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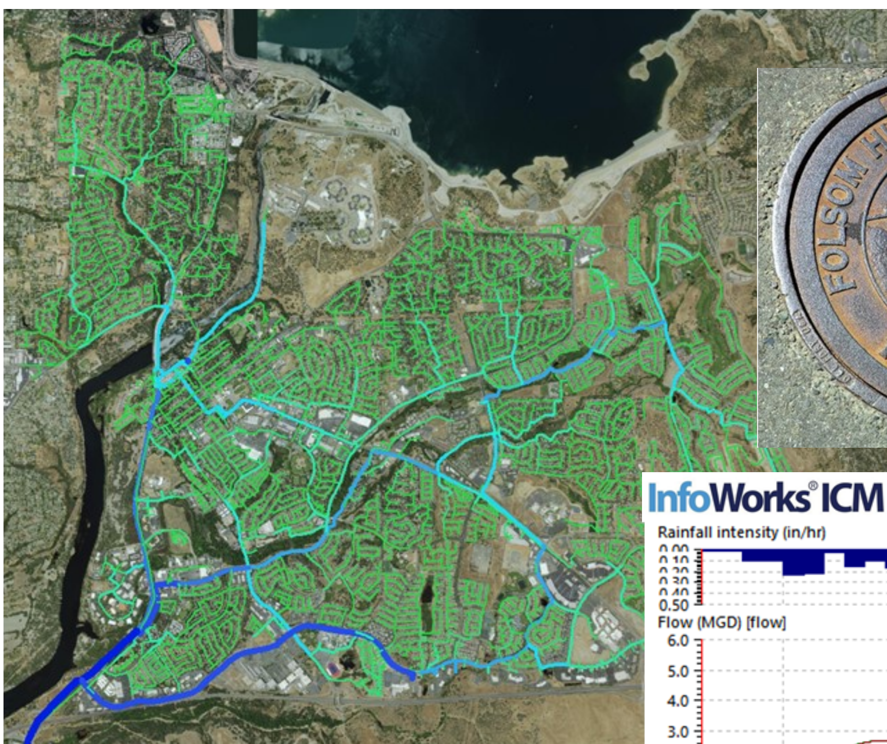
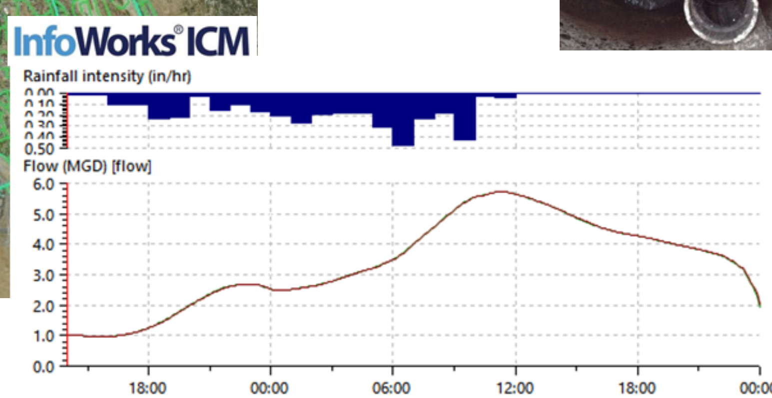
SECAP 2017

2016 System-wide Hydraulic Evaluation and Capacity Assurance Plan Update

PROJECT REPORT

September 2017





WATERWORKS ENGINEERS

1322 Blue Oaks Blvd
Roseville, CA, 95678

SECAP 2017

SYSTEM-WIDE HYDRAULIC EVALUATION AND CAPACITY ASSURANCE PLAN UPDATE

DRAFT PROJECT REPORT

Date: September, 2017

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GLOSSARY

AAGR	Average Annual (Compound) Growth Rate: $P_{future} = P_{Present} x(1+i)^n$
ADWF	Average Dry Weather Flow; not influenced by rainfall; does not include RDII or GWI, averaged across single day
Basin	smallest unit of sewer system isolated by an individual flow meter
CDCR	California Dept. of Corrections & Rehabilitation
CIP	Capital Improvement Project
CIPP	Cured in place pipe; sewer pipe rehabilitation technology
CS / InfoWorks	Innovyze InfoWorks CS fully dynamic hydraulic modeling software (discontinued)
design storm	Standard precipitation event to calibrate hydraulic model; specified depth, duration, and probabilistic return period
DIA	nominal diameter
Diurnal Flow	Daily Hydrograph
DOF	California Department of Finance
DWF	Sewer Dry Weather Flow; not influenced by rainfall; does not include RDII or GWI
EDU	Equivalent Dwelling Unit; single household sewer producing equivalent unit
EX / EXST	Existing
FAR	Floor to Area Ratio; building floor space to at-grade parcel area ratio
Fixed Density	owner occupied residential housing such as single family homes
Forcemain	Pressurized sewer pipeline that is pumped from pump station
FPA	Folsom Plan Area south of 50, currently in construction
GIS	ESRI ArcGIS (Geographical Information System) software or data
GP	2035 General Plan (accessed in 2016, draft format)
gpd	gallons per day
gpm	gallons per minute (694.44 gpm per 1.00 mgd)
GWDR	SWRCB Order No. 2006-0003 Statewide General Waste Discharge Requirements
GWI	Groundwater Infiltration; seasonal; constant underlying baseflow
HH	Household Size
HW	Hazen Williams empirical hydraulic roughness coefficient for pressurized forcemains
hydrograph	Graph of sewer flow vs time
hyetograph	Graph of rainfall intensity (inches) vs time
I/I	Inflow and Infiltration; includes RDII and GWI
ICM / InfoWorks	Innovyze InfoWorks Integrated Catchment Modeling fully dynamic hydraulic modeling software (2016 current version 7.0)
ID	actual inner diameter

Interceptor	Convergence of trunk lines into larger, common pipe
Invert	Lowest flow line of sewer pipe
K	Ratio of Time Recession; RTK method
Land Use	Supersedes zoning; applied to wastewater generation rates
Lateral	Lateral service gravity line (typically 4")
Main	City owned gravity sewer main (typically 6" to 24" DIA)
Mannings N	Manning's empirical open channel flow hydraulic roughness coefficient
mgd	million gallons per day
MH	Manhole
MP	Master Plan; Previous ECOLOGIC (consulting firm) Master Plan or SECAP produced in 2003, 2005, and 2008
MTPSCS	Metropolitan Transportation Plan / Sustainable Communities Strategy
N Value	Manning's empirical open channel flow hydraulic roughness coefficient
NOAA	U.S. Department of Commerce: National Oceanic and Atmospheric Administration
North of 50	Existing City sewered area north of Highway 50
O&M	Operation and Maintenance
OD	actual outside diameter
PDWF	Peak Dry Weather Flow; peak instantaneous dry weather flow; ADWF after multiplied by peaking factor
PS	Sewer Pump Station; interchangeable with lift station
R	Fraction of rainfall volume entering sewer system as RDII; see RTK method
RDII	Rain Derived Inflow and Infiltration; sewer flow from surface (inflow) or below-grade groundwater (infiltration)
RTK	Triangular synthetic unit hydrograph to characterize RDII response to rainfall event
Sac Calc	Sacramento Calculator Software built on Sacramento Method
SACOG	Sacramento Area Council of Governments
Sacramento Method	Standard Sacramento County drainage manual method to identify the intensity, duration, and probabilistic return of a precipitation event
SECAP	System Evaluation and Capacity Assurance Plan
Sewershed	largest unit of sewer system; includes separate basins that discharge to common trunk line
Soffit / Crown	Inner top of pipe
South of 50	City Folsom Plan Area south of 50, currently in construction
SSCO	Sanitary Sewer Cleanout; private or public; provides delineation between private and public pipe; location to service lateral service line
SSMH	Sanitary Sewer Manhole; manhole
SSMP	Sanitary Sewer Master Plan; official municipal document mandated by SWRCB

SSOAP	U.S. Environmental Protection Agency (EPA) Sanitary Sewer Overflow and Analysis Program Software
SWRCB	State Water Resources Control Board
Synthetic Unit Hydrograph	Summation of unit hydrographs resulting in common hydrograph from specified precipitation
T	Time to Peak; equivalent to Time of Concentration; see RTK method
Trunk	Large diameter gravity sewer main (typically 24" DIA)
UBO	Ultimate Build Out
Unit Hydrograph	Theoretical hydrograph resulting from a unit of precipitation
Variable Density	renter occupied residential housing such as apartments
WaterWorks	Water Works Engineers
Wet Weather Flow	Wet Weather Flow; influenced by rainfall; may include GWI, RDII
WW Generation Rate	Average sewer flow applied to parcels with specific land use to produce ADWF
WWE	Water Works Engineers
Zoning	Planning department zone delineation for individual City parcel

1 INTRODUCTION

1.1 Project Background

Water Works Engineers, LLC (Water Works) is under contract with the City of Folsom to update the System Evaluation and Capacity Assurance Plan (SECAP 2017). In February 2003, the City of Folsom (City) prepared a SECAP, which included a GIS-based collection system hydraulic model (InfoWorks CS), to identify and address collection system hydraulic deficiencies. The intent of the SECAP is to prevent sanitary sewer overflows (SSOs) by identifying system hydraulic capacity deficiencies and developing and implementing a Capital Improvement Plan (CIP) to mitigate those deficiencies. The City has completed several updates to the SECAP as required to meet regulatory compliance requirements, which includes the ongoing development and implementation of its Sewer System Management Plan (SSMP) in accordance with State Water Resources Control Board Order No. 2006-0003 Statewide General Waste Discharge Requirements for Sanitary Sewer Systems (GWDRs). As part of the compliance process, the City periodically updates its physical hydraulic model to more accurately represent collection system repairs, rehabilitation, and replacement and new infrastructure (existing and planned growth). In addition, the City calibrates the updated physical model with flow data collection from permanent dry and wet weather monitoring stations.

1.2 Project Objective

The general objective of this project is the continued proactive maintenance of the City's wastewater collection system assets through a SECAP update and associated hydraulic model update. A summary of the steps involved in this project are listed below:

- Reviewed previous master plans, memos, hydraulic models, and updated the physical hydraulic model in GIS to accurately portray existing conditions (4" - 54" sized pipes).
- Produced parcel-by-parcel sewer loads calibrated to existing dry weather flow monitoring and scaled up to meet General Plan and Ultimate Build Out development scenario requirements.
- Built new InfoWorks ICM 7.0 hydraulic model, identified new inputs, and calibrated it with permanent wet weather flow monitoring and rain fall data.
- Simulated peak wet weather flow hydraulic scenarios based on a chosen design storm.
- Conducted capacity assessment and sensitivity analysis (by loading the model with increasing design storms) and stressing the collection system model to identify constraints.
- Updated the City's list of capital improvement projects and prioritized basins for additional Inflow/Infiltration reduction studies and mitigation measures that maximize efficient use of the City's budget.

Throughout this project, Water Works has been in ongoing correspondence with the Environmental & Water Resources Department with assistance from the Community Development Department in coordinating and procuring project data.

1.3 Description of Service Area

Folsom is located at the northeast edge of Sacramento County, and borders Placer County to the north and El Dorado county to the east. Located at the foot of the historic Folsom Dam, the City of Folsom owns and operates a sewer collection system that traverses 20 square miles of rolling hills and a 500-foot elevation change, includes on-bridge crossings of the American River Canyon, collects flows from Folsom State Prison, and is expanding coverage by approximately 20% due to planned development south of Highway 50.

Total sewered area (not including the Folsom State Prison basin) is approximately 12,000 acres, of which close to half is made up of single family lots. The City sewer collection system is comprised of over 275 miles of gravity sewer pipe and 9 pump stations, with 3 independent sewersheds covering 19 identifiable sewer basins. Approximately 2/3^{rds} of the collection system is made up of 6” diameter pipe and ranges up in size to 54”. The majority of the system pipe material is VCP, with a significant remainder made of PVC. The City of Folsom does not own or operate any wastewater treatment facilities. The City discharges all wastewater flows to Sacramento Regional County Sanitation District (SRCSD) conveyance facilities at the FE3 Pump Station on Iron Point Road and the FE2 Folsom Blvd Interceptor. Flows from these two locations are treated 30 miles away at the Regional SRCSD WWTP near the City of Elk Grove.

1.4 Previous System Assessments and Rehabilitation Projects

The following list details major previous studies and sources of data that inform this project:

- Permanent Sewer Flow Meter Data (2015 to present)
- Water Meter Consumption Data (2015 to present)
- Sewer Collection System 2007-2012 Capacity Analysis Update (2013)
    - This report was developed by Water Works whereby the performance of sewer basins was monitored and analyzed since the last 2008 updated hydraulic model. It was recommended that modifications be made to the flow monitoring system, culminating in the 2015 Flow Meter Replacement Project. This project upgraded two existing flume-style and created three new metering sites with advanced FloDar (doppler radar technology) meters that helped better isolate Basin 3, Basin 9, and Basin 06B. Other communication improvements were made to the system throughout this project and large-scale calibration was conducted.
- City of Folsom Monitoring and Reporting Plan (2011)
- Wastewater Collection System Capacity Analysis (2008)
    - Analysis from previous updated hydraulic model in 2008 showed high levels of surcharging on the Folsom Blvd 27” Trunk line, and recommended upstream diversions be installed to shift flows over to the Folsom East 33” trunk line. This culminated in the 2009 Basin 06 diversion project whereby B06 was broken up into B06A (East Bidwell towards Folsom West 27”), B06B (Orchard Dr to Folsom East 33”), and B06C (Blue Ravine Blvd to Folsom East 33”)
- Sewer Modeling Files (2008)

- Wastewater Collection System Capacity Analysis Update (2006)
    - The 2006 updated hydraulic model recommended that upstream diversion projects for the Folsom Blvd 27” be analyzed, laying the groundwork for the B06 diversion project in 2009.
- Wastewater Collection System Capacity Analysis (2003)
    - A new hydraulic model was developed in 2003, which was subsequently updated in 2006 and 2008. Analysis from the 2003 model recommended an upstream diversion from the Folsom Blvd 27” to alleviate surcharging there. This culminated in the B07 Diversion project where flows were diverted off Blue Ravine Rd and towards the Oak Ave PS.

1.5 Future City Growth

The City is beginning the construction of water and sewer infrastructure for the south of Highway 50 Folsom Plan Area, which will significantly expand the City area by approximately 20%. The Folsom Plan Area will discharge flows directly into SRCSD’s FE-3 pump station however, and will not impact the existing sewer collection system north of Highway 50. As such, this study is limited to existing City limits and infrastructure North of 50 and projected development excluding growth South of 50 as adapted from the City’s 2035 General Plan Update.

2 PHYSICAL MODEL DEVELOPMENT

2.1 Sources of Physical Model

2.1.1 City GIS

The City provided the latest updated sewer GIS network which Water Works further adapted and modified within GIS to portray existing conditions and optimize hydraulic model parameters.

2.1.2 Previous Hydraulic Model

The City also provided the files for the previous InfoWorks CS models used in the 2003 through 2008 master plans. The CS model was converted into the new InfoWorks ICM software and several simulations were successfully completed to confirm the model still operated. This previous model was a useful source of comparison for model parameters and the pipe network was exported to GIS to help update any missing data fields within the City GIS. The CS model had modeled approximately one third of the sewer network (SS pipes larger than 6" diameter), totaling 75 miles of pipe. In comparison, the new InfoWorks ICM model incorporated almost the entire City-owned SS network, which included approximately 252 miles of pipe. Modeling the entire sewer collection system helps to improve the accuracy of the hydraulic model and provides the City with a useful tool for analyzing more granular changes to the sewer collection system that may occur with small development projects and infrastructure rehabilitation and replacement projects.

The sewer pipes included in the new hydraulic model are listed by diameter in Table 1. Note that the original City GIS network does include SRCSD-owned and abandoned facilities, which were not modeled as part of the SECAP study.

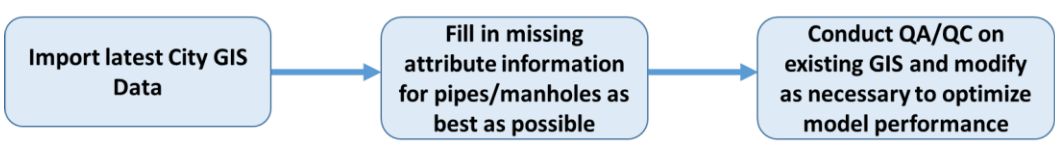
Table 1: Sewer Network Statistics

Size (in)	SS Network (miles)		
	City GIS	2008 CS	2017 Model*
0	0.2	n/a	n/a*
2	0.4	n/a	0.1
4	5.1	0.1	0.4
6	189.3	5.3	178.8
8	34.5	24.5	32.1
10	12.0	12.1	12.0
12	11.0	10.2	11.1
14	0.2	n/a	n/a*
15	4.0	4.1	3.8
16	0.3	0.1	n/a*
18	4.3	2.7	3.0
20	1.3	1.4	1.3
21	1.2	1.2	1.2
24	5.5	5.4	5.4
27	1.9	1.9	1.9
30	0.5	0.5	0.5
33	0.6	0.6	0.6
36	2.9	2.6	n/a*
54	0.6	0.7	0.1
66	1.9	1.2	n/a*
TOTAL	277.7	74.6	252.1

**Abandoned and non-City owned pipes (SRCSD facilities) were not modeled.*

2.2 Physical Model Update Methodology

Incorporating the entire City-owned sewer network into ICM involved the process summarized below:



The process was built on ongoing correspondence with the Environmental/Water Resources Department regarding recent capital improvement projects and system mapping, including a workshop presentation at City Hall (July 28th, 2016).

2.2.1 Filling in Missing Attribute Information

Approximately a quarter of the City-provided GIS data for the Sewer network was missing pipe invert elevation information. To fill in these gaps, Water Works started off with importing the matching CS sewer network, which effectively brought down missing invert elevation data from 25% to 21% of the total. This is displayed in Figure 1.

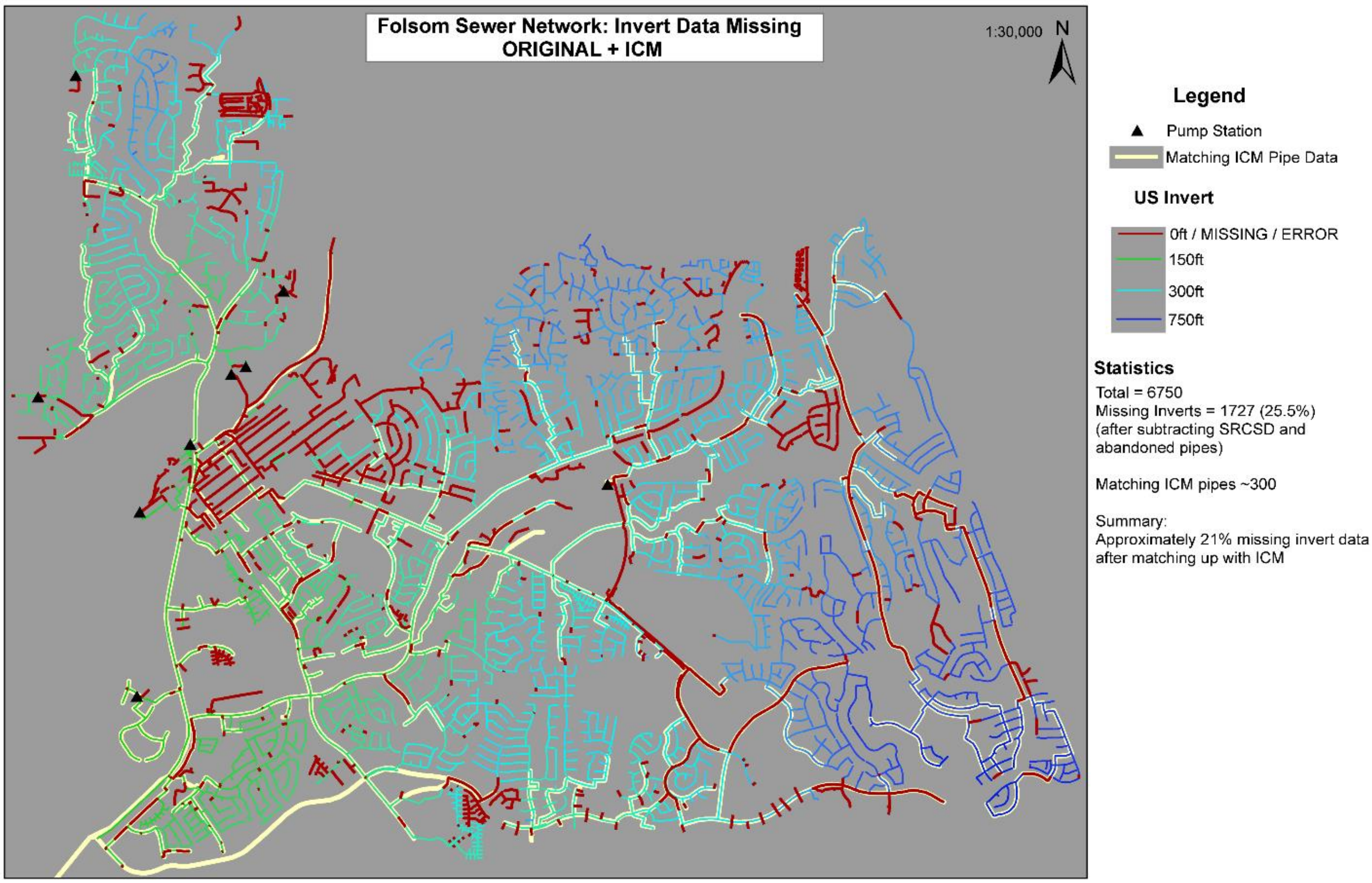


Figure 1: Folsom Sewer Network, Invert Data Missing

The City and Water Works collaborated on filling in as many of the remaining gaps as possible with as-built record drawings of collection system infrastructure. The remainder of the missing invert information was addressed by manually editing pipe inverts to estimated/interpolated values informed by engineering judgement and City design standards. This process was clearly documented and is summarized in Figure 3 below.

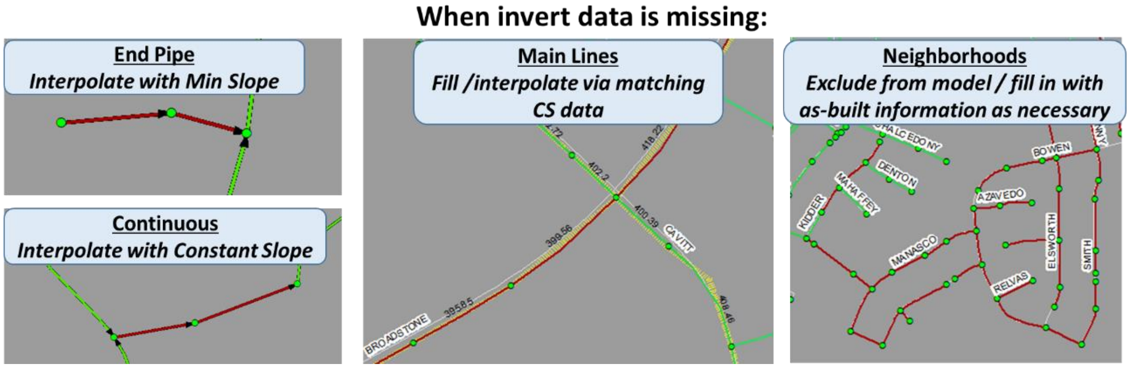


Figure 3: Filling in Missing Invert Data Procedures

Similarly, approximately 35% of the City-provided GIS sewer network data for manholes was missing manhole rim elevation data. Water Works utilized Sacramento County digital elevation maps in GIS (accessed August 2016) and spatially interpolated rim elevations, reducing missing rim elevation data to 5% (after accounting for a NGVD 28 to NAVD 88 datum shift). The remainder of the missing data was filled in by manually interpolating values based on nearby manholes or assuming the manhole rim elevation was four feet higher than the highest incoming pipe invert. The location of manholes with missing rim elevations that were determined using the process described above are shown in Figure 2.

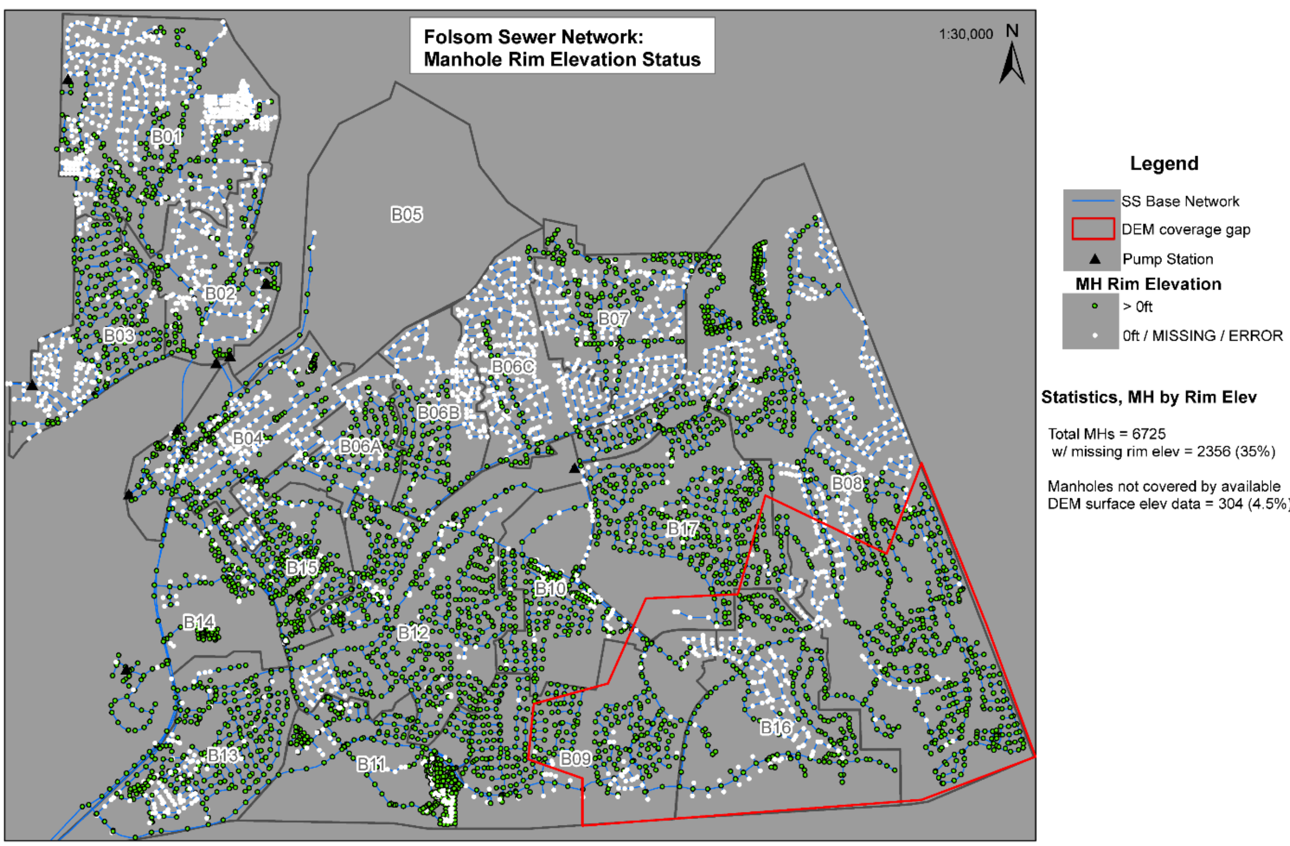


Figure 2: Missing Rim Elevation Map

2.2.2 Modifying Inaccurate Attribute Information

With the help of ICM's ability to automatically flag sewer network inconsistencies, Water Works identified some inaccurate invert elevation information and manually adjusted the data to match actual conditions so that ICM could operate smoothly. This process is summarized below:

When invert data is inaccurate:

Negative/Zero Slope	Flow not continuous across MH	Wrong Vertical Datum
Investigate and modify as req'd	*Modify as req'd by raising/lowering inverts or interpolating constant/min slopes to achieve smooth transition*	*Raise entire neighborhood inverts a constant elevation*

2.2.3 Common Pipe and Manhole Attributes Assumed by Model

Where corresponding attribute information was missing, individual pipes were assumed to have a Manning's roughness coefficient N-value of 0.013, which is standard for vitrified clay sewer pipe. In addition, the model assumes that all manholes are standard, fully benched, 48-in diameter circular manholes with a cone at grade.

2.2.4 Collection System Capital Improvements

The City provided a map of wastewater capital improvement projects (CIPs) that had been built since the 2003 SECAP and it is included as Appendix A-1. Water Works verified that they had been included in the GIS data and physical hydraulic model. It is apparent that the focus of the City's CIPs since 2003 have been on relieving surcharged conditions in the 27" Folsom Blvd sewer trunk and improving sewer performance in the Historic Old Town district. Select capacity improvements from that list are displayed below with a brief description of the project:

- Old Town Sewer Rehab (2015)
  - The removal and realignment of approximately 3000 LF of local sewer mains and service laterals in the vicinity of Natoma St/ Mormon and Scott St to improve sewer access and sewer performance.
- Historic Sutter St Improvements (2009)
  - Approximately 1000 LF replacement or realignment of local sewer mains and service laterals, and large grease interceptors along Sutter St to improve sewer performance.
- Basin 6 Diversion Project (2009)
  - Several hundred feet of new sewer diversion lines along Orchard Dr and Blue Ravine, that break up B06 into three separate basins. This effectively diverts 2/3rds of the former B06 sewer flow from the 27" to 33" sewershed, thereby relieving surcharged conditions on the 27" trunk.
- Orange Grove Sewer Project (2008)
  - Realignment of 2000 LF of local sewer mains and service laterals in the Orange Grove and Natomas St area to improve sewer performance.
- Comstock Sewer Project (2006)

- The realignment of several sewer mains in the Comstock/Riley St area to improve sewer performance in the area.
- Basin 7 Diversion Project (2003)
    - New 1500 LF diversion from Blue Ravine to Oak Avenue. This effectively diverts Basin 7 flows off of the 27" trunk and towards the Oak Ave PS and FE3 sewershed, thereby relieving surcharged conditions on the 27" trunk.

2.2.5 Pump Stations and Forcemains

The previous CS model incorporated the three largest City-owned pump stations but did not model the force mains. As part of this study, all nine City-owned pump stations were modeled, along with their respective forcemains. Modeled pump stations and other descriptions are listed in Table 2, along with estimated storage volume available at each pump station. The VFD pumps were modeled by using ICM Real Time Control (RTC), in which the model is programmed to track the progression of wet well inflow with constant step increases/decreases in pump discharge. This leads to a stepped discharge hydrograph which generally matches the shape and magnitude of the inflow hydrograph.

Table 2: Pump Station Information

Pump Station	Pump Type	Sewer Basin Description	Single Pump Capacity (gpm)	No. of Pumps	Max Capacity (gpm)	Wet Well Storage (gal)
Station # 2	VFD	Basin 1/2/3 Discharge	1991	3	5973	140,355
Station # 3	CS	Overflow Basin 1/2/3	1140	3	7364	8617
6A	CS	Part of Basin 1	318	2	636	9193
Young Wo	CS	Part of Basin 4	282	2	564	5488
Orangevale Ave	CS	Part of Basin 3	269	2	538	2782
Mountain Oak	CS	Part of Basin 2	165	2	330	4840
Del Norte Vista	CS	Part of Basin 2	50	2	100	6158
Lake Forest	CS	Part of Basin 14	715	2	1430	10,661
Oak Ave # 9	VFD	Basin 7/8 Discharge	2000	3	7320	57,455

2.2.6 ICM Model Outfalls

The previous CS model incorporated SRCSD facilities and several hundred feet of the SRCSD Folsom Blvd interceptor in the model. For the purposes of this study, only City-owned facilities were modeled, with two outfall locations (i.e., model end-nodes) at the start of the SRCSD FE2 Folsom Blvd Interceptor and inlet to the FE3 Pump Station on Iron Point Road.

2.2.7 Hydraulic Loading

The hydraulic model wastewater loading was accomplished via a point load to a manhole node from individual parcels (i.e., subcatchments). The manhole nodes were automatically assigned to parcels within GIS based on closest proximity to the parcel centroid, but Water Works also manually checked and modified some manhole assignments to accurately portray existing conditions. In some cases, a particularly large or long-shaped parcel or one that hadn't been subdivided yet was manually assigned a manhole along the closest sewer line downstream of the location. An example snapshot of the resultant parcel loading system within ICM is displayed in Figure 4.

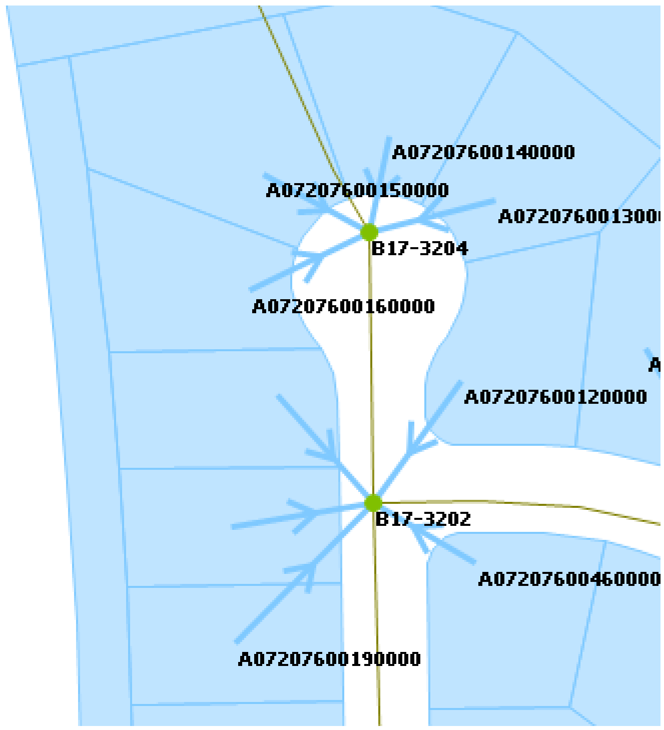


Figure 4: Parcel Hydraulic Loading

2.3 Final Existing Sewer Collection System in ICM Model

To facilitate discussion of the sewer collection system and quickly identify how a specific basin relates to the entire collection system, each basin can be placed inside an overall larger sewershed. The City of Folsom has three identifiable sewersheds that drain to the following locations: 1) 27" trunk on Folsom Blvd ("Folsom West" sewershed); 2) 33" trunk on Folsom Blvd ("Folsom East" sewershed); and 3) SRCSD's FE3 Pump Station ("FE3" sewershed). In addition, there are several hydraulic relief overflow locations (i.e., fully operational weirs) the allow for areas that may become surcharged during peak flows to flow into other areas of the collection system. The overflows were modeled within ICM by raising the overflow relief pipe upstream invert to match the known elevation of the overflow weir. A basin connectivity diagram is displayed in Figure 5. In addition, a map of the modeled sewer system is displayed in Figure 6.

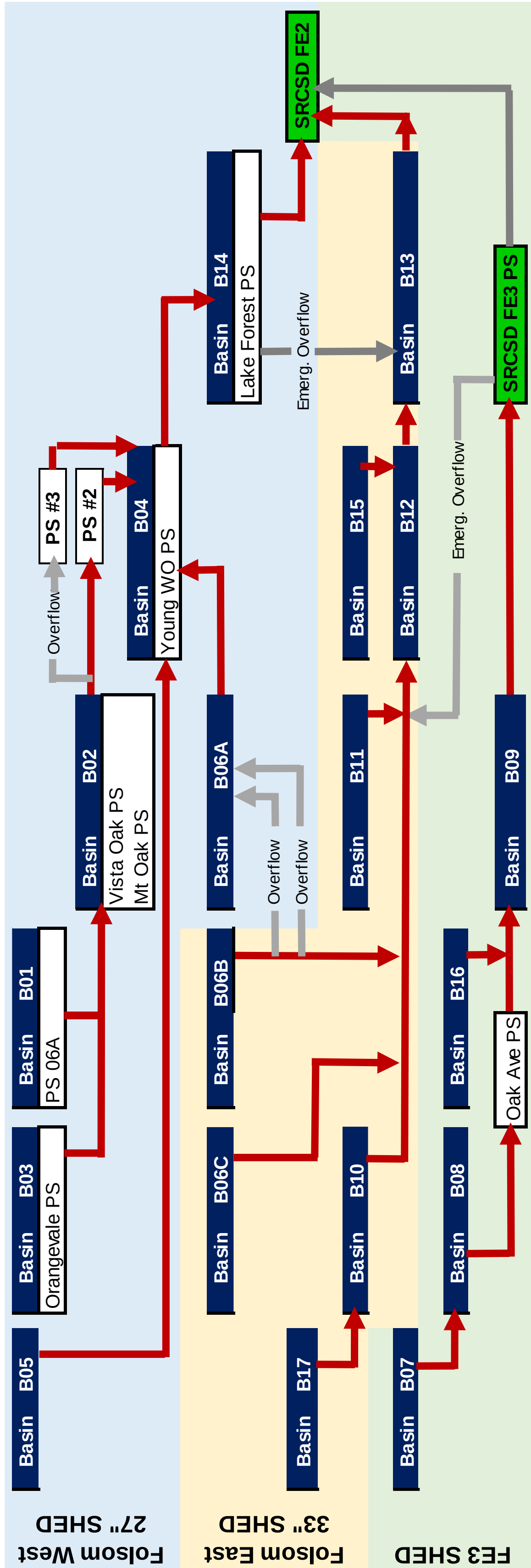


Figure 5: Basin Connectivity Chart

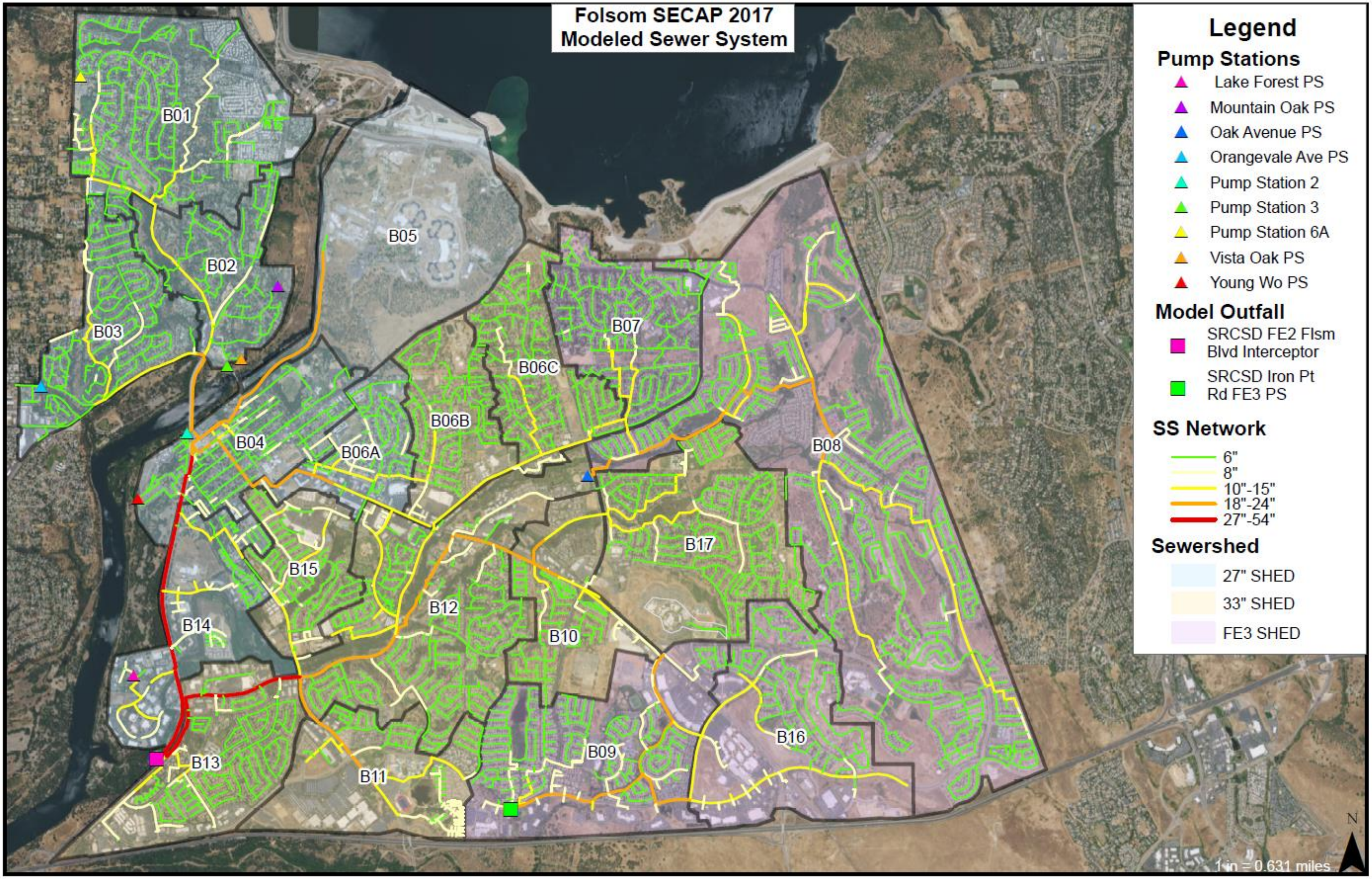


Figure 6: SECAP 2016 Modeled Sewer System

3 GROWTH SCENARIO DEVELOPMENT

3.1 Sources of Land Use Information

Water Works Engineers incorporated several sources of land use data and development projections for this study from official City sources and other City-sponsored public agencies. The process was built on an ongoing, collaborative correspondence with the Community Development & Environmental/Water Resources Departments including a presentation and workshop at City Hall (October 21st, 2016). In addition, this analysis accounted for the anticipated development south of Highway 50 in the Folsom Plan Area (FPA) and adjusted projections accordingly for the existing City limits north of Highway 50.

3.1.1 2035 General Plan

The previous land use assumptions presented in the 2003 SECAP were a useful source of comparison for this study but were ultimately superseded by the City's updated 2035 General Plan. The new General Plan (in draft format at the time of this study) is a comprehensive document that projects growth and development by specifically tying it to employment studies and market analysis in collaboration with the work conducted by the Sacramento Area Council of Governments (SACOG) and other public agencies. For this study, commercial and industrial projection data was specifically adapted from the 2035 General Plan Draft (accessed in August 2016). The City provided the Sacramento County-updated land parcels, sewer collection system, and land zoning overlay/delineations in GIS format to Water Works Engineers in August 2016.

3.1.2 2016 MTPSCS / SACOG

The draft 2016 Metropolitan Transportation Plan / Sustainable Communities Strategy (MTPSCS) produced by SACOG (accessed in August 2016) was referenced for future population projections for the City of Folsom.

3.1.3 CA Department of Finance

The City of Folsom existing population was determined from population statistics posted by CA Department of Finance (CA DOF) which are based on the U.S. Census.

3.2 Existing and Future Growth Scenarios Development

Water Works took the approach of developing and simulating three primary scenarios as part of this study using the City-provided General Plan zoning overlay along with vacant parcels. Corresponding wastewater generation rates were developed and assigned to the various zoning / land use designations in order to load and calibrate the model.

3.2.1 2035 General Plan Zoning

The 2035 General Plan (GP) zoning overlay was used for all growth scenarios with the primary difference between scenarios being the increasing development of vacant parcels and densification of occupied parcels. The zoning was analyzed and modified in some areas for the purposes of this study, one example being the A-1-A (Agricultural Reserve District) designation for the large lot occupied by the Folsom Lake Community College was changed to "SCHOOL". In addition, irregular non-occupied parcels such as medians, roadways, and community landscapes were changed to “OPEN” or “OTHER”. Some State, Federal, and City-owned parcels were also modified to “OPEN” or “OTHER” zones to reflect the unlikelihood of their development. The definition of OTHER and OPEN as land uses are explained in the next section. A description of each 2035 GP zone is listed in Table 3 and displayed visually in Figure 7. Please note that the vacant parcels do indeed have an actual 2035 GP zone designation, but are shown as vacant for reference.

Table 3: 2035 GP Zoning Descriptions

2035 GP Zoning Descriptions			
RESIDENTIAL ZONING		**INDUSTRIAL ZONING**	
R-1-L	Single Family Dwelling, Large Lot District	M-1	Light Industrial Districts
R-1-ML	Single Family Dwelling Medium Lot District	M-2	General Industrial District
R-1-M	Single Family Dwelling, Small Lot District	M-L	Limited Manufacturing District
R-2	Two Family Residence District		
R-3	Neighborhood Apartment District	**MISC. ZONING & COMBINING DESIGNATIONS**	
R-4	General Apartment District	A-1-A	Agricultural Reserve District
R-M	Residential, Multi Family Dwelling District	SP	Specific Plan District
RMH	Trailer, Trailer Parks	PD	Planned Development District
		OSC	Open Space Conservation
COMMERCIAL ZONING		HD	Historic District
BP	Business Professional District	MU	Mixed Use
C-1	Neighborhood Business Districts		
C-2	Central Business District		
C-3	General Commercial District		

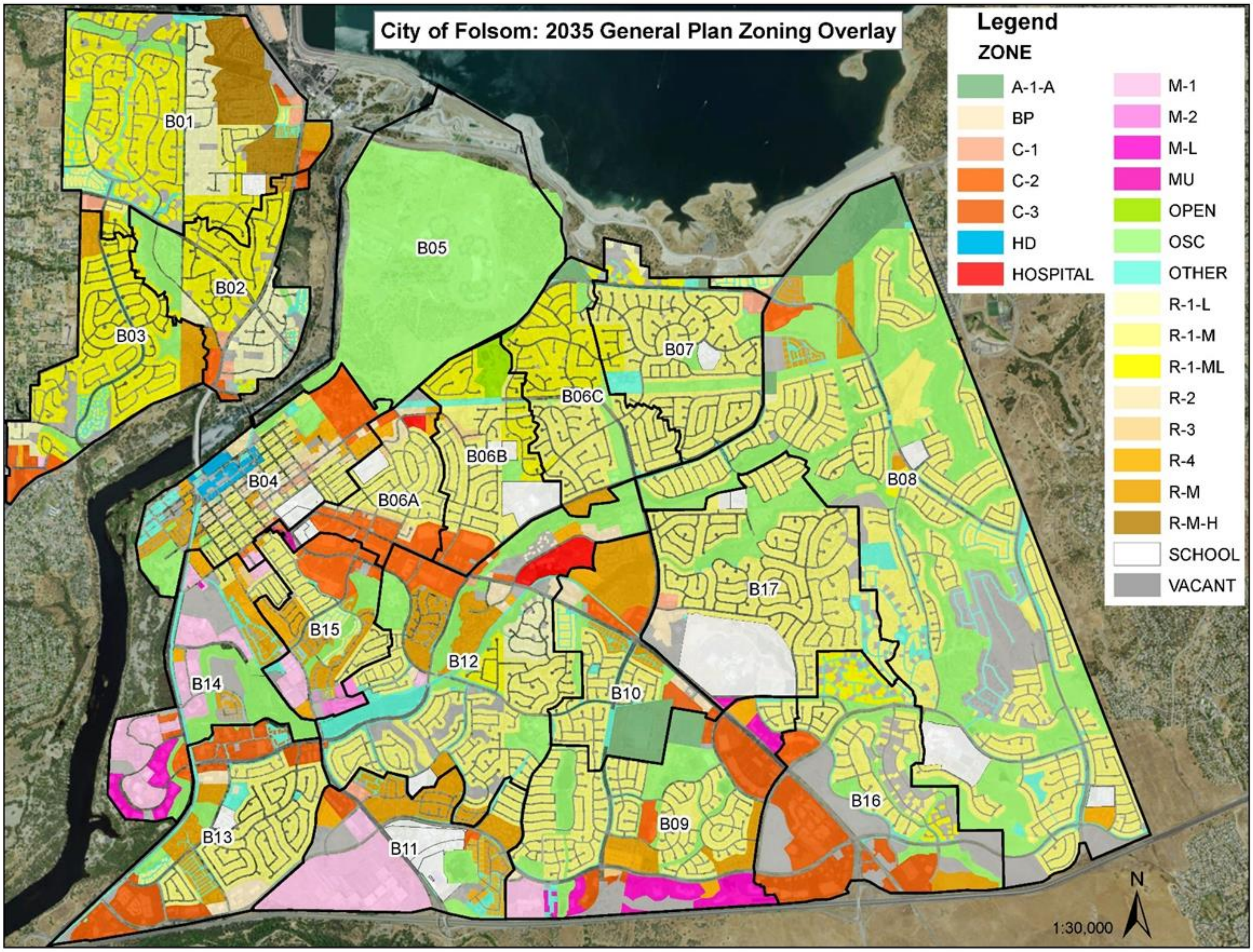


Figure 7: 2035 GP Zoning Overlay

3.2.2 Land Use

Water Works Engineers developed 5 land use categories for the purposes of calculating average dry weather sewage flows to each parcel, and assigned each 2013 GP zone to one of those land uses. Some of the zones were automatically assigned land uses, while others (such as A-1-A, SP, PD, and OSC) had to be manually assigned to specific land uses based on more research, often in conjunction with looking at satellite imagery and researching ownership. As discussed in the previous section, the “OTHER” land use was open space or an assumed impervious surface that does not generate sewage (ADWF), but could conceivably drain towards the sewer collection system and contribute rain derived infiltration / inflow

(RDII). On the other hand, the “OPEN” land use was assumed to have natural drainage that led away from the existing sewer collection system, and did not contribute RDII or ADWF. The relationship between 2035 GP zoning and model Land Use is detailed in Table 4 and displayed visually in Figure 8. Vacant parcels are designated by land use first and affixed with “VAC” (e.g., RESIDENTIAL VAC).

Table 4: Zone to Land Use

Zone	Land Use
R-1-L R-1-ML R-1-M R-2	Residential (Fixed Density)
R-3 R-4 R-M RMH	Residential (Variable Density)
BP C-1 C-2 C-3 HD	Commercial
M-1 M-2 M-L	Industrial
A-1-A SP PD MU OSC	Manual Assignment (e.g., land uses shown above, or School / Hospital / Other / Open)

Residential land use was subdivided into “fixed density” and “variable density” zones. Fixed density refers to residential zoning where the number of housing units per parcel is constant or “fixed”. The R-1 zones allow for only one housing unit per parcel, and the R-2 zone allows for 2 housing units per parcel. Variable density zones refer to higher density residential development such as condos or apartments where there is a maximum density of housing units per acre is allowed, but actual density may vary, i.e. not every development is built at the maximum density of housing units allowed.

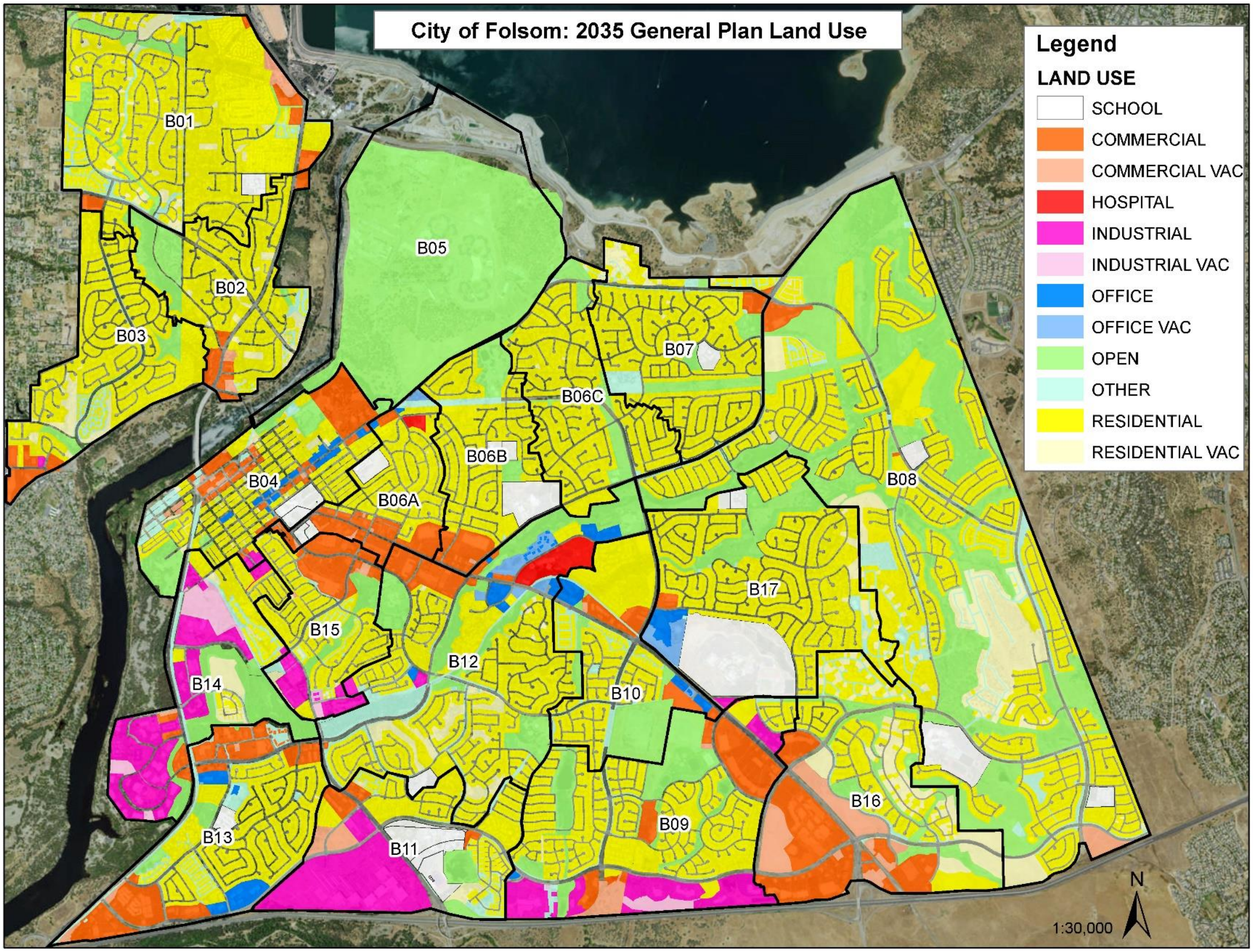


Figure 8: 2035 GP Land Use

3.2.3 Existing Conditions Scenario

The purpose of the existing conditions scenario was to simulate operation of the sewer collection system calibrated to the most recent flow monitoring data available. This was used to validate and re-prioritize existing City CIPs and short-term O&M goals driven by state regulatory requirements in line with the City's SSMP. The approach is summarized below:

EXST

Existing Conditions Scenario:
- Given existing population (2015)
- Given GP zoning
- Accounted for existing vacancies
- Variable density (some residential, commercial, industrial) tied to actual, calibrated basin flows

3.2.4 General Plan Scenario

The purpose of the General Plan Scenario was to simulate the sewer collection system at the projected development levels presented in the latest 2035 General Plan and SACOG plan. This is considered an intermediate planning horizon that is the primary driver for intermediate capital improvement projects and to identify future capacity triggers for CIPs. The approach is summarized below:

GP

General Plan Scenario:
- Given future population (2035)
- Given GP zoning
- Developed all residential land and variable densities that matched projected population
- Developed all non-residential, vacant land at lower Floor to Area ratios that matched projected demand

3.2.5 Ultimate Build-out Scenario

The purpose of the Ultimate Build-out Scenario was to explore an unknown planning horizon and maximize all infill development and population densification. This "what-if" scenario was not intended to develop immediately actionable capital improvement projects but to inform future discussions and facilitate long term exploration of projects that will facilitate densification within existing City limits.

UBO

Ultimate Build-out Scenario:
- Given future population (buildout)
- Given GP zoning
- Developed all residential land and variable densities that matched projected population
- Fully developed all non-residential, vacant land at same Floor-To-Area ratios as Existing Conditions

8

3.2.6 Residential Development Analysis

Projected Population

The City of Folsom existing population was determined by information provided by the CA DOF. The 2035 GP scenario population target is based on employment estimates from SACOG which delineates projected population South of 50 in the Folsom Plan Area (FPA) and the Center & Corridor and Established Communities North of 50. The resultant calculated Average Annual (Compound) Growth Rate was used to determine student enrollment growth in Folsom schools. The target populations are listed in Table 5 and visually displayed in Figure 9.

Table 5: Projected Population

Area	EXST (2016)		GP (2035)		UBO		Calculated AAGR[4]
	EDU	Pop[3]	EDU[1]	Pop[2]	EDU[1]	Pop[2]	
FPA (South of 50)	0	0	6,688	17,456	10,210	26,648	n/a
Center&Corridor Communities	n/a		2,186	5,705	2,196	5,732	
Established Communities			27,230	71,070	29,248	76,337	
Total	27,106	70,746	36,104	94,231	41,654	108,717	1.52%
Total Minus FPA (South of 50)	27,106	70,746	29,416	76,776	31,444	82,069	0.43%

[1] SACOG MTP/SCS 2016 Plan Appendix E-3, Attachment A, Table A-1
[2]Calculated population = EDU * 2.61
[3]CA DOF (2016) E-1 estimate: 77,246 city residents, minus 1/1/10 est. of 6,500 group quarters at the State Prison included in the total population estimate
[4]Average Annual (Compound) Growth Rate: $P_{future} = P_{Present} x(1+i)^n$

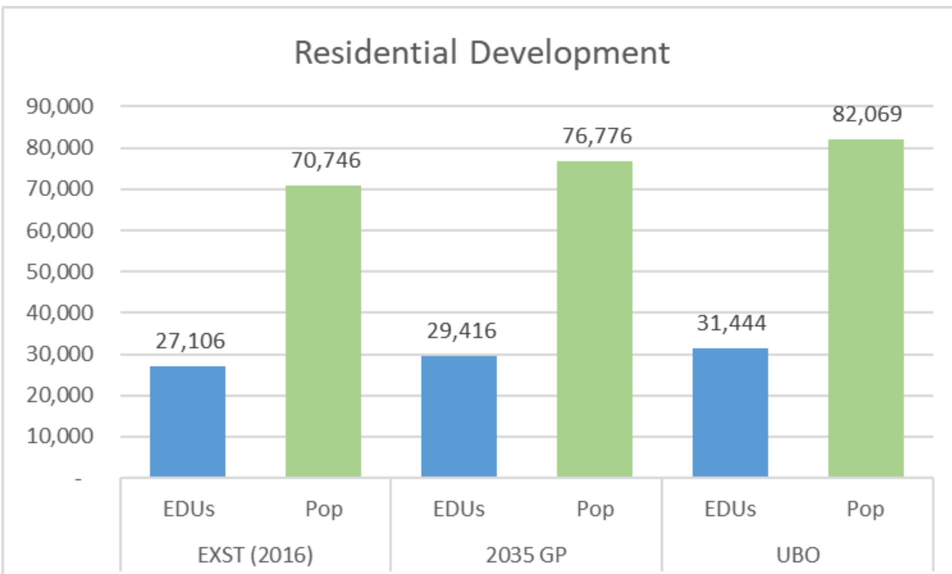


Figure 9: Residential Development North of 50 Only

Household (EDU) Size

The average persons per equivalent dwelling unit (EDU) reported by SACOG for the City is 2.61 pers/EDU, however owner-occupied households are also reported on average to be a larger 2.75 pers/EDU while non-owner occupied housing a smaller 2.30 pers/EDU. To account for this, Water Works assumed that fixed density housing (e.g., single/dual family lots) were owner occupied, and variable density housing (i.e., apartments) were renter occupied. This results in Folsom being 2/3^{rds} owner occupied and 1/3rd renter occupied, which is consistent with the 68.5% owner-occupied housing unit rate reported for Folsom in the 2010 Census.

Residential Land Use Population and Flow Assignment

The residential hydraulic load assignment in ICM was a combination of using A) land use, B) population targets, and C) flow monitoring data. For the existing conditions scenario, the process took these steps:

Step 1: Apportioned available population/EDUs between variable and fixed density residential zones amongst basins by assigning it to all non-vacant fixed density zone parcels first (i.e., single family homes).
Step 2: Remaining population/EDUs were apportioned to non-vacant variable zone parcels (i..e, apartments) by modifying the relative densities of these parcels (i.e., EDUs/acre)

In comparison, the GP and UBO scenarios also had to account for vacant parcels assigned residential land use. Water Works assumed equal development among zone types for all vacant parcels, meaning that specific basins weren't favored to develop sooner. The iterative process between modifying vacant parcels and fixed/variable density zoning was accomplished via spreadsheet which included every single City parcel. The process took these steps:

Step 1: Apportioned available population/EDUs between variable and fixed density residential zones amongst basins by assigning it to all non-vacant fixed density zone parcels first (i.e., single family homes).

Step 2: Remaining population/EDUs were apportioned to non-vacant variable zone parcels (i..e, apartments) by modifying the relative densities of these parcels (i.e., EDUs/acre)

Step 3: Vacant parcels (i.e., undeveloped 10 acre R-1 lot) were artificially "subdivided" at a given density of EDUs/acre that summed the remaining leftover population/EDUs. The reported maximum allowable density reported in the 2035 GP was used as a reference.

The result is an equal split between fixed and variable housing between all the scenarios (approximately 2/3rd fixed and 1/3rd variable. The final results are listed in Table 6 and Table 7 below. The far-right column entitled "Max Allow." In Table 6 is the current maximum allowable development density reported in the 2035 GP for each GP zoning designation.

Zone Type		Non-Vacant Residential Density			Vacant Residential Density & Other			
		EX	GP	UBO	EDU Size	GP (VAC)	UBO (VAC)	Max Allow.
		EDUs	EDUs	EDUs	Pers/ EDU	EDUs	EDUs	EDUs
Fixed Density	R-1-L	1/par	1/par	1/par	2.75	2/ac	3/ac	3/ac
	R-1-ML	1/par	1/par	1/par		3/ac	4.4/ac	4.4/ac
	R-1-M	1/par	1/par	1/par		2.1/ac	7.3/ac	7.3/ac
	R-2	2/par	2/par	2/par		6/ac	14.5/ac	14.5/ac
Variable Density	R-3	12/ac	12/ac	12/ac	2.3	12/ac	12/ac	29/ac
	R-4	12/ac	12/ac	12/ac		12/ac	12/ac	29/ac
	R-Ms	10/ac	10/ac	10.8/ac		10/ac	10.8/ac	12.4/ac
	R-M-H	6.5/ac	6.5/ac	6.5/ac		6.5/ac	6.5/ac	7/ac

Table 6: Residential Inputs

It should be noted that the housing density for fixed density vacant residential zones is based on EDUs per acre rather than EDUs per parcel, because large undeveloped vacant residential land may not be subdivided yet.

Table 7: Summary of Residential EDUs

Type	EX	GP	UBO
Fixed Density EDUs	18,122	18,986	20,529
Variable Density EDUs	8,995	10,380	10,904
Fixed vs. Variable % Split	66% / 34%	65% / 35 %	65% / 35%
TOTAL	27,117	29,366	31,433

3.2.7 Non-Residential Land Use Population and Flow Assignment

Non-Residential Acre Demand

The 2035 GP reported commercial (retail), office, and industrial projected acreage demand for future scenarios. The net acre demand was built on the respective projected number of employees. Water Works adapted the projections by accounting for 2016 existing occupied and vacant land. A summary of the total demand and vacant acres for each scenario are listed in Table 8 below.

Table 8: Non-Residential Development Summary

Non-Residential Development Summary[1,2]									
Type of Land Use	Scenario						FAR[5]		
	EXST		GP		UBO				
	Active Acres	# Employees	Active Acres	# Employees	Active Acres	# Employees	EXST	GP	UBO
Retail[3]	880	n/a	970	n/a	1,062	n/a	0.25	0.12	0.25
Office[2]	104	10,938	148	13,354	148	13,354	0.30	0.30	0.30
Industrial	503	6100	525	6366	563	6827	0.40	0.15	0.40

[1] Number of employees is not used to set retail acre demand.
[2] There is not enough office space to meet demand past the General Plan window (2035).
[3] The 2035 GP uses the Retail delineation for Commercial land use, but the two are considered interchangeable.
[4]The existing scenario Floor to Area Ratios (FAR) were reported in the 2035 GP, and vacant parcels do not produce flow. For GP, all parcels are developed (i.e., nothing is vacant), but the FARs are reduced in order to obtain the active area calculated. In UBO, all parcels are developed and the FAR's are "maximized" back to existing levels.

Non-Residential Development

Existing scenario non-residential development in ICM was a combination of using the land use, projected acre demand, and flow monitoring data to correctly apportion flow between amongst basins. The iterative process is summarized in the diagram below:

In comparison, the 2035 GP scenario also had to account for vacant parcels assigned commercial, office, and industrial zoning. Water Works assumed equal development among zone types for all vacant parcels, meaning that specific basins weren't favored to develop sooner. Consequently, to meet 2035 GP demand, the Floor to Area Ratios (FAR) for vacant parcels were reduced from existing levels. The process is displayed below:

Conversely, UBO scenario FARs for vacant parcels were kept at existing levels, implying that maximum development would occur across all non-residential parcels. This process is displayed below:

3.2.8 Other Development Analysis

School Growth

The 2035 GP listed the maximum capacity and current (2012) enrollment of schools in Folsom. Water Works adapted this information and tied the growth of the schools to the calculated AAGR (growth rate) of the City, leading to projected 2035 GP and UBO enrollment. The school enrollment is listed in Table 9. Please note that Folsom Lake College average dry weather flow is tied directly to estimated water usage and is not calculated via enrollment.

Table 9: School Enrollment

School Name	Enrollment				AAGR
	EXST	Max Capacity	GP	UBO	
Blanche Sprentz El.	350	**577**	386	**577**	0.43%
Carl Sundahl El.	377	**602**	416	**602**	0.43%
Empire Oaks El.	663	**830**	732	**830**	0.43%
Folsom Hills El.	585	**767**	646	**767**	0.43%
Gold Ridge El.	637	**765**	703	**765**	0.43%
Natoma Station El.	573	**794**	633	**794**	0.43%
Oak Chan El.	485	**754**	535	**754**	0.43%
Russel Ranch El.	640	**737**	707	**737**	0.43%
Sandra J Gallardo El.	698	**880**	771	**880**	0.43%
Theodore Judah El.	449	**662**	496	**662**	0.43%
Folsom Middle	1279	**1409**	1412	**1409**	0.43%
Sutter Middle	1314	**1366**	1451	**1366**	0.43%
Folsom High	2034	**2289**	2246	**2289**	0.43%
Vista del Lago High	1445	**1533**	1595	**1533**	0.43%
Folsom Lake High	98	**150**	108	**150**	0.43%

Commercial Zoned Residential Projects (Conditional Use Permits)

Based on communication with the City, Water Works accounted for specific residential projects that had been built on commercially zoned property. This was done by modifying the existing GP zone and assigning it a land use consistent with the conditional use permit. Those specific projects are listed in Table 10. The updated land use was utilized when applying the correct wastewater generation rate to that specific parcel.

Table 10: Commercial Zoned Residential Projects/CUPs (Conditional Use Permit)

Project Name	APN(s)	Type of Project	Existing Commercial Zone	Updated land use based on CUP
Folsom Alzheimer's Facility	071-1950-002	Special Care Center	C-1	R-M
The Commons at Prarie City	072-0010-061, 062	Residential Care Facility	BP	R-M
CountryHouse at Broadstone	072-2680-008	Memory Care Residence	C-3	R-M
Iron Point Retirement Community	072-3120-023	Retirement Community	M-L	R-M
Oakmont Senior Living Community	071-1960-002	Assisted Living Community	BP	R-M
Reflections II	(multiple)	Single Family Residential	C-2	R-1-M
East Bidwell Apts (planned)	071-0190-0860	Apartments	C-2	R-4
Veranda Subdivision	071-1950-1300	Residential Subdivision	C-1	R-M

Folsom State Prison

The existing 2016 ADWF for Folsom State Prison (0.76 MGD according to flow monitoring data) has been consistently decreasing over the couple past years and is lower than the maximum value permitted under the CDCR's (California Dept. of Corrections & Rehabilitation) agreement for wastewater disposal with the City. The agreement allows CDCR to discharge an average daily rate (ADWF) of 1.15 MGD and a maximum instantaneous daily DWF of 2.50 MGD.

WaterWorks took the following approach for modeling Folsom State Prison flows:

- Existing Conditions Scenario: Modeled the observed FM-calibrated ADWF of 0.76 MGD which approximately equals 1.21 MGD Peak DWF given existing peaking factors.
- General Plan: Modeled the upper allowable ADWF of 1.15 MGD, which approximately equals 1.84 MGD Peak DWF given existing peaking factors.
- Ultimate Build Out: Modeled the upper allowable PDWF of 2.50 MGD, by effectively applying an ADWF load of 1.56 given existing peaking factors. This conservative, "what-if" scenario is unlikely, because existing peaking factors would have to increase significantly, given that the upper allowable ADWF of 1.15 MGD only produces 1.84 MGD of PDWF. This scenario is a useful exercise, however, in gauging the impact of maximum allowable Prison flow discharges on the Folsom West 27" trunk. This information is summarized in Table 11 below.

Table 11: Projected Prison Flow

ADWF (mgd)	EXST	GP	UBO
	0.76	1.15	1.56*

*Equals 2.50 MGD PDWF at peak time

Major Wastewater Producers

Water Works downloaded potable water usage data from the City's water meter database for 11 of the largest water users in the City, and tied wastewater generation from these parcels to the usage in lieu of system-wide wastewater generation rates. It was assumed that winter water usage was equivalent to dry weather sewage flow produced because irrigation would presumably be turned off in the winter. During the model development process, the largest water users were referred to as "major wastewater producers," and are listed in Table 12.

Table 12: Major Wastewater Producers

Major Wastewater Producers		Estimated ADWF (gpd)
1	Vibra Hospital	4,742
2	Mercy Hospital	33,810
3	Agilent	53,280
4	CISO	10,172
5	Gekkeikan	26,232
6	Intel Folsom	168,128
7	Kaiser	10,322
8	Kikkoman	55,666
9	Micron Tech	8,302
10	R Squared	6,911
11	Folsom Lake CC	13,336

Young Wo PS Flows

Average dry weather flow from the parcels upstream of the Young Wo PS, which include the Corp Yard and VFW lodge, were based on the listed flows in the *Young Wo Pumping Station Capacity Analysis (2012)* technical memorandum presented by the J. CROWLEY GROUP for the City. Reference Appendix A.2.

4 DRY WEATHER MODEL DEVELOPMENT

4.1 Wastewater Generation Flow Rates

Residential WW Generation

The 2003 SECAP used separate residential wastewater generations rates for each basin that ranged from 63 to 135 gpd/person. For this study, improved flow meter data and the use of different population densities per EDU for fixed and variable residential zoning effectively decreased the variability between basins and allowed for the use of a consistent residential sewage flow factor of 70 gpd/person for all basins for calibration of the model to recent flow meter data. The average flow per capita has decreased since the 2003 SECAP (which reported 85 gpd/person). This decrease is consistent with an overall regional trend of decreased per capita flows that is related to improved water conservation.

Non-Residential WW Generation

The 2003 SECAP used a consistent 1550 gal/acre-day (gpad) as the standard wastewater generation rate for all commercial and industrial properties. As part of the model calibration process and after considering actual water use data from major wastewater producers, Water Works utilized the reduced wastewater generation rates listed in Table 13. The 50 gpd/student flow factor for school wastewater generation was listed in the City's design standards for Junior and Senior-High Schools, assumed to be equal for all students.

Table 13: Wastewater Generation Rates

Type	ADWF (gpd/unit)	Unit
RESIDENTIAL	70	Person
COMMERCIAL	1500	Active Floor Space (acre)
OFFICE	1200	
INDUSTRIAL	1200	
STUDENT	50	Student

4.2 May 2016 DWF Analysis

To properly calibrate the existing dry weather flow (DWF) model, flow meter data that best represented existing DWF conditions was used from the 5 weekdays in May 2016, from 5:00 AM 5/9 to 5:00 AM 5/14. This was the last week before Folsom schools were closed for the summer break. The summary of the data is listed in Table 14 below. Refer to Appendix A.3.

Disregarding prison flow increases by scenario, the % flow split between Residential and Non-Residential sewage generation remains at 77% / 33% between all three scenarios, reflecting the underlying assumption that business growth/demand is tied to residential growth.

Table 14: May 2016 FM Data (ADWF)

Flow Meter Manhole	Flow Meter Name	Representative Basin	5/9/16-5/14/16 ADWF (mgd)
B02-8102	OldOakAve/BaldwinDamRd	B1	0.35
B02-9348	GreenbackLn	B3	0.28
B03-9259	FolsomBlvd/NatomaSt	B4	1.96
B05-1084	Prison Line	B5	0.77
B04-6059	Liedesdorff	CAP[1]	0.79
B04-4841	Wool/Mormon St	B6A	0.19
B12-10015	Orchard	B06B	0.17
B06-3434	Blue Ravine/ Middle School	B06C	0.39
B08-3615	BlueRavine/OakAvePkwy	B7	0.26
B09-6727	FE3 PS	B9	1.86
B10-1490	E Bidwell/WillowCrk	B10	0.73
B12-0539	PrairieCityRd/WillardDr	B11	0.34
B13-0554	BlueRavineRd/PrairieCityRd	B12	1.94
B13-0674	Folsom 33	CAP[1]	2.52
B13-9183	Folsom East	B13	3.28
B14-0046	Folsom West	B14	1.98
B15-1851	Sibley/Levy	B15	0.23
B09-6367	Iron Pt/Broadstone	B16	0.16
B10-3208	OakAvePkwy/WillowCreekRd	B17	0.28
Oak Avenue PS (Pump Flow Meter)		B08[2]	0.95
PS2		B02	0.57
SRCSD Hazel TRITON Meter		City Total	6.46

[1]CAP indicates the meter serves as a "capacity" flow meter that is used to confirm line capacity but is not directly used to determine total basin contribution.

[2]The flow meter at this facility is on the pressure discharge side of the pump station, resulting in a hydrograph that displays highly variable flows in line with the pump cycling. This data was interpolated to estimate the upstream gravity (non-pressure) hydrograph.

It should be noted that SRCSD operates a sewer flow meter on its FE2 interceptor on Folsom Boulevard at Hazel Avenue downstream of the City of Folsom. Flow meter results for this meter over the same time period are shown above. The average day flow during this period for the SRCSD meter was 6.46 MGD. The total average flow from Folsom's three outfall flow meters (Folsom East, Folsom West, and FE3 PS) was 7.12 MGD, which is in relatively close agreement.

Table 15 below shows the calculated ADWF from each sewer basin using the sewer generation rates from Table 13 for each model scenario. The calculated ADWF of 7.176 MGD closely matches the total measured May ADWF of 7.12 MGD from the City's three outfall meters.

Table 15: Calculated ADWF by Basin

Calculated ADWF (mgd)			
Basin	EX	GP	UBO
B01	0.479	0.501	0.525
B02	0.132	0.144	0.157
B03	0.262	0.274	0.289
B04	0.318	0.336	0.346
B05	0.760	1.150	1.56*
B06A	0.208	0.213	0.224
B06B	0.179	0.180	0.190
B06C	0.296	0.298	0.300
B07	0.266	0.278	0.288
B08	0.980	1.126	1.303
B09	0.478	0.485	0.499
B10	0.297	0.298	0.310
B11	0.480	0.509	0.525
B12	0.515	0.545	0.605
B13	0.353	0.357	0.372
B14	0.307	0.358	0.377
B15	0.270	0.281	0.289
B16	0.191	0.304	0.363
B17	0.405	0.420	0.445
TOTAL	**7.176**	**8.057**	**8.90**
Percent Increase from Existing ADWF		**12%**	**24%**

**Please see section 3.2.8 for basis of UBO Prison scenario ADWF*

Table 16 below shows the calculated ADWF flow totals for each land use type for each model scenario.

Table 16: Calculated ADWF by Land Use / Zone

Land Use	Zone	ADWF (mgd)		
		EX	GP	UBO
Residential (Fixed)	R-1-L	0.075	0.081	0.084
	R-1-ML	0.576	0.626	0.649
	R-1-M	2.750	2.858	3.126
	R-2	0.088	0.090	0.092
Residential (Variable)	R-3	0.033	0.033	0.033
	R-4	0.336	0.436	0.436
	R-M	0.931	1.054	1.139
	R-M-H	0.148	0.148	0.148
Office	BP	0.037	0.053	0.053
Commercial	C-1	0.018	0.022	0.026
	C-2	0.125	0.135	0.144
	C-3	0.159	0.176	0.193
	HD	0.008	0.010	0.011
Industrial	M-1	0.379	0.386	0.398
	M-2	0.009	0.009	0.011
	M-L	0.076	0.079	0.084
Schools		0.622	0.665	0.733
Hospitals		0.039	0.039	0.039
Prison		0.760	1.150	1.56*
TOTAL		**7.176**	**8.057**	**8.90**

**Please see section 3.2.8 for basis of UBO Prison scenario ADWF*

4.3 Peaking Factors

The observed hourly peaking factors (diurnal curves) measured at each flow meter are applied to ADWF in the hydraulic model by basin to allow for real-time dynamic hydraulic modeling. The peaking factors for each sewer basin are listed in **Table 17** and displayed graphically in

Table 17: 8AM DWF Peaking Factors (Max)

27" Flsm West		33" Flsm East		24" FE3	
Basin	8AM PF	Basin	8AM PF	Basin	8AM PF
B01	1.82	B06C	1.55	B07	1.58
B02	1.51	B06B	1.54	B08	1.87
B03	1.44	B17	1.77	B16	1.35
B05	1.65	B10	1.61	B09	1.66
B06A	1.32	B15	1.44		
B04	1.53	B11	1.68		
B14	1.69	B12	1.53		
		B13	1.42		

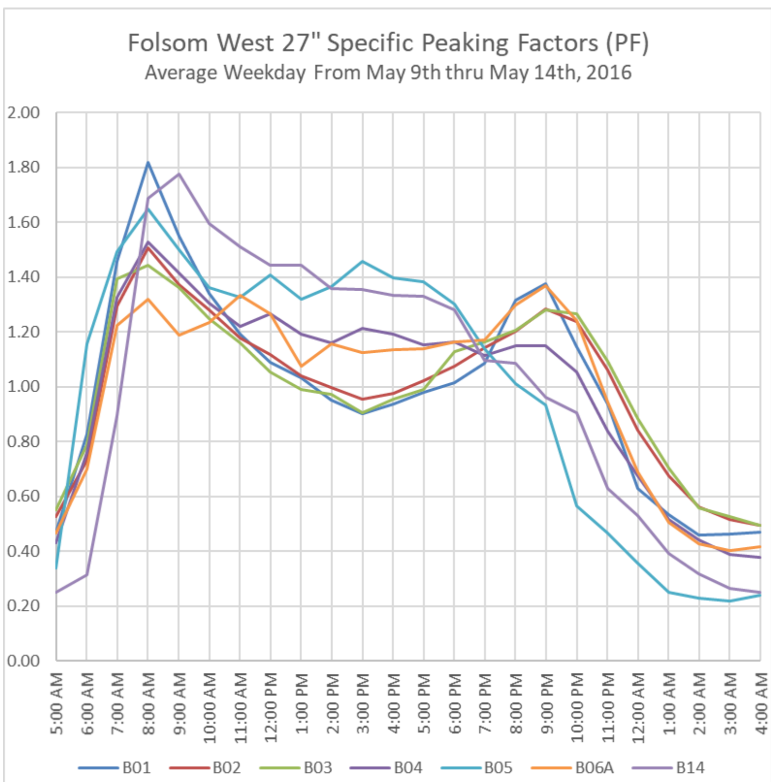


Figure 10: Folsom West 27" DWF Peaking Factors

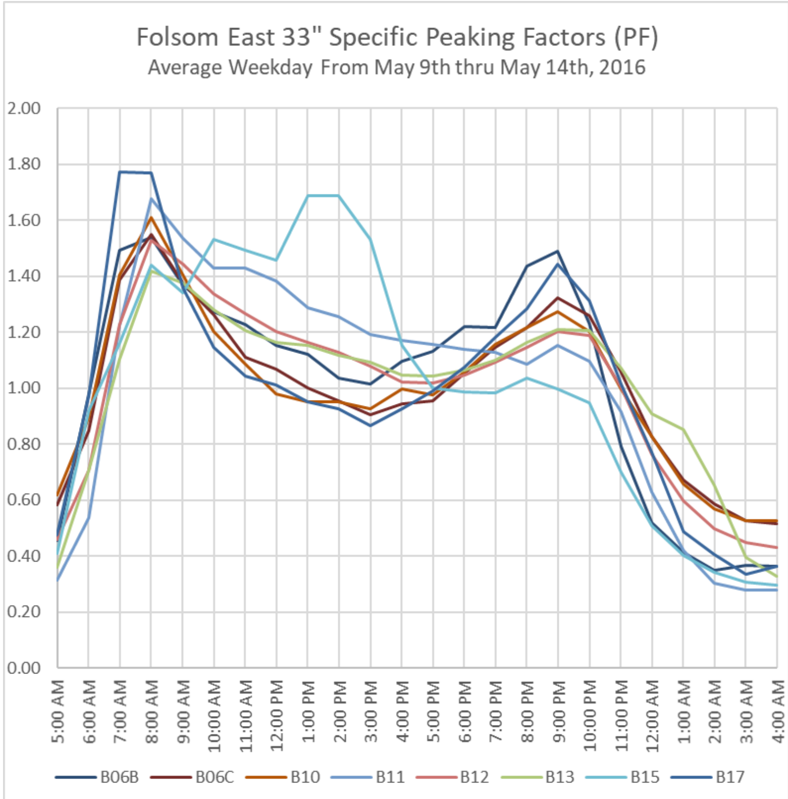


Figure 11: Folsom East 33" DWF Peaking Factors

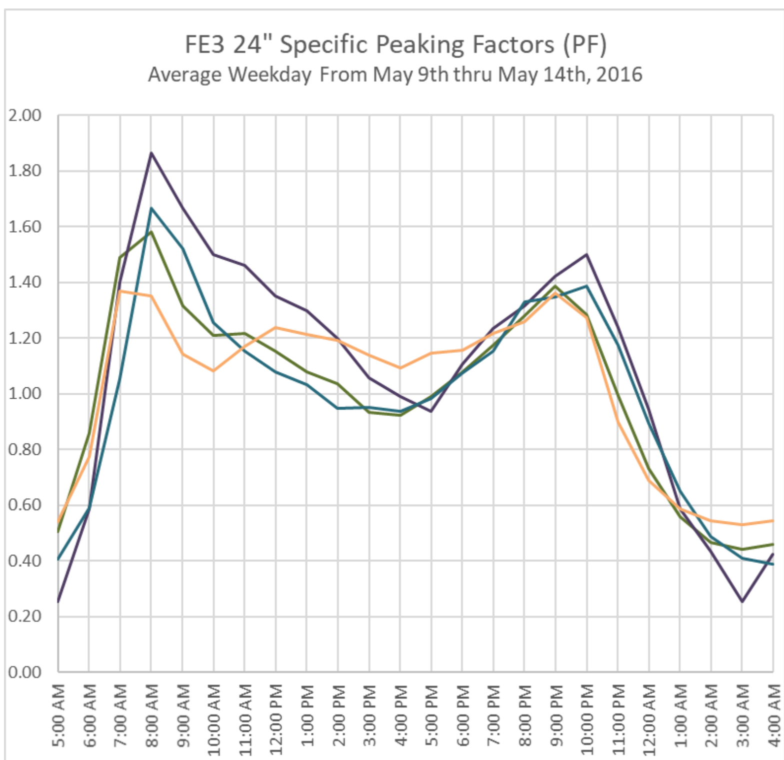


Figure 12: FE3 24" DWF Peaking Factors

Residential Peaking Factors

The peaking factors of a typical residence in Folsom given the data used in this study is best approximated by analyzing the response from basins B06C and B07. These basins are almost exclusively residential and made up of fixed density housing such as single or dual family homes. The results are displayed below in Table 18 and Figure 13.

Table 18: Residential Peaking Factors

Residential Peaking Factors Based on B05C and B07 results		
Hour	B06C	B07
5:00 AM	0.50	0.58
6:00 AM	0.86	0.85
7:00 AM	1.49	1.38
8:00 AM	1.58	1.55
9:00 AM	1.31	1.37
10:00 AM	1.21	1.26
11:00 AM	1.22	1.11
12:00 PM	1.15	1.07
1:00 PM	1.08	1.00
2:00 PM	1.03	0.95
3:00 PM	0.93	0.91
4:00 PM	0.92	0.94
5:00 PM	0.99	0.96
6:00 PM	1.08	1.05
7:00 PM	1.17	1.14
8:00 PM	1.28	1.22
9:00 PM	1.39	1.32
10:00 PM	1.28	1.26
11:00 PM	0.99	1.06
12:00 AM	0.73	0.83
1:00 AM	0.56	0.67
2:00 AM	0.47	0.59
3:00 AM	0.44	0.53
4:00 AM	0.46	0.52

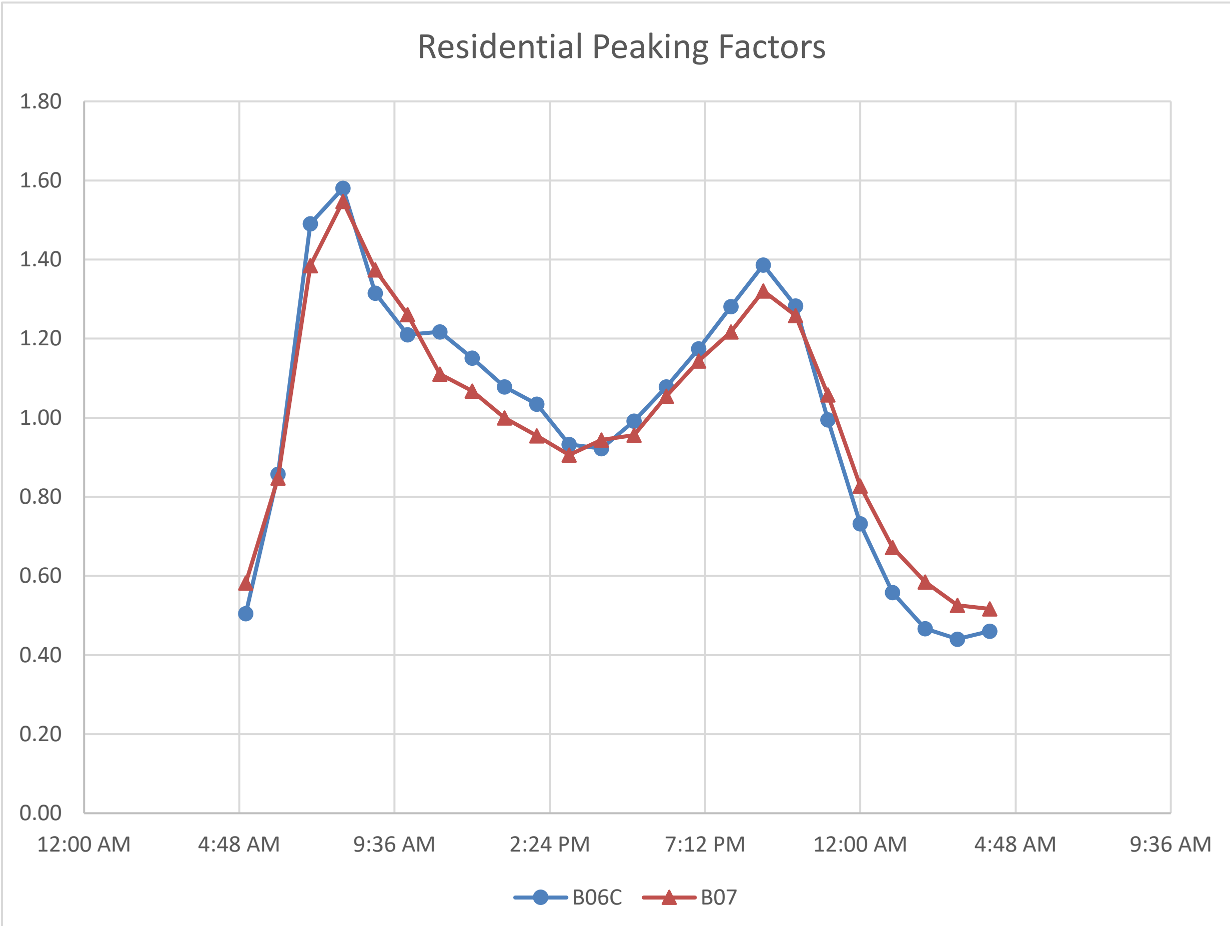


Figure 13: Typical Residential Peaking Factors

4.4 Spatial and Temporal Model Calibration

Comparisons of the hydraulic model dry weather flow hydrographs to observed May 2016 flows at the three main sewershed outfall flow meters are displayed below in Figure 14 through Figure 16. The calibrated hydraulic model results closely match the observed results from the May 2016 data, within approximately 0.5 MGD for almost all data points.

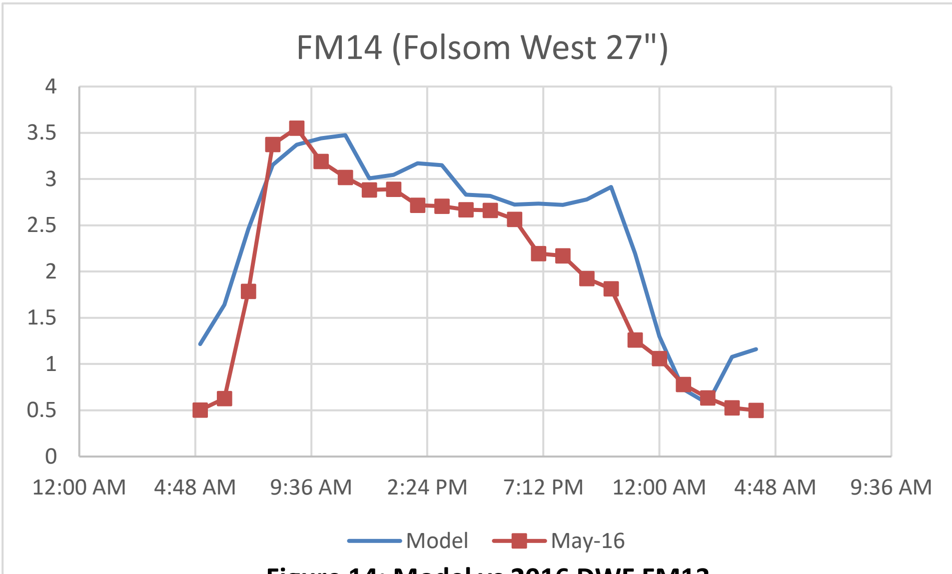


Figure 14: Model vs 2016 DWF FM13

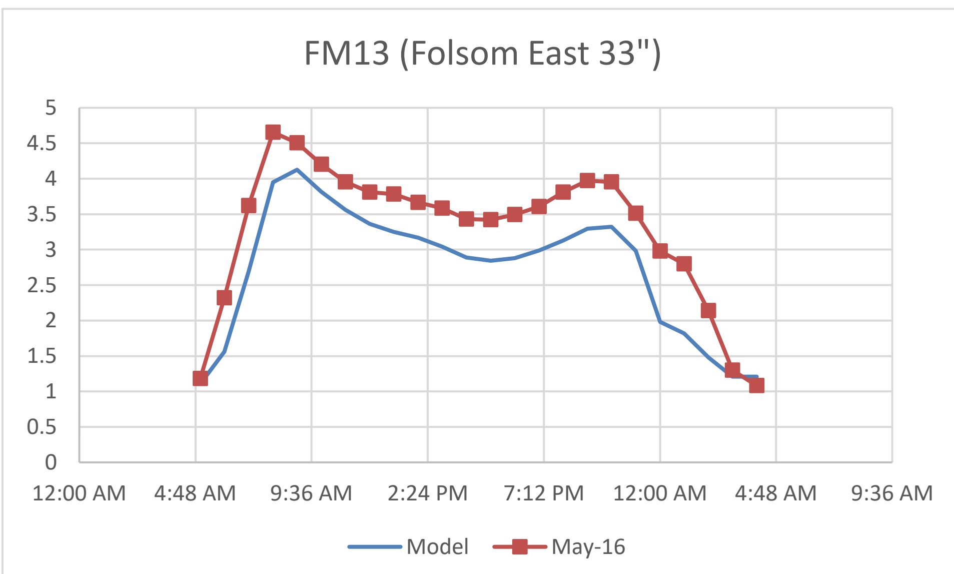


Figure 15: Model vs 2016 DWF FM14

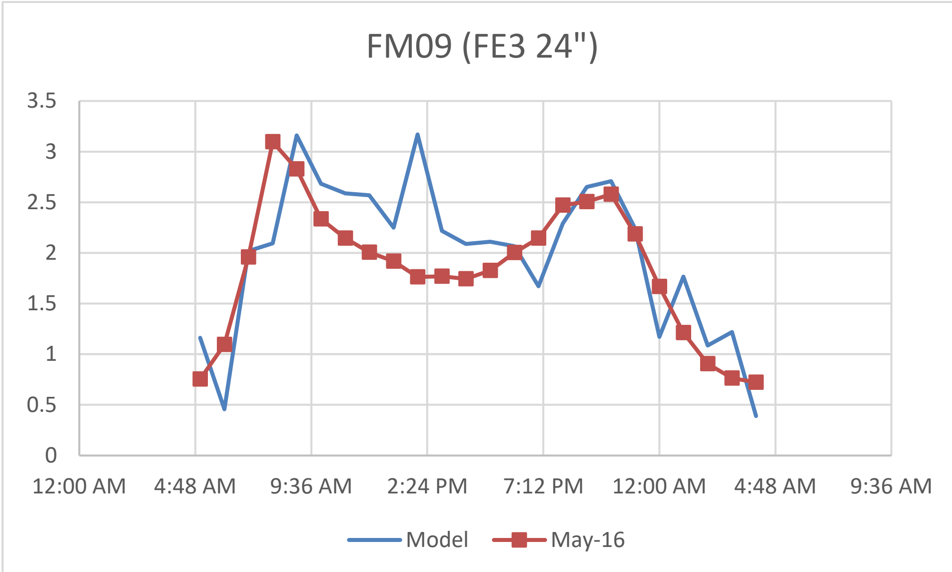


Figure 16: Model vs 2016 DWF FM09

5 WET WEATHER MODEL DEVELOPMENT

5.1 Wastewater Flow Characterization

5.1.1 Rainfall Dependent Infiltration and Inflow (RDII)

Rainfall Dependent Infiltration and Inflow (RDII) is rainfall runoff that enters a closed sewer collection system through manhole and pipe defects, manhole lids and clean-outs, and is visually represented in Figure 18. The relative magnitude of the RDII is often correlated with the age of the collection system. High intensity inflows typically dissipate soon after rainfall stops as opposed to low intensity groundwater infiltration that can stay at elevated levels for many days after a storm, as evident in a sample hydrograph displayed in Figure 17.

The flow meter data used to generate the design storm for the hydraulic model peak wet weather flow (PWWF) analysis occurred in January 2017 in the middle of a record winter rainfall season that was recognized as lifting drought conditions in many parts of the California. January 2017 was the wettest January on record for Sacramento. As such, antecedent moisture conditions were very high before and after the storm, which conservatively affects the hydraulic model by maximizing RDII responsiveness and measured peak flows. In comparison, storms occurring earlier in the winter season had lower antecedent moisture conditions and a higher soil capacity to absorb rainfall that attenuated RDII responses.

RDII was applied in the hydraulic model by calculating the total for each basin, and then distributing it by contributing parcel area if the parcel did not have the "OPEN" land use which is assumed to drain away from the sewer collection system.

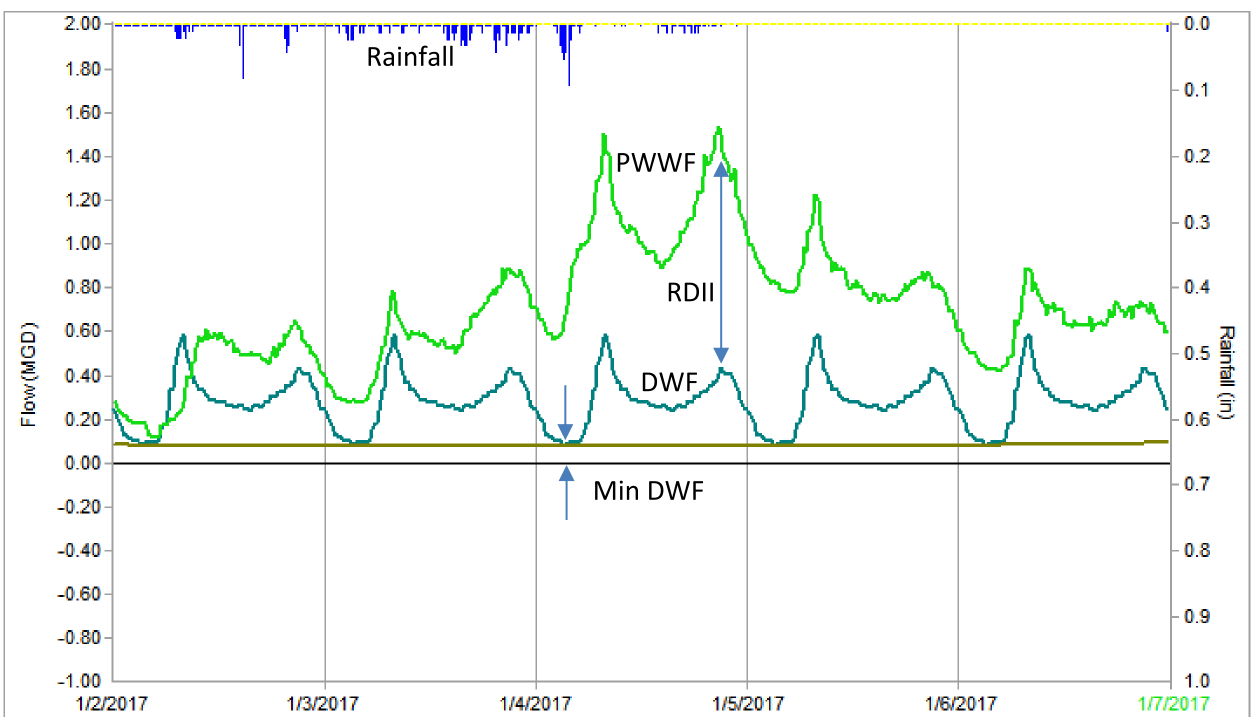


Figure 17: Typical Wet Weather Flow Hydrograph

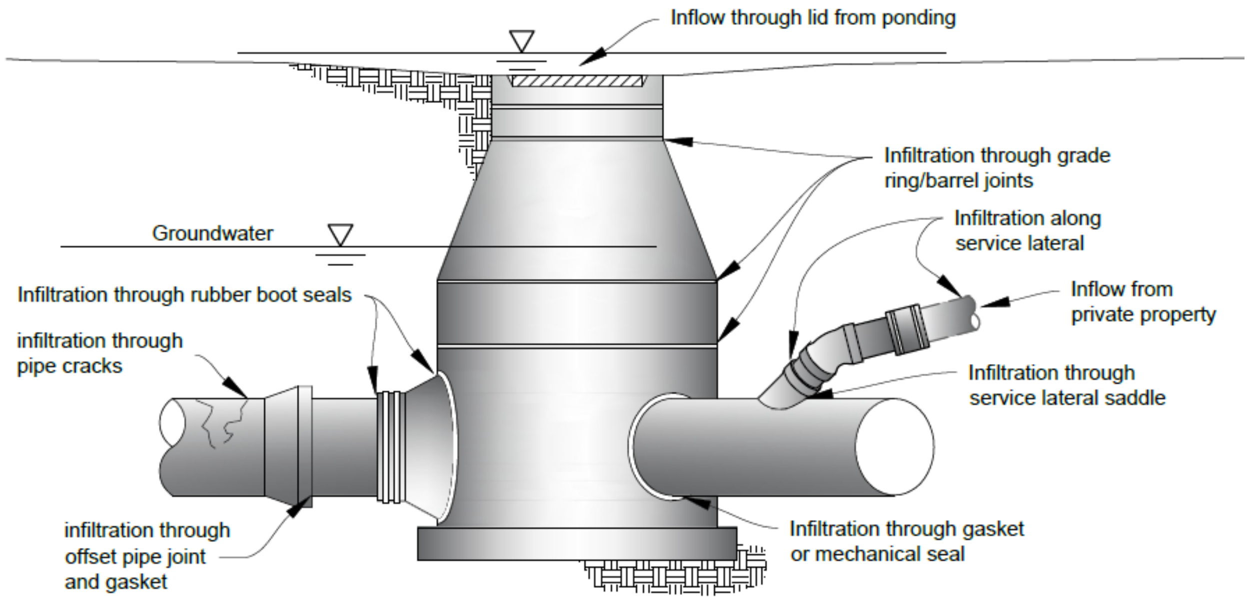


Figure 18: Common Sources of I&I

5.1.2 Seasonal Groundwater Infiltration Baseflow

Not influenced by short term storms but driven by seasonal variations and longer term rainfall totals, year-round groundwater infiltration (GWI) baseflow is also a common source of flow into a collection system. Max flows are typically observed during late winter (late spring for regions with snow melt) and minimum flows in the Fall. For this study, additional GWI baseflow was estimated per basin by subtracting May 2016 DWF average minimum flows from February 2017 Winter minimum flows during a period of dry weather. This is listed below in Table 19. For the purposes of the hydraulic model, the additional GWI baseflow is applied similarly to RDII, where it is apportioned out by area across basins to individual parcels.

Table 19: GWI by Basin

Basin	Additional Winter GWI (MGD)
B01	0.03
B02	0.00
B03	0.00
B04	0.00
B05	0.00
B06A	0.00
B06B	0.00
B06C	0.08
B07	0.04
B08	0.24
B09	0.00
B10	0.00
B11	0.01
B12	0.42
B13	0.52
B14	0.12
B15	0.01
B16	0.03
B17	0.09
Total	1.58

5.2 Calculation of Peak Wet Weather Design Flows

5.2.1 Rainfall Data Source and Calibration

The rainfall data used to develop the model RDII response to storm events was derived from the 15-min increment rainfall data from the City Corp Yard tipping-bucket-style rain gauge. The temporal distribution of the City rainfall data was utilized, and the reported rainfall total depth was calibrated by scaling it up to match available daily NOAA (National Oceanic and Atmospheric Administration) rainfall totals as shown in Figure 20 and Figure 19 below.

The largest rain storm in the last several years occurred from January 7th-11th, totaling 6.3”, and was used as the design storm benchmark to calibrate the wet weather model. The wet weather flow data from this January 2017 event is shown in Appendix A.4.

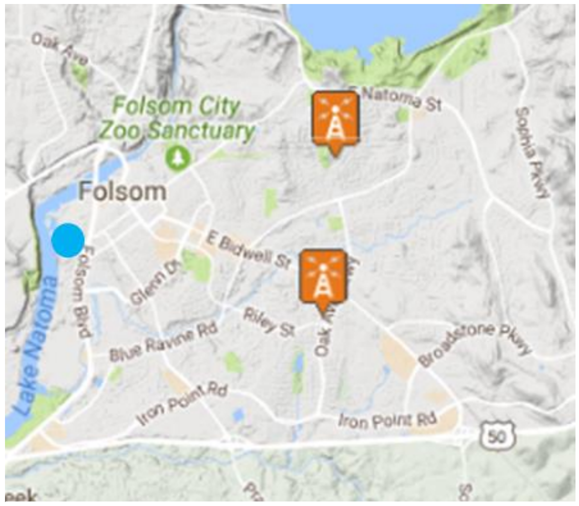


Figure 19: NOAA Daily Rainfall Stations

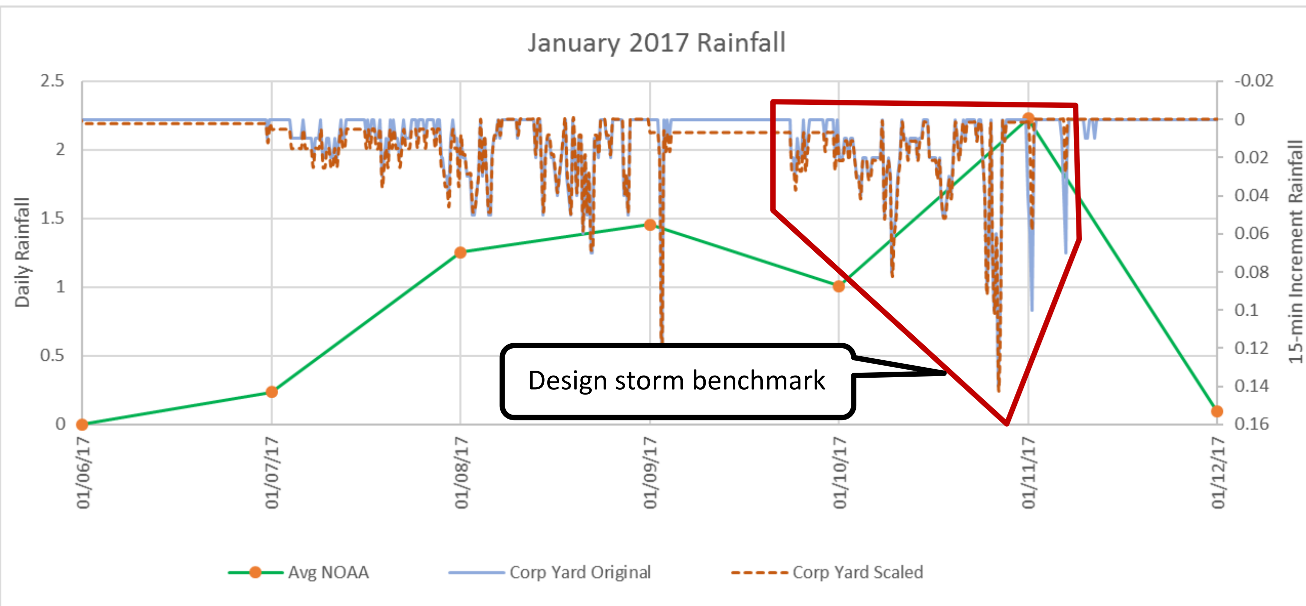


Figure 20: January 2017 Rainfall

5.2.2 January 10th Rainfall Event

The storm centered around January 10th was a very long, extended event that equaled a NOAA 10-yr/4-day storm and can be summed up with the following characteristics:

- Max 6-hr cumulative rainfall depth = 0.78”
- Max 24-hr cumulative rainfall depth = 2.35”.
- Max 4-day cumulative rainfall depth = 6.07”. Exactly matches NOAA 10yr/4-day storm (6.07”)

5.2.3 Design Storm Development Methodology

The hydrologic Sacramento Method was used to develop the design storm and is a well-documented approach that is referenced in Sacramento County's design standards and the 2003 SECAP hydraulic model. The Sacramento Method is statistically based on over eight decades of historical data and incorporates regional and elevation adjustments, where higher intensity rain falls closer to Folsom Lake and at higher elevations. The design storm was produced via the SacCalc Hydrologic Calculator software distributed by Sacramento County (accessed January 2017).

The three main components of a design storm are the total rainfall depth, storm duration, and probabilistic return period or frequency of that storm. The City of Folsom's standard design storm is the 10-year return, 6-hr duration, 1.73-in rainfall storm listed in NOAA Atlas 14, Volume 6, Version 2. The temporal distribution of the storm was developed via the Sacramento Method for Rainfall Zone 3 at a mean elevation of 350 feet. The single high-resolution rain gauge was applied equally across the City basins for calibration purposes.

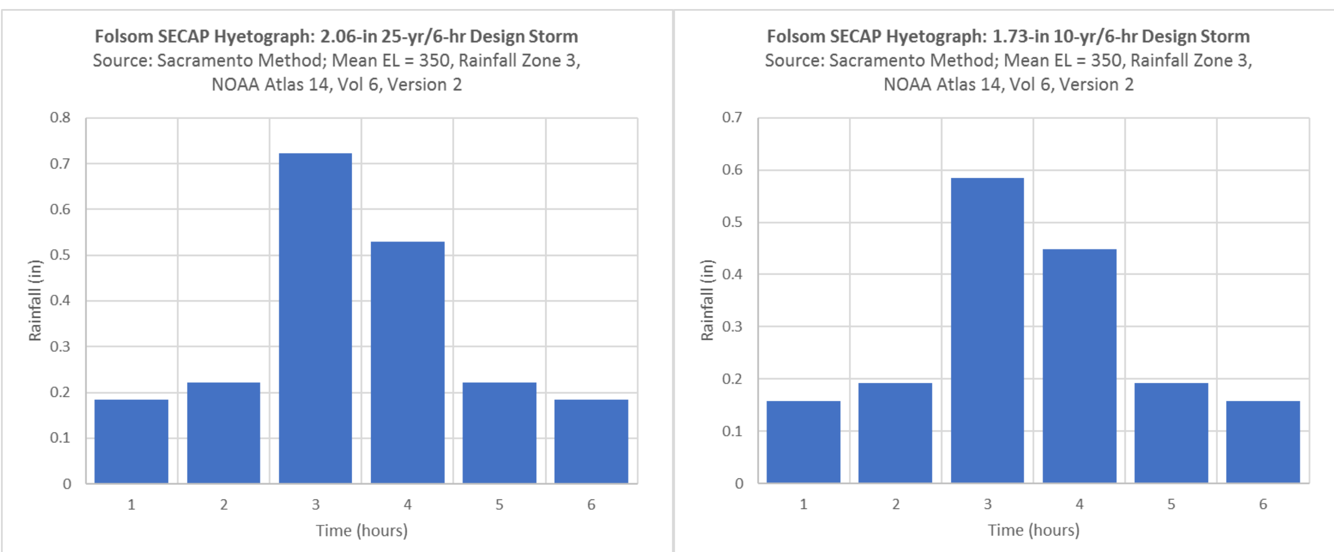


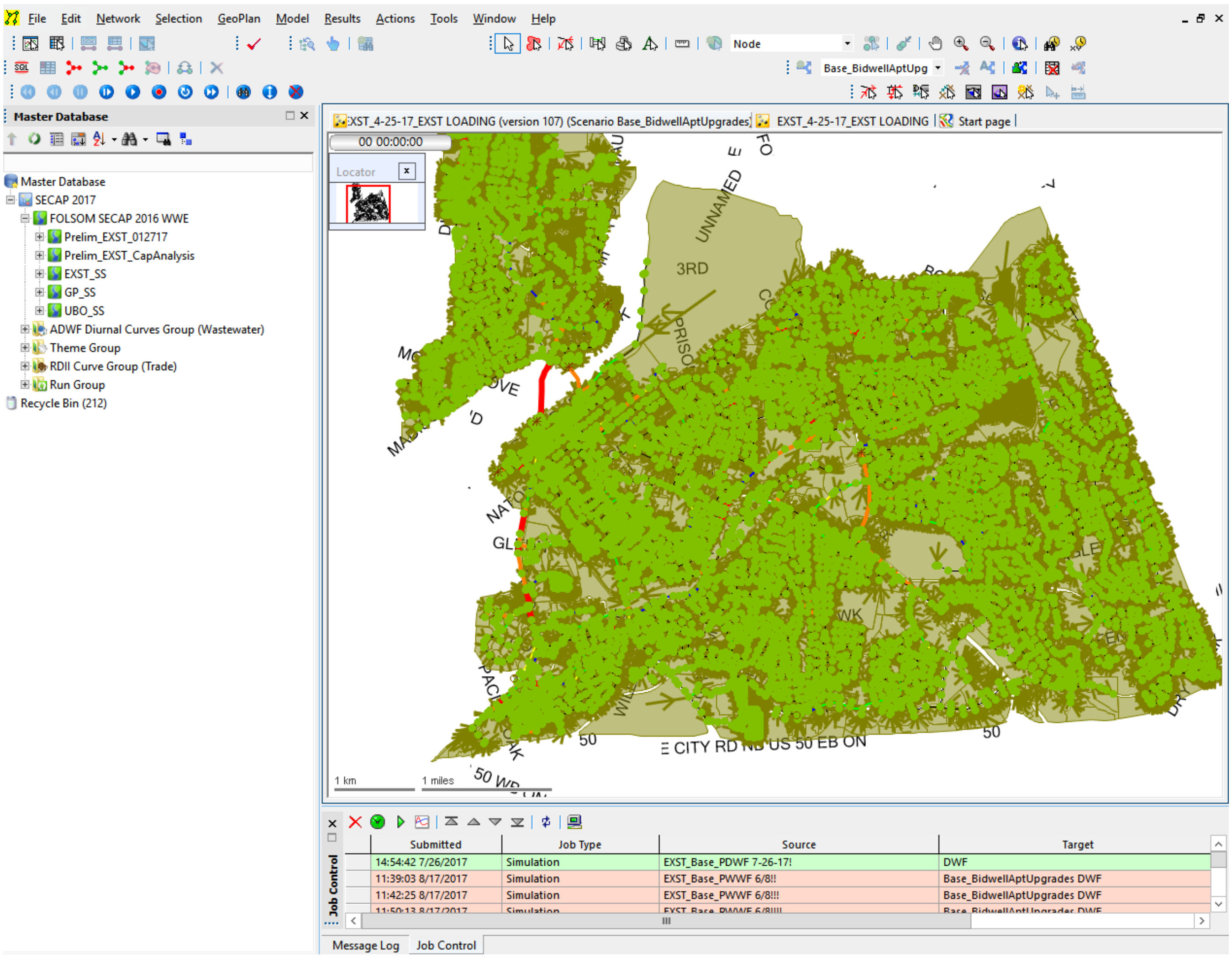
Figure 21: Folsom SECAP Hyetograph

5.2.4 RDII SYNTHETIC UNIT HYDROGRAPH DEVELOPMENT

The rainfall and flow meter data along with the chosen 10-yr/6-hr design storm hyetograph was entered into the EPA's Sanitary Sewer Overflow Analysis and Planning (SSOAP) Toolbox software. Within the software, sewer sub-basin specific unit RDII hydrographs were developed to best fit the observed storm response from Jan 7th to 11th. Those unit hydrographs were then utilized to develop theoretical RDII response hydrographs specific to the 10-yr/6-hr design storm hyetograph for simulation of this specific event within the hydraulic model. The basin specific 10-yr/6-hr design storm RDII hydrographs are shown in Appendix A.5.

5.2.5 ICM Hydraulic Model

The hydraulic model was simulated using Innovyze InfoWorks ICM 7.0 (Integrated Catchment Modeling) software, which is a fully dynamic computational engine built on an implicit numerical solution scheme. Numerous different scenarios and the effects of implementing specific CIPs such as diversions, overflows, and sensitivity analysis were all simulated within the software.



6 SHORT-TERM MODEL RESULTS & RECOMMENDATIONS

6.1 Summary

The 10-yr/6-hr peak wet weather flow hydraulic model results are presented below. Figure 22 shows the design storm event hydrographs at the collection system's main 3 outfalls into the SRCSD system. Table 20 shows the overall flow results for the Existing, General Plan, and Ultimate Build-Out scenarios.

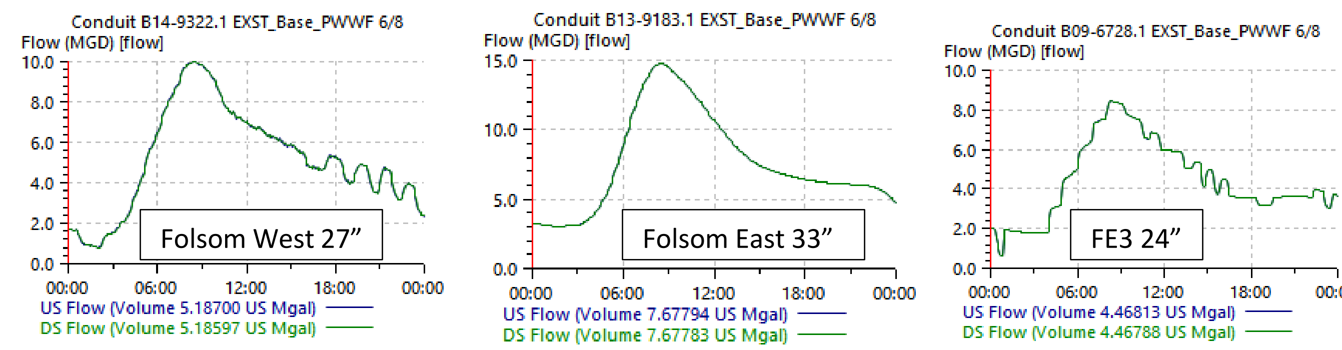


Figure 22: Existing Conditions 10-yr/6-hr PWWF Hydrographs (by main sewershed)

Table 20: 10yr6hr PWWF Results (mgd)

Location	ADWF			PDWF			GWI	10yr/6hr Peak RDII	10yr/6hr PWWF			Jan 10th FM Results PWWF
	EXST	GP	UBO	EXST	GP	UBO			EXST	GP	UBO	
Folsom West (27" Trunk)	2.8	3.3	3.8	5.09	5.79	6.7	0.2	4.6	9.9	11	11.6	8.2
Folsom East (33" Trunk)	2.5	2.5	2.7	5.62	5.4	5.71	1.1	8.1	14.8	15	15	14.7
FE3 (24" Trunk)	1.9	2.2	2.5	3.8	3.99	5.14	0.3	4.3	8.4	9.6	9.7	9.0
Total[1]	7.1	8	8.9	14.5	15.2	17.6	1.6	17	33.8	35	36.4	31.9
2008 ECOLOGIC Total[2]	9.3	-	11.0	-			-	-	31.8	-	34.6	-
Triton SRCSD FM[1]												28.8

[1]The total reported value is instantaneous and summed across the three flow meter sites. Actual downstream peak flow at the SRCSD FE2 interceptor and Triton Flow Meter site would be reduced, due to effects of FE3 PS and flow attenuation.
[2]These values were referenced from the 2008 ECOLOGIC Master Plan.

Discussion

The 10y/6hr design storm total of 1.6” was utilized to produce the RDII hydrographs. The RDII response parameters of each basin were calibrated from the January 10th storm, which was the largest, longest storm in several years and equaled the response of a 10-yr/4-day storm. As the event occurred amidst the middle of a very wet winter, antecedent levels were likely high and the system was as responsive as it could be (conservative). The 10-yr/6-hr modeled Folsom East sewershed results were approximately equal to the observed January 10th storm response. Conversely, the Folsom West sewershed and to a lesser extent the FE3 sewershed had larger modeled responses. This difference may be attributed to the unknown spatial distribution of the storm, i.e., it may have been centered on the City and the upper reaches of Folsom West/FE3 received less consistent storm coverage.

Comparison to 2008 Hydraulic Model Results

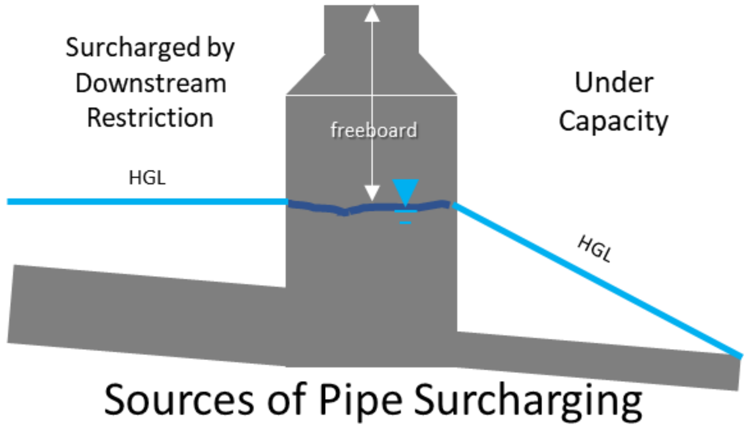
As listed in Table 20, the 2008 ECOLOGIC hydraulic model 10yr/6hr PWWF results are approximately 5-6% lower than the SECAP 2017 results. Interestingly, the listed SECAP 2017 ADWF is lower than in 2008, and the decrease may be related to increased water conservation, but also possibly because seasonal GWI was added to the 2008 ADWF (making it a dry winter ADWF). Regardless, if the 2008 ADWF is higher than SECAP 2017 but the overall PWWF is lower, then that implies that RDII may have increased between 2007 and 2017. One final point to highlight is that the City upgraded their flow monitoring program in 2015, and the increased performance of the 2016-2017 flow monitors may have contributed to the difference in results.

6.2 MODEL RESULTS

Several capacity-related deficiencies were identified via the 10-yr/6-hr wet weather hydraulic model scenarios and some are recommended to be added to a list of short-term capital improvement projects (CIPs) that may affect the upcoming sewer rate study. The City defines a capacity deficiency according to the following criteria:

1. Any location where surcharging is occurring to within less than 5' from the surface of the upstream manhole (5-ft freeboard) due to a downstream restriction in flow. Note that some smaller diameter pipes and associated manholes are installed less than 5' deep, and in those cases, these are not considered capacity deficiencies.
2. Any location where surcharging above the crown of the pipe exceeds 2'-0" due to a downstream restriction in flow.

The hydraulic model results indicate several solitary sewer pipe segments that are slightly surcharged, but do not meet the capacity deficiency criteria described above. These pipes are essentially at capacity for the model scenario but present no risk in causing a sewer overflow, and do not warrant a capital improvement project and are therefore not analyzed or discussed further in this report. These pipe segments are typically individual segments with slopes that are less than the surrounding pipe segment slopes, causing them to show as being at capacity for gravity flow. A list of capacity deficiencies from the 10yr/6hr wet weather hydraulic model scenarios is listed below with supporting figures included in Appendix B.1, B.2, and B.3. The profile/long section view of the of the areas of concern are shown in Appendix C.1 and C.2 with hydraulic grade lines plotted. Please note that a line that is surcharged is not necessarily under capacity, but is merely sucharged because of a downstream restriction. This difference is highlighted in the diagram below.



6.2.1 Key Results

The areas of concern encountered when analyzing the existing 10yr6hr results are highlighted in Appendices C.6 through C.9 and are discussed below.

Area of Concern #1: 27" Trunk Folsom Blvd (B14)

Reference Appendix C.6 for map highlighting area of concern.

Modeled Results

- EXST: Surcharging to within ~5-ft of surface at SSMH B14-6121
- GP: Surcharging to within ~3-ft of surface at SSMH B14-6121
- UBO: Surcharging to < 3-ft to surface at SSMH B14-6121

Discussion

The Folsom Blvd 27" trunk has several locations where pipe slope is minimal and the line is slightly under capacity at existing conditions resulting in minor surcharging, particularly at SSMH B14-6121. For GP and UBO scenarios, however, surcharging increases and is almost entirely driven by assumed growth in Folsom State Prison flows. Current Prison flows are only at 70% of permitted ADWF and 50% of permitted max PDWF. Whether or not sewer flows from Folsom Prison are actually expected to rise in the future is unknown based on a lack of available planning documents for the Prison.

Area of Concern #2: 12" Main Blue Ravine & Bidwell (& upstream on Flower Drive B06C)

Reference Appendix C.7 for map highlighting area of concern.

Modeled Results

- EXST: Surcharging to within ~3-ft of surface at Blue Ravine and Bidwell at SSMH B12-2161
- GP and UBO unchanged

Discussion

The 12" main on Blue Ravine (built in 2010 under the B06 Diversion Project) is under capacity. Modeled peak wet weather flows are approximately 2.1 MGD, but the pipe as designed has a capacity of 1.5 mgd at d/D=1. This is causing surcharging in the branching manhole B12-2161 next to the Blue Ravine / Bidwell bridge crossing. The upstream portions of Flower Drive are modeled as slightly surcharged, but have greater than 5-ft of freeboard.

Area of Concern #3: 6" Main Montrose Dr (B06B)

Reference Appendix C.8 for map highlighting area of concern.

Modeled Results

- EXST: Surcharging to within ~5-ft of surface at SSMH B06-4599 and B06-2267
- GP and UBO unchanged

Discussion

Several 6" lines along Montrose Dr are under capacity due to flatter than recommended slopes. No action is recommended, however, as a low 6" overflow weir exists at the Montrose and School intersection (directs flow to B06A). This weir controls excess surcharging and subsequent downstream flow levels by diverting most of the surcharged flows (above the soffit of the downstream pipe).

6.2.2 Oak Ave Pump Station

Modeled PWWF influent at the Oak Ave PS is shown in Figure 23 through Figure 24 below with max values of 6.2 mgd (EXST), 6.4 mgd (GP), and 6.7 mgd (UBO). This closely matched the January 2017 flow meter

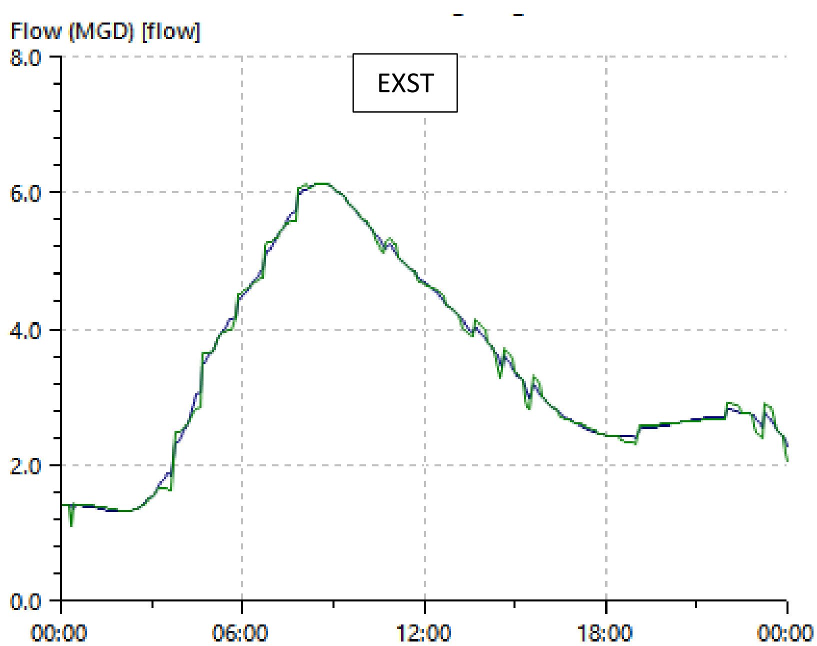


Figure 23: Exst 10yr/6hr PWWF Oak Ave PS

results of 6.3 mgd. Existing max pumping capacity with two pumps is 7.0 MGD, with the third redundant pump providing an additional 3.51 MGD capacity.

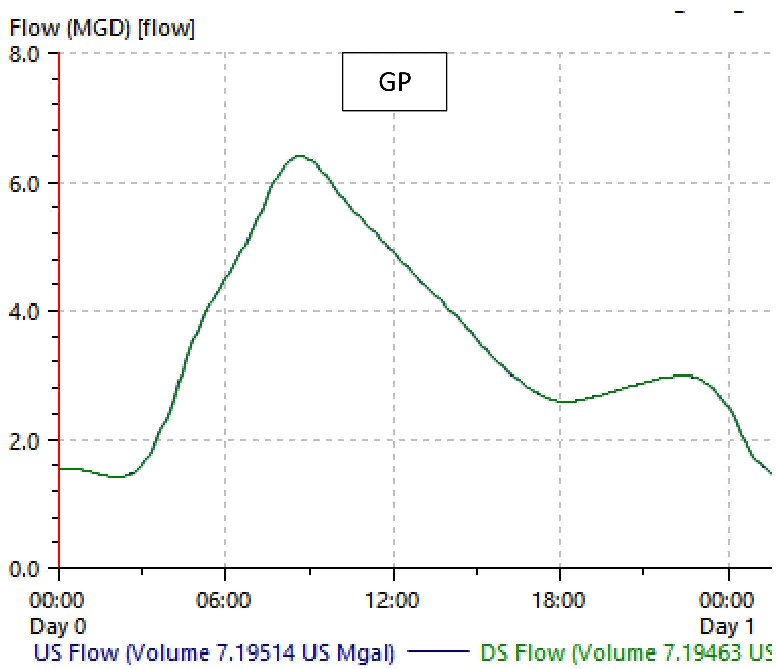


Figure 25: GP 10yr/6hr PWWF Oak Ave PS

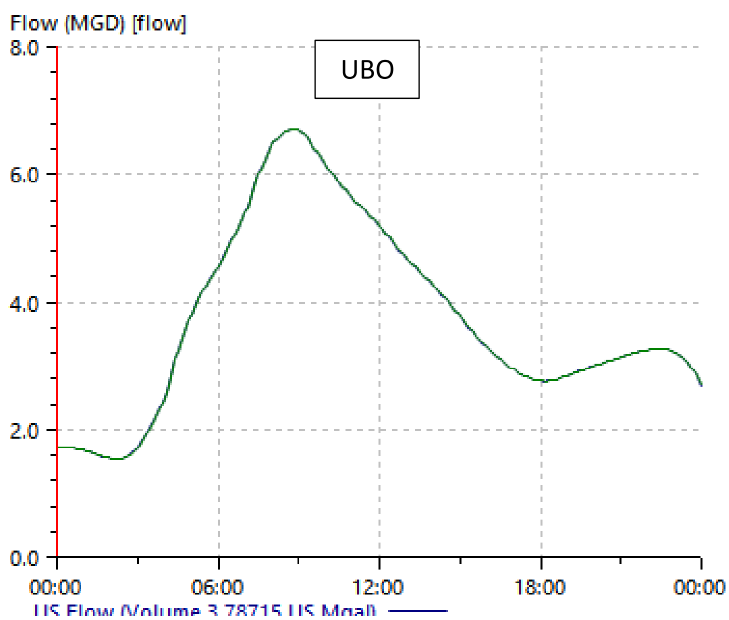


Figure 24: UBO 10yr/6hr PWWF Oak Ave PS

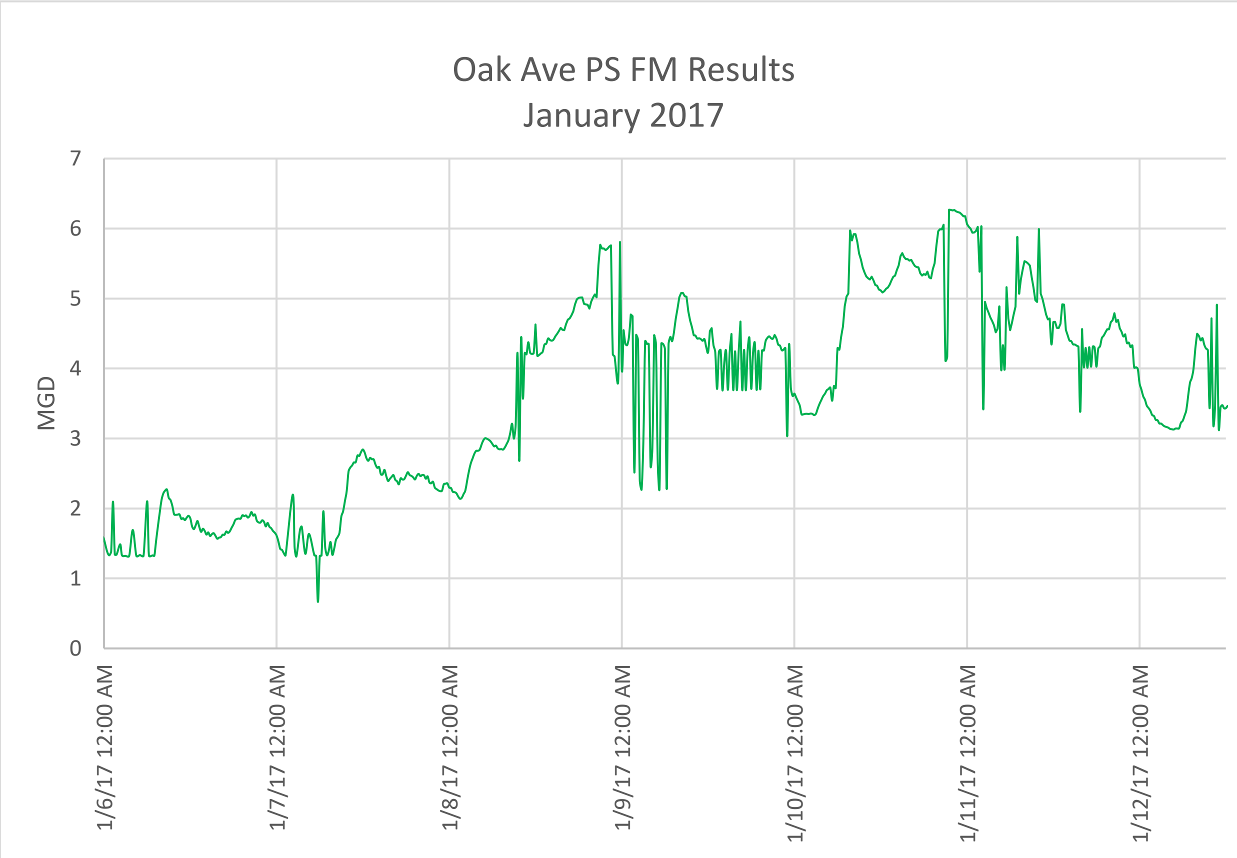


Figure 26: Jan 2017 PWWF Oak Ave PS

6.3 I&I Reduction Program Recommendations

6.3.1 Sewer Basin I&I Comparison

Determining the relative magnitude of observed RDII (Rain Derived Inflow and Infiltration) and GWI (Groundwater Infiltration) per In-Dia.-Mi of sewer system piping for each Basin is a useful method of comparing basins to allow for targeting of I&I reduction efforts. The I&I performance of each basin is presented, and the basins are ranked relative to each other in Table 21. The basins are ranked in order, with #1 representing the largest response to storm events, (i.e., the "leakiest basin").

Table 21: I&I Basin Rankings

Basins	GPD/in-dia-mi Peak RDII + GWI	Ranking	Recommended Prioritization	Comments
B01	102,080	14		
B02	99,015	15		*
B03	54,254	18		
B04	150,029	7	4	Addresses Folsom Blvd 27"
B05	-	19		**
B06A	171,784	5	3	Addresses Folsom Blvd 27"
B06B	106,034	12		
B06C	158,490	6	1	Addresses Blue Ravine/Bidwell 12"
B07	105,350	13		
B08	120,804	10		
B09	86,210	16		
B10	255,038	2		
B11	224,297	4		
B12	109,783	11		
B13	303,353	1		Lowest performing basin
B14	239,253	3	2	Addresses Folsom Blvd 27"
B15	128,995	9		
B16	72,343	17		Highest performing basin
B17	129,981	8		

*Basin 2 relative I&I performance may change based on updated information from the proposed Pump Station 3 Flow Meter
**In-dia-mile SS information for Prison utilities in Basin 05 are unknown

Water Works Engineer's final recommendations regarding priority for I&I reduction also accounted for whether key hydraulic deficiencies defined previously are downstream of the highly ranked basins. In the case of Basins B13, B10, and B11 which are ranked as #1, #2, and #4 respectively, these basins do not have any hydraulic capacity deficiencies downstream of them, therefore their final prioritization is reduced in favor of basins where I&I reduction could reduce flow to an area of hydraulic capacity concern.

A targeted basin I&I reduction program is anticipated to last at least several years, with Phase 1 being an investigation period to identify sources of excess I&I as well as specific system rehabilitation CIPs to address those, and Phase 2 being the construction of the rehab CIPs and confirmation of the rehab CIP effectiveness in reducing I&I. A visual aid for a typical I&I program is displayed in Figure 27.

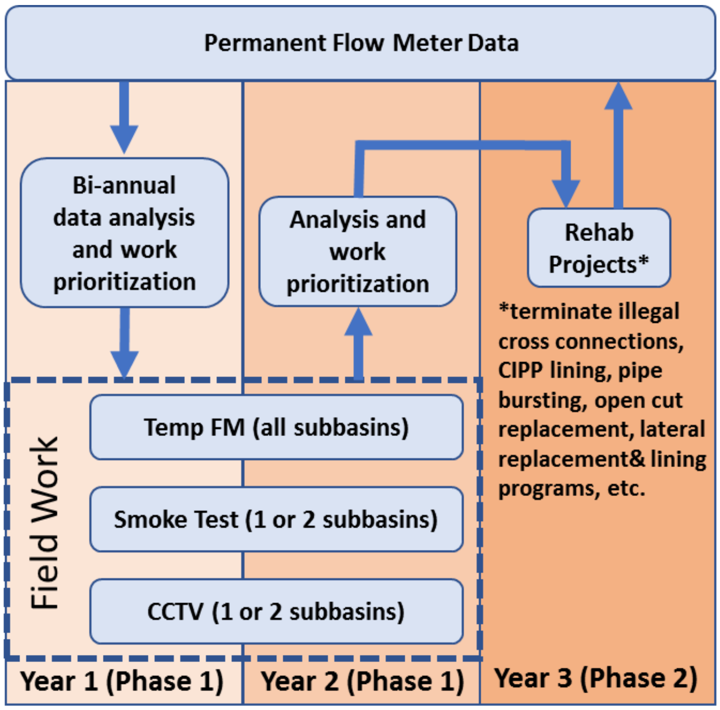


Figure 27: Sample I&I Program

6.3.2 Reducing I&I to address Bidwell and Blue Ravine Surcharging

A B06C I&I reduction program is recommended to be prioritized over Folsom West 27” basins unless the Blue Ravine to Bidwell diversion weir is installed. If so, then B06C should be reduced in overall priority behind Folsom West 27” basins, and B14 should be the next targeted basin.

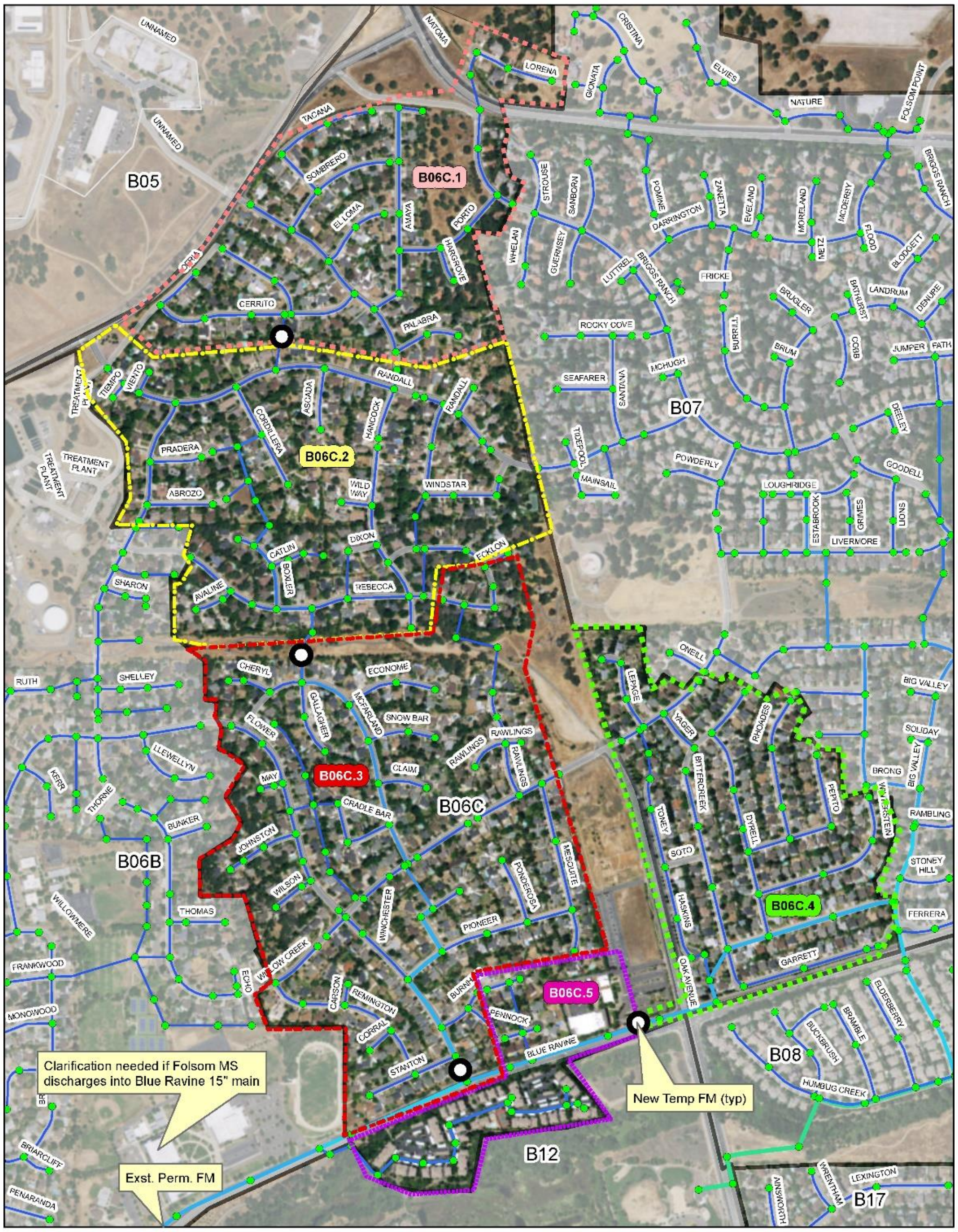
A Basin B06C I&I reduction program cost (present worth) is listed below in Table 22. A preliminary/sample B06C I&I plan is displayed in Figure 28 , and is subject to change based on potential City O&M records of recent smoke testing and CCTV efforts in this basin which may reduce the cost estimates presented below.

Table 22: B06C I&I Reduction Program Cost Estimate

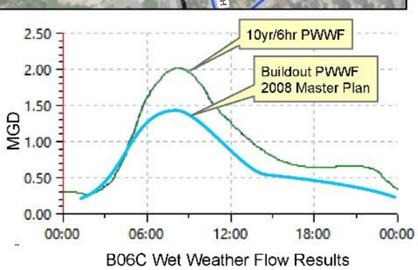
B06C I&I Reduction Project Phase 1						
Year 1	**Type**	**Duration (months)**	**Quantity**	**Unit**	**Unit Cost**	**Cost**
	Temp. FM	6	5	Temp. FM	$ 2,170	$ 65,100
	FM Analysis					$ 12,000
	Subtotal	*(rounded up to nearest $1000)*				$ 78,000
Year 2	**Type**	**Size (in)**	**Length**	**Unit**	**Unit Cost**	**Cost**
	Smoke	6"-8"	16,500	ft	$ 1.00	$ 16,500
	Smoke Analysis			LS		$ 8,250
	CCTV	6"-8"	15,000	ft	$ 3.00	$ 45,000
	CCTV Analysis			LS		$ 20,000
	Subtotal	*(rounded up to nearest $1000)*				$ 90,000
					Total	$ 168,000

*Assumed to be contracted work. Temporary flow metering includes rental, installation, calibration, removal, and data delivery by supplier. Phase 1 involves investigation only, Phase 2 involves actual rehabilitation.

The concept behind the proposed I&I reduction program would be to further subdivide Basin B06C into 5 sub-areas by placing 5 temporary flow monitors as shown in Figure 28 during the winter season in order to further pinpoint sources of I&I. Following analysis of the data, smoke testing and CCTV would be targeted at the areas of that basin that display the highest I&I during storm events.



Est. Pipe Age	Pipe Statistics	Subbasin Flow Metering
B06.C.1 = 35 yrs	6" = 49,750 LF	B06.C.1 Temp FM (6" line)
B06.C.2 = 33 yrs	8" = 5,750 LF	B06.C.2 Temp FM (8" line)
B06.C.3 = 33 yrs	10" = 1,750 LF	B06.C.3 Temp FM (12" line)
B06.C.4 = 29 yrs	12" = 5,500 LF	B06.C.4 Temp FM (12" line)
B06.C.5 = 19 to 32 yrs		B06.C.5 Permanent B06C FM



Basin Statistics

> 1000 parcels
> 98% Single Fam.
283 acres (RDII)
12 miles of pipe
82 in-dia-mile

I&I Reduction Target

>0.5 MGD PWWF

Figure 28: Sample I&I Reduction B06C Program: Phase 1

6.3.3 Reducing I&I to address Folsom West 27" Trunk Surcharging

The I&I reduction programs for Folsom West 27" should be modeled after the sample B06C reduction program listed above. Individual sub-basins would be isolated with temporary flow meters, and then smoke testing and CCTV field investigations would be applied strategically based on the FM results. As discussed previously, if the Bidwell and Blue Ravine overflow/diversion CIP is implemented, it is recommended that the B06C I&I reduction program not be implemented until after several Folsom West 27" I&I reduction programs are conducted.

6.3.4 Oak Avenue Pump Station Capacity

The upstream sewershed discharging into the Oak Ave Pump station is very large and encapsulates Basin 08 and Basin 07. These basins are ranked relatively low for I&I compared to the rest of the City based on the rankings listed in Table 21 and are of such a size that they are not recommended for an I&I reduction program at this time. Possible diversion relief projects are discussed in sections below.

6.4 SHORT TERM CAPITAL IMPROVEMENT PROJECTS

The short-term CIPs discussed below and the I&I Reduction Programs discussed above are assigned an estimated cost in Table 23. There are no triggers linked to these improvements and they are recommended for immediate implementation.

6.4.1 27" Trunk Folsom Blvd (#1. B14)

A. I&I Reduction

If an I&I reduction program is ineffective in reducing peak wet weather flows in the 27" Folsom West sewershed, then a parallel relief line or a trunk sewer replacement would mitigate capacity issues along the trunk. These are discussed in Section 7 of this report.

B. Confirm GIS-provided Slopes

Confirming the GIS data for the Folsom 27" trunk is recommended as a short-term task, as the GIS indicates some negative slopes along Folsom Blvd (between Parkshore and Blue Ravine). Given the criticality of this trunk line and the cost to install a parallel relief line or replace the line, having accurate surveyed data to confirm model output is recommended. As part of such a resurveying effort, it is also recommended that the City survey the manholes upstream of PS 2 and PS 3 up until the Greenback intersection. Along with the installation of a PS3 flow meter discussed below, it is crucial that the GIS-provided slopes around the Greenback intersection be validated so as to improve the performance and accuracy of the hydraulic model in splitting flows between PS2 and PS3. This will improve the efficacy of the long term I&I reduction programs in the Folsom West 27" sewershed.

6.4.2 12" Main Blue Ravine and Bidwell (#2. B06C)

Reference Appendix C.9 for a plan view of the improvements listed below.

A. Diversion Weir to Orchard Dr Line

An abandoned line exists between B06-2282 and B06-2283 which was effectively bypassed via the B06C diversion project. This project installed B06-2282 and cut into that line, redirecting flow from Bidwell to Blue Ravine. A diversion weir structure could be installed within or adjacent to B06-2282. This would effectively restore small, controlled overflows into the older line, and redirect it to Bidwell and then Orchard Dr, which has sufficient capacity. A detail of the manhole is shown in Figure 29 below. Notice that the outgoing 12" line is effectively 6-ft higher than the base.

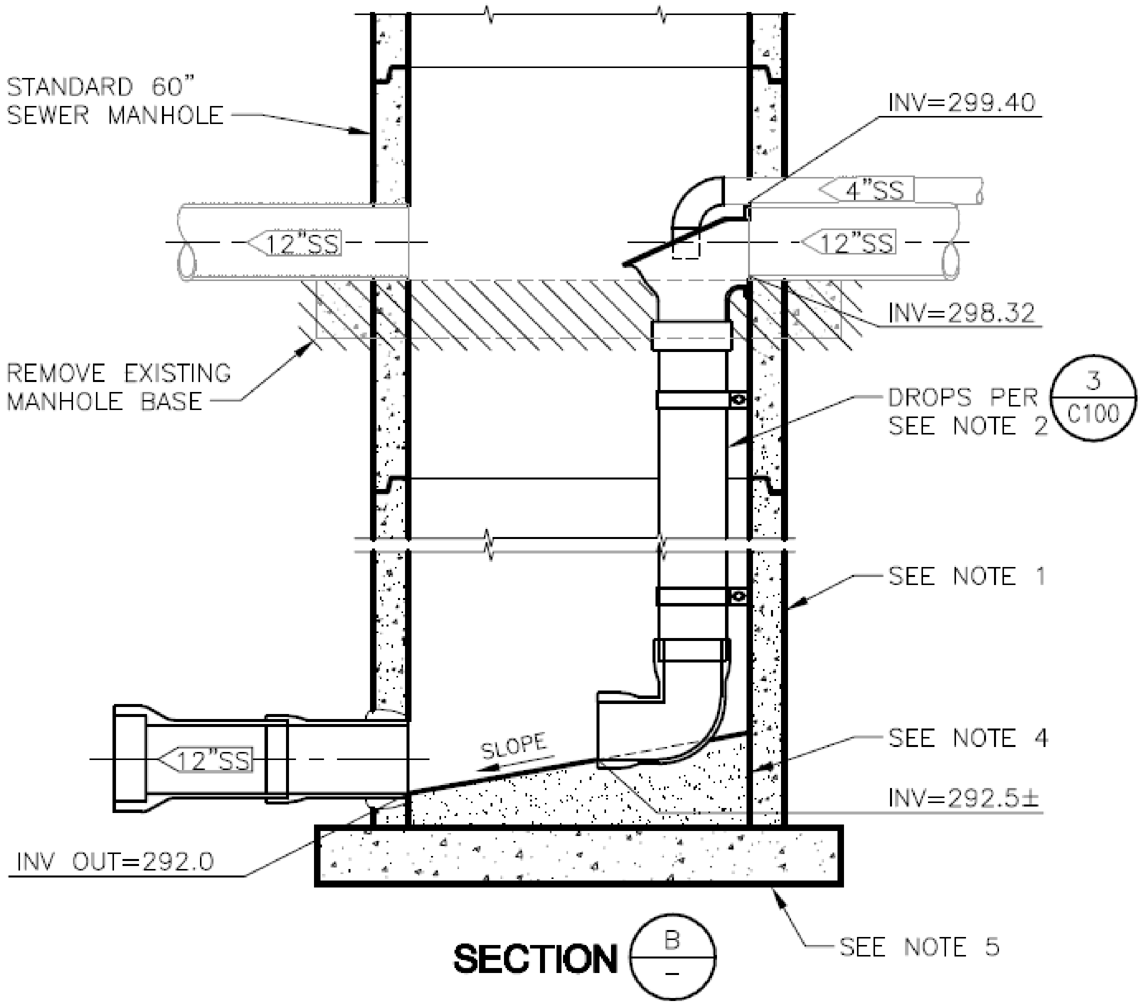


Figure 29: SSMH B06-2282 Record Drawing

B. Sealed Manhole Lids

Due to the surcharging at Bidwell and Blue Ravine, it is recommended that the manhole lids be sealed at B12-2163 and B12-2161.

6.4.3 Pump Station 3 Flow Meter Installation (#3. B02)

SECAP 2017 was the first time that all of the City's pump stations were modeled because the previous 2008 hydraulic model was limited to larger diameter mains and only covered Oak Ave PS, PS2, and Lake Forest PS (and FE3). The process of adding remaining pump stations to the hydraulic model highlighted future need for flow meter data from Pump Station 3 as it was estimated via the model approximately 1.1 mgd 10yr/6hr PWWF was diverted from B01/B02/B03. Consequently, to ensure the efficacy of the long term I&I reduction programs in the Folsom West 27" sewershed, it is recommended that a flow meter be added at Pump Station 3. A magnetic flow meter on the discharge piping may be the least expensive option compared to installing an upstream gravity flow meter. It has not been confirmed if the existing telemetry system at PS3 is capable of transmitting additional data from a new flow meter to the City's SCADA system. The recommended reporting period is in 1-minute increments to capture short duration pump runs, if possible.

6.4.4 City WTP or Oak Ave PS Rain Gauge Installation (#4)

To provide redundancy to the sole rain gauge at the Corp Yard and improve the efficacy of the ongoing I&I Program, it is recommended an additional rain gauge be installed at the City WTP (the existing weather station is offline and may be out of order) or at Oak Ave PS (preferred). SCADA and data transmission capacity is unknown at these locations.

6.4.5 Short-Term CIP Cost Summary

Table 23: Short-Term CIPs

Short Term CIPs	Description	Cost (present)
#1.B B14: 27" Trunk Folsom Blvd	Resurvey 27" Trunk	$ 25,000
#2.A B06C: 12" Blue Ravine and Bidwell	Diversion Weir to Orchard Dr	$ 75,000
#2.B B06C: Blue Ravine and Bidwell	Seal 2x Manhole Lids	$ 8,000
#3.B02: Pump Station 3	Install Flow Meter	$ 50,000
#4 City WTP or Oak Ave PS	Install 2nd Perm. Rain Gauge	$ 10,000
I&I Reduction Program: Phase 1	Description	Cost (present)
1. B06C (2 years)	Phase 1, 11.9 mi SS	$ 168,000
2. B14 (2 years)	Phase 1, 8.4 mi SS	$ 119,000
3. B04 (2 years)	Phase 1, 11 mi SS	$ 156,000
4. B06A (2 years)	Phase 1, 7.1 mi SS	$ 101,000
I&I Reduction Program: Phase 2 (CIPs)	Description	Cost (present)
none identified		$ -

7 LONG-TERM MODEL RESULTS & RECOMMENDATIONS

The primary purpose of the Folsom SECAP is to develop short term recommendations that influence CIPs and O&M decision making based on the standard 10-yr/6hr design storm. As a secondary role, the Folsom SECAP is intended to conduct a sensitivity analysis to determine the performance of the system at higher design storms to help facilitate long-term planning.

7.1.1 Sensitivity Analysis

To conduct the sensitivity analysis, the RDII load per sewershed was artificially increased until an SSO occurred or it matched an estimated 25-yr/6-hr design storm response. The results are listed below and are compared with the 2008 Wastewater Collection System Capacity Analysis Update (ECOLOGIC) sewershed totals. The analysis shows that surcharging in the Folsom Blvd 27" trunk increases until an SSO is modelled in the 25-yr/6-hr UBO scenario. No other spills occur within the sewer system and capacity issues at the Blue Ravine and Bidwell intersection are mitigated with short term CIPs. Figures highlighting the hydraulic modelling results are displayed in Appendices C.3 thru C.5.

Table 24: Trunk PWWF Results Summary

Hydraulic Model PWWF Trunkline Results							
Design Storm	Scenario	d/D and capacity results			PWWF		
		Folsom West 27"	Folsom East 33"	FE3 24"	Folsom West 27"	Folsom East 33"	FE3 24"
		@ B14-6121	@ B13-0682	@ B09-6726	@ B14-6121	@ B13-0682	@ B09-6726
10-yr/ 6-hr	EXST	1 At capacity	0.75	0.73	9.9	14.8	8.4
	GP	Under Capacity 3.9-ft freeboard	0.75	0.78	10.58	14.9	8.8
	UBO	Under Capacity 1.8-ft freeboard	0.76[3]	0.8	11.5	15.1	9.3
25-yr/ 6-hr	EXST	Under Capacity 3.0-ft freeboard	0.82	0.85	10.9	16.4	9.4
	GP	Under Capacity 1.9-ft freeboard	0.82	0.88	11.6	16.5	9.6
	UBO	Under Capacity Potential SSO	0.84	0.95	12.2	17.6	9.9
	UBO w/ CIPs[2]	0.6	0.92	0.85	12.8	17	9.05
10yr6hr	2008 (ECOLOGIC) Update: Future Conditions (UBO)				9.9	15.8	8.9

[1]The Basin 06C diversion project diverted 2.3 mgd of PWWF from the Folsom West to the Folsom East sewershed.
[2]Includes 36" Folsom Blvd Trunk replacement, Blue Ravine/Bidwell 0.5-mgd diversion, and Oak Ave PS 1-mgd diversion

7.1.2 Folsom Blvd 27" Trunk Mitigation

The majority of the Folsom Blvd 27" trunk would need to be replaced or supplemented to provide sufficient capacity to operate in a 25-yr/6-hr UBO scenario. Several options are presented in Table 25 below. Implementing the Folsom Blvd 27" trunk mitigation CIP (36" replacement) results are highlighted in Appendix D.1.

Table 25: Long Term CIPs: Folsom Blvd 27" Mitigation

Long Term CIPs: Folsom Blvd 27" Mitigation				
Option	Type	Description	Discussion	Cost (Present)
A	Replace in Place	36" 10,000 LF pipe d/D = 0.55 @ N=0.013	Provide excess future capacity and extend useful life of Folsom Blvd Trunk	$10,800,000
B	Replace in Place	30" 10,000 LF pipe d/D=0.85@N=0.012, d/D=0.95@N=0.013	Meet long term capacity and extend useful life of Folsom Blvd Trunk	$ 9,000,000
C	Parallel Relief Pipe	5,000 LF 18" pipe d/D = 1.0@N=0.012	Reduce surcharging along Folsom Blvd Trunkline to d/D=1 at SSMH 6121. No effect on useful life of Folsom Blvd Trunk.	$ 2,700,000

Water Works recommends that a Folsom Blvd 27" trunk replacement or mitigation project be inserted into a long-term CIP list, but with the project trigger linked to the results and analysis of other factors listed below:

1) Prison long term flow projections
2) Continual I&I analysis, effectiveness of I&I reduction programs, and updated hydraulic model simulations after the implementation of the short-term CIPs (re-survey of 27" trunk and PS3 flow meter installation)
3) New planned developments or conditional use permits resulting in any additional sewer flows in the Folsom West 27" sewershed.
4) Remaining useful life of the existing VCP 27" trunk line, along with any inspection data detailing deficiencies in the pipe.

7.1.3 Pump Station 2 Emergency Shutoff and Diversion to Pump Station 3

In an emergency, it would be possible to transfer all B01, B02, and B03 flows to Pump Station 3 and cease operations at Pump Station 2, as the listed capacity of Pump Station 3 with all three pumps in operation is 10.6 mgd. The modeled EXST 10yr-6hr PWWF from Basins 1,2 and 3 is 3.5 mgd (and up to 4.0 mgd for a UBO 25yr/6hr scenario). This would require physically blocking flows towards Pump Station 2 at the Greenback and Folsom Auburn intersection, something that could best be accomplished with two inflatable plugs (one for redundancy). Such an operation would require emergency traffic control measures and would potentially have a high impact on peak traffic due to its location on an arterial route. It is important to keep in mind, however, that there are some local sewers that discharge towards Pump Station 2 along River Road and Leidesdorff Road (modeled at 0.0310 mgd in the 10yr/6hr EXST PWWF scenario). Pump Station 2 has a listed storage capacity of 140,000 gallons, which is sufficient to handle the accrued upstream flow of 15,000 gallons over a 24-hour period, for example. This potential emergency procedure does not require a specific CIP or improvements.

7.1.4 Decrease Oak Avenue PS PWWF Inflow

Modeled PWWF to the Oak Avenue pump station is 7.3 MGD in a 25-yr/6-hr UBO event. This is higher than the capacity of the two regular pumps at maximum operation (~7.00 MGD). If the existing third redundant pump was not available, then 20,000 gal of detention may be required. The Oak Ave pump station currently has a total capacity of 54,000 gal (wetwell + 30,000 gal emergency storage) which is sufficient for such a scenario. An upstream diversion from the pump station sewershed could eliminate the need for emergency storage however, and provide increased redundancy if I&I rates or planned developments/CUPs increase.

The City requested that possible long-term diversion locations be identified to decrease Oak Ave PS inflows and bypass flows directly towards the FE3 trunk. Based on the results of this research, however, there is no practical way to divert flow from B08 to B16 (the FE3 sewershed). A high ridge in the local topography separates B08 from B16 that may not be feasibly crossed with typical construction methodology (i.e., very deep conditions for gravity pipe). There are however two locations where flow could be diverted via overflow lines from Oak Ave PS to B10 (Folsom East 33”), and B08 to B17 (Folsom East 33”). The diversion options are listed in Table 26 below and displayed graphically in Figure 30, in addition to Appendix D.3 and D.4.

Table 26: Long Term CIPs: Oak Ave PS Diversion

Oak Ave PS Diversion Options			
Option	Description	Discussion	Cost
A	8” 1300LF pipe	Oak Ave PS to B10 along Oak Ave. Max 1.00 mgd before triggering downstream upgrades. Depending on the upstream connection type (i.e., at invert, springline, or crown) the pipe may always be utilized and effectively decrease the pump station usage during regular operations and potentially increase the useful lifespan of the pumps.	$500,000
B	8” 2000 LF pipe	B08 to B17 along Silberhorn Dr. Negligible benefit due to the need for extensive downstream upgrades before diverting any flow greater than 0.20 mgd.	$600,000

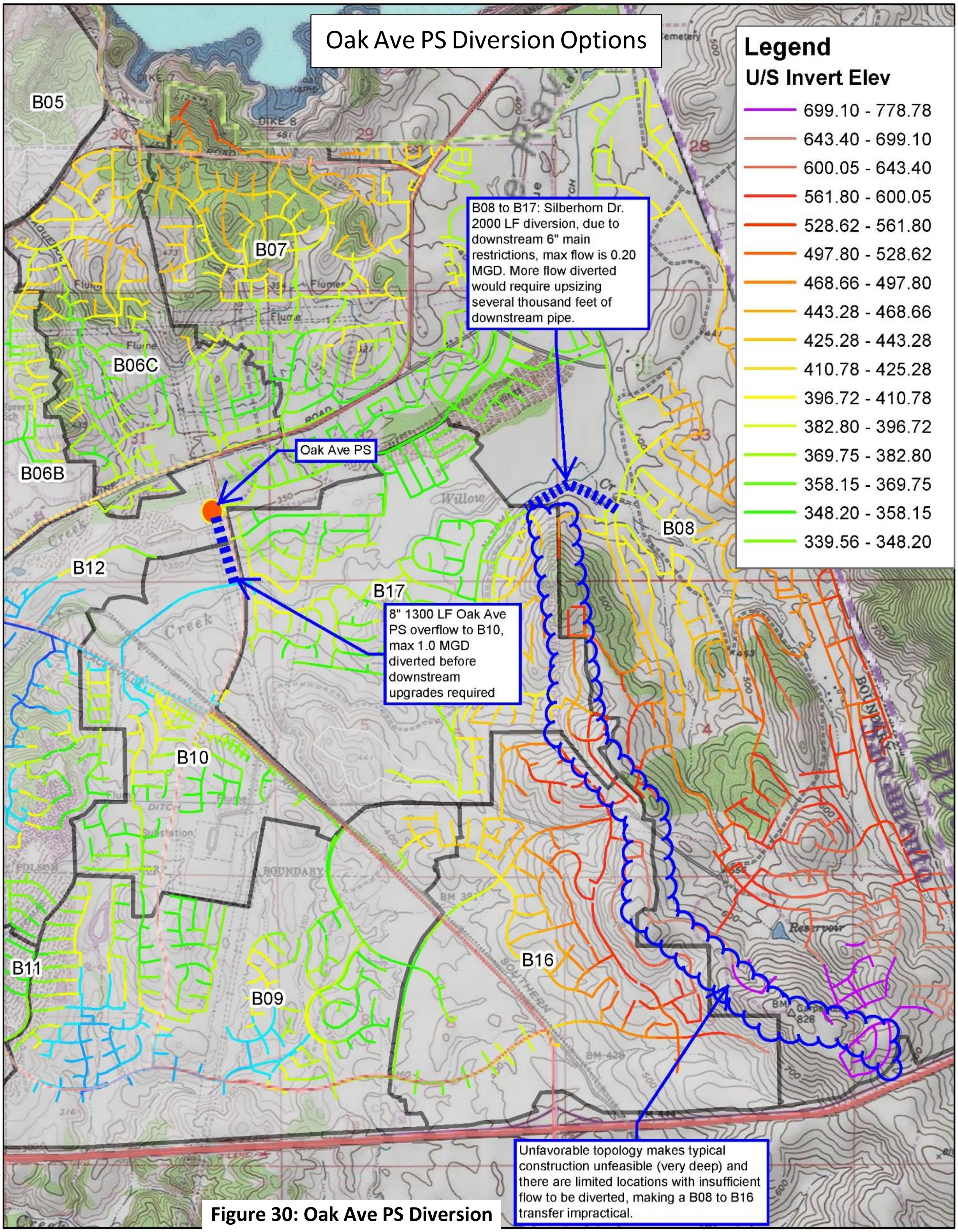
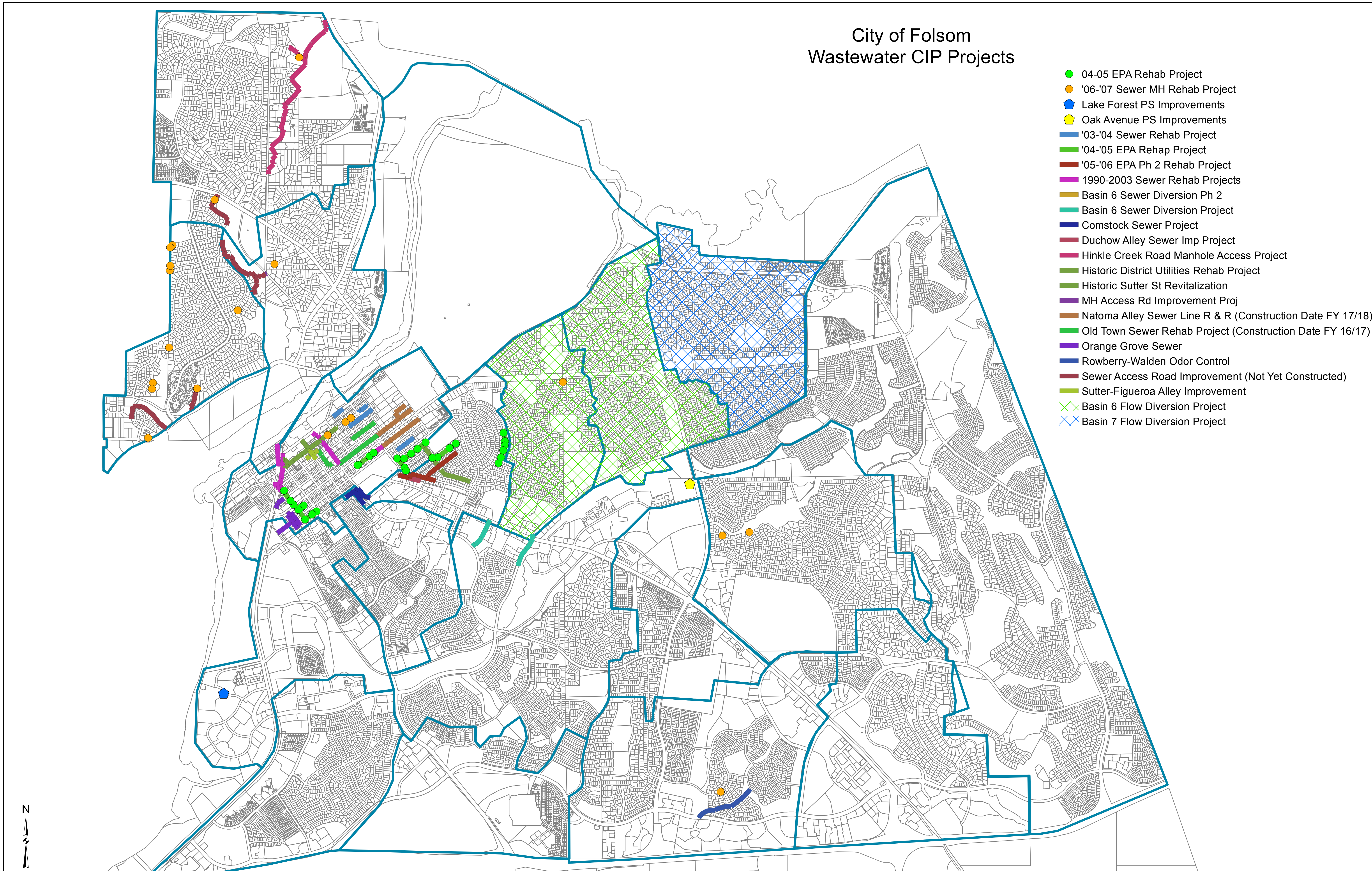


Figure 30: Oak Ave PS Diversion

8 APPENDICES

Appendix A.1 Folsom Wastewater CIP Map


City of Folsom
Wastewater CIP Projects
04-05 EPA Rehab Project
'06-'07 Sewer MH Rehab Project
Lake Forest PS Improvements
Oak Avenue PS Improvements
'03-'04 Sewer Rehab Project
'04-'05 EPA Rehap Project
'05-'06 EPA Ph 2 Rehab Project
1990-2003 Sewer Rehab Projects
Basin 6 Sewer Diversion Ph 2
Basin 6 Sewer Diversion Project
Comstock Sewer Project
Duchow Alley Sewer Imp Project
Hinkle Creek Road Manhole Access Project
Historic District Utilities Rehab Project
Historic Sutter St Revitalization
MH Access Rd Improvement Proj
Natoma Alley Sewer Line R & R (Construction Date FY 17/18)
Old Town Sewer Rehab Project (Construction Date FY 16/17)
Orange Grove Sewer
Rowberry-Walden Odor Control
Sewer Access Road Improvement (Not Yet Constructed)
Sutter-Figueroa Alley Improvement
Basin 6 Flow Diversion Project
Basin 7 Flow Diversion Project
N

Appendix A.2 Young Wo Pump Station TM

J. CROWLEY GROUP, INC.

PO Box 1593
Carmichael, CA 95609

Technical Memorandum 010-009

TO: Todd Eising, City of Folsom

FROM: Jim Crowley, J. Crowley Group

DATE: November 29, 2012

SUBJECT: YOUNG WO PUMPING STATION CAPACITY ANALYSIS

The Young Wo wastewater pumping station (PS) serves Lake Natoma Shores, an area bounded by Lake Natoma and Folsom Boulevard (see attached Figure 1. The service area includes single-family residential units, a Veterans of Foreign Wars (VFW) lodge, and a portion of the City's corporation yard. This technical memorandum investigates the Lake Natoma Shores service area's projected wastewater flows and the system capacity. The results of the analysis validate that the existing system capacity is sufficient to handle the reasonable worst-case flow scenario. The system's actual flows have been recorded to be significantly less than the worst-case scenario, resulting in system capacity that is significantly greater than the worst-case scenario. Factoring in the additional emergency storage, the system's capacity is considered sufficient for the reasonably projected flows.

System Description

A portion of the City's Corporation Yard wastewater system flows to the Young Wo PS. That portion of the system includes five small pumping stations (CY1 through CY5). Pump station CY3 collects the flows from pump station CY1 and pump station CY2, and pump station CY5 collects the flows from pump station CY4. Pump stations CY5 and CY3 pump the wastewater from the City's corporation yard into the gravity system that feeds the Young Wo PS. The Young Wo PS pumps wastewater through a 4-inch diameter force main that transitions to a gravity system at Forrest Street, near Fong Street, which then discharges into the 27-inch line in Folsom Boulevard. See the attached Figure 1 for a map of the wastewater system.

System Capacity

Data for the Corporation Yard pump stations indicates a combined instantaneous flow capacity of approximately 146 gpm; when pumping stations CY3 and CY5 pump simultaneously. However, the pumps run for less than 30 seconds at these flow rates before shutting off at low wetwell levels. The Corporation Yard pump stations only serve bathrooms and showers, and therefore projected flows are much less than the combined pumping capacity of 146 gpm, as presented below in Table 2 – City Corporation Yard Flow Projections..

The Young Wo PS contains two submersible 5 HP pumps rated for 110 gpm at 55 feet total dynamic head. Pump capacity is based on the system head curve and friction loss in the 4-inch force main. Assuming a conservative friction factor (higher friction loss), the conservative pump capacity is estimated at 100 gpm. Industry standards list a maximum velocity of 7-10 feet per second for a force main. The existing 4-inch force main is well below these levels at 2.5-3.7 feet per second for pump discharge of 110 gpm and 150 gpm, respectively. The wet well has a total volume of 4,887 gallons. The operating volume (pump start to high level alarm elevation) is 940 gallons.

The Young Wo PS force main discharges flow into the 6-inch sewer on Forest Street and Fong Street, which then becomes an 8-inch sewer from Fong Street to the connection to the 27-inch sewer in Folsom Boulevard. Pipeline capacities based on the City of Folsom Design and Procedures Manual and Improvement Standards (May 22, 2003) are presented in Table 1.

Table 1. Gravity Sewer Pipeline Capacities

Reach	Capacity
Forest Street 6-inch	160 gpm
Fong 6-inch	160 gpm
Fong-Folsom 8-inch	330 gpm

Flow Projections

The City of Folsom Design and Procedures Manual and Improvement Standards (May 22, 2003) is used to develop the wastewater flow projections. Additional assumptions as described here are made for the City Corporation Yard and the VFW Lodge. The City Corporation Yard includes five small pumping stations. Flow from three pumping stations is delivered to pumping stations CY5 and CY3. Both these stations pump into the same force main that discharges into the Young Wo PS collection system. The only facilities connected to the Corporation Yard stations are showers, toilets, and sinks located in the trailer offices. There are a total of 2 showers, 10 toilets, and 15 sinks. Flow generation assumes 1.6 gallons per flush, 2.0 gpm showerheads, and 2.0 gpm sink faucets as summarized in Table 2. The total projected daily flow from the Corp Yard is 2,420 gpd.

Table 2. City Corporation Yard Flow Projection

Element	Units	Unit Flow	Flow
Shower	1 hour per day	2.0 gpm	60 gpd
Toilet	600 flushes per day	1.6 gpf	960 gpd
Sink Faucet	700 min. per day	2.0 gpm	1,400 gpd
Total:			**2,420 gpd**

The VFW Lodge current occupancy rating is 74 persons for dining and 150 total persons for gathering. The Lodge is approximately 2,000 square feet and maintains two restrooms. City Standards call for 0.3 equivalent ESD (1 ESD = 400 gpd) per 1,000 square feet for halls and lodges. Average daily flow projection is therefore 240 gpd. However, VFW staff indicates they can hold events with up to 150 persons, which would likely generate a larger peak flow than 0.3 ESD/1,000 square feet. For this analysis, a peak flow is estimated based on the City's restaurant unit flow (2.0 ESD/1,000 square feet) and an estimate of toilet/sink uses as shown in Table 3.

Table 3. VFW Lodge Flow Projection

Element	Units	Unit Flow	Flow
Restaurant Area	2,000 square feet	800 gpd/1,000 square feet	1,600 gpd
Toilet	200 flushes per event	1.6 gpf	320 gpd
Sink Faucet	300 min. per event	2.0 gpm	600 gpd
Total:			**2,520 gpd**

Cumulative Flow projections to the Young Wo PS are summarized in Table 4.

Table 4. Young Wo PS Flow Projections

Element	Units	Unit Flow	Flow
Residential	65	400 gpd	26,000 gpd
VFW Lodge – see Table 2	--	--	2,520 gpd
City Corporation Yard	--	--	2,420 gpd
Subtotal Dry Weather Flow:			30,940 gpd
Wet Weather Peaking Flow	Peaking factor	3.8	117,572 gpd
Groundwater Infiltration – for total gravity system tributary to Wo PS			
6-inch collection system length	5,200 ft.	50 gal/day/in-diam/mile	295 gpd
4-inch collection system length	2560 ft.	50 gal/day/in-diam/mile	97 gpd
2-inch collection system length	1,400 ft.	50 gal/day/in-diam/mile	26 gpd
Subtotal Groundwater Infiltration:			418 gpd
Total Design Flow:			117,990 gpd 82 gpm

The Young Wo PS force main discharges into a gravity system on Forest Street as shown in the attached Figure 1. Table 5 projects the additional flow from houses connected to the gravity system to the discharge point at the 27-inch interceptor in Folsom Boulevard. For conservative purposes, flow is assumed to enter the sewer at the upstream portion of each respective reach.

Table 5. Gravity System Flow Projections

Element	Units	Unit Flow	Flow
Forest Street 6-inch			
Residential	8	400 gpd	3,200 gpd
Wet Weather Peaking Flow	Peaking factor	4.0	12,800 gpd
Groundwater Infiltration	367 LF 6-inch	50 gal/day/in-diam/mile	21 gpd
Total Reach Flow:			12,821 gpd 9 gpm
Fong St. 6-inch			
Residential	4	400 gpd	1,600 gpd
Wet Weather Peaking Flow	Peaking factor	4.0	6,400 gpd
Groundwater Infiltration	260 LF 6-inch	50 gal/day/in-diam/mile	15 gpd
Total Reach Flow:			6,415 gpd 4.4 gpm
Fong St to Folsom Blvd. 8-inch			
Residential	36	400 gpd	14,400 gpd
Wet Weather Peaking Flow	Peaking factor	3.9	56,160 gpd
Groundwater Infiltration – for total gravity system tributary to Wo PS	1,200 6-inch	50 gal/day/in-diam/mile	68 gpd
Total Reach Flow:			56,228 gpd 39 gpm

Capacity Summary

This analysis utilized a conservative approach in estimating all factors of the analysis. The conservative approach provides the highest reasonably expected flows and the lowest reasonably expected system capacities within the design guidelines. The analysis presents a reasonably expected worst-case scenario to demonstrate the system's full capacity. Operation's data from the last two years, and other City sewer studies, indicate that actual flows are much less and system capacities are higher than assumed in the analysis. Specific assumptions and actual data are listed below.

- The estimated peak wet weather flow is 117,990 gpd. Actual daily peak wet weather flow over the last two winters (2010/11 and 2011/12) was only 21,000 gpd.
- Data from the 2010/11 and 2011/12 winter seasons, when flow is the highest, indicates the pumps only run a combined 1.5 hours per day. There are approximately 15 pump starts per day, with each start lasting about 7 minutes.
- The pump capacity analysis assuming a higher friction loss coefficient, which results in capacity of

100 gpm. Actual flow meter records indicate an average current capacity of approximately 150 gpm.

- Flow projections assume high wet weather flow peaking factors of 3.7-4.0. The City's 2008 Sewer Capacity Study indicates an actual lower peaking factor of 3.0 for the Young Wo PS area.
- Flow projections assume maximum use of Corporation Yard bathrooms and shower facilities coinciding with the largest allowable event at the VFW Lodge, and maximum flow from every residential customer, all during a large rainstorm.
- The analysis assumes one of the two pumps has failed and is not available.
- None of the emergency storage in the Young Wo PS wetwell is utilized in the analysis.

Assuming these conservative values, the projected flows are compared to system capacities in Tables 6 and 7. Table 6 compares the actual operational data to design value for the Young Wo PS inflow and pumps. Table 7 compares the design capacities to the design values for the pumping station and downstream gravity system. As indicated in the tables, all elements of the system contain excess capacity under the reasonable worst-case scenario projected conditions.

Table 6. Young Wo Pumping Station Design Versus Actual

Element	Actual Historic Value	Worst-Case Design Flows	Excess Capacity
Maximum Daily Flow	21,000 gpd (15 gpm)	117,990 gpd (82 gpm)	Yes
Pump Output Capacity	150 gpm	100 gpm	Yes

Table 7. Capacity Comparison

Element	Capacity	Worst-Case Design Flows	Excess Capacity
Young Wo PS	100 gpm	82 gpm	Yes
Forrest St 6-inch sewer	160 gpm	109 gpm (100 gpm+9 gpm)	Yes
Fong St 6-inch sewer	160 gpm	114 gpm (109 gpm + 4.4 gpm)	Yes
Fong St./Folsom Blvd. 8-inch sewer	330 gpm	153 gpm (114 gpm + 39 gpm)	Yes

The City's emergency response procedures and emergency storage in the Young Wo PS provide an additional layer of protection and system capacity. The pump station is fully alarmed for mechanical failures and high water level circumstances, with alarms powered by a backup emergency power generator should power fail. There are two high water level alarms. The first alarm triggers the auto dialer to notify the on-call emergency response staff. The second alarm, at 0.5 feet higher than the first alarm, signals through the SCADA, which also notifies the on-call emergency response staff. The City's emergency operating procedures maintain a site response in less than 30 minutes after an alarm. Once onsite, the emergency by-pass pumping can be set up and mitigate any issues.

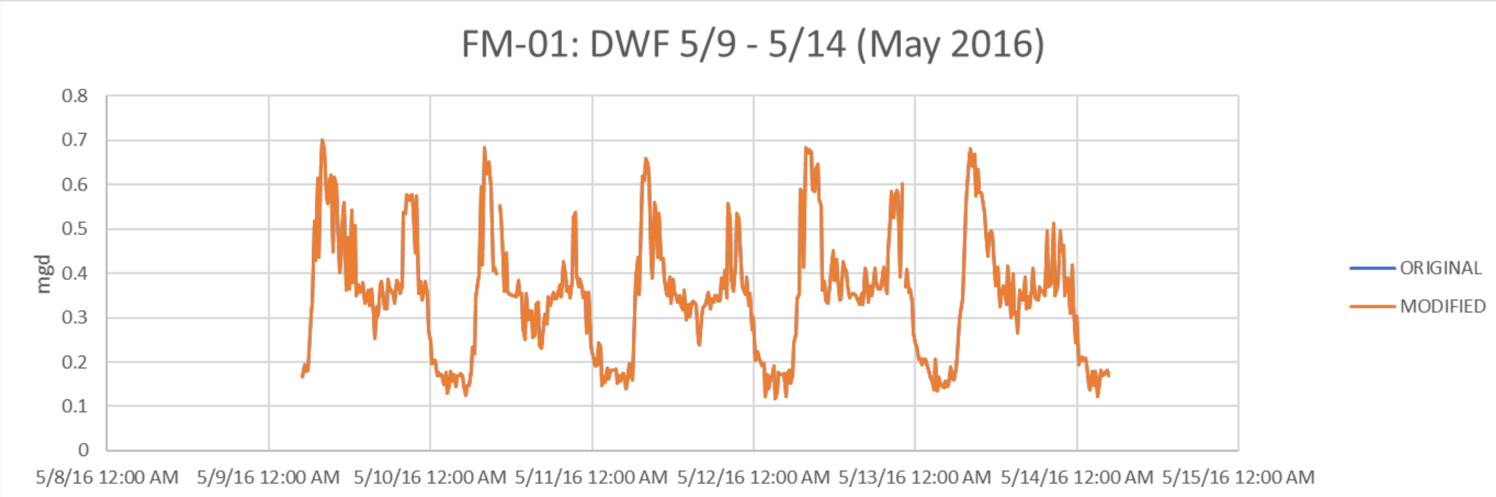
The wetwell has a total storage volume of approximately 4,887 gallons. The emergency storage is considered to be the volume above the dialer high water level alarm sensor (a total height of 8 feet), for a volume of approximately 3,000 gallons. Assuming the worst-case flow rate of 82 gpm into the PS, this represents approximately 36 minutes of storage. When using the highest daily flow rate from the last two years of data (21,000 gpd), the emergency storage represents 200 minutes (3.3 hours) of storage.

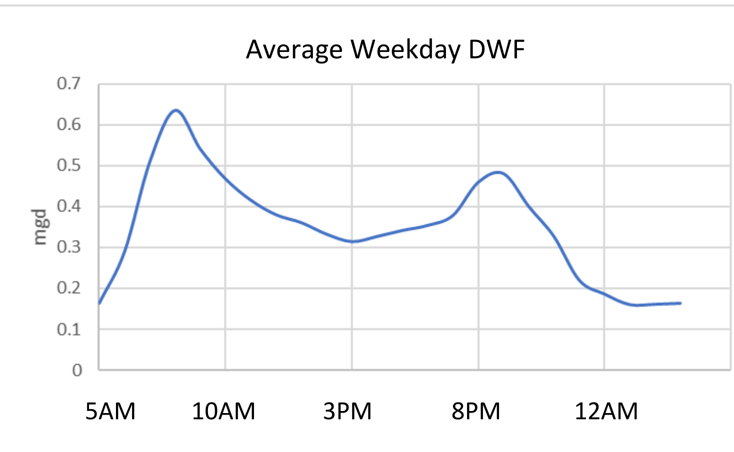
The analysis validates that the existing system capacity is sufficient to handle the reasonable worst-case flow scenario. The system's actual flows from operations data are significantly less than the worst-case scenario, resulting in system capacity that is significantly greater than the worst-case scenario. Factoring in the additional emergency storage, the system's capacity is considered sufficient for the reasonably projected flows.

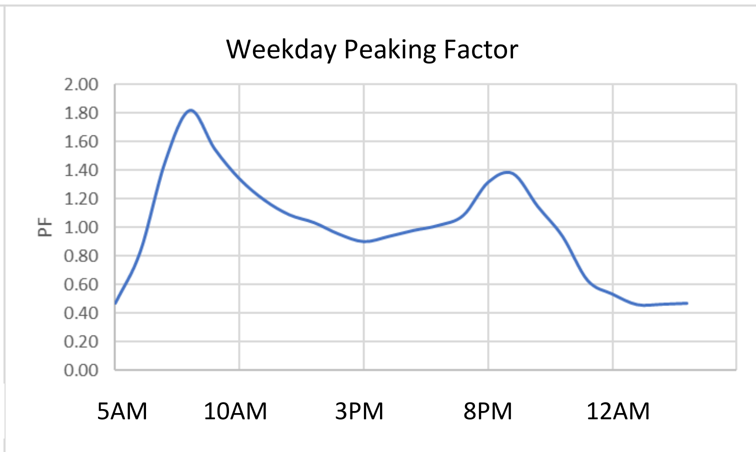

Sewer Structure
Standard
Flushing Branch
End of line
Tie-in
ARV
Pump Station
Grease Interceptor
Sewer Pipe
Gravity Sewer Main
Force Main
ER BIKE TRL
LEIDESDORFF ST
UNNAMED RD
FORREST ST
SUTTER ST
FONG ST
FONG CT
JOE MURER CT
FORREST ST FONG ST ALY
YOUNG WO CIR
YOUNG WO CIR YOUNG WO CIR ALY
AMERICAN RIVER BIKE TRL
MORMON ST
N

Appendix A.3 DWF May 2016 FM Data

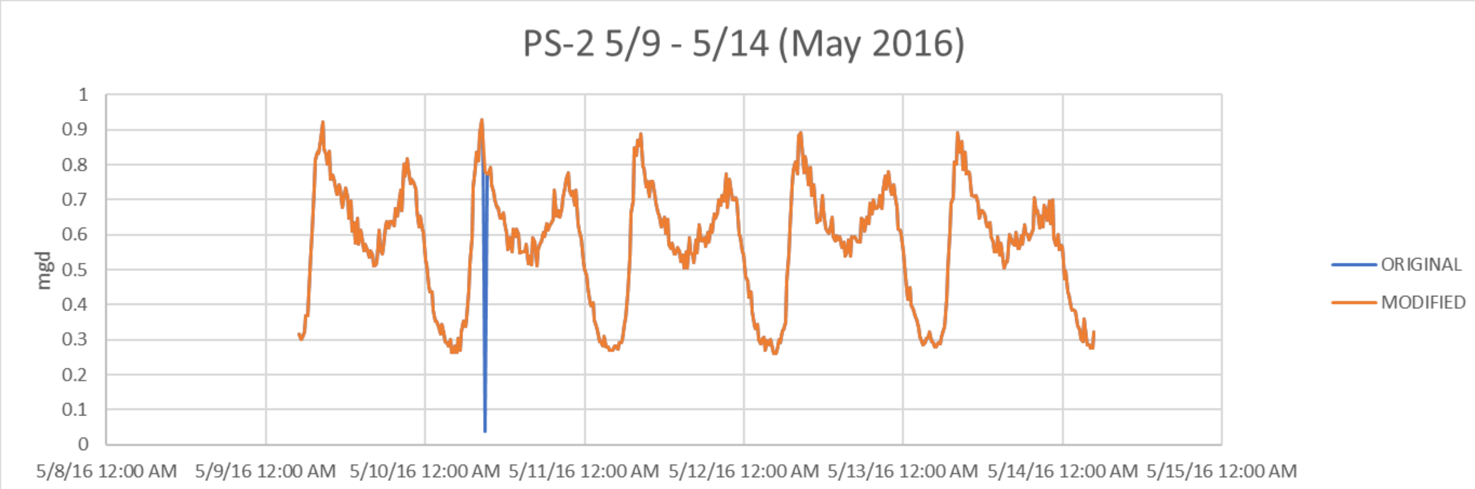
Meter Name	**FM-01**
Representative Basin	**B01**
Location	**Old Oak Ave / Baldwin Dam Rd**
ADWF (mgd)	**0.35**

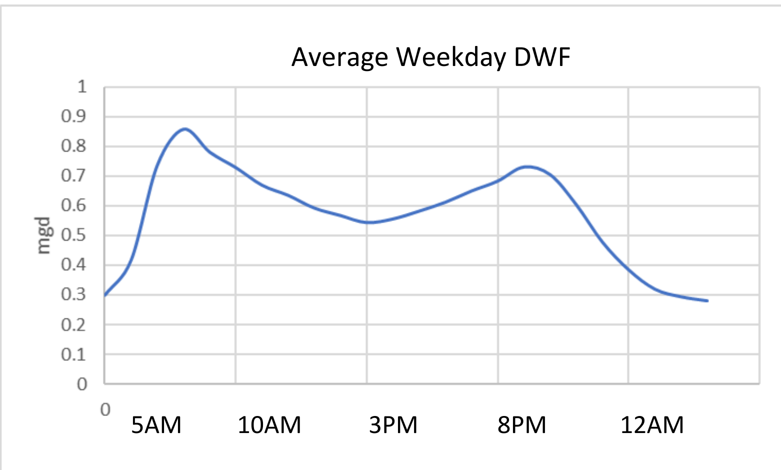


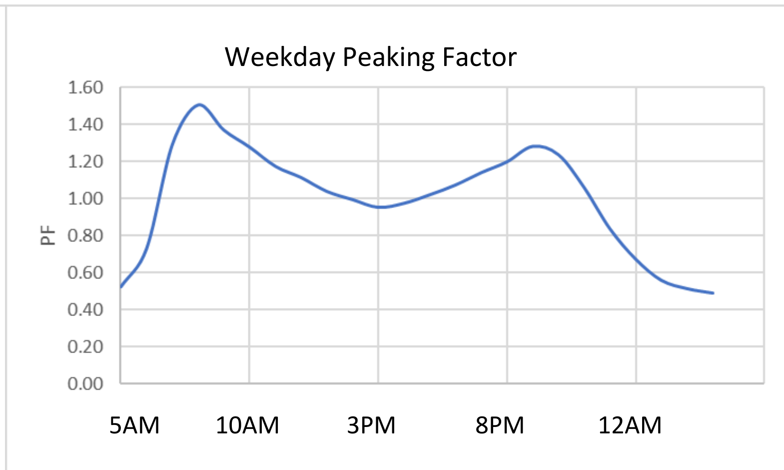




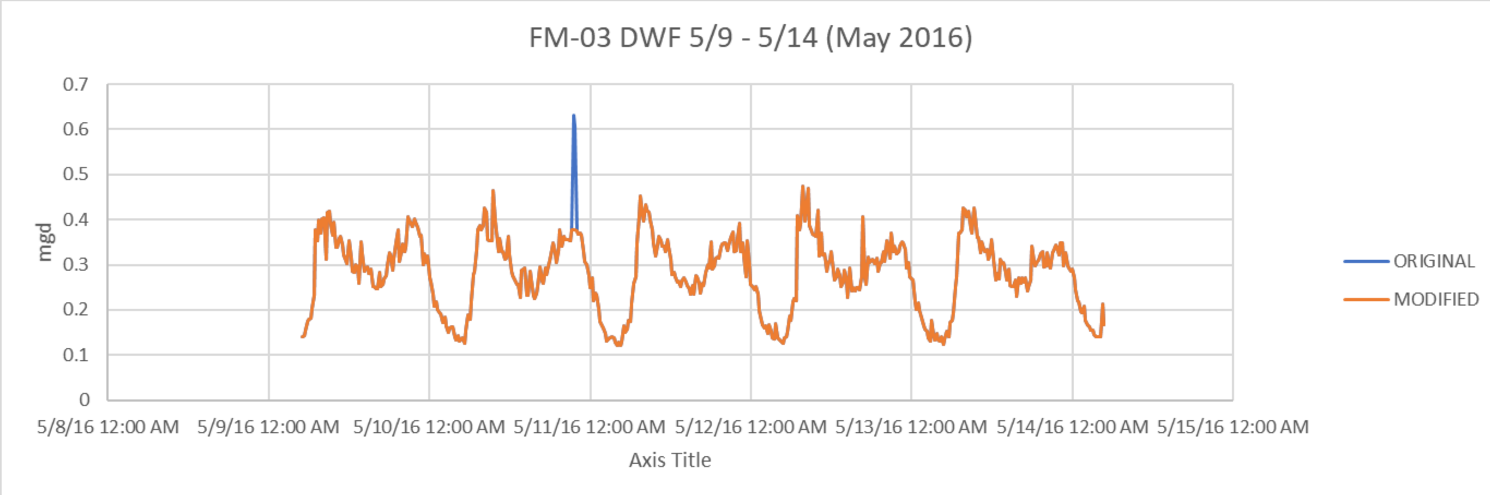
Meter Name	**PS-2**
Representative Basin	**B02**
Location	**Pump Station 2**
ADWF (mgd)	**0.57**

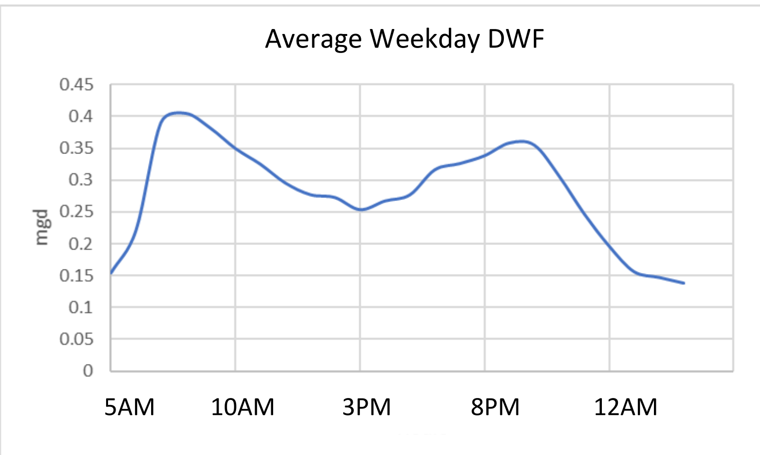


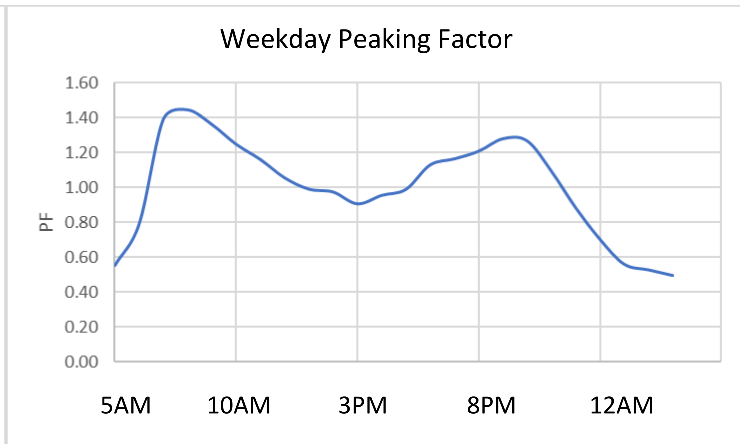




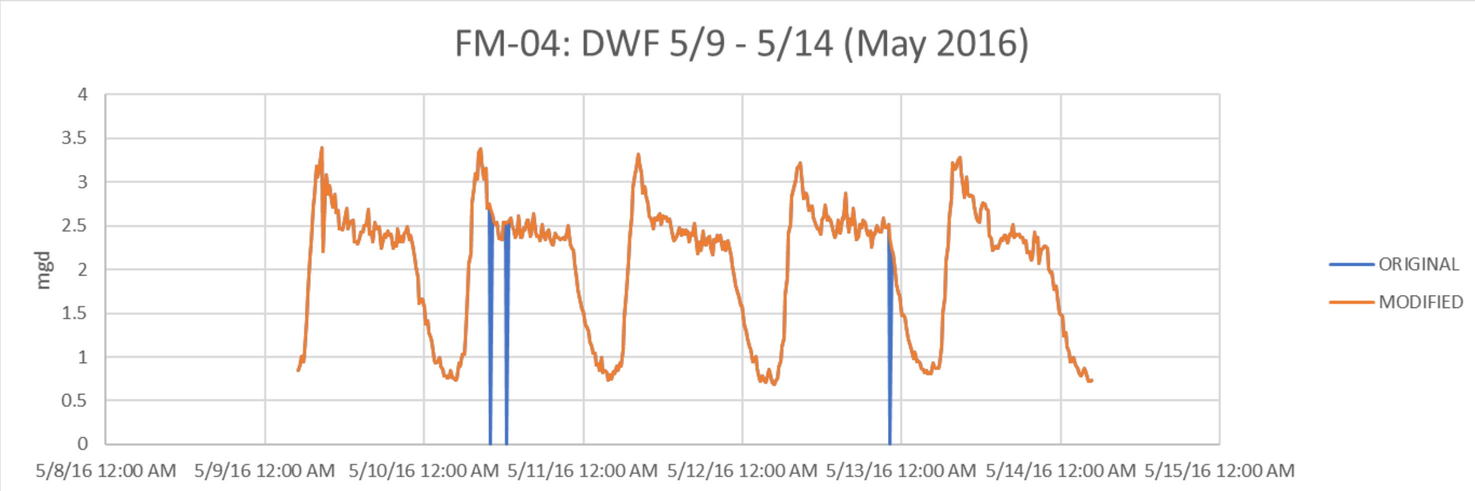
Meter Name	**FM-03**
Representative Basin	**B03**
Location	**Greenback Ln**
ADWF (mgd)	**0.28**

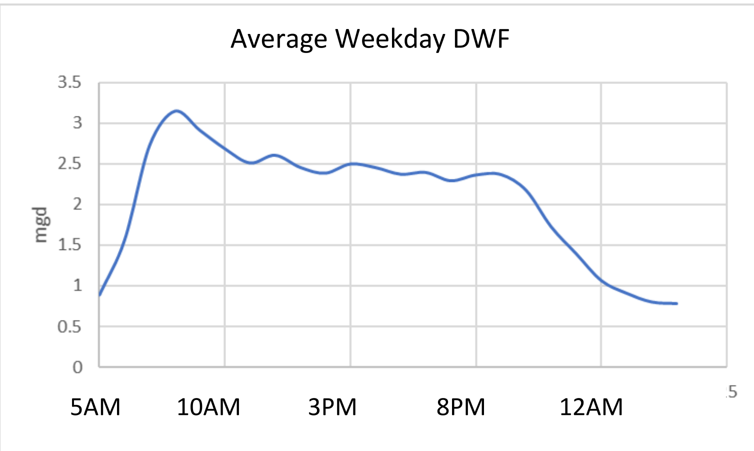


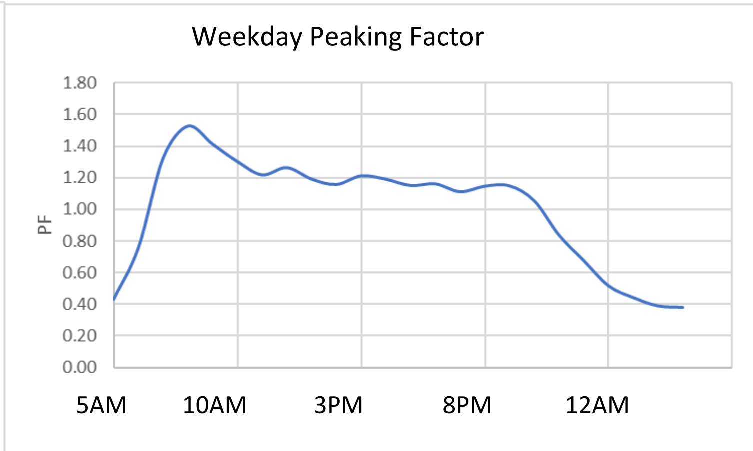




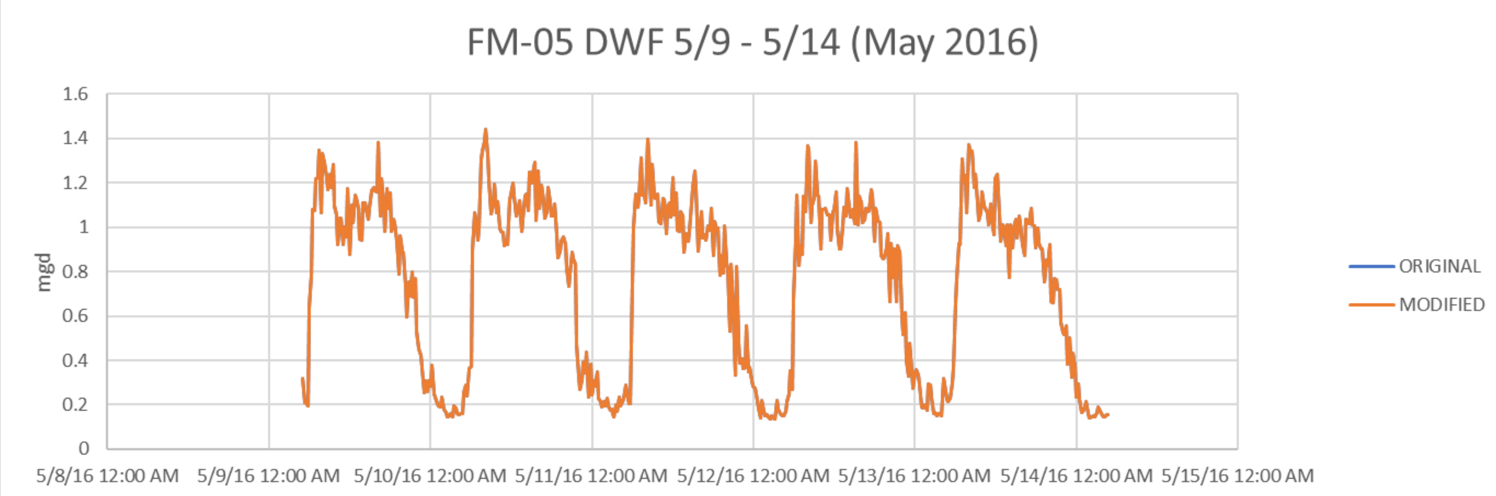
Meter Name	**FM-04**
Representative Basin	**B04**
Location	**Folsom Blvd / Natoma St**
ADWF (mgd)	**2.06**

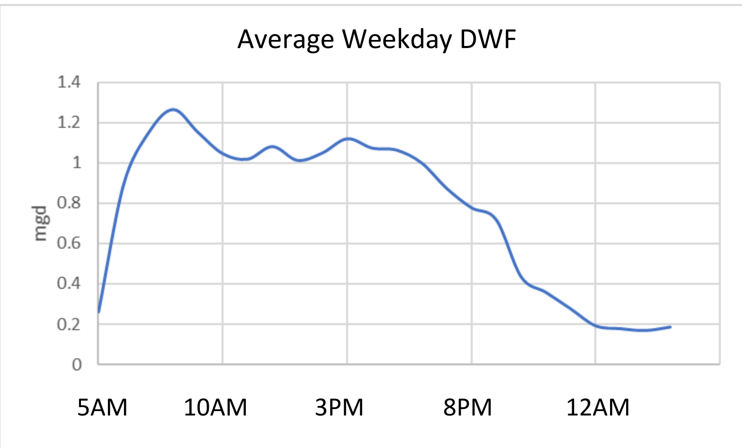


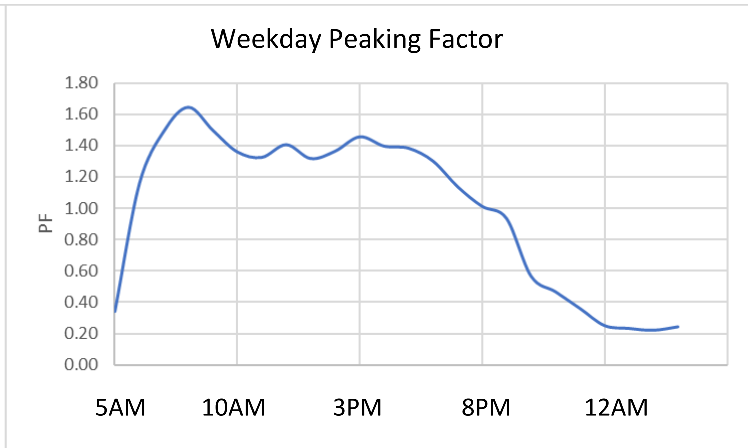




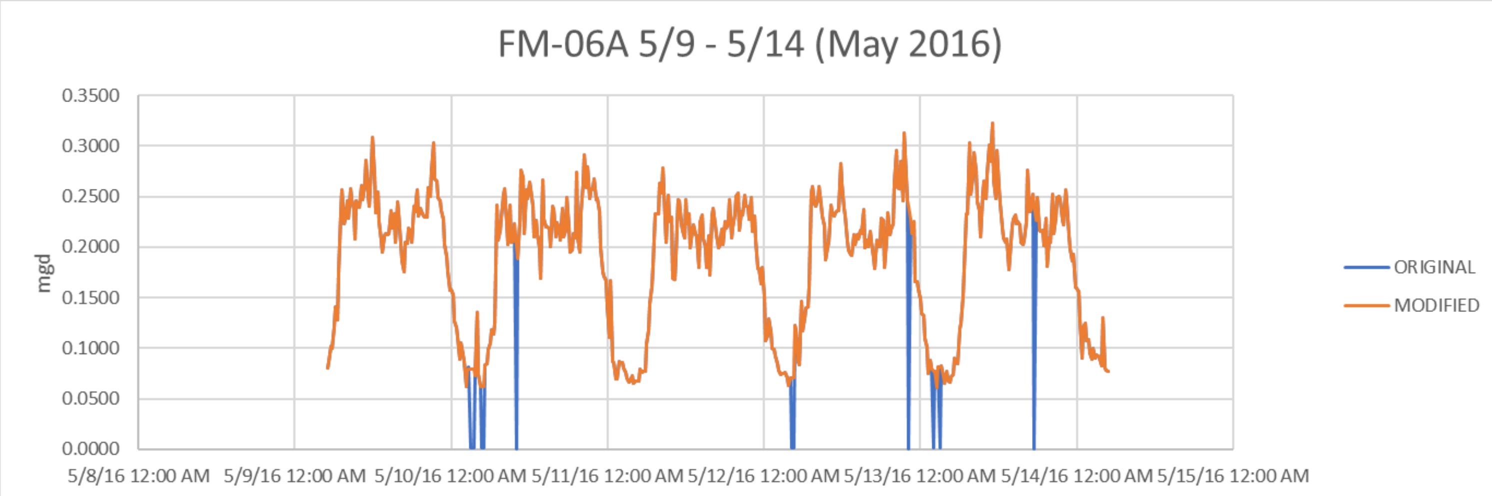
Meter Name	**FM-05**
Representative Basin	**B05**
Location	**Folsom State Prison Meter**
ADWF (mgd)	**0.76**

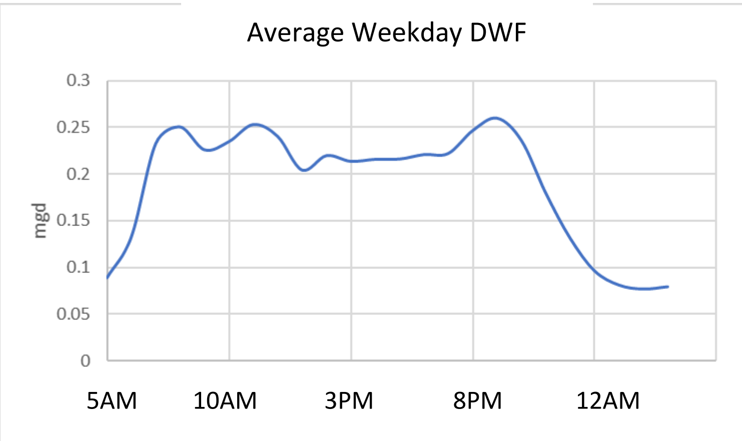


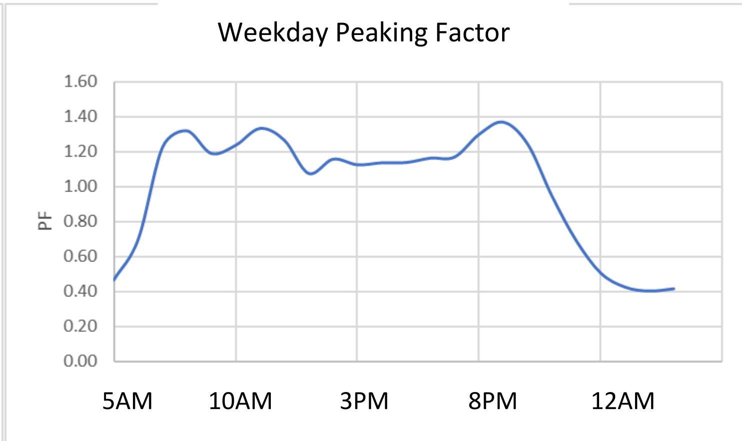




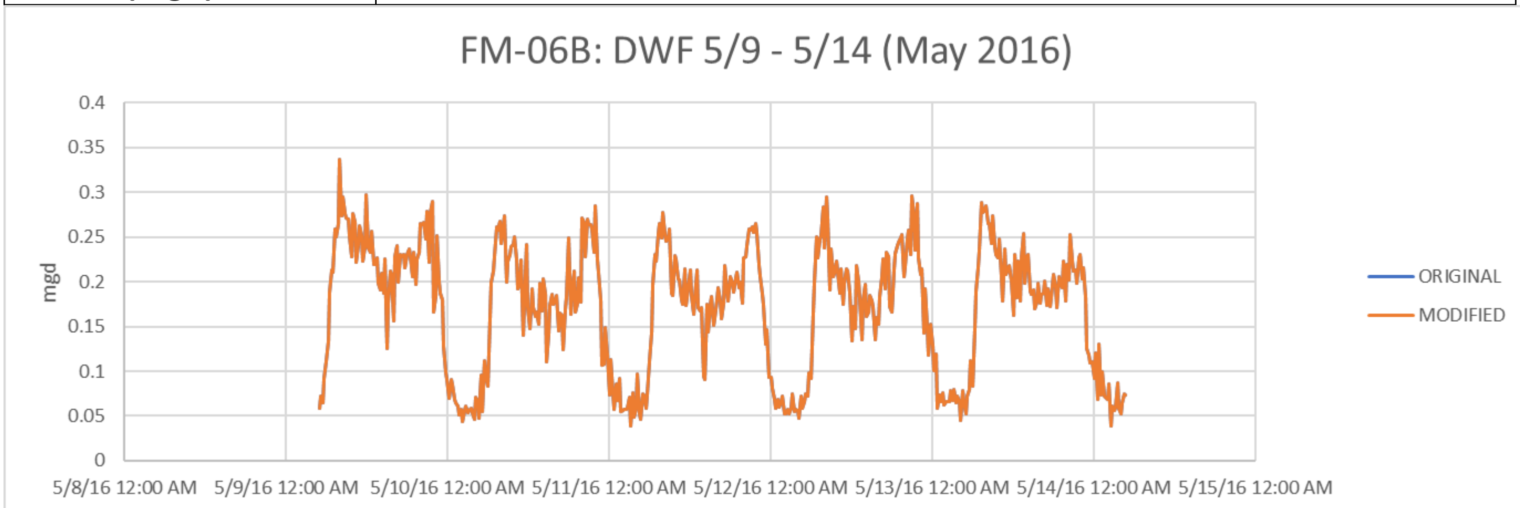
Meter Name	FM-06A
Representative Basin	B06A
Location	Wool/Mormon St
ADWF (mgd)	0.19

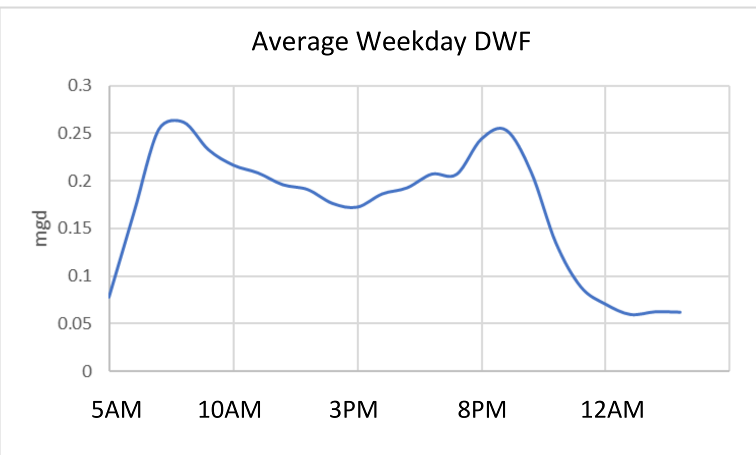


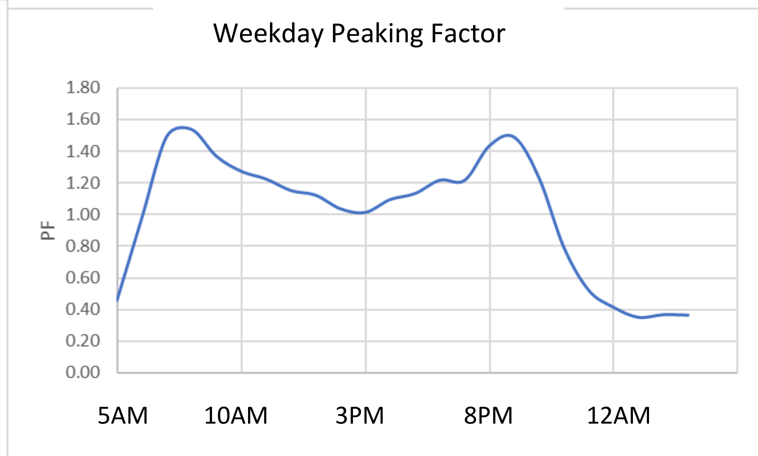




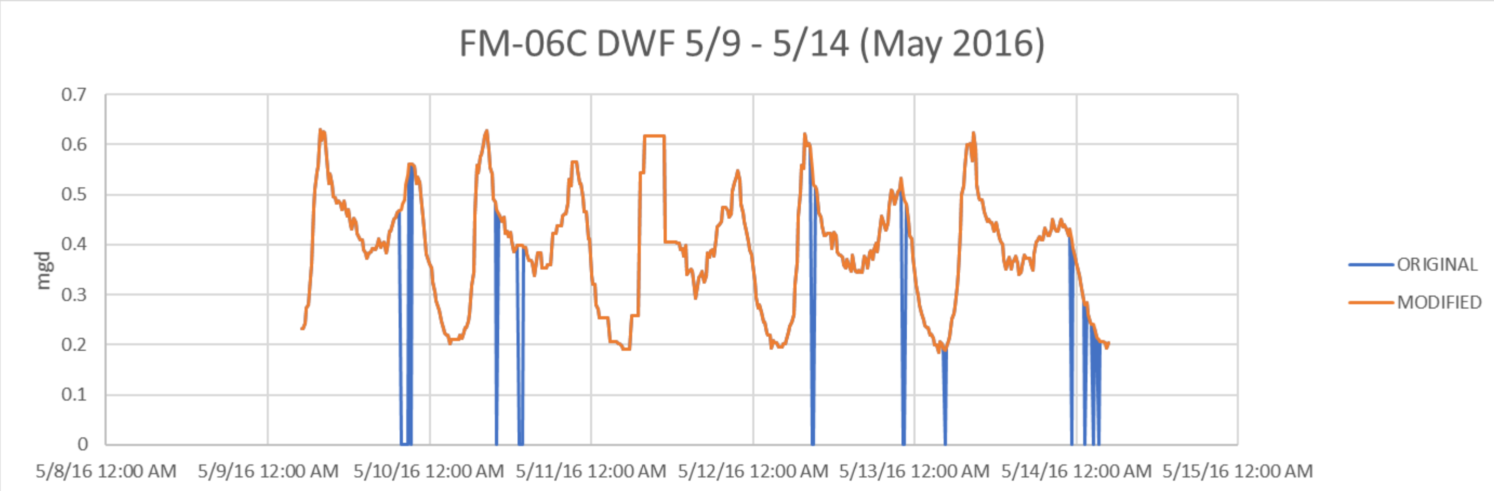
Meter Name	FM-06B
Representative Basin	B06B
Location	Orchard Dr
ADWF (mgd)	0.17

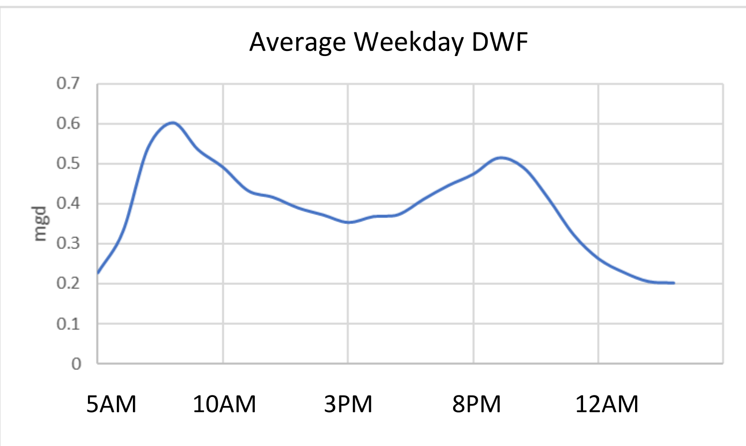


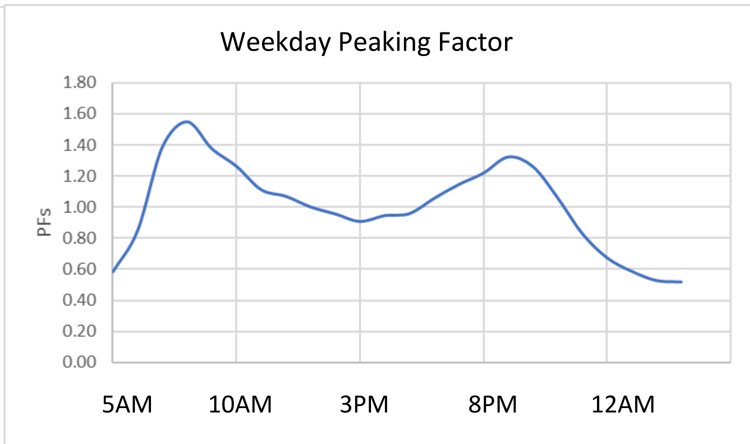




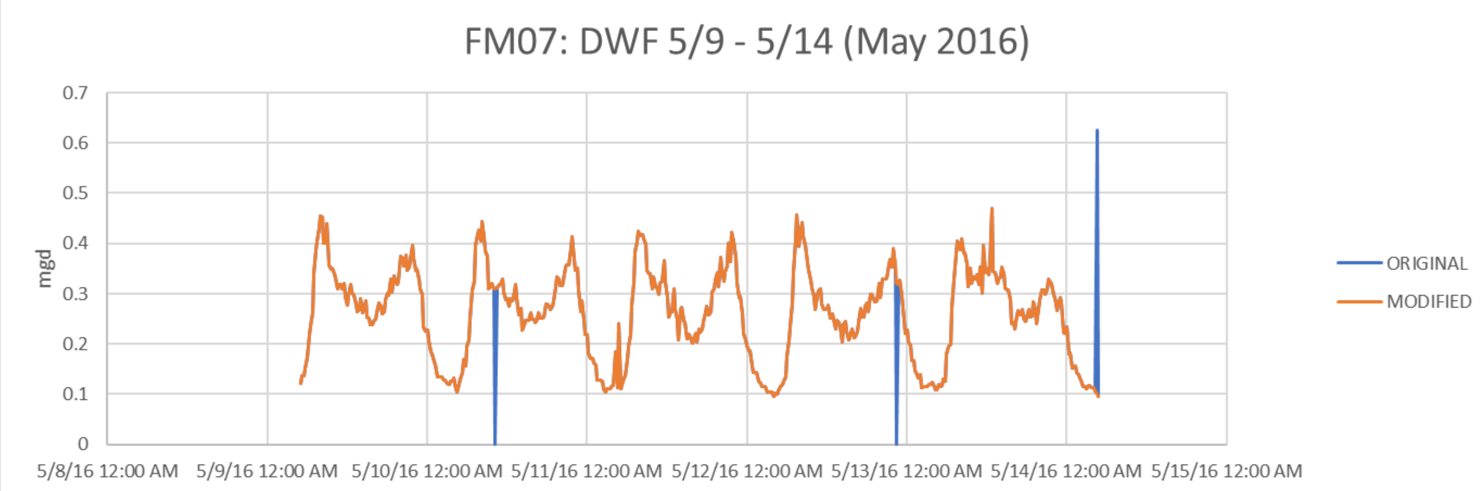
Meter Name	FM-06C
Representative Basin	B06C
Location	Blue Ravine Middle School
ADWF (mgd)	0.39

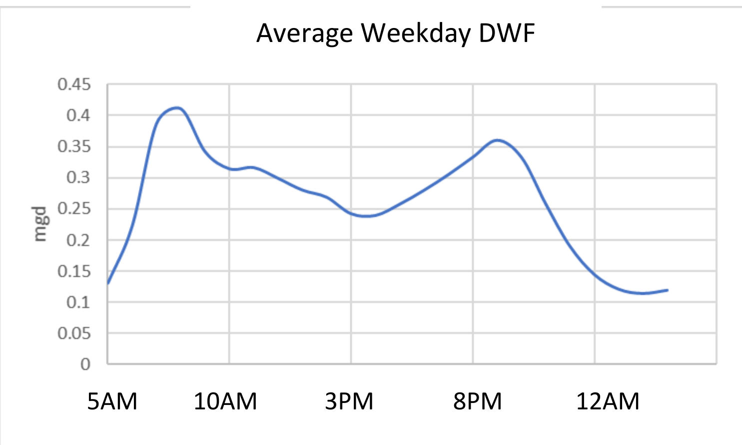


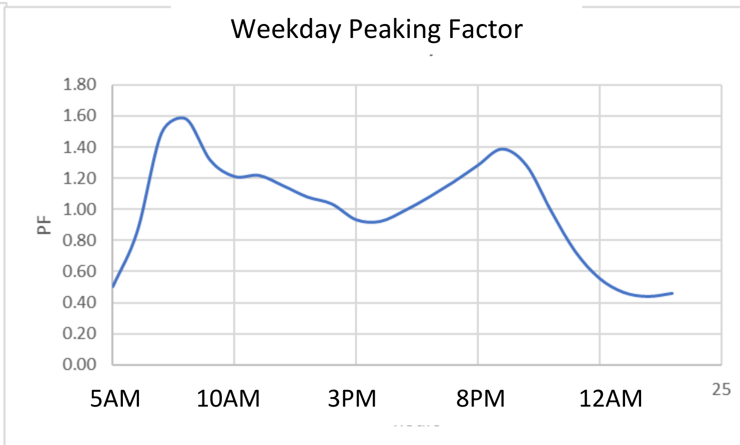




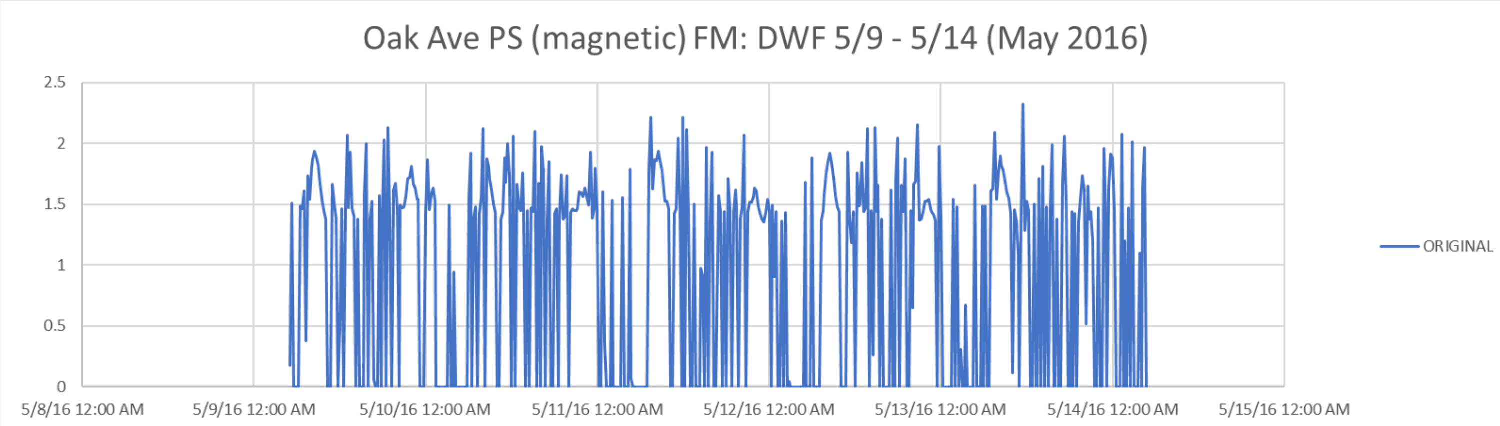
Meter Name	**FM-07**
Representative Basin	**B07**
Location	**Blue Ravine Oak Ave**
ADWF (mgd)	**0.26**

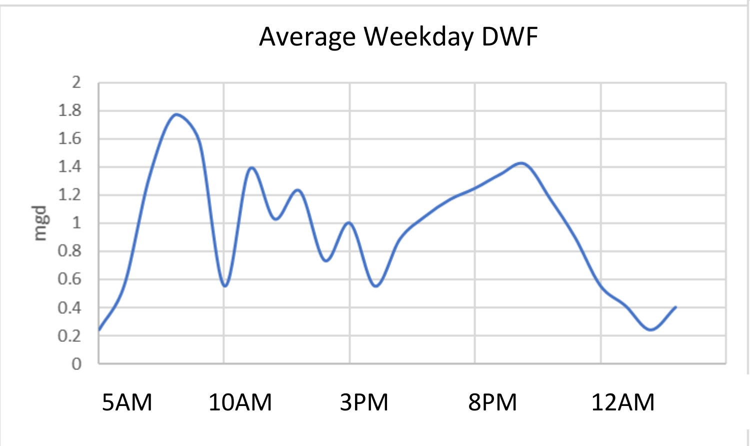


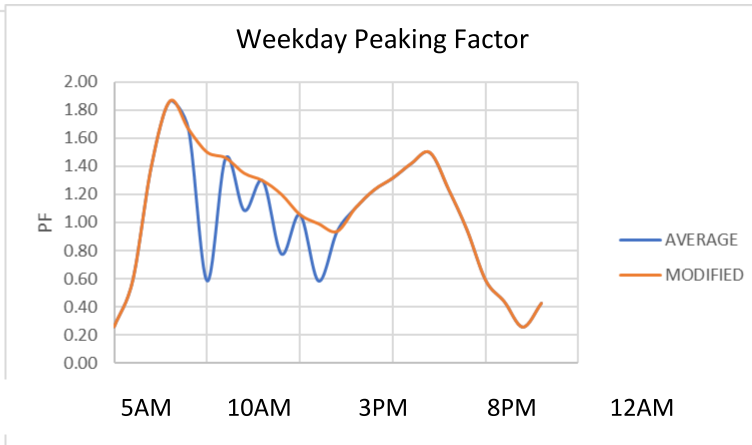




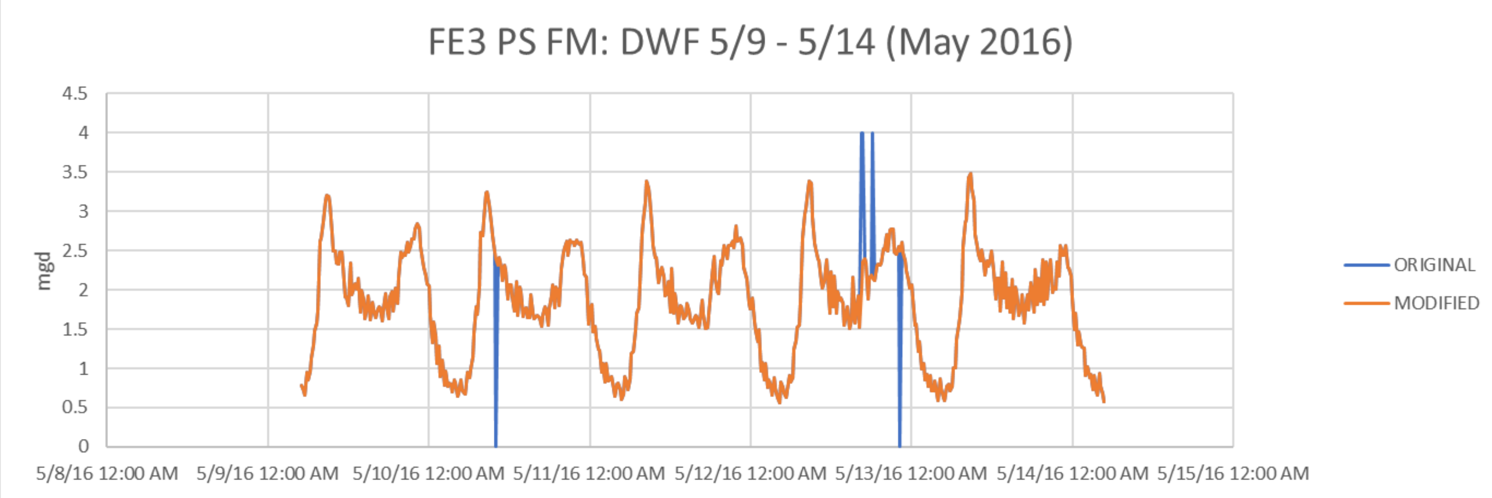
Meter Name	FM-08
Representative Basin	B08
Location	Oak Ave PS
ADWF (mgd)	0.95

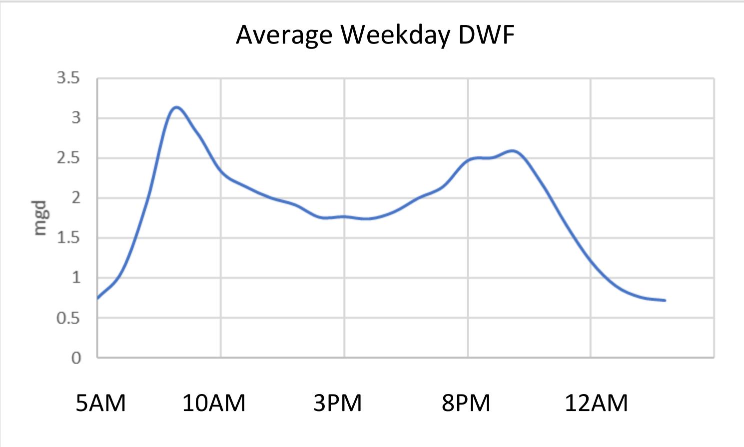


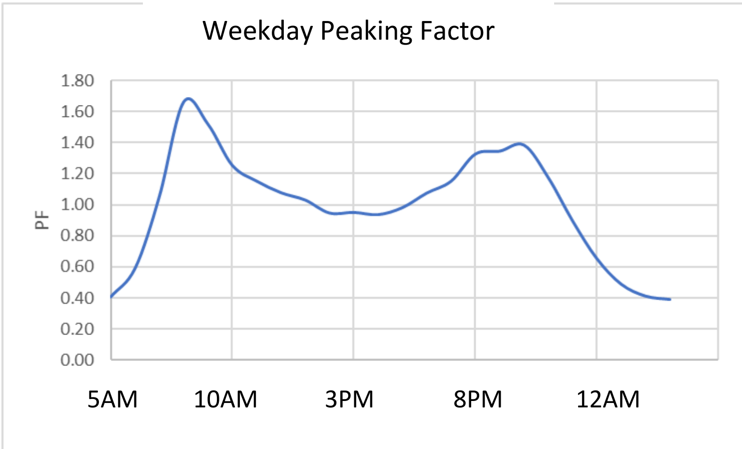




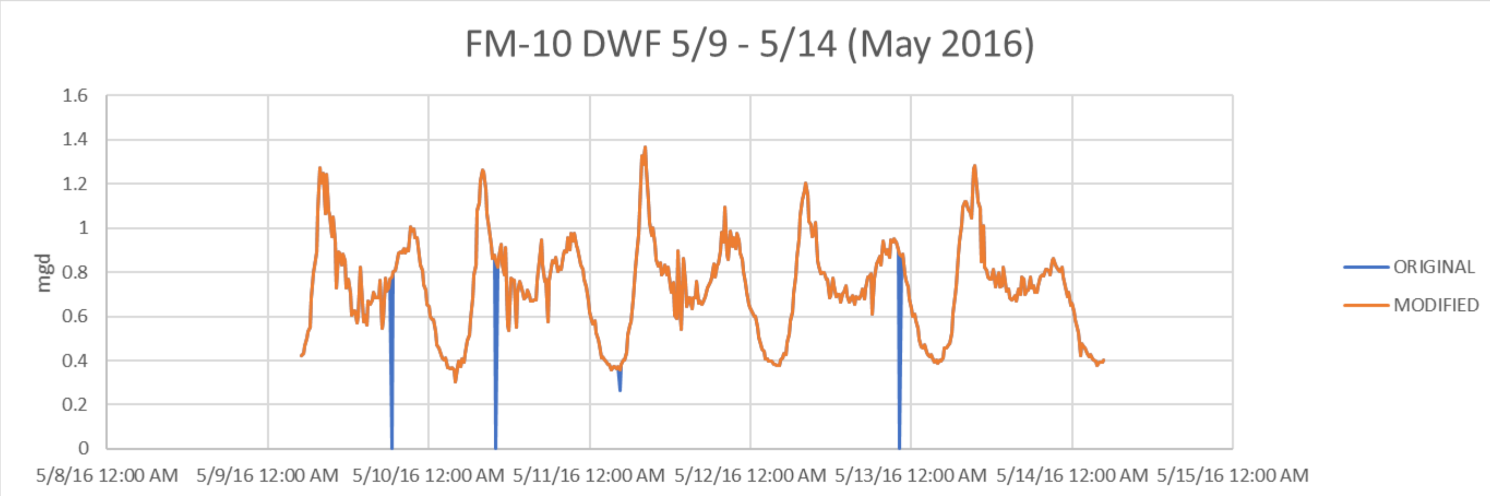
Meter Name	**FM-09**
Representative Basin	**B09**
Location	**FE3 PS**
ADWF (mgd)	**1.86**

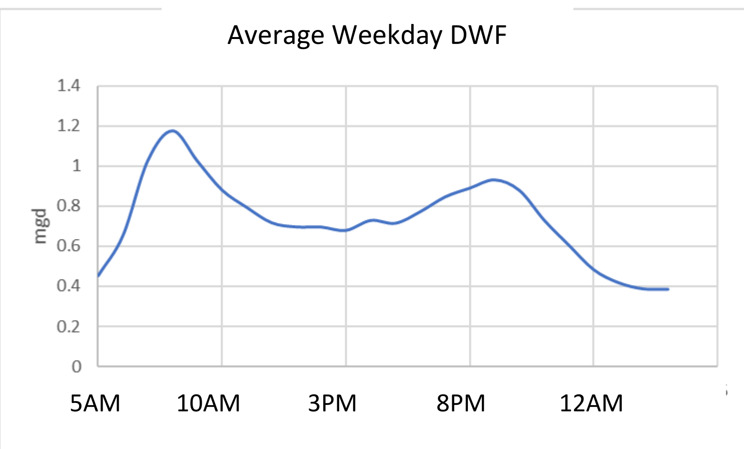


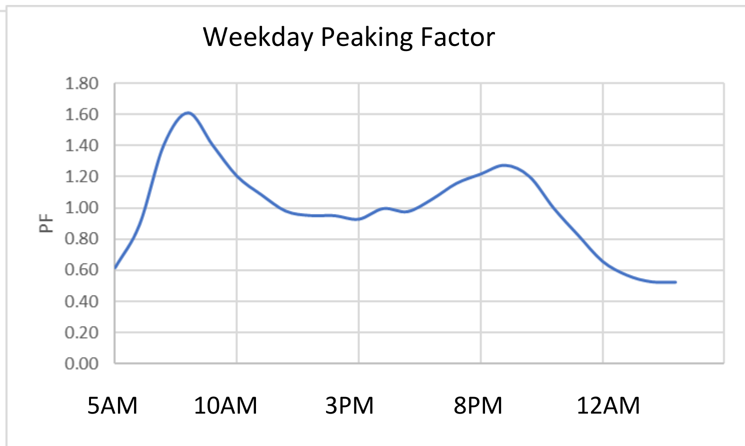




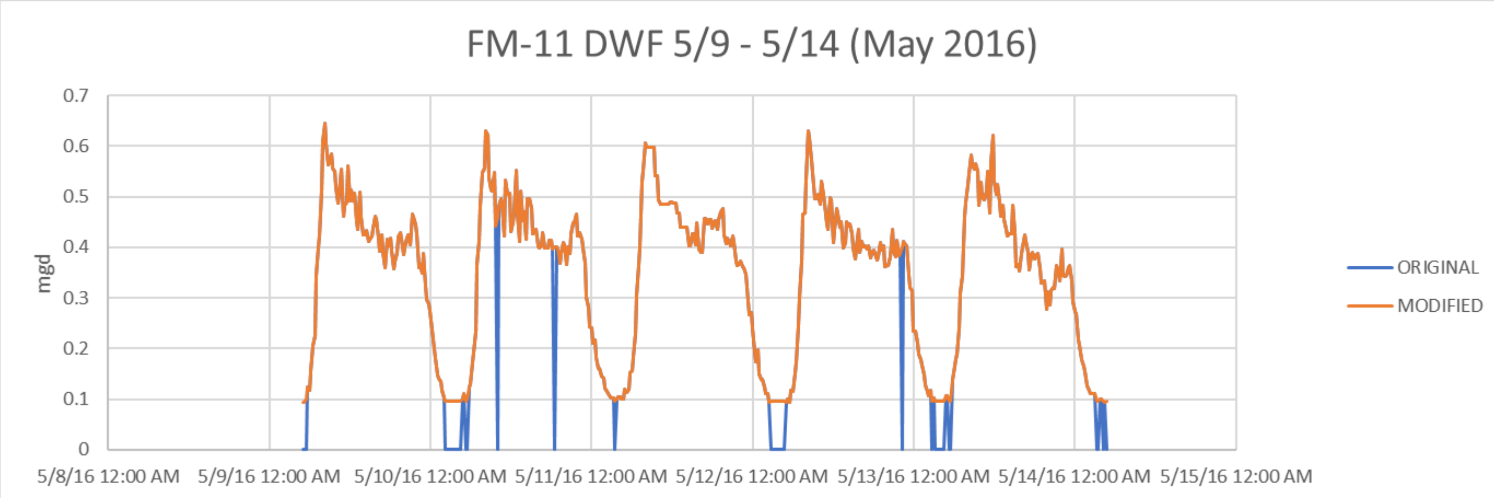
Meter Name	FM-10
Representative Basin	B10
Location	East Bidwell Willow Creek
ADWF (mgd)	0.73

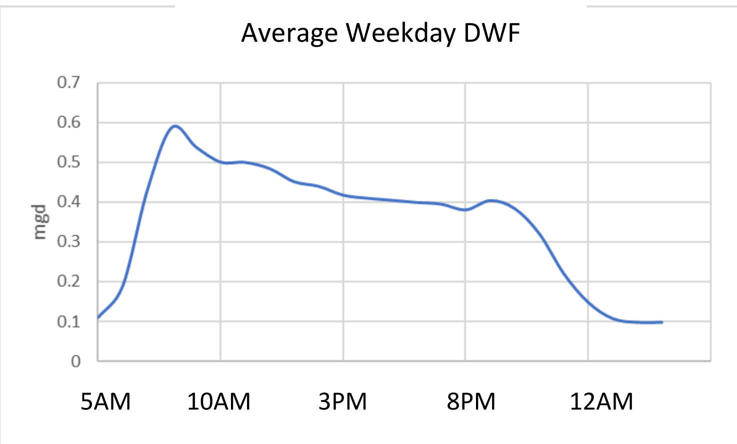


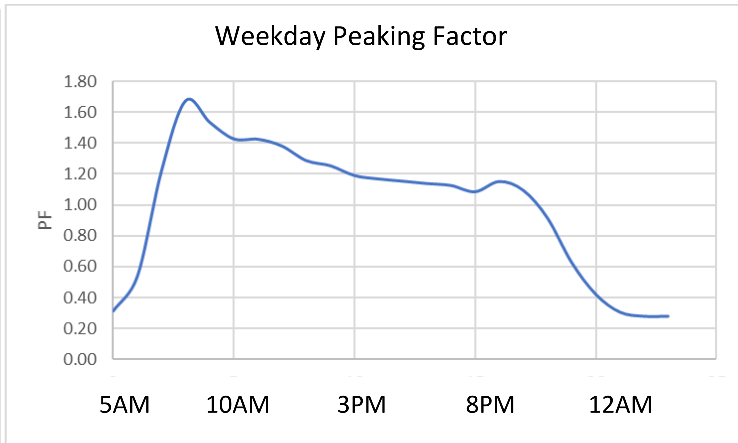




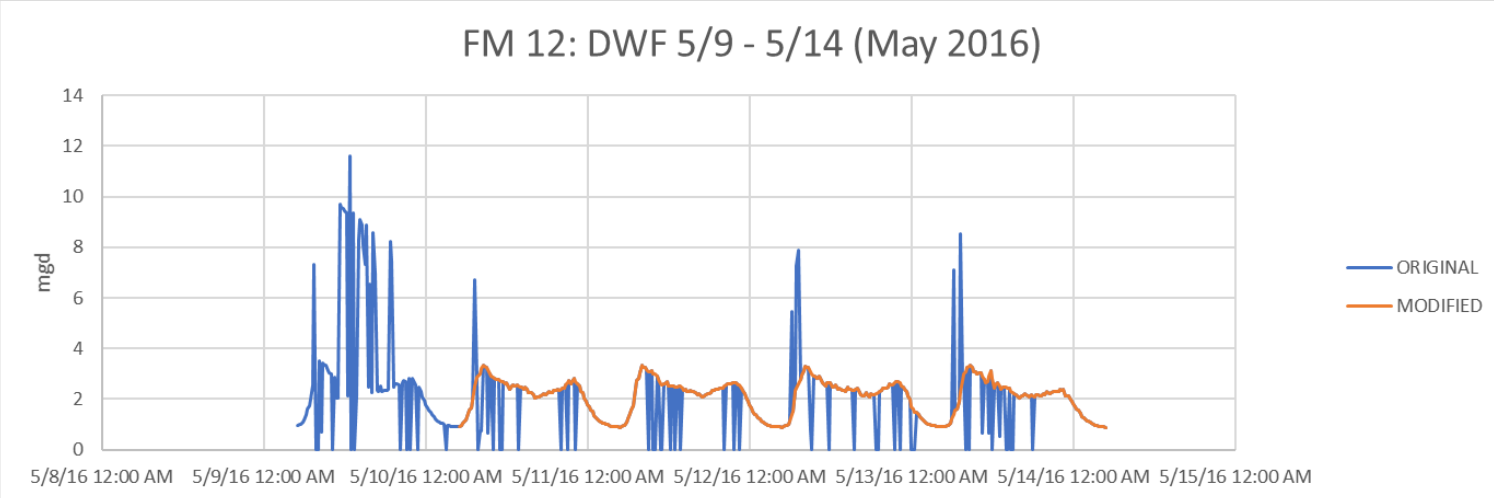
Meter Name	**FM-11**
Representative Basin	**B11**
Location	**Prairie City Willard**
ADWF (mgd)	**0.35**

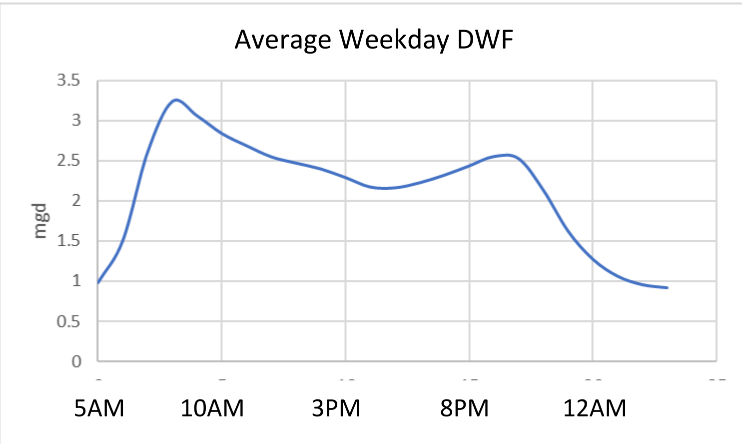


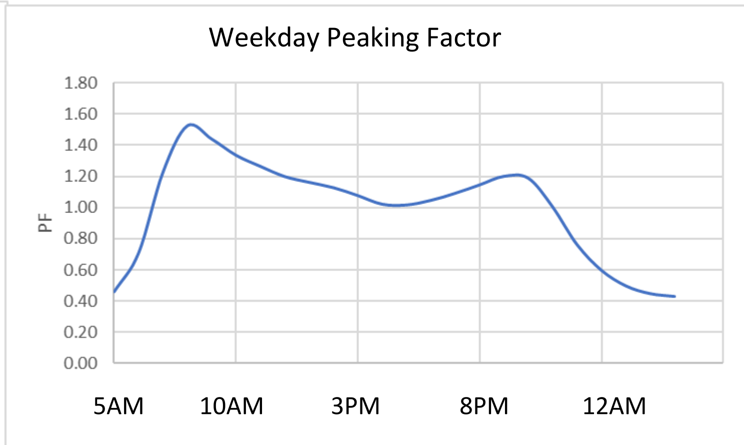




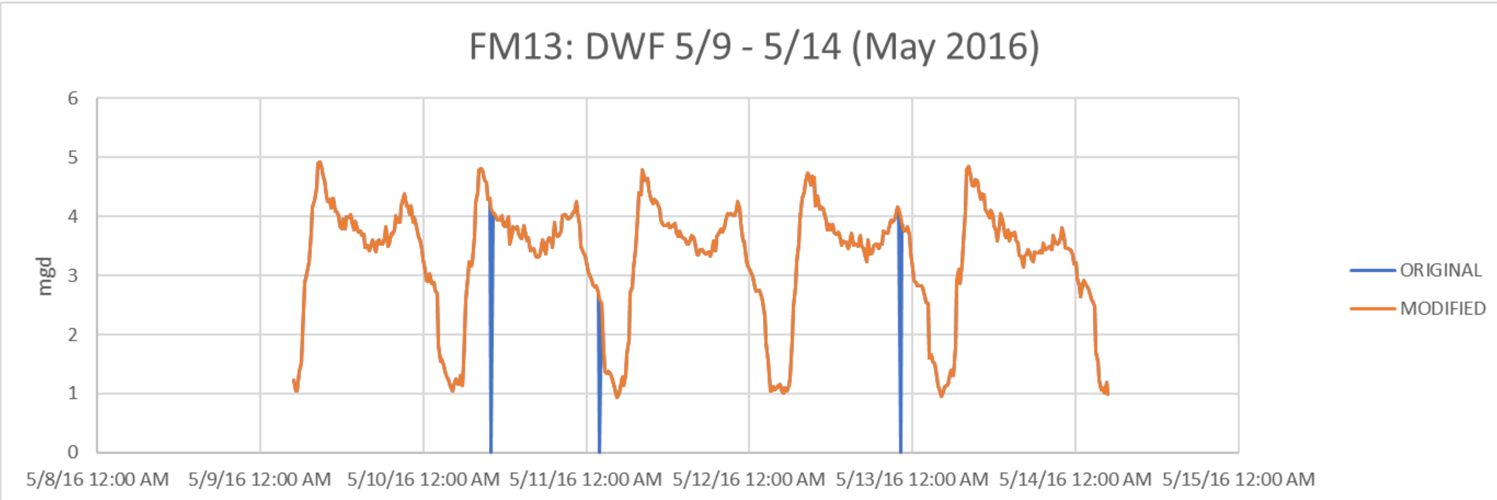
Meter Name	**FM-12**
Representative Basin	**B12**
Location	**Blue Ravine Prairie City**
ADWF (mgd)	**2.12**

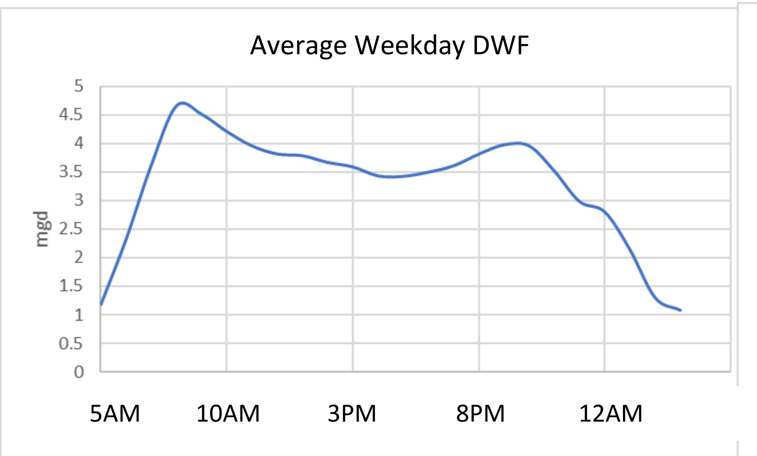


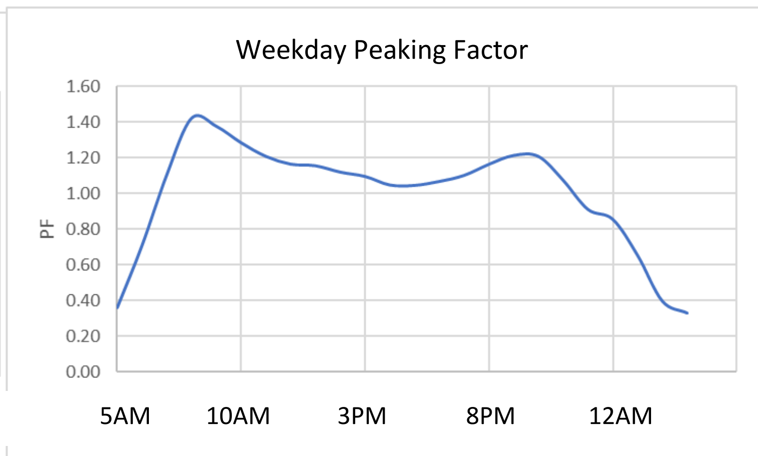




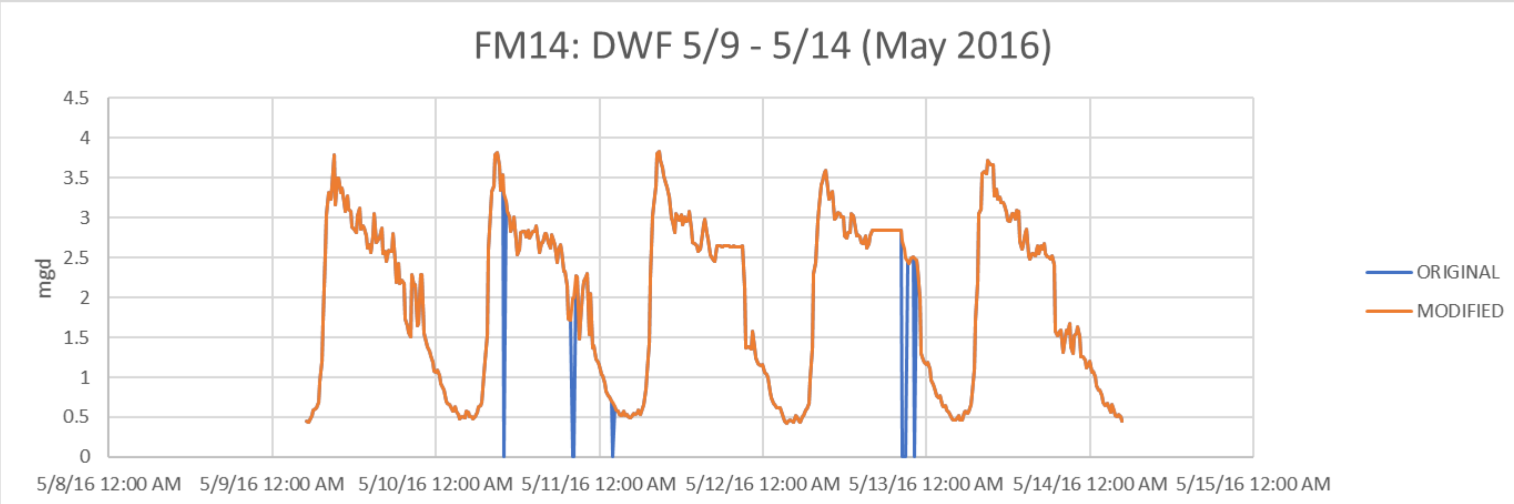
Meter Name	**FM-13**
Representative Basin	**B13**
Location	**Folsom East**
ADWF (mgd)	**3.28**

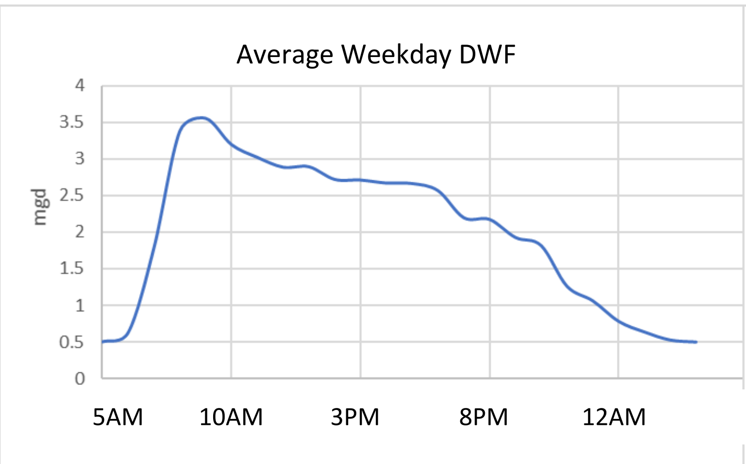


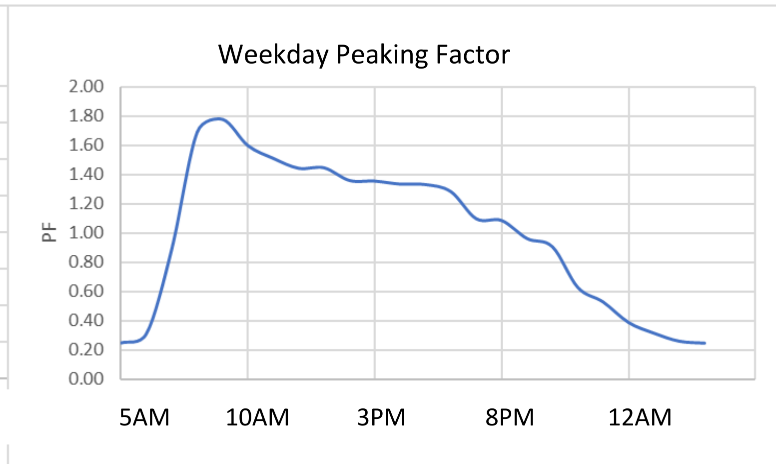




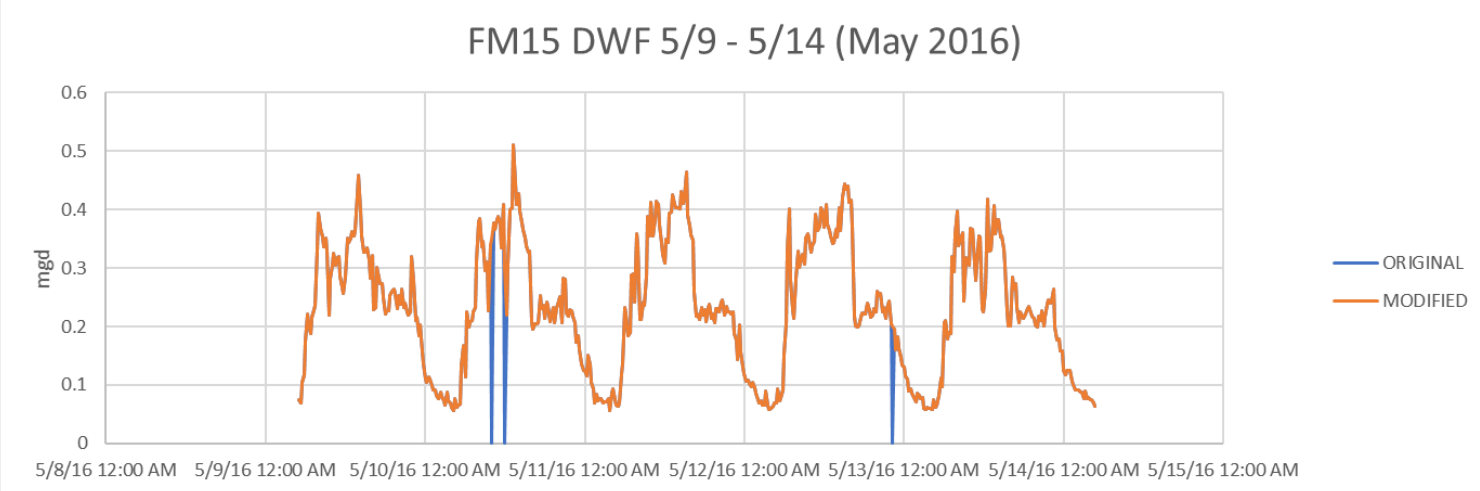
Meter Name	**FM-14**
Representative Basin	**B14**
Location	**Folsom West**
ADWF (mgd)	**2.00**

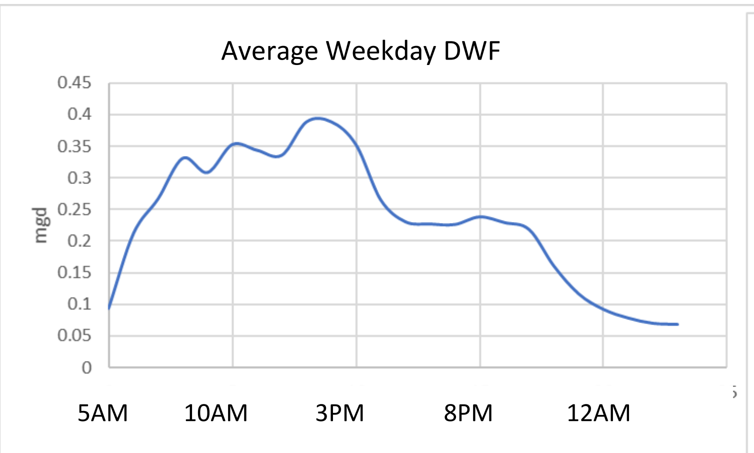


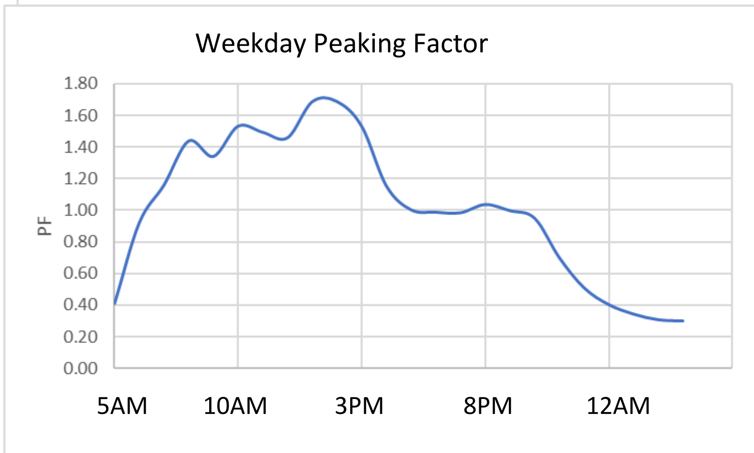




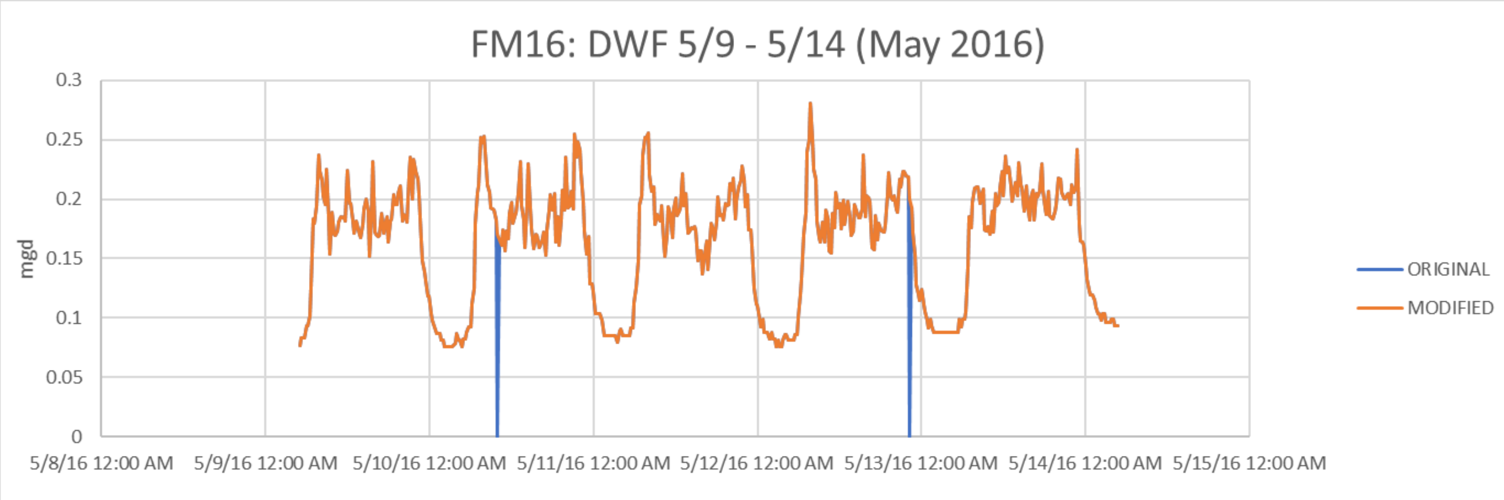
Meter Name	**FM-15**
Representative Basin	**B15**
Location	**Sibley Levy**
ADWF (mgd)	**0.23**

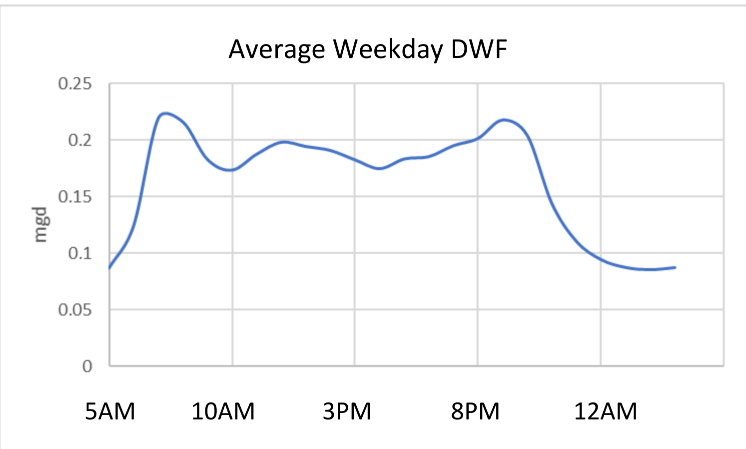


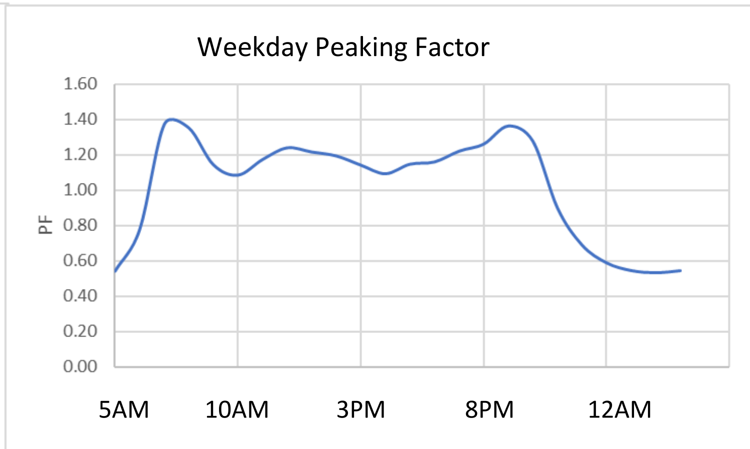




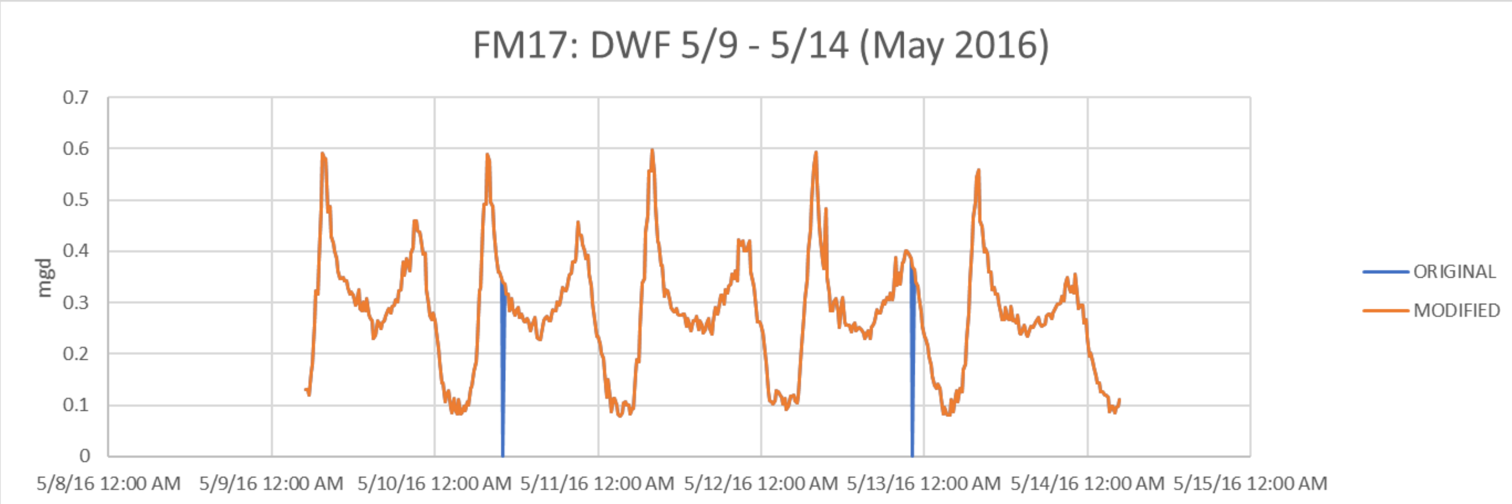
Meter Name	FM-16
Representative Basin	B16
Location	Iron Pt Broadstone
ADWF (mgd)	0.16

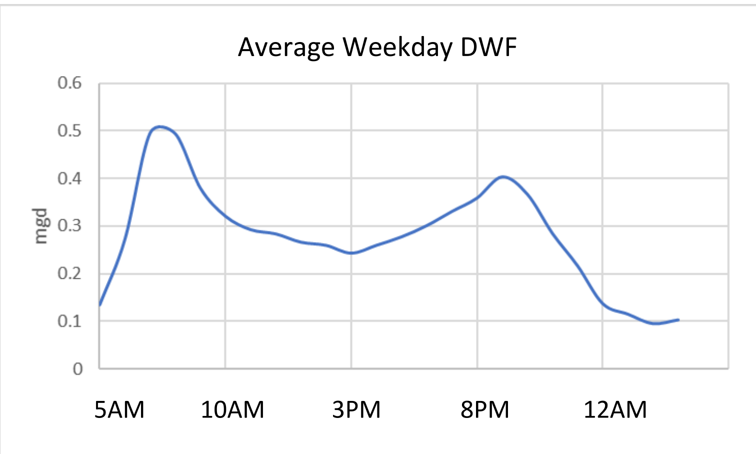


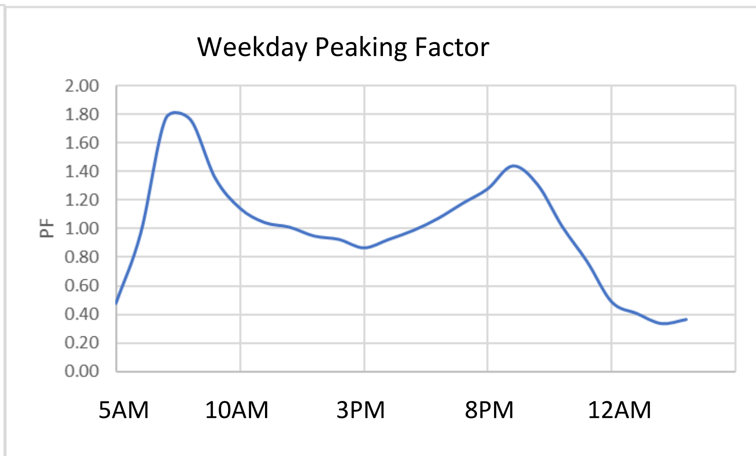




Meter Name	**FM-17**
Representative Basin	**B16**
Location	**Oak Ave / Willow Crk Rd**
ADWF (mgd)	**0.28**



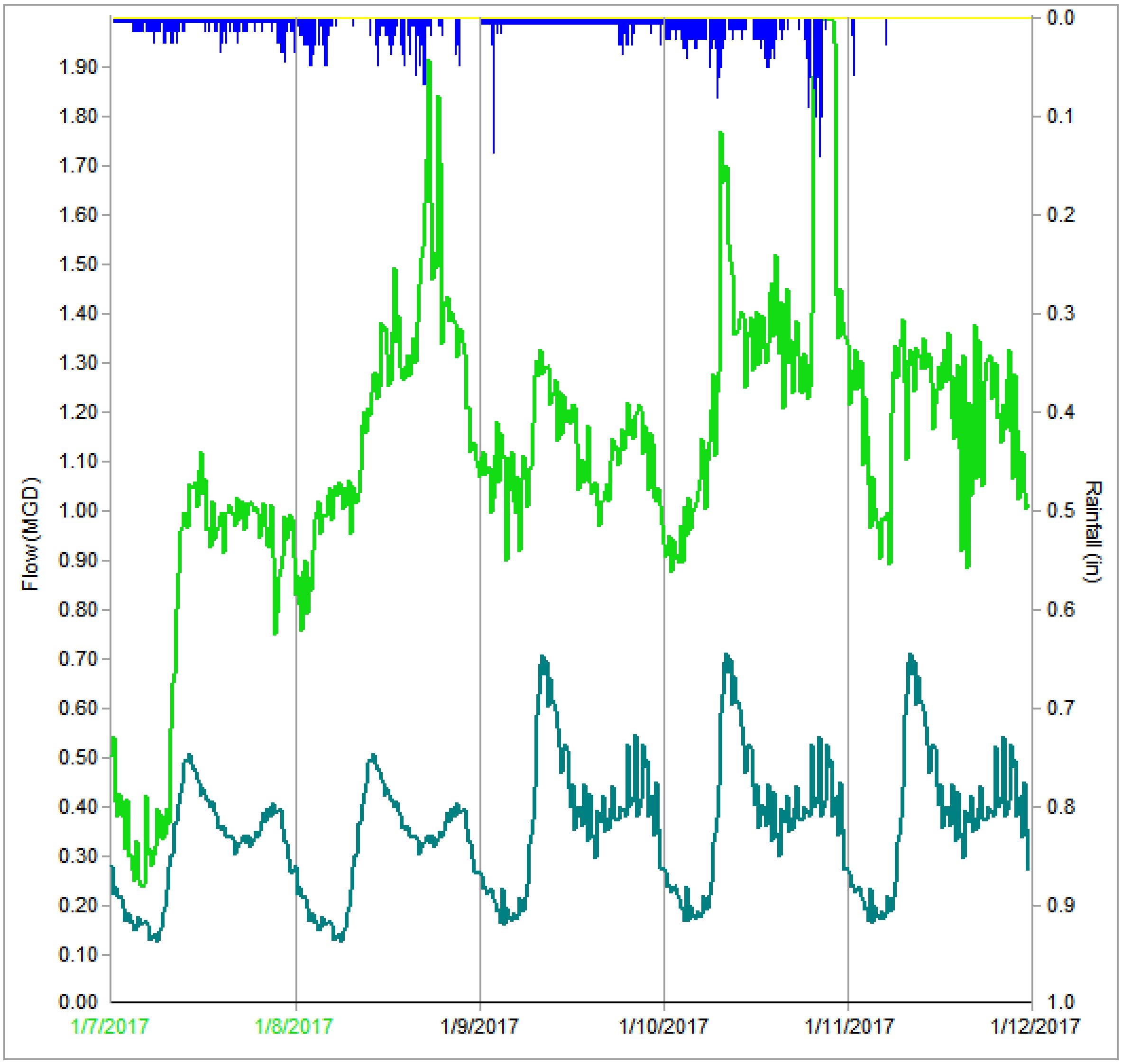




Appendix A.4 WWF Jan 10th 2017 Hydrographs

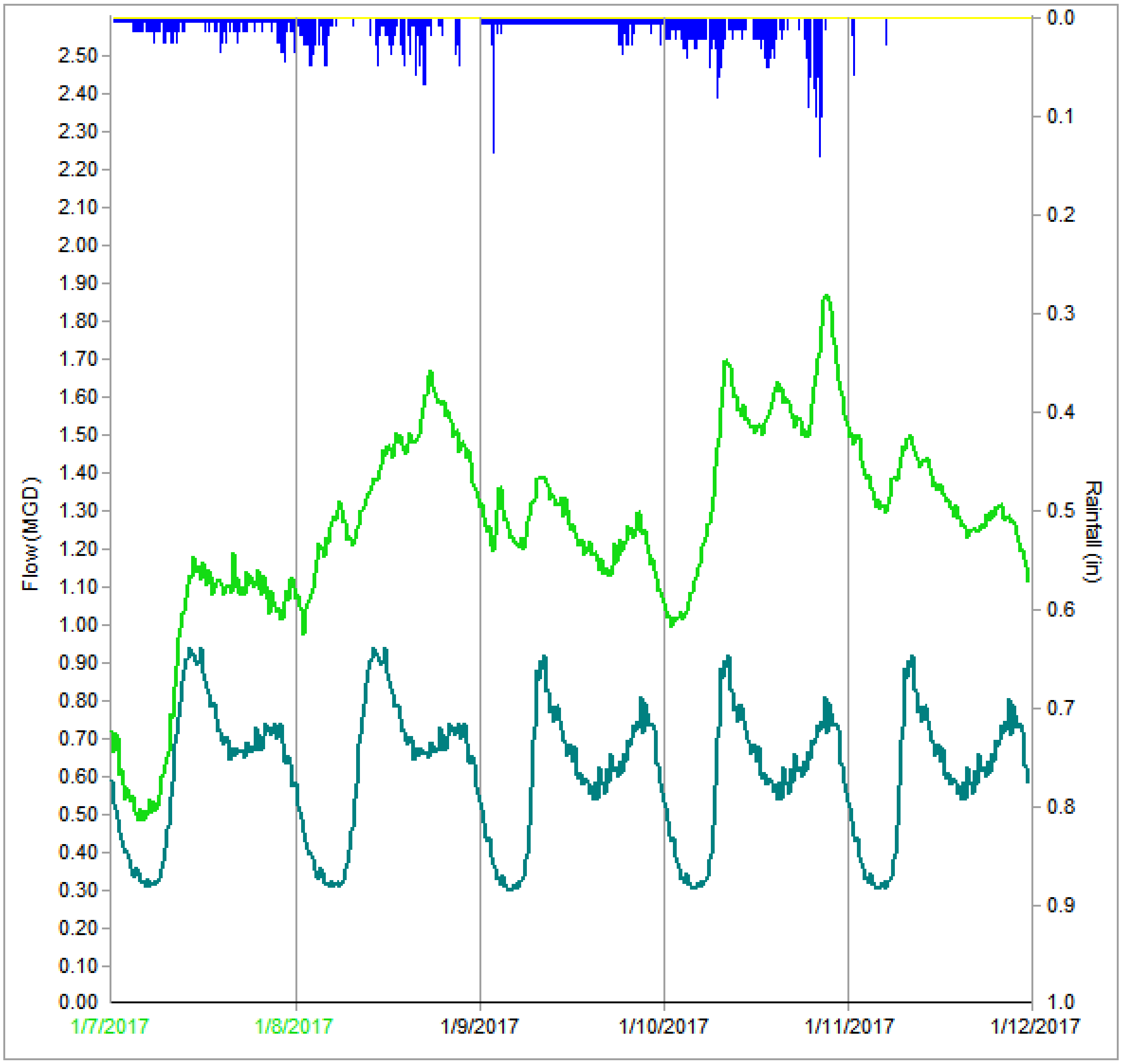
FM-01

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



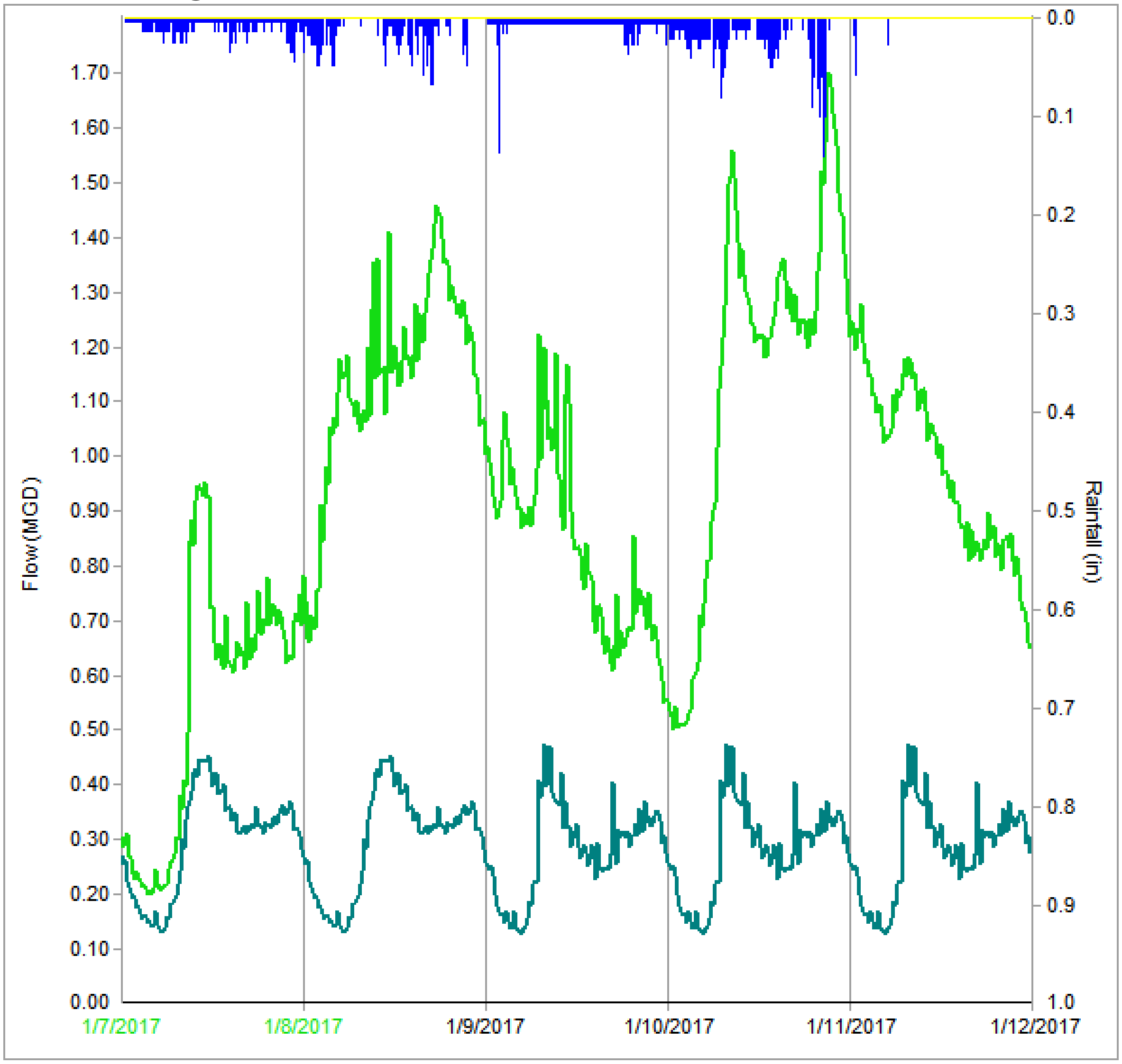
FM-02

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



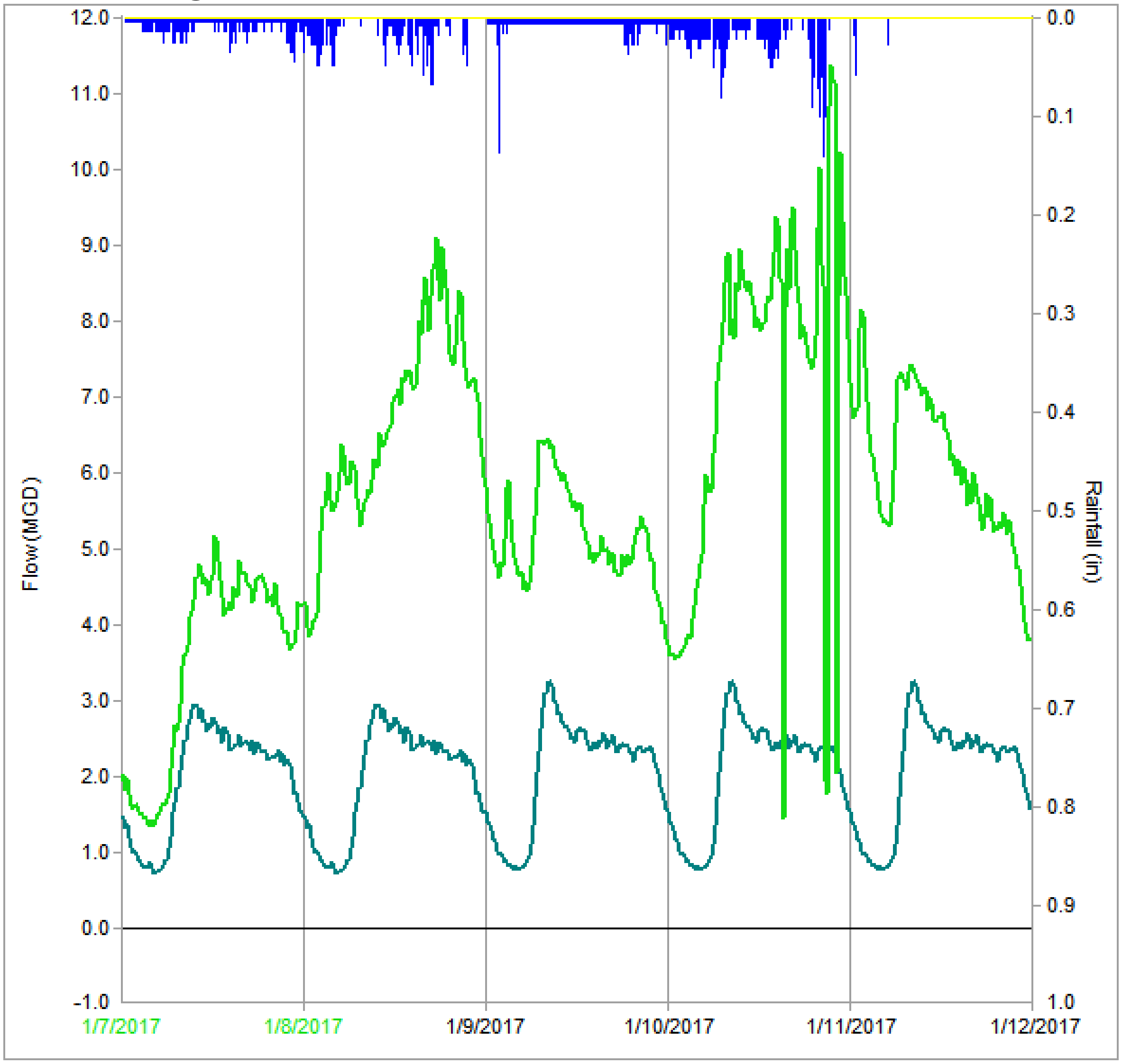
FM-03

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



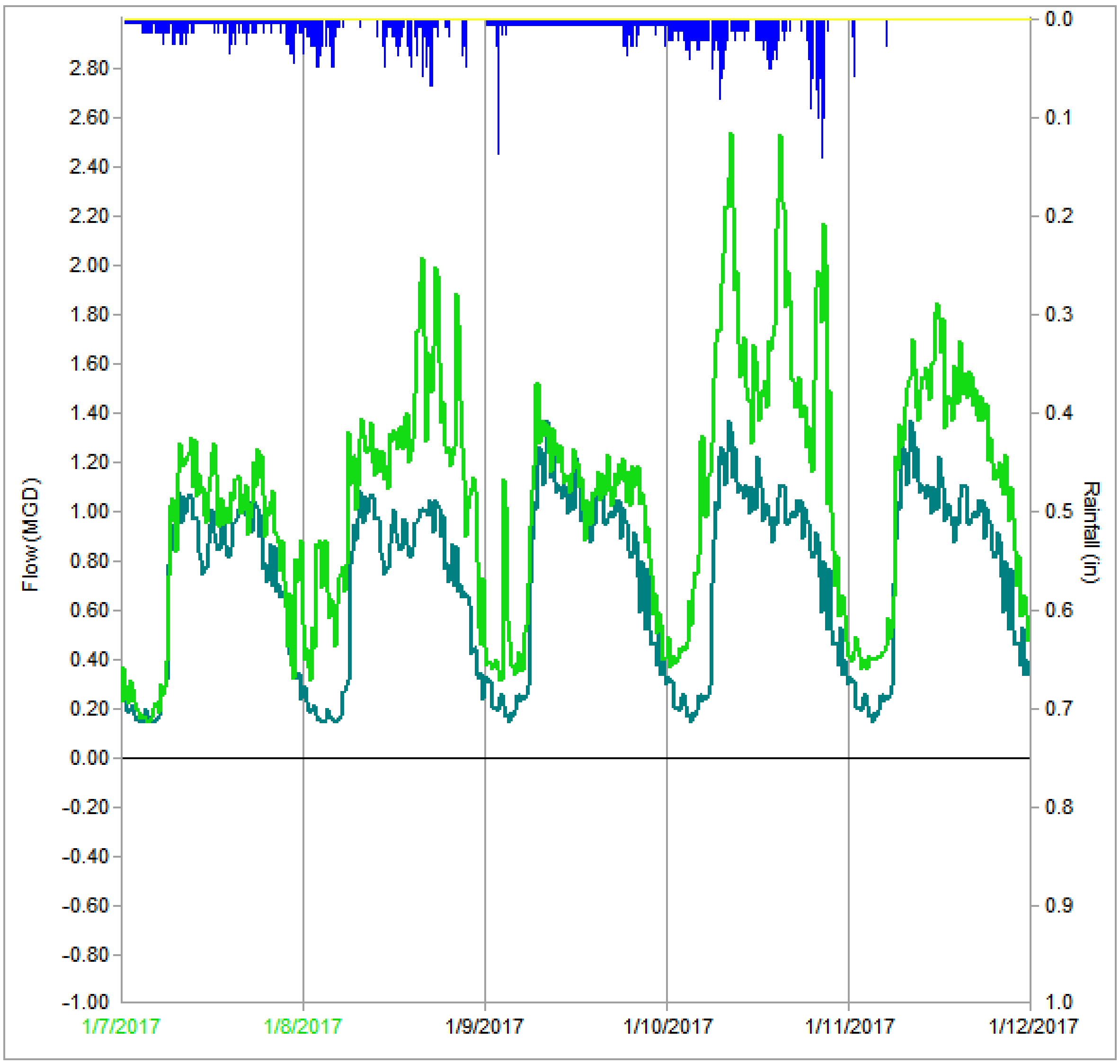
FM-04

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



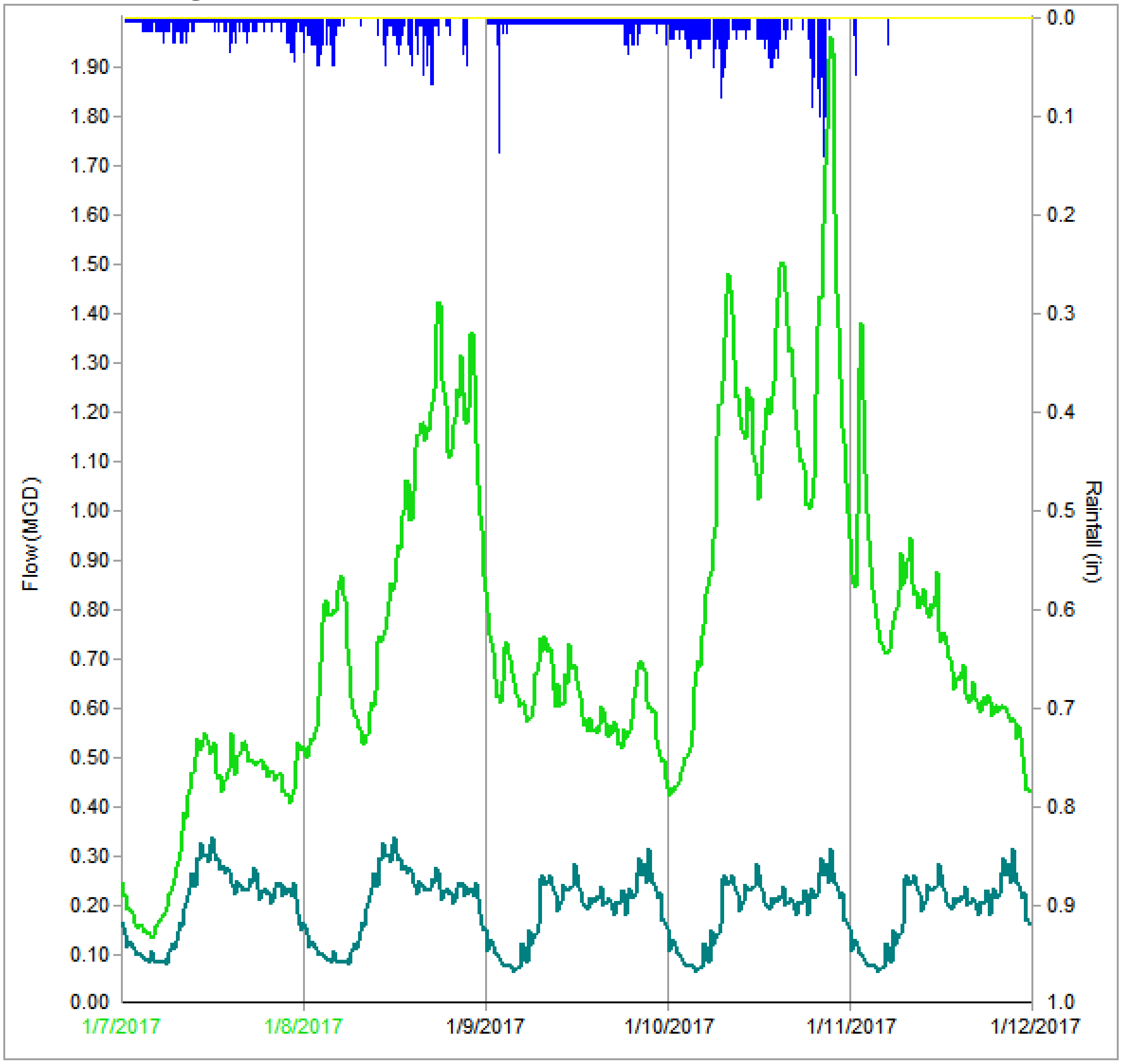
FM-05

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



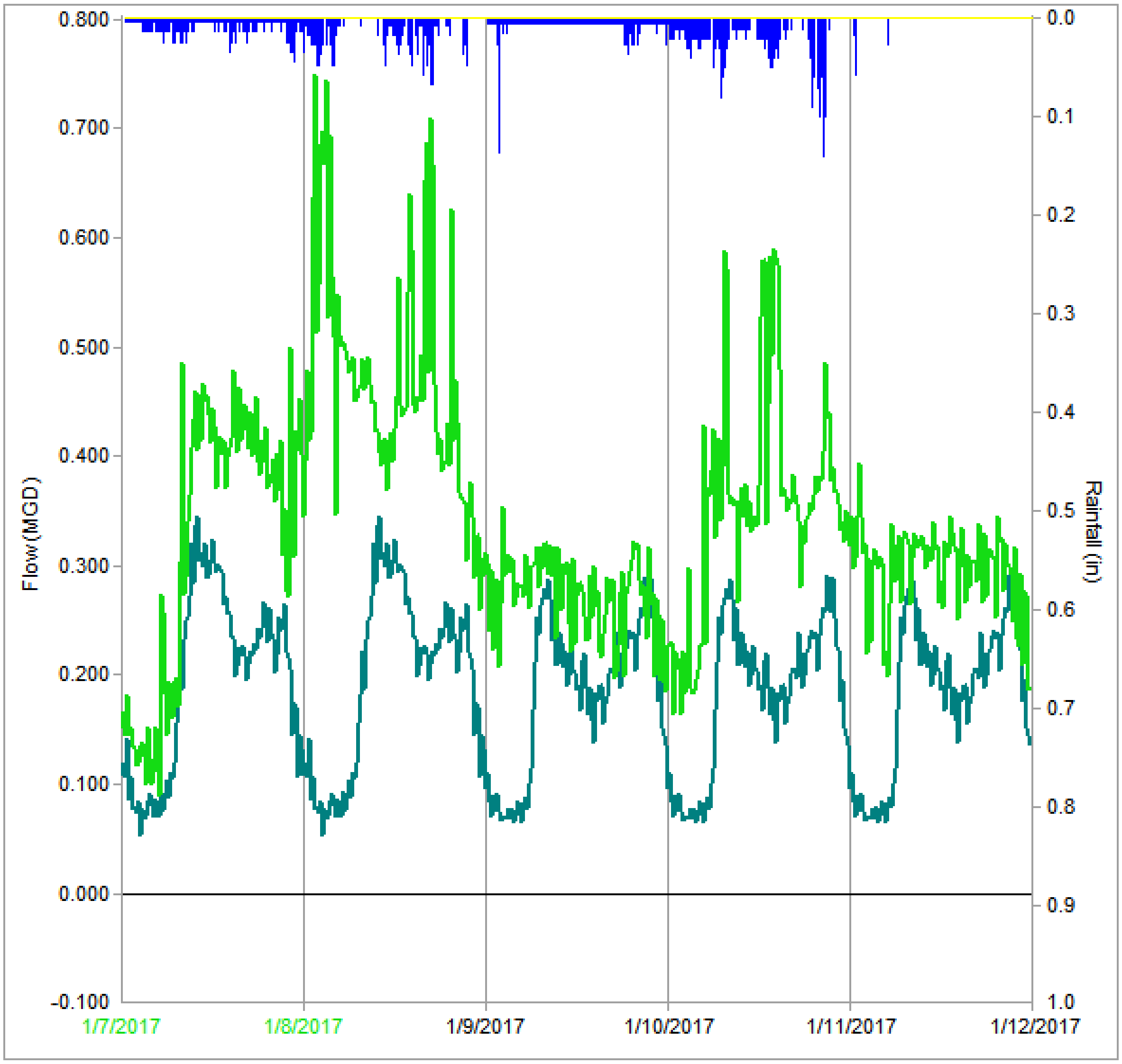
FM-06A

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



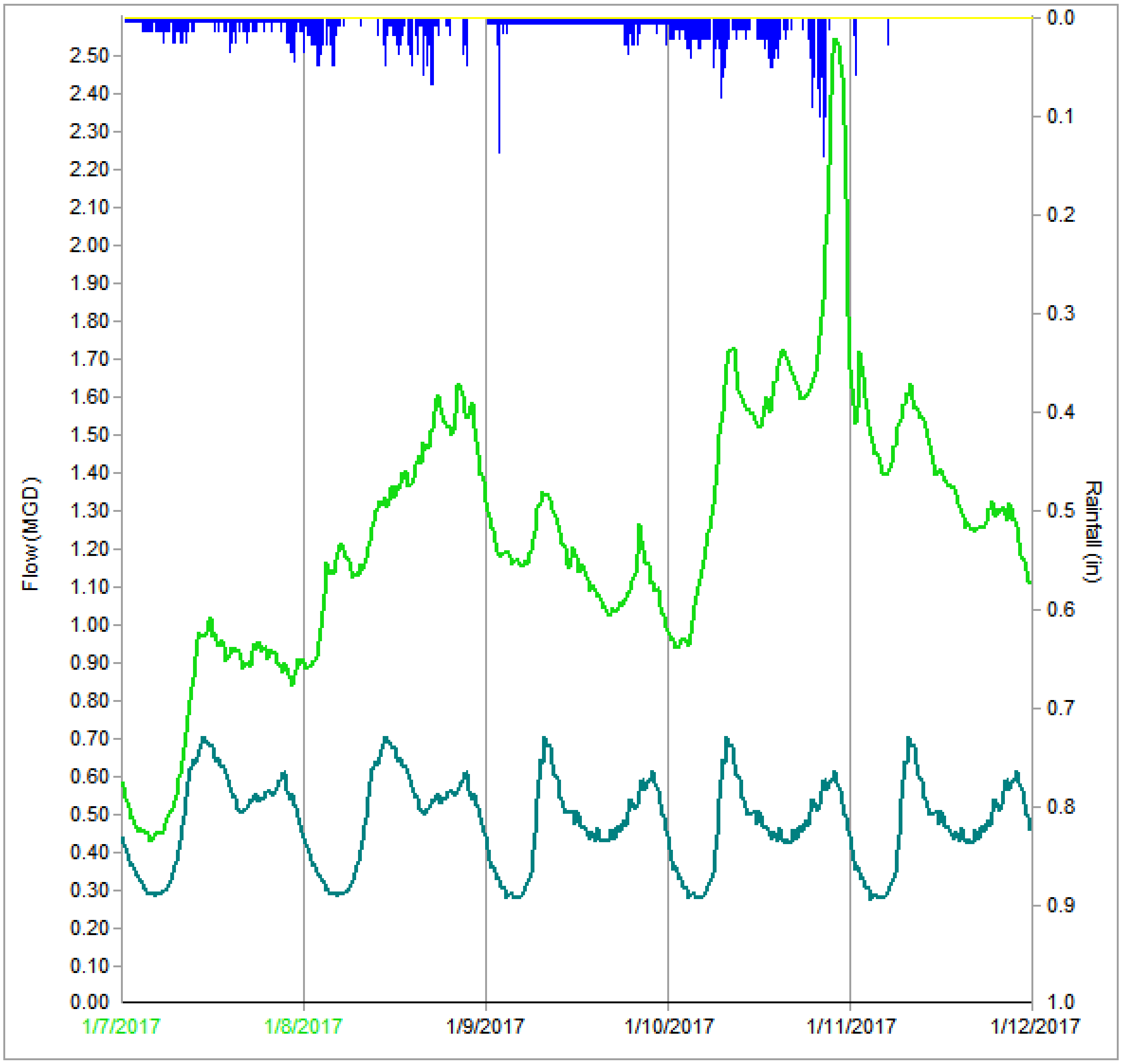
FM-06B

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



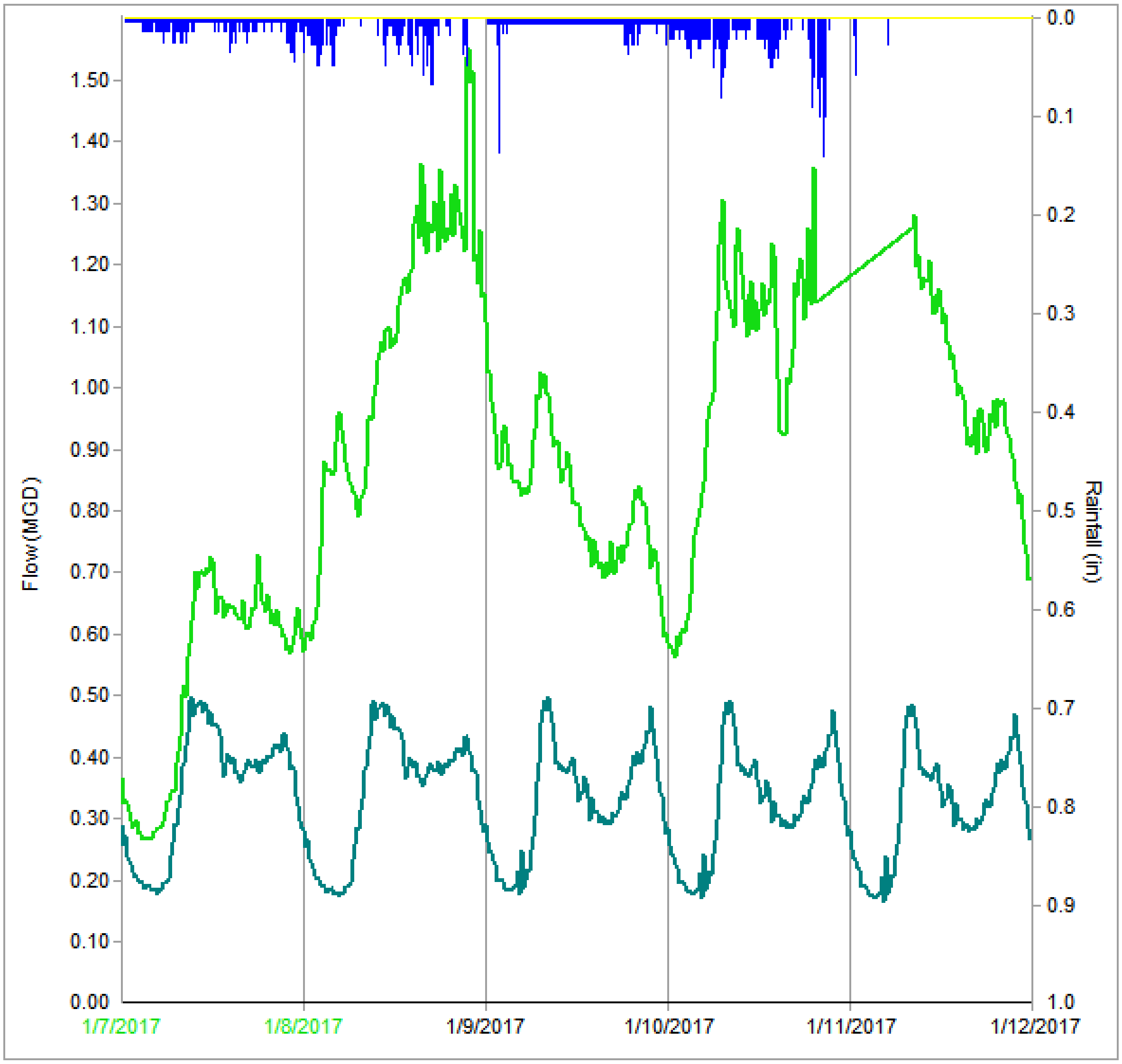
FM-06C

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



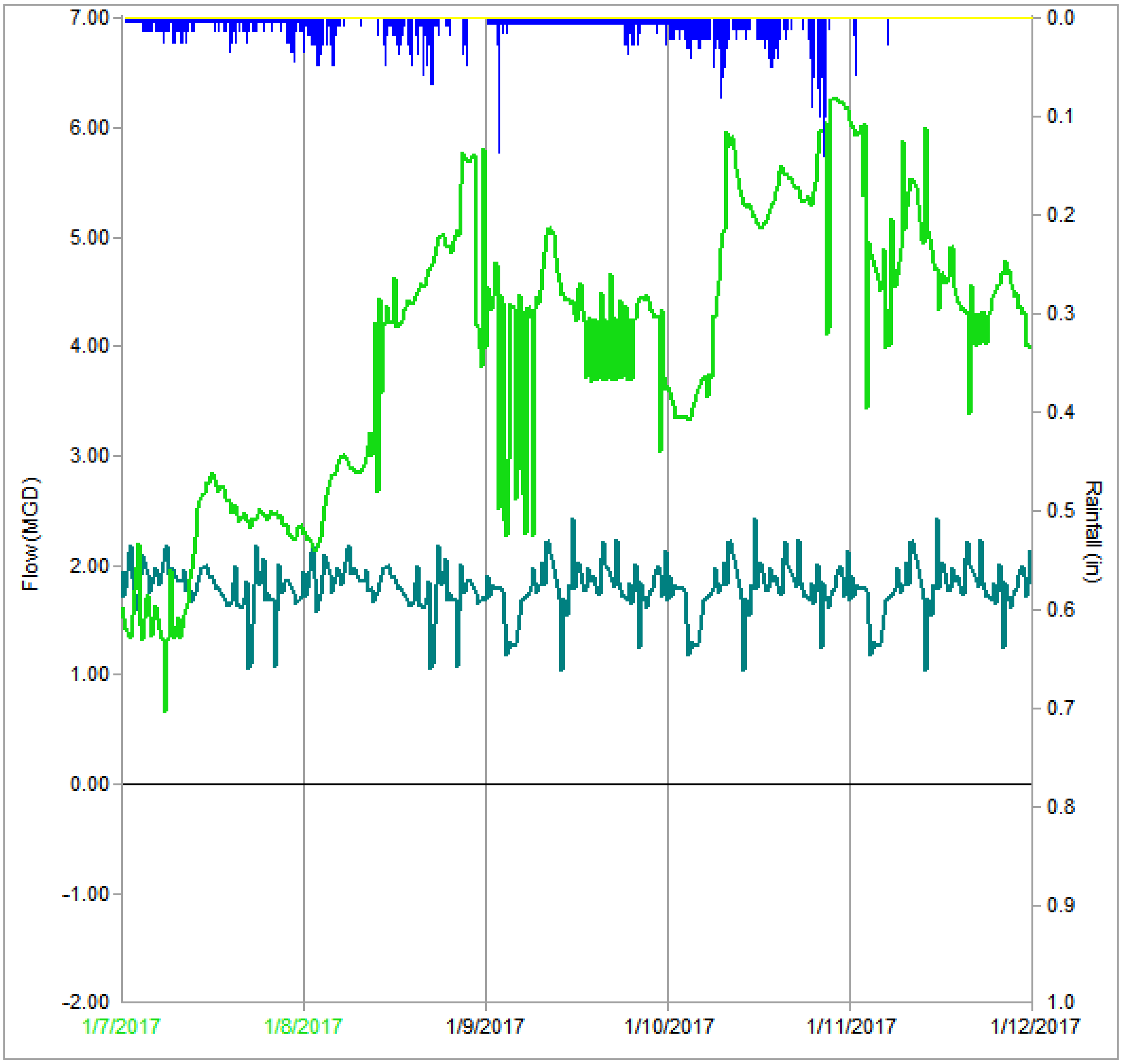
FM-07

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



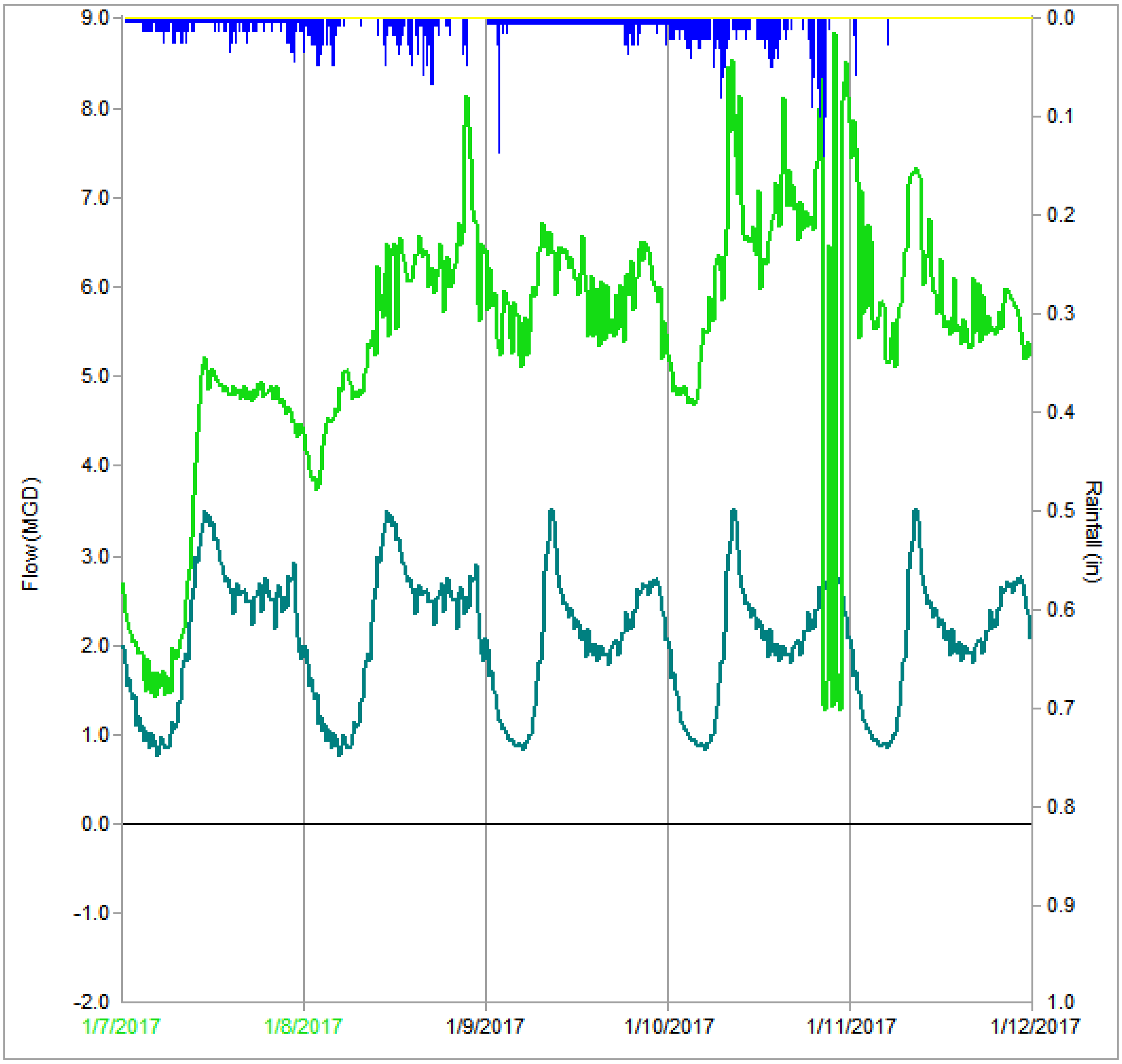
FM-08

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



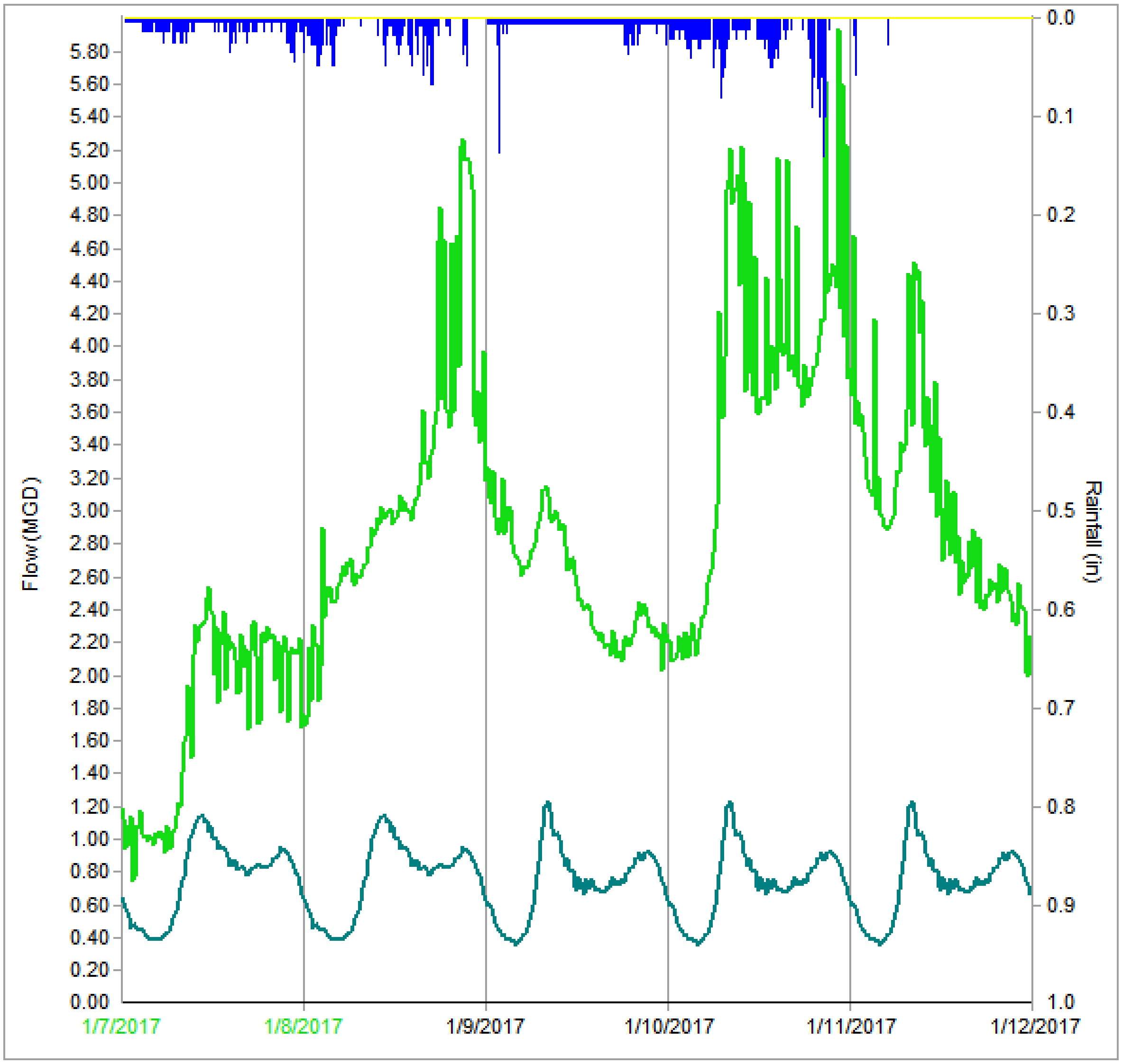
FM-09

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



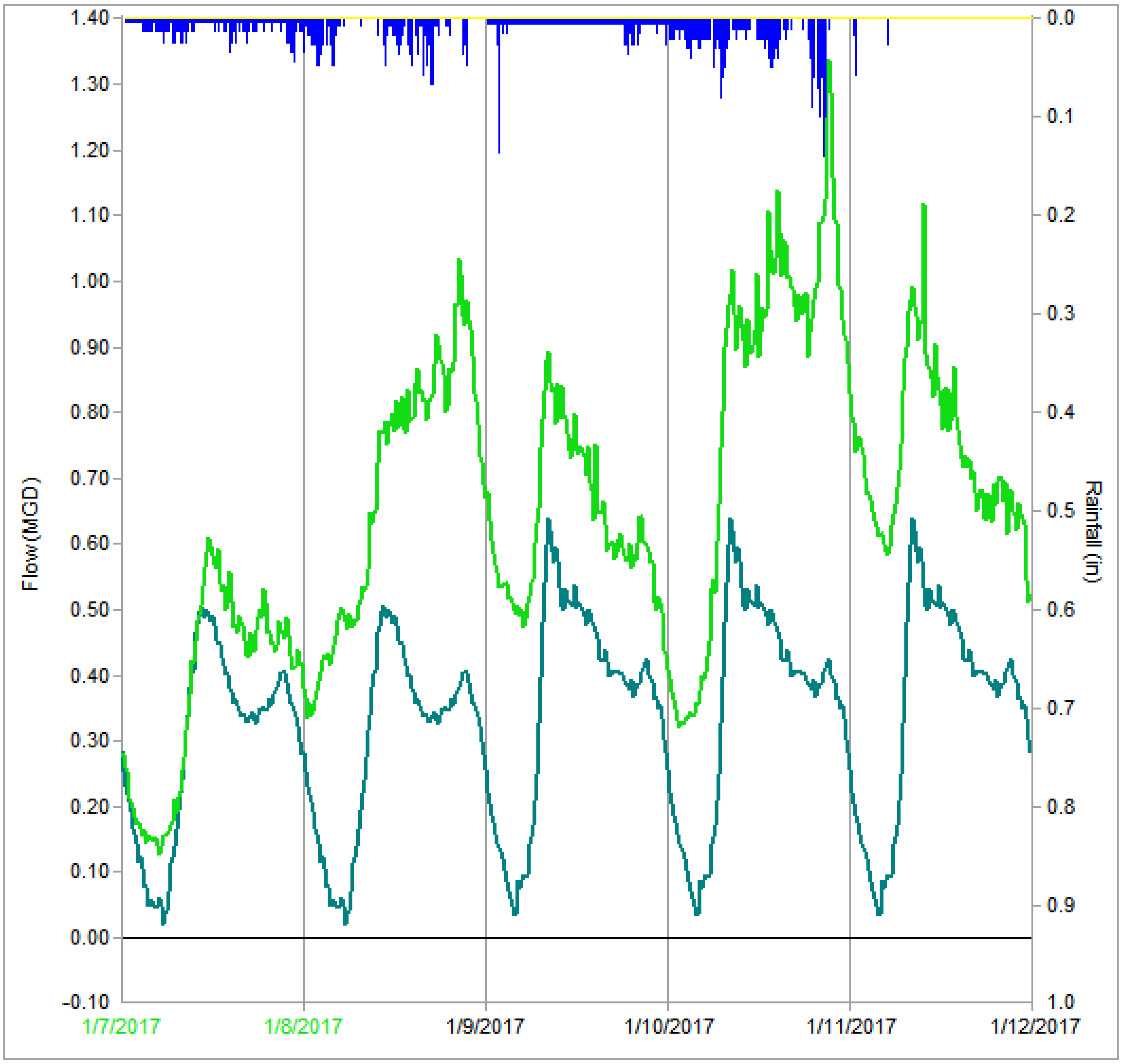
FM-10

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



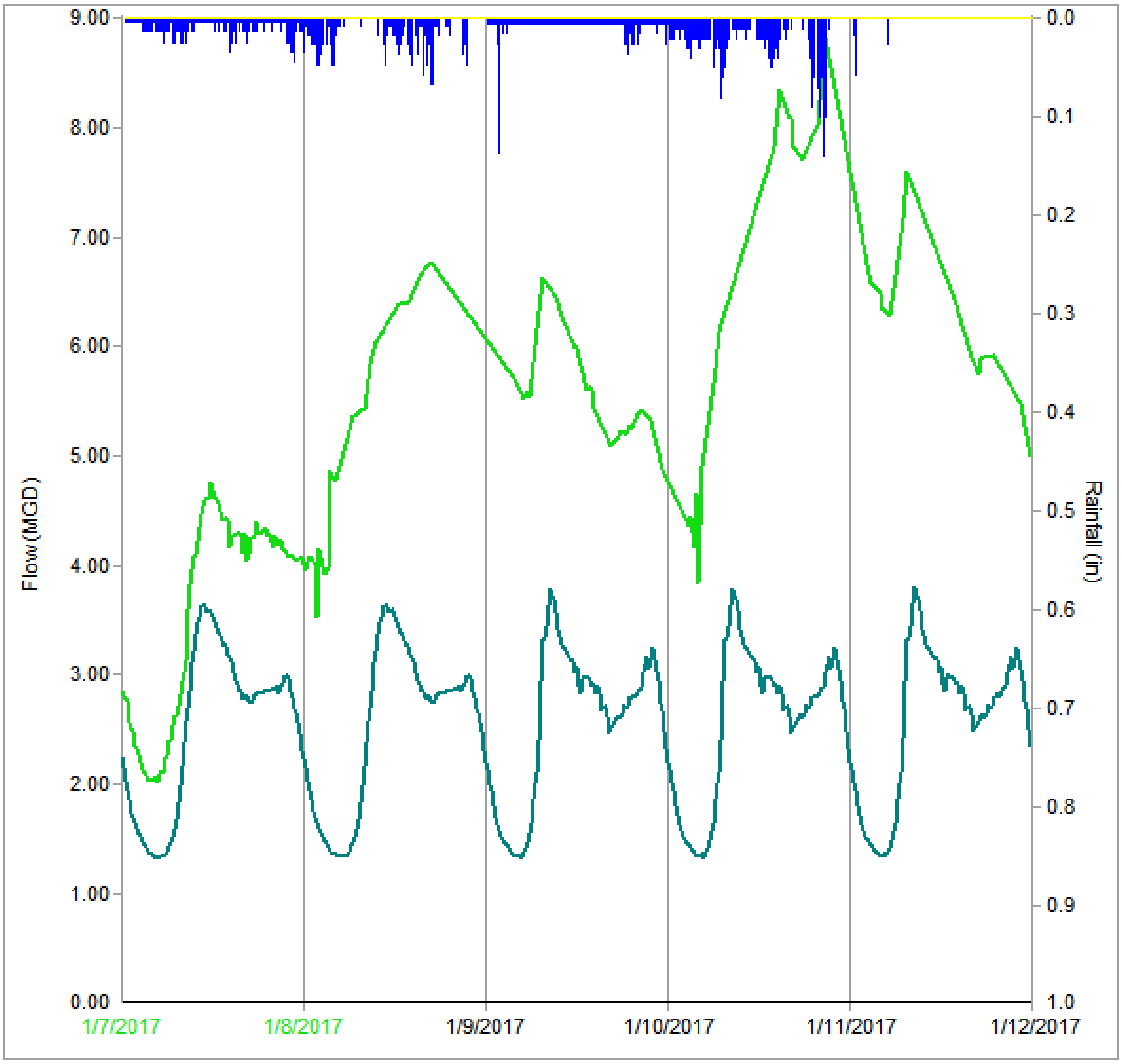
FM-11

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



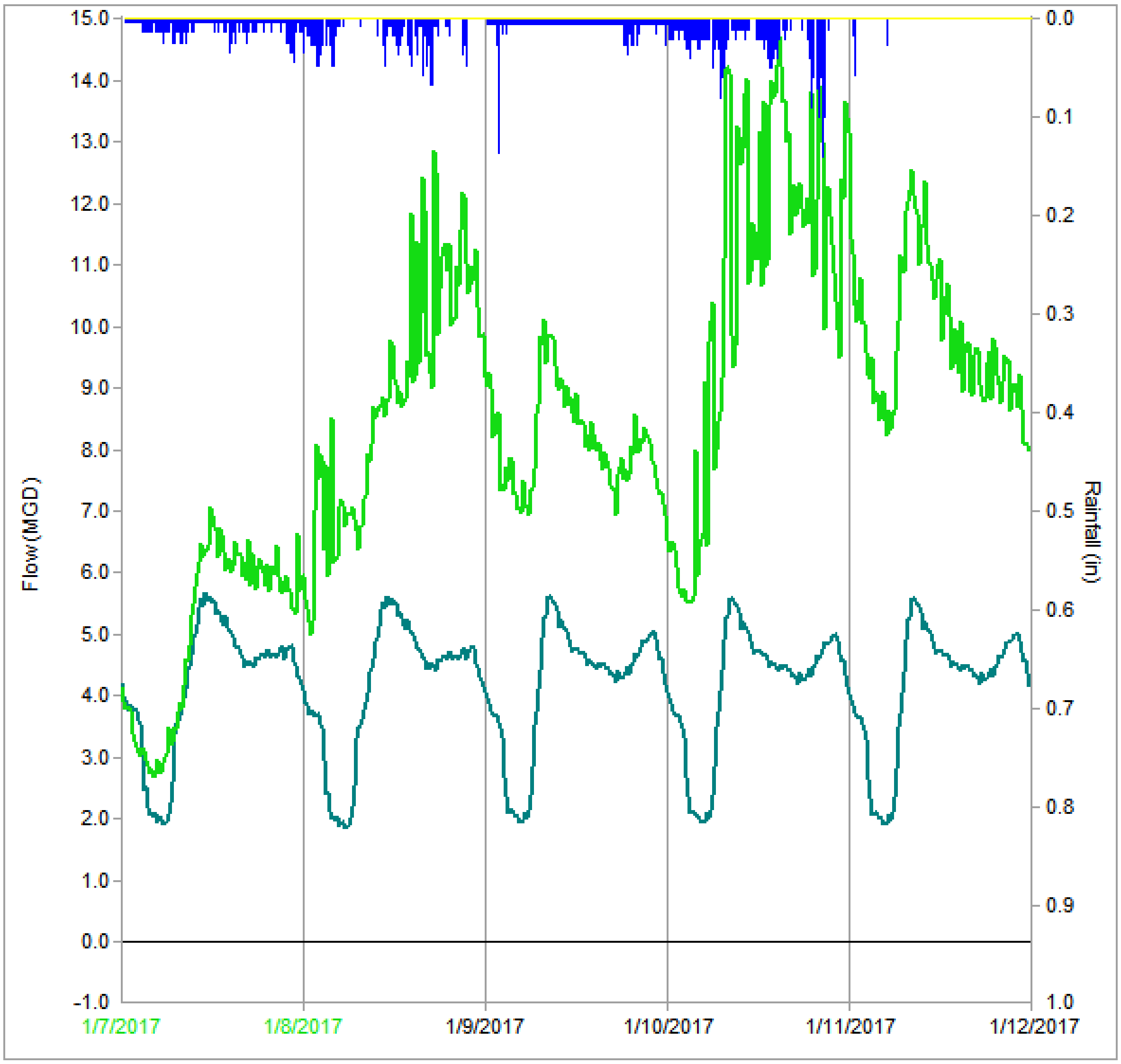
FM-12

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



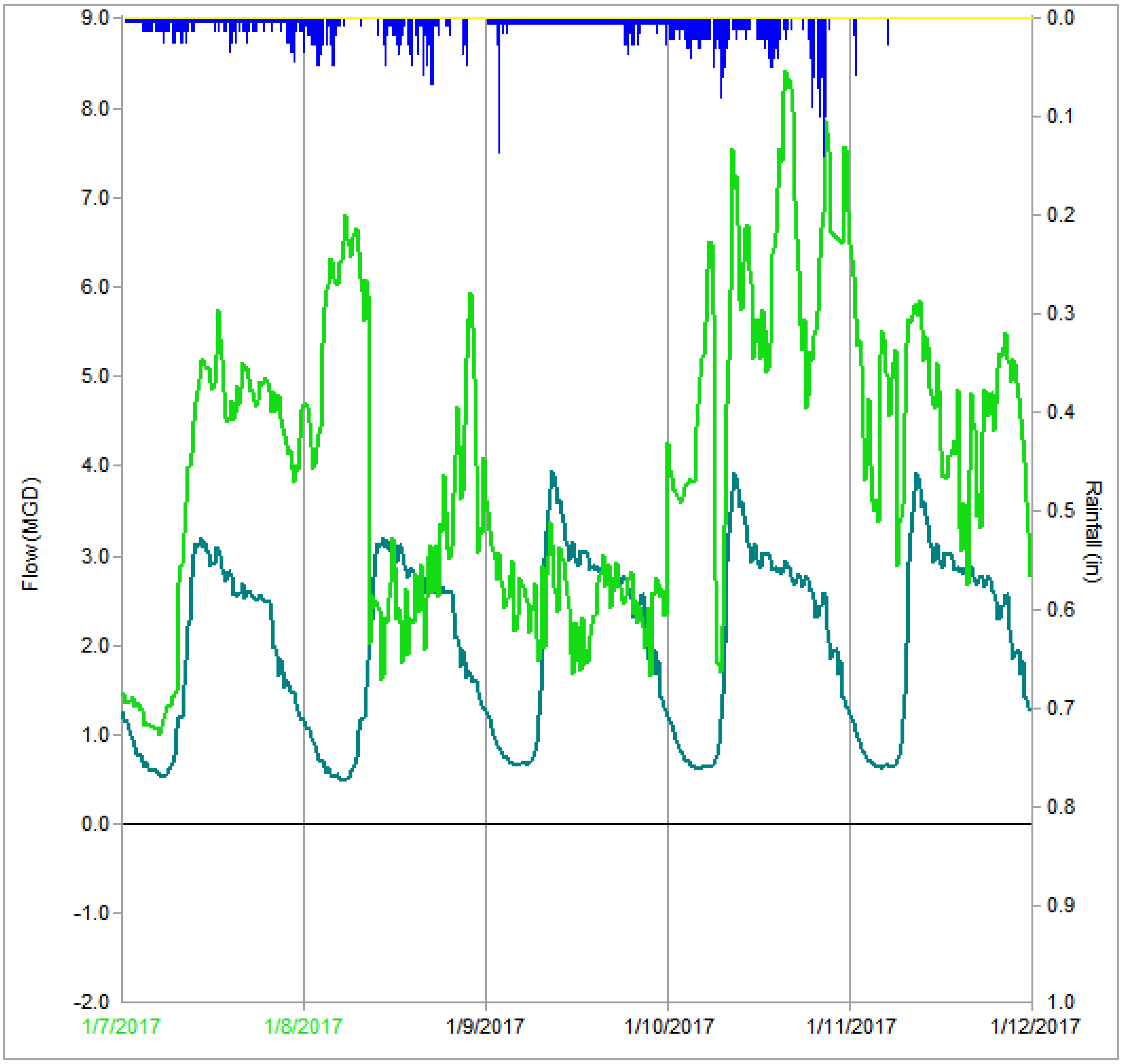
FM-13

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



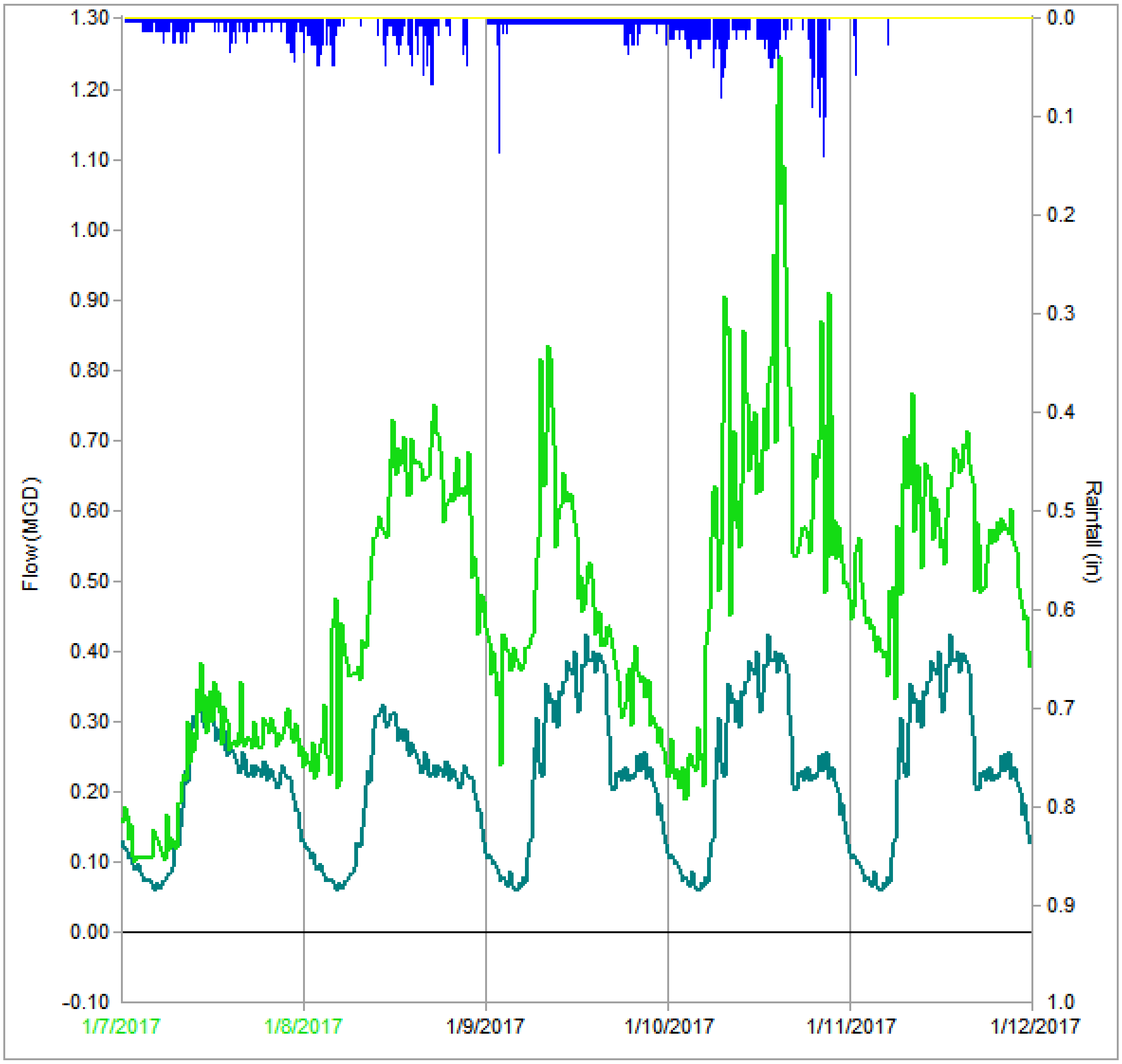
FM-14

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



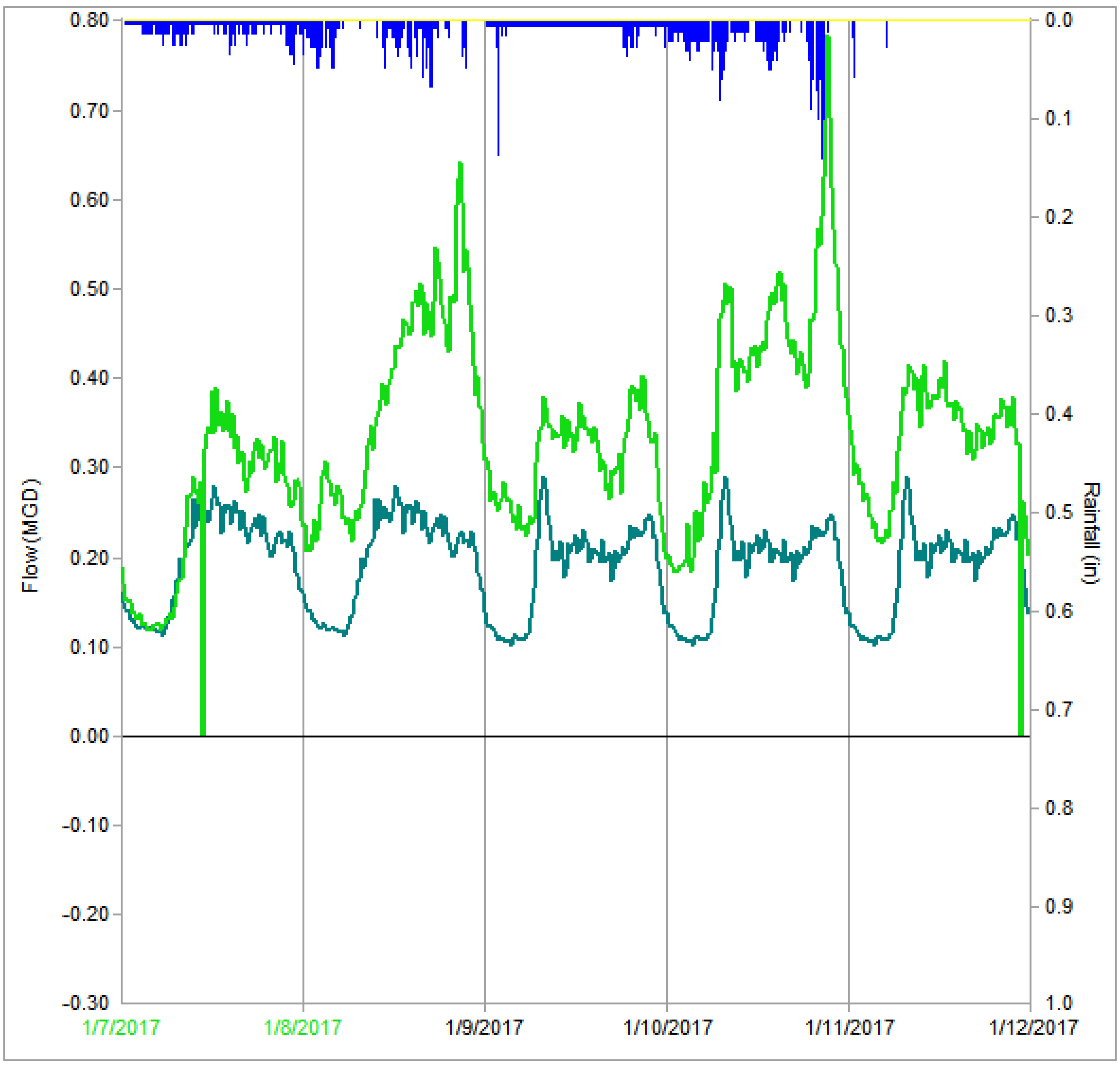
FM-15

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



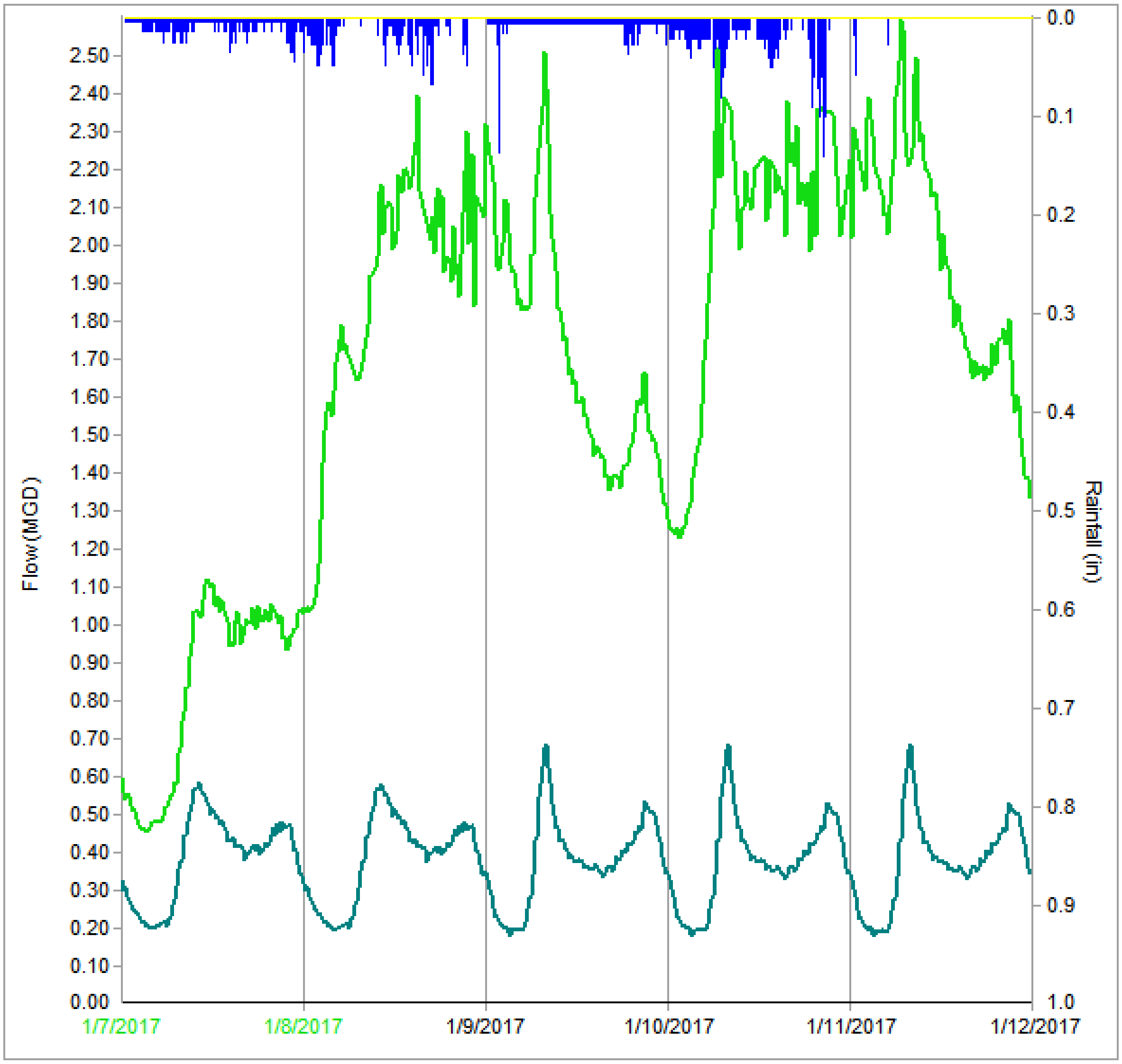
FM-16

Blue: Rainfall
Green: Observed WWF
Teal: Average DWF



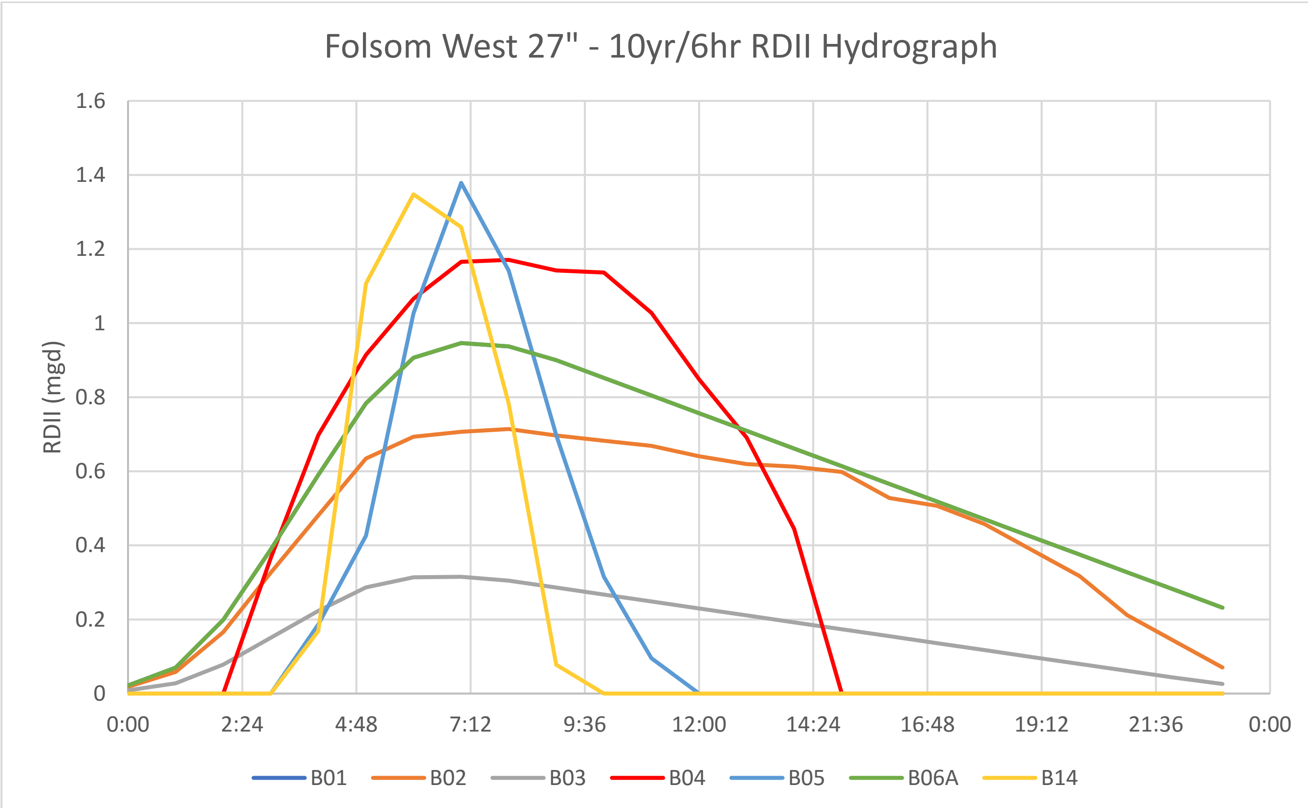
FM-17

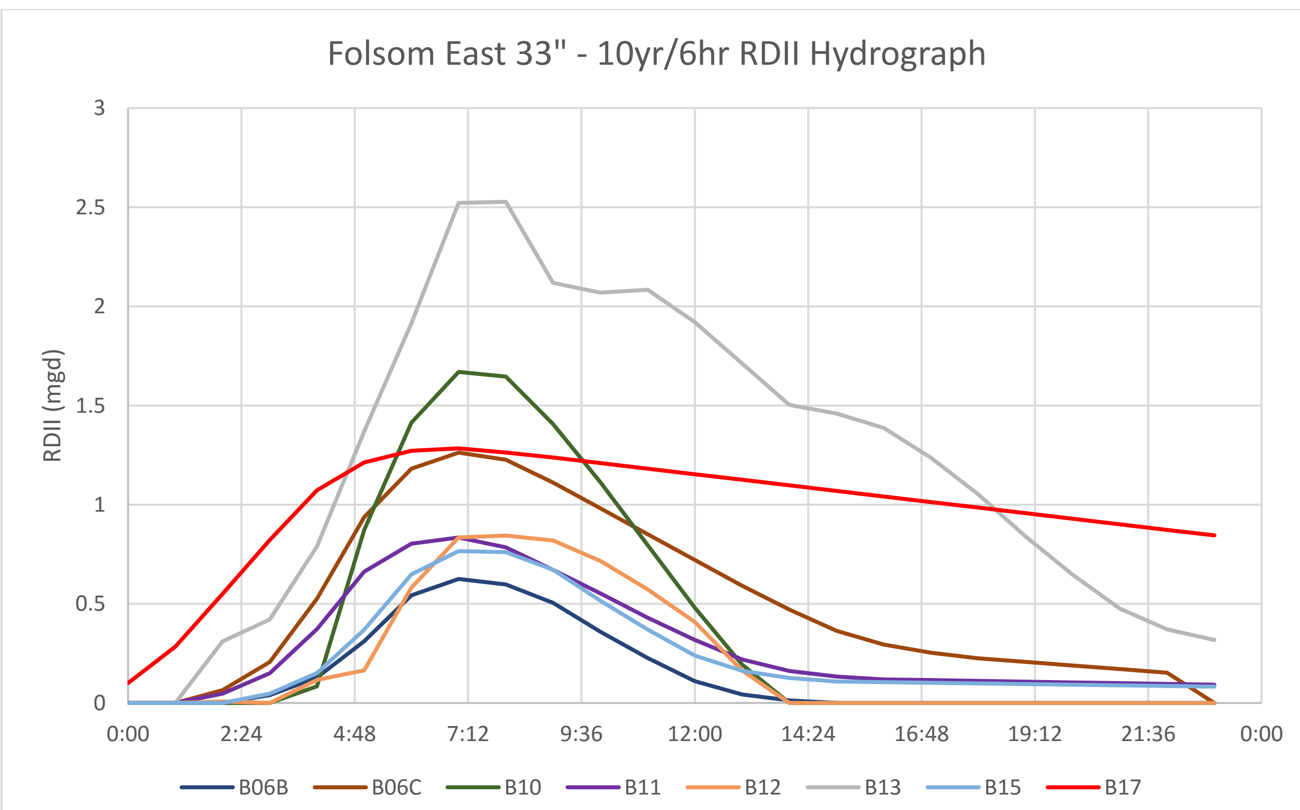
Blue: Rainfall
Green: Observed WWF
Teal: Average DWF

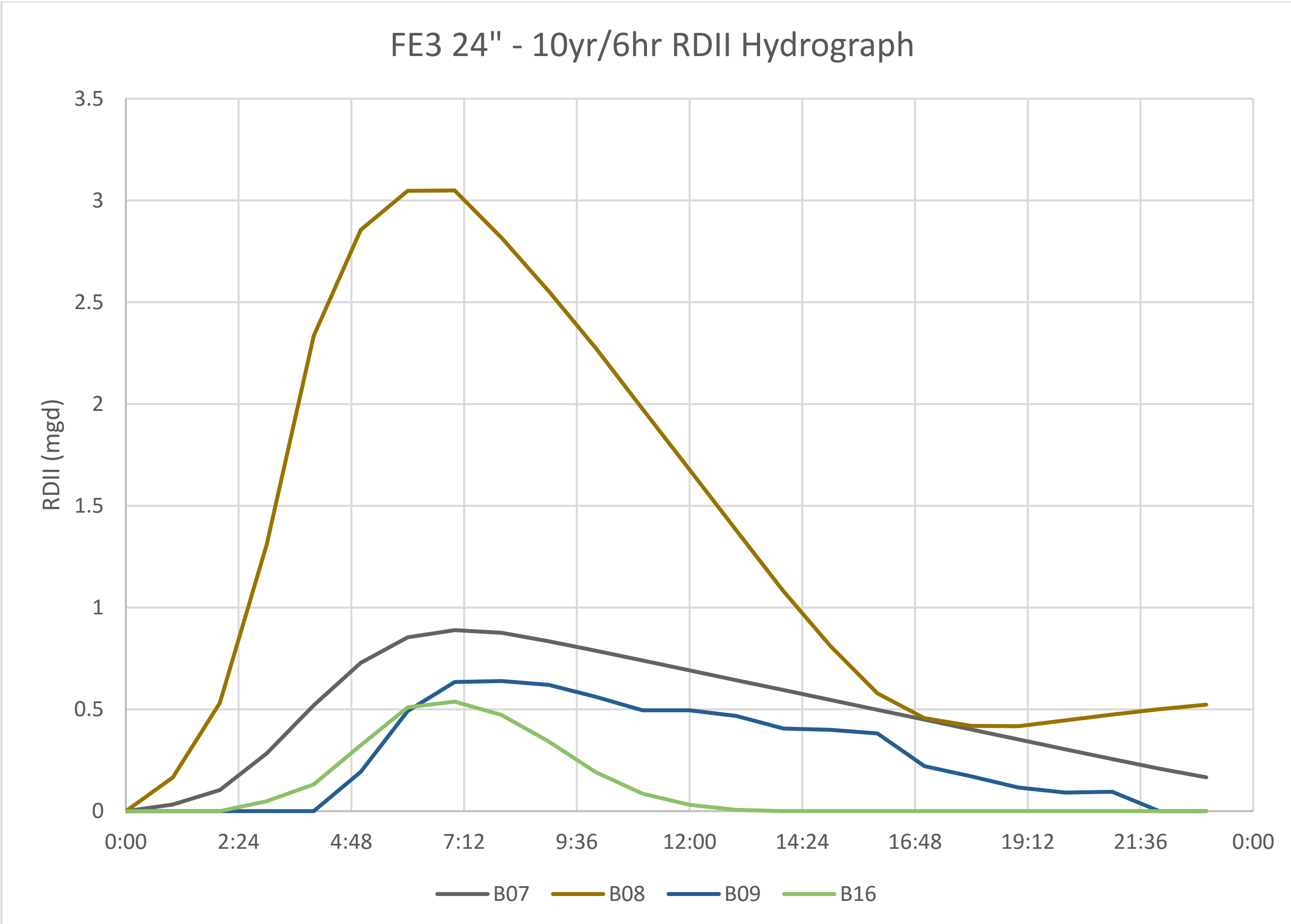


Appendix A.5 RDII Basin Hydrographs

10yr/6hr RDII Hydrograph by Basin

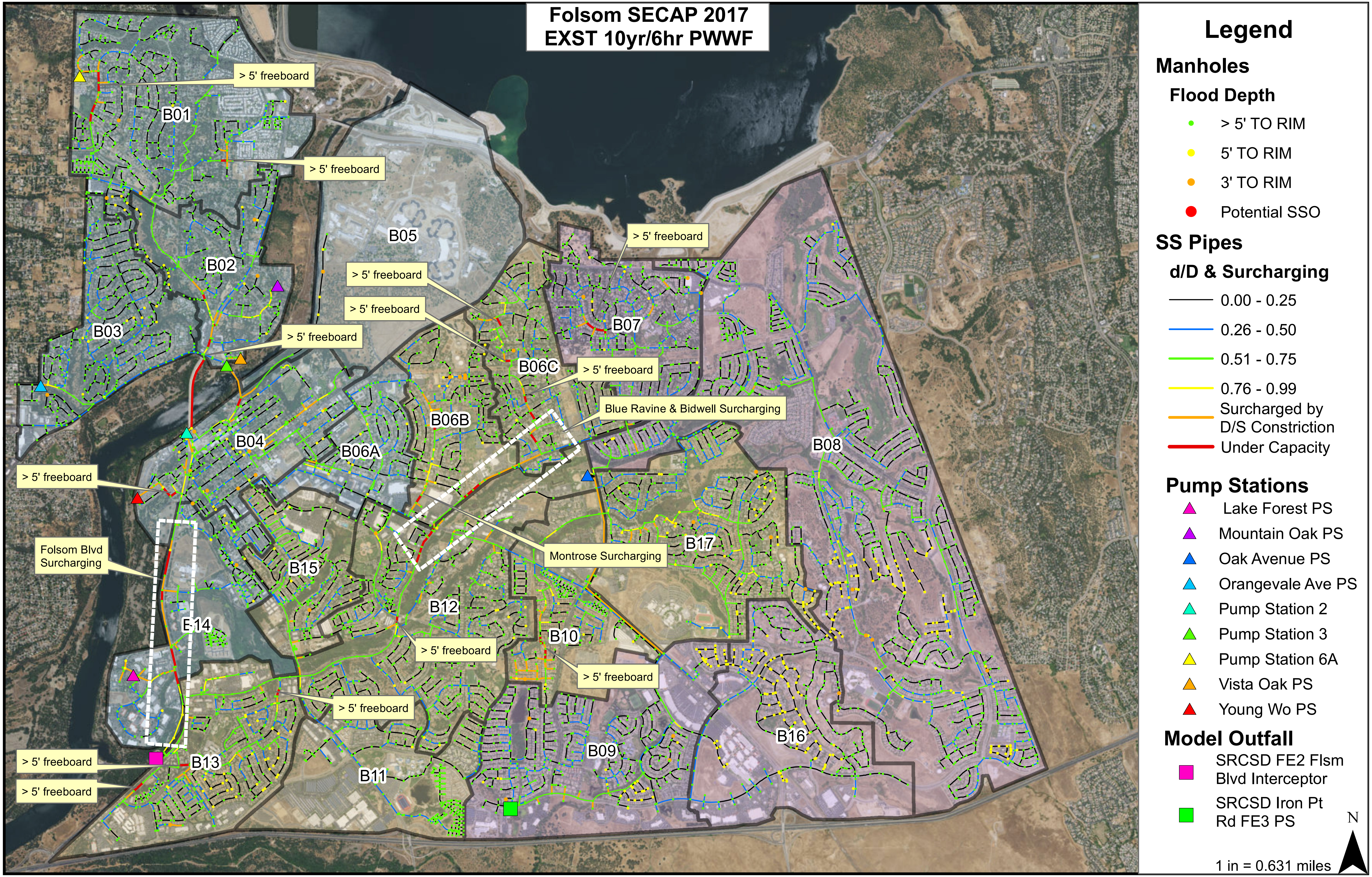




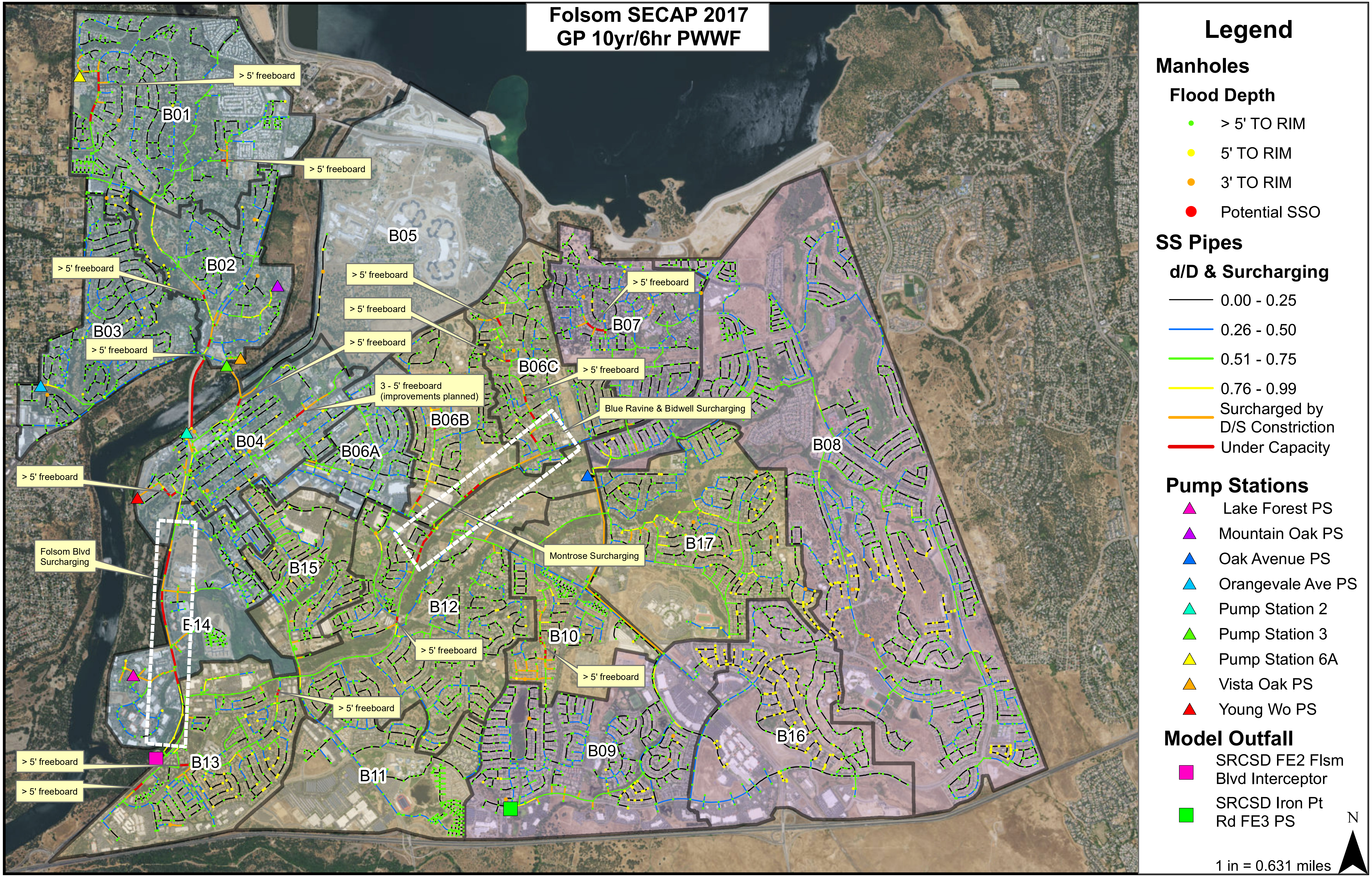


FE3 24" - 10yr/6hr RDII Hydrograph
RDII (mgd)
3.5
3
2.5
2
1.5
1
0.5
0
0:00
2:24
4:48
7:12
9:36
12:00
14:24
16:48
19:12
21:36
0:00
B07
B08
B09
B16

Appendix B.1 10yr/6hr EXST PWWF Results


Folsom SECAP 2017
EXST 10yr/6hr PWWF
B01
B02
B03
B04
B05
B06A
B06B
B06C
B07
B08
B09
B10
B11
B12
B13
B14
B15
B16
B17
> 5' freeboard
Blue Ravine & Bidwell Surcharging
Montrose Surcharging
Folsom Blvd Surcharging
Legend
Manholes
Flood Depth
> 5' TO RIM
5' TO RIM
3' TO RIM
Potential SSO
SS Pipes
d/D & Surcharging
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 0.99
Surcharged by D/S Constriction
Under Capacity
Pump Stations
Lake Forest PS
Mountain Oak PS
Oak Avenue PS
Orangevale Ave PS
Pump Station 2
Pump Station 3
Pump Station 6A
Vista Oak PS
Young Wo PS
Model Outfall
SRCSD FE2 Flsm Blvd Interceptor
SRCSD Iron Pt Rd FE3 PS
N
1 in = 0.631 miles

Appendix B.2 10yr/6hr GP PWWF Results



Folsom SECAP 2017
GP 10yr/6hr PWWF
Legend
Manholes
Flood Depth
> 5' TO RIM
5' TO RIM
3' TO RIM
Potential SSO
SS Pipes
d/D & Surcharging
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 0.99
Surcharged by D/S Constriction
Under Capacity
Pump Stations
Lake Forest PS
Mountain Oak PS
Oak Avenue PS
Orangevale Ave PS
Pump Station 2
Pump Station 3
Pump Station 6A
Vista Oak PS
Young Wo PS
Model Outfall
SRCSD FE2 Flsm Blvd Interceptor
SRCSD Iron Pt Rd FE3 PS
N
1 in = 0.631 miles
B01
B02
B03
B04
B05
B06A
B06B
B06C
B07
B08
B09
B10
B11
B12
B13
B14
B15
B16
B17
> 5' freeboard
3 - 5' freeboard (improvements planned)
Blue Ravine & Bidwell Surcharging
Montrose Surcharging
Folsom Blvd Surcharging

Appendix B.3 10yr/6hr UBO PWWF Results

Folsom SECAP 2017
UBO 10yr/6hr PWWF

Legend

Manholes

Flood Depth

- > 5' TO RIM
- 5' TO RIM
- 3' TO RIM
- Potential SSO

SS Pipes

d/D & Surcharging

- 0.00 - 0.25
- 0.26 - 0.50
- 0.51 - 0.75
- 0.76 - 0.99
- Surcharged by D/S Constriction
- Under Capacity

Pump Stations

- Lake Forest PS
- Mountain Oak PS
- Oak Avenue PS
- Orangevale Ave PS
- Pump Station 2
- Pump Station 3
- Pump Station 6A
- Vista Oak PS
- Young Wo PS

Model Outfall

- SRCSD FE2 Flsm Blvd Interceptor
- SRCSD Iron Pt Rd FE3 PS

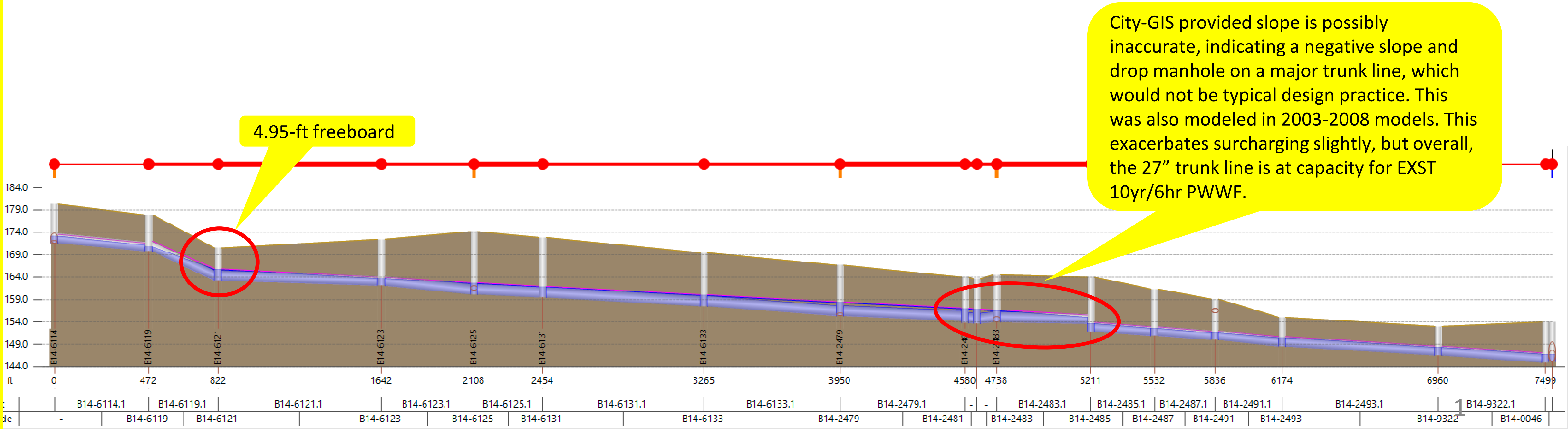
N

1 in = 0.631 miles

Appendix C.1 Long Section/Profile of Concerned Areas

Existing PWWF 10yr/6hr RESULTS

B14: Folsom Blvd 27” trunk profile

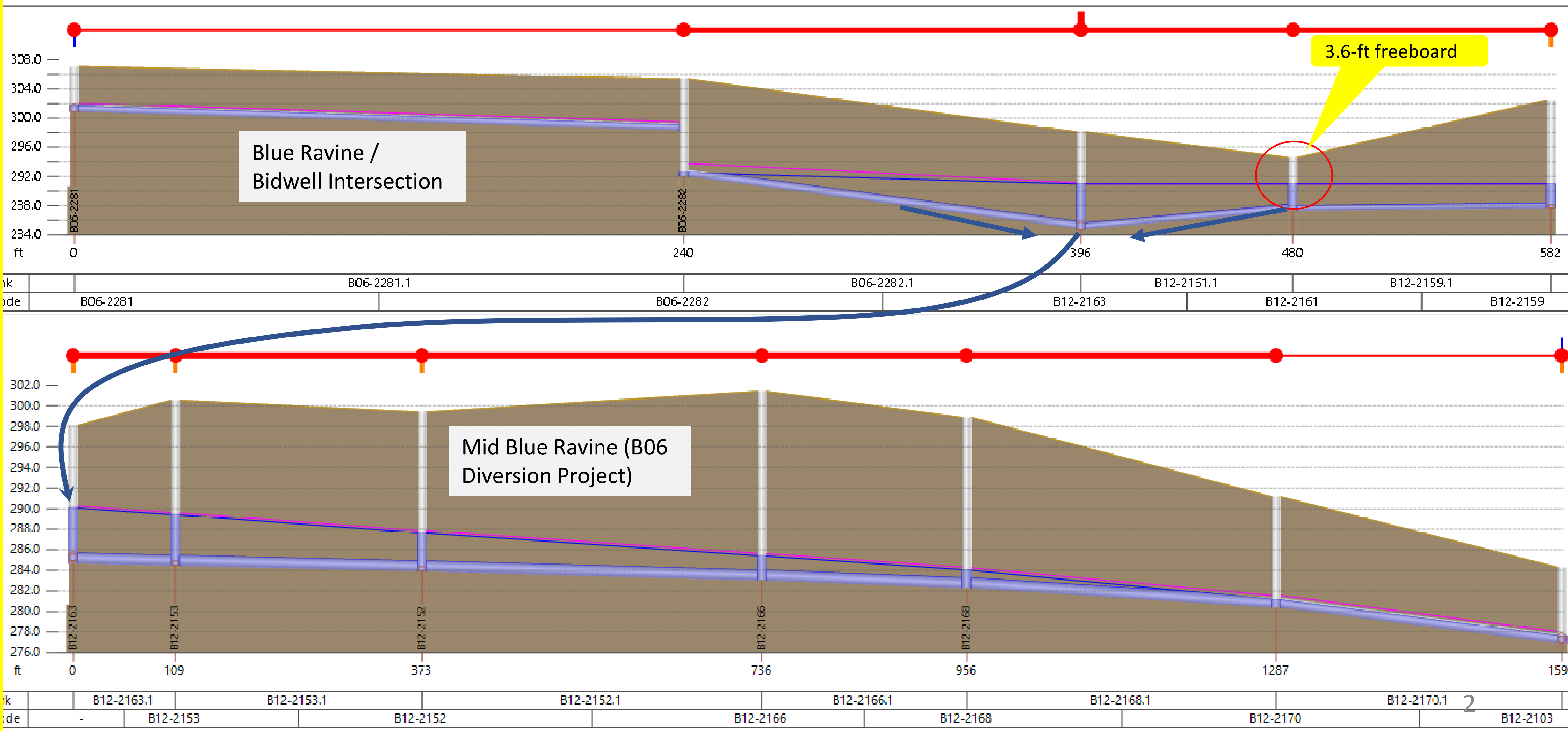


Existing PWWF 10yr/6hr RESULTS

B06C + B06B: Blue Ravine and Bidwell 12” profile

Source of Surcharging Issues

-The Blue Ravine 12” main downstream is under capacity

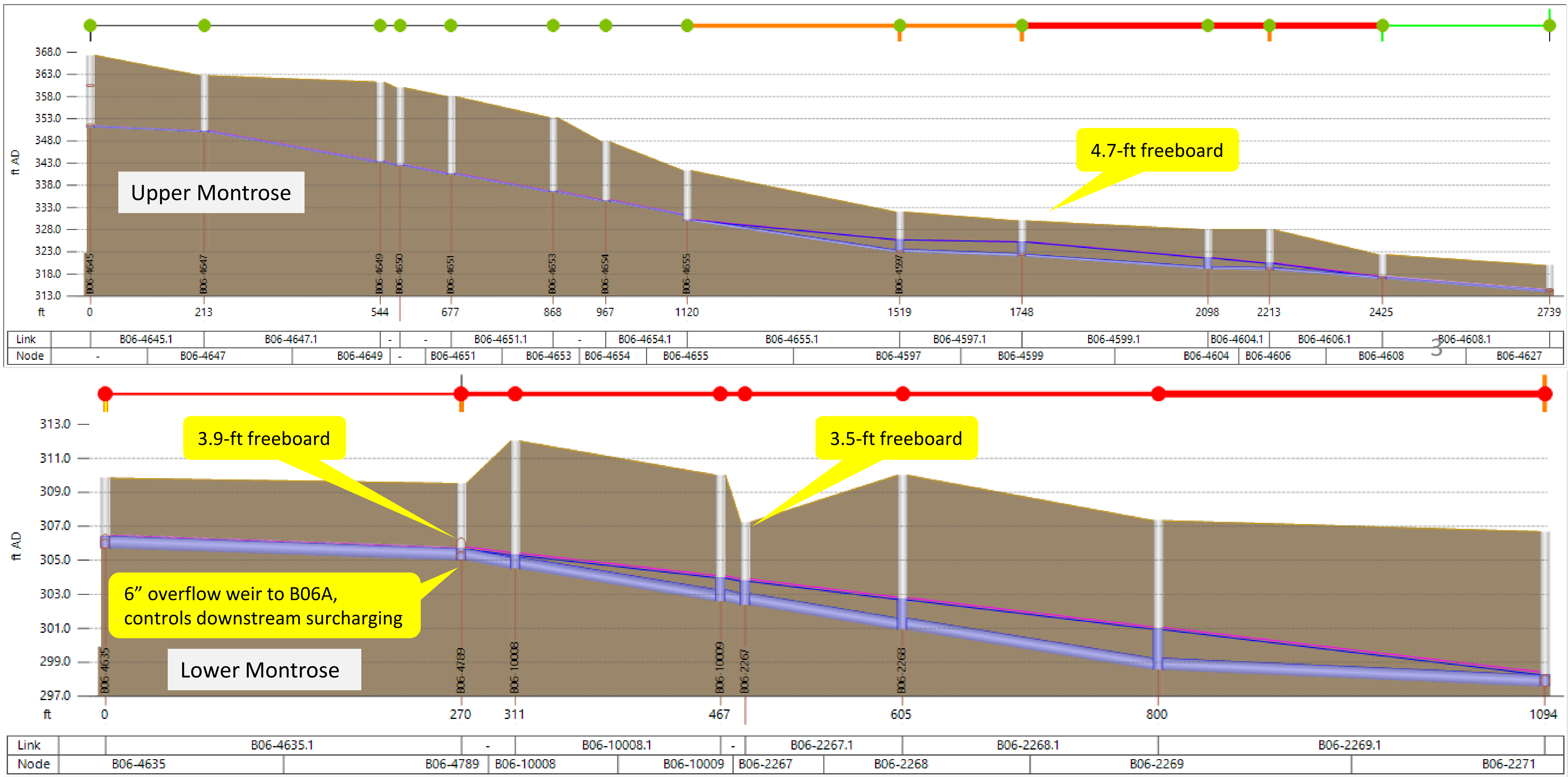


Existing PWWF 10yr/6hr RESULTS

B06B: Montrose 6” and 8” profile

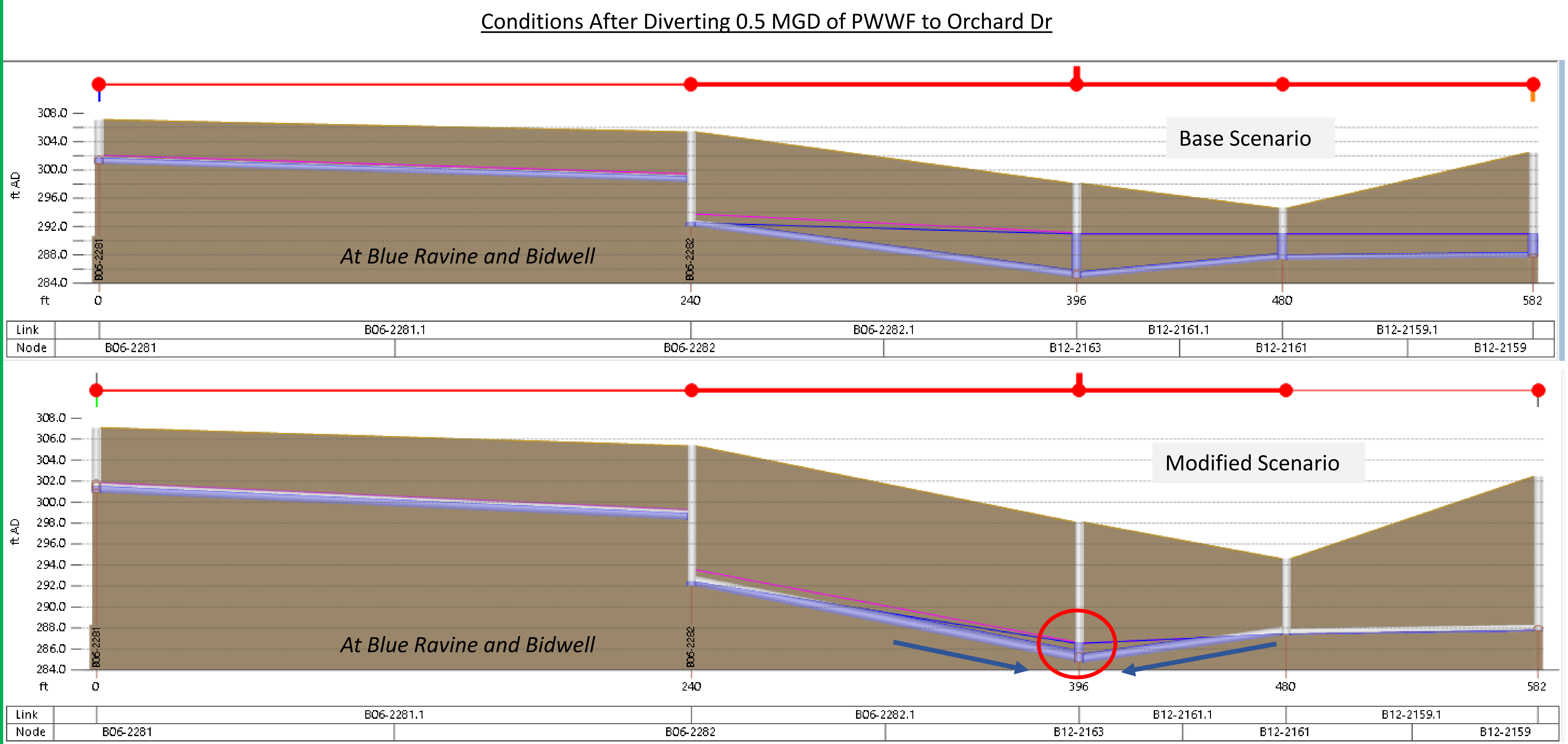
<u>Source of Surcharging Issues</u>

-Upper and lower portions of Montrose 6” and 8” main are under capacity and is backing up flows for several pipe segments.



Existing PWWF 10yr/6hr RECOMMENDED IMPROVEMENTS

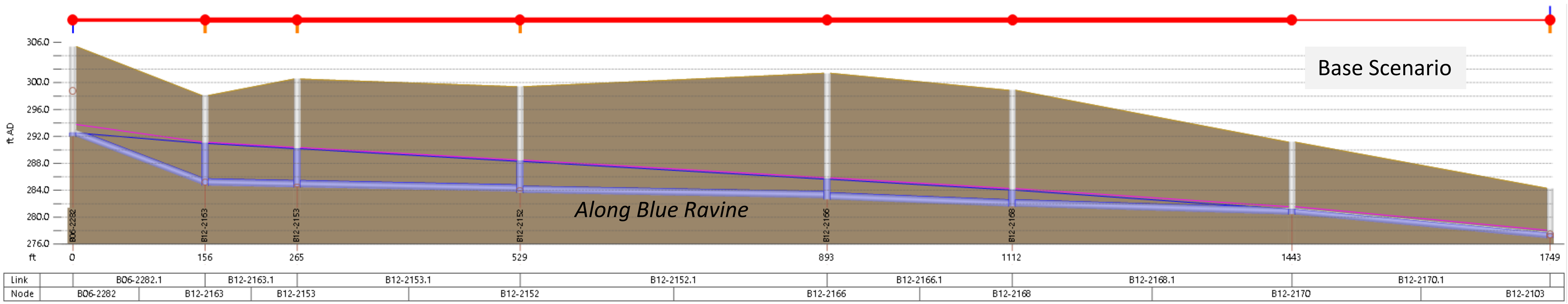
B06C + B06B: Blue Ravine and Bidwell 12" profile after CIP (0.5 mgd Diversion)

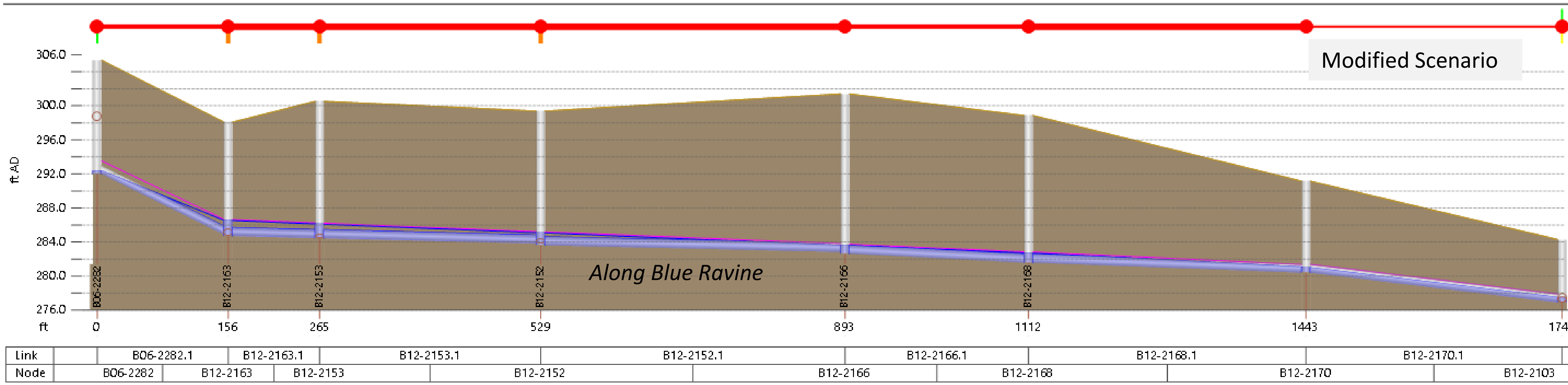


Existing PWWF 10yr/6hr RECOMMENDED IMPROVEMENTS

B06C + B06B: Blue Ravine and Bidwell 12” profile after CIP (0.5 mgd Diversion)

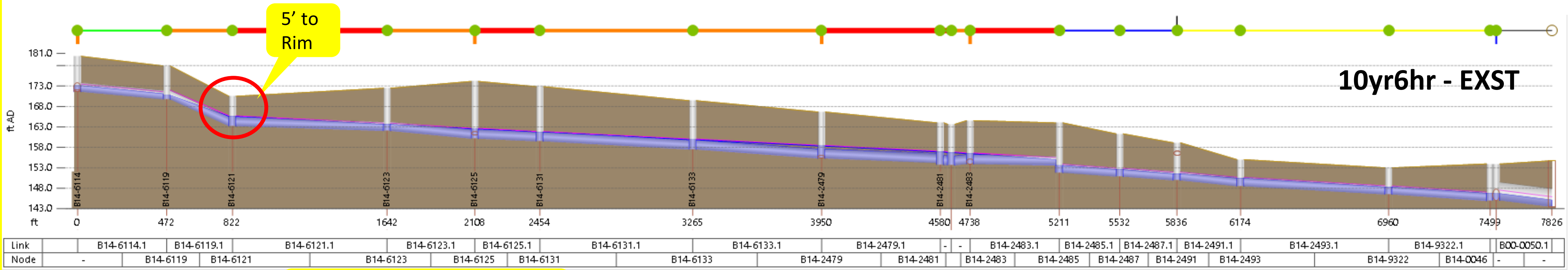
Conditions After Diverting 0.5 MGD of PWWF to Orchard Dr

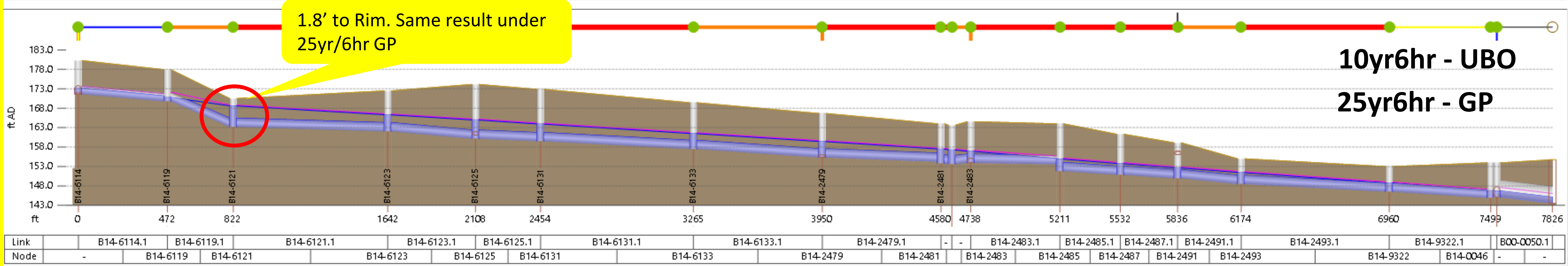


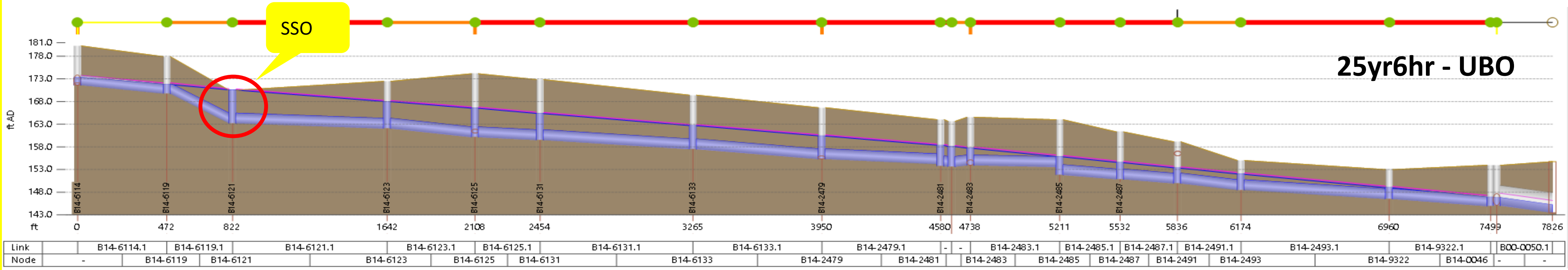


Appendix C.2 Long Section/Profile of Folsom Blvd 27” Trunk under Sensitivity Analysis

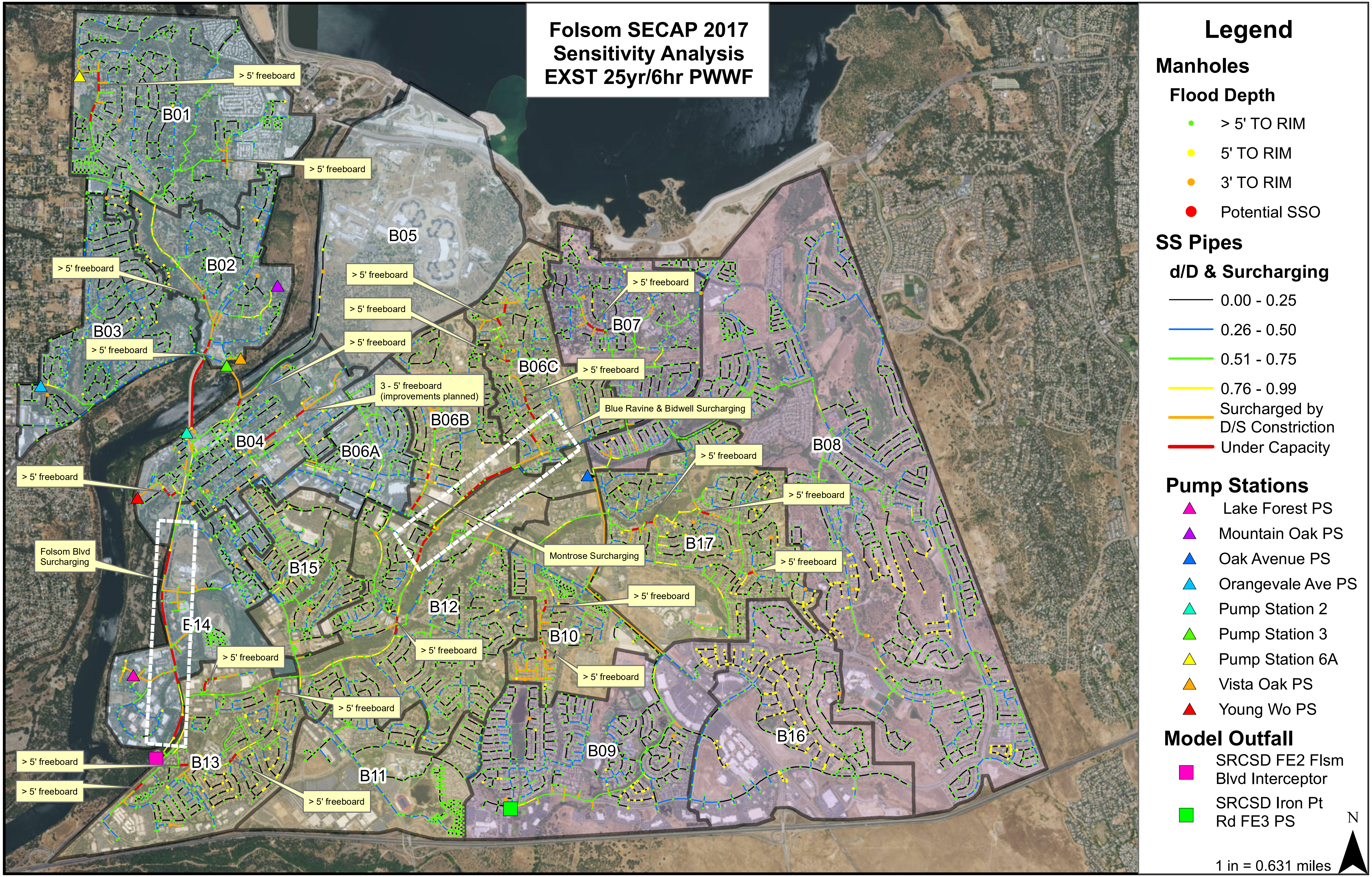
B14: Folsom Blvd: Surcharging (27” trunk)





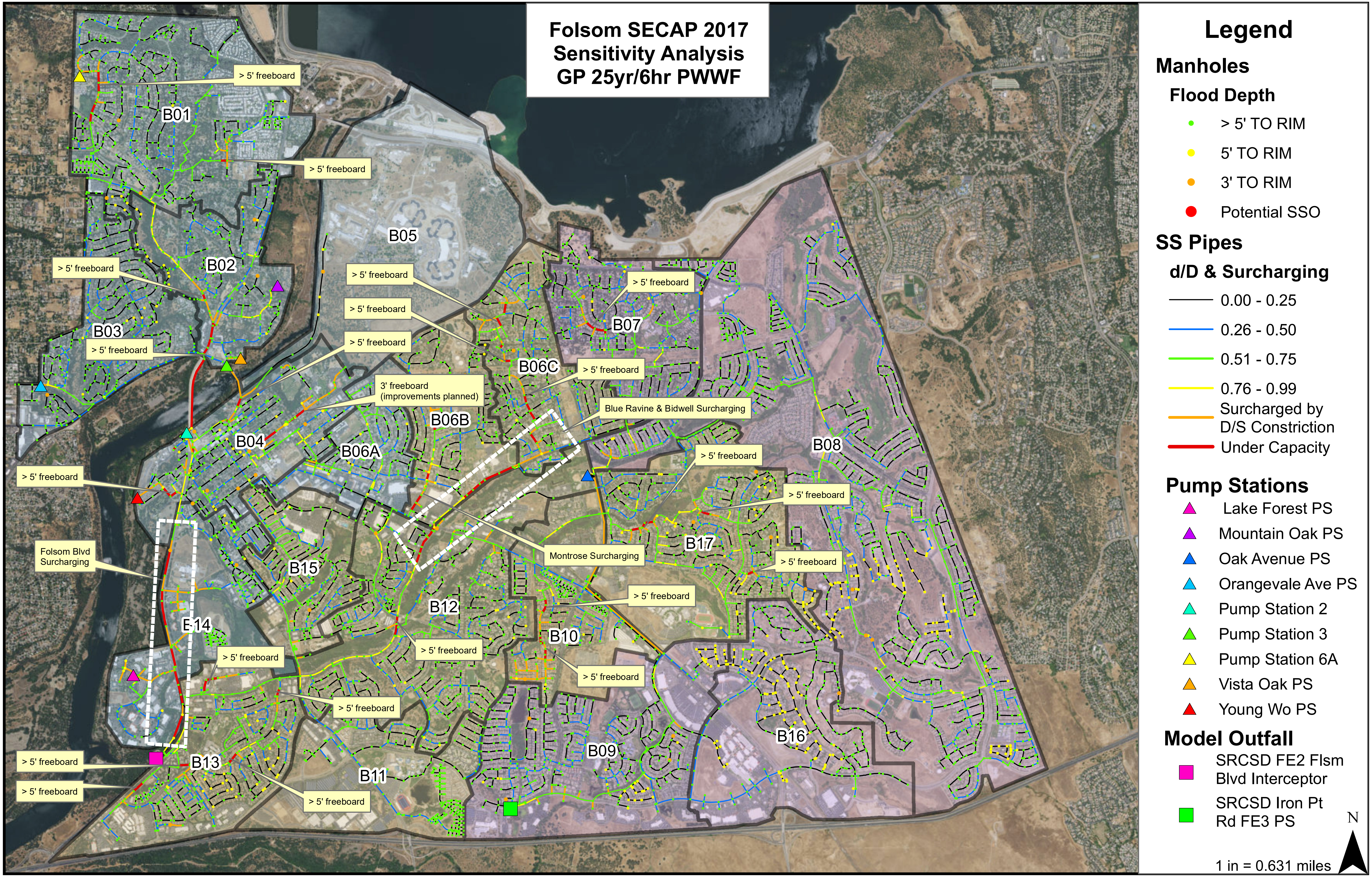


Appendix C.3 Sensitivity Analysis: 25yr/6hr EXST PWWF Results



Folsom SECAP 2017
Sensitivity Analysis
EXST 25yr/6hr PWWF
Legend
Manholes
Flood Depth
> 5' TO RIM
5' TO RIM
3' TO RIM
Potential SSO
SS Pipes
d/D & Surcharging
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 0.99
Surcharged by D/S Constriction
Under Capacity
Pump Stations
Lake Forest PS
Mountain Oak PS
Oak Avenue PS
Orangevale Ave PS
Pump Station 2
Pump Station 3
Pump Station 6A
Vista Oak PS
Young Wo PS
Model Outfall
SRCSD FE2 Flsm Blvd Interceptor
SRCSD Iron Pt Rd FE3 PS
N
1 in = 0.631 miles
B01
B02
B03
B04
B05
B06A
B06B
B06C
B07
B08
B09
B10
B11
B12
B13
B14
B15
B16
B17
> 5' freeboard
3 - 5' freeboard (improvements planned)
Blue Ravine & Bidwell Surcharging
Montrose Surcharging
Folsom Blvd Surcharging

Appendix C.4 Sensitivity Analysis: 25yr/6hr GP PWWF Results


Folsom SECAP 2017
Sensitivity Analysis
GP 25yr/6hr PWWF
Legend
Manholes
Flood Depth
> 5' TO RIM
5' TO RIM
3' TO RIM
Potential SSO
SS Pipes
d/D & Surcharging
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 0.99
Surcharged by D/S Constriction
Under Capacity
Pump Stations
Lake Forest PS
Mountain Oak PS
Oak Avenue PS
Orangevale Ave PS
Pump Station 2
Pump Station 3
Pump Station 6A
Vista Oak PS
Young Wo PS
Model Outfall
SRCSD FE2 Flsm Blvd Interceptor
SRCSD Iron Pt Rd FE3 PS
N
1 in = 0.631 miles
B01
B02
B03
B04
B05
B06A
B06B
B06C
B07
B08
B09
B10
B11
B12
B13
B14
B15
B16
B17
> 5' freeboard
3' freeboard (improvements planned)
Blue Ravine & Bidwell Surcharging
Montrose Surcharging
Folsom Blvd Surcharging

Appendix C.5 Sensitivity Analysis: 25yr/6hr UBO PWWF Results

Folsom SECAP 2017 Sensitivity Analysis UBO 25yr/6hr PWWF

Legend

Manholes

Flood Depth

- > 5' TO RIM
- 5' TO RIM
- 3' TO RIM
- Potential SSO

SS Pipes

d/D & Surcharging

- 0.00 - 0.25
- 0.26 - 0.50
- 0.51 - 0.75
- 0.76 - 0.99
- Surcharged by D/S Constriction
- Under Capacity

Pump Stations

- Lake Forest PS
- Mountain Oak PS
- Oak Avenue PS
- Orangevale Ave PS
- Pump Station 2
- Pump Station 3
- Pump Station 6A
- Vista Oak PS
- Young Wo PS

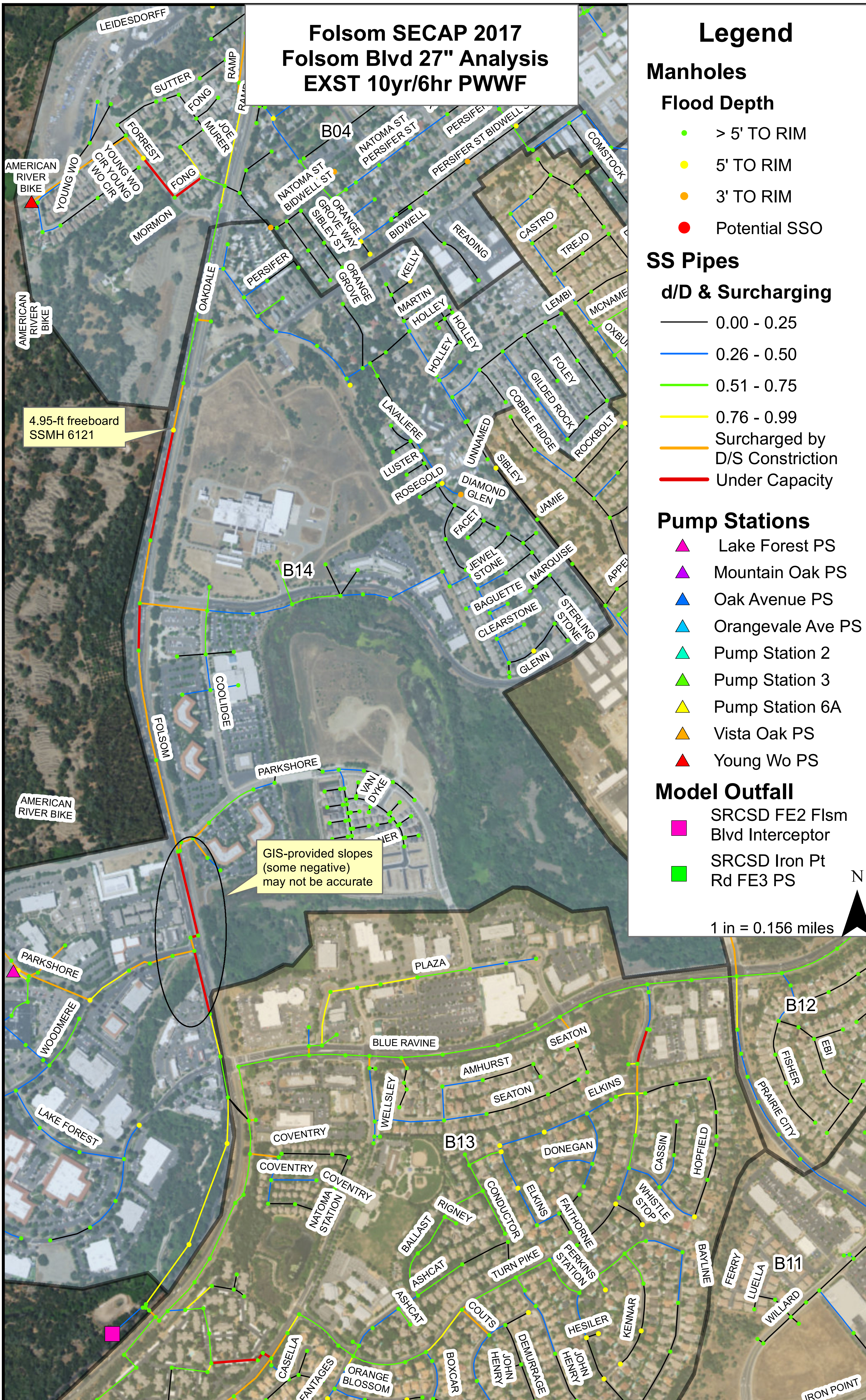
Model Outfall

- SRCSD FE2 Flsm Blvd Interceptor
- SRCSD Iron Pt Rd FE3 PS

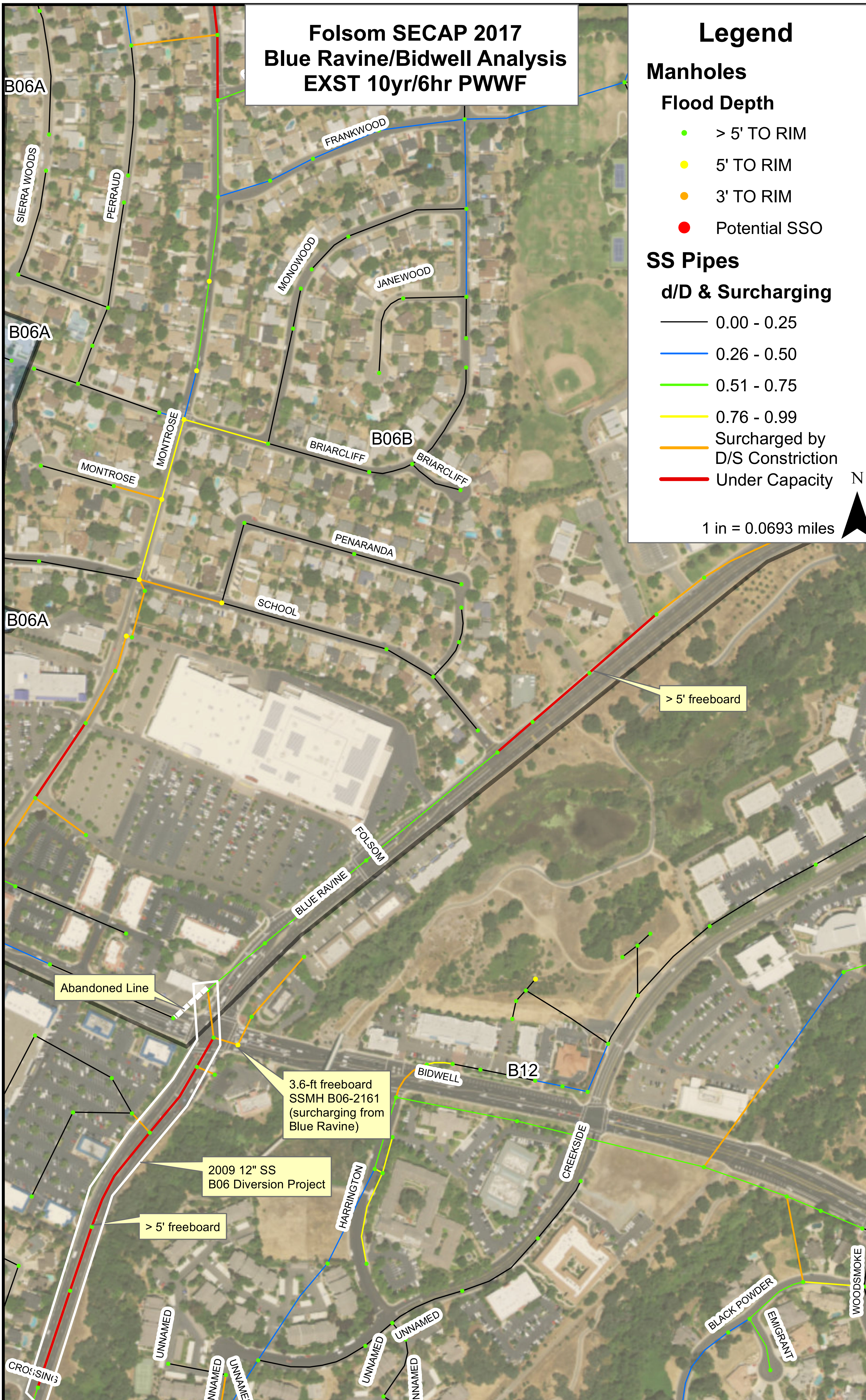
N

1 in = 0.631 miles

Appendix C.6 Area of Concern: Folsom Blvd 27" Area


Folsom SECAP 2017
Folsom Blvd 27" Analysis
EXST 10yr/6hr PWWF
Legend
Manholes
Flood Depth
> 5' TO RIM
5' TO RIM
3' TO RIM
Potential SSO
SS Pipes
d/D & Surcharging
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 0.99
Surcharged by D/S Constriction
Under Capacity
Pump Stations
Lake Forest PS
Mountain Oak PS
Oak Avenue PS
Orangevale Ave PS
Pump Station 2
Pump Station 3
Pump Station 6A
Vista Oak PS
Young Wo PS
Model Outfall
SRCSD FE2 Flsm Blvd Interceptor
SRCSD Iron Pt Rd FE3 PS
N
1 in = 0.156 miles
4.95-ft freeboard SSMH 6121
GIS-provided slopes (some negative) may not be accurate
B04
B14
B13
B12
B11

Appendix C.7 Area of Concern: Bidwell and Blue Ravine 12" Area

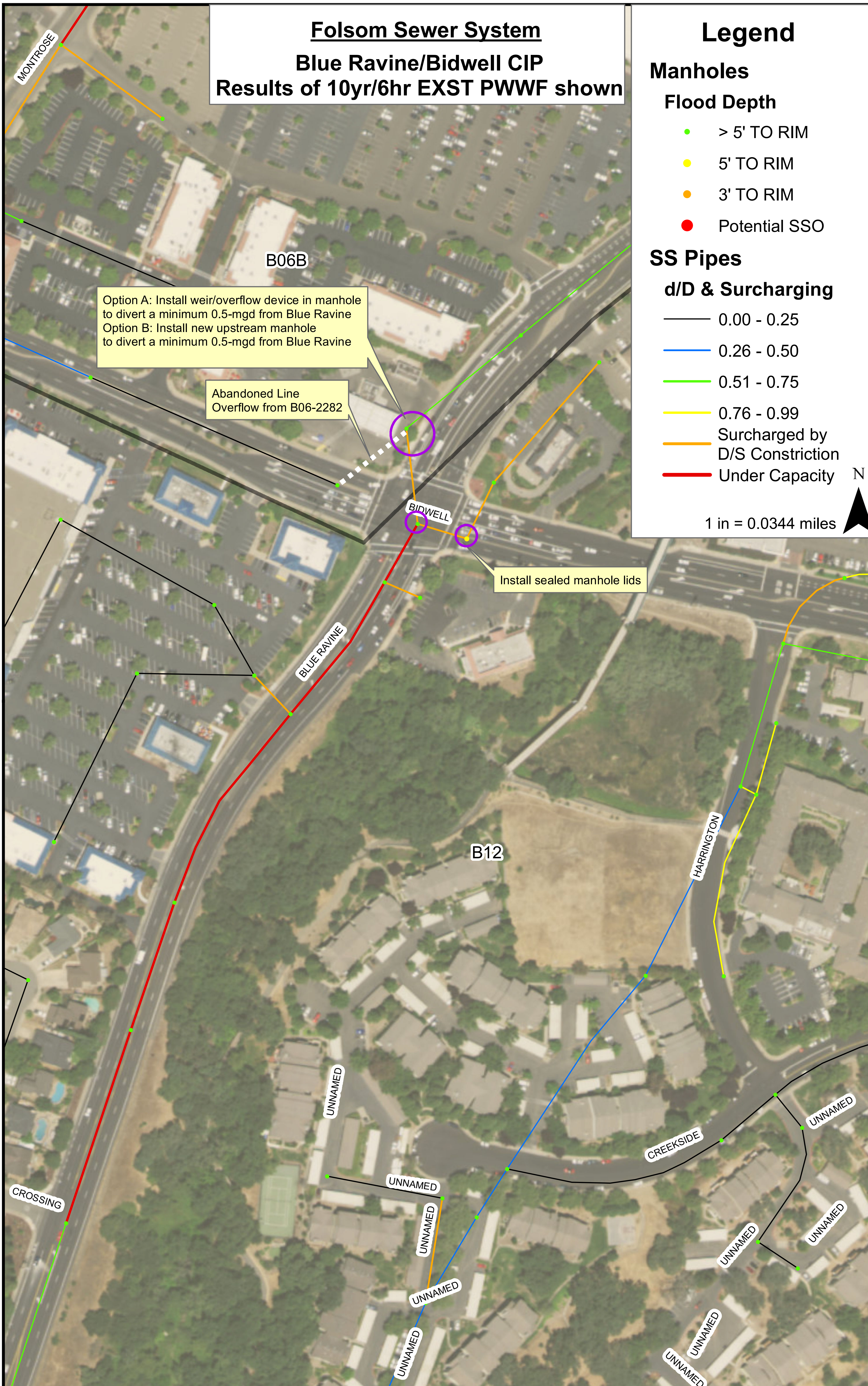


Folsom SECAP 2017
Blue Ravine/Bidwell Analysis
EXST 10yr/6hr PWWF
Legend
Manholes
Flood Depth
> 5' TO RIM
5' TO RIM
3' TO RIM
Potential SSO
SS Pipes
d/D & Surcharging
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 0.99
Surcharged by D/S Constriction
Under Capacity
N
1 in = 0.0693 miles
B06A
B06B
B12
SIERRA WOODS
PERRAUD
FRANKWOOD
MONOWOOD
JANEWOOD
MONTROSE
BRIARCLIFF
PENARANDA
SCHOOL
FOLSOM
BLUE RAVINE
BIDWELL
CREEKSIDE
HARRINGTON
UNNAMED
CROSSING
BLACK POWDER
EMIGRANT
WOODSMOKE
> 5' freeboard
Abandoned Line
3.6-ft freeboard SSMH B06-2161 (surcharging from Blue Ravine)
2009 12" SS B06 Diversion Project
> 5' freeboard

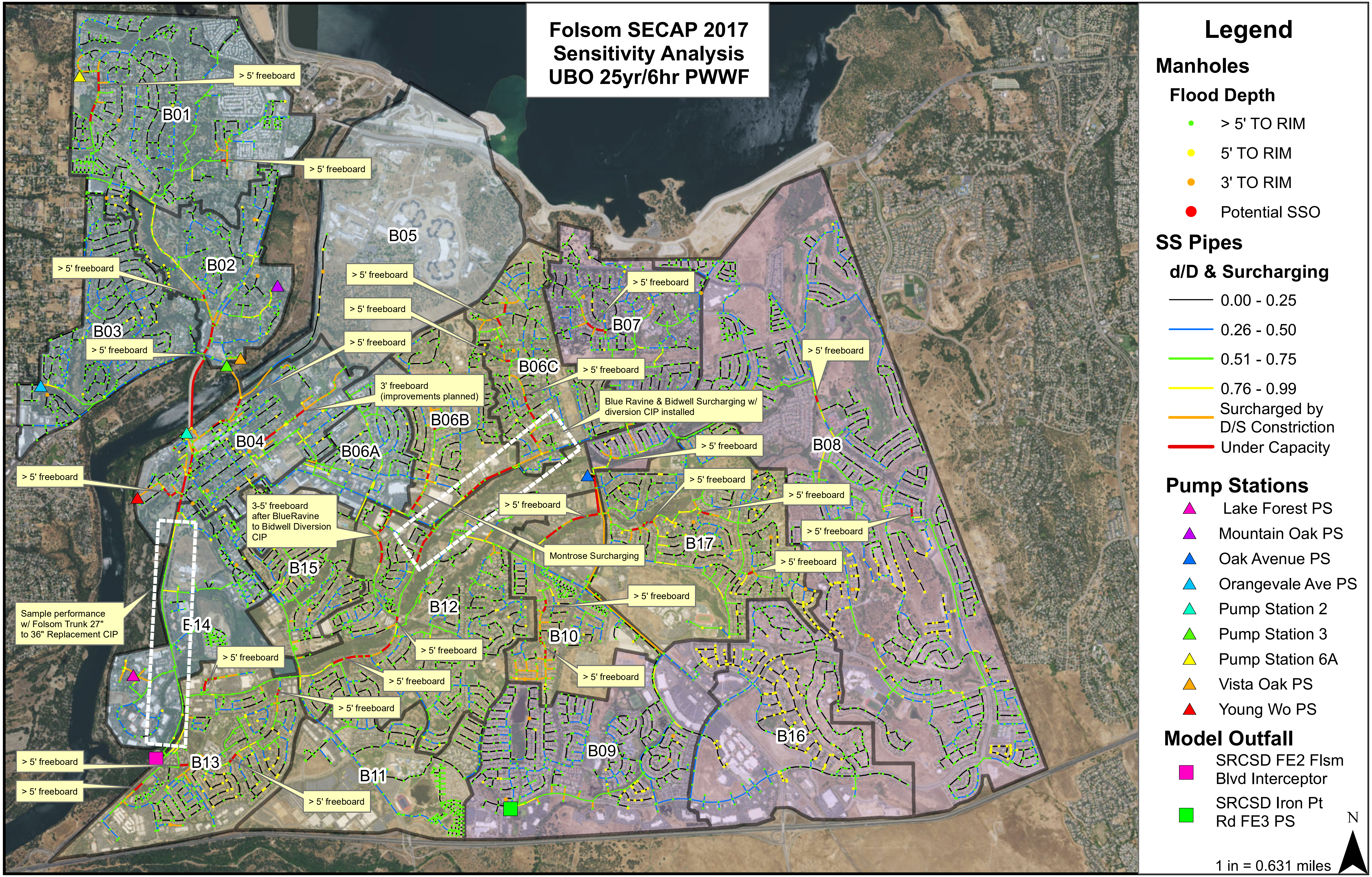
Appendix C.8 Area of Concern: Montrose and School 6" Area


Folsom Sewer System
Montrose/School Analysis
Results of 10yr/6hr EXST PWWF shown
Legend
Manholes
Flood Depth
> 5' TO RIM
5' TO RIM
3' TO RIM
Potential SSO
SS Pipes
d/D & Surcharging
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 0.99
Surcharged by D/S Constriction
Under Capacity
N
1 in = 0.0631 miles
B06A
B06A
B06B
B12
ALEZANE
TALISMAN
LISAWOOD
PERRAUD
SIERRA WOODS
RUGOSA
WILLOWMERE
FRANKWOOD
MONOWOOD
JANEWOOD
MONTROSE
CORALIE
GRENOBLE
BRIARCLIFF
BRIARCLIFF
MONTROSE
PENARANDA
SCHOOL
BLUE RAVINE
FOLSOM
BIDWELL
4.7-ft freeboard (EXST 10yr/6hr)
2.7-ft freeboard (UBO 25yr/6hr)
4.4-ft freeboard (EXST 10yr/6hr)
4.3-ft freeboard (UBO 25yr/6hr)
3.5-ft freeboard (EXST 10yr/6hr)
3.2-ft freeboard (UBO 25yr/6hr)
6" overflow weir to B06A
controls D/S surcharging
3.8-ft freeboard (EXST 10yr/6hr)
3.6-ft freeboard (UBO 25yr/6hr)
3.5-ft freeboard (EXST 10yr/6hr)
3.4-ft freeboard (UBO 25yr/6hr)
> 5-ft freeboard

Appendix C.9 Bidwell and Blue Ravine Improvements


Folsom Sewer System
Blue Ravine/Bidwell CIP
Results of 10yr/6hr EXST PWWF shown
Legend
Manholes
Flood Depth
> 5' TO RIM
5' TO RIM
3' TO RIM
Potential SSO
SS Pipes
d/D & Surcharging
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 0.99
Surcharged by D/S Constriction
Under Capacity
N
1 in = 0.0344 miles
Option A: Install weir/overflow device in manhole to divert a minimum 0.5-mgd from Blue Ravine
Option B: Install new upstream manhole to divert a minimum 0.5-mgd from Blue Ravine
Abandoned Line Overflow from B06-2282
Install sealed manhole lids
B06B
B12
MONTROSE
BIDWELL
BLUE RAVINE
HARRINGTON
CREEKSIDE
CROSSING
UNNAMED

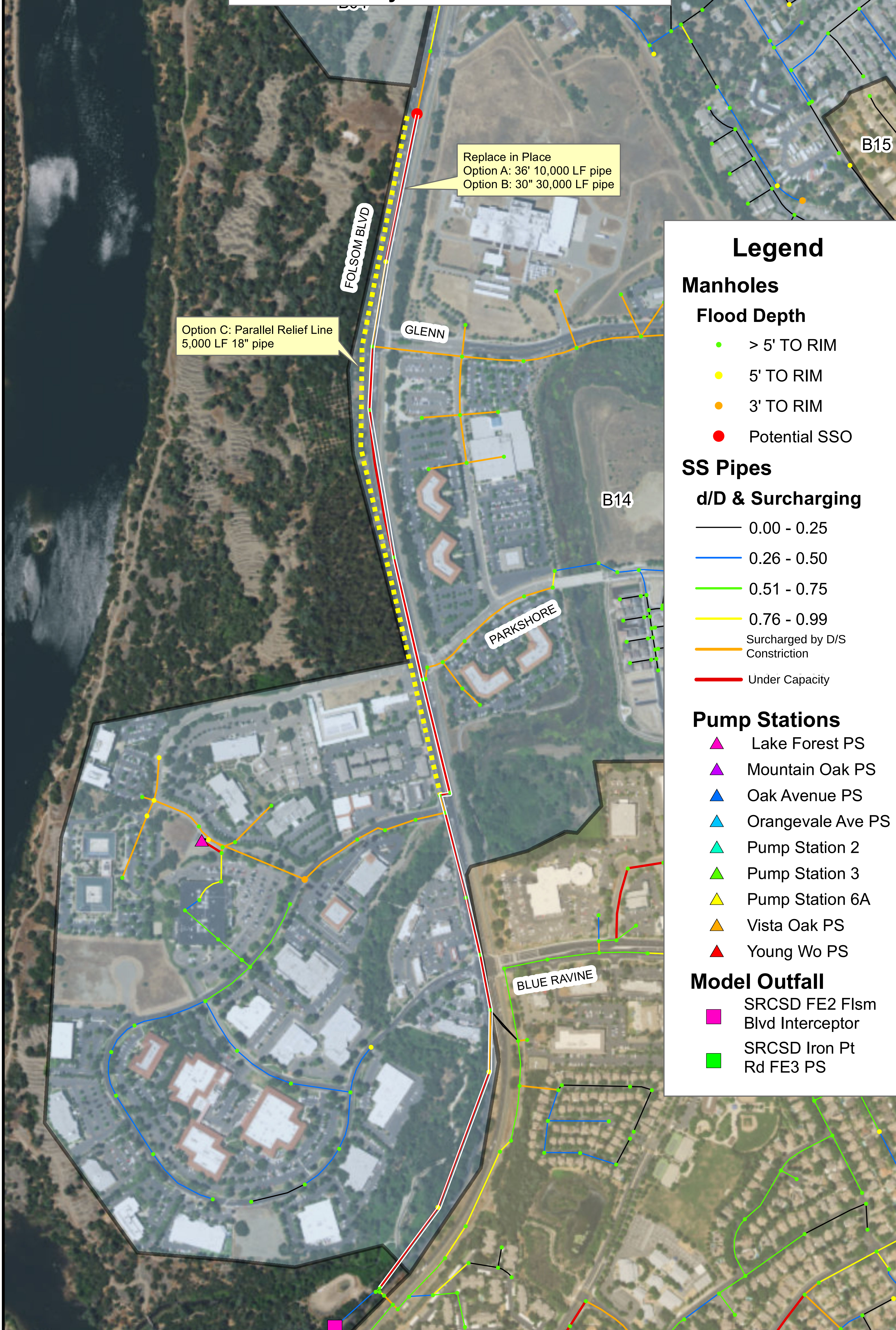
Appendix D.1 25yr/6hr UBO PWWF with CIPs Results



Folsom SECAP 2017
Sensitivity Analysis
UBO 25yr/6hr PWWF
B01
B02
B03
B04
B05
B06A
B06B
B06C
B07
B08
B09
B10
B11
B12
B13
B14
B15
B16
B17
> 5' freeboard
3' freeboard (improvements planned)
Blue Ravine & Bidwell Surcharging w/ diversion CIP installed
3-5' freeboard after BlueRavine to Bidwell Diversion CIP
Montrose Surcharging
Sample performance w/ Folsom Trunk 27" to 36" Replacement CIP
Legend
Manholes
Flood Depth
> 5' TO RIM
5' TO RIM
3' TO RIM
Potential SSO
SS Pipes
d/D & Surcharging
0.00 - 0.25
0.26 - 0.50
0.51 - 0.75
0.76 - 0.99
Surcharged by D/S Constriction
Under Capacity
Pump Stations
Lake Forest PS
Mountain Oak PS
Oak Avenue PS
Orangevale Ave PS
Pump Station 2
Pump Station 3
Pump Station 6A
Vista Oak PS
Young Wo PS
Model Outfall
SRCSD FE2 Flsm Blvd Interceptor
SRCSD Iron Pt Rd FE3 PS
N
1 in = 0.631 miles

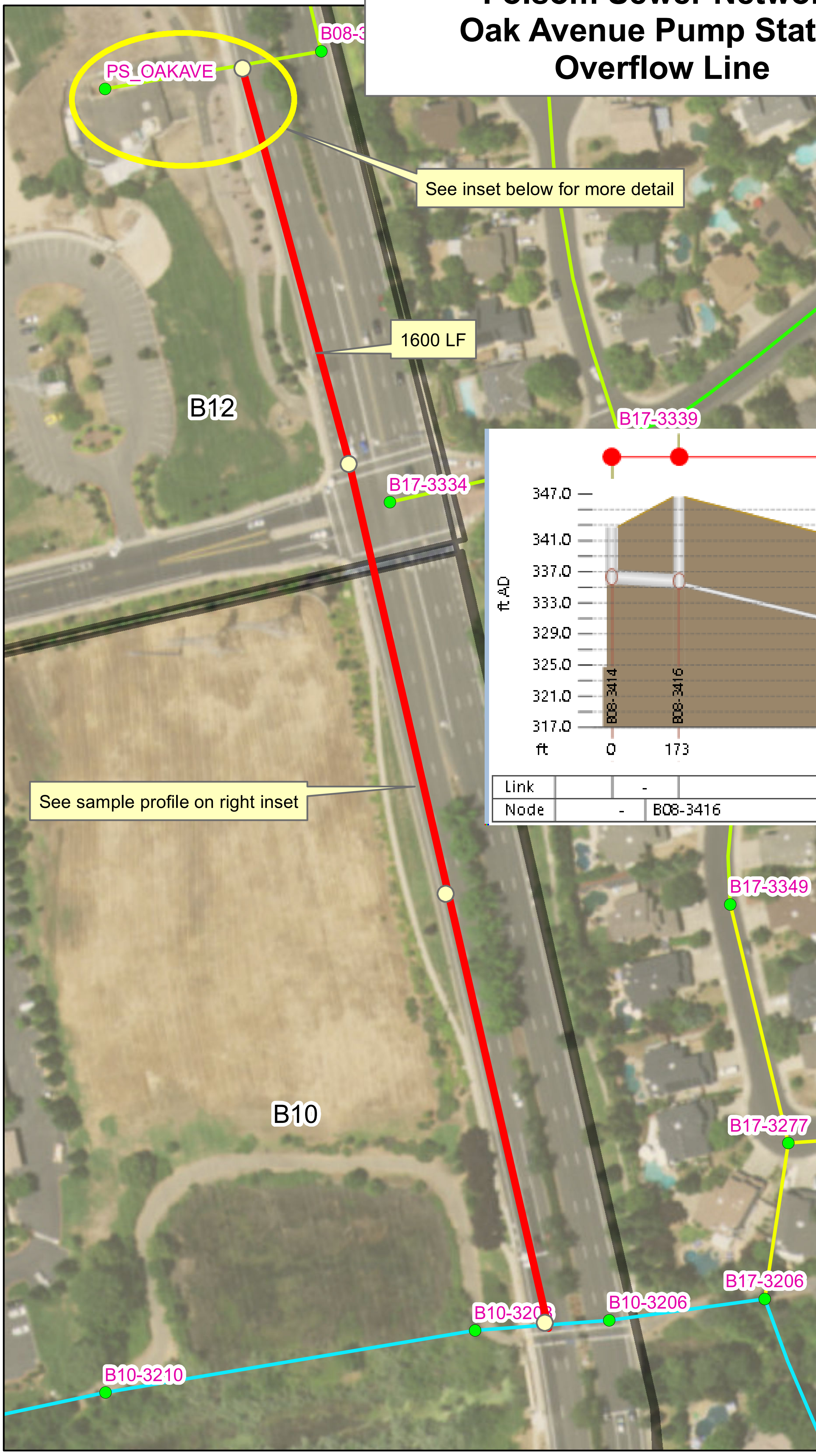
Appendix D.2 Folsom Blvd 27” CIP Plan

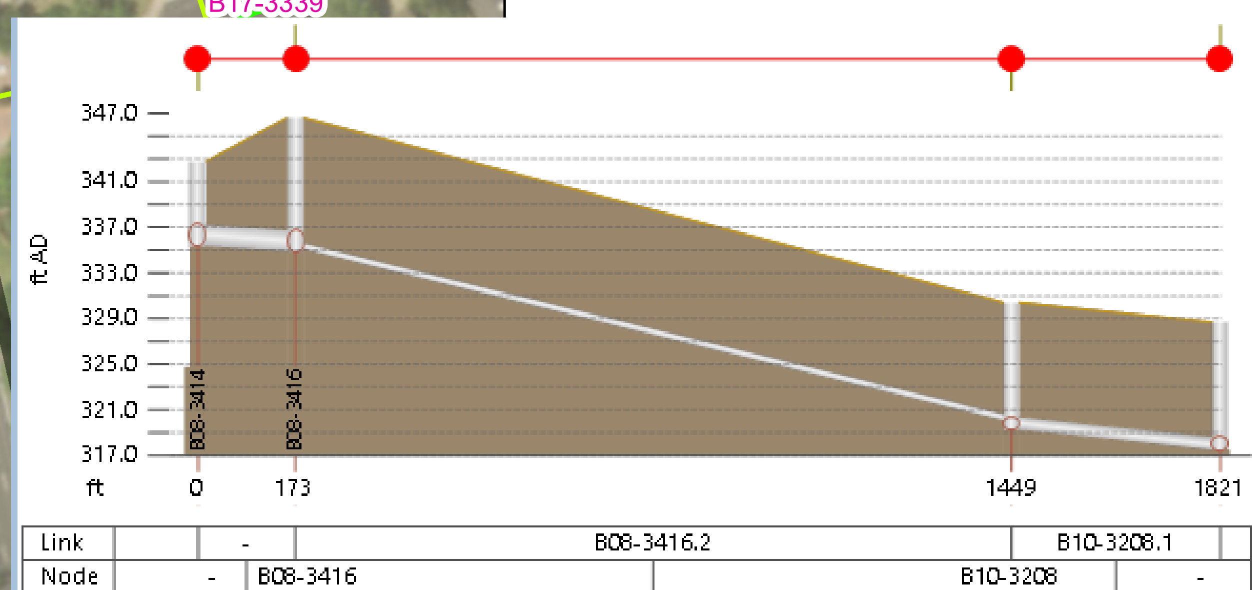
Folsom Sewer System
Folsom Blvd 27" Trunk Mitigation CIPs
Results of 25yr/6hr UBO PWWF Shown

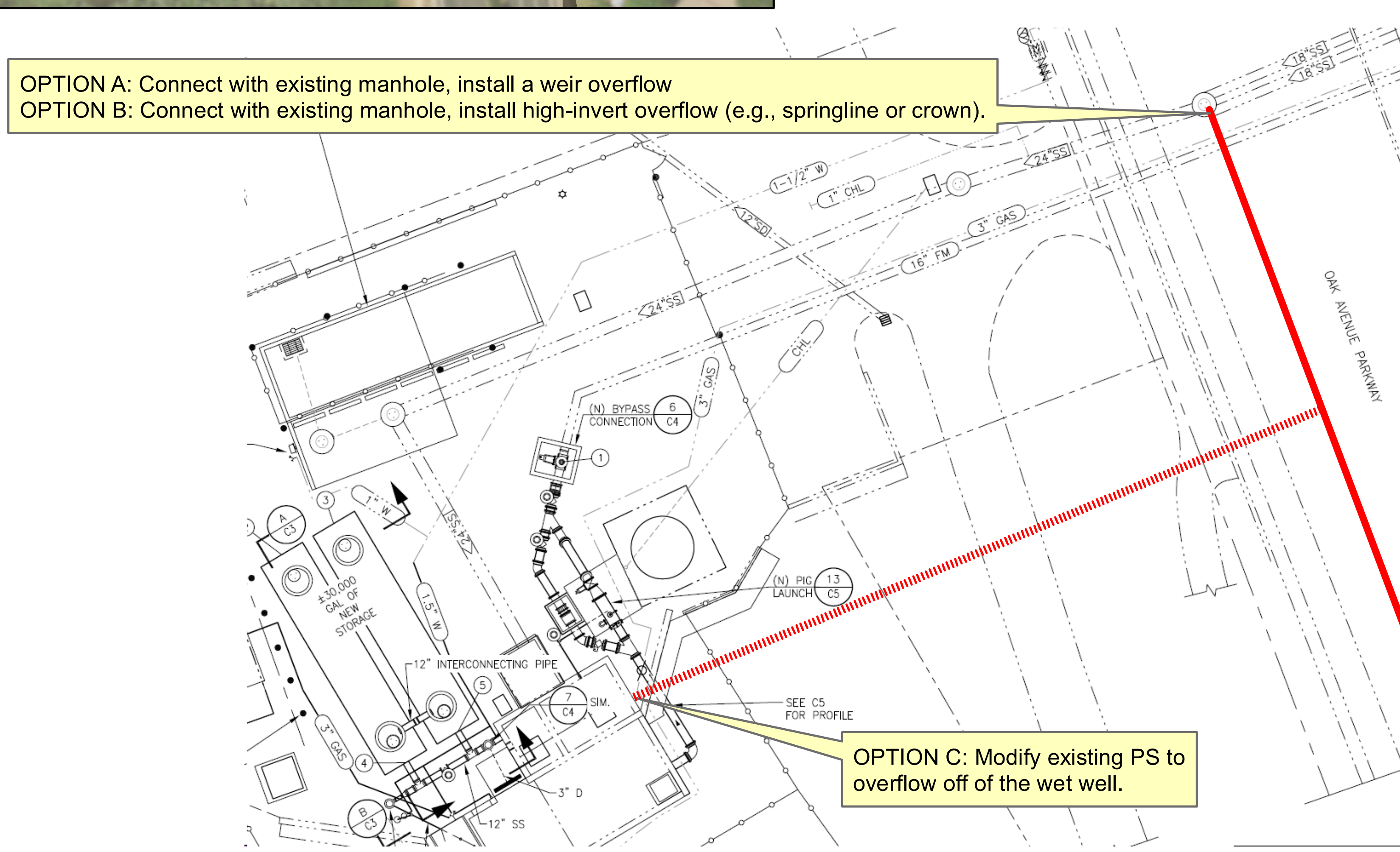


Appendix D.3 Oak Ave PS Relief Plan

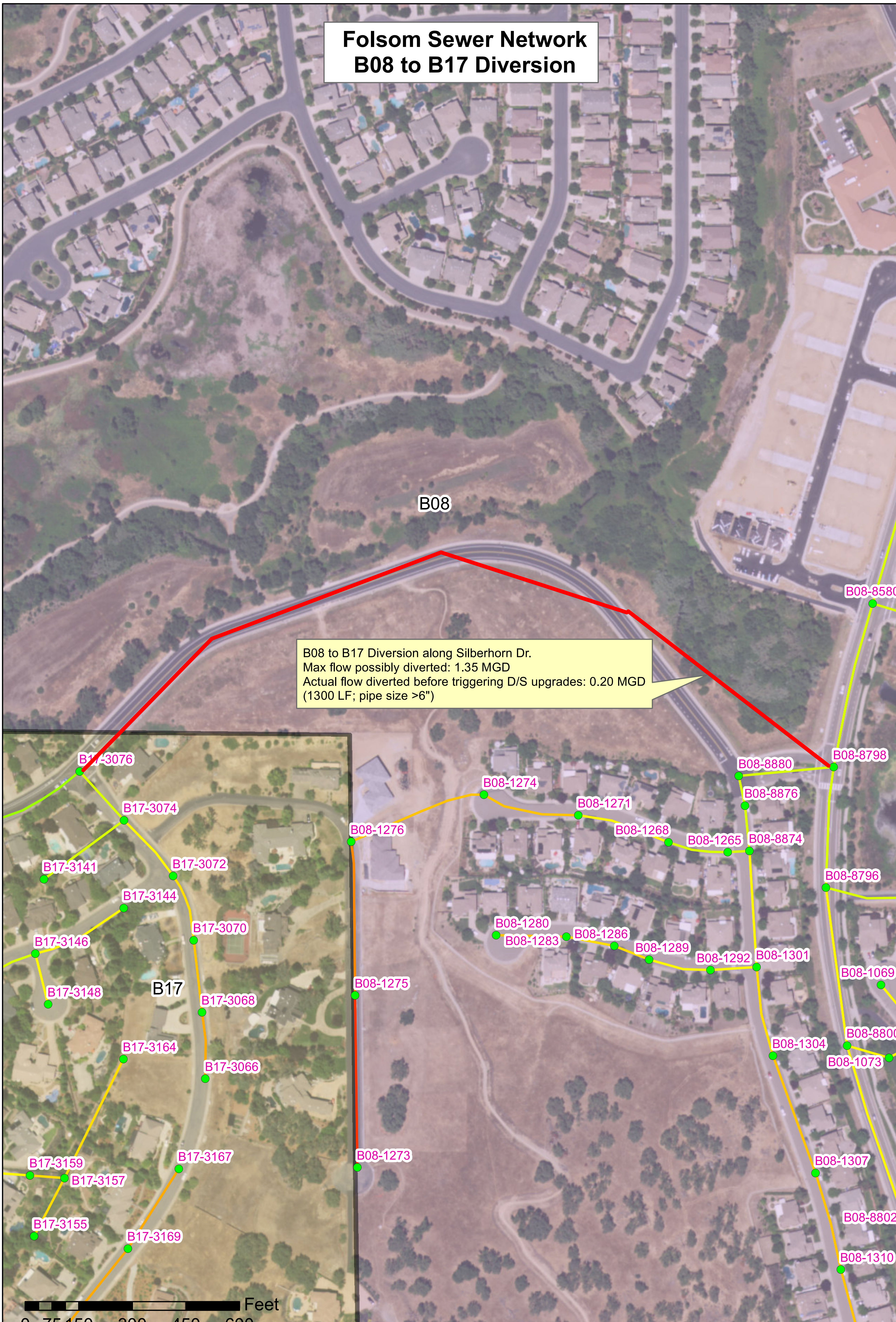
Folsom Sewer Network
Oak Avenue Pump Station
Overflow Line







Appendix D.4 B08 to B17 Silberhorn Diversion Option


Folsom Sewer Network
B08 to B17 Diversion
B08
B17
B08 to B17 Diversion along Silberhorn Dr.
Max flow possibly diverted: 1.35 MGD
Actual flow diverted before triggering D/S upgrades: 0.20 MGD
(1300 LF; pipe size >6")
B08-8580
B08-8880
B08-8798
B08-1274
B08-8876
B08-1271
B08-1276
B08-1268
B08-1265
B08-8874
B08-8796
B08-1280
B08-1283
B08-1286
B08-1289
B08-1292
B08-1301
B08-1069
B08-1275
B08-8800
B08-1304
B08-1073
B08-1273
B08-1307
B08-8802
B08-1310
B17-3076
B17-3074
B17-3141
B17-3072
B17-3144
B17-3070
B17-3146
B17-3148
B17-3068
B17-3164
B17-3066
B17-3159
B17-3167
B17-3157
B17-3155
B17-3169
Feet
0 75 150 300 450 600

(intentionally left blank)

End of Report

1322 Blue Oaks Blvd
Roseville, CA, 95678