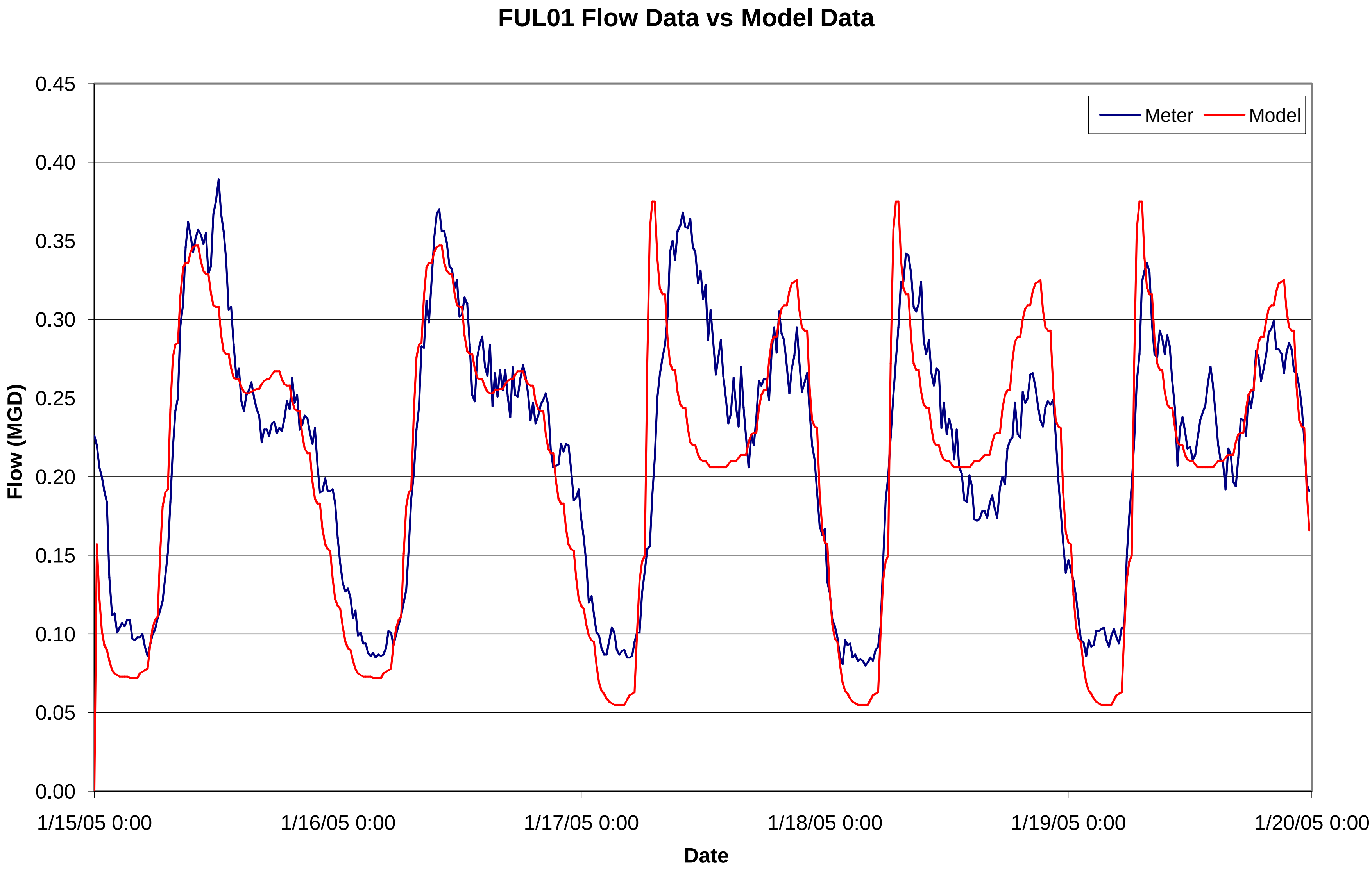
FOC022 Flow Data vs Model Data
Meter
Model
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Flow (MGD)
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date


FOC023 Flow Data vs Model Data
Meter
Model
Flow (MGD)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

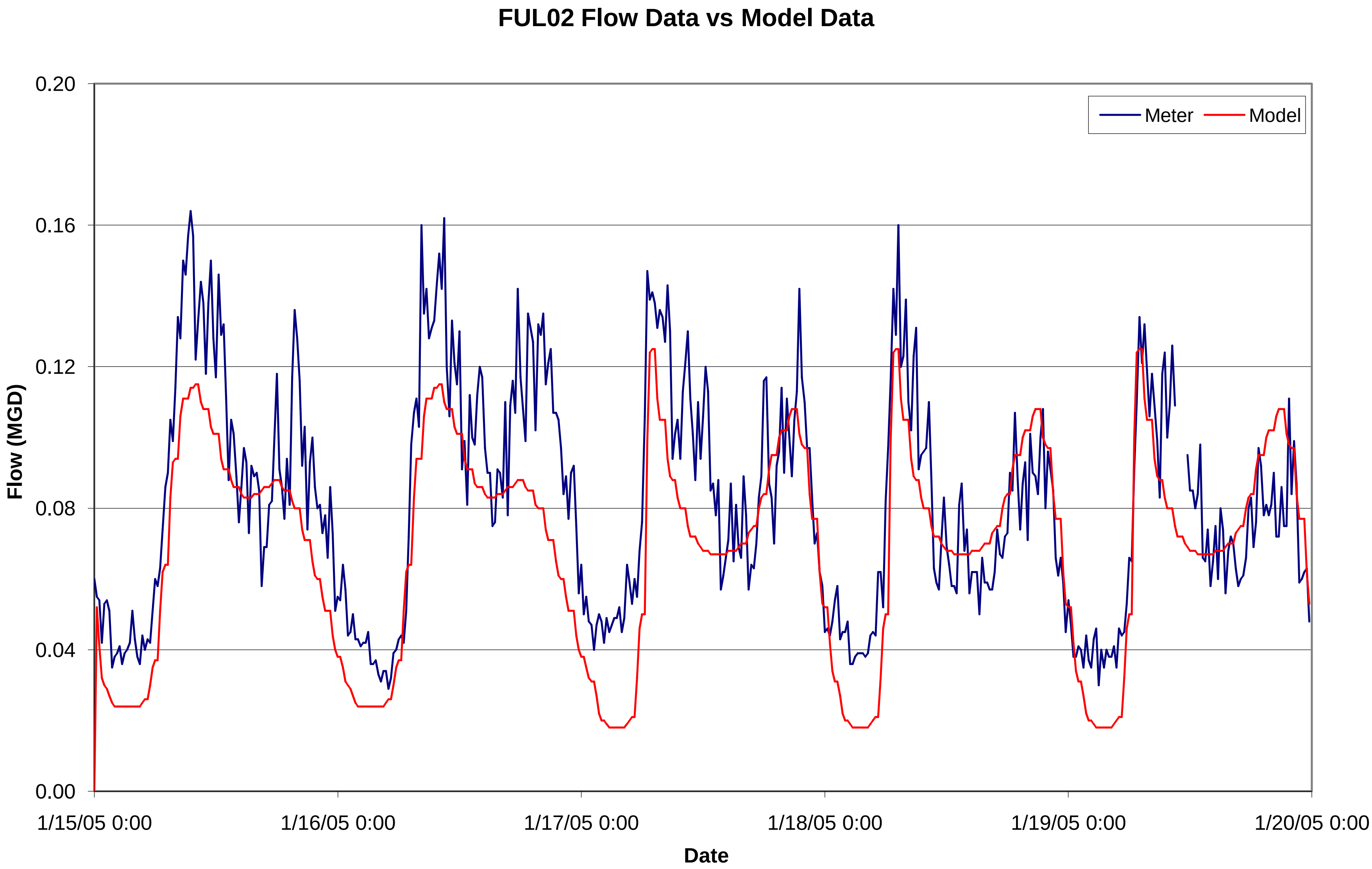

FOC121 Flow Data vs Model Data
Meter
Model
Flow (MGD)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

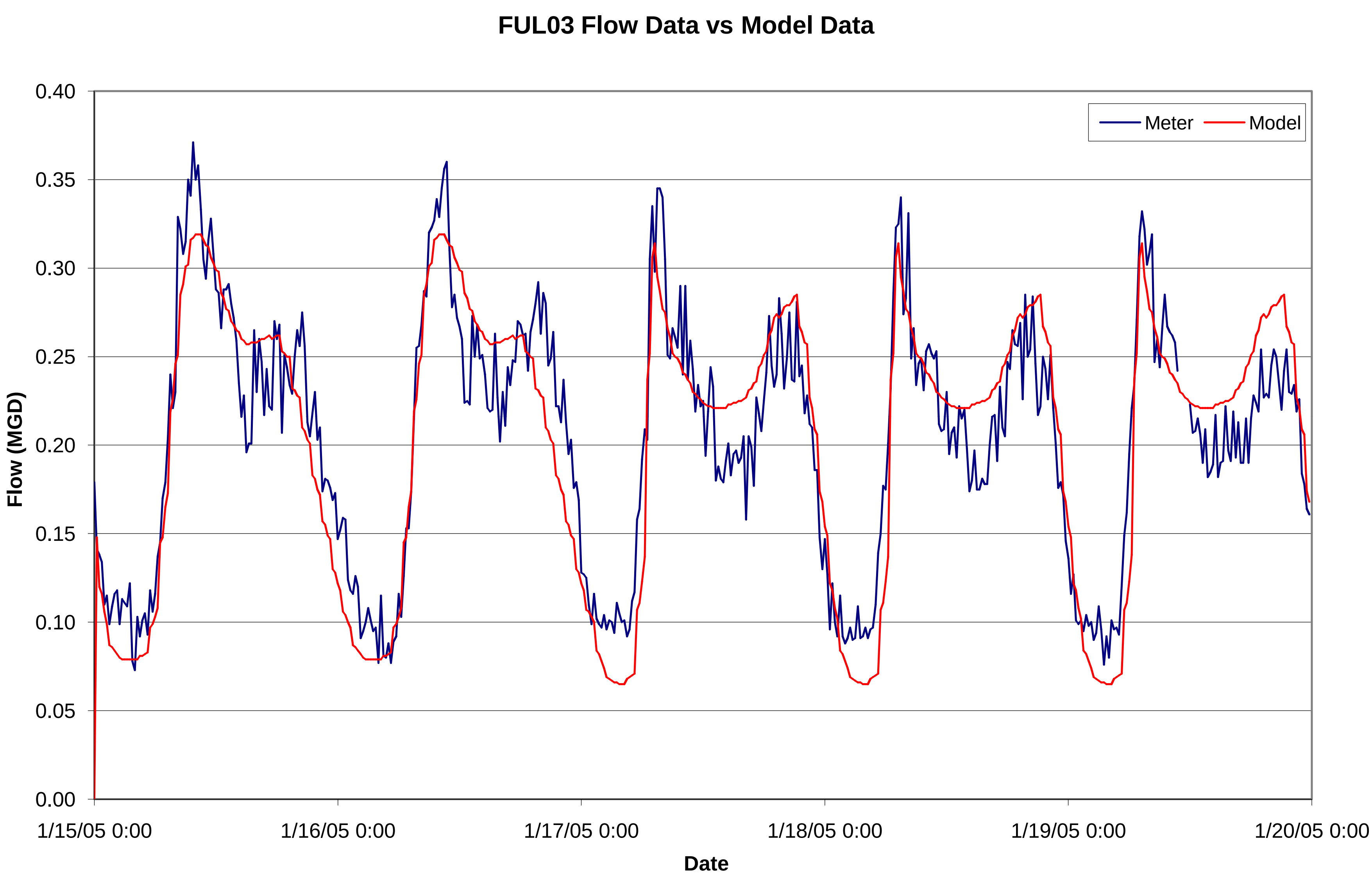


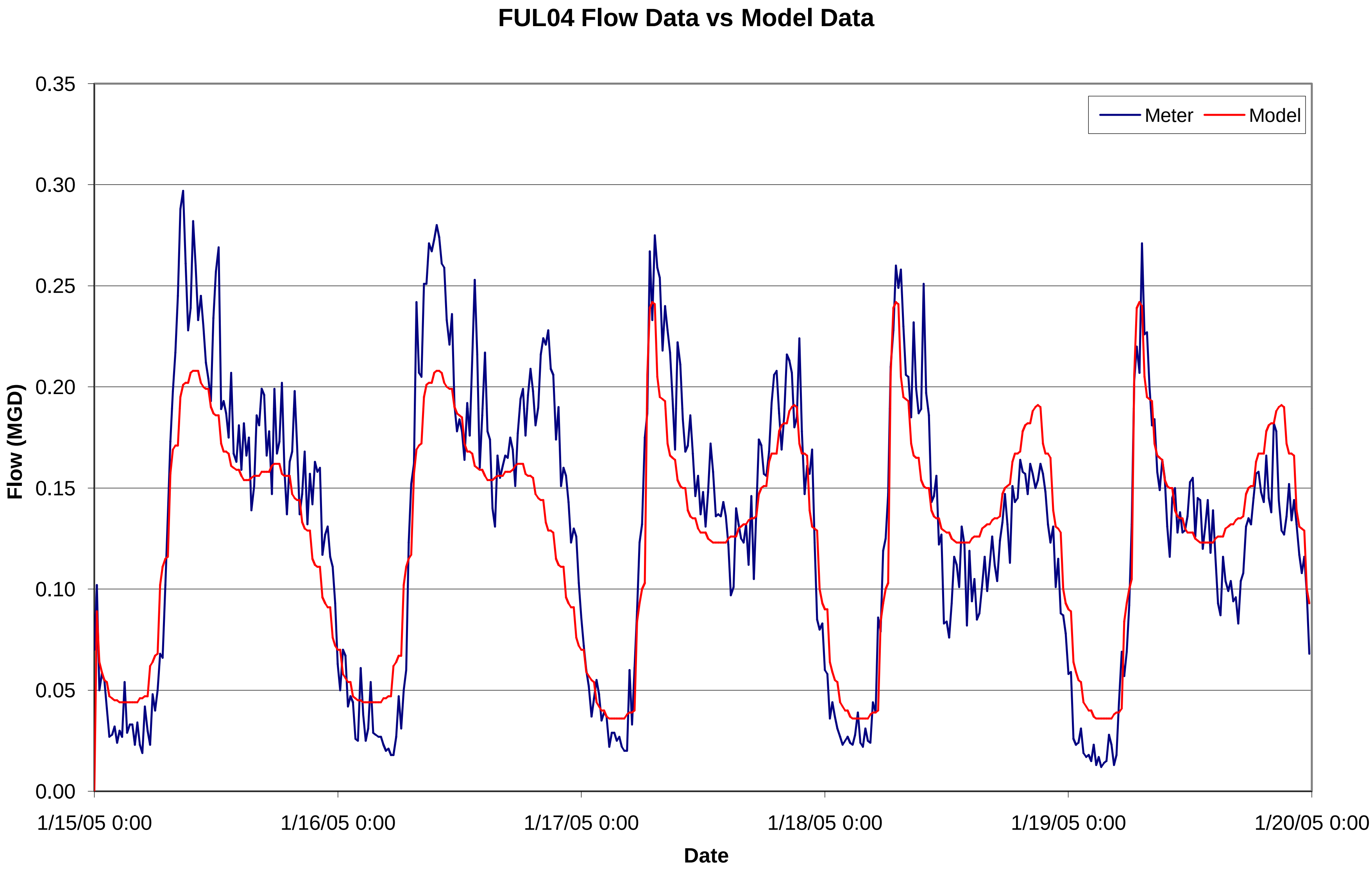
FOC209 Flow Data vs Model Data
Meter
Model
Flow (MGD)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

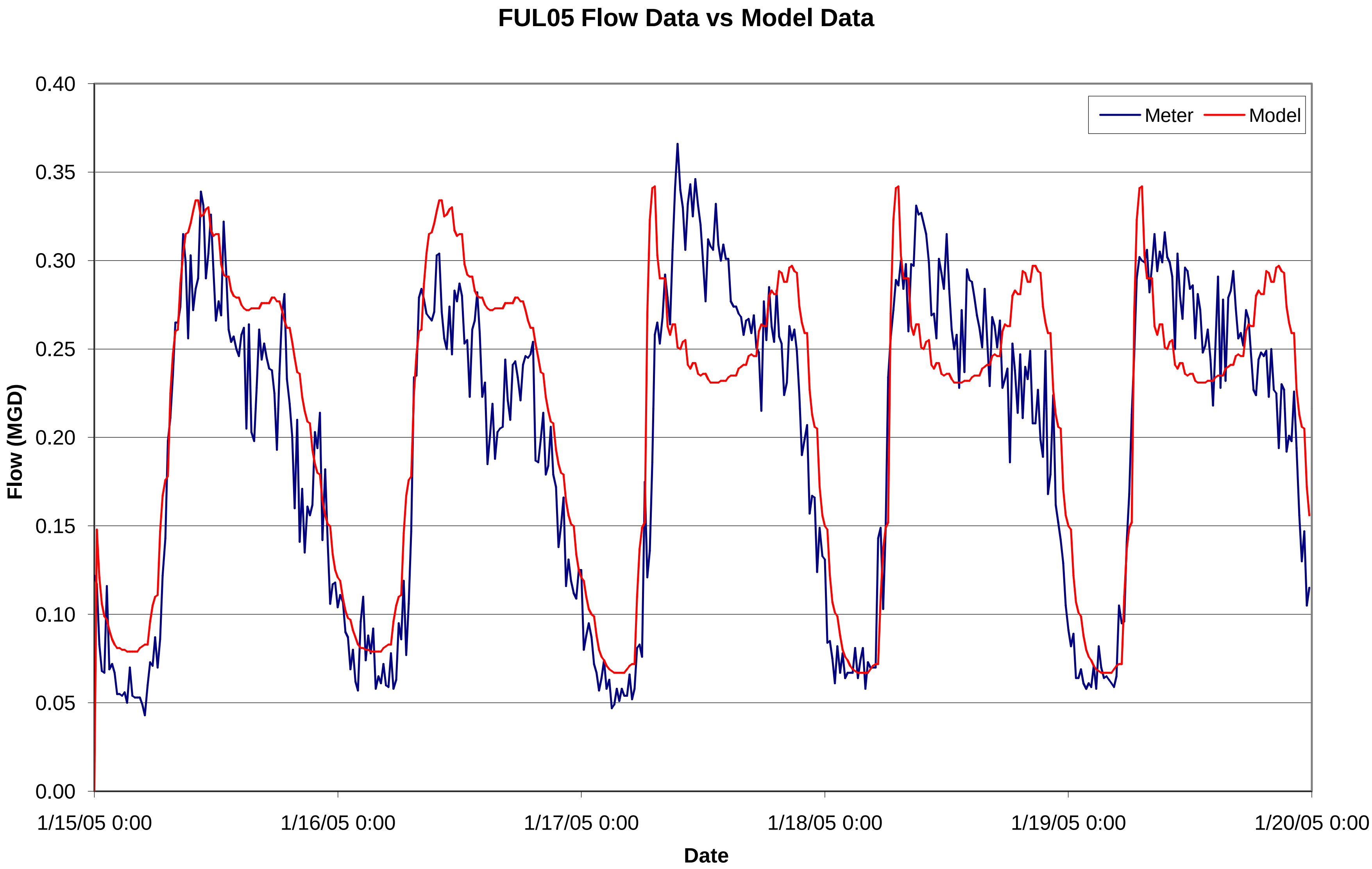


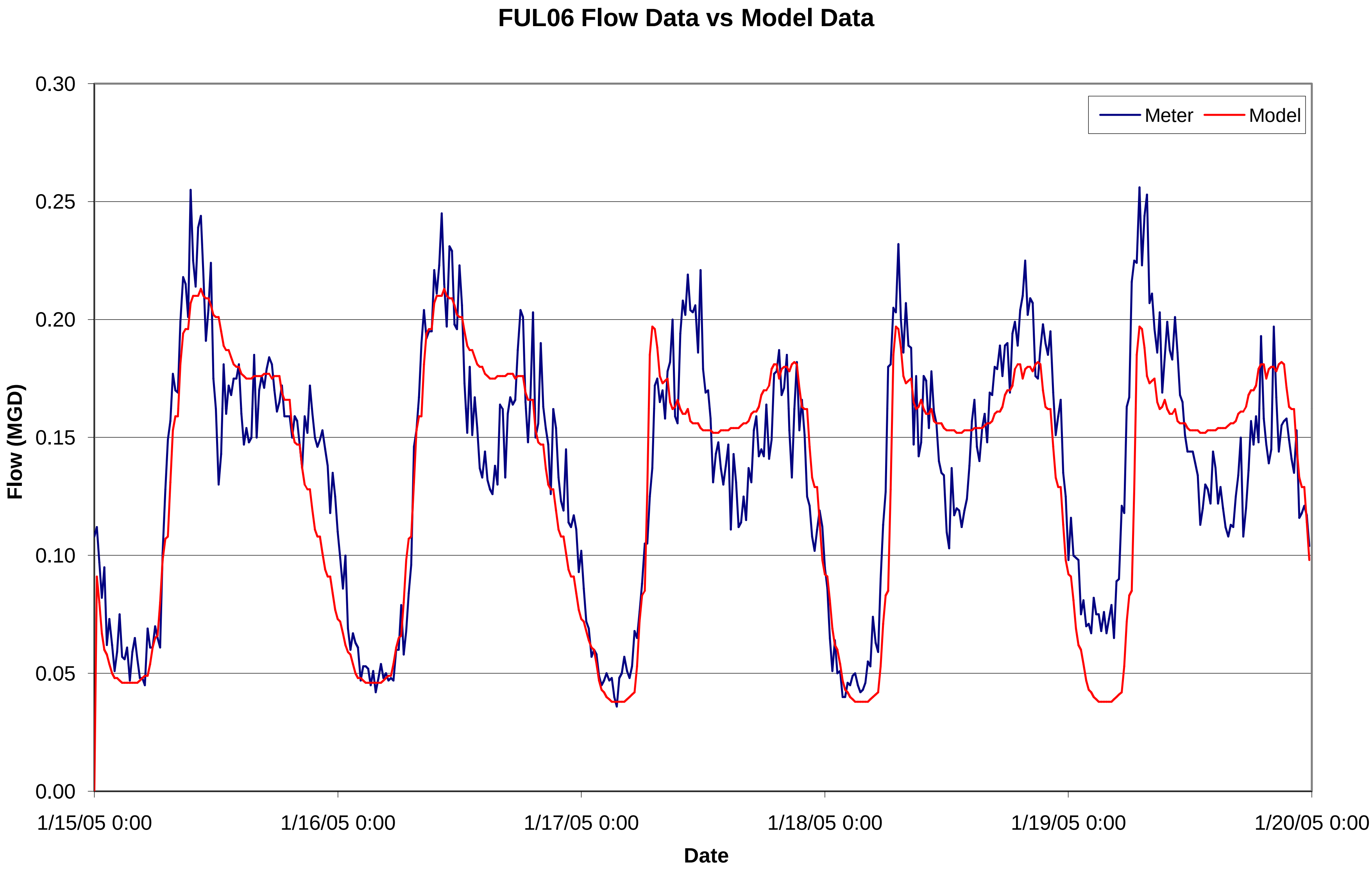
FUL01 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date


FUL02 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.20
0.16
0.12
0.08
0.04
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

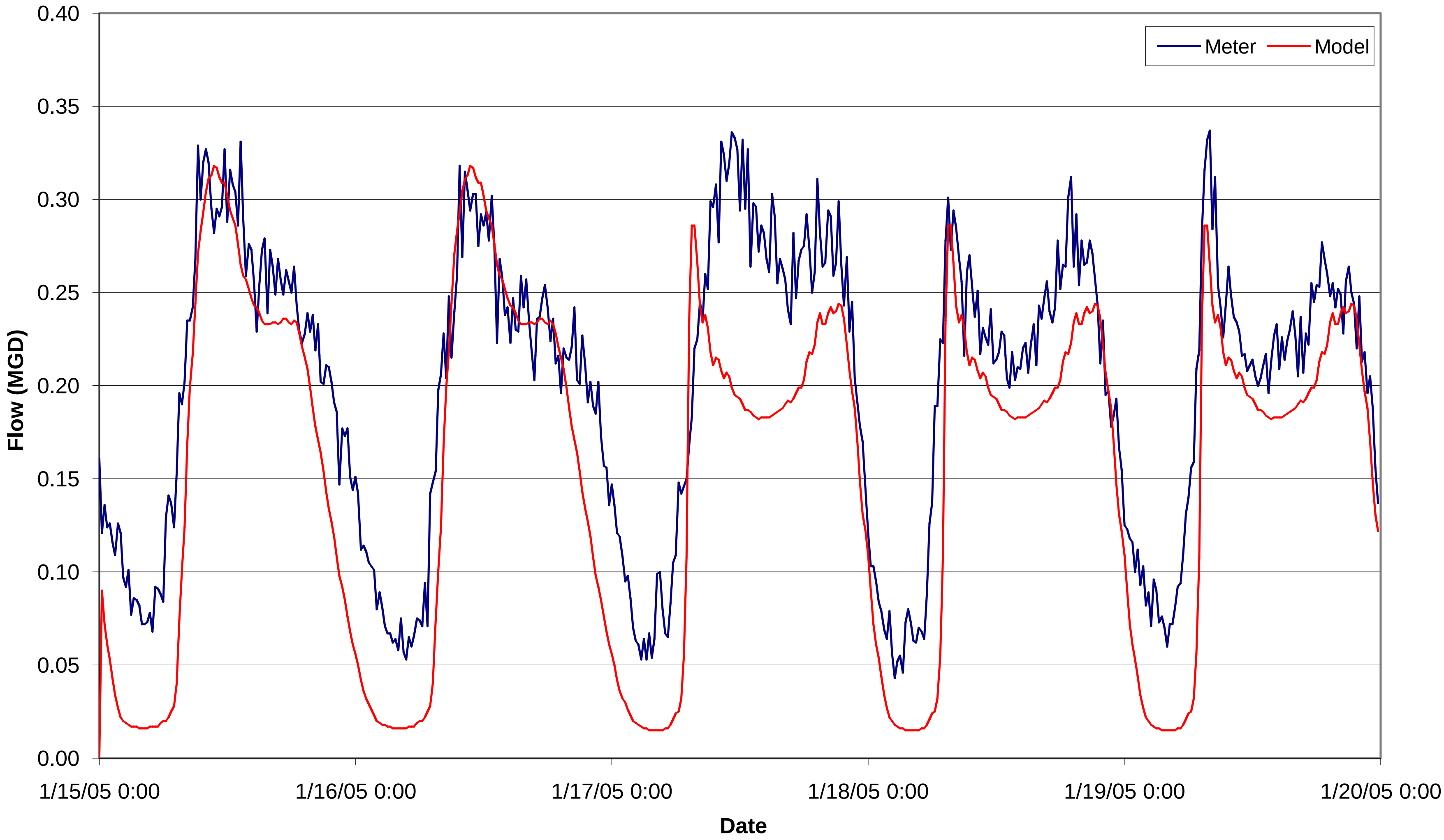

FUL03 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date


FUL04 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

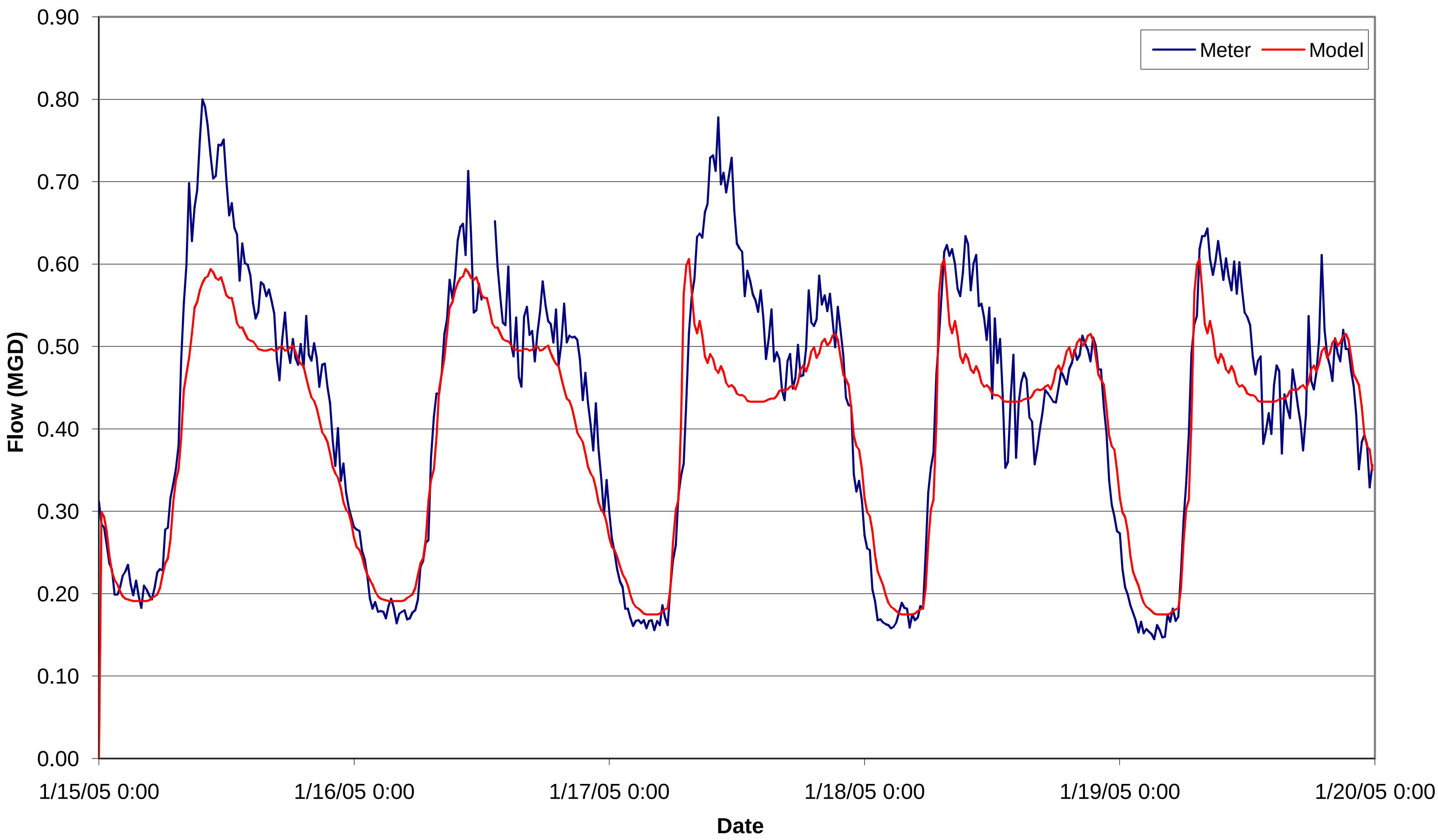

FUL05 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

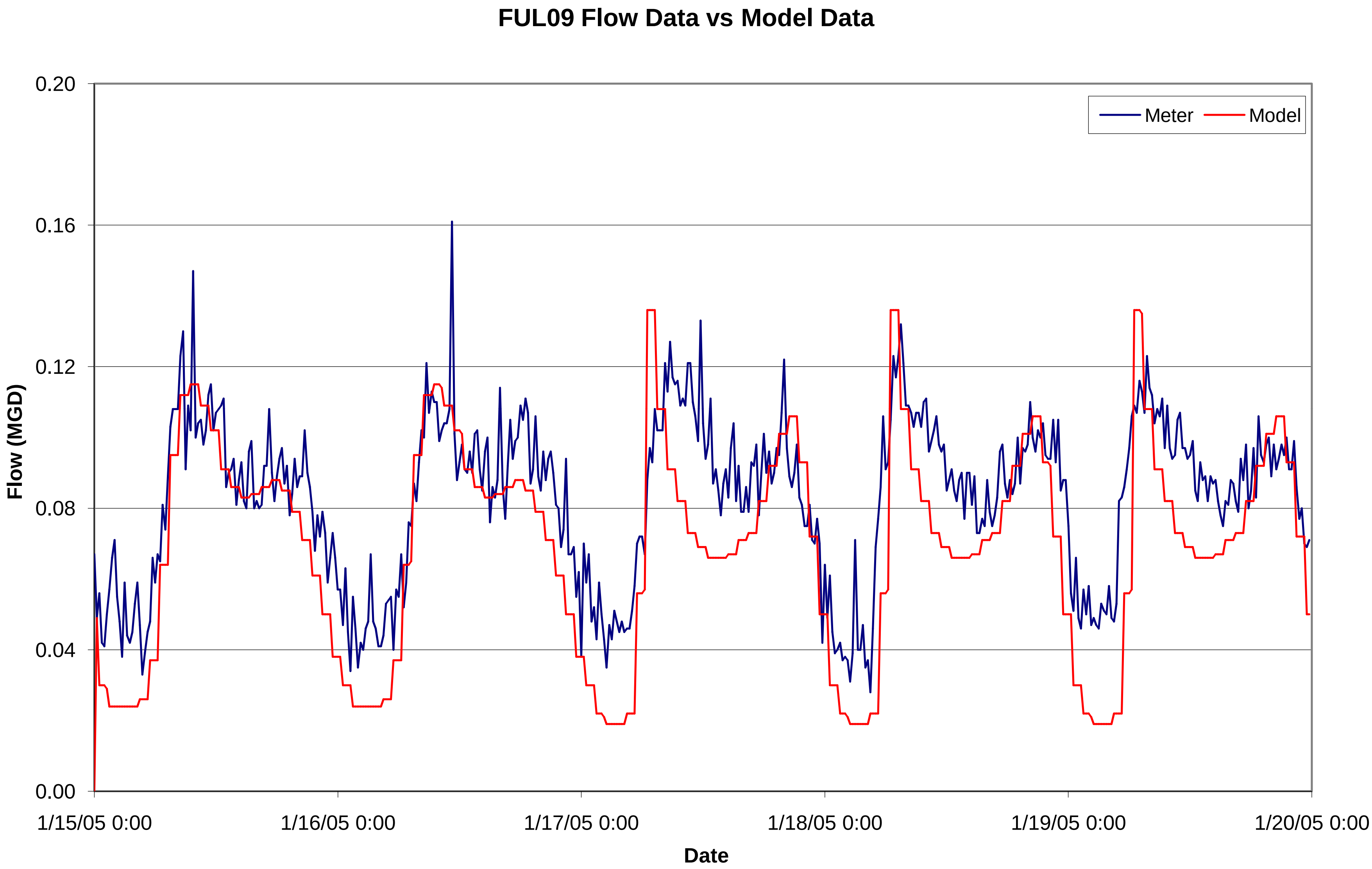

FUL06 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

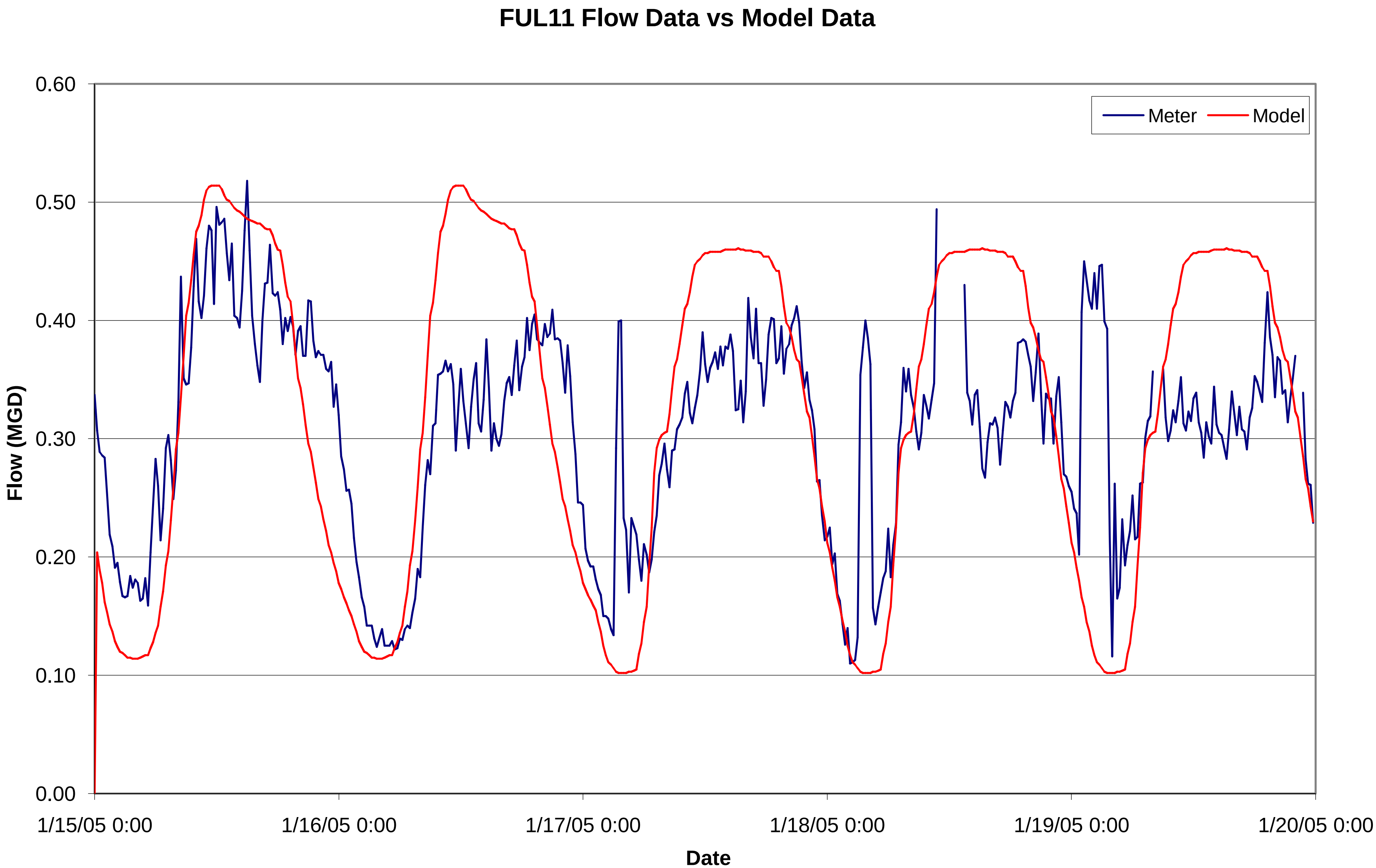
FUL07 Flow Data vs Model Data

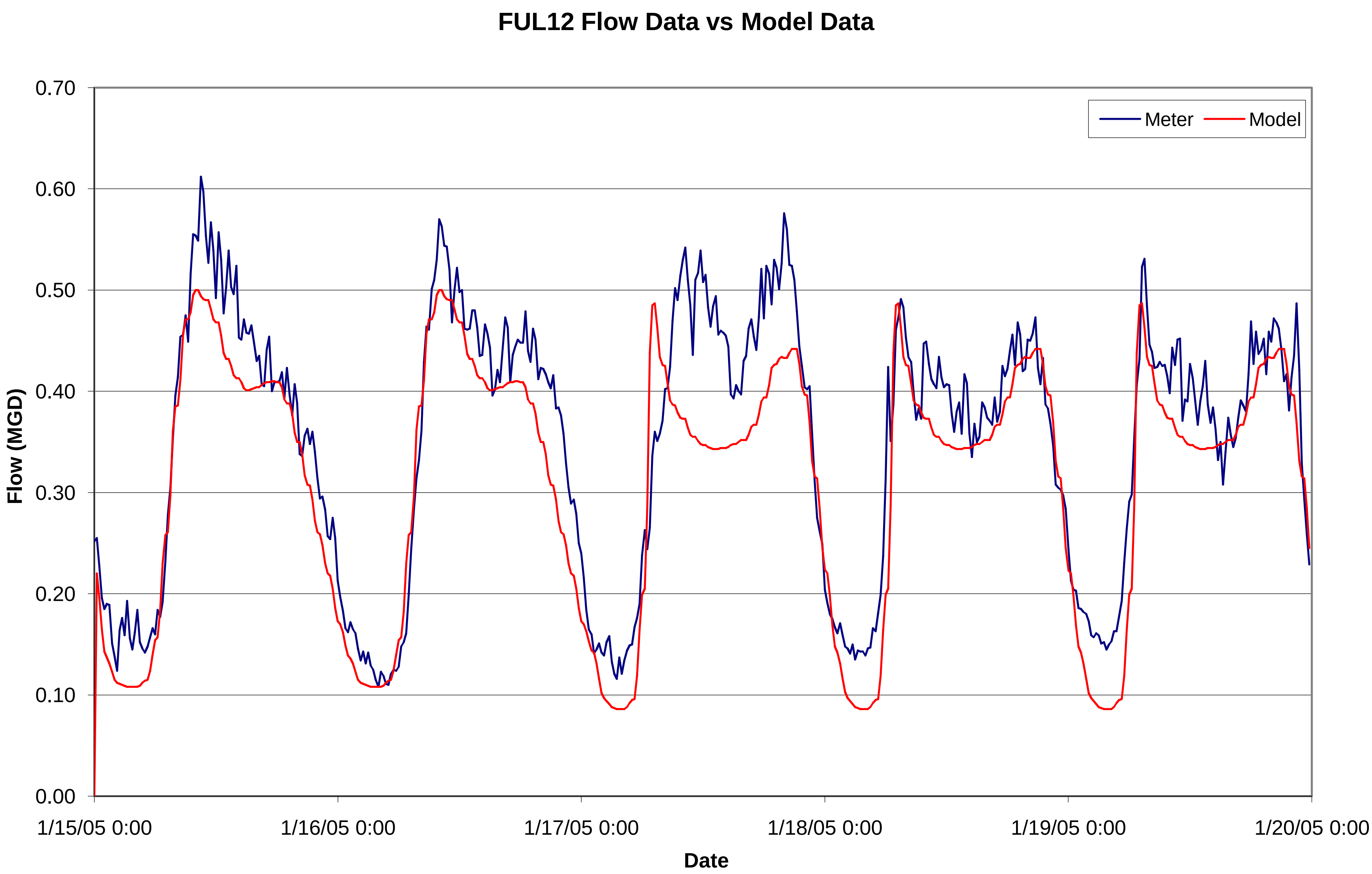


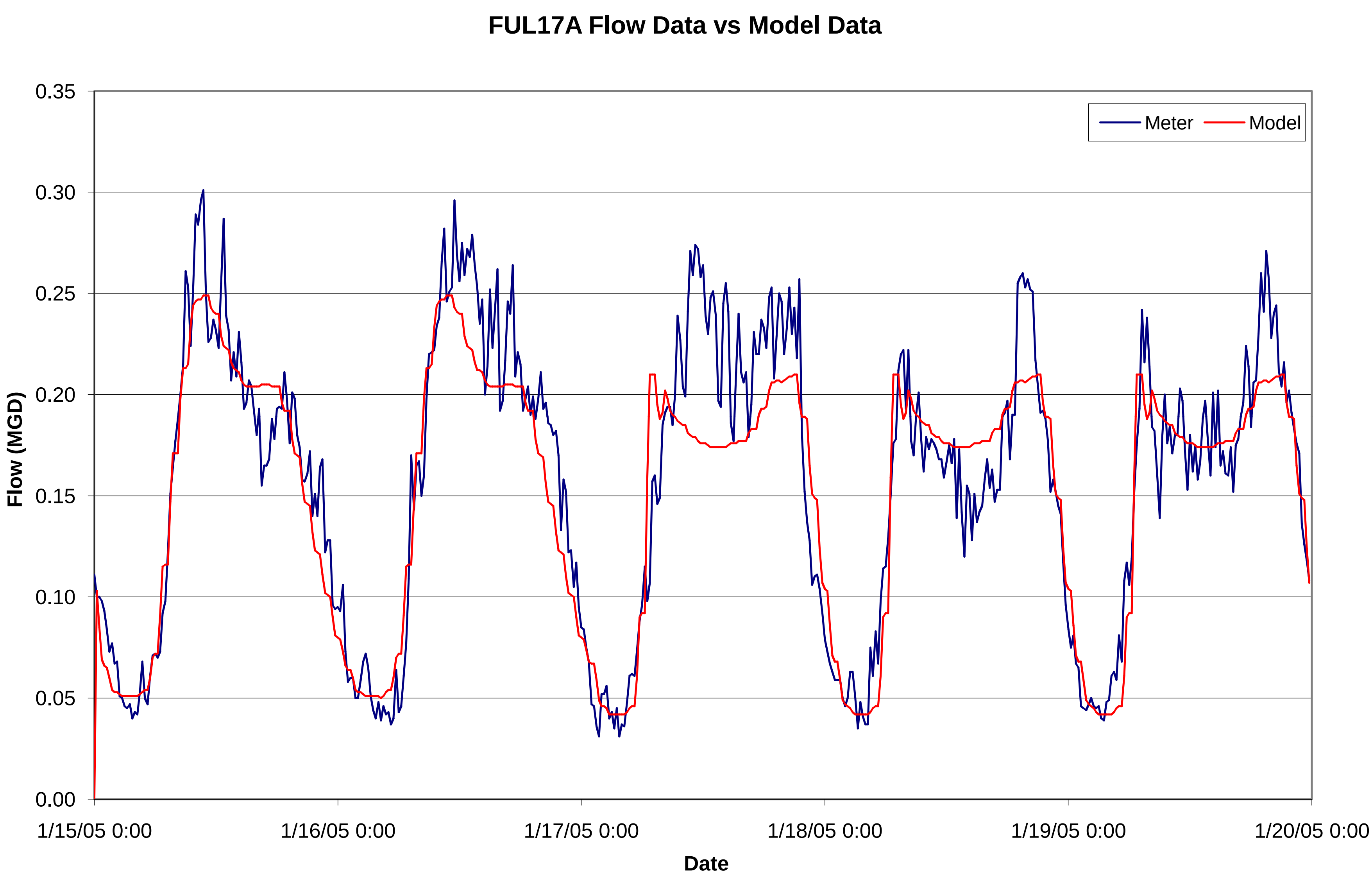
FUL08 Flow Data vs Model Data



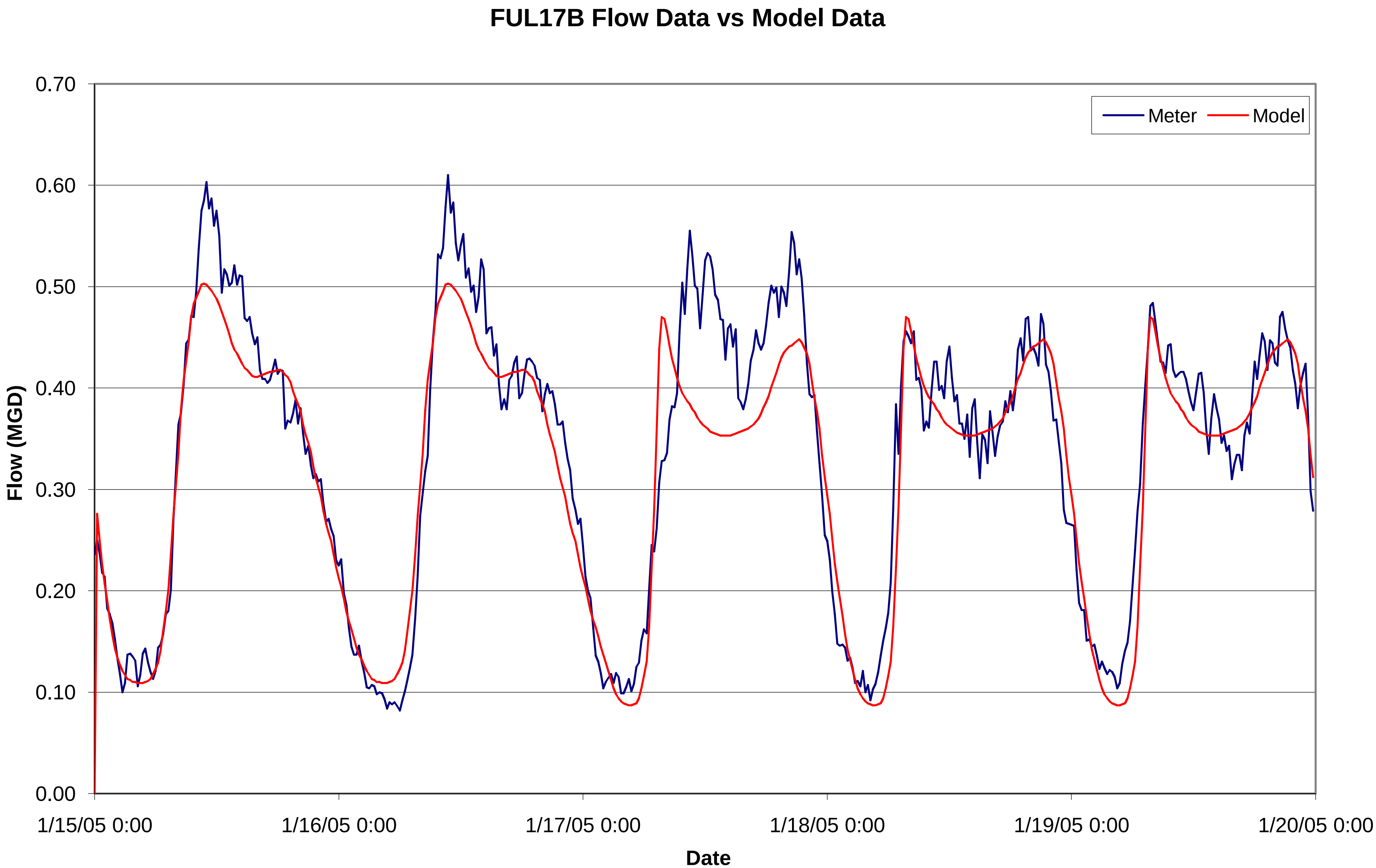

FUL09 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.20
0.16
0.12
0.08
0.04
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

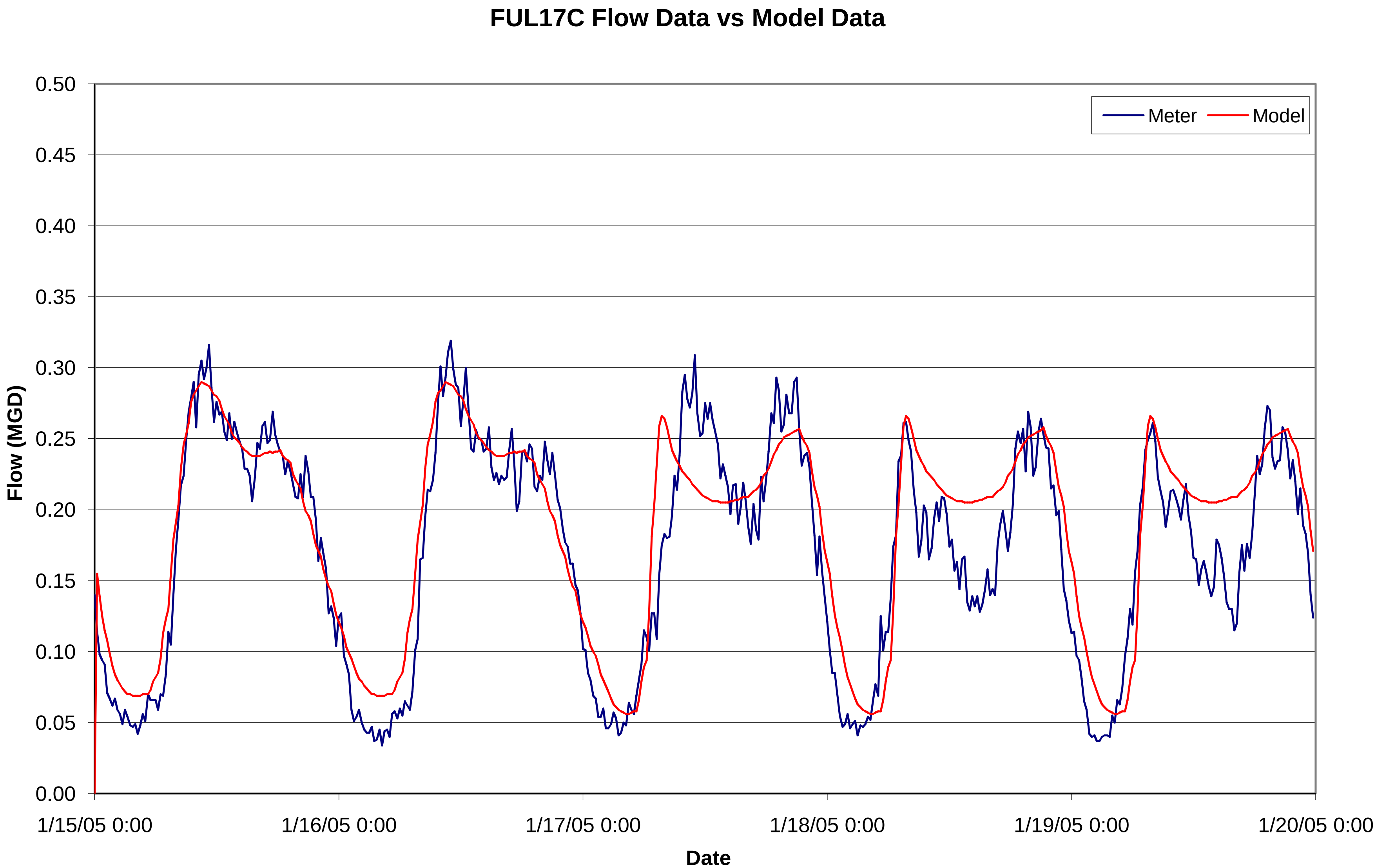

FUL11 Flow Data vs Model Data
Meter
Model
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Flow (MGD)
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date


FUL12 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

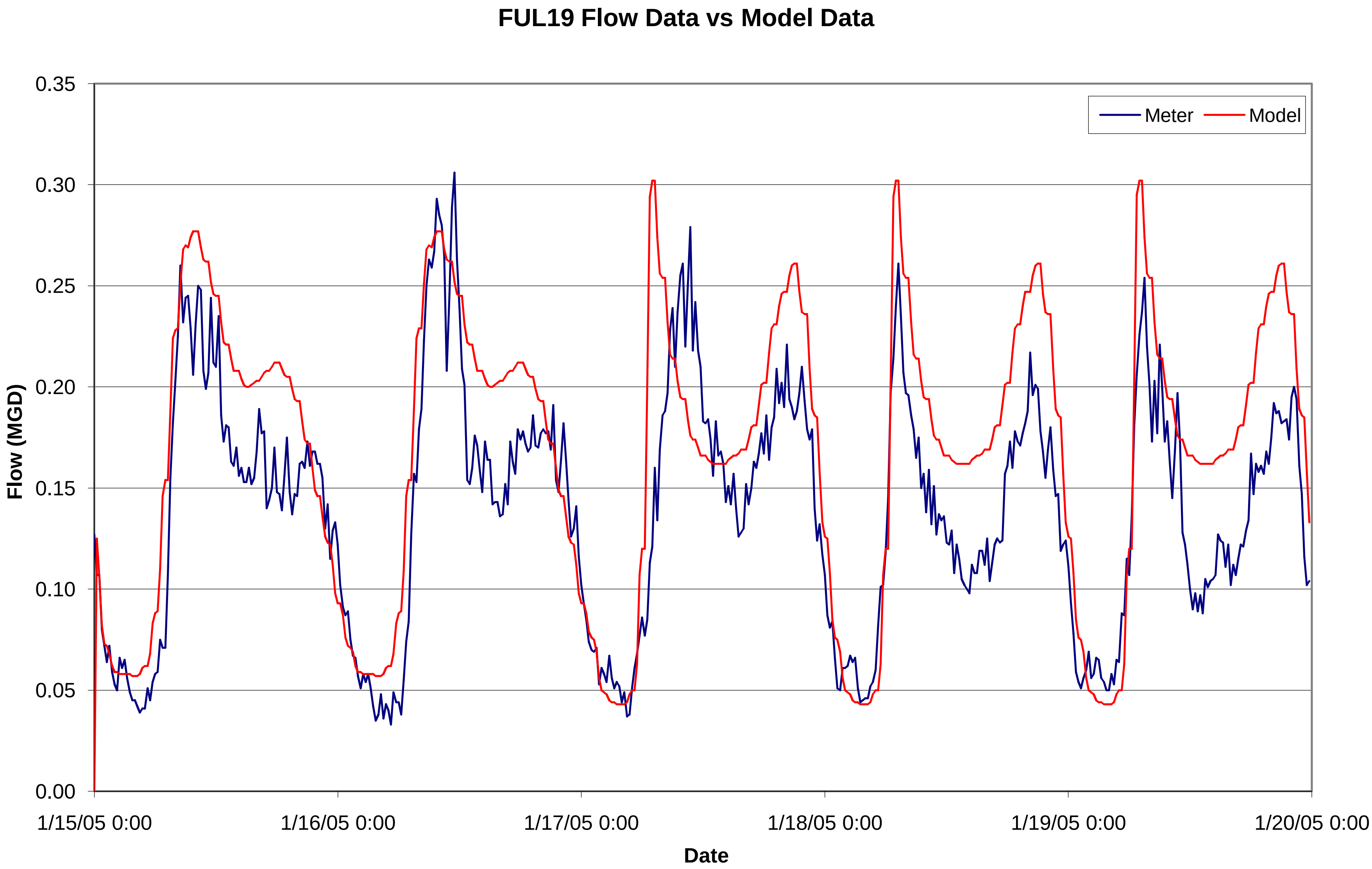


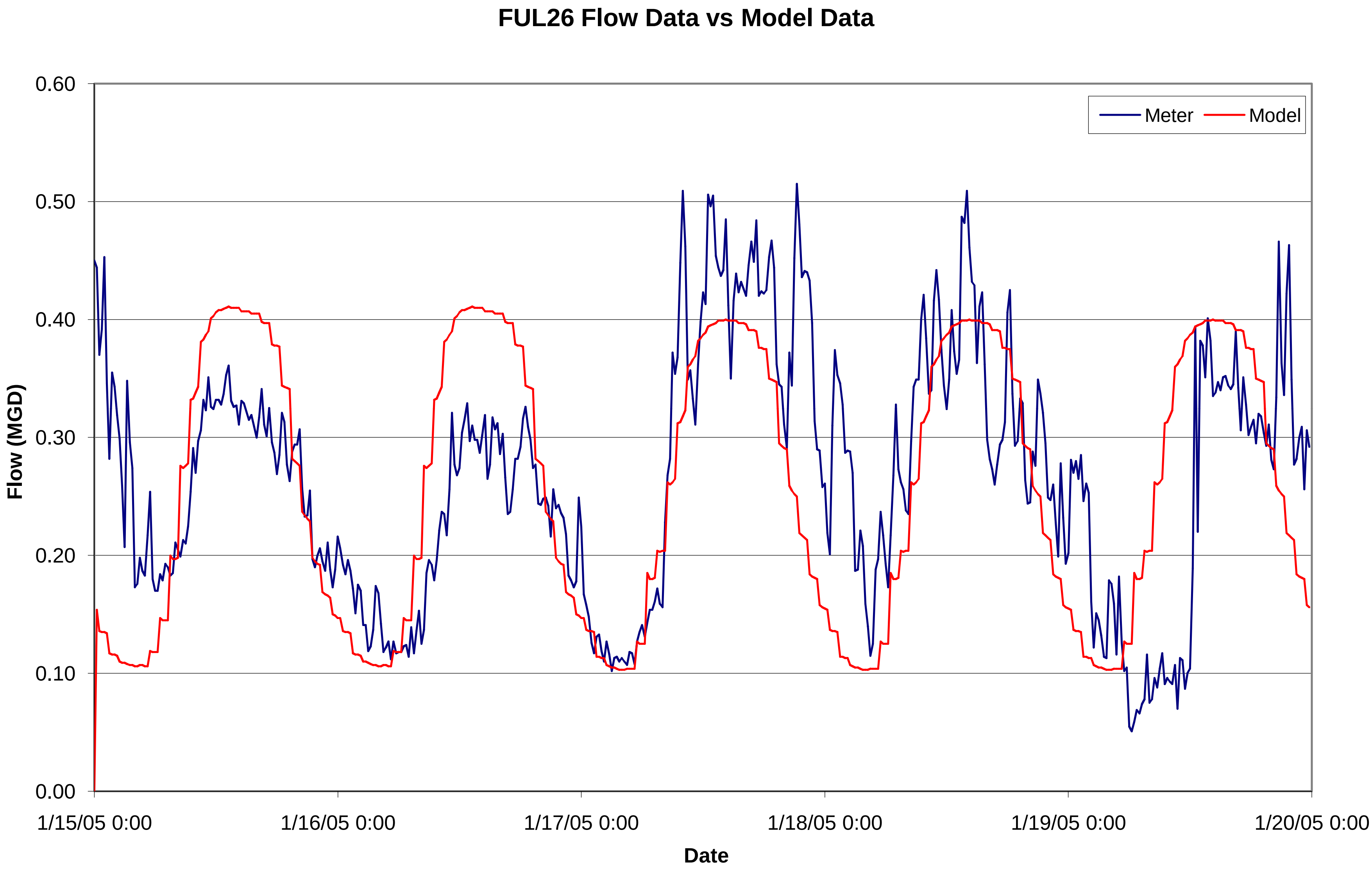
FUL17A Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date


FUL17B Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

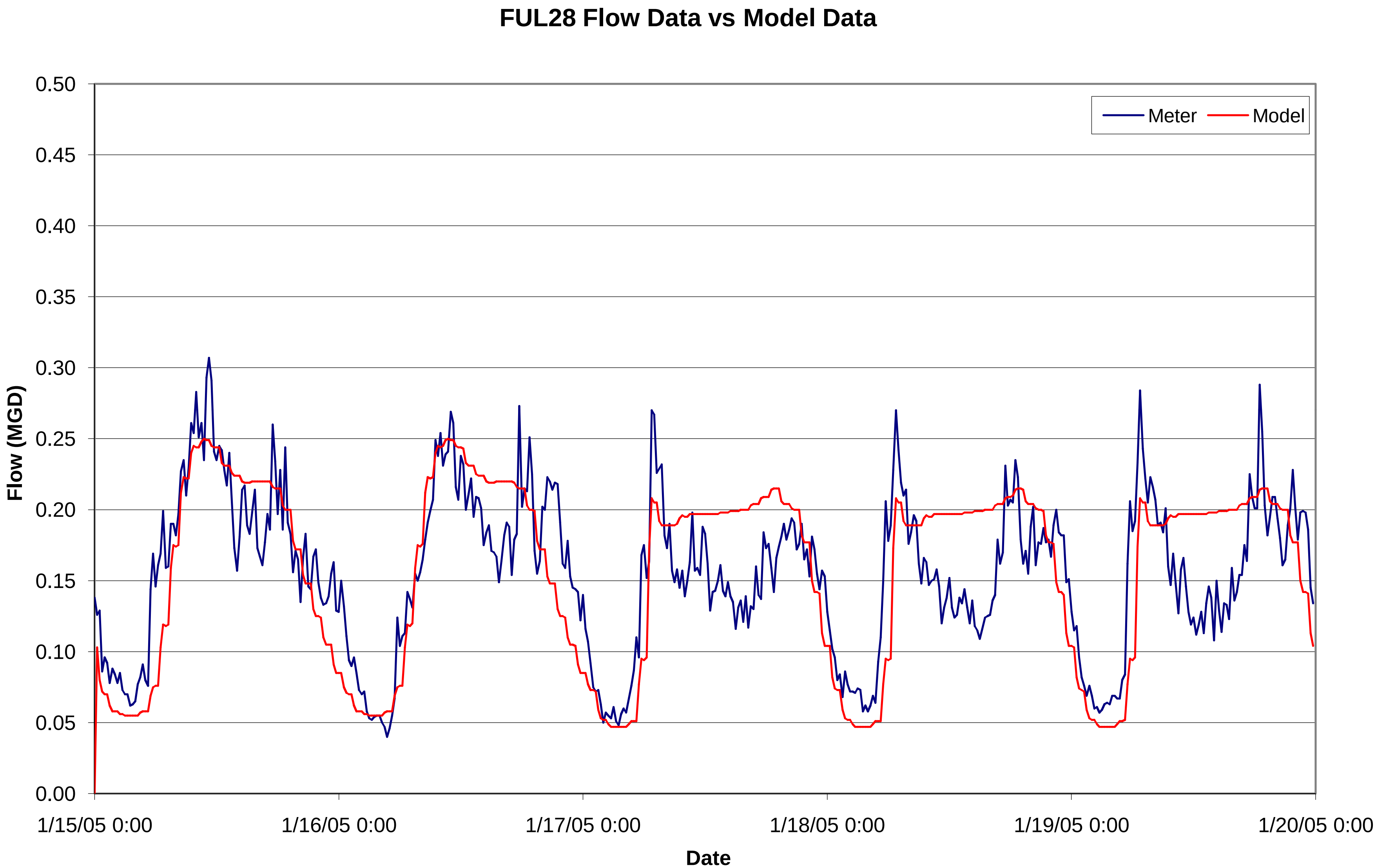


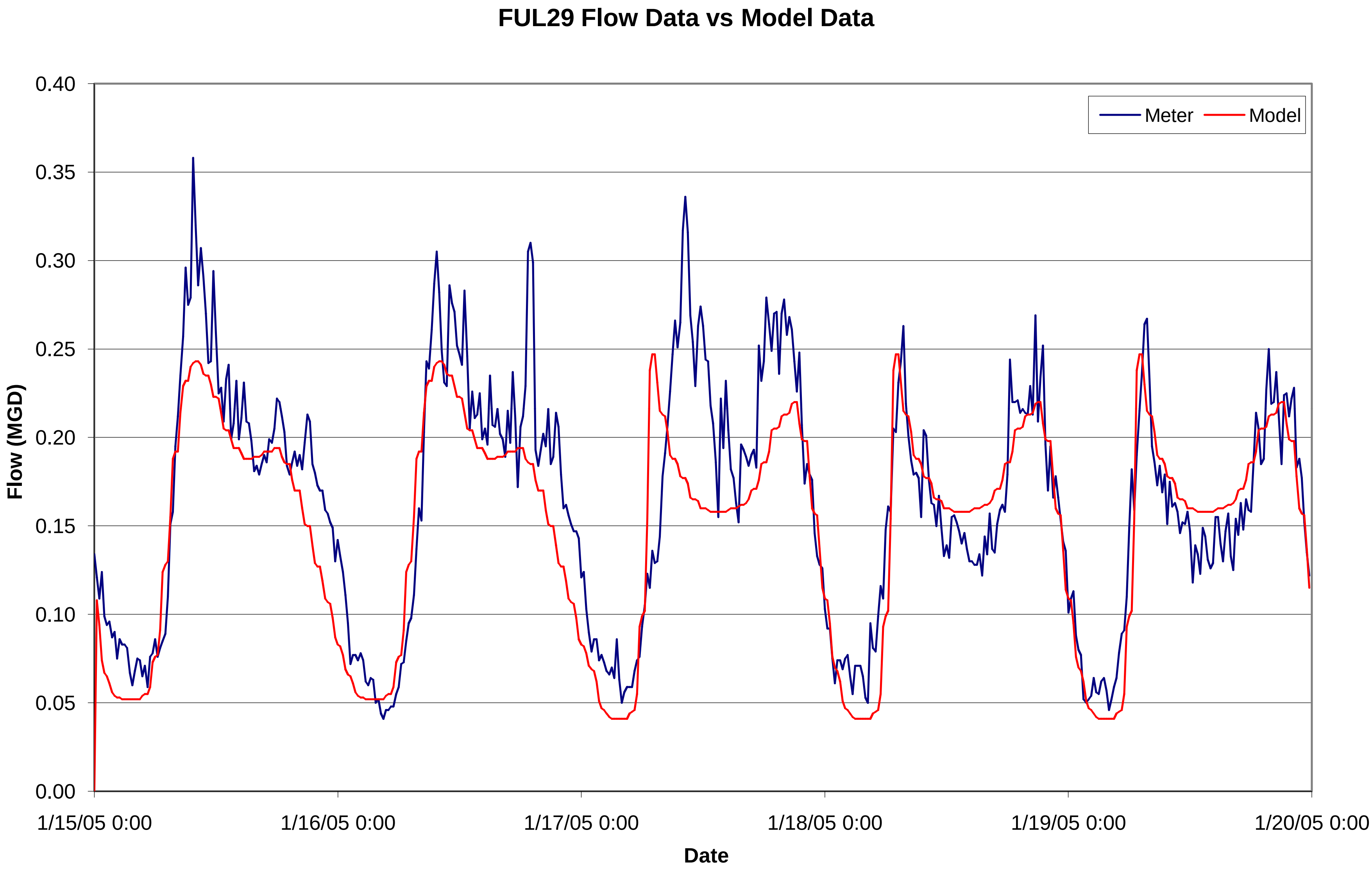
FUL17C Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

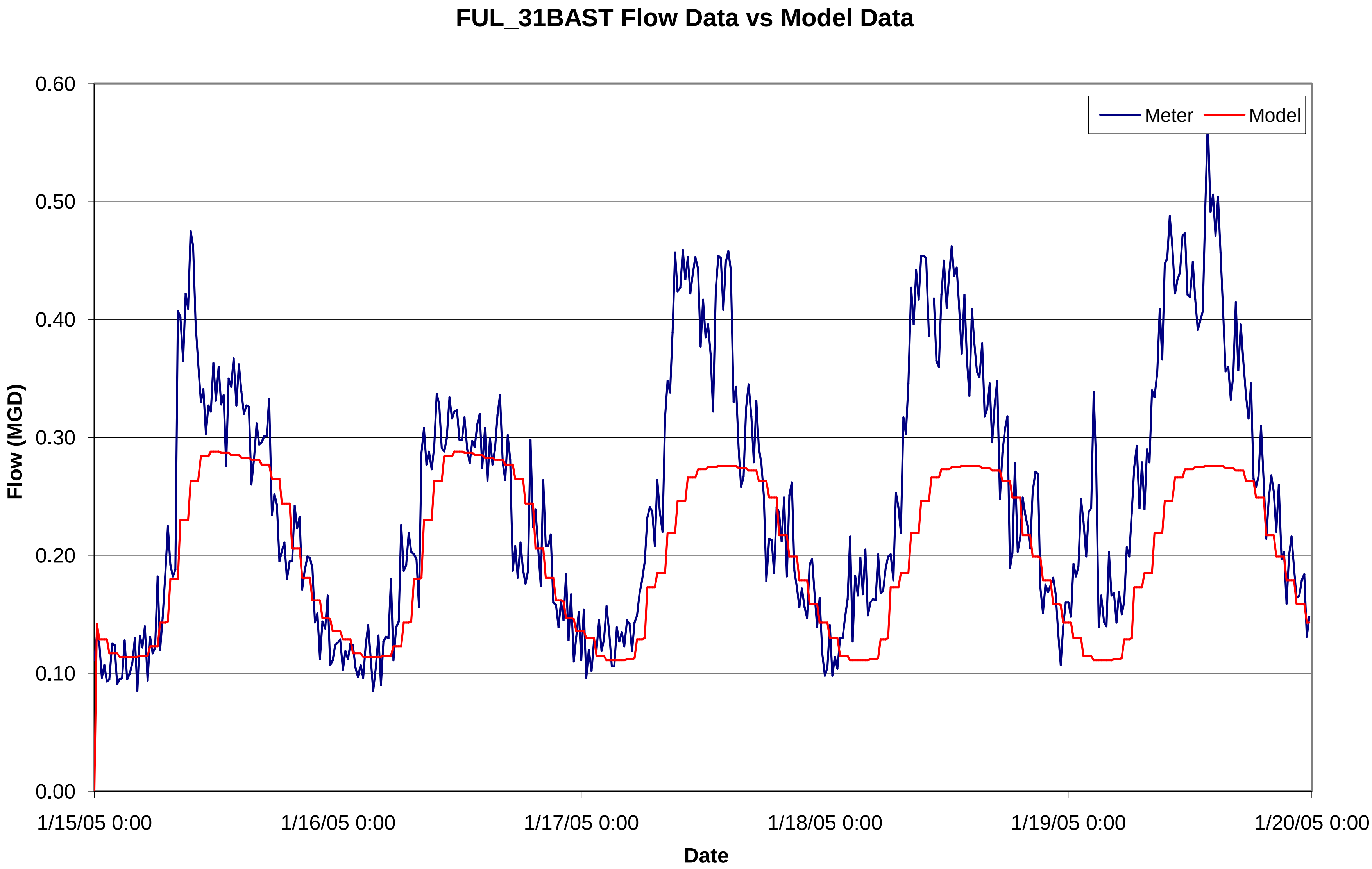

FUL19 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

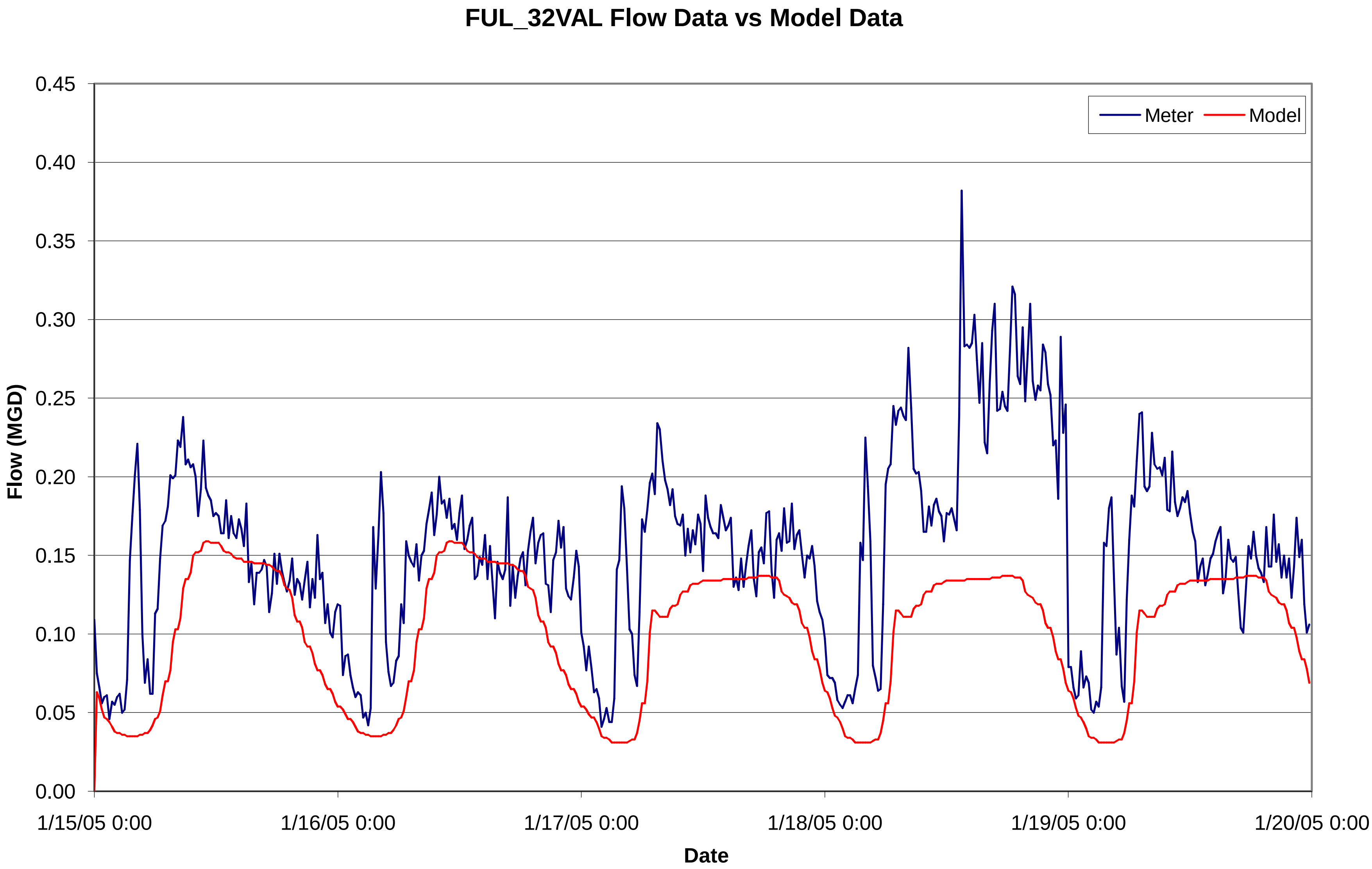


FUL26 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

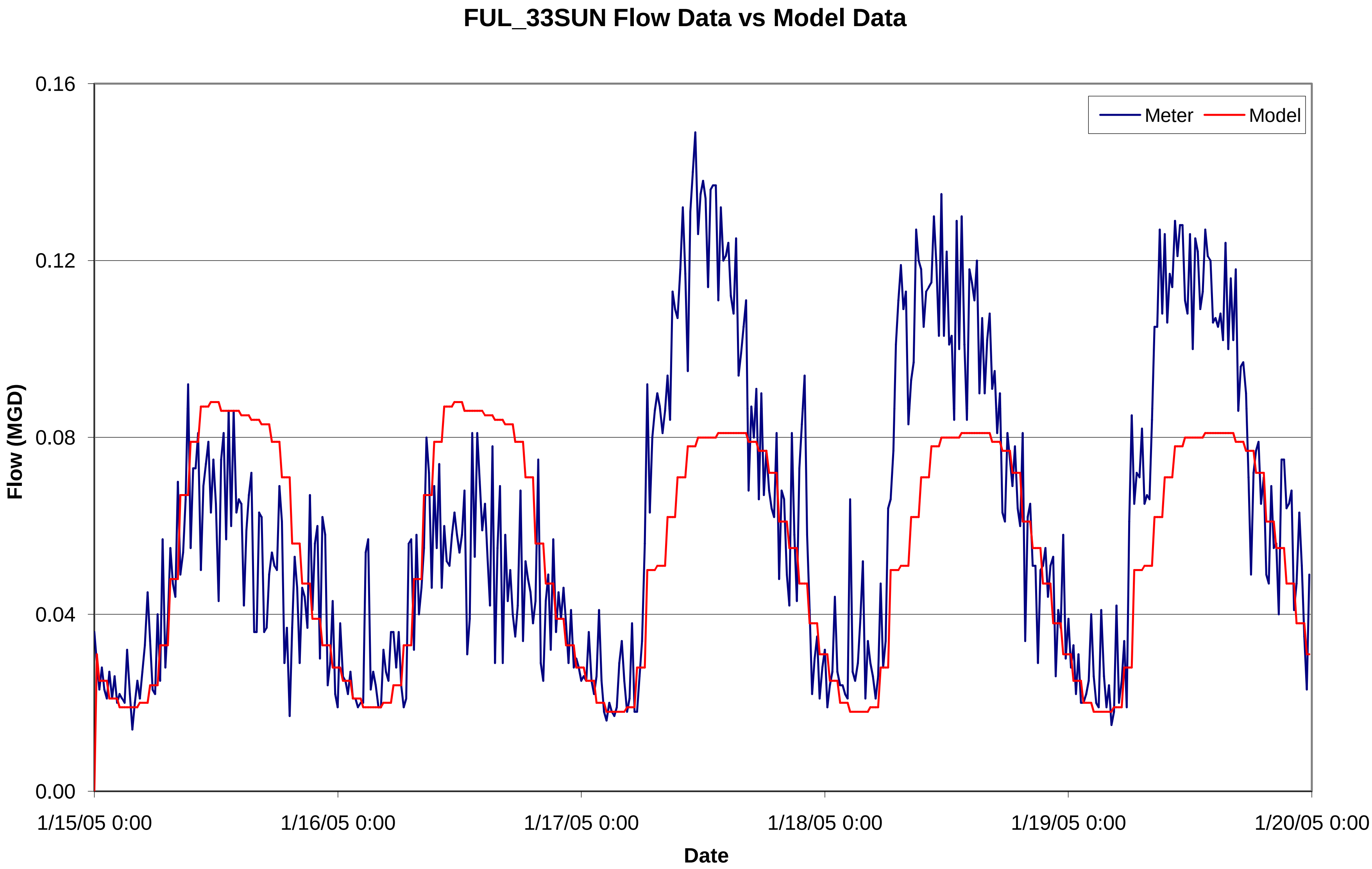

FUL28 Flow Data vs Model Data
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Flow (MGD)
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date
Meter
Model


FUL29 Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

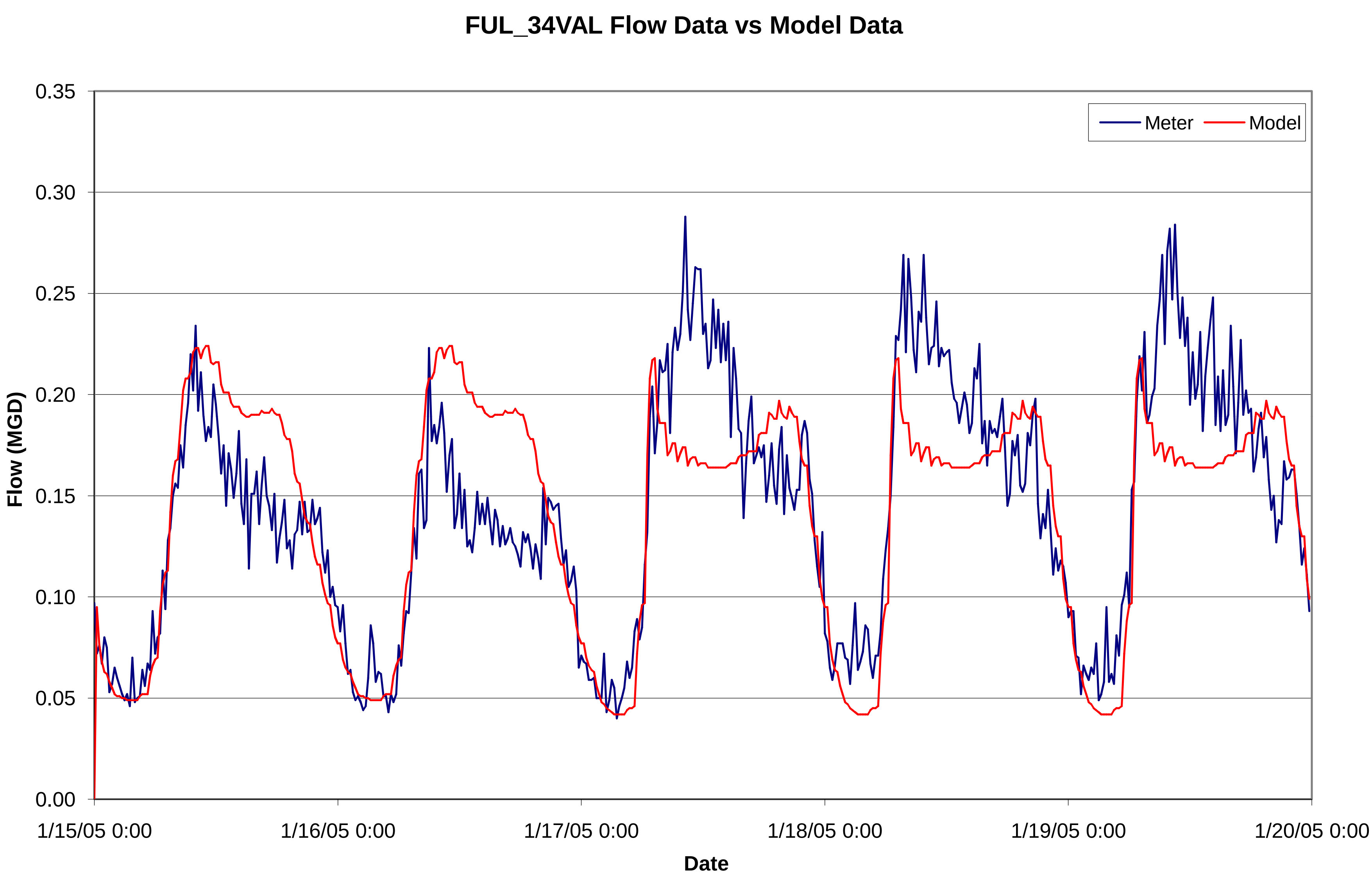

FUL_31BAST Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

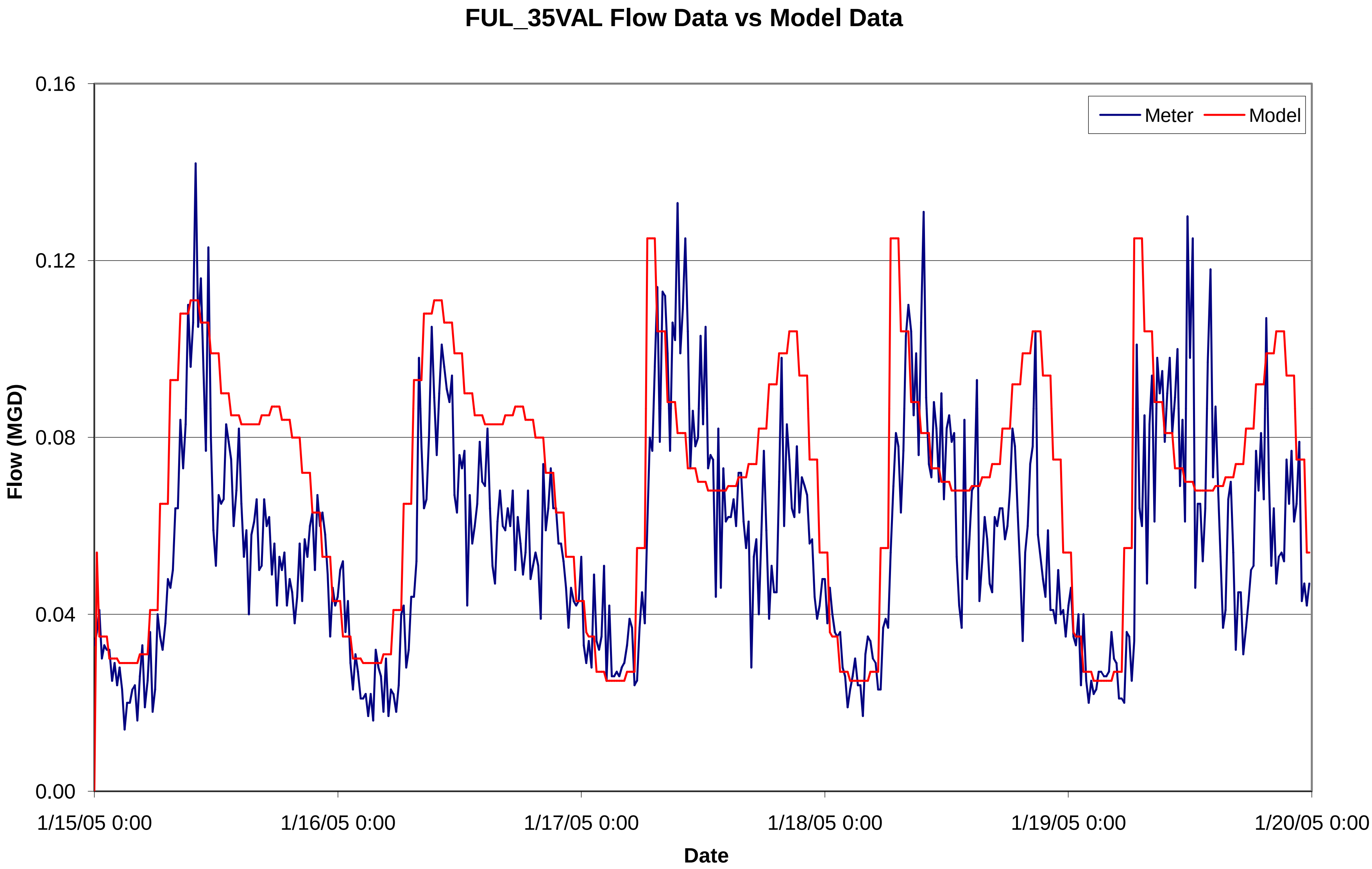


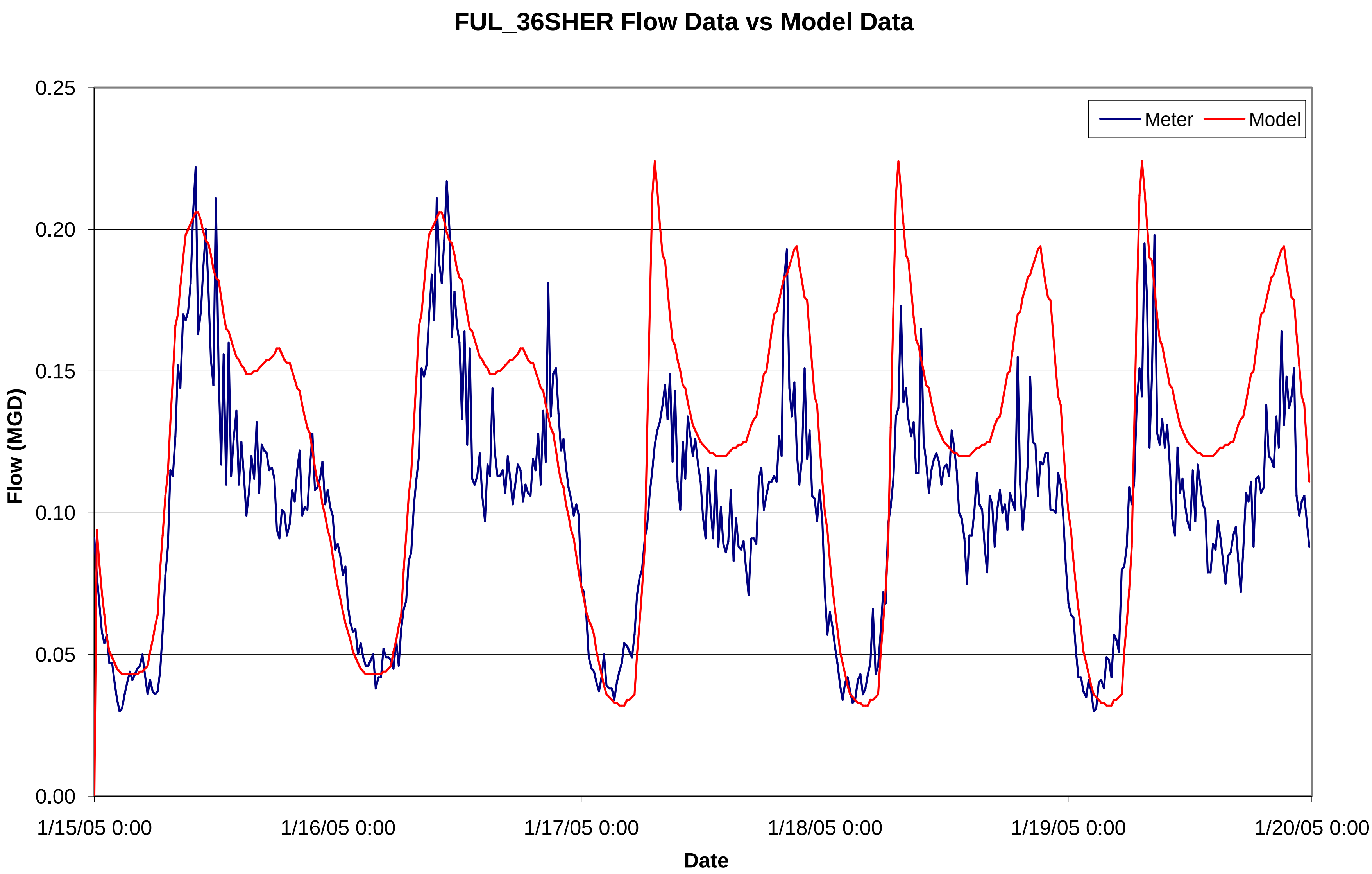
FUL_32VAL Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date



FUL_33SUN Flow Data vs Model Data
Flow (MGD)
0.16
0.12
0.08
0.04
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date
Meter
Model

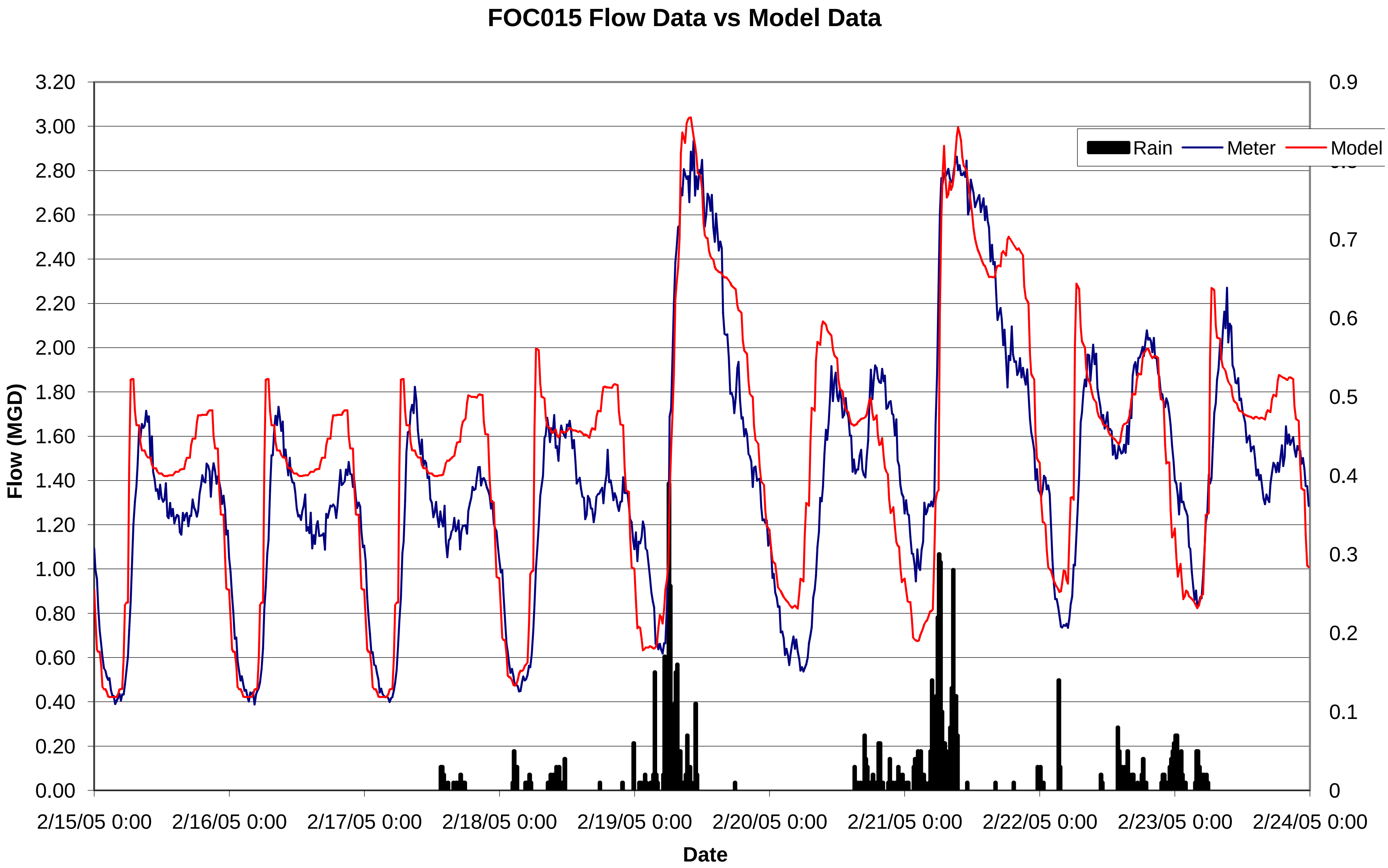

FUL_34VAL Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

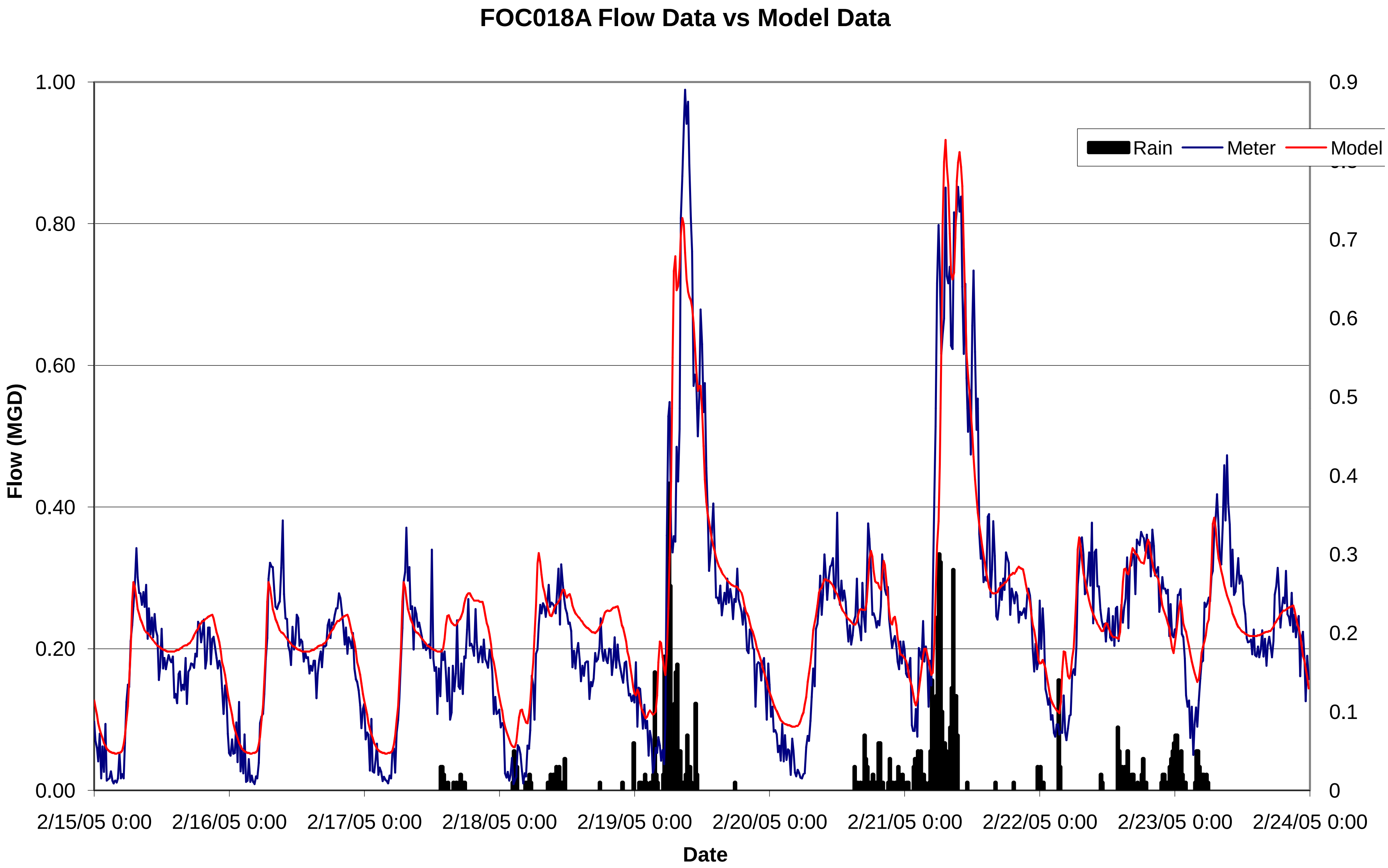

FUL_35VAL Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.16
0.12
0.08
0.04
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date



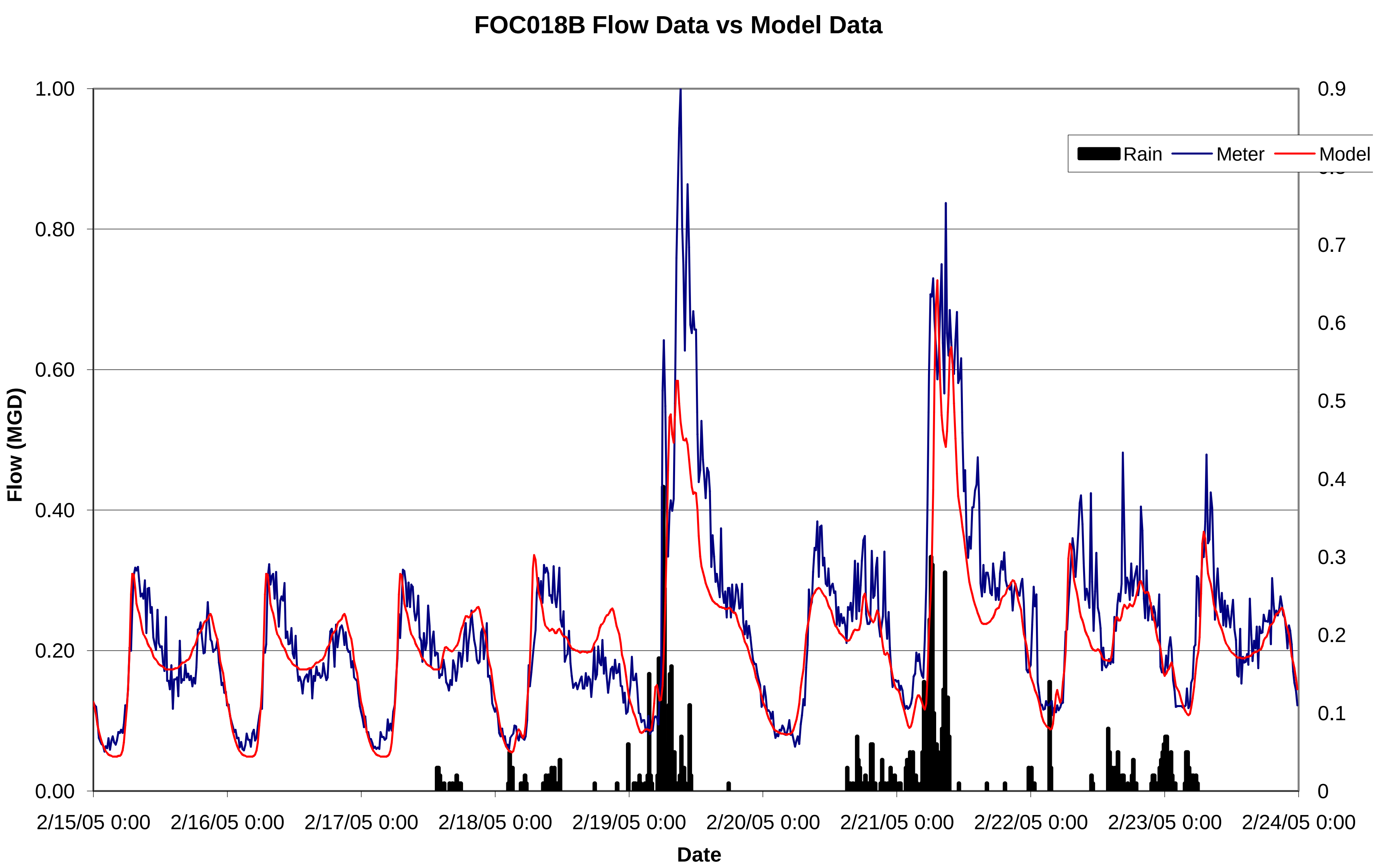
FUL_36SHER Flow Data vs Model Data
Meter
Model
Flow (MGD)
0.25
0.20
0.15
0.10
0.05
0.00
1/15/05 0:00
1/16/05 0:00
1/17/05 0:00
1/18/05 0:00
1/19/05 0:00
1/20/05 0:00
Date

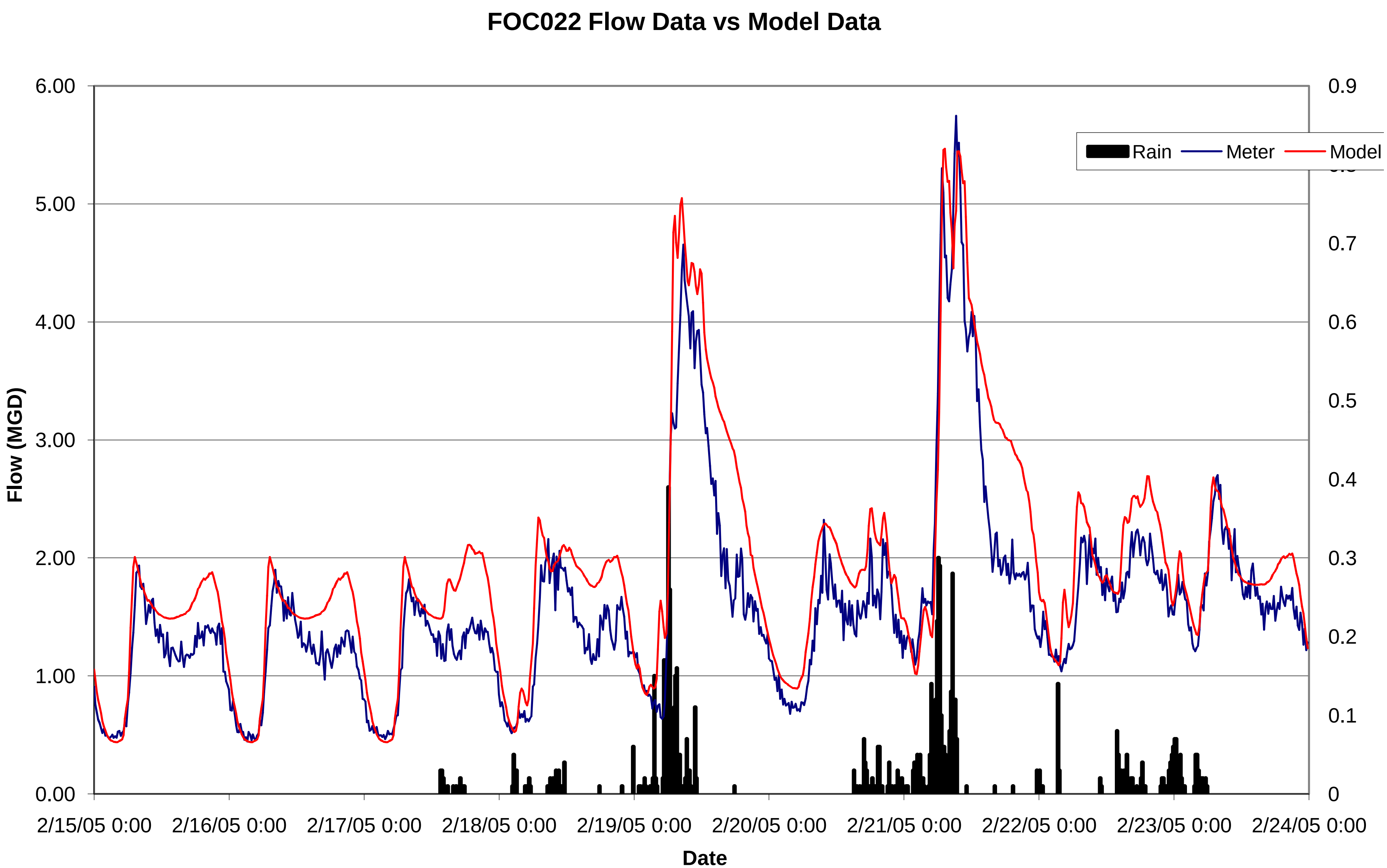
Appendix D - Wet Weather Calibration Plots

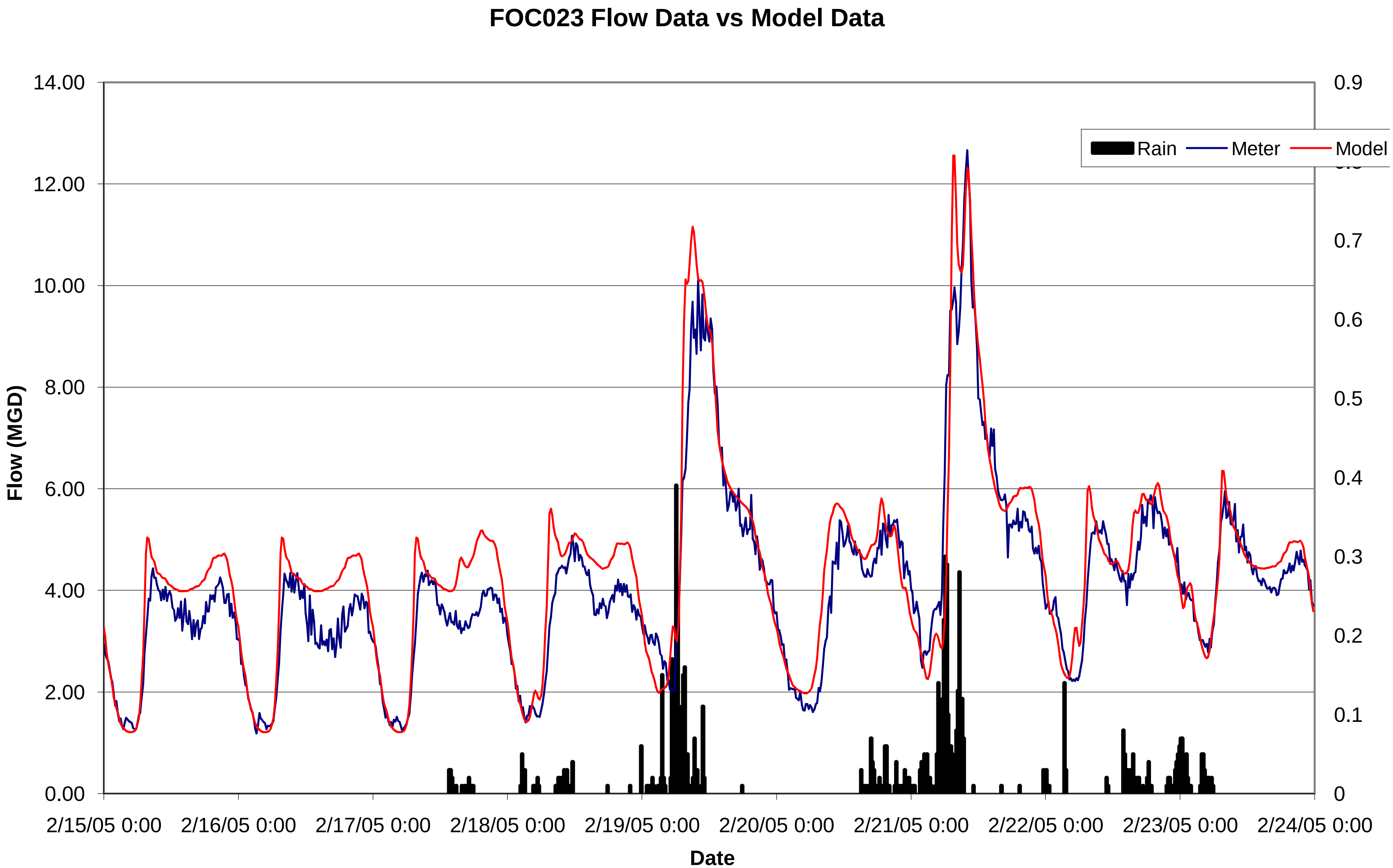

FOC015 Flow Data vs Model Data
Rain
Meter
Model
Flow (MGD)
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date


FOC018A Flow Data vs Model Data
Flow (MGD)
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

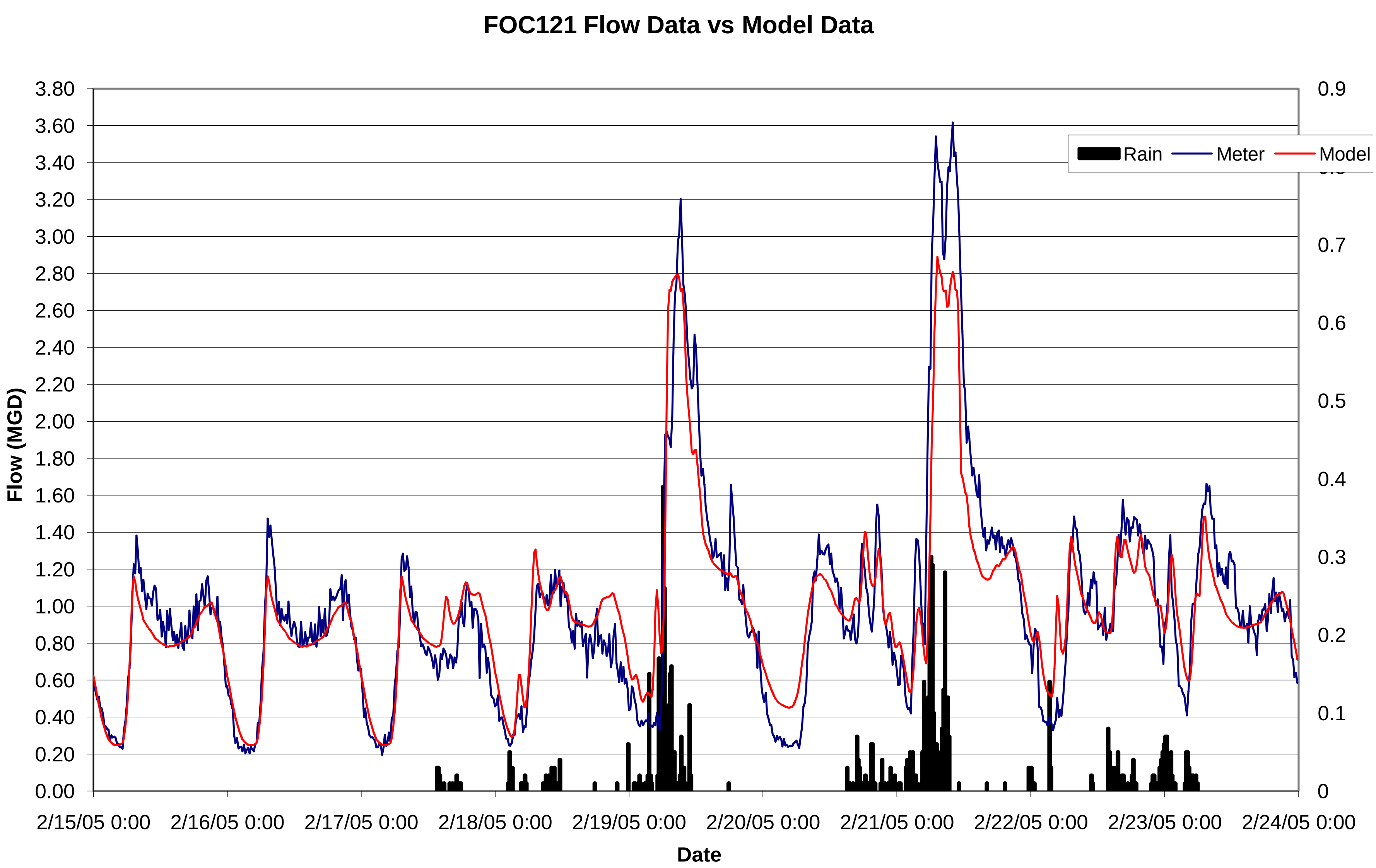
FOC018B Flow Data vs Model Data



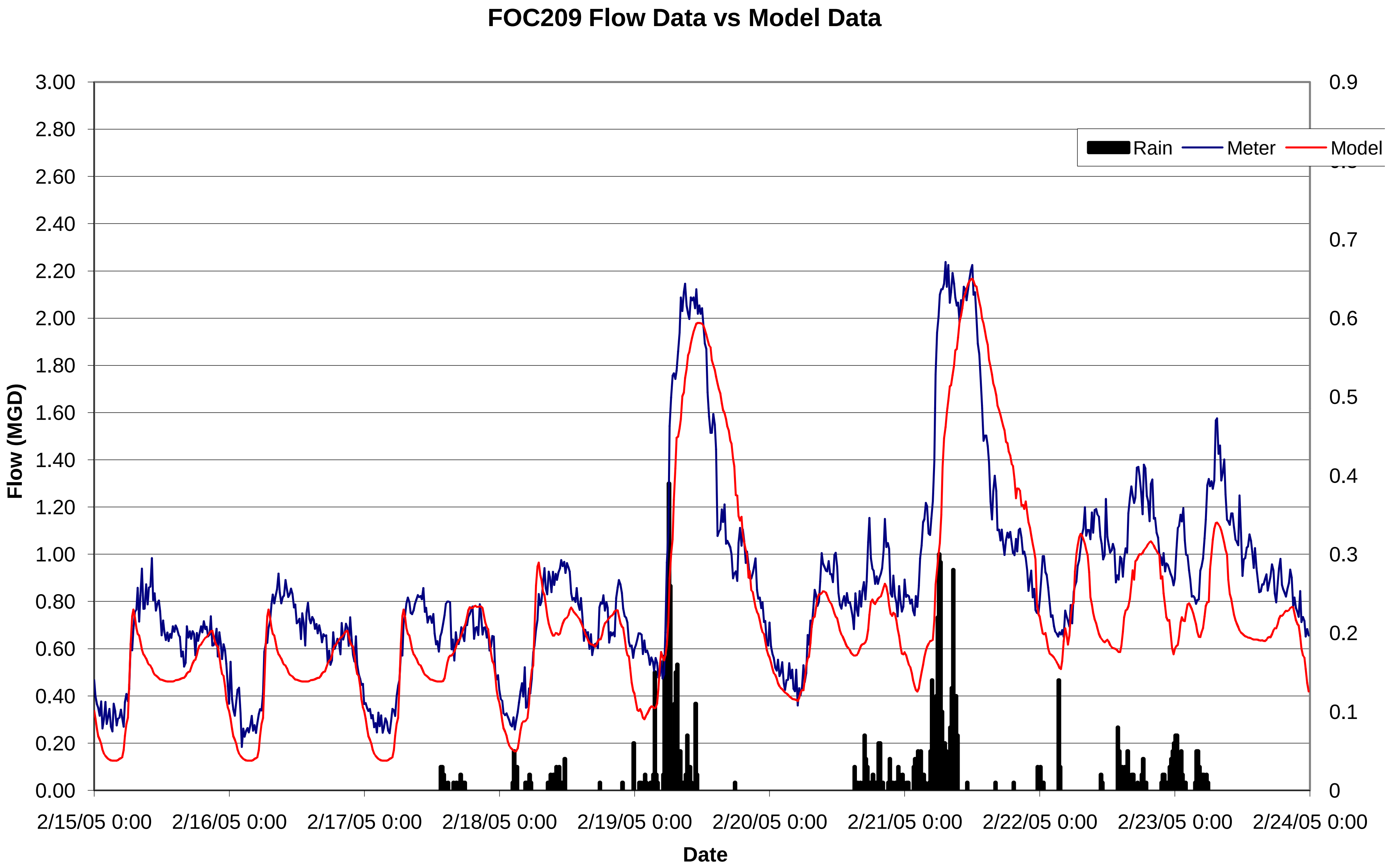

FOC022 Flow Data vs Model Data
Flow (MGD)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date



FOC023 Flow Data vs Model Data
Flow (MGD)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

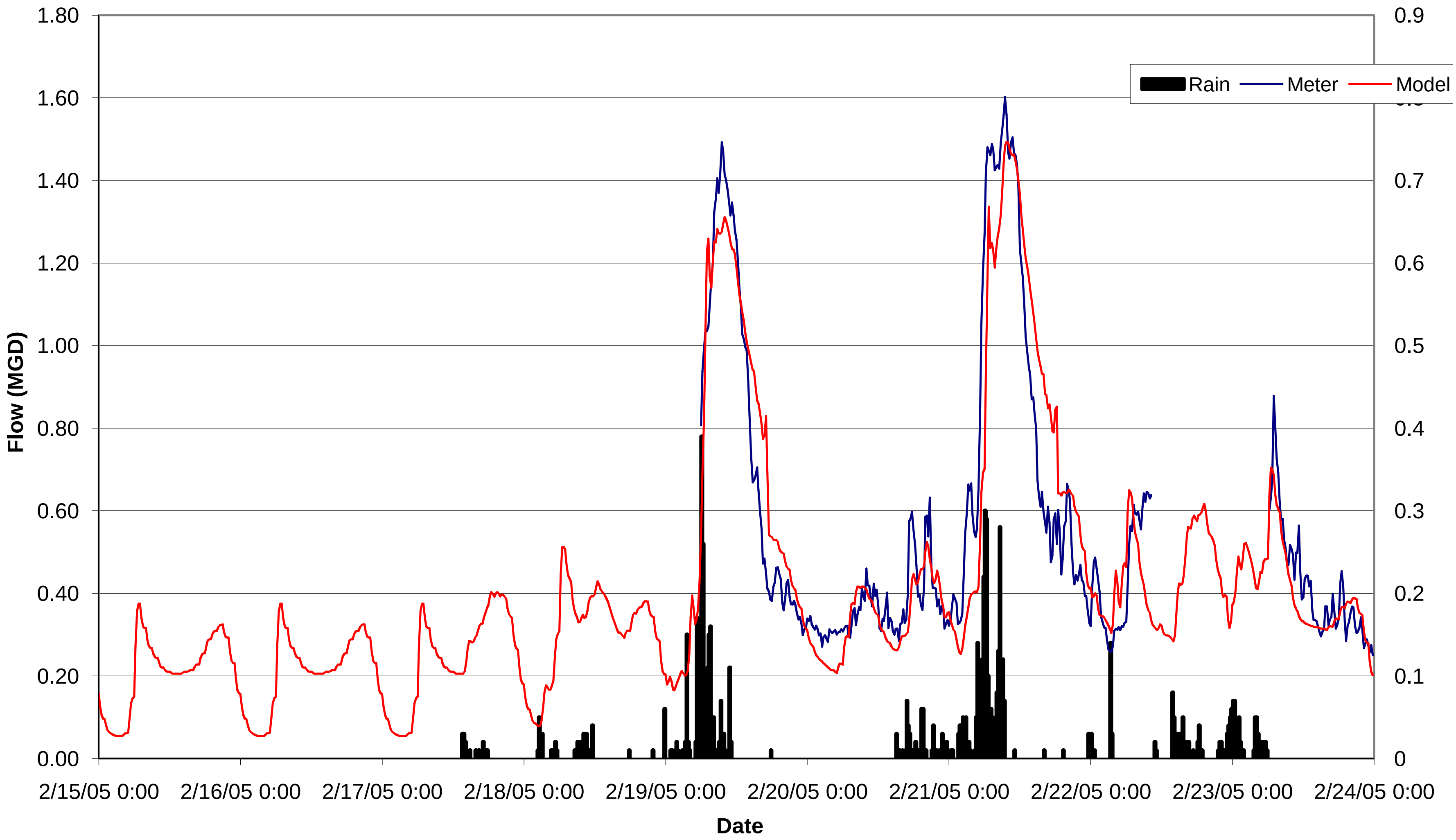


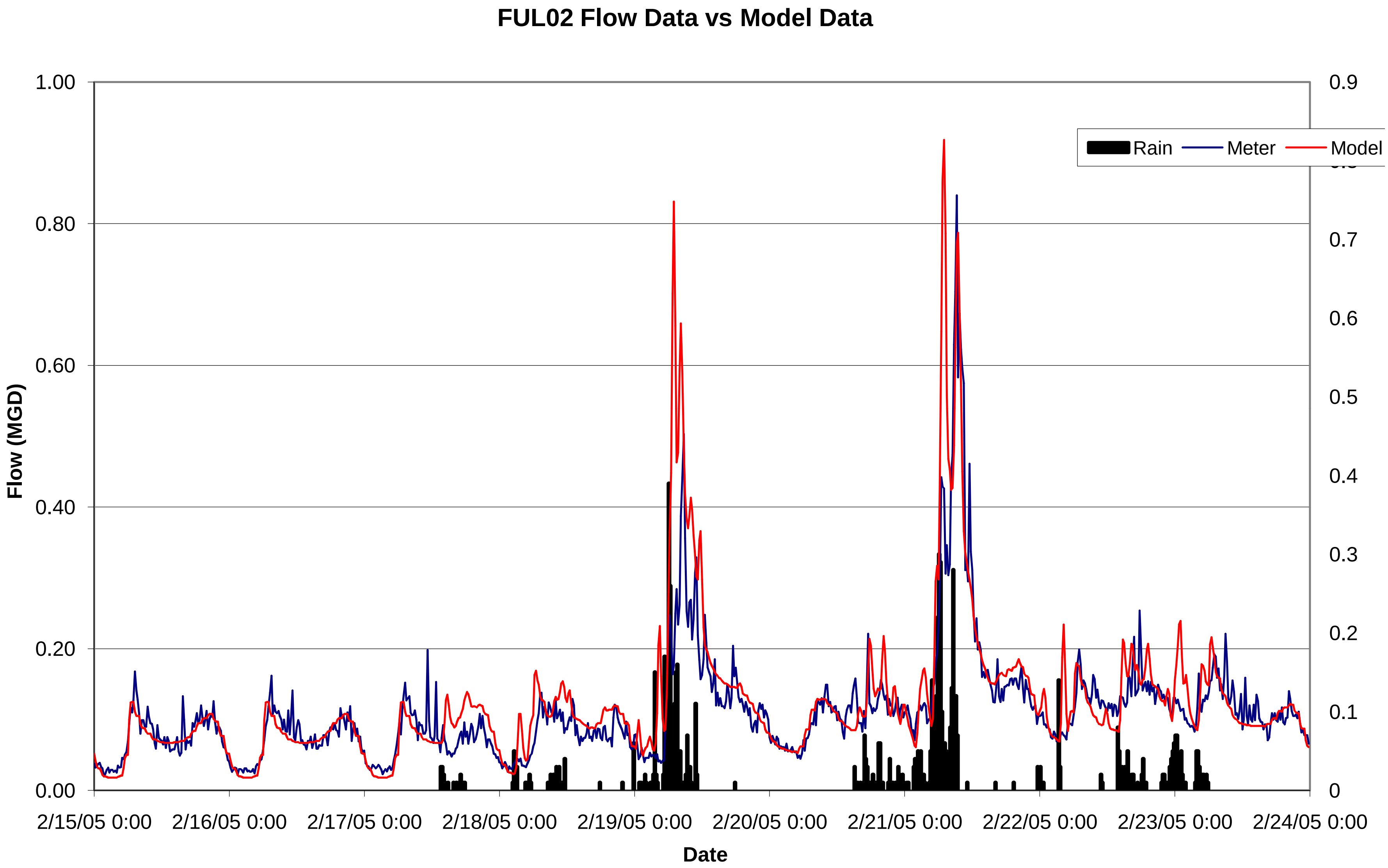
FOC121 Flow Data vs Model Data
Rain
Meter
Model
Flow (MGD)
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

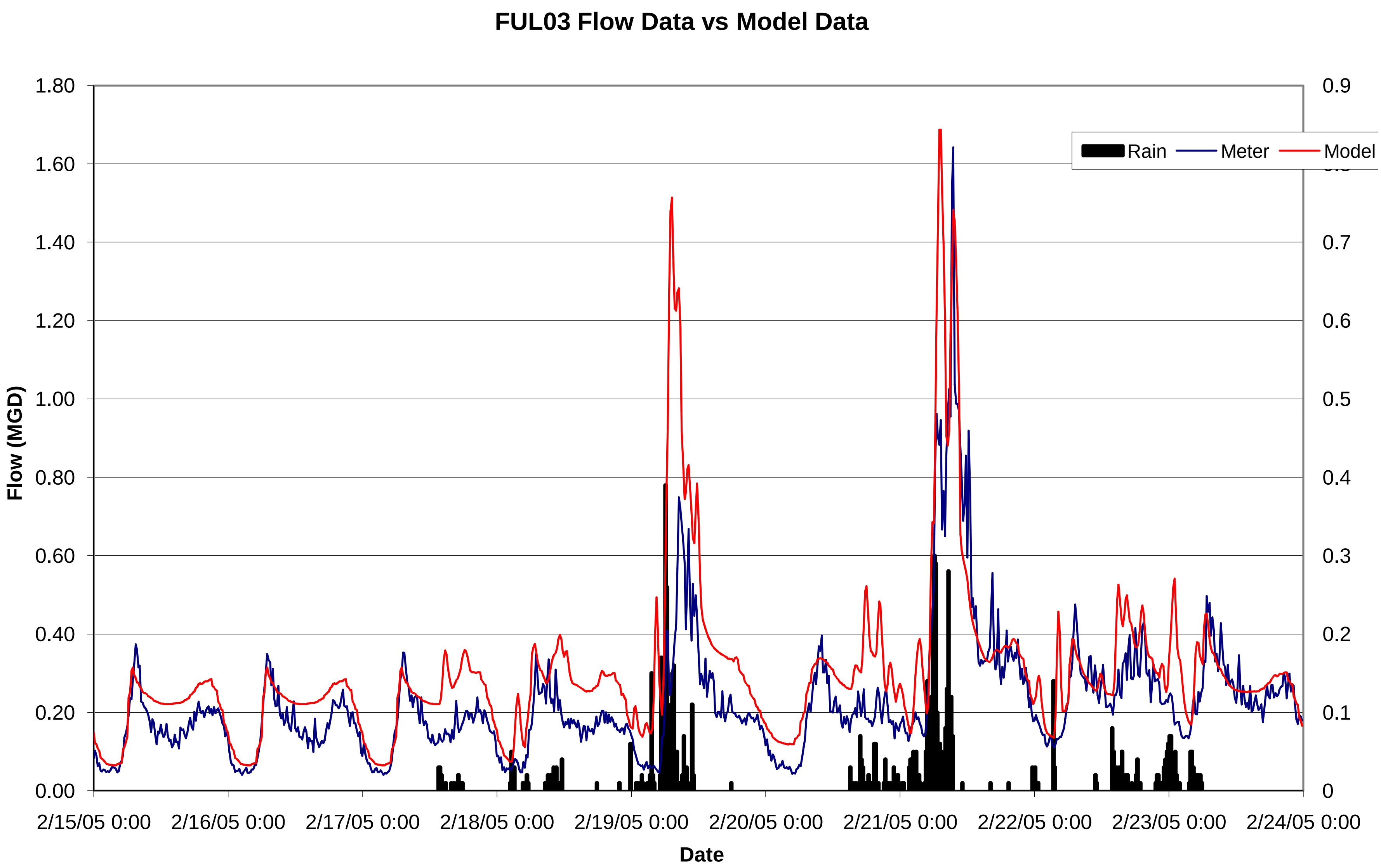


FOC209 Flow Data vs Model Data
Flow (MGD)
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

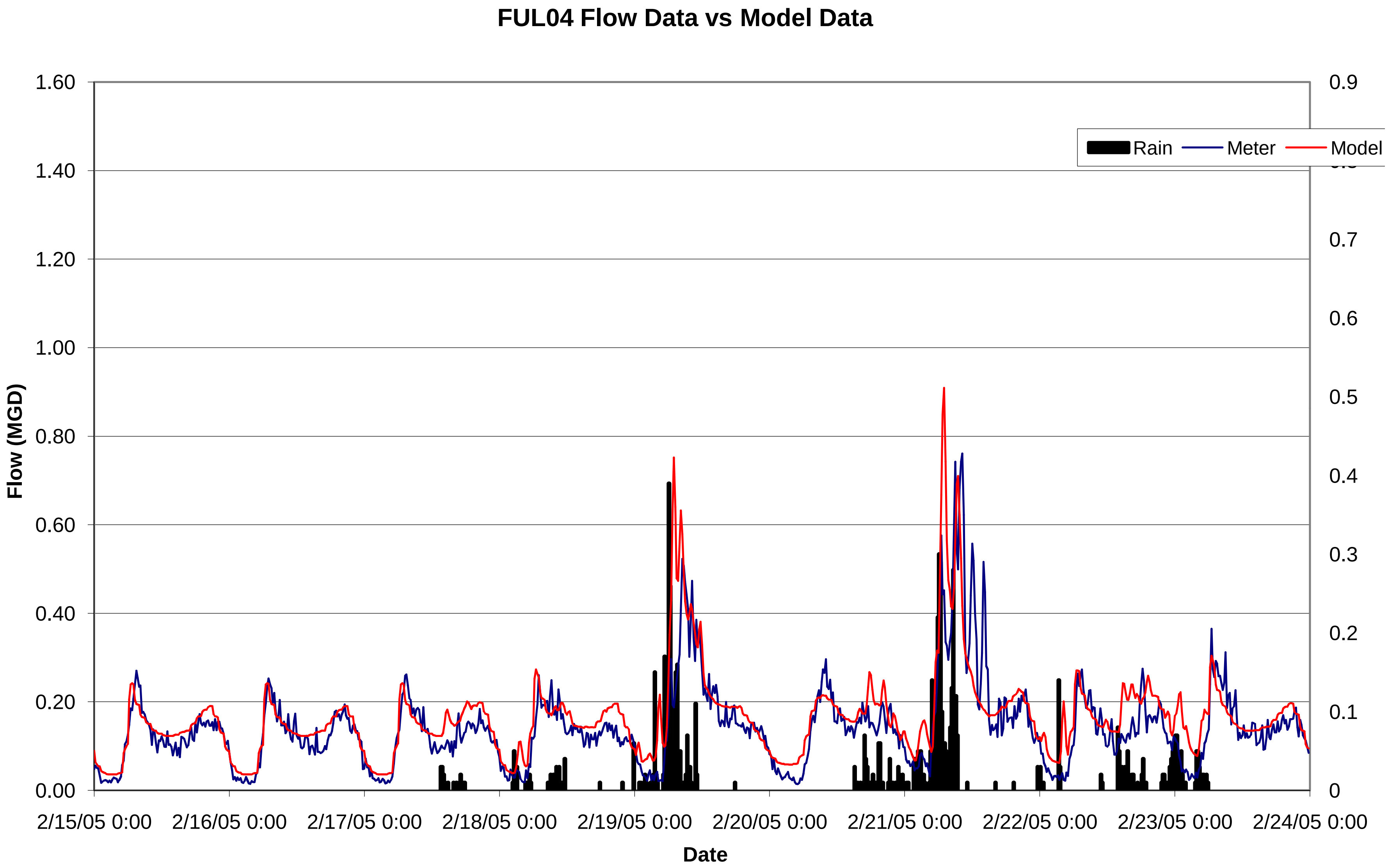
FUL01 Flow Data vs Model Data



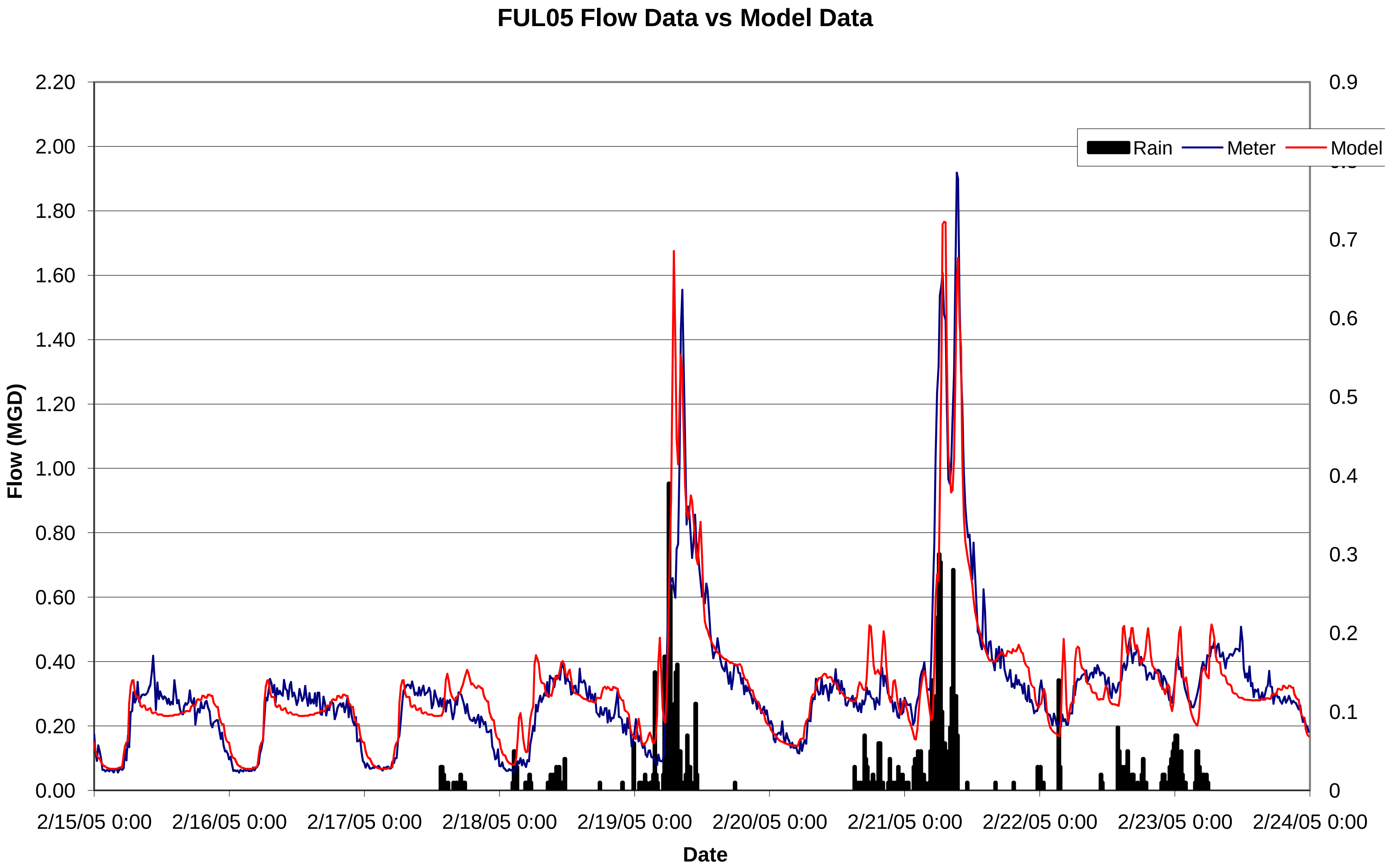

FUL02 Flow Data vs Model Data
Rain
Meter
Model
Flow (MGD)
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date



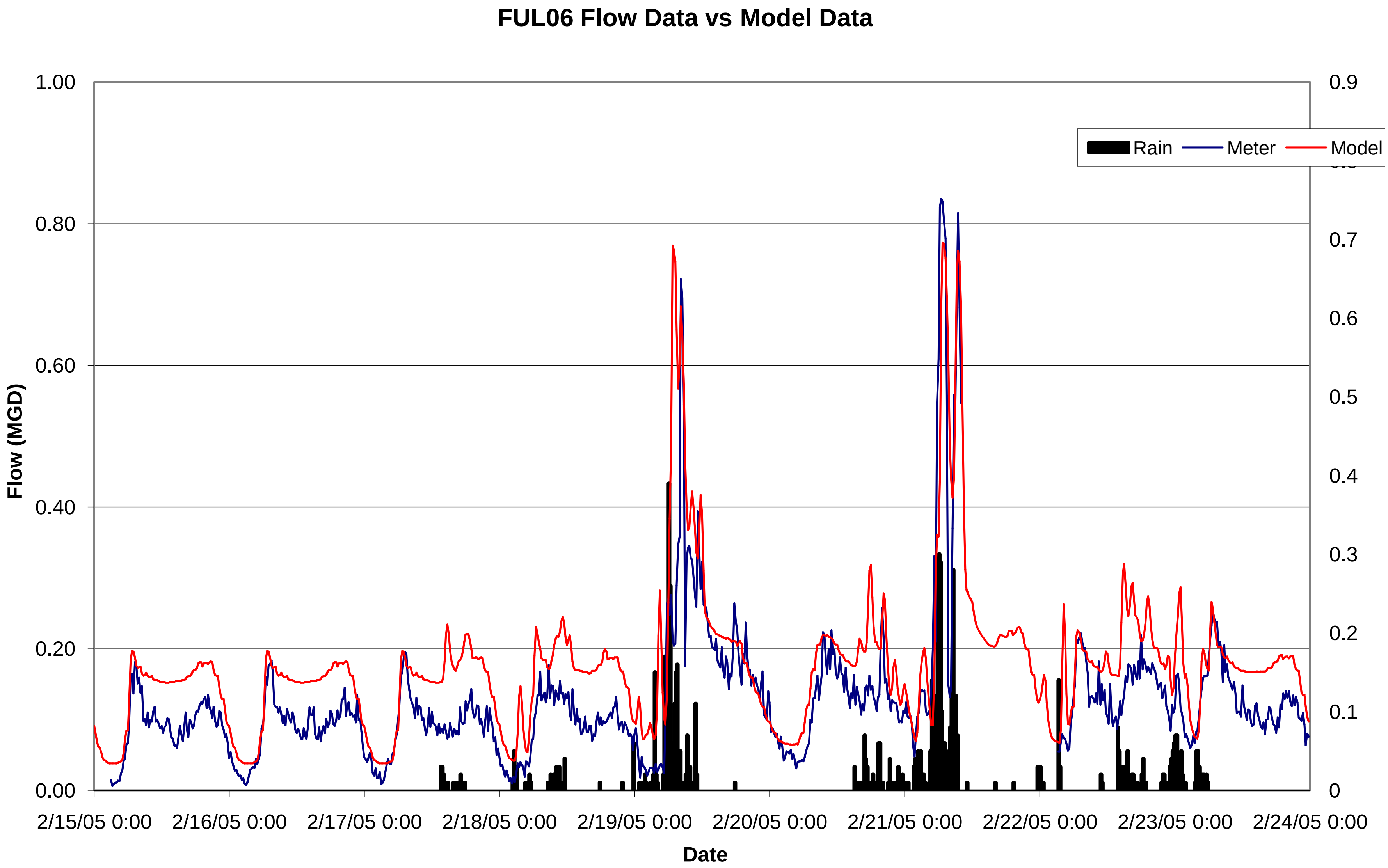
FUL03 Flow Data vs Model Data
Rain
Meter
Model
Flow (MGD)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date



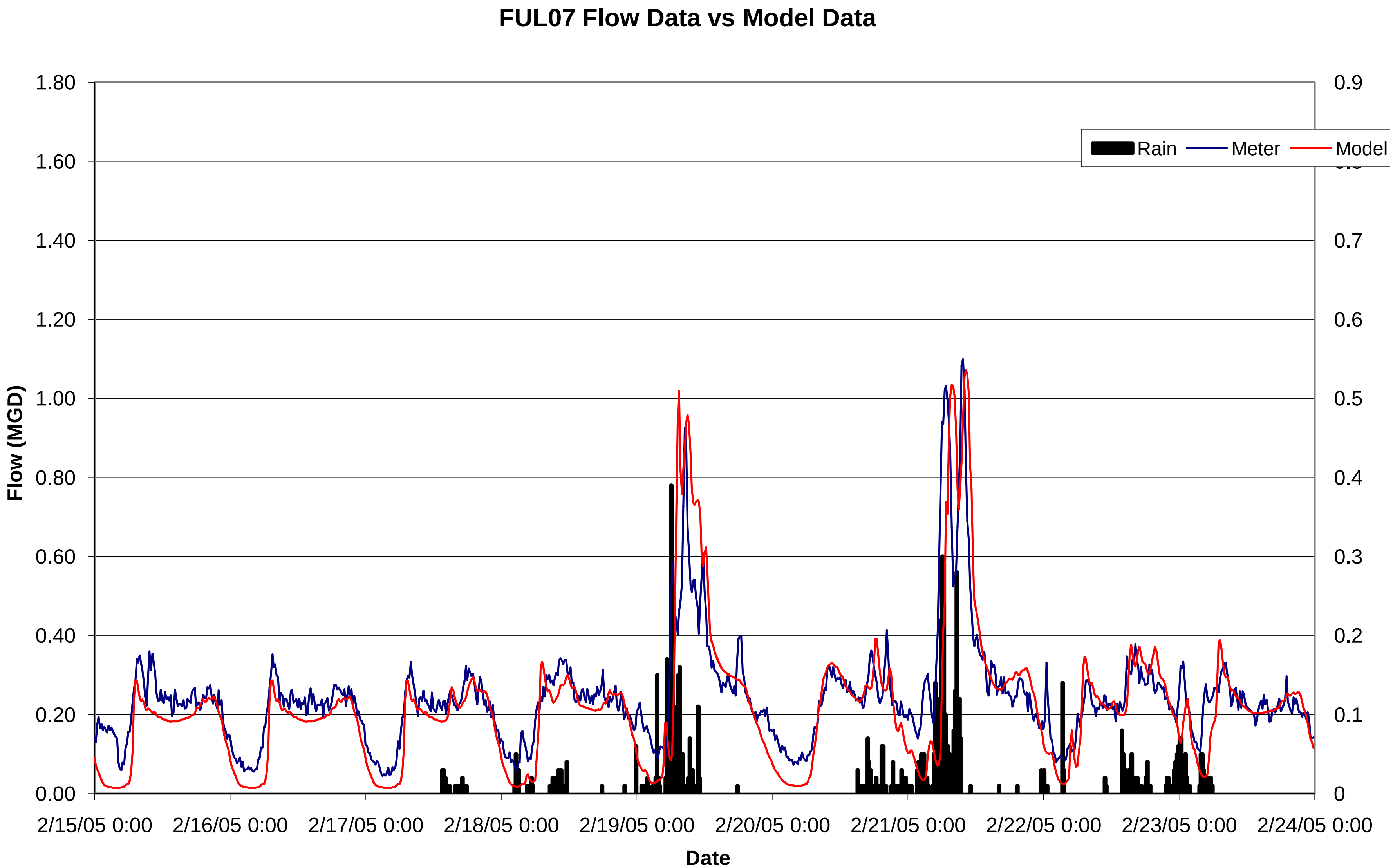
FUL04 Flow Data vs Model Data
Rain
Meter
Model
Flow (MGD)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date



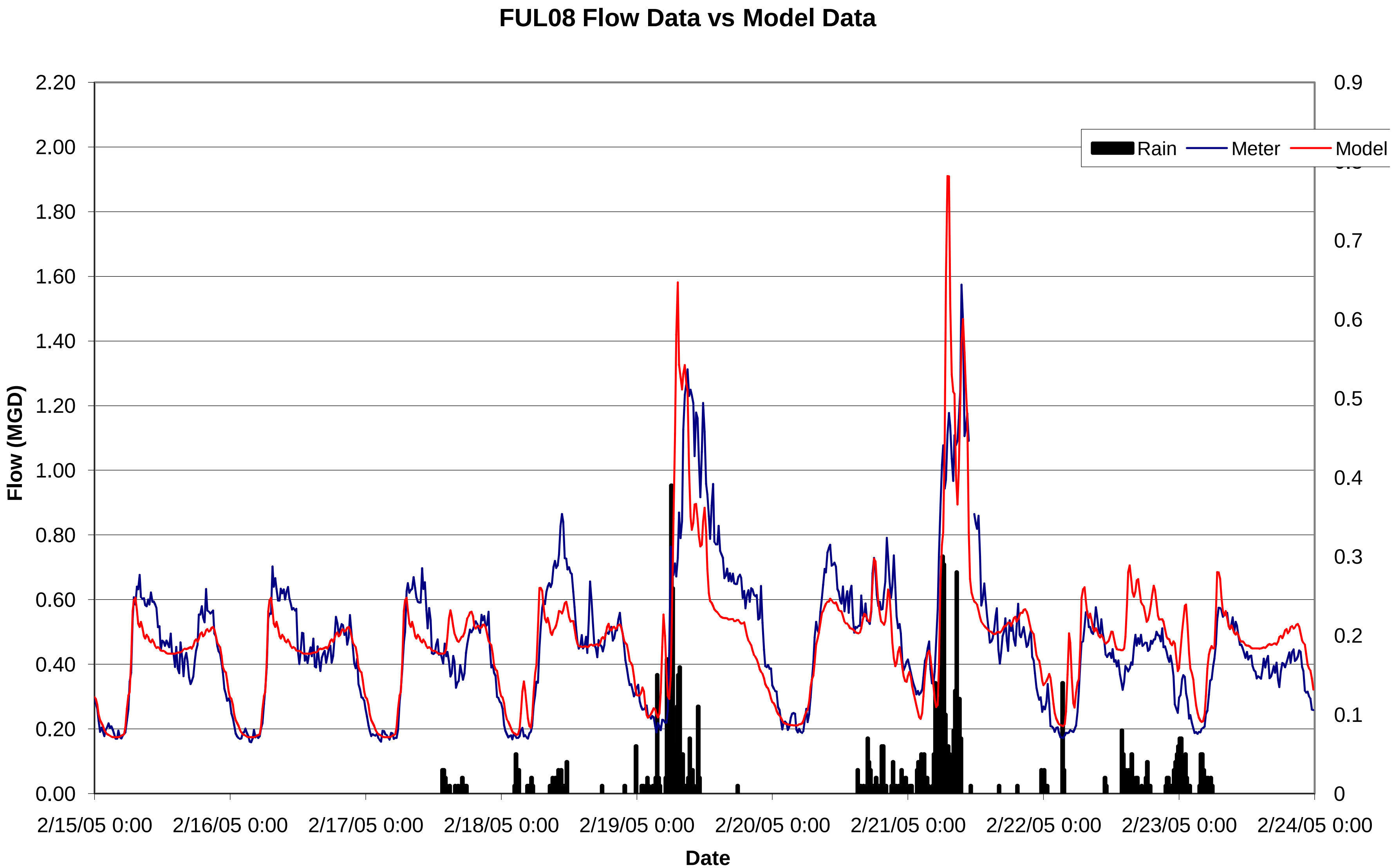
FUL05 Flow Data vs Model Data
Rain
Meter
Model
Flow (MGD)
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

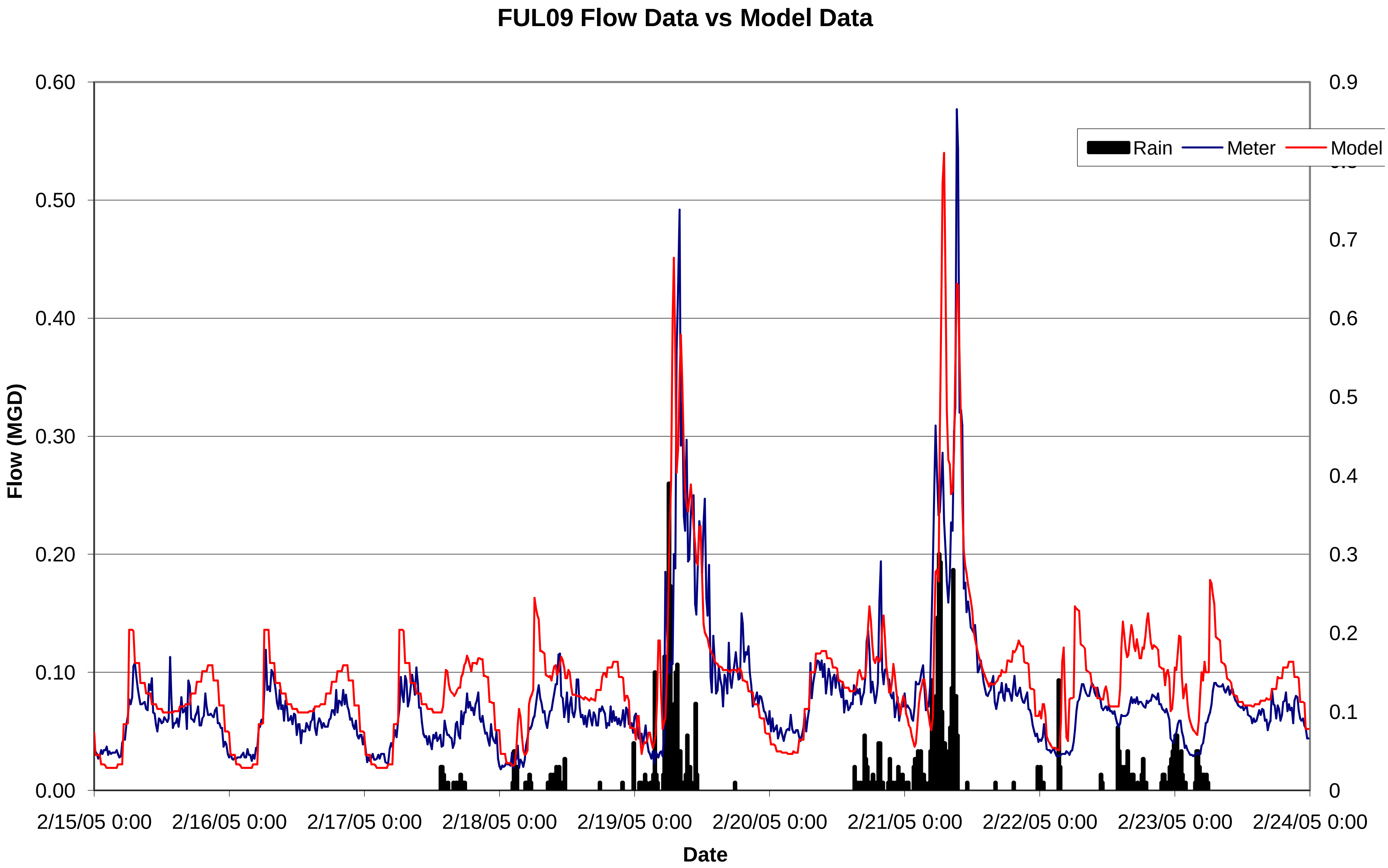


FUL06 Flow Data vs Model Data
Rain
Meter
Model
Flow (MGD)
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

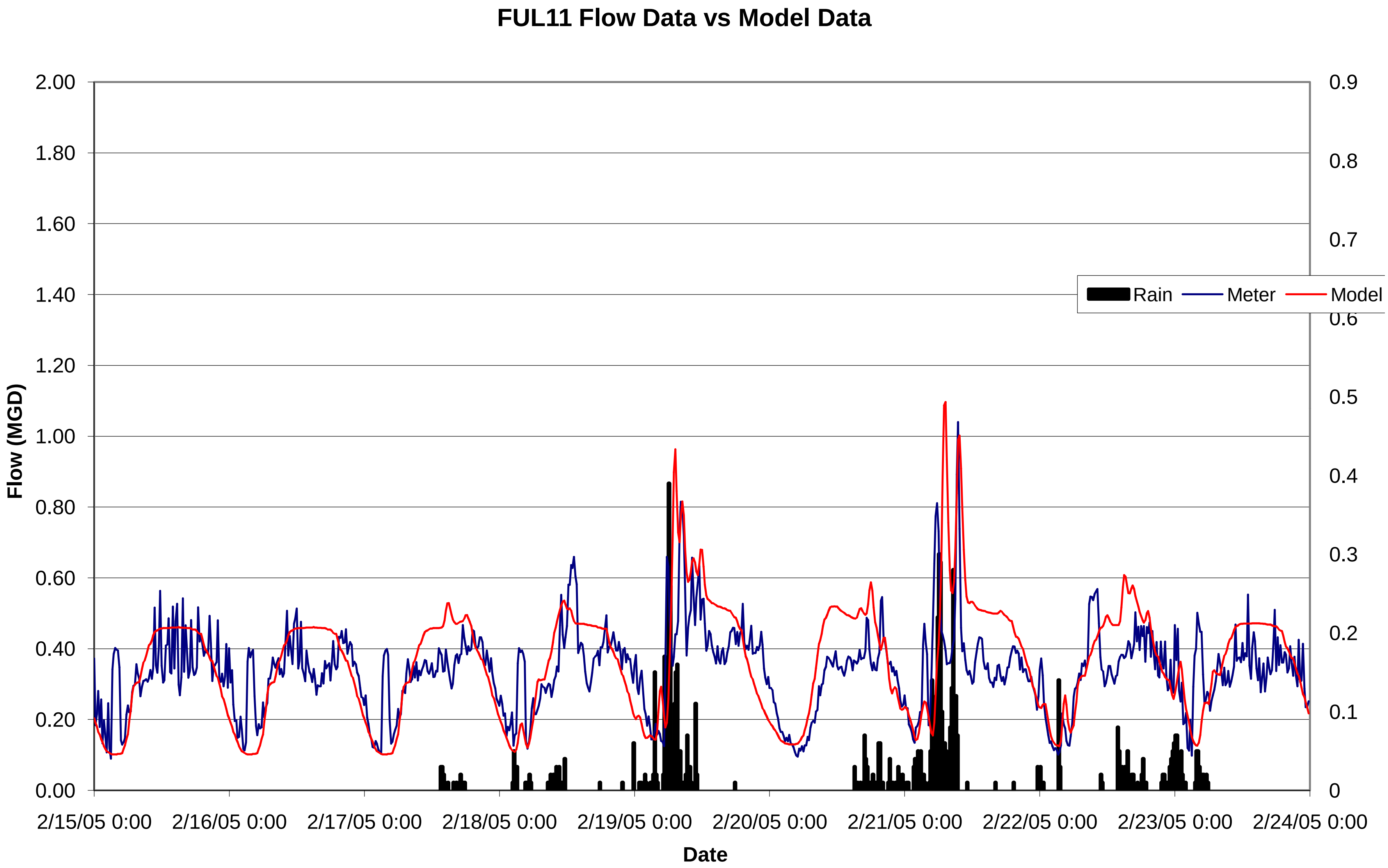


FUL07 Flow Data vs Model Data
Flow (MGD)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

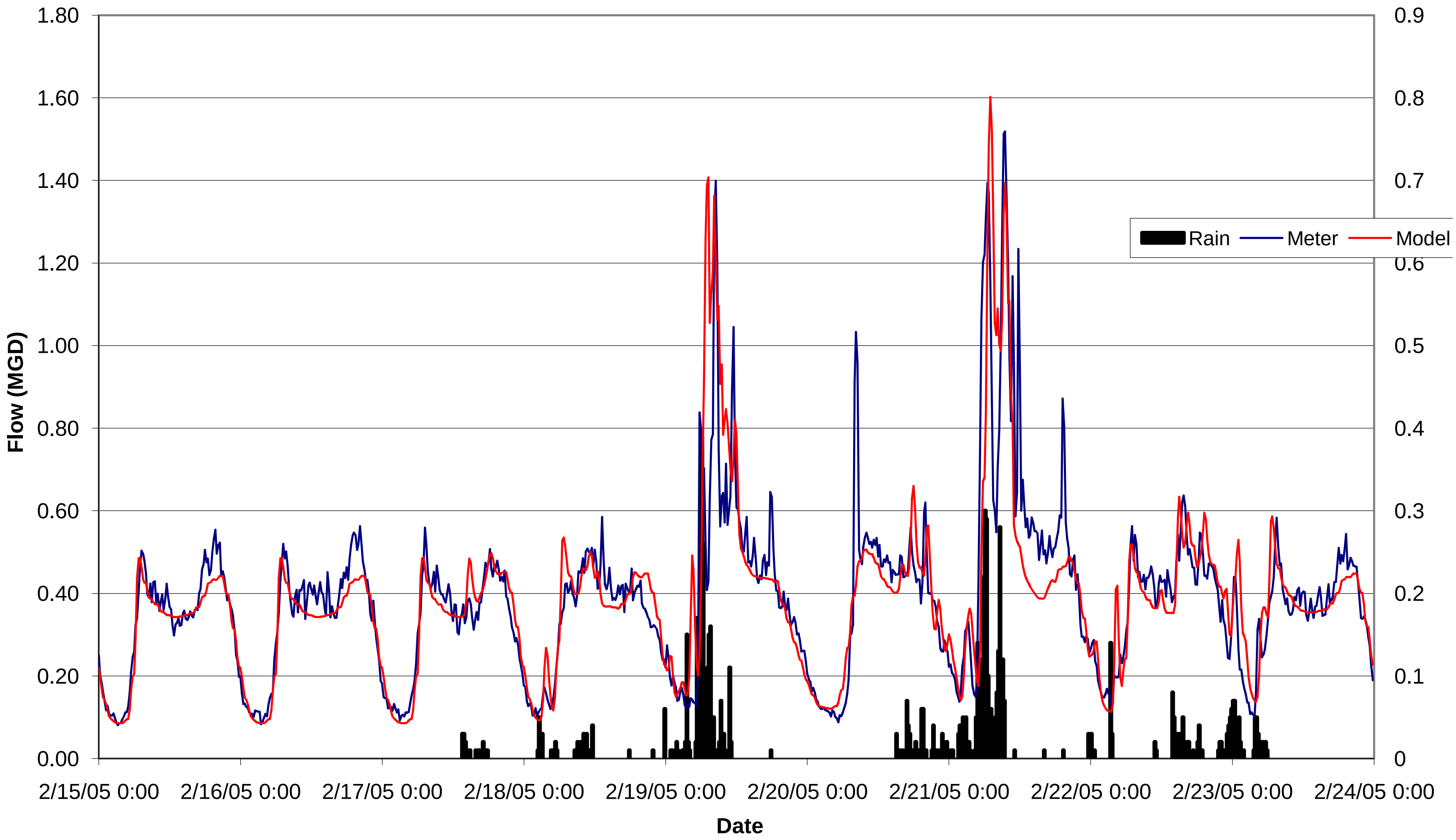

FUL08 Flow Data vs Model Data
Rain
Meter
Model
Flow (MGD)
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

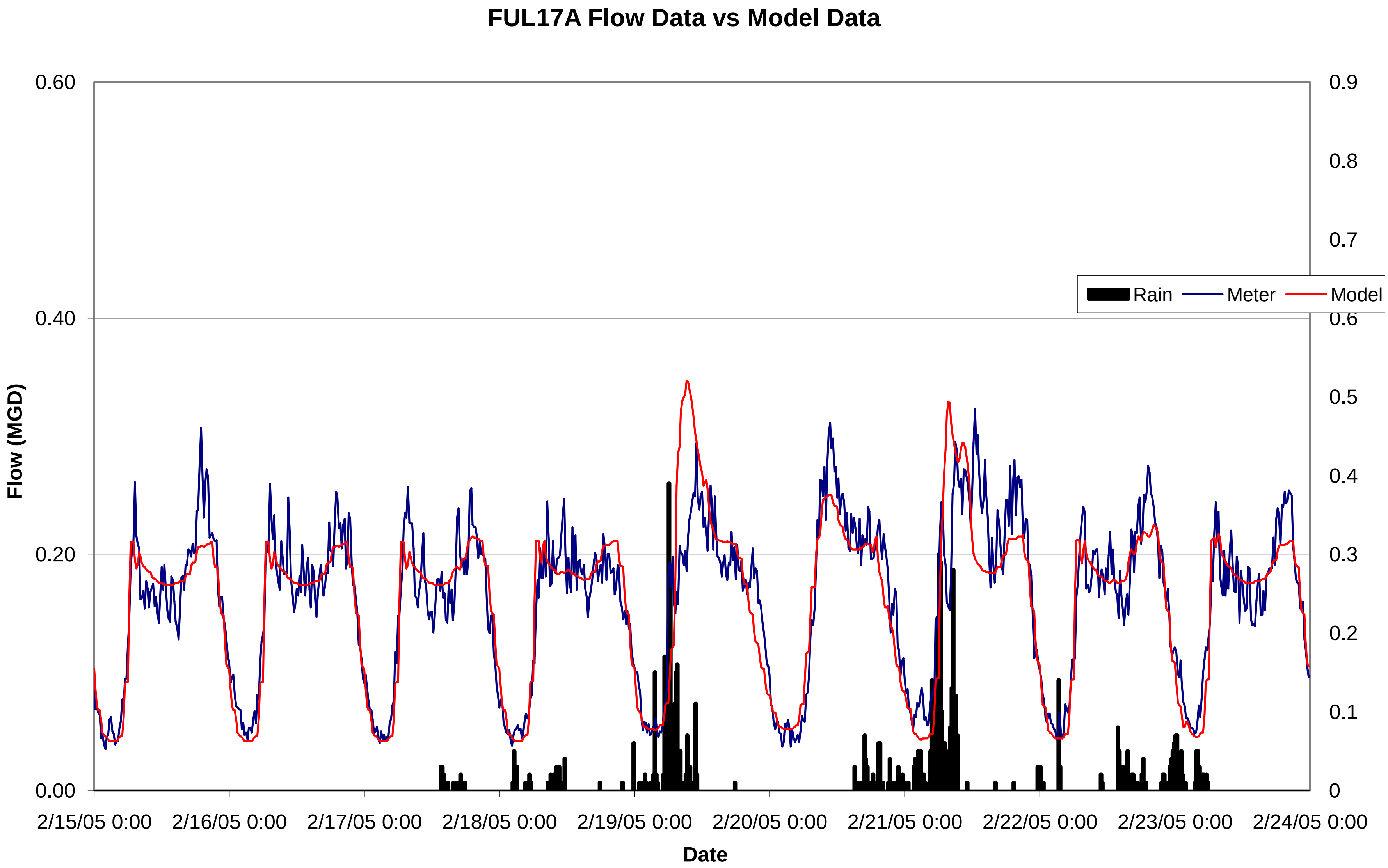


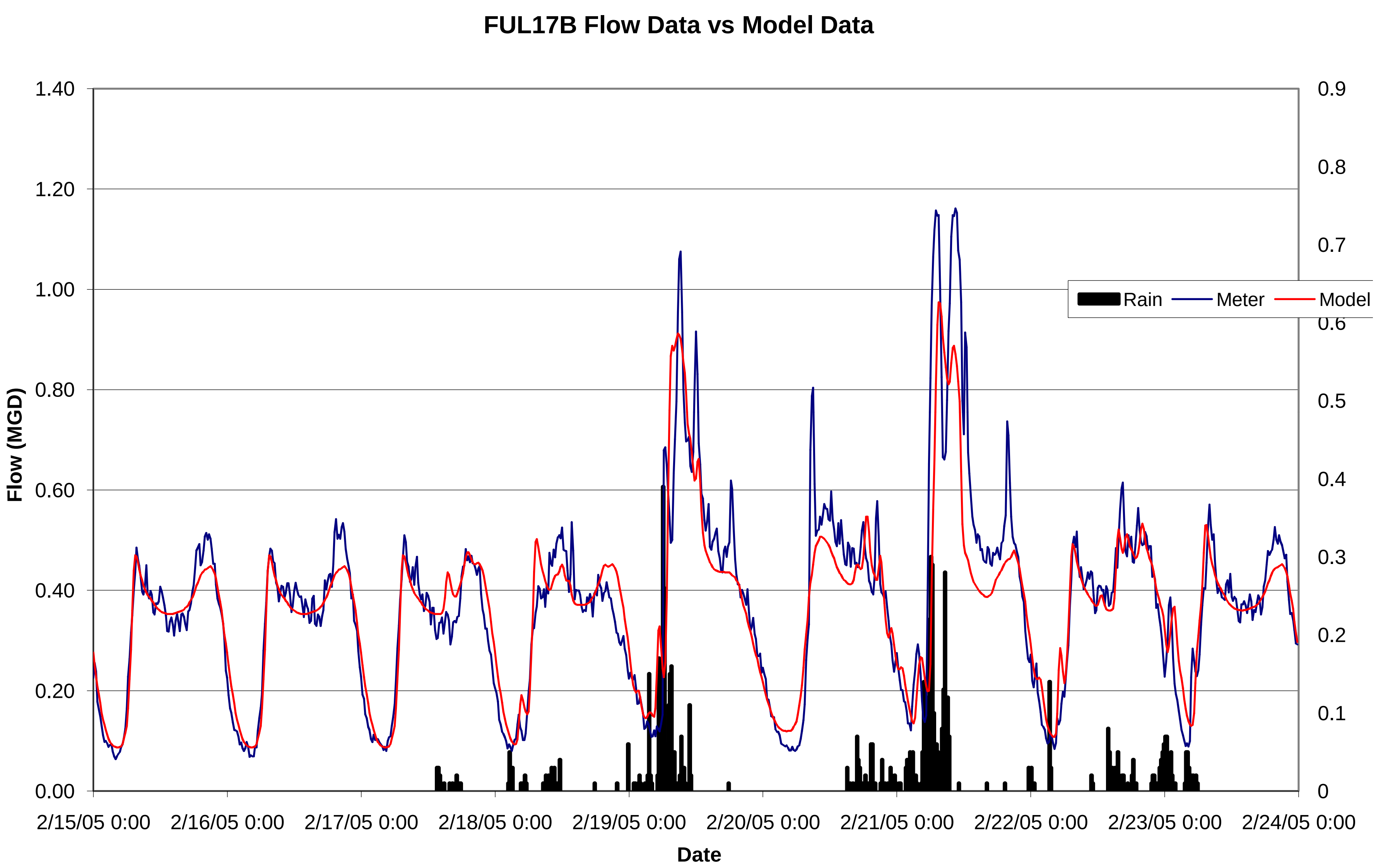
FUL09 Flow Data vs Model Data
Flow (MGD)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.9
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

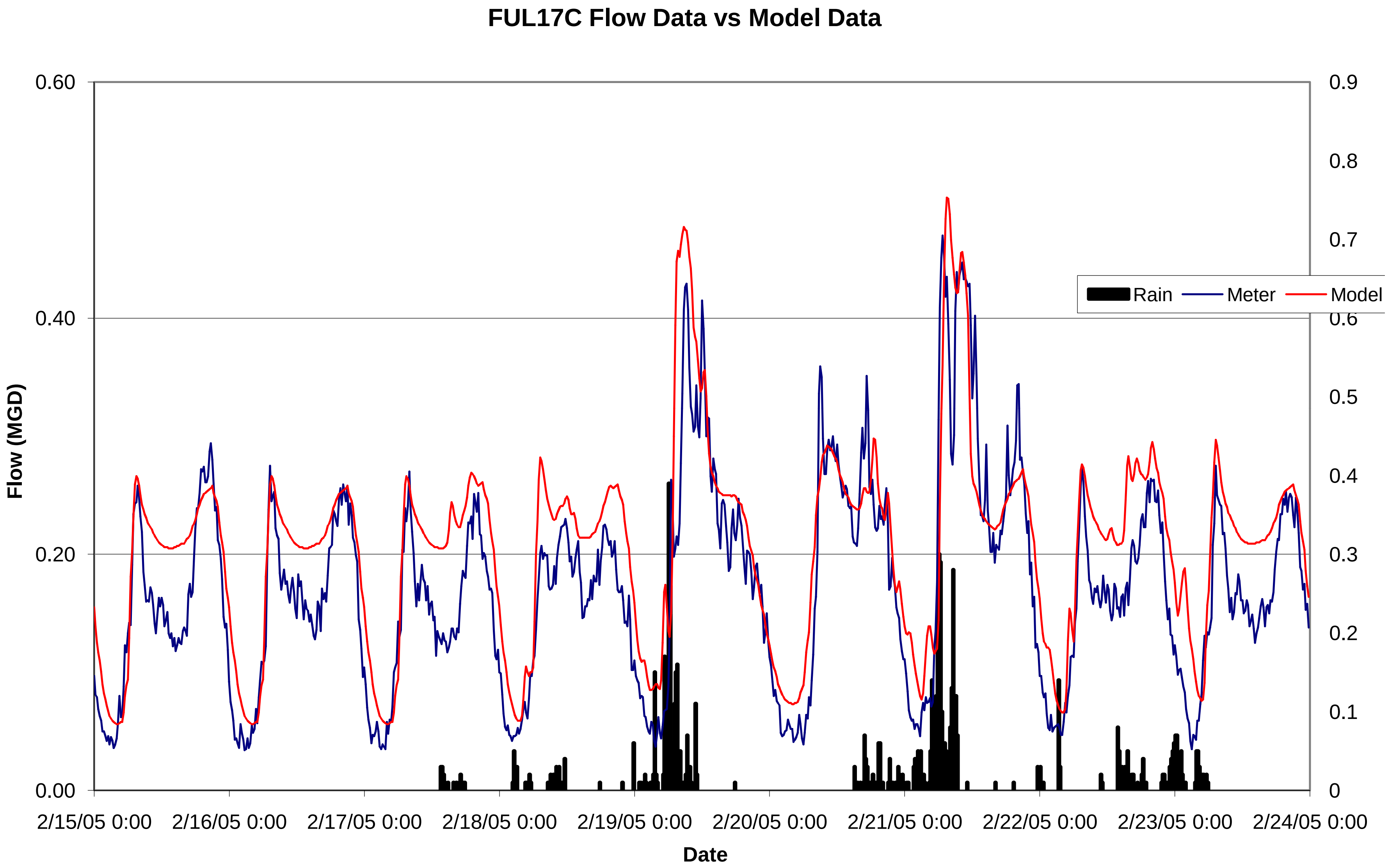

FUL11 Flow Data vs Model Data
Flow (MGD)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

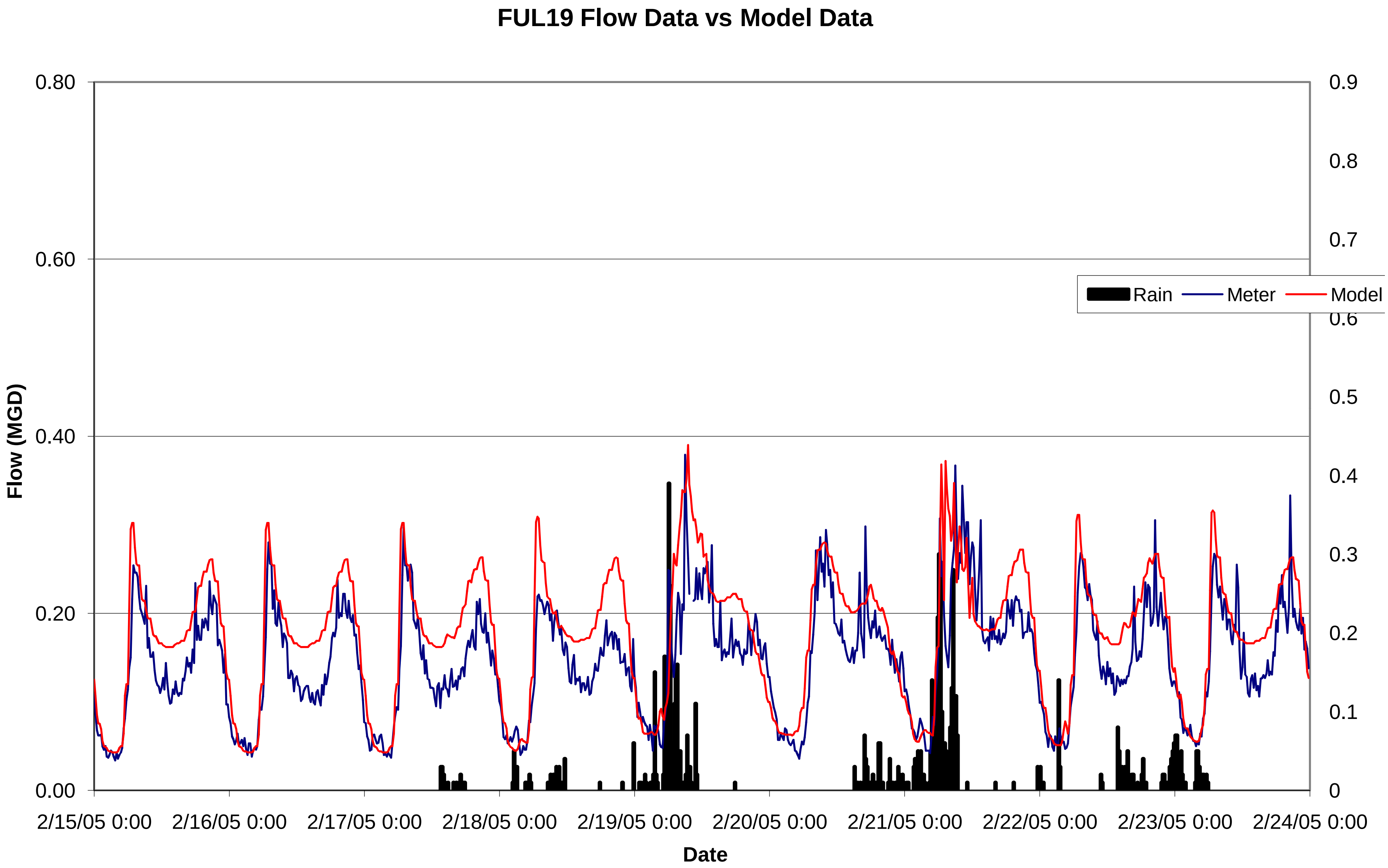
FUL12 Flow Data vs Model Data



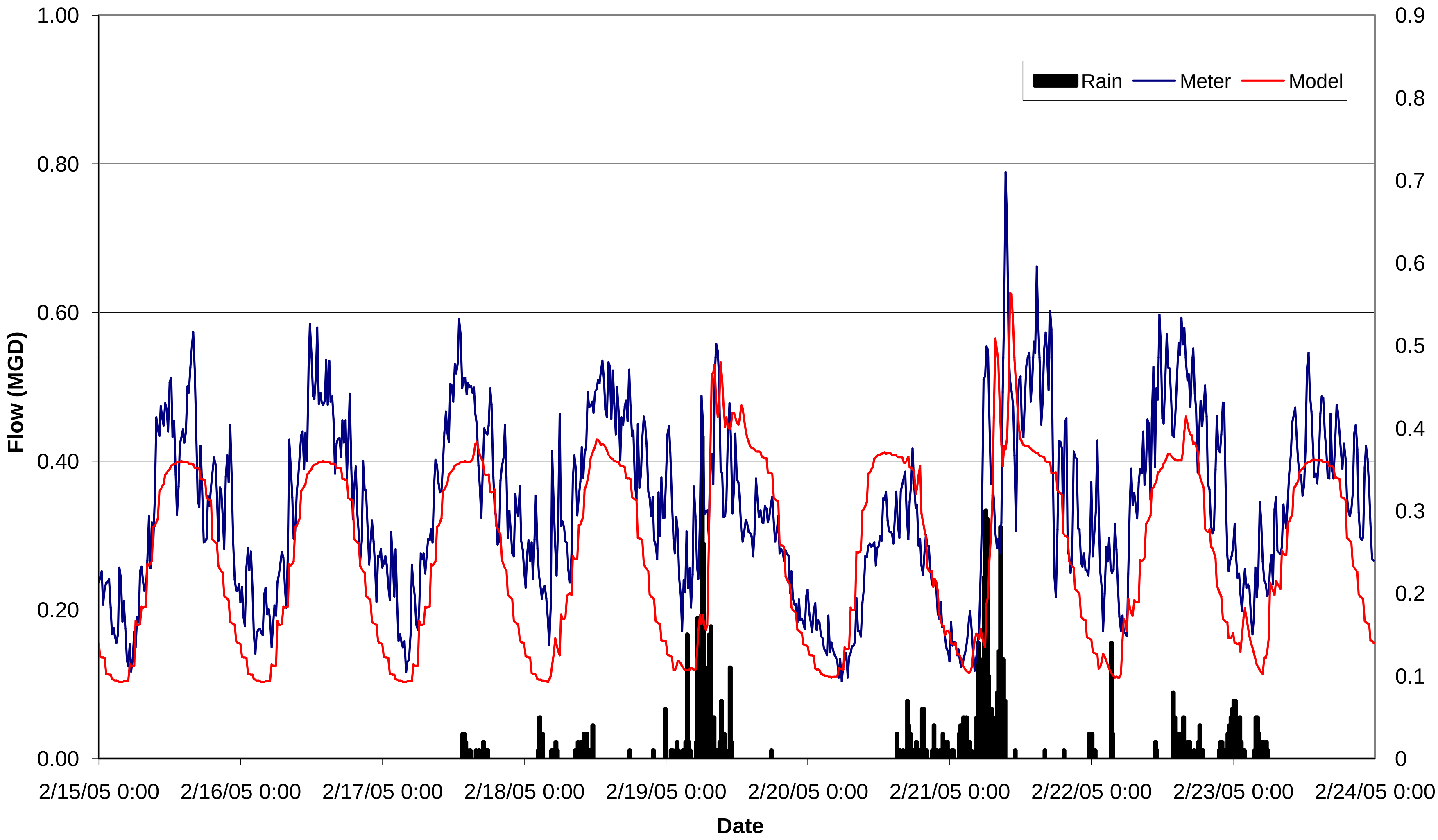

FUL17A Flow Data vs Model Data
Flow (MGD)
0.60
0.40
0.20
0.00
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

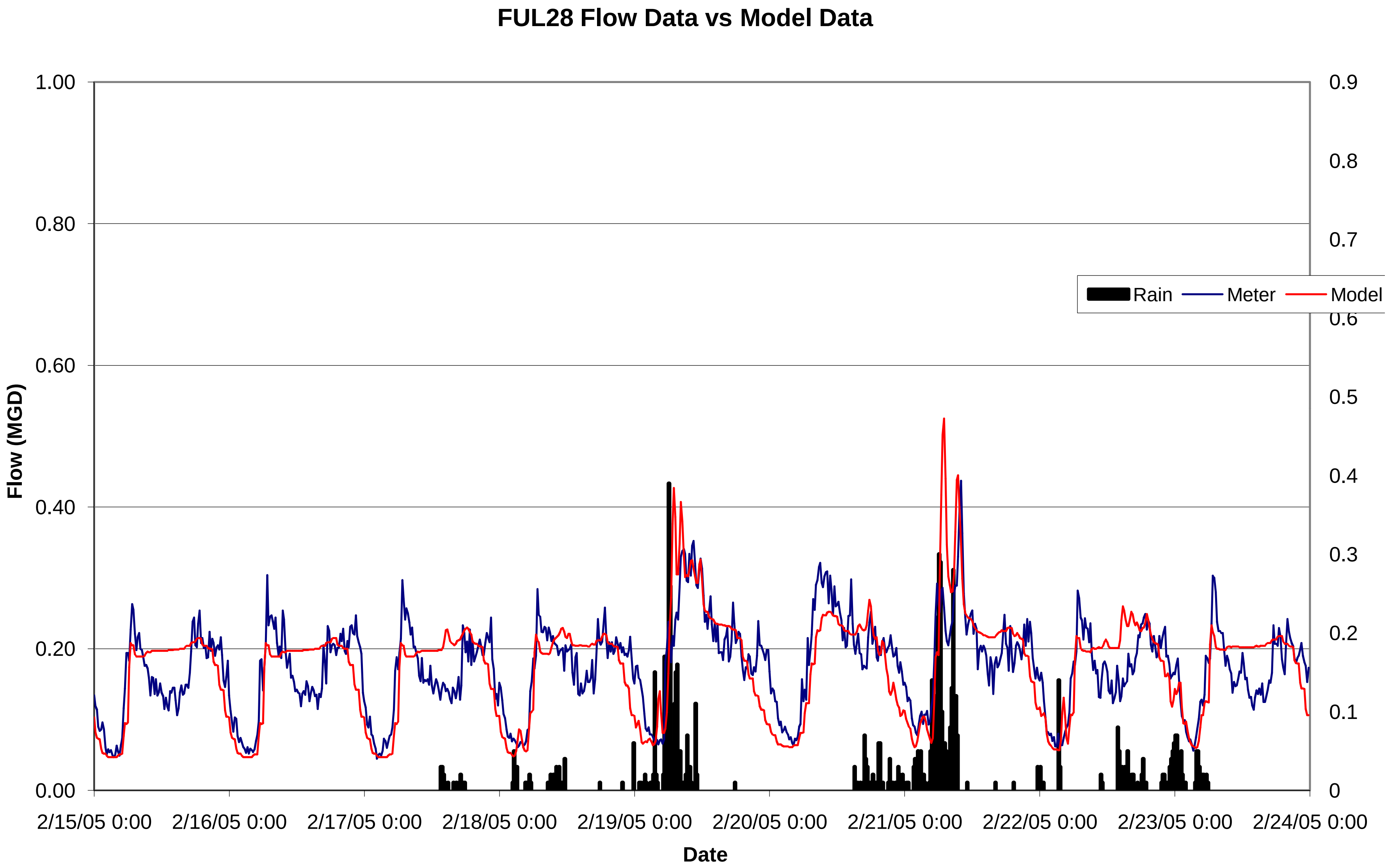

FUL17B Flow Data vs Model Data
Flow (MGD)
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date


FUL17C Flow Data vs Model Data
Flow (MGD)
0.60
0.40
0.20
0.00
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

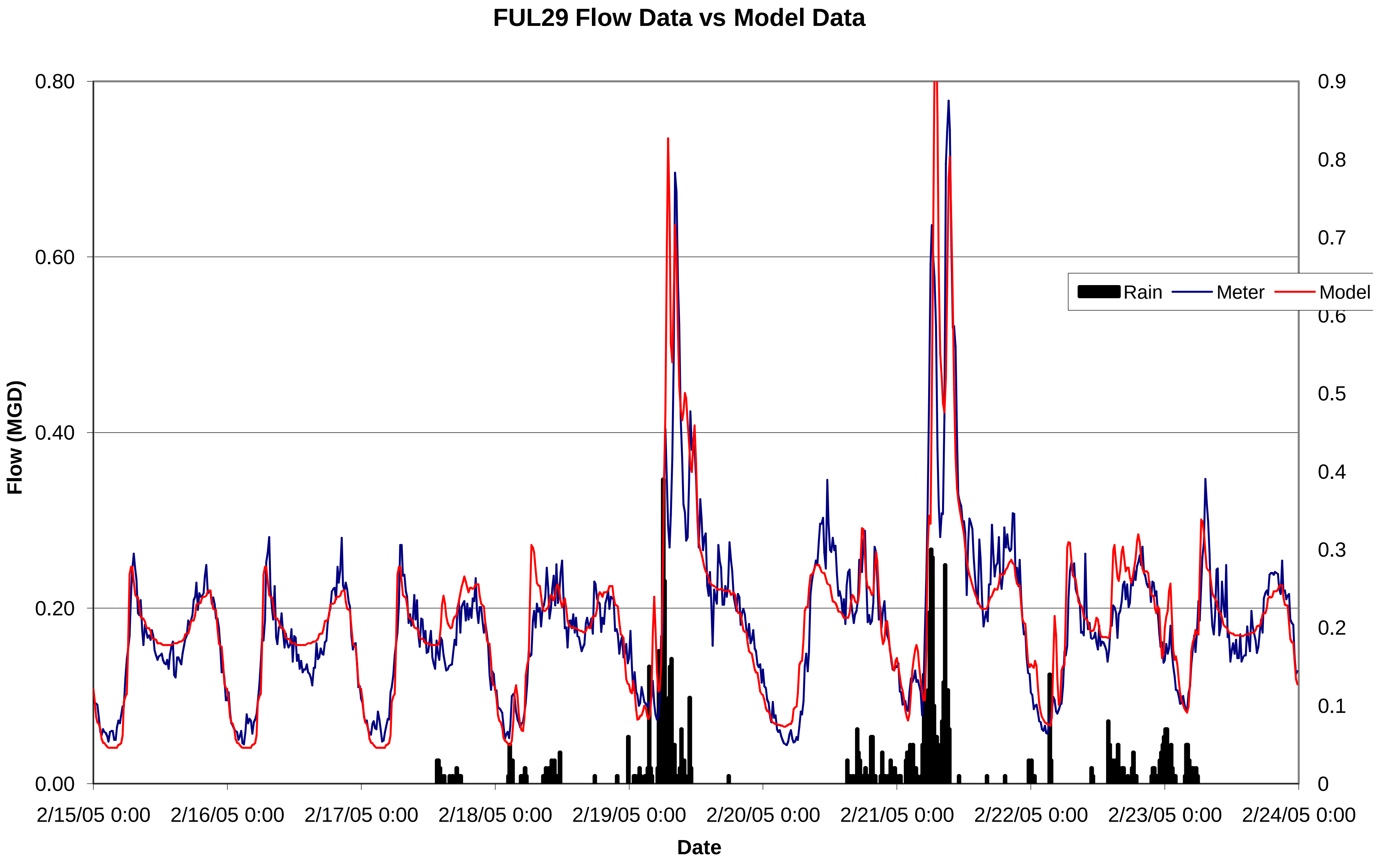

FUL19 Flow Data vs Model Data
Flow (MGD)
0.80
0.60
0.40
0.20
0.00
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date

FUL26 Flow Data vs Model Data





FUL28 Flow Data vs Model Data
Flow (MGD)
1.00
0.80
0.60
0.40
0.20
0.00
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date


FUL29 Flow Data vs Model Data
Flow (MGD)
0.80
0.60
0.40
0.20
0.00
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rain
Meter
Model
2/15/05 0:00
2/16/05 0:00
2/17/05 0:00
2/18/05 0:00
2/19/05 0:00
2/20/05 0:00
2/21/05 0:00
2/22/05 0:00
2/23/05 0:00
2/24/05 0:00
Date