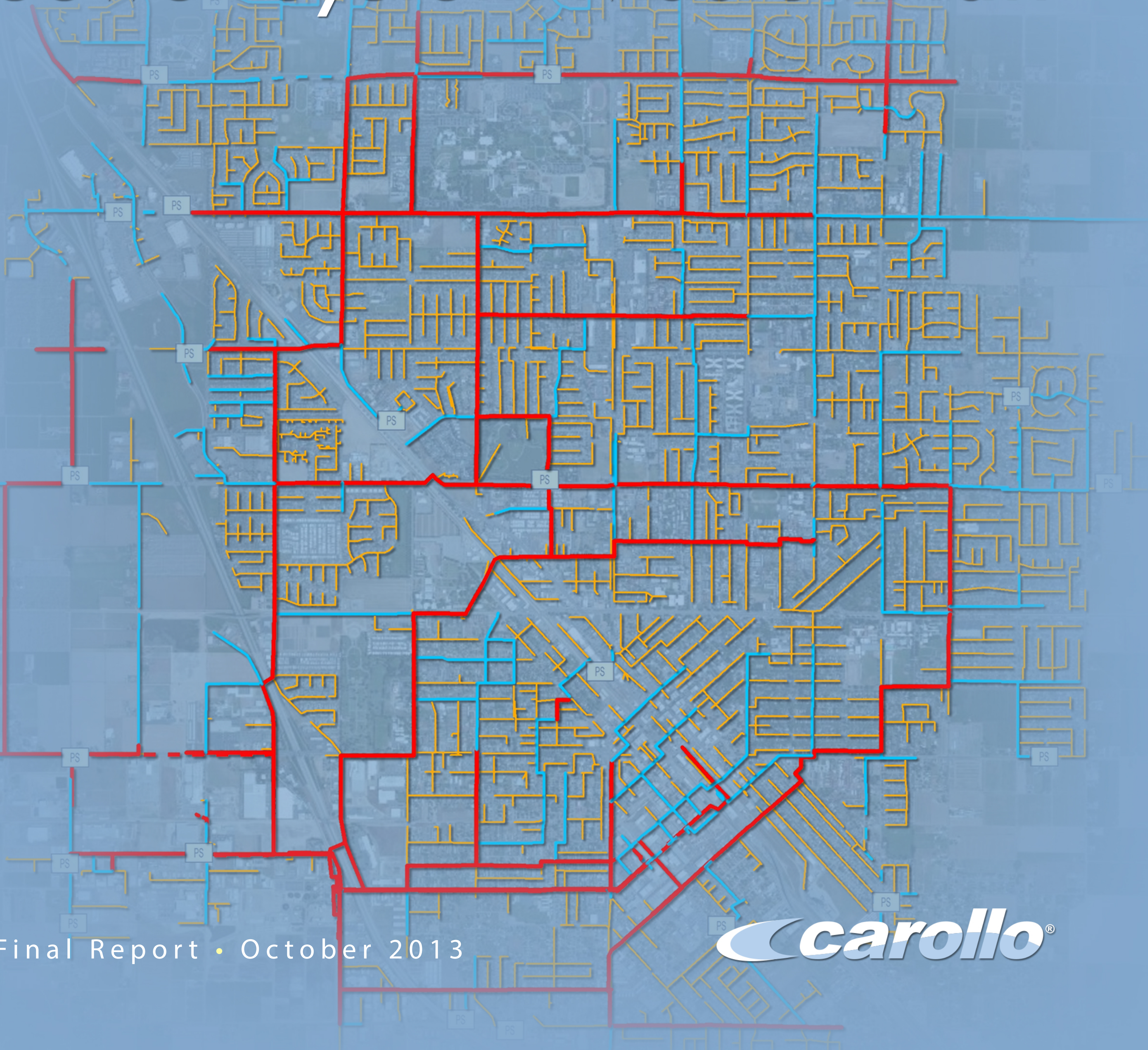
CITY OF
TURLOCK
INC. 1908

Sewer System Master Plan



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City of Turlock

SEWER SYSTEM MASTER PLAN

FINAL

October 2013

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City of Turlock

SEWER SYSTEM MASTER PLAN

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LIST OF ABBREVIATIONS

°F	Degrees Fahrenheit
AACE	Association for the Advancement of Cost Engineering
AAF	Average Annual Flow
ADMMF	Average Daily Maximum Month Flow
ADWF	Average Dry Weather Flow
BWF	Base Wastewater Flow
Carollo	Carollo Engineers, Inc.
CCTV	Closed-Circuit Television
cfs	Cubic Feet Per Second
CIP	Capital Improvement Plan
City	City of Turlock
d/D	Flow Depth To Pipe Diameter Ratio
DOF	Department of Finance
DWF	Dry Weather Flow
ENR CCI	Engineering News Record Construction Cost Index
EPA	Environmental Protection Agency
ft/s	Feet Per Second
ft^2	Square Feet
GIS	Geographic Information System
gpd	Gallons Per Day
gpd/ac	Gallons Per Day Per Acre
gpm	Gallons Per Minute
GUI	Graphical User Interface
GWI	Groundwater Infiltration
HGL	Hydraulic Grade Line
HP	Horsepower
I/I	Infiltration and Inflow
IDW	Inverse Distance Weighting
Master Plan	Sewer System Master Plan
mgd	Million Gallons Per Day
MSL	Mean Sea Level
n	Manning Friction Coefficient

NRCS	Natural Resources Conservation Service
PWWF	Peak Wet Weather Flow
RDII	Rainfall Derived Infiltration and Inflow
ROW	Right Of Way
SOI	Sphere Of Influence
SSO	Sanitary Sewer Overflow
SWMM	Stormwater Management Model
TRWQCF	Turlock Regional Water Quality Control Facility
V&A	V&A Consulting Engineers, Inc.
WaPUG	Wastewater Planning Users Group
WISP	West Industrial Specific Plan
WWF	Wet Weather Flow
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

This executive summary presents a brief background of the City of Turlock (City) sewer collection system, the need for this Master Plan, proposed improvements to mitigate existing system deficiencies, and proposed expansion projects. A summary of capital improvement project costs is included at the end of this summary.

ES.1 INTRODUCTION

The City is located in Stanislaus County on the eastern side of California's San Joaquin Valley, about 100 miles east of the San Francisco Bay Area and 90 miles south of Sacramento. State Highway 99 intersects the City along the north-south axis, providing regional transport to Stockton and Sacramento to the north and Fresno and Bakersfield to the south.

The City is bordered primarily by agricultural land, which helps establish it as a stand-alone community. In addition, agriculture is a major defining feature of the City's identity and comprises a large component of the City's economy. The City's downtown core, originally established around the railroad station, has since grown outward to include residential, commercial, and industrial developments. Turlock is attractive to food processors and distributors because of its location in the Central Valley and abundance of locally-grown products. The City was incorporated in 1908.

The City owns, maintains, and operates its own sanitary sewer collection system and associated facilities, including gravity sewer pipelines, lift stations, force mains, and the Turlock Regional Water Quality Control Facility (TRWQCF).

ES.2 STUDY AREA

The City recently updated its General Plan. The City's General Plan study area consists of the City limits, the City's sphere of influence (SOI), and areas urban reserve (primarily used as agricultural land). The City's SOI is nearly conterminous with the City limits along its western edge, but varies along the eastern side of the City.

The General Plan update describes projected growth over the next 20 years as occurring as infill within current City limits, as well as limited new development outside City limits. City policy is that all infill growth areas within the current City limits must be at least 70 percent built-out before new development areas are allowed to annex. The General Plan includes three new distinct development areas. The land area remaining in the General Plan Planning Boundary is designated as Urban Reserve, or land that is not expected to develop within the planning horizon of the General Plan.

The study area boundary for this Master Plan coincides with the General Plan study area boundary (Figure ES.1). This area includes developed land within the City limits, infill areas within the existing City limits, and areas proposed for annexation and development within the study area boundary. The study area includes developed land within the City limits, infill areas within the existing City limits, and areas proposed for annexation and development that is outside the City limits and SOI. In addition, there are several County-owned islands within the City that are expected to be annexed and developed according to the development plan in the General Plan.

The City recently updated its General Plan to the planning horizon of 2030. The land use, zoning designations, and development assumptions used in this Master Plan are consistent with those provided in the General Plan.

ES.3 SANITARY SEWER SERVICE AREA

The City's collection system consists of sewer mains, trunk sewers, lift stations, stormwater connections, and flow diversions that collect and convey wastewater to the TRWQCF. The City's collection system is shown in Figure ES.2.

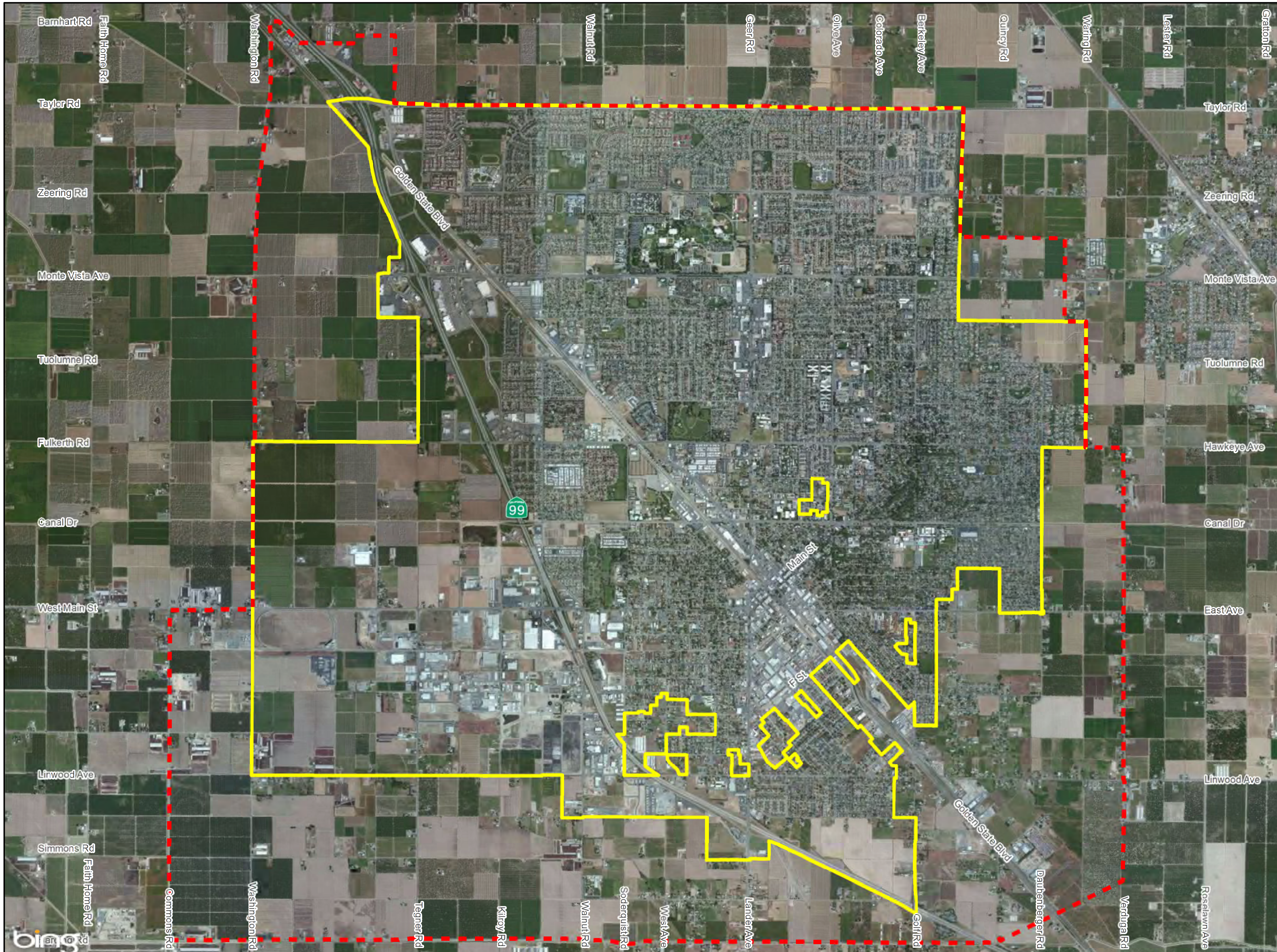
The City collects, treats, and disposes of wastewater originating from residential, commercial, institutional, and industrial customers within the service area. The City also collects and treats wastewater flows from the unincorporated communities of Denair and Keyes. In addition, the City receives approximately 1.0 million gallons per day (mgd) of primary treated wastewater from the City of Ceres. However, wastewater from the City of Ceres is conveyed through a separate pipeline to the TRWQCF; therefore, it does not flow through the City's sanitary sewer collection system.

ES.4 WASTEWATER FLOWS

The Average Dry Weather Flow (ADWF) is the average flow that occurs on a daily basis during the dry weather season. The ADWF includes the base wastewater flow (BWF) generated by the City's residential, commercial, and industrial users, plus dry weather groundwater infiltration (GWI). For the City, the ADWF was estimated throughout the service area based on the historical influent flow data from the TRWQCF, and from the flow monitoring program.

Peak wet weather flow (PWWF) is the highest observed flow that occurs following a design storm event. Wet weather I/I cause flows in the collection system to increase. PWWF is typically used for designing sewers and lift stations. Therefore, the PWWF and the "Design Flow" are synonymous and will be used interchangeably throughout this report.

The City's sewers and lift stations were evaluated based on their capacity to convey PWWF. PWWFs were simulated by routing the 10-year, 24-hour design storm through the calibrated hydraulic model.



Legend

City Limits

General Plan Boundary

Feet

0 3,500 7,000

Figure ES.1
Master Plan Study Area
Sewer System Master Plan
City of Turlock

CITY OF TURLOCK INC. 1908

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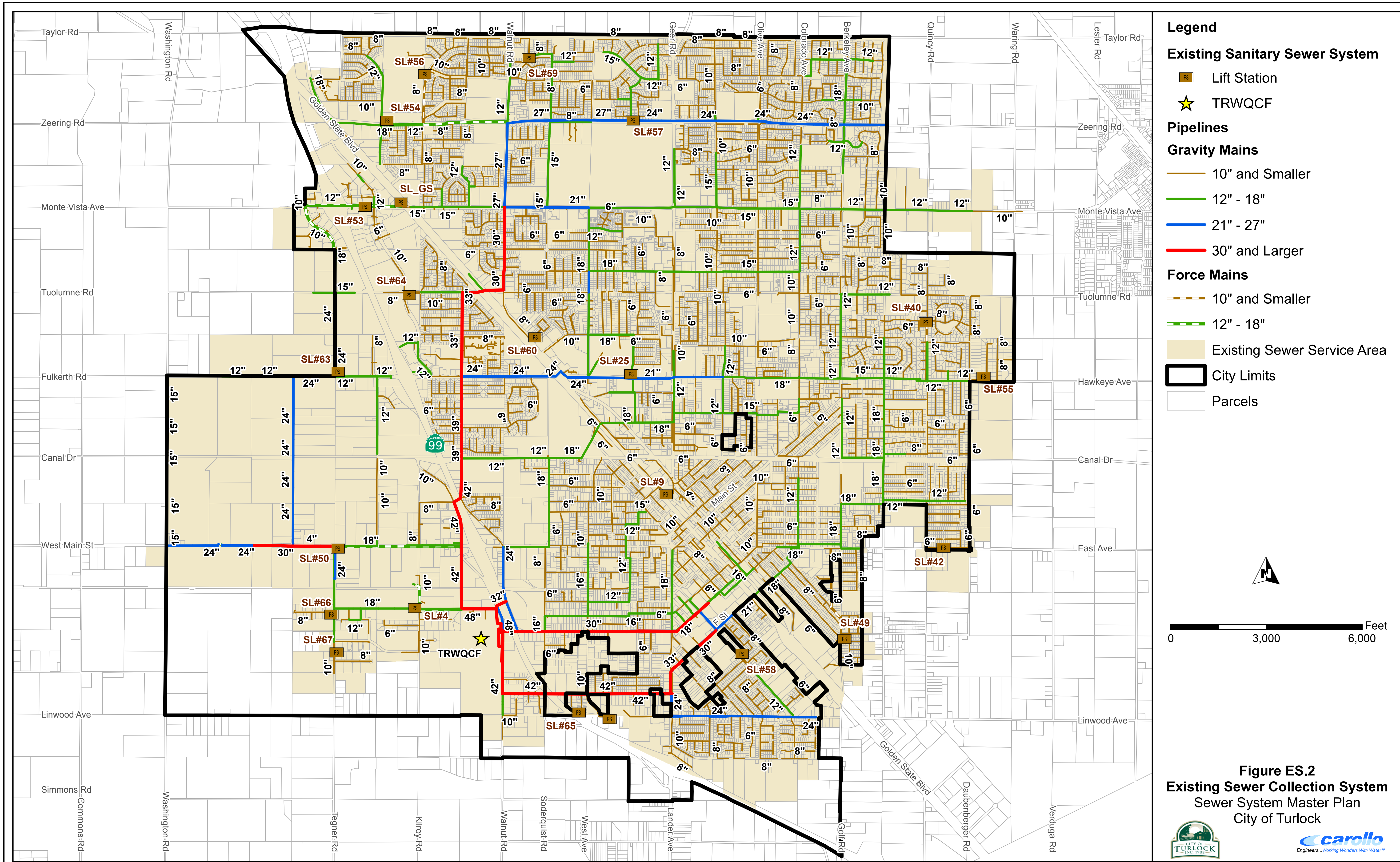


Figure ES.2
Existing Sewer Collection System
Sewer System Master Plan
City of Turlock

The existing and future design flows that reach the TRWQCF are dependant on a number of factors. There is significant inflow in the downtown area of the City due to storm drainage inlets that are connected to the sanitary sewer. These storm drains connections cause large flow spikes at the TRWQCF during rainfall events. The capacity analysis of the wastewater collection system indicates that the City's collection system is not capable of conveying peak flows within the specified criteria during the 10-year, 24-hour design storm. Capacity deficiencies in the collection system throttle the peak flow rates that reach TRWQCF. In addition, the existing influent pump station has a capacity of approximately 30 mgd. In actuality, peak wet weather flows during the design storm exceeded 30 mgd, which means flow was stored in the collection system.

The City is currently in the process of constructing a new influent pump station, which is expected to be online in 2014. The new headworks will be configured so that the existing influent pump station (Pump Station No. 1) can be utilized during high flow conditions via an overflow to the existing influent pump station. In addition, modifications to the influent pipelines will be constructed which will allow City staff to divert additional flow to Pump Station No. 1 if necessary.

With the current influent pump station, the PWWF peaks at just over 30 mgd for a period of approximately 11 hours. Flow above 30 mgd is temporarily stored in the collection system and could overflow. After the new influent pump station is operational, the PWWF at the TRWQCF will increase to approximately 41.7 mgd.

The build-out PWWF depends on a number of factors. The most important impact on capacity is the stormwater from storm drainage inlets that are connected to the sewer system. As part of the capacity evaluation of the collection system, Carollo developed improvement alternatives assuming (1) storm drainage connections to the sanitary sewer will remain, or (2) the City will implement storm drainage system improvements to remove the connections. The build-out PWWF is projected to be 63.0 mgd if the storm drainage connections to the sanitary sewer system will remain. If these connections are removed, the build-out PWWF is projected to be 37.9 mgd.

Table ES.1 summarizes the existing and build-out PWWFs. As shown in Table ES.1, removing the storm drain inlets from the sewer system will greatly reduce the flows influent to the TRWQCF during wet weather. Based on modeling results, the peak flows would drop from 63.0 mgd to 37.9 mgd, which represents a 34 percent reduction in flows.

Table ES.1 Existing and Build-Out Design Flows Sewer System Master Plan City of Turlock			
Flow Condition	**ADWF (mgd)**	**PWWF (mgd)**	**Peaking Factor**
Existing	10.6	31.0[1] 41.7[2]	2.9 3.9
Build-Out	19.4	37.9[3] 63.0[4]	2.0 3.2

Notes:
(1) The existing PWWF is controlled by the current capacity of the influent pump station.
(2) When the new headworks comes online, the PWWF will increase. Values presented assume that the new gate and Pump Station No. 1 will remain closed.
(3) Assumes that storm drainage connections to the sanitary sewer system are removed.
(4) Assumes that storm drainage connections to the sanitary sewer system will remain.

ES.5 CAPACITY EVALUATION

Following the dry and wet weather flow calibration of the City's hydraulic model, a capacity analysis of the existing and future collection system was performed based on established planning criteria. The capacity analysis of the City's sewer identified areas of capacity deficiencies.

The wastewater and stormwater systems are connected in the older downtown sections of the City. The connections contribute high flows to the sanitary sewer collection system during rainfall events. During storms, the combined wastewater and stormwater cause water levels in the sewers to rise, and significantly increases the City's risk of sanitary sewer overflows (SSOs).

At build-out, the City's wastewater flows are expected to roughly double. As such, there are some areas of the existing collection system that cannot convey the build-out design flow without flows backing up above allowable levels.

ES.6 COLLECTION SYSTEM CAPACITY IMPROVEMENTS

The collection system was analyzed under existing conditions and future build-out conditions. Findings from the collection system analysis were used to develop system improvements to remove capacity deficiencies.

As previously noted, the wastewater and stormwater systems are connected in the older downtown areas of the City. An important consideration is whether to eliminate storm drainage system connections to the sanitary sewer system. Improvements were identified for two different scenarios: (1) assuming that the direct storm drain connections to sewer would remain in place (existing situation), and (2) assuming that the storm drainage connections in downtown area would be segregated from the sewer system (storm inlets removed). The results of this analysis were presented to City staff at a planning meeting on February 7, 2013. The City concluded that the preferred approach was to segregate (i.e., remove) the storm drainage system connections from the sanitary sewer system. Accordingly, the proposed improvements and costs presented in this Master Plan assume the separation of the sewer and storm drainage systems.

Figure ES.3 illustrates the proposed sanitary sewer improvements necessary to correct the existing deficiencies and to serve future users. The improvements were developed assuming shown storm drainage connections to the sanitary system would be removed. Detailed information related to each improvement project is provided in Table ES.2.

Figure ES.4 shows the storm drainage system improvements that are required to remove the storm drainage system connections to the sanitary sewer. Table ES.2 also includes information related to the storm drainage system improvement projects shown in Figure ES.4.

ES.6.1 Differentiating between Improvements for Existing Users and Future Users

An existing deficiency is one where the existing facility's capacity is insufficient to meet the planning criteria (e.g., pipeline upgrades required to prevent severe surcharging during the design wet weather event). If a project was proposed to correct an existing deficiency exclusively, then existing users were assigned 100 percent of the project's benefit, and, 100 percent of the costs.

An existing sewer or lift station may have sufficient capacity to convey current PWWFs, but as growth continues and more users are added to the system, the increased flow results in capacity deficiencies. These projects, as well as new trunk sewers to extend wastewater collection system service to future growth areas, are considered future improvements and allocated to future users. In some cases, a project is needed to correct an existing capacity deficiency but it is sized to accommodate additional flows from future development. In these cases, the hydraulic modeling results were used to determine the cost breakdown between existing and future users based on the ratio of existing and build out average dry weather flows.

ES.6.2 Project Prioritization

Most of the improvements are driven by future development, which consist of new sewers that serve future growth or improvements to existing facilities that are needed to serve future growth. When fully implemented, the capital projects will allow the conveyance of PWWFs to the TRWQCF during build-out conditions.

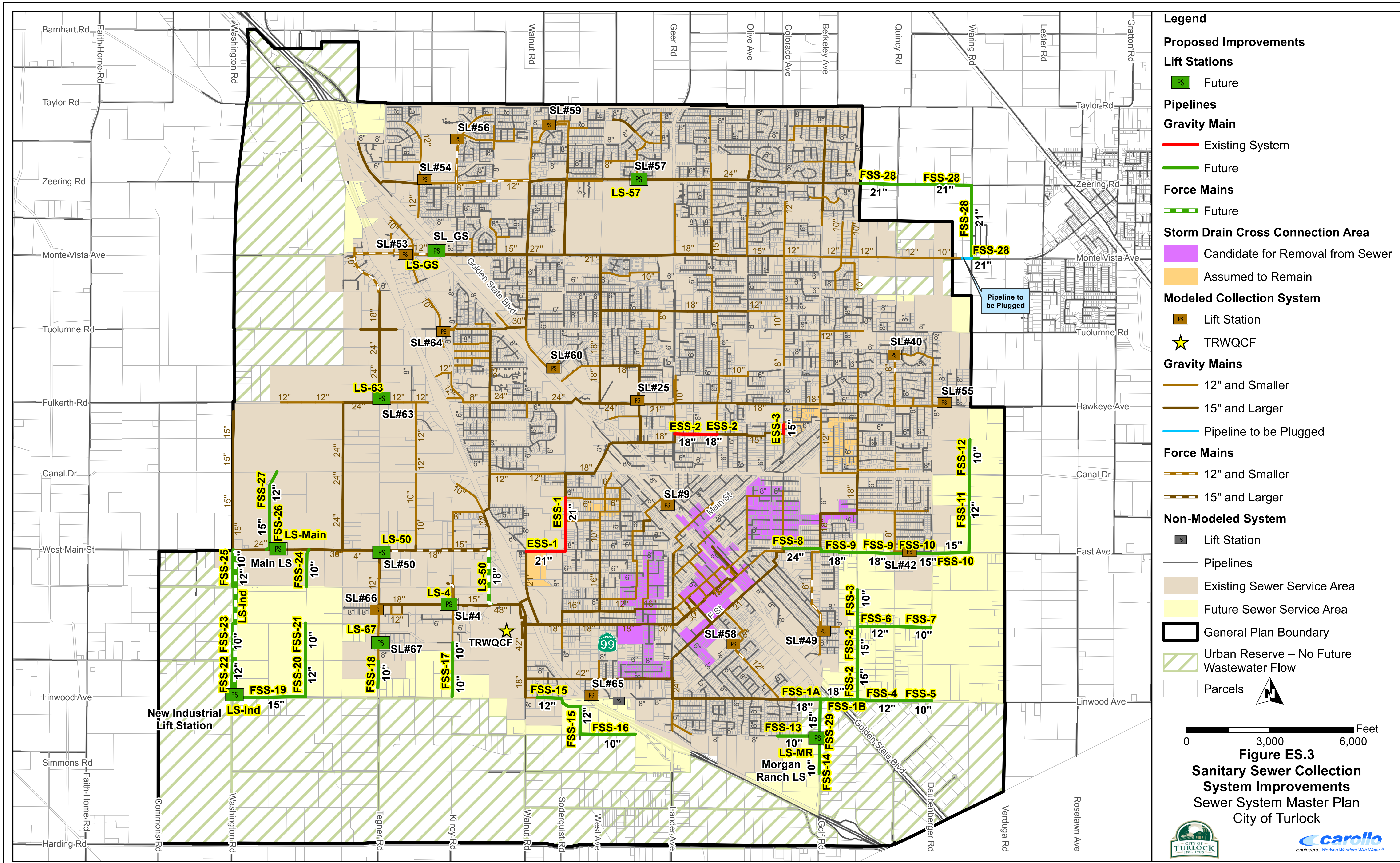


Figure ES.3
Sanitary Sewer Collection System Improvements
Sewer System Master Plan
City of Turlock

Table ES.2 Proposed Improvements
Sewer System Master Plan
City of Turlock

Figure No.	Type of Improvement	Description/ Street	Description / Limits	Project Length/Size and Cost: Ex. Size/ Diam. (in)	New Size/ Diam. (in)	Replace/ New	Length (ft)	Capital Improvement Phasing: Phase 1 2013-2015	Phase 2 2016-2020	Phase 3 2021-2025	Phase 4 2026-2030	Phase 5 After 2030
Existing System Improvements												
Pipelines												
ESS-1	Pipe	W. Main St./N. Soderquist Rd.	Julian St. to S. Tully Rd.	18	21	Replace	3,350				X	
ESS-2	Pipe	Wayside Dr.	N. Denair Ave, to Geer Rd.	15	18	Replace	1,520				X	
ESS-3	Pipe	Colorado Ave.	North of Escandido Ave. to south of Escondido Ave.	12	15	Replace	320				X	
Projects to Remove Direct Connections to Sewer System (2)												
ESD-11	Pipe	Johnson Rd	Marshall St to Canal Dr	8/12/15	30	Replace	1,120				X	
ESD-17	Pipe	D St	6th to Lander Ave	10/18	48	Replace	780		X			
ESD-19	Pipe	West South Ave	Columbia St to High St	12	36	Replace	490		X			
ESD-20	Pipe	West South Ave	High St to Vermont Ave	12	36	Replace	900		X			
ESD-21	Pipe	West South Ave	Vermont Ave to South Ave	12	48	Replace	910		X			
ESD-22	Pipe	West Ave South	South Ave to Linwood Ave	-	48	New	2,820		X			
ESD-24	Pipe	South Ave	Corner of West Ave South, remove outfall to existing infrastructure	15	-	Abandon	-					
ESD-25	Pipe	Montana Ave	Gabriel St to West Ave South	-	30	New	670		X			
ESD-26	Pipe	Lander Ave	E St to Linwood Ave, Adjust inverts to match prposed Linwood trunkline	-	60	Replace	1,580	X				
ESD-27	Pipe	Lander Ave	At F St, influent pipe to Pump Station No. 2 Wet Well	42	-	Abandon	-					
ESD-43	Pipe	Canal Drive	Johnson Rd and Canal Dr, provides connection to canal trunkline	-	30	New	50				X	
ESD-47	Pipe	Marshall St	Berkeley Ave to Johnson Rd	-	30	New	1,720				X	
ESD-48	Pipe	Rose St	Merritt St to Canal Dr	-	21	New	2,150				X	
ESD-50	Pipe	Olive Ave, Golden State Blvd	Thor St to southeast of Minerva St	-	36	New	3,490		X			
ESD-51	Pipe/Casing(1)	Golden State Blvd, 1st Street	Pipe & Casing under Train Tracks, east of Golden State Blvd	-	48/60	New	130		X			
ESD-52	Pipe	D St	1st St to 6th St	-	48	New	2,060		X			
ESD-53	Pipe	F St	8th St to Lander Ave	-	36	New	680	X				
ESD-54	Pipe	F St	Southwest of 8th St, Remove connection to sewer	33	-	Abandon	-					
ESD-55	Pipe	Lander Ave	D St to E St	42	60	Replace	950		X			
ESD-56	Pipe	Lander Ave	Linwood Ave to Glenwood Ave	42	-	Abandon	-					
ESD-57	Pipe	Linwood Ave	Lander Ave to West Linwood Ave Basin	-	72	New	6,690	X				
ESD-58	Pipe	Columbia St	Locust St to West Ave South	-	18	New	2,280		X			
ESD-59	Pipe	Castor St, Laurel St	Locust St to High St	-	15	New	830		X			
ESD-60	Pipe	High St	Laurel St to West Ave South	-	24	New	1,910		X			
ESD-61	Pipe	Vermont Ave	Orange St to West Ave South	-	24	New	1,540		X			
ESD-62	Pipe	Martinez St, Williams Ave	Parnell Ave to West Ave South	-	15	New	1,070		X			
ESD-63	Pipe	Orange St	South Ave to Montana Ave	-	24	New	1,980		X			
ESD-64	Pipe	Lewis St	Maple St to Orange St	-	15	New	600		X			
ESD-65	Pipe	Montana Ave	Orange St to west of Gabriel St	-	30	New	900		X			
ESD-66	Pipe/Casing(1)	Linwood Ave, under Highway 99	Boring under Highway 99, under Linwood Ave	-	72/84	New	240	X				

Table ES.2 Proposed Improvements
Sewer System Master Plan
City of Turlock

Figure No.	Type of Improvement	Description/ Street	Description / Limits	Project Length/Size and Cost: Ex. Size/ Diam. (in)	New Size/ Diam. (in)	Replace/ New	Length (ft)	Capital Improvement Phasing: Phase 1 2013-2015	Phase 2 2016-2020	Phase 3 2021-2025	Phase 4 2026-2030	Phase 5 After 2030
ESD-BN-2	Basin	Linwood Ave	West Linwood Ave Basin	-	123 ac-ft	New	-	X				
Buildout System Improvements												
Pipelines												
FSS-1A	Pipe	E. Linwood Ave.	Golf Rd. to east of 5th St.	--	18	New	780		X			
FSS-1B	Pipe	E. Linwood Ave.	S. Johnson Rd. to Golf Rd.	--	18	New	1,360			X		
FSS-2	Pipe	S. Johnson Rd.	Briar Rd. to E. Linwood Ave.	--	15	New	2,650			X		
FSS-3	Pipe	S. Johnson Rd.	South of East Ave. to Brier Rd.	--	10	New	1,320			X		
FSS-4	Pipe	E. Linwood Ave.	S. Quincy Rd. to S. Johnson Rd.	--	12	New	1,350			X		
FSS-5	Pipe	E. Linwood Ave.	East of S. Quincy Rd. to S. Quincy Rd.	--	10	New	1,300			X		
FSS-6	Pipe	Brier Rd.	S. Quincy Rd. to S. Johnson Rd.	--	12	New	1,340			X		
FSS-7	Pipe	Brier Rd.	S. Daubenberger Rd. to S. Quincy Rd.	--	10	New	1,330			X		
FSS-8	Pipe	Alley north of East Ave.	N. Berkeley Avenue to Bell St.	18	24	Replace	1,310				X	
FSS-9	Pipe	East Ave.	N. Quincy Rd. to N. Berkeley Ave.	--	18	New	2,800				X	
FSS-10	Pipe	East Ave.	West of N. Verduga Rd. to N. Quincy Rd.	--	15	New	2,680				X	
FSS-11	Pipe	West of N. Verduga Rd.	Canal Dr. to East Ave.	--	12	New	2,770				X	
FSS-12	Pipe	West of N. Verduga Rd.	South of Hawkey to Canal Dr.	--	10	New	1,270				X	
FSS-13	Pipe	E. Glenwood Ave.	5th St. to Golf Rd.	--	10	New	1,450		X			
FSS-14	Pipe	Golf Rd.	South of E. Glenwood Ave to E. Glenwood Ave.	--	10	New	1,340		X			
FSS-15	Pipe	W. Glenwood Ave.	West of Lander Avenue to east of S. Walnut Rd.	--	12	New	2,730		X			
FSS-16	Pipe	W. Glenwood Ave.	West of Lander Avenue to south of Linwood Ave.	--	10	New	1,980		X			
FSS-17	Pipe	S. Kilroy Rd.	W. Linwodd Ave. to Spengler Wy.	--	10	New	1,930			X		
FSS-18	Pipe	Tegner Rd.	North of W. Linowood Ave. to south of Humphrey Ct.	--	10	New	950			X		
FSS-19	Pipe	W. Linwood Ave.	S. Washington Rd. to east of S. Washington Rd.	--	15	New	2,890					X
FSS-20	Pipe	East of S. Washington Rd.	North of W. Linwood Ave. to W. Linwood Ave.	--	12	New	1,290					X
FSS-21	Pipe	East of S. Washington Rd.	Ruble Rd. to north of W. Linwood Ave.	--	10	New	1,350					X
FSS-22	Pipe	S. Washington Rd.	Clayton Rd. to W. Linwood Ave.	--	12	New	1,330					X
FSS-23	Pipe	S. Washington Rd.	Ruble Rd. to Clayton Rd.	--	10	New	1,320					X
FSS-24	Pipe	East of S. Washington Rd.	South of West Main St. to West Main St.	--	10	New	1,350				X	
FSS-25	Pipe	S. Washington Rd.	South of West Main St. to West Main St.	--	10	New	1,320				X	
FSS-26	Pipe	Clinton Rd.	North og West Main St. to West Main St.	--	15	New	1,430				X	
FSS-27	Pipe	Clinton Rd.	W. Canal Dr. to north of West Main St.	--	12	New	1,440				X	
FSS-28	Pipe	Christoffersen Pkwy./N. Waring Rd.	Redirect Denair flows to 24-inch sewer on Christoffersen	--	21	New	6,850			X		
FSS-29	Pipe	Golf Road	Glenwood Ave. to E. Linwood Ave.	--	15	New	1,440		X			
Lift Stations [5]												
LS-MR	Lift Station	Morgan Ranch	Assumed 2 pumps	--	1.2 mgd	Replace	-		X			

Table ES.2 **Proposed Improvements**
Sewer System Master Plan
City of Turlock

				Project Length/Size and Cost				Capital Improvement Phasing				
Figure No.	**Type of Improvement**	**Description/ Street**	**Description / Limits**	**Ex. Size/ Diam. (in)**	**New Size/ Diam. (in)**	**Replace/ New**	**Length (ft)**	**Phase 1 2013-2015**	**Phase 2 2016-2020**	**Phase 3 2021-2025**	**Phase 4 2026-2030**	**Phase 5 After 2030**
LS-4	Lift Station	Kilroy Road	Assumed 3 pumps	2.3 mgd	3.6 mgd	Replace	-				X	
LS-50	Lift Station	Tegner Road	Assumed 3 pumps	2.3 mgd	12.8 mgd	Replace	-		X			
	Force Main	N. Walnut Rd.	Extend existing 18-inch force main	--	18	Extend	1,910		X			
LS-57	Lift Station	Picadilly Lane	Assumed 2 pumps	4.6 mgd	6.0 mgd	Replace	-			X		
LS-63	Lift Station	Fulkerth/Tegner	Assumed 2 pumps	3.5 mgd	5.1 mgd	Replace	-				X	
LS-67	Lift Station	Humphrey Ct.	Assumed 2 pumps	0.6 mgd	1.4 mgd	Replace	-			X		
LS-GS	Lift Station	Golden State Blvd.	Assumed 3 pumps (current capacity unknown)	n/a	3.0 mgd	Replace	-				X	
LS-Main	Lift Station	Main St. Near Clinton Rd.	Assumed 3 pumps (current capacity unknown)	n/a	4.7 mgd	Replace	-			X		
LS-Ind	Lift Station	New Industrial Lift Station	Assumed 2 pumps	--	2.8 mgd	New	-					X
	Force Main	S. Washington Rd.	W. Linwood Ave. to W. Main St.	--	12	New	5,000					X
	Land Acquisition	Corner of S. Washington Rd. and W. Linwood Ave.	Land Acquisition assumed 0.25 acres	--	0.25 acres	New						X

Notes:
1. Proposed casings size and carrier pipe size.
2. These projects are the required storm drainage system projects to remove direct connections to the sewer system, and to eliminate storm drainage system capacity deficiencies. Costs are included in the Sewer CIP. These projects are listed in the Storm Drainage CIP, but costs are not included in the Storm Drainage CIP.
3. Lift station capacities refer to the total capacity unless noted otherwise.

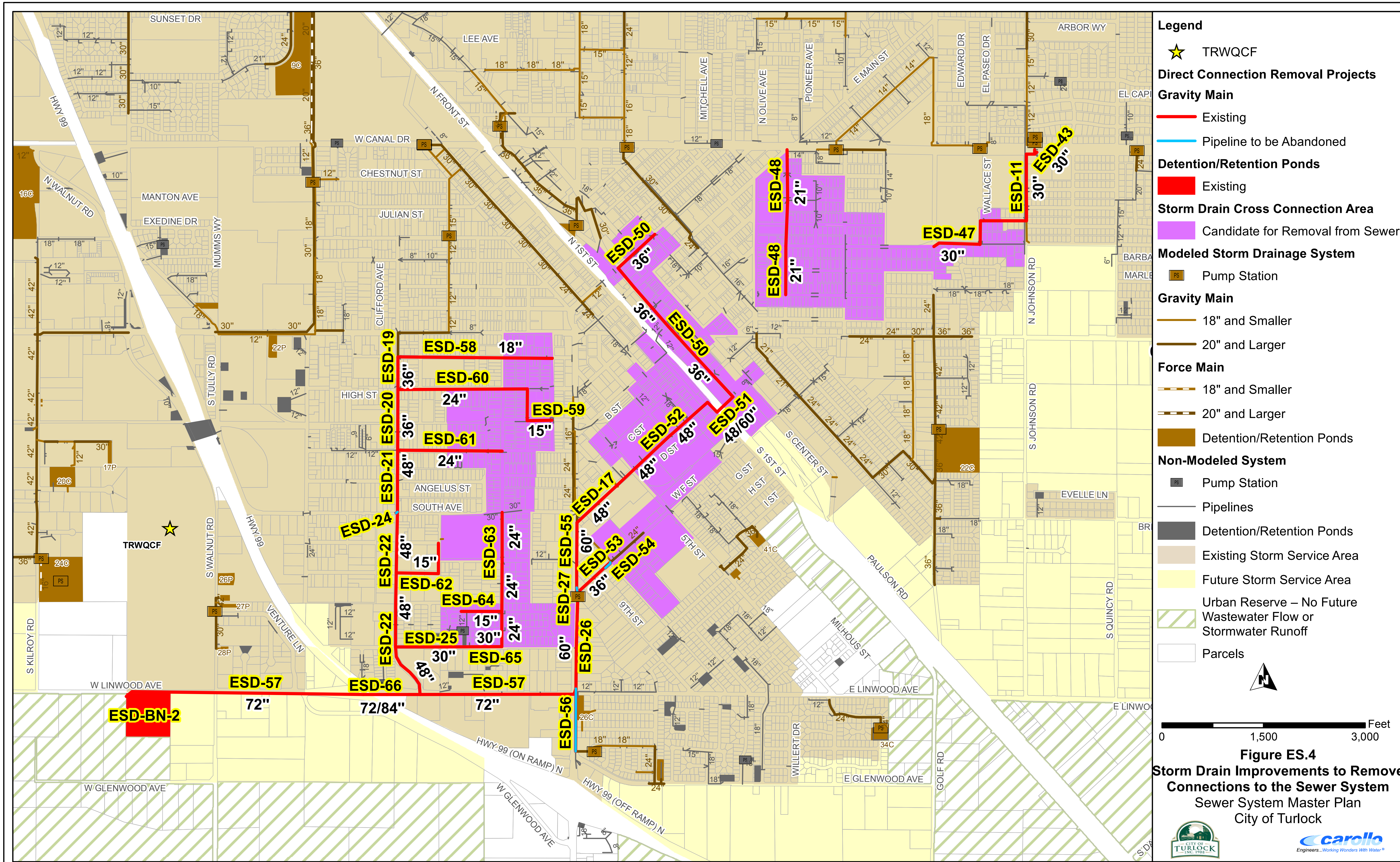


Figure ES.4
Storm Drain Improvements to Remove Connections to the Sewer System
Sewer System Master Plan
City of Turlock

Prioritizing the required capital improvements for the City's sewer system is an important aspect of this study. The improvement projects were prioritized based on the following objectives:

- Implementing storm drainage system improvement projects to remove storm drain connections from the sanitary sewer system
- Upgrading existing facilities to mitigate current capacity deficiencies and to serve future users
- Building the new trunks necessary to serve future users

Storm drainage system projects and other improvements to existing facilities will provide sufficient capacity to mitigate existing issues and to convey increased flows resulting from future growth. Future development will require the construction of sewers to serve new users.

The projects were grouped into the following phases:

- <u>Phase 1</u>: Years 2013 through 2015
- <u>Phase 2</u>: Years 2016 through 2020
- <u>Phase 3</u>: Years 2021 through 2025
- <u>Phase 4</u>: Years 2026 through 2030
- <u>Phase 5</u>: After 2030

The projects were phased based on the best available information for how the City will develop moving forward. The actual implementation of the improvements serving future users ultimately depends on growth. The priorities presented below are estimates, and changes in the City's planning assumptions or growth projections could increase or decrease the priority of each improvement.

- **Phase 1 Projects (2013-2015)**. The highest priority projects to address capacity deficiencies in the sewer system are the main backbone features of the storm drainage system improvement projects need to remove storm drainage system connections to the sewer system. These include a new storm basin (ESD-BN-2) and other major storm drain pipelines to the basin (ESD-26, ESD-53, ESD-57, and ESD-66).
- **Phase 2 Projects (2016-2020)**. The second phase targets the majority of the remaining improvement projects to remove storm drain connections from the sewer system. These include:
  - ESD-17
  - ESD-19 to ESD-22
  - ESD-24 and ESD-25

- ESD-50 to ESD-52
- ESD-55
- ESD-58 to ESD-65

Phase 2 also targets additional growth related improvements, which could potentially be required in the relatively near term. These projects include:

- FSS-1A, FSS-13 to FSS-16, and FSS-29
- Morgan Ranch Lift Station, Lift Station 50

A project to upgrade Lift Station 50 is targeted for Phase 2. Significant growth is expected in the Turlock Regional Industrial Park, and this lift station will convey a significant portion of that projected growth. This project also includes an extension of the existing 18-inch force main. The purpose of extending the force main is to discharge flows from this lift station into a larger interceptor located closer to the plant. The hydraulic model showed that if the existing force main discharge point remained for build-out conditions, flows upstream of the interceptor would back up above allowable levels. Routing the force main further downstream eliminates the simulated surcharging.

- **Phase 3, 4, and 5 Projects (2021-2025, 2026-2030, and after 2030)**. Project ESS-1 through ESS-3 are recommended in order to address relatively minor capacity deficiencies in the existing sewer collection system. These projects are targeted for Phase 3. In addition, the remaining storm drainage system projects that remove storm drain connections to the sewer (ESD-11, ESD-43, ESD-47, and ESD-48) are targeted for Phase 4.

  Phase 3 through 5 growth projects are longer-term projects driven by development at the outer edges of the planning area, and will be grouped together. The Phase 3 through 5 growth projects include the following:

  - FSS-1B to FSS-7
  - FSS-8 to FSS-12
  - FSS-17 to FSS-18
  - FSS-19 to FSS-23
  - FSS-24 to FSS-27
  - FSS-28

A number of lift stations upgrades are targeted for long-term implementation, including Lift Station 4, Lift Station 57, Lift Station 63, Lift Station 67, the Golden State Lift Station, Main Lift Station, as well as the new Industrial Lift Station and force main.

ES.7 CAPITAL IMPROVEMENT PLAN

The capacity upgrades set the foundation for the City's sewer system capital improvement plan (CIP). The CIP cost estimates are opinions developed from bid tabulations, cost curves, and information obtained from previous studies.

The cost estimates presented in the CIP have been prepared for general master planning purposes and for guidance in project evaluation and implementation. Final costs of a project will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other variable factors such as preliminary alignment generation, investigation of alternative routings, and detailed utility and topography surveys.

The Association for the Advancement of Cost Engineering (AACE) defines an Order of Magnitude Estimate, deemed appropriate for master plan studies, as an approximate estimate made without detailed engineering data. It is normally expected that an estimate of this type would be accurate within plus 50 percent to minus 30 percent. This section presents the assumptions used in developing order of magnitude cost estimates for recommended facilities.

The CIPs are prioritized based on their urgency to mitigate existing deficiencies and for servicing anticipated growth. It is recommended that improvements to mitigate existing deficiencies be assigned the highest priority. Expansion of the system to accommodate growth should be implemented as the City grows.

The implementation phases are in 5-year increments, except for the first phase, which runs from 2013 through 2015. A summary by phase is provided in Table ES.3. The total capital cost of the City's CIP for the sanitary sewer improvements is $71.3 million.

Table ES.3 Capital Cost Summary
Sewer System Master Plan
City of Turlock

	Project Phasing					
User Type	**Phase 1 2013-15 ($, mill.)**	**Phase 2 2016-20 ($, mill.)**	**Phase 3 2021-25 ($, mill.)**	**Phase 4 2026-30 ($, mill.)**	**Phase 5 Post 2030 ($, mill.)**	**Total ($, mill.)**
Sewer System(2)						
Exiting Users	8.6	8.4	0.0	3.1	0.0	20.1
Future Users	5.1	19.6	9.8	11.7	4.5	50.7
Total	**13.7**	**28.0**	**9.8**	**14.8**	**4.5**	**70.8**

Notes:
(1) Costs are based on the Engineering News Record Construction Cost Index of 821 (1967 base year, San Francisco, March 2013).
(2) Sewer system costs include storm drainage project to remove storm drain cross connections from the sewer system.

Chapter 1

BACKGROUND

This chapter presents the need for this Sewer System Master Plan (Master Plan) and the objectives of the study. A list of abbreviations is also provided to assist the reader in understanding the information presented.

1.1 INTRODUCTION

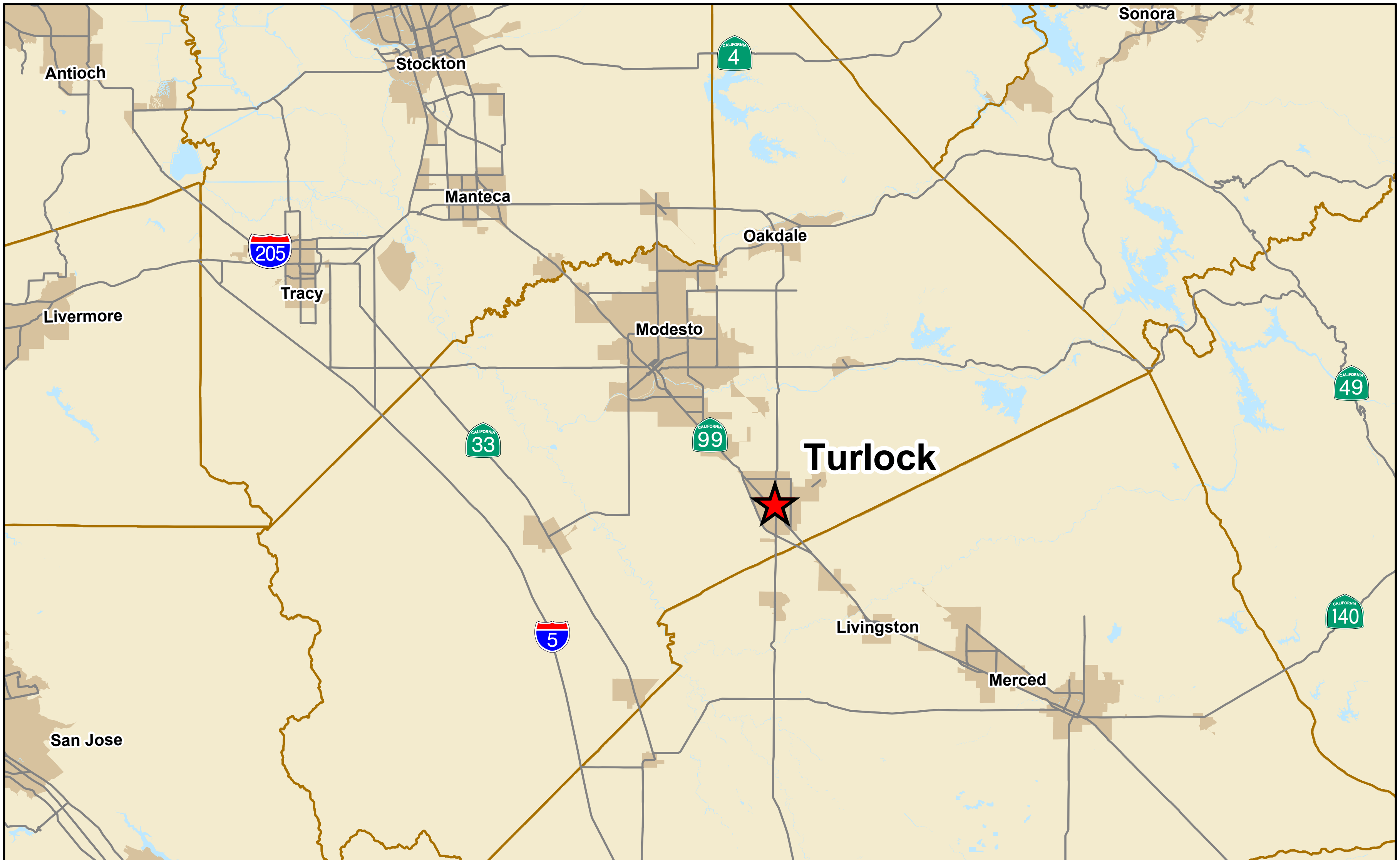
The City of Turlock (City) is located in Stanislaus County on the eastern side of California's San Joaquin Valley, about 100 miles east of the San Francisco Bay Area and 90 miles south of Sacramento. Figure 1.1 presents a regional location map of the City. State Highway 99 intersects the City along the north-south axis, providing regional transport to Stockton and Sacramento to the north, and Fresno and Bakersfield to the south.

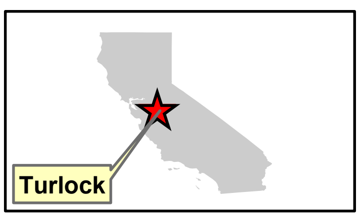
The City is bordered primarily by agricultural land, which helps establish it as a stand-alone community. In addition, agriculture is a major defining feature of the City's identity and comprises a large component of the City's economy. The City's downtown core, originally established around the railroad station, has since grown outward to include residential, commercial, and industrial developments. Turlock is attractive to food processors and distributors because of its location in the Central Valley and abundance of locally grown products. The City was incorporated in 1908.

The City owns, maintains, and operates its own sanitary sewer collection system and associated facilities, including gravity sewer pipelines, lift stations, force mains, and the Turlock Regional Water Quality Control Facility (TRWQCF).

1.2 SANITARY SEWER SERVICE AREA

Figure 1.2 illustrates the City's current sewer service area. The City manages and maintains approximately 225 miles of gravity sewer lines, 24 lift stations, and force mains. All wastewater generated within the sewer service area is conveyed to the TRWQCF for treatment. The City collects, treats, and disposes of wastewater originating from residential, commercial, institutional, and industrial customers within the service area. The City also collects and treats wastewater flows from the unincorporated communities of Denair and Keyes. In addition, the City receives approximately 1.0 million gallons per day (mgd) of primary treated wastewater from the City of Ceres. However, wastewater from the City of Ceres is conveyed through a separate pipeline to the TRWQCF; therefore, it does not flow through the City's sanitary sewer collection system.





Legend

City of Turlock

Major Roads

Urban Areas

County Boundary

Hydrography

N

0 7.5 15 Miles

Figure 1.1
Regional Location Map
Sewer System Master Plan
City of Turlock

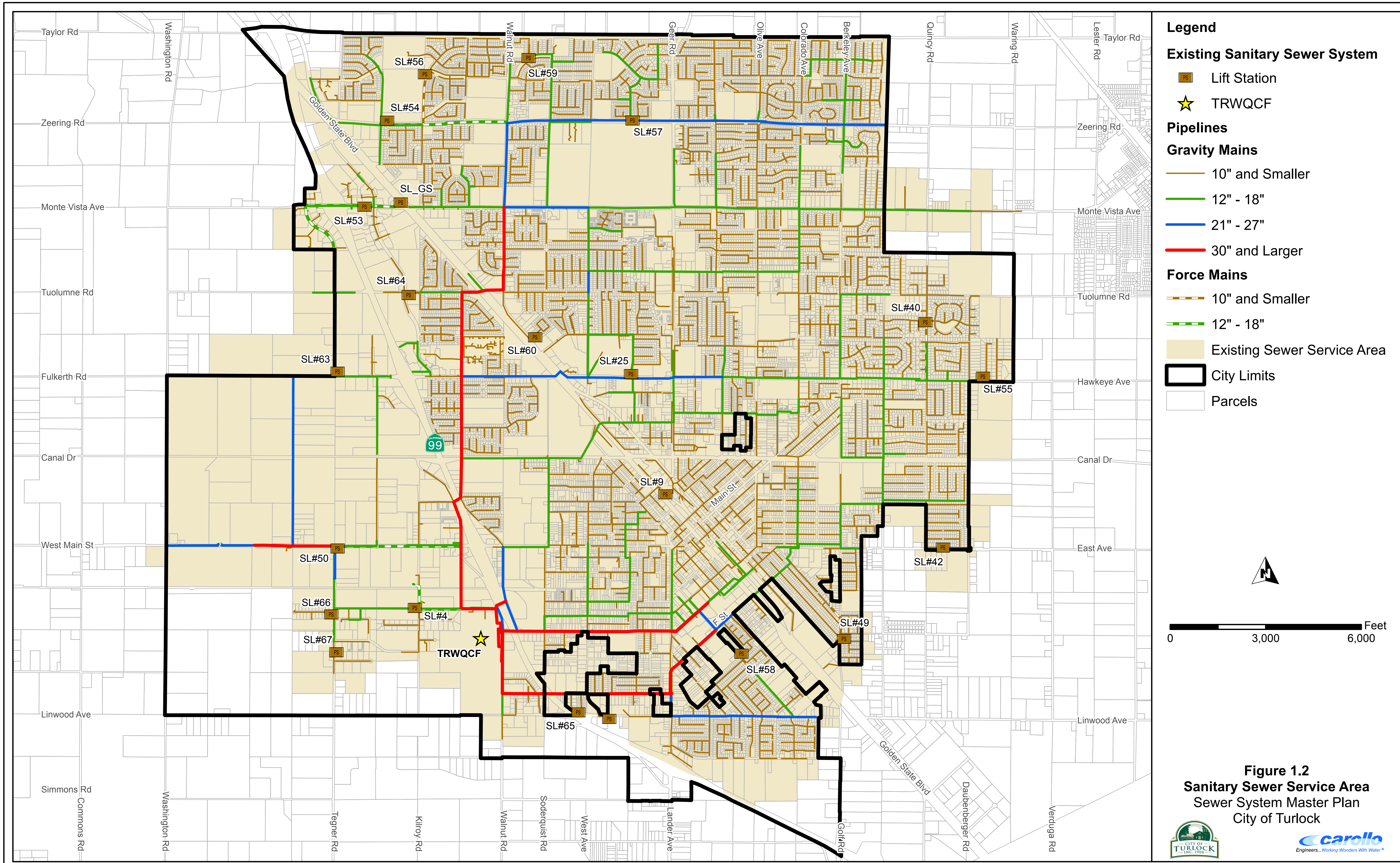


Figure 1.2
Sanitary Sewer Service Area
Sewer System Master Plan
City of Turlock

The City recently updated its General Plan to the planning horizon of 2030. The land use, zoning designations, and development assumptions used in this Master Plan are consistent with those provided in the General Plan. The improvement projects recommended in this Master Plan are meant to serve existing and future customers as development extends to the General Plan Study Area Boundary. Should future planning conditions change, such as accelerated growth or more intense developments, revisions and adjustments to the Master Plan recommendations would be necessary.

1.3 SCOPE AND AUTHORIZATION

The purpose of the Master Plan is to identify capacity deficiencies in the sanitary sewer collection system, develop feasible alternatives to correct these deficiencies, and plan infrastructure that will serve future development. On September 30, 2011, the City approved a professional service agreement with Carollo Engineers, Inc. (Carollo) to prepare this Master Plan for the sanitary sewer collection system, which included the following main tasks:

- Collect and review data
- Conduct collection system condition assessment
- Development wastewater flow estimates
- Conduct flow monitoring program
- Create hydraulic model
- Evaluate capacity of sanitary sewer collection system
- Develop a phased capital improvement program
- Master Plan preparation

1.4 REPORT ORGANIZATION

The Master Plan contains seven chapters, followed by appendices that provide supporting documentation for the information presented in the report. The chapters are briefly described below:

Chapter 1 - Background. This chapter presents the need for this Master Plan and the objectives of the study. A list of reference materials is provided to assist the reader in understanding the information presented.

Chapter 2 - Study Area Description. This chapter presents a description of the study area, defines the land use classifications, and summarizes the historical population trends.

Chapter 3 - Planning Criteria. This chapter presents the planning criteria for evaluating the sanitary sewer collection system. The planning criteria address the collection system capacity, gravity sewer slopes, and maximum depth of flow within a sewer.

Chapter 4 - Wastewater Design Flows. This chapter summarizes the flow-monitoring program and presents the calculation of the design flows used to model the existing and future sewer system.

Chapter 5 - Wastewater Collection System Facilities and Hydraulic Model. This chapter presents an overview of the City's wastewater collection system. This chapter also describes the development and calibration of the City's sanitary sewer collection system hydraulic model.

Chapter 6 - Capacity Evaluation and Proposed Improvements. This chapter discusses the capacity evaluation of the collection system. This chapter also presents improvements to mitigate existing system deficiencies and for servicing future growth.

Chapter 7 - Capital Improvement Plan. This chapter presents the recommended Capital Improvement Plan (CIP) for the City's wastewater collection system. The CIP includes a description of the capital improvement projects, a summary of the capital costs, and assessment of the costs that the City will need to recover from existing ratepayers and future development. This chapter is organized to assist the City in making finance decisions.

1.5 ACKNOWLEDGMENTS

Carollo wishes to acknowledge and thank Mike Pitcock, Director of Development Services/City Engineer; Dan Madden, Municipal Services Director; Anthony Orosco, Senior Civil Engineer; Rich Fulz, City Land Surveyor/Development Services Supervisor, and Larry Gilley, Utilities Manager. Their cooperation and courtesy in obtaining a variety of necessary information were valuable components in completing and producing this report.

1.6 REFERENCE MATERIAL

The following documents were referenced in the preparation of this Master Plan:

- City of Turlock General Plan, Policy Document, Public Review Draft, October 2011, Dyett & Bhatia
- City of Turlock Standard Specifications and Drawings, March 2008, City of Turlock Development Services, Engineering Division
- City of Turlock General Plan, Existing Conditions Report, March 2009, Dyett & Bhatia
- Stanislaus County Standards and Specifications, 2007 Edition, Stanislaus County Department of Public Works
- City of Turlock 2012 Sanitary Sewer Flow Monitoring and Inflow/Infiltration Study, January 2013, V&A

STUDY AREA DESCRIPTION

This chapter presents a description of the study area, defines the land use classifications, and summarizes the historical population trends.

2.1 STUDY AREA

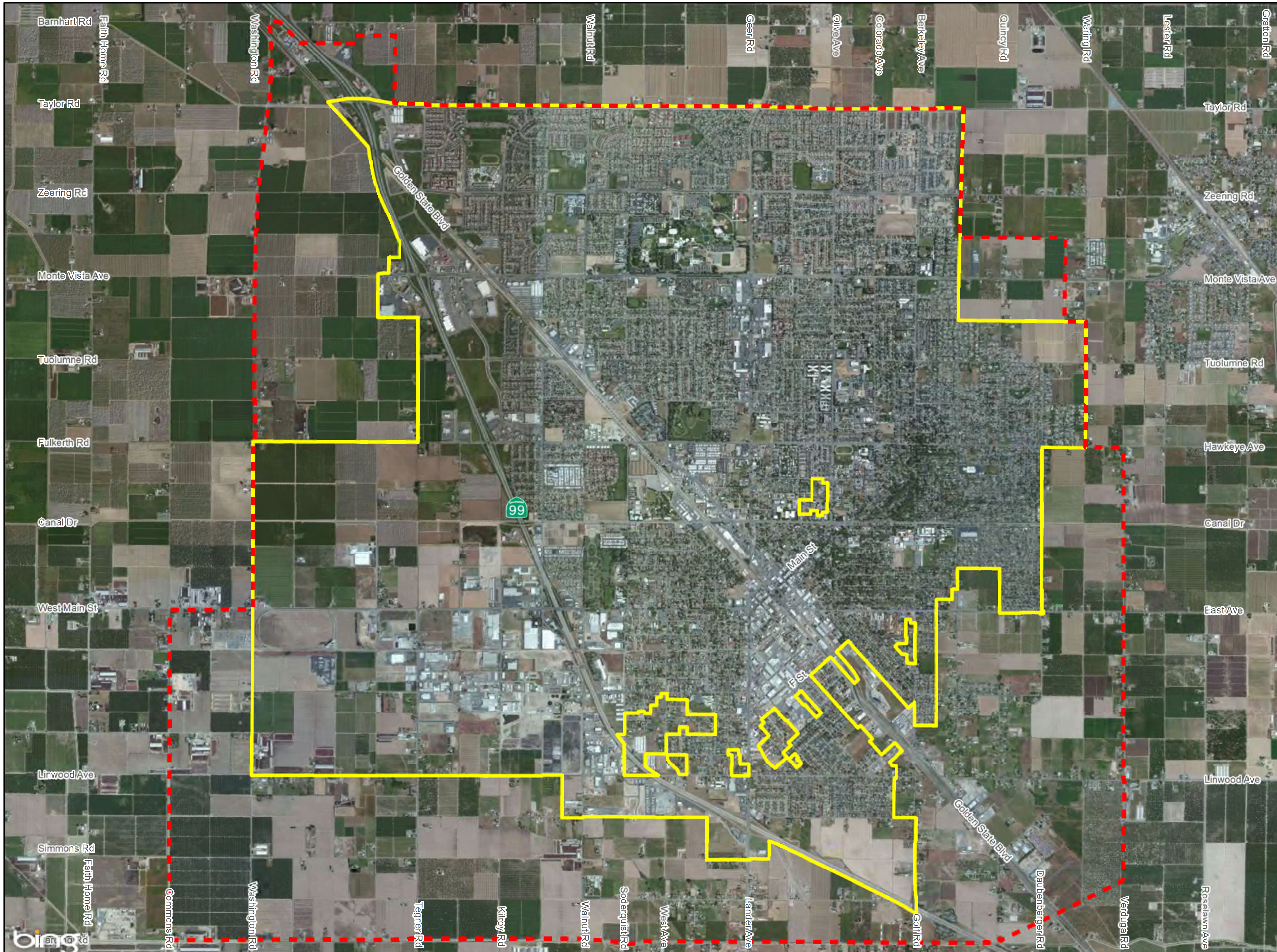
The City of Turlock (City) recently updated its General Plan. The City's General Plan study area consists of the City limits, the City's sphere of influence (SOI), and areas urban reserve (primarily used as agricultural land). The City's SOI is nearly conterminous with the City limits along its western edge, but varies along the eastern side of the City.

The General Plan update describes projected growth over the next 20 years as occurring as infill within current City limits, as well as limited new development outside City limits. City policy is that all infill growth areas within the current City limits must be at least 70 percent built-out before new development areas are allowed to annex. The General Plan includes three new distinct development areas. The land area remaining in the General Plan Planning Boundary is designated as Urban Reserve, or land that is not expected to develop within the planning horizon of the General Plan.

The study area boundary for this Master Plan coincides with the General Plan study area boundary (Figure 2.1). This area includes developed land within the City limits, infill areas within the existing City limits, and areas proposed for annexation and development within the study area boundary. The study area includes developed land within the City limits, infill areas within the existing City limits, and areas proposed for annexation and development that is outside the City limits and SOI. In addition, there are several County-owned islands within the City that are expected to be annexed and developed according to the development plan in the General Plan.

2.2 PLANNING PERIOD

The study area includes the existing City limits and development within the General Plan Study Area boundary that could occur through the year 2030 and beyond. Build-out of the majority of the City is projected to occur by year 2030, whereas full build-out of the Turlock Regional Industrial Park (TRIP) is expected to occur some time after 2030. Existing and projected populations and land uses within the Study Area are discussed in this chapter.



Legend

City Limits

General Plan Boundary

Feet

0 3,500 7,000

Figure 2.1
Master Plan Study Area
Sewer System Master Plan
City of Turlock

2.3 CLIMATE

The City is characterized by an "inland Mediterranean" type climate; summers are hot and dry and winters are cool and moist. Approximately 88 percent of the annual rainfall occurs between November and April, with an average annual rainfall of 11.4 inches[1]. In winter months, fog conditions often persist and can last for several days, but the season is generally short.

2.4 TOPOGRAPHY

The City is located in the heart of California's Central Valley. The City is predominantly flat and slopes to the southwest. The City ranges in elevation from about 116 feet above mean sea level (msl) on the eastside of the City, to 93 feet above msl on the west side of the City. Figure 2.2 shows the topography of the study area.

2.5 LAND USE

Land use and population information are integral components in determining the amount of wastewater generated within a City. The type of land use in an area will affect the volume and characteristics of the wastewater generation. Therefore, adequately estimating the generation of wastewater from various land use types is important in sizing and maintaining effective sanitary sewer system facilities. Existing land use was utilized to develop the initial estimate of wastewater flows for current conditions.

An important tool for determining land use and population projections is the City's 2030 General Plan, which guides development within the study area and establishes long-range development policies. Land use assumptions used in this study are consistent with those for existing and proposed development published in the 2030 General Plan.

The following land use descriptions are paraphrased from the City's General Plan. Pages from the General Plan are included in Appendix A for reference.

[1] Source: Historical data from Western Regional Climate Center, Modesto, CA (Station: Cty-Co H Sham FD APT [KMOD])

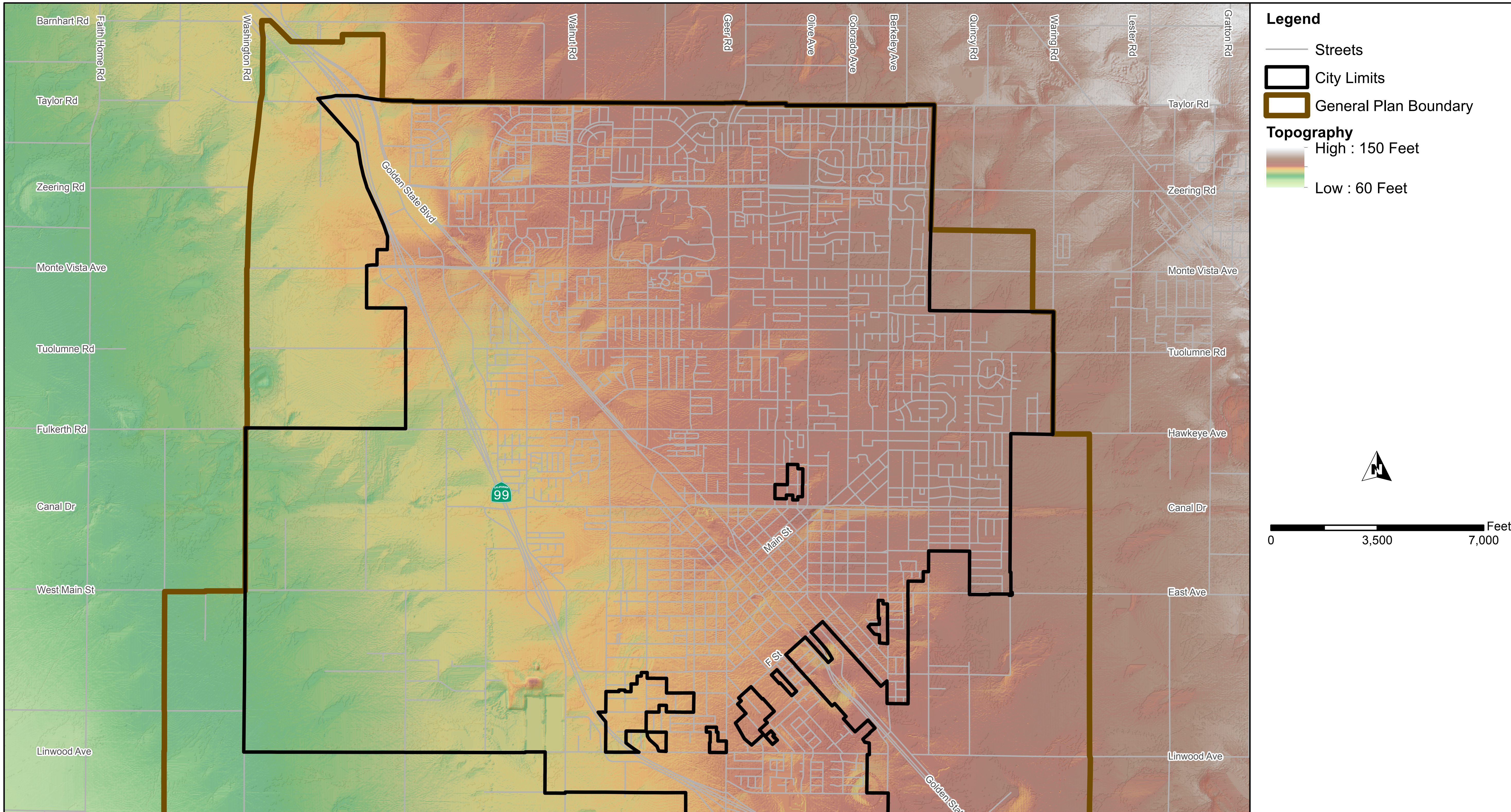


Figure 2.2
Study Area Topography
Sewer System Master Plan
City of Turlock

Residential. Areas designated as residential permit housing, childcare facilities, places of religious assembly, retail grocery stores not exceeding 2,500 square feet, and residential care facilities consistent with Federal and State Laws. Residential densities are per gross acre of developable land. Average densities are equivalent to the average densities assumed in the General Plan for calculation purposes.

- Very Low Density (VLDR) allows 0.2 to 3.0 units per gross acre, and assumes 3.0 persons per unit. An average density of 1.6 units per gross acre is assumed.
- Low Density (LDR) allows 3.0 to 7.0 units per gross acre, and assumes 3.2 persons per unit. An average density of 5.0 units per gross acre is assumed.
- Low-Medium Density (LDR-MDR) allows 5.0 to 10.0 units per gross acre, and assumes 3.0 persons per unit. An average density of 7.5 units per gross acre is assumed.
- Medium Density (MDR) allows 7.0 to 15.0 units per gross acre, and assumes 2.7 persons per unit. An average density of 11.0 units per gross acre is assumed.
- High Density (HDR) allows 15.0 to 40.0 units per gross acre, and assumes 2.4 persons per unit. An average assumed density is not listed in the General Plan for this classification, but 27 units per gross acre are assumed for this Master Plan.

Commercial and Mixed Use. Commercial land use classifications vary widely and constitute distinct purposes. Mixed use designations generally consist of a combination of commercial and residential and/or office uses.

- Downtown Mixed Use (DT) applies to Turlock's traditional Downtown area and indicates the area where the Downtown Overlay zoning districts apply. This classification includes apparel stores, restaurants, specialty shops, entertainment uses, bookstores, travel agencies, hotels/motels, and other similar uses. It also includes financial institutions, medical and professional offices, and other general office space. Nonresidential development in this classification should not exceed a FAR of 3.0.
- Office (O) includes business and professional offices, with a maximum FAR of 0.35.
- Community Commercial (CC) encompasses retail and personal service users, including retail stores, food and drug stores, apparel stores, specialty shops, home furnishings, durable goods, offices, restaurants, and other similar uses. This designation should not exceed 0.25 FAR.
- Regional Commercial (RC) includes large-scale shopping centers, factory outlets, discount stores, and other commercial uses. Development in this designation should not exceed 0.35 FAR, except for hotels/motels, which may have up to 2.0 FAR.

- Highway Commercial (HWC) provides for uses designated to serve motorists traveling along major highways, and include service stations, hotels/motels, restaurants, auto sales, and other automobile-dependent uses. This designation may not exceed 0.35 FAR.
- Heavy Commercial (HC) includes heavy, wholesale, and service commercial uses that do not require highly visible locations, or where noise levels or other conditions may limit the suitability for other retail uses, which may not exceed 0.35 FAR.
- Multiple Use Designations occur when several land use designations are combined. Land uses with multiple designations are permitted to develop at the highest density or FAR allowed by the associated designations.

Industrial. This designation provides for large- and small-scale industrial, manufacturing, distributing, and heavy commercial uses.

- Industrial (I) designation includes land uses such as food processing, fabricating, motor vehicle service and repair, truck yards and terminals, warehousing and storage uses, wholesale uses, construction supplies, building material facilities, offices, and other similar uses. Development in this designation may not exceed 0.6 FAR.
- Business Park (BP) provides for office centers, research and development facilities, medical and professional office, institutional uses, limited light industrial uses, warehousing and distributing, “back office” uses, and other similar applications. Development may not exceed 0.35 FAR.

Public/Institutional (PUB). This classification applies to the City’s major public and private institutional uses, including public safety facilities, public schools, California State University Stanislaus, State fairgrounds, and other prominent public uses and facilities. Stormwater detention basins are also designated as public uses on the land use diagram.

Parks (P). This designation applies to existing and planned public parks and open space, including specialized public recreation facilities.

Urban Reserve (UR). This classification is established for identifying land that is reserved for future unspecified urban uses. Agricultural uses are permitted on property that is classified UR, though they may eventually be replaced by permanent urban development. Public and recreational facilities may also be located on land classified as UR.

2.5.1 Service Area Land Use

Wastewater flows were determined from existing and future land uses in the City’s sanitary sewer service area. Table 2.1 includes the existing land use totals for the 2012 sewer service area, including the breakdown between developed and vacant land. Figure 2.3 shows the City’s existing land uses.

Table 2.1 Existing Service Area Land Use
Sewer System Master Plan
City of Turlock

Land Use Category	Existing Service Area (acres)
Residential	
Agricultural	1,575
Residential Ranchette	117
Low & Medium Residential	3,358
High Density Residential	228
Commercial/Industrial	
Commercial	649
Office	118
Industrial	807
Other	
Mixed Use	69
Public/Semi-Public/Community Facility	684
Parks & Open Space	209
Vacant	816
Streets/ROW	2,126
Total	**10,757**

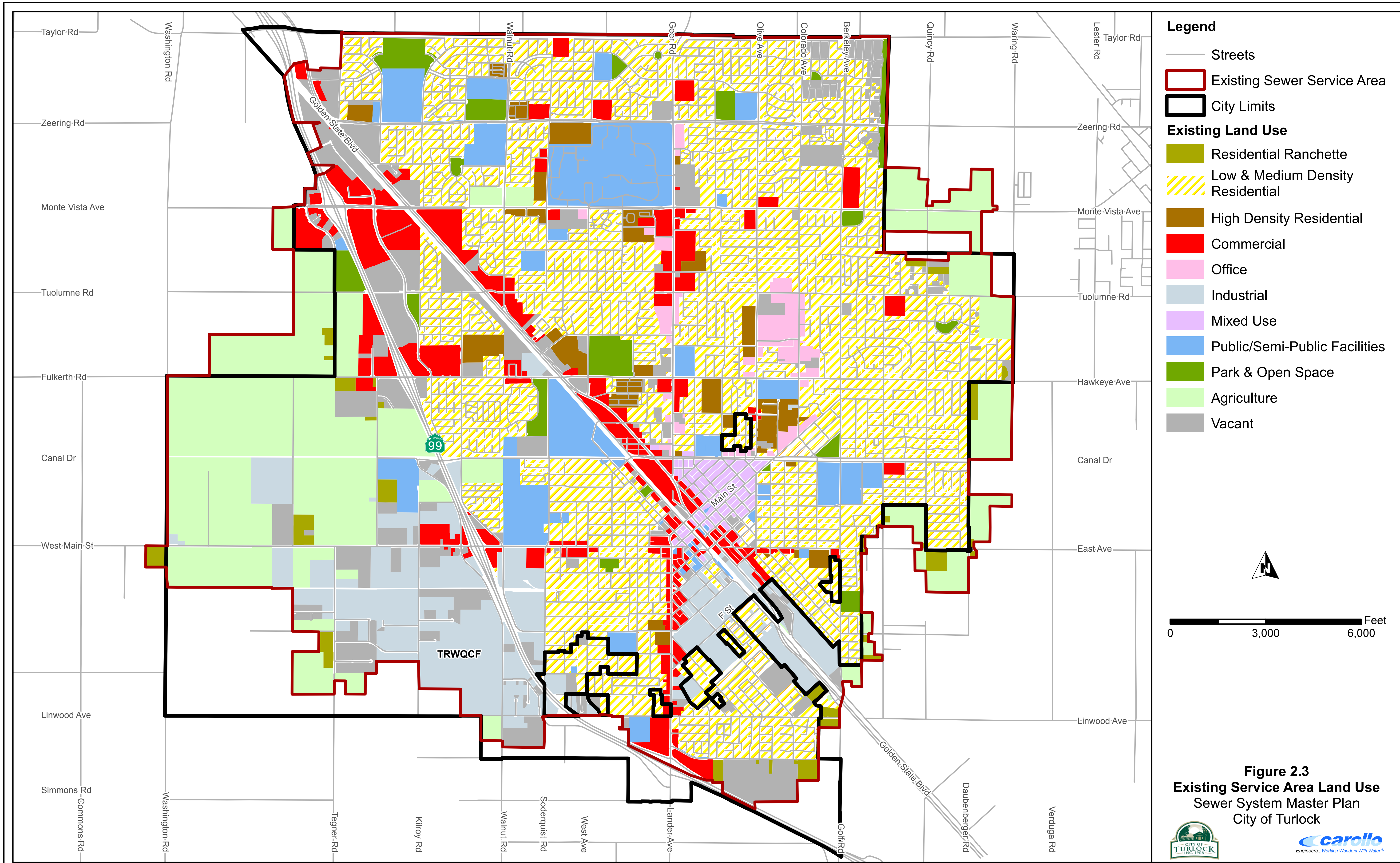


Figure 2.3
Existing Service Area Land Use
Sewer System Master Plan
City of Turlock

Table 2.2 includes the 2030 General Plan land use totals for build-out of the General Plan boundary. Figure 2.4 shows the build-out service area land use.

2.5.1.1 Existing Service Area Land Use

The City provides wastewater collection service to residents, businesses, and other institutions within its service area, which is approximately 10,757 acres (includes developed and undeveloped land) or 16.8 square miles. The largest land use category is residential (agricultural, residential ranchette, low and medium density, and high density), which accounts for approximately 49 percent of the total current service area acreage. Commercial land uses (commercial, office) make up approximately 7 percent of the total. Industrial designations comprise 8 percent of the service area. Other land uses, such as mixed use, public, parks and open space, and vacant land account for the remaining 36 percent of the total service area.

2.5.1.2 Future Service Area Land Use

At build-out of the General Plan boundary, the City will encompass approximately 16,895 acres (26.4 square miles). Build-out is defined as complete development of the General Plan Boundary. At build-out, the largest land use category is residential (very low density, low density, low-medium density, medium density, medium density/office, high density, and urban reserve), which accounts for approximately 56 percent of the total General Plan acreage. Commercial land uses (business park, community commercial, community commercial/office, heavy commercial, highway commercial, neighborhood commercial, downtown, and office) make up approximately 11 percent of the total. Industrial designations comprise 11 percent of the service area. Other land uses, such as public, parks, and detention basins account for the remaining 22 percent of the total service area.

2.6 HISTORICAL AND PROJECTED POPULATION

The City has historically been an agricultural-based community that has placed heavy emphasis on a growth management strategy that preserves a distinct “edge” of urban development. As such, the City is surrounded by agricultural fields and supports food processing facilities and related agricultural services.

According to data collected from the California Department of Finance (DOF), the City’s 2010 population was approximately 68,279. This corresponds to an increase of 23 percent from the City’s 55,359 population in the year 2000[2], and an average annual population growth of 2.1 percent since 2000. Since 1990, the City’s population has grown from 42,224, an increase of 26,055 people, or a total growth of nearly 62 percent.

[2] Source: California Department of Finance

Table 2.2 Build-Out Service Area Land Use
Sewer System Master Plan
City of Turlock

Land Use Category	Build-Out Service Area (acres)
Residential	
Urban Reserve	4,570
Very Low Density	289
Low Density	2,916
Low-Medium Density	408
Medium Density	872
Medium Density/Office	6
High Density	345
High Density/Office	15
Commercial/Industrial	
Business Park	272
Community Commercial	509
Community Commercial/Office	15
Community Commercial/Office/High Density Residential	9
Heavy Commercial	367
Highway Commercial	194
Neighborhood Commercial	164
Downtown	255
Office	22
Neighborhood Center	1,854
Industrial	272
Other	
Public	934
Park	361
Detention Basin	89
Streets/ROW	2,432
Total	**16,895**

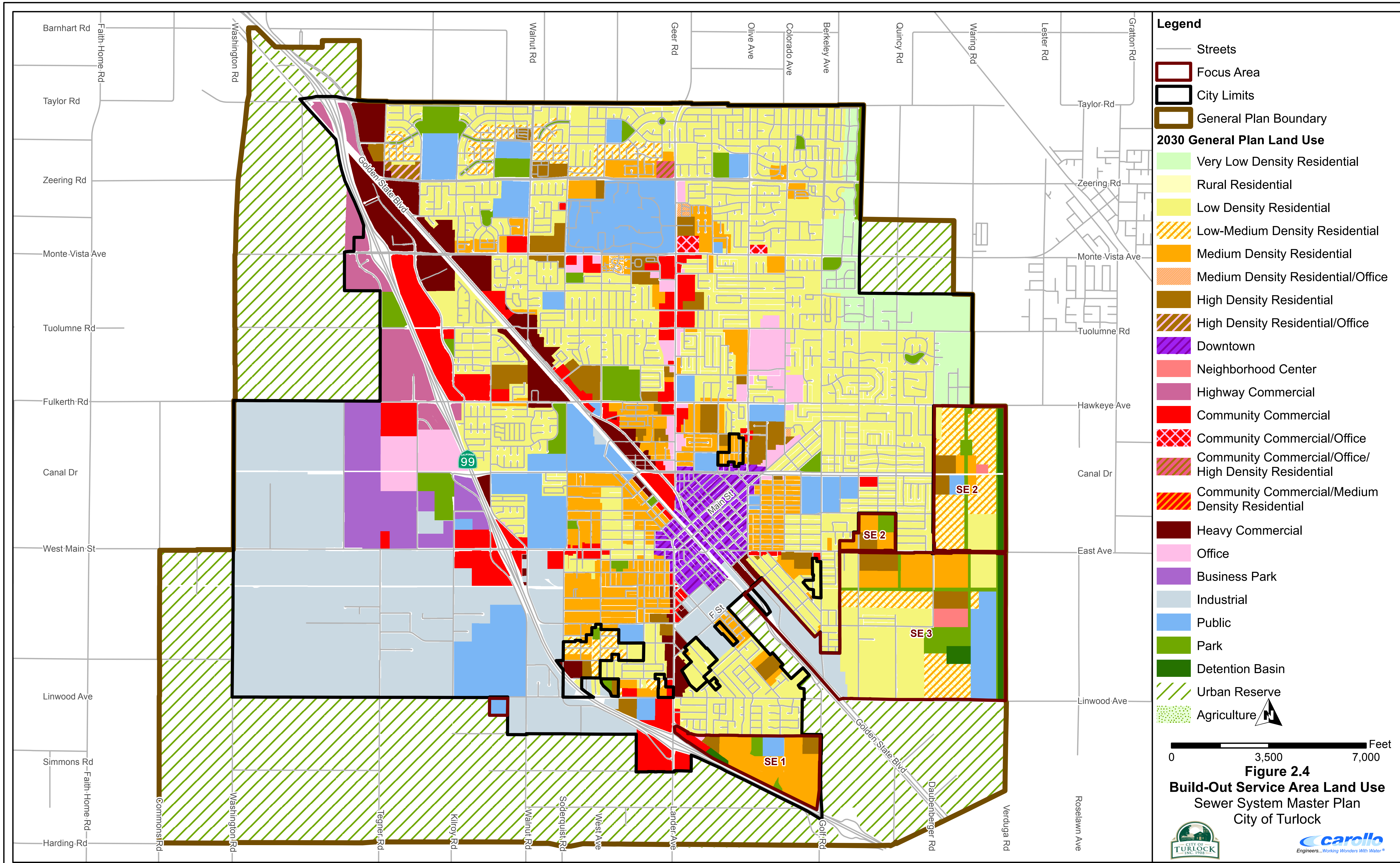


Figure 2.4
Build-Out Service Area Land Use
Sewer System Master Plan
City of Turlock

The City’s 2030 General Plan Update includes population projections for Turlock. Table 2.3 provides a summary of the City’s projected population. Figure 2.5 illustrates the City’s historical population based on DOF estimates and the population projections provided in the 2030 General Plan Update. Intermediate projections (for the years 2015, 2020, and 2025) were calculated by assuming steady growth through the 2030 planning period. The population forecast results in an annual growth rate of approximately 2.2 percent per year.

Table 2.3 Historical and Projected Population
Sewer System Master Plan
City of Turlock

Projected Years	2010	2015	2020	2025	2030
Population	68,300	75,900	84,500	94,000	104,500

Notes:
(1) Source of 2010 population data: California Department of Finance.
(2) Population projections for the year 2030 were taken from the City’s 2030 Draft General Plan Update. Population projections for years 2015, 2020, and 2025 are based on a constant growth rate to achieve the 2030 forecasts.

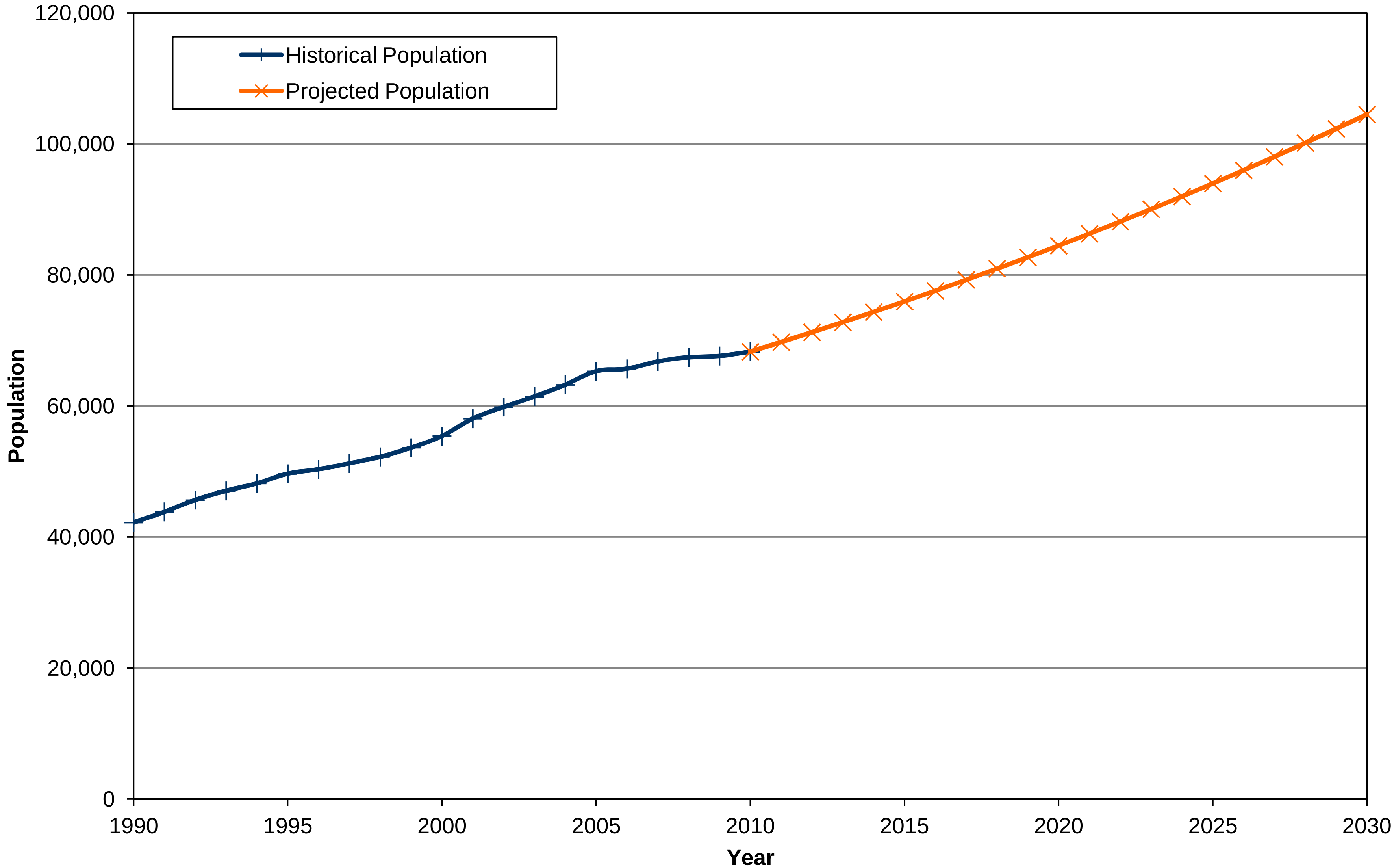


Figure 2.5
Historical and Projected Population
Sewer System Master Plan
City of Turlock

PLANNING CRITERIA

The capacity of the City of Turlock's (City) sanitary sewer collection system was evaluated based on the planning criteria defined in this chapter. The criteria include standards from the City's Improvement Standards and Specifications (Improvement Standards), Stanislaus County Improvement Standards and Specifications, and other planning criteria developed by Carollo based on engineering judgment and past experience. The planning criteria address the collection system capacity, gravity sewer slopes, and maximum depth of flow within a sewer.

Capacity analysis of the wastewater collection system was performed in accordance with the criteria established in this chapter. The City's Improvement Standards stipulate general policies of the City and outline sewer design criteria. Some of these criteria were modified for the Master Plan as discussed below.

3.1 GRAVITY SEWERS

Capacity analysis of the gravity sewers will be performed in accordance with the criteria established in this section. Sewer pipe capacities are dependent on many factors, including roughness of the pipe, the maximum allowable depth of flow, minimum velocity, and slope of pipe.

3.1.1 Manning Coefficient (n)

The Manning coefficient 'n' is a friction coefficient that varies with respect to pipe material, size of pipe, depth of flow, smoothness of pipe and joints, and extent of root intrusion. For sewer pipes, the Manning coefficient typically ranges between 0.011 and 0.017, with 0.013 being a representative value used for sewer system master planning. For this study, a Manning coefficient of 0.013 was assigned to all existing sewer collection system pipelines in the hydraulic model, and then refined as necessary during model calibration to accurately simulate measured levels and velocities. A Manning coefficient of 0.013 was assumed for all future collection system pipelines.

3.1.2 Flow Depth Criteria (d/D)

The primary criterion used to identify capacity deficient trunk sewers or to size new improvements is the maximum flow depth to pipe diameter ratio (d/D). The d/D value is defined as the depth (d) of flow in a pipe during peak flow conditions divided by the pipe's diameter (D). The City's Improvement Standards do not define the acceptable d/D values for various pipe diameters, nor does the County's Improvement Standards. Based on Carollo's experience and industry standards, the following d/D criteria were established.

3.1.2.1 Flow Depth for Existing Sewers

Maximum flow depth criteria for existing sanitary sewers are established based on a number of factors, including the acceptable risk tolerance of the utility, local standards and codes, and other factors. Using a conservative d/D ratio when evaluating existing sewers may lead to unnecessary replacement of existing pipelines. Conversely, lenient flow depth criteria could increase the risk of sanitary sewer overflows (SSOs). Ultimately, the maximum allowable flow depth criteria should be established to be as cost effective as possible while at the same time reducing the risk of SSOs to the extent possible.

For the Turlock collection system model, water levels (hydraulic grade line) were allowed to rise up to five feet below the manhole rim during peak wet weather flow (PWWF) conditions. A capacity deficient sewer (i.e., system bottleneck) raises the hydraulic grade line of upstream sewers, leading to backwater conditions. The greater the capacity deficiency, the higher water levels will surcharge upstream of the bottleneck pipeline (or pipelines). The hydraulic model is used to determine “backwater” pipelines in order to specify which specific pipelines are the actual root causes of the capacity deficiency. Capital projects are proposed to provide greater flow capacity for the deficient sewers, which eliminates the backwater conditions that cause surcharging.

3.1.2.2 Flow Depth for New Sewers

When designing new sewers, it is common practice to adopt variable flow depth criteria for different pipe sizes. Design d/D ratios typically range from 0.5 to 0.92, with the lower values used for smaller pipes, which may experience flow peaks greater than design flow or may experience blockages from debris, paper or rags.

Sewers less than 12 inches in diameter shall be designed to flow half full at peak wet weather flow rates. Sewers 12 to 18 inches in diameter shall be designed to flow at two-thirds depth at peak flow rate. Sewers larger than 18 inches in diameter shall be designed to flow at a d/D of 0.75 at peak flow rate. The maximum allowable d/D ratios for design flow conditions are summarized in Table 3.1.

Table 3.1 Maximum Flow Depth Criteria
Sewer System Master Plan
City of Turlock

Existing Sewers	
Peak Wet Weather Flow	Surcharge to 5′ Below Manhole Rim
New Sewers	
Diameter Less than 12 inches	d/D = 0.50
Diameter 12 inches up to Diameter 18 inches	d/D = 0.67
Diameter Greater than 18 inches	d/D = 0.75

3.1.3 Design Velocities and Minimum Slopes

In order to minimize the settlement of sewage solids, sewer velocity should be equal to or greater than 2 feet per second (ft/s) for all sewers when flowing at design flow d/D (based on roughness coefficient of 0.013). At this velocity, the sewer flow will typically provide self-cleaning for the pipe. Table 3.2 lists the recommended minimum slopes and their corresponding maximum flows for maintaining self-cleaning velocities (equal to or greater than 2 ft/s) when the pipe is flowing at its maximum depth.

The recommended minimum slopes presented in Table 3.2 are consistent with those presented in the City's standards for sewers up to 18-inches in diameter. The City does not specify minimum slopes for sewers larger than 18-inches in diameter.

Table 3.2 Minimum Slope and Maximum Flow
Sewer System Master Plan
City of Turlock

Pipe Diameter (inches)	Minimum Slope[1] (ft/ft)	Calculated Flow at Maximum d/D Criteria		
		d/D	Maximum Flow (cfs)	Maximum Flow (mgd)
8	0.0024[2]	0.50	0.30	0.19
10	0.0018[2]	0.50	0.47	0.30
12	0.0015[2]	0.67	1.08	0.70
15	0.0011[2]	0.67	1.68	1.09
18	0.0009[2]	0.67	2.48	1.60
21	0.0009	0.75	4.39	2.84
24	0.0008	0.75	5.73	3.70
27	0.0007	0.75	7.25	4.69
30	0.0006	0.75	8.95	5.79
36	0.0004	0.75	12.89	8.33
42	0.0004	0.75	17.55	11.34
48	0.0003	0.75	22.92	14.81

Notes:
1. Recommended minimum slope to maintain velocities greater than or equal to 2 ft/s with d/D values of 0.5. This is to ensure that the self-cleaning velocity of 2 ft/s is achieved even when pipelines are not flowing full.
2. Source: City of Turlock Standards and Specifications (2008). Minimum pipe slopes recommended by the City result in velocities less than 2 ft/s when for the maximum d/D criteria.

3.1.4 Changes in Pipe Size

When a smaller sewer joins a large one, the invert of the larger sewer will be lowered sufficiently to maintain the same energy gradient.

3.1.5 Lift Stations and Force Mains

The City's Improvement Standards and Specifications do not contain requirements related to lift station design capacities or force main design recommendations. Standard industry practice is to require that sewage lift stations have sufficient firm capacity (capacity with the largest pump out of service) to pump the design flow. For the design of force mains, the minimum and maximum recommended velocities are 2.0 and 6.5 ft/s, respectively. The Hazen-Williams formula is commonly used for the design of force mains. The Velocity Equation is:

Velocity Equation: $V = 1.32\ C\ R^{0.63}\ S^{0.54}$

Where: V = mean velocity, ft/s

C = roughness coefficient

R = hydraulic radius, ft

S = slope of the energy grade line, ft/ft

The value of the Hazen-Williams 'C' varies with the type of pipe material. The value is influenced by the type of construction and age of the pipe. A 'C' value of 120 will be used for this Master Plan.

FLOW MONITORING AND WASTEWATER FLOWS

This chapter summarizes the flow monitoring program and presents the calculation of the design flows used to model the existing and future sewer system.

4.1 FLOW MONITORING PROGRAM

Carollo contracted with V&A Consulting Engineers (V&A) to conduct a temporary flow monitoring program for the sanitary sewer collection system. The purpose of the flow monitoring program was to assist in the development of design flow criteria, and to correlate actual collection system flows to the hydraulic model predicted flows. Flow monitoring data was also used to calibrate the collection system hydraulic model for dry weather and wet weather flow, and to help to identify areas of the system with the highest rates of infiltration/inflow (I/I). The temporary flow monitoring program was conducted for a period of approximately six weeks from January 20, 2013 to February 29, 2013.

The “Sanitary Sewer Flow Monitoring and Inflow/Infiltration Study, January 2013” prepared by V&A summarizes the flow monitoring program and was submitted to the City of Turlock (City) as a stand-alone report. A copy of the report is included in Appendix B.

4.1.1 Flow Monitoring Sites and Tributary Areas

Thirteen (13) open-channel flowmeters were installed at locations selected by Carollo and the City. The meter sites were selected to best isolate and model the critical areas and subareas within the sewer system. The 13 flow monitoring locations, as well as the area tributary to each site, are shown on Figure 4.1. Table 4.1 lists the flow monitoring locations and the diameters for the sewers where the meters were installed. Figure 4.2 provides a schematic illustration of the flow monitoring locations.

4.1.2 Flowmeter Installation and Flow Calculation

V&A installed five Teledyne Isco 2150, three Hach Sigma 910 and five Marsh-McBirney Flo-Dar flowmeters. Isco 2150 and Sigma 910 meters use a pressure transducer to collect depth readings and ultrasonic Doppler sensors on the probe to determine the average fluid velocity. The Flo-Dar flowmeter is a non-contact flowmeter that uses radar to measure velocity and a down-looking ultrasonic sensor to measure depth. V&A selected the optimal type of flowmeter to use on a site-to-site basis based on the hydraulic characteristics at each site, as well as other factors. For example, the Flo-Dar flowmeter is commonly used in high velocity, small diameter pipes.

Table 4.1 Flow Monitoring Locations
Sewer System Master Plan
City of Turlock

Monitor Site	Manhole ID	Pipe Diameter (in.)	Location
Site 1	H5N09	42	812 South Walnut Road
Site 2	H5W15	30	812 South Walnut Road
Site 3	G5S06	30	802 South Walnut Road
Site 4	G5E13	48	1000 W Sacramento Avenue
Site 5	G6S03	16	Intersection of Soderquist Road and Angelus Street
Site 6	G6W01	16	Intersection of Angeles Street and West Avenue
Site 7	G8S116	24	Intersection of 5th Street and W. F Street
Site 8	H8S40	33	Intersection of Lander Avenue and W. F Street
Site 9	G5E25	15	Intersection of W. Main Street and N. Walnut Road
Site 10	E5S22	24	Intersection of Fulkerth Road and N. Tully Road
Site 11	E6S33	18	Intersection of Dels Lane and W. Hawkeye Avenue
Site 12	C6W22	21	Intersection of W. Monte Vista Avenue and Crowell Road
Site 13	C5S02A	30	Intersection of N. Walnut Road and W. Monte Vista

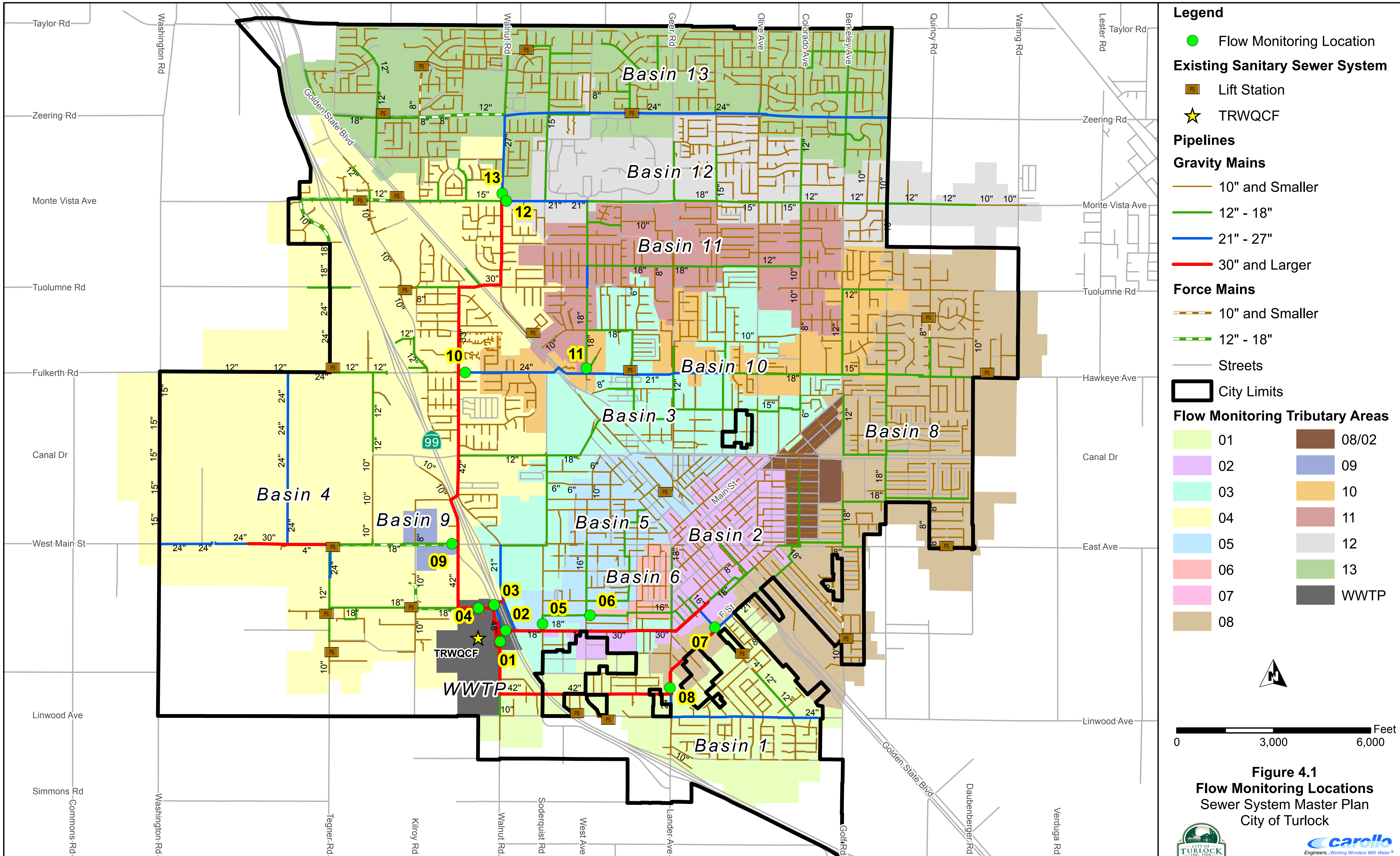


Figure 4.1
Flow Monitoring Locations
Sewer System Master Plan
City of Turlock

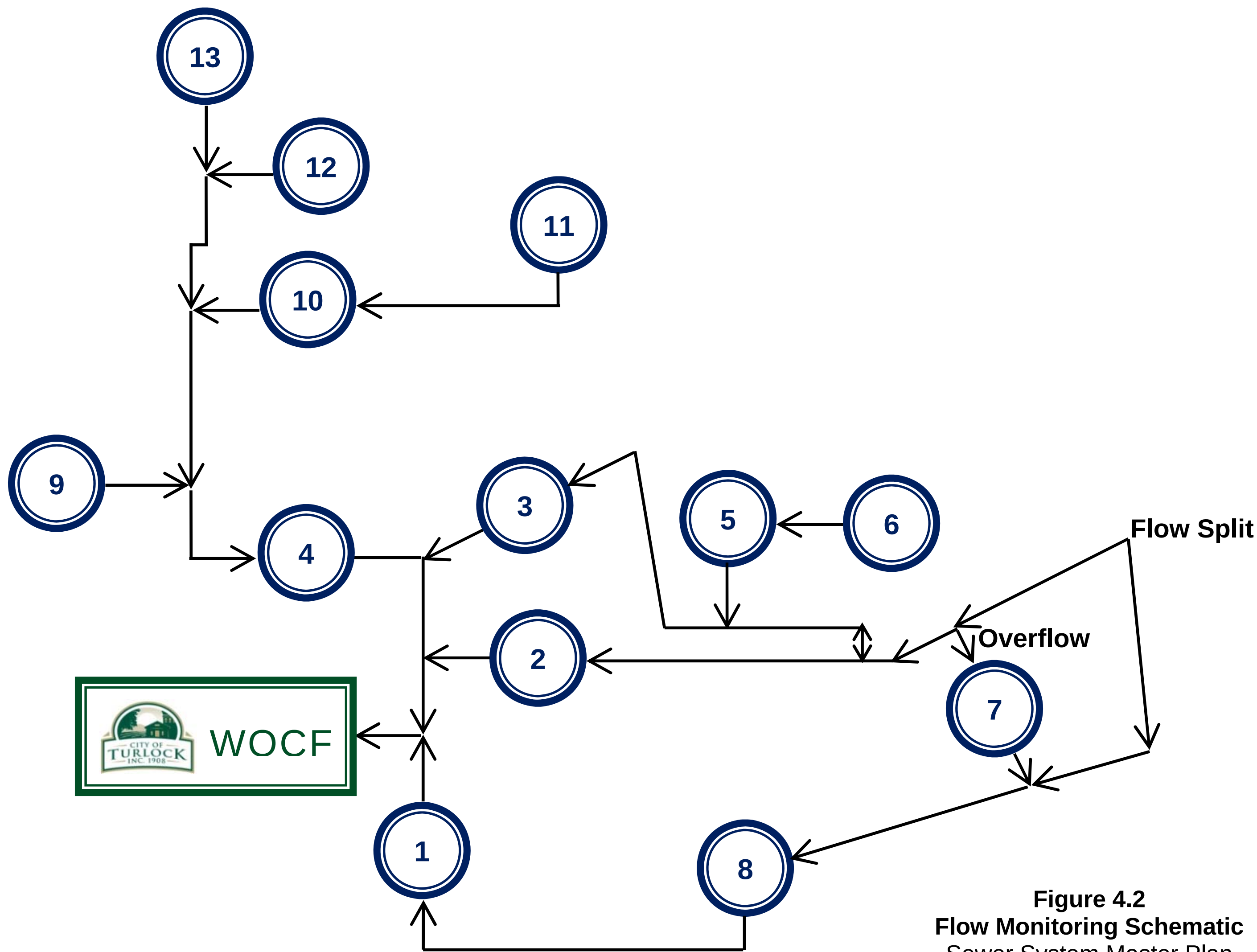


Figure 4.2
Flow Monitoring Schematic
Sewer System Master Plan
City of Turlock

In order to ensure that each meter was accurate and calibrated, manual level and velocity measurements were taken by V&A when each meter was installed and again when they were removed. These manual measurements were compared to simultaneous level and velocity readings from the flowmeters. The pipe diameter was also verified, because the pipe diameter is needed to calculate flow rate in a pipe based on the velocity and level measurements. In addition, the depth of sediment, if any, was measured as this affects the cross sectional area of flow within a pipe.

V&A conducted an analysis of the data retrieved from each flowmeter, and made adjustments as needed for calibration based on the field measurements, and to account for any sediment build up. The flow at each meter was then calculated at 5-minute intervals based on the continuity equation:

$$Q = V \times A$$

where,

Q = Pipeline flow rate, cfs

V = Average velocity, ft/s

A = Cross sectional flow area, ft^2

Finally, the 5-minute flow, velocity, and level data were aggregated into 15-minute increments.

4.1.3 Rain Gauges

Three rain gauges were installed to capture rainfall that occurred throughout the study area. The location of each rain gauge is shown on Figure 4.3 and summarized in Table 4.2. The rain gauges were distributed in an attempt to provide as much coverage of the topography of the City as possible.

Table 4.2 Rain Gauge Locations
Sewer System Master Plan
City of Turlock

Rain Gauge Number	Installed By	Location	Elevation (ft)
RG North	V&A	Turlock Jr. High School: 3951 N Walnut Road	103
RG Central	V&A	Crowell Elementary School: 118 North Avenue	106
RG South	V&A	Intersection of 8th Street and West F Street	101

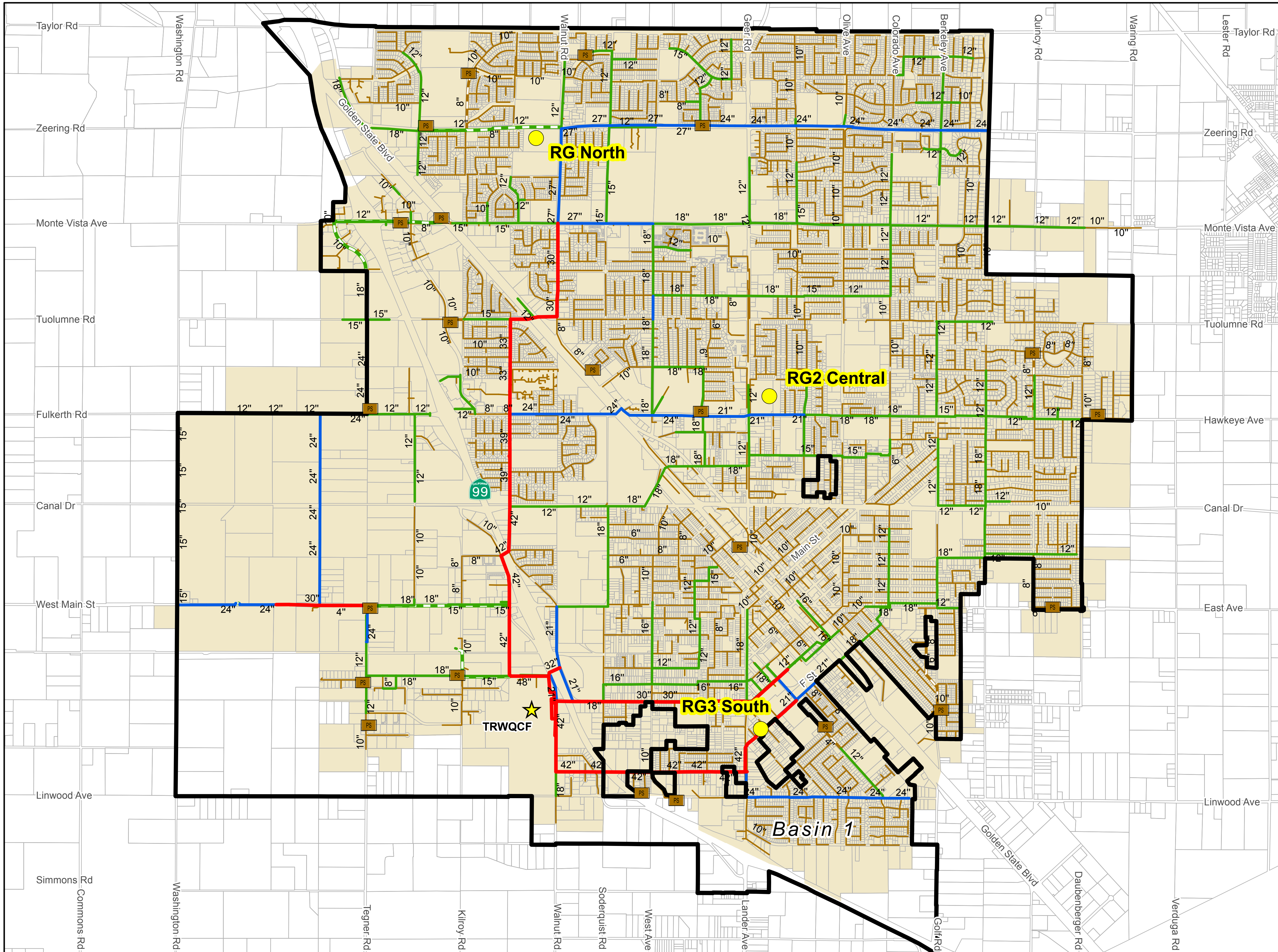


Figure 4.3
Rain Gauge Locations
Sewer System Master Plan
City of Turlock

4.2 WASTEWATER FLOW COMPONENTS

This section describes and provides definitions of commonly used terminology in the wastewater collection system analysis and evaluations conducted as part of this project. Wastewater flows vary according to the season. Dry weather flow (DWF) or base flow is flow generated by routine water usage in the residential, commercial, business and industrial sectors of the collection system.

The other component of DWF is the contribution of dry weather groundwater infiltration (GWI) into the collection system. Dry weather GWI will enter the sewer system when the relative depth of the groundwater table is higher than the depth of the pipeline and when the susceptibility of the sanitary sewer pipe allows infiltration through defects such as cracks, misaligned joints, and broken pipelines.

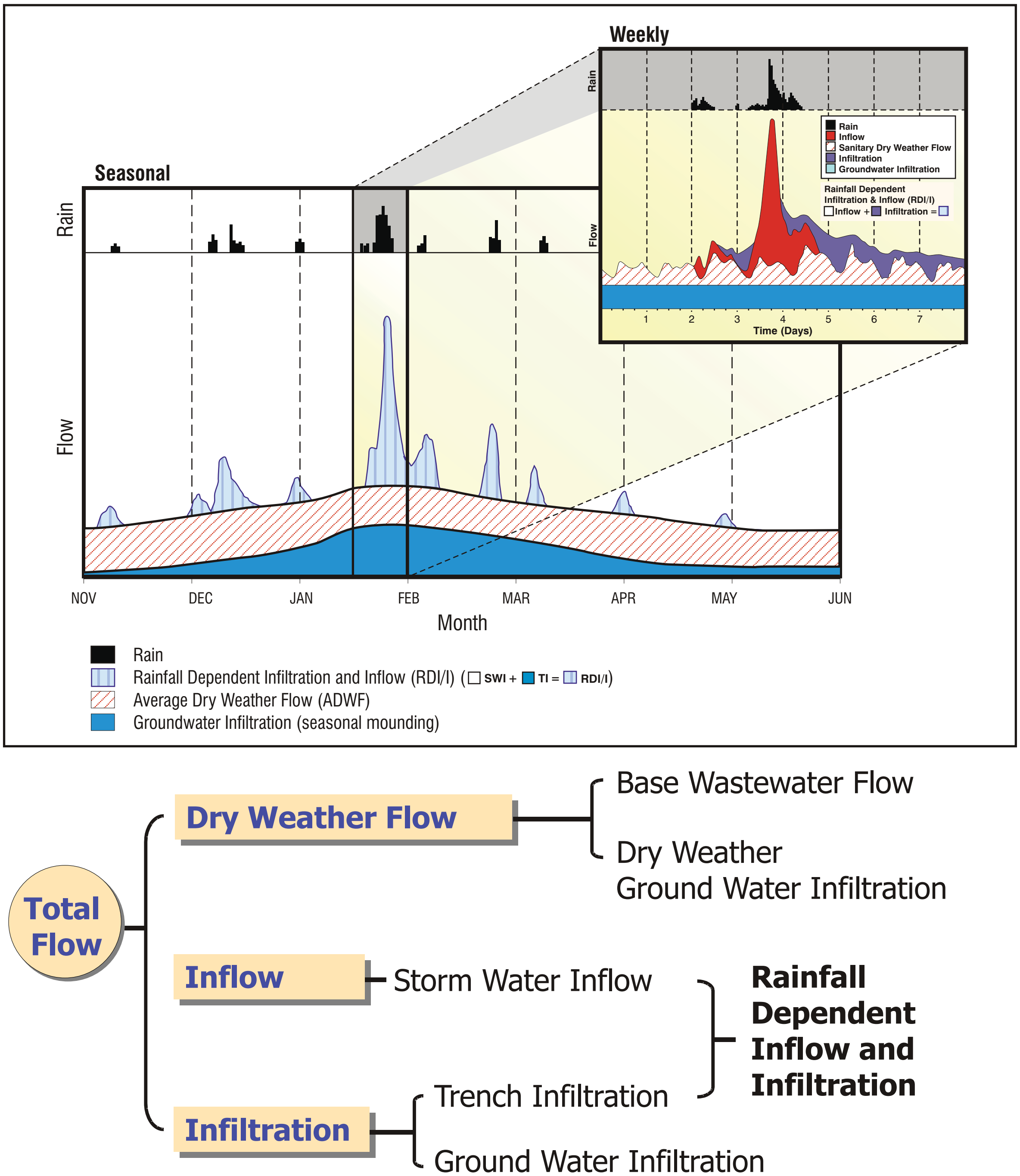
Wet weather flow (WWF) includes storm water inflow, trench infiltration, and GWI. The storm water inflow and trench infiltration comprise the WWF component termed infiltration/inflow (I/I). The response in the sewer system to rainfall is seen immediately (as with inflow) or within hours after the storm (as with infiltration).

Wet Weather GWI is caused by the rising of the groundwater table above the sewer pipes. Sewer pipes close to a body of water can be greatly influenced by groundwater effects. As the groundwater table fluctuates over the wet weather season, this fluctuation is seen as a mounding effect in flow monitoring data.

Figure 4.4 illustrates the various flow components, which are described in detail in the following sections.

4.2.1 Base Wastewater Flow

The base wastewater flow (BWF) is the flow generated by the City's customers independent of wet weather influences. BWF is estimated by measuring flows during dry weather conditions. The flow has a diurnal pattern that varies depending on the type of use. Commercial and industrial patterns, though they vary depending on the type of use, typically have more consistent higher flows during business hours and lower flows at night. Furthermore, the diurnal flow pattern experienced during a weekend may vary from the diurnal flow experienced during a weekday.



Note: This figure is not based on flow data specific to the City or this Master Plan

Figure 4.4
Typical Wastewater Flow Components
Sewer System Master Plan
City of Turlock

4.2.2 Average Annual Flow

The average annual flow (AAF) is the average flow that occurs on a daily basis throughout the year, including both periods of dry and wet weather conditions.

4.2.3 Average Dry Weather Flow

The average dry weather flow (ADWF) is the average flow that occurs on a daily basis during the dry weather season. The ADWF includes the BWF generated by the City's residential, commercial, and industrial users, plus the dry weather GWI component. For the City, the ADWF was estimated throughout the service area based on the historical influent flow data from the Turlock Regional Water Quality Control Facility (TRWQCF), and from the flow monitoring program.

4.2.4 Groundwater Infiltration

GWI is the result of extraneous water entering the sewer system through defects in pipes and manholes. GWI is related to the condition of the sewer pipes, manholes, and groundwater levels. GWI may occur throughout the year, although rates are typically higher in the late winter and early spring. Dry weather GWI (or base infiltration) cannot easily be separated from BWF by flow measurement techniques. Therefore, dry weather GWI is typically grouped with BWF.

4.2.5 Infiltration and Inflow

All wastewater collection systems have some I/I, although the characteristics and severity vary by region and individual collection system. Some of the most common sources of I/I are shown on Figure 4.5. Infiltration is defined as storm water flows that enter the sewer system by percolating through the soil and then through defects in pipelines, manholes, and joints. Examples of infiltration entry points are cracks in pipelines, misaligned joints, and root penetration. Inflow is defined as storm water that enters the sewer system via a storm drain cross connections, leaky manhole covers, or cleanouts. Examples of inflow entry points are roof drain and downspout connections, leaky manhole covers, and illegal storm drain connections.

The adverse effects of I/I entering the sewer system is that it increases both the flow volume and peak flows, as illustrated on Figure 4.6. If too much I/I enters the sewer system such that the sewer system is operating at or above its capacity, Sanitary Sewer Overflows (SSOs) could occur.

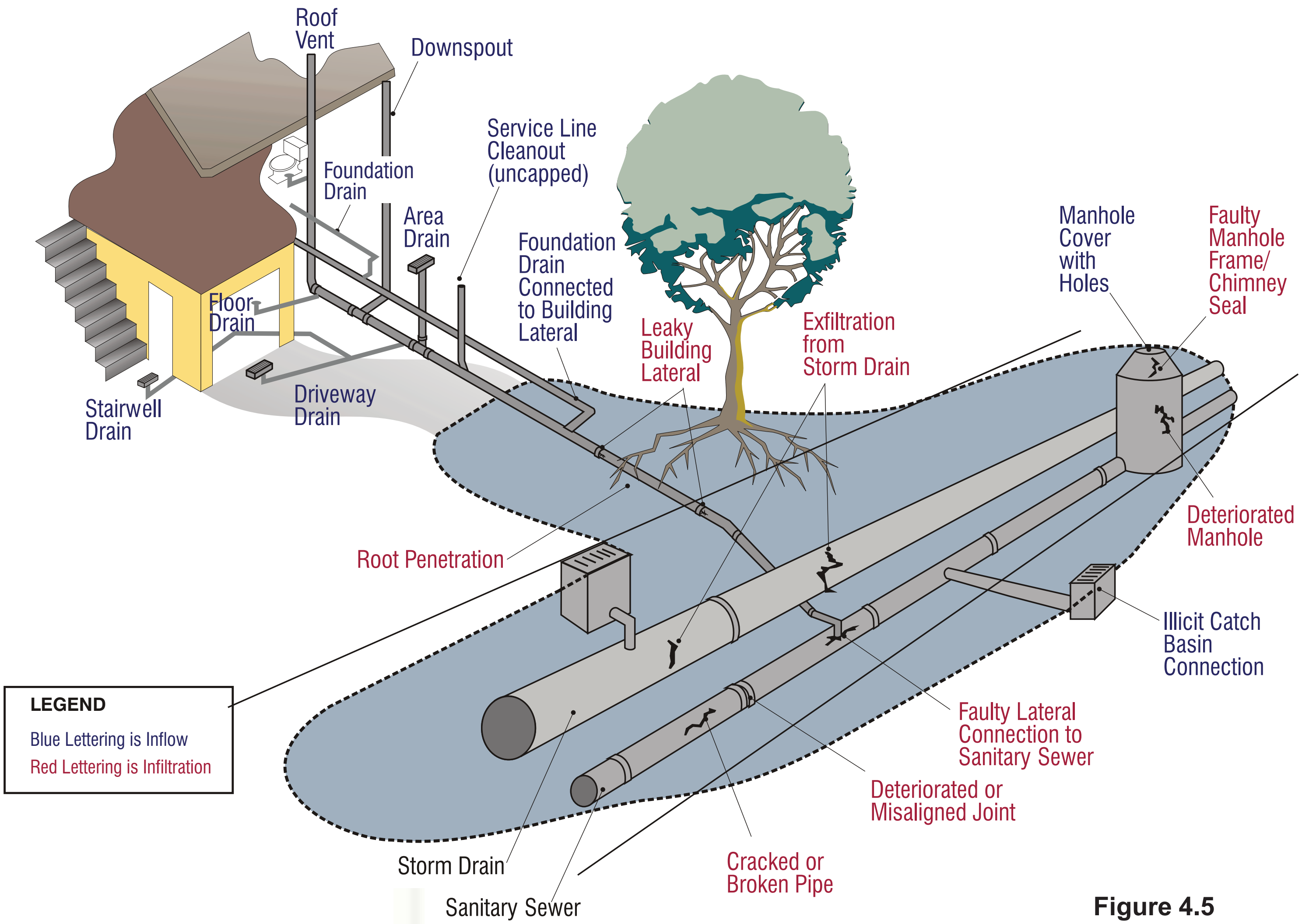


Figure 4.5
Typical Sources of Infiltration and Inflow
Sewer System Master Plan
City of Turlock

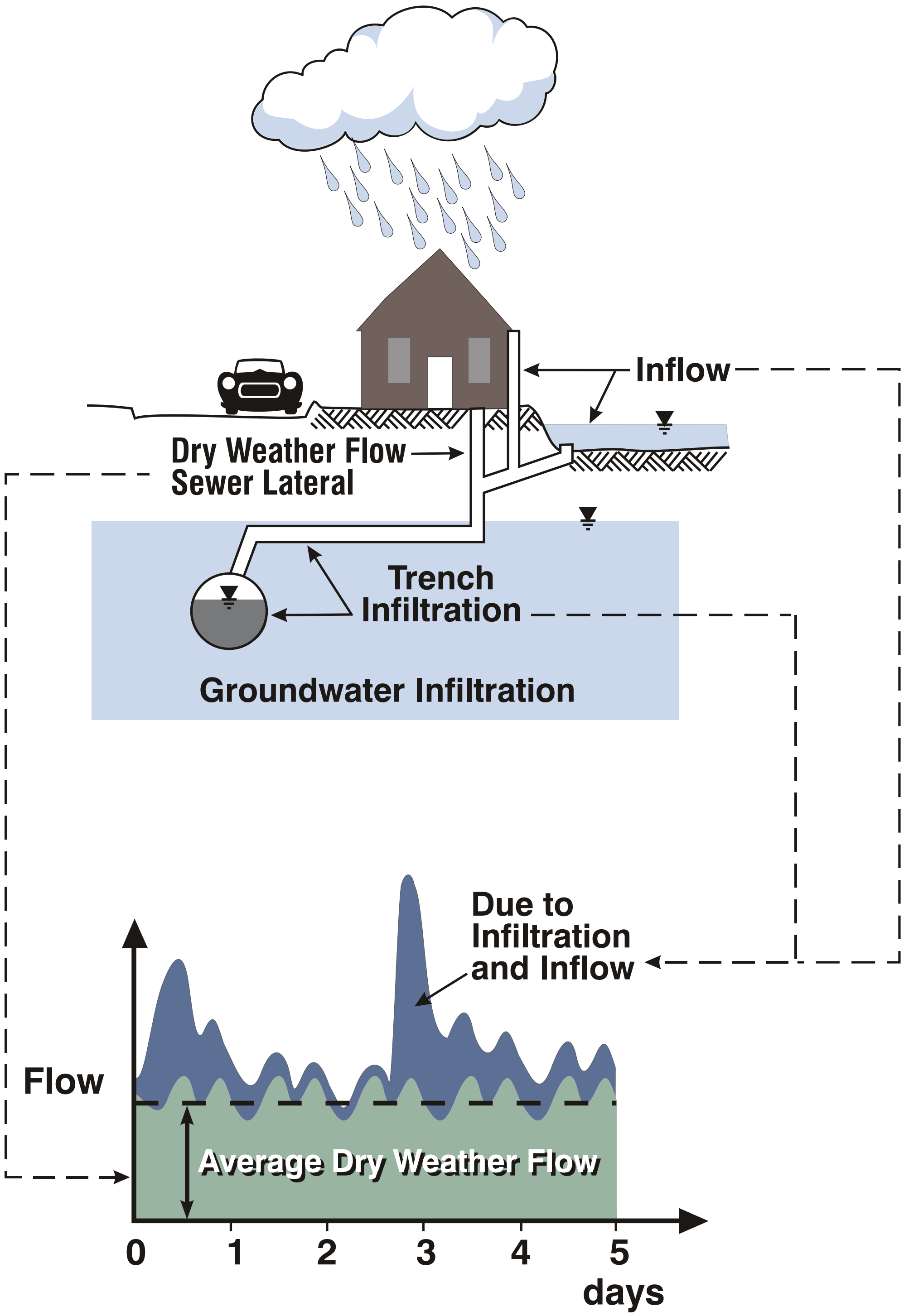


Figure 4.6
Typical Effects of Infiltration and Inflow
Sewer System Master Plan
City of Turlock

4.2.6 Peak Wet Weather Flow

Peak wet weather flow (PWWF) is the highest observed flow that occurs following a design storm event. Wet weather I/I cause flows in the collection system to increase. PWWF is typically used for designing sewers and lift stations. Therefore, the PWWF and the “Design Flow” are synonymous and will be used interchangeably throughout this report.

4.3 FLOW MONITORING RESULTS

This section summarizes the results of the flow monitoring program, including dry weather flow data, rainfall data, and wet weather flow data. Data collected from Meter 2 is presented throughout this and other chapters as an example of the type of data and the results from the flow monitoring program. Refer to Appendix B for additional data summaries and other information associated with the remaining meter sites.

4.3.1 Dry Weather Flow Data

During the flow monitoring period, depth and velocity data were collected at each meter at 5-minute intervals. The 5-minute data was then aggregated to 15-minute data by V&A. Carollo aggregated the 15-minute data to hourly data for use in the hydraulic model. Characteristic dry weather 24-hour diurnal flow patterns for each site were developed based on the hourly data. The hourly flow data were used to calibrate the hydraulic model for the observed dry weather flows during the flow monitoring period.

Hourly patterns for weekday and weekend flows vary and were separated to better understand dry weather flow. V&A used the data from days least affected by rainfall to estimate the weekday and weekend dry weather flows. In addition, V&A provided estimates for the average weekday and weekend levels and velocities at each site, which are used in dry weather flow calibration.

Figure 4.7 illustrates a typical variation of weekday and weekend flow in the City, which is based on the data collection from Meter 2. Similar graphics associated with the remaining sites are included in Appendix B. Table 4.3 summarizes the dry weather flows at each meter. Figure 4.8 provides a schematic illustration of the information presented in Table 4.3.

4.3.2 Rainfall Data

There was one significant rainfall event that occurred during the course of the flow monitoring period, as well as a few other relatively minor events. Figure 4.9 illustrates the total accumulation of rainfall over the course of the flow monitoring period for each of the five rain gauges. Table 4.4 summarizes the total rainfall recorded at each of the three rain gauges during the main rainfall event, as well as over the entire flow monitoring period. The

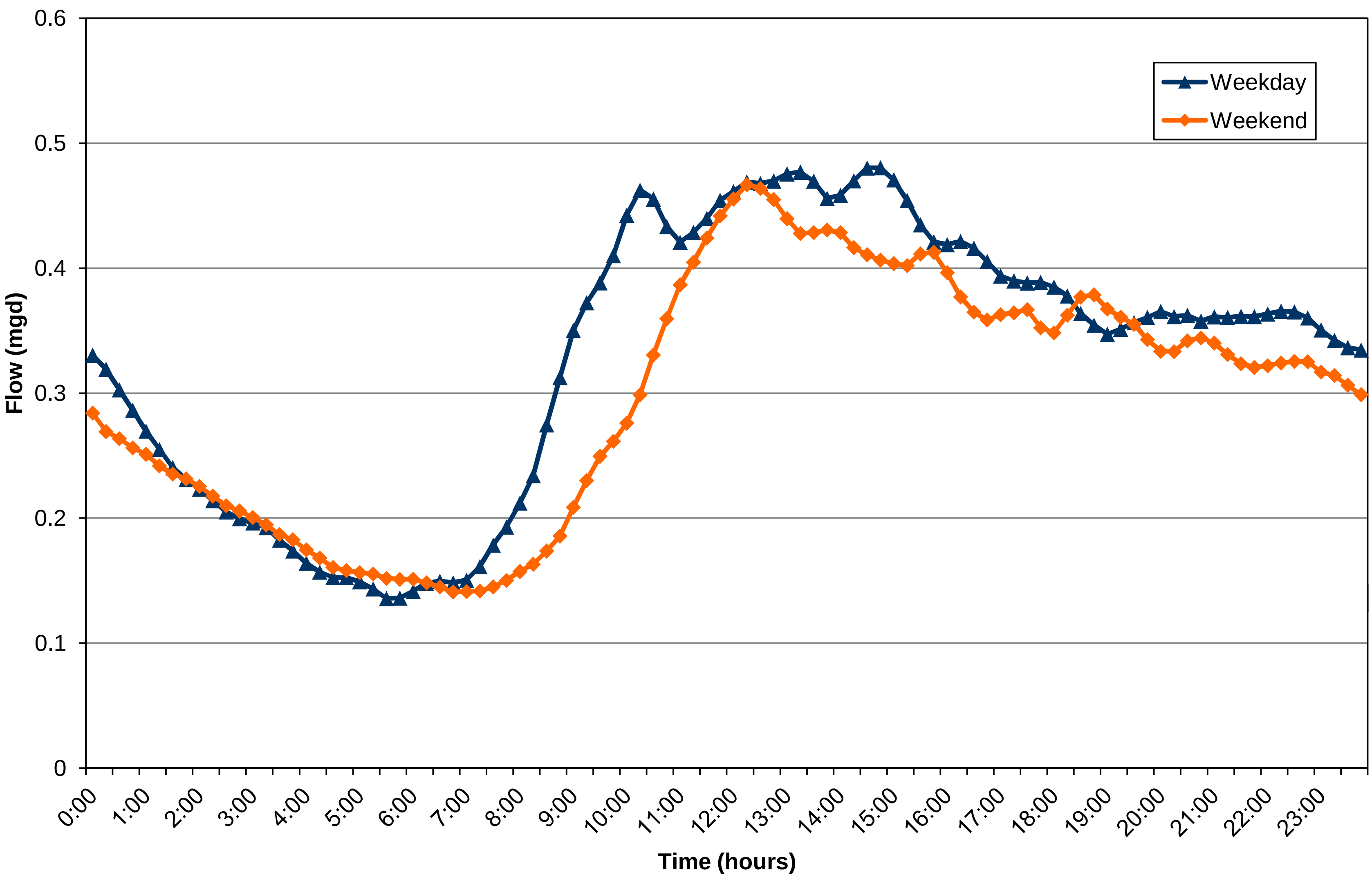


Figure 4.7
Typical Weekday vs. Weekend Flow Variation (Meter 2)
Sewer System Master Plan

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Table 4.3 Dry Weather Flow Summary
Sewer System Master Plan
City of Turlock

Monitor Site	Weekday Dry Weather Flow (mgd)	Weekend Dry Weather Flow (mgd)	Overall Dry Weather Flow (mgd)	Weekend/ Weekday Ratio
Site 1	2.29	1.17	1.97	1.96
Site 2	0.33	0.30	0.32	1.11
Site 3	1.27	1.22	1.25	1.04
Site 4	5.60	5.46	5.56	1.03
Site 5	0.49	0.53	0.50	0.92
Site 6	0.09	0.09	0.09	1.01
Site 7	0.00	0.00	0.00	1.00
Site 8	1.84	1.00	1.60	1.85
Site 9	0.05	0.05	0.05	1.03
Site 10	1.15	1.15	1.15	1.00
Site 11	0.61	0.63	0.61	0.98
Site 12	1.19	1.17	1.18	1.01
Site 13	1.02	1.09	1.04	0.94

Notes:
(1) Source: Sanitary Sewer Flow Monitoring and Inflow/Infiltration Study, January 2013
(2) Overall Dry Weather Flow = (5 x Weekday + 2 x Weekend)/7

Table 4.4 Rainfall Event Summary
Sewer System Master Plan
City of Turlock

	Measured Rainfall (in.)		
Rainfall Event	**RG North**	**RG Central**	**RG South**
January 19-23, 2012	0.75	0.80	0.73
February 7, 2012	0.34	0.33	0.36
February 12-15, 2012	0.18	0.18	0.22
February 29, 2012	0.07	0.06	0.08
Total over Monitoring Period	**1.37**	**1.37**	**1.39**

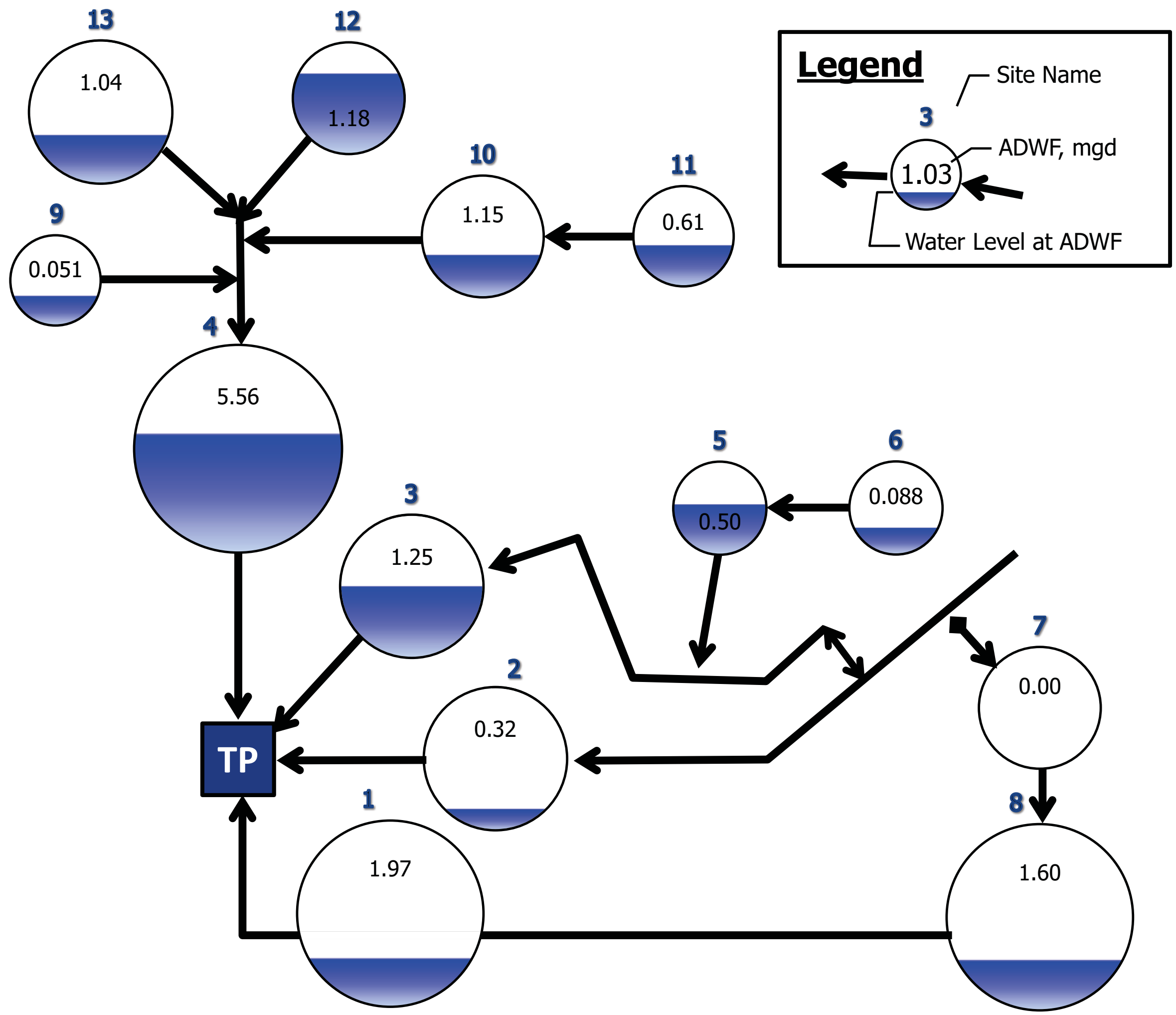

Figure 4.8
Dry Weather Flow Schematic
Sewer System Master Plan
City of Turlock

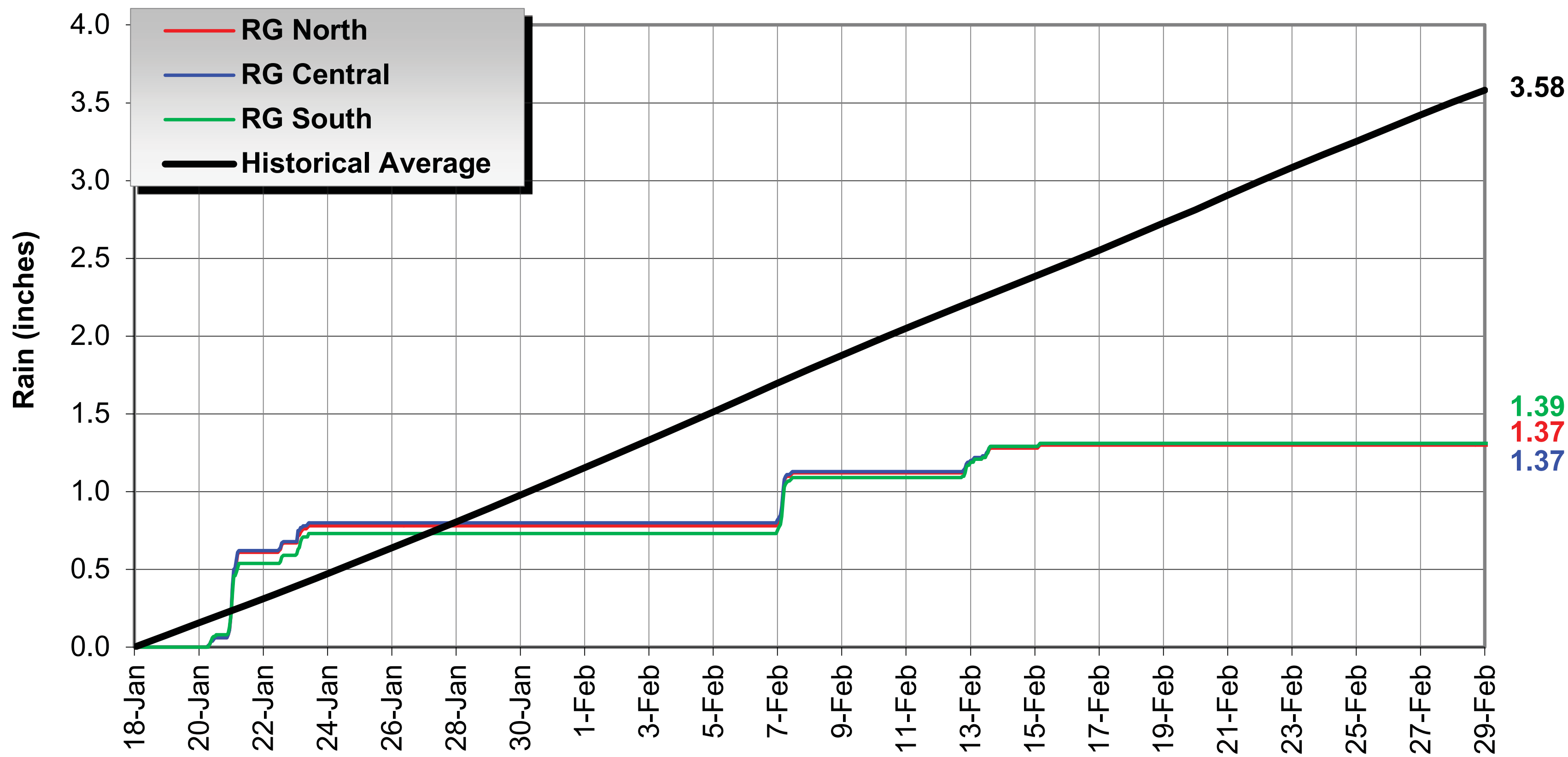

Figure 4.9
Rainfall Accumulation Plot
Sewer System Master Plan
City of Turlock

flow monitoring report prepared by V&A (Appendix B) classifies each of the rainfall events as less than 1-year, 24-hour event. However, the storms did present data in terms of the collection system's I/I response to wet weather flow events, and is appropriate for I/I analysis and model calibration purposes.

The rainfall recorded over the duration of the flow monitoring period ranged from 1.37 inches to 1.39 inches. The historical average rainfall for the flow-monitoring period is roughly 3.58 inches. Therefore, the measured rainfall totals ranged from roughly 38 percent to 39 percent of the historical average for the Turlock area.

In order to perform I/I analysis and to aid in model calibration, the amount of rainfall that affected the individual flow monitoring basins (i.e., tributary areas) was calculated by V&A. The individual rainfall hyetographs (the distribution of rainfall over time) were generated using the Inverse Distance Weighting (IDW) method, which is an interpolation method that assumes the influence of each rain gauge location diminishes with distance. For more detailed information related to this calculation, refer to Appendix B. Figure 4.10 illustrates the rainfall hyetograph generated for Meter 2 using this method. Figure 4.9 shows the accumulated rainfall over the flow monitoring program for Meter 2 as well. Similar graphics for each of the remaining flow monitoring sites are provided in Appendix B for reference.

4.3.3 Wet Weather Flow Data

The flow monitoring data were also evaluated to determine how the collection system responds to wet weather events. As mentioned above, the flow monitoring program captured one main rainfall event. The rainfall event that occurred between January 20, 2012 to January 21, 2012 was associated with the largest I/I response during the flow monitoring period, and is the most appropriate to be used for I/I analysis.

Figure 4.11 shows an example of the wet weather response at Meter 2 during the January 20-23 rainfall event. Figure 4.11 illustrates the volume of I/I that entered the system from the collection system upstream of Site 2. The light blue area is the base sanitary flow while the gray area is the measured flow from the flow monitoring period. As can be seen in the figure, discernible amounts of I/I do enter the system during wet weather events. Similar graphs were generated for the remaining monitoring sites can be found in Appendix B.

The flow monitoring data was used to conduct an analysis of the system's I/I response. The metric typically used to quantify the severity of the system's I/I is the R-value. The R-value is defined as the percentage of rainfall volume that makes it into the collection system as I/I. Table 4.5 summarizes the results for the January 20-21, 2012 rainfall event. As shown in Table 4.5, the R-Values vary from 0.2 percent in Basins 1 and 13 to 12.8 percent in Basin 6. The City's overall R-Value for the rainfall event was roughly 1.8 percent. In general, an R-Value of 5 percent or more is usually considered to be significant.

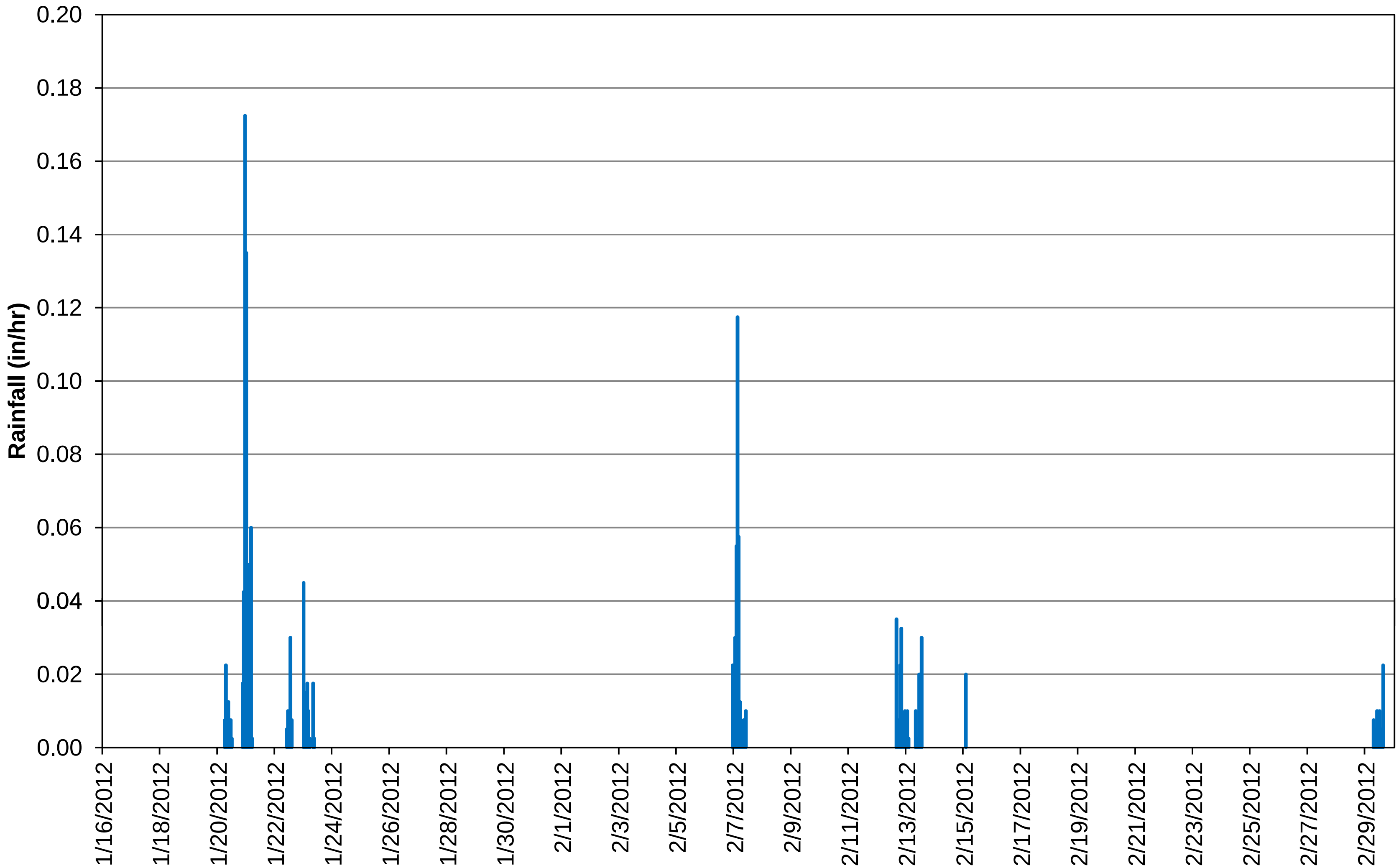

Figure 4.10
Rainfall Activity Over Flow Monitoring Period (Meter 2)
Sewer System Master Plan

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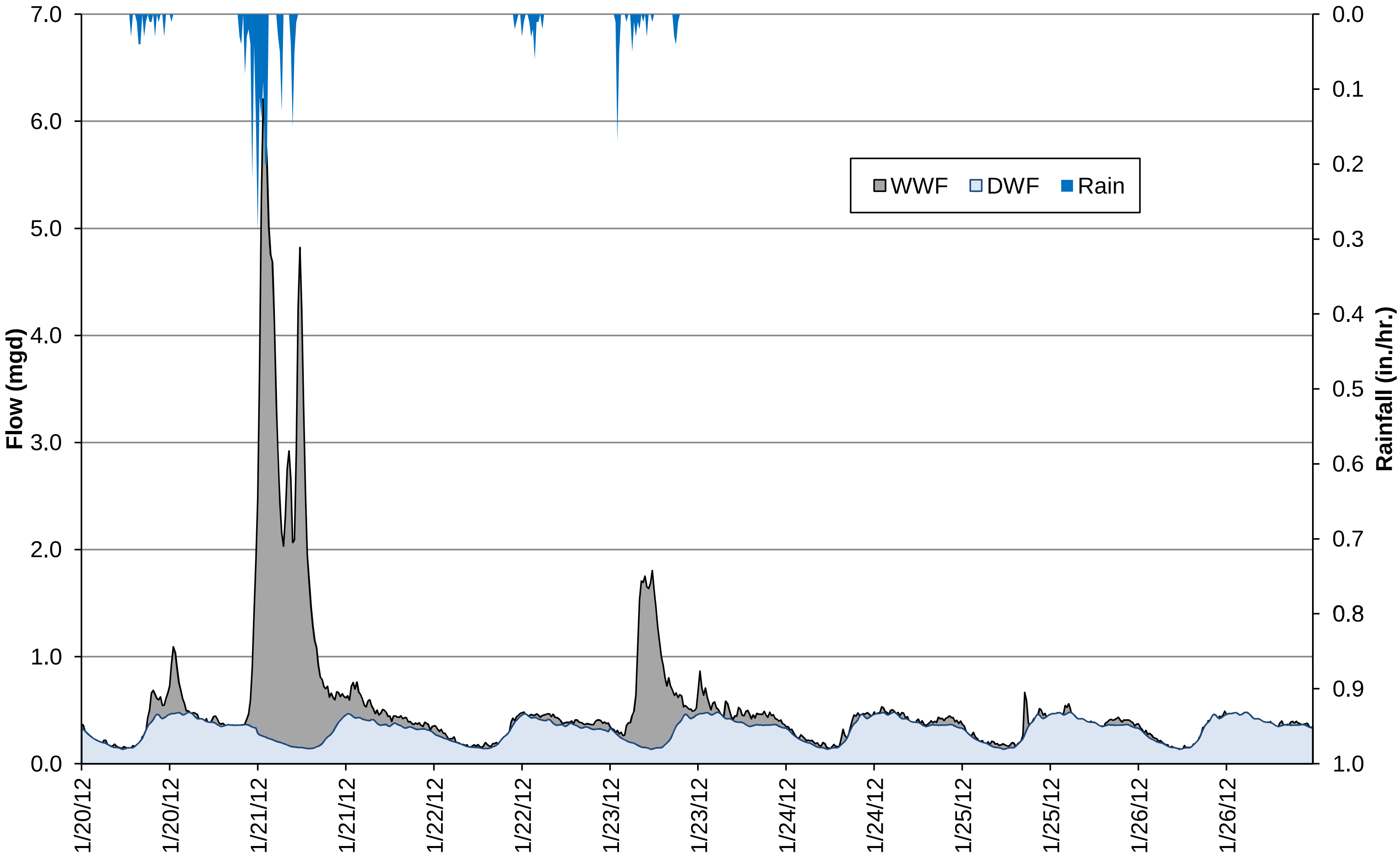

Figure 4.11
Example Wet Weather Flow Response (Meter 2)
Sewer System Master Plan

Table 4.5	I/I Analysis Summary Sewer System Master Plan City of Turlock				
Basin	**Dry Weather Flow (mgd)**	**Estimated Total I/I (gallons)**	**R- Value (%)**	**Peak I/I Rate (mgd)**	**Peak I/I to DWF Ratio**
Basin 1	0.37	616,000	4.1%	1.61	4.36
Basin 4	2.14	281,000	0.4%	5.80	2.71
Basin 5	0.41	16,000	0.2%	0.57	1.38
Basin 6	0.088	155,000	12.8%	0.42	4.84
Basin 9	0.051	6,000	0.7%	0.06	1.26
Basin 10	0.53	172,000	0.9%	0.43	0.80
Basin 11	0.61	58,000	0.4%	0.15	0.24
Basin 12	1.18	183,000	1.1%	0.58	0.49
Basin 13	1.04	50,000	0.2%	0.49	0.47
Basin 2,3,8	2.68	2,345,000	4.7%	9.14	3.42
City Total	**9.11**	**3,882,000**	**1.8**%	**19.05**	**2.09**

Notes:
(1) Source: Sanitary Sewer Flow Monitoring and Inflow/Infiltration Study, January 2013.
(2) Results are taken from the January 20 to January 23, 2012 rainfall event.

The R-Value for each basin is determined by isolating I/I associated with individual flow monitoring basins (i.e., excluding flow rates from upstream flow monitors) and calculating the ratio of the volume of water that enters the system as I/I versus the volume of rainfall that fell over the flow monitoring basin tributary area. In some cases, flow splits and/or overflows affect the calculated R-Value for certain flow monitoring tributaries and can skew the results. In these cases, tributary areas that cannot be isolated are combined for the purposes of Table 4.5.

Another important metric to quantify the severity of the system's I/I response is the peak measured I/I rate, which was calculated by subtracting the baseline flow from the peak measured flow during the storm event. As shown in Table 4.5, the measured peak I/I rate to dry weather flow ratio ranged from 0.24 in Basin 11 to 4.84 in Basin 6. Citywide, the peak I/I rate to dry weather flow ratio from the rainfall event was 2.09. It should be noted, however, that the peak I/I rates presented in Table 4.5 are classified as less than a 1-year event. Therefore, the peak I/I rate during the design storm event will be higher.

4.4 TURLOCK REGIONAL WATER QUALITY CONTROL FACILITY FLOWS

- In addition to the flow monitoring program, historical daily TRWQCF influent flow data since January 2002 were reviewed to establish wastewater flow criteria. Flow data from January 2002 through December 2012 are summarized in Table 4.6. Average annual flow (AAF): Total annual flow divided by the number of days in the year. Average flow entering the plant over the entire year, without consideration of season (dry or wet).
- Average dry weather flow (ADWF): Average TRWQCF influent flow during the months of June through September.
- Average day maximum month flow (ADMMF): Highest average monthly flow at the TRWQCF during the year.
- Peak wet weather flow (PWWF): Peak hourly flow observed at the TRWQCF for the wet weather months of a given year.

The ADWF ranged from 9.7 mgd in 2011 to 12.9 mgd in 2005 and 2006, respectively. Over the last 5 years that data were available (2008-2012), the City's ADWF influent to the TRWQCF was 10.5 mgd. The highest hourly flow recorded at the TRWQCF was 31.5 mgd in 2009.

4.5 EXISTING AND PROJECTED WASTEWATER FLOWS

Relationships between land use and wastewater flow were identified to develop average wastewater flow predictions. These relationships, called wastewater generation coefficients, were established based on the average wastewater flow generated for each existing land use type. Once coefficients are developed based on existing conditions, the land use flow coefficients can be used to estimate average day flow through build-out of the study area.

4.5.1 Existing Wastewater Flow Coefficients and Average Dry Weather Flow

Flow coefficients provide a means to estimate flow per acre for each land use category. Wastewater flow coefficients are expressed in gallons per day per acre (gpd/ac), applied to land use acreage for calculating average day flow generated from a particular land use. A flow coefficient was developed for each land use classification included in the City's General Plan. The resulting flow was entered in the sewer system hydraulic model. Flow coefficients for residential areas typically range between 400 to 4,000 gpd/ac, and commercial and industrial areas may range from 500 to 2,500 gpd/ac. Open space and agriculture land uses were assumed to generate negligible amounts of sewage flow. The coefficients were developed using the following procedure:

Table 4.6 Historical Monthly TRWQCF Influent Flows
Sewer System Master Plan
City of Turlock

Year	AAF[1] (mgd)	ADWF[1],[2] (mgd)	ADMMF[1] (mgd)	PWWF[1] (mgd)
2002	12.1	11.2	13.9	31.2
2003	11.9	12.0	12.5	26.0
2004	12.0	11.9	12.9	27.7
2005	12.9	12.9	13.5	29.5
2006	13.0	12.9	13.6	28.3
2007	12.7	12.8	13.3	29.6
2008	12.1	12.0	13.3	n/a
2009	10.9	10.6	11.7	31.5
2010	10.7	10.4	11.5	29.5
2011	9.9	9.7	10.6	n/a
2012	10.0	9.8	10.9	n/a
5-Year Avg. (2008-2012)	**10.7**	**10.5**	**11.6**	**--**

Notes:
(1) Source: TRWQCF Influent flow records. Totals include flow from Denair and Keyes, but do not include flows from Ceres.
(2) Dry weather months are considered June through September.
(3) When data for all twelve months of the year was not available, total annual flow was calculated as the average daily flow times days per year.

- Average flows for each flow metering tributary area were derived from the flow monitoring data.
- Flows associated with each of the City's existing significant industrial users (SIUs) were identified based on meter data provided by the City. A summary of the average flows associated with each SIU is provided in Appendix C. Each SIU was assigned to the appropriate flow metering tributary area and its average flows were subtracted from the average flows measured during the flow monitoring period. Flows associated with the SIUs were input into the model as "point loads".
- Using GIS, the acres for each existing land use type contained in each flow monitoring tributary area were calculated, excluding the SIU areas.
- Preliminary coefficients for each land use type are estimated based on the approximate number of dwelling units per acre, the assumed per capita wastewater generation rates, and the typical number of people per dwelling unit for each land use type.
- The coefficients for each flow metering tributary were then adjusted up or down (balanced) so that the calculated average flows from each tributary match what was measured during the flow monitoring period.
- Once the coefficients for each of the flowmeter tributary areas were balanced, the weighted average of the coefficients for each existing land use type was calculated based on the acreage contribution from each metering tributary area.
- The weighted average wastewater generation coefficients were then adjusted for the entire developed sewer service area to the match the five-year average ADWF of 10.5 mgd. The adjusted weighted average coefficients are considered representative of the wastewater generation by land use for the City as a whole, and are used to project future average wastewater flows.

The calibrated wastewater flow coefficients developed for the Master Plan are summarized in Table 4.7. A wastewater flow balance was performed to test the accuracy of the flow coefficient estimates. Applying the coefficients to land uses yielded a total influent ADWF of 10.6 mgd, which is within one-percent of the five-year average ADWF (10.5 mgd). As with most cities throughout California, residential land use makes up the majority of developed land and wastewater flow. For Turlock, residential customers make up approximately 52 percent of the current flow (5.56 mgd). Additionally, Turlock's industrial sector also makes up a significant portion of the City's current flow. Industrial customers account for 29 percent of the current flow (3.12 mgd). Commercial customers account for roughly 5 percent of the current flow (0.58 mgd), and other land uses, such as public land use areas and Denair and Keyes, account for the remaining 13 percent of current flow (1.35 mgd).

4.5.2 Projected Average Dry Weather Flow

Developing an accurate estimate of the quantity of wastewater is an important step in maintaining and sizing sewer system facilities, for both existing conditions and future developments. The future ADWF for build-out of the study area was determined by multiplying the wastewater generation coefficients by the build-out land use acreage. Land uses for future development are described in the City's General Plan, which represents proposed build-out conditions. The projected increase in wastewater flow at build-out of the General Plan is summarized in Table 4.8.

Table 4.7 Existing ADWF by Land Use
Sewer System Master Plan
City of Turlock

Existing Land Use Category	Wastewater Generation Coefficient (gpd/acre)	Existing Sewer Service Area (acres)	Average Dry Weather Flow (mgd)
Residential			
Agriculture	0	1,575	0.00
Residential Ranchette	384	117	0.05
Low & Medium Residential	1,350	3,358	4.53
High Density Residential	4,300	228	0.98
Commercial			
Commercial	750	649	0.49
Office	750	118	0.09
Industrial			
Industrial (Unmetered, Non- SIU)	500	706	0.35
Industrial (Metered, SIU)	--	101	2.77
Other			
Mixed Use	2,300	69	0.16
Public/Semi-Public/Community Facility	750	684	0.51
Park & Open Space	100	209	0.02
Denair/Keyes	--	--	0.66
Vacant	0	816	0.00
Streets, Etc.	0	2,126	0.00
Total	**--**	**10,757**	**10.61**

Table 4.8 Future Increase in ADWF by Land Use
Sewer System Master Plan
City of Turlock

Land Use Category	Wastewater Generation Coefficient (gpd/acre)	Existing Service Area Infill[1]		Build-Out Service Area		Total Future Growth	
		Vacant/Ag. Areas (acres)	ADWF (mgd)	New Growth Areas (acres)	ADWF (mgd)	Total Future Growth (acres)	ADWF (mgd)
Residential							
Urban Reserve	0	326	0.00	4,171	0.00	4,498	0.00
Very Low Density Residential	384	111	0.04	26	0.01	137	0.05
Low Density Residential	1,350	106	0.14	277	0.37	383	0.52
Low-Medium Density Residential	1,800	63	0.11	201	0.36	264	0.48
Medium Density Residential	2,100	110	0.23	132	0.28	242	0.51
Medium Density Residential/Office	1,900	0	0.00	0	0.00	0	0.00
High Density Residential	4,300	73	0.31	67	0.29	140	0.60
Commercial							
Business Park	750	230	0.17	0	0.00	230	0.17
Community Commercial	750	138	0.10	41	0.03	178	0.13
Community Commercial/Office	750	10	0.01	0	0.00	10	0.01

Table 4.8 Future Increase in ADWF by Land Use
Sewer System Master Plan
City of Turlock

Land Use Category	Wastewater Generation Coefficient (gpd/acre)	Existing Service Area Infill[1]		Build-Out Service Area		Total Future Growth	
		Vacant/Ag. Areas (acres)	ADWF (mgd)	New Growth Areas (acres)	ADWF (mgd)	Total Future Growth (acres)	ADWF (mgd)
Community Commercial/ Office/High Density Residential	750	8	0.01	0	0.00	8	0.01
Heavy Commercial	750	107	0.08	32	0.02	139	0.10
Highway Commercial	750	87	0.06	37	0.03	123	0.09
Neighborhood Center	750	0	0.00	22	0.02	22	0.02
Downtown	750	10	0.01	0	0.00	10	0.01
Office	750	130	0.10	0	0.00	130	0.10
Industrial							
Industrial	3,300	769	2.54	547	1.80	1,316	4.34
Other							
Public	750	50	0.04	121	0.09	171	0.13
Park	100	38	0.00	71	0.01	109	0.01
Detention Basin	0	2	0.00	85	0.00	87	0.00
Streets, ROW, etc.	0	22	0.00	368	0.00	390	0.00
Total	**--**	**2,391**	**3.96**	**6,197**	**3.31**	**8,587**	**7.27**

Notes:
1. Infill includes existing vacant land as well as agricultural land that will be converted to other land uses in the future.
2. Build-out service area is the area currently outside the existing sewer service area.

Table 4.9 summarizes the total existing and build-out average dry weather flows. As shown in Table 4.9, the TRWQCF influent is projected to increase by 85 percent to 19.4 mgd at build-out.

Table 4.9 Existing and Build-Out ADWF
Sewer System Master Plan
City of Turlock

Flow Condition	Average Dry Weather Flow (mgd)
Existing Average Dry Weather Flow	
Excluding Denair, Keyes, or Ceres	9.95
Existing Denair ADWF	0.33
Existing Keyes ADWF	0.33
Total Existing Influent ADWF	***10.61***
Existing Ceres ADWF	0.94
Total Existing Influent ADWF + Ceres	***11.55***
Build-Out Average Dry Weather Flow	
Existing ADWF w/o Denair, Keyes, or Ceres	9.95
Future increase in ADWF	7.27
Projected Denair ADWF	1.20
Projected Keyes ADWF	0.99
Total Build-Out Influent ADWF	***19.41***
Build-Out Ceres ADWF	2.00
Total Build-Out Influent ADWF + Ceres	***21.41***

4.6 DESIGN FLOWS

The design flow is the maximum hourly flow rate used for the capacity evaluation and design of the sanitary sewer system, which is determined based on the selected design storm and future land use and growth conditions. The design flow includes the average dry weather flow and the peak I/I rate. Capacity requirements are assessed by routing the design storm through the hydraulic model. For the Master Plan, a 10-year, 24-hour design storm rainfall pattern was used to generate the design flow in the sewer system The 10-year, 24-hour storm was derived based on historical data compiled in the NOAA Atlas 14 precipitation-frequency charts (publicly available). Figure 4.12 shows the estimated rainfall generated from the 10-year, 24-hour design storm.

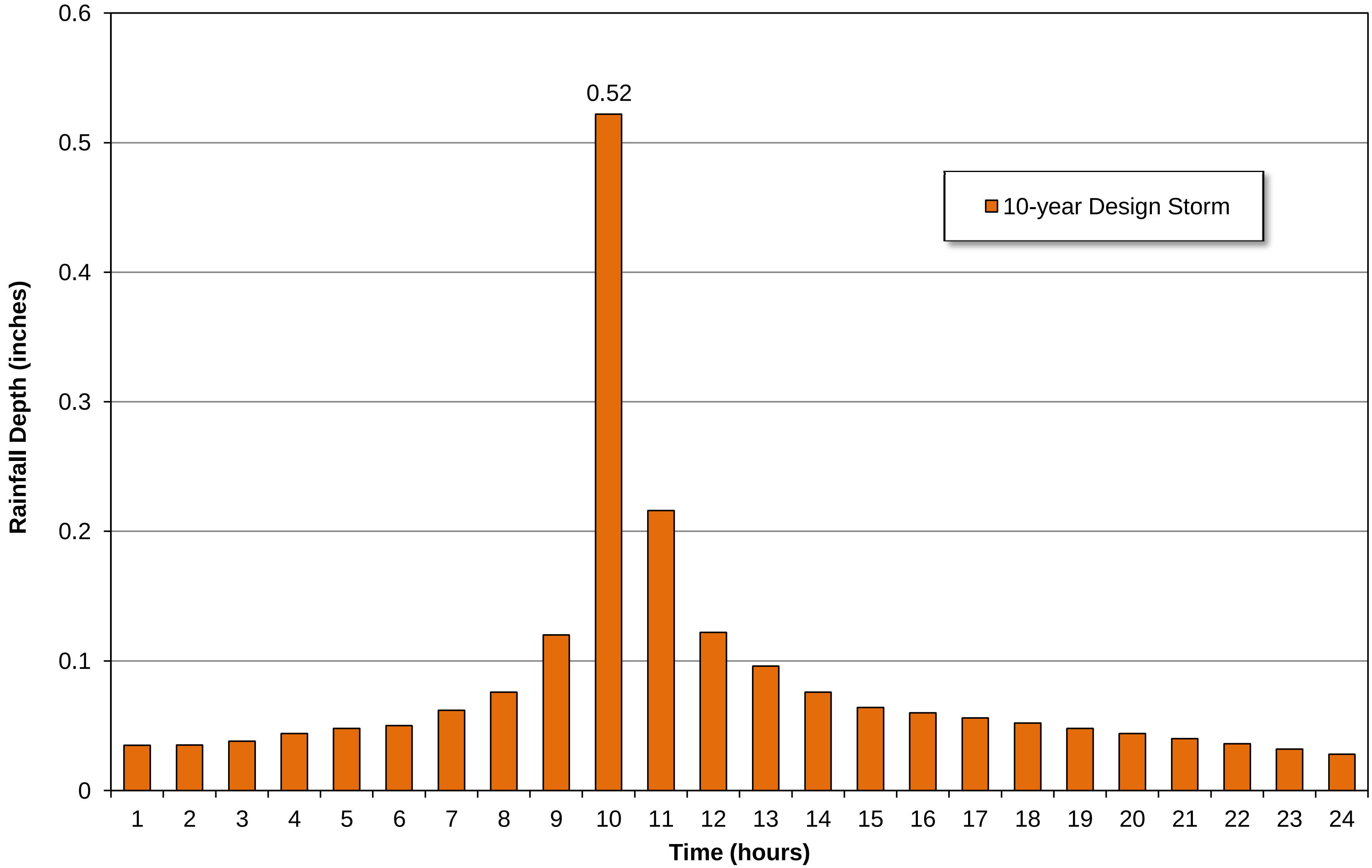

Figure 4.12
Estimated Rainfall from the
10-Year, 24-Hour Design Storm
Sewer System Master Plan

The hydraulic model was calibrated under both dry weather and wet weather conditions. Detailed information regarding the calibration of the City's hydraulic model is provided in Chapter 5.

Build-out design flows were estimated in a similar manner. Peak I/I rates for future growth areas (e.g., vacant areas within the existing service area, growth areas outside of the current service area, etc.) were developed based on a peak I/I rate of 1,000 gallons per day per acre (gpd/ac). Chapter 6 summarizes the existing and projected design flow in greater detail.

4.7 PLANNING CRITERIA SUMMARY

The recommended planning criteria and design flow parameters for this Master Plan are summarized in Table 4.10, Table 4.11 and Table 4.12.

Table 4.10 Planning Criteria Summary: Minimum Slopes
Sewer System Master Plan
City of Turlock

Pipe Size (inches)	Minimum Slope(1) (ft/ft)	Pipe Capacity		
		Maximum d/D Criteria	Maximum Flow (cfs)	Maximum Flow (mgd)
8	0.0024(2)	0.50	0.30	0.19
10	0.0018(2)	0.50	0.47	0.30
12	0.0015(2)	0.67	1.08	0.70
15	0.0011(2)	0.67	1.68	1.09
18	0.0009(2)	0.67	2.48	1.60
21	0.0009	0.75	4.39	2.84
24	0.0008	0.75	5.73	3.70
27	0.0007	0.75	7.25	4.69
30	0.0006	0.75	8.95	5.79
36	0.0004	0.75	12.89	8.33
42	0.0004	0.75	17.55	11.34
48	0.0003	0.75	22.92	14.81

Notes:
1. Recommended minimum slope to maintain a velocity greater than or equal to 2 feet/second with d/D values equal to 0.5. Manning's n=0.013.
2. Source: City of Turlock Standards and Specifications (2008). Minimum slopes specified by the City result in velocities that are less than 2 ft/s with the maximum d/D criteria.

Table 4.11 Planning Criteria Summary: Allowable Flow Depth and Roughness Coefficients
Sewer System Master Plan
City of Turlock

Assumptions for limiting Flow Depth, d/D	
The following flow depth criteria were used in the analysis:	
Maximum d/D for Existing Sewers	
Peak Wet Weather Flow:	Pipes allowed to surcharge 5 feet below manhole rim
Maximum d/D for New Sewers (during Peak Wet Weather Flow)	
Diameter Less than 12-inches:	d/D = 0.50
Diameter 12 to 18-inches:	d/D = 0.67
Diameter Greater than 18-inches:	d/D = 0.75
Headloss Assumptions	
Gravity Pipes:	Manning's n = 0.013
Pressure Pipes:	Hazen Williams C = 120
Changes in Pipe Size	
When a smaller sewer joins a larger one, sewer crowns will be matched.	

Table 4.12 Planning Criteria Summary: Flow Coefficients
Sewer System Master Plan
City of Turlock

Land Use Designation	Code	ADWF Coefficient (gpd/acre)
Very Low Density Residential	VLDR	384
Low Density Residential	LDR	1,350
Low-Medium Density Residential	LDR-MDR	1,800
Medium Density Residential	MDR	2,100
Medium Density Residential/ Office	MDRO	1,900
High Density Residential	HDR	4,300
Downtown Mixed Use	DT	750
Office Commercial	O	750
Community Commercial	CC	750
Regional Commercial	RC	750
Highway Commercial	HWC	750
Heavy Commercial	HC	750
Industrial	I	3,300
Business Park	BP	750
Public/Institutional	PUB	750
Parks	P	100
Urban Reserve	UR	0
Roadways and Railroads	--	0

COLLECTION SYSTEM FACILITIES AND HYDRAULIC MODEL

This chapter describes the development and calibration of the City of Turlock's (City's) collection system hydraulic model.

5.1 COLLECTION SYSTEM FACILITIES

The City's collection system consists of sewer mains, trunk sewers, lift stations, stormwater connections, and flow diversions that collect and convey wastewater to the Turlock Regional Water Quality Control Facility (TRWQCF), located southwest of the City near West Main Street and South Walnut Road. The City's collection system is shown in Figure 5.1. The collection system consists of four trunk systems each serving different parts of the City.

- The first trunk runs along Walnut and Tully Avenue extending to the North and servicing the west industrial areas, the City of Keyes, and the northern portion of the City.
- The second trunk serves the lower and east portions of the City following Montana Avenue and W Street.
- The last two trunks serve the middle of the City, including the downtown area, with trunk sewers running down South Avenue, D Street, Tully Road, and Soderquist Road.

5.1.1 Gravity Collection System

Initial construction of the collection system started in 1947. The trunk sewer along South Avenue and D Street was originally constructed in 1947. Many of the major interceptors were originally constructed in the early 1970s, including alignments along Tully Road, Montana Avenue, Hawkeye Avenue, and Monte Vista Avenue.

There are several direct stormwater connections in the older central business district to the sewer that contribute large volumes of inflow into the collection system. In addition, there are small amounts of infiltration present. The age and condition of the collection system facilities will impact the quantity of inflow and infiltration allowed to enter the system. Typically, older sewer pipes have a greater potential of allowing significant infiltration and inflow into the collection system. Older pipelines should be a priority when considering pipelines for rehabilitation. This includes the elimination of direct storm connections.

The City's existing sanitary sewer collection system is comprised of 225 miles of pipe ranging from 4 inches to 48 inches in diameter. Table 5.1 presents a summary by diameter of the known sewers in the collection system.

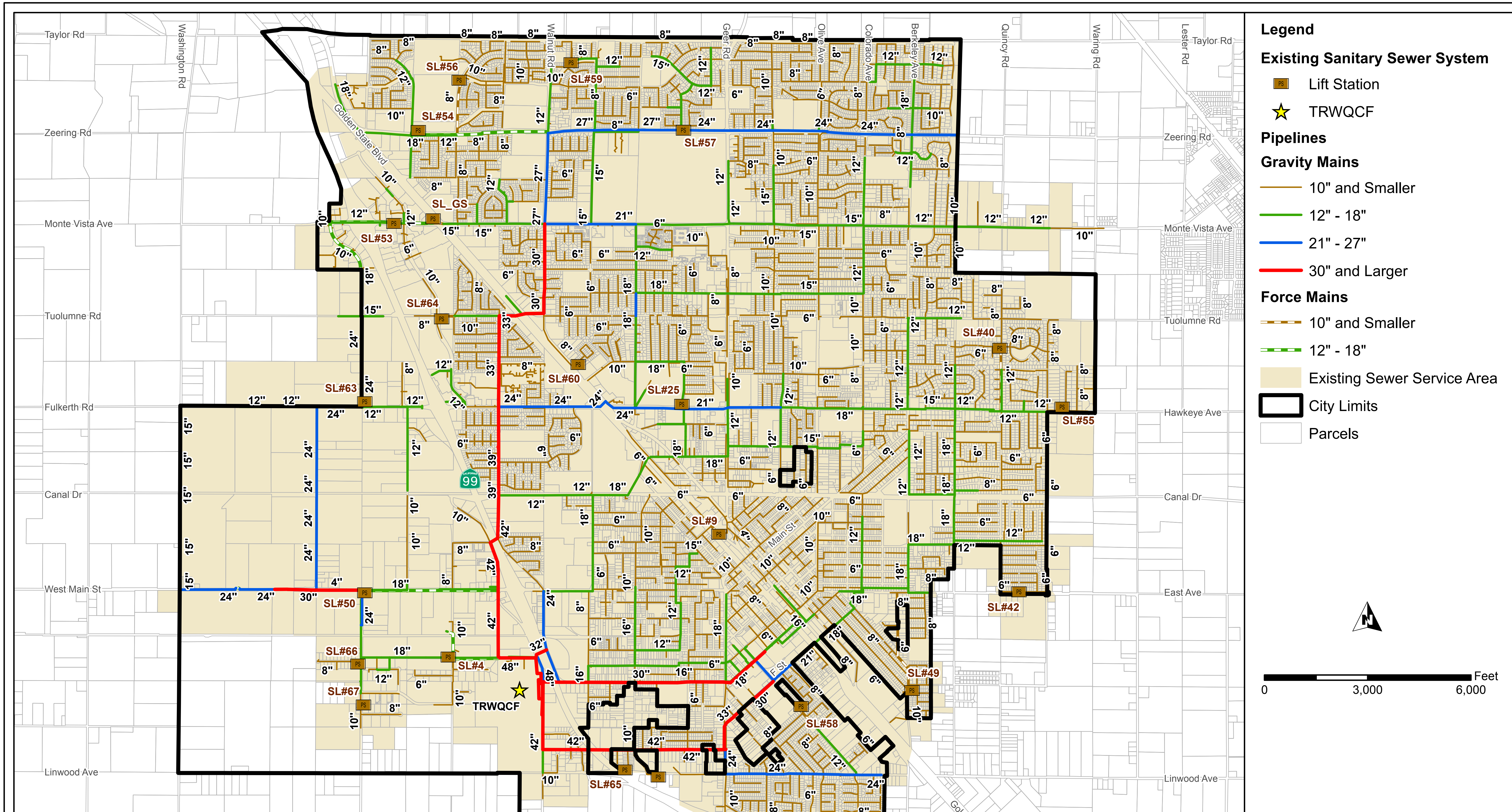

Figure 5.1
Existing Sewer Collection System
Sewer System Master Plan
City of Turlock

Table 5.1 Collection System Sewer Size Summary
Sanitary Sewer Master Plan
City of Turlock

Diameter (inches)	Length (feet)	Diameter (inches)	Length (feet)
4	7,532	21	10,122
6	428,263	24	33,350
8	377,285	27	7,857
10	76,310	30	13,715
12	98,937	32	318
15	31,117	33	4,297
16	10,352	39	2,620
18	69,705	42	14,465
21	10,122	48	1,956
		Total (feet)	**1,188,201**
		Total (miles)	**225**

5.1.2 Lift Stations and Force Mains

The City operates and maintains 24 wastewater lift stations throughout the City. Table 5.2 summarizes the available design data for the City's lift stations.

5.2 HYDRAULIC MODEL DEVELOPMENT

The City's collection system hydraulic model was constructed using a multi-step process utilizing data from a variety of sources. This section summarizes the hydraulic model development process, including a summary of the modeling software selection, a description of the modeled collection system, the hydraulic model elements, and the model creation process.

Table 5.2	Lift Station Information Sanitary Sewer Master Plan City of Turlock				
Lift Station	**Location**	**# of Pumps**	**Capacity Per Pump (gpm)**	**Total Capacity (gpm)**	**Firm Capacity(1) (gpm)**
4	Kilroy Road	2	800	1,600	800
9	N. First Street	2	200	400	200
25	Donnelly Park	2	500	1,000	500
40	Quincy/Castleview	2	500	1,000	500
42	East Avenue	2	100	200	100
49	Berkeley/Brier	2	200	400	200
50	Tegner	2	800	1,600	800
53	Monte Vista/Crossings	2	600	1,200	600
54	Pitman High	2	1,200	2,400	1,200
55	Hawkeye/Tartan	2	200	400	200
56	Sports Complex	2	1,600	3,200	1,600
57	Picadilly	2	1,600	3,200	1,600
58	5th and Silva	2	300	600	300
59	Paseo Belleza	2	300	600	300
60	Divinian/Veeck	2	200	400	200
63	Fulkerth/Tegner	2	1,200	2,400	1,200
64	Tuolumne/Countryside	2	600	1,200	600
65	Esperanza/Linwood	2	n/a	n/a	n/a
66	Liberty Parkway	2	200	400	200
67	Humphrey Ct.	2	200	400	200
SLGS	Monte Vista/Golden State	2	n/a	n/a	n/a
LS MAIN	West Main/Clinton	2	n/a	n/a	n/a
PRIVATE	West Main/Fransil	2	n/a	n/a	n/a
SL KILROY	Kilroy/Industrial Rowe	2	n/a	n/a	n/a

Notes:
(1) With one pump out of service

5.2.1 Selected Hydraulic Modeling Software

The hydraulic model H_2OMAP SWMM, by Innovyze (formerly MWH Soft) was selected for the City's collection system model. H_2OMAP SWMM is a fully dynamic, geospatial wastewater and stormwater modeling and management software application. The hydraulic modeling engine for the H_2OMAP SWMM software package uses the Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM), which is widely used throughout the world for planning, analysis, and design related to stormwater runoff, combined sewers, sanitary sewers, and other drainage systems. H_2OMAP SWMM routes flows through the model using the Dynamic Wave method, which solves the complete Saint Venant, one-dimensional equations of fluid flow.

The latest version (v 12.0) of H_2OMAP SWMM was used to assemble the H_2OMAP SWMM hydraulic model (H_2OMAP SWMM model).

5.2.2 Modeled Collection System and Skeletonization

Skeletonization is the process by which sewer systems are stripped of pipelines not considered essential for the intended analysis purpose. The purpose of skeletonizing a system is to develop a model that accurately simulates the hydraulics of a collection system, while at the same time reducing the complexity of a large model.

It is common practice in sewer system master planning to exclude small diameter sewers when developing a hydraulic computer model. The City's hydraulic model includes pipelines that are 10 inches in diameter and larger. Some smaller diameter sewers (8-inches in diameter and smaller) are also included in the City's hydraulic model where needed for connectivity. Otherwise, sewers 8-inches in diameter and smaller were excluded from the model.

The modeled sewer system consists of approximately 79 miles of sanitary sewer pipelines ranging in diameter from 4 inches (smaller pipelines are force mains) to 48 inches, and 24 sanitary sewer lift stations. Figure 5.2 presents the City's modeled wastewater collection system. Table 5.3 presents a summary of the modeled sewer system by diameter and length of pipe.

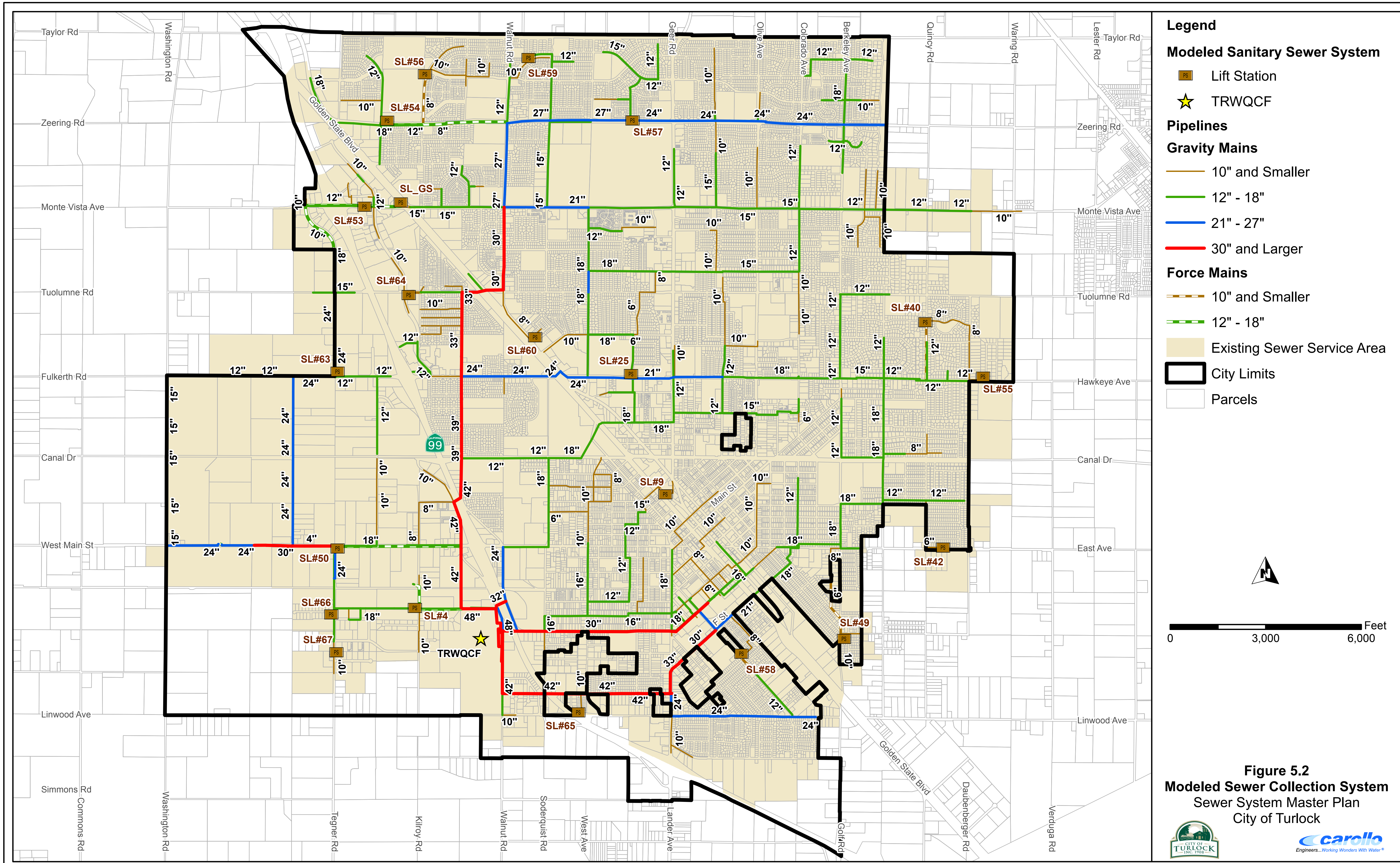

Figure 5.2
Modeled Sewer Collection System
Sewer System Master Plan
City of Turlock

Table 5.3	Collection System Pipeline Used in Hydraulic Model Sanitary Sewer Master Plan City of Turlock		
Diameter (inches)	**Length (feet)**	**Diameter (inches)**	**Length (feet)**
4	2,775	24	33,350
6	11,358	27	7,857
8	30,239	30	13,715
10	74,865	32	318
12	98,690	33	4,297
15	30,878	39	2,567
16	10,352	42	14,465
18	69,108	48	1,956
21	10,122	**Total (feet)**	**417,017**
		Total (miles)	**79**

5.2.3 Elements of the Hydraulic Model

The following provides a brief overview of the major elements of the hydraulic model and the required input parameters associated with each:

- **Junctions:** Sewer manholes, cleanouts, as well as other locations where pipe sizes change or where pipelines intersect are represented by junctions in the hydraulic model. Required inputs for junctions include rim elevation, invert elevation, and surcharge depth (used to represent pressurized systems). Junctions are also used to represent locations where flows are split or diverted between two or more downstream links.
- **Pipes:** Gravity sewers and force mains are represented as pipes in the hydraulic model. Input parameters for pipes include length, friction factor (e.g., Manning's n for gravity mains, Hazen Williams C for force mains), invert elevations, diameter, and whether or not the pipe is a force main.
- **Storage Nodes:** For sewer system modeling, storage nodes typically are used to represent lift station wet wells (although other storage basins, etc. can be modeled as storage nodes). Input parameters for storage nodes include invert elevation, wet well depth, and wet well cross section.
- **Pumps:** Pumps are included in the hydraulic model as links. Input parameters for pumps include pump curves and operational controls.

- **Outfalls:** Outfalls represent areas where flow leaves the system. For sewer system modeling, an outfall typically represents the connection to the influent pump station at a wastewater treatment plant (WWTP).
- **Rain Gauges:** Rain gauges are input into the hydraulic model to simulate historical or theoretical hourly rainfall events.
- **Subcatchments:** Subcatchments represent the hydrologic units of land area whose topography and drainage characteristics direct surface runoff from know storm drainage cross connections to a single discharge point in the sewer system. Subcatchment parameters ultimately determine how much stormwater inflow enters the sewer system. Other sources of flow into the system (sanitary flows, rainfall derived infiltration and inflow from sources other than the storm drain cross connection, etc.) are modeled as inflows, as described in the next bullet.
- **Inflows:** The following are the three types of wastewater flow sources that can be injected into individual model junctions (and storage nodes):
  – External. External inflows can represent any number of flows into the collection system, such as metered flow data or groundwater inflow. External inflows are applied to a specific model junction by applying a baseline flow value and a pattern that varies the flow by hour, day, or month of the year.
  – Dry Weather. Dry weather inflows simulate base sanitary wastewater flows and represent the average flow. The dry weather flows can be multiplied by up to four patterns that vary the flow by month, day, hour, and day of the week (e.g., weekday or weekend). The dry weather diurnal patterns are adjusted during the dry weather calibration process.
  – RDII. RDII flows are applied in the model by assigning a unit hydrograph and a corresponding tributary area to a given junction. The unit hydrographs consists of several parameters that are used to adjust the volume of RDII that enters the system at a given location. These parameters are adjusted during the wet weather calibration process.

5.2.4 Wastewater Load Allocation

Determining the quantity of dry weather wastewater flows generated by a municipality and how the flows are distributed throughout the collection system is an important component of the hydraulic modeling process. Various techniques can be used to assign wastewater flows to individual model junctions, depending on the type of data that is available. Adequate estimates of the volume of wastewater are important in maintaining and sizing sewer system facilities, both for present and future conditions. Baseline wastewater loads were allocated (assigned to specific nodes) in the hydraulic model based on land use data provided by the City and wastewater flow coefficients (these are described in detail in Chapter 3).

The flow coefficients and land use data to specific land use category into an average dry weather flow, as described below:

- **Step 1:** The City's service area was broken up into 1,094 individual loading polygons. Each loading polygon represents the geographic area that contributes flows into a single model node (i.e., trunk system manhole). In an all pipe model, however, a loading polygon could be as small as a few parcels. In a skeletonized model, such as the City's hydraulic model, a loading polygon will usually encompass a particular subdivision or grouping of lots.
- **Step 2:** The loads were calculated for each loading polygon using geographic information systems (GIS) software program by multiplying the appropriate flow coefficient by the land use acreage.
- **Step 3:** The hydraulic model's load allocation assigned the calculated average dry weather flow to the appropriate node in the sewer system model.
- **Step 4:** The allocated loads were adjusted as necessary during the dry weather flow calibration process (see Section 5.3) to closely match the actual measured dry weather flows recorded during the flow monitoring period.

5.2.5 Model Construction

The City's hydraulic model combines information on the physical and operational characteristics of the wastewater collection system, and performs calculations to solve a series of mathematical equations to simulate flows in pipes.

The model construction process consisted of six steps, as described below:

- **Step 1** - The City's geographic information system (GIS) shape files for the sewer collection system were obtained.
- **Step 2** - The GIS data were reviewed and formatted to allow easy import into the H_2OMAP SWMM modeling platform. The City's GIS did not include information on pipeline inverts or manhole rims. These data were input manually based on as-built drawings, survey data, and other available sources of information.
- **Step 3** - The City's GIS data were skeletonized to exclude gravity sewers 8 inches in diameter and smaller (except where needed for connectivity).
- **Step 4** - The collection system pipeline and facility data were imported into the modeling software and verified. Physical and operational data for the City's wastewater collection facilities was not available from the GIS data. This type of data, such as wet well dimensions, pump stations, and other special features, were input manually into the model based on available information. In addition, pipelines and junctions with missing inverts or invert discrepancies were reviewed and manually input or modified based on City records, field reconnaissance, and engineering judgment.

Once all the relevant data was input into the hydraulic model, the model was reviewed to verify that the model data was input correctly and that the flow direction and size of the modeled pipelines were logical. Additionally, the modeled lift stations were also checked to verify that they operated correctly.

- **Step 5:** Dry weather wastewater flows were then allocated to the appropriate model junctions. These flows were scaled up or down, as necessary, to match the dry weather flows recorded during the flow monitoring period.
- **Step 6** - The hydraulic model contains certain run parameters that need to be set by the user at the beginning of the project. These include run dates, time steps, reporting parameters, output units, and flow routing method. Once the run parameters were established, the model was debugged to ensure that it ran without errors or warnings.

5.3 HYDRAULIC MODEL CALIBRATION

Hydraulic model calibration is a crucial component of the hydraulic modeling effort. Calibrating the model to match data collected during the flow monitoring program ensures the most accurate results possible. The calibration process consists of calibrating to both dry and wet weather conditions.

For this project, both dry and wet weather flow monitoring were conducted at 13 metering sites for a period of approximately six weeks in early 2012. Dry weather flow (DWF) calibration ensures an accurate depiction of base wastewater flow generated within the study area. The wet weather flow (WWF) calibration consists of calibrating the hydraulic model to a specific storm event or events to accurately simulate the peak and volume of infiltration/inflow (I/I) into the sewer system. The amount of I/I is essentially the difference between the WWF and DWF components. In Turlock, the majority of I/I enters the system through storm drain connections to the sewer system in the downtown area, and small amounts of I/I are contributed throughout the remainder of the collection system.

5.3.1 Calibration Standards

The hydraulic model was calibrated in accordance with international modeling standards. The Wastewater Planning Users Group (WaPUG), a section of the Chartered Institution of Water and Environmental Management, has established generally agreed upon principles for model verification. The dry weather and wet weather calibration focused on meeting the recommendations on model verification contained in the “Code of Practice for the Hydraulic Modeling of Sewer Systems,” published by the WaPUG (WaPUG 2002), as summarized below:

- **Dry Weather Calibration Standards:** Dry weather calibration should be carried out for two dry weather days and the modeled flows and depths should be compared to the field measured flows and depths. Both the modeled and field measured flow hydrographs should closely follow each other in both shape and magnitude.

In addition to the shape, the flow hydrographs should also meet the following criteria as a general guide:

- The timing of flow peaks and troughs should be within one hour.
- The peak flow rate should be within the range of ±10 percent.
- The volume of flow (or the average rate of flow) should be within the range of ±10%. If applicable, care should be taken to exclude periods of missing or inaccurate data.

- **Wet Weather Calibration Standards:** For at least two storm events from the flow monitoring period, the model simulated flows and depths should be compared to the field measured flows and depths. The flow hydrographs for both events should closely follow each other in both shape and magnitude, until the flow has substantially returned to dry weather flow rates.

  In addition to the shape, the flow hydrographs should also meet the following criteria as a general guide:

  - The timing of the peaks and troughs should be similar with regard to the duration of the events.
  - The peak flow rates at significant peaks should be in the range of +25 percent to -15 percent and should be generally similar throughout.
  - The volume of flow (or the average flow rate) should be within the range of +20 percent to -10 percent.

  The WaPUG recommends that for wet weather calibration, the use of a single calibration period incorporating a number of rainfall events should be considered whenever possible. In other words, if the flow monitoring program captured several back to back storms, it may be preferable to use the back to back storms events as the calibration storms, as opposed to calibrating to two separate storms that have occurred weeks or months apart.

5.3.2 Dry Weather Flow Calibration

The DWF calibration process consists of several elements, as outlined below:

- **Divide the system into areas tributary to each flowmeter.** The first step in the calibration process was to divide the City into flowmeter tributary areas. Thirteen tributary areas were created, one for each flowmeter from the temporary flow monitoring program. A map showing the locations of each flow monitoring site and their associated tributary area are provided in Chapter 4 along with a schematic of the flow meters.
- **Define flow volumes within each area.** The next step was to define the flow volumes within each area, which was accomplished in the flow allocation step.

- **Create diurnal patterns to match the temporal distribution of flow.** A diurnal curve is a pattern of hourly multipliers that are applied to the base flow to simulate the variation in flow that occurs throughout the day. Two diurnal curves were developed for each flow monitoring tributary area, one representing weekday flow and one representing weekend flow. The diurnal patterns were initially developed based on the flow monitoring data and adjusted as part of the calibration process until the model simulated flows closely matched the field measured flows. Figure 5.3 shows the calibrated weekday and weekend diurnal patterns for the area tributary to Site 3. Similar diurnal curves were developed for each of the meters and its tributary area. These additional curves are available in Appendix D.

- **Adjust model variables to match field measured velocity and flow depths.** Once the model simulated flows acceptably matched the field measured flows, the model simulated velocity and flow depth were compared to the field measured velocity and flow depth. Adjustments were made to various model parameters until the modeled and measured velocity and depth closely matched one another. The primary varied parameters for this process are pipeline roughness (Manning's n) and sediment buildup in the pipe, although other parameters can also be adjusted as calibration results are generated.

  Manning's roughness coefficients, or n values, have industry accepted ranges based on a number of variables. Roughness coefficients increase over time depending on the construction methods, installation quality, system maintenance, and other environmental factors. There can be certain factors within the City's collection system that can result in roughness coefficients that differ from the typical range. For example, pipeline bellies, joint misalignment, cracks, and debris (e.g., root intrusion, etc.) lead to increased turbulence in a pipe, as well as the apparent Manning's n factor.

  If the model is unable to reasonably match the field measured flow depth and velocity without leaving the acceptable range of Manning's roughness coefficients, further investigation is conducted to help determine the cause of the discrepancy. Some issues that could cause such a discrepancy can include errors in the slope or diameter of a pipeline, downstream blockages, pipeline sags, and, in some cases, influences from downstream lift station operations.

Table 5.4 provides a summary of the dry weather flow calibration using the average and daily peak flow results for both weekday and weekend conditions. As shown on Table 5.4, with a few exceptions, the model simulated average and peak flows for both weekday and weekend DWF were all within 10 percent. In general, the percent difference between the overall modeled and measured DWF ranged between 0.0 and 5.4 percent.

Appendix D contains a detailed dry weather flow calibration summary sheet for each of the 13 metering sites. Each calibration sheet provides plots that compare the model simulated and field measured flow, velocity, and level data for both weekday and weekend conditions. An example of the dry weather calibration for Site 2 is shown on Figure 5.4.

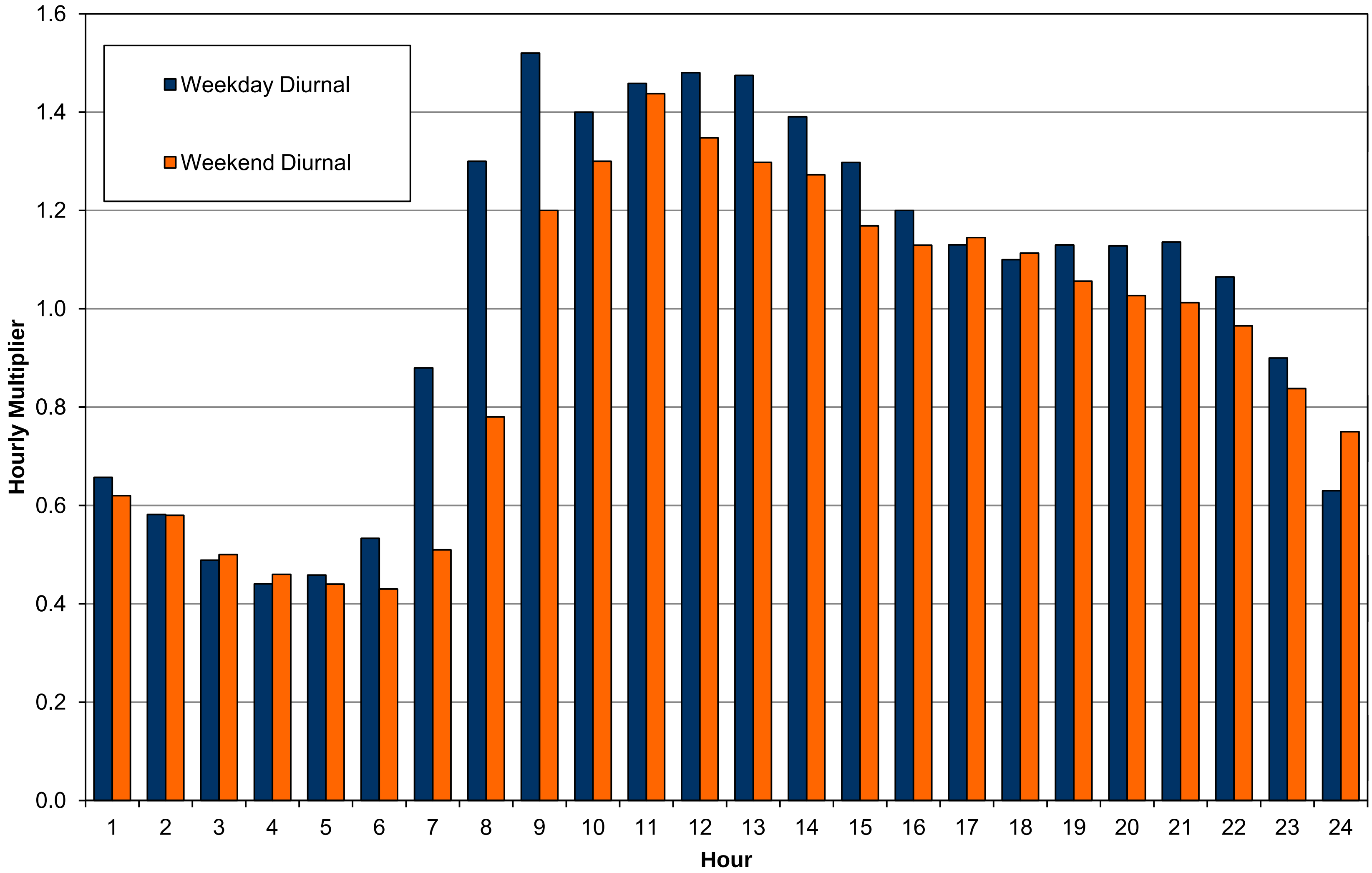

Figure 5.3
Example Diurnal Patterns (Meter 2)
Sewer System Master Plan
City of Turlock

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Table 5.4 Dry Weather Flow Calibration Results
Sewer System Master Plan
City of Turlock

		Weekday Dry Weather Flow												Weekend Dry Weather Flow												Average Dry Weather Flow[4]		
		Measured Data[1]				Modeled Data[2]				Percent Error[3]				Measured Data[1]				Modeled Data[2]				Percent Error[3]						
Meter Number	Pipe Diameter (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Avg. Velocity (%)	Avg. Level (%)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Avg. Velocity (%)	Avg. Level (%)	Measured ADWF (mgd)	Modeled ADWF (mgd)	Percent Difference (%)
1	42	2.290	2.750	1.74	11.3	2.188	2.571	1.52	11.8	-4.5%	-6.5%	-13.0%	4.9%	1.171	1.524	0.99	10.6	1.267	2.028	1.02	10.6	8.2%	33.1%	3.1%	0.8%	1.971	1.925	-2.3%
2	30	0.329	0.472	1.05	4.5	0.342	0.470	1.13	4.5	3.8%	-0.5%	8.4%	-1.7%	0.297	0.460	1.00	4.4	0.276	0.383	1.05	4.0	-7.0%	-16.8%	5.7%	-7.5%	0.320	0.323	0.9%
3	30	1.268	1.715	0.80	15.1	1.298	1.656	0.84	14.5	2.3%	-3.4%	5.8%	-3.5%	1.220	1.866	0.81	14.6	1.315	1.897	0.85	14.5	7.8%	1.7%	5.7%	-0.3%	1.254	1.303	3.8%
4	48	5.600	6.734	1.26	27.2	5.882	6.969	1.32	27.7	5.0%	3.5%	5.2%	1.8%	5.463	7.315	1.24	26.9	5.806	7.497	1.31	27.7	6.3%	2.5%	5.0%	2.8%	5.561	5.861	5.4%
5	16	0.487	0.656	1.00	8.5	0.479	0.647	1.02	8.6	-1.7%	-1.4%	2.1%	1.3%	0.532	0.807	1.04	8.8	0.511	0.771	1.04	8.9	-3.8%	-4.5%	-0.1%	1.0%	0.500	0.488	-2.4%
6	16	0.088	0.122	0.45	4.7	0.088	0.122	0.47	4.6	0.2%	-0.4%	3.6%	-2.2%	0.087	0.125	0.52	4.3	0.087	0.125	0.45	4.7	0.1%	-0.2%	-12.9%	9.5%	0.088	0.088	0.2%
7	24	0.000	0.000	0.00	0.0	0.000	0.000	0.00	0.0	0.0%	0.0%	0.0%	0.0%	0.000	0.000	0.00	0.0	0.000	0.000	0.00	0.0	0.0%	0.0%	0.0%	0.0%	0.000	0.000	0.0%
8	33	1.843	2.175	1.95	9.6	1.820	2.147	1.96	10.4	-1.3%	-1.3%	0.2%	8.2%	0.996	1.163	1.47	7.7	1.020	1.397	1.66	8.1	2.4%	20.2%	12.8%	5.5%	1.601	1.591	-0.6%
9	15	0.052	0.068	0.33	4.9	0.053	0.069	0.27	4.6	1.6%	1.5%	-17.6%	-5.9%	0.050	0.078	0.32	4.9	0.050	0.079	0.27	4.6	0.4%	1.6%	-15.2%	-6.5%	0.051	0.052	1.3%
10	24	1.147	1.391	1.76	8.5	1.134	1.382	1.76	8.4	-1.1%	-0.7%	0.1%	-0.9%	1.148	1.508	1.74	8.5	1.149	1.505	1.76	8.4	0.1%	-0.2%	1.0%	-0.9%	1.147	1.138	-0.8%
11	18	0.610	0.788	1.36	7.4	0.605	0.763	1.44	7.4	-0.8%	-3.2%	6.2%	1.0%	0.625	0.865	1.35	7.5	0.618	0.834	1.44	7.5	-1.1%	-3.5%	6.9%	0.0%	0.614	0.609	-0.9%
12	21	1.185	1.402	1.14	15.2	1.192	1.389	1.05	14.3	0.6%	-0.9%	-8.1%	-5.4%	1.174	1.447	1.12	15.2	1.185	1.450	1.04	14.4	1.0%	0.2%	-7.5%	-5.4%	1.182	1.190	0.7%
13	30	1.021	1.402	1.05	10.3	1.029	1.311	1.07	10.8	0.8%	-6.5%	1.9%	4.5%	1.089	1.465	1.12	10.3	1.097	1.452	1.11	11.0	0.7%	-0.9%	-0.5%	6.3%	1.040	1.049	0.8%

Notes:

1. Source: City of Turlock Temporary Flow Monitoring Program, V&A Consulting Engineers
2. Average flow, level, and velocity are calculated from weekday/weekend dry weather flow monitoring data. Maximum flow values are hourly peaks corresponding to either weekend or weekday confitions, as appropriate.
3. Percent Difference = (Modeled - Measured)/Measured*100.
4. Average Dry Weather Flow = (5*Weekday Dry Weather Flow + 2*Weekend Dry Weather Flow)/7

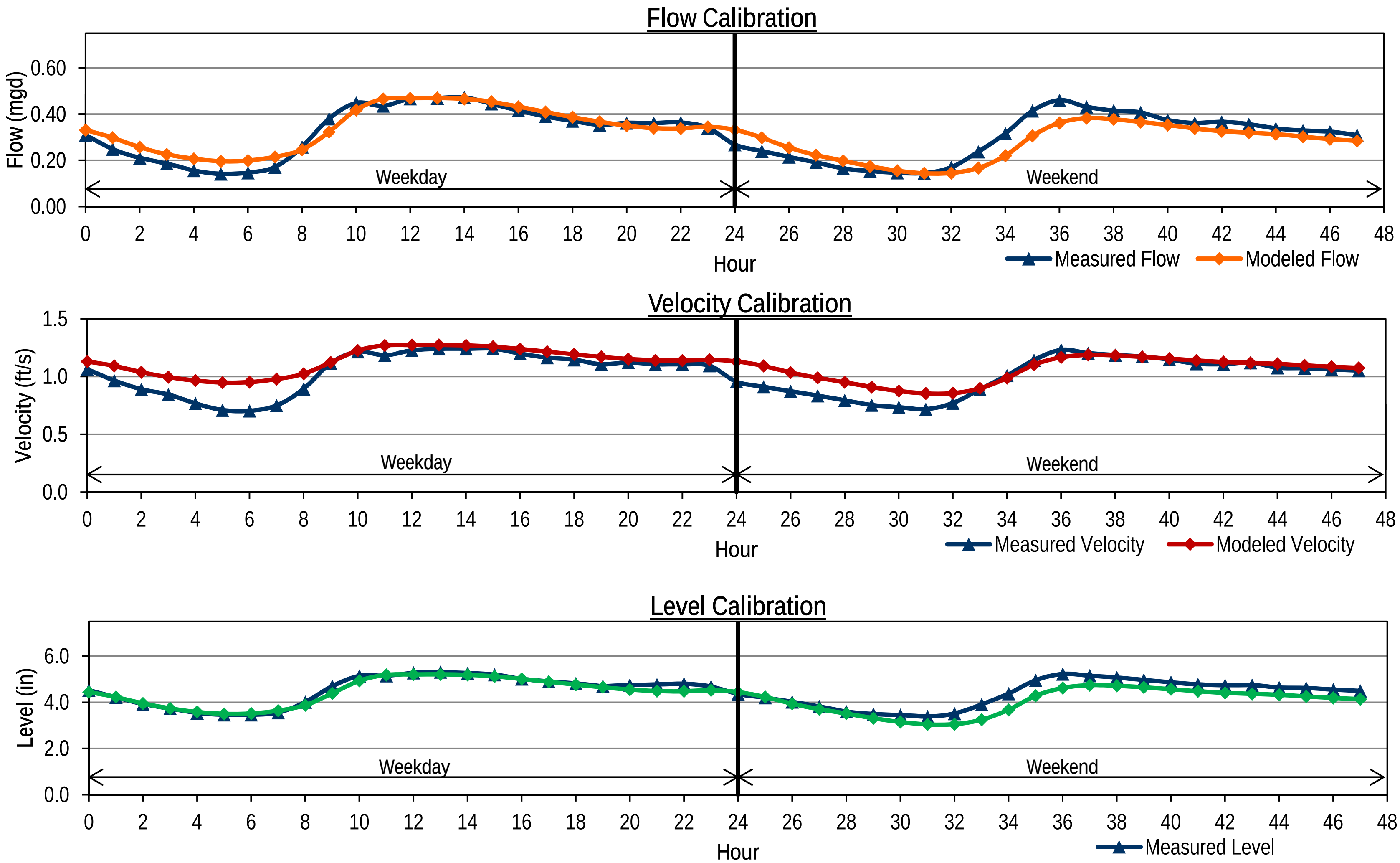

Figure 5.4
Example Dry Weather
Flow Calibration (Meter 2)
Sewer System Master Plan
City of Turlock

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As shown on Figure 5.4 and in Appendix D, there is excellent overall correlation of the field measured data to the model output results. However, there were a few sites where the modeled flows, levels, or velocities were slightly outside of the generally accepted calibration tolerances. The majority of these sites were only marginally outside of the acceptable tolerances, and therefore the model was considered calibrated.

5.3.3 Wet Weather Flow Calibration

The WWF calibration enables the hydraulic model to accurately simulate I/I entering the collection system during a large storm. As outlined below, the WWF calibration process consists of several elements:

- **Identify calibration rainfall events.** The WWF calibration process consists of running model simulations of historic rainfall events based on data collected as part of the temporary flow monitoring program. The goal of any wet weather flow monitoring program is to capture and characterize a system's response to a significant rainfall event, preferably during wet antecedent moisture conditions.

  The selection of a particular calibration storm or group of storms is based on a review of the flow and rainfall data. For WWF calibration, the model was run from January 20, 2012 to February 5, 2012, and calibrated to the main rainfall event that occurred during the course of the flow monitoring period.

  In order to run a model simulation for the January 20, 2012 to February 5, 2012 rainfall events, the hourly rainfall data were input into the model for these events. Each flow monitoring tributary area, or basin, was assigned a specific rainfall hyetograph, which was calculated for each basin based on the rainfall data collected at the rain gauges installed as part of the temporary flow monitoring program. Refer to Chapter 3 and Appendix B for more detail on how this computation was performed.

- **Define RDII tributary areas.** For the WWF calibration, RDII flows are superimposed on top of the DWF. The model calculates RDII by assigning "RDII Inflows" to each node in the model. RDII inflows consist of both a unit hydrograph and the total area that is tributary to the model node. The RDII tributary areas were calculated in GIS using the loading polygons, excluding any large vacant, open space, or other areas in the system which are not expected to contribute to I/I into the collection system. The tributary area provides a means to transform hourly rainfall depth from the rainfall hyetographs into a rainfall volume. The rainfall volume is transformed into actual RDII flows using the unit hydrograph, as described in the next step.

- **Refine Subcatchment Parameters.** The storm drainage connections to the sewer system were modeled by creating stormwater subcatchments that simulate surface water runoff to the sewer system. There are a number of parameters that are input and refined during model calibration for each subcatchment, including the area, percent impervious, width, slope, and roughness. These parameters were refined during model calibration to match the flow monitoring data for the downtown areas where the majority of wet weather flow is from the storm drain cross connections.

- **Create I/I parameter database and modify to match field measured flows.** The main step in the WWF calibration process involves creating custom unit hydrographs for each flow monitoring tributary area using the "RTK Method," which is widely used in collection system master planning. Using the RTK Method, the RDII unit hydrograph is the summation of three separate triangular hydrographs (short term, medium term, and long term), which are each defined by three parameters: R, T, and K. R represents the fraction of rainfall over the sewershed that enters the collection system; T represents the time to peak of the hydrograph; and K represents the ratio of time to recession to the time to peak. Therefore, there are a total of nine separate variables associated with each unit hydrograph. Figure 5.5 shows the shape of an example unit hydrograph.

  The hydrographs utilize the R-values (percent of rainfall that enters the collection system) calculated for each basin to simulate I/I. The nine variables in each unit hydrograph were initially set based on engineering judgment and then adjusted until the model simulated flows (both peak flows and average flows) matched closely with the field measured flows.

  As with the dry weather calibration, the wet weather calibration process compared the meter data with the model output. Comparisons were made for average and peak flows as well as the temporal distribution of flow until flows returned to their baseline levels. According to the WaPUG, a hydraulic model is generally considered to be satisfactorily calibrated to WWF conditions if the modeled peak flows are within +25 percent to -15 percent of the field measured data, and if the average modeled flows are within +20 percent to -10 percent of the field measured data.

- **Refine model variables to match field measured velocity and flow depths.** After the model was considered to be satisfactorily calibrated for wet weather flows, the model simulated velocities and flow depths were checked against the field measured velocities and flow depths during the calibration storms. Refinements were made to the various model parameters so that the modeled and measured velocity and depth closely matched one another. If any adjustments were made to Manning's n-values or other parameters, the DWF calibration was rechecked as well to make sure that the flow depth and velocities still matched well under DWF conditions.

Appendix E contains a detailed wet weather flow calibration summary sheet for each of the 13 meter sites. Each calibration sheet provides plots that compare the model simulated and field measured flow, velocity, and level data for the calibration storms. An example of the wet weather calibration for Site 2 is shown on Figure 5.6.

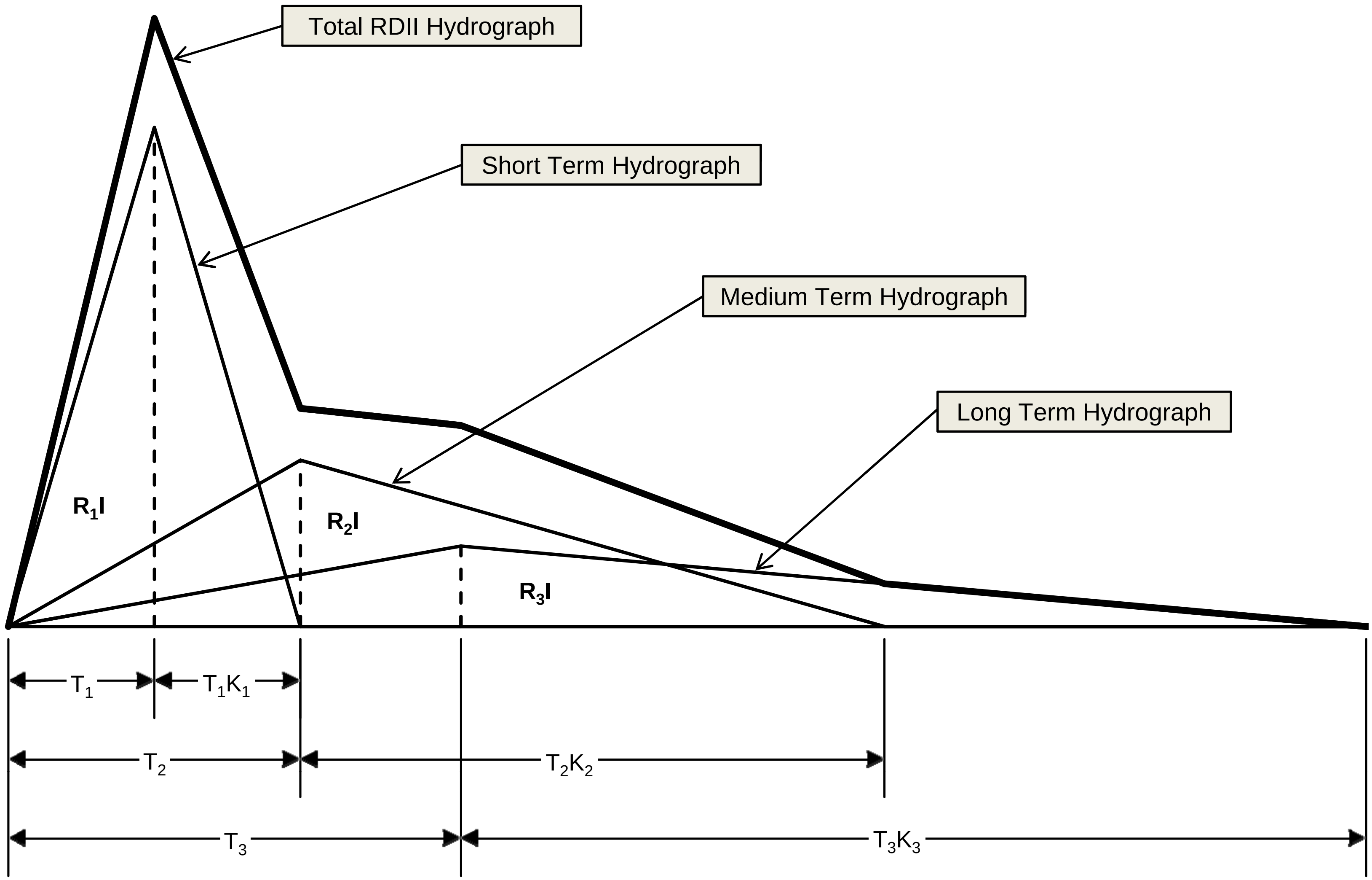

Figure 5.5
Example RDII Hydrograph
Sanitary Sewer Master Plan
City of Turlock

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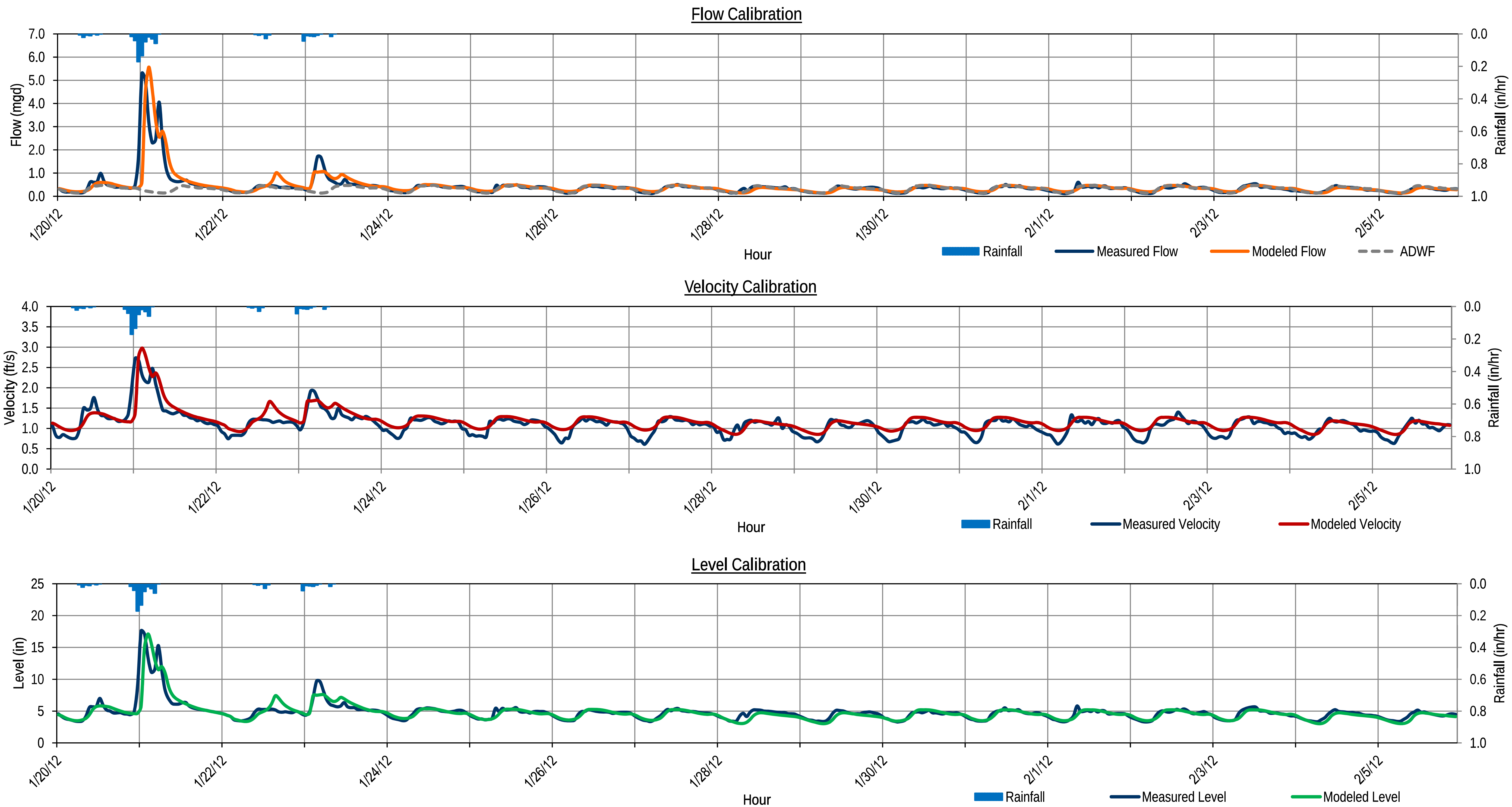

Figure 5.6
Example Wet Weather
Flow Calibration (Meter 2)
Sanitary Sewer Master Plan
City of Turlock

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Table 5.5 provides a summary of the wet weather flow calibration using the average and peak flow results. As shown on Table 5.5, the model simulated average and peak flows at all meter sites were within the acceptable tolerances for the calibration storm, and therefore the model was considered calibrated and ready to use for capacity analysis purposes.

In addition, a verification storm from the wet weather event on October 13, 2009 and plant influent data were used to verify that the flows simulated in the model closely matched the flows measured at the TRWQCF (see Figure 5.7).

Table 5.5 Wet Weather Flow Calibration Results
Sewer System Master Plan
City of Turlock

		Storm 1 (3/13/2012-3/15/2012)					
		Measured Data[1]		Modeled Data[2]		Percent Error[3]	
Meter Number	Pipe Diameter (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (%)	Peak Flow (%)
1	42	1.946	3.859	1.926	4.098	-1.0%	6.2%
2	30	0.409	5.283	0.427	5.566	4.2%	5.4%
3	30	1.288	3.524	1.382	3.947	7.3%	12.0%
4	48	5.590	8.132	5.964	8.216	6.7%	1.0%
5	16	0.509	1.174	0.516	1.293	1.4%	10.1%
6	16	0.099	0.414	0.097	0.532	-1.7%	*28.7%*
7	24	0.011	1.008	0.004	0.851	*-65.2%*	*-15.5%*
8	33	1.560	2.734	1.589	3.187	1.9%	16.6%
9	15	0.052	0.161	0.054	0.144	2.8%	-10.6%
10	24	1.161	1.668	1.169	1.682	0.7%	0.9%
11	18	0.624	0.914	0.622	0.873	-0.3%	-4.5%
12	21	1.204	1.527	1.201	1.578	-0.2%	3.4%
13	30	1.048	1.713	1.070	1.539	2.0%	-10.1%

Notes:
1. Source: City of Turlock Temporary Flow Monitoring Program, V&A Consulting Engineers
2. Average flows are calculated from flow monitoring data. Maximum flow values are hourly peaks.
3. Percent Difference = (Modeled - Measured)/Measured*100.

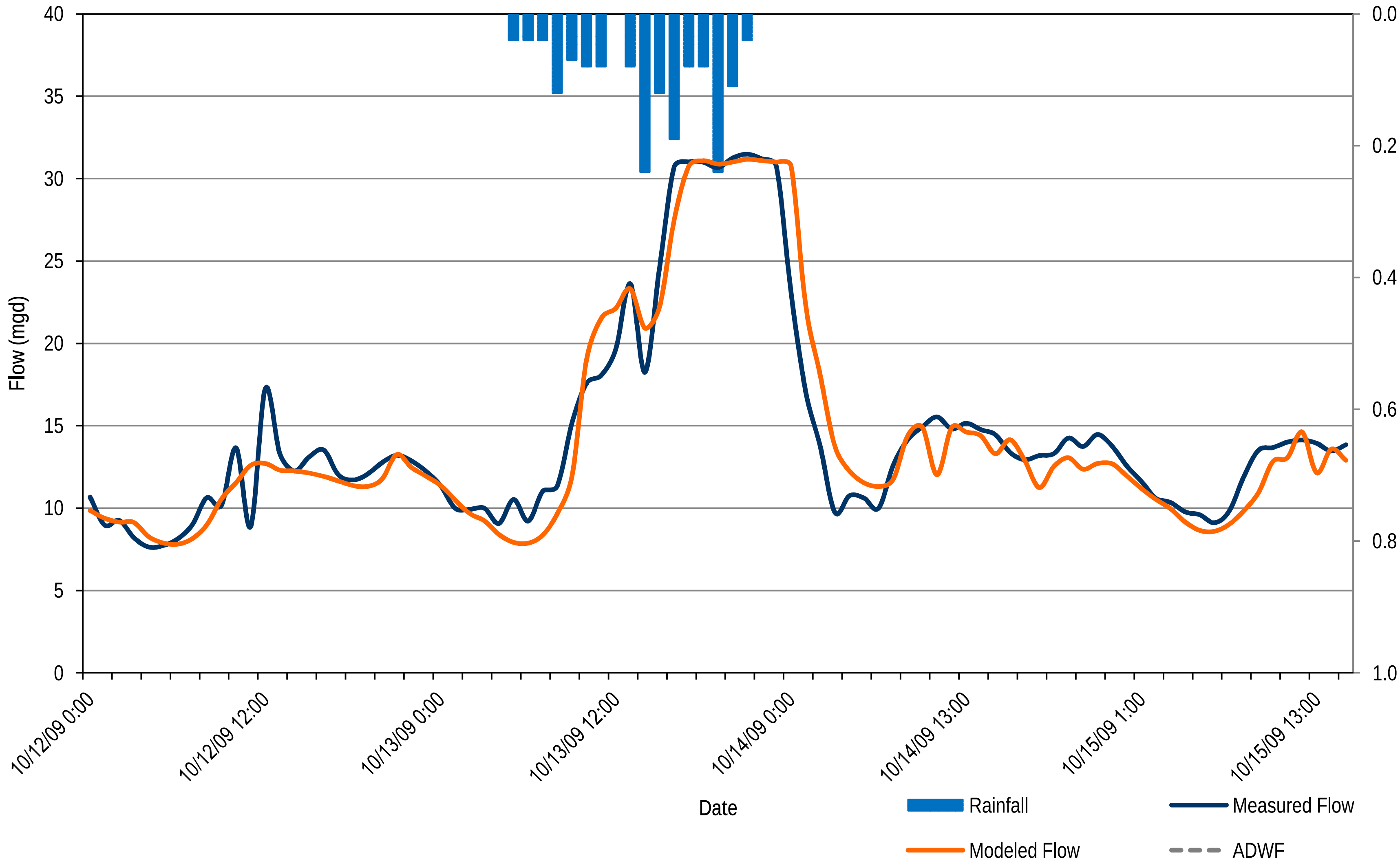


Figure 5.7
Wet Weather Flow Verification at the TRWQCF
Sewer System Master Plan
City of Turlock

DESIGN FLOW ANALYSIS AND CAPACITY EVALUATION

This chapter discusses the modeled design flows for the City of Turlock (City) sewer collection system, the hydraulic evaluation of the collection system, and the proposed projects to increase capacity.

6.1 DESIGN FLOW ANALYSIS

The City's sewers and lift stations were evaluated based on their capacity to convey peak wet weather flow (PWWF). If the sewers violated the flow depth criteria described in Chapter 3, then they were considered capacity deficient and improvements were proposed. PWWFs were simulated by routing the 10-year, 24-hour design storm through the calibrated hydraulic model.

The existing and future design flows that reach the Turlock Regional Water Quality Control Facility (TRWQCF) are dependant on a number of factors. There is significant inflow in the downtown area of the City due to storm drainage inlets that are connected to the sanitary sewer. These storm drains connections cause large flow spikes at the TRWQCF during rainfall events. The capacity analysis of the wastewater collection system (discussed in detail in Section 6.2) indicates that the City's collection system is not capable of conveying peak flows within the specified criteria during the 10-year, 24-hour design storm. Capacity deficiencies in the collection system throttle the peak flow rates that reach TRWQCF. In addition, the existing influent pump station has a capacity of approximately 30 million gallons per day (mgd). In actuality, peak wet weather flows during the storm exceeded 30 mgd, which means flow was stored in the collection system.

The City is currently in the process of constructing a new influent pump station, which is expected to be online in 2014. The new headworks will be configured so that the existing influent pump station (Pump Station No. 1) can be utilized during high flow conditions via an overflow to the existing influent pump station. In addition, modifications to the influent pipelines will be constructed which will allow City staff to divert additional flow to Pump Station No. 1 if necessary.

Figure 6.1 shows a hydrograph of the simulated PWWF reaching the TRWQCF at current flow conditions. The red line shows the PWWF at the TRWQCF with the existing influent pump station only (current condition).

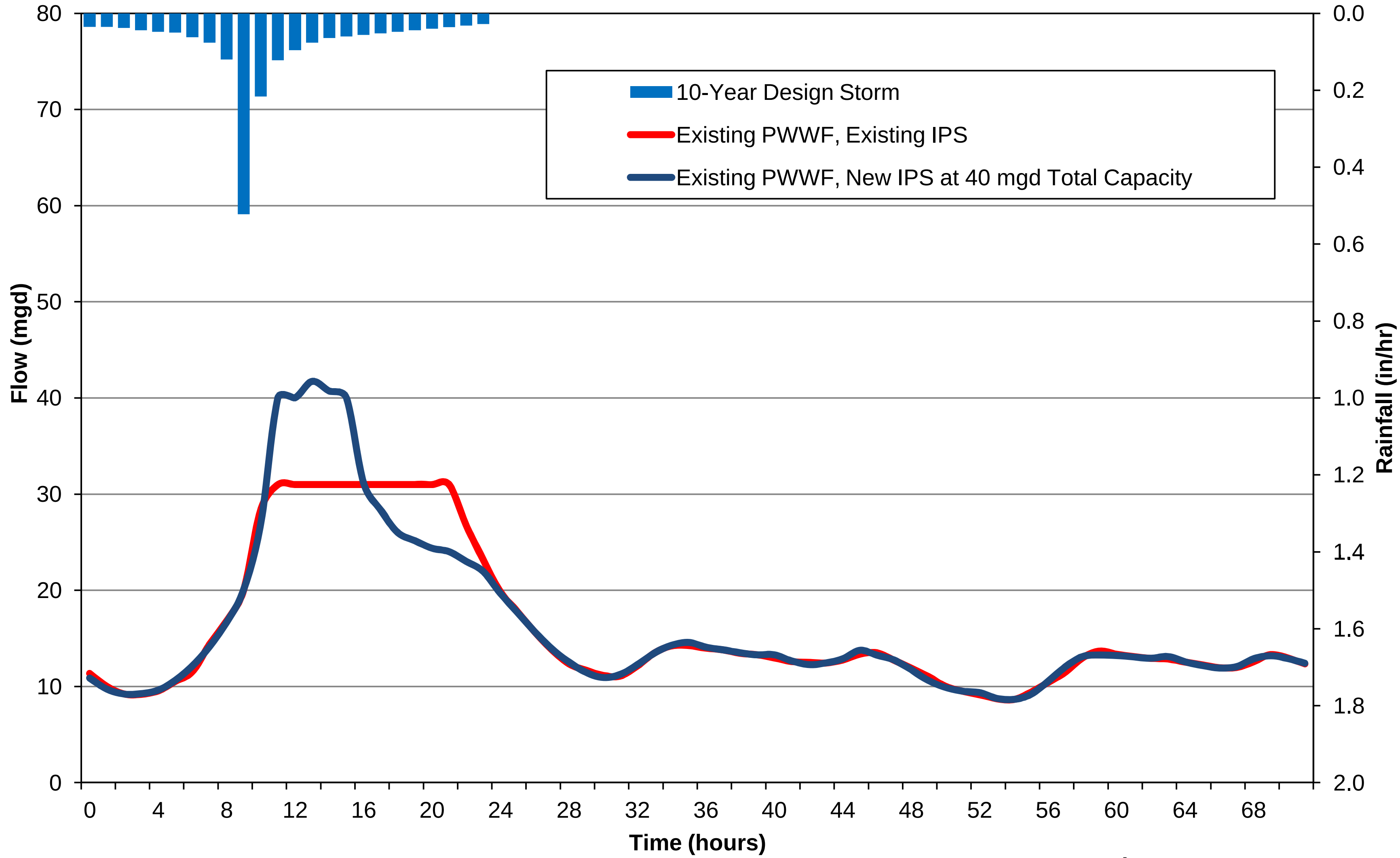


Figure 6.1
Existing PWWF Hydrograph
Sewer System Master Plan
City of Turlock

With the current influent pump station, the PWWF peaks at just over 30 mgd for a period of approximately 11 hours. Flow above 30 mgd is temporarily stored in the collection system and could overflow. After the new influent pump station is operational, the PWWF at the TRWQCF will increase to approximately 41.7 mgd (shown on Figure 6.1 in blue).

The build-out PWWF depends on a number of factors. The most important impact on capacity is the stormwater from storm drainage inlets that are connected to the sewer system. As part of the capacity evaluation of the collection system (Section 6.2), Carollo developed improvement alternatives assuming (1) storm drainage connections to the sanitary sewer will remain, or (2) the City will implement storm drainage system improvements to remove the connections. Figure 6.2 illustrates the projected PWWF at build-out for both assumptions. As shown on Figure 6.2, the build-out PWWF is projected to be 63.0 mgd if the storm drainage connections to the sanitary sewer system will remain. If these connections are removed, the build-out PWWF is projected to be 37.9 mgd.

Table 6.1 summarizes the existing and build-out PWWFs. As shown in Table 6.1, removing the storm drain inlets from the sewer system will greatly reduce the flows influent to the TRWQCF during wet weather. Based on modeling results, the peak flows would drop from 63.0 mgd to 37.9 mgd, which represents a 34 percent reduction in flows.

Table 6.1 Existing and Build-Out Design Flows
Sewer System Master Plan
City of Turlock

Flow Condition	ADWF (mgd)	PWWF (mgd)	Peaking Factor
Existing	10.6	31.0[(1)]	2.9
		41.7[(2)]	3.9
Build-Out	19.4	37.9[(3)]	2.0
		63.0[(4)]	3.2

Notes:
(1) The existing PWWF is controlled by the current capacity of the influent pump station.
(2) When the new headworks comes online, the PWWF will increase. Values presented assume that the new gate and Pump Station No. 1 will remain closed.
(3) Assumes that storm drainage connections to the sanitary sewer system are removed.
(4) Assumes that storm drainage connections to the sanitary sewer system will remain.

6.2 CAPACITY EVALUATION

This section summarizes the results of the capacity evaluation of the City's sewer collection system including gravity pipelines and lift stations. The evaluation was conducted for existing and future build-out design flow conditions.

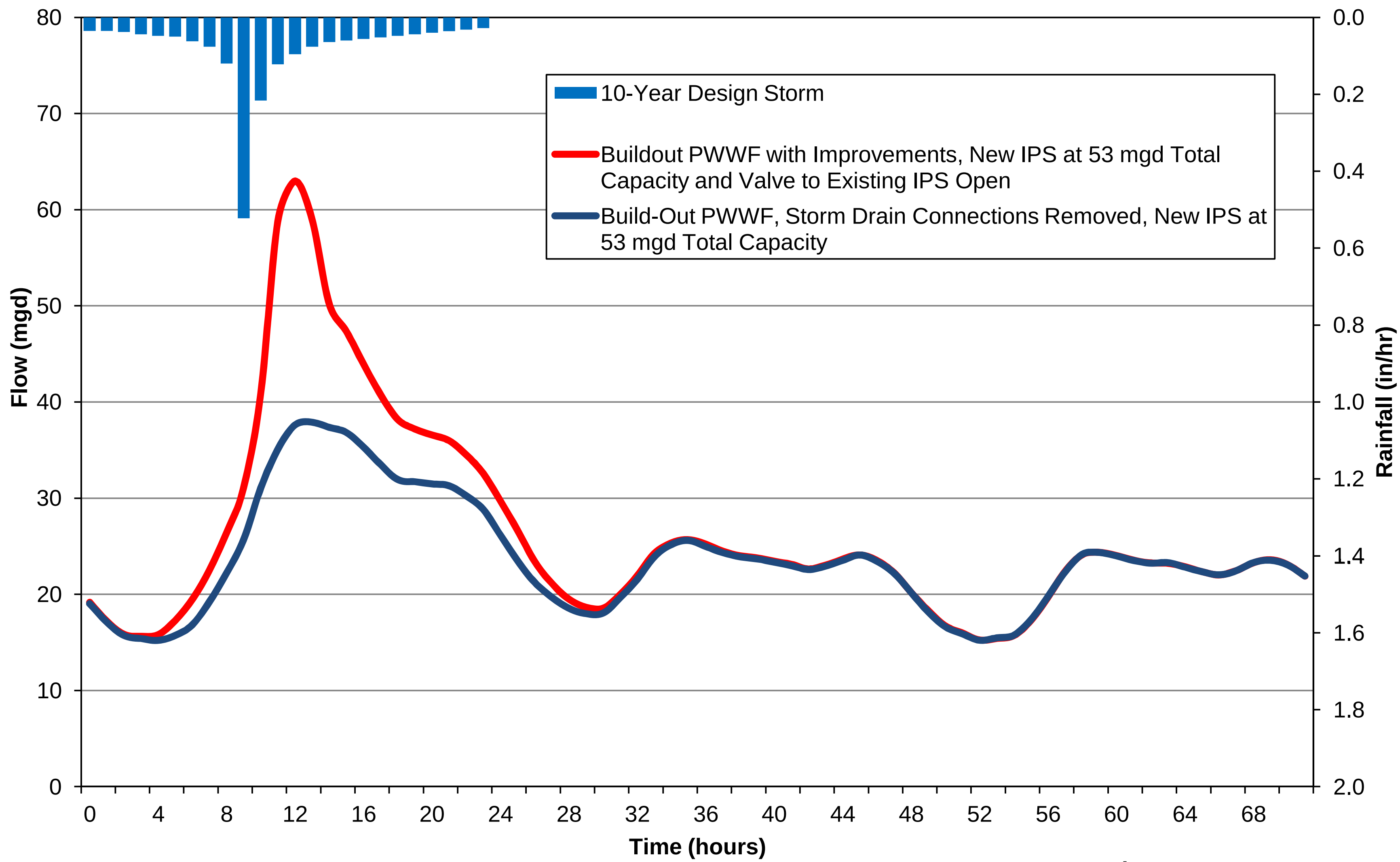


Figure 6.2
Build-Out PWWF Hydrograph
Sewer System Master Plan
City of Turlock

6.2.1 Gravity Collection System Evaluation

Following the dry and wet weather flow calibration, which is summarized in detail in Chapter 5, a capacity analysis of the existing and future collection system was performed based on planning criteria presented in Chapter 3. The capacity analysis of the City's sewer identified areas of capacity deficiencies.

This section discusses the locations of current and projected hydraulic deficiencies resulting from flows exceeding the maximum flow depth criteria.

- **Current Conditions.** For the existing sewer collection system, the PWWF was routed through the hydraulic model. In accordance with the established flow depth criteria for existing sewers, manholes where the hydraulic grade line (HGL) encroached within five feet of the manhole rim, were identified.

  Note that the pipelines with an HGL that encroached within five feet of the manhole rim are not necessarily capacity deficient. In many cases, a surcharged condition within a given pipeline segment is due to backwater effects created by a downstream bottleneck. An illustration of backwater effects is shown in Figure 6.3. For this reason, the hydraulic model was analyzed to identify the pipeline segments that are the cause of the surcharged conditions.

  The wastewater and stormwater systems are connected in the older downtown sections of the City. The connections contribute high flows to the sanitary sewer collection system during rainfall events. During storms, the combined wastewater and stormwater cause water levels in the sewers to rise, and significantly increases the City's risk of sanitary sewer overflows (SSOs).

  Following the completion of the existing system analysis, improvement projects and alternatives were identified to mitigate existing system pipeline capacity deficiencies. The recommended improvement projects are discussed in greater detail in Section 6.3.

- **Build-Out Conditions.** The build-out system analysis was performed in a manner similar to the existing system analysis. The purpose of the build-out system evaluation is to verify that the existing system improvements were appropriately sized to convey build out PWWFs, and to identify the locations of sewers that are adequately sized to convey existing PWWFs, but cannot convey build-out PWWFs. Additionally, new trunk sewers were added to the hydraulic model and sized to service major growth areas beyond the current City sewer service area.

  At build-out, the City's wastewater flows are expected to roughly double. As such, there are some areas of the existing collection system that cannot convey the build-out design flow without flows backing up above allowable levels. Future system improvement recommendations are described in Section 6.3.

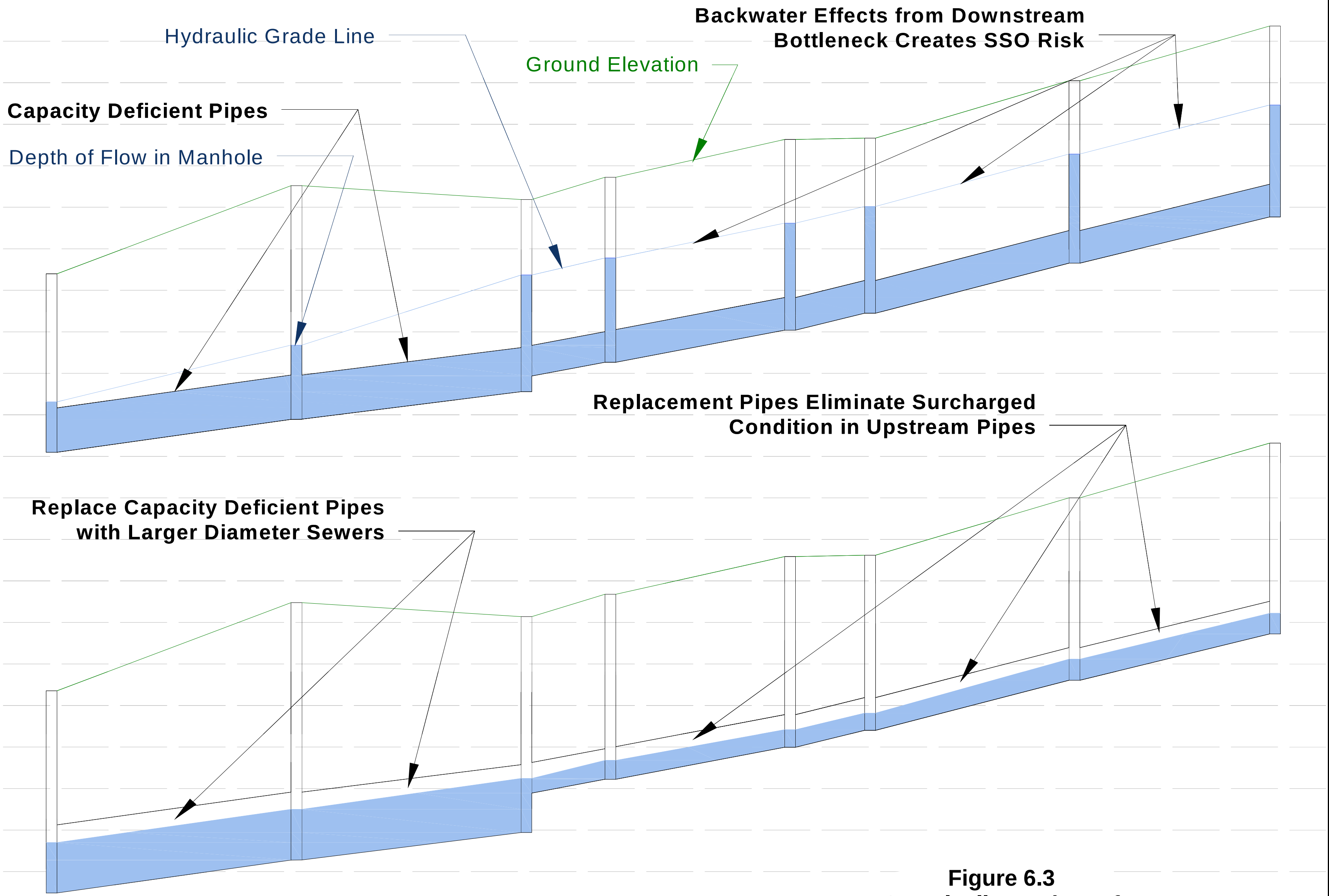


Figure 6.3
Sample Illustration of Backwater Effects in a Sewer
Sewer System Master Plan
City of Turlock

6.2.2 Lift Station Capacity Evaluation

The City's hydraulic model includes lift stations that service the major trunk system (typically pipes 10 inches or larger). Lift stations that serve 8-inch diameter and smaller pipes are not included in the hydraulic model. In accordance with the established planning criteria, the City's existing modeled lift stations were evaluated to determine if each one has available capacity to convey existing and future PWWF. Lift stations with an influent PWWF above the existing firm capacity were flagged as deficient. Table 6.2 summarizes the results of the lift station evaluation.

- **Current Conditions.** As shown in Table 6.2, all of the City lift stations included in the hydraulic model are adequately sized to convey the current peak wet weather flows.
- **Build-Out Conditions.** Similar to the existing system analysis, the City's modeled lift stations were analyzed for build-out PWWF conditions. Based on the analysis, the following lift stations will need to be upgraded to convey future peak flows:
  - Lift Station 4
  - Lift Station 50
  - Lift Station 57
  - Lift Station 63
  - Golden State Lift Station
  - Main Lift Station

  In addition, due to the topography of the Turlock Regional Industrial Park (TRIP), a new lift station is required to serve future industrial users in the southwest corner of the TRIP. The new lift station will be located near the intersection of West Linwood Avenue and South Washington Road, and will convey wastewater flows north through a 12-inch diameter force main to an existing 24-inch diameter trunk sewer at West Main Street and South Washington Road.

6.3 COLLECTION SYSTEM CAPACITY IMPROVEMENTS

The collection system was analyzed under existing conditions and future build-out conditions. Findings from the collection system analysis were used to develop system improvements to remove capacity deficiencies.

Table 6.2 Lift Station Evaluation
Sewer System Master Plan
City of Turlock

		Lift Station Data					Existing Lift Station Capacity Analysis			Buildout Lift Station Capacity Analysis		
					Firm Capacity		Existing PWWF	Existing Capacity Deficiency		Buildout PWWF	Buildout Capacity Deficiency	
Lift Station	**Location**	**Pump**	**Capcity (gpm)**	**Total Capacity (gpm)**	**(gpm)**	**(mgd)**	**(mgd)**	**(yes/no)**	**(mgd)**	**(mgd)**	**(yes/no)**	**(mgd)**
4	Kilroy Road	1	800	1,600	800	1.15	1.22	no	0.00	***2.38***	***yes***	***1.23***
		2	800									
9	N. First Street	1	200	400	200	0.29	0.15	no	0.00	0.15	no	0.00
		2	200									
25	Donnely Park	1	500	1,000	500	0.72	0.16	no	0.00	0.16	no	0.00
		2	500									
40	Quincy/Castleview	1	500	1,000	500	0.72	0.17	no	0.00	0.26	no	0.00
		2	500									
42	East Avenue	1	100	200	100	0.14	0.03	no	0.00	0.05	no	0.00
		2	100									
49	Berkely/Brier	1	200	400	200	0.29	0.17	no	0.00	0.25	no	0.00
		2	200									
50	Tegner	1	800	1,600	800	1.15	2.24	no	0.00	***8.54***	***yes***	***7.39***
		2	800									
53	Monte Vista/Crossings	1	600	1,200	600	0.86	0.56	no	0.00	0.60	no	0.00
		2	600									
54	Pitman High	1	1,200	2,400	1200	1.73	0.73	no	0.00	0.89	no	0.00
		2	1,200									
55	Hawkeye/Tartan	1	200	400	200	0.29	0.03	no	0.00	0.04	no	0.00
		2	200									
56	Sports Complex	1	1,600	3,200	1600	2.30	0.22	no	0.00	0.22	no	0.00
		2	1,600									
57	Picadilly	1	1,600	3,200	1600	2.30	0.73	no	0.00	***3.02***	***yes***	***0.72***
		2	1,600									
58	5th and Silva	1	300	600	300	0.43	0.13	no	0.00	0.13	no	0.00
		2	300									
59	Paseo Belleza	1	300	600	300	0.43	0.02	no	0.00	0.02	no	0.00
		2	300									
60	Divinian/Veeck	1	200	400	200	0.29	0.02	no	0.00	0.20	no	0.00
		2	200									
63	Fulkerth/Tegner	1	1,200	2,400	1200	1.73	0.69	no	0.00	***2.55***	***yes***	***0.82***
		2	1,200									
64	Tuolumne/Countryside	1	600	1,200	600	0.86	0.17	no	0.00	0.28	no	0.00
		2	600									
65	Esperanza/Linwood	1	n/a	n/a	n/a	n/a	0.01	no	0.00	0.01	no	0.00
		2	n/a									
66	Liberty Parkway	1	200	400	200	0.29	0.03	no	0.00	0.07	no	0.00
		2	200									
67	Humphrey Court	1	200	400	200	0.29	0.14	no	0.00	0.70	yes	0.41
		2	200									
Golden State	Monte Vista/Golden State	1	n/a	n/a	n/a	n/a	0.47	assumed no	0.00	***1.97***	***assumed yes***	***0.00***
		2	n/a									
Kilroy	Kilroy/Industrial Rowe	1	n/a	n/a	n/a	n/a	0.29	assumed no	0.00	0.31	assumed no	0.00
		2	n/a									
Main	West Main/Clinton	1	n/a	n/a	n/a	n/a	0.06	assumed no	0.00	***3.11***	***assumed yes***	***0.00***
		2	n/a									
Private	West Main/Fransil	1	n/a	n/a	n/a	n/a	0.05	no	0.00	0.05	no	0.00
		2	n/a									

As previously noted, the wastewater and stormwater systems are connected in the older downtown areas of the City. An important consideration is whether to eliminate storm drainage system connections to the sanitary sewer system. Improvements were identified for two different scenarios: (1) assuming that the direct storm drain connections to sewer would remain in place (existing situation), and (2) assuming that the storm drainage connections in downtown area would be segregated from the sewer system (storm inlets removed). The results of this analysis were presented to City staff at a planning meeting on February 7, 2013. The City concluded that the preferred approach was to segregate (i.e., remove) the storm drainage system connections from the sanitary sewer system. Accordingly, the proposed improvements and costs presented in this Master Plan assume the separation of the sewer and storm drainage systems.

The proposed improvements that will serve future users are sized for build-out conditions. As the City continues to grow beyond its current limits, it is recommended that new pipelines and pump stations be designed so that the facilities have sufficient capacity for build-out conditions. Building a smaller interim project with the plans of upsizing in the future to account for further growth is not recommended because a second project to expand would be more costly and impractical to construct. Therefore, the proposed pipe diameters for each project listed in the CIP represent the ultimate diameters for build-out conditions.

In accordance with the established planning criteria, new sewer pipelines were sized such that the maximum flow depth to pipe diameter ratio (d/D) did not exceed the values summarized in Chapter 3. In other words, the new sewers were sized to prevent surcharging during PWWF conditions.

Figure 6.4 illustrates the proposed sanitary sewer improvements necessary to correct the existing deficiencies and to serve future users. The improvements were developed assuming shown storm drainage connections to the sanitary system would be removed. Detailed information related to each improvement project is provided in Table 6.3.

Figure 6.5 shows the storm drainage system improvements that are required to remove the storm drainage system connections to the sanitary sewer. Table 6.3 also includes information related to the storm drainage system improvement projects shown in Figure 6.5.

6.3.1 Differentiating between Improvements for Existing Users and Future Users

An existing deficiency is one where the existing facility's capacity is insufficient to meet the planning criteria (e.g., pipeline upgrades required to prevent severe surcharging during the design wet weather event). If a project was proposed to correct an existing deficiency exclusively, then existing users were assigned 100 percent of the project's benefit, and, 100 percent of the costs.

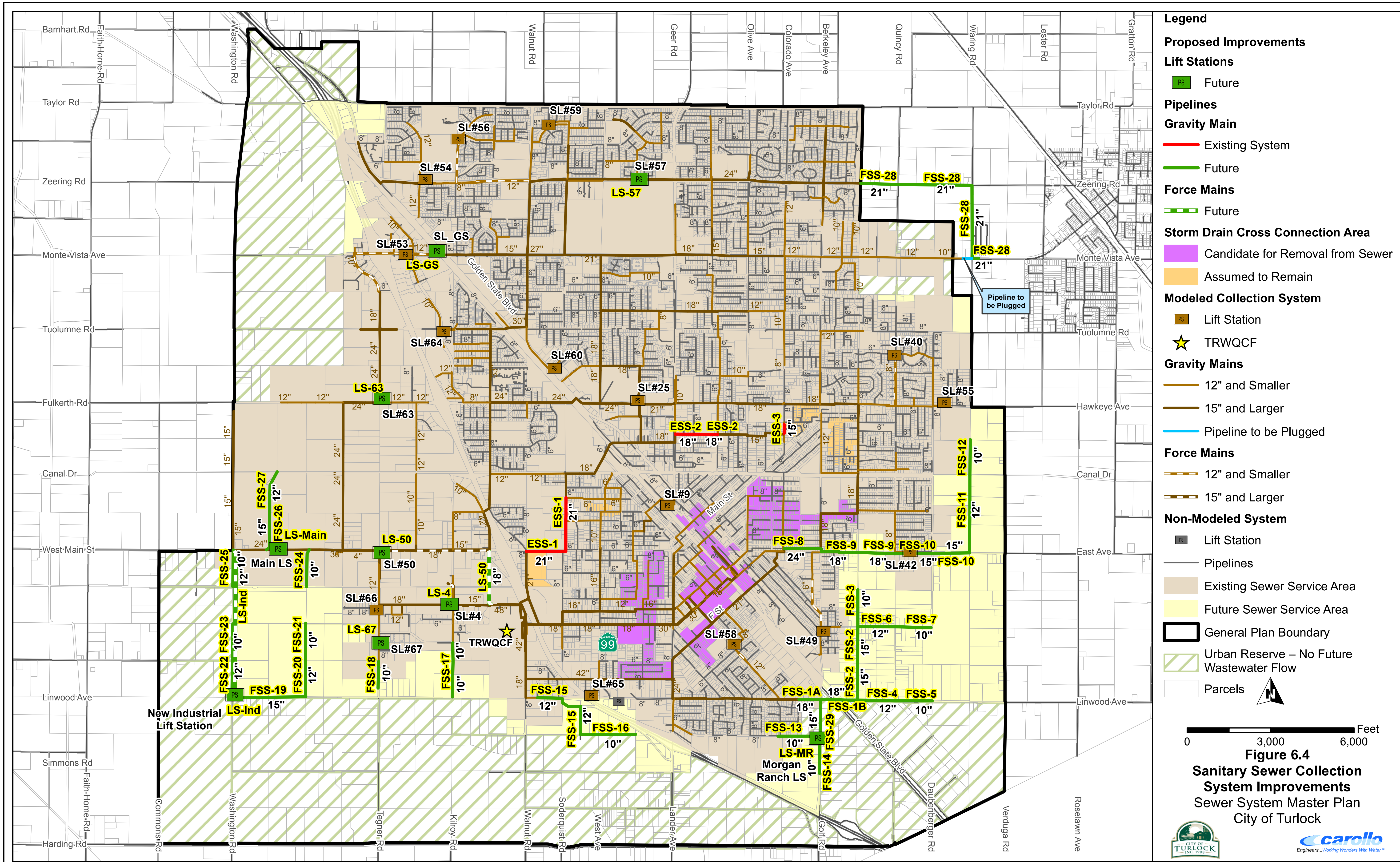


Figure 6.4
Sanitary Sewer Collection System Improvements
Sewer System Master Plan
City of Turlock

Table 6.3 Proposed Improvements
Sewer System Master Plan
City of Turlock

Figure No.	Type of Improvement	Description/ Street	Description / Limits	Project Length/Size and Cost Ex. Size/ Diam. (in)	New Size/ Diam. (in)	Replace/ New	Length (ft)	Capital Improvement Phasing Phase 1 2013-2015	Phase 2 2016-2020	Phase 3 2021-2025	Phase 4 2026-2030	Phase 5 After 2030
Existing System Improvements												
Pipelines												
ESS-1	Pipe	W. Main St./N. Soderquist Rd.	Julian St. to S. Tully Rd.	18	21	Replace	3,350				X	
ESS-2	Pipe	Wayside Dr.	N. Denair Ave, to Geer Rd.	15	18	Replace	1,520				X	
ESS-3	Pipe	Colorado Ave.	North of Escandido Ave. to south of Escondido Ave.	12	15	Replace	320				X	
Projects to Remove Direct Connections to Sewer System [2]												
ESD-11	Pipe	Johnson Rd	Marshall St to Canal Dr	8/12/15	30	Replace	1,120				X	
ESD-17	Pipe	D St	6th to Lander Ave	10/18	48	Replace	780		X			
ESD-19	Pipe	West South Ave	Columbia St to High St	12	36	Replace	490		X			
ESD-20	Pipe	West South Ave	High St to Vermont Ave	12	36	Replace	900		X			
ESD-21	Pipe	West South Ave	Vermont Ave to South Ave	12	48	Replace	910		X			
ESD-22	Pipe	West Ave South	South Ave to Linwood Ave	-	48	New	2,820		X			
ESD-24	Pipe	South Ave	Corner of West Ave South, remove outfall to existing infrastructure	15	-	Abandon	-					
ESD-25	Pipe	Montana Ave	Gabriel St to West Ave South	-	30	New	670		X			
ESD-26	Pipe	Lander Ave	E St to Linwood Ave, Adjust inverts to match prposed Linwood trunkline	-	60	Replace	1,580	X				
ESD-27	Pipe	Lander Ave	At F St, influent pipe to Pump Station No. 2 Wet Well	42	-	Abandon	-					
ESD-43	Pipe	Canal Drive	Johnson Rd and Canal Dr, provides connection to canal trunkline	-	30	New	50				X	
ESD-47	Pipe	Marshall St	Berkeley Ave to Johnson Rd	-	30	New	1,720				X	
ESD-48	Pipe	Rose St	Merritt St to Canal Dr	-	21	New	2,150				X	
ESD-50	Pipe	Olive Ave, Golden State Blvd	Thor St to southeast of Minerva St	-	36	New	3,490		X			
ESD-51	Pipe/Casing[1]	Golden State Blvd, 1st Street	Pipe & Casing under Train Tracks, east of Golden State Blvd	-	48/60	New	130		X			
ESD-52	Pipe	D St	1st St to 6th St	-	48	New	2,060		X			
ESD-53	Pipe	F St	8th St to Lander Ave	-	36	New	680	X				
ESD-54	Pipe	F St	Southwest of 8th St, Remove connection to sewer	33	-	Abandon	-					
ESD-55	Pipe	Lander Ave	D St to E St	42	60	Replace	950		X			
ESD-56	Pipe	Lander Ave	Linwood Ave to Glenwood Ave	42	-	Abandon	-					
ESD-57	Pipe	Linwood Ave	Lander Ave to West Linwood Ave Basin	-	72	New	6,690	X				
ESD-58	Pipe	Columbia St	Locust St to West Ave South	-	18	New	2,280		X			
ESD-59	Pipe	Castor St, Laurel St	Locust St to High St	-	15	New	830		X			
ESD-60	Pipe	High St	Laurel St to West Ave South	-	24	New	1,910		X			
ESD-61	Pipe	Vermont Ave	Orange St to West Ave South	-	24	New	1,540		X			
ESD-62	Pipe	Martinez St, Williams Ave	Parnell Ave to West Ave South	-	15	New	1,070		X			
ESD-63	Pipe	Orange St	South Ave to Montana Ave	-	24	New	1,980		X			
ESD-64	Pipe	Lewis St	Maple St to Orange St	-	15	New	600		X			
ESD-65	Pipe	Montana Ave	Orange St to west of Gabriel St	-	30	New	900		X			
ESD-66	Pipe/Casing[1]	Linwood Ave, under Highway 99	Boring under Highway 99, under Linwood Ave	-	72/84	New	240	X				

Table 6.3 **Proposed Improvements**
Sewer System Master Plan
City of Turlock

Figure No.	Type of Improvement	Description/ Street	Description / Limits	Project Length/Size and Cost: Ex. Size/ Diam. (in)	New Size/ Diam. (in)	Replace/ New	Length (ft)	Capital Improvement Phasing: Phase 1 2013-2015	Phase 2 2016-2020	Phase 3 2021-2025	Phase 4 2026-2030	Phase 5 After 2030
ESD-BN-2	Basin	Linwood Ave	West Linwood Ave Basin	-	123 ac-ft	New	-	X				
Buildout System Improvements												
Pipelines												
FSS-1A	Pipe	E. Linwood Ave.	Golf Rd. to east of 5th St.	--	18	New	780		X			
FSS-1B	Pipe	E. Linwood Ave.	S. Johnson Rd. to Golf Rd.	--	18	New	1,360			X		
FSS-2	Pipe	S. Johnson Rd.	Briar Rd. to E. Linwood Ave.	--	15	New	2,650			X		
FSS-3	Pipe	S. Johnson Rd.	South of East Ave. to Brier Rd.	--	10	New	1,320			X		
FSS-4	Pipe	E. Linwood Ave.	S. Quincy Rd. to S. Johnson Rd.	--	12	New	1,350			X		
FSS-5	Pipe	E. Linwood Ave.	East of S. Quincy Rd. to S. Quincy Rd.	--	10	New	1,300			X		
FSS-6	Pipe	Brier Rd.	S. Quincy Rd. to S. Johnson Rd.	--	12	New	1,340			X		
FSS-7	Pipe	Brier Rd.	S. Daubenberger Rd. to S. Quincy Rd.	--	10	New	1,330			X		
FSS-8	Pipe	Alley north of East Ave.	N. Berkeley Avenue to Bell St.	18	24	Replace	1,310				X	
FSS-9	Pipe	East Ave.	N. Quincy Rd. to N. Berkeley Ave.	--	18	New	2,800				X	
FSS-10	Pipe	East Ave.	West of N. Verduga Rd. to N. Quincy Rd.	--	15	New	2,680				X	
FSS-11	Pipe	West of N. Verduga Rd.	Canal Dr. to East Ave.	--	12	New	2,770				X	
FSS-12	Pipe	West of N. Verduga Rd.	South of Hawkey to Canal Dr.	--	10	New	1,270				X	
FSS-13	Pipe	E. Glenwood Ave.	5th St. to Golf Rd.	--	10	New	1,450		X			
FSS-14	Pipe	Golf Rd.	South of E. Glenwood Ave to E. Glenwood Ave.	--	10	New	1,340		X			
FSS-15	Pipe	W. Glenwood Ave.	West of Lander Avenue to east of S. Walnut Rd.	--	12	New	2,730		X			
FSS-16	Pipe	W. Glenwood Ave.	West of Lander Avenue to south of Linwood Ave.	--	10	New	1,980		X			
FSS-17	Pipe	S. Kilroy Rd.	W. Linwodd Ave. to Spengler Wy.	--	10	New	1,930			X		
FSS-18	Pipe	Tegner Rd.	North of W. Linowood Ave. to south of Humphrey Ct.	--	10	New	950			X		
FSS-19	Pipe	W. Linwood Ave.	S. Washington Rd. to east of S. Washington Rd.	--	15	New	2,890					X
FSS-20	Pipe	East of S. Washington Rd.	North of W. Linwood Ave. to W. Linwood Ave.	--	12	New	1,290					X
FSS-21	Pipe	East of S. Washington Rd.	Ruble Rd. to north of W. Linwood Ave.	--	10	New	1,350					X
FSS-22	Pipe	S. Washington Rd.	Clayton Rd. to W. Linwood Ave.	--	12	New	1,330					X
FSS-23	Pipe	S. Washington Rd.	Ruble Rd. to Clayton Rd.	--	10	New	1,320					X
FSS-24	Pipe	East of S. Washington Rd.	South of West Main St. to West Main St.	--	10	New	1,350				X	
FSS-25	Pipe	S. Washington Rd.	South of West Main St. to West Main St.	--	10	New	1,320				X	
FSS-26	Pipe	Clinton Rd.	North og West Main St. to West Main St.	--	15	New	1,430				X	
FSS-27	Pipe	Clinton Rd.	W. Canal Dr. to north of West Main St.	--	12	New	1,440				X	
FSS-28	Pipe	Christoffersen Pkwy./N. Waring Rd.	Redirect Denair flows to 24-inch sewer on Christoffersen	--	21	New	6,850			X		
FSS-29	Pipe	Golf Road	Glenwood Ave. to E. Linwood Ave.	--	15	New	1,440		X			
Lift Stations [(5)]												
LS-MR	Lift Station	Morgan Ranch	Assumed 2 pumps	--	1.2 mgd	Replace	-		X			

Table 6.3 Proposed Improvements
Sewer System Master Plan
City of Turlock

Figure No.	Type of Improvement	Description/ Street	Description / Limits	Project Length/Size and Cost: Ex. Size/ Diam. (in)	New Size/ Diam. (in)	Replace/ New	Length (ft)	Capital Improvement Phasing: Phase 1 2013-2015	Phase 2 2016-2020	Phase 3 2021-2025	Phase 4 2026-2030	Phase 5 After 2030
LS-4	Lift Station	Kilroy Road	Assumed 3 pumps	2.3 mgd	3.6 mgd	Replace	-				X	
LS-50	Lift Station	Tegner Road	Assumed 3 pumps	2.3 mgd	12.8 mgd	Replace	-		X			
	Force Main	N. Walnut Rd.	Extend existing 18-inch force main	--	18	Extend	1,910		X			
LS-57	Lift Station	Picadilly Lane	Assumed 2 pumps	4.6 mgd	6.0 mgd	Replace	-			X		
LS-63	Lift Station	Fulkerth/Tegner	Assumed 2 pumps	3.5 mgd	5.1 mgd	Replace	-				X	
LS-67	Lift Station	Humphrey Ct.	Assumed 2 pumps	0.6 mgd	1.4 mgd	Replace	-			X		
LS-GS	Lift Station	Golden State Blvd.	Assumed 3 pumps (current capacity unknown)	n/a	3.0 mgd	Replace	-				X	
LS-Main	Lift Station	Main St. Near Clinton Rd.	Assumed 3 pumps (current capacity unknown)	n/a	4.7 mgd	Replace	-			X		
LS-Ind	Lift Station	New Industrial Lift Station	Assumed 2 pumps	--	2.8 mgd	New	-					X
	Force Main	S. Washington Rd.	W. Linwood Ave. to W. Main St.	--	12	New	5,000					X
	Land Acquisition	Corner of S. Washington Rd. and W. Linwood Ave.	Land Acquisition assumed 0.25 acres	--	0.25 acres	New						X

Notes:
1. Proposed casings size and carrier pipe size.
2. These projects are the required storm drainage system projects to remove direct connections to the sewer system, and to eliminate storm drainage system capacity deficiencies. Costs are included in the Sewer CIP. These projects are listed in the Storm Drainage CIP, but costs are not included in the Storm Drainage CIP.
3. Lift station capacities refer to the total capacity unless noted otherwise.

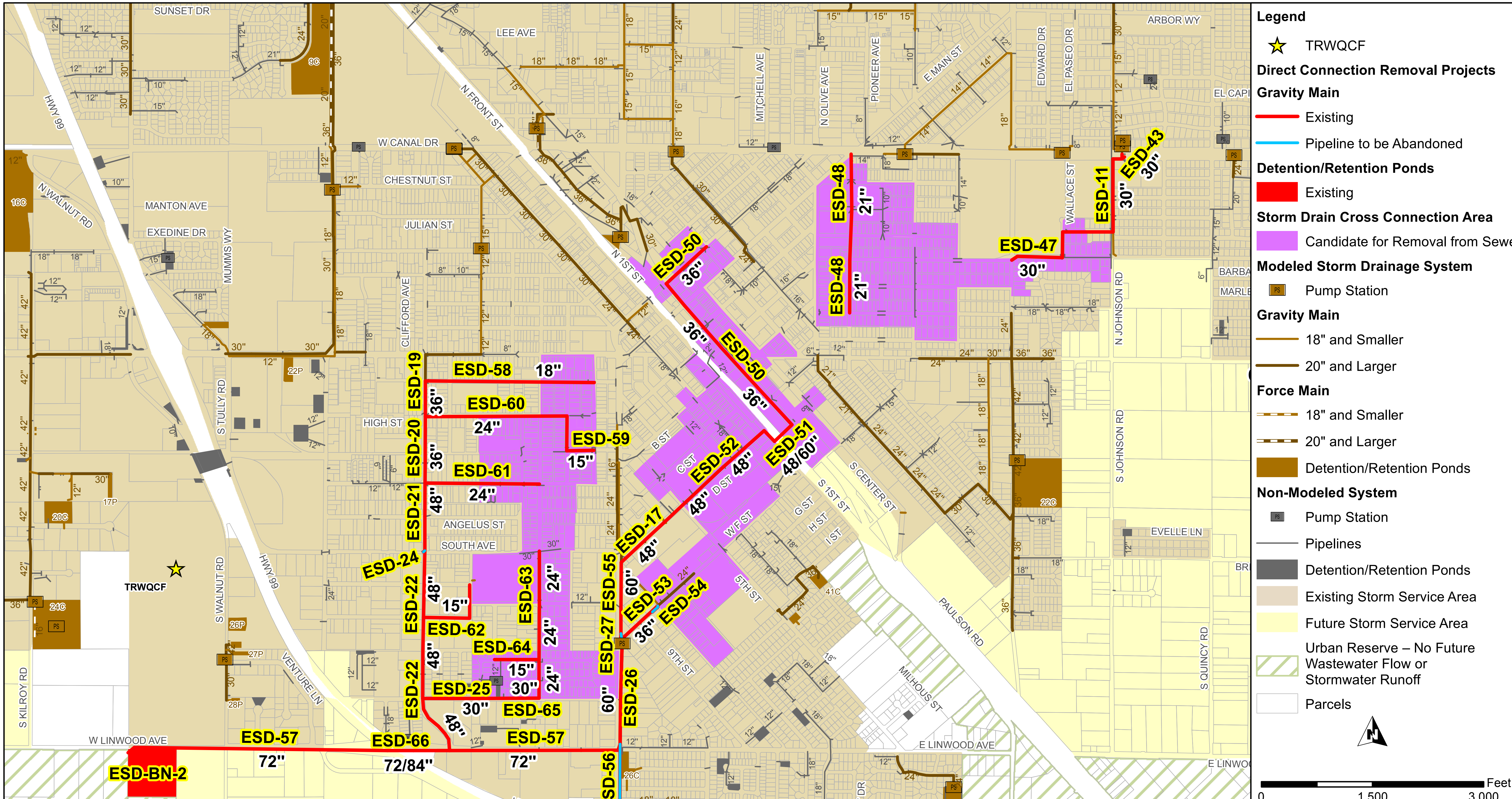


Figure 6.5
Storm Drain Improvements to Remove Connections to the Sewer System
Sewer System Master Plan
City of Turlock

An existing sewer or lift station may have sufficient capacity to convey current PWWFs, but as growth continues and more users are added to the system, the increased flow results in capacity deficiencies. These projects, as well as new trunk sewers to extend wastewater collection system service to future growth areas, are considered future improvements and allocated to future users. In some cases, a project is needed to correct an existing capacity deficiency but it is sized to accommodate additional flows from future development. In these cases, the hydraulic modeling results were used to determine the cost breakdown between existing and future users based on the ratio of existing and build out average dry weather flows. More information on the breakdown in cost split between existing and future users is provided in Chapter 7.

6.3.2 Existing System Improvements

When a capacity increase is required, existing sewers can be upgraded or a parallel relief sewer can be constructed. For the Master Plan, it was assumed that a capacity deficient sewer would be upgraded to a larger diameter sewer. The decision to replace or construct a parallel sewer should be made during the preliminary design phase. The upgraded pipeline generally followed the same slope as the existing pipeline, unless the available data revealed negative or flat slopes in an existing alignment.

During the preliminary design phase, the existing sewer should be inspected by closed circuit television (CCTV) to determine its structural condition. If severely deteriorated, the existing sewer should be upgraded. If moderately deteriorated, slip lining or cured-in-place pipe lining can rehabilitate the existing sewer.

The majority of improvements are storm drainage system improvement projects to remove storm drainage system connections from the sewer system. These projects have the highest priority. A detailed description of these projects, as well as the other recommended storm drainage system improvements is provided in the City's Stormwater Master Plan, and will not be repeated in this document.

In addition, a few relatively minor and lower priority sewer system pipeline improvements are recommended:

- **Improvement Project ESS-1:** Replace approximately 3,350 feet of existing 18-inch diameter sewer on West Main Street and North Soderquist Road with a new 21-inch sewer.
- **Improvement Projects ESS-2 and 3:** These projects consist of replacing 1,520 feet of 15-inch sewer with a new 18-inch sewer, and 320 feet of 12-inch sewer with a 15-inch sewer.

No lift station improvements are required to accommodate existing design flows.

6.3.3 Build-Out System Improvements

The following summarizes the recommended new trunk sewers that will serve future users, and replacement of existing sewers that would need to be replaced in order to accommodate build-out PWWFs. The locations of the new trunk sewers are conceptual and are likely to change during the design phase. The locations shown are possible alignments based on available information and are intended to assist in the development of probable construction costs. No investigation into the feasibility of these alignments has been conducted. However, an attempt was made to place new trunk sewer alignments within existing streets or other feasible pipeline alignments.

- **Improvement Projects FSS-1B to FSS-7:** This group of improvement projects forms the backbone collection system that will provide sewer service to the SE3 master plan area. The pipelines needed to serve this area include a network of 10-inch and 12-inch trunks, as well as a 15-inch diameter sewer on South Johnson Road, and an 18-inch diameter sewer on East Linwood Avenue from South Johnson Road. The 18-inch diameter sewer will connect to an existing 24-inch diameter trunk sewer on East Linwood Avenue.
- **Improvement Projects FSS-8 to FSS-12:** In order to provide sewer service to the SE2 master plan area, a new trunk sewer is required. The new trunk would begin as a 10-inch and 12-inch pipeline flowing south into a new 15-inch and 18-inch diameter trunk sewer that flows west on East Avenue. In addition, the hydraulic model analysis indicated that the existing 18-inch pipeline in the alley north of East Avenue from North Berkeley Avenue to Bell Street does not have sufficient capacity to convey the flows from the new master plan area, and should be replaced with a 24-inch trunk sewer.
- **Improvement Projects FSS-1A, FSS-13, FSS-14, FSS-29, and Morgan Ranch Lift Station:** In order to provide service to the SE1 master plan area, also known as Morgan Ranch, two new 10-inch trunk sewers will flow east and north to a new lift station located at the intersection of Golf Road and East Glenwood Avenue. The Morgan Ranch Lift Station will pump the flow from SE1 to a new 15-inch diameter sewer that will flow north to Linwood Avenue. At Linwood Avenue, the 15-inch sewer will flow into a short reach of 18-inch diameter sewer and will connect to the existing 24-inch diameter trunk on Linwood Avenue.
- **Improvement Projects FSS-15 and FSS-16:** This group of improvements would serve a small pocket of commercial and industrial land uses in the southern edge of the existing City limits, and would consist of a new 10-inch and 12-inch diameter trunk sewer that would connect to the existing collection system on West Linwood Avenue.
- **Improvement Projects FSS-17 through FSS-27, and Industrial Area Lift Stations:** The City’s West Industrial Specific Plan (WISP) provided guidance for the future infrastructure plans for the TRIP. The hydraulic model was used to confirm/refine the proposed pipeline sizing and lift station capacities as identified in the WISP.

- **Lift Station 63 and Golden State Lift Station:** It is recommended that the City upgrade Lift Station 63 and the Golden State Lift Station to convey build-out flows from the Town of Keyes, as well as new growth in the western edge of the City limits.
- **Improvement Project FSS-28 and Lift Station 57:** Several possible options were considered to most efficiently convey build-out wastewater flows from the Town of Denair through the City's collection system. The recommended approach is to construct a new 21-inch diameter sewer to route flows north to the existing 24-inch diameter trunk sewer on West Christoffersen Parkway. In addition, routing future Denair flows to this pipeline will require that Lift Station 57 be upgraded.

6.3.4 Project Prioritization

Most of the improvements listed in Table 6.3 are driven by future development, which consist of new sewers that serve future growth or improvements to existing facilities that are needed to serve future growth. When fully implemented, the capital projects will allow the conveyance of PWWFs to the TRWQCF during build-out conditions.

Prioritizing the required capital improvements for the City's sewer system is an important aspect of this study. The improvement projects were prioritized based on the following objectives:

- Implementing storm drainage system improvement projects to remove storm drain connections from the sanitary sewer system
- Upgrading existing facilities to mitigate current capacity deficiencies and to serve future users
- Building the new trunks necessary to serve future users

Storm drainage system projects and other improvements to existing facilities will provide sufficient capacity to mitigate existing issues and to convey increased flows resulting from future growth. Future development will require the construction of sewers to serve new users.

The projects were grouped into the following phases:

- Phase 1: Years 2013 through 2015
- Phase 2: Years 2016 through 2020
- Phase 3: Years 2021 through 2025
- Phase 4: Years 2026 through 2030
- Phase 5: After 2030

The projects were phased based on the best available information for how the City will develop moving forward. The actual implementation of the improvements serving future users ultimately depends on growth. The priorities presented below are estimates, and changes in the City's planning assumptions or growth projections could increase or decrease the priority of each improvement.

- **Phase 1 Projects (2013-2015)**. The highest priority projects to address capacity deficiencies in the sewer system are the main backbone features of the storm drainage system improvement projects need to remove storm drainage system connections to the sewer system. These include a new storm basin (ESD-BN-2) and other major storm drain pipelines to the basin (ESD-26, ESD-53, ESD-57, and ESD-66).

- **Phase 2 Projects (2016-2020)**. The second phase targets the majority of the remaining improvement projects to remove storm drain connections from the sewer system. These include:
  - ESD-17
  - ESD-19 to ESD-22
  - ESD-24 and ESD-25
  - ESD-50 to ESD-52
  - ESD-55
  - ESD-58 to ESD-65

  Phase 2 also targets additional growth related improvements, which could potentially be required in the relatively near term. These projects include:
  - FSS-1A, FSS-13 to FSS-16, and FSS-29
  - Morgan Ranch Lift Station, Lift Station 50

  A project to upgrade Lift Station 50 is targeted for Phase 2. Significant growth is expected in the Turlock Regional Industrial Park, and this lift station will convey a significant portion of that projected growth. This project also includes an extension of the existing 18-inch force main. The purpose of extending the force main is to discharge flows from this lift station into a larger interceptor located closer to the plant. The hydraulic model showed that if the existing force main discharge point remained for build-out conditions, flows upstream of the interceptor would back up above allowable levels. Routing the force main further downstream eliminates the simulated surcharging.

- **Phase 3, 4, and 5 Projects (2021-2025, 2026-2030, and after 2030)**. Project ESS-1 through ESS-3 are recommended in order to address relatively minor capacity deficiencies in the existing sewer collection system. These projects are targeted for Phase 3. In addition, the remaining storm drainage system projects that remove storm drain connections to the sewer (ESD-11, ESD-43, ESD-47, and ESD-48) are targeted for Phase 4.

Phase 3 through 5 growth projects are longer-term projects driven by development at the outer edges of the planning area, and will be grouped together. The Phase 3 through 5 growth projects include the following:

– FSS-1B to FSS-7
– FSS-8 to FSS-12
– FSS-17 to FSS-18
– FSS-19 to FSS-23
– FSS-24 to FSS-27
– FSS-28

A number of lift stations upgrades are targeted for long-term implementation, including Lift Station 4, Lift Station 57, Lift Station 63, Lift Station 67, the Golden State Lift Station, Main Lift Station, as well as the new Industrial Lift Station and force main.

CAPITAL IMPROVEMENT PLAN

This section presents the recommended capacity related capital improvement plan (CIP) for the City of Turlock (City) sewer collection system and a summary of the capital costs.

7.1 CAPITAL IMPROVEMENT PROJECT COSTS

The capacity upgrades set the foundation for the City's sewer system CIP. The cost estimates presented in this study are opinions developed from bid tabulations, cost curves, and information obtained from previous studies. The costs are based on an Engineering News Record Construction Cost Index (ENR CCI) of 10,386 (San Francisco, March 2013), with a base year of 1913. The City has indicated that they use a less commonly used version of the ENR CCI index, in which the index was reset to 100 in the year 1967. Based on a review of available documentation from ENR, it was determined that an ENR CCI of 10,386 for San Francisco with a base year of 1913 would be equivalent to an ENR CCI of 821 for San Francisco with a base year of 1967. The following summarizes the cost basis for this Master Plan:

ENR CCI_{1913} = 10,386 (San Francisco, March 2013)

ENR CCI_{1967} = 821 (San Francisco, March 2013)

The cost estimates presented in the CIP have been prepared for general master planning purposes and for guidance in project evaluation and implementation. Final costs of a project will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other variable factors such as preliminary alignment generation, investigation of alternative routings, and detailed utility and topography surveys.

The Association for the Advancement of Cost Engineering (AACE) defines an Order of Magnitude Estimate, deemed appropriate for master plan studies, as an approximate estimate made without detailed engineering data. It is normally expected that an estimate of this type would be accurate within plus 50 percent to minus 30 percent. This section presents the assumptions used in developing order of magnitude cost estimates for recommended facilities.

7.2 CONSTRUCTION UNIT COSTS

The construction costs are representative of sewer system facilities under normal construction conditions and schedules. Costs have been estimated for public works construction.

7.2.1 Gravity Sewer Unit Costs

Sewer pipeline improvements range in size from 10 inches to 24 inches in diameter in this study. Pipe casings are included for major crossings (e.g., creeks, canals, highways, and railroad) of the trunk sewers. Unit costs for the construction of pipelines and appurtenances (i.e., manholes) are shown in Table 7.1.

The construction cost estimates are based upon these unit costs. The unit costs are for "typical" field conditions with construction in stable soil at a depth ranging between 10 feet to 15 feet. Construction of pipelines in undeveloped areas is anticipated to cost less than those constructed in developed areas, such as downtown. The unit costs in Table 7.1 are discounted by 30 percent for pipelines that will be built in undeveloped areas. This discount is based on a review of bid tabulations that were constructed in developed and undeveloped areas. Pipelines built in undeveloped areas ranged from 30 to 50 percent less than pipelines built in developed areas.

Table 7.1 Gravity Sewer Unit Costs
Sewer System Master Plan
City of Turlock

	Pipeline Unit Costs(1) ($/LF)	
Diameter (inches)	Schedule A (Developed Area)	Schedule B(2) (Undeveloped Area)
8	103	72
10	129	90
12	154	108
15	193	135
18	210	147
21	245	172
24	281	196
27	316	221
30	351	245
33	386	270
36	421	295
39	456	319
42	491	344

Notes:
(1) Costs are based on the Engineering News Record Construction Cost Index of 821 (1967 base year, San Francisco, March 2013).
(2) Schedule B Unit Cost = 70 percent of Schedule A Unit Cost

7.2.2 Lift Station Unit Costs

Lift station improvements include increasing the firm capacity (defined as the largest pump out of service) to convey design flows. The lift station cost versus capacity curve shown in Figure 7.1 was developed based on projects of similar size in California. Costs were generated by inputting the appropriate total capacity and calculating the corresponding costs.

7.3 PROJECT COSTS AND CONTINGENCIES

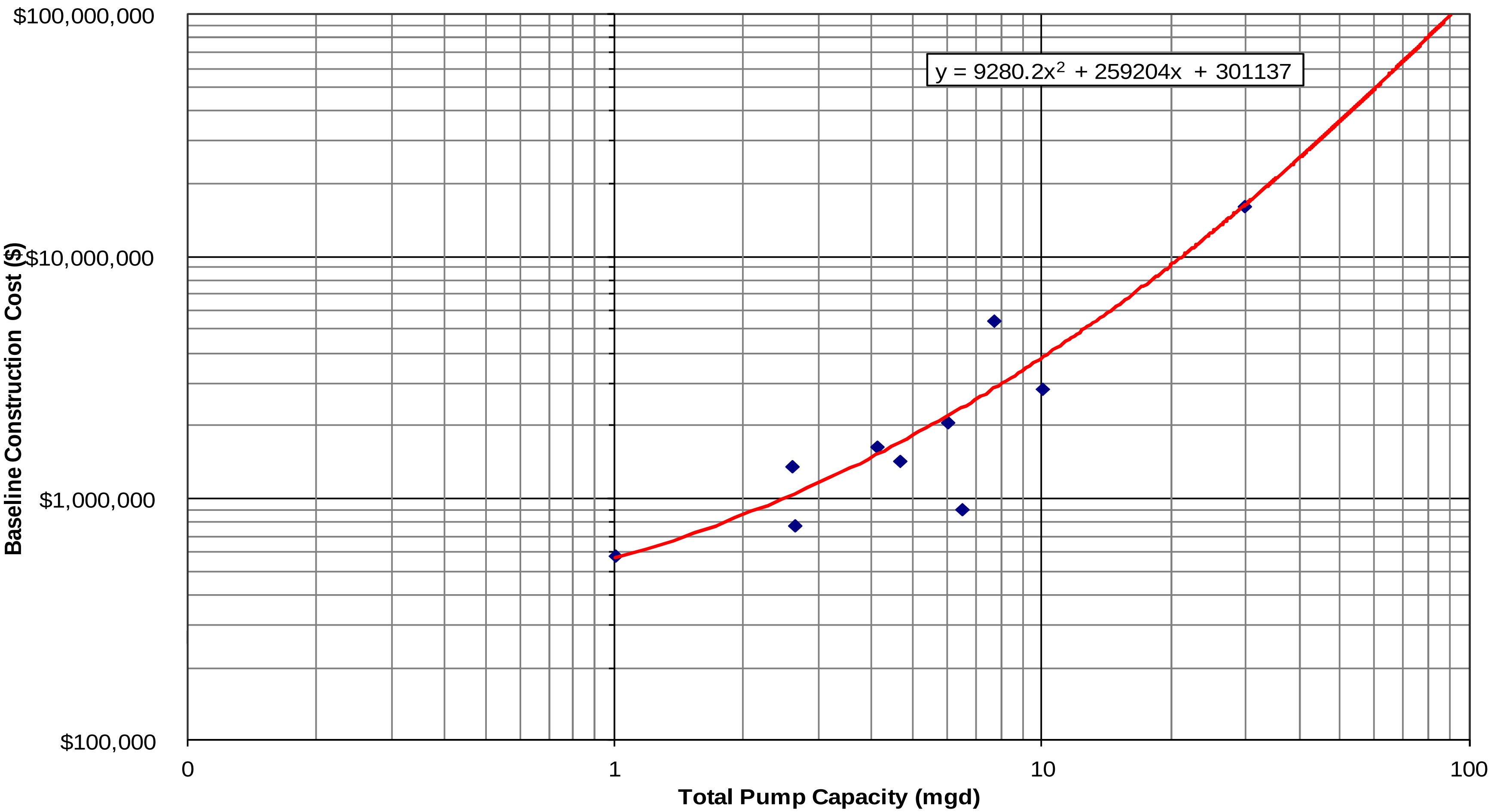
Baseline construction costs are the total estimated construction costs, in dollars, of the proposed improvements. Pipeline baseline construction costs were calculated by multiplying the estimated length by the unit cost. Lift and pump station baseline construction costs were calculated based on the required pump capacity in the pump capacity curve.

Contingency costs are applied to the baseline construction costs to account for unexpected construction conditions, the need for unforeseen mechanical items, and variations in final quantities, and other project considerations. A 25 percent contingency was applied to account for unknown site conditions such as poor soils, unforeseen conditions, environmental mitigations, and other unknowns and is typical for master planning projects. An additional 30 percent project construction contingency cost was added to account for project engineering, construction phase professional services, and project administration.

Example:

Baseline Construction Cost	**$1,000,000**
Construction Contingency (25%)	$250,000
Estimated Construction Cost	**$1,250,000**
Engineering Cost +	
Construction Management +	
Project Administration (30%)	$375,000
Capital Improvement Cost	**$1,625,000**

The proposed sanitary sewer system CIP is presented in Table 7.2. This table shows the recommended project phasing. The implementation timeframe was based on the priority of each project to correct existing deficiencies or to serve future users.



ENR CCI_{1967} = 821 (San Francisco, March 2013)
ENR CCI_{1913} = 10,368 (San Francisco, March 2013)

Figure 7.1
Lift Station Cost vs. Capacity Curve
Sewer System Master Plan
City of Turlock

Table 7.2 Capital Improvement Plan
Sewer System Master Plan
City of Turlock

Figure No.	Type of Improvement	Description/ Street	Description / Limits	Pipeline Cost Schedule (A or B)	Project Length/Size and Cost: Ex. Size/ Diam. (in)	New Size/ Diam. (in)	Replace/ New	Length (ft)	Capital Improvement Cost[(2),(3)] ($)	Capital Improvement Phasing: Phase 1 2013-2015 ($)	Phase 2 2016-2020 ($)	Phase 3 2021-2025 ($)	Phase 4 2026-2030 ($)	Phase 5 After 2030 ($)	Future Users Benefit (%)	Cost Allocation Category: Existing Improvements ($)	Future Improvements ($)
Existing System Improvements																	
Pipelines																	
ESS-1	Pipe	W. Main St./N. Soderquist Rd.	Julian St. to S. Tully Rd.	A	18	21	Replace	3,350	$ 1,336,000				$ 1,336,000		5%	$ 1,274,575	$ 61,425
ESS-2	Pipe	Wayside Dr.	N. Denair Ave, to Geer Rd.	A	15	18	Replace	1,520	$ 520,000				$ 520,000		2%	$ 508,444	$ 11,556
ESS-3	Pipe	Colorado Ave.	North of Escandido Ave. to south of Escondido Ave.	A	12	15	Replace	320	$ 101,000				$ 101,000		0%	$ 101,000	$ -
Projects to Remove Direct Connections to Sewer System[(4)]																	
ESD-11	Pipe	Johnson Rd	Marshall St to Canal Dr	A	8/12/15	30	Replace	1,120	$ 574,000				$ 574,000		30%	$ 400,400	$ 171,600
ESD-17	Pipe	D St	6th to Lander Ave	A	10/18	48	Replace	780	$ 640,000		$ 640,000				45%	$ 350,350	$ 286,650
ESD-19	Pipe	West South Ave	Columbia St to High St	A	12	36	Replace	490	$ 302,000		$ 302,000				20%	$ 240,800	$ 60,200
ESD-20	Pipe	West South Ave	High St to Vermont Ave	A	12	36	Replace	900	$ 554,000		$ 554,000				20%	$ 440,800	$ 110,200
ESD-21	Pipe	West South Ave	Vermont Ave to South Ave	A	12	48	Replace	910	$ 746,000		$ 746,000				20%	$ 594,400	$ 148,600
ESD-22	Pipe	West Ave South	South Ave to Linwood Ave	A	-	48	New	2,820	$ 2,314,000		$ 2,314,000				25%	$ 1,727,250	$ 575,750
ESD-24	Pipe	South Ave	Corner of West Ave South, remove outfall to existing infrastructure	A	15	-	Abandon	-	$ -						-	$ -	$ -
ESD-25	Pipe	Montana Ave	Gabriel St to West Ave South	A	-	30	New	670	$ 343,000		$ 343,000				45%	$ 187,550	$ 153,450
ESD-26	Pipe	Lander Ave	E St to Linwood Ave, Adjust inverts to match prposed Linwood trunkline	A	-	60	Replace	1,580	$ 1,620,000	$ 1,620,000					30%	$ 1,129,800	$ 484,200
ESD-27	Pipe	Lander Ave	At F St, influent pipe to Pump Station No. 2 Wet Well	A	42	-	Abandon	-	$ -						-	$ -	$ -
ESD-43	Pipe	Canal Drive	Johnson Rd and Canal Dr, provides connection to canal trunkline	A	-	30	New	50	$ 26,000				$ 26,000		20%	$ 20,800	$ 5,200
ESD-47	Pipe	Marshall St	Berkeley Ave to Johnson Rd	A	-	30	New	1,720	$ 882,000				$ 882,000		50%	$ 439,000	$ 439,000
ESD-48	Pipe	Rose St	Merritt St to Canal Dr	A	-	21	New	2,150	$ 772,000				$ 772,000		50%	$ 384,500	$ 384,500
ESD-50	Pipe	Olive Ave, Golden State Blvd	Thor St to southeast of Minerva St	A	-	36	New	3,490	$ 2,148,000		$ 2,148,000				50%	$ 1,069,500	$ 1,069,500
ESD-51	Pipe/Casing[(1)]	Golden State Blvd, 1st Street	Pipe & Casing under Train Tracks, east of Golden State Blvd	A	-	48/60	New	130	$ 414,000		$ 414,000				50%	$ 206,500	$ 206,500
ESD-52	Pipe	D St	1st St to 6th St	A	-	48	New	2,060	$ 1,690,000		$ 1,690,000				50%	$ 841,000	$ 841,000
ESD-53	Pipe	F St	8th St to Lander Ave	A	-	36	New	680	$ 419,000	$ 419,000					50%	$ 208,000	$ 208,000
ESD-54	Pipe	F St	Southwest of 8th St, Remove connection to sewer	A	33	-	Abandon	-	$ -						-	$ -	$ -
ESD-55	Pipe	Lander Ave	D St to E St	A	42	60	Replace	950	$ 975,000		$ 975,000				30%	$ 679,000	$ 291,000
ESD-56	Pipe	Lander Ave	Linwood Ave to Glenwood Ave	A	42	-	Abandon	-	$ -						-	$ -	$ -
ESD-57	Pipe	Linwood Ave	Lander Ave to West Linwood Ave Basin	A	-	72	New	6,690	$ 8,234,000	$ 8,234,000					30%	$ 5,737,900	$ 2,459,100
ESD-58	Pipe	Columbia St	Locust St to West Ave South	A	-	18	New	2,280	$ 702,000		$ 702,000				50%	$ 349,500	$ 349,500
ESD-59	Pipe	Castor St, Laurel St	Locust St to High St	A	-	15	New	830	$ 234,000		$ 234,000				50%	$ 116,000	$ 116,000
ESD-60	Pipe	High St	Laurel St to West Ave South	A	-	24	New	1,910	$ 783,000		$ 783,000				50%	$ 390,000	$ 390,000
ESD-61	Pipe	Vermont Ave	Orange St to West Ave South	A	-	24	New	1,540	$ 632,000		$ 632,000				50%	$ 314,500	$ 314,500
ESD-62	Pipe	Martinez St, Williams Ave	Parnell Ave to West Ave South	A	-	15	New	1,070	$ 302,000		$ 302,000				50%	$ 150,500	$ 150,500
ESD-63	Pipe	Orange St	South Ave to Montana Ave	A	-	24	New	1,980	$ 813,000		$ 813,000				50%	$ 404,500	$ 404,500
ESD-64	Pipe	Lewis St	Maple St to Orange St	A	-	15	New	600	$ 169,000		$ 169,000				50%	$ 84,500	$ 84,500
ESD-65	Pipe	Montana Ave	Orange St to west of Gabriel St	A	-	30	New	900	$ 462,000		$ 462,000				50%	$ 230,000	$ 230,000
ESD-66	Pipe/Casing[(1)]	Linwood Ave, under Highway 99	Boring under Highway 99, under Linwood Ave	A	-	72/84	New	240	$ 765,000	$ 765,000					30%	$ 533,400	$ 228,600
ESD-BN-2	Basin	Linwood Ave	West Linwood Ave Basin	-	-	123 ac-ft	New	-	$ 2,620,000	$ 2,620,000					65%	$ 917,000	$ 1,703,000
						Existing Improvements Subtotal			**$ 32,092,000**	**$ 13,658,000**	**$ 14,223,000**	**$ -**	**$ 4,211,000**	**$ -**		**$ 20,031,469**	**$ 11,938,531**
Buildout System Improvements																	
Pipelines																	
FSS-1A	Pipe	E. Linwood Ave.	Golf Rd. to east of 5th St.	B	--	18	New	780	$ 187,000		$ 187,000				100%	$ -	$ 187,000
FSS-1B	Pipe	E. Linwood Ave.	S. Johnson Rd. to Golf Rd.	B	--	18	New	1,360	$ 325,000			$ 325,000			100%	$ -	$ 325,000
FSS-2	Pipe	S. Johnson Rd.	Briar Rd. to E. Linwood Ave.	B	--	15	New	2,650	$ 582,000			$ 582,000			100%	$ -	$ 582,000
FSS-3	Pipe	S. Johnson Rd.	South of East Ave. to Brier Rd.	B	--	10	New	1,320	$ 193,000			$ 193,000			100%	$ -	$ 193,000
FSS-4	Pipe	E. Linwood Ave.	S. Quincy Rd. to S. Johnson Rd.	B	--	12	New	1,350	$ 237,000			$ 237,000			100%	$ -	$ 237,000
FSS-5	Pipe	E. Linwood Ave.	East of S. Quincy Rd. to S. Quincy Rd.	B	--	10	New	1,300	$ 190,000			$ 190,000			100%	$ -	$ 190,000
FSS-6	Pipe	Brier Rd.	S. Quincy Rd. to S. Johnson Rd.	B	--	12	New	1,340	$ 236,000			$ 236,000			100%	$ -	$ 236,000
FSS-7	Pipe	Brier Rd.	S. Daubenberger Rd. to S. Quincy Rd.	B	--	10	New	1,330	$ 195,000			$ 195,000			100%	$ -	$ 195,000
FSS-8	Pipe	Alley north of East Ave.	N. Berkeley Avenue to Bell St.	A	18	24	Replace	1,310	$ 596,000				$ 596,000		100%	$ -	$ 596,000
FSS-9	Pipe	East Ave.	N. Quincy Rd. to N. Berkeley Ave.	B	--	18	New	2,800	$ 670,000				$ 670,000		100%	$ -	$ 670,000

Table 7.2 Capital Improvement Plan
Sewer System Master Plan
City of Turlock

Figure No.	Type of Improvement	Description/ Street	Description / Limits	Pipeline Cost Schedule (A or B)	Project Length/Size and Cost: Ex. Size/ Diam. (in)	New Size/ Diam. (in)	Replace/ New	Length (ft)	Capital Improvement Cost(2),(3) ($)	Capital Improvement Phasing: Phase 1 2013-2015 ($)	Phase 2 2016-2020 ($)	Phase 3 2021-2025 ($)	Phase 4 2026-2030 ($)	Phase 5 After 2030 ($)	Future Users Benefit (%)	Cost Allocation Category: Existing Improvements ($)	Future Improvements ($)
FSS-10	Pipe	East Ave.	West of N. Verduga Rd. to N. Quincy Rd.	B	--	15	New	2,680	$ 588,000				$ 588,000		100%	$ -	$ 588,000
FSS-11	Pipe	West of N. Verduga Rd.	Canal Dr. to East Ave.	B	--	12	New	2,770	$ 486,000				$ 486,000		100%	$ -	$ 486,000
FSS-12	Pipe	West of N. Verduga Rd.	South of Hawkey to Canal Dr.	B	--	10	New	1,270	$ 185,000				$ 185,000		100%	$ -	$ 185,000
FSS-13	Pipe	E. Glenwood Ave.	5th St. to Golf Rd.	B	--	10	New	1,450	$ 213,000		$ 213,000				100%	$ -	$ 213,000
FSS-14	Pipe	Golf Rd.	South of E. Glenwood Ave to E. Glenwood Ave.	B	--	10	New	1,340	$ 197,000		$ 197,000				100%	$ -	$ 197,000
FSS-15	Pipe	W. Glenwood Ave.	West of Lander Avenue to east of S. Walnut Rd.	A	--	12	New	2,730	$ 684,000		$ 684,000				100%	$ -	$ 684,000
FSS-16	Pipe	W. Glenwood Ave.	West of Lander Avenue to south of Linwood Ave.	B	--	10	New	1,980	$ 289,000		$ 289,000				100%	$ -	$ 289,000
FSS-17	Pipe	S. Kilroy Rd.	W. Linwodd Ave. to Spengler Wy.	B	--	10	New	1,930	$ 283,000			$ 283,000			100%	$ -	$ 283,000
FSS-18	Pipe	Tegner Rd.	North of W. Linowood Ave. to south of Humphrey Ct.	B	--	10	New	950	$ 140,000			$ 140,000			100%	$ -	$ 140,000
FSS-19	Pipe	W. Linwood Ave.	S. Washington Rd. to east of S. Washington Rd.	B	--	15	New	2,890	$ 634,000					$ 634,000	100%	$ -	$ 634,000
FSS-20	Pipe	East of S. Washington Rd.	North of W. Linwood Ave. to W. Linwood Ave.	B	--	12	New	1,290	$ 226,000					$ 226,000	100%	$ -	$ 226,000
FSS-21	Pipe	East of S. Washington Rd.	Ruble Rd. to north of W. Linwood Ave.	B	--	10	New	1,350	$ 198,000					$ 198,000	100%	$ -	$ 198,000
FSS-22	Pipe	S. Washington Rd.	Clayton Rd. to W. Linwood Ave.	B	--	12	New	1,330	$ 234,000					$ 234,000	100%	$ -	$ 234,000
FSS-23	Pipe	S. Washington Rd.	Ruble Rd. to Clayton Rd.	B	--	10	New	1,320	$ 193,000					$ 193,000	100%	$ -	$ 193,000
FSS-24	Pipe	East of S. Washington Rd.	South of West Main St. to West Main St.	B	--	10	New	1,350	$ 198,000				$ 198,000		100%	$ -	$ 198,000
FSS-25	Pipe	S. Washington Rd.	South of West Main St. to West Main St.	B	--	10	New	1,320	$ 193,000				$ 193,000		100%	$ -	$ 193,000
FSS-26	Pipe	Clinton Rd.	North og West Main St. to West Main St.	B	--	15	New	1,430	$ 314,000				$ 314,000		100%	$ -	$ 314,000
FSS-27	Pipe	Clinton Rd.	W. Canal Dr. to north of West Main St.	B	--	12	New	1,440	$ 254,000				$ 254,000		100%	$ -	$ 254,000
FSS-28	Pipe	Christoffersen Pkwy./N. Waring Rd.	Redirect Denair flows to 24-inch sewer on Christoffersen	B	--	21	New	6,850	$ 1,913,000		$ 1,913,000				100%	$ -	$ 1,913,000
FSS-29	Pipe	Golf Road	Glenwood Ave. to E. Linwood Ave.	B	--	15	New	1,440	$ 315,000			$ 315,000			100%	$ -	$ 315,000
Lift Stations (5)																	
LS-MR	Lift Station	Morgan Ranch	Assumed 2 pumps	A	--	1.2 mgd	New	-	$ 1,017,000		$ 1,017,000				100%	$ -	$ 1,017,000
LS-4	Lift Station	Kilroy Road	Assumed 3 pumps	A	2.3 mgd	3.6 mgd	Replace	-	$ 2,202,000				$ 2,202,000		100%	$ -	$ 2,202,000
LS-50	Lift Station	Tegner Road	Assumed 3 pumps	A	2.3 mgd	12.8 mgd	Replace	-	$ 8,351,000		$ 8,351,000				100%	$ -	$ 8,351,000
	Force Main	N. Walnut Rd.	Extend existing 18-inch force main	A	--	18	Extend	1,910	$ 621,000		$ 621,000				100%	$ -	$ 621,000
LS-57	Lift Station	Picadilly Lane	Assumed 2 pumps	A	4.6 mgd	6.0 mgd	Replace	-	$ 3,559,000			$ 3,559,000			100%	$ -	$ 3,559,000
LS-63	Lift Station	Fulkerth/Tegner	Assumed 2 pumps	A	3.5 mgd	5.1 mgd	Replace	-	$ 3,029,000				$ 3,029,000		100%	$ -	$ 3,029,000
LS-67	Lift Station	Humphrey Ct.	Assumed 2 pumps	A	0.6 mgd	1.4 mgd	Replace	-	$ 1,103,000			$ 1,103,000			100%	$ -	$ 1,103,000
LS-GS	Lift Station	Golden State Blvd.	Assumed 3 pumps (current capacity unknown)	A	n/a	3.0 mgd	Replace	-	$ 1,869,000				$ 1,869,000		100%	$ -	$ 1,869,000
LS-Main	Lift Station	Main St. Near Clinton Rd.	Assumed 3 pumps (current capacity unknown)	A	n/a	4.7 mgd	Replace	-	$ 2,802,000			$ 2,802,000			100%	$ -	$ 2,802,000
LS-Ind	Lift Station	New Industrial Lift Station	Assumed 2 pumps	B	--	2.8 mgd	New	-	$ 1,788,000					$ 1,788,000	100%	$ -	$ 1,788,000
	Force Main	S. Washington Rd.	W. Linwood Ave. to W. Main St.	B	--	12	New	5,000	$ 1,191,000					$ 1,191,000	100%	$ -	$ 1,191,000
	Land Acquisition	Corner of S. Washington Rd. and W. Linwood Ave.	Land Acquisition assumed 0.25 acres	B	--	0.25 acres	New		$ 24,000					$ 24,000	100%	$ -	$ 24,000
							Buildout Improvements Subtotal		**$ 38,704,000**	**$ -**	**$ 13,472,000**	**$ 10,160,000**	**$ 10,584,000**	**$ 4,488,000**		**$ -**	**$ 38,704,000**
Capital Improvement Plan Total																	
							CIP Total (Existing and Buildout)		**$ 70,796,000**	**$ 13,658,000**	**$ 27,695,000**	**$ 10,160,000**	**$ 14,795,000**	**$ 4,488,000**		**$ 20,031,469**	**$ 50,642,531**

Notes:
1. Proposed casings size and carrier pipe size.
2. Baseline Construction Cost plus 25% to account for unforeseen events and unknown conditions.
3. Estimated Construction Cost plus 30% to cover other costs including Engineering, Construction Management, and Project Administration.
4. These projects are the required storm drainage system projects to remove direct connections to the sewer system, and to eliminate storm drainage system capacity deficiencies. Costs are included in the Sewer CIP. These projects are listed in the Storm Drainage CIP, but costs are not included in the Storm Drainage CIP.
5. Lift station capacities refer to the total capacity unless noted otherwise.
6. Costs are based on the Engineering News Record Construction Cost Index of 821 (1967 base year, San Francisco, March 2013).

7.3.1 Capital Improvement Project Implementation

The Capital Improvement Projects (CIPs) are prioritized based on their urgency to mitigate existing deficiencies and for servicing anticipated growth. It is recommended that improvements to mitigate existing deficiencies be assigned the highest priority. Expansion of the system to accommodate growth should be implemented as the City grows.

The implementation phases are in 5-year increments, except for the first phase, which runs from 2013 through 2015. Each project is itemized by phase in Table 7.2 and a summary by phase is provided in Table 7.3. The total capital cost of the City's CIP for the sanitary sewer improvements is $70.8 million.

Table 7.3 Capital Cost Summary
Sewer System Master Plan
City of Turlock

	Project Phasing					
User Type	**Phase 1 2013-15 ($, mill.)**	**Phase 2 2016-20 ($, mill.)**	**Phase 3 2021-25 ($, mill.)**	**Phase 4 2026-30 ($, mill.)**	**Phase 5 Post 2030 ($, mill.)**	**Total ($, mill.)**
Sewer System(2)						
Exiting Users	8.6	8.4	0.0	3.1	0.0	20.1
Future Users	5.1	19.6	9.8	11.7	4.5	50.7
Total	**13.7**	**28.0**	**9.8**	**14.8**	**4.5**	**70.8**

Notes:
(1) Costs are based on the Engineering News Record Construction Cost Index of 821 (1967 base year, San Francisco, March 2013).
(2) Sewer system costs include storm drainage project to remove storm drain cross connections from the sewer system.

Table 7.4 summarizes the total estimated capital costs by facility type. Pipelines account for $40.6 million of the $71.3 million CIP (57 percent) of the total CIP. Lift/Pump Stations account for $27.6 million (39 percent). The remaining $2.6 million (4 percent) is associated with the new storm basin to remove storm drainage system connections to the sanitary sewer system.

Table 7.4	**Capital Cost Summary by Facility Type Sewer System Master Plan City of Turlock**
Facility Type	**Capital Cost[1],[2] ($, mill.)**
Pipelines	40.6
Lift/Pump Stations[3]	27.6
Basins[2]	2.6
Total	**70.8**

Notes:
(1) Costs are based on the Engineering News Record Construction Cost Index of 821 (1967 base year, San Francisco, March 2013).
(2) Sewer system costs include storm drainage project to remove storm drain cross connections from the sewer system.
(3) Lift/pump station costs include associated force main costs.

7.3.2 Cost Allocation between Existing and Future Users

The improvements either benefit existing users or are required for new development and future users. Some of the projects provide benefit to both existing and future users. An opinion of benefit to future users, based on preliminary project information, is included in Table 7.2. A summary of the existing and future user cost share for the proposed projects by phase is summarized in last column of Table 7.5. As shown in Table 7.5, existing users account for roughly $20.1 million (28 percent) of the total CIP, and future users account for the remaining $50.7 million (72 percent).

Table 7.5	**Capital Cost Summary by User Type Sewer System Master Plan City of Turlock**
User Type	**Capital Cost[1],[2] ($, mill.)**
Existing Users	20.1
Future Users	50.7
Total	**70.8**

Notes:
(1) Costs are based on the Engineering News Record Construction Cost Index of 821 (1967 base year, San Francisco, March 2013).
(2) Sewer system costs include storm drainage project to remove storm drain cross connections from the sewer system.

APPENDIX A – DESCRIPTION OF DIFFERENT LAND USES (GENERAL PLAN EXCERPTS)

2 Land Use and Economic Development

The way in which a City allocates its land to meet the needs of residents and businesses is central to the General Plan. In order to accommodate a growing, changing population and increasingly diversifying employment, Turlock must meet the needs of these groups and uses while still maintaining the aspects of the built environment that current citizens value: a compact city with a small-town feel.

Chapter 2, the Land Use and Economic Development Element, begins by describing the City's existing land use pattern, and then describes land use classifications and the City's development potential. Policies and a land use plan, referred to as the General Plan Land Use Diagram, designate the proposed general location and extent of each use category. The Element also includes policies to manage growth and inter-jurisdictional relationships. The following chapter, Chapter 3: New Growth Areas and Infrastructure, focuses on detailed standards for land use, design, infrastructure, and development phasing in the areas for new urban development. Issues related to city form, design, and character are addressed in Chapter 6: City Design.

The General Plan Land Use Diagram and the land use policies will have a major impact on Turlock's form and character over the life of the General Plan. Critical issues faced by Turlock that are addressed in this Element include: direction of urban expansion and phasing of growth, location of retail and neighborhood centers, revitalization of downtown, and location of proposed parks and recreational facilities. The General Plan Land Use Diagram is a graphic representation of the planning values and ideals of the community as expressed throughout the Plan. General Plan text should be read in conjunction with the Land Use Diagram.

Land use decisions affect residents and business interests alike.

2.1 CURRENT LAND USE PATTERN

Overview

Turlock's current land use pattern and built form are products of the City's historical growth within an agricultural area. Turlock was incorporated in 1908. Like many San Joaquin Valley towns from the time period, the original downtown core was focused around the railroad station, with streets arranged in a grid oriented to the tracks. The town proceeded to grow outward, shifting to an orthogonal north-south grid matching the rural road and parcel pattern around it. Golden State Boulevard, paralleling the railroad, was part of the original highway through the Central Valley, which became U.S. 99 roadway in 1926.

The city's growth since the 1940s has mainly occurred north of the downtown area and east of the railroad. When the California State University, Stanislaus campus opened in 1965, it was still well to the north of town. By the end of the 1980s housing boom, Turlock had reached Zeering Road on the north and Daubenberger Road on the east. Completion in 1973 of the Route 99 freeway bypass, a long arc to the west, also drew development west of the railroad.

Beginning in the 1990s, Turlock's growth occurred through a master planning process, one area at a time. Almost all the recent residential development has occurred north of Monte Vista Avenue on the east side of the railroad. The "Northwest Triangle," north of Fulkerth Road between the railroad and Highway 99, has also grown to be a major new commercial area.

It is the City's goal to continue to provide a balance of jobs and housing in Turlock, which stimulates the local economy, reduces commuting, and maintains Turlock's competitiveness in the region. Therefore, the master planning process has extended to the non-residential sector, as well. In 2006, Turlock completed the Westside Industrial Specific Plan (WISP), which identified land use, transportation improvements, infrastructure improvements, and design guidelines for industrial and business park uses for some 2,500 acres west of Route 99. Aided by this specific plan, the city's industrial sector is expanding and shifting to this area.

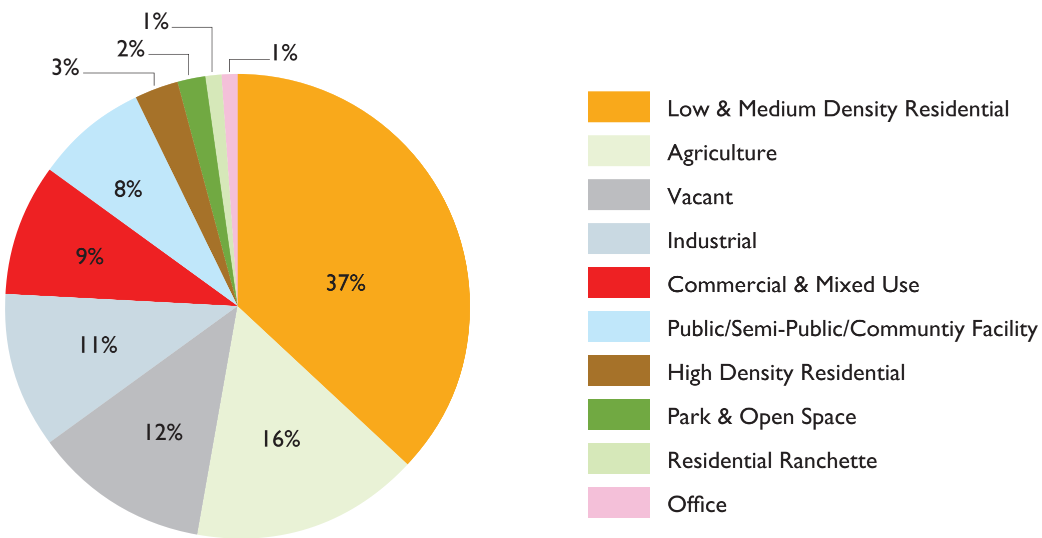
LAND USE DISTRIBUTION AND MAGNITUDE

There are approximately 8,730 acres in the current city limits (not including the County islands), and an additional 8,560 acres of land are contained within the Study Area outside of city limits. Figure 2-1 and Table 2-1 show the breakdown of existing land uses in the city limits, and each

TABLE 2–1: EXISTING LAND USE IN THE CITY LIMITS		
LAND USE	ACRES	PERCENT OF CITY LIMITS
Residential	3,589	41%
Very Low Density "Ranchettes" (< 3 du/ac)	125	1%
Low and Medium Density (3-15 du/ac)	3,235	37%
High Density (15-30 du/ac)	229	3%
Agriculture	1,413	16%
Vacant	1,023	12%
Industrial	934	11%
Commercial and Mixed Use	760	9%
Public/Semi-Public/Community Facility	683	8%
Park and Open Space	209	2%
Office	118	1%
Total	**8,730**	**100%**

Sources: City of Turlock; Dyett & Bhatia, 2009

Figure 2-1: Existing Land Use in Turlock City Limits



The majority of the developed land in Turlock is traditional single family detached homes, built at less than seven units per acre.

land use is discussed in more detail in the paragraphs that follow. It is important to note that the existing land uses shown in these figures and described below, which illustrate how land is currently actually developed and/or being used, are not the same as the General Plan land use *classifications,* which express desired land uses, as described in the following section.

Residential

Altogether, residential land uses occupy 41 percent of the land in the city limits. The majority of existing residential development is located on the east side of the railroad, north of Downtown. There are also several residential neighborhoods on Turlock's west side, between the railroad and Highway 99. Of the 3,589 acres of residential development, 90 percent is low- and medium-density (3 to 15 units per acre), 6 percent is high density or multifamily (15 to 30 units per acre), and three percent is residential "ranchettes," which are very low density homes on large lots (less than 3 units per acre). The majority of Turlock's residential development is low density single family homes, ranging from three to seven dwelling units per acre. Older neighborhoods close to Downtown also consist of predominantly single family homes, but have slightly higher densities than the more recently developed areas. While multifamily housing types occupy just three percent of the land area in Turlock, these high density projects contain many more units than single family development on comparable acreage. Some of the more recently developed neighborhoods in the northwest quadrant of the city include a greater diversity of housing types, including townhouses and three-story apartment complexes.

Residential "estate" lots, with densities from 0.2 to 3.0 units per acre, make up much of the eastern border of the city near Denair. They function as part of the rural buffer between the two communities. Residential development outside of the city limits, in the southeastern quadrant of the Study Area, is primarily very low density "ranchette" style homes, generally on five- to ten-acre parcels.

Commercial, Office, and Mixed Use

Commercial development in Turlock is comprised of several specific nodes in different locations, and makes up approximately nine percent of the land within city limits. Mixed use development, which generally involves a mix of commercial and residential or office uses, is also included in this category. The largest concentration of retail development is Monte Vista Crossings, located just east and south of the Monte Vista interchange of SR 99. Developed over the last ten years, Monte

Vista Crossings includes numerous large anchor tenants such as Target, Safeway, Home Depot, and Kohl's; two hotels; and numerous smaller national-brand specialty stores and restaurants.

Community-oriented shopping areas, comprising both national chains and locally-owned businesses, characterize the Downtown core and the Geer Road corridor. Much of the development Downtown can be characterized as mixed use, though it is primarily commercial with some office and residential uses mingled throughout. Emanuel Medical Center is a large office land use northeast of downtown, with the hospital anchoring a collection of smaller medical offices surrounding it. Older automobile-oriented commercial development lines Golden State Boulevard and is also concentrated just south of Downtown.

Industrial

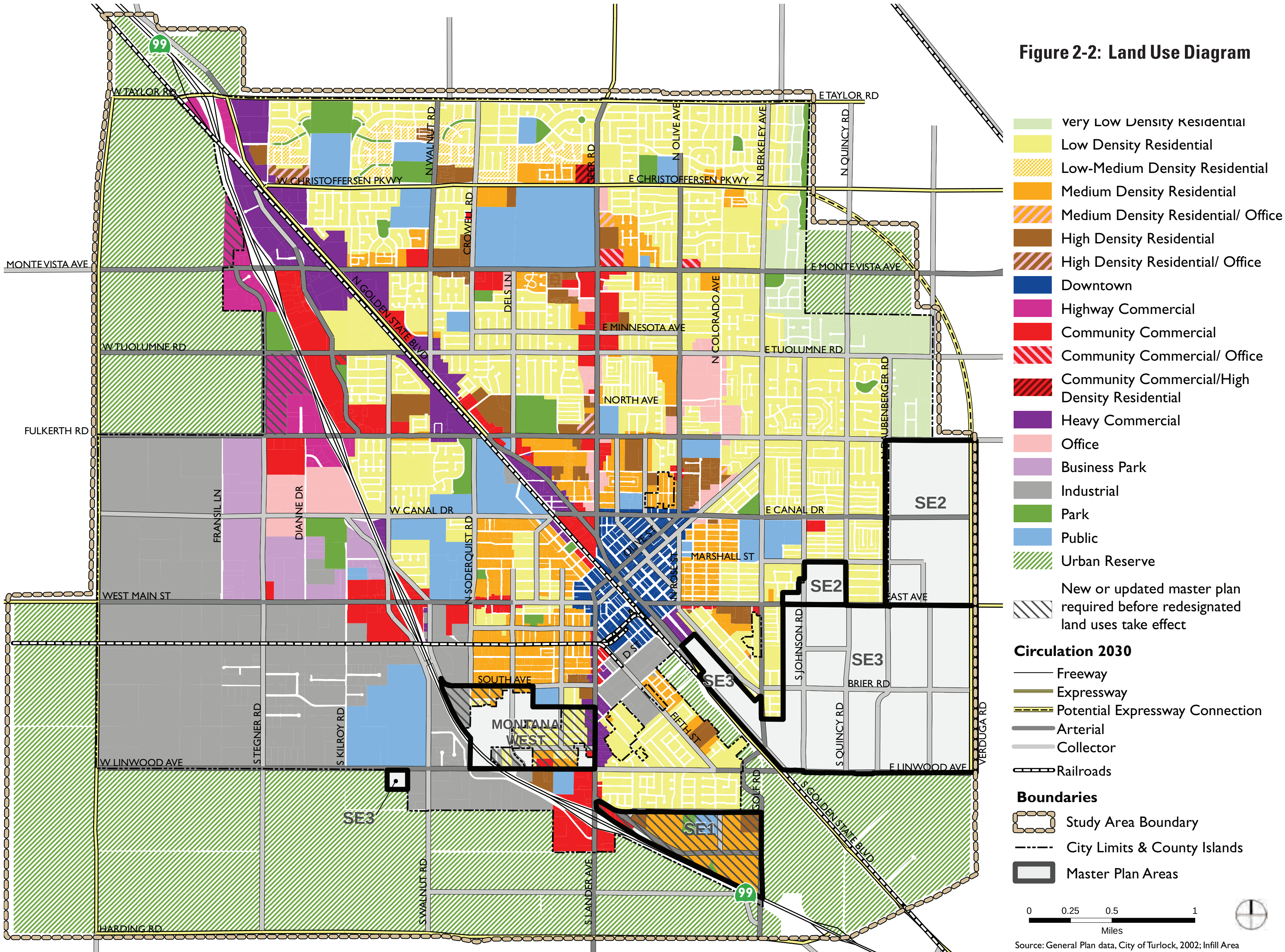
Eleven percent of the Study Area (934 acres) is currently developed with industrial uses. The industrial development east of Highway 99 is located immediately south of the downtown core, on both sides of the railroad tracks. Additional industry is located just west of the SR 99/Lander Avenue interchange. In 2006, approximately 2,000 acres were designated for industrial and industrial business park uses in the Turlock Regional Industrial Park (TRIP). Approximately 450 acres has been developed as such. Most of Turlock's industrial users are in the food processing industry, including Foster Farms, Sensient Flavors, and Kozy Shack.

Public, Semi-Public, and Community Facility

Public, semi-public, and community facility uses account for approximately eight percent of development within city limits. These uses include city buildings, schools and other government-owned facilities. Several large public and institutional users have sizable land holdings in Turlock. The California State University, Stanislaus (CSUS) occupies 210 acres along Monte Vista Avenue and Geer Road. The Stanislaus County Fairgrounds are on 67 acres, just northwest of the downtown core on the west side of the railroad. The City wastewater treatment facility is on 166 acres in the TRIP. The remainder of acreage in public, semi-public or community facility use consists primarily of public school grounds and stormwater detention areas.

Prior to the adoption of the Westside Industrial Specific Plan, the majority of industrial development in Turlock was centrally located, south of Downtown.

Figure 2-2: Land Use Diagram



Source: General Plan data, City of Turlock, 2002; Infill Area data and Opportunity sites data, Dyett and Bhatia, 2012; Map base data, City of Turlock, 2008.

Vacant Sites

Vacant land is scattered throughout the city. Parcels range from small urban infill sites measuring less than one acre to large, formerly agricultural parcels measuring up to 25 acres. Some vacant parcels are clustered, creating larger development opportunity sites of 100 acres or more. Altogether, vacant sites make up around 12 percent of the land area within the city limits, approximately 1,020 acres. Areas where vacant land is more concentrated include along SR 99, in the TRIP, along major corridors such as Geer and Golden State Boulevard, and near CSU-Stanislaus. The County islands in the southern part of town also contain vacant sites, though most are a quarter acre or less in size.

Larger Study Area and Agricultural Uses

Agriculture is the predominant existing land use in the unincorporated area outside of city limits but inside the Study Area boundary. Additionally, many vacant parcels within city limits are currently in agricultural use, especially those in the TRIP and in the undeveloped portions of the far eastern edge of the city. In the TRIP, there are over 1,000 acres of farmland, while the area is zoned for industrial uses.

Agriculture characterizes most large undeveloped parcels in the Study Area.

2.2 LAND USE CLASSIFICATIONS

The following descriptions apply to land uses indicated on the Land Use Diagram (Figure 2-2) and the Master Plan Area Diagram (Figure 2-3). The legend on the diagram is an abbreviated version of the descriptions. The classifications are adopted as General Plan policy and are intentionally broad enough to avoid duplicating existing City or County zoning regulations. More than one zoning district may be consistent with a single General Plan land use category, and revisions to the zoning regulations will be necessary to implement the General Plan.

According to State law, the General Plan must establish standards of population density and building intensity for each land use classification. The General Plan stipulates residential densities in housing units per gross acre; population density can be obtained by applying average persons per housing unit count[1]1 to the housing unit densities. For nonresidential uses, the Plan specifies a maximum permitted ratio of gross floor area to site area (Floor Area Ratio or FAR).

1 Based on 2000 U.S. Census data, the number of persons per total housing units is 2.9.

Table 2-2 shows gross density standards for residential categories and FAR standards for the other uses. Assumed averages for residential categories are listed in the descriptions that follow.

RESIDENTIAL

Residentially-designated areas permit housing, as well as childcare facilities, places of religious assembly, retail grocery stores not exceeding 2,500 square feet in size, and Residential Care Facilities consistent with applicable Federal and State Laws. A brief description of each of the Residential General Plan designations follows.

Residential densities are per gross acre of developable land, provided that at least one housing unit may be built on each existing legal parcel designated for residential use. State-Mandated second dwelling units and density bonuses for the provision of affordable housing are in addition to densities otherwise permitted.

Assumed average densities and persons per unit (based on Census information and recent demographic trends) are used to calculate probable housing unit and population holding capacity for each residential classification; however, neither the averages nor the totals constitute General Plan policy. The housing types referred to in the discussion below are illustrated in the City Design Element.

Very Low Density (VLDR)

The Very Low Density Residential uses allows 0.2 - 3.0 units per gross acre. It assumes three persons per unit, resulting in population density of one to nine persons per gross acre. Typical lots will be one-third of an acre in size. This designation is proposed primarily for the northeast edge of Turlock and is to act as a residential, large lot buffer between the higher density urban uses in Turlock and the lower density rural uses in Denair; the intent is to maintain parcel sizes that can serve to keep both Turlock and Denair as separate, independent communities. The average density assumed for General Plan calculations is 1.6 units per gross acre.

Low Density (LDR)

The Low Density Residential designation allows 3.0 to 7.0 units per gross acre and assumes 3.2 persons per household resulting in a range of population density of 13 to 22 persons per gross acre. Housing in this density range is typical of recent subdivisions built throughout Turlock, though

TABLE 2–2: LAND USE CLASSIFICATIONS AND DENSITY – MINIMUMS AND MAXIMUMS			
LAND USE		**MINIMUM AND MAXIMUM RESIDENTIAL DENSITY (GROSS DWELLING UNITS PER ACRE)**	**TYPICAL NON-RESIDENTIAL DENSITY (FAR)[1]**
VLDR	Very Low Density Residential	0.2 – 3.0	
LDR	Low Density Residential	3.0 – 7.0	
LDR_MDR	Low and Medium Density Residential	5.0 – 10.0	
MDR	Medium Density Residential	7.0 – 15.0	
HDR	High Density Residential	15.0 – 40.0	
DT	Downtown Mixed Use[2]	7.0 – 40.0	Plus 4.0
O	Office		0.35
CC	Community Commercial		0.25
HC	Heavy Commercial		0.35
HWC	Highway Commercial		0.35
RC	Regional Commercial		0.35[3]
I	Industrial		0.60
BP	Business Park		0.35
PUB	Public/Semi-Public (includes detention basins)		NA
P	Park		NA
UR	Urban Reserve		NA

1. FAR = Floor Area Ratio, defined as the ratio between gross floor area of structures on a site and gross site area. Thus, a building with a floor area of 100,000 square feet on a 50,000 square-foot lot will have a FAR of 2.0.
2. Downtown Mixed Use allows a combination of residential development of 7.0-40.0 units per acre as well as non-residential development of FAR 4.0 maximum.
3. FAR for a hotel in the Regional Commercial designation may be up to 3.0.

Low-Medium Density Residential development in North Turlock.

few subdivisions have achieved densities at the high end of the range. The intent of the classification is to provide locations for construction of single-family homes with a range of lot sizes. The typical density assumed for General Plan calculations is 5.0 units per gross acre.

Low-Medium Density (LDR-MDR)

Low-Medium Density Residential areas have between 5.0 and 10.0 units per gross acre. At three persons per unit, this translates to a population density of 15 to 30 persons per gross acre. The intent of the LDR-MDR designation is to accommodate a range of more compact housing types in a traditional neighborhood environment, including small-lot single family homes as well as single family attached townhouse units. The establishment of an RL4.5 zoning district as part of the new zoning ordinance adopted in January of 1997, allows for 4,500 square foot lots (gross density = 9 units per acre), which are typically located in the LDR-MDR area. Because housing at this density accommodates a range of traditional single family homes, small-lot single family homes, and townhouses, it will reach Turlock's largest residential market and is expected to account for about half of all housing added in the Study Area during the next twenty years. The typical density assumed for General Plan calculations is 7.5 units per gross acre.

Medium Density (MDR)

The Medium Density Residential area allows 7.0 to 15.0 units per gross acre and assumes 2.7 persons per household, with an equivalent population density of 19 to 41 persons per gross acre. Virtually all new attached residences are expected to be built in this density range, which recognizes that attached townhome and multifamily units will make up an increasing percentage of the City's housing stock in years to come. Attached family units offer a way to reduce the cost of owner-occupied housing. Housing of this type is consistent with the General Plan policies seeking to limit the expansion of the City in order to preserve agricultural lands and maintain a compact urban form, while responding to many households' preference for family units. Mobile home parks and apartments within this density range will meet the needs of many households without the financial means or the desire to be homeowners.

At the lower end of the range, this designation allows zero-lot-line homes, semi-detached houses and duplexes, typically built at 7 to 11 units per acre. The upper end of the density range accommodates townhouses (ranging from 12 to 15 units per acre) and low-rise garden or "walk-up" apartments (around 15 units per acre). Most existing mobile-home parks at full occupancy are also within the Medium Density range. The typical density assumed for General Plan calculations is 11.0 units per gross acre.

In some cases, particularly in older residential neighborhoods immediately surrounding the Downtown core, the MDR designation is applied to lots that are smaller than one acre in size. Traditionally, these lots have been developed with single family homes, but recent "tear-downs" and redevelopment have created small multifamily projects amidst single family neighborhoods. While a mix of housing types within a neighborhood is desirable, the General Plan puts additional standards describing "graduated density" in place for development of medium density multifamily housing on traditional single family lots so as to ensure continued neighborhood quality and character (see Section 2.5).

High Density (HDR)

The High Density Residential designation allows 15.0 to 40.0 units per gross acre and assumes 2.4 persons per household (plus State-mandated bonus for affordability where applicable). The resulting range of population density will be approximately 36 to 84 persons per gross acre. Similar to MDR, the HDR classification supports the policy direction of achieving more compact development as Turlock grows over the next 20 years. High density housing supports compact development, provides housing choices to match changing demographics, and facilitates needed affordable housing. The State-mandated density bonus could result in net densities as high as 48 units per acre at the top end of the range. The resulting housing type will to a great extent be determined by unit size, parking, and open space requirements but will include triplexes and quadruplexes, stacked townhouses, walk-up garden apartments, and apartment buildings with elevators. The typical density assumed for General Plan calculation is 22.5 units per gross acre.

The Sierra Oaks apartments, High Density Residential development in northwest Turlock, are built at approximately 22 units per acre.

Professional and medical office uses are found along Geer Road, Downtown, and close to the Emanuel Medical Center (top). Community commercial uses serve residents' daily shopping needs and are primarily located along major corridors (bottom).

COMMERCIAL AND MIXED USE

The General Plan includes a number of commercial land use classifications, each with a separate purpose. This category also includes mixed use designations, which generally consist of a combination of commercial and residential and/or office uses.

Downtown Mixed Use (DT)

This classification is applied to Turlock's traditional Downtown and indicates the area in which the Downtown Overlay zoning districts apply. The classification provides for a full range of retail and personal services uses, including apparel stores, restaurants, specialty shops, entertainment uses, bookstores, travel agencies, hotels/motels and other similar uses serving a community-wide market and a larger daytime employment population. It is also intended to accommodate banks, financial institutions, medical and professional offices, and other general offices and community institutional uses. Additional use limitations and special development standards, including separate parking requirements, are applicable to the downtown core area as identified in the Downtown Turlock Plan (centered on Main Street) and Overlay Zoning regulations. Nonresidential development in this classification shall generally not exceed a FAR of 4.0. The DT classification also applies to the older residential neighborhoods in the downtown area and provides for both single and multiple-family uses at densities ranging from 7.0 to 40.0 units per gross acre. Residential development either as a mixed use or as an independent use in the downtown area is encouraged.

Office (O)

The Office category includes business and professional offices, with a maximum FAR of 0.35. The areas near the Police Services/TID headquarters, Emanuel Medical Center, and on Geer Road between West Canal Drive and Hawkeye Road are suitable for offices but not for retail businesses (except for employee-serving uses such as restaurants and child care).

Community Commercial (CC)

This designation provides for a full range of retail and personal service uses, including retail stores, food and drug stores, apparel stores, specialty shops, home furnishings, durable goods, offices, restaurants and other similar uses that serve a neighborhood or community wide market. Scale, rather than use, distinguishes areas serving a neighborhood versus community wide market. Large scale commercial uses (large discount centers, big box retailers, etc.) serving a region wide market are specifically excluded from this designation. Development in this designation shall not exceed 0.25 FAR. While facilitating automobile access and parking, Community Commercial areas shall also be designed such that they are pedestrian- and bicycle-oriented, in order to enable nearby residents to accomplish their daily shopping needs without a vehicle.

Regional Commercial (RC)

This designation provides for region-serving commercial uses, including large-scale shopping centers, discount "club" type stores, factory outlets, and other commercial uses such as retail stores, food and drug stores, apparel stores, specialty shops, motor vehicle sales, home furnishings, commercial entertainment facilities, hotels/motels and other similar uses that serve a region wide market. Development in this designation shall not exceed 0.35 FAR, except for hotels/motels, which may have FARs up to 2.0. In the future, as development shifts from the north Turlock area to the south, the area east of State Route 99 south of Glenwood Avenue could also been an attractive site for region serving retailers, in close proximity to the proposed new freeway interchange. Regional Commercial and/or large-scale region serving uses are not permitted on Geer Road and other areas classified for Community and Neighborhood Commercial development.

Market analysis has demonstrated that as of the time of this General Plan Update, regional commercial uses (specifically discount superstores) are currently not economically prudent land uses in Turlock. While the Land Use Diagram does not designate any areas in Turlock as Regional Commercial, City Council has determined that further study should be undertaken on this topic once the city reaches approximately 27,000 housing units, at which time the land use can be reconsidered. Policy 2.6-e provides detail on implementation.

Highway Commercial (HWC)

This designation provides for uses designed to serve motorists traveling along State Route 99 at or near interchanges that are convenient and safe for such uses, and to a lesser extent along Golden State Boulevard. This designation is also intended to provide locations for uses that depend on high visibility from the freeway. Allowable uses in this designation include service stations, hotels/motels, restaurants, auto sales and other similar types of automobile-dependent uses. This designation corresponds to the Commercial Thoroughfare zoning district. The maximum allowable FAR is 0.35.

Multiple use designations allow, but do not require, horizontal and/or vertical mixed use developments.

Heavy Commercial (HC)

This designation provides for heavy, wholesale and service commercial uses that do not need highly visible locations, or in locations where noise levels or other conditions may limit the suitability for other more retail-oriented uses. These uses can often serve as a buffer, transitioning between industrial activities or major transportation corridors and residential areas. Typical uses in this classification include repair facilities, distributing uses, sales of building materials, motor vehicle sales and service, contractor's yards and storage-oriented uses. The uses in this classification are often similar in character to industrial uses. Historically, many of these types of uses have been located along Golden State Boulevard. Development in this designation shall not exceed a FAR of 0.35.

Multiple Use Designations

The General Plan Land Use Diagram also shows several "multiple use" designations, which combine several land use designations. Examples include "CC_O" and "O_HDR." In these cases, the property may be developed either as a mixed use project (horizontal or vertical) or developed as any one of the single uses in the designation. In other words, a site designated O_HDR may be developed as high density residential, office, or both. The project is permitted to develop at the highest density or FAR allowed by the multiple designations.

INDUSTRIAL

Industrial (I)

This designation provides for large and small scale industrial, manufacturing, distributing and heavy commercial uses such as food processing, fabricating, motor vehicle service and repair, truck yards and terminals, warehousing and storage uses, wholesale uses, construction supplies, building material facilities, offices, contractors' yards and the like. The majority of Industrial uses are found in the Turlock Regional Industrial Park (TRIP), encompassing approximately 2,500 acres west of S.R. 99 between Fulkerth Road and Linwood Avenue. Incidental retail and services may also be permitted provided they are primarily oriented to employees and businesses within the area. Development in the designation shall not exceed a FAR of 0.6.

Business Park (BP)

This designation provides for office centers, research and development facilities, medical and professional offices, institutional uses, limited light industrial uses, warehousing and distributing, "back-office" uses, and other similar uses locating in a low intensity, landscaped setting with high design and development standards. Similar to the Industrial designation, Business Park uses are found primarily in the TRIP. Incidental retail and services may also be permitted provided they are primarily oriented to provide services to employees and businesses within the area. Development in this designation shall not exceed a FAR of 0.35.

PUBLIC / INSTITUTIONAL (PUB)

This classification is applied to the city's major public and private institutional uses, including public safety facilities, public schools, California State University Stanislaus (CSUS), the State fairgrounds, and other prominent public uses and facilities. The Land Use Diagram shows the specific locations of existing major Public/Institutional facilities. Stormwater detention basins are also designated as public uses on the Land Use Diagram. Except for sites that have been acquired, the Land Use Diagram shows only the general location of future public or institutional uses in the area they will be needed. Selection of specific sites is the responsibility of the applicable governmental agencies and/or private institutions serving the Turlock area.

The designation on the Land Use Diagram of any future public or institutional site that has not been acquired shall not be construed to limit the existing or future use of the designated land. The predominant land use designation surrounding any property designated for public facilities shall be used to determine the potential use of the property prior to its acquisition by the applicable governmental agency or private institution.

PARKS (P)

This designation is applied to existing and planned public parks and open space, including specialized public recreational facilities such as Pedretti Park and the Regional Sports Park. Except for sites that have been acquired, the Land Use Diagram shows only the general location of future parks in the areas they will be needed.

The designation on the Land Use Diagram of any future park site that has not been acquired shall not be construed to limit the existing or future use of the designated land. The predominant

The Westside Industrial Specific Plan designates a large area as Business Park, accommodating office, research & development, light industrial, and similar uses (top). Public and institutional uses in Turlock include schools, public safety facilities, CSUS, and the County Fairgrounds (bottom).

land use designation surrounding any property designated for a future park site shall be used to determine the potential use of the property prior to its acquisition by the City of Turlock.

Parks shown on the Land Use Diagram are those that the City has determined are required to support the needs of Turlock's future population, and will be funded. However, this does not preclude additional parkland from being developed. Parks are also allowed in residential districts upon approval of a Minor Discretionary Permit (MDP). Also, given their small size, some the mini-park sites may not be large enough to be displayed on the Land Use Diagram, but this shall not prevent a site from being considered to have been appropriately classified. Chapter 4: Parks, Schools, and Community Facilities contains information and policies pertaining to park locations, types, and standards both within existing city limits and in new growth areas.

URBAN RESERVE (UR)

This classification is established for the purpose of identifying land that is reserved for future unspecified urban uses. Additional environmental analysis, a General Plan amendment, master planning, and annexation, if located outside the city, will be required before urban uses and/or development is permitted on land classified Urban Reserve. However, given the master plan programming and phasing described in Chapter 3, it is unlikely that areas designated Urban Reserve on the Land Use Diagram will be required for urban uses during the buildout period of this General Plan. Agricultural uses are permitted on property classified Urban Reserve, although they may eventually be replaced by permanent urban development. Public facilities and recreation facilities may also be located on land classified Urban Reserve.

In some cases, areas designated as Urban Reserve may already have some developed uses (for example, in the area north of Taylor Road to Barnhart Road, near State Route 99). Should these properties desire incorporation, the City shall work with the property owners on annexation agreements (see Policy 2.10-b).

MASTER PLAN AREAS

The Land Use Diagram also shows areas that are designated as new Master Plan Areas. These correspond to areas that shall be planned, pre-zoned, and annexed to the city one at a time, according to the phasing diagram (see Section 3.1). Rather than depicting specific plan uses on parcels, the Master Plan Area designation requires that each area achieve a specific mix of land uses, intensities, and other requirements (described in detail in Section 3.2) that are to be determined through the preparation of a master plan for each one. Figure 2-3 shows the residential density ranges planned for each new Master Plan Area.

2.3 DEVELOPMENT POTENTIAL

Development potential is calculated based on assumptions about new residential and commercial development that could be built under the General Plan land use designations and their respective densities and intensities over the timeframe of the General Plan. It also takes into account properties that have approved or pending development project applications associated with them at the time of the General Plan's writing, which, along with vacant and underutilized properties, accommodate a portion of the city's expected future growth. A detailed list of the proposed, pending, and approved development projects at the time of the General Plan's writing is found in the *Existing Conditions and Key Issues* report (March 2009).

POPULATION AND EMPLOYMENT PROJECTIONS

Over the next 20 years, Turlock is expected to attract a substantial number of new residents and new jobs. Historical and recent growth trends give some indication of the amount and type of growth that Turlock can expect to see. The General Plan plays an important role in projecting these growth numbers, estimating how much land for housing and employment the new growth will require, analyzing Turlock's existing capacity for new development, and determining where the remaining demand for urban land uses should go.

This section describes Turlock's projected population and employment in 2030, the time horizon of the General Plan. The location, phasing, and land uses of this growth are described in Chapter 3: New Growth Areas and Infrastructure.

Residential Population

Population Projections

Turlock has grown rapidly since the 1970s. Its 2000 population of 55,810 was a 32 percent increase over the 1990 count. The 2007 American Community Survey shows 26 percent growth between 2000 and 2007, bringing the estimated population to 70,412. Turlock added some 3,644 housing

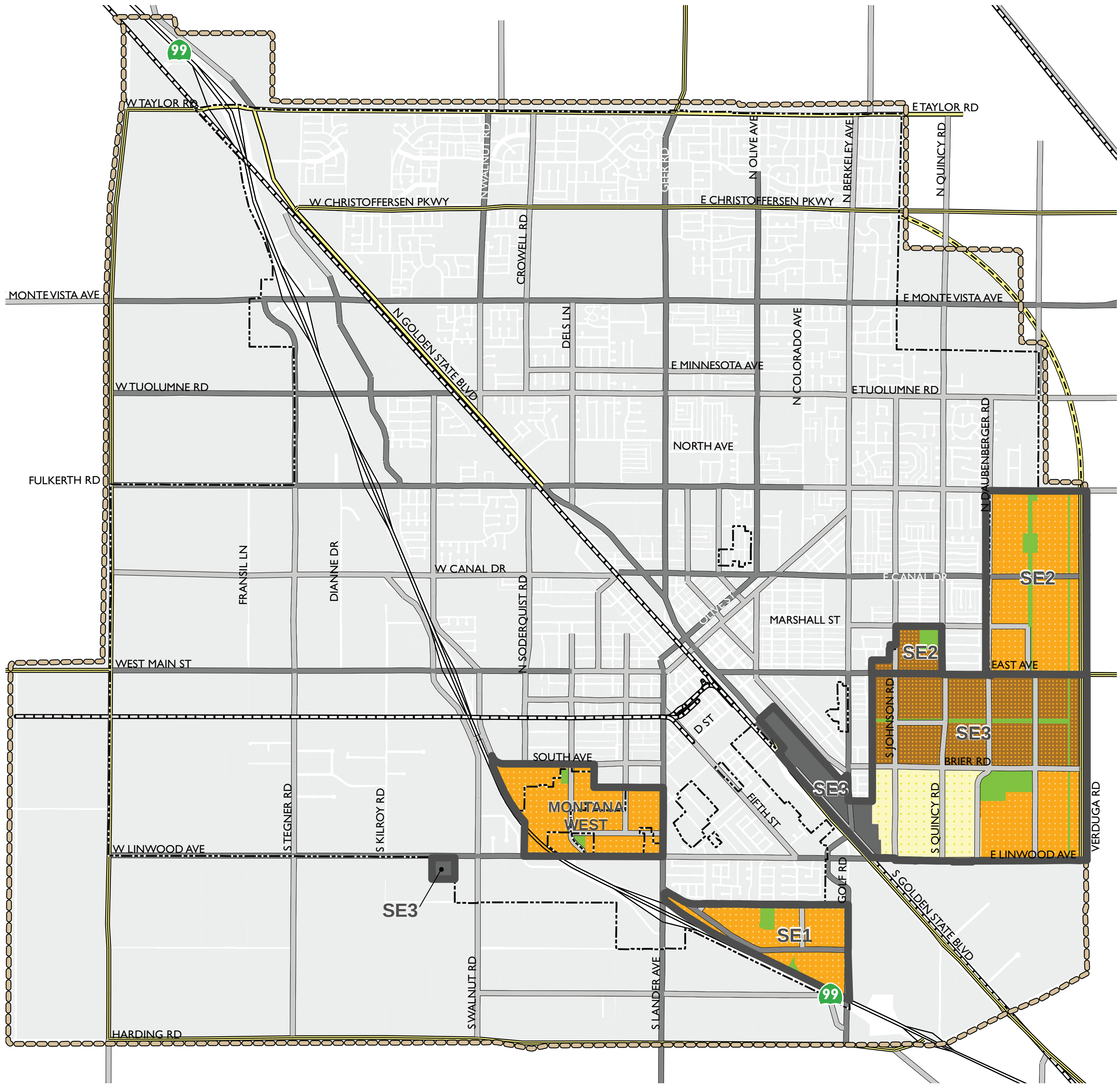


Figure 2-3: Proposed Master Plan Areas

Very Compact Mixed Use
(Minimum Average Density: 11 du/acre; Maximum Average Density 20% Higher)

Compact Mixed Use Neighborhood
(Minimum Average Density: 8 du/acre; Maximum Average Density 20% Higher)

Low Density Neighborhood
(Minimum Average Density: 5 du/acre; Maximum Average Density 20% Higher)

Non-Residential Only

Park

Circulation (2030)

Freeway
Expressway
Potential Expressway Connection
Arterial
Collector
Railroads

Boundaries

Proposed Master Plan Areas
Study Area Boundary
City Limits & County Islands

0 0.25 0.5 1
Miles

Source: General Plan data, City of Turlock, 2002; Infill Area data and Opportunity sites data, Dyett and Bhatia, 2012; Map base data, City of Turlock, 2008.

units in the 1990s and issued permits for another 4,745 units between 2000 and 2008. Since 2000, housing development has kept pace with estimated population growth.

Population projections for the City of Turlock in 2030 are derived from countywide forecasts from a variety of public and private sources. These sources cite a variety of factors driving growth in the Central Valley in general and Stanislaus County in particular. According to the Public Policy Institute of California (PPIC), over half of the growth in the Central Valley has been due to migration. Job growth, affordable housing, and strong family relationships are the primary reasons for migrating to the Central Valley. Although most of the migration comes from coastal California where housing is less affordable, an additional component is also generated from outside the U.S. (e.g. Latin America, Asia). Additionally, the Central Valley's newest residents are more likely than its out-migrants to be married and have children.

This trend is supported by analysis from the Center for the Continuing Study of the California Economy (CCSCE). According to the CCSCE, net migration (the difference between immigration into and emigration from the area) now accounts for the majority of the population growth in the San Joaquin Valley. Additionally, net migration has been the largest component of growth in Stanislaus County since 2000.

At the outset of the General Plan Update process, Turlock was estimated to gain between 36,000 to 55,000 new residents by 2030. The low end forecast projects 106,500 people by 2030, or a 51 percent increase over current levels; this forecast assumes the City's percentage share of County population of 13.2 percent remains constant. In contrast, the high end forecast projects 127,000 people by 2030, or a 76 percent increase over current levels; this forecast assumes that the change in the City's population growth rate relative to historic trends will mirror the projected change in the County's population growth rate.

Buildout Population

At buildout, assuming construction at midpoint densities and intensities, the Study Area could support approximately 104,500 residents. This represents an average 1.9 percent annual growth rate from 2008 through 2030. In light of an extended period of slower growth in California between 2008 and 2012, this General Plan uses the low end population forecast as its guidance for buildout. This is also more consistent with recently developed forecasts that revise downward the amount of projected growth in the San Joaquin Valley by 2030.

With an average household size of 2.92 persons per household, 36,000 new residents equates to approximately 12,300 new households and 12,800 new housing units (assuming a vacancy rate of approximately 3.6 percent). Different housing types often attract different household sizes. Traditional single family homes are assumed to have 3.1 to 3.3 persons per household, whereas multifamily housing types may average 2.4 to 2.8 persons per household. Overall, Turlock's average household size across all housing types is around three persons per household.

However, it is important to note that current economic conditions have placed a strain on the Central Valley that may require a longer recovery period than other areas of the State. Until unemployment and housing market conditions stabilize, growth will likely occur at a substantially slower rate in the short term, and the ultimate buildout of the General Plan may not occur by 2030. In order to accommodate population and job growth at the pace at which it occurs, this plan stipulates that development occur in phases. These are discussed in more detail in Chapter 3.

Non-Residential

Similar to population, employment projections for the City of Turlock are based on forecasts provided at the County level. Given the various economic factors that could influence future growth in the City, the General Plan relies on these county-wide forecasts to provide a high and low range estimate for Turlock and bracket potential outcomes. Again, the actual outcome will depend on a variety of demographic and policy considerations as well as differences between the City and County growth patterns.

A number of factors drive job growth in the Central Valley in general and Stanislaus County in particular. A significant proportion of the future job growth in the County will be related to providing goods and services to the local and regional population. In other words, growth in the local population and workforce will be an important driver for future employment growth. North San Joaquin's economy (Merced, Stanislaus, and San Joaquin) is also likely to get a boost from the continued expansion of educational facilities such as CSU Stanislaus and UC Merced, as well as spill-over from the San Francisco Bay Area economy. The presence of lower-skilled workers, inexpensive land, and central location in the State will also ensure that the region remains competitive for manufacturing.

According to the Stanislaus Council of Governments (StanCOG), the region anticipates more rapid growth in the Service and Retail Trade industry sectors relative to education or other industries. Government jobs are expected to experience minimal growth. Additionally, because of the changing nature of the local economy, StanCOG anticipates unemployment levels will gradually decrease by 2030, and become more reflective of statewide rates.

Turlock is estimated to gain between 17,200 and 35,000 new jobs by 2030. The low end forecast (46,200 total jobs or a 59 percent increase over current levels) assumes the City's percentage share of County employment of 14.3 percent remains constant. The high end forecast (64,000 total jobs by 2030 or a 121 percent increase over current levels) assumes that the change in the City's employment growth rate relative to historic trends will mirror the projected change in the County's employment growth rate. At buildout, the land uses described in the General Plan would support around 51,000 total jobs—close to the midpoint of the jobs forecast.

TABLE 2–3: GENERAL PLAN BUILDOUT BY LAND USE DESIGNATION: RESIDENTIAL

LAND USE	ACRES	AVERAGE GROSS DENSITY (DU/AC)	HOUSING UNITS	POPULATION
Very Low Density Residential	289	1.6	460	1,300
Low Density Residential	2,916	5.0	14,580	41,050
Low/Medium Density Residential	408	7.5	2,930	8,230
Medium Density Residential	875	11.0	8,890	25,030
High Density Residential	345	22.5	7,130	20,070
Office and/or High Density Residential[1]	15	22.5	170	470
Office and/or Medium Density Residential[2]	6	11.0	30	100
Community Commercial and/or Office and/or High Density Residential[3]	9	22.5	60	180
Downtown Mixed Use[4]	164	22.5	2,780	7,810
Neighborhood Center[5]	22	22.5	80	230
Total	**5,049**		**37,120**	**104,480**

Note: Items may not sum to totals due to rounding.

1. Assumes 50% buildout as residential. Assumption supported by Housing Element analysis. Actual buildout may vary.
2. Assumes 50% buildout as residential. Assumption supported by Housing Element analysis. Actual buildout may vary.
3. Assumes 33% buildout as residential. Assumption supported by Housing Element analysis. Actual buildout may vary.
4. Assumes 75% buildout as residential. Assumption supported by Housing Element analysis. Actual buildout may vary.
5. Neighborhood Center classification applies only to master plan areas and is defined in Chapter 3. Assumes 25% buildout as residential. Actual buildout may vary.

General Plan Development Potential

Full buildout of the General Plan, including all master plan areas, would result in a total of around 37,120 housing units citywide (including existing) and a cumulative population of around 104,500 (Table 2-3). Of these, new housing units and population would be 12,800 and 36,000 respectively. More detail on phasing and buildout by phase is found in Chapter 3: New Growth Areas and Infrastructure.

Table 2-4 shows the potential non-residential buildout in terms of square feet of new buildings and number of jobs. Jobs are calculated based on standard assumptions about square footage per employee for various employment types. An average vacancy rate of 7 percent is also assumed.

TABLE 2–4: GENERAL PLAN BUILDOUT BY LAND USE DESIGNATION: NON-RESIDENTIAL

LAND USE	ACRES	TYPICAL FAR	SQUARE FEET	JOBS
Downtown Mixed Use[1]	164	1.0	1,791,120	4,160
Office	255	0.35	2,541,250	7,820
Office and/or High Density Residential[2]	15	0.35	112,770	350
Community Commercial	510	0.25	5,550,210	10,320
Community Commercial and/or Office	15	0.30	198,380	460
Community Commercial and/or Office and/or High Density Residential[3]	9	0.30	75,580	180
Office and/or Medium Density Residential[4]	6	0.35	47,620	150
Heavy Commercial	367	0.35	5,593,930	8,670
Highway Commercial	172	0.35	2,618,140	4,870
Industrial[5]	1,857	0.60	12,555,430	11,680
Business Park[6]	272	0.35	621,110	1,925
Neighborhood Center[7]	22	0.30	215,260	400
Total	**3,664**		**31,920,900**	**51,040**

Note: Items may not sum to totals due to rounding.

1. Assumes 25% buildout as non-residential. Actual buildout may vary.
2. Assumes 50% buildout as office. Actual buildout may vary.
3. Assumes 50% buildout as non-residential. Actual buildout may vary
4. Assumes 50% buildout as non-residential. Actual buildout may vary.
5. Assumes 15% buildout of available land inventory, per employment projections.
6. Assumes 15% buildout of available land inventory, per employment projections.
7. Neighborhood Center classification applies only to master plan areas and is defined in Chapter 3. Assumes 75% buildout as non-residential. Actual buildout may vary.

An important consideration to recognize in this calculation is that the TRIP in particular represents an approximately 50-year (or more) industrial land supply—far beyond the time horizon of this General Plan. Altogether, available land in the TRIP alone (Industrial and Business Park designations) could support nearly 56,000 jobs. However, employment projections for Turlock indicate that over the course of the General Plan buildout, through 2030, the city is likely to gain between 6,000 and 8,000 industrial jobs. This corresponds to roughly 15 percent of the TRIP being built out, or around 390 acres. Using this assumption regarding the TRIP, and assuming full buildout of the other non-residential land uses, Turlock will be able to support approximately 51,000 jobs at General Plan buildout.

It should be noted that for the purposes buildout calculations, approximate acreages of various residential and non-residential land uses are assumed for the master plan areas. These amounts are based on the conceptual plans for these areas, described in Chapter 3. Actual buildout of each land use type will depend on subsequent master planning processes. Similarly, for the purpose of infrastructure capacity calculations, the General Plan and supporting documents assume a 25 percent buildout of the TRIP. By using this higher buildout assumption for capacity calculations, the plan allows for a "cushion" in industrial development, as many large industrial users require substantial flexibility in site size and location.

Downtown Turlock is home to many thriving small businesses in a walkable, mixed use environment.

2.4 DOWNTOWN

The Downtown is roughly one quarter-mile square (160 acres), consisting of a core commercial area of approximately 90 acres, and residential, civic and heavy commercial uses at the periphery. It owes its location and geometry to the Union Pacific Railroad. Historic records indicate that the town survey started at what is now the southeast corner of the intersection of Center and East Main streets. From there, as in most towns of the San Joaquin Valley, an orthogonal street network was extended out parallel and perpendicular to the railroad tracks. Newer parts of the town were laid out in true cardinal directions; the transition between the new grid and the older diagonal one is never clean and is often disorienting.

The emergence of newer shopping centers in recent years, first along Geer Road and then at Monte Vista Crossings, has significantly reduced Downtown's share in the retail and commercial growth experienced by the City. The shopping complexes along Geer Road rival the retail

Implementation of the Downtown Design Guidelines has contributed to a cohesive aesthetic and improved streetscape.

in Downtown in size and proximity to residents and exceed it in activity. Both Geer Road and Monte Vista Crossings have better access and orientation to the automobile, proximity to newer neighborhoods, easier parking and larger sites than Downtown.

Compared to the newer shopping centers, Downtown, with its narrow streets, short blocks (typically 400-foot square), and historic buildings, is more appealing and better suited to exploration on foot. However, it lacks both a critical mass of supporting activity and attractions that could draw people from afar.

A survey conducted as part of the 1992 Downtown Plan estimated the amount of commercial space in Downtown to be about 1.4 million square feet. Of the 0.8 million square feet of retail space in the Downtown, automobile dealers and home furnishings accounted for the two largest groups of businesses. Eating and drinking establishments, specialty retail and apparel stores together constituted about 350,000 square feet of space. The survey did not consider Downtown's condition at that time as being prosperous. Banking establishments, the post office and other service establishments have been strong stabilizing elements, and cooperative marketing efforts, such as the Farmer's Market, have increased Downtown's visibility.

A second study of Turlock's Downtown was completed in 2008, which focused on marketing and branding opportunities. The study identified wedding planning and bridal shopping as a brand for Downtown, which, driven by a concerted marketing effort, could guide local business development and spur tourism and visitor spending.

LONG-TERM VIABILITY

Downtown's long-term economic viability will depend on its ability to compete not only with the newer shopping centers, but more critically with regional discount and retail operations, such as Wal-Mart and freeway-oriented regional shopping centers. Its success will depend on specialty stores offering wider selection than department stores, competitive pricing by merchants, and a pleasant environment for pedestrians where one-of-a-kind shops, restaurants and entertainment facilities can attract patronage from the entire City and beyond.

The 1992 Downtown Master Plan

The 1992 Downtown Master Plan offered a comprehensive urban design, parking-landscape framework, and a funding mechanism for implementation. It helped to identify infrastructure and beautification improvements for Downtown Turlock, which were implemented successfully and are responsible for many positive aspects of Downtown's environment today..

The 2003 Downtown Design Guidelines and Zoning Regulations

Adopted in 2003, the Downtown Design Guidelines and Zoning Regulations build on the vision for Downtown Turlock outlined in the Downtown Master Plan. The Zoning Regulations and Guidelines are intended to encourage and facilitate appropriate private investment within the Downtown Area that reflects the historic commercial character of the core and the traditional residential character of the adjoining neighborhoods. The documents contain guidelines and standards for physical design and land use in the area, emphasizing the importance of pedestrian access and accessibility throughout the Downtown Area, making it a place people can access easily and where they will want to linger and spend time.

The goals for the Zoning Regulations and Design Guidelines include:

- To ensure the current and future success of the Downtown by preserving and enhancing its unique historic character.
- To encourage future development that is compatible with the overall feel of Downtown.
- To protect and enhance the pedestrian environment and accessibility in and around the Downtown Core Area.
- To conserve the traditional character of the immediate surrounding residential neighborhoods while guiding future development for use and reinvestment through alternative uses.
- To promote renovation of historic buildings in Downtown and promote new investment and construction.

Downtown Planning Update

Using a portion of the funding that the city received through the Smart Valley Places Partnership, Turlock initiated an update to the Downtown Design Guidelines and Zoning Regulations in January 2011. Issues to be addressed in this update include the location of a potential train station downtown, as well as the possibility of allowing heights up to 60 feet in certain zones (Office/Residential and Industrial/Residential) for the purpose of providing additional housing. The infrastructure analysis in the General Plan will ensure that adequate infrastructure exists to support this potential increased intensity.

POLICIES

Guiding Policies

The Downtown Plan offers specific recommendations for guiding Downtown's growth into the future.

2.4-a **Preserve and enhance Downtown Turlock.** Continue efforts to preserve and enhance Downtown. Encourage development of Downtown as a mixed-use, day and evening activity center. Encourage office and residential development near Downtown.

Continuing viability of the Downtown is of economic as well as symbolic value to the City. Downtown has scale and character that is hard to replicate in shopping centers elsewhere. Downtown should be the preferred location for accountants, attorneys, dentists, realtors, engineers, and other local-serving office tenants, unless they provide medical services and need to be near the Emanuel Medical Center. Downtown provides a good location for the concentration of non-medical offices.

Implementing Policies

See also policies in Section 2.11, Economic Development, concerning economic support for Downtown; and in Section 7.5, Cultural and Historic Resources, concerning preserving Downtown's historic character.

2.4-b **Update the Downtown Zoning Overlay District and Design Guidelines.** Undertake a comprehensive update to the 2003 Downtown Zoning and Design guidelines to update uses and standards to respond to current economic needs and trends. Evaluate potential locations for intermodal hub, public parking needs, design standards, and maximum densities.

2.4-c **Downtown Property-Based Improvement District (PBID).** Support the continuation of the Downtown Property-Based Improvement District (PBID) for the Plan's funding and implementation.

2.4-d **Preserve and promote historic character.** Work with the Turlock Historical Society and the Turlock Downtown Property Owners' Association to provide information and guidance to property owners interested in restoring or recapturing the original architectural style and integrity of historical buildings.

2.4-e **Support arts and culture Downtown.** Continue to demonstrate the City's commitment to the arts and historic resources by supporting private and nonprofit arts and cultural efforts.

2.4-f **Continue to improve access and wayfinding.** Continue to improve access to and within Downtown. Issues addressed should include entrances to Downtown and signage.

For detailed policies refer to the Downtown Master Plan.

2.4-g **Facilitate mixed use.** Facilitate and encourage development of mixed-use projects in Downtown through the development review, permitting, and fee process.

2.4-h **Preserve residential adjacency.** Preserve residential areas north and east of Downtown.

These areas are well established and contribute to the diversity of scale and use near Downtown. Permitting non-residential uses will create pressure on surrounding residences to convert to other uses as well.

General Plan policies encourage a mix of housing types in compact, walkable neighborhoods, to provide for Turlock's diverse population.

2.5 RESIDENTIAL AREAS

The General Plan promotes the development of walkable, compact, mixed use residential neighborhoods in new development areas. Compact neighborhoods use resources more efficiently, conserve valuable farmland, and are convenient to residents. New residential development will include a broad mix of housing types, from traditional single family homes to townhouses and apartments, in order to serve the needs of Turlock's diverse population and changing demographics.

Some community facilities that are appropriate for residential environments, such as day care, elderly care, and alcohol and drug abuse treatment facilities, shall be allowed within neighborhoods in accordance with State and federal law.

Below are the land use policies related to residential areas. For detailed information on housing types and program policies, refer to the Housing Element, and for design policies, refer to the City Design Element.

POLICIES

Guiding Policies

2.5-a **Housing type diversity.** Increase the diversity in the citywide mix of housing types by encouraging development of housing at a broad range of densities and prices, including small-lot single-family, townhouses, apartments, and condominiums. Aim to achieve an overall housing type mix of 60 percent traditional single family, 40 percent medium and higher density housing types.

The current mix is 70 percent single family and 30 percent medium and high density.

2.5-b **New neighborhood character.** Foster the development of new residential areas that are compact, mixed use, and walkable, with a distinct identity, an identifiable center, and a "neighborhood" orientation.

See also Chapter 3: New Growth Areas and Infrastructure; and Chapter 6: City Design.

2.5-c **Infill and existing neighborhoods.** Preserve the scale and character of existing neighborhoods while allowing and encouraging appropriate infill development.

Implementing Policies

2.5-d **Zoning ordinance revision to match General Plan.** Revise the zoning ordinance and residential design guidelines to be consistent with the objectives and classifications in the General Plan, including the General Plan Land Use Diagram. These would include, but are not limited to:

- Establishing minimum and maximum densities consistent with the Plan
- Establishing graduated density standards (see Policy 2.5-l)
- Establishing overlay districts for traditional neighborhoods (see Policy 2.5-m)
- Accommodating potential future regional retail uses, such as discount superstores (see Policy 2.6-e)

2.5-e **"No net loss" of housing.** Do not allow development at less than the minimum density prescribed by each residential land use category, without rebalancing the overall plan to comply with the "no net loss" provisions of State housing law.

2.5-f **Master planning required.** Require comprehensive master planning of new residential neighborhoods in expansion areas consistent with the requirements in the General Plan. Also require that 70 percent of one master plan area is completed (building permits issued) before another starts.

See Chapter 3: New Growth Areas and Infrastructure.

2.5-g **Locations for high density development.** Maintain the highest residential development intensities Downtown, along transit corridors, near transit stops, and in new neighborhood centers.

2.5-h **Transit and pedestrian accessibility from housing.** Work with developers of affordable and multifamily housing to encourage the construction of transit-oriented and pedestrian-oriented amenities and appropriate street improvements that encourage walking and transit use.

2.5-i **Housing downtown.** Create incentives to increase residential development Downtown, on infill sites and in existing buildings. Examples include:

- Providing public subsidies for the development of affordable housing
- Utilizing Historic Building Code where applicable to encourage development of the second floors in Downtown Turlock
- Reducing on-site parking requirements
- Updating the Capital Facility Fee program to more closely reflect the reduced contribution of walkable neighborhoods to the need for additional roadway and operational infrastructure (see Policy 5.3-k).

2.5-j **Redevelopment in existing neighborhoods.** Preserve and enhance existing pedestrian-oriented neighborhoods and commercial districts by pursuing redevelopment that reinforces activity, making investments in the public realm, establishing overlay districts to preserve the neotraditional character of development, and avoiding designating competing commercial areas in close proximity.

2.5-k **Improvements in existing neighborhoods.** Enhance the character of existing neighborhoods by implementing public realm improvements where needed, and by allowing changes in scale and/or use on specified sites.

2.5-l **Graduated density.** Amend the zoning ordinance to establish graduated density standards for medium and high density residential development in neighborhoods with narrow lots, by today's standards, generally located south of Canal, east of Soderquist, north of South Avenue and west of Golden State Boulevard. In these neighborhoods, the narrow lots often cannot support Medium Density Residential development unless combined with neighboring parcels. The standard would tie allowable density to lot size, ensuring that the maximum residential density is only permitted on single lots over a certain minimum size, or on adjacent lots being developed as a single site.

2.5-m **Traditional Neighborhood Overlay Zones.** Establish overlay zoning districts for areas immediately adjacent to the Downtown, but outside the Downtown Overlay Districts which were developed post-WWII to preserve the historic quality and cohesiveness of these neighborhoods. Areas include Southwest Turlock generally bounded by Canal, Golden State, Linwood and Highway 99. Other neighborhoods may also qualify for special overlay zoning based upon prior zoning practices.

TABLE 2–5: PER CAPITA TAXABLE RETAIL SALES, 2000 AND 2008						
	TURLOCK		MODESTO		STANISLAUS COUNTY	
TYPE OF BUSINESS	2000	2008	2000	2008	2000	2008
Retail Stores						
Apparel	$139	$438	$539	$730	$247	$398
General Merchandise	1,879	3,160	2,516	2,286	1,504	1,692
Food Stores	724	763	591	668	509	596
Eating and Drinking Places	977	1,398	1,052	1,296	734	982
Home Furnishings and Appliances	262	357	556	485	313	323
Building Materials and Farm Implements	680	1,079	861	570	649	727
Auto Dealers and Auto Supplies	1,830	1,372	1,123	750	1,720	1,472
Service Stations	949	1,655	586	878	641	1,472
Other Retail Stores	985	1,328	1,816	1,553	1,358	1,255
Retail Total	8,426	11,549	9,642	9,217	7,675	8,720
Other Outlets	2,905	2,607	1,888	2,271	3,004	3,704
Total All Outlets	**$11,332**	**$14,156**	**$11,530**	**$11,489**	**$11,124**	**$12,795**

Notes:

Population in 2000: Turlock = 55,810; Modesto = 188,856; Stanislaus County = 466,997

Population in 2008: Turlock = 70,158; Modesto = 209,936; Stanislaus County = 525,903

Sources: Census 2000; California Department of Finance, 2008; California Board of Equalization, 2000 and 2008

2.6 RETAIL, COMMERCIAL AND MIXED USE AREAS

Retail areas offer convenience to Turlock residents and help shape the City's image. As of 2007, about 14 percent of Turlock's residents are employed in the retail trade sector. (See Table 2-7 in Section 2.10: Economic Development for more information on employment by industry.) Shopping and use of services are activities that enable social contact as well as business transactions. Though residents may not be familiar with neighborhoods outside their own, community shopping areas are likely to be equally well known by people living in all areas of the City. Therefore, retail districts are a critical element of people's perception of their city.

Retail and related uses within the City are also important ingredients in the City's success from a fiscal and employment viewpoint. Sales tax revenues represent the largest single revenue source

Mixed use developments with ground-floor retail are encouraged in new neighborhood centers (top). Regional retail serves both Turlock residents and the surrounding area, and can be an important source of tax revenue. However, its development also runs the risk of hurting existing local businesses if not timed appropriately (bottom).

in the City's General Fund: in fiscal year 2008-2009, sales tax revenues accounted for over 26 percent of General Fund revenue (approximately $10.6 million). Moreover, such businesses also provide jobs in the community.

As shown in Table 2-5, per capita sales in Turlock in 2000 were above the average for Stanislaus County but below the city of Modesto. By 2008, per capita sales in Turlock were higher than both Modesto and the county as a whole, showing substantial increases in many categories, including apparel, general merchandise, building materials, and service stations. The strong increases in general merchandise and apparel is related to the opening of Monte Vista Crossings Shopping Center in 2000, and its subsequent growth, with Home Depot and Target as the main anchors. Additionally, residents of smaller communities (Patterson, Newman, Delhi, and Hughson, as well as Keyes and Denair) come to Turlock to make purchases.

However, despite Turlock's per capita sales growth in apparel, it is still small relative to Modesto. This is also the case with home furnishings and appliances, which are types of merchandise for which shoppers like to have a wide selection. Turlock's relatively weak per capita sales in these categories reflect continuing weak selection in the City compared to other nearby destinations. Plan policies support the addition of retail facilities that will provide more choice in these and other categories.

Turlock's previous General Plan succeeded in considerably expanding the retail sector in the City. As such, there remains ample land designated for retail uses that is yet undeveloped. Regarding retail, the focus of this plan is to maintain the viability of existing retail, allow regional-serving retail to develop at key locations along the freeway, and encourage the development of small, neighborhood-serving commercial uses in new neighborhoods that are walkable to a majority of new homes. The following policies relate to the land use aspects of retail and related uses. For urban design policies relating to neighborhood center design, refer to the City Design Element.

POLICIES

Guiding Policies

2.6-a **Regional retail areas.** Foster strong, attractive regional retail developments in the City along the Highway 99 corridor that serve both local and regional needs, at a time when market conditions indicate that Turlock can support these uses without undermining existing local businesses.

2.6-b **Neighborhood and community commercial areas.** Facilitate the development of neighborhood and community commercial areas, which will: (a) conveniently serve current and future residential needs, (b) provide employment opportunities, (c) contribute to the attractiveness of the community, and (d) contribute to the City's tax base. Mixed use commercial areas are also encouraged, and shall be incorporated into new master plan areas.

2.6-c **Downtown retail.** Make Downtown a unique shopping district emphasizing specialty shops, entertainment opportunities, restaurants, and professional services.

See Section 2.4 for discussion and policies on Downtown.

2.6-d **Pedestrian orientation of commercial areas.** Emphasize compact form and pedestrian orientation in new community and neighborhood commercial areas, in locations that many residents can reach on foot, by bicycle, or by short drives.

Local-serving shopping centers are key elements of the neighborhoods described in Section 3.2.

Implementing Policies

2.6-e **Timing and location of regional retail.** Once Turlock grows to approximately 27,000 housing units, conduct an updated Discount Superstore Market Demand Analysis to determine the economic impacts of allowing this type of retail use within the city. As appropriate, evaluate a range of zoning options to accommodate discount superstores, including, but not limited to:

- Increasing the allowable percentage of non-taxable floor area for discount superstores; or
- Designating a new Regional Commercial zoning district or an overlay district that may include areas along State Route 99 located adjacent to Monte Vista Avenue, Fulkerth Road, Lander Avenue, or by the new southeast interchange.

2.6-f **Regional commercial developments fund transportation improvements.** Require regional commercial center developers to fund transportation improvements that will be necessary to accommodate the level of activity anticipated.

2.6-g **Local-serving shopping in new neighborhoods.** In new master-planned residential neighborhoods, ensure development of neighborhood-oriented mixed-use centers that provide convenience shopping for nearby residents. Local shopping centers

The adoption of the Westside Industrial Specific Plan has enabled substantial new industrial development on large parcels west of Highway 99.

should be collocated with uses such as parks, schools, offices, and community facilities in order to create a neighborhood center where multiple tasks can be accomplished in one trip.

Section 3.2 includes more detail on requirements for neighborhood centers in master plans.

2.6-h **Incentives for mixed use projects.** Encourage the development of mixed use (vertical and horizontal) developments on sites that have dual use designations by providing incentives. These could include:

- Updating the Capital Facility Fee program to more closely reflect the reduced contribution of walkable neighborhoods to the need for additional roadway and operational infrastructure
- FAR or residential density bonuses
- Reduced parking requirements and opportunities for shared parking

2.6-i **Limit future retail on Geer Road.** Limit additional "neighborhood/community commercial" and "strip commercial" centers along Geer Road by restricting changes in zone districts from residential or office to commercial.

2.6-j **Distribution of retail.** Distribute shopping areas so that new neighborhood centers will be located in conjunction with new housing development in master plans or in areas currently underserved by existing retail.

This policy will improve access to neighborhood centers and avoid proposals for more shopping centers than can be supported. A rule of thumb is that at least 5,000 households are needed to support a supermarket that must compete with large existing stores. In each trade area only one is likely to succeed, and duplication will cause vacancy, substandard development, or attempts to locate inappropriate uses on sites that are unable to attract a supermarket.

2.6-k **Small neighborhood groceries allowed.** Continue to allow neighborhood grocery stores not exceeding 2,500 square feet in areas wherever they can be supported and will not create unacceptable traffic problems or nuisance due to hours of operation.

The Land Use Diagram does not recognize all existing neighborhood groceries or indicate sites at all locations suitable for additional stores.

2.6-l **Retail in the Downtown Master Plan.** Continue to implement the Downtown Master Plan, emphasizing the creation of a retail district that serves both everyday and specialty retail needs.

See Section 2.4 for discussion of the Downtown.

2.7 INDUSTRIAL AREAS

Turlock's agricultural setting has historically provided a basis for the City's industry. Food processing is the primary industry, providing the largest number of industrial jobs in Turlock. Four of the top ten employers in the city are food processors, and Foster Farms, the third-largest employer in the city, employs 1,500 workers. Fourteen percent of jobs in Turlock are in manufacturing, and four percent are in the warehousing and transportation industries, which are large users of industrial space. More detail on employment by industry is found in Section 2.11, Economic Development.

Through the creation and implementation of the Westside Industrial Specific Plan (WISP), Turlock has reaffirmed the continuing importance of industrial development as a main source of jobs and economic growth in the City. Policies in this section reinforce the WISP and aim to make industrial development a viable enterprise without negatively impacting other land uses in the city.

POLICIES

Guiding Policies

2.7-a **Concentrate industrial uses in the TRIP.** Minimize conflicts between industry and other land uses by concentrating industrial activity west of Highway 99, specifically in the Turlock Regional Industrial Park (TRIP) area.

Though some industry, including major poultry processing operations, is located east of the freeway, future industrial growth will be directed to the west, into the TRIP, where land use conflicts will be minimized.

2.7-b **Attract industry to Turlock.** Enhance the positive factors that have made the City attractive to industry, including freeway access, available large parcels of land, inexpensive power, a streamlined development process, and an appropriately-skilled workforce.

Some of the factors that affect industrial location are not within the control of the City; for example, the long-term availability of water. The City's investigation of alternative water sources including well-head treatment may result in a solution to this problem before it becomes a constraint on future development. Plan policies in section 3.3 address these issues.

Implementing Policies

2.7-c **Focus industrial uses west of Highway 99.** Focus industrial development west of Highway 99 by continuing to implement the Westside Industrial Specific Plan.

2.7-d **Incentives for public amenities.** Offer added incentives to industrial projects in the TRIP that contribute to the pedestrian, bicycle, or transit networks and/or public amenities and open space.

2.7-e **Truck routes and industrial streets.** Designate appropriate truck routes and "industrial streets" in order to accommodate industrial traffic and avoid unanticipated conflicts.

See Policy 5.5-k.

2.7-f **Design to minimize impacts.** Design industrial development to minimize potential community impacts adversely affecting residential and commercial areas in relation to local and regional air quality and odor, adequacy of municipal service, local traffic conditions, visual quality, and noise levels.

2.7-g **Buffers between uses.** Buffer industrial and heavy commercial areas from adjacent residential, commercial, and recreation areas using public infrastructure, right-of-way, landscaping, or a combination thereof.

2.7-h **Single-use industrial areas.** Designate industrial areas to be solely utilized by industrial uses to maintain and encourage mutually supportive, attractive, and compact industrial environments and to be protected from encroachment or preemption by other incompatible uses.

2.8 PROFESSIONAL OFFICE AND BUSINESS PARK AREAS

In recent years, office employment in Turlock is provided by jobs in education (Turlock school districts and CSUS), government (City of Turlock and Turlock Irrigation District), and the health care industry (Emanuel Medical Center). The City's largest concentrations of office space are along East Main Street and Canal Drive in the central part of the city, City Hall on South Broadway, around Emanuel Medical Center, and Downtown. Offices are also found along the southern part of Geer Road, mixed with retail businesses. As the City grows, it is likely that the space needed for both government services and health-care related services will increase.

While office employment has not historically been a major contributor to the City's economy, there are good reasons to implement strategies to increase office activities. Growth in trade, manufacturing and service sectors, projected to account for the largest increase in employment over the next 20 years, is likely to spur office development. Office employment does not create heavy demands on the City's water supply and wastewater treatment facilities, or directly generate air pollution emissions. Further, expansion of office activities such as those in the finance, insurance and real estate (FIRE) category would diversify the City's economic base and offer more varied employment opportunities for Turlock area residents.

POLICIES

Guiding Policies

2.8-a **Provision of sites for office and business park uses.** Contribute to diversifying the City's employment base by maintaining large sites designated for office/business park use, including sites on Golden State Boulevard and business park sites in the TRIP.

2.8-b **Office locations.** Encourage local-serving offices to locate in and near Downtown and in proximity to existing professional office clusters, such as the Emanuel Medical Center.

Implementing Policies

2.8-c **Nodes of offices throughout the city.** Continue creating a concentration of medical offices in the vicinity of Emanuel Hospital, while still encouraging new nodes of office development along Geer Road and North Golden State Boulevard.

2.8-d Offices linking destinations. Link two prominent office clusters—Emanuel Medical Center and Downtown—by extending the Office designation along Colorado Avenue to East Main Street. These offices may be part of mixed use developments that include retail and/or residential uses.

2.8-e Largest office users in the TRIP. Direct the largest office users to appropriately designated sites in the TRIP office and business park areas.

2.8-f City administrative offices located Downtown. Prioritize Downtown as a preferred location for the construction of any new City administrative offices, to maintain the government's central location and to set a precedent for Downtown office development.

2.9 THE PLANNING AREA AND CITY/COUNTY RELATIONSHIPS

As described in Section 1.3, The Planning Area is the geographic area for which the General Plan establishes policies about future urban growth, long-term agricultural activity, and natural resource conservation. The boundary of the Planning Area, which encompasses approximately 40 square miles, was determined by the City Council in response to State law requiring each city to include in its General Plan all territory within the boundaries of the incorporated area as well as "any land outside its boundaries which in the planning agency's judgment bears relation to its planning" (California Government Code Section 65300). The Planning Area is defined as such because it is that portion of the unincorporated area that has a direct impact on City services and infrastructure demands.

Turlock also defines a Study Area, which is a smaller area (27 square miles) defining the outer limit of where urban development may take place over the next 20 years. The Study Area includes land that is currently unincorporated, as well. As described in Chapter 3: New Growth Areas and Infrastructure, unincorporated areas within the Study Area shall be annexed into Turlock following an explicit phasing and master planning process. Inclusion of unincorporated land in the Planning Area and the Study Area does not mean that the City disagrees with County policies—in many cases the intent of the General Plan is to support or express agreement with County policies for surrounding areas. Additional policies relating to City/County relationships are addressed in Chapter 3: New Growth areas and Infrastructure; and Section 7.2: Agriculture and Soil Resources.

POLICIES

Guiding Policies

2.9-a **Agriculture belongs in unincorporated areas.** Support Stanislaus and Merced County policies that promote continued agricultural activity on lands surrounding the urban areas designated on the General Plan Diagram.

2.9-b **Urban land uses belong in incorporated areas.** Work with Stanislaus County to direct growth to incorporated areas and established unincorporated communities.

A key policy of the General Plan is the limited and orderly expansion of the City. This policy would be undermined by approval of urban activities in unincorporated areas.

2.9-c **Encourage infill and more compact development to protect farmland.** Relieve pressures to convert valuable agricultural lands to urban uses by encouraging infill development.

2.9-d **Incorporate existing urbanized areas.** Seek to include in the City all urbanized areas contiguous with City territory. The City's first priority for annexation shall be the numerous unincorporated County islands located wholly within Turlock (see accompanying policies in Section 3.1). A second area of priority, should property owners desire it, is the area of commercial uses north of Taylor Road on both sides of State Route 99 to Barnhart Road. While the City shall not initiate the annexation of these properties, it will work with property owners on developing financing and infrastructure improvement strategies to facilitate annexation should they express interest.

2.9-e **Work with County on regional projects.** Cooperate with County agencies in planning for transportation improvements and other major projects affecting multiple agencies.

The Stanislaus County Expressway Study and the County's Congestion Management Program are two of the major projects in which the City and County are participating. Both projects are led by the Stanislaus Council of Governments (StanCOG), the County's Regional Transportation Agency.

2.9-f **Work with County on mitigating impacts of growth.** Work with Stanislaus County to implement financing mechanisms to ensure that development within the Planning Area pays its fair share of both City and County improvements required to mitigate the impacts of growth.

Implementing Policies

2.9-g **Stanislaus County plans for Denair and Keyes.** Stanislaus County shall remain responsible for land use planning for the unincorporated communities of Keyes and Denair. However, the City of Turlock shall review development proposals in these communities to ensure that they are consistent with the City's ability to provide wastewater treatment services, on which they depend.

2.9-h **Cooperate at the City/County line.** Seek Stanislaus County cooperation in designating unincorporated land for uses compatible with adjacent City lands.

2.9-i **LAFCO approval for Sphere of Influence changes.** Seek LAFCO approval of Sphere of Influence changes to reflect the General Plan Diagram, upon completion of the master plan updates for the sewer, water, and wastewater treatment systems, and upon completion of the Capital Facilities Fee update (within two years of adoption of the General Plan).

LAFCO action would clearly demarcate those areas that are expected to be urbanized and incorporated in the future. Lands not within the City's Sphere of Influence (and outside of Keyes and Denair) are to remain subject to the County's regulations for lands designated for agricultural use. Including Turlock's expansion areas in the City's sphere will mean that prezoning and annexation criteria relating to orderly expansion of the City will have to be met before development proposals will be considered.

2.9-j **Phasing of annexations.** Annexations to the City should proceed according to the phasing plan described in Section 3.1.

2.9-k **Fee-sharing programs.** Update the City's agreement with Stanislaus County regarding collection of the public facilities fee. The agreement should stipulate that the City will collect and pass on to the County development fees for County improvements, and the County will refer to the City applications for development in the City's Sphere of Influence.

The fee sharing agreement helps avoid the fiscalization of land use decisions in the county, discourage urban commercial development in unincorporated areas, and promote urban infill and redevelopment.

This policy is consistent with the Stanislaus County General Plan, which was amended following a pioneering agreement made between the City and County. Subsequent to that time, the County entered into similar agreements with each of the cities in the

County. However, the agreement between Turlock and the County lapsed without renewal. This policy advocates renegotiation of the agreement without provision of a sales tax revenue pass-through.

2.9-l **County island incorporation.** Work with Stanislaus County to identify possible revenue tools for underwriting necessary improvements in order to encourage incorporation of County islands.

Development standards in the islands differ from those in the surrounding areas. Incorporation should be made a condition of project approval on any property in any of the islands. See also policies in Section 3.1, Growth Strategy, for timing strategies related to County island incorporation.

2.9-m **Work with StanCOG on regional issues.** Continue to participate with StanCOG on matters of mutual concern to the City and County. These include programs such as regional expressway studies, housing needs determination, the Regional Transportation Plan (RTP), the Sustainable Communities Strategy (SCS), and others.

Land in Urban Reserve is predominantly agricultural in nature, and is anticipated to remain as such through the buildout of this General Plan.

2.10 URBAN RESERVE

The General Plan Diagram classifies land in the Turlock Study Area for a variety of land uses, which the City believes addresses future community needs through the year 2030. Land classified as Urban Reserve in this General Plan is that which is believed may remain committed to agricultural uses for the foreseeable future. On the other hand, land outside current city limits that is believed to be necessary to accomodate future growth is designated as master plan areas. It is the City's intent that land classified as Urban Reserve should remain agricultural in use over the course of the planning period (through 2030), but may eventually give way to urban uses as the community's economic needs continue to evolve over time (likely beyond the time horizon of this General Plan). The timing of conversion of Urban Reserve land to urban uses may be reconsidered if development occurs at a substantially slower or faster pace than projected in this Plan. However, this conditions would generally give way to another update of the General Plan.

Policies that address the timing and circumstances for the reclassification of land classified Urban Reserve to specific land use classifications to accommodate urban uses are outlined below. The conversion of Urban Reserve land to urban uses is treated in more detail in Chapter 3: New Growth Areas and Infrastructure.

POLICIES

Guiding Policies

2.10-a **Consider needs beyond the year 2030.** Ensure the City's ability to accommodate future urban growth and development beyond the 2030 time horizon of the General Plan.

Implementing Policies

2.10-b **Reclassifying Urban Reserve land.** Land classified Urban Reserve, located within the Study Area but situated outside the city's Sphere of Influence, may not be reclassified to accommodate specific urban uses and annexed until the following occurs:

a) the City Council finds that the City has less than a four year supply of vacant land for development in its inventory and all master plans identified in this General Plan have been fully developed; or
b) the City Council, by a 4/5ths affirmative vote, finds in the public interest to reclassify property to accommodate an industrial or commercial use that will be the source of significant employment. A comprehensive General Plan Amendment shall accompany any secondary residential use in this area.

In either case, the reclassification must take place as part of a master planning process, or, ideally, trigger an update to the General Plan.

2.11 ECONOMIC DEVELOPMENT

Turlock's economy has traditionally been based on agriculture, agriculture-related industries (primarily food processing), and other manufacturing. Its location in the heart of the San Joaquin Valley, home to some of the most fertile farmland in the world, naturally led to Turlock's agricultural heritage and employment base.

Over the past 50 years, Turlock's population has grown from 9,000 in 1960 to 70,000 today. The economy has shifted to focus on schools, government, and service businesses to serve the population. The largest single employer is now the Turlock Unified School District. The largest industry sectors are state and local government (15 percent), retail (14 percent), manufacturing (14 percent), health care and social assistance (12 percent) and accommodation and food services (10 percent). These activities will likely remain the strongest components of the city's job base as the population continues to grow.

While most economic activity occurs in the private sector, the City can take an active role in furthering its economic prosperity. Examples of what the City can do to spur economic development include:

- Ensuring that local policies do not impede the needs of businesses to move or expand;
- Facilitating and acting as a catalyst for development in strategic market segments, especially those that may spur other activities or provide fiscal benefits;
- Coordinating and providing for infrastructure improvements; and
- Generating revenue to support community development objectives.

This section describes Turlock's economic development strategy and provides policies to implement the City's goals.

ECONOMIC CONTEXT AND EMPLOYMENT PROFILE

Overall, the key economic drivers in Stanislaus County are retail trade, manufacturing, and public or non-profit (e.g. health care) related sectors. While the manufacturing sector reflects the regions' competitive location and labor force characteristics, the latter two sectors are primarily population driven. Modesto currently serves as the primary employment center in Stanislaus County, providing about 70 percent of the total jobs, with Turlock in second at about 20 percent.

Turlock's employment composition is reflective of the County as a whole. Turlock's major sectors are State and Local Government (15 percent), Retail Trade (14 percent), Manufacturing (14 percent), Health Care and Social Assistance (12 percent) and Hotel and Food Services (10 percent). For the County, Manufacturing and Retail Trade represent the largest employment sectors, followed by "Health Care & Social Assistance." These three sectors account for about 40 percent of total jobs in Turlock and 45 percent Countywide (Table 2-6).

The leading employers in Turlock and the County reflect the trends described above. As shown in Table 2-7, the Turlock Unified School District (TUSD) employs the highest number of employees in the City with 2,200 employees. Emanuel Medical Center is second, with over 1,500 employees. The City's poultry processing plant, Foster Farms, is the third-largest employer in the City with a total of 1,500 employees. Overall, the top ten employers employ a total of approximately 8,000 employees in the City or close to 30 percent of the total. Four of the top employers within the County are located in the City, which includes California State University (CSU) Stanislaus, Emanuel Medical Center, Foster Farms, and Stanislaus County Community Services.

For the most part, historical employment growth has reinforced the economic patterns described above and substantiates the declining importance of agriculture both regionally and locally (near and within urbanized areas). Specifically, population-driven sectors such as State and Local Government, Health Care & Social Assistance and Accommodations & Food Services have provided the largest contributions to employment growth in Turlock and the County as a whole since 2000. Meanwhile, agriculture was the only sector to experience declining employment across all jurisdictions during this period. Turlock also experienced a significant decrease in Management of Companies and Enterprises (with 1,100 jobs) and Construction (with 300 jobs).

Jobs/Housing Balance

Commute patterns play an increasingly important role in population growth and thus, urban land demand. Information on Turlock's jobs-housing balance and the travel patterns of both local residents and employees provide important insight into its evolving role in the regional economy. In the long-run, areas such as Turlock that are not centrally located relative to major job centers need to expand economically in order to sustain future population.

TABLE 2–6: EMPLOYMENT BY INDUSTRY IN STANISLAUS COUNTY AND TURLOCK (2007)				
	STANISLAUS COUNTY		TURLOCK CITY	
MAJOR INDUSTRY[1]	#	%	#	%
Accommodation & Food Services	13,629	7.8%	2,693	9.5%
Admin & Support & Waste Mgmt.	7,732	4.4%	1,140	4.0%
Agriculture, Forestry, Fishing & Hunting	12,880	7.3%	1,840	6.5%
Arts, Entertainment, & Recreation	1,660	0.9%	N/A	N/A
Construction	11,164	6.4%	1,793	6.3%
Educational Services[2]	2,246	1.3%	100	0.4%
Federal Government	1,100	0.6%	90	0.3%
Finance & Insurance	3,985	2.3%	725	2.6%
Health Care & Social Assistance	19,821	11.3%	3,398	12.0%
Information	2,331	1.3%	203	0.7%
Local Government	23,500	13.4%	2,908	10.3%
Mgmt. of Companies and Enterprises	1,866	1.1%	207	0.7%
Manufacturing	22,771	13.0%	4,004	14.2%
Mining	29	0.0%	0	0.0%
Non-Classified	71	0.0%	N/A	N/A
Other Services	7,595	4.3%	1,211	4.3%
Professional, Scientific, & Tech Skills	5,460	3.1%	676	2.4%
Public Administration	66	0.0%	0	0.0%
Real Estate & Rental & Leasing	2,166	1.2%	252	0.9%
Retail Trade	22,111	12.6%	4,018	14.2%
State Government (Includes CSU Stanislaus)[2]	1,800	1.0%	1,227	4.3%
Transportation, Warehousing, and Utilities	5,600	3.2%	1,034	3.7%
Wholesale Trade	6,027	3.4%	739	2.6%
Total Employment (All Industries)	**175,610**	**100.0%**	**28,258**	**100.0%**
Total Employment as a % of County	**100.0%**		**16.1%**	

1. Based on the annual average employment for each industry. N/A represents confidential data.
2. According to the U.S. Census NAICS code for 2007, public schools and college universities are generally categorized in the Educational Services industry. However, California EDD included the primary and secondary public schools in Local Government and higher education (e.g. CSU Stanislaus) employees in the State Government category.

Sources: California EDD and EPS

TABLE 2–7: CITY OF TURLOCK TOP 10 MAJOR EMPLOYERS		
EMPLOYER	**INDUSTRY**	**NUMBER OF EMPLOYEES[1]**
Turlock Unified School District	School District	2,202
Emanuel Medical Center	Healthcare Facility	1,549
Foster Farms	Poultry Processor	1,500
CSU, Stanislaus	Public University	1,100
Turlock Irrigation District	Water & Electric Utility	495
Wal-Mart	Retailer	415
City of Turlock	City Government	351
Mid-Valley Dairy (Sunny Side Farms)	Dairy Products	215
Sensient Dehydrated Flavors Inc.	Food Manufacturer	180
Subtotal		8,007
Estimated Jobs in Turlock in 2008		28,995
% of Total Turlock Jobs		27.6%

1. Information as of March 2008.

Sources: Indicators (Stanislaus Economic Development & Workforce Alliance) and City of Turlock.

Historical data on Turlock's jobs-housing balance and jobs to employee ratios suggest that the City has maintained relatively balanced population and employment growth. Specifically, since 1991 the City has consistently provided about 1.1 jobs per household (Table 2-8). This ratio compares favorably to the County as a whole which provides about one job per household. In addition, the City provided about one job per resident in the workforce in 2007, a 12 percent increase from 1991. Again, the City has out-performed the County in this regard as the County currently provides about 0.8 jobs per resident in the workforce.

The 2000 Census provides detailed data on travel patterns by both place of work and place of residence. Although relatively dated, this data also suggest that most of Turlock's residents and employees work and live locally. Specifically, about 48 percent of the City's employed residents worked in Turlock while about 82 percent worked in the County in 2000 (Table 2-9). In addition, about 54 percent of Turlock employees live in the City and about 81 percent live in the County. Turlock is a city where most people work locally: over 50 percent of jobs in Turlock are held by Turlock residents, and 82 percent of Turlock residents work somewhere in Stanislaus County.

TABLE 2–8: JOBS TO EMPLOYEES RATIO AND JOBS TO HOUSING UNIT RATIO			
COUNTY/CITY	1991	2001	2007
Stanislaus County			
Jobs to Housing Unit Ratio			
Jobs	133,549	164,475	175,124
Housing Units	132,027	150,807	176,622
Jobs to Housing Unit Ratio	**1.01**	**1.09**	**0.99**
Jobs to Employees Ratio			
Employees	159,100	196,400	210,900
Jobs to Employees Ratio	**0.84**	**0.84**	**0.83**
City of Turlock			
Jobs to Housing Unit Ratio			
Jobs	18,720	22,906	28,258
Housing Units	15,921	19,096	23,993
Jobs to Housing Unit Ratio	**1.18**	**1.20**	**1.18**
Jobs to Employees Ratio			
Employees	19,800	24,900	26,700
Jobs to Employees Ratio	**0.95**	**0.92**	**1.06**

Sources: California EDD Quarterly Census of Employment and Wages; California Department of Finance; California Employment Development Department Labor Market Info

A healthy, active Downtown is an important economic asset.

Over 75 percent of the Turlock workforce commutes less than 30 minutes to work. Less than five percent of Turlock workers commute to the San Francisco Bay Area.

ECONOMIC DEVELOPMENT STRATEGY

Over the time frame of this General Plan, the City of Turlock is expected to add around 45,000 new residents, an increase of nearly 65 percent. In order to support this population, the City will need to add jobs. While many jobs will "naturally" arise from the services needed to support this growing population (such as schools, retail and personal services, police and fire protection, and others), additional jobs in other sectors—appropriate for workers with a range of skill types—will also be necessary.

TABLE 2–9: SUMMARY OF EMPLOYED RESIDENTS' PLACE OF WORK AND RESIDENCE IN 2000		
PLACE[1]	TOTAL	% OF TOTAL
Local Residents		
Place of Work		
Turlock	10,000	48.6%
Modesto	3,920	19.0%
Ceres	555	2.7%
Other Cities	1,055	5.1%
Remainder of County	2,305	11.2%
Subtotal Stanislaus County	**16,780**	**81.5%**
Other Counties		
Alameda	213	1.0%
San Joaquin	754	3.7%
Merced	2,090	10.1%
Remainder of Other Counties	756	3.7%
Subtotal Other Counties	**3,813**	**18.5%**
Total Employed Residents	**20,593**	**100.0%**
City Jobs		
Place of Residence of Employees		
Turlock	10,000	54.4%
Modesto	2,360	12.8%
Ceres	775	4.2%
Other Cities	1,850	10.1%
Remainder of County	1,815	9.9%
Subtotal Stanislaus County	**14,950**	**81.3%**
Other Counties		
Alameda	38	0.2%
San Joaquin	338	1.6%
Merced	2,764	13.4%
Remainder of Other Counties	307	1.5%
Subtotal Other Counties	**3,447**	**18.7%**
Total City Jobs	**18,397**	**100.0%**

1. Data available for the year 2000 only.

Source: U.S. Census

The City recognizes that while its location in the Central Valley lends many advantages in job attraction, it is also a competitive environment. Many similar cities in the Valley possess the same assets—central location, available inexpensive land, freeway and rail access—and therefore Turlock must build upon its unique strengths and differentiate itself from its neighbors.

Turlock's Strengths

Turlock's strongest assets for economic development include:

- **CSU-Stanislaus,** a four-year public university campus with approximately 6,800 full-time equivalent students. Disciplines seeing the most significant growth include business, health sciences and services, psychology, security and protective services, agriculture, and biomedical sciences. Similarly, Turlock has a well-educated workforce, with education levels exceeding those of Stanislaus County overall (23 percent of Turlock residents had a bachelor's degree or higher in 2007, versus 16 percent countywide).

- Adoption of the **Westside Industrial Specific Plan (WISP)** in 2006, which allocated over 2,600 acres for industrial and business park development on the west side of Highway 99. Through development of the TRIP, Turlock aims to enable significant industrial development and improve the jobs-housing balance in the area. The plan covers land use regulations, design guidelines, and phasing. Through the creation and nurturing of an 'Agri-Science' industry cluster, which would include biotech, life sciences, and agri-business, the TRIP aims to create a "bridge" for Turlock's current agriculture and manufacturing industries to transition to newer products and technologies.

- **A strong existing food processing sector,** including such large employers as Foster Farms, Sensient Flavors, Supherb Farms, and Mid-Valley Dairy. These businesses form an "anchor" and may help attract similar establishments by appearing as a long-time successful industrial node.

- **Emanuel Medical Center,** with its 209-bed acute care hospital, 145-bed skilled nursing facility, 49-bed assisted living facility, and outpatient medical offices for primary care on Colorado Avenue and Monte Vista Avenue, is both a community and a regional asset and a source of high paying, high-skilled jobs.

Many unincorporated county islands are in need of substantial investment and public infrastructure improvements.

- **Downtown Turlock,** anchored by City Hall, is home to historic building stock, recently implemented streetscape and public realm improvements, and a number of restaurants and specialty shops. The Downtown Property Owners Association is actively involved in the betterment and continued development of Downtown and works closely with the City. Additionally, in 2008, a Branding, Development, and Marketing Action Plan was completed for the Downtown that posed the idea of a bridal shopping and wedding planning theme for the area.

- **Youth Sports.** Particularly with the completion of the Regional Sports Park, Turlock has become a center for youth sports competitions attracting teams from across the State. This activity has had noticeable positive "spin-off" impacts, providing business for hotels and restaurants. With the establishment of more community parks through 2030, as well as increased utilization of the County Fairgrounds, Turlock can further establish itself as a youth and amateur sports destination.

- **Competitively priced electricity.** Turlock's homes and businesses receive electric power from the Turlock Irrigation District (TID), which offers power at significantly lower rates than many other providers. For many industrial users with large power needs, such as cold storage facilities, this is a significant asset.

- **An active Chamber of Commerce.** The Turlock Chamber of Commerce, comprised of over 500 members, plays an active role in advocating for business interests and a strong local economy. The Chamber facilitates networking and business opportunities amongst its members, and it maintains a strong working relationship with the City.

- **Available water and wastewater treatment capacity.** With the development and recent upgrade of the Turlock Regional Water Quality Control Facility (TRWQCF), Turlock is well positioned to accommodate future growth in the residential, commercial and industrial sectors. The TRWQFC now produces recycled water suitable for reuse in city landscaping and in industrial processes. The current and planned treatment facilities will occupy less than half of the facility's 140 acre site, allowing for ample future expansion.

- **Land available at low cost.** Not only does the TRIP enable significant industrial development in Turlock, but the specific plan area has ample developable land. Land costs in Turlock are significantly lower than those in coastal California or even the outer edges of the Bay Area; this is the case for both industrial/commercial as well as residential land.

- **Presence of County Fairgrounds.** Turlock hosts the Stanislaus County Fairgrounds, a major asset for business generation and tourist attraction. The Fairgrounds are used not only for the annual County Fair but also for other regional events throughout the year. The County has also expressed interest in expanding the fairgrounds.

Turlock's Challenges

Turlock's economic development strategy must not only capitalize on the City's strengths, but also recognize and address its challenges. Some challenges that Turlock faces regarding economic growth include:

- **Location.** While Turlock is ideally located for distribution to west coast markets, particularly the San Francisco Bay Area, other nearby cities enjoy this same advantage, including Modesto, Manteca, and Lodi. Moreover, Turlock has excellent access to Highway 99 but limited access to Interstate 5. The City cannot change its location, but it can direct its efforts toward economic development that benefits from the City's location but is not entirely dependent upon it. Additionally, planning efforts are underway with Stanislaus County and the City of Patterson to develop West Main Street as an east-west expressway that would connect Turlock more efficiently to I-5.

- **Downtown Turlock.** While Downtown has made great strides in recent years, the current economic downturn has taken a toll on the area's vitality. The deep recession that has affected the entire nation has also impacted Downtown Turlock, raising vacancy rates and turnover in the past few years. The existing stores and the presence of City Hall create activity during the day, but the area experiences less activity at night. More people living close to Downtown, and more active uses in Downtown buildings (or new buildings) would be of great benefit.

- **Lack of linked economic activities.** While Turlock has numerous economic assets and several employers with over 1,000 jobs, they have not attracted a significant amount of linked economic activities—either because they take care of their needs in-house, or because they rely on suppliers and other businesses outside of Turlock or even the State. Some examples of linked activities and economic synergies do exist, such as between the hospital and the university's nursing program, but more horizontal and vertical linkages could be made.

Economic development policies aim to both attract new economic growth as well as support and strengthen the city's existing business establishments.

New industrial establishments are an important employment generator for the city.

- **Social Issues and Public Safety.** Turlock, like many other communities in the Central Valley, struggles with a number of social issues such as homelessness. While the majority of Turlock's neighborhoods are safe and secure, the persistence of some of these social and public safety issues may affect the city's image.

- **Perception of Permit Process for Small Businesses.** Many involved in Turlock's economic development have voiced concern over the City's practices as not being sufficiently "business friendly" to attract new employers. Even though the City has made strides in improving its permitting process, some involved in Turlock's economic development voice concern over the perception of the City's practices as not being sufficiently easy and welcoming to attract new employers. Rigid code enforcement for small businesses and renovations were cited as potential problem areas.

- **Transportation and Infrastructure Maintenance.** The City has struggled to maintain the quality of existing city streets that are seeing heavy industrial truck traffic, and those in the western neighborhoods. Much of this is attributable to fiscal issues. Investment in infrastructure is critical to attracting businesses, but at the same time, the City must maintain a fee structure that requires major users to help pay the way.

- **County Islands.** Turlock has several areas of unincorporated county land surrounded on all sides by the incorporated city, creating "county islands." Because the county is lands are not served by city infrastructure, the lack of improvements and the quality of development is generally below the City's standards and therefore negatively impacts Turlock's image. The City is engaged in developing a strategy with Stanislaus County to incorporate and upgrade these areas.

Economic development policies aim to both leverage the City's assets and address its challenges in order to foster continued economic growth through 2030. The policies presented in this section include specific economic development programs as well as more generalized strategies for improving the City's overall business climate and image, and promote a positive working relationship with the private sector. Other related policies, especially pertaining to Downtown, transportation and utilities, and public safety can be found elsewhere in this Chapter, as well as in Chapter 3 (New Development Areas), Chapter 5 (Circulation), Chapter 6 (City Design), and Chapter 10 (Safety).

POLICIES

Guiding Policies

2.11-a **Support existing businesses.** Retain, improve, and promote existing businesses in Turlock and foster local start-up businesses.

2.11-b **Attract businesses to serve local residents and regional shoppers.** Attract community-serving retail, and basic industrial and service activities to meet the needs of our residents, while continuing to promote and develop Turlock as a regional shopping destination.

2.11-c **Facilitate new development.** Define clear development standards and process development applications expeditiously.

2.11-d **Support and maintain Downtown Turlock.** Support and contribute to a clean, safe, pedestrian-friendly, and well-maintained Downtown.

2.11-e **Strengthen the City's image.** Create an image for Turlock that will help attract and retain economic activity, and proactively market that image regionally and statewide.

2.11-f **Sustain fiscal health.** Ensure the continued economic sustainability of the community and fiscal health of the City government.

2.11-g **Maintain the jobs-workers balance.** Maintain a balance between jobs and the number of employed residents.

2.11-h **Recognize and promote strength in the food processing sector.** Even as Turlock pursues jobs in new industries, continue to recognize and promote the City's current strength as a food processing center, with a workforce highly skilled in this industry.

Implementing Policies

Industry Targeting and Recruitment

2.11-i **Monitor new industrial trends.** Monitor regional, state, and national economic trends in order to identify new and emerging industries suitable for Turlock.

Among others, industries to watch include agricultural and food sciences, clean technology manufacturing, and health care,

2.11-j **Engage in strategic planning.** Every five years, complete a citywide economic development strategic plan that focuses on industry targeting, job creation, marketing, and local business support. Evaluate progress, accomplishments, and challenges every year in an annual report that will help guide subsequent efforts.

2.11-k **Increase linked activities and businesses.** Work with large existing employers to identify and recruit related businesses and those that provide goods and services to meet their business needs.

2.11-l **Attract jobs for local residents.** Set economic development target and implementation measures to increase the percentage of employed residents who work in the City to 60 percent of the total by 2020.

As of 2000, 49 percent of employed Turlock residents worked in the city.

2.11-m **Bolster sports tournament industry.** Incorporate sports facilities suitable for tournaments into the design of new community parks and recreation areas. Encourage local hotels and other traveler-supported businesses to sponsor sports tournaments and contribute to the upkeep of the facilities in exchange for advertising and marketing rights.

Promoting and Facilitating Industrial Development

2.11-n **Direct industrial users to the TRIP.** Direct new industrial users to the TRIP and continue to implement the WISP.

2.11-o **Advertise available land.** Continue to market the availability of development sites by routinely updating the City's database of available vacant and underutilized parcels and making it available on the City's website. These can include both large industrial and business park parcels in the TRIP as well as smaller office or retail sites in shopping centers, along major roads, and Downtown.

2.11-p **Promote the TRIP.** Develop and implement a marketing strategy aimed at potential large industrial, R&D, and business park employers in order to attract more development and jobs to the TRIP.

2.11-q **Continue to review permit streamlining.** Ensure that the City's permitting procedures are streamlined through the continuing review of the system by the Development Collaborative to solicit input from the business community and work with the City to improve business processes.

2.11-r **Continue to offer economic incentives.** To the extent possible, continue to offer economic development incentives in specific economic zones.

At present, this includes the Enterprise Zone 40. All of the TRIP is included in this zone. The zone makes available a number of beneficial tax deductions, credits, and incentives that reduce the cost of development, hiring, and capital investment.

2.11-s **Re-evaluate fees.** Continue the current effort to update the City's building permit fees to better reflect actual costs to the city. Periodically reevaluate development impact fees to reflect any adjustments in the cost of construction, any outside grant funding awarded to the City, and any other appropriate adjustments.

2.11-t **Improve connection to Interstate 5.** Work with Stanislaus County and the City of Patterson to establish West Main Street as an expressway connecting Turlock to I-5.

2.11-u **Encourage land assembly.** Continue to encourage landowners of small parcels to assemble their properties to better facilitate commercial or industrial development. Strategies can include hosting informational meetings at the City, contacting property owners directly, developing financial incentives for land assembly, and promoting new graduated density zoning amendment (forthcoming; see Policy 2.4-l).

Fostering Partnerships

2.11-v **Engage business organizations.** Maintain a strong working relationship between the City and the Turlock Chamber of Commerce, as well as other local and regional business groups such as the Downtown Property Owners Association and the Stanislaus County Workforce Alliance.

2.11-w **Continue to participate in annual meetings with Chamber of Commerce and the Workforce Alliance.** Continue to participate in the annual summits and business conferences sponsored by the Chamber of Commerce and the Stanislaus County Workforce Alliance in order to identify how the City can best assist them or improve City services.

2.11-x **Continue to participate in local business organizations' meetings.** Continue to attend and participate in all meetings of the Chamber of Commerce and the Downtown Property Owners Association.

2.11-y **Support business outreach strategies.** Continue to support the business outreach strategies of the Development Collaborative Advisory Committee to solicit input on how the City can improve its services.

2.11-z **Foster ongoing and new partnerships with CSUS.** Maintain the City's relationship with CSUS, and continue to pursue new opportunities to work with the university on workforce training, community services, sharing of facilities, and employer recruitment efforts, among others.

2.11-aa **Provide a City resource for regional events management.** Establish a "go-to" person at the City who will be a source of information on upcoming regional events, such as youth sports tournaments. This City resource will be someone that businesses, such as hotels, can contact for information on when large groups of visitors will be coming to Turlock and pursue business opportunities accordingly. Also establish a monthly calendar on the City's website that shows local events.

2.11-ab **County Fairgrounds strategy.** Work with the Stanislaus County Fair Board to either expand the County Fairgrounds at its current site, or to identify a new site west of State Route 99 for relocation.

Workforce Training and Local Start-up Support

2.11-ac **Partner with CSU-Stanislaus in workforce training.** Coordinate with CSU-Stanislaus to publicize available educational and training programs by using the City's website and making information available through the library and City Hall.

2.11-ad **Support new start-ups.** Continue to support the assistance program for local start-up businesses.

Continue to work with the Stanislaus Economic Development and Workforce Alliance and CSU-Stanislaus to establish a branch of the Central California Small Business Development Center (SBDC) in Turlock. SBDCs offer classes in starting and operating a small business.

Supporting Downtown and Neighborhood Commercial Centers

2.11-ae **Enable renovation of Downtown buildings.** Work with the Building Division and a structural engineer to identify less expensive seismic retrofit, fire safety, and ADA compliance options for older buildings Downtown in order to encourage their renovation.

2.11-af **Market the Downtown Turlock commercial district.** Continue working with the Chamber of Commerce and the Downtown Property Owners Association to support marketing, promotions, and events that bring people to Downtown.

In particular, the focus should be on establishing ongoing events (weekly, monthly) that will bring people Downtown on a regular basis. Examples include an additional farmers' market or craft market, children's activities, or an outdoor performing arts/ concert series.

Fostering a Positive Image

2.11-ag **Pursue beautification projects.** Continue implementation of the Downtown Design Guidelines, and begin implementation of the Turlock Beautification Master Plan.

2.11-ah **Market Turlock's assets.** Market information about Turlock's livability, great schools and parks, relative affordability, and other features to prospective employers to help encourage businesses to locate in the city.

2.11-ai **Educate users about the improved permitting process.** Work to diffuse any lingering negative perceptions about Turlock's permitting process by showcasing improvements that have been made in recent years, as well as any future improvements.

2.11-aj **Promote Turlock's workforce.** In addition to marketing Turlock as a desirable destination for new employees, strongly promote the quality of Turlock's existing workforce (high educational attainment, specific skill sets, etc.) to potential employers. Similarly, promote the City's capacity for additional workforce training through partnerships with CSUS.

2.11-ak **Master Wayfinding Program.** Continue to implement Turlock's Master Wayfinding Sign Program, aimed at improving signage and wayfinding throughout the City, improving visitors' experiences in Turlock, and promoting the City's assets.

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APPENDIX B – 2012 FLOW MONITORING AND INFLOW/INFILTRATION STUDY

Appendix B is included in the enclosed electronic copy.

2012 FLOW MONITORING AND INFLOW / INFILTRATION STUDY

City of Turlock

January 2013

V&A

2012 FLOW MONITORING AND INFLOW / INFILTRATION STUDY

Prepared for

Prepared by

January 2013

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APPENDIX

ABBREVIATIONS, TERMS AND DEFINITIONS USED IN THIS REPORT

Table i. Abbreviations

Abbreviation	Term
ADWF	average dry weather flow
CCTV	closed-circuit television
CIP	capital improvement plan
CO	carbon monoxide
d/D	depth/diameter ratio
FM	flow monitor
gpd	gallons per day
gpm	gallons per minute
GWI	groundwater infiltration
H_2S	hydrogen sulfide
I/I	inflow and infiltration
IDM	inch-diameter-mile (miles of pipeline multiplied by the diameter of the pipeline in inches)
IDW	inverse distance weighting
LEL	lower explosive limit
mgd	million gallons per day
NOAA	National Oceanic and Atmospheric Administration
Q	flow rate
RDI	rainfall-dependent infiltration
RRI	rainfall-responsive infiltration
RG	rain gauge
SSO	sanitary sewer overflow
WEF	Water Environment Federation
WRCC	Western Regional Climate Center

Table ii. Terms and Definitions

Term	Definition
Attenuation	Flow attenuation in a sewer collection system is the natural process of the reduction of the peak flow rate through redistribution of the same volume of flow over a longer period of time. This occurs as a result of friction (resistance), along the sewer pipes. As the flows from the basins combine within the trunk sewer lines, the peaks from each basin will (a) not necessarily coincide at the same time, and (b) due to the length and time of travel through the trunk sewers, peak flows will ***attenuate*** as the peak flows move downstream. The sum of the peak flows of individual basins upstream will generally be greater than the measured peak flows observed at points downstream. Additional information on this concept is presented on page 13.
Average dry weather flow (ADWF)	Average flow rate or pattern from days without noticeable inflow or infiltration response. ADWF usage patterns for weekdays and weekends differ and must be computed separately. ADWF can be expressed as a numeric average or as a curve showing the variation in flow over a day. ADWF includes the influence of normal groundwater infiltration (not related to a rain event).
Basin	Sanitary sewer collection system upstream of a given location (often a flow meter), including all pipelines, inlets, and appurtenances. Also refers to the ground surface area near and enclosed by pipelines. A basin may refer to the entire collection system upstream from a flow meter or exclude separately monitored basins upstream.
Depth/diameter (*d/D*) ratio	Depth of water in a pipe as a fraction of the pipe's diameter. A measure of fullness of the pipe used in capacity analysis.
Design storm	A theoretical storm event of a given duration and intensity that aligns with historical frequency records of rainfall events. For example, a 10-year, 24-hour design storm is a storm event wherein the volume of rain that falls in a 24-hour period would historically occur once every 10 years. Design storm events are used to predict I/I response and are useful for modeling how a collection system will react to a given set of storm event scenarios.
Infiltration and inflow	Infiltration and inflow (I/I) rates are calculated by subtracting the ADWF flow curve from the instantaneous flow measurements taken during and after a storm event. Flow in excess of the baseline consists of inflow, rainfall-responsive infiltration, and rainfall-dependent infiltration. **Total I/I** is the total sum in gallons of additional flow attributable to a storm event.
Infiltration, *groundwater*	Groundwater infiltration (**GWI**) is groundwater that enters the collection system through pipe defects. GWI depends on the depth of the groundwater table above the pipelines as well as the percentage of the system that is submerged. The variation of groundwater levels and subsequent groundwater infiltration rates is seasonal by nature. On a day-to-day basis, groundwater infiltration rates are relatively steady and will not fluctuate greatly.
Infiltration, *rainfall-dependent*	Rainfall-dependent infiltration (**RDI**) is similar to groundwater infiltration but occurs as a result of storm water. The storm water percolates into the soil, submerges more of the pipe system, and enters through pipe defects. RDI is the slowest component of storm-related infiltration and inflow, beginning gradually and often lasting 24 hours or longer. The response time depends on the soil permeability and saturation levels.
Infiltration, *rainfall-responsive*	Rainfall-responsive infiltration (**RRI**) is storm water that enters the collection system through pipe defects, but normally in sewers constructed close to the ground surface such as private laterals. RRI is independent of the groundwater table and reaches defective sewers via the pipe trench in which the sewer is constructed, particularly if the pipe is placed in impermeable soil and bedded and

Term	Definition
	backfilled with a granular material. In this case, the pipe trench serves as a conduit similar to a French drain, conveying storm drainage to defective joints and other openings in the system.
Inflow	**Inflow** is defined as water discharged into the sewer system, including private sewer laterals, from **direct** connections such as downspouts, yard and area drains, holes in manhole covers, cross-connections from storm drains, or catch basins. Inflow creates a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows. Overflows are often attributable to high inflow rates.
Normalization	To run an “apples-to-apples” comparison amongst different basins, calculated metrics must be **normalized**. Individual basins will have different runoff areas, pipe lengths and sanitary flows. There are three common methods of normalization. Depending on the information available, one or all methods can be applied to a given project: ❖ Pipe Length: The metric is divided by the length of pipe in the upstream basin expressed in units of inch-diameter-mile (IDM). ❖ Basin Area: The metric is divided by the estimated drainage area of the basin in acres. ❖ ADWF: The metric is divided by the average dry weather sanitary flow (ADWF).
Normalization, *inflow*	The peak I/I flow rate is used to quantify inflow. Although the instantaneous flow monitoring data will typically show an inflow peak, the inflow response is measured from the I/I flow rate (in excess of baseline flow). This removes the effect of sanitary flow variations and measures only the I/I response: ❖ Pipe Length: The peak I/I flow rate is divided by the length of pipe (IDM) in the upstream basin. The result is expressed in gallons per day (gpd) per IDM (gpd/IDM). ❖ Basin Area: The peak I/I flow rate is divided by the geographic area of the upstream basin. The result is expressed in gpd per acre. ❖ ADWF: The peak I/I flow rate is divided by the average dry weather flow (ADWF). This is a ratio and is expressed without units.
Normalization, *GWI*	The estimated GWI rates are compared to acceptable GWI rates, as defined by the Water Environment Federation, and are used to identify basins with high GWI: ❖ Pipe Length: The GWI flow rate is divided by the length of pipe (IDM) in the upstream basin. The result is expressed in gallons per day (gpd) per IDM (gpd/IDM). ❖ Basin Area: The GWI flow rate is divided by the geographic area of the upstream basin. The result is expressed in gpd per acre. ❖ ADWF: The GWI flow rate is divided by the average dry weather flow (ADWF). This is a ratio and is expressed without units.
Normalization,	The estimated RDI rates at a period 24 hours or more after the conclusion of a

Term	Definition
RDI	storm event are used to identify basins with high RDI: ❖ Pipe Length: The RDI flow rate is divided by the length of pipe (IDM) in the upstream basin. The result is expressed in gallons per day (gpd) per IDM (gpd/IDM). ❖ Basin Area: The RDI flow rate is divided by the geographic area of the upstream basin. The result is expressed in gpd per acre. ❖ ADWF: The RDI flow rate is divided by the average dry weather flow (ADWF). This is a ratio and is expressed without units.
Normalization, *total I/I*	The estimated totalized I/I in gallons attributable to a particular storm event is used to identify basins with high total I/I. Because this is a totalized value rather than a rate and can be attributable solely to an individual storm event, the volume of the storm event is also taken into consideration. This allows for a comparison not only between basins but also between storm events: ❖ Pipe Length: Total gallons of I/I is divided by the length of pipe (IDM) in the upstream basin and the rainfall total (inches) of the storm event. The result is expressed in gallons per IDM per inch-rain. ❖ Basin Area (R-Value): Total gallons of I/I is divided by total gallons of rainfall water that fell within the acreage of the basin area. This is a ratio and is expressed as a percentage. R-Value is described as "the percentage of rainfall that enters the collection system." Systems with R-Values less than 5%[1] are often considered to be performing well. ❖ ADWF: Total gallons of I/I is divided by the ADWF and the rainfall total of the storm event. The result is expressed in million gallons per MGD of ADWF per inch of rain.
Peaking factor	Ratio of peak measured flow to average dry weather flow. This ratio expresses the degree of fluctuation in flow rate over the monitoring period and is used in capacity analysis.
Surcharge	When the flow level is higher than the crown of the pipe, then the pipeline is said to be in a **surcharged** condition. The pipeline is surcharged when the *d*/*D* ratio is greater than 1.0.
Synthetic hydrograph	A set of algorithms has been developed to approximate the actual I/I hydrograph. The synthetic hydrograph is developed strictly using rainfall data and response parameters representing response time, recession coefficient and soil saturation.
Weekend/weekday ratio	The ratio of weekend ADWFs to weekday ADWFs. In residential areas, this ratio is typically slightly higher than 1.0. In business districts, depending on the type of service, this ratio can be significantly less than 1.0.

[1] Keefe, P.N. "Test Basins for I/I Reduction and SSO Elimination." 1998 WEF Wet Weather Specialty Conference, Cleveland.

EXECUTIVE SUMMARY

Scope and Purpose

V&A has completed sanitary sewer flow monitoring with inflow and infiltration (I/I) analysis within the City of Turlock (City). Flow monitoring was performed over a period of one month from January 21, 2012 to February 29, 2012 at 13 open-channel flow monitoring sites.

The purpose of this study was to measure sanitary sewer flows at the flow monitoring sites, estimate available sewer capacity and analyze the amount of infiltration and inflow (I/I) occurring in the basins upstream from the flow monitoring sites.

Site Flow Monitoring and Capacity Results

Peak flows and the associated flow levels (depths) are important factors to consider in understanding the capacity and hydraulic performance within a collection system. Table 1 summarizes the peak recorded flows, levels, *d*/*D* ratios, and peaking factors per site during the flow monitoring period. Capacity analysis data is presented on a site-by-site basis and represents the hydraulic conditions only at the site locations. Hydraulic conditions in other areas of the collection system will differ. The cells highlighted in yellow are occasions when the peak level occurred independent of rainfall. These occasions may be the result of blockages or pump station operations.

Table 1. Capacity Analysis Summary

Site	ADWF (mgd)	Peak Measured Flow (mgd)	Peaking Factor	Diameter (in)	Peak Level Rain Events (in)	Peak Level Period (in)	*d*/*D* Ratio Period	Level Surcharged above Crown (ft)
Site 1	1.97	4.33	2.2	42	15.78	16.26	0.39	-
Site 2	0.32	6.21	19.4	30	19.43	19.43	0.65	-
Site 3	1.25	3.61	2.9	30	19.48	22.70	0.76	-
Site 4	5.56	10.67	1.9	48	31.45	34.83	0.73	-
Site 5	0.50	1.28	2.6	16	14.30	14.30	0.89	-
Site 6	0.088	0.49	5.5	16	6.78	6.78	0.42	-
Site 7	n/a	1.86	n/a	24	18.10	18.10	0.75	-
Site 8	1.60	2.95	1.8	33	12.11	12.11	0.37	-
Site 9	0.051	0.32	6.2	15	7.17	11.03	0.74	-
Site 10	1.15	1.68	1.5	24	9.58	9.58	0.40	-
Site 11	0.61	1.23	2.0	18	9.77	23.06	1.28	0.4 ft
Site 12	1.18	1.71	1.4	21	16.81	16.99	0.81	-
Site 13	1.04	1.98	1.9	30	10.68	11.01	0.37	-

The following capacity analysis results are noted:

- **Peaking Factor:** Sites 2, 6 and 9 had peaking factors that exceeded typical design threshold limits for peak flow to average dry weather flow ratio. It is noted that the hydraulic conditions through Site 9 are largely dependent on the operations of an upstream pump station.
- ***d*/*D* Ratio:** Sites 3, 5, 11 and 12 had *d*/*D* ratios that exceeded common threshold values for *d*/*D* ratio. Site 11 surcharged 0.4 feet above the pipe crown; however, it is noted that the surcharge event at Site 11 site was not related to a storm event and is not included in Figure 18.

Figure 1 shows bar graphs summarizing the site-by-site *d*/*D* ratios and peaking factors. Figure 2 shows a schematic diagram of the peak measured flows with peak flow levels during the January 21, 2012 storm event.

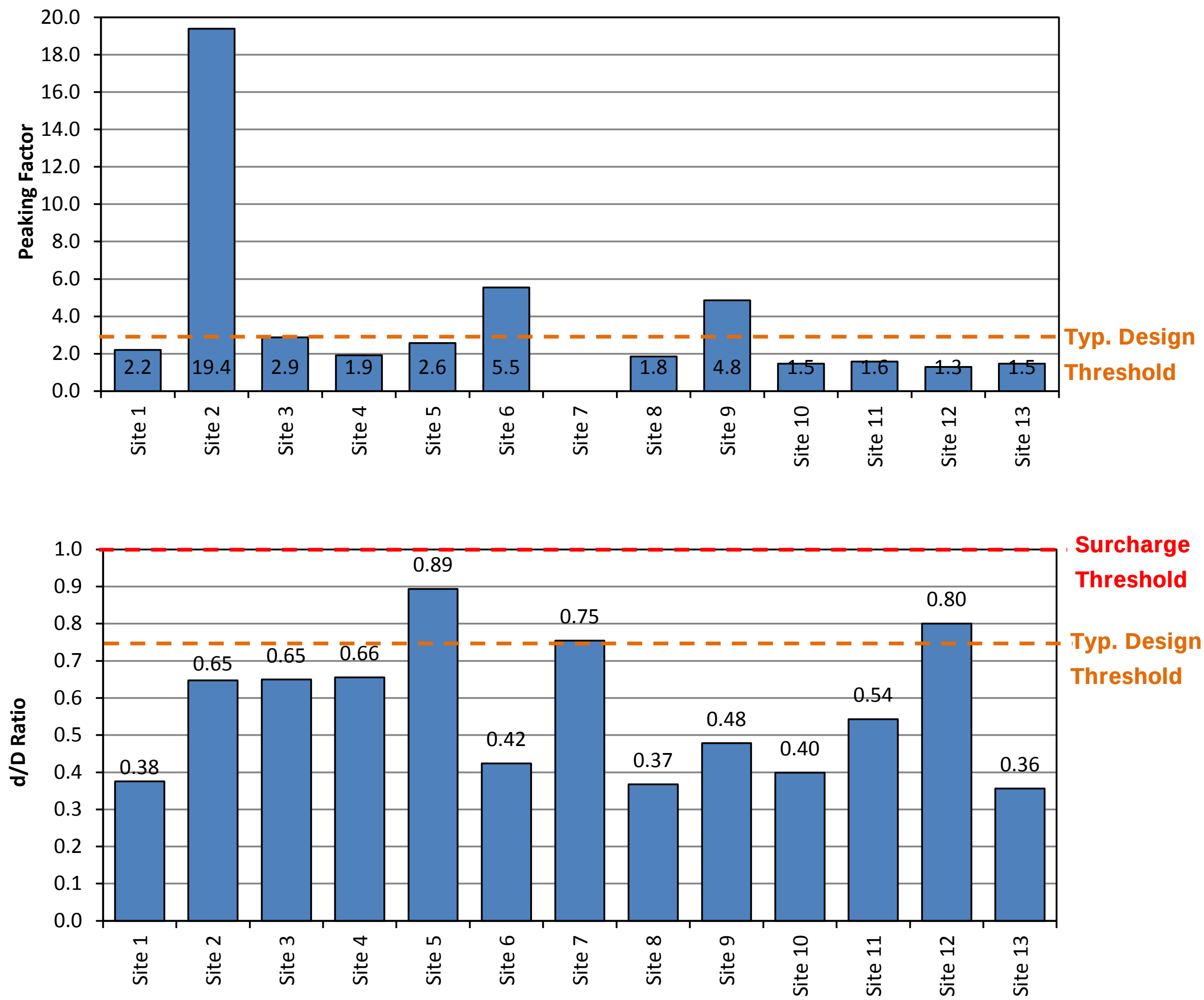


Figure 1. d/D Ratios and Peaking Factors for January 19 – 23, 2012 Rainfall Event

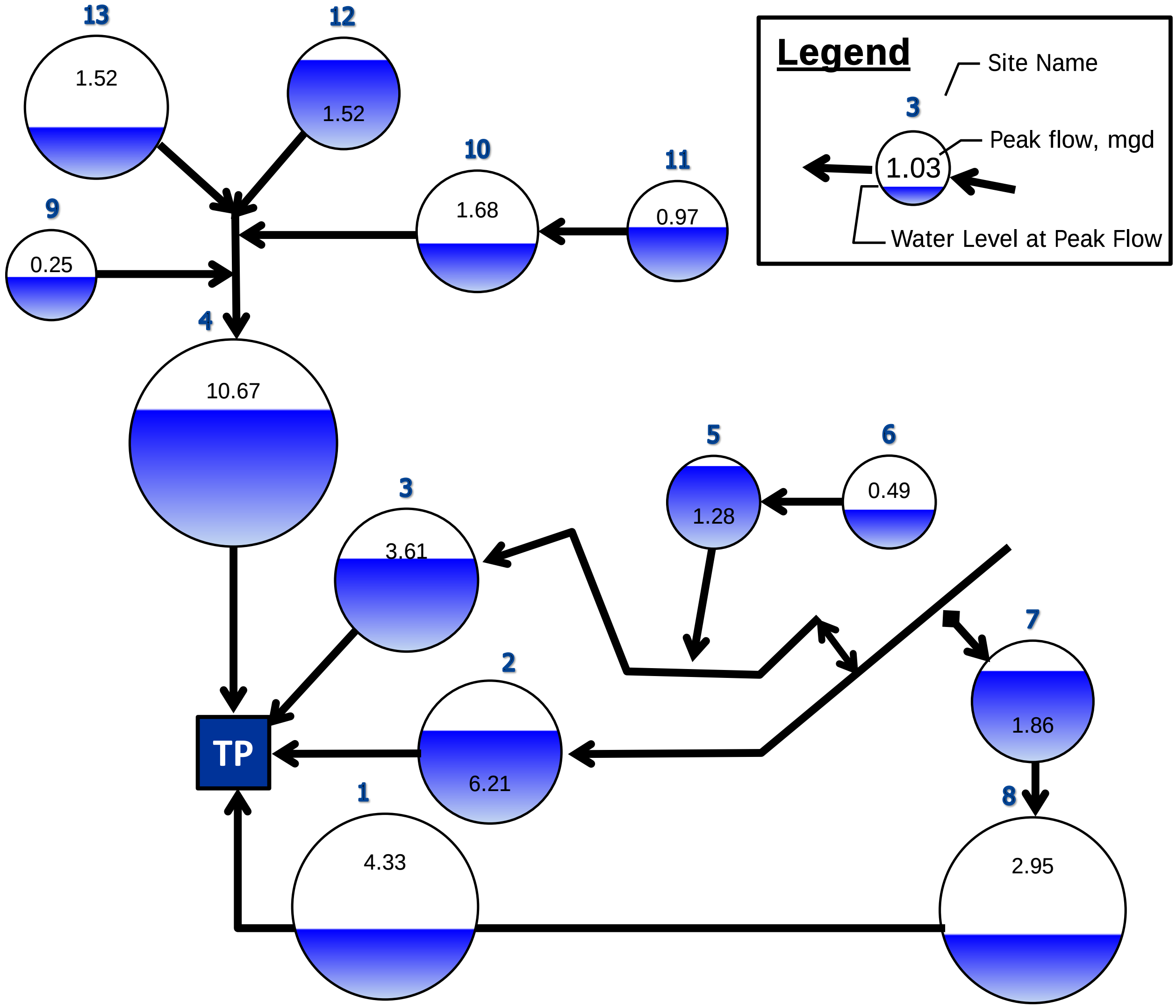


Figure 2. Peak Measured Flow Schematic (Peak Flow, January 21, 2012)

Basin Inflow and Infiltration Analysis Results

Table 2 summarizes the flow monitoring and I/I results for the flow monitoring basins that were isolated during this study. Infiltration and inflow rankings are shown such that 1 represents the highest infiltration or inflow contribution and 10 represents the least. I/I results were taken from the January 19 – 23, 2012 rainfall event. Please refer to the "I/I Methods" section for more information on inflow analysis methods. Figure 3 and Figure 4 show basin maps of the overall inflow and infiltration rankings.

Table 2. I/I Analysis Summary

Basin	ADWF (mgd)	Peak I/I Rate (mgd)	Total Infiltration (gallons)	R-Value	Inflow Ranking	Combined I/I Ranking
Basin 1	0.37	1.61	616,000	4.1%	3	3
Basin 4	2.14	5.80	281,000	0.4%	4	7
Basin 5	0.41	0.57	16,000	0.2%	6	9
Basin 6	0.088	0.42	155,000	12.8%	1	1
Basin 9	0.051	0.06	6,000	0.7%	5	6
Basin 10	0.53	0.43	172,000	0.9%	8	5
Basin 11	0.61	0.15	58,000	0.4%	10	8
Basin 12	1.18	0.58	183,000	1.1%	7	4
Basin 13	1.04	0.49	50,000	0.2%	9	10
Basin 2,3,8	2.68	9.14	2,345,000	4.7%	2	2
WWTP	9.11	19.05	3,882,000	1.8%		

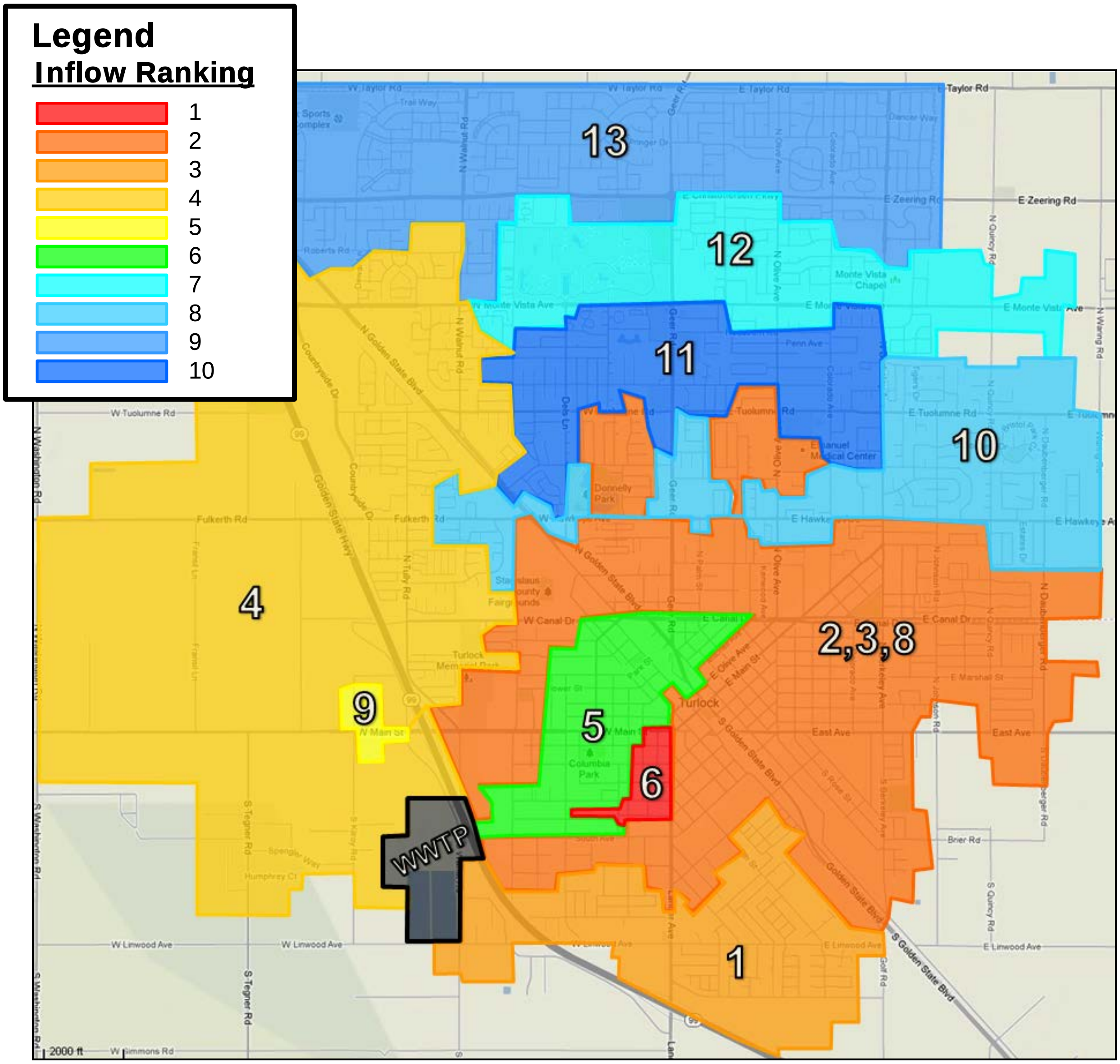


Figure 3. Inflow Temperature Map (by rank)

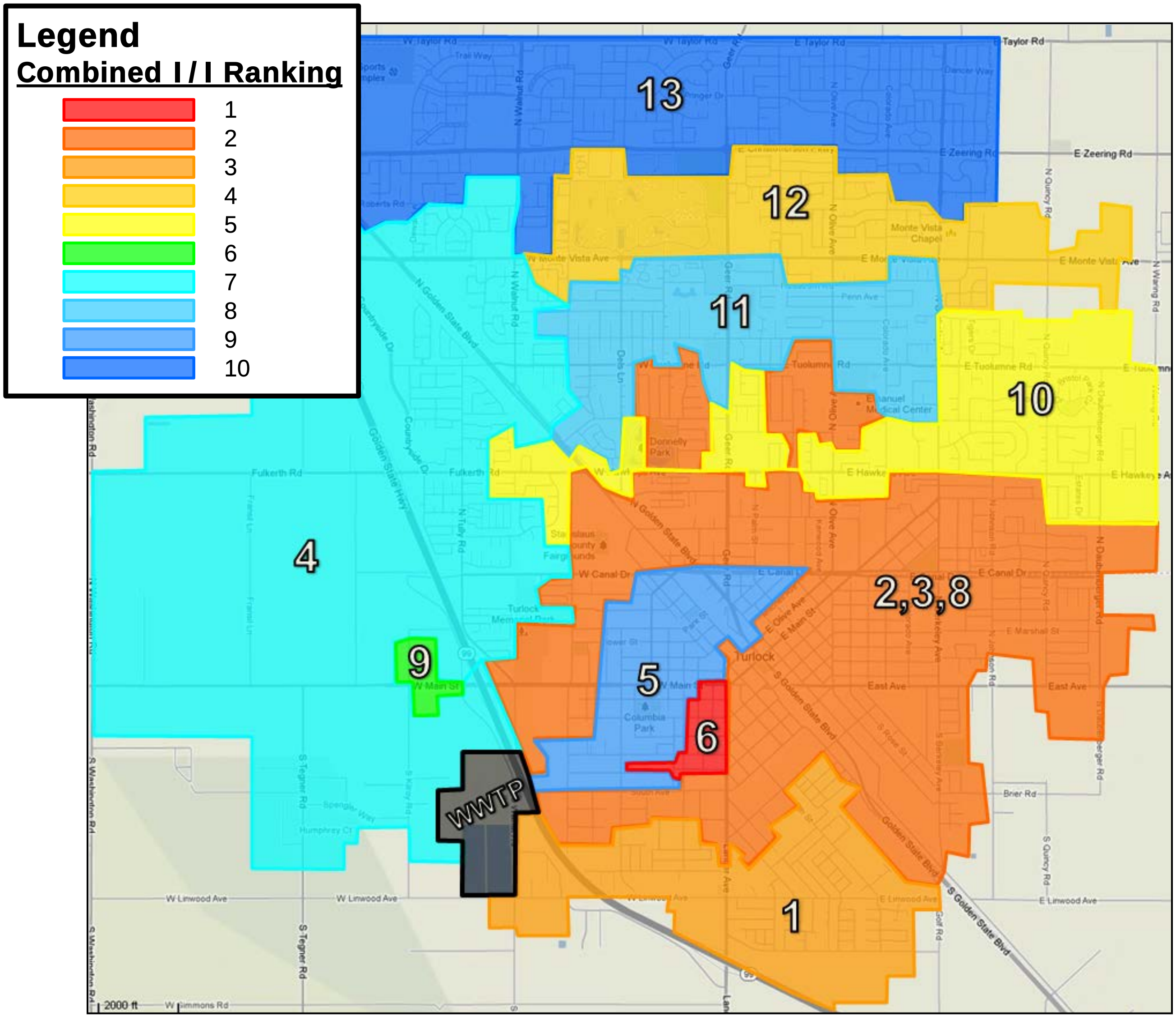


Figure 4. Combined I/I Temperature Map (by rank)

Recommendations

V&A advises that future I/I reduction plans consider the following recommendations:

1. **Determine I/I Reduction Program:** The City should examine its I/I reduction needs to determine a future I/I reduction program.
    a. If peak flows, sanitary sewer overflows, and pipeline capacity issues are of greater concern, then priority can be given to investigate and reduce sources of inflow within the basins with the greatest inflow problems. The highest inflow occurred in Basins 1, 2, 3, 6 and 8.
    b. If total infiltration and general pipeline deterioration are of greater concern, then the program can be weighted to investigate and reduce sources of infiltration within the basins with the greatest infiltration problems.
        i. There was no evidence of high RDI or GWI rates within the collection system.
2. **I/I Investigation Methods:** Potential I/I investigation methods include the following:
    a. Smoke testing: the objective with this step is to ascertain whether defects from laterals originate via direct connections or through laterals with breaks, offset joints and/or cracks. The City could perform smoke testing on segments with known sources of I/I from laterals to find the 'low hanging fruit'; i.e., the direct connections from area drains, roof leaders or other similar connections.
    b. Sub-basin flow monitoring: Larger basins with high I/I can be reduced into smaller sub basins by conducting a more focused flow monitoring and I/I study specific to focused basins.
    c. Nighttime reconnaissance work to (1) investigate and determine direct point sources of inflow and (2) determine the areas and pipe reaches responsible for high levels of infiltration contribution.
    d. Focused CCTV I/I Inspection: CCTV I/I inspection can determine exact locations of infiltration occurring within the pipe mains and at the lateral-to-pipe main joint. The CCTV I/I inspection will document which laterals have significant volumes of infiltration contributing to the collection system, and may document whether the I/I is occurring in the upper or lower portion of the pipe lateral. A great benefit from this work is that the percentage of infiltration coming from laterals versus pipe mains can be effectively quantified.
3. **I/I Reduction Cost-Effectiveness Analysis:** The City should conduct a study to determine which is more cost-effective: (1) locating the sources of inflow and infiltration and systematically rehabilitating or replacing the faulty pipelines or (2) continued treatment of the additional rainfall-dependent I/I flow.

INTRODUCTION

Preface

Turlock is the second largest city in Stanislaus County with a population of over 70,000 and a total area of approximately 16.9 square miles. The wastewater treatment plant processes roughly 9 million gallons per day (mgd) of flow during dry weather. The collection system has over 204 miles of sewer lines ranging in diameter from 4 inches to 48 inches and includes 18 sewer lift stations.

Scope and Purpose

V&A was retained by Carollo Engineers (Carollo) to perform wet weather sanitary sewer flow monitoring and inflow and infiltration (I/I) analysis within the City of Turlock (City). Flow monitoring was performed over a period of one month from January 21, 2012 to February 29, 2012 at 13 open-channel flow monitoring sites. The purpose of this study was to measure sanitary sewer flows at the flow monitoring sites, estimate available sewer capacity and analyze the amount of infiltration and inflow (I/I) occurring in the basins upstream from the flow monitoring sites.

Flow Monitoring Sites

Flow monitoring sites are the locations where the flow monitors were placed. Flow monitoring site data may include the flows from one or many drainage basins. To isolate a flow monitoring basin, an addition or subtraction of flows may be required[2]. Capacity and flow rate information is presented on a site-by-site basis. The flow monitoring locations are listed in Table 3 and shown in Figure 5.

Table 3. List of Flow Monitoring Sites

Monitoring Site	Pipe Diameter (in)	Location
Site 1	42	Walnut Road, North of Treatment Plant entrance
Site 2	30	Walnut Road, near Auto Machine shop
Site 3	30	Walnut Road, South of freeway underpass
Site 4	48	Walnut Road, South of freeway underpass
Site 5	16	Intersection of South Avenue and Soderquist Road
Site 6	16	580 Angelus Street
Site 7	24	Intersection of 5th Street and D Street
Site 8	33	Intersection of Lander Avenue and F Street
Site 9	15	Main Street between Kilroy Road and Walnut Road
Site 10	24	Fulkerth Road between Tully Road and Logan Lane
Site 11	18	Dels Lane between Pedras Road and Hawkeye Avenue

[2] There is error inherent in flow monitoring. Adding and subtracting flows increases error on an additive basis. For example, if Site A has error ±10% and Site B has error ±10%, then the resulting flow when subtracting Site A from Site B would be ±20%.

Monitoring Site	Pipe Diameter (in)	Location
Site 12	21	Intersection of Monte Vista Avenue and Norwich Lane
Site 13	30	Walnut Road, North of Monte Vista Avenue

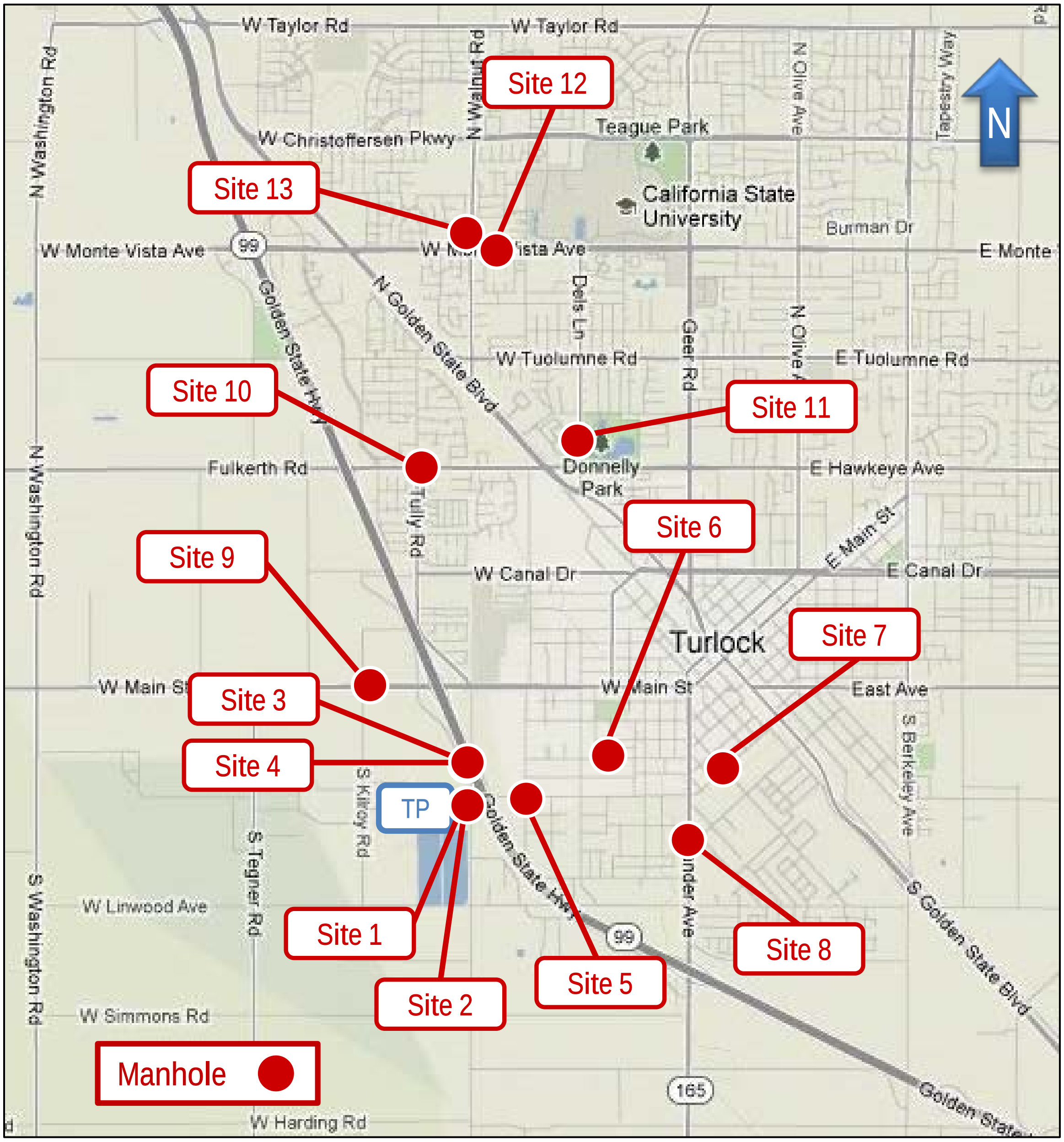
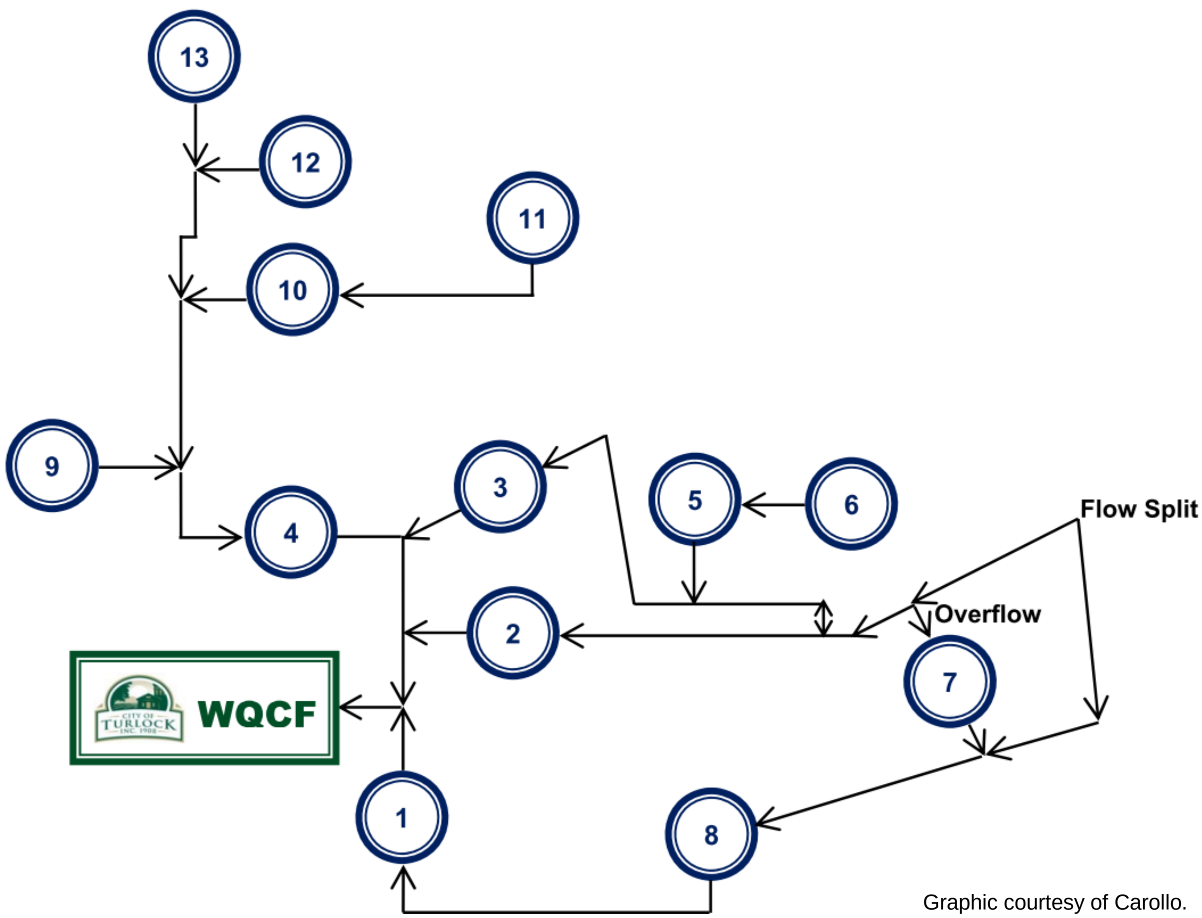


Figure 5. Flow Monitoring Site Map

Flow Monitoring Basins

Flow monitoring basins are localized areas of a sanitary sewer collection system upstream of a given location (often a flow meter), including all pipelines, inlets, and appurtenances. The basin refers to the ground surface area near and enclosed by pipelines. A basin may refer to the entire collection system upstream from a flow meter or may exclude separately monitored basins upstream. I/I analysis in this report will be conducted on a basin-by-basin basis.

Within the City, there are several locations with cross-connections between trunk sewers or overflow bypass sewers to help equalize basins and prevent sanitary sewer overflows during peak rain events. However, unless the inter-basin connections are plugged, the behavior of flows may not be known with certainty. Figure 6 shows the flow monitoring schematic for this project. Table 4 lists the basins that were isolated and thus utilized for I/I analysis. Figure 7 illustrates the basins utilized for I/I analysis.



Graphic courtesy of Carollo.

Figure 6. Flow Monitoring Schematic

Table 4. List of Isolated Basins for I/I Analysis

Basin	Area (acres)	Basin Flow Calculation
Basin 1	731	$Q_{Basin\ 1} = Q_{Site\ 1} - Q_{Site\ 8}$
Basin 2	484	$Q_{Basin\ 2} = Q_{Site\ 2} + Q_{Site\ 7}$
Basin 3	955	$Q_{Basin\ 3} = Q_{Site\ 3} - Q_{Site\ 5}$
Basin 4	3,158	$Q_{Basin\ 4} = Q_{Site\ 4} - (Q_{Site\ 9} + Q_{Site\ 10} + Q_{Site\ 12} + Q_{Site\ 13})$
Basin 5	398	$Q_{Basin\ 5} = Q_{Site\ 5} - Q_{Site\ 6}$
Basin 6	60	$Q_{Basin\ 6} = Q_{Site\ 6}$
Basin 8	984	$Q_{Basin\ 8} = Q_{Site\ 8} - Q_{Site\ 7}$
Basin 9	43	$Q_{Basin\ 9} = Q_{Site\ 9}$
Basin 10	866	$Q_{Basin\ 10} = Q_{Site\ 10} - Q_{Site\ 11}$
Basin 11	643	$Q_{Basin\ 11} = Q_{Site\ 11}$
Basin 12	786	$Q_{Basin\ 12} = Q_{Site\ 12}$
Basin 13	1,505	$Q_{Basin\ 13} = Q_{Site\ 13}$
Basin 2,3,8	2,423	$Q_{Basin\ 2,3,8} = Q_{Site\ 2} + Q_{Site\ 3} + Q_{Site\ 8} - Q_{Site\ 5}$
WWTP[3]	10,757	$Q_{Basin\ WWTP} = Q_{Site\ 1} + Q_{Site\ 2} + Q_{Site\ 3} + Q_{Site\ 4}$

Notes

- Site 7 monitored an overflow line that connects Basin 2 to Basin 8. Site 7 was important for modeling purposes and the data is presented within appropriate sections of report; however, as Site 7 does not have an isolated upstream basin, the data will not be analyzed for I/I.
- Due to several splits, overflows and cross-connections within the collection system between Basins 2, 3 and 8, these basins will be combined for the purposes of I/I analysis and basin rankings into a single basin named “Basin 2,3,8” with a basin area of 2,423 acres.
- The areas shown in Table 4 were provided by Carollo Engineers. The areas assigned to Basins 2, 3 and 8 are valid during dry weather flow conditions, with acknowledgement that the aforementioned cross-connections between these basins may alter drainage basin areas during wet weather conditions.

[3] Area for the WWTP includes 144 acres of unmetered drainage area.

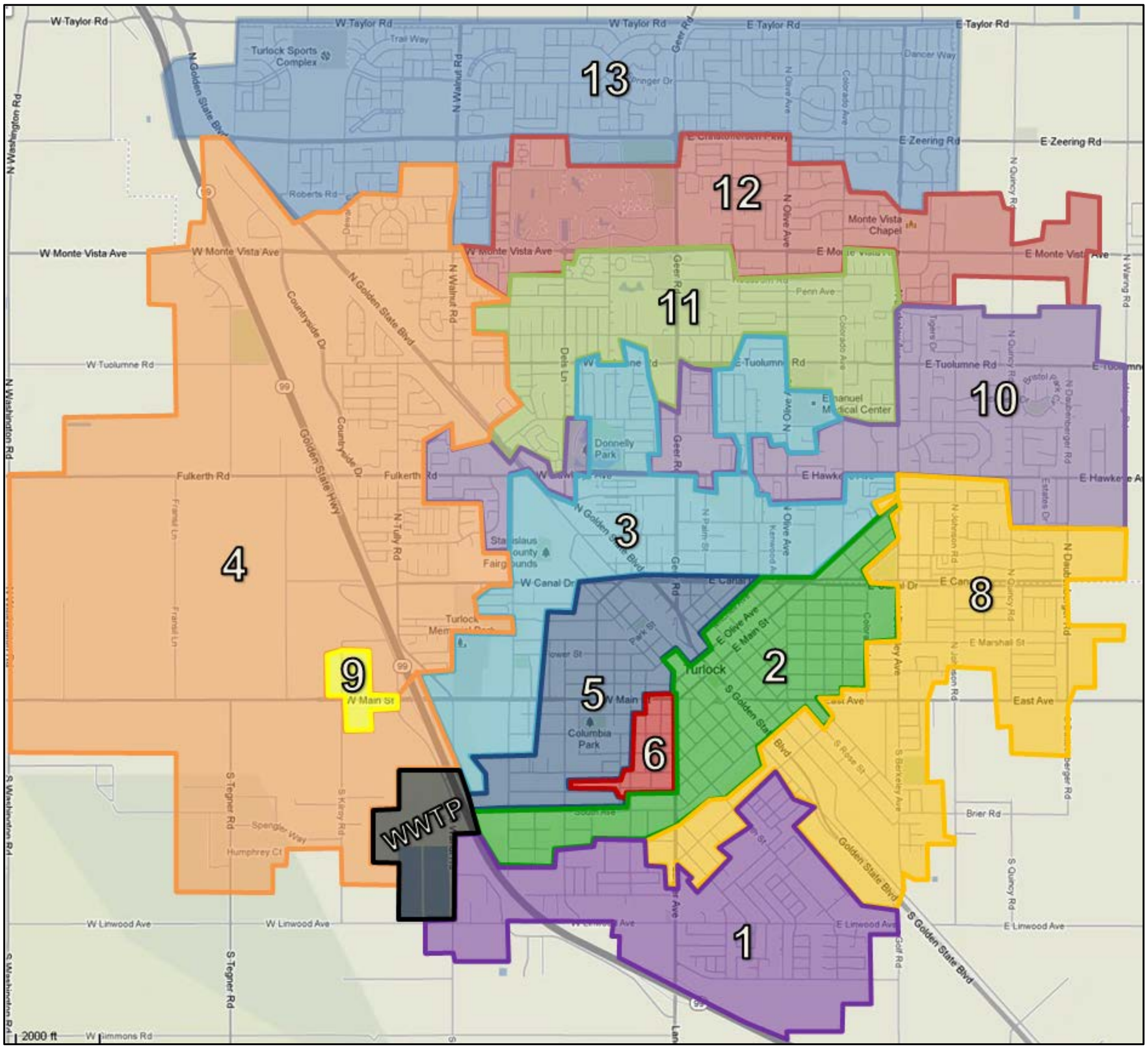


Figure 7. Flow Monitoring Basins

Attenuation

Flow attenuation in a sewer collection system is the natural process of the reduction of the peak flow rate through redistribution of the same volume of flow over a longer period of time. This occurs as a result of friction (resistance) along the sewer pipes. Fluids are constantly working towards equilibrium. For example, a volume of fluid poured into a static vessel with no outside turbulence will eventually stabilize to a static state, with a smooth fluid surface without peaks and valleys. Attenuation within a sanitary sewer collection system is similar to this concept. A flow profile with a strong peak will tend to stabilize towards equilibrium, as shown in Figure 8.

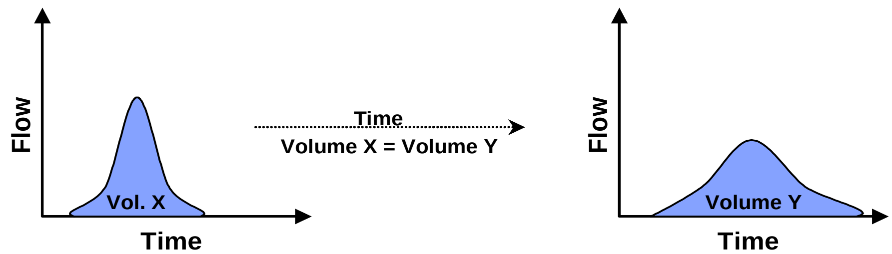


Figure 8. Attenuation Illustration

As the flows from the basins combine within the trunk sewer lines, the peaks from each basin will (a) not necessarily coincide at the same time, and (b) due to the length and time of travel through the trunk sewers, peak flows will attenuate prior to reaching the treatment facility. The sum of the peak flows of the individual basins within a collection system will usually be greater than the peak flows observed at the treatment facility.

Due to attenuation and especially the difficulties of synchronizing flows from basins with different travel times, when subtracting flows between basins, the accuracy in reported peak flows decreases. Per the basin equations listed in Table 4, it should be expected that the “level of confidence” of reported peak flows within basins requiring subtraction of flows would be less. For example, Basin 4 required the subtraction of 3 flow meters and the possibility for error within this location is emphasized[4].

[4] Calculations made based on long-term averaged measurements (such as average daily flows) are less affected by attenuation than those based on instantaneous measurements (such as peak flows). Peak instantaneous flow results for a basin requiring subtraction from upstream basins are less accurate. RDI calculations and total I/I calculations are made over a longer period of time and are not subject to attenuation.

METHODS AND PROCEDURES

Confined Space Entry

A confined space (Photo 1) is defined as any space that is large enough and so configured that a person can bodily enter and perform assigned work, has limited or restricted means for entry or exit and is not designed for continuous employee occupancy. In general, the atmosphere must be constantly monitored for sufficient levels of oxygen (19.5% to 23.0%), and the absence of hydrogen sulfide (H_2S) gas, carbon monoxide (CO) gas, and lower explosive limit (LEL) levels. A typical confined space entry crew has members with OSHA-defined responsibilities of Entrant, Attendant and Supervisor. The Entrant is the individual performing the work. He or she is equipped with the necessary personal protective equipment needed to perform the job safely, including a personal four-gas monitor (Photo 2). If it is not possible to maintain line-of-sight with the Entrant, then more Entrants are required until line-of-sight can be maintained. The Attendant is responsible for maintaining contact with the Entrants and maintaining records of all Entrants, if there are more than one. The Supervisor is responsible for developing the safe work plan for the job at hand prior to entering.

Photo 1. Confined Space Entry

Photo 2. Typical Personal Four-Gas Monitor

Flow Meter Installation

V&A installed five Teledyne Isco 2150, three Hach Sigma 910 and five Marsh-McBirney Flo-Dar flow meters in the sewer lines listed in Table 1. Isco 2150 and Sigma 910 meters use a pressure transducer to collect depth readings and ultrasonic Doppler sensors on the probe to determine the average fluid velocity. Figure 9 shows a typical installation for a flow meter with a submerged sensor. A Flo-Dar flow meter is a non-contact flow meter that uses radar to measure velocity and a down-looking ultrasonic sensor to measure depth. Figure 10 shows illustrations of a typical Flo-Dar installation.

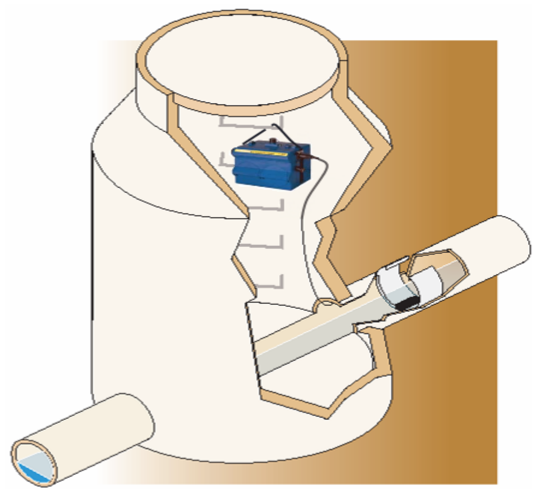


Figure 9. Typical Installation for Flow Meter with Submerged Sensor

Figure 10. Typical Hach Marsh-McBirney Flo-Dar Installation

Manual level and velocity measurements were taken during installation of the flow meters and again when they were removed. These manual measurements were compared to simultaneous level and velocity readings from the flow meters to ensure proper calibration and accuracy. The pipe diameter was also verified in order to accurately calculate the flow cross-section. The continuous depth and velocity readings were recorded by the flow meters on 5-minute intervals.

Flow Calculation

Data retrieved from each flow meter was placed into a spreadsheet program for analysis. Data analysis includes data comparison to field calibration measurements, as well as necessary geometric adjustments as required for sediment (sediment reduces the pipe's wetted cross-sectional area available to carry flow). Area-velocity flow metering uses the continuity equation,

$$Q = V \cdot A$$

where Q is the volume flow rate, V is the average velocity as determined by the ultrasonic sensor, and A is the cross-sectional area of flow as determined from the depth of flow. For circular pipe,

$$A = \left[\frac{D^2}{4}\cos^{-1}\left(1-\frac{2d}{D}\right)\right] - \left[\left(\frac{D}{2}-d\right)\left(\frac{D}{2}\right)\sin\left(\cos^{-1}\left(1-\frac{2d}{D}\right)\right)\right]$$

where D is the pipe diameter and d is the depth of flow.

RESULTS AND ANALYSIS

Rainfall: Rain Gauge Data

V&A installed three rain gauges for this project. Rain gauges were distributed in an attempt to provide as much coverage of the topography and of the City area as possible. The locations are detailed in Table 5 and illustrated in Figure 11.

Table 5. Rain Gauge Site Information

ID	Address	Latitude	Longitude	Elev. (ft)
RG North	Turlock Jr. High School: 3951 N Walnut Road	37.5286°	-120.8694°	103
RG2 Central	Crowell Elementary School: 118 North Avenue	37.5091°	-120.8468°	106
RG3 South	Intersection of 8th Street and West F Street	37.4836°	-120.8475°	101

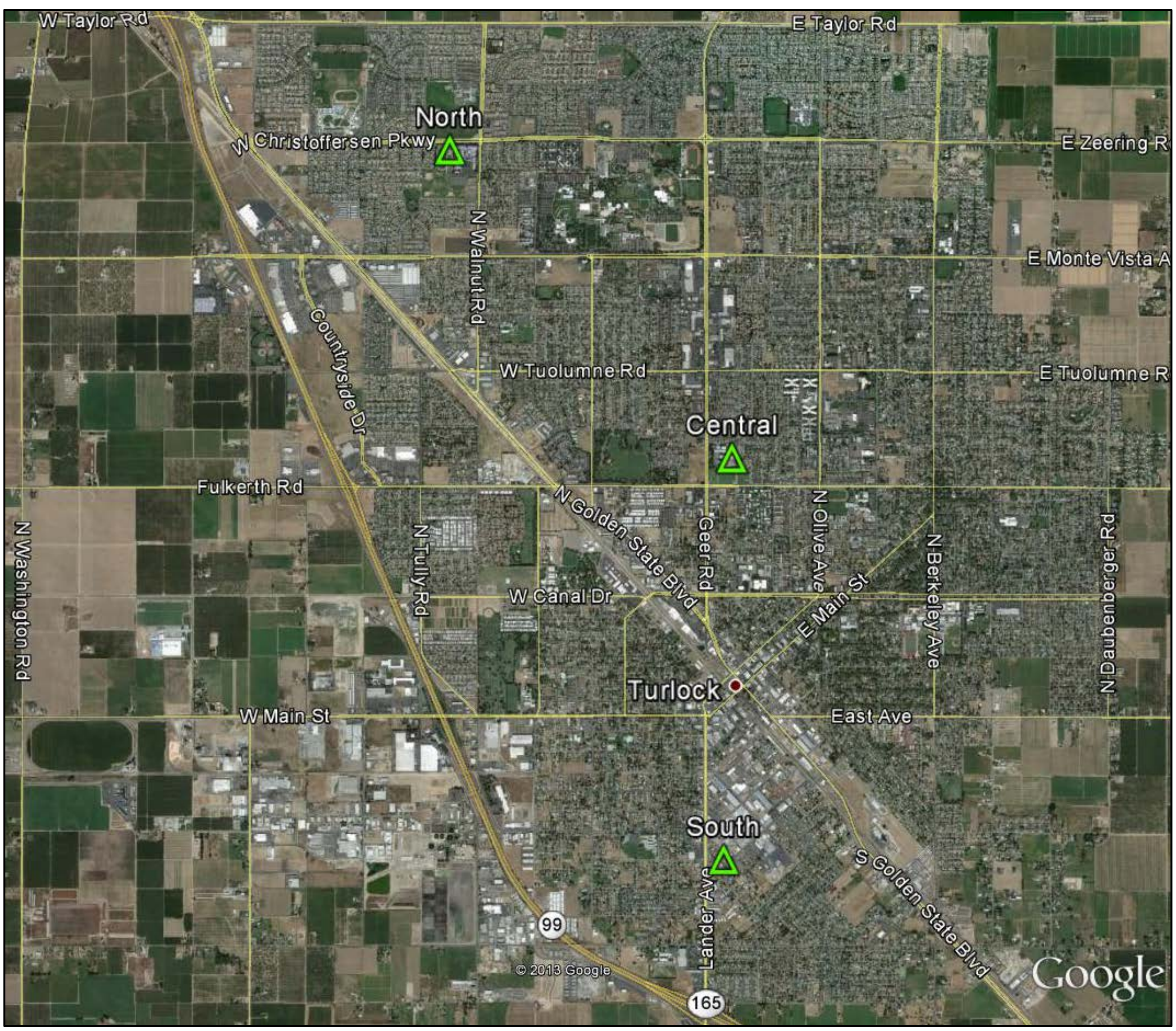


Figure 11. Rain Gauge Locations

There were four main rainfall events that occurred over the course of the flow monitoring period, summarized in Table 6. Figure 12 graphically displays the rainfall activity recorded over the flow monitoring period (RG North shown).

Table 6. Rainfall Events Used for I/I Analysis

Rainfall Event	RG North (in)	RG Central (in)	RG South (in)
January 19 - 23, 2012	0.75	0.80	0.73
February 7, 2012	0.34	0.33	0.36
February 12 - 15, 2012	0.18	0.18	0.22
February 29, 2012	0.07	0.06	0.08
Total over Monitoring Period	*1.37*	*1.37*	*1.39*

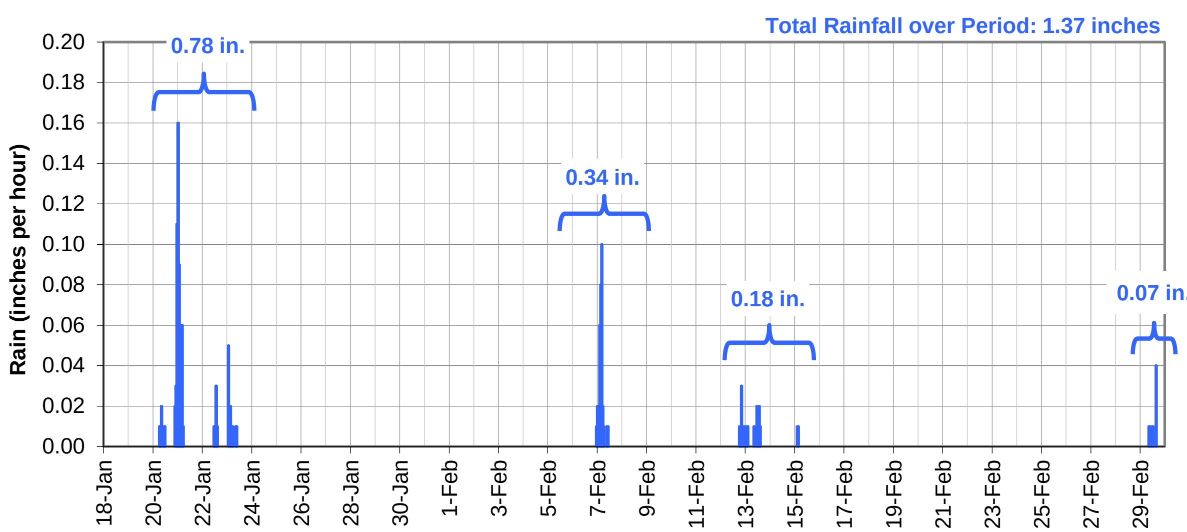


Figure 12. Rainfall Activity over Flow Monitoring Period (RG North)

Figure 13 shows the rain accumulation plot of the period rainfall, as well as the historical average rainfall[5] in the District during this project duration. Rainfall totals for the North, Central and South rain gauges were at 38%, 38% and 39% of historical normal levels during this time period, respectively.

[5] Historical data taken from the WRCC (Station 49073 in Turlock): http://www.wrcc.dri.edu/summary/climsmnca.html

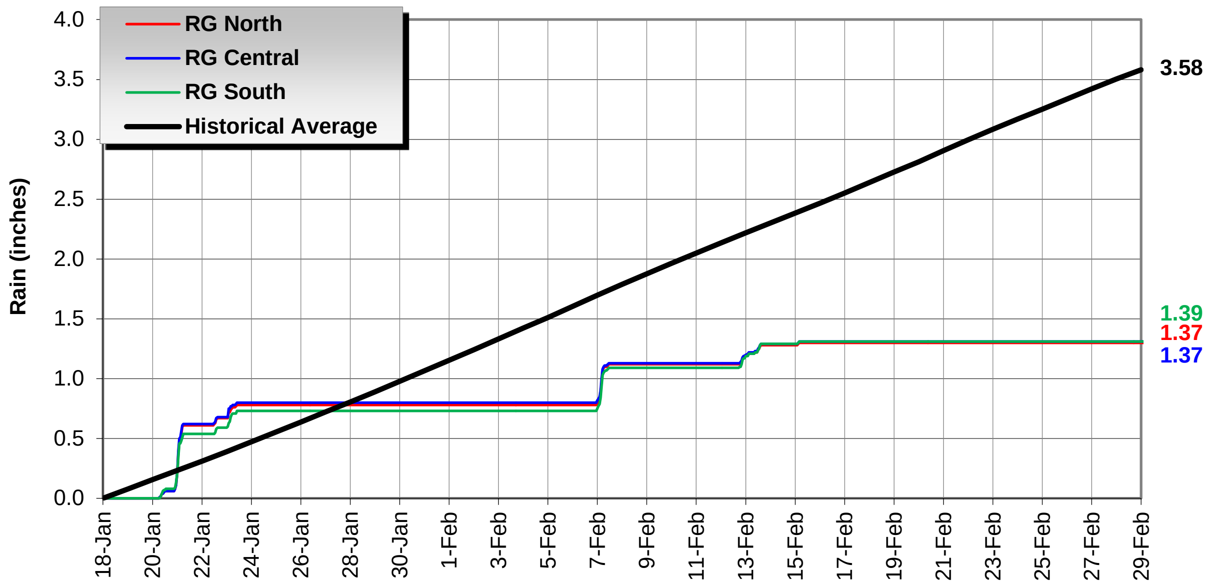


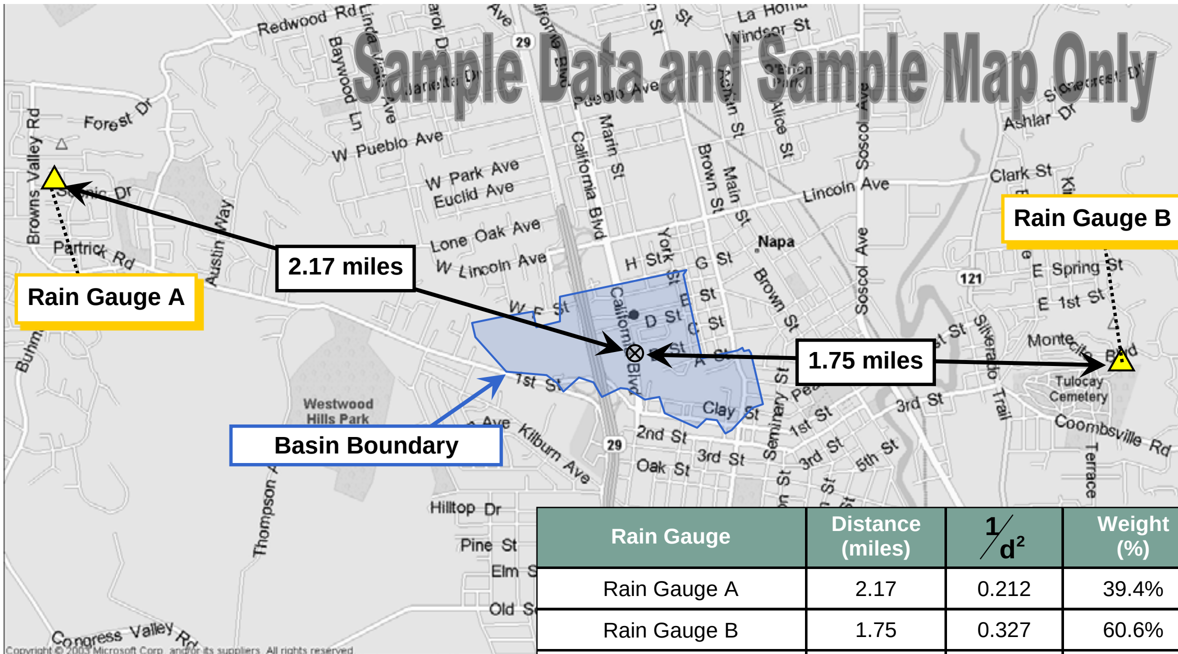
Figure 13. Rainfall Accumulation Plot

Rainfall: Rain Gauge Triangulation

The rainfall affecting the sanitary sewer collection system basins must be calculated based on the proximity to the rain gauge locations. The mean precipitation for the sanitary sewer collection system was calculated by taking data from seven local rain gauges and using the Inverse Distance Weighting (IDW) method. The IDW is an interpolation method that assumes the influence of each rain gauge location diminishes with distance. The center of a sanitary sewer collection system was identified and a weighted average was taken of the precipitation data from nearby rain gauge locations. The IDW function is as follows:

$$weight(d) = \frac{1/d^p}{\sum 1/d^p},$$ where: d = distance p = power ($p > 0$)

The value of p is user defined. The most common choice for hydrological studies of watershed areas is $p = 2$. Figure 14 illustrate the IDW method (sample data). The rain gauge distribution as calculated for each flow monitoring site is shown in Table 7.



Rain Gauge	Distance (miles)	$1/d^2$	Weight (%)
Rain Gauge A	2.17	0.212	39.4%
Rain Gauge B	1.75	0.327	60.6%
Totals		**0.5389**	**100%**

Figure 14. Rainfall Inverse Distance Weighting Method

Table 7. Rain Gauge Distribution by Basin

Basin	RG North	RG Central	RG South
Basin 1	0%	0%	100%
Basin 4	34%	36%	30%
Basin 5	0%	29%	71%
Basin 6	0%	11%	89%
Basin 9	0%	43%	57%
Basin 10	0%	100%	0%
Basin 11	15%	85%	0%
Basin 12	34%	66%	0%
Basin 13	83%	17%	0%
Basin 2,3,8	0%	55%	45%
WWTP	24%	46%	30%

Rainfall: Storm Event Classification

It is important to classify the relative size of a major storm event that occurs over the course of a flow monitoring period[6]. Storm events are classified by intensity and duration. Based on historical data, frequency contour maps for storm events of given intensity and duration have been developed by the National Oceanic and Atmospheric Administration (NOAA) for all areas within the continental United States. For example, the NOAA Rainfall Frequency Atlas[7] classifies a 10-year, 24-hour storm event at the latitude and longitude coordinates of Rain Gauge North as 2.02 inches (Figure 15). This means that in any given year, at this specific location, there is a 10% chance that 2.02 inches of rain will fall in any 24-hour period.

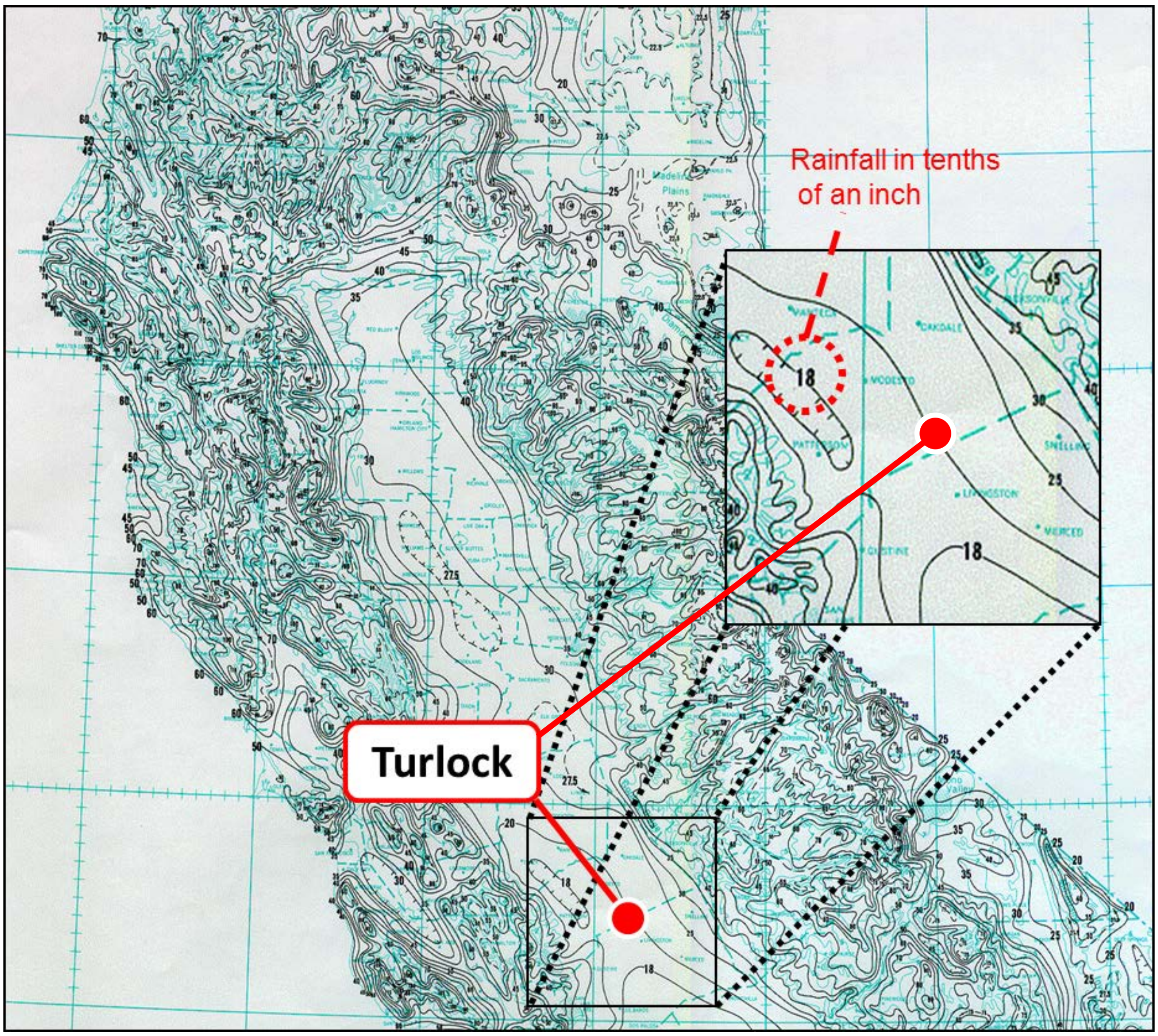


Figure 15. NOAA Northern California Rainfall Frequency Map

[6] Sanitary sewers are often designed to withstand I/I contribution to sanitary flows for "design" storm events of specific sizes.

[7] NOAA Western U.S. Precipitation Frequency Maps Atlas 2, 1973: http://www.wrcc.dri.edu/pcpnfreq.html

From the NOAA frequency maps, for a specific latitude and longitude, the rainfall densities for period durations ranging from 5 minutes to 60 days are known for rain events ranging from 1-year to 100-year intensities. These are plotted to develop a rain event frequency map specific to each rainfall monitoring site. Superimposing the peak measured densities for the January 19 – 23 rainfall event on the rain event frequency plot determines the classification of the storm event for each rain gauge, as shown in Figure 16 for RG North. All rain events were classified as less-than 1-year events at all three rain gauges.

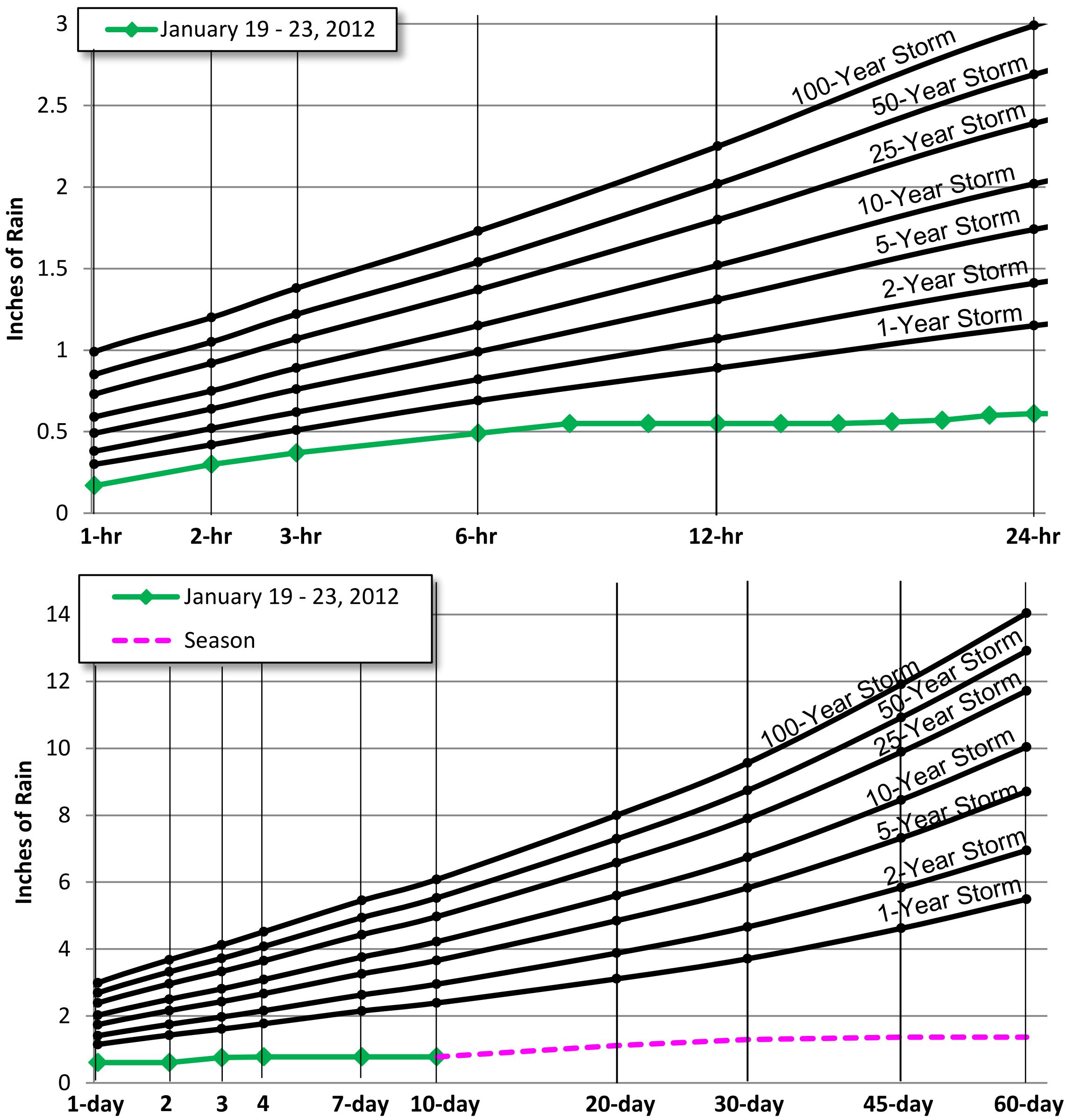


Figure 16. Storm Event Classification – RG North

Flow Monitoring: Average Dry Weather Flows

Weekday and weekend flow patterns differ and must be separated when determining average dry weather flows. Days least affected by rainfall were used to estimate weekend and weekday average flows. Table 8 lists the average dry weather flow (ADWF) recorded during this study for the flow monitoring sites. Figure 17 shows a schematic diagram of the average dry weather flows and flow levels. Detailed graphs of the flow monitoring data on a site-by-site basis are included in *Appendix A*.

Table 8. Dry Weather Flow Summary

Monitoring Site	Weekday ADWF (mgd)	Weekend ADWF (mgd)	Overall ADWF (mgd)	Weekend/ Weekday Ratio
Site 1	2.29	1.17	1.97	0.51
Site 2	0.33	0.30	0.32	0.90
Site 3	1.27	1.22	1.25	0.96
Site 4	5.60	5.46	5.56	0.98
Site 5	0.49	0.53	0.50	1.09
Site 6	0.088	0.087	0.088	0.99
Site 7	n/a	n/a	n/a	n/a
Site 8	1.84	1.00	1.60	0.54
Site 9	0.052	0.050	0.051	0.97
Site 10	1.15	1.15	1.15	1.00
Site 11	0.61	0.63	0.61	1.02
Site 12	1.19	1.17	1.18	0.99
Site 13	1.02	1.09	1.04	1.07
WWTP	9.49	8.15	9.11	0.86

Note: Site 7 is an overflow pipeline and is dry during dry weather flow conditions.

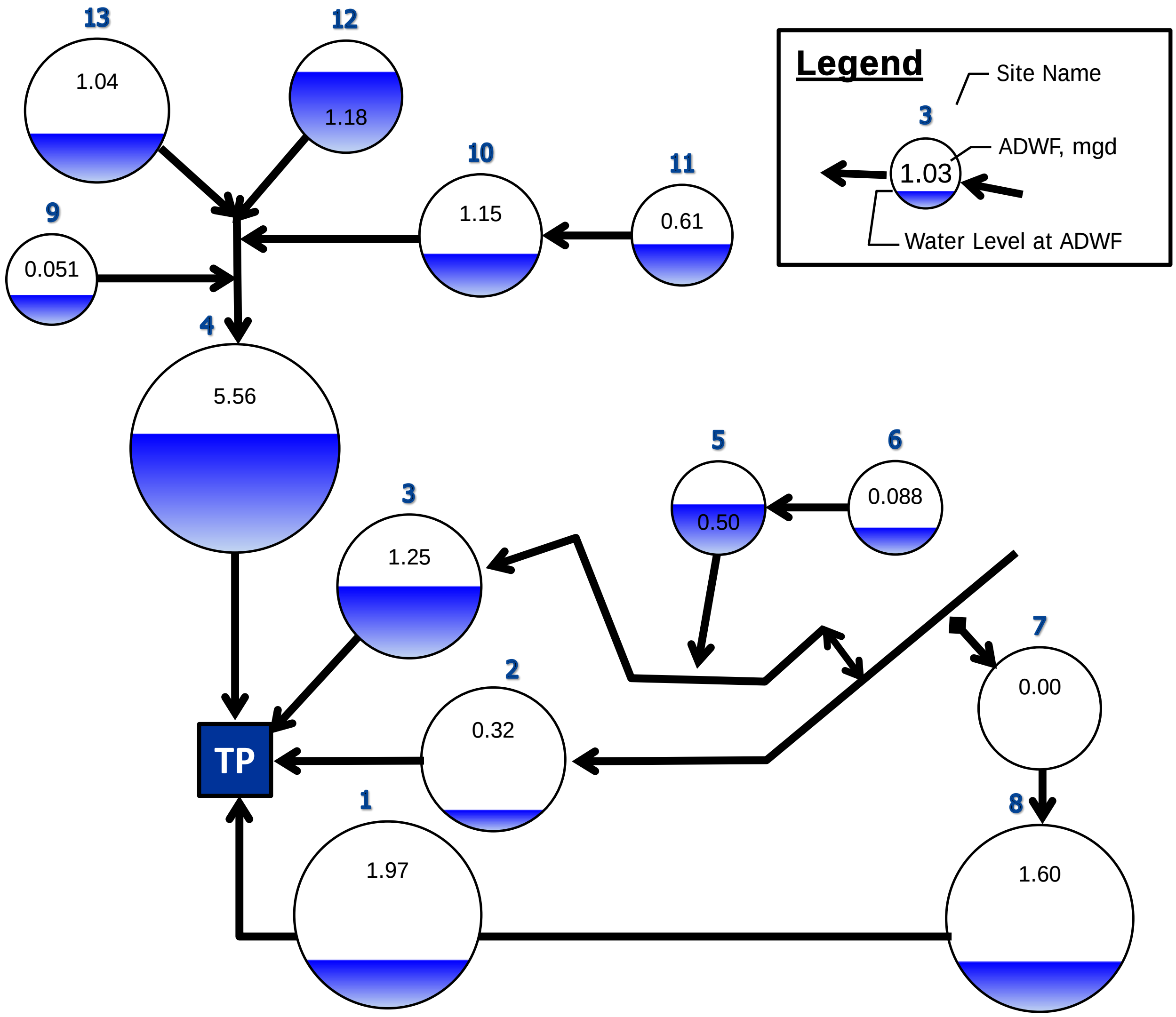


Figure 17. Average Dry Weather Flow Schematic

Flow Monitoring: Peak Measured Flows and Pipeline Capacity Analysis

Peak flows and the associated flow levels (depths) are important factors to consider in understanding the capacity and hydraulic performance within a collection system. The peak flows and flow levels reported are the peak measurements taken across the entirety of the flow monitoring period and may or may not have occurred simultaneously for all sites. The following capacity analysis terms are defined as follows:

- **Peaking Factor:** Peaking factor is defined as the peak measured flow divided by the average dry weather flow (ADWF). A peaking factor threshold value of 3.0 is commonly used for sanitary sewer design.
- ***d*/*D* Ratio:** The *d*/*D* ratio is the peak measured depth of flow (*d*) divided by the pipe diameter (*D*). A *d*/*D* ratio of 0.75 is a common maximum threshold value used for pipe design. The *d*/*D* ratio for each site was computed based on the maximum depth of flow from the flow monitoring study.

Table 9 summarizes the peak recorded flows, levels, *d*/*D* ratios, and peaking factors per site during the flow monitoring period. Capacity analysis data is presented on a site-by-site basis and represents the hydraulic conditions only at the site locations. Hydraulic conditions in other areas of the collection system will differ. The cells highlighted in yellow are occasions when the peak level occurred independent of rainfall. These occasions may be the result of blockages or pump station operations.

Table 9. Capacity Analysis Summary

Site	ADWF (mgd)	Peak Measured Flow (mgd)	Peaking Factor	Diameter (in)	Peak Level Rain Events (in)	Peak Level Period (in)	*d*/*D* Ratio Period	Level Surcharged above Crown (ft)
Site 1	1.97	4.33	2.2	42	15.78	16.26	0.39	-
Site 2	0.32	6.21	19.4	30	19.43	19.43	0.65	-
Site 3	1.25	3.61	2.9	30	19.48	22.70	0.76	-
Site 4	5.56	10.67	1.9	48	31.45	34.83	0.73	-
Site 5	0.50	1.28	2.6	16	14.30	14.30	0.89	-
Site 6	0.088	0.49	5.5	16	6.78	6.78	0.42	-
Site 7	n/a	1.86	n/a	24	18.10	18.10	0.75	-
Site 8	1.60	2.95	1.8	33	12.11	12.11	0.37	-
Site 9	0.051	0.32	6.2	15	7.17	11.03	0.74	-
Site 10	1.15	1.68	1.5	24	9.58	9.58	0.40	-
Site 11	0.61	1.23	2.0	18	9.77	23.06	1.28	0.4 ft
Site 12	1.18	1.71	1.4	21	16.81	16.99	0.81	-
Site 13	1.04	1.98	1.9	30	10.68	11.01	0.37	-

The following capacity analysis results are noted:

- **Peaking Factor:** Sites 2, 6 and 9 had peaking factors that exceeded typical design threshold limits for peak flow to average dry weather flow ratio. It is noted that the hydraulic conditions through Site 9 are largely dependent on the operations of an upstream pump station.
- ***d/D* Ratio:** Sites 3, 5, 11 and 12 had *d/D* ratios that exceeded common threshold values for *d/D* ratio. Site 11 surcharged 0.4 feet above the pipe crown; however, it is noted that the surcharge event at Site 11 site was not related to a storm event and is not included in Figure 18.

Figure 18 shows bar graphs summarizing the site-by-site peaking factors and *d/D* ratios for the January 19 – 23, 2012 storm event. Figure 19 shows a schematic diagram of the peak measured flows with peak flow levels ratios for the January 19 – 23, 2012 storm event.

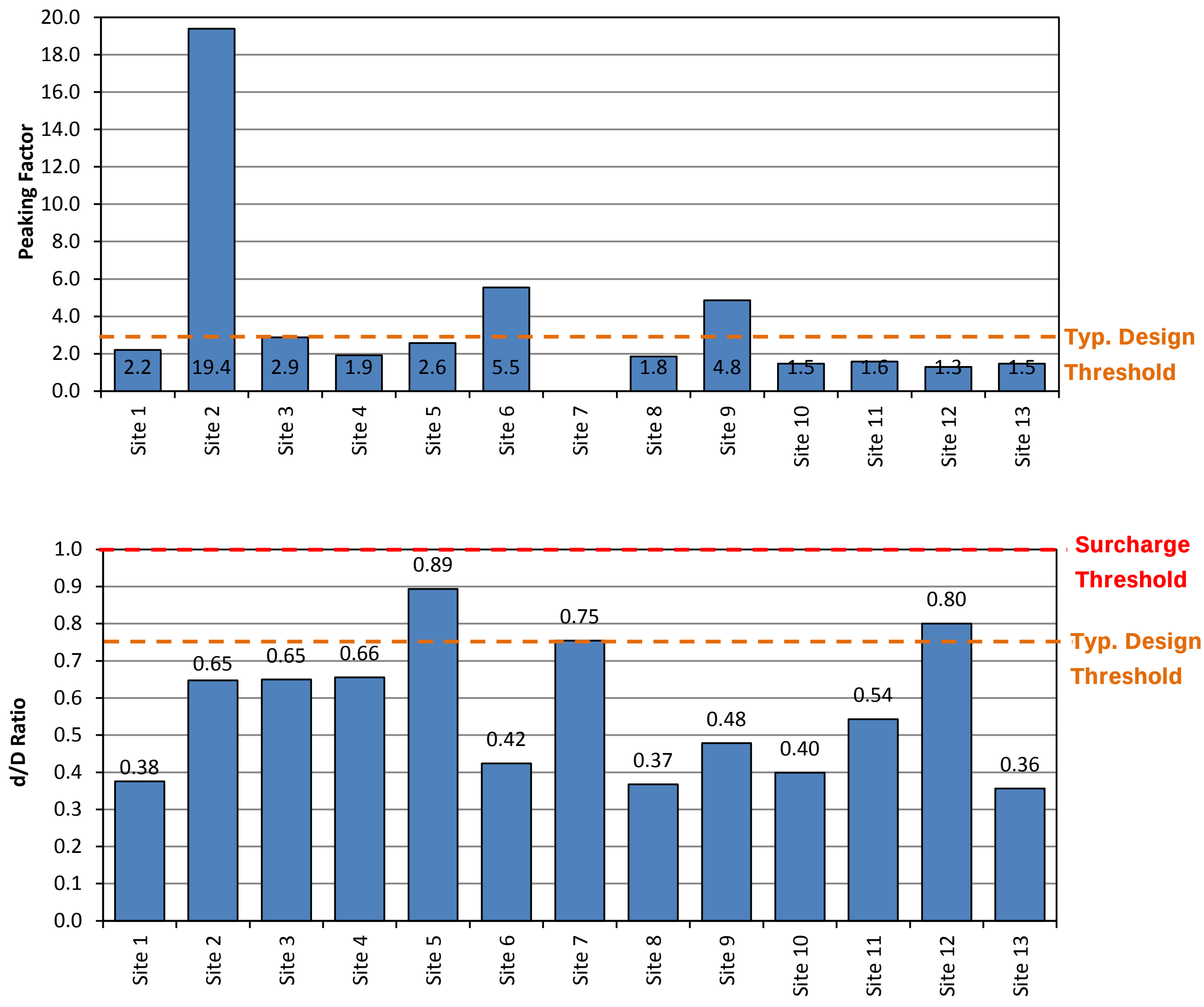


Figure 18. d/D Ratios and Peaking Factors for January 19 – 23, 2012 Rainfall Event

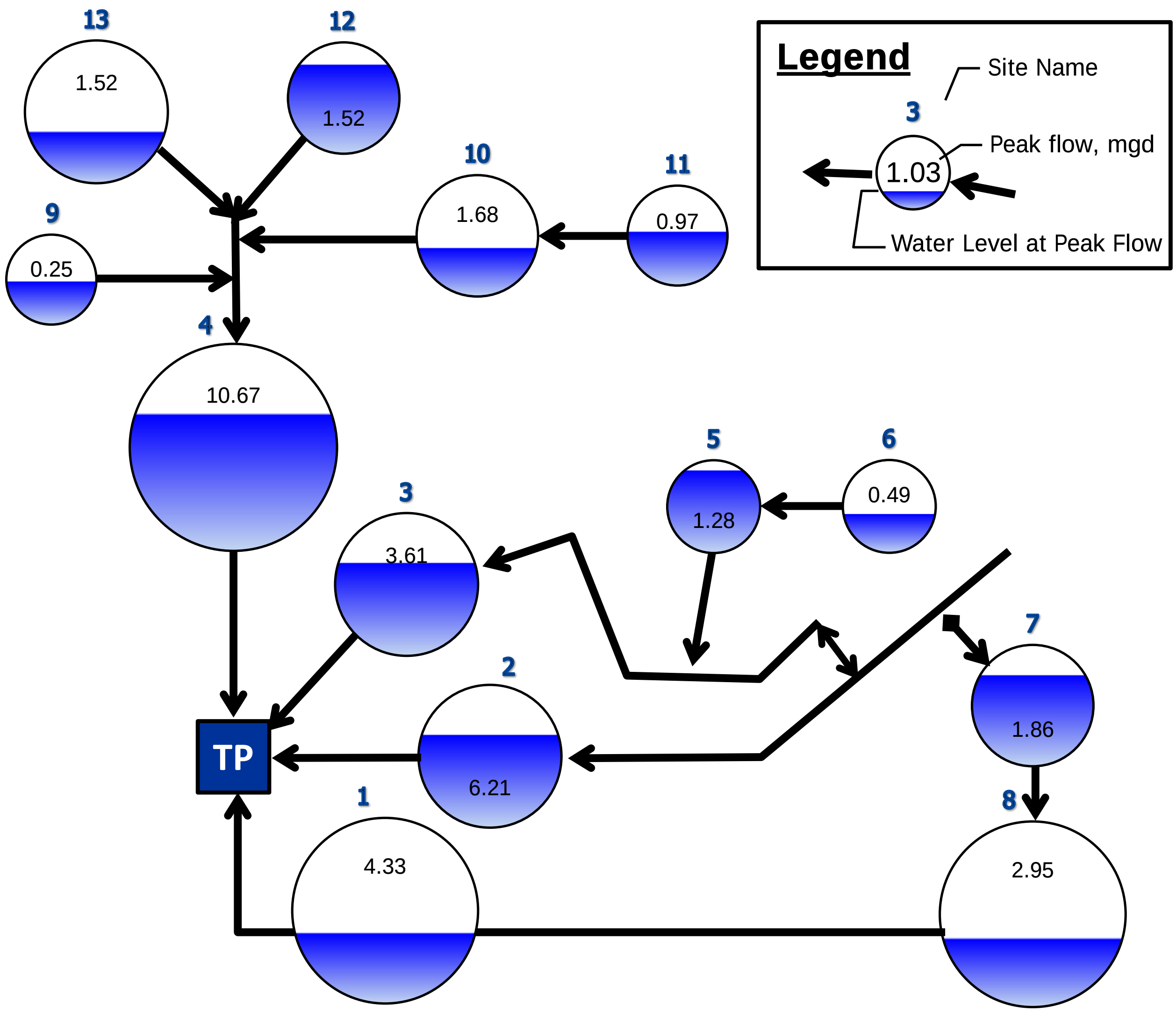


Figure 19. Peak Measured Flow Schematic (Peak Flow, January 21, 2012)

Inflow / Infiltration: Definitions and Identification

Inflow and infiltration (I/I) consist of storm water and groundwater that enter the sewer system through pipe defects and improper storm drainage connections. They are distinguished as follows:

Inflow

- **Definition:** Storm water inflow is defined as water discharged into the sewer system, including private sewer laterals, direct connections such as downspouts, yard and area drains, holes in manhole covers, cross-connections from storm drains, or catch basins.
- **Impact:** This component of I/I creates a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows. Because the response and magnitude of inflow is tied closely to the intensity of the storm event, the short-term peak instantaneous flows may result in surcharging and overflows within a collection system. Severe inflow may result in sewage dilution, resulting in the upset of the biological, or secondary, treatment at the treatment facility.
- **Cost of Source Identification and Removal:** Inflow locations are usually less difficult to find and less expensive to correct than infiltration sources. Inflow sources include direct and indirect cross-connections with storm drainage systems, roof downspouts, and various types of surface drains. Generally, the costs to identify and remove sources of inflow are low compared to potential benefits to public health and safety or the costs of building new facilities to convey and treat the resulting peak flows.
- **Graphical Identification:** Inflow is usually recognized graphically by large-magnitude, short-duration spikes immediately following a rain event.

Infiltration

- **Definition:** Infiltration is defined as water entering the sanitary sewer system through defects in pipes, pipe joints, and manhole walls, which may include cracks, offset joints, root intrusion points, and broken pipes.
- **Impact:** Infiltration typically creates long-term annual volumetric problems. The major impact is the cost of pumping and treating the additional volume of water, and of paying for treatment (for municipalities that are billed strictly on flow volume).
- **Cost of Source Detection and Removal:** Infiltration sources are usually harder to find and more expensive to correct than inflow sources. Infiltration sources include defects in deteriorated sewer pipes or manholes that may be widespread throughout a sanitary sewer system.
- **Graphical Identification:** Infiltration is often recognized graphically by a gradual increase in flow after a wet-weather event. The increased flow typically sustains for a period after rainfall has stopped and then gradually drops off as soils become less saturated and as groundwater levels recede to normal levels.

Components of Infiltration

Infiltration can be further subdivided into components as follows:

- **Groundwater Infiltration (GWI):** Groundwater infiltration depends on the depth of the groundwater table above the pipelines, as well as the percentage of the system submerged. The variation of groundwater levels and subsequent groundwater infiltration rates is seasonal by nature. On a day-to-day basis, groundwater infiltration rates are relatively steady and will not fluctuate greatly.

- **Rainfall-Dependent Infiltration (RDI):** This component occurs as a result of storm water and enters the sewer system through pipe defects, as with groundwater infiltration. The storm water first percolates directly into the soil and then migrates to an infiltration point. Typically, the time of concentration for rainfall-related infiltration may be 24 hours or longer, but this depends on the soil permeability and saturation levels.
- **Rainfall-Responsive Infiltration (RRI):** This component is storm water which enters the collection system indirectly through pipe defects, and normally occurs in sewers constructed close to the ground surface, such as private laterals. Rainfall-responsive infiltration is independent of the groundwater table and reaches defective sewers via the pipe trench in which the sewer is constructed, particularly if the pipe is placed in impermeable soil and bedded and backfilled with a granular material. In this case, the pipe trench serves as a conduit similar to a French drain, conveying storm drainage to defective joints and other openings in the system. This type of infiltration can have a quick response and graphically can look very similar to inflow.

Figure 20 illustrates the possible sources and components of I/I.

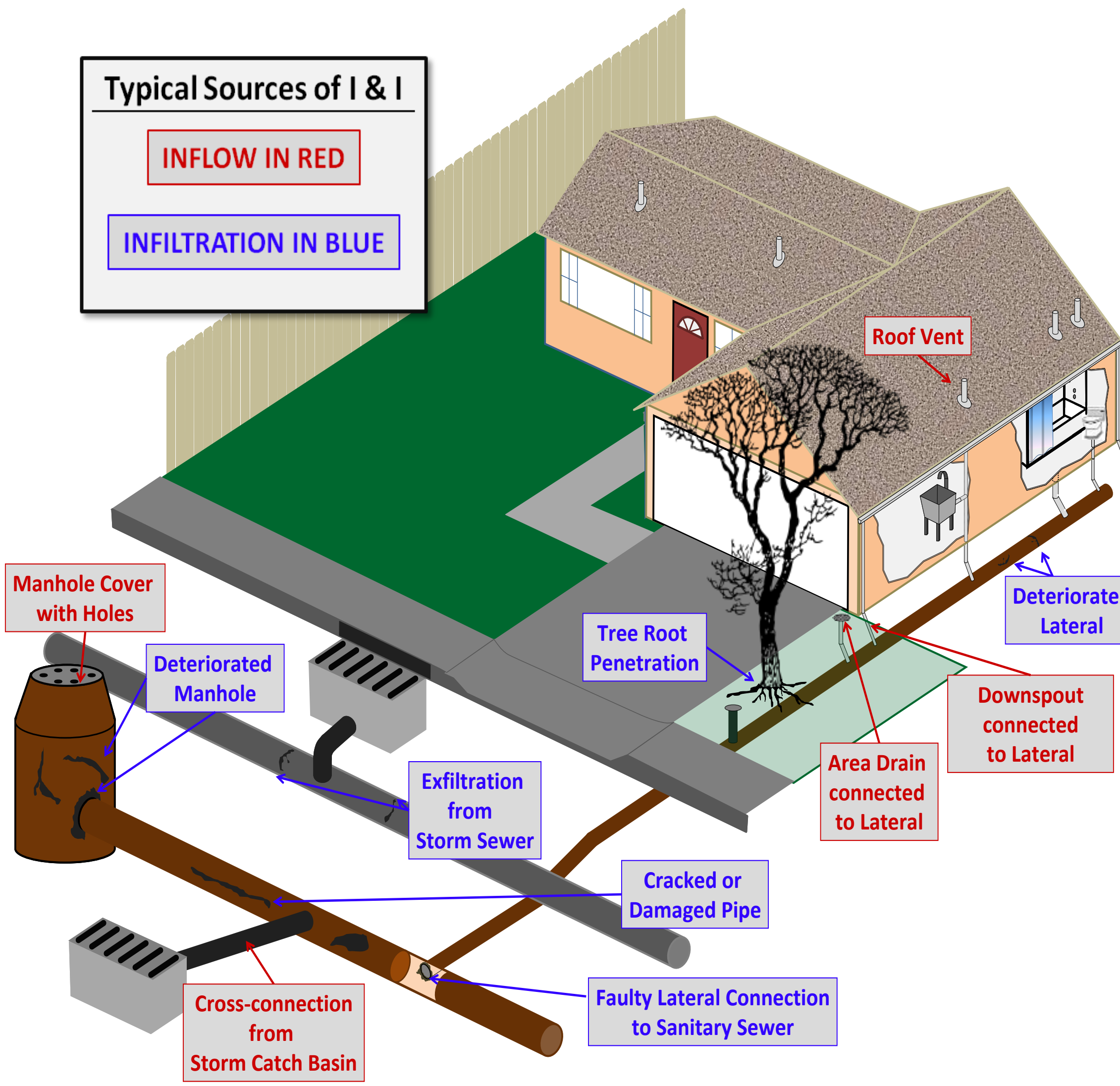


Figure 20. Typical Sources of Infiltration and Inflow

Inflow / Infiltration: Overview of Analysis Methods

After differentiating I/I flows from ADWF flows, various calculations can be made (1) to determine which I/I component (inflow or infiltration) is more prevalent at a particular site and (2) to compare the relative magnitude of the I/I components between drainage basins and between storm events.

Inflow Analysis

Peak I/I Flow Rate: Inflow is characterized by sharp, direct spikes occurring during a rainfall event. Peak I/I rates are used for inflow analysis[8]. After determining the peak I/I flow rate for a given site, and for a given storm event, there are ways to *normalize* the peak I/I rates for an "apples-to-apples" comparison amongst the different drainage basins:

- **Peak I/I Flow Rate per Acre:** Peak measured I/I rate divided by the geographic area of the upstream basin in acres. Units are gpd per acre.
- **Peak I/I Flow Rate to ADWF Ratio:** Peak measured I/I rate divided by average dry weather flow (ADWF). This is a ratio and is expressed without units.

Infiltration Indicators

Dry Weather Groundwater Infiltration: GWI analysis is conducted by looking at minimum dry weather flow to average dry weather flow ratios and comparing them to established standards to quantify the rate of excess groundwater infiltration. These methods are discussed in further detail in the "Groundwater Analysis" section later in this report.

Rain Dependent Infiltration (RDI): Infiltration occurring after the conclusion of a storm event is classified as rainfall-dependent infiltration. Analysis is conducted by looking at the infiltration rates at set periods after the conclusion of a storm event. Depending on the system and the time required for flows to return to ADWF levels, RDI may be examined after different time periods to determine the basins with the greatest or most sustained rainfall-dependent infiltration rates. For this study, the infiltration rates from midnight to 10:00am on January 22, 2012 were calculated[9]. This RDI rate was divided by average dry weather flow (ADWF). This is a ratio and is expressed without units as a percentage.

Combined I/I Analysis

Total Infiltration: The total inflow and infiltration is measured in gallons per site and per storm event. Because it is based on total I/I volume, it is an indicator of combined inflow and infiltration and is used to identify the overall volumetric influence of I/I within the monitoring basin. As with inflow, pipe length, basin area, and dry weather flow are used to normalize combined I/I for basin comparison:

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[8] I/I flow rate is the realtime flow less the estimated average dry weather flow rate. It is an estimate of flows attributable to rainfall. By using peak measured flow rates (inclusive of ADWF), the I/I flow rate would be skewed higher or lower depending on whether the storm event I/I response occurs during low flow or high flow hours.

[9] This date/time was used because there was a period of dry weather immediately following a good sized rainfall event, when soil saturation levels were as high as measured during this study, but the effects of inflow would be minimal.

- **R-Value:** Total infiltration (gallons) divided by the total rainfall that fell within the acreage of a particular basin (gallons of rainfall). This is expressed as a percentage and is explained as "the percent of rain that enters the sanitary sewer collection system." Systems with R-values less than 5%[10] are often considered to be performing well.

- **Combined I/I Flow Rate per ADWF:** Total infiltration (gallons) divided by the ADWF (gpd) and divided by storm event rainfall (inches of rain). Final units are million gallons per mgd of ADWF per inch-rain.

Figure 21 illustrates a sample of how this analysis is conducted and some of the measurements that are used to distinguish infiltration and inflow. Similar graphs generated for the individual flow monitoring sites can be found in *Appendix B*.

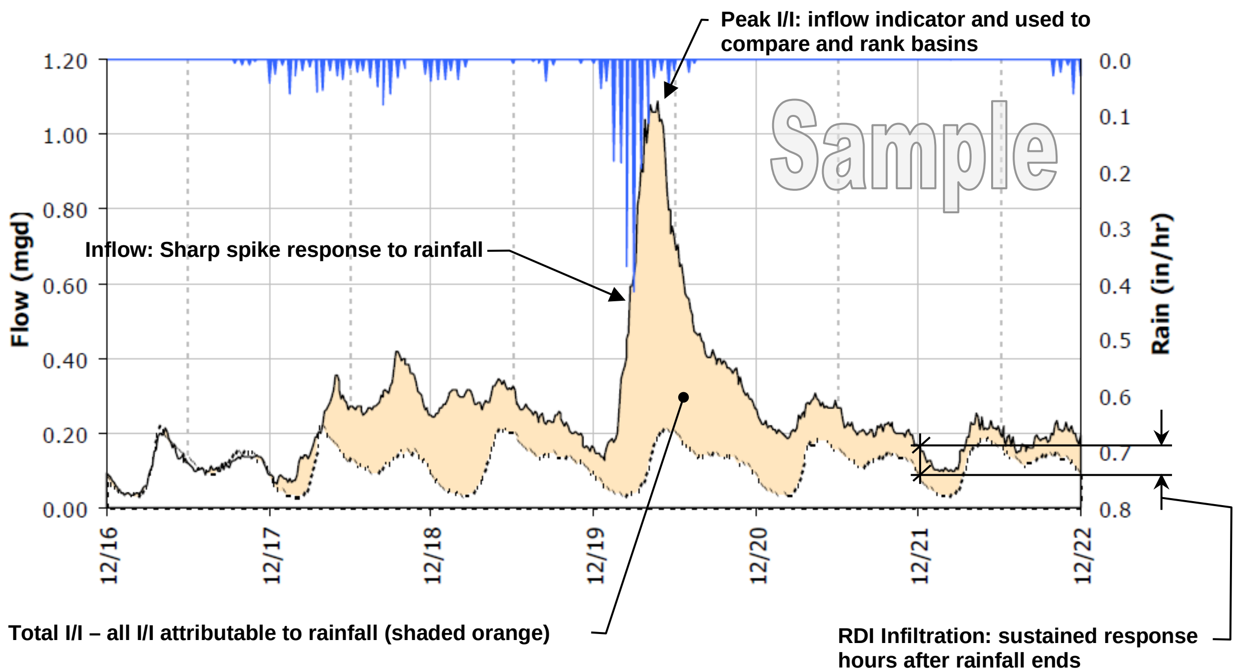


Figure 21. Sample Infiltration and Inflow Isolation Graph

The infiltration and inflow indicators were normalized by the per-ACRE and per-ADWF methods in this report. Final rankings were determined by weighting per-ACRE and per-ADWF normalization methods by 50% and 50%, respectively, with ties broken by the per-ACRE method.

[10] Keefe, P.N. "Test Basins for I/I Reduction and SSO Elimination." 1998 WEF Wet Weather Specialty Conference, Cleveland.

Inflow and Infiltration: Results

Inflow Results Summary

Inflow is storm water discharged into the sewer system through direct connections such as downspouts, area drains, cross-connections to catch basins, etc. These sources transport rain water directly into the sewer system and the corresponding flow rates are tied closely to the intensity of the storm. This component of I/I often causes a peak flow problem in the sewer system and often dictates the required capacity of downstream pipes and transport facilities to carry these peak instantaneous flows.

Table 10 summarizes the peak measured I/I flows and inflow analysis results. Inflow results were taken from the January 19 – 23, 2012 rainfall event. Figure 22 and Figure 23 show bar graph summaries of the inflow analysis, and Figure 24 shows a map summary of the inflow analysis results per basin.

Table 10. Basins Inflow Analysis Summary

Basin	ADWF (mgd)	Peak I/I Rate (mgd)	Peak I/I per Acre (GPAD)	Peak I/I per ADWF	Inflow Ranking
Basin 1	0.37	1.61	2,205	4.36	3
Basin 4	2.14	5.80	1,838	2.71	4
Basin 5	0.41	0.57	1,430	1.38	6
Basin 6	0.088	0.42	7,031	4.84	1
Basin 9	0.051	0.06	1,519	1.26	5
Basin 10	0.53	0.43	495	0.80	8
Basin 11	0.61	0.15	229	0.24	10
Basin 12	1.18	0.58	733	0.49	7
Basin 13	1.04	0.49	324	0.47	9
Basin 2,3,8	2.68	9.14	3,773	3.42	2
WWTP	9.11	19.05	1,795	2.09	

A ranking of 1 represents most inflow after normalization.

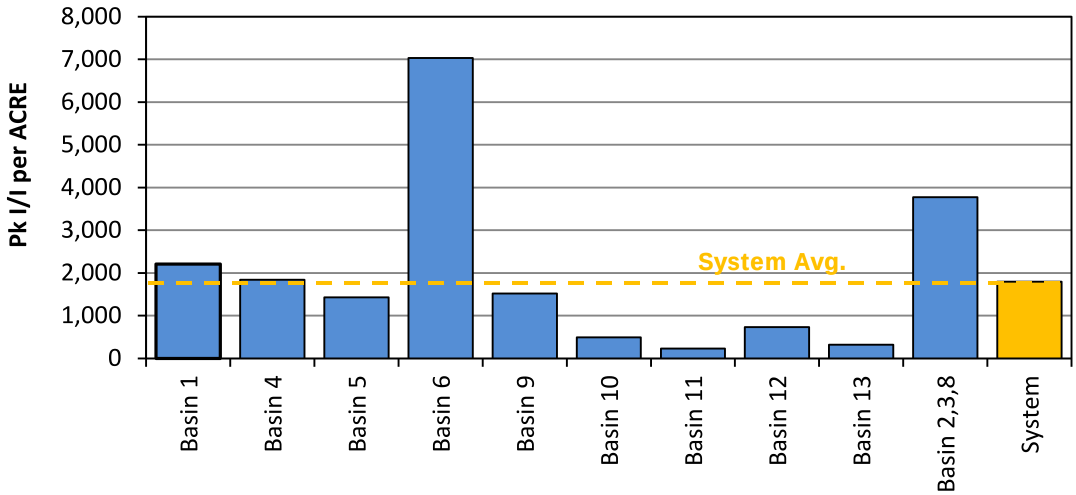


Figure 22. Bar Graphs: Inflow Analysis Summary – Peak I/I Normalized to Basin Area

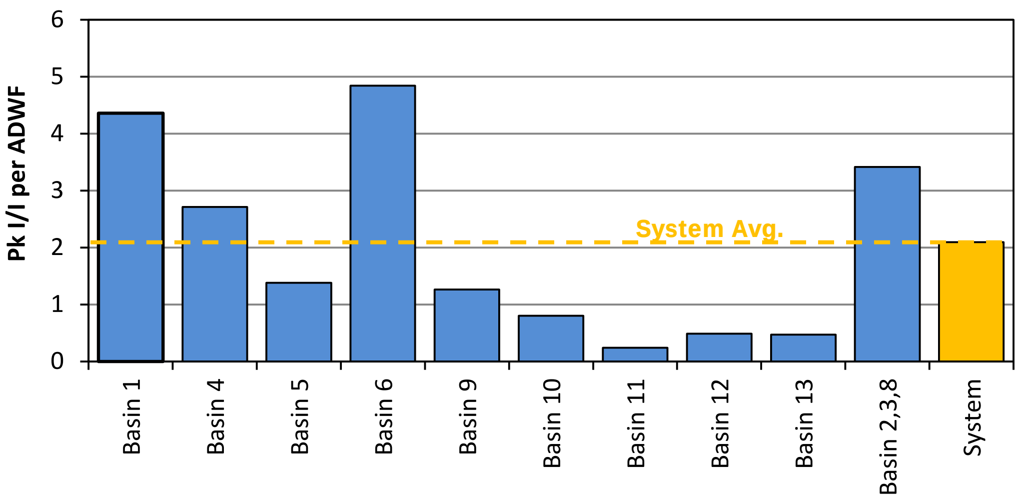


Figure 23. Bar Graphs: Inflow Analysis Summary – Peak I/I Normalized to ADWF

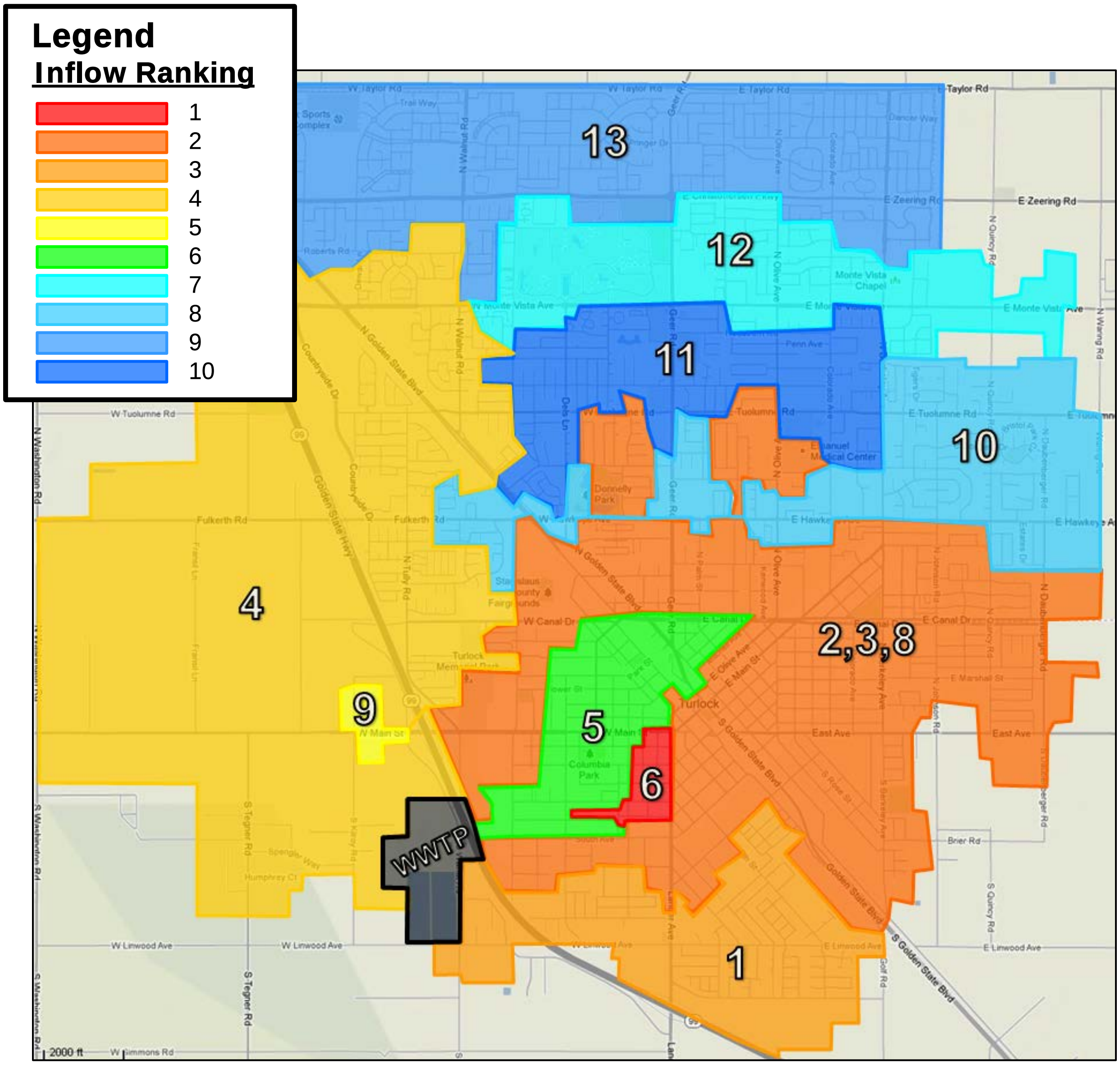


Figure 24. Inflow Temperature Map (by rank)

Infiltration Results Summary

Infiltration is defined as water entering the sanitary sewer system through defects in pipes, pipe joints, and manhole walls, which may include cracks, offset joints, root intrusion points, and broken pipes. Increased flows into the sanitary sewer system are usually tied to groundwater levels and soil saturation levels. Infiltration sources transport rain water into the system *indirectly*; flow levels in the sanitary system increase gradually, are typically sustained for a period after rainfall has stopped, and then gradually drop off as soils become less saturated and as groundwater levels recede to normal. Infiltration typically creates long-term annual volumetric problems. The major impact is the cost of pumping and treating the additional volume of water, and of paying for treatment (for municipalities that are billed strictly on flow volume).

RDI within the City collection system was negligible. Flows returned to baseline levels very quickly – within hours of the conclusion of a rainfall event. Figure 25 shows the rainfall, baseline, realtime and I/I flow response at the treatment facility for the largest rainfall event of the season. The RDI within the collection system based on the data collected during this study is considered negligible.

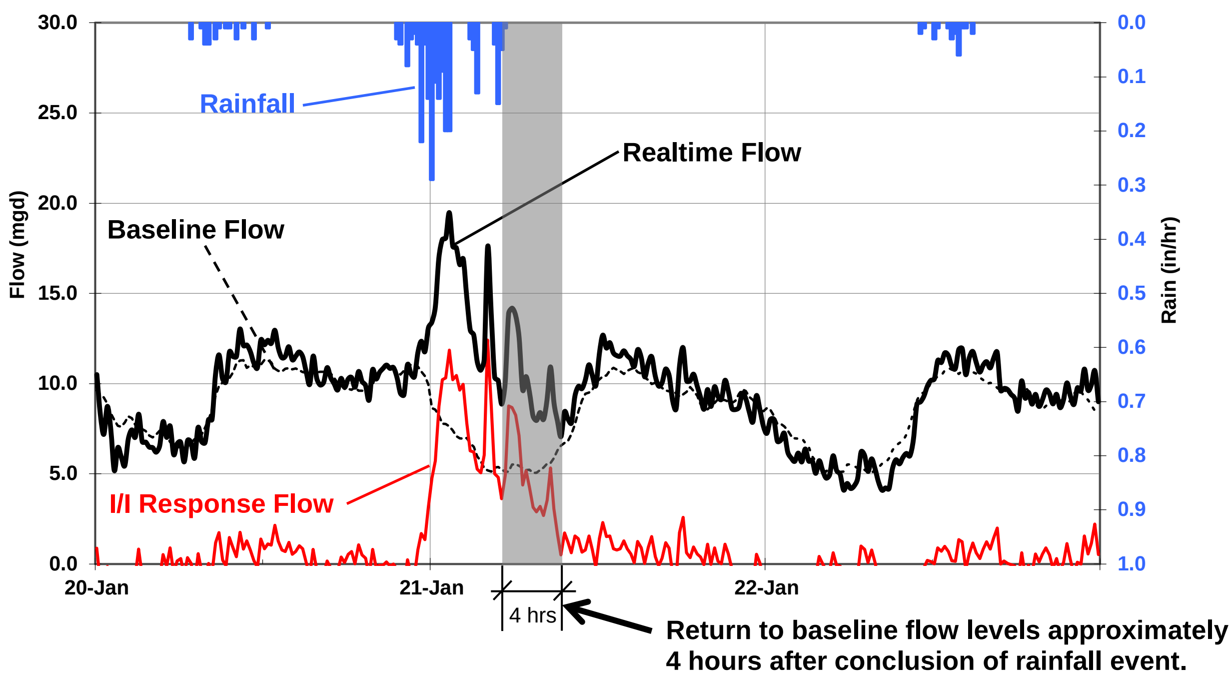


Figure 25. Illustration of Negligible RDI

Groundwater Infiltration Results Summary

Dry weather (ADWF) flow can be expected to have a predictable diurnal flow pattern. While each site is unique, experience has shown that, given a reasonable volume of flow and typical loading conditions, the daily flows fall into a predictable range when compared to the daily average flow. If a site has a large percentage of groundwater infiltration occurring during the periods of dry weather flow measurement, the amplitudes of the peak and low flows will be dampened[11]. Figure 26 shows a sample of two flow monitoring sites, both with nearly the same average daily flow, but with considerably different peak and low flows. In this sample case, Site B1 may have a considerable volume of groundwater infiltration.

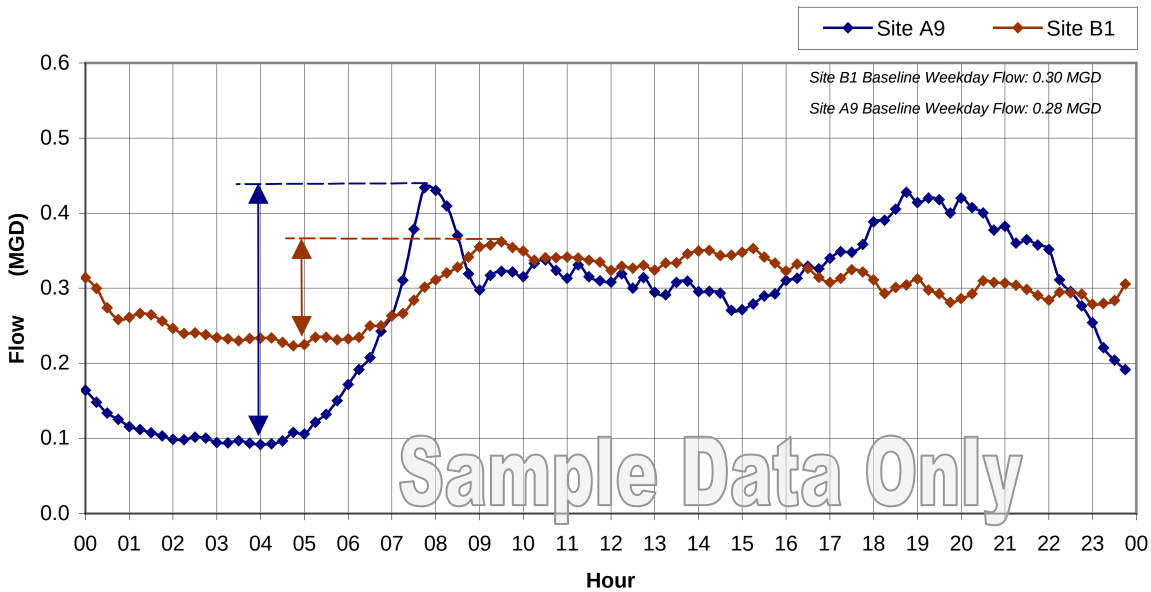


Figure 26. Groundwater Infiltration Sample Figure

It can be useful to compare the low-to-ADWF flow ratios for the flow metering sites. A site with abnormal ratios, and with no other reason to suspect abnormal flow patterns (such as proximity to pump station, treatment facilities, industrial usage, etc.), has a possibility of higher levels of groundwater infiltration in comparison to the rest of the collection system. While it is known that there are high industrial discharges into the collection system, the analysis was completed and is presented henceforth.

Figure 27 plots the low-to-ADWF flow ratios against the ADWF flows for the basins monitored during this study. The dotted line shows "typical" low-to-ADWF ratios per the Water Environment Federation (WEF)[12].

[11] In an extreme, theoretical case, if there were 0.2 mgd of ADWF flow and 2.0 mgd of groundwater infiltration, the peaks and lows would be barely recognizable; the ADWF flow would be nearly a straight line.

[12] WEF Manual of Practice No. 9, "Design and Construction of Sanitary and Storm Sewers."

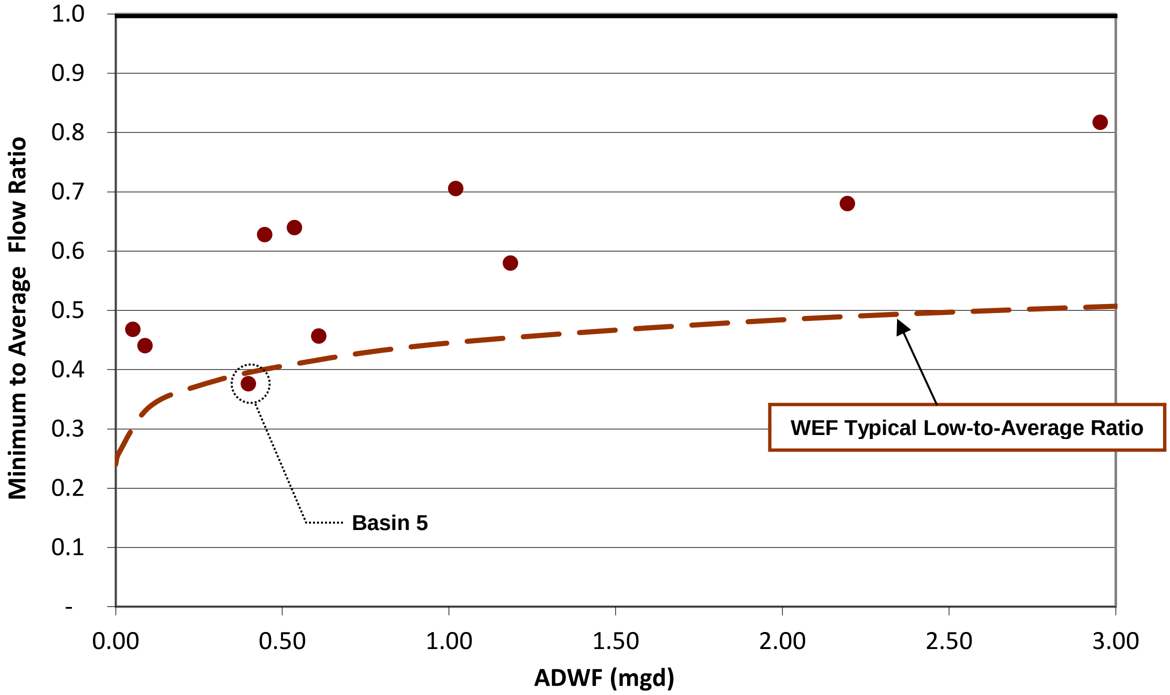


Figure 27. Minimum Flow Ratios vs. ADWF[13]

The following GWI analysis results are noted:

- All basins with the exception of Basin 5 had higher than normal WEF typical low-to-average ratios.

Typically, higher than normal typical low-to-average ratios are an indication of high GWI rates within the drainage basin. However, it is known that there is a large industrial discharge component within the City collection system. Also given the negligible RDI rates present within this system (refer to previous section) it is believed that the higher than normal WEF typical low-to-average is predominantly due to industrial discharge and that excessive groundwater infiltration is probably not a significant factor within the City collection system.

[13] Due to attenuation, it should be expected that sites with larger flow volumes should not have quite the peak-to-average and low-to-average flow ratios as sites with lesser flow volumes, which is why the WEF typical trend lines slope closer to 1.0 as the ADWF increases, as shown in the figure.

Combined I/I Results Summary

Combined I/I analysis considers the totalized volume (in gallons) of both inflow and rainfall-dependent infiltration over the course of a storm event.

Table 11 summarizes the combined I/I flow results. In this study, the flows did not return to baseline levels between storm events. As a result, the combined I/I results were taken from the period that encompasses the three events from March 13 through March 29, 2012 (refer to the *I/I Methods* section for more information on inflow analysis methods). Figure 28 and Figure 29 show bar graph summaries of the combined I/I analysis, and Figure 30 shows a temperature map summary of the combined I/I analysis results per basin.

Table 11. Basins Combined I/I Analysis Summary

Basin	ADWF (mgd)	Total I/I (gallons)	R-Value	Total I/I per ADWF	Combined I/I Ranking
Basin 1	0.37	616,000	4.1%	2.23	3
Basin 4	2.14	281,000	0.4%	0.17	7
Basin 5	0.41	16,000	0.2%	0.05	9
Basin 6	0.088	155,000	12.8%	2.40	1
Basin 9	0.051	6,000	0.7%	0.15	6
Basin 10	0.53	172,000	0.9%	0.40	5
Basin 11	0.61	58,000	0.4%	0.12	8
Basin 12	1.18	183,000	1.1%	0.20	4
Basin 13	1.04	50,000	0.2%	0.06	10
Basin 2,3,8	2.68	2,345,000	4.7%	1.16	2
WWTP	9.11	3,882,000	1.8%	0.56	

Ranking of 1 represents most combined I/I after normalization.

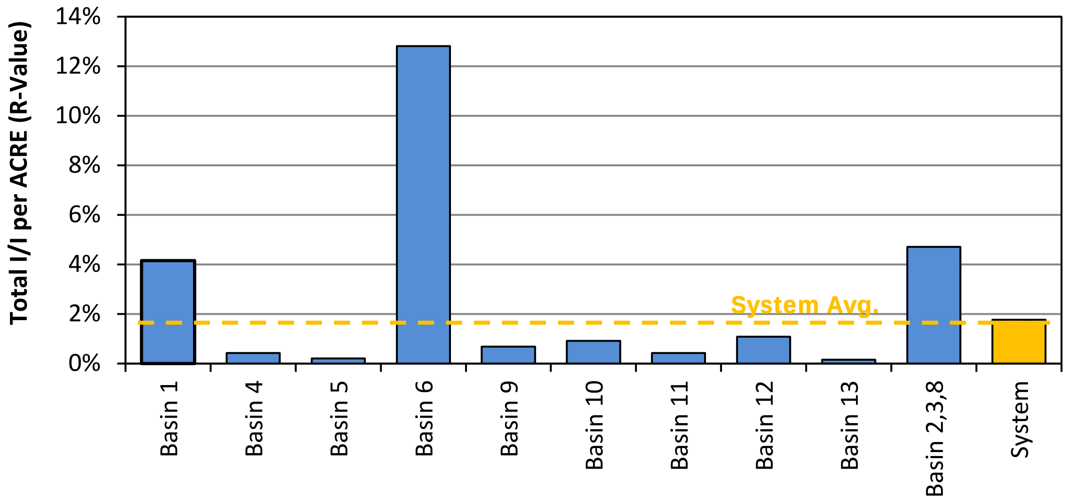


Figure 28. Bar Graphs: Combined I/I Analysis Summary – Total I/I Normalized to Basin Area

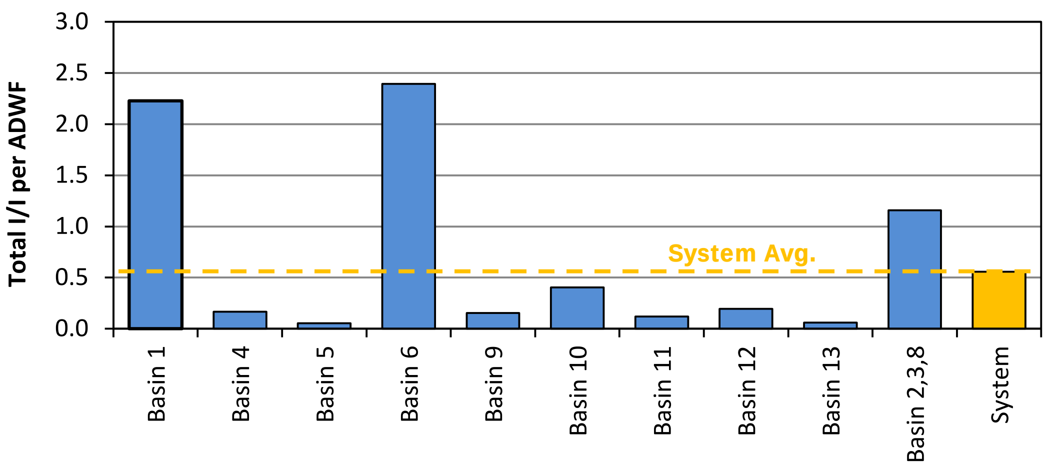


Figure 29. Bar Graphs: Combined I/I Analysis Summary – Total I/I Normalized to ADWF

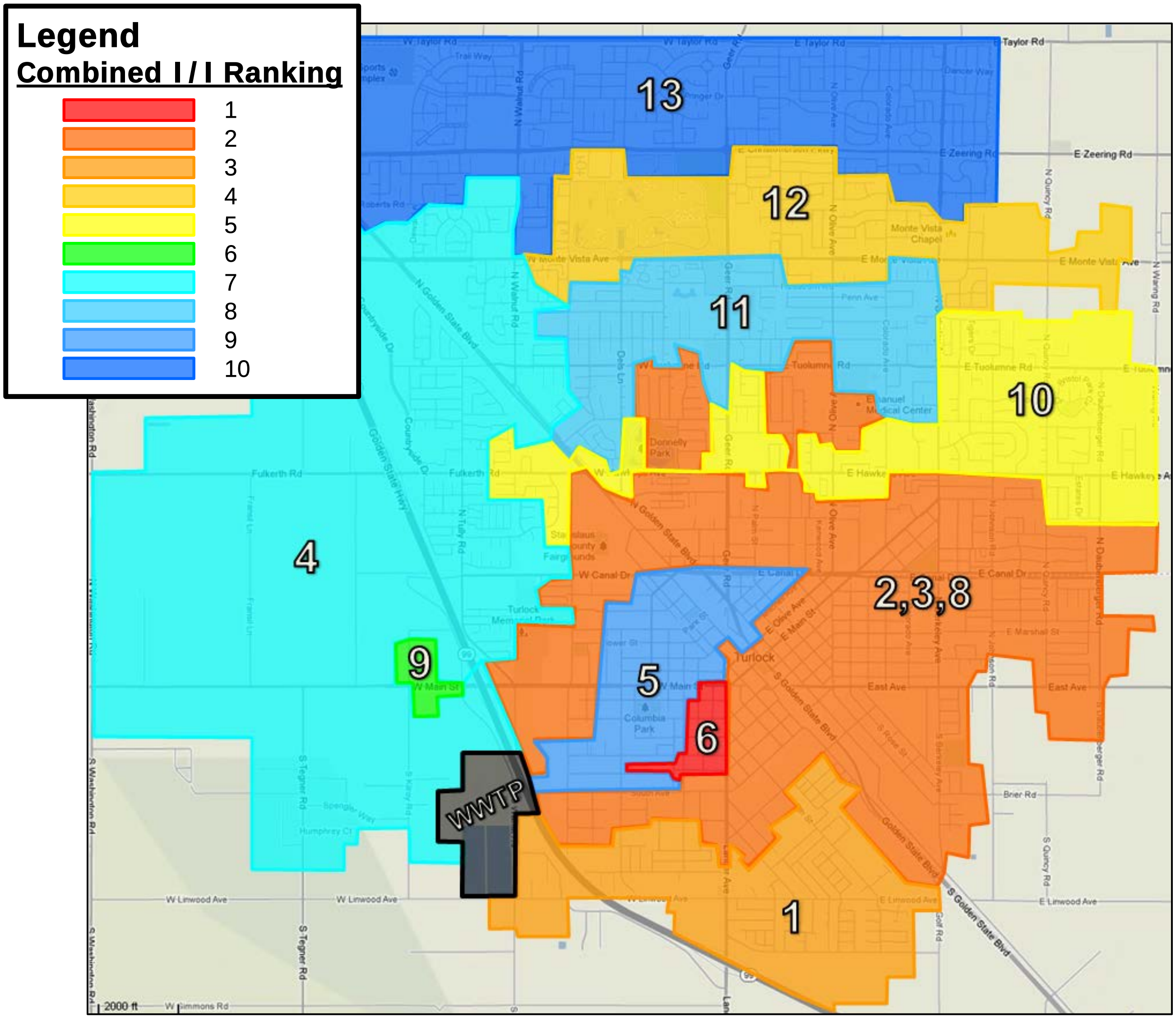


Figure 30. Combined I/I Temperature Map (by rank)

RECOMMENDATIONS

V&A advises that future I/I reduction plans consider the following recommendations:

1. **Determine I/I Reduction Program:** The City should examine its I/I reduction needs to determine a future I/I reduction program.
    a. If peak flows, sanitary sewer overflows, and pipeline capacity issues are of greater concern, then priority can be given to investigate and reduce sources of inflow within the basins with the greatest inflow problems. The highest inflow occurred in Basins 1, 2, 3, 6 and 8.
    b. If total infiltration and general pipeline deterioration are of greater concern, then the program can be weighted to investigate and reduce sources of infiltration within the basins with the greatest infiltration problems.
        i. There was no evidence of high RDI or GWI rates within the collection system.
2. **I/I Investigation Methods:** Potential I/I investigation methods include the following:
    a. Smoke testing: the objective with this step is to ascertain whether defects from laterals originate via direct connections or through laterals with breaks, offset joints and/or cracks. The City could perform smoke testing on segments with known sources of I/I from laterals to find the 'low hanging fruit'; i.e., the direct connections from area drains, roof leaders or other similar connections.
    b. Sub-basin flow monitoring: Larger basins with high I/I can be reduced into smaller sub basins by conducting a more focused flow monitoring and I/I study specific to focused basins.
    c. Nighttime reconnaissance work to (1) investigate and determine direct point sources of inflow and (2) determine the areas and pipe reaches responsible for high levels of infiltration contribution.
    d. Focused CCTV I/I Inspection: CCTV I/I inspection can determine exact locations of infiltration occurring within the pipe mains and at the lateral-to-pipe main joint. The CCTV I/I inspection will document which laterals have significant volumes of infiltration contributing to the collection system, and may document whether the I/I is occurring in the upper or lower portion of the pipe lateral. A great benefit from this work is that the percentage of infiltration coming from laterals versus pipe mains can be effectively quantified.
3. **I/I Reduction Cost-Effectiveness Analysis:** The City should conduct a study to determine which is more cost-effective: (1) locating the sources of inflow and infiltration and systematically rehabilitating or replacing the faulty pipelines or (2) continued treatment of the additional rainfall-dependent I/I flow.

APPENDIX A

FLOW MONITORING SITES: DATA, GRAPHS, INFORMATION

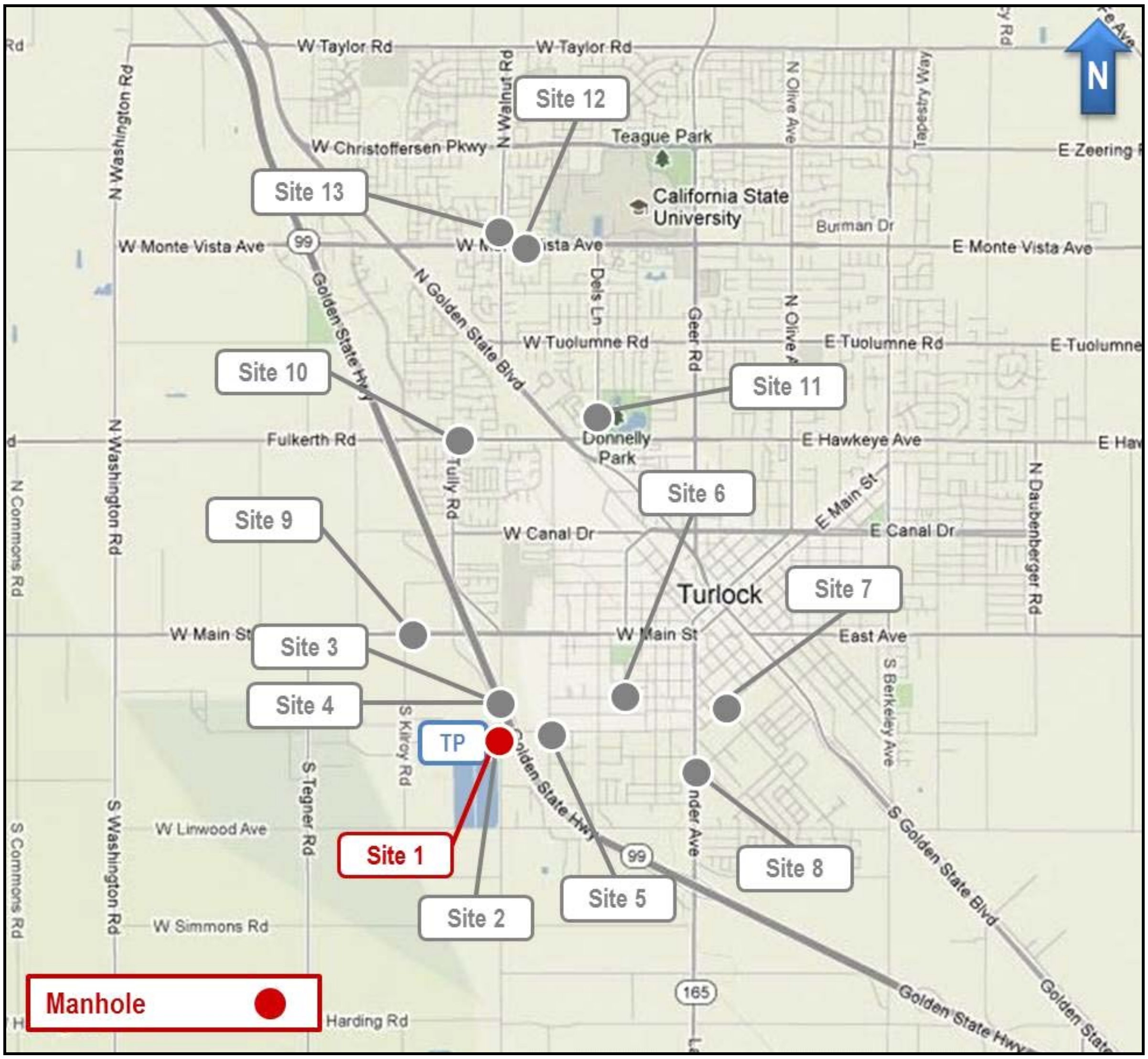
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 1

Location: Walnut Road, North of Treatment Plant entrance

Data Summary Report



Vicinity Map: Site 1

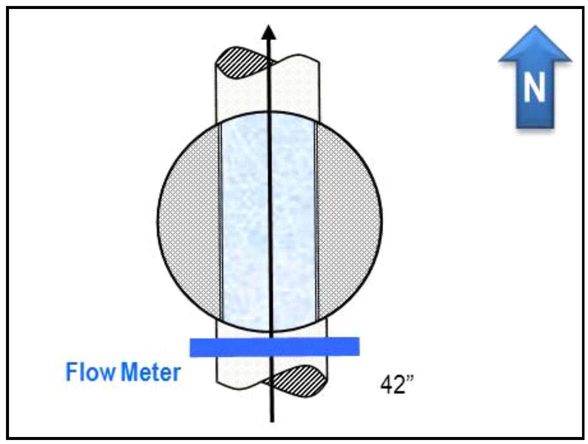
SITE 1

Site Information

Location:	Walnut Road, North of Treatment Plant entrance
Coordinates:	120.8672° W, 37.4853° N
Rim Elevation:	97 feet
Pipe Diameter:	42 inches
Baseline Flow:	1.971 mgd
Peak Measured Flow:	4.333 mgd

Satellite Map

Sewer Map



Flow Sketch

Street View

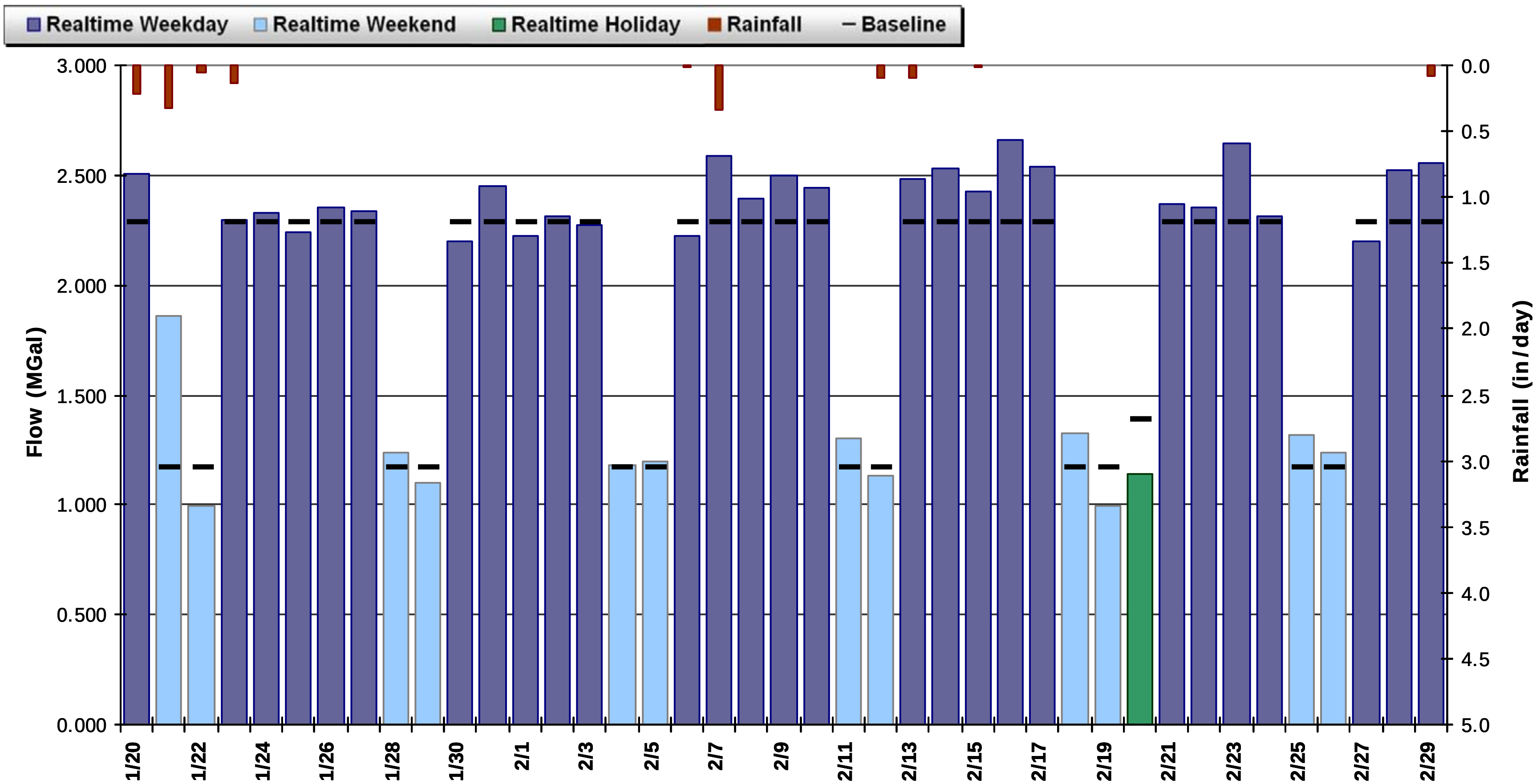
Plan View

SITE 1

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 2.031 MGal **Peak Daily Flow: 2.661 MGal** **Min Daily Flow: 0.997 MGal**

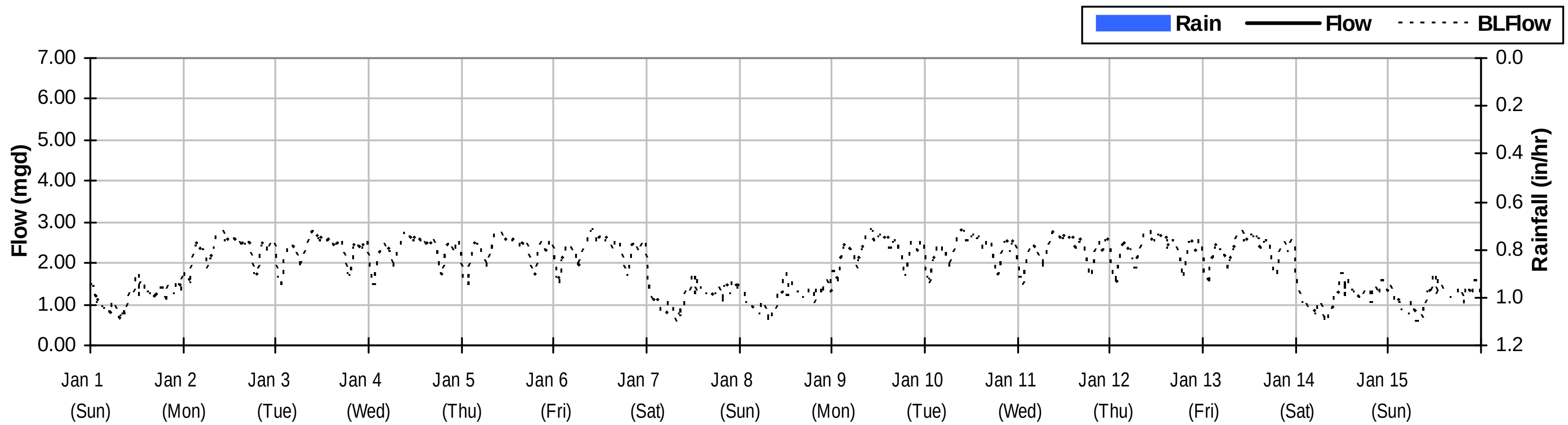
Total Period Rainfall: 1.39 inches

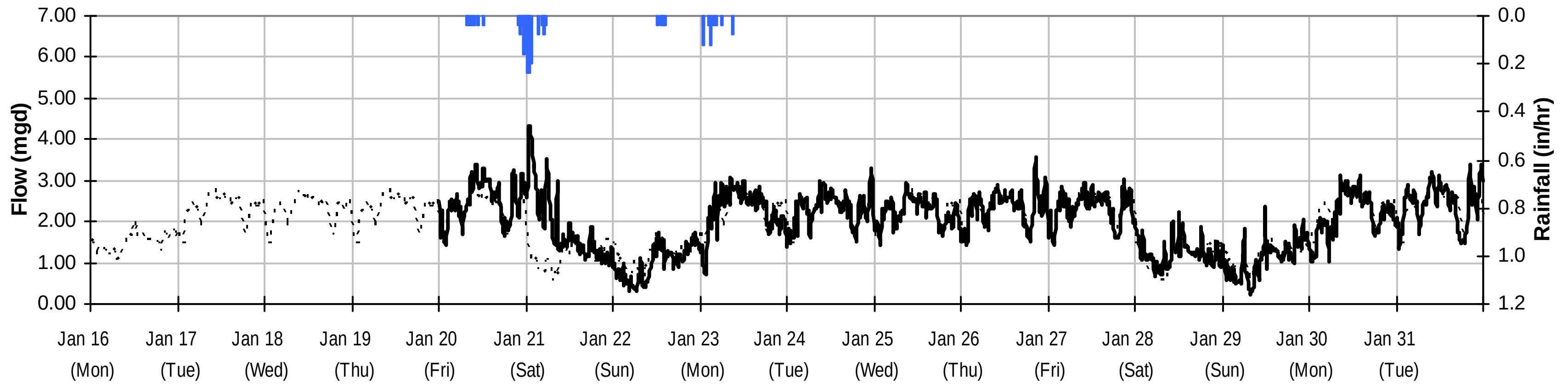


SITE 1

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.73 inches **Avg Flow: 1.992 mgd** **Peak Flow: 4.333 mgd** **Min Flow: 0.240 mgd**

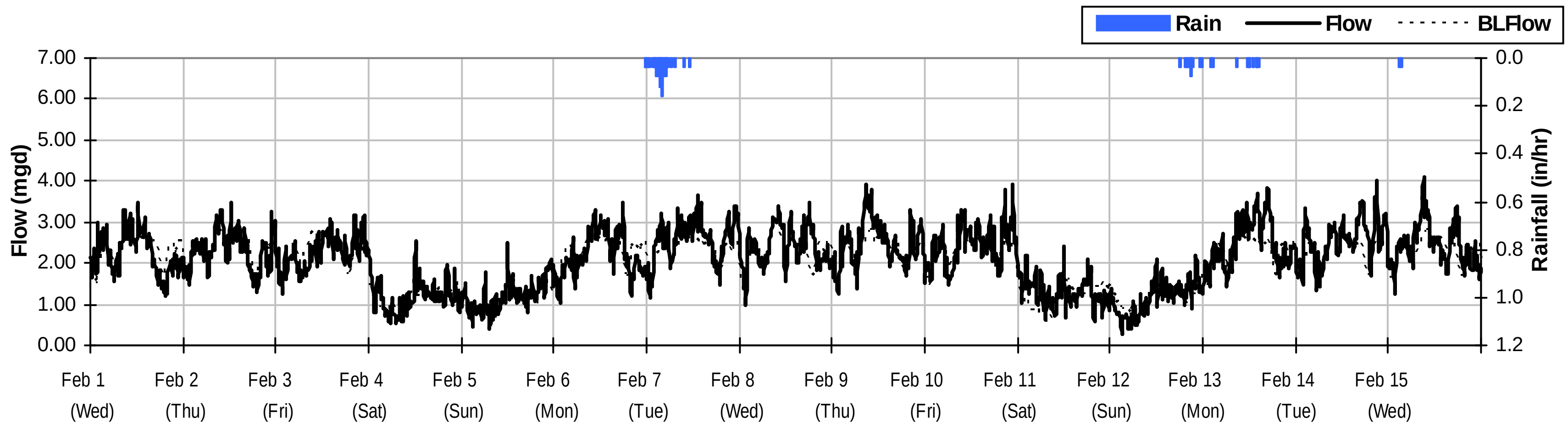


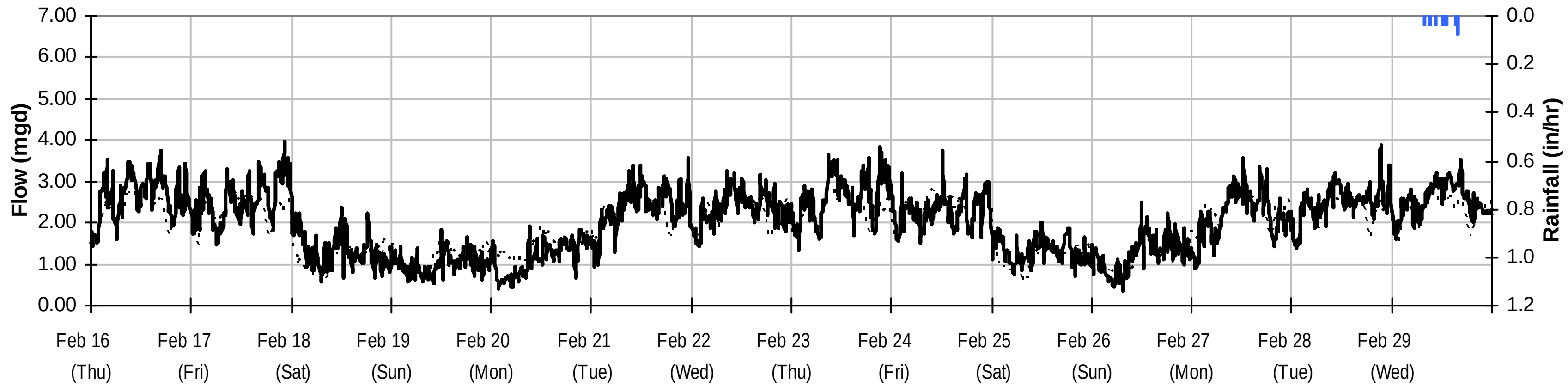


SITE 1

Monthly Flow Summary: February, 2012

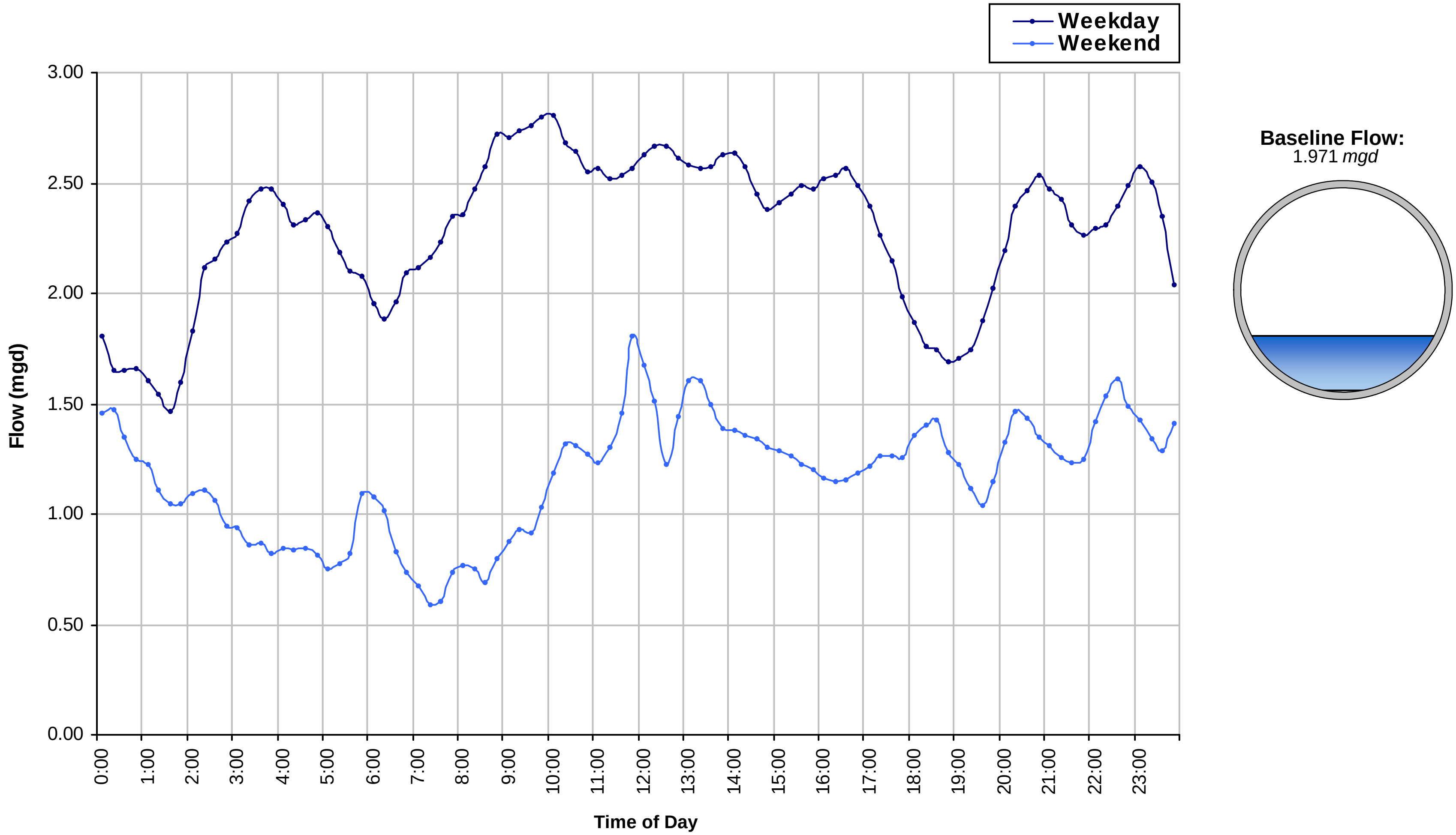
Total Monthly Rainfall: 0.66 inches **Avg Flow: 2.048 mgd** **Peak Flow: 4.081 mgd** **Min Flow: 0.246 mgd**





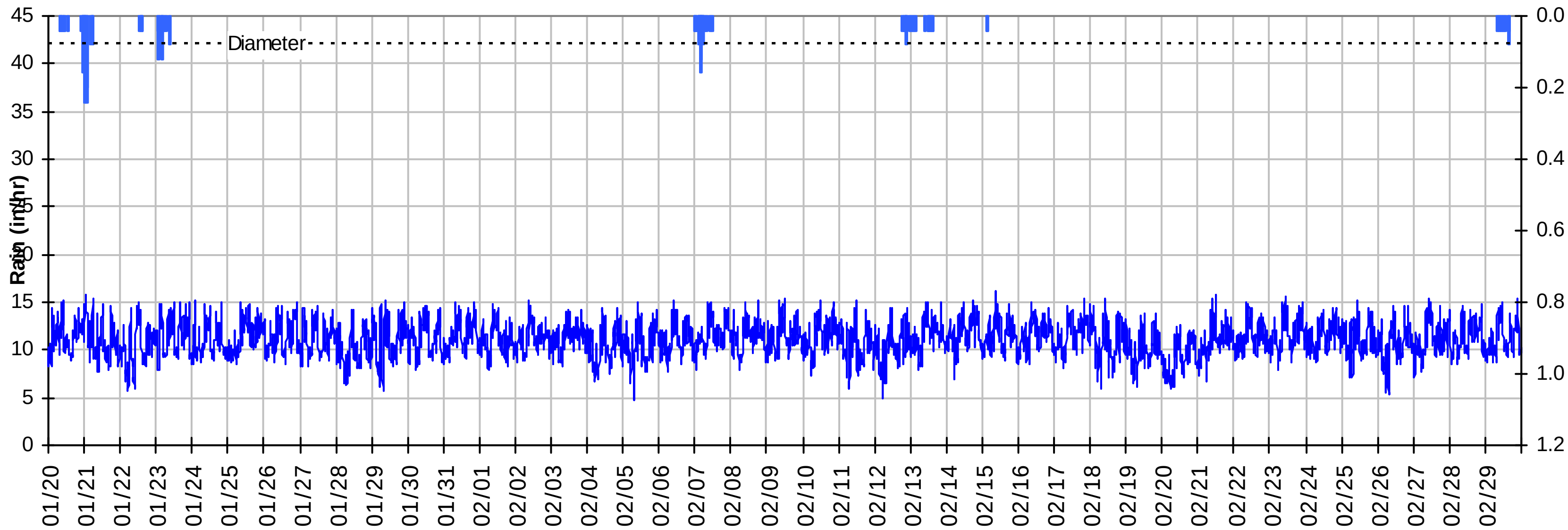
SITE 1

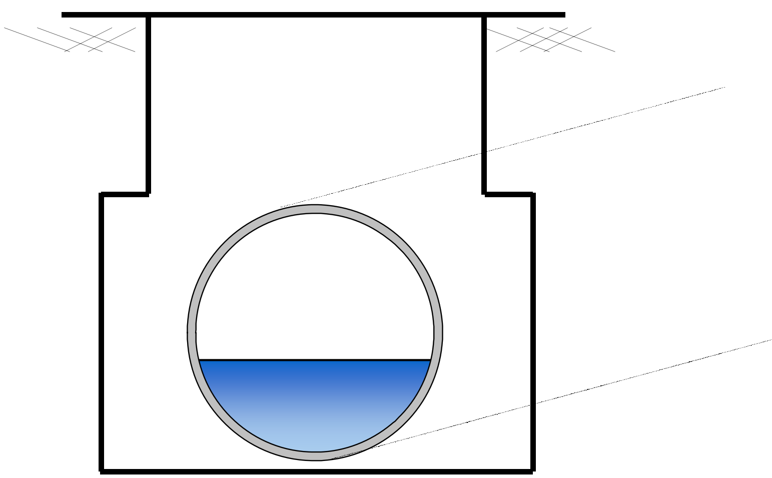
Baseline Flow Hydrographs



SITE 1
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





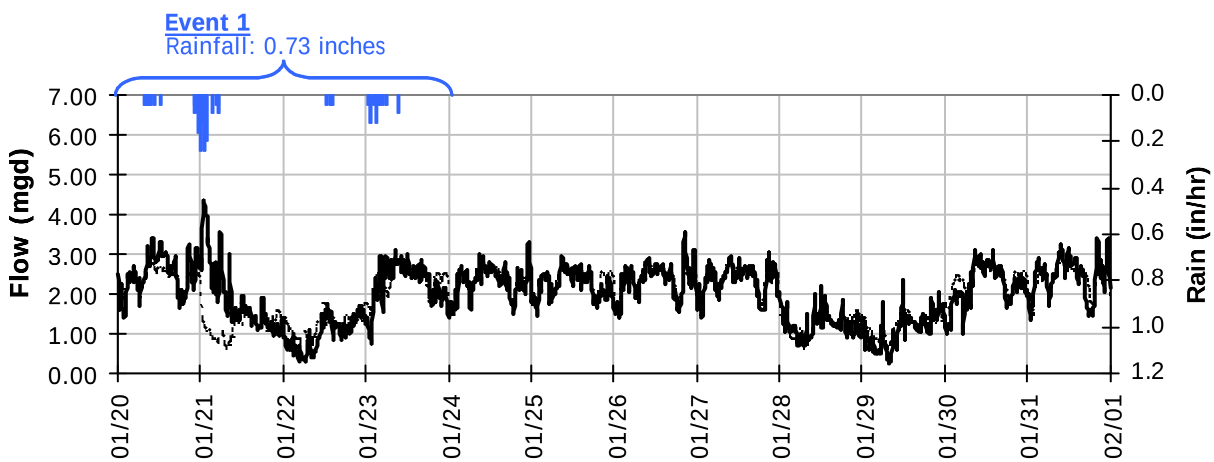
Pipe Diameter: 42 *inches*

Peak Measured Level: 16.3 *inches*

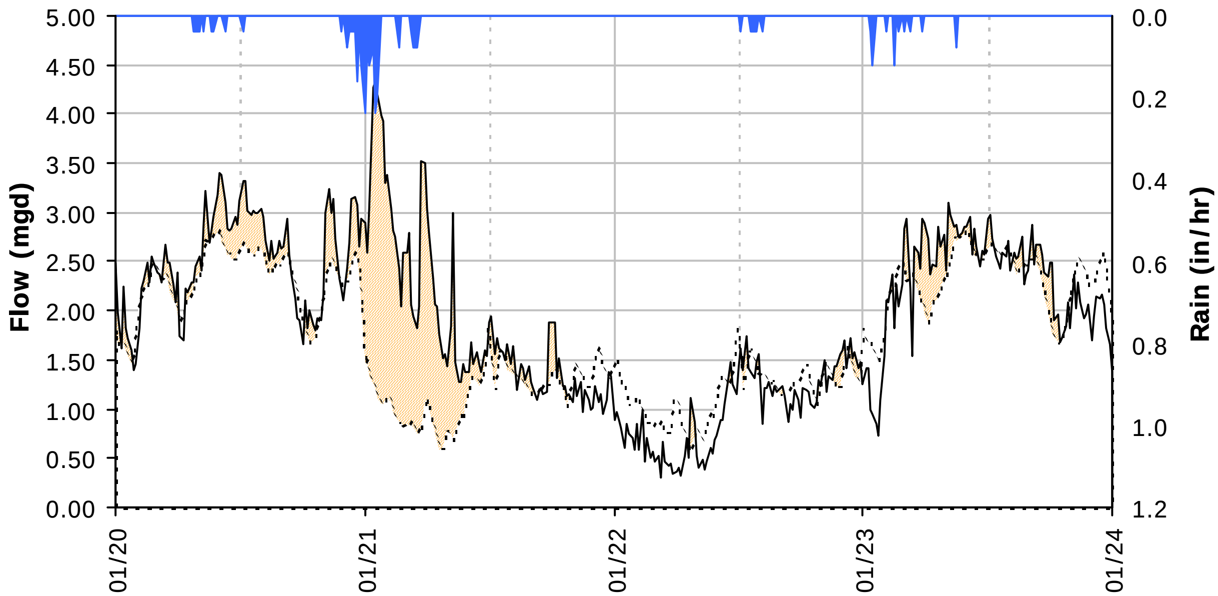
Peak d/D Ratio: 0.39

SITE 1
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph



Storm Event I/I Analysis (Rain = 0.73 inches)

Capacity

Peak Flow: 4.33 *mgd*
PF: 2.20
Peak Level: 15.78 *in*
d/D Ratio: 0.38

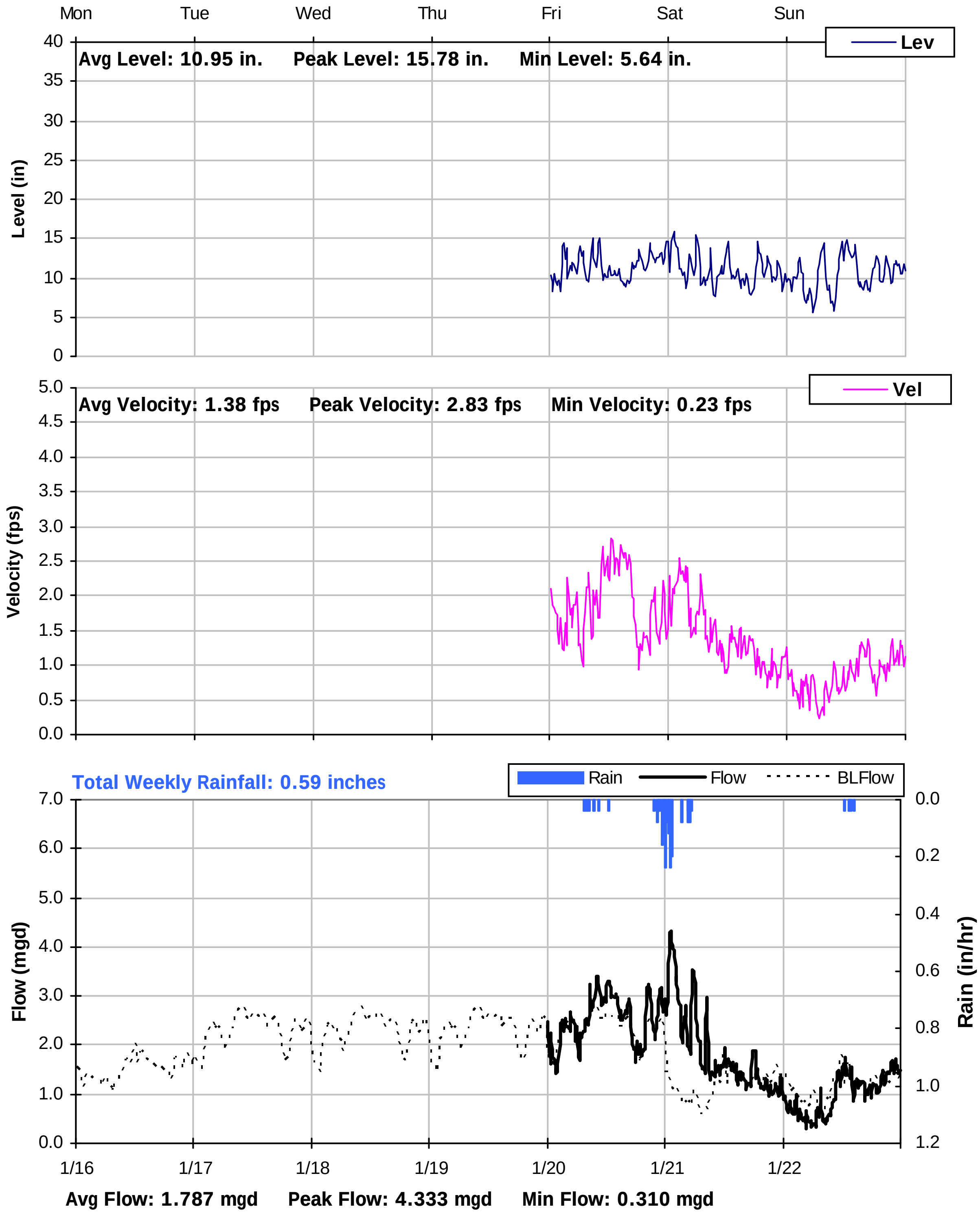
Inflow

Peak I/I Rate: 3.11 *mgd*
Pk I/I:Acre: 1,815 *gpd/acre*
Pk I/I:ADWF: 1.58

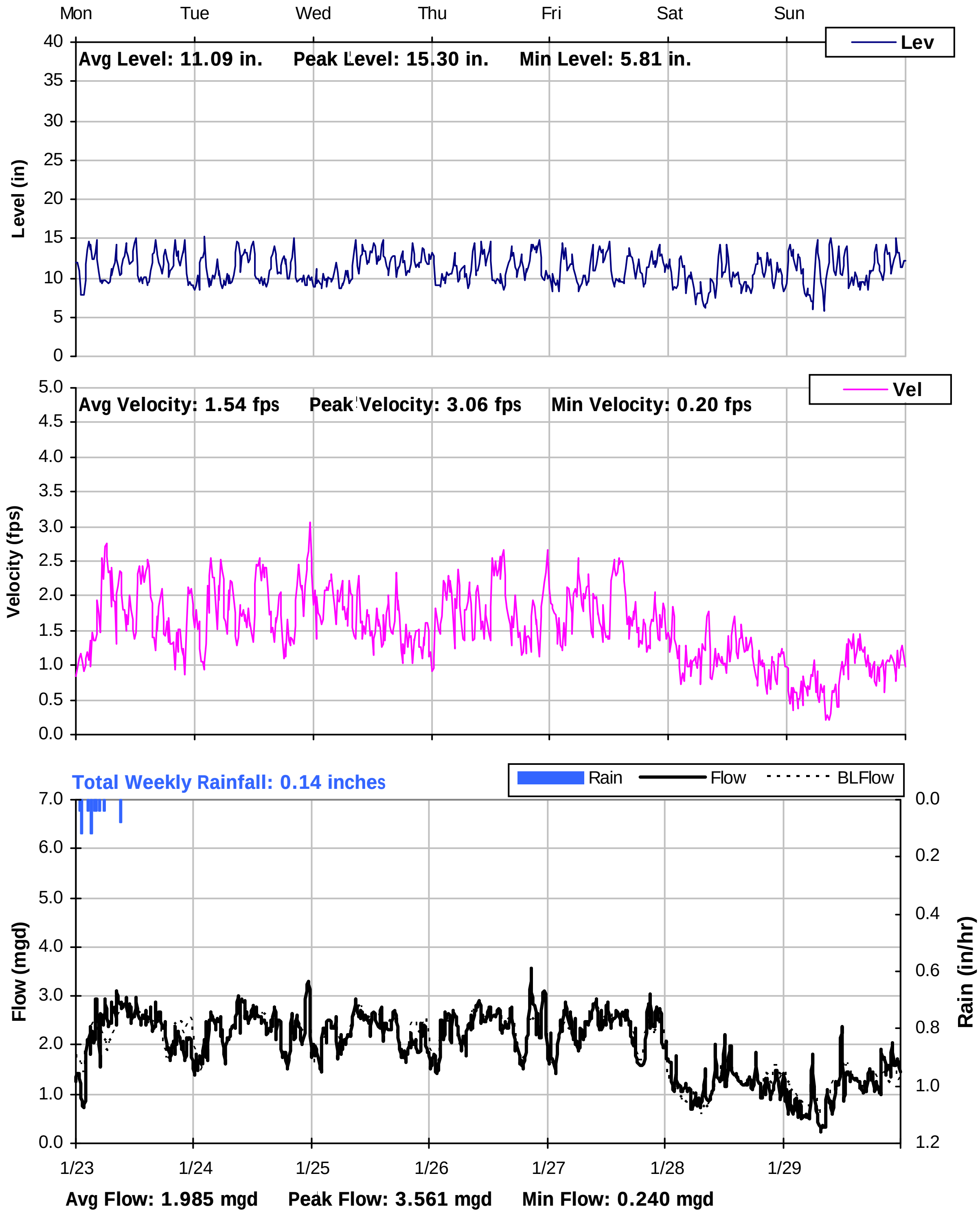
Combined I/I

Total I/I: 909,000 *gallons*
R-Value: 2.7%
Total I/I:ADWF: 0.63 *per in-rain*

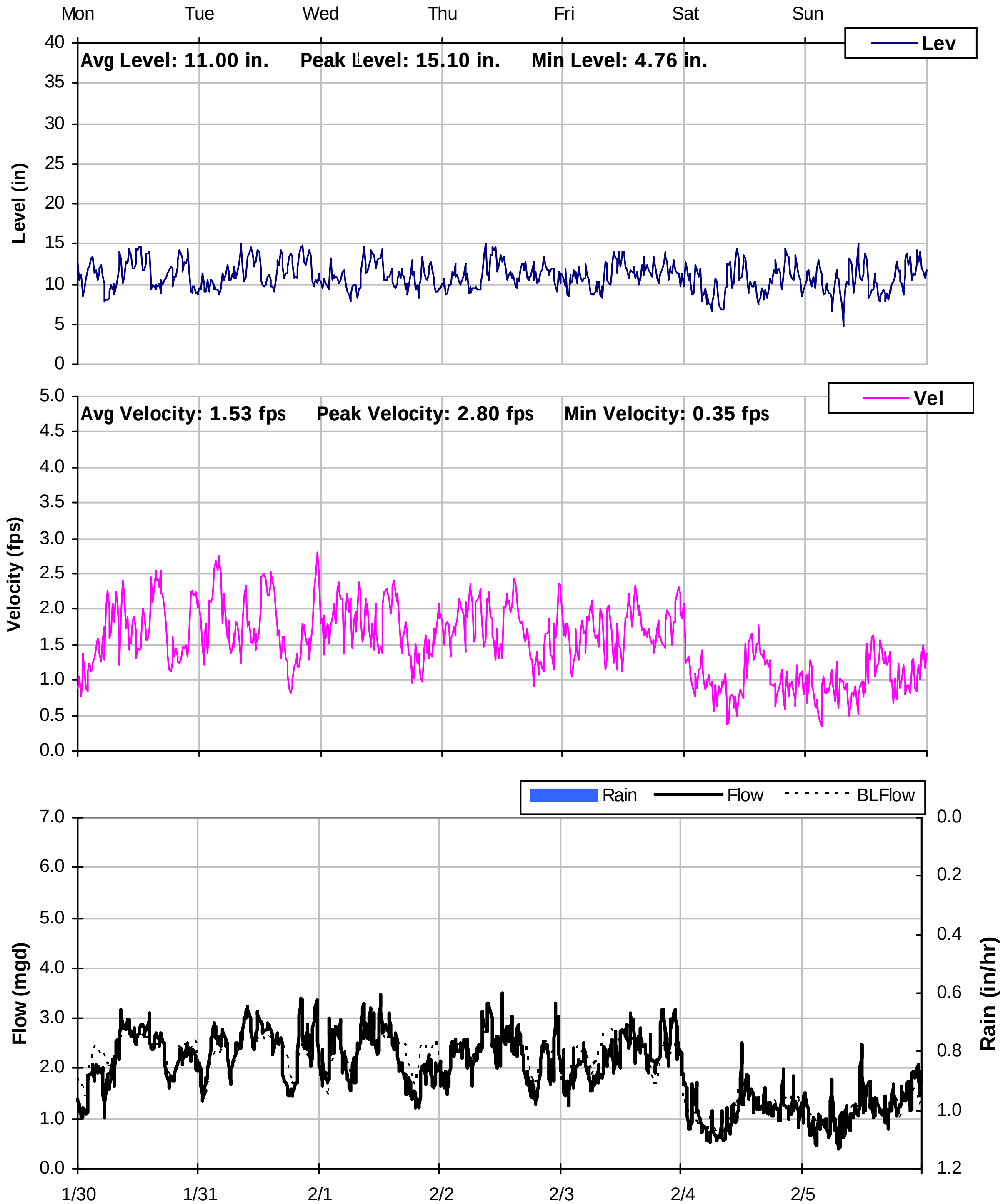
SITE 1
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



SITE 1
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012

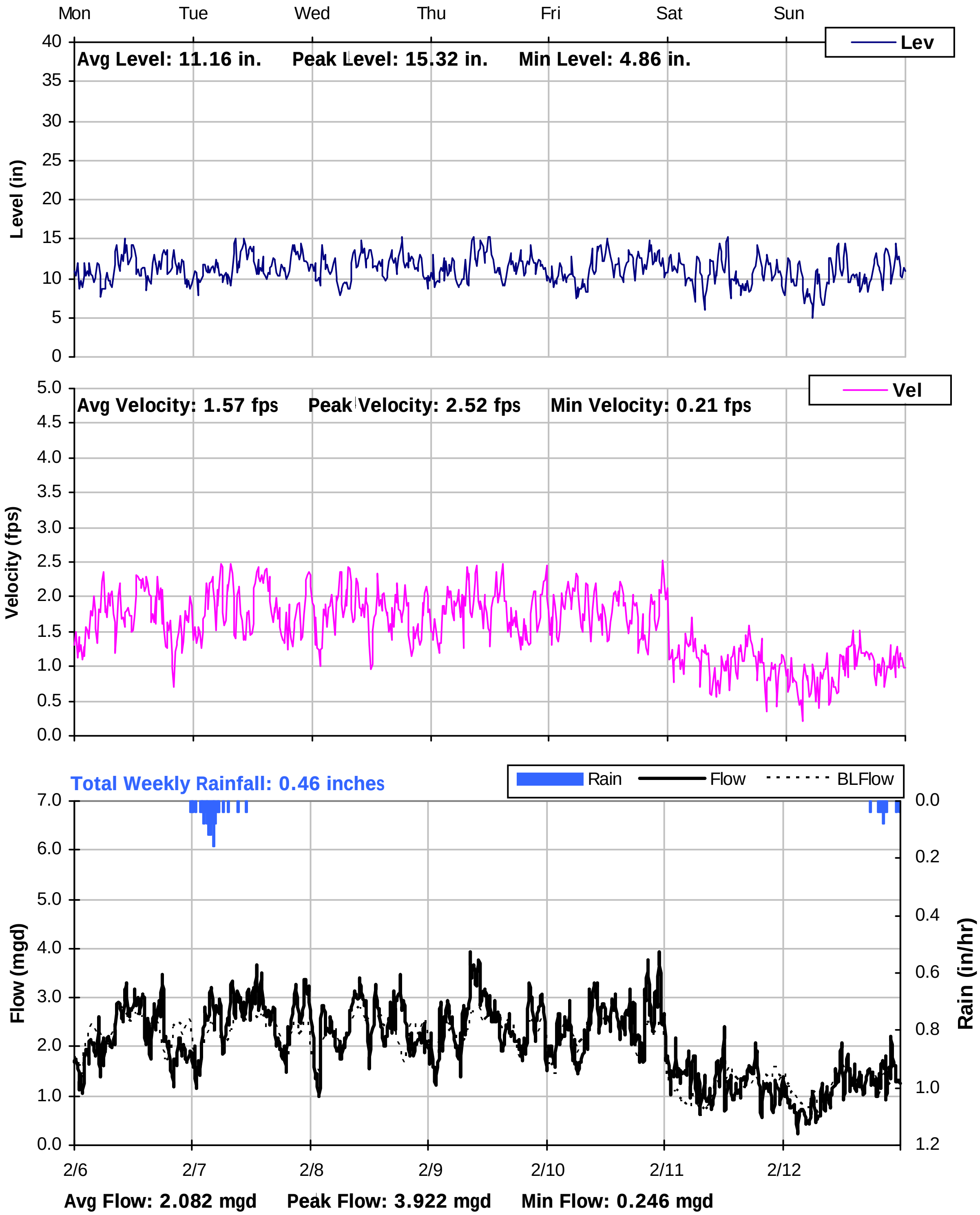


SITE 1
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



Avg Flow: 1.977 mgd Peak Flow: 3.460 mgd Min Flow: 0.380 mgd

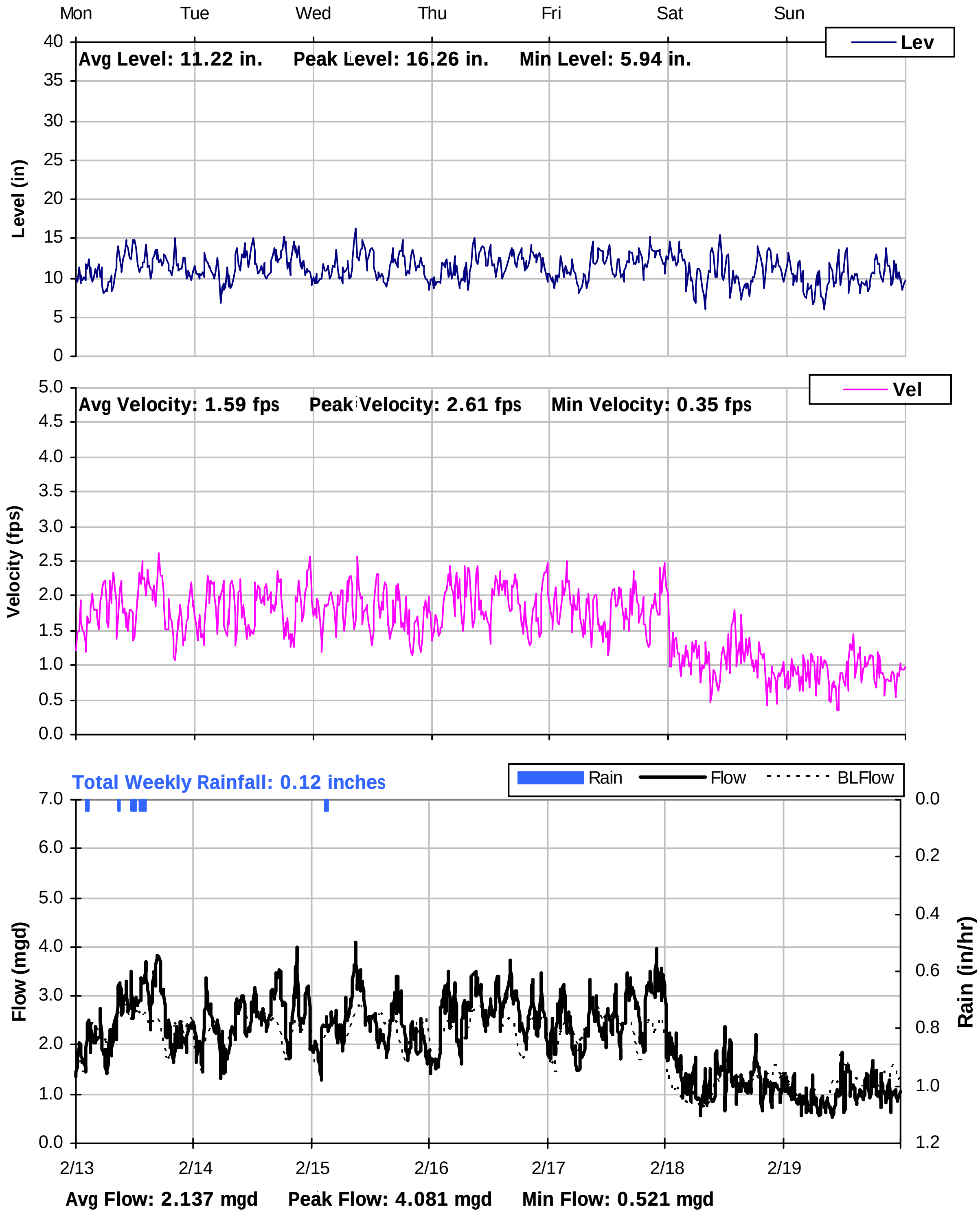
SITE 1
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



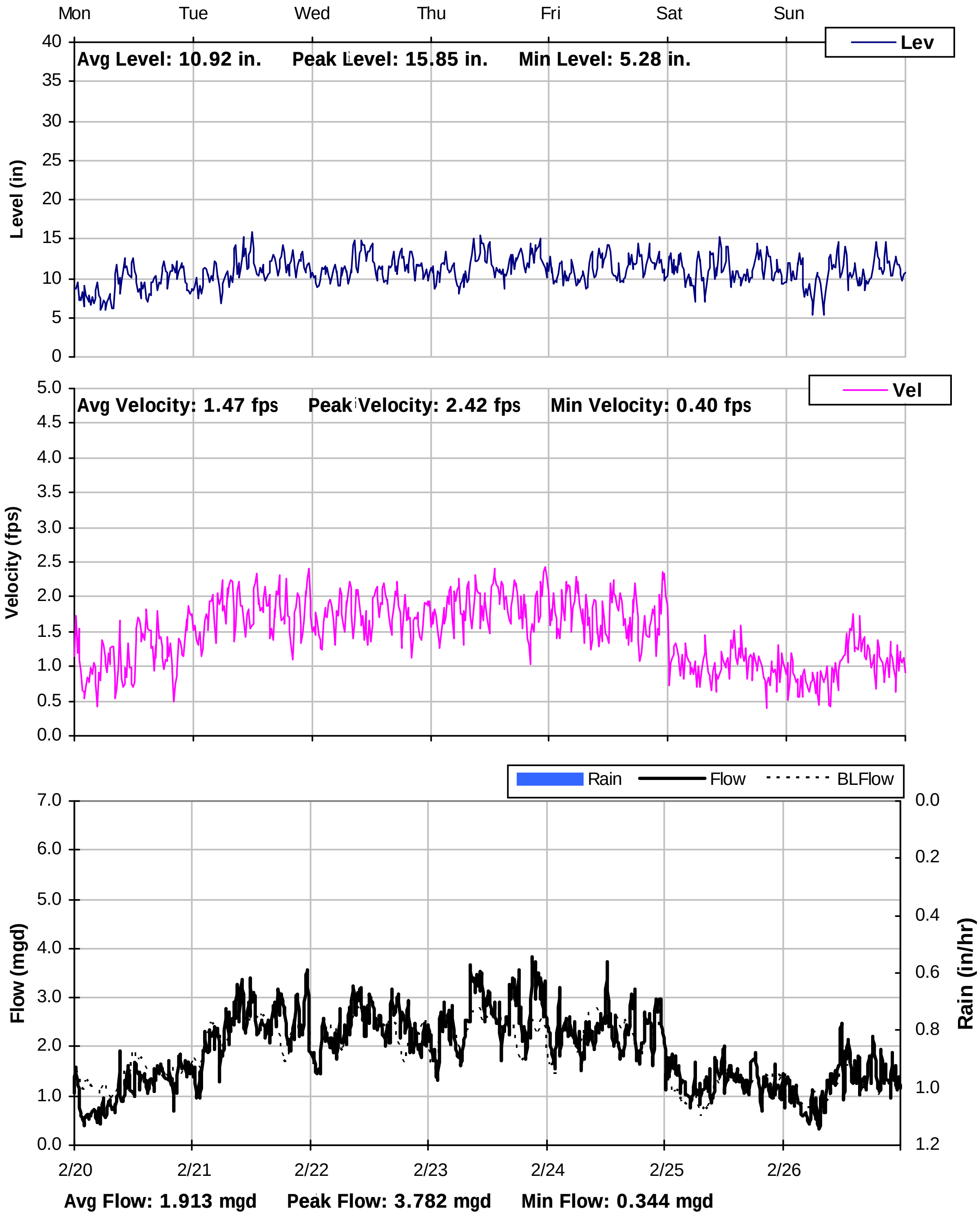
SITE 1

Weekly Level, Velocity and Flow Hydrographs

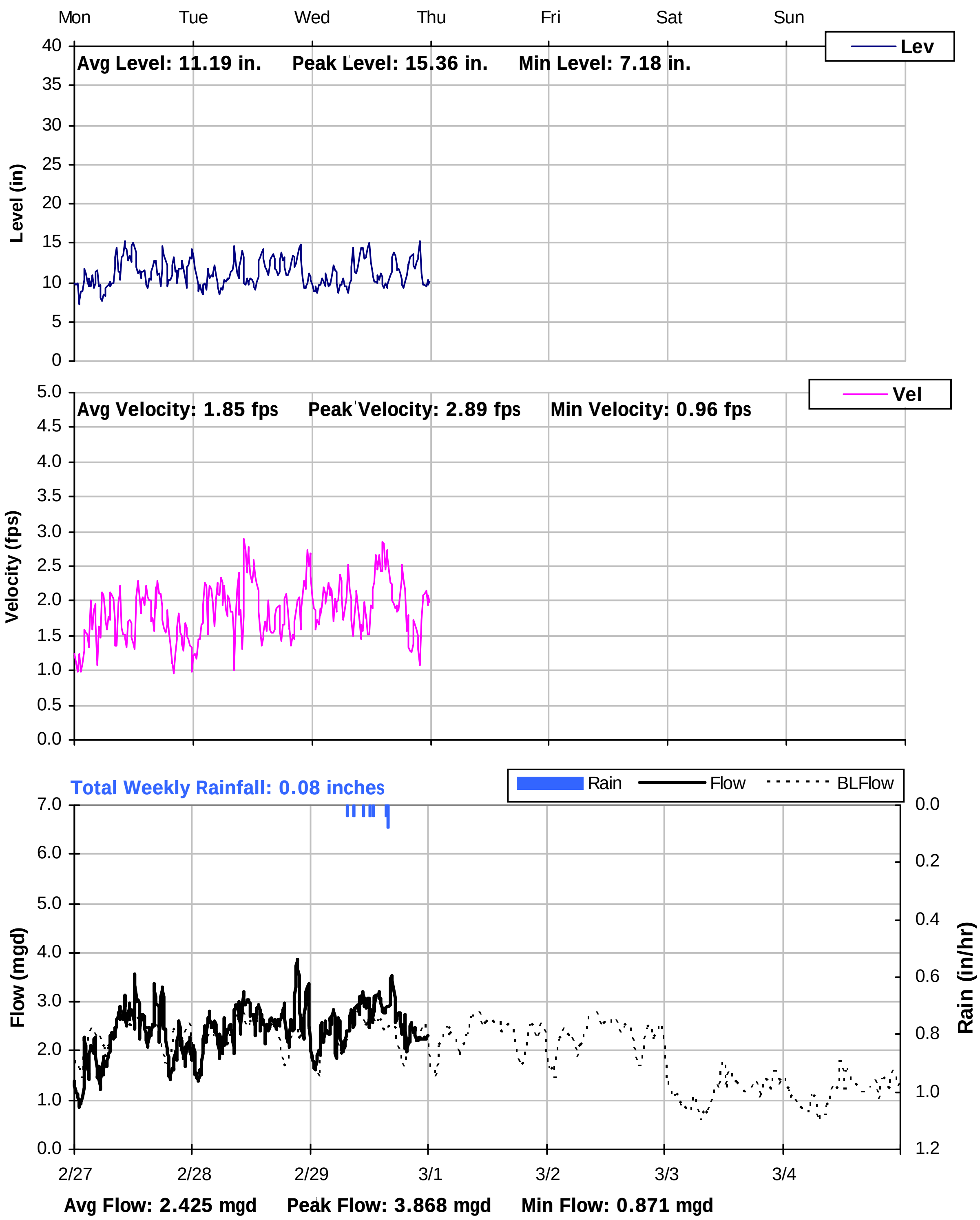
2/13/2012 to 2/20/2012



SITE 1
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



SITE 1
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



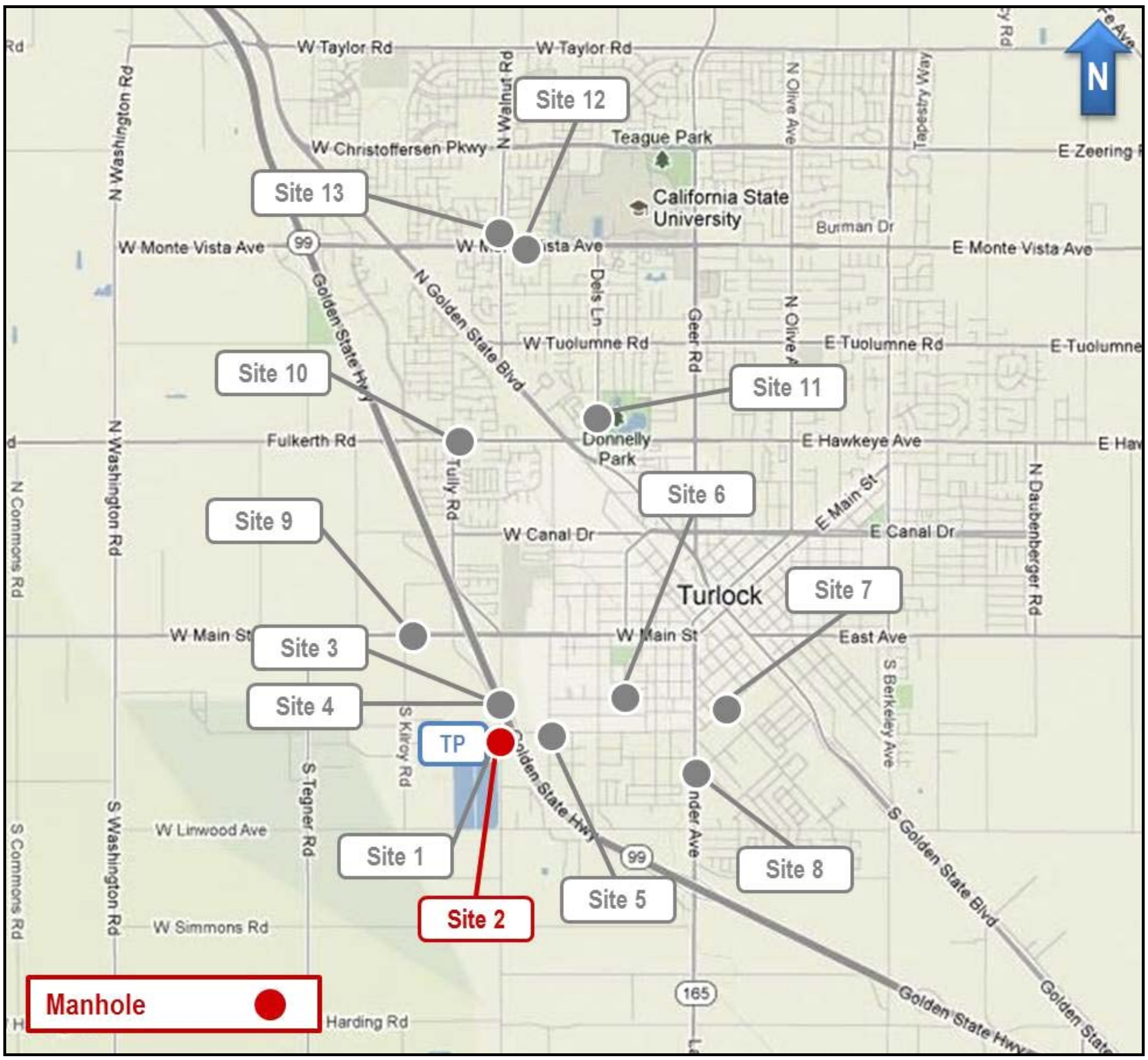
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 2

Location: Walnut Road, near Auto Machine shop

Data Summary Report



Vicinity Map: Site 2

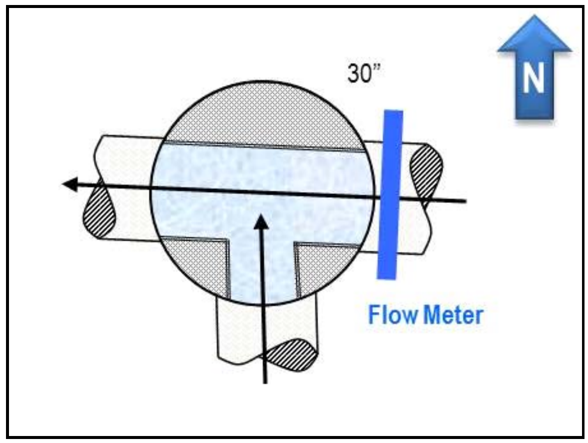
SITE 2

Site Information

Location:	Walnut Road, near Auto Machine shop
Coordinates:	120.8671° W, 37.4855° N
Rim Elevation:	97 feet
Pipe Diameter:	30 inches
Baseline Flow:	0.320 mgd
Peak Measured Flow:	6.210 mgd

Satellite Map

Sewer Map



Flow Sketch

Street View

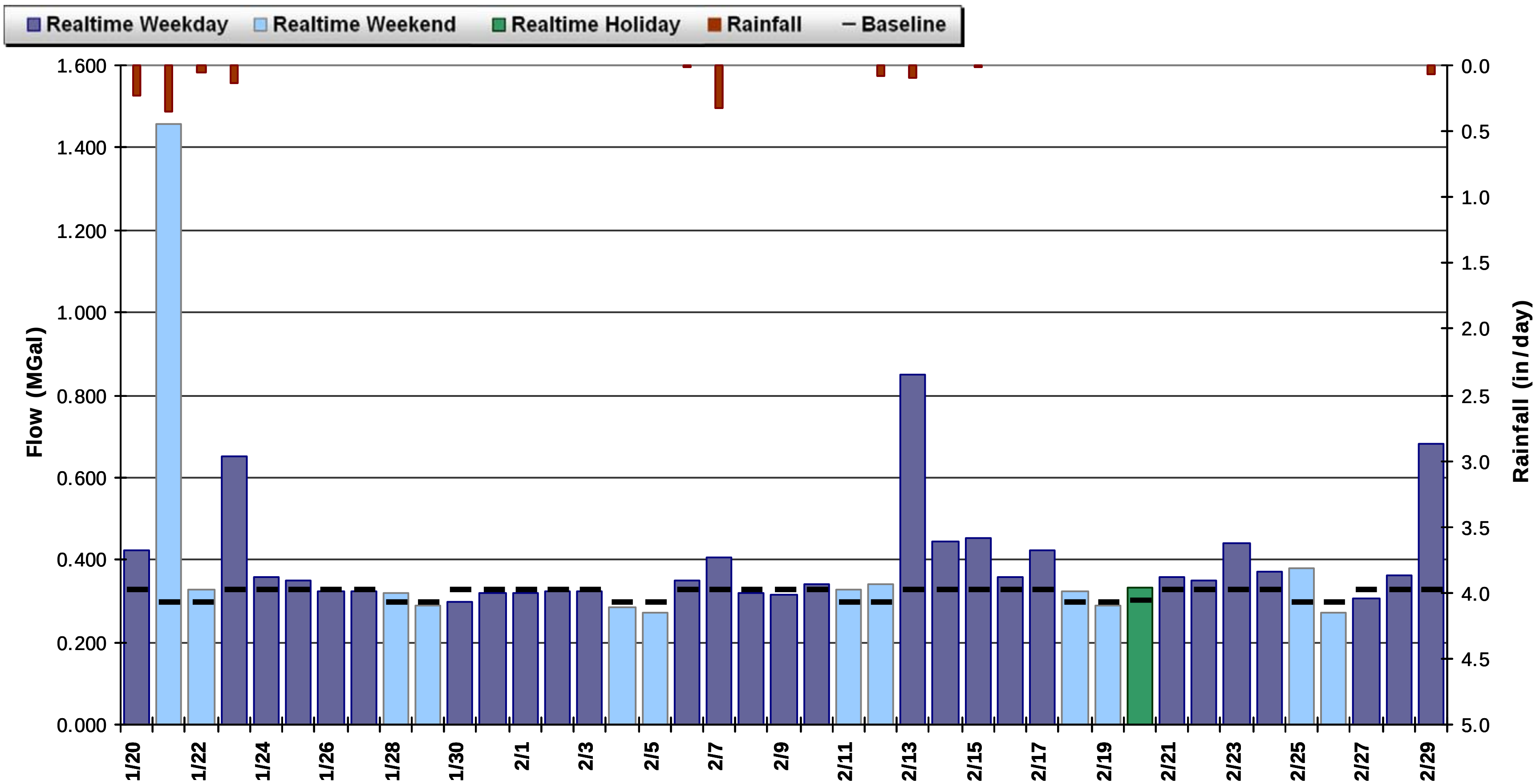
Plan View

SITE 2

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.399 MGal **Peak Daily Flow: 1.459 MGal** **Min Daily Flow: 0.270 MGal**

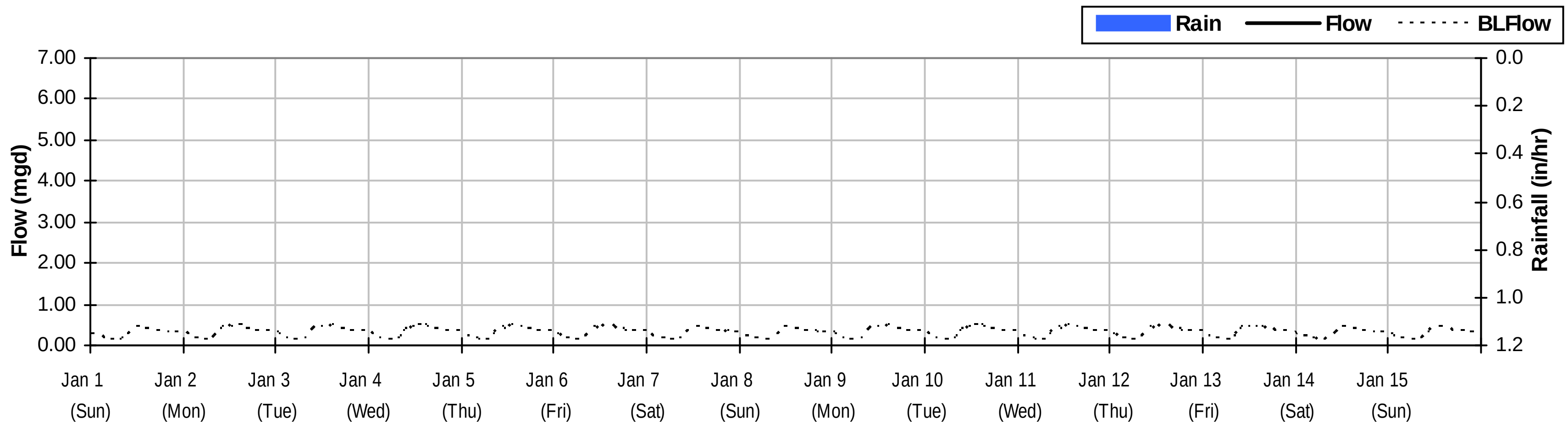
Total Period Rainfall: 1.38 inches

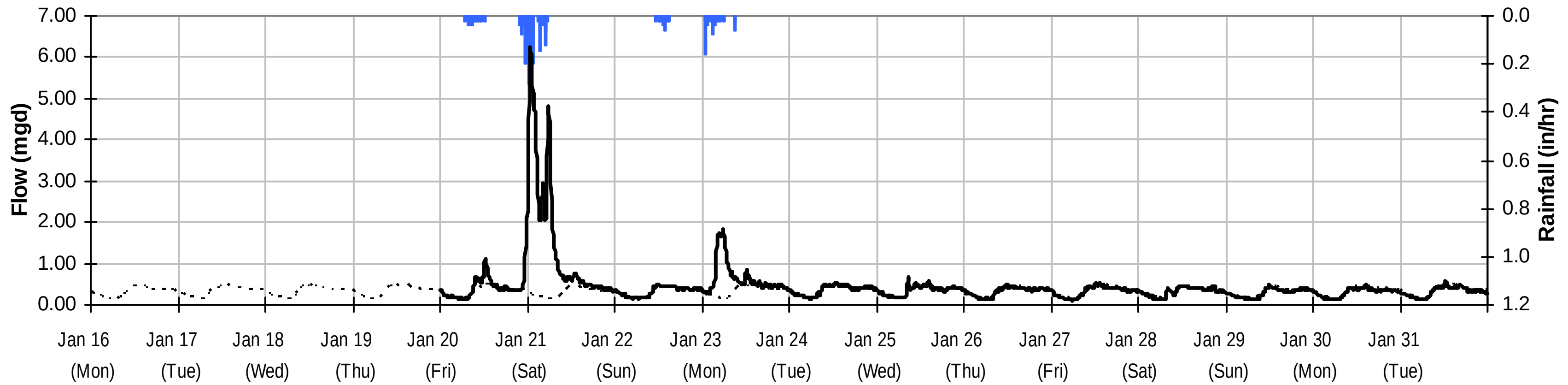


SITE 2

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.77 inches **Avg Flow: 0.453 mgd** **Peak Flow: 6.210 mgd** **Min Flow: 0.104 mgd**

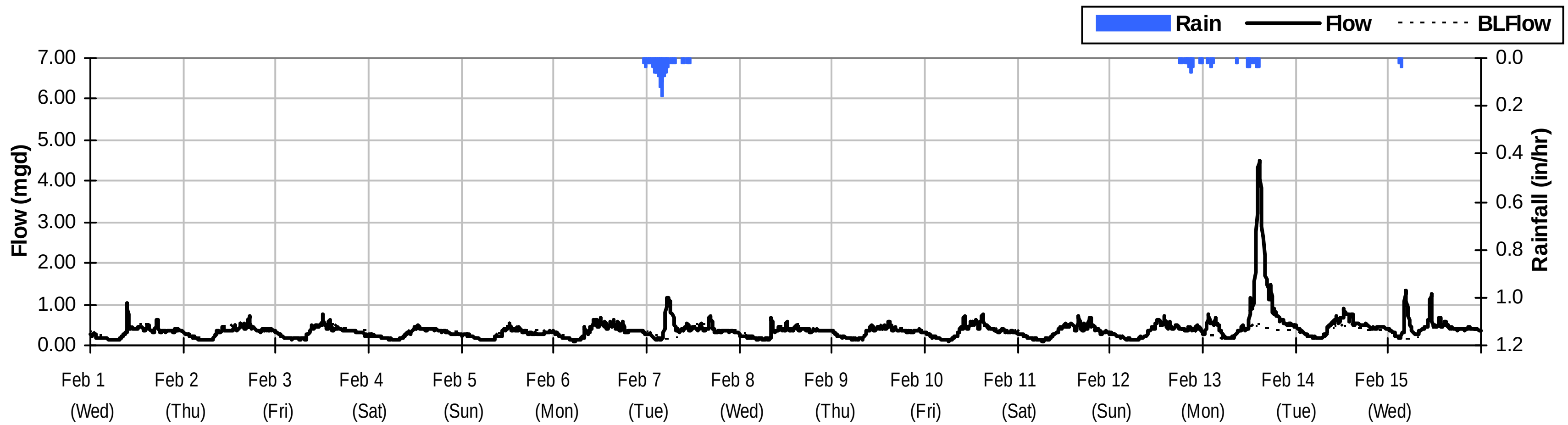


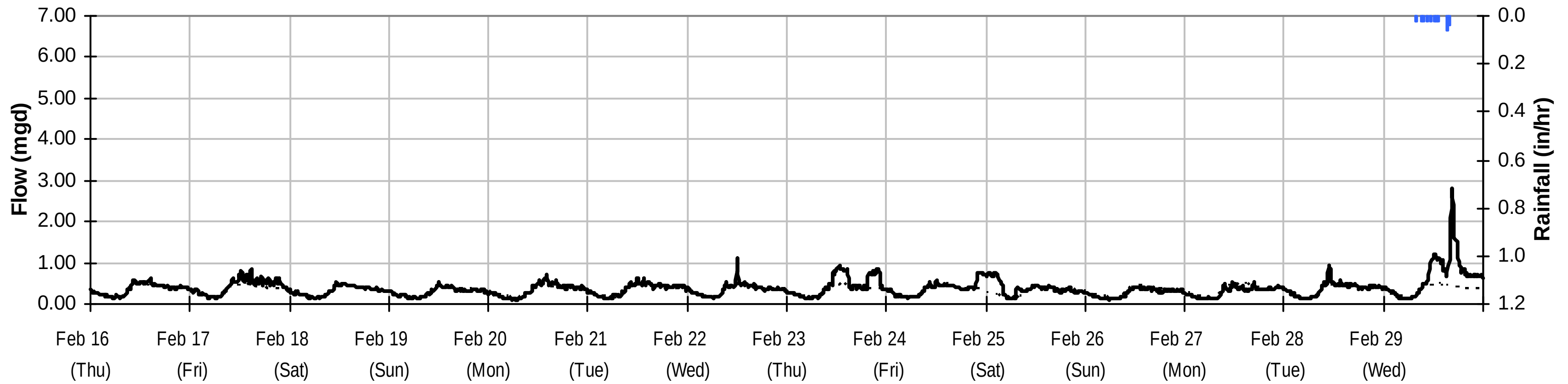


SITE 2

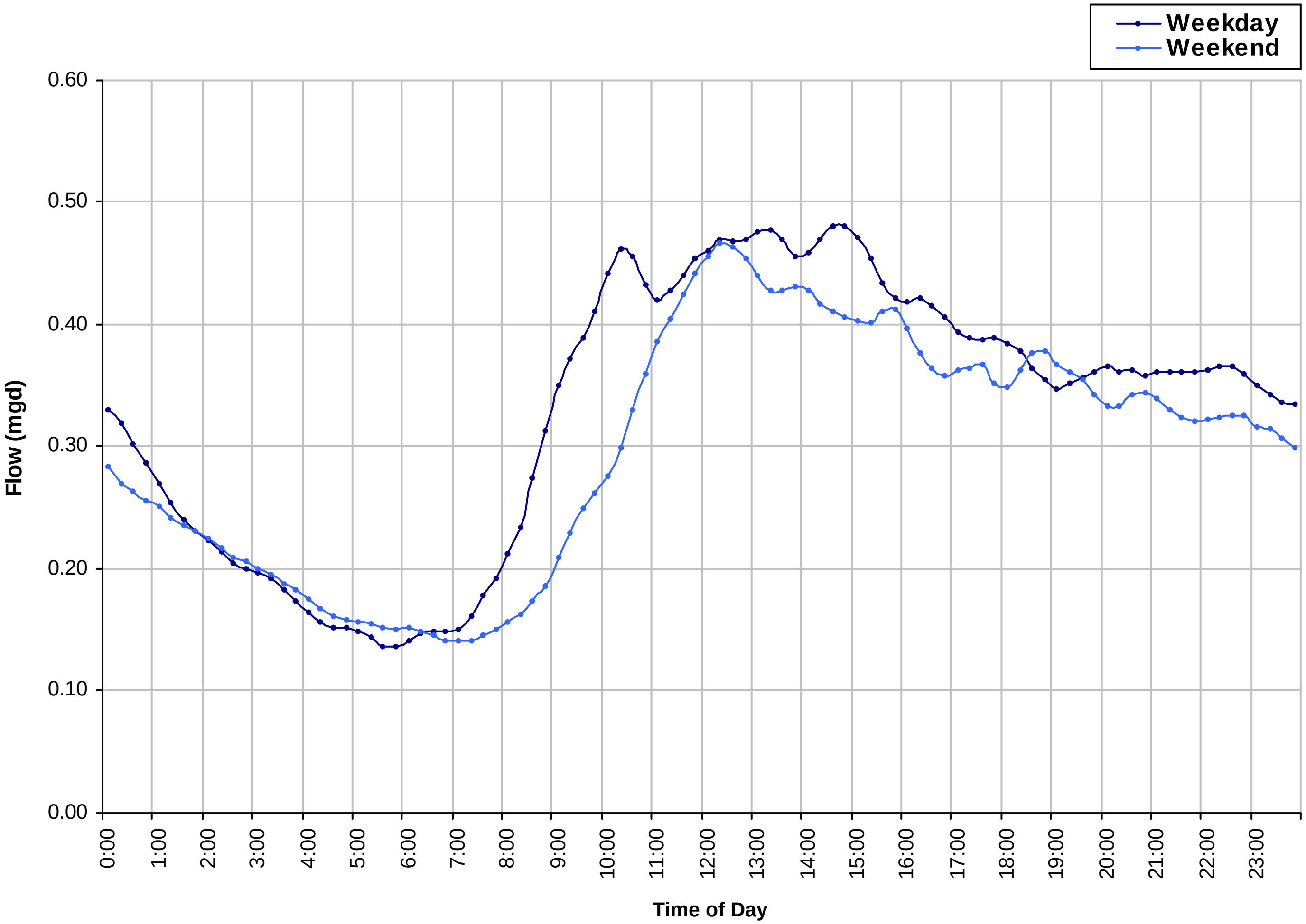
Monthly Flow Summary: February, 2012

Total Monthly Rainfall: 0.61 inches **Avg Flow: 0.376 mgd** **Peak Flow: 4.499 mgd** **Min Flow: 0.102 mgd**

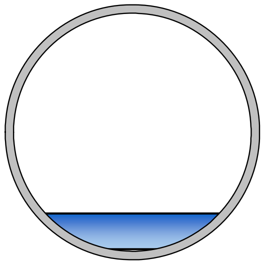




SITE 2
Baseline Flow Hydrographs

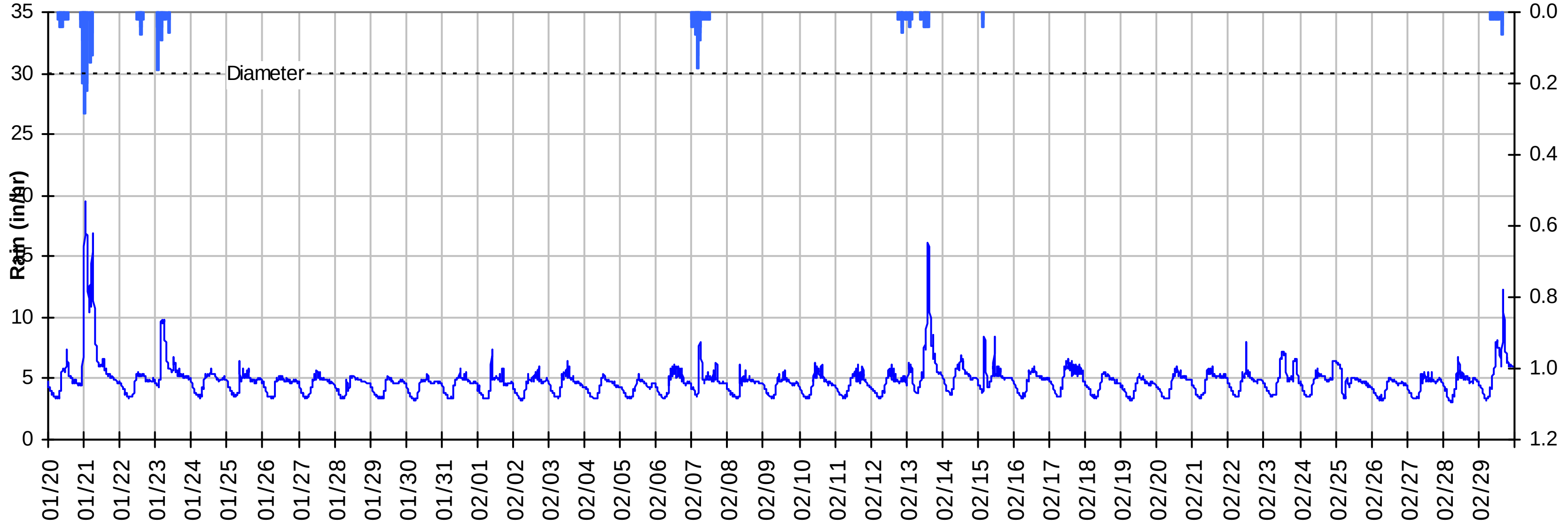


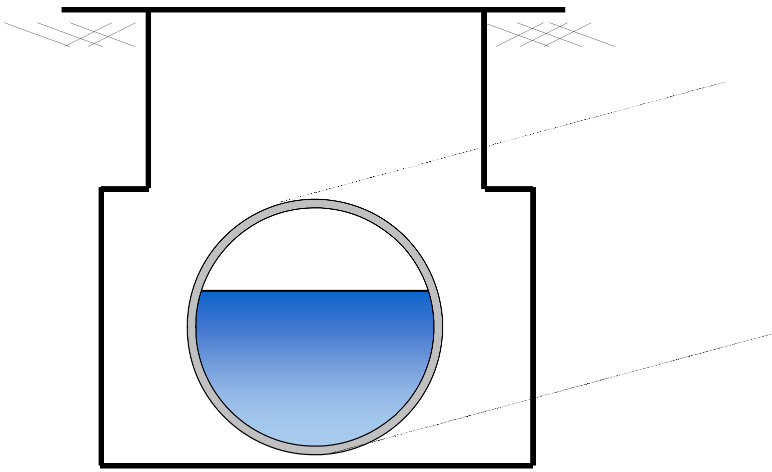
Baseline Flow:
0.320 *mgd*



SITE 2
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





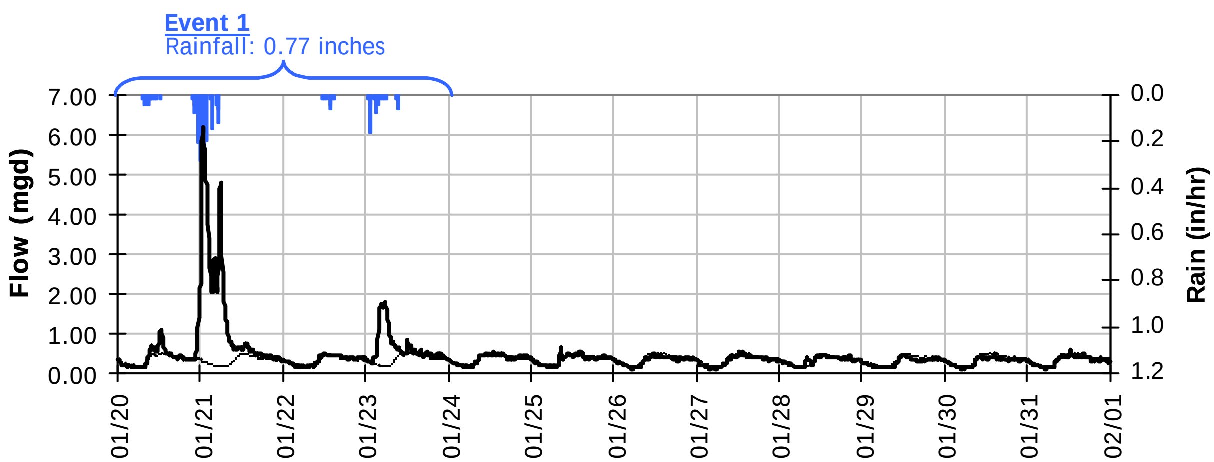
Pipe Diameter: 30 *inches*

Peak Measured Level: 19.4 *inches*

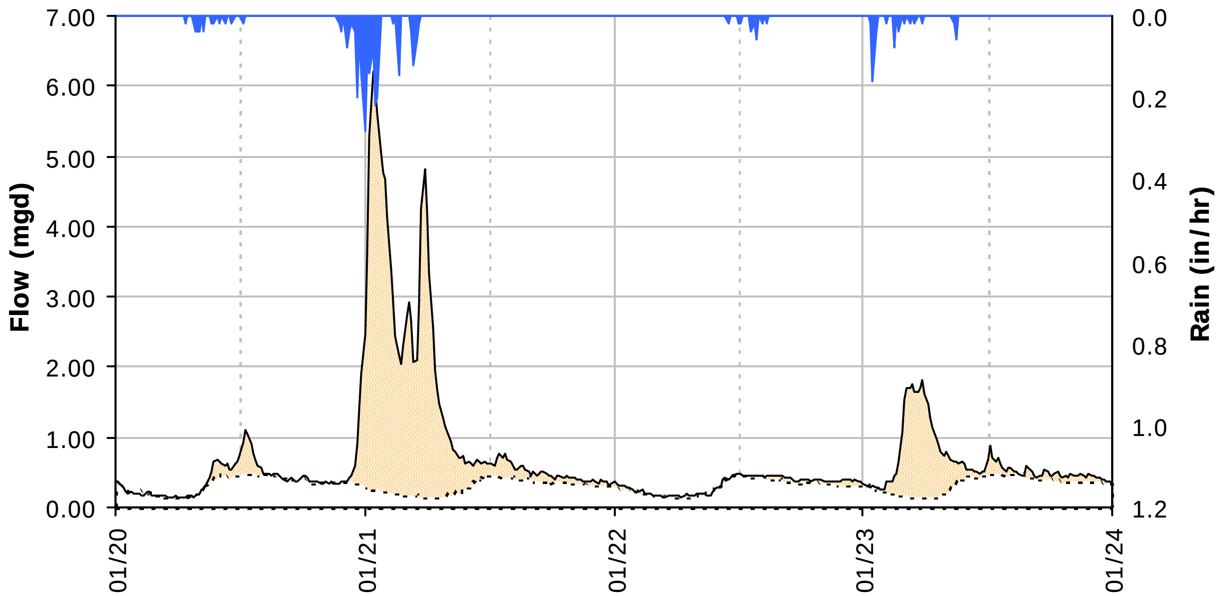
Peak d / D Ratio: 0.65

SITE 2
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph



Storm Event I/I Analysis (Rain = 0.77 inches)

Capacity

Peak Flow: 6.21 *mgd*
PF: 19.39
Peak Level: 19.43 *in*
d/D Ratio: 0.65

Inflow

Peak I/I Rate: 5.95 *mgd*
Pk I/I:Acre: 12,295 *gpd/acre*
Pk I/I:ADWF: 18.59

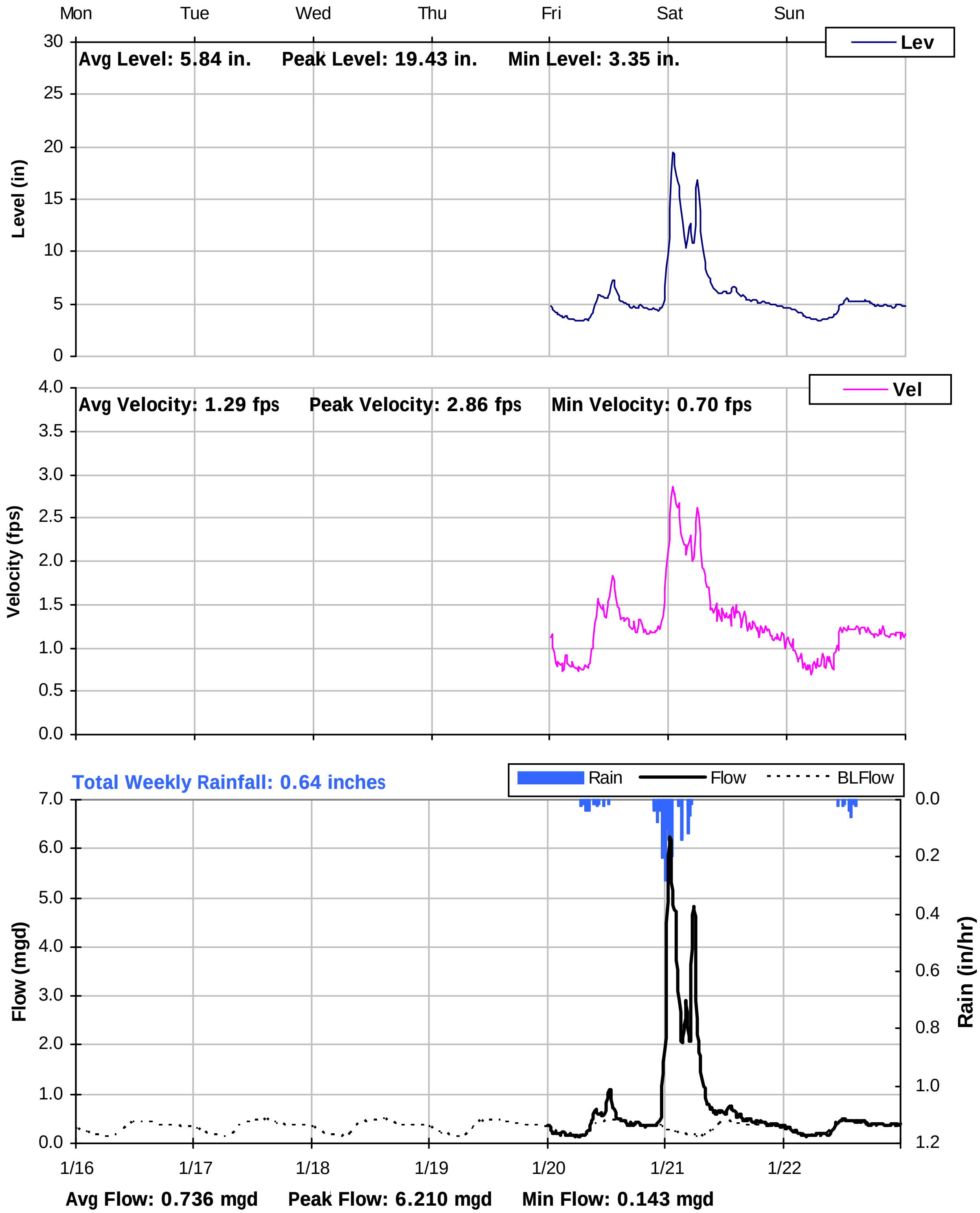
Combined I/I

Total I/I: 1,606,000 *gallons*
R-Value: 15.9%
Total I/I:ADWF: 6.54 *per in-rain*

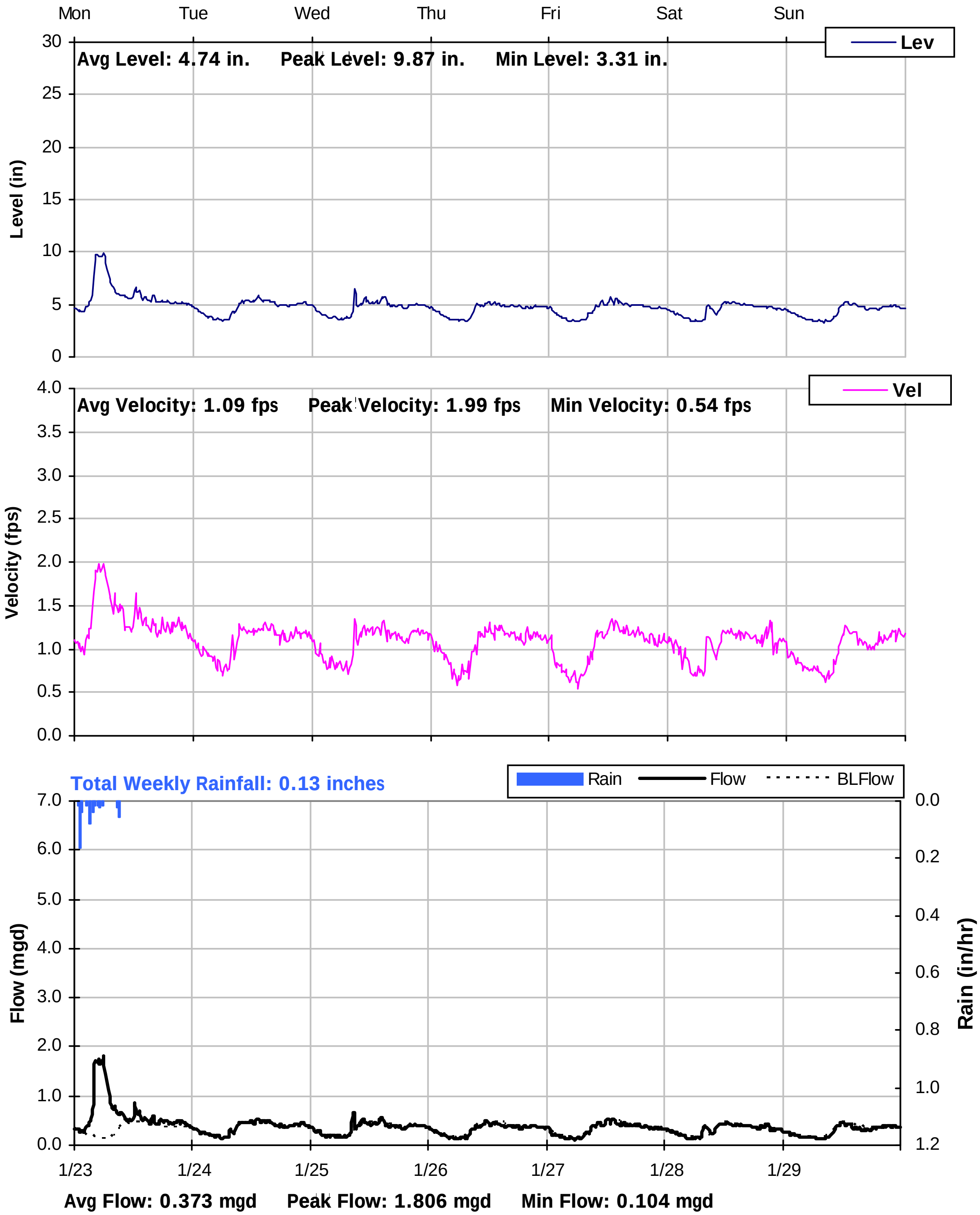
SITE 2

Weekly Level, Velocity and Flow Hydrographs

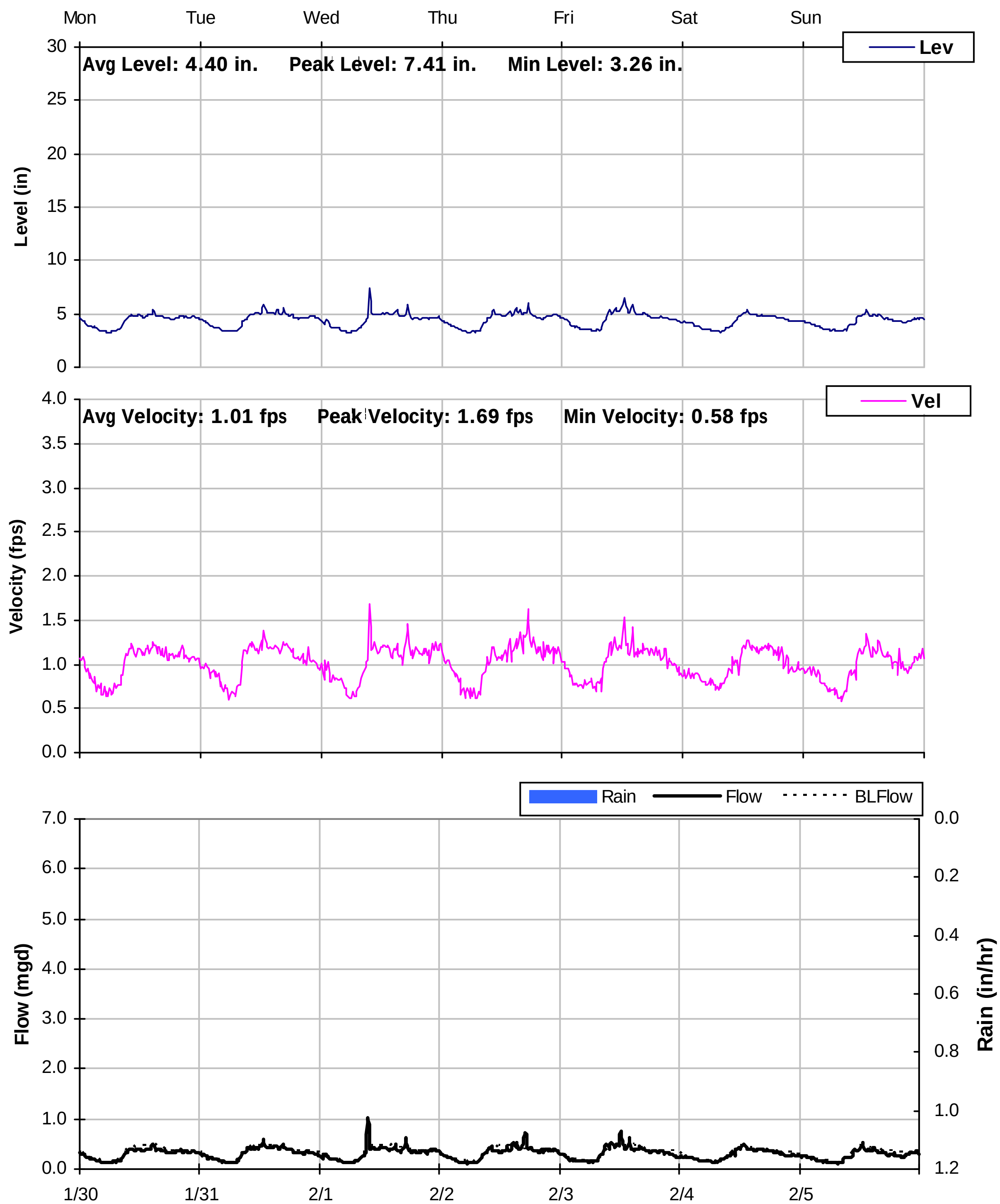
1/16/2012 to 1/23/2012



SITE 2
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012

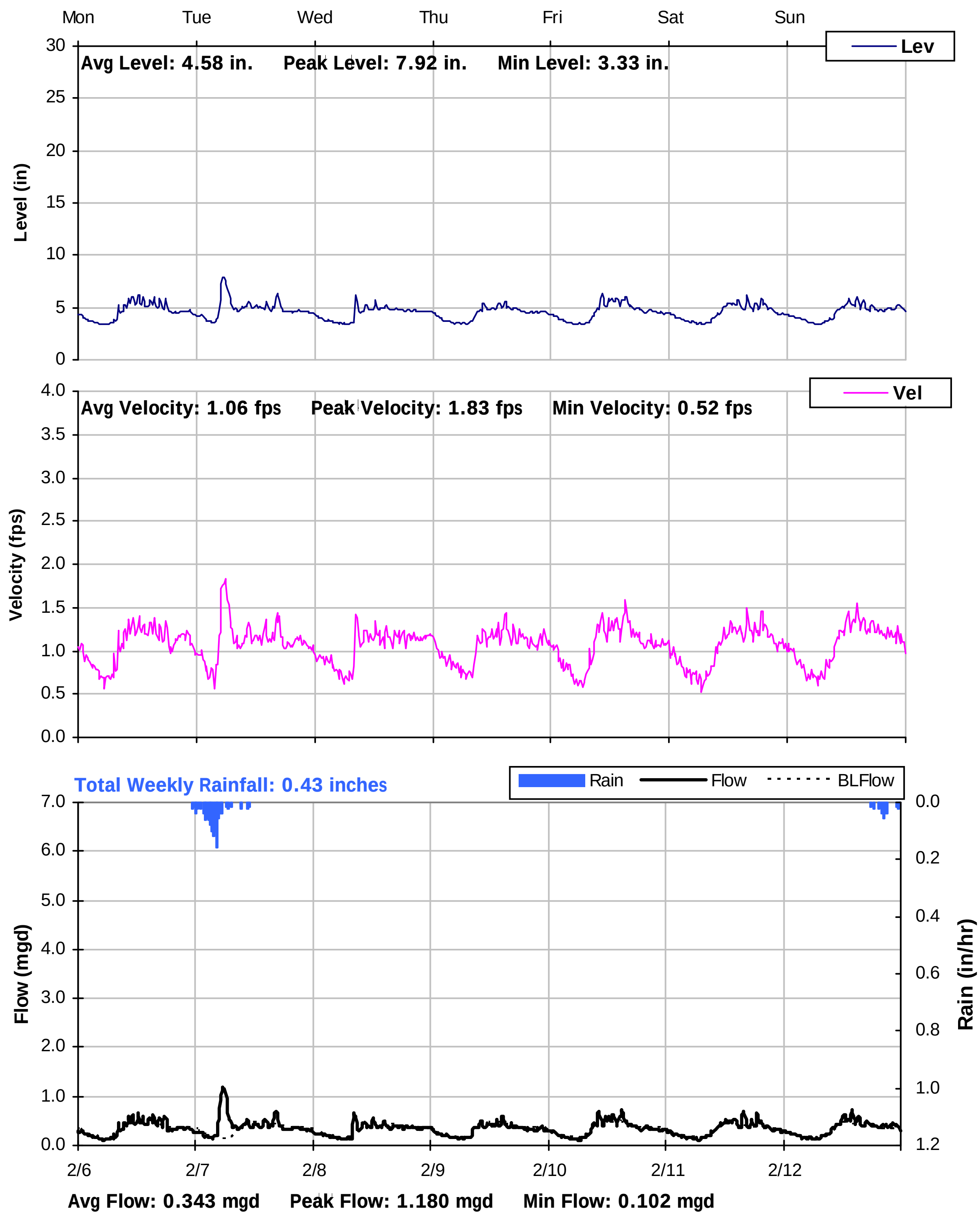


SITE 2
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012

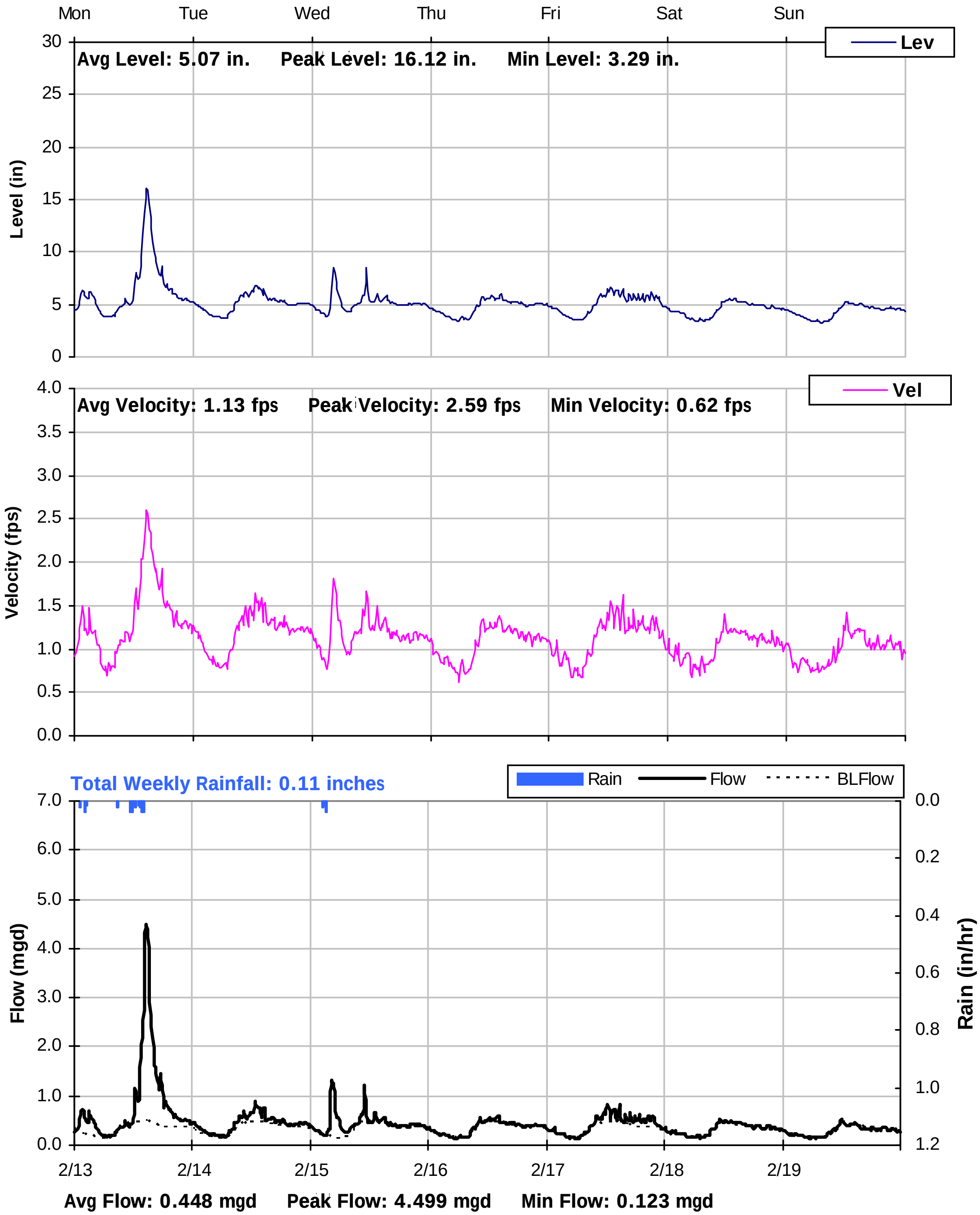


Avg Flow: 0.305 mgd Peak Flow: 1.034 mgd Min Flow: 0.113 mgd

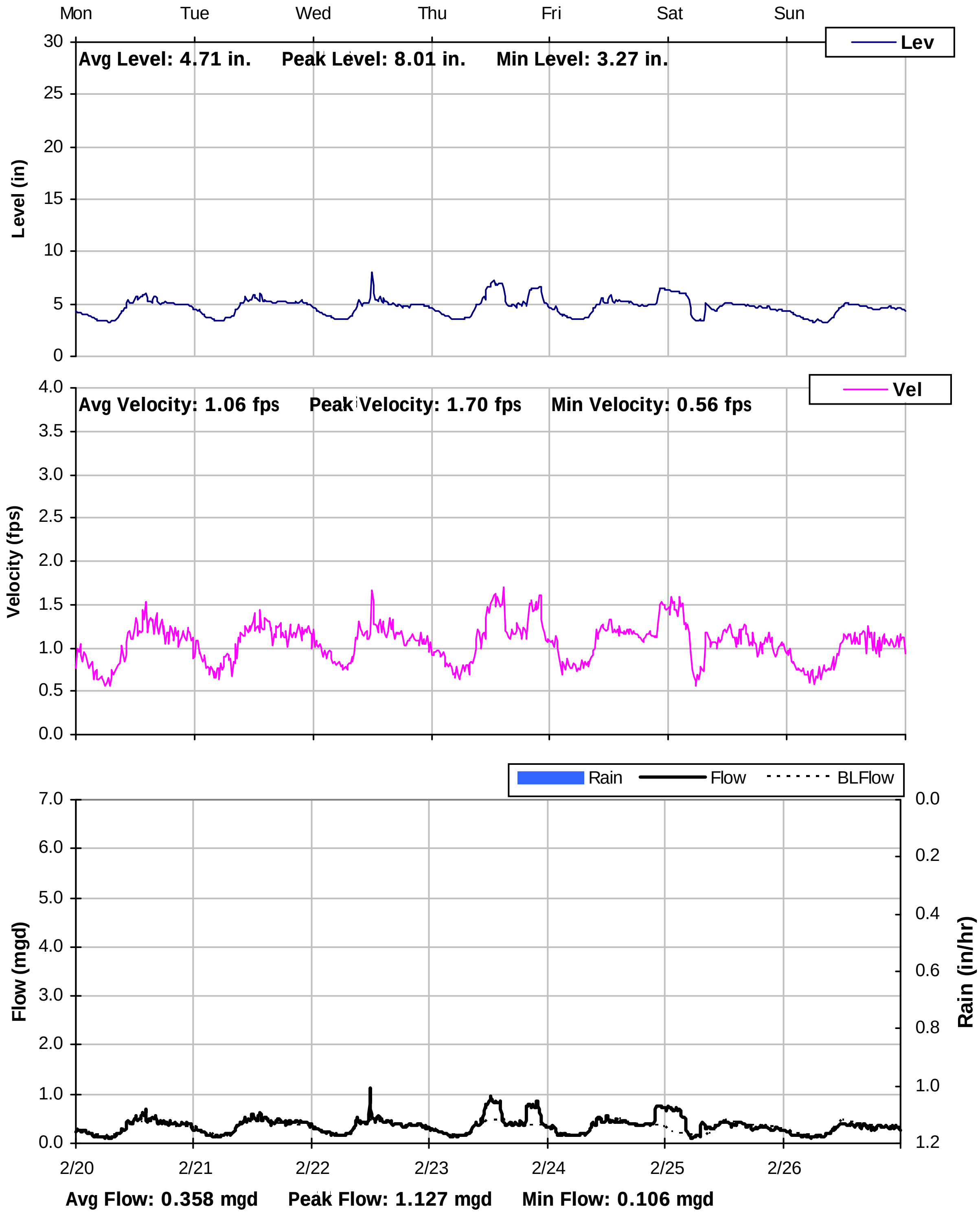
SITE 2
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



SITE 2
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012



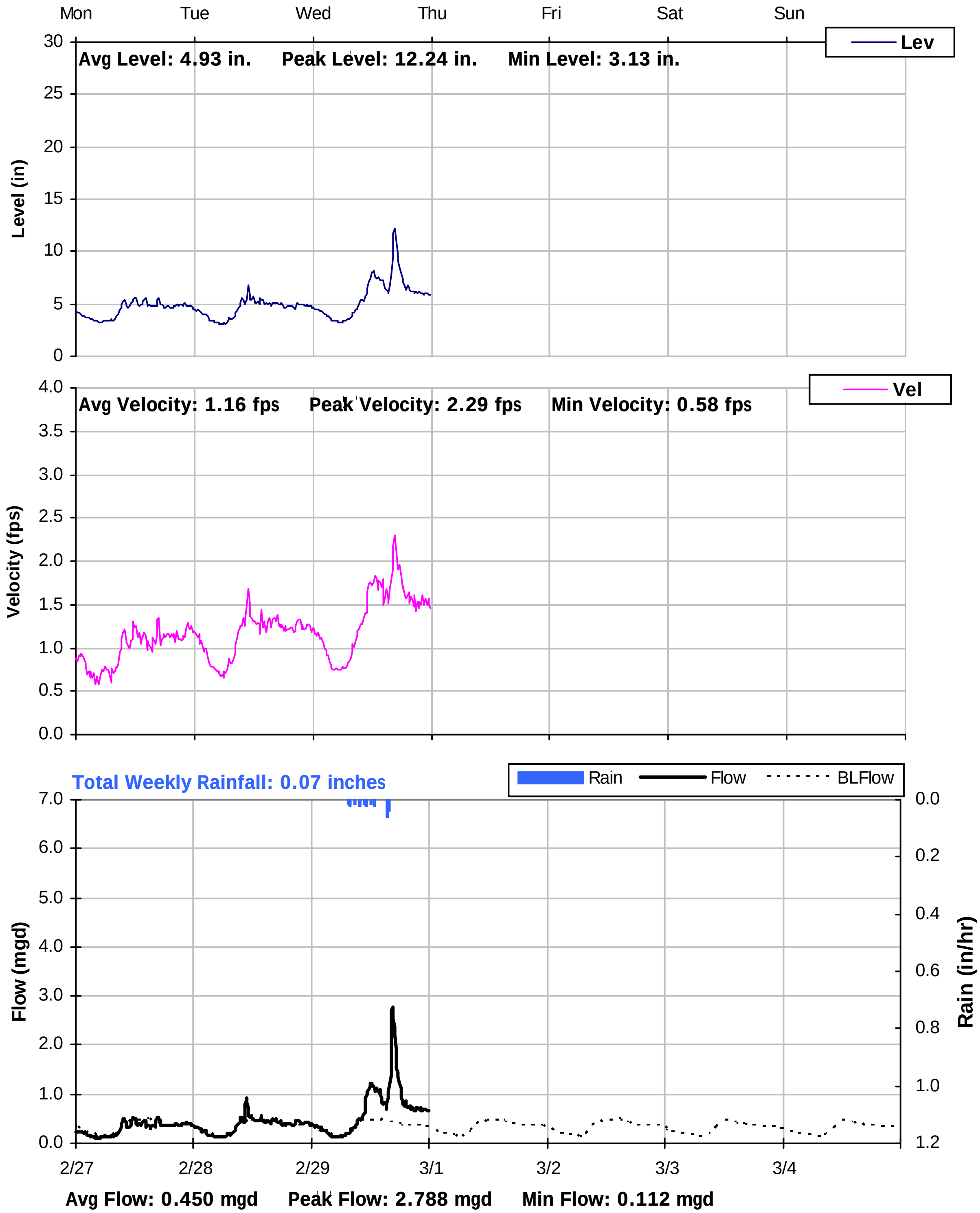
SITE 2
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



SITE 2

Weekly Level, Velocity and Flow Hydrographs

2/27/2012 to 3/5/2012



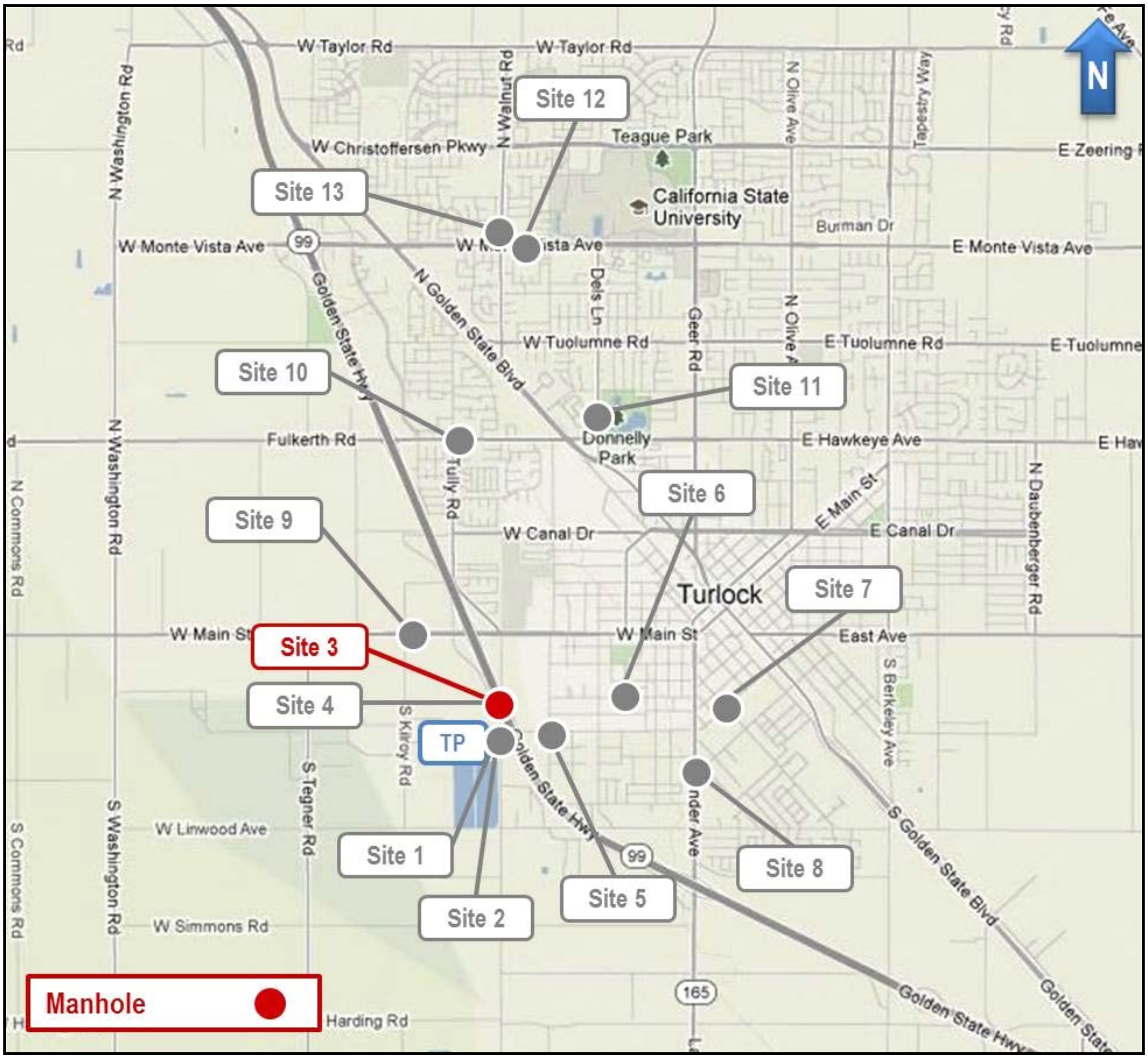
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 3

Location: Walnut Road, South of freeway underpass

Data Summary Report



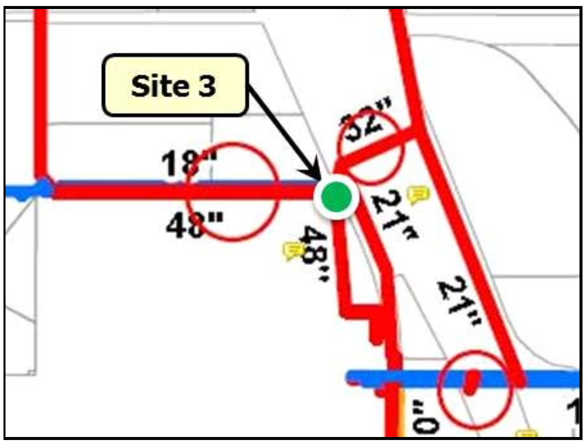
Vicinity Map: Site 3

SITE 3

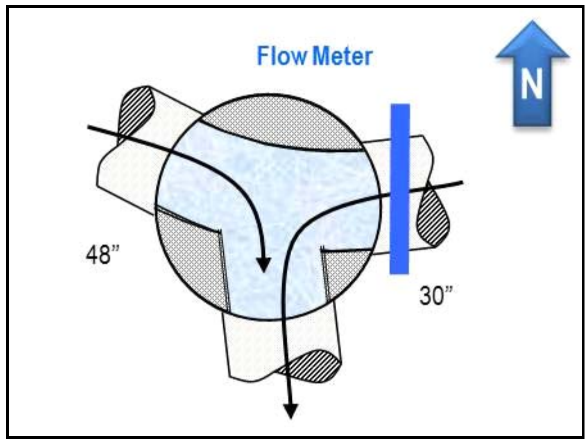
Site Information

Location:	Walnut Road, South of freeway underpass
Coordinates:	120.8679° W, 37.4872° N
Rim Elevation:	96 feet
Pipe Diameter:	30 inches
Baseline Flow:	1.254 mgd
Peak Measured Flow:	3.605 mgd

Satellite Map



Sewer Map



Flow Sketch

Street View

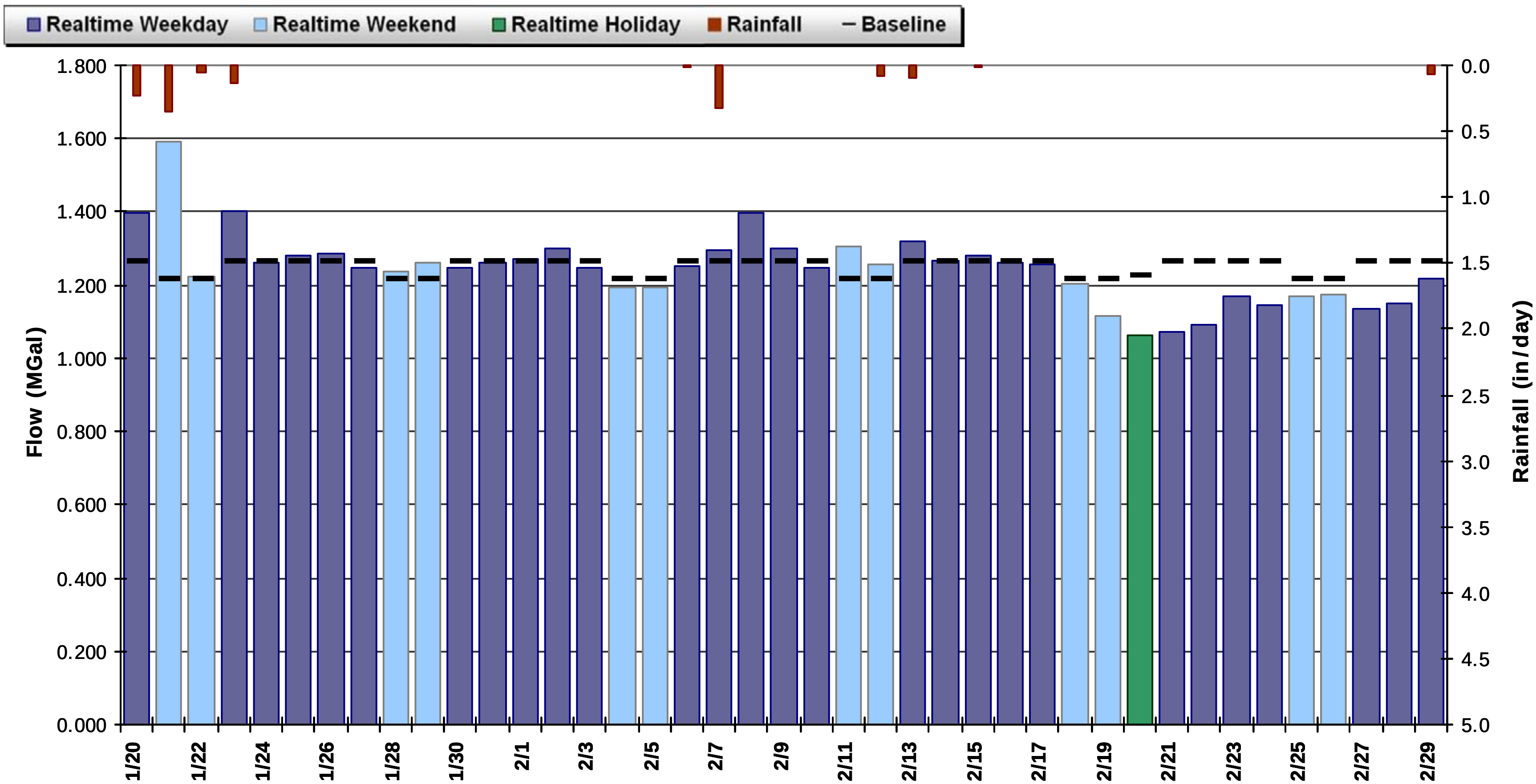
Plan View

SITE 3

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 1.245 MGal **Peak Daily Flow: 1.590 MGal** **Min Daily Flow: 1.064 MGal**

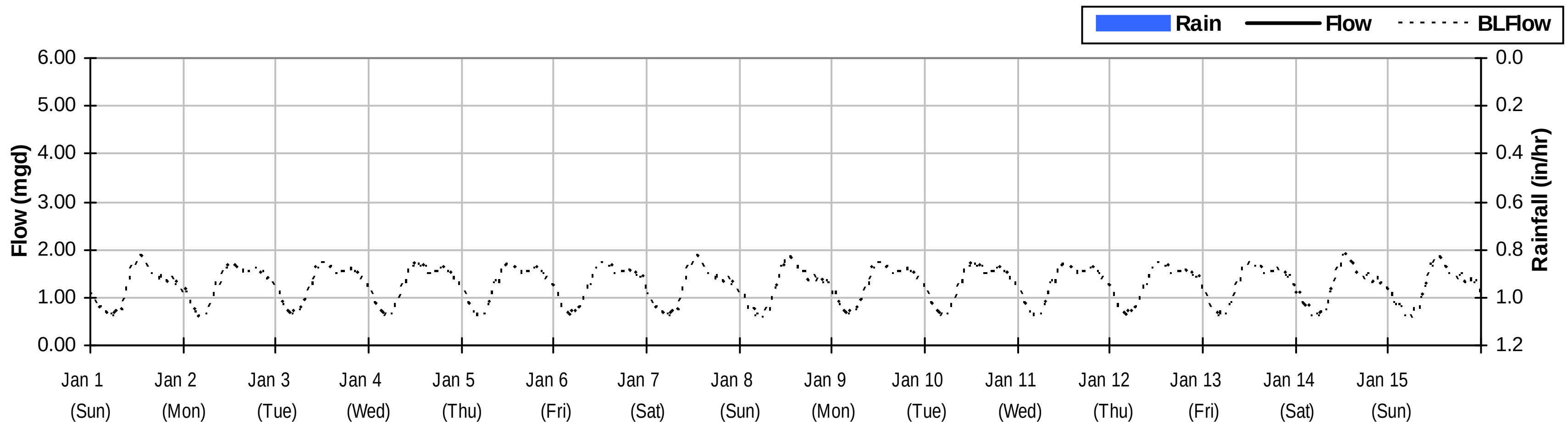
Total Period Rainfall: 1.38 inches

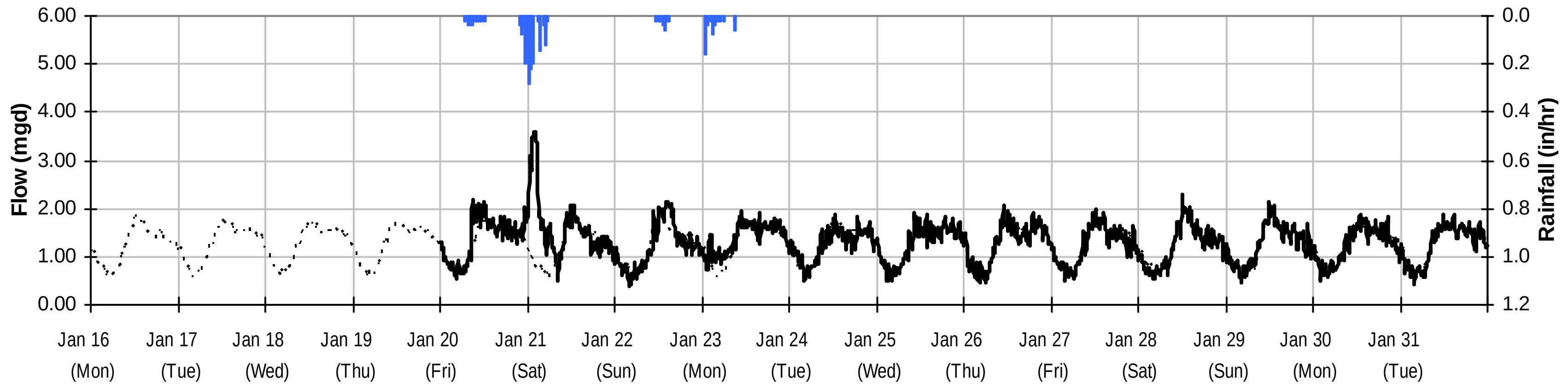


SITE 3

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.77 inches **Avg Flow: 1.308 mgd** **Peak Flow: 3.605 mgd** **Min Flow: 0.400 mgd**

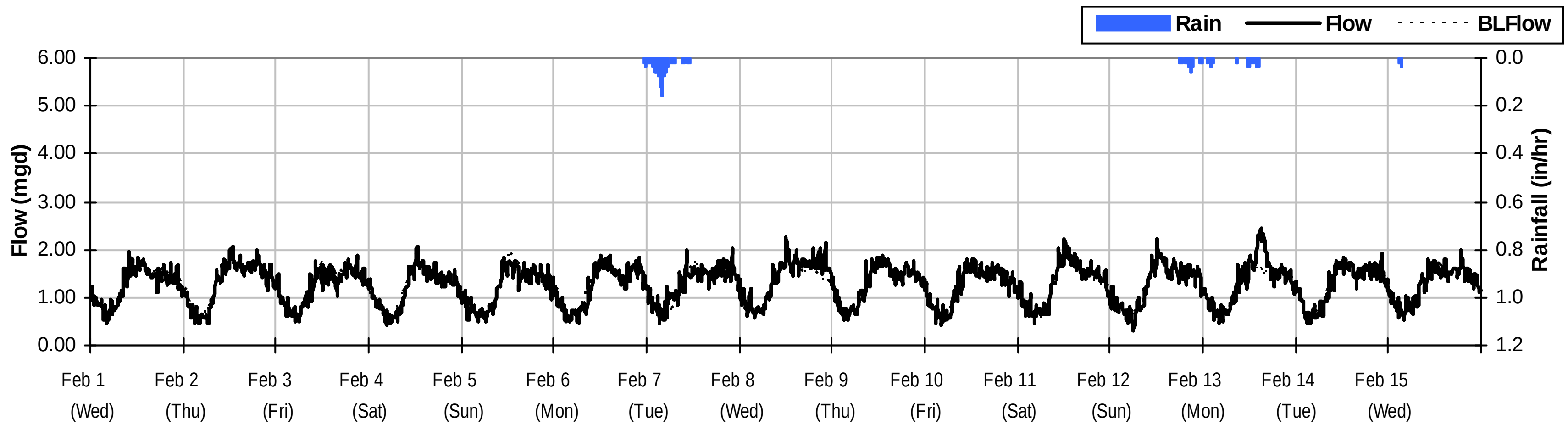


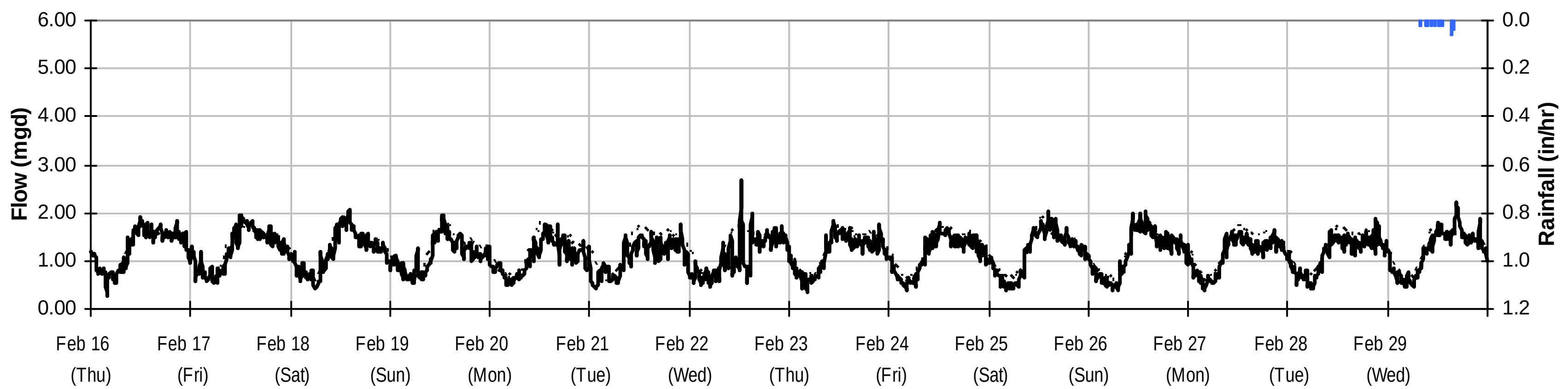


SITE 3

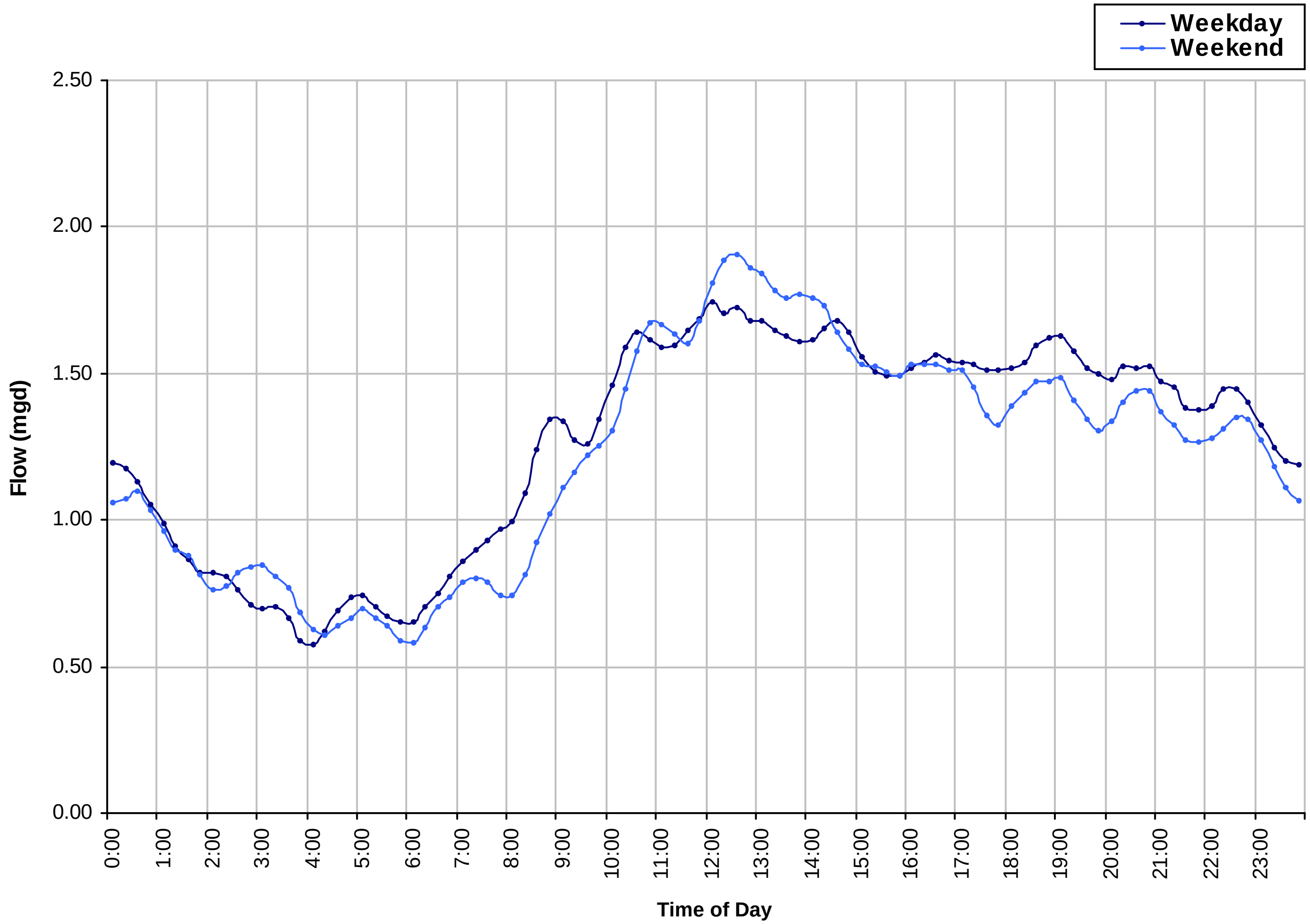
Monthly Flow Summary: February, 2012

Total Monthly Rainfall: 0.61 inches **Avg Flow: 1.219 mgd** **Peak Flow: 2.643 mgd** **Min Flow: 0.273 mgd**

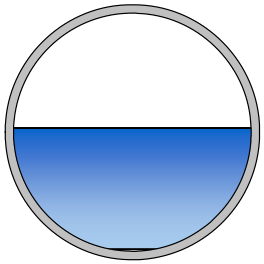




SITE 3
Baseline Flow Hydrographs

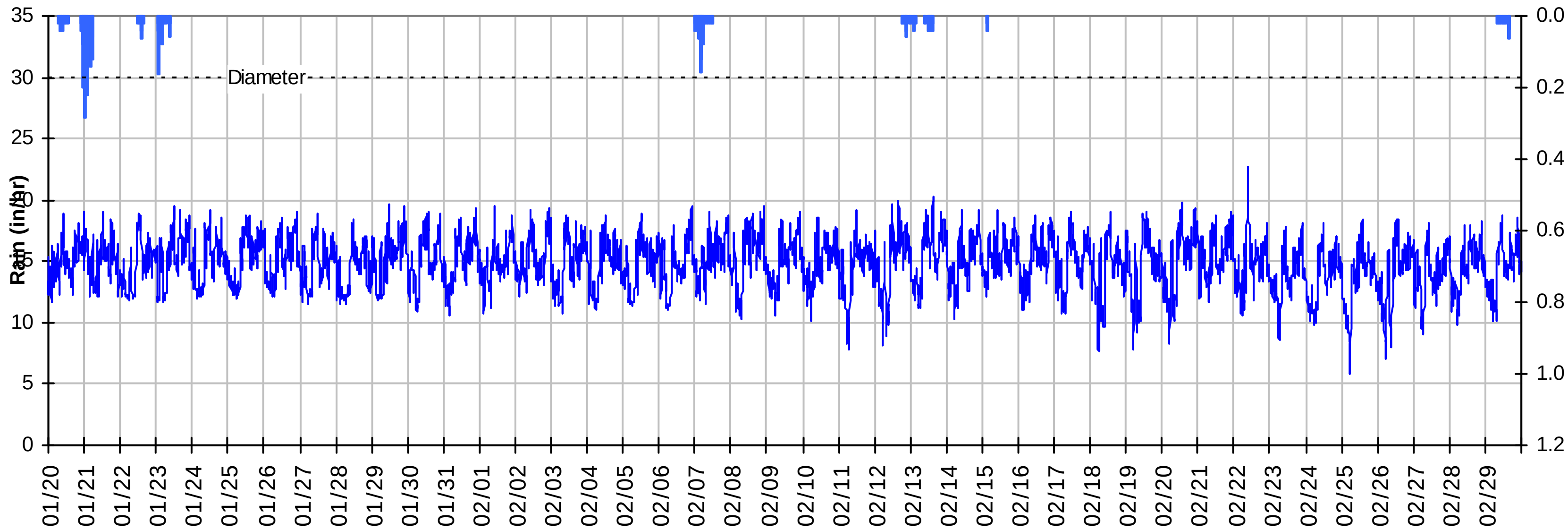


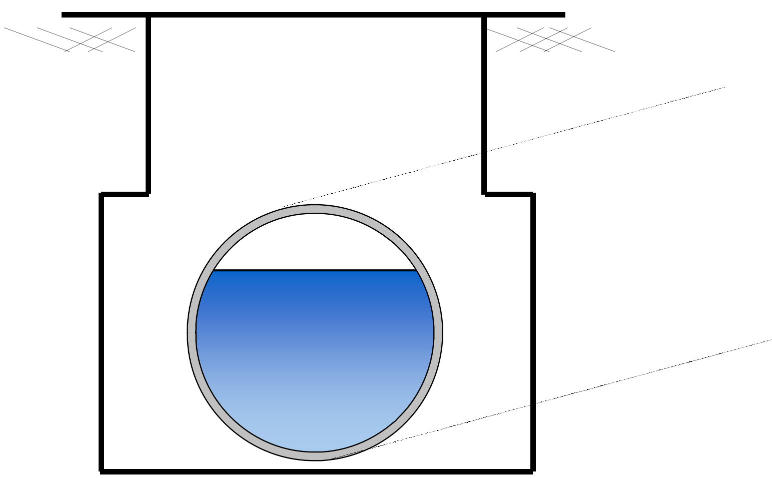
Baseline Flow:
1.254 *mgd*



SITE 3
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





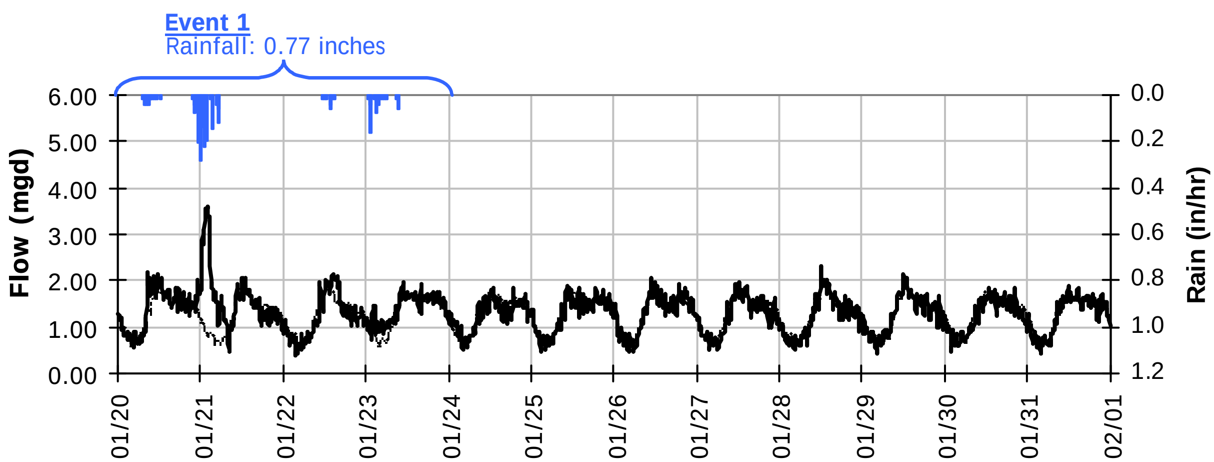
Pipe Diameter: 30 *inches*

Peak Measured Level: 22.7 *inches*

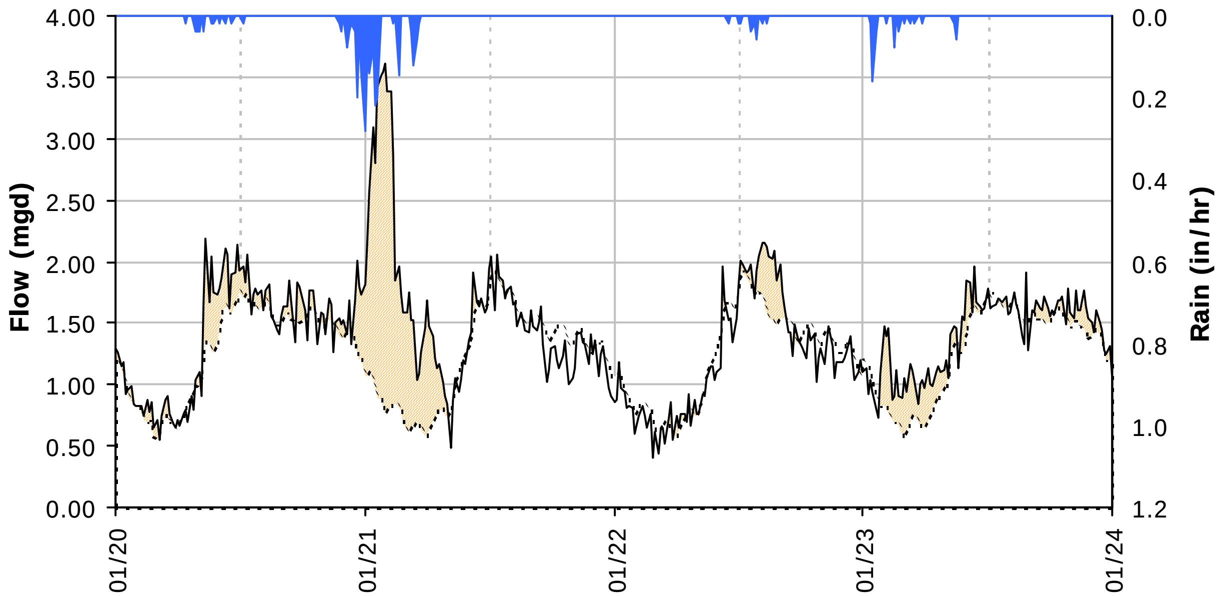
Peak d/D Ratio: 0.76

SITE 3
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



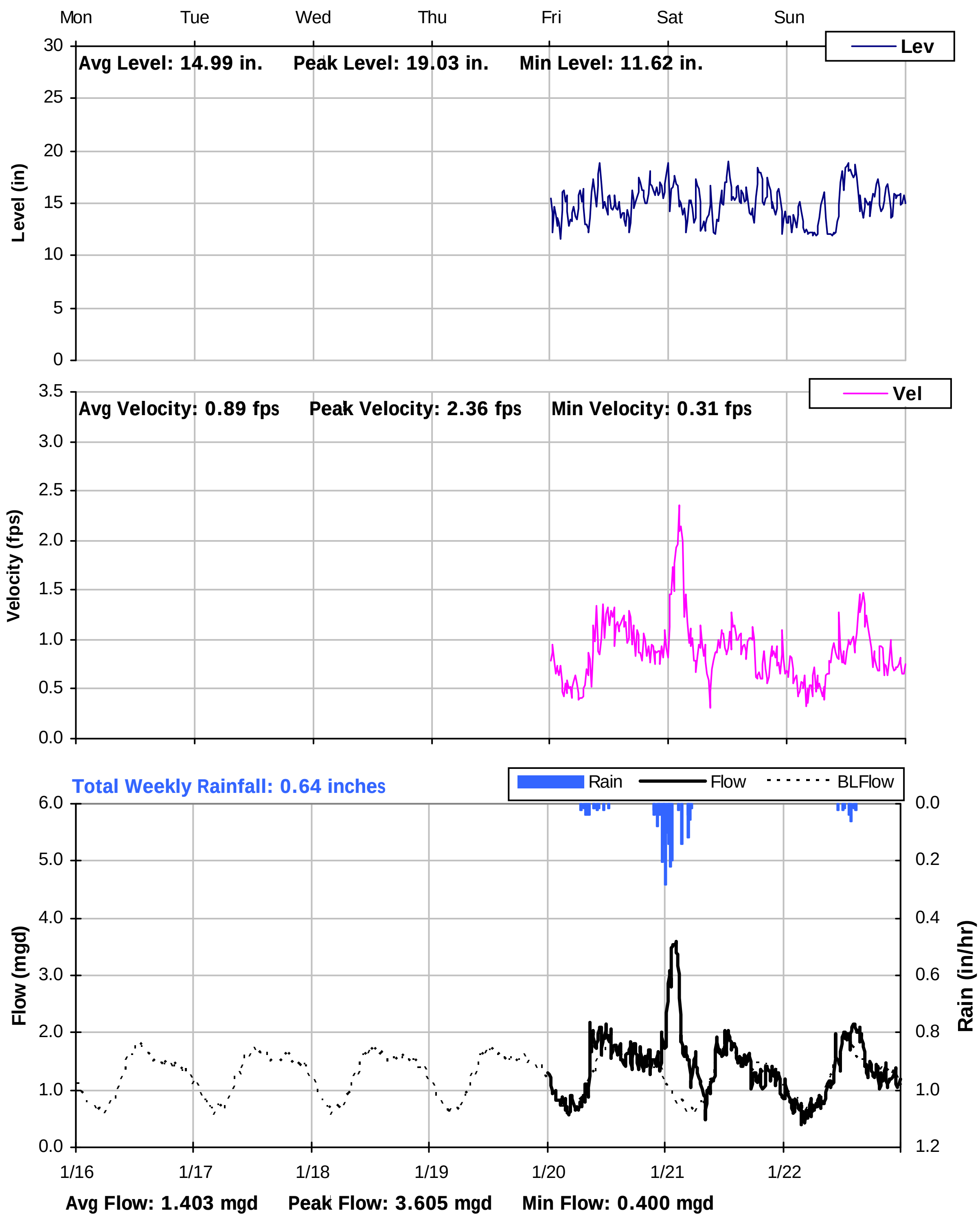
Event 1 Detail Graph



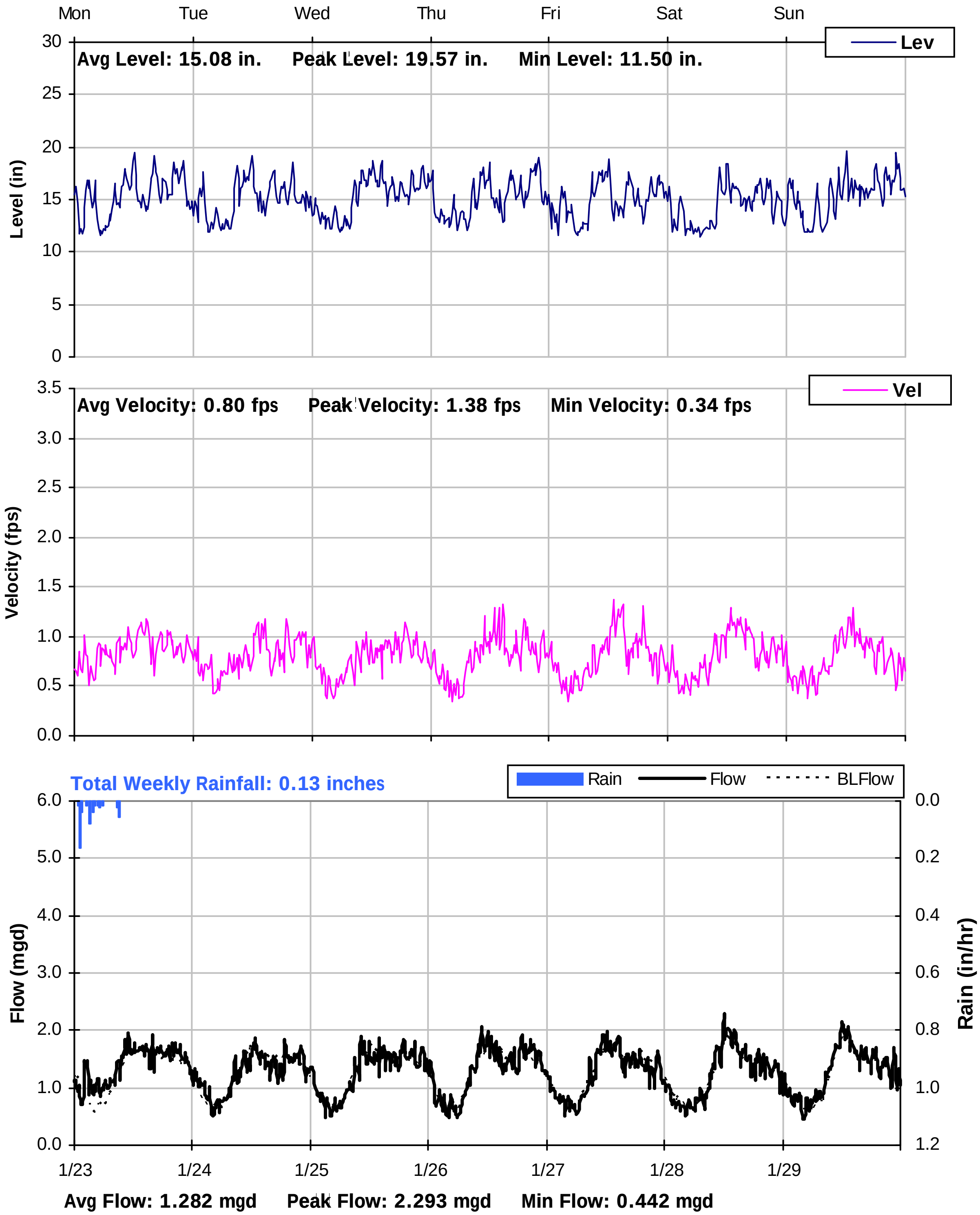
Storm Event I/I Analysis (Rain = 0.77 inches)

Capacity		Inflow		Combined I/I	
Peak Flow:	3.61 *mgd*	**Peak I/I Rate:**	2.84 *mgd*	**Total I/I:**	617,000 *gallons*
PF:	2.87	**Pk I/I:Acre:**	2,012 *gpd/acre*	**R-Value:**	2.1%
		Pk I/I:ADWF:	2.27	**Total I/I:ADWF:**	0.64 *per in-rain*
Peak Level:	19.48 *in*				
d/D Ratio:	0.65				

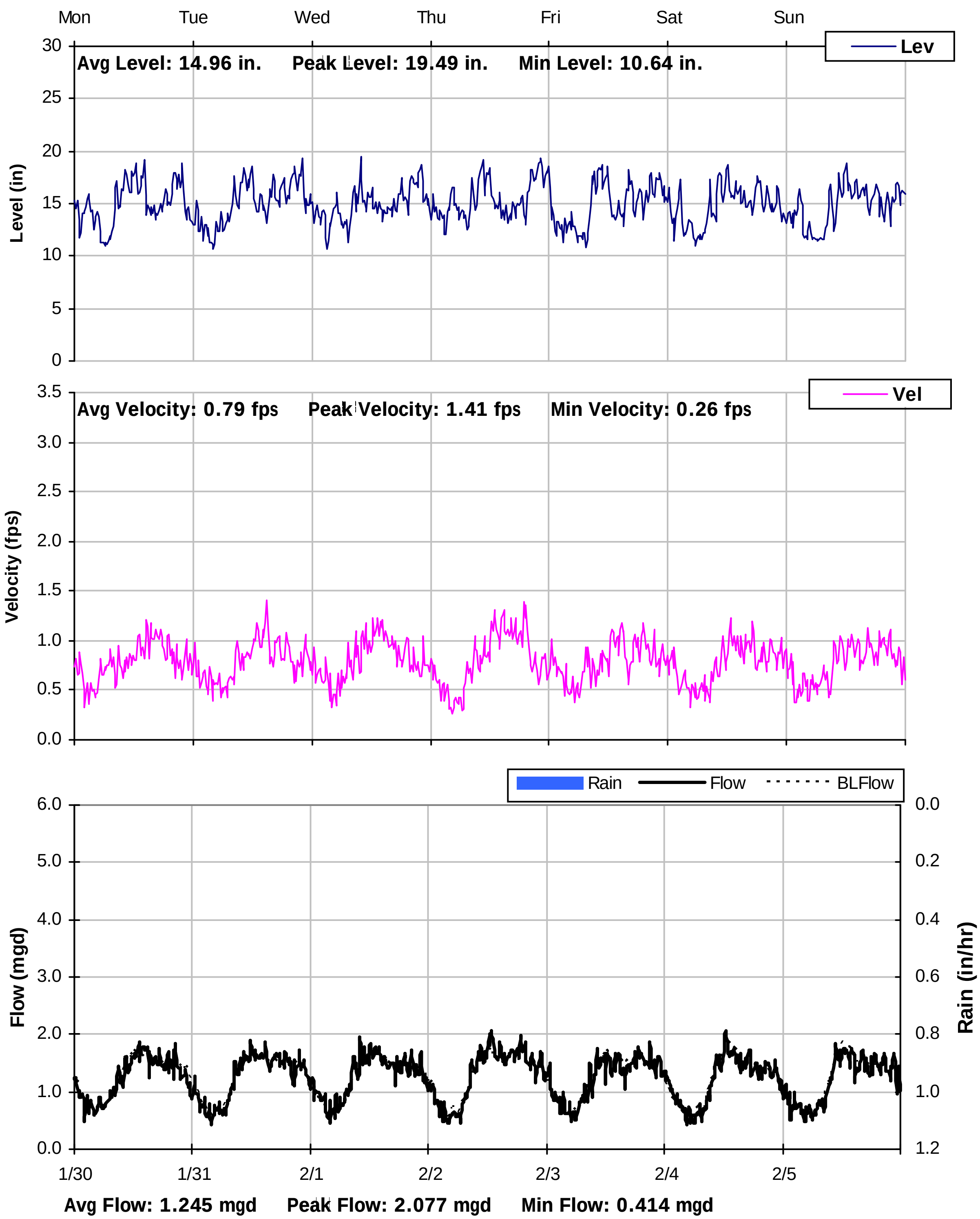
SITE 3
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



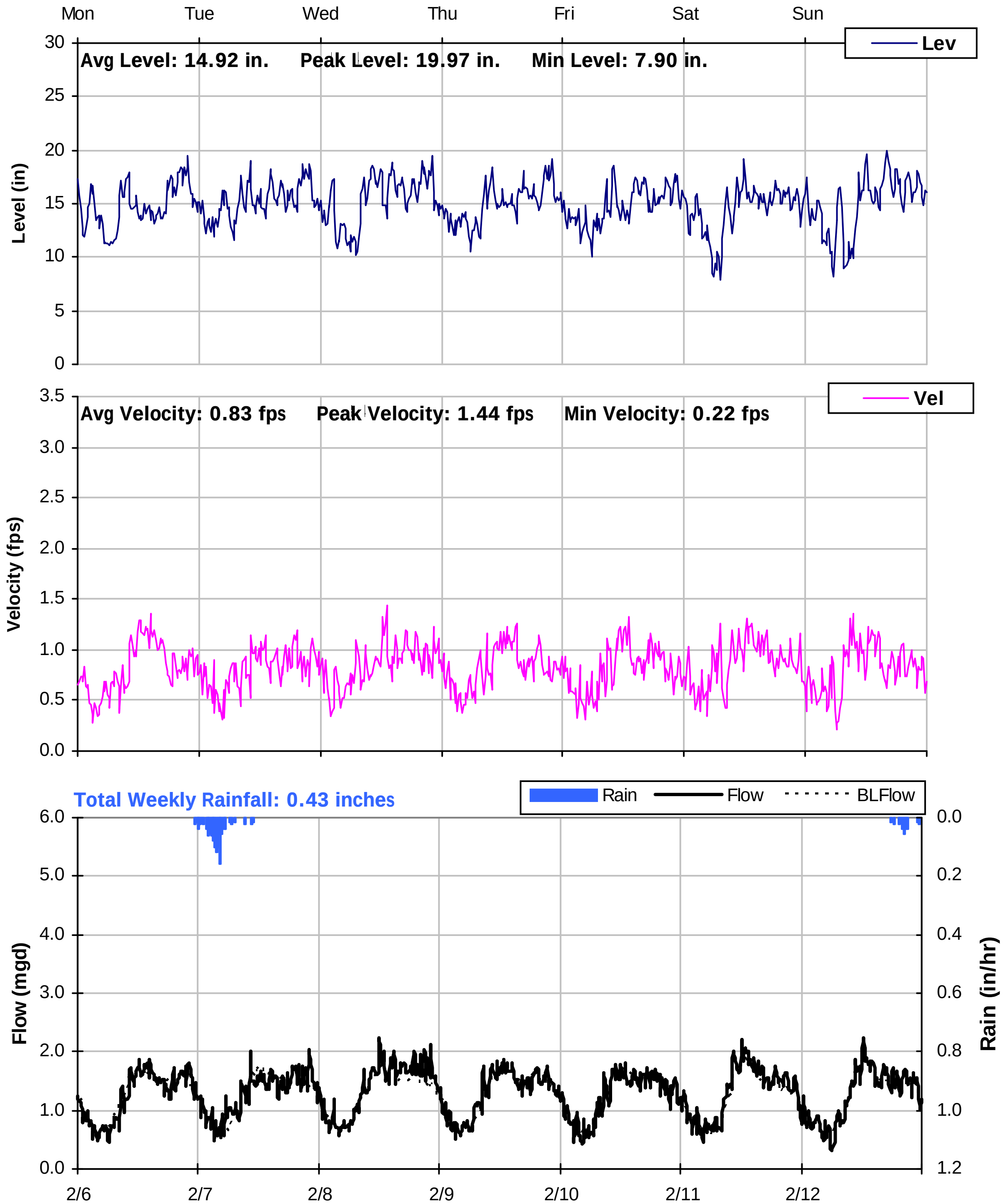
SITE 3
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



SITE 3
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012

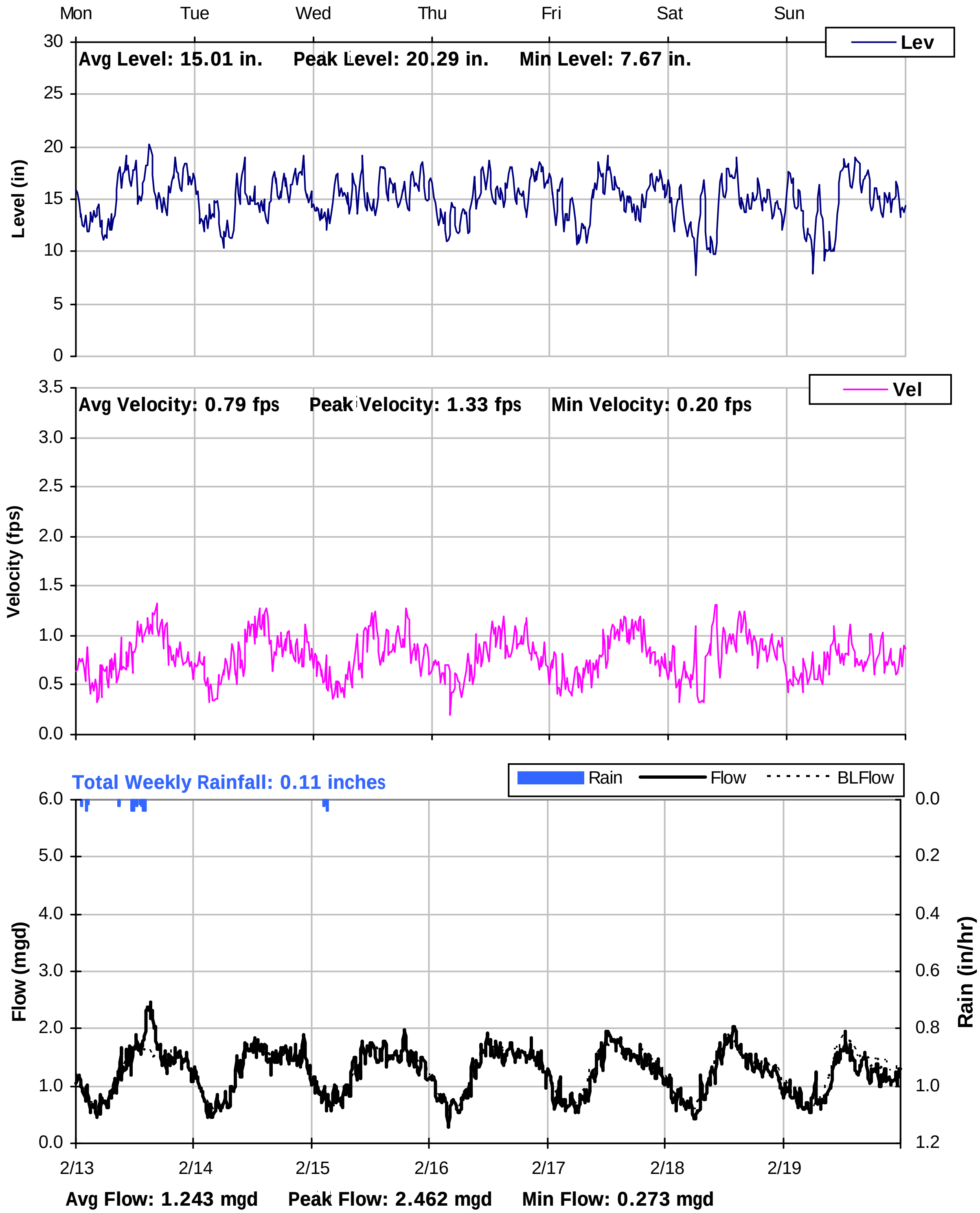


SITE 3
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012

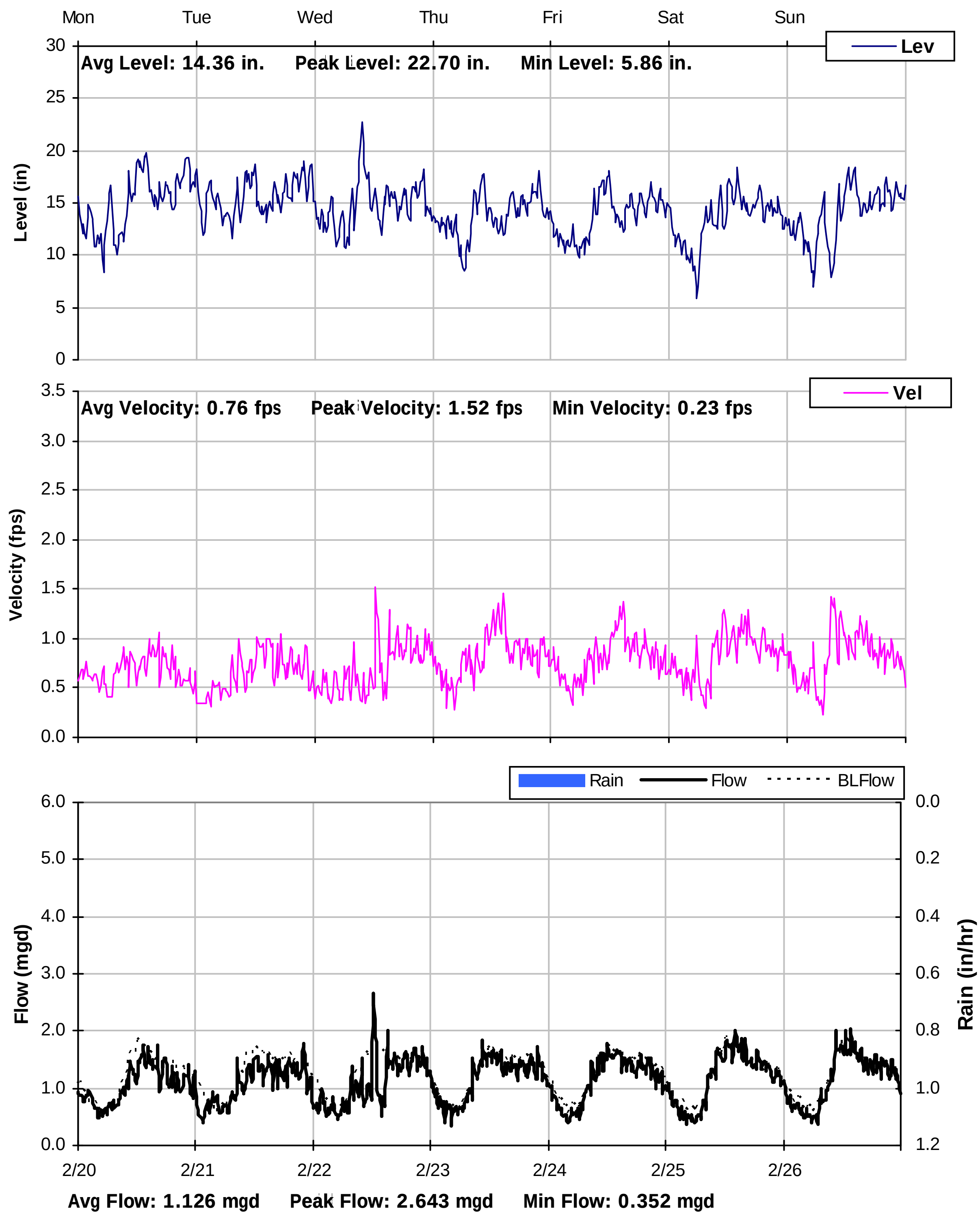


Avg Flow: 1.293 mgd   Peak Flow: 2.242 mgd   Min Flow: 0.299 mgd

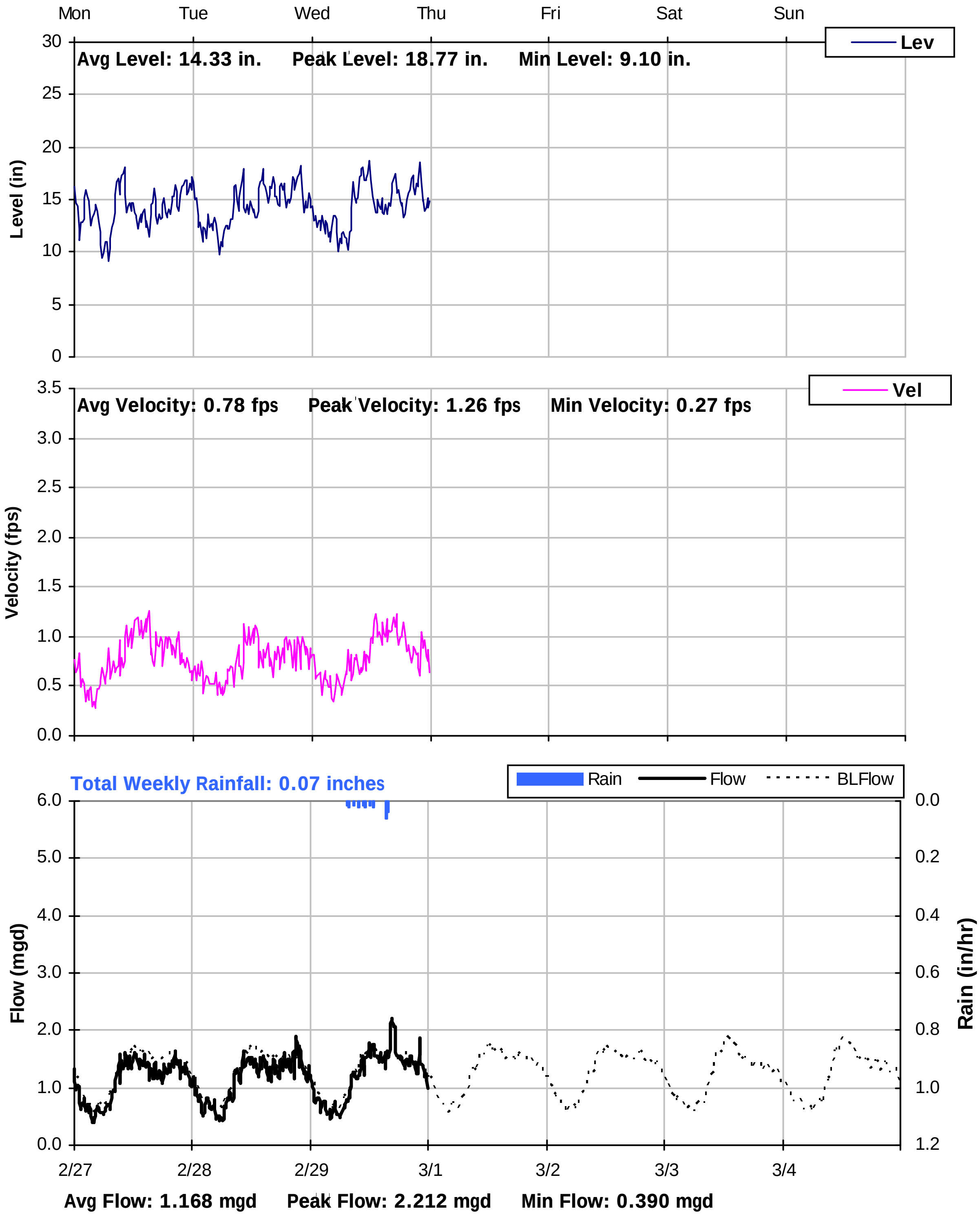
SITE 3
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012



SITE 3
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



SITE 3
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



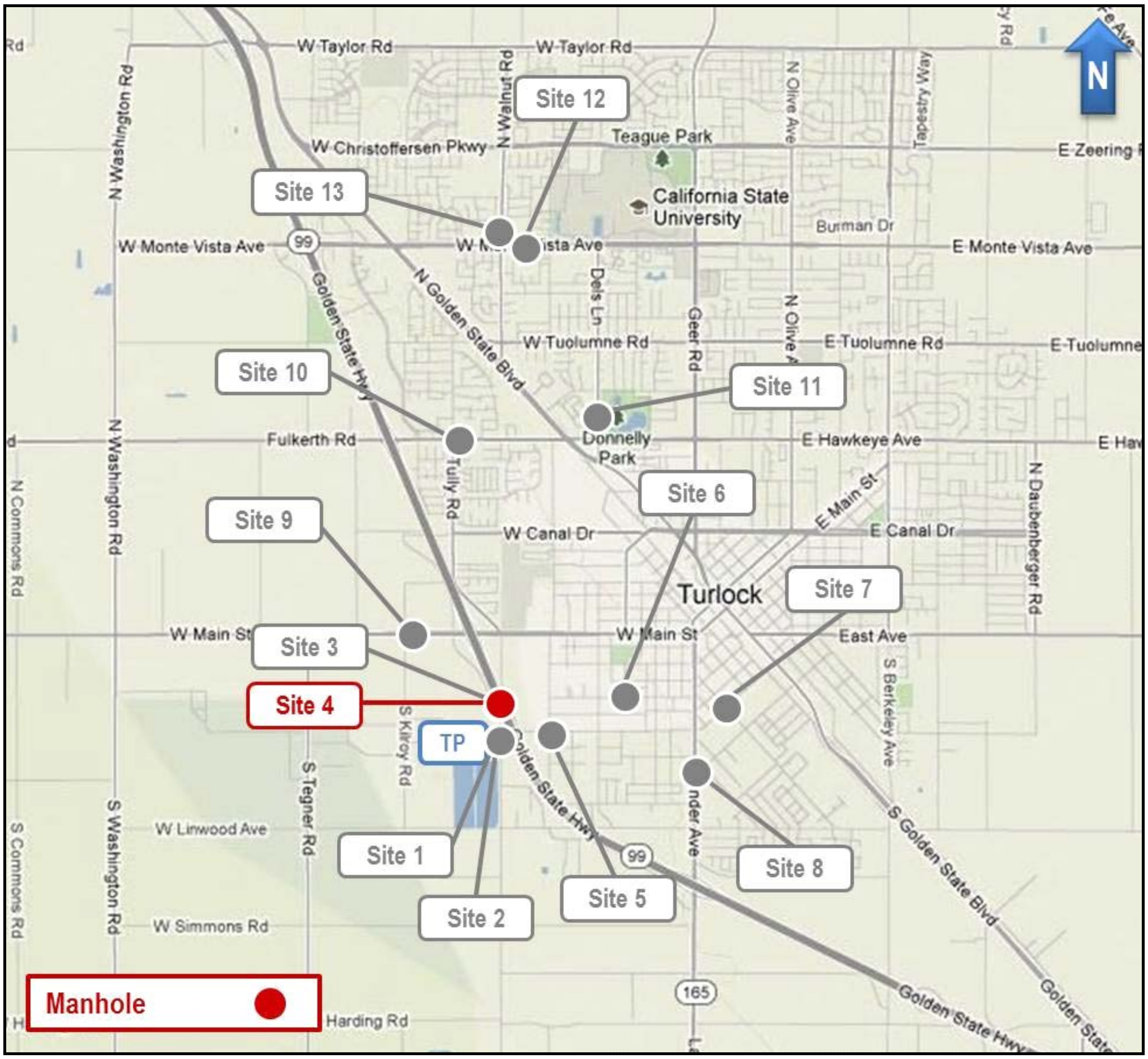
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 4

Location: Walnut Road, South of freeway underpass

Data Summary Report



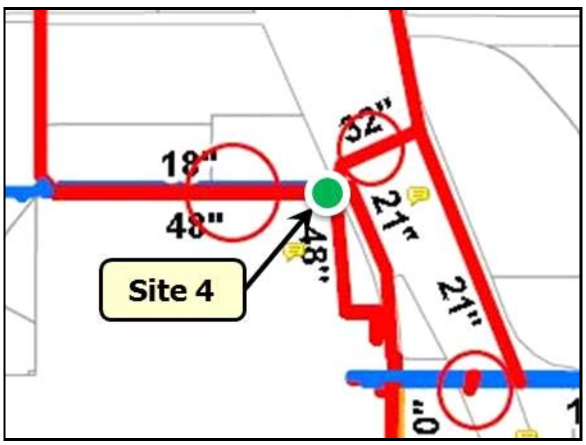
Vicinity Map: Site 4

SITE 4

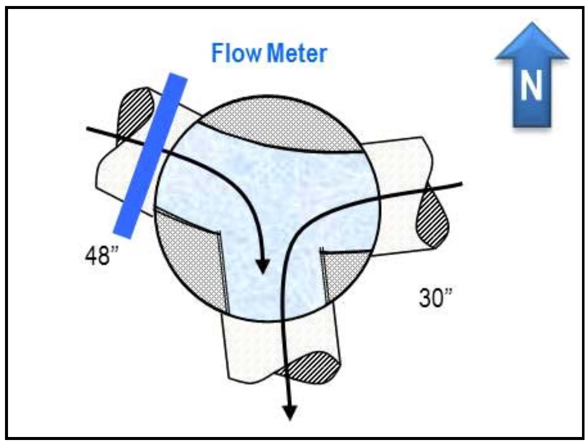
Site Information

Location:	Walnut Road, South of freeway underpass
Coordinates:	120.8679° W, 37.4872° N
Rim Elevation:	96 feet
Pipe Diameter:	48 inches
Baseline Flow:	5.561 mgd
Peak Measured Flow:	10.674 mgd

Satellite Map



Sewer Map



Flow Sketch


Street View

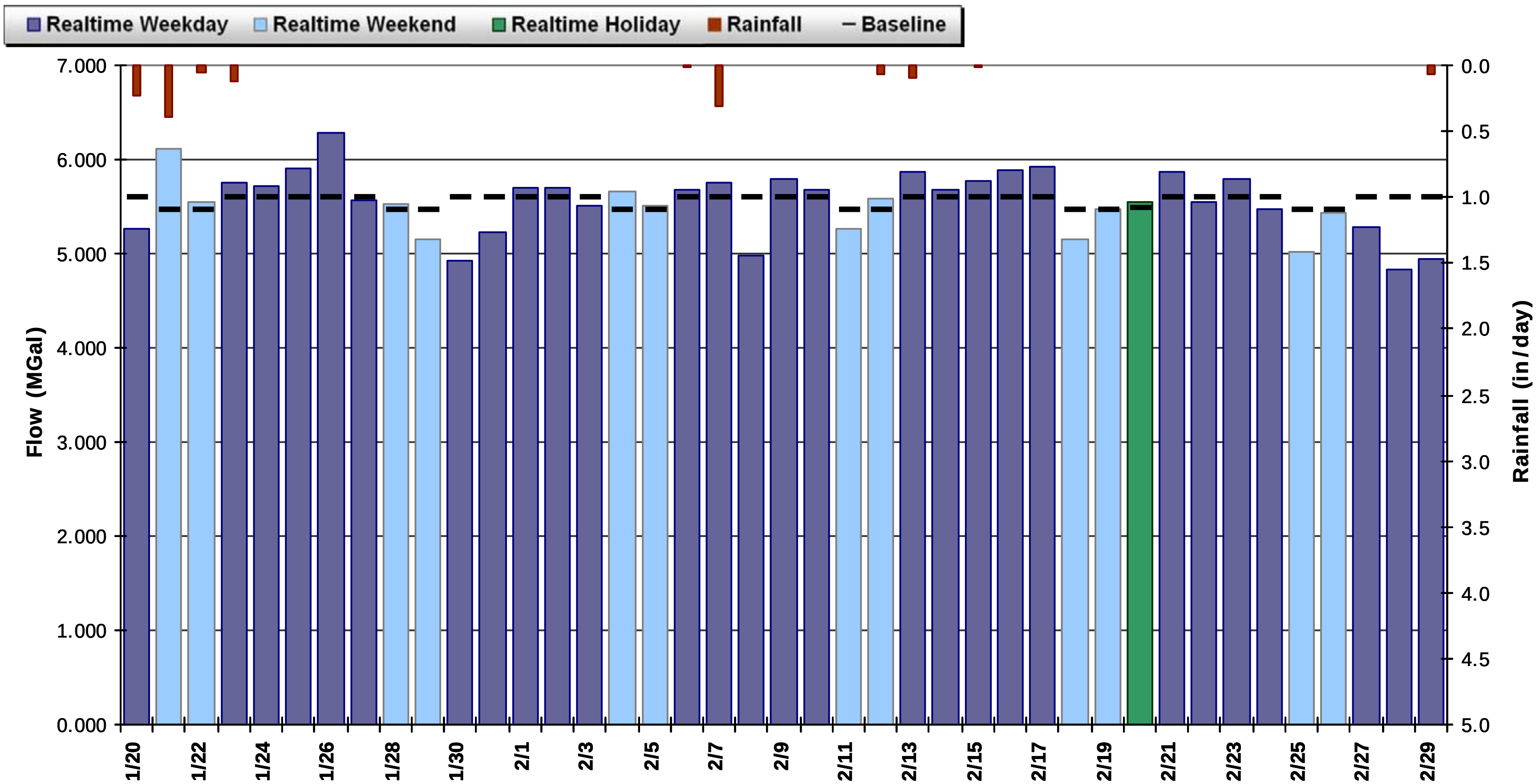

Plan View

SITE 4

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 5.544 MGal **Peak Daily Flow: 6.276 MGal** **Min Daily Flow: 4.839 MGal**

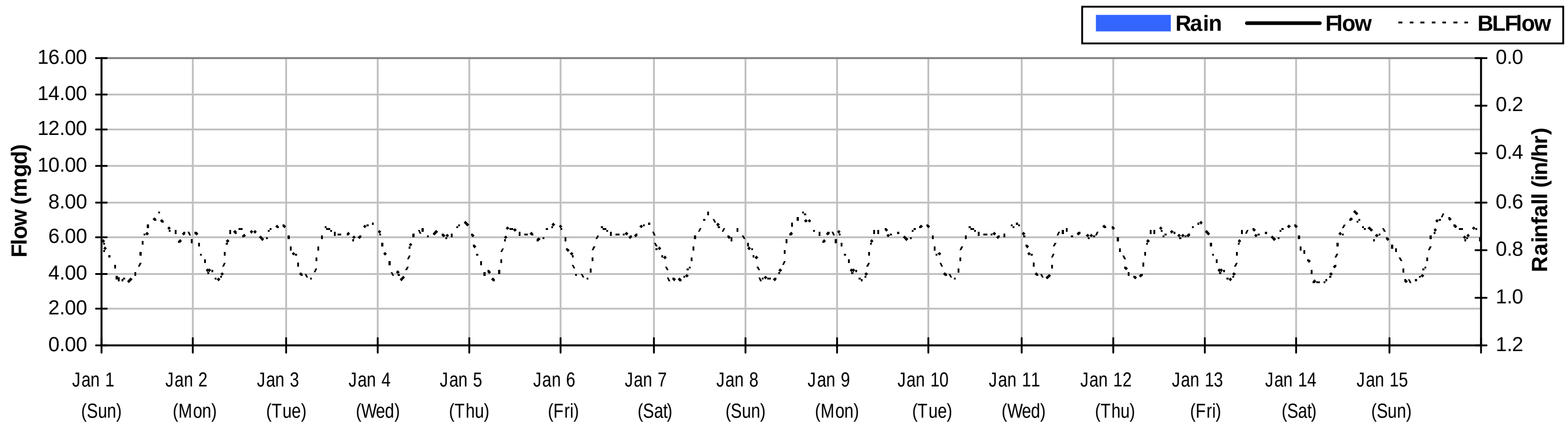
Total Period Rainfall: 1.37 inches

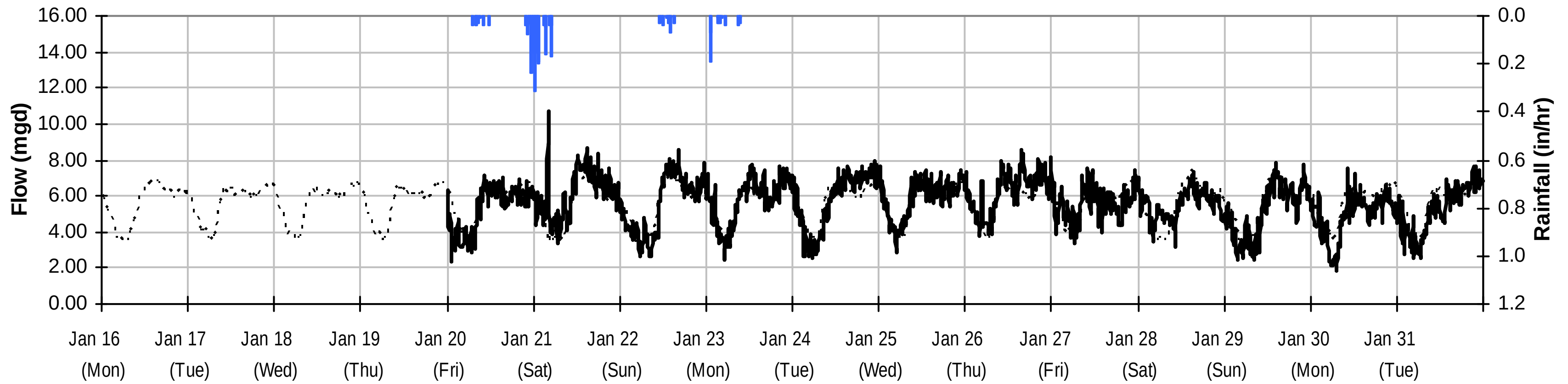


SITE 4

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.8 inches **Avg Flow: 5.579 mgd** **Peak Flow: 10.674 mgd** **Min Flow: 1.839 mgd**

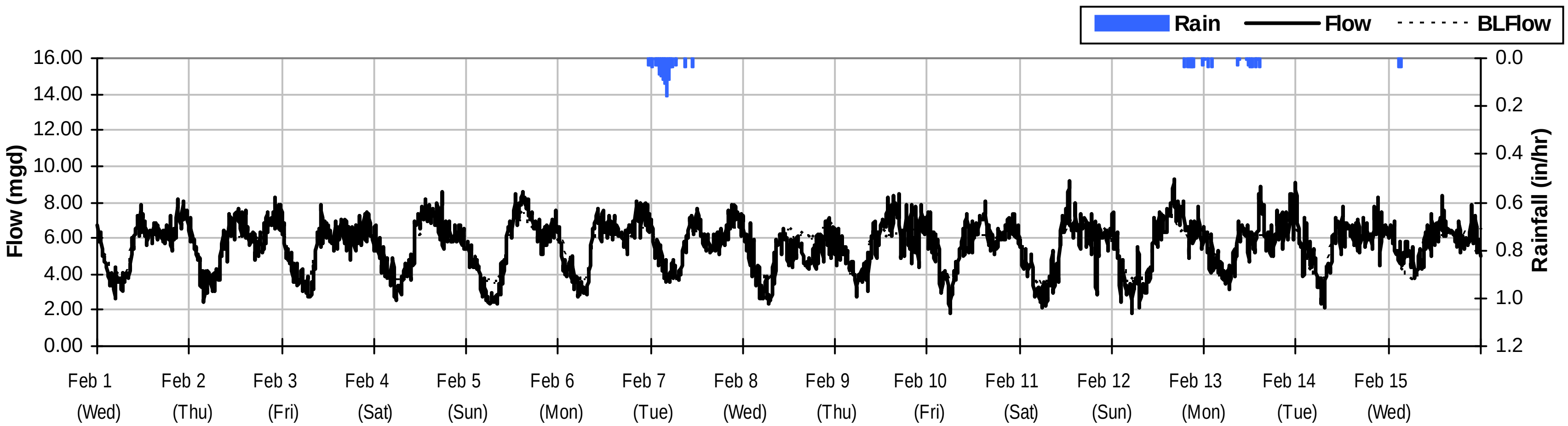


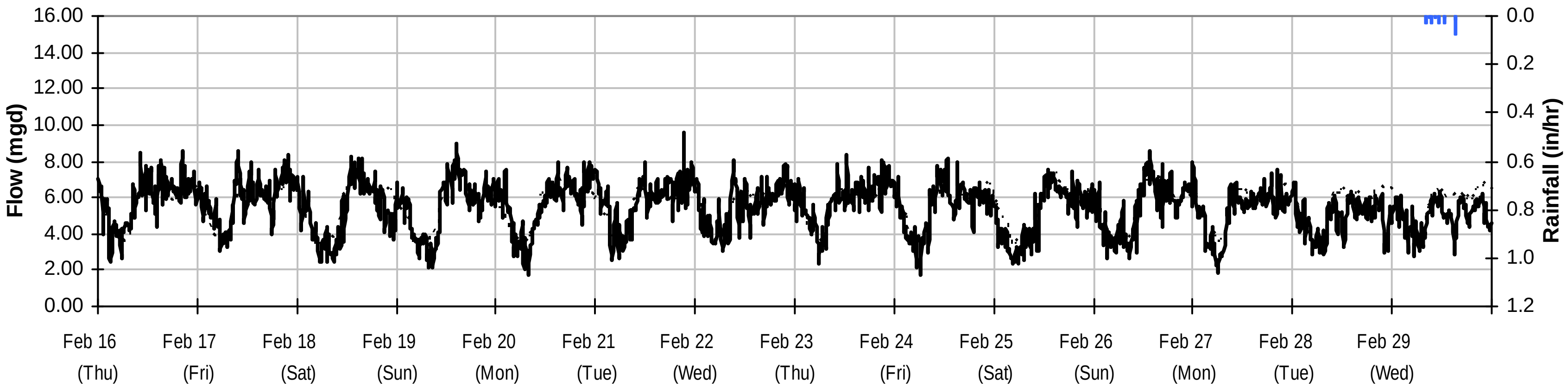


SITE 4

Monthly Flow Summary: February, 2012

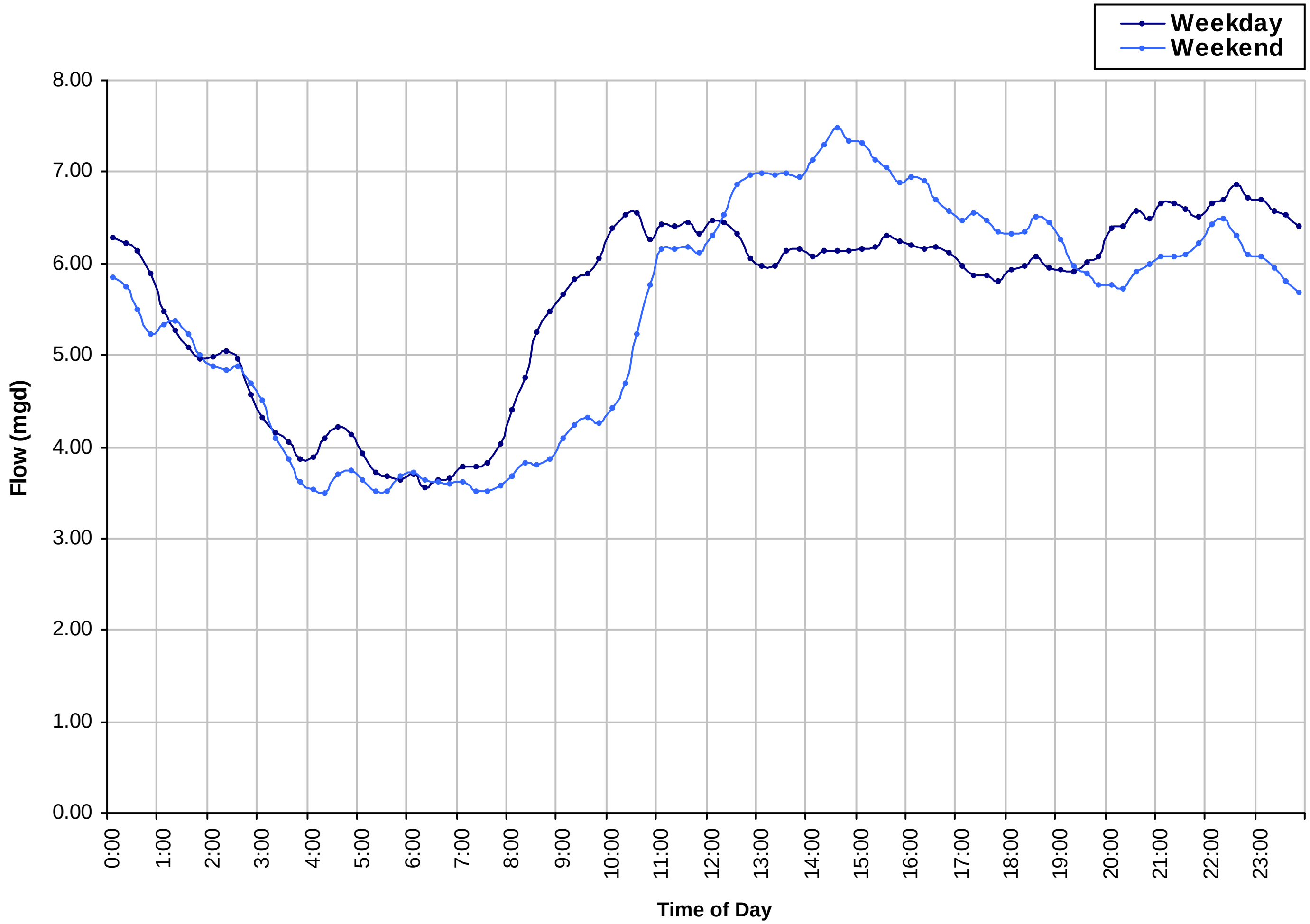
Total Monthly Rainfall: 0.57 inches **Avg Flow: 5.529 mgd** **Peak Flow: 9.538 mgd** **Min Flow: 1.742 mgd**



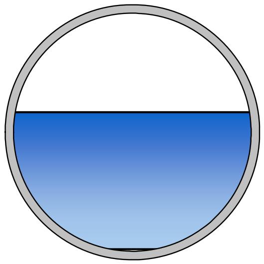


SITE 4

Baseline Flow Hydrographs

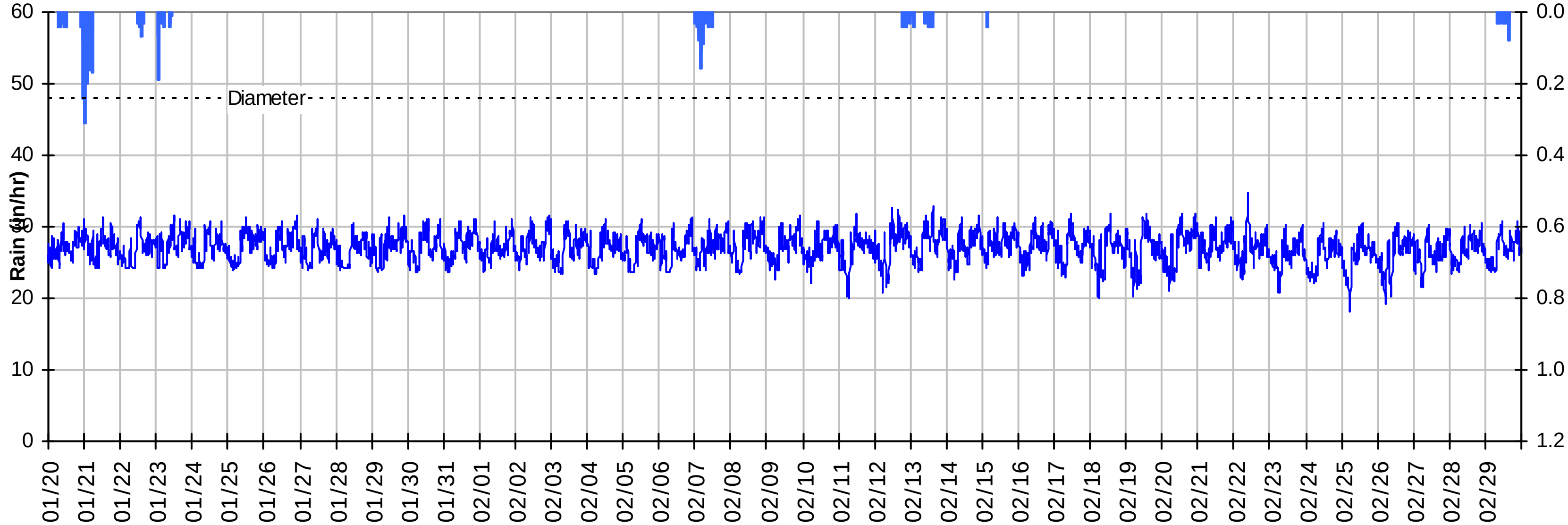


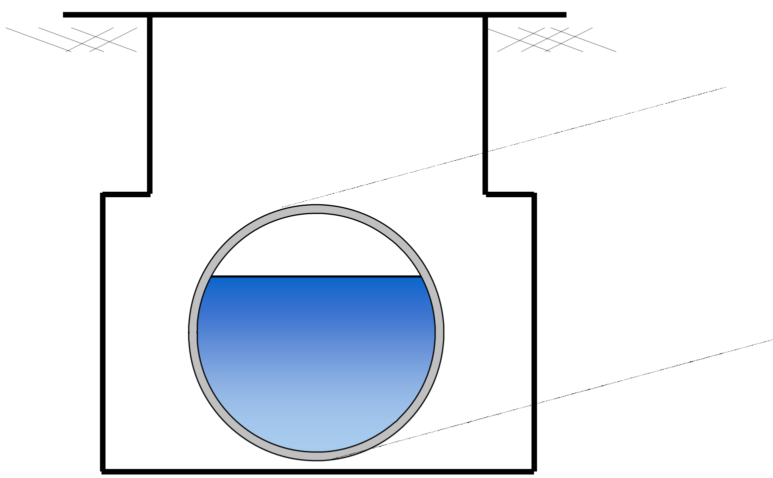
Baseline Flow:
5.561 *mgd*



SITE 4
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





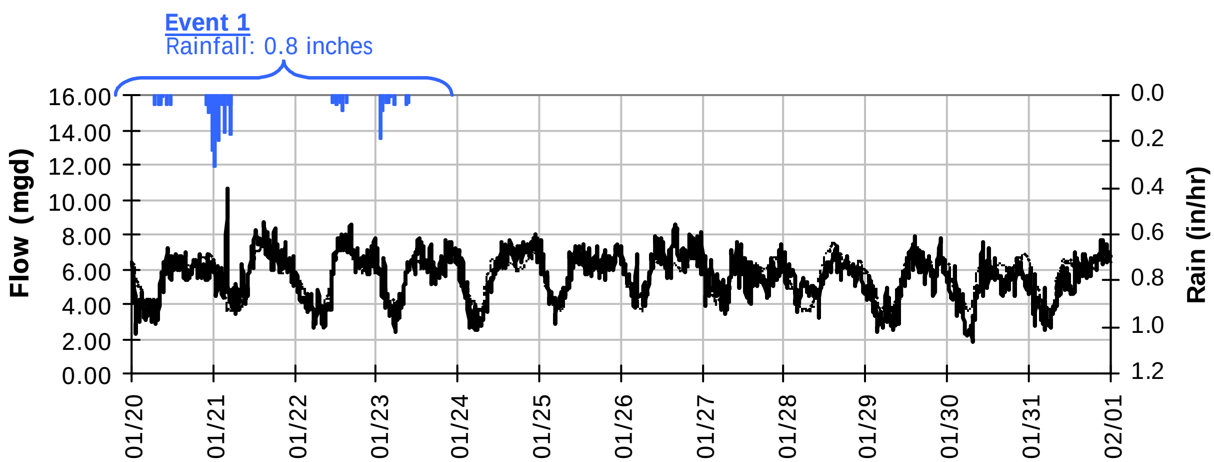
Pipe Diameter: 48 *inches*

Peak Measured Level: 34.8 *inches*

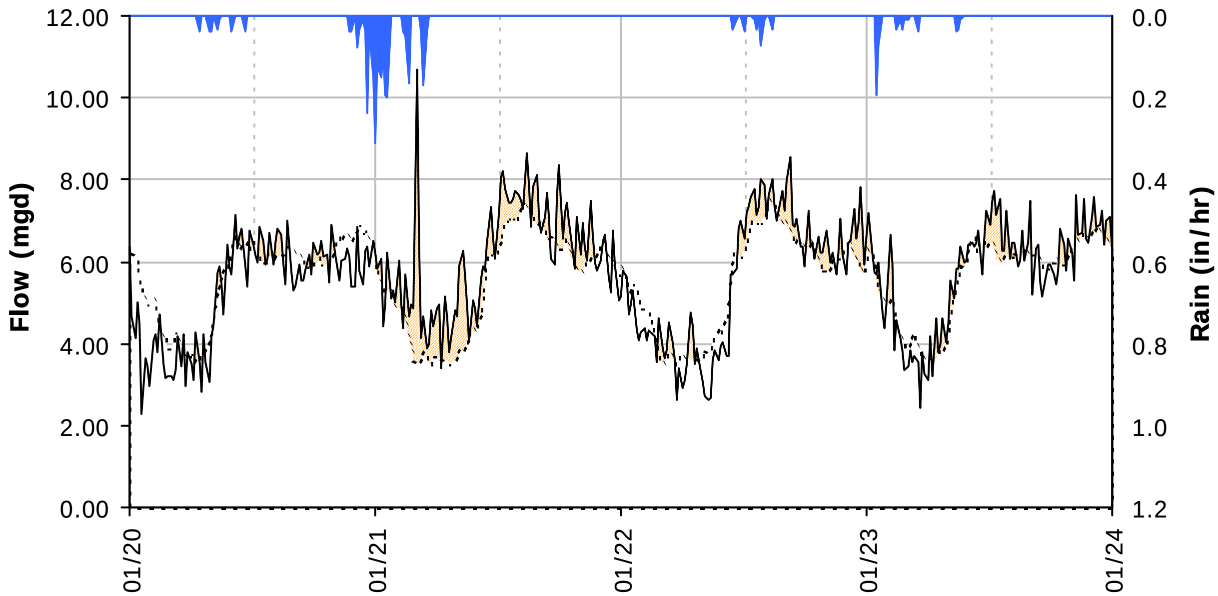
Peak d/D Ratio: 0.73

SITE 4
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph



Storm Event I/I Analysis (Rain = 0.80 inches)

Capacity

Peak Flow: 10.67 *mgd*
PF: 1.92
Peak Level: 31.45 *in*
d/D Ratio: 0.66

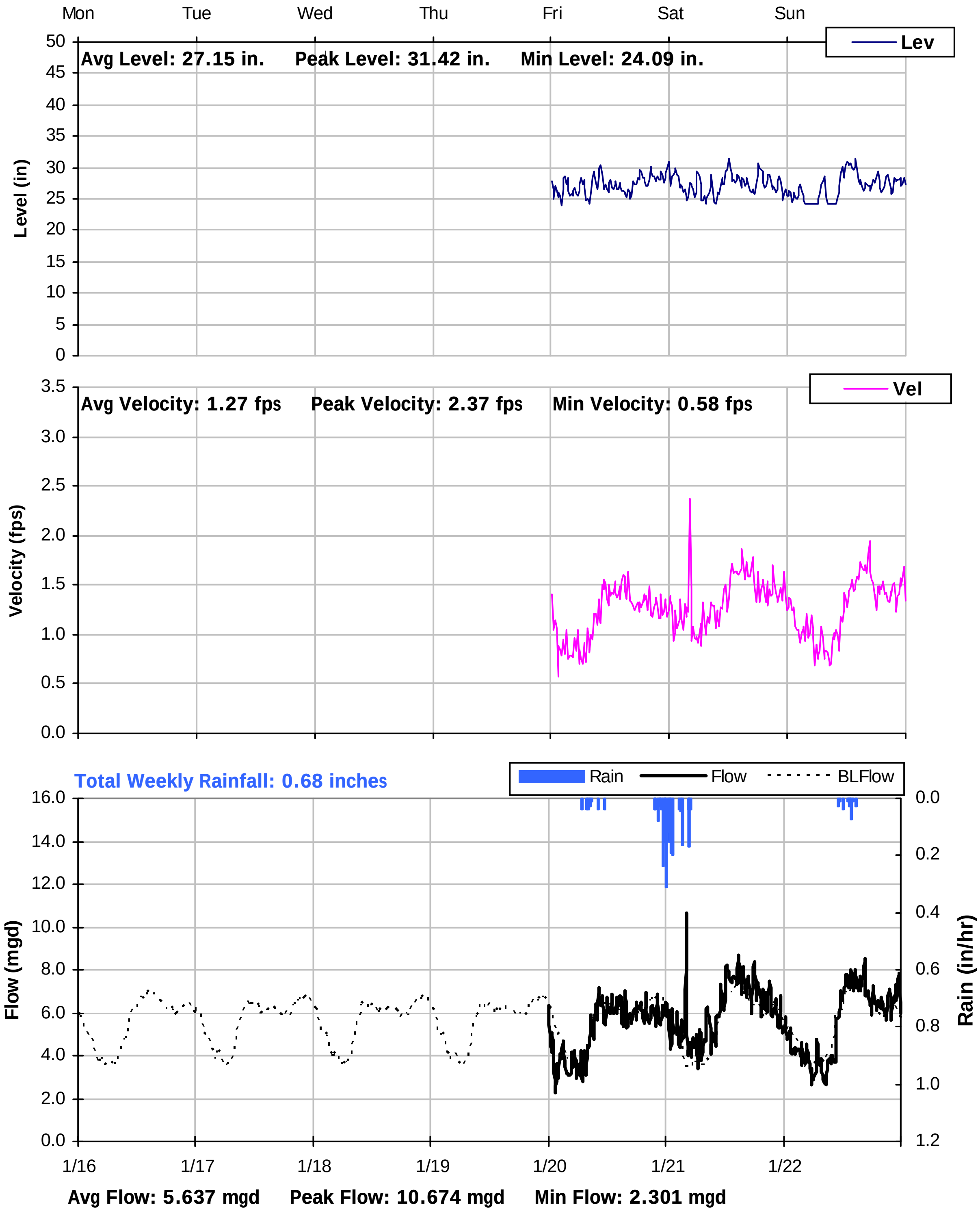
Inflow

Peak I/I Rate: 7.14 *mgd*
Pk I/I:Acre: 1,020 *gpd/acre*
Pk I/I:ADWF: 1.28

Combined I/I

Total I/I: 750,000 *gallons*
R-Value: 0.5%
Total I/I:ADWF: 0.17 *per in-rain*

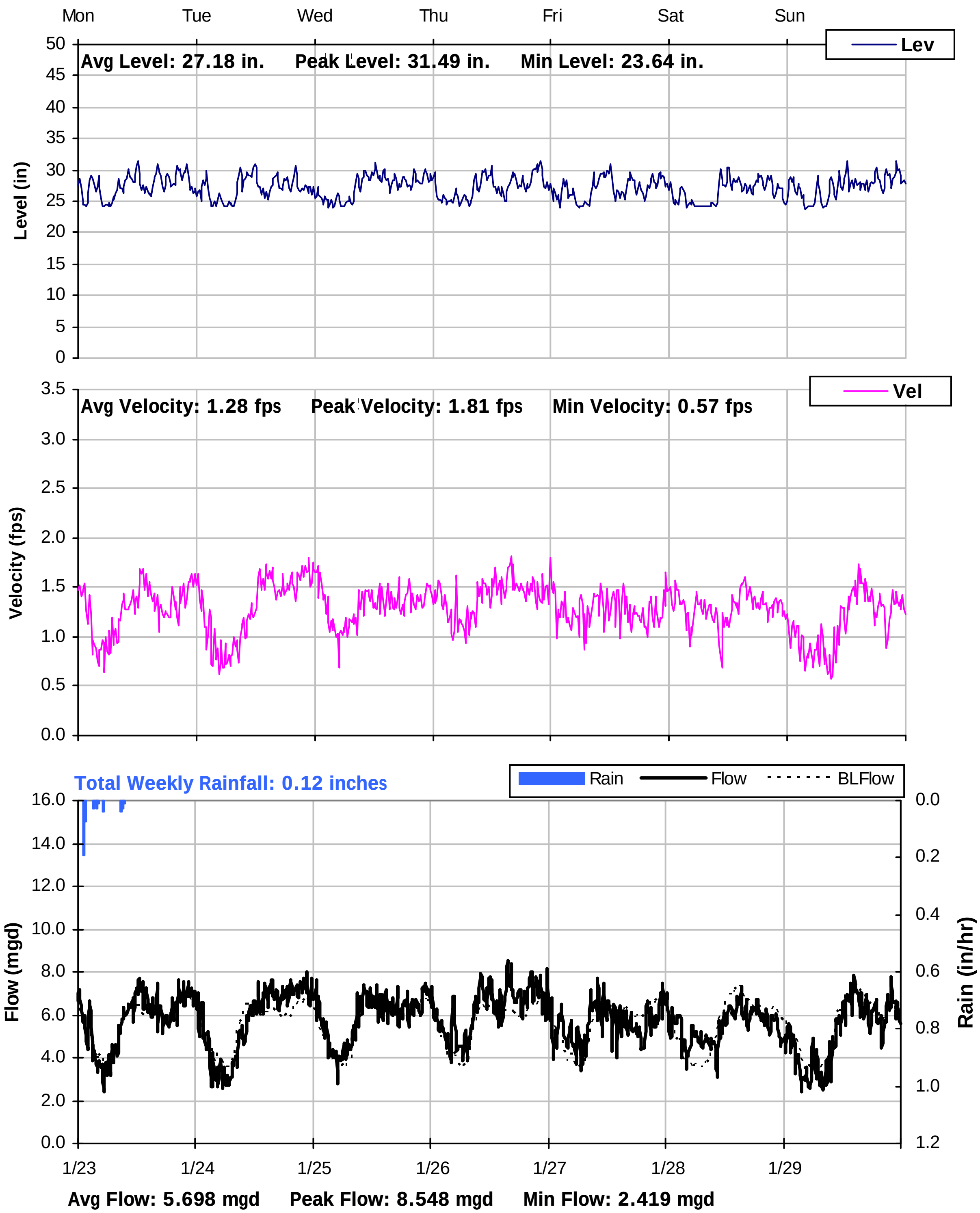
SITE 4
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



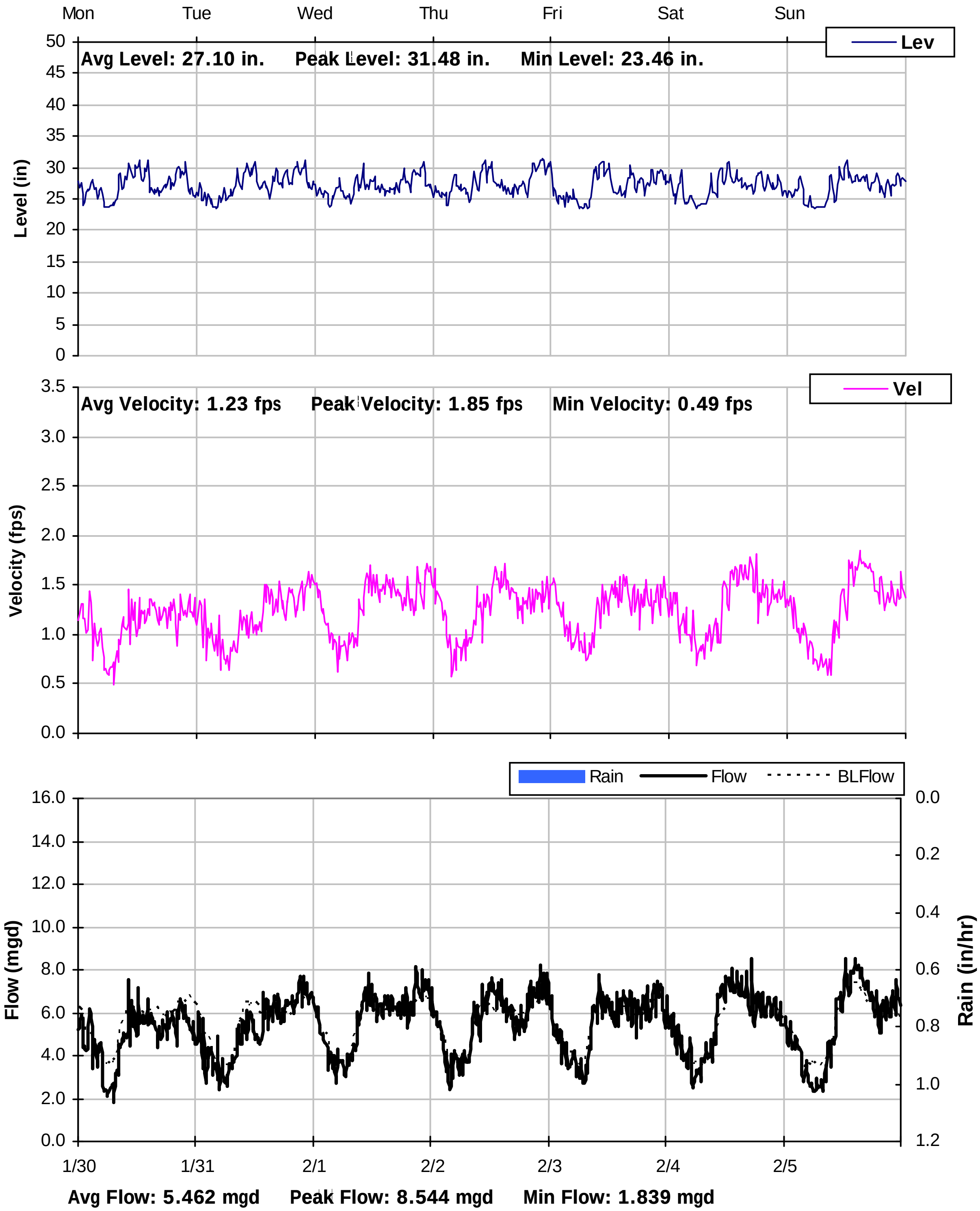
SITE 4

Weekly Level, Velocity and Flow Hydrographs

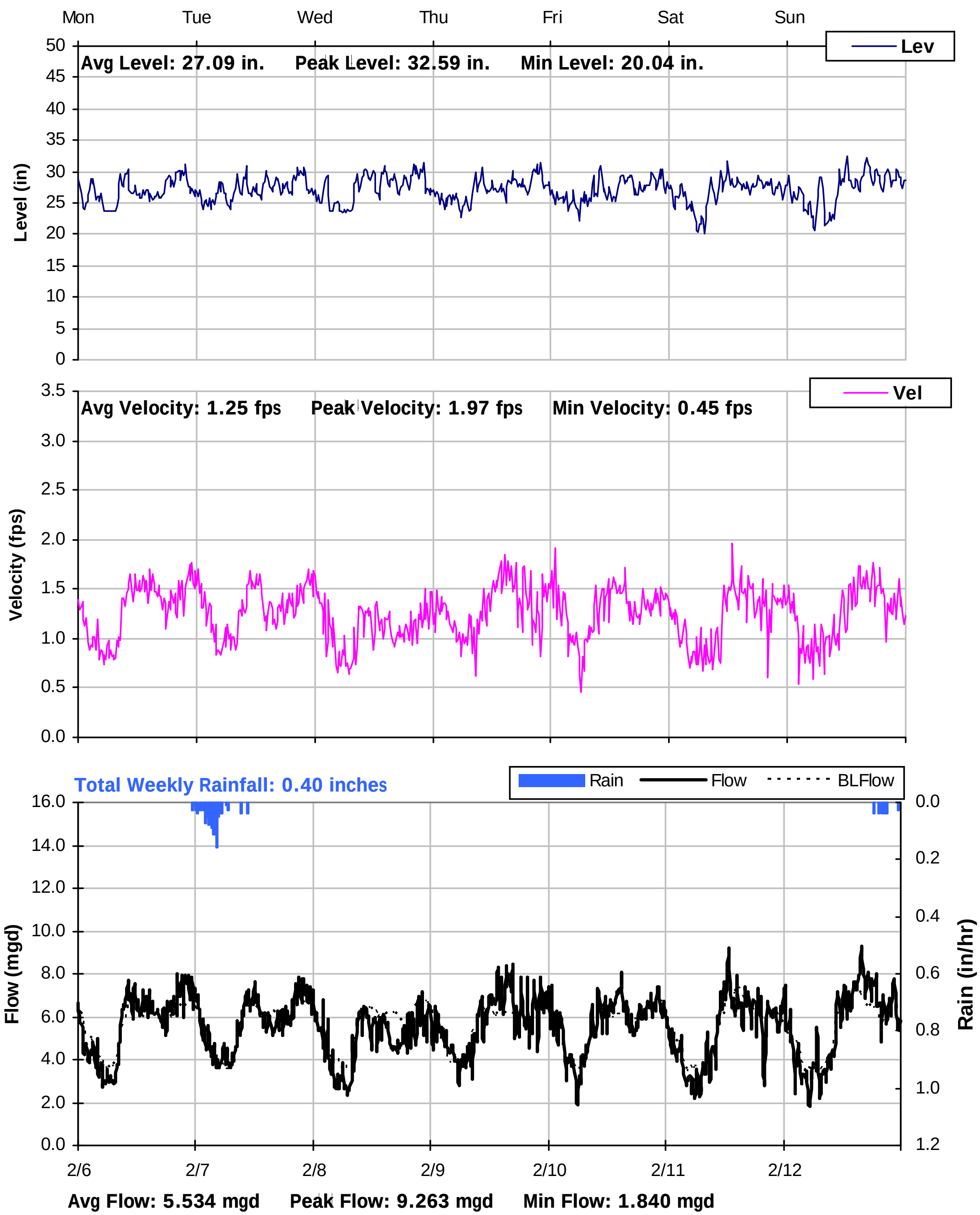
1/23/2012 to 1/30/2012



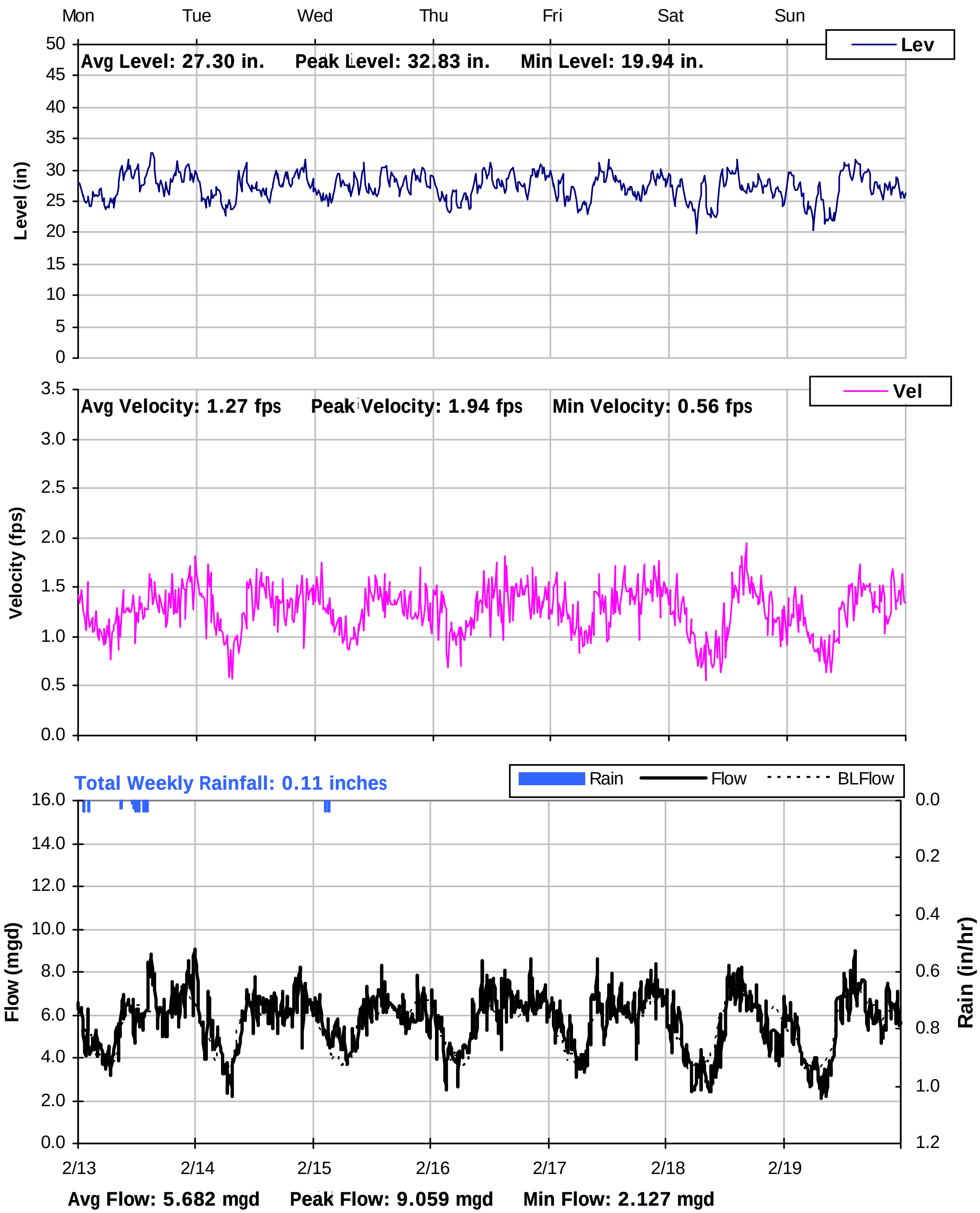
SITE 4
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



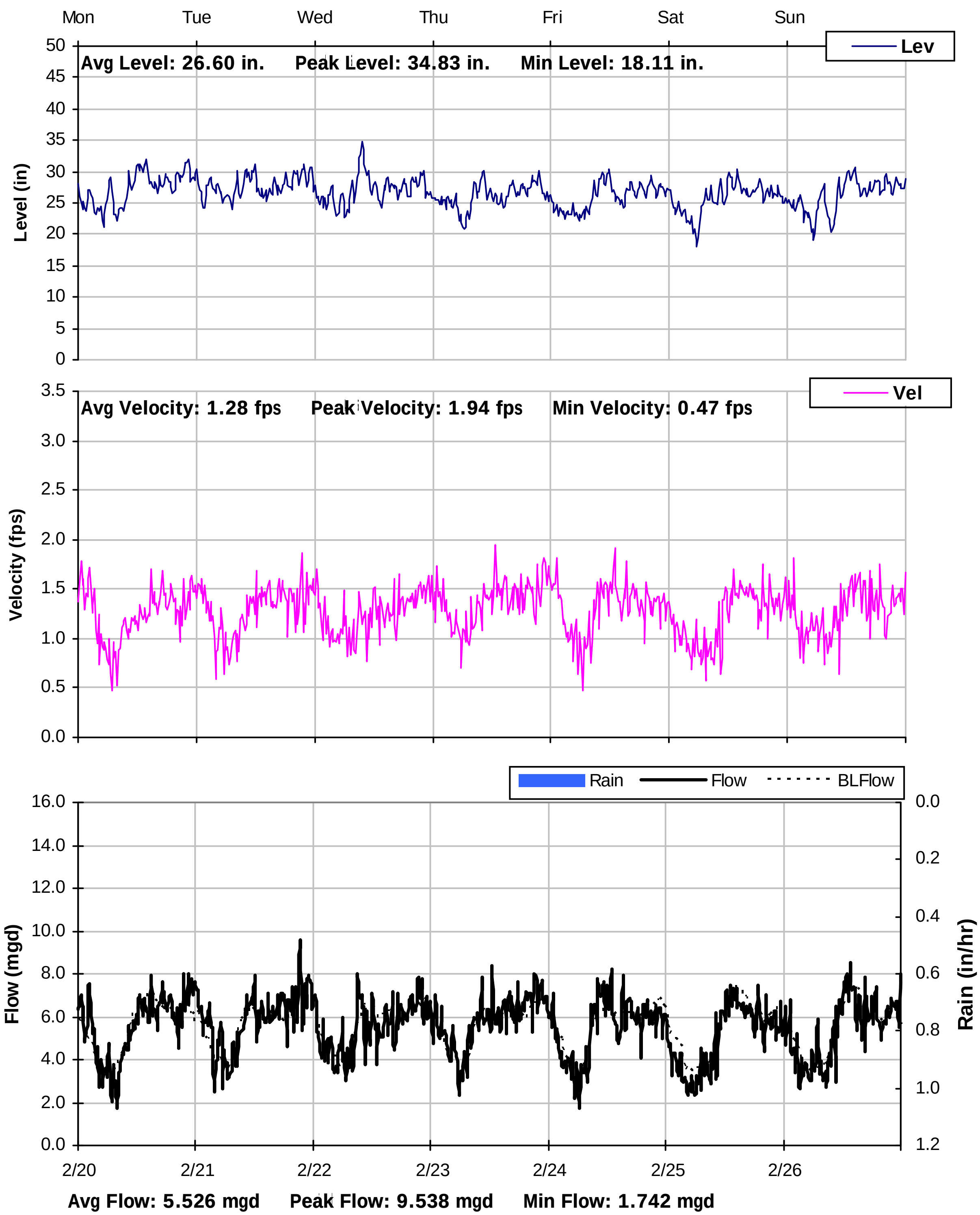
SITE 4
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



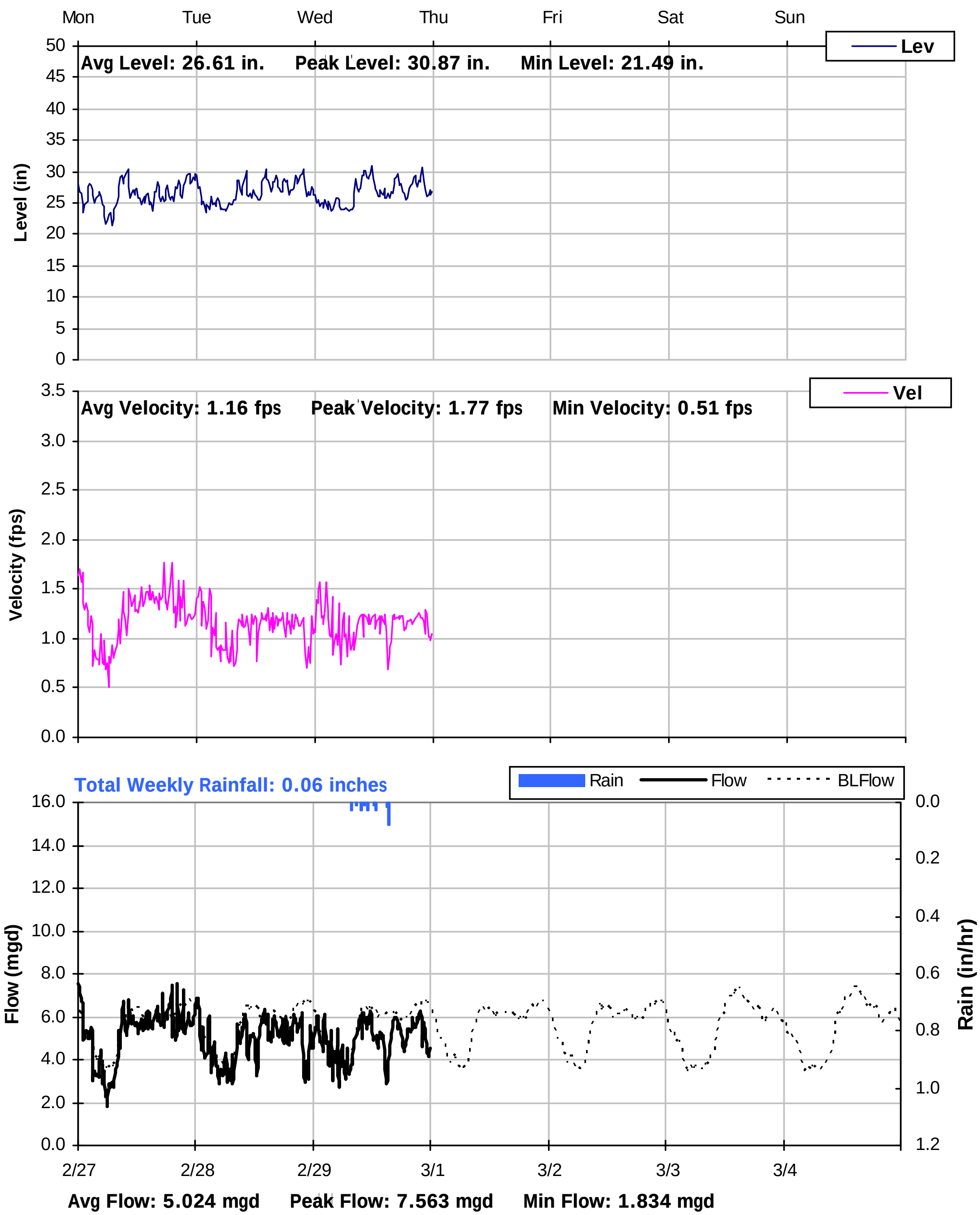
SITE 4
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012



SITE 4
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



SITE 4
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



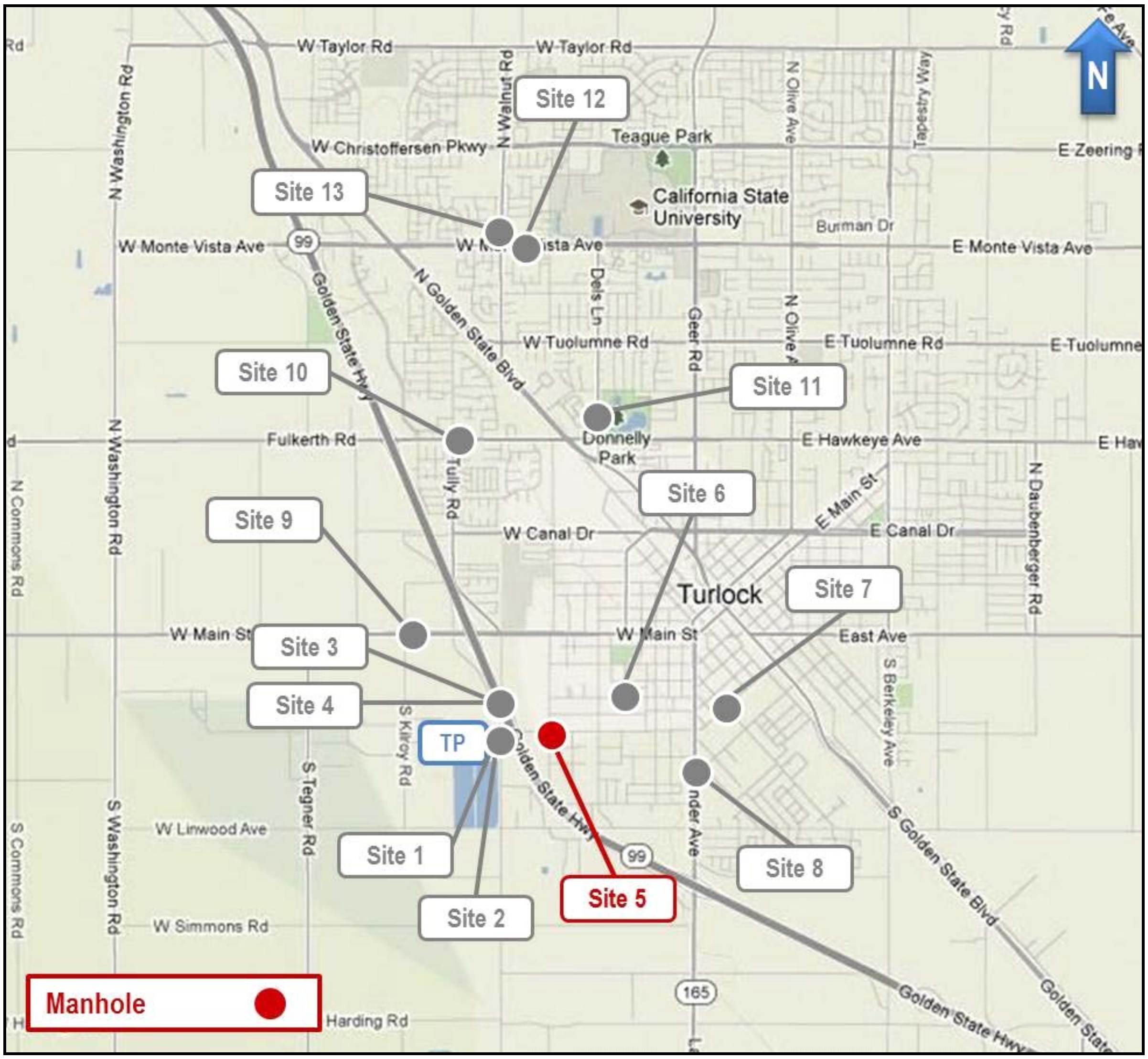
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 5

Location: Intersection of South Avenue and Soderquist Road

Data Summary Report



Vicinity Map: Site 5

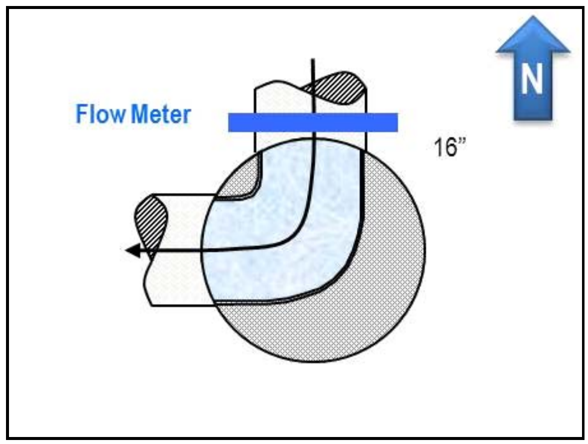
SITE 5

Site Information

Location:	Intersection of South Avenue and Soderquist Road
Coordinates:	120.8626° W, 37.4854° N
Rim Elevation:	98 feet
Pipe Diameter:	16 inches
Baseline Flow:	0.500 mgd
Peak Measured Flow:	1.281 mgd

Satellite Map

Sewer Map



Flow Sketch

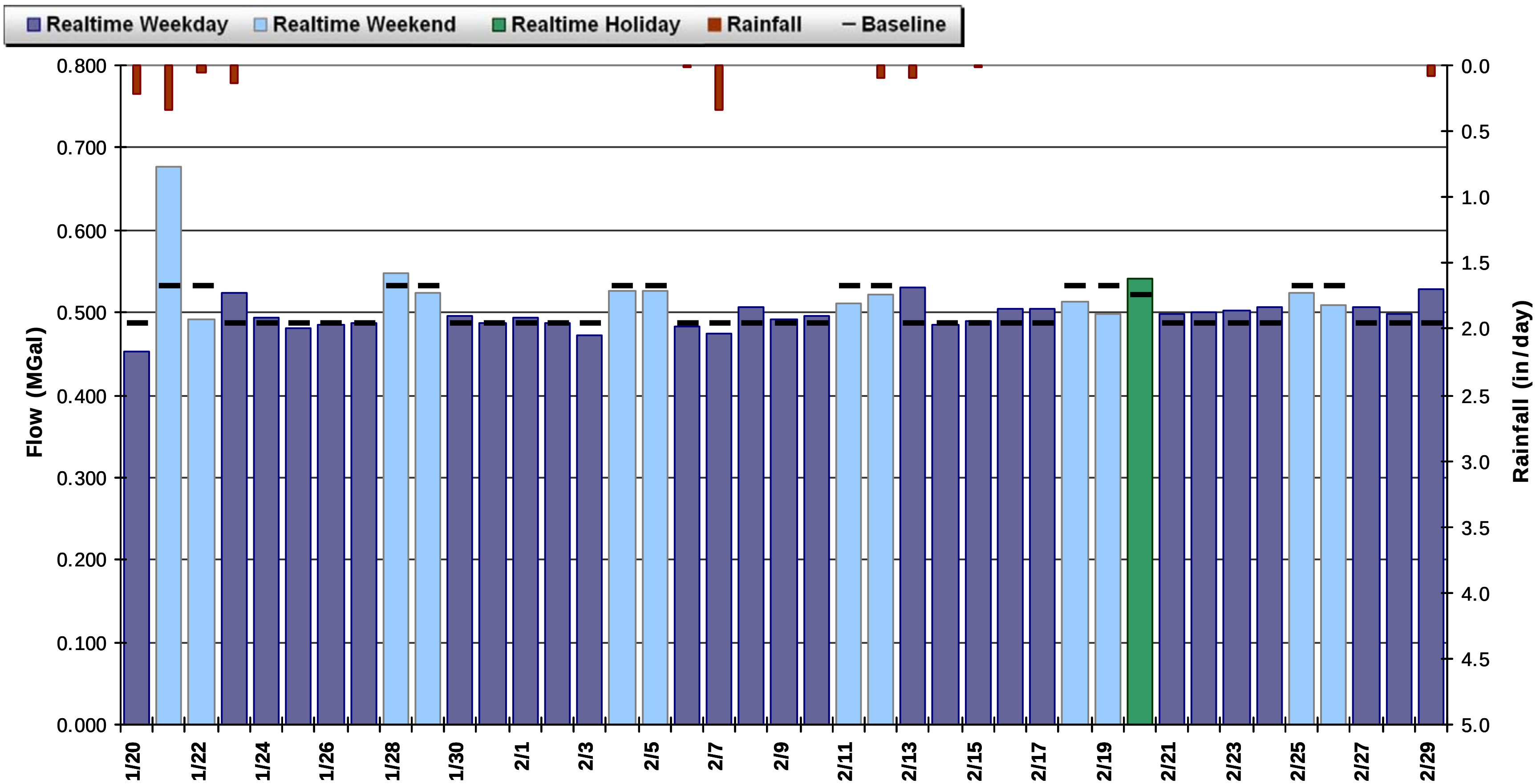
Street View

Plan View

SITE 5
Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.507 MGal **Peak Daily Flow: 0.677 MGal** **Min Daily Flow: 0.453 MGal**

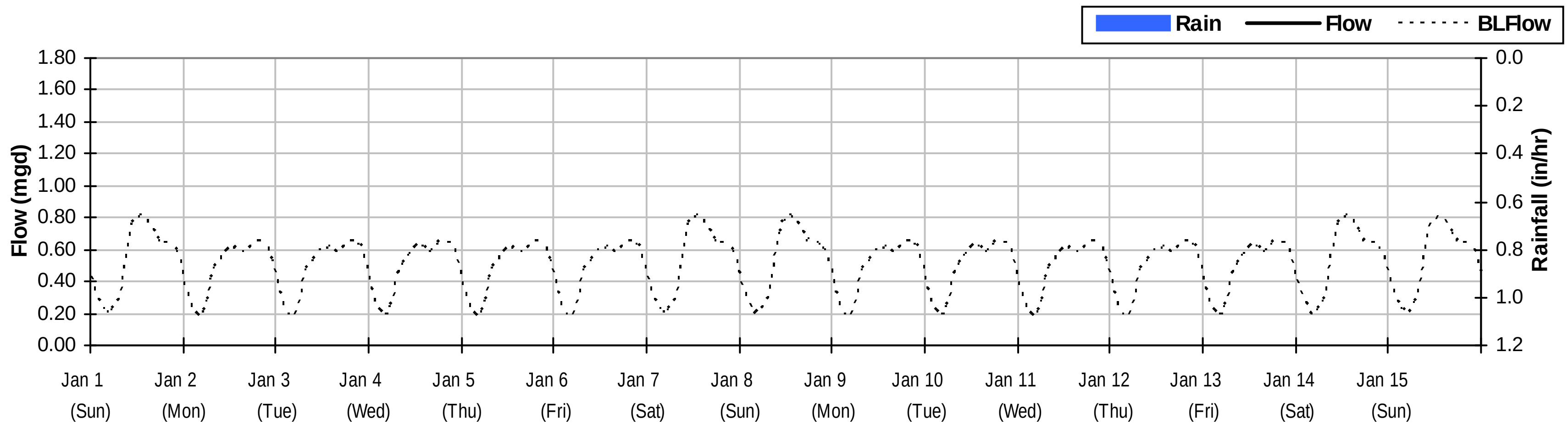
Total Period Rainfall: 1.39 inches

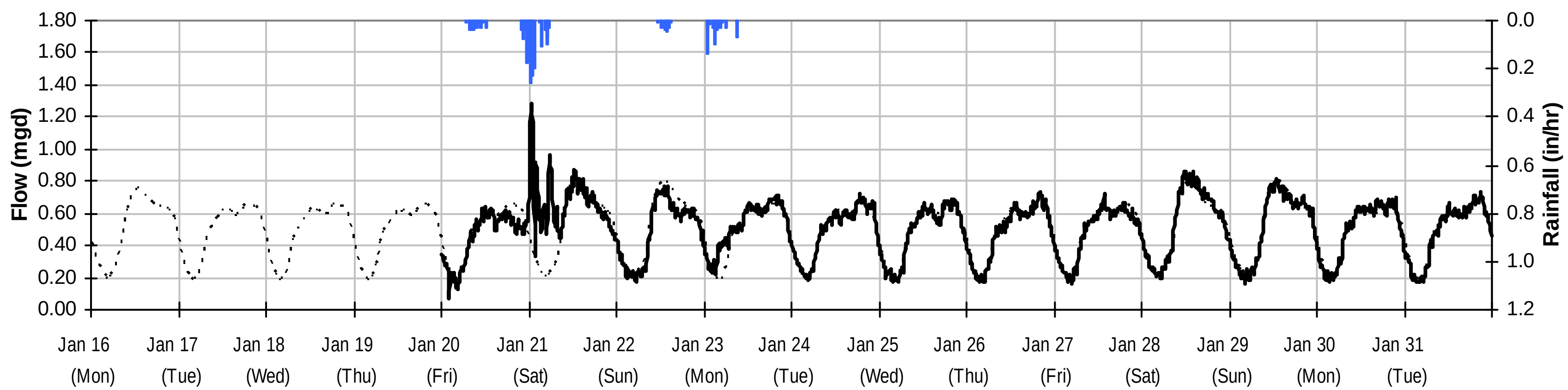


SITE 5

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.75 inches **Avg Flow: 0.512 mgd** **Peak Flow: 1.281 mgd** **Min Flow: 0.067 mgd**

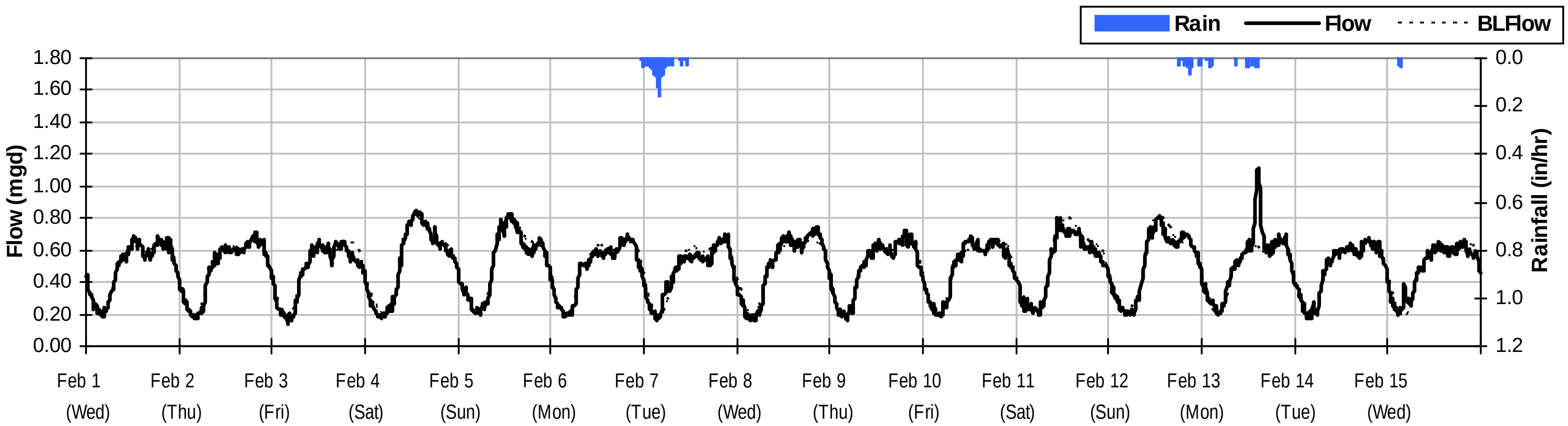


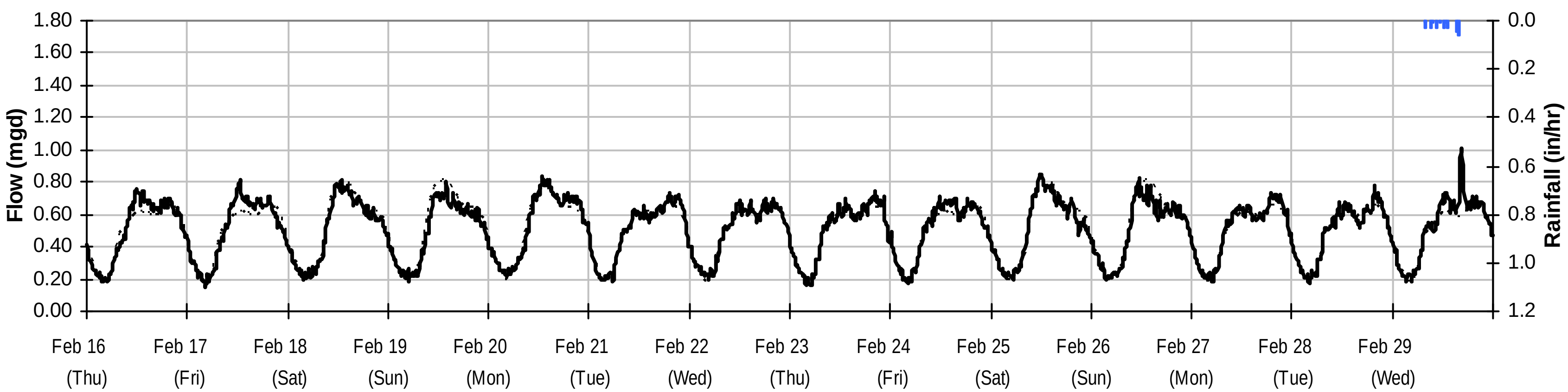


SITE 5

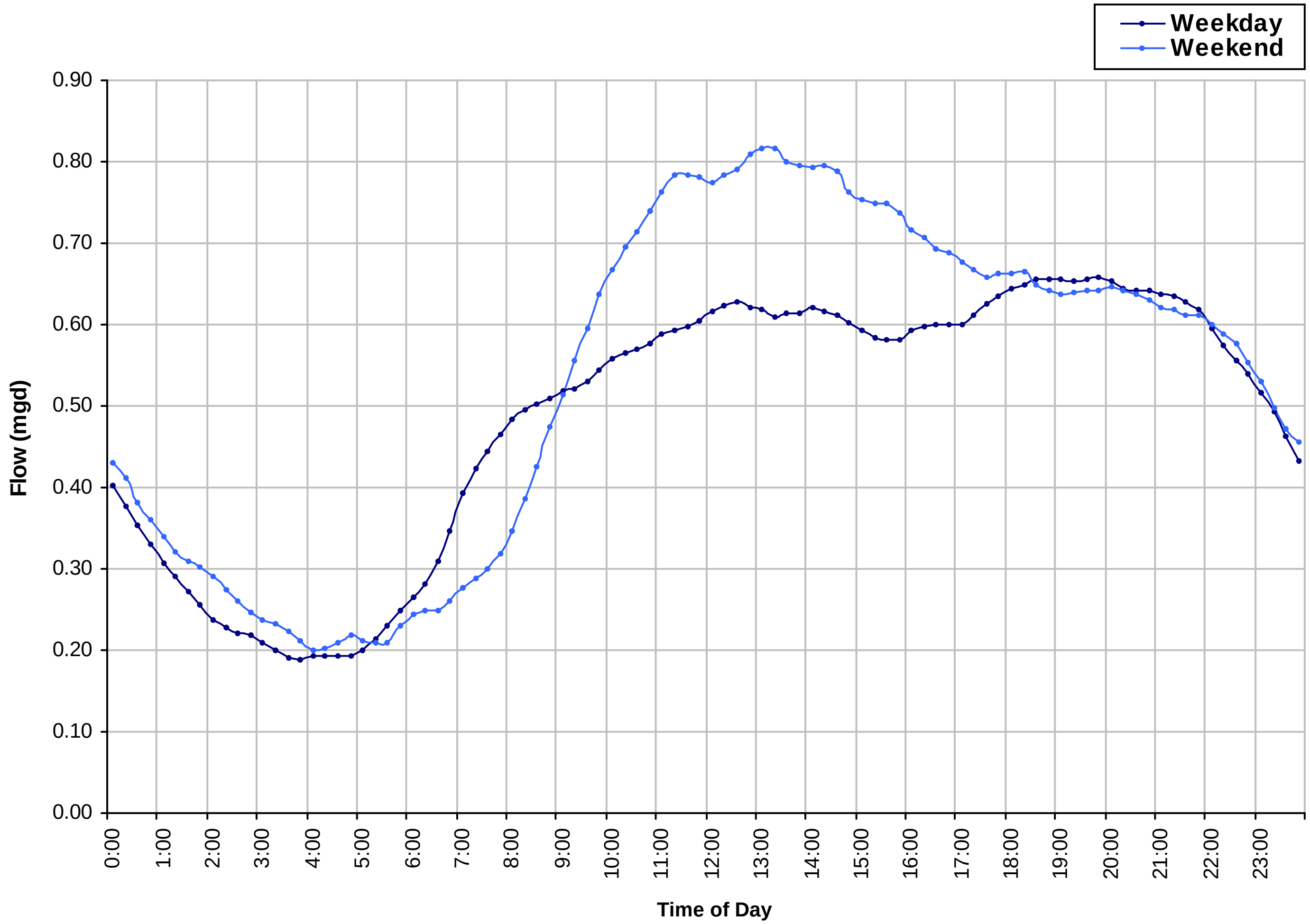
Monthly Flow Summary: February, 2012

Total Monthly Rainfall: 0.64 inches **Avg Flow: 0.504 mgd** **Peak Flow: 1.115 mgd** **Min Flow: 0.143 mgd**

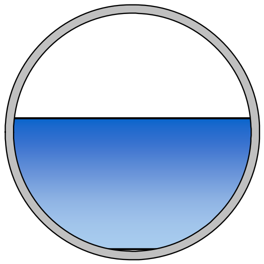




SITE 5
Baseline Flow Hydrographs

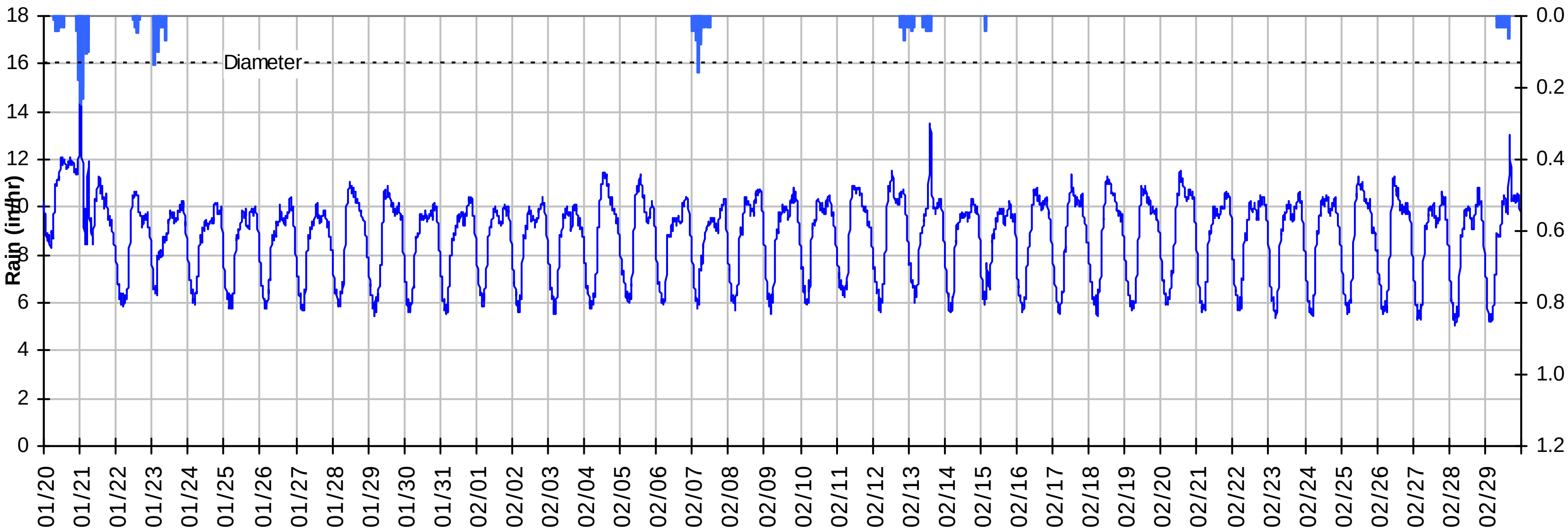


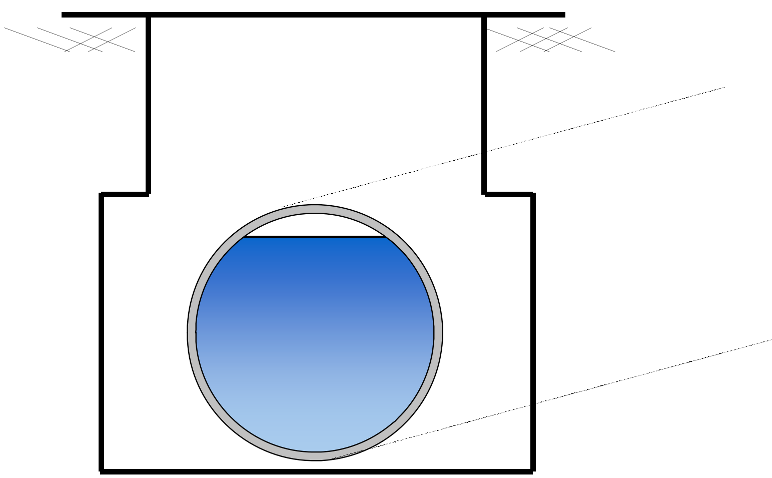
Baseline Flow:
0.500 *mgd*



SITE 5
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





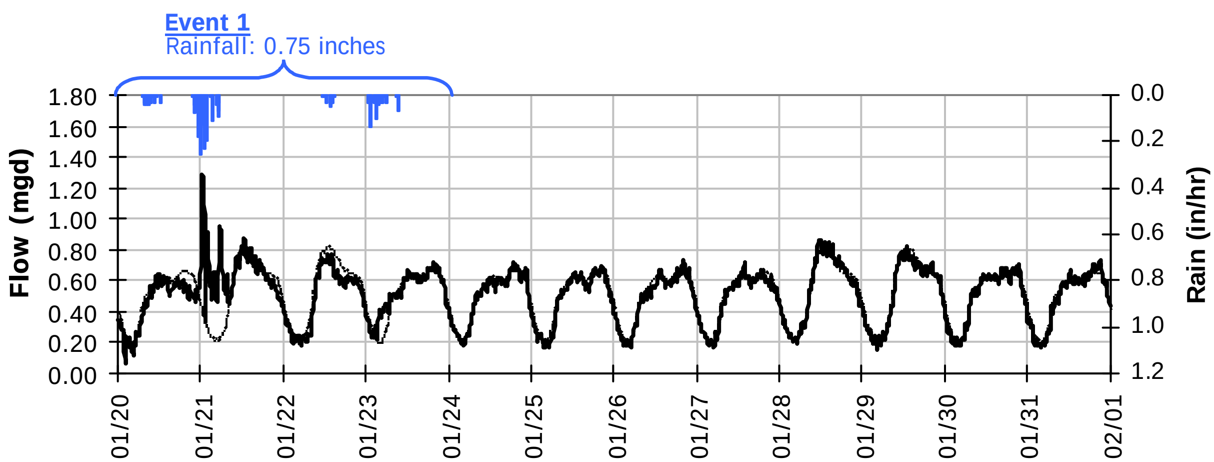
Pipe Diameter: 16 *inches*

Peak Measured Level: 14.3 *inches*

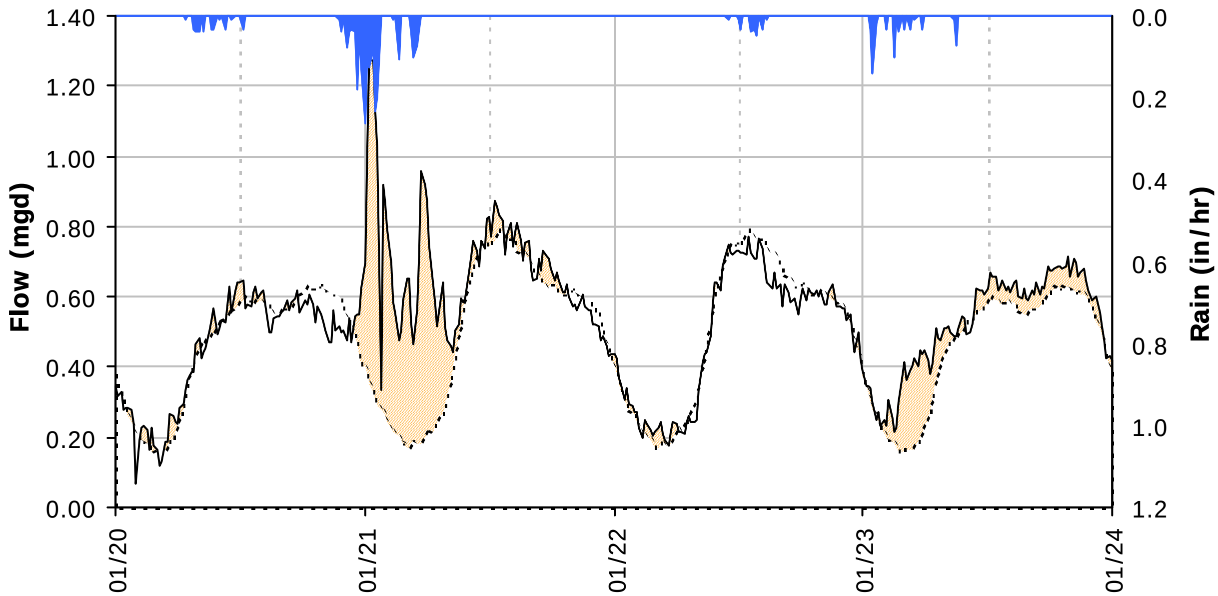
Peak d/D Ratio: 0.89

SITE 5
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph



Storm Event I/I Analysis (Rain = 0.75 inches)

Capacity

Peak Flow: 1.28 *mgd*
PF: 2.56

Peak Level: 14.30 *in*
d/D Ratio: 0.89

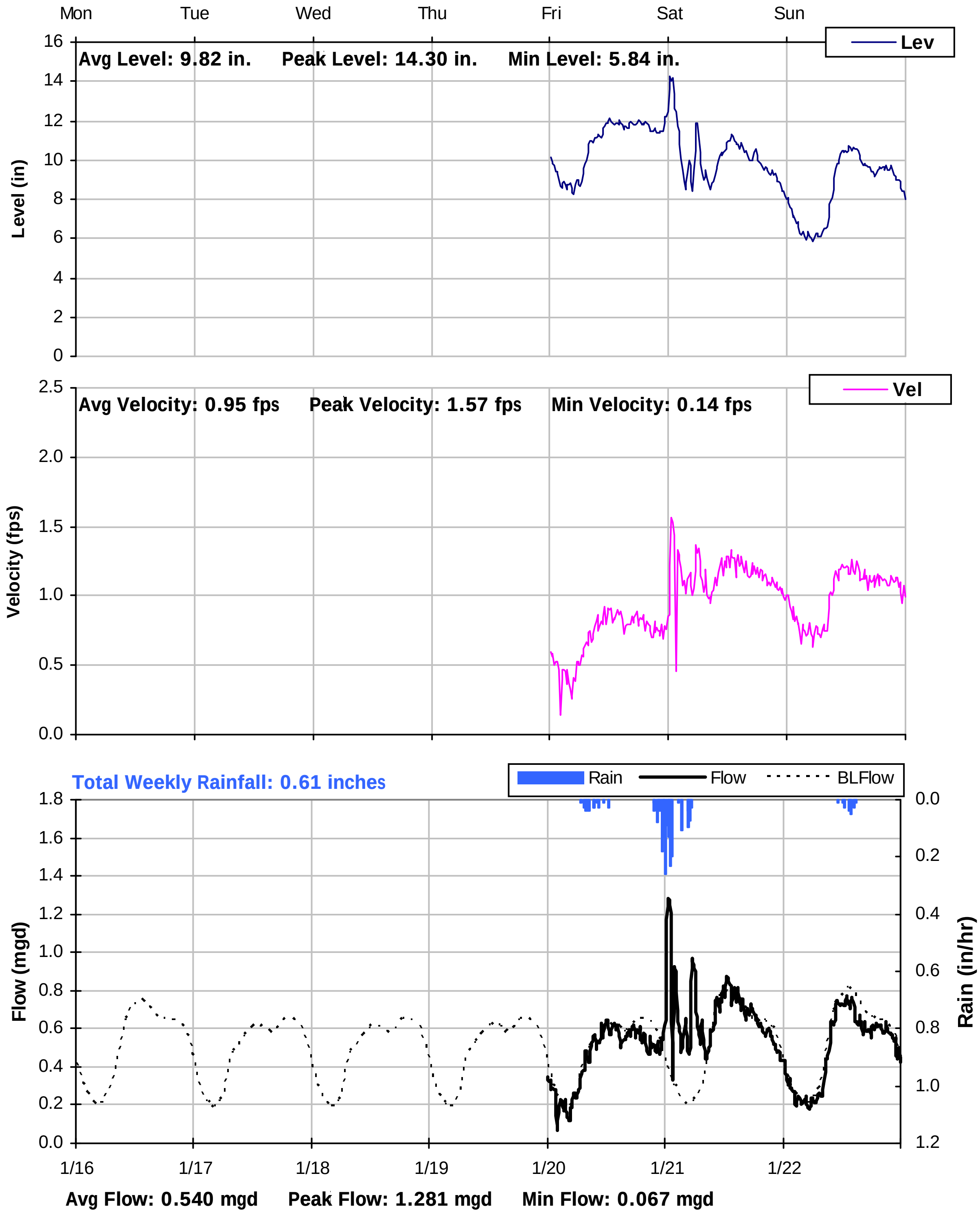
Inflow

Peak I/I Rate: 0.91 *mgd*
Pk I/I:Acre: 1,983 *gpd/acre*
Pk I/I:ADWF: 1.82

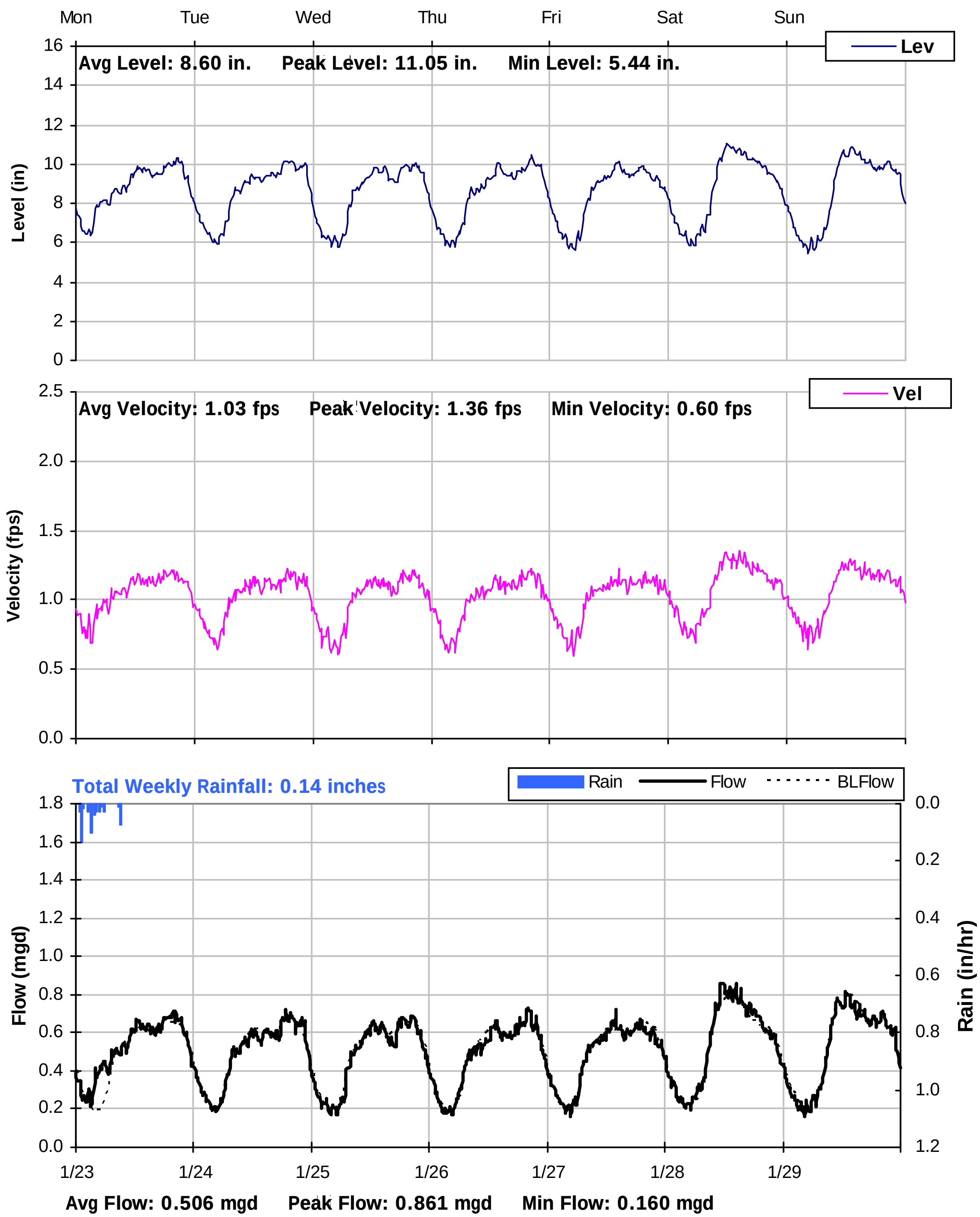
Combined I/I

Total I/I: 171,000 *gallons*
R-Value: 1.8%
Total I/I:ADWF: 0.46 *per in-rain*

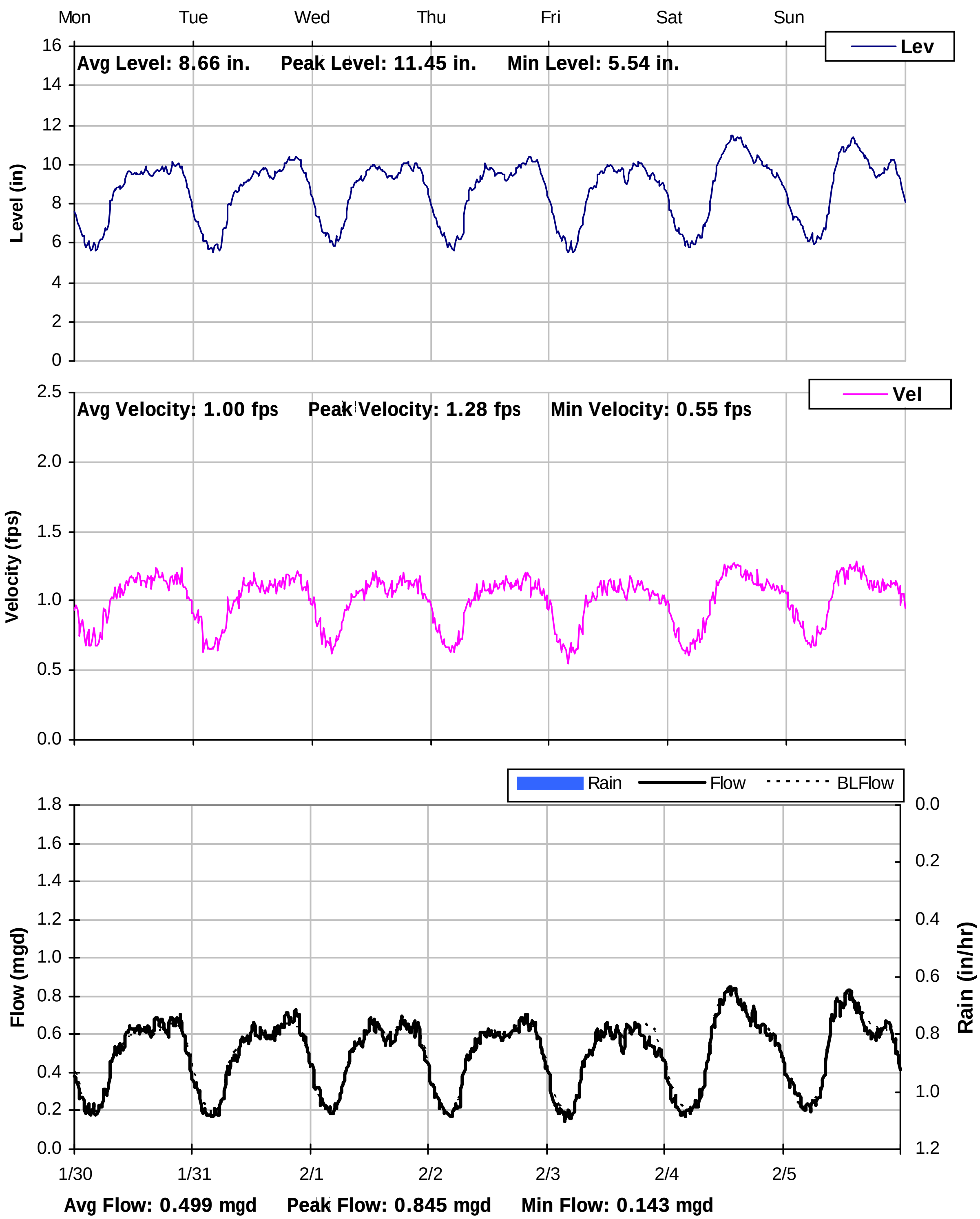
SITE 5
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



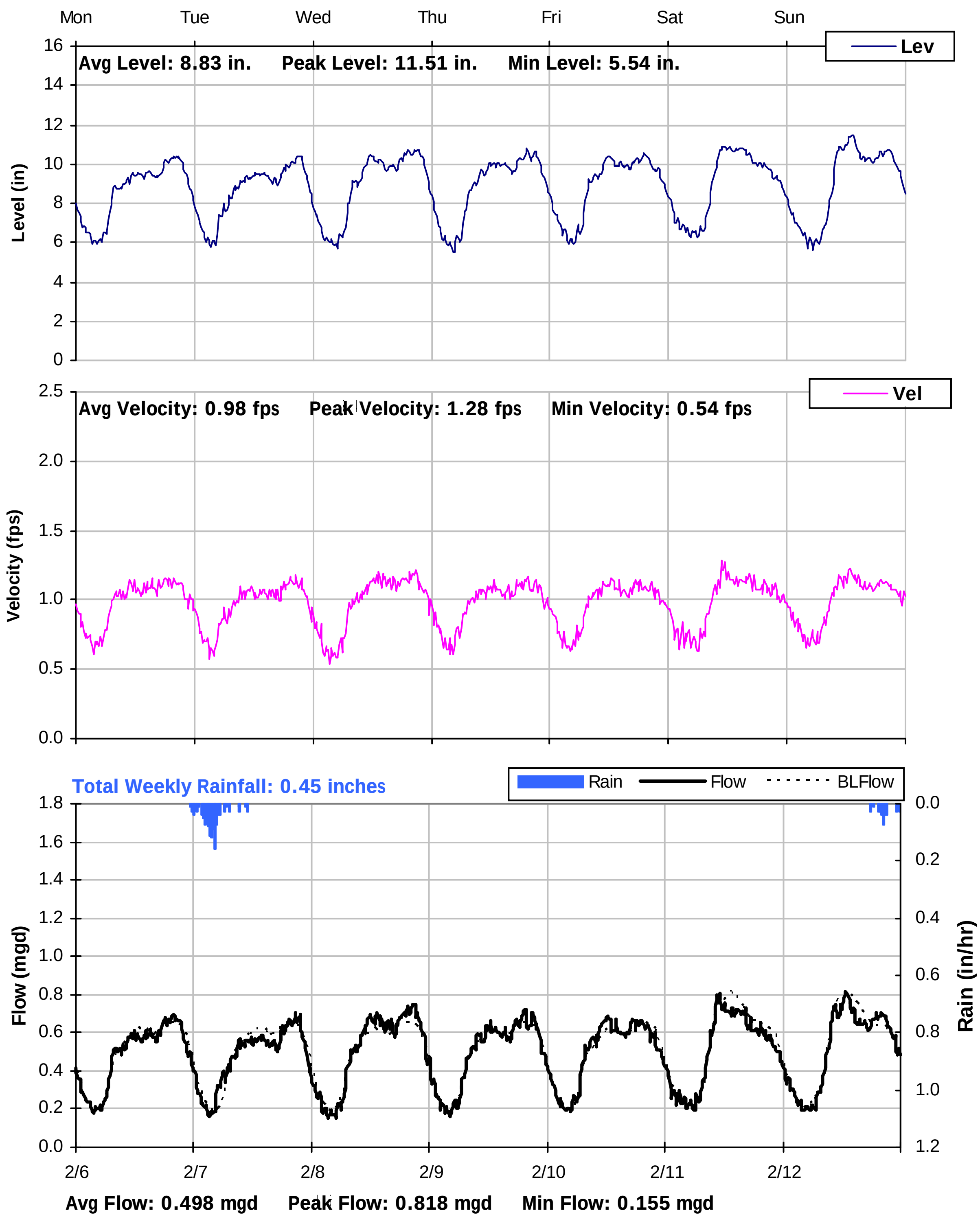
SITE 5
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



SITE 5
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



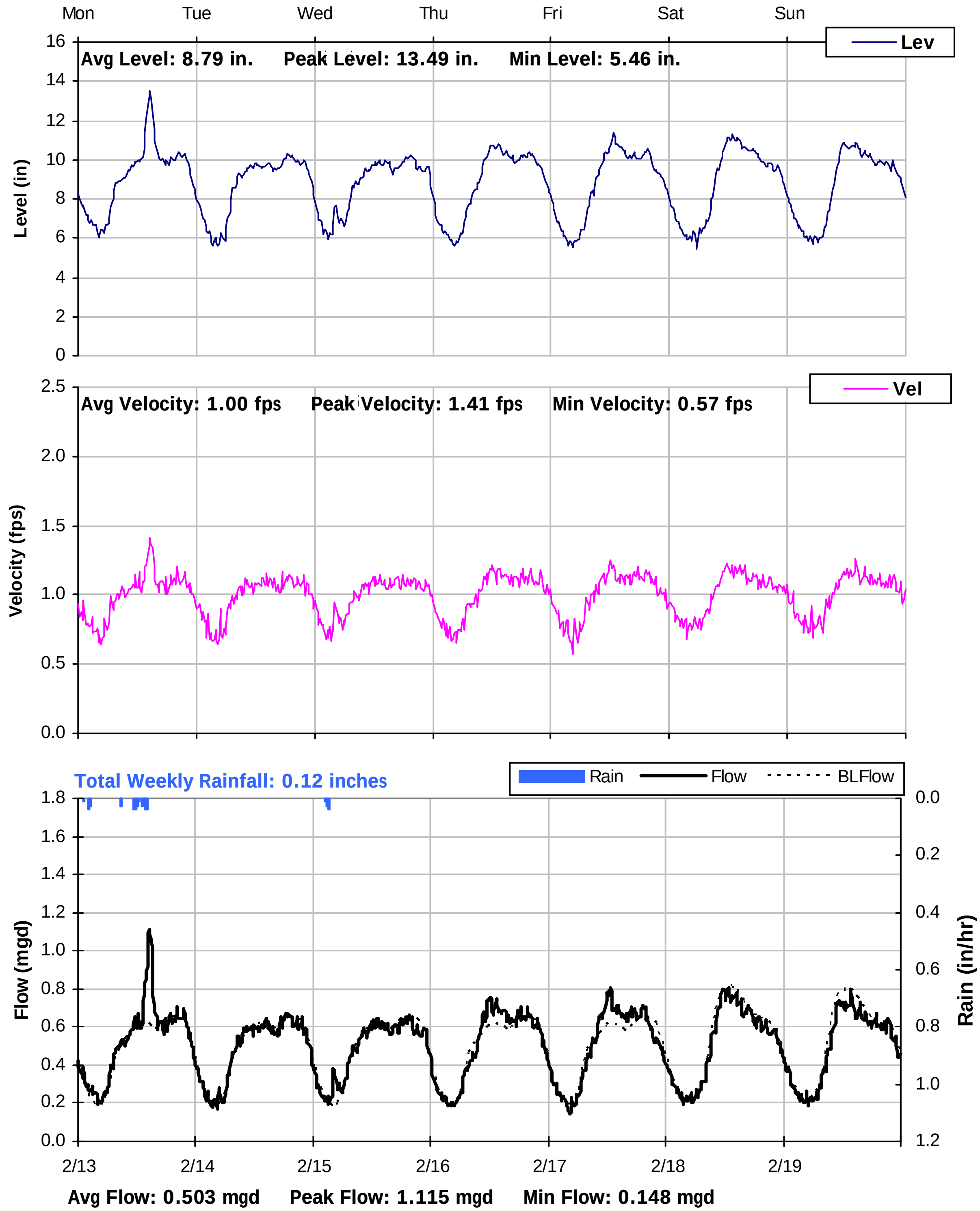
SITE 5
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



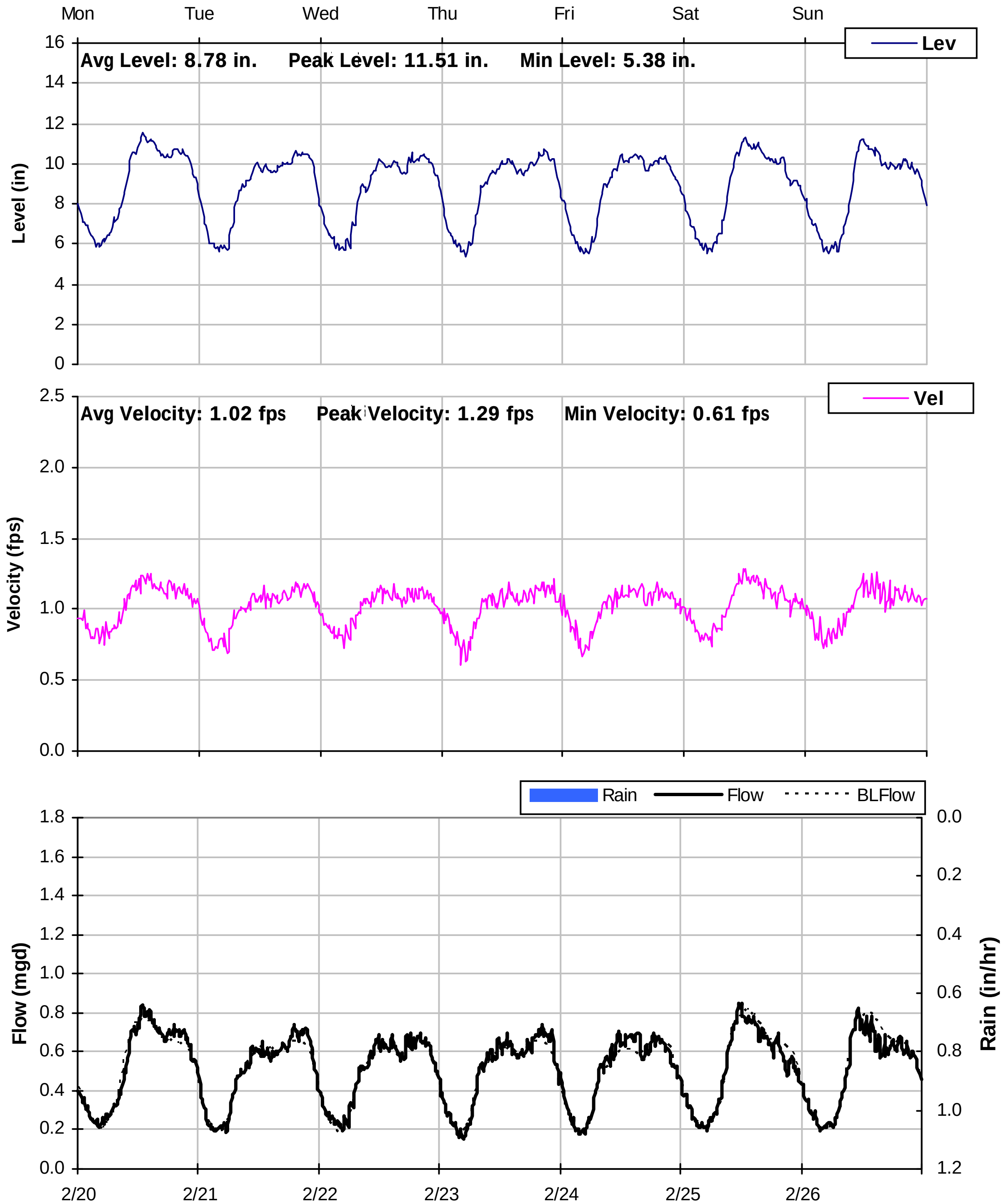
SITE 5

Weekly Level, Velocity and Flow Hydrographs

2/13/2012 to 2/20/2012

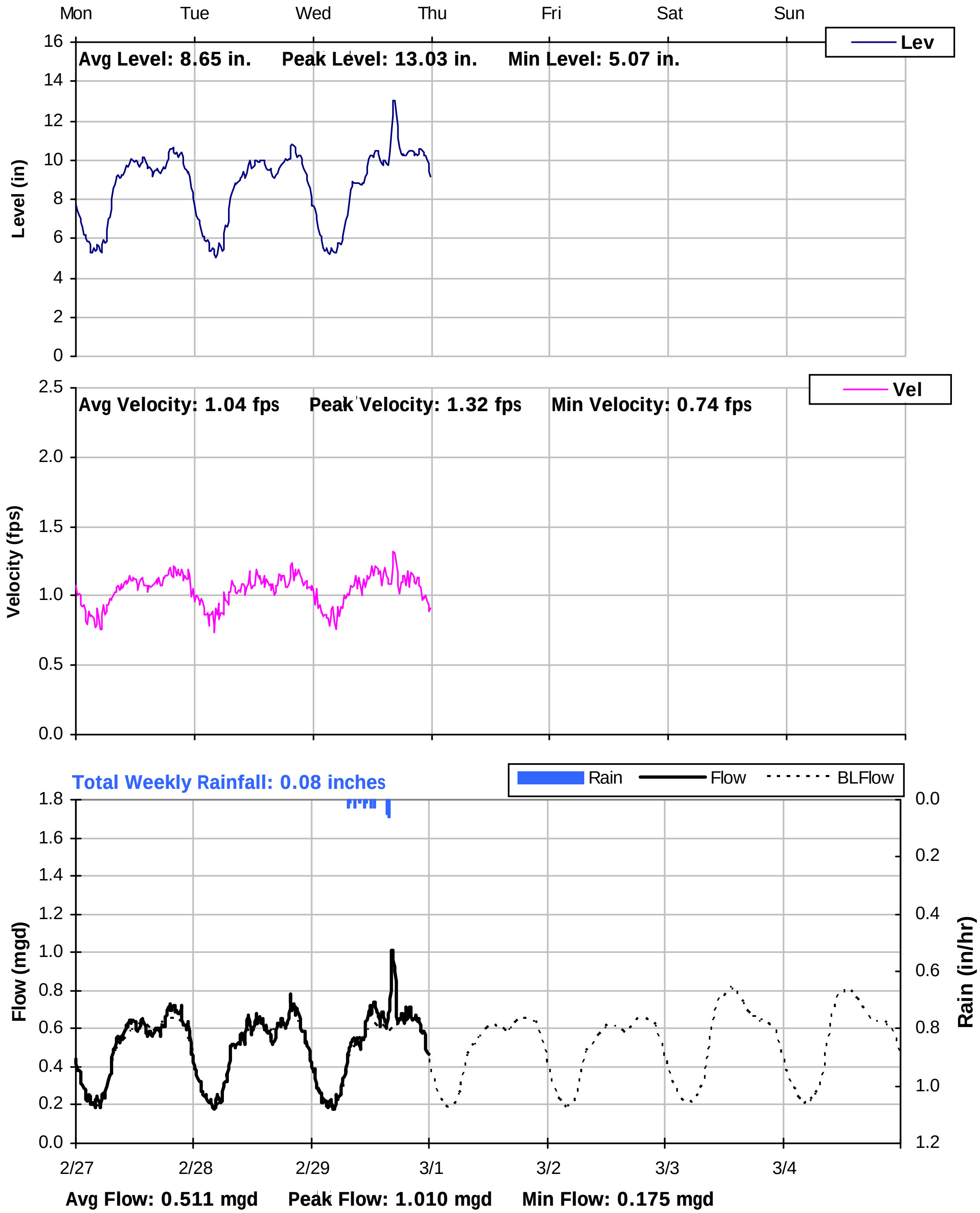


SITE 5
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



Avg Flow: 0.512 mgd   Peak Flow: 0.847 mgd   Min Flow: 0.156 mgd

SITE 5
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



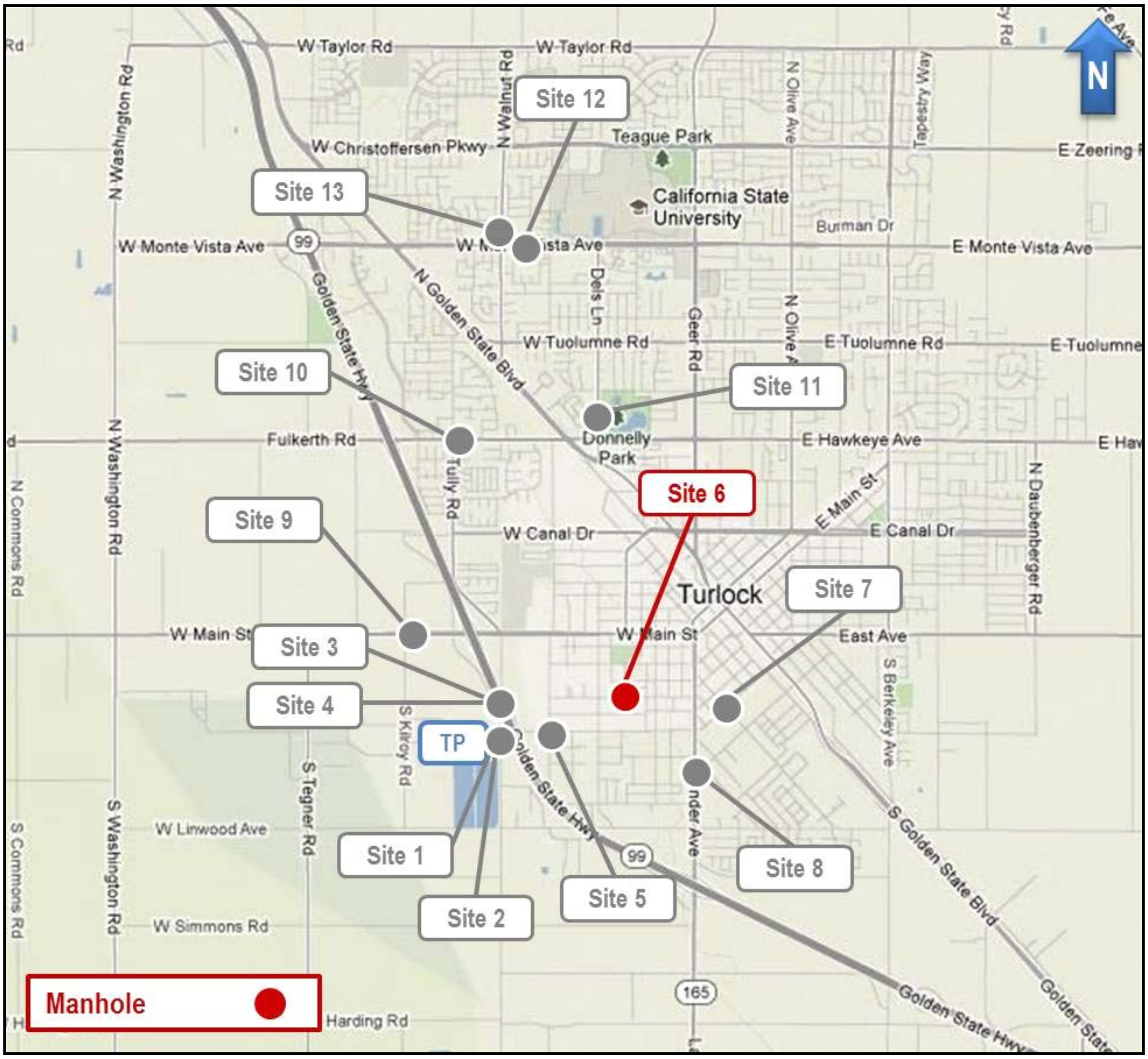
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 6

Location: 580 Angelus Street

Data Summary Report



Vicinity Map: Site 6

SITE 6

Site Information

Location: 580 Angelus Street

Coordinates: 120.8557° W, 37.4867° N

Rim Elevation: 98 feet

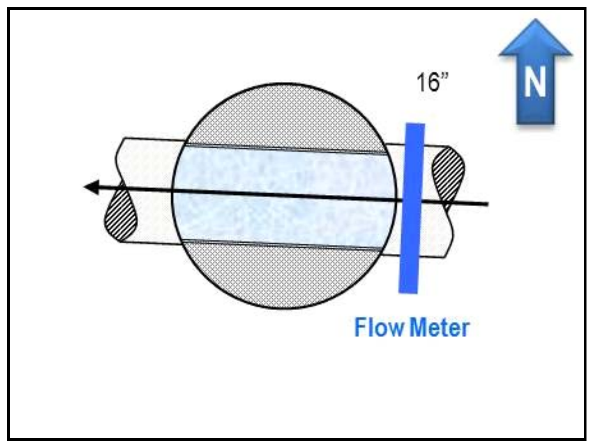
Pipe Diameter: 16 inches

Baseline Flow: 0.088 mgd

Peak Measured Flow: 0.487 mgd

Satellite Map

Sewer Map



Flow Sketch

Street View

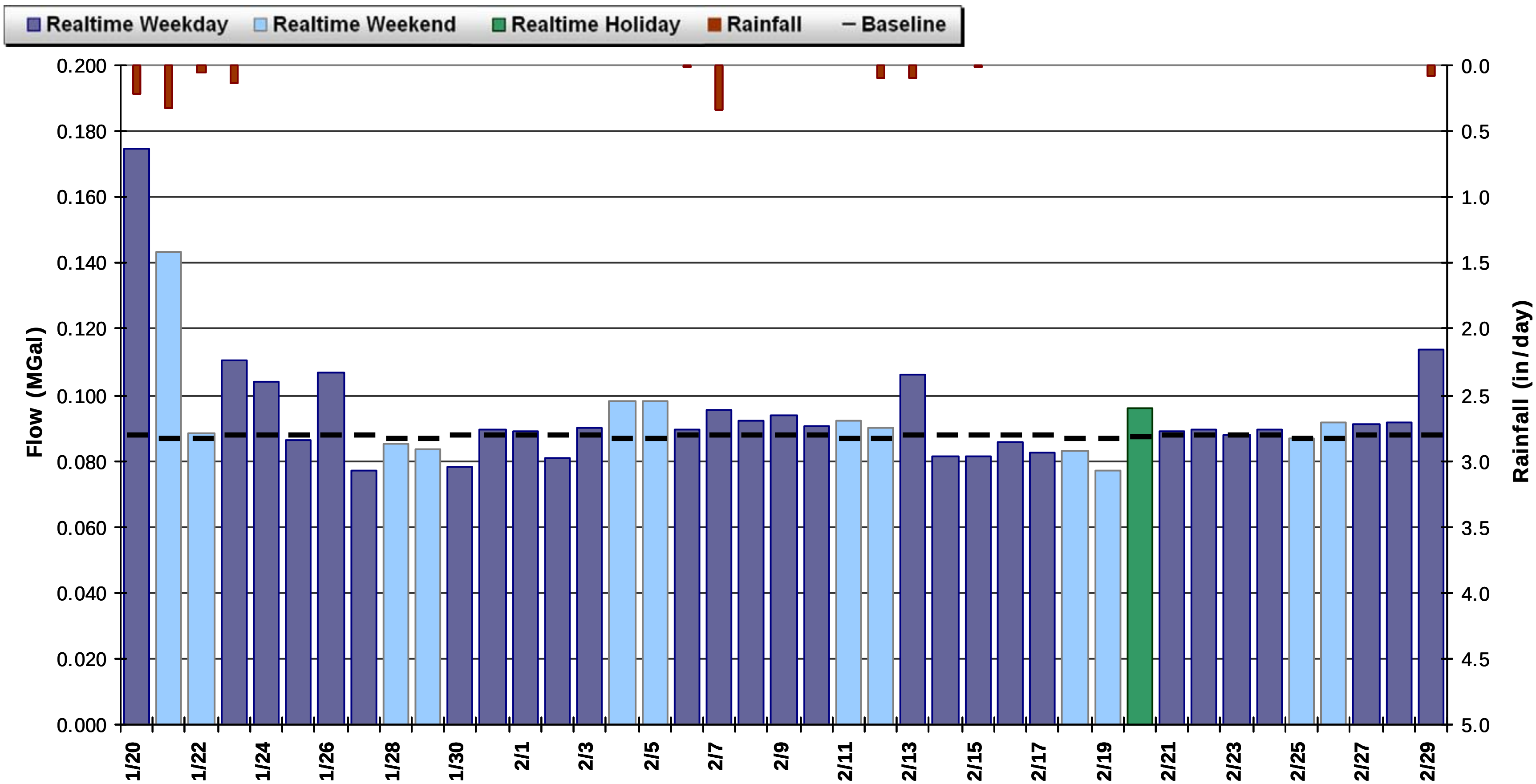
Plan View

SITE 6

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.094 MGal **Peak Daily Flow: 0.175 MGal** **Min Daily Flow: 0.077 MGal**

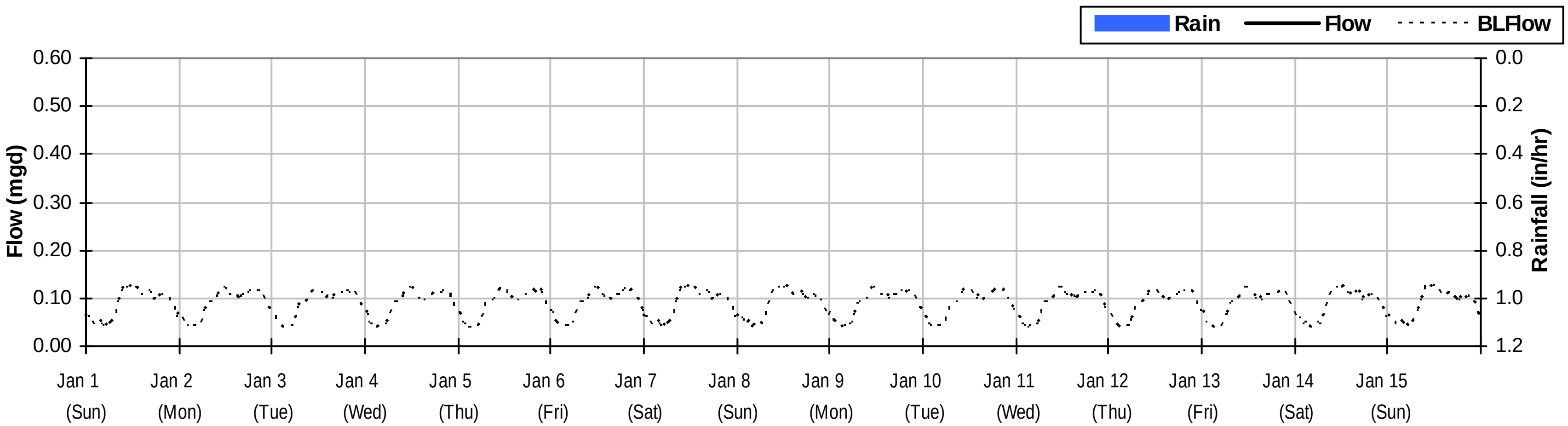
Total Period Rainfall: 1.39 inches

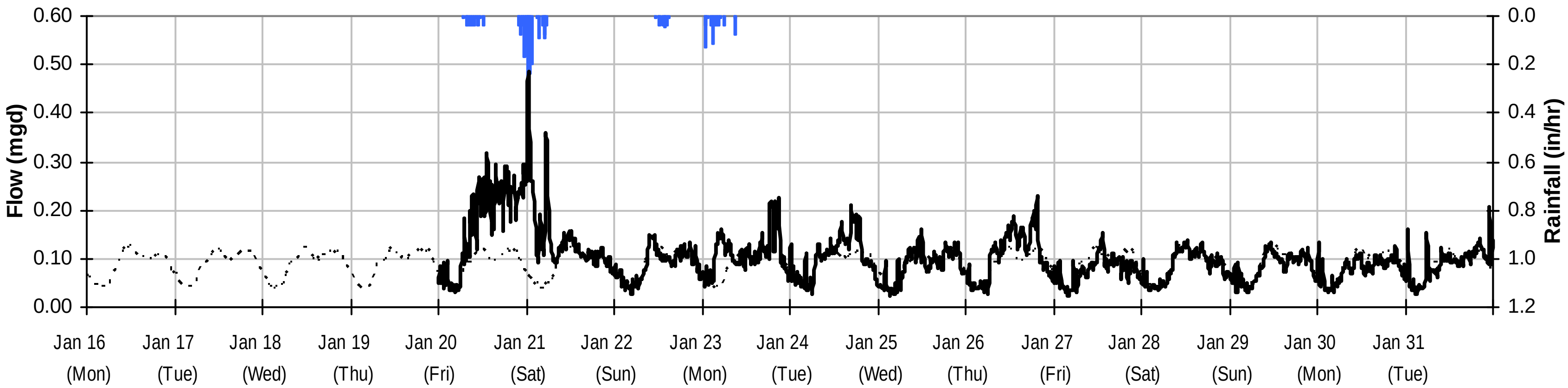


SITE 6

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.74 inches   **Avg Flow: 0.102 mgd**   **Peak Flow: 0.487 mgd**   **Min Flow: 0.024 mgd**

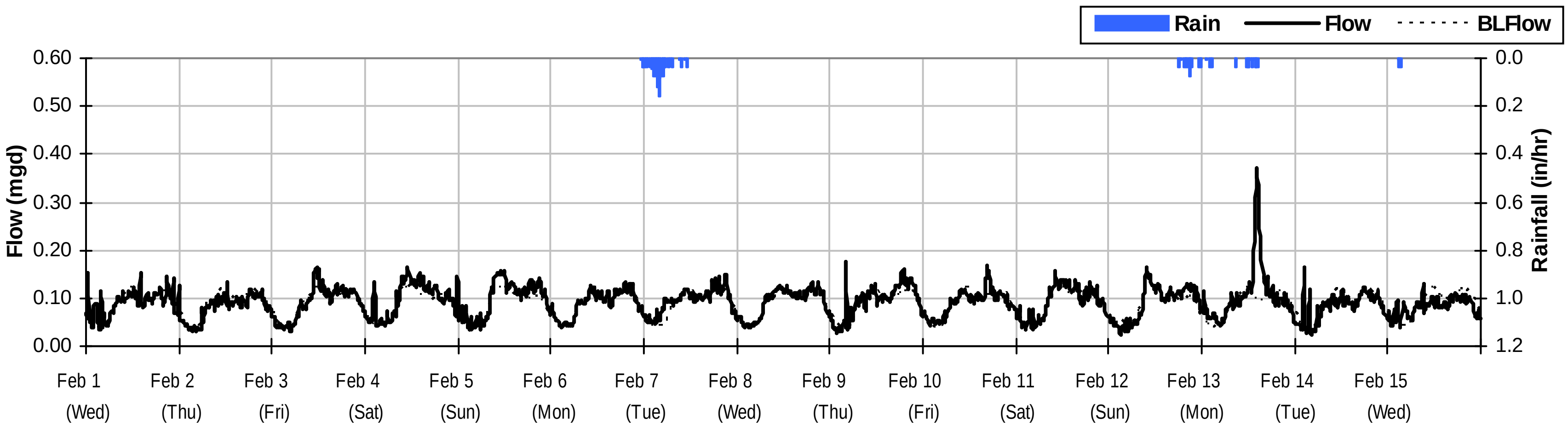


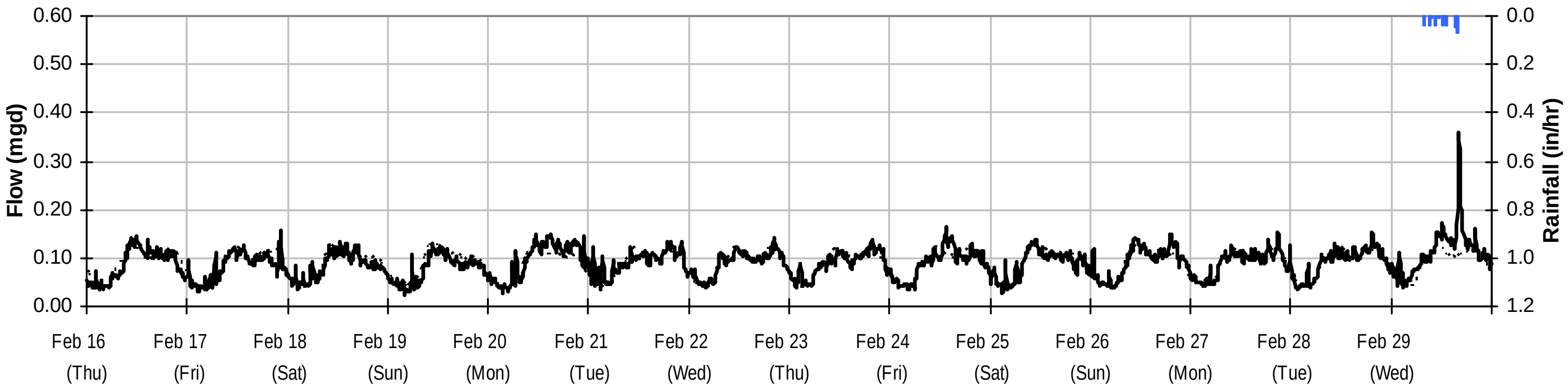


SITE 6

Monthly Flow Summary: February, 2012

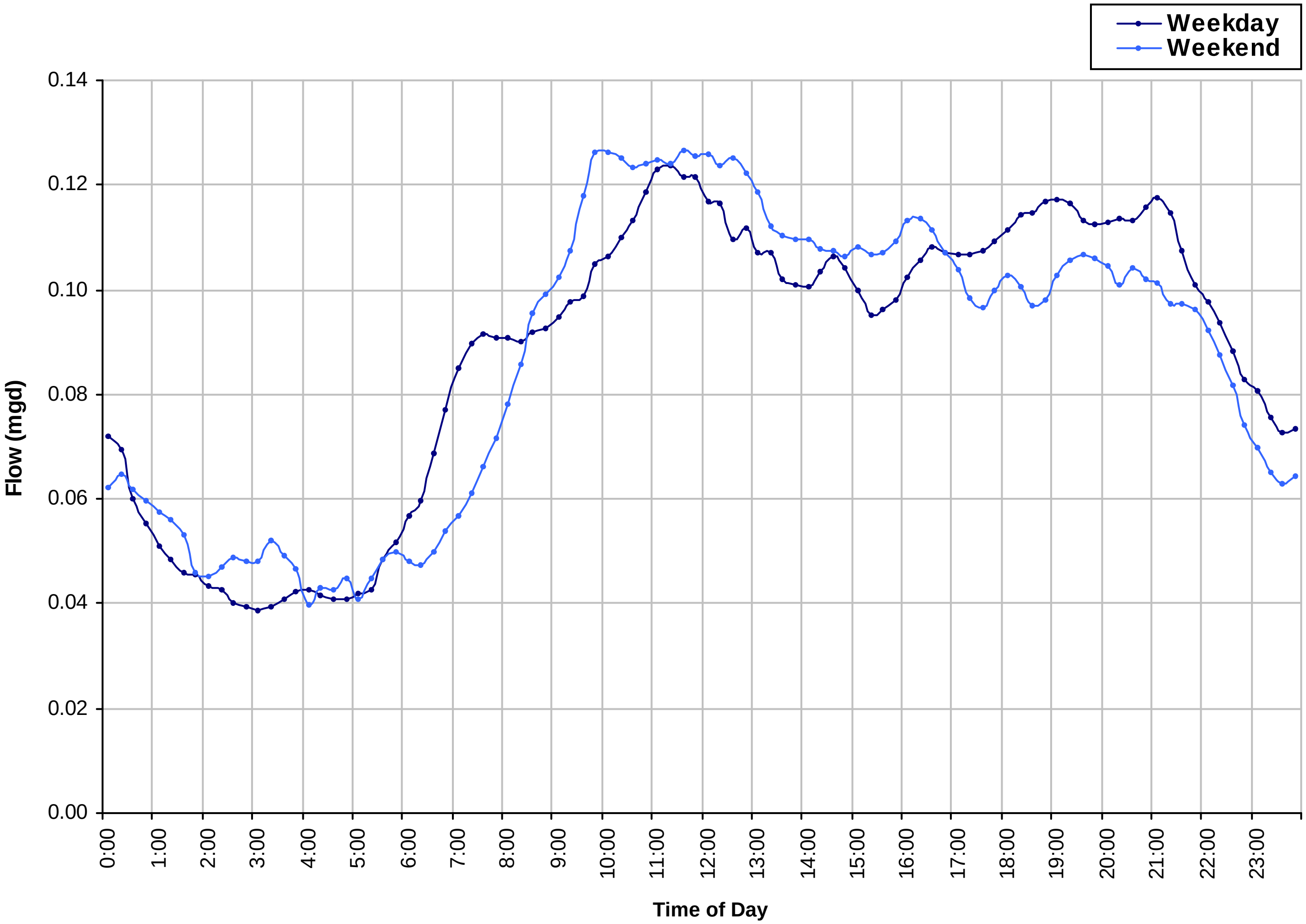
Total Monthly Rainfall: 0.65 inches **Avg Flow: 0.090 mgd** **Peak Flow: 0.370 mgd** **Min Flow: 0.022 mgd**



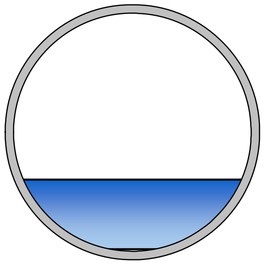


SITE 6

Baseline Flow Hydrographs

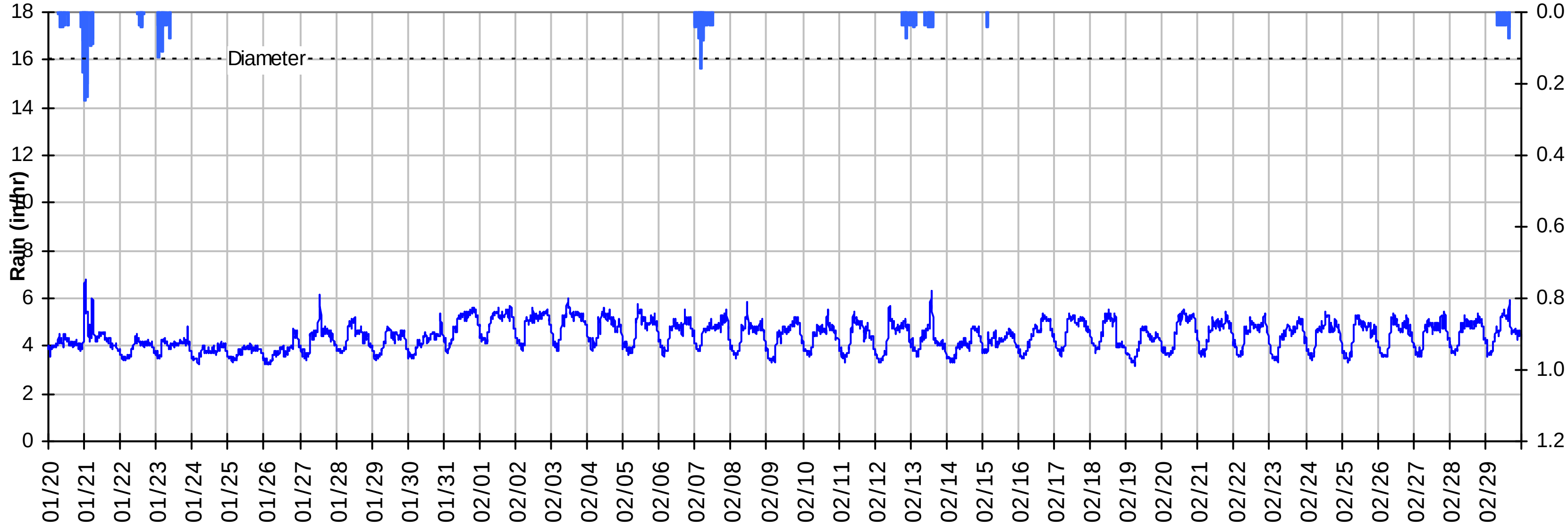


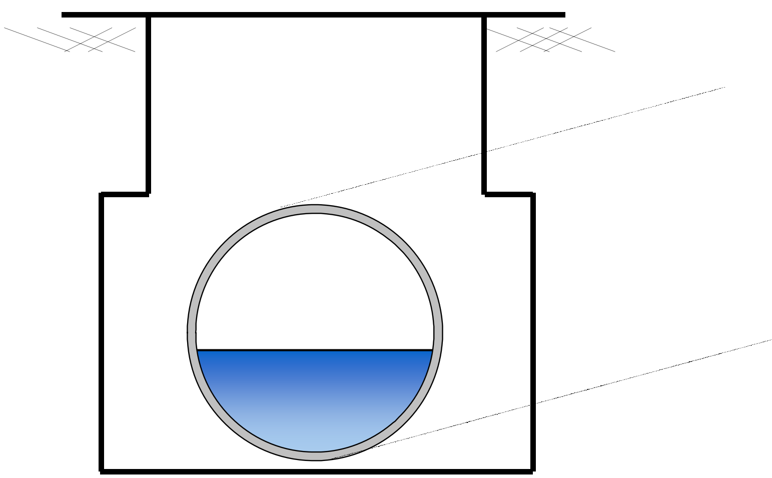
Baseline Flow:
0.088 *mgd*



SITE 6
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





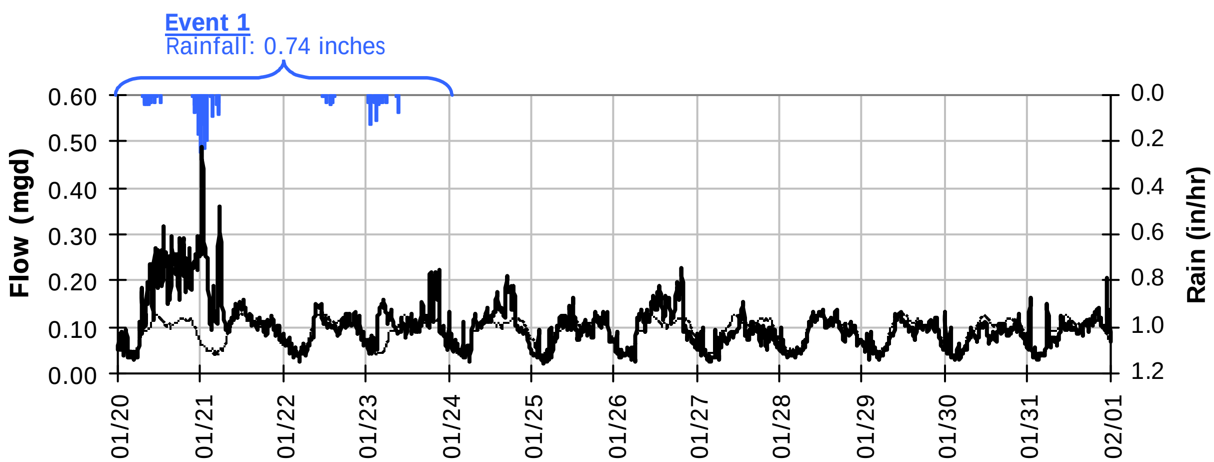
Pipe Diameter: 16 *inches*

Peak Measured Level: 6.78 *inches*

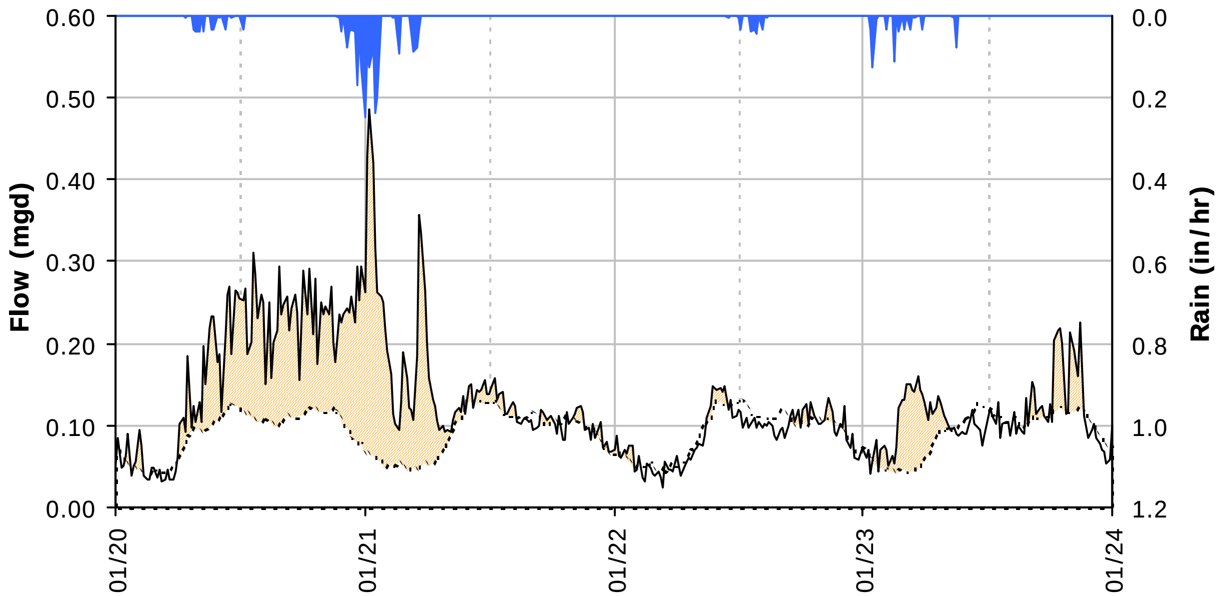
Peak d / D Ratio: 0.42

SITE 6
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



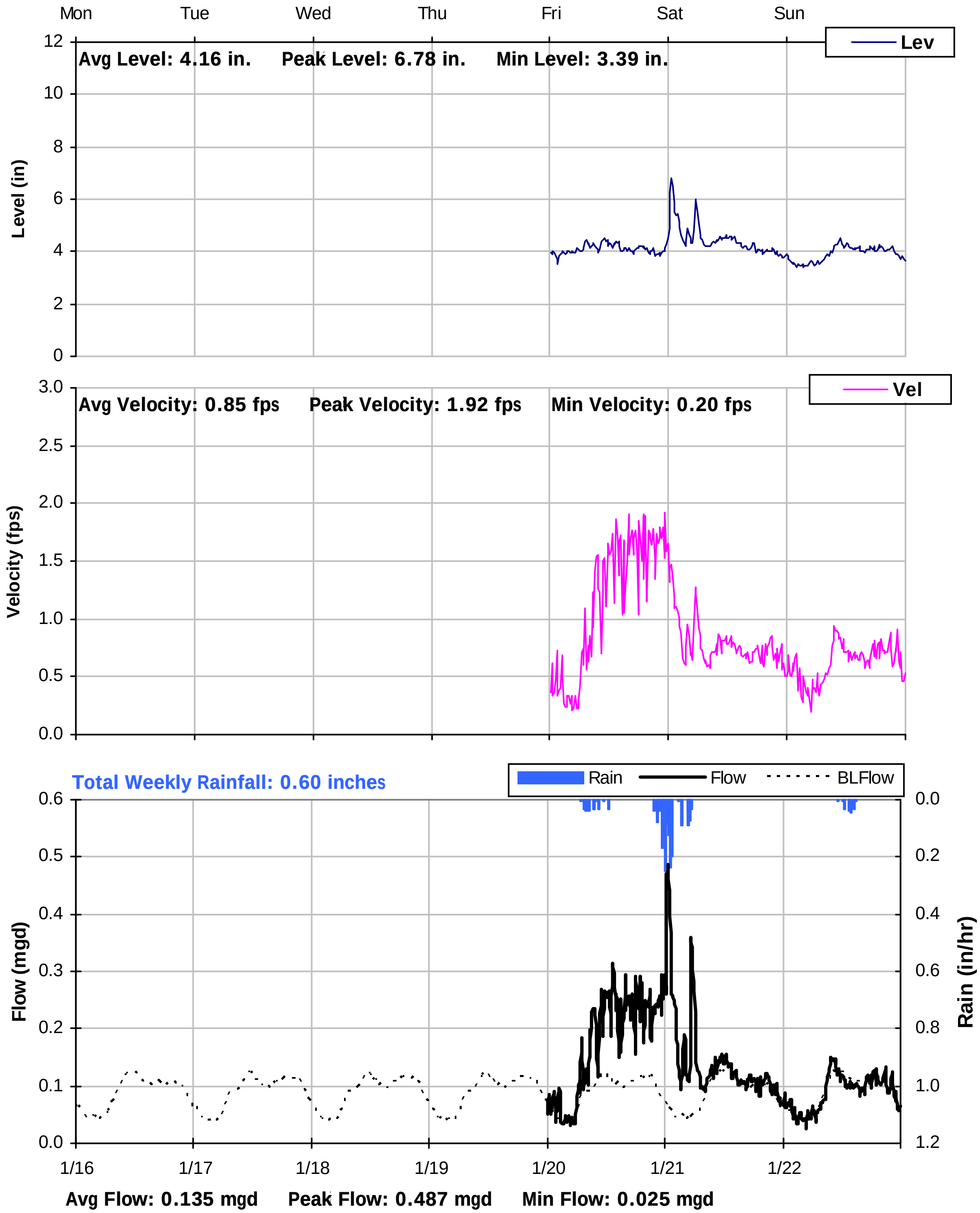
Event 1 Detail Graph



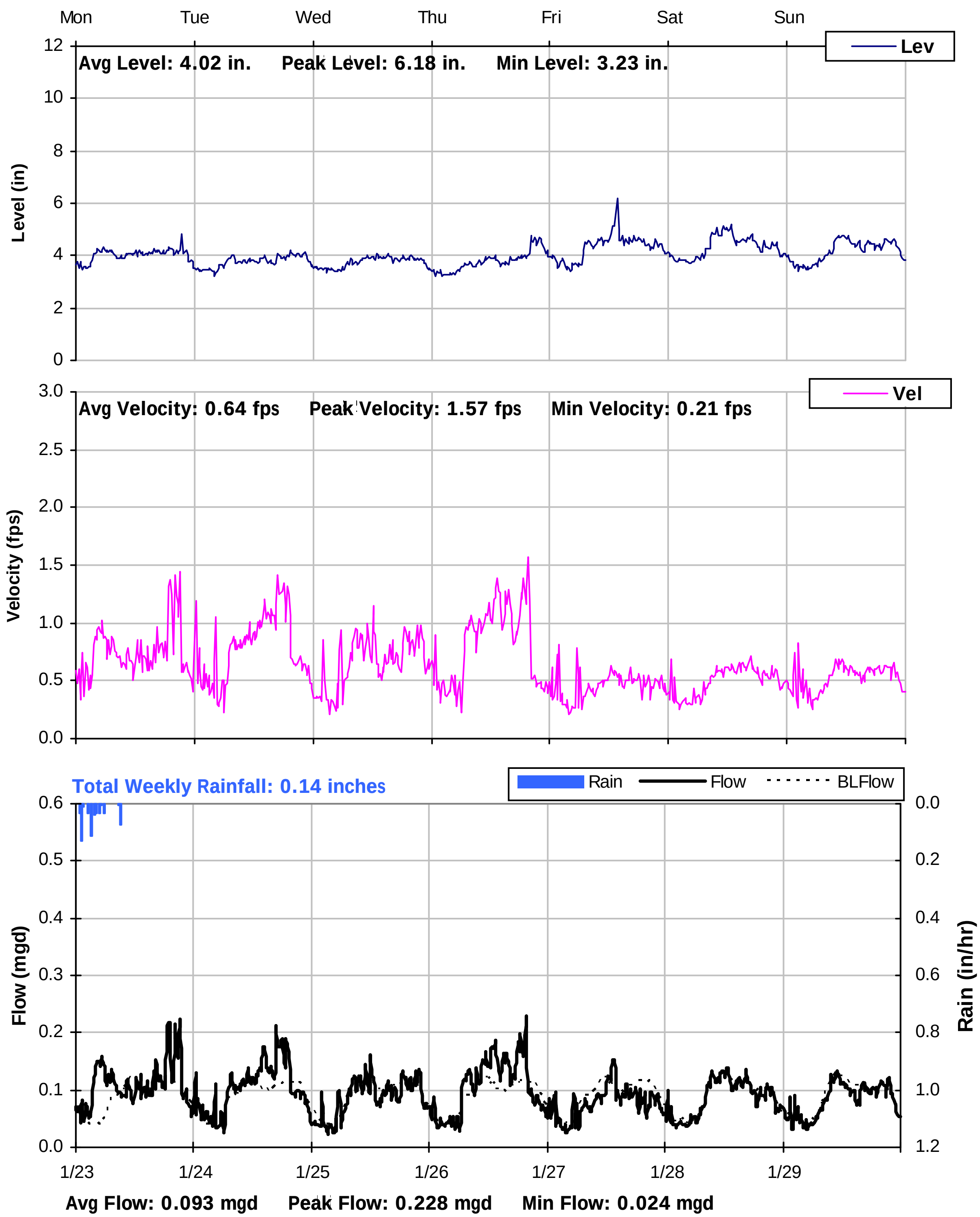
Storm Event I/I Analysis (Rain = 0.74 inches)

Capacity		Inflow		Combined I/I	
Peak Flow:	0.49 *mgd*	**Peak I/I Rate:**	0.42 *mgd*	**Total I/I:**	155,000 *gallons*
PF:	5.55	**Pk I/I:Acre:**	7,031 *gpd/acre*	**R-Value:**	12.8%
		Pk I/I:ADWF:	4.84	**Total I/I:ADWF:**	2.40 *per in-rain*
Peak Level:	6.78 *in*				
d/D Ratio:	0.42				

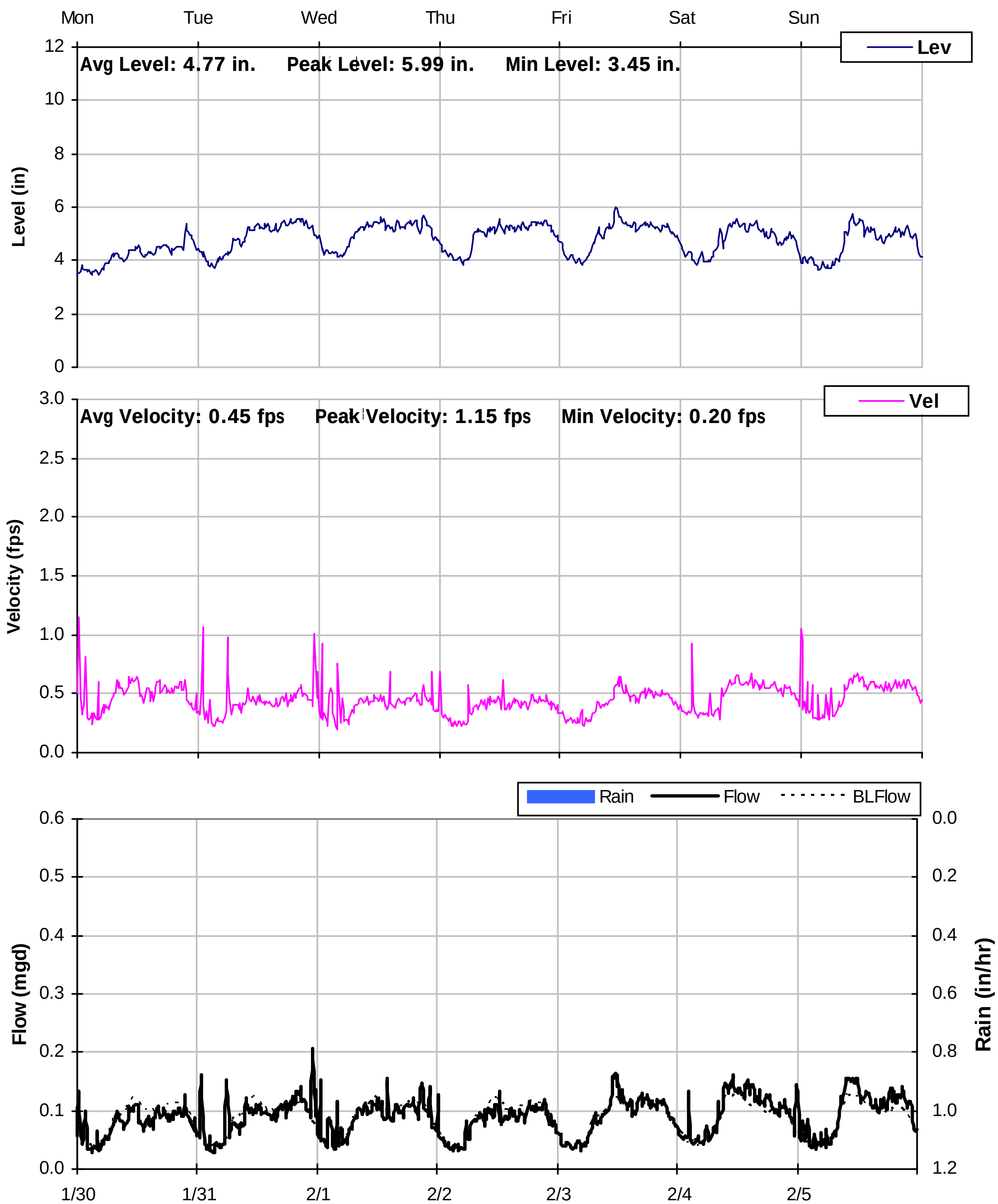
SITE 6
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



SITE 6
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012

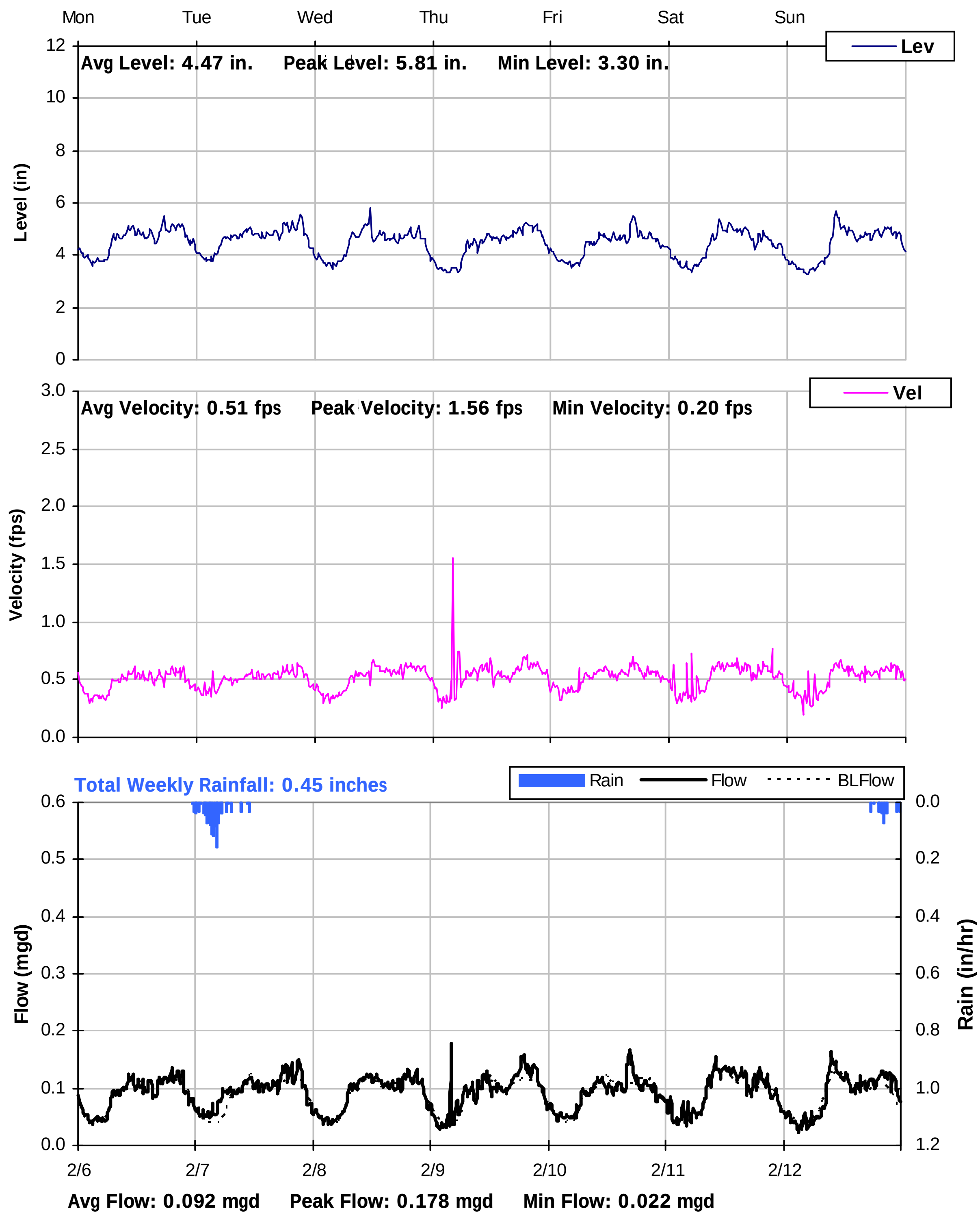


SITE 6
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012

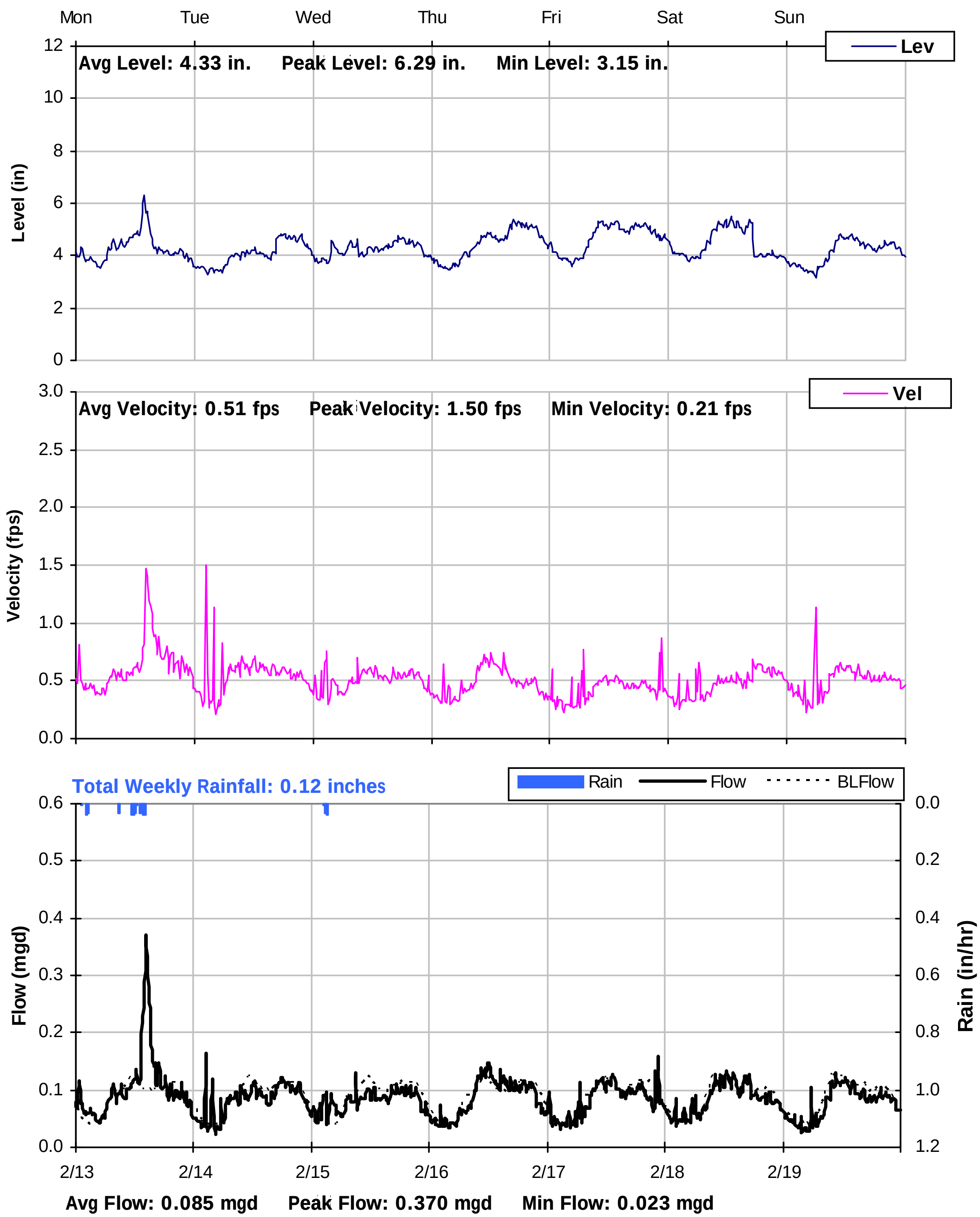


Avg Flow: 0.089 mgd **Peak Flow: 0.205 mgd** **Min Flow: 0.028 mgd**

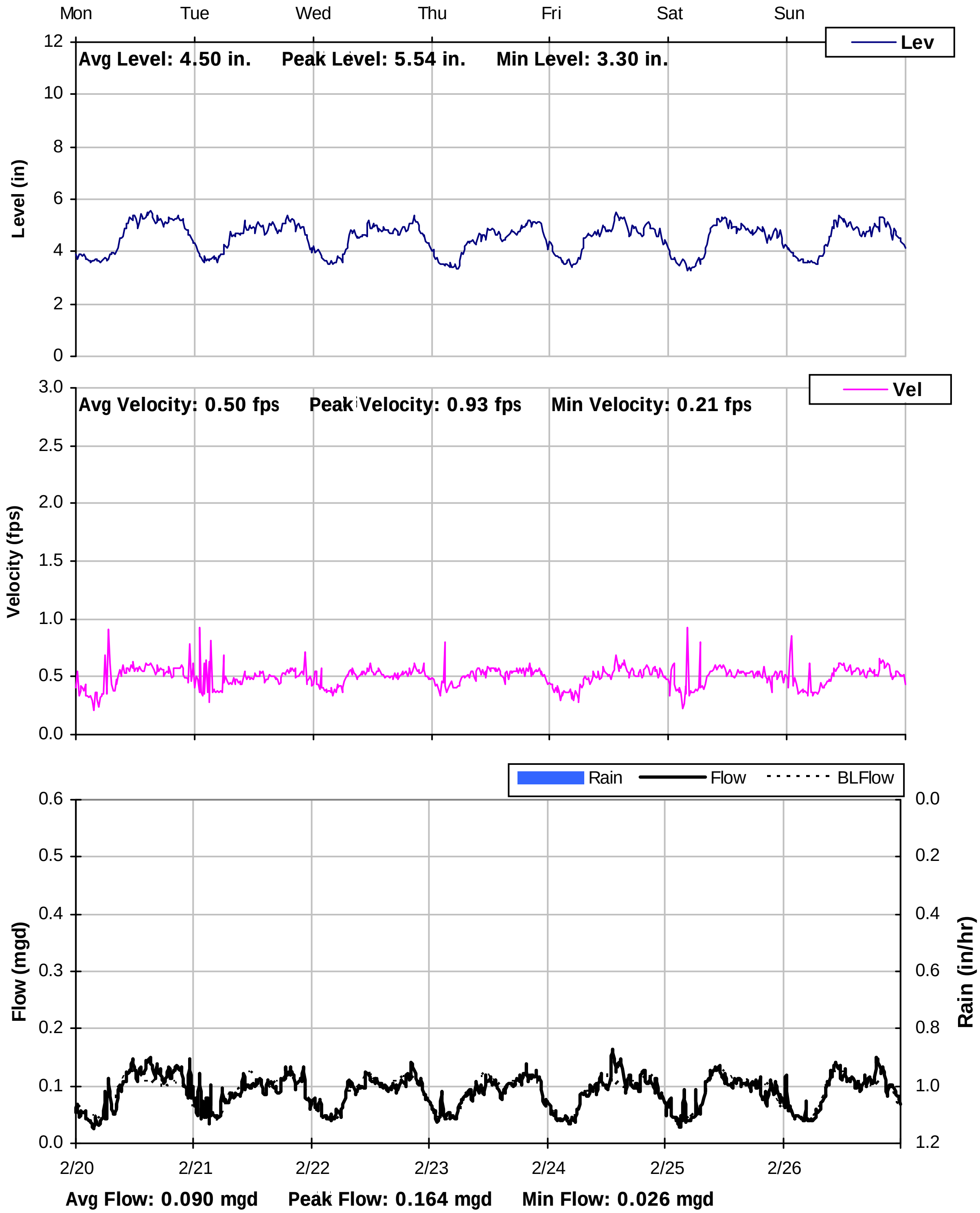
SITE 6
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



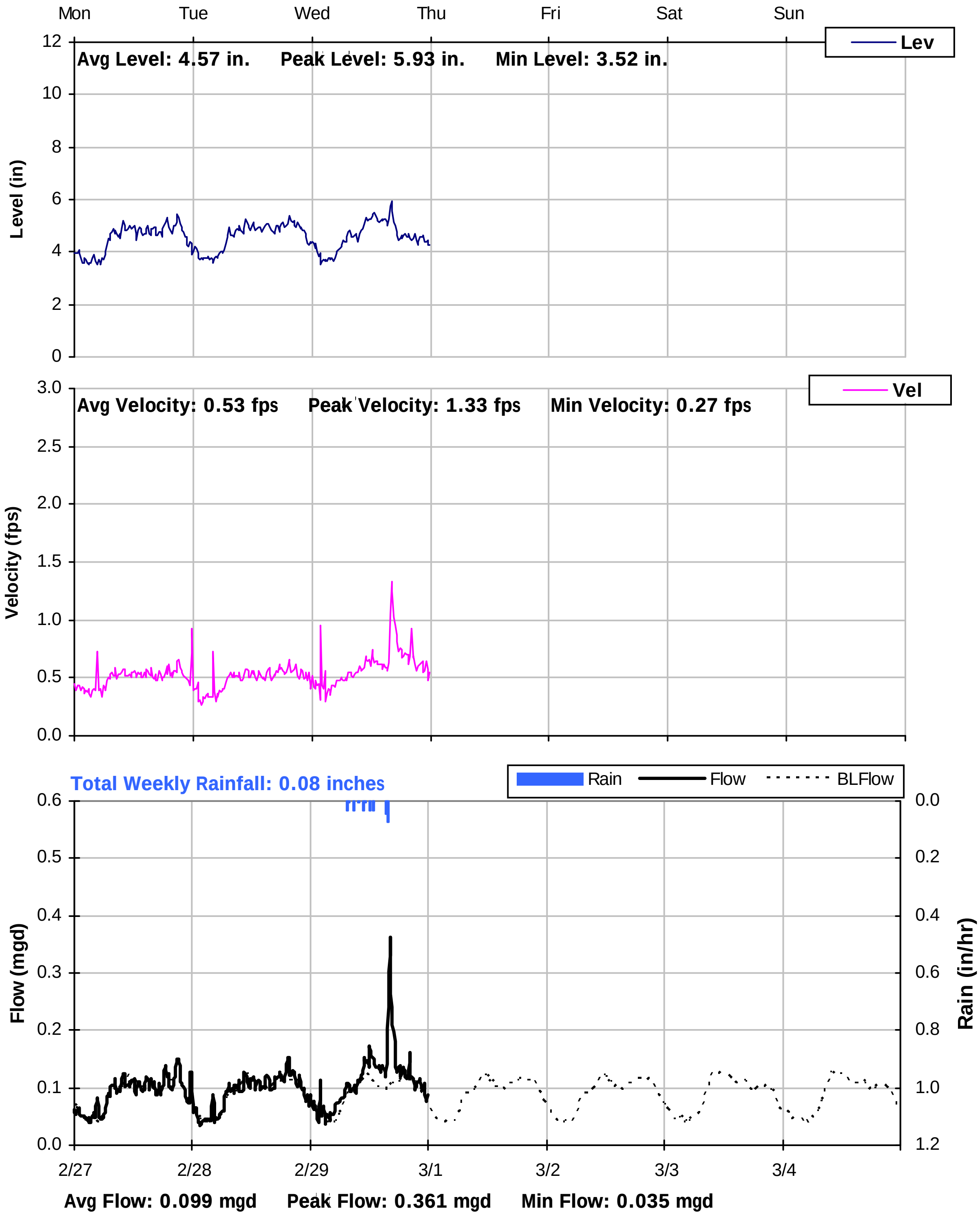
SITE 6
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012



SITE 6
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



SITE 6
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 7

Location: Intersection of 5th Street and D Street

Data Summary Report

Vicinity Map: Site 7

SITE 7

Site Information

Location: Intersection of 5th Street and D Street

Coordinates: 120.8460° W, 37.4872° N

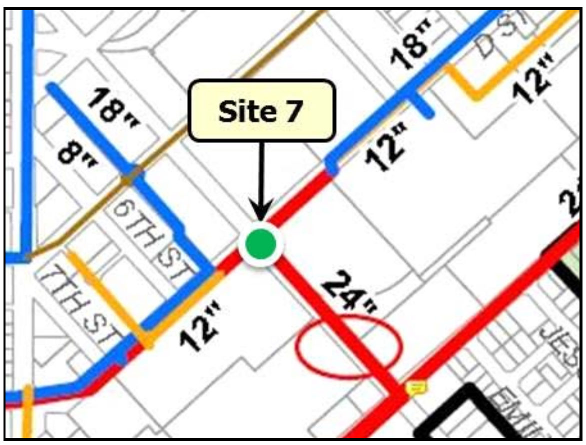
Rim Elevation: 101 feet

Pipe Diameter: 24 inches

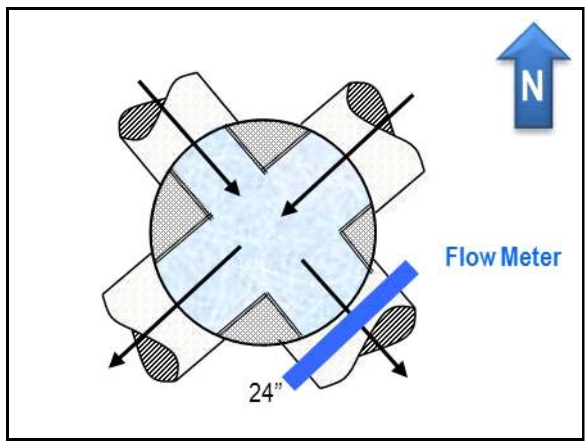
Baseline Flow: 0.001 mgd

Peak Measured Flow: 1.861 mgd

Satellite Map



Sewer Map



Flow Sketch

Street View

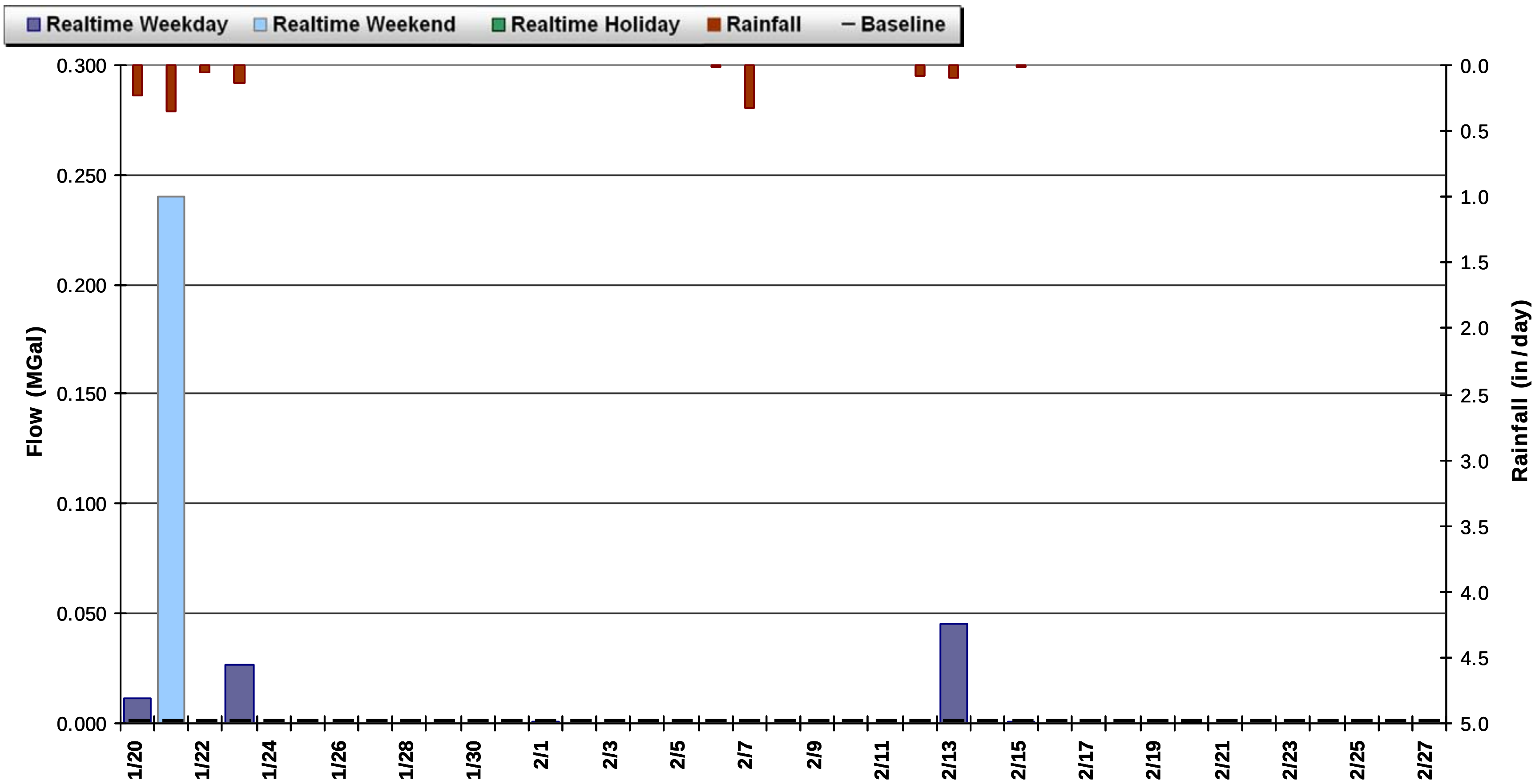
Plan View

SITE 7

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.008 MGal **Peak Daily Flow: 0.240 MGal** **Min Daily Flow: 0.000 MGal**

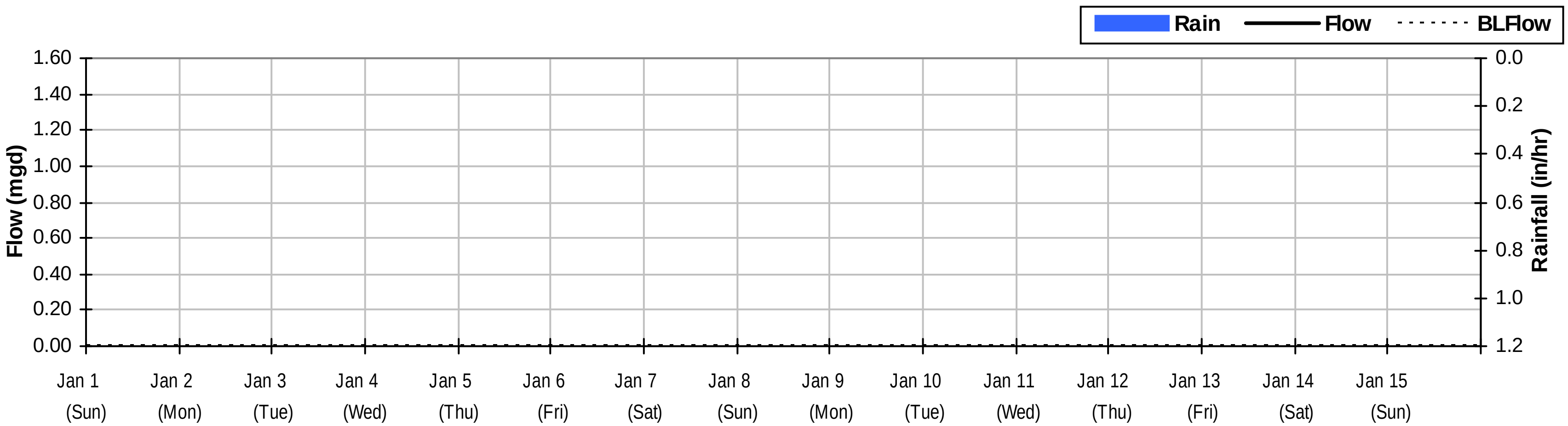
Total Period Rainfall: 1.31 inches

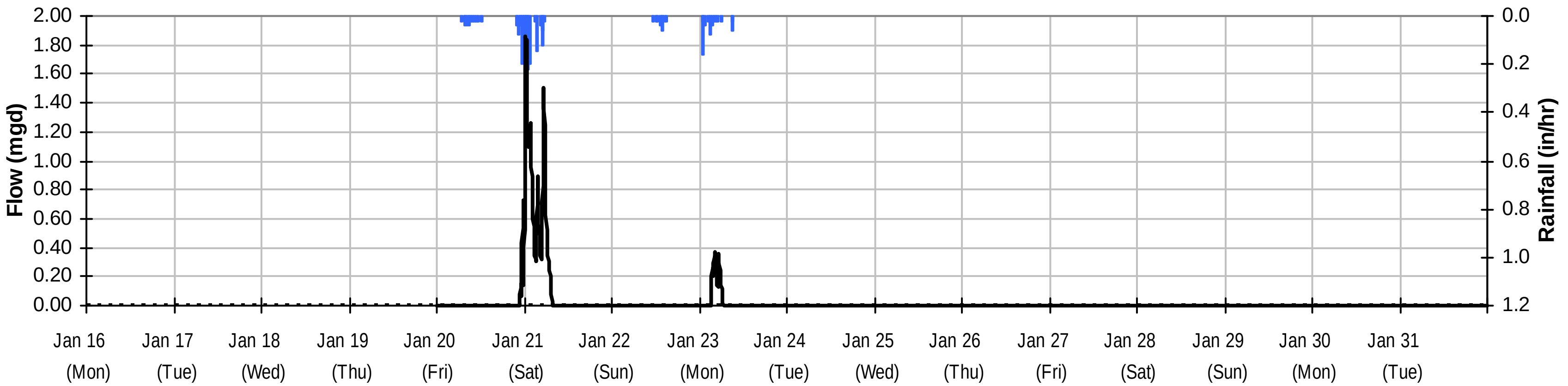


SITE 7

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.77 inches **Avg Flow: 0.023 mgd** **Peak Flow: 1.861 mgd** **Min Flow: 0.000 mgd**

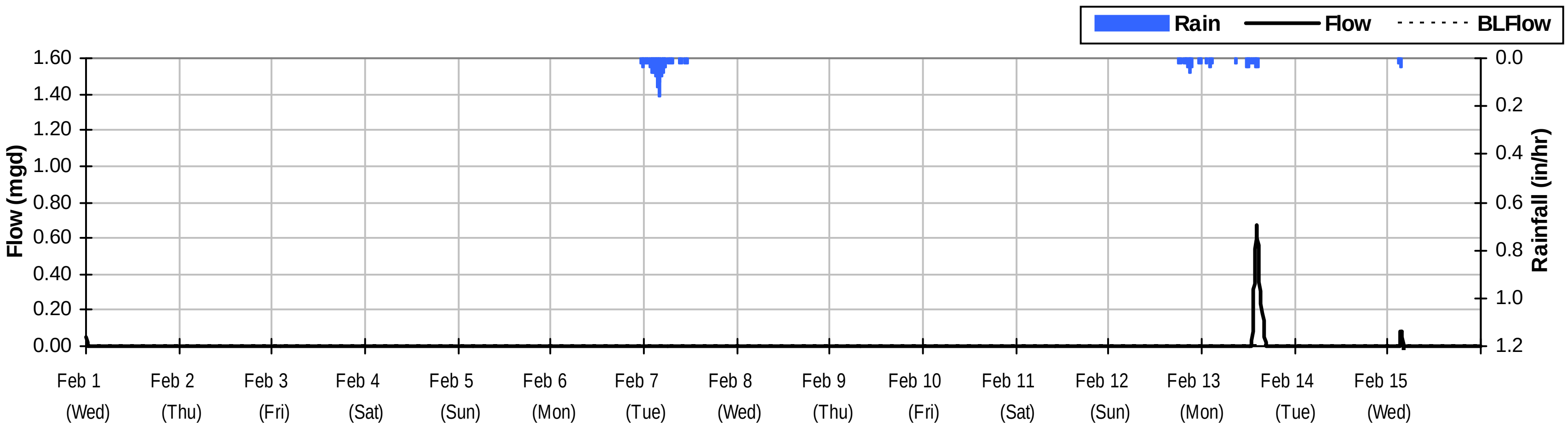


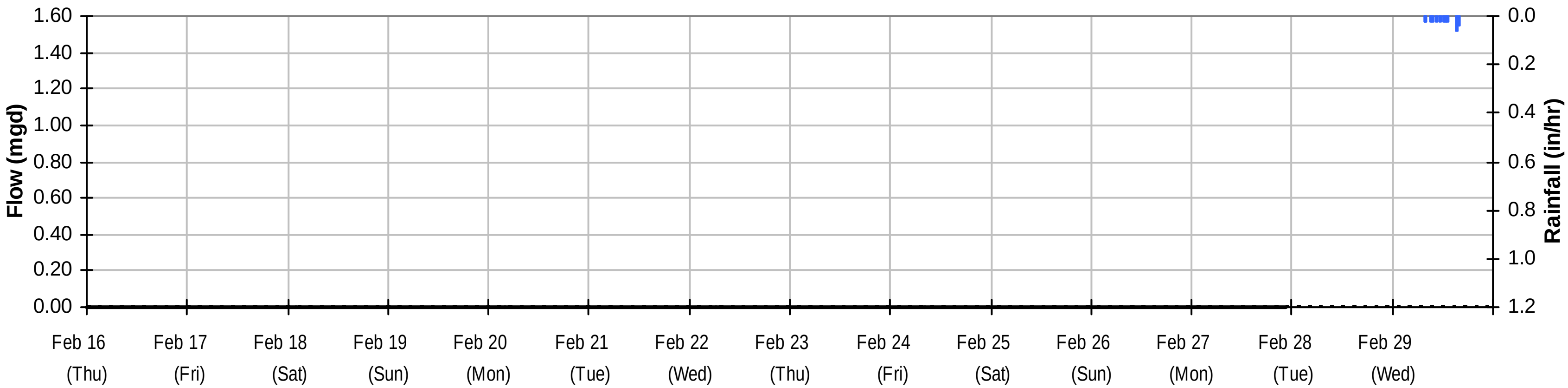


SITE 7

Monthly Flow Summary: February, 2012

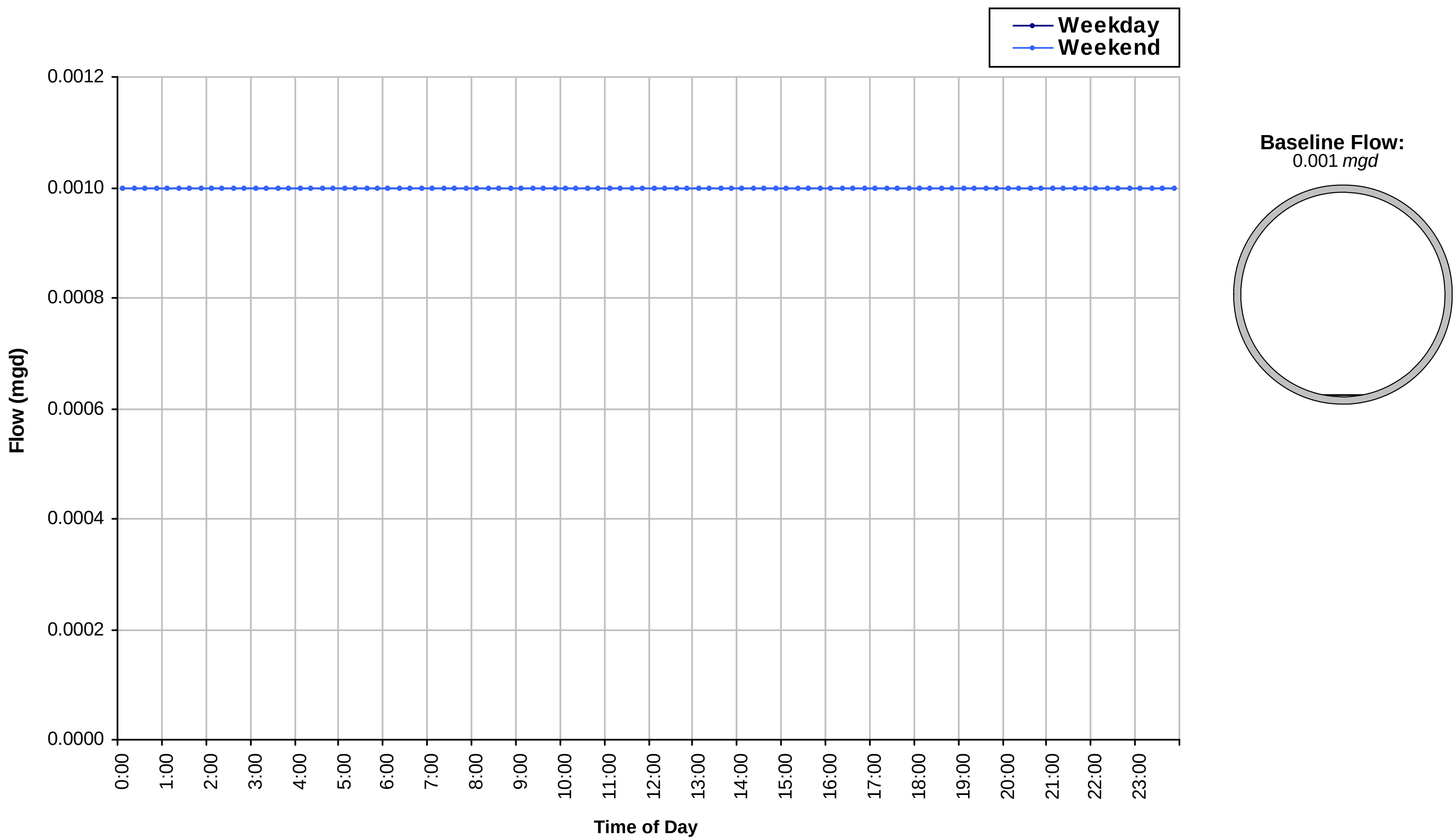
Total Monthly Rainfall: 0.61 inches **Avg Flow: 0.002 mgd** **Peak Flow: 0.672 mgd** **Min Flow: -0.056 mgd**





SITE 7

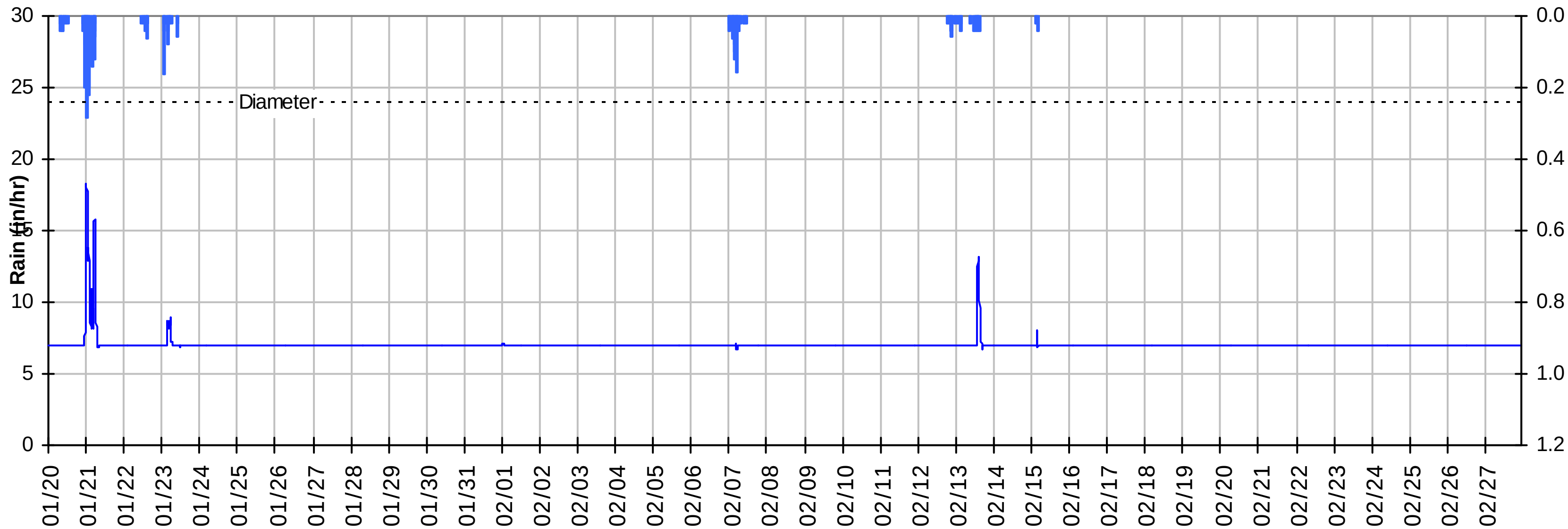
Baseline Flow Hydrographs

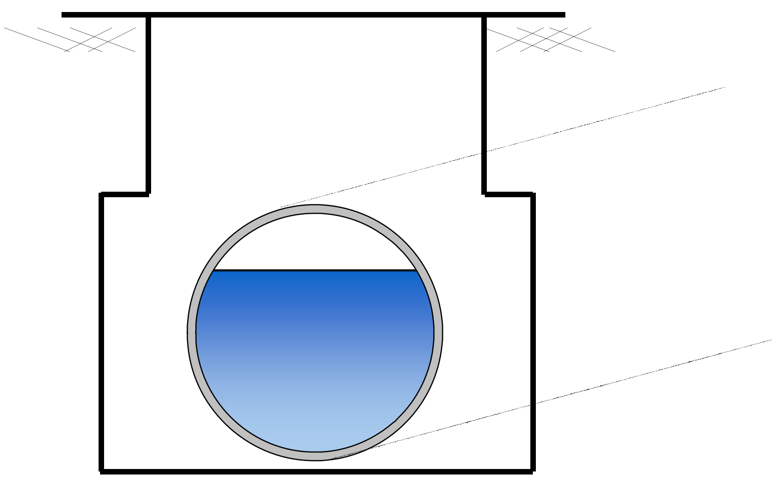


SITE 7

Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





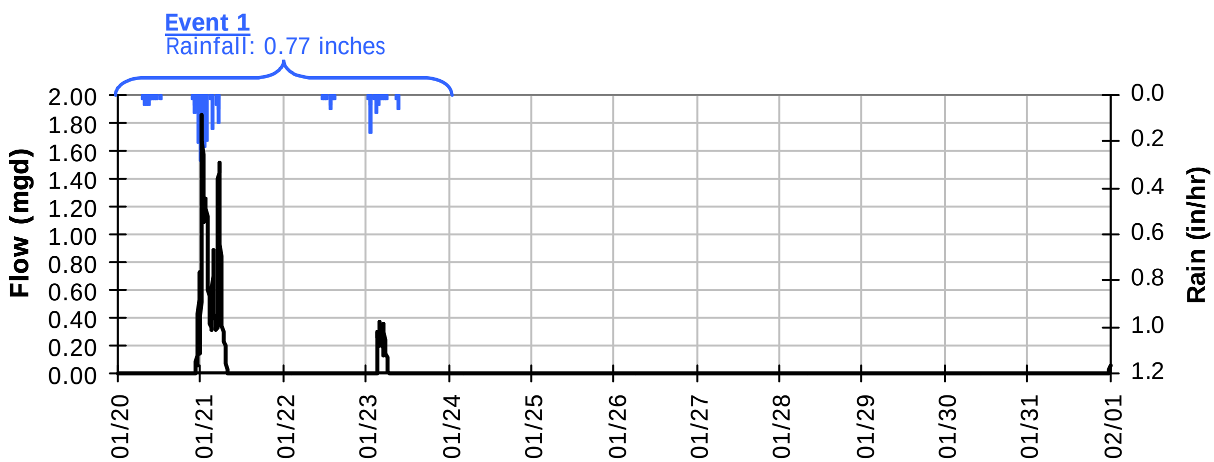
Pipe Diameter: 24 *inches*

Peak Measured Level: 18.1 *inches*

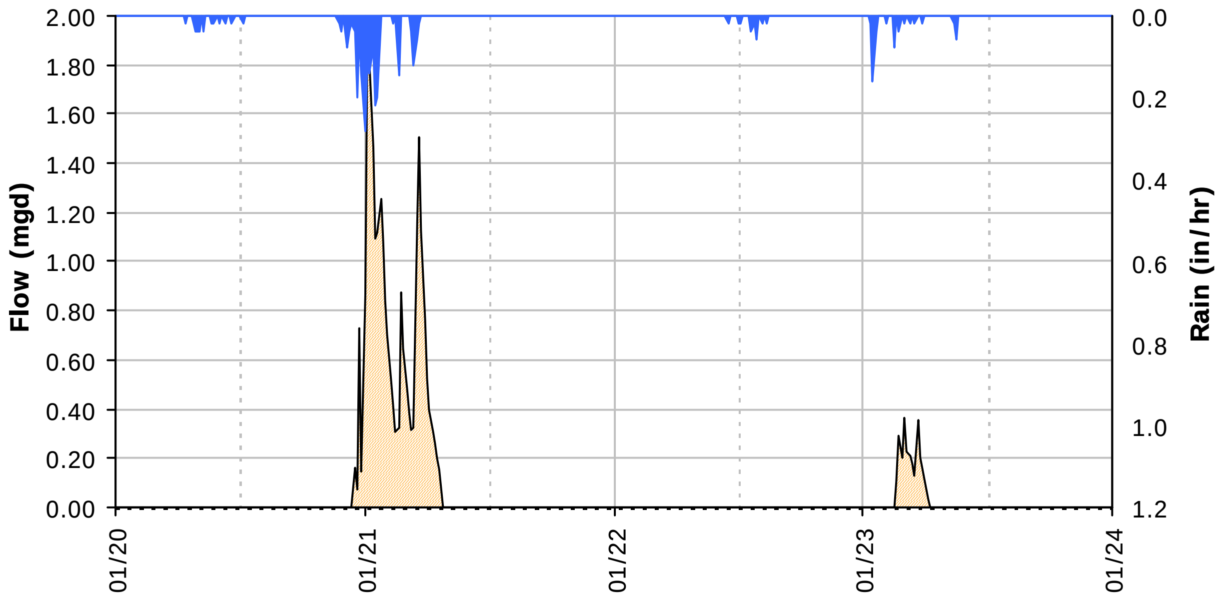
Peak d / D Ratio: 0.75

SITE 7
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph



Storm Event I/I Analysis (Rain = 0.77 inches)

Capacity

Peak Flow: 1.86 *mgd*
PF: 1860.90
Peak Level: 18.10 *in*
d/D Ratio: 0.75

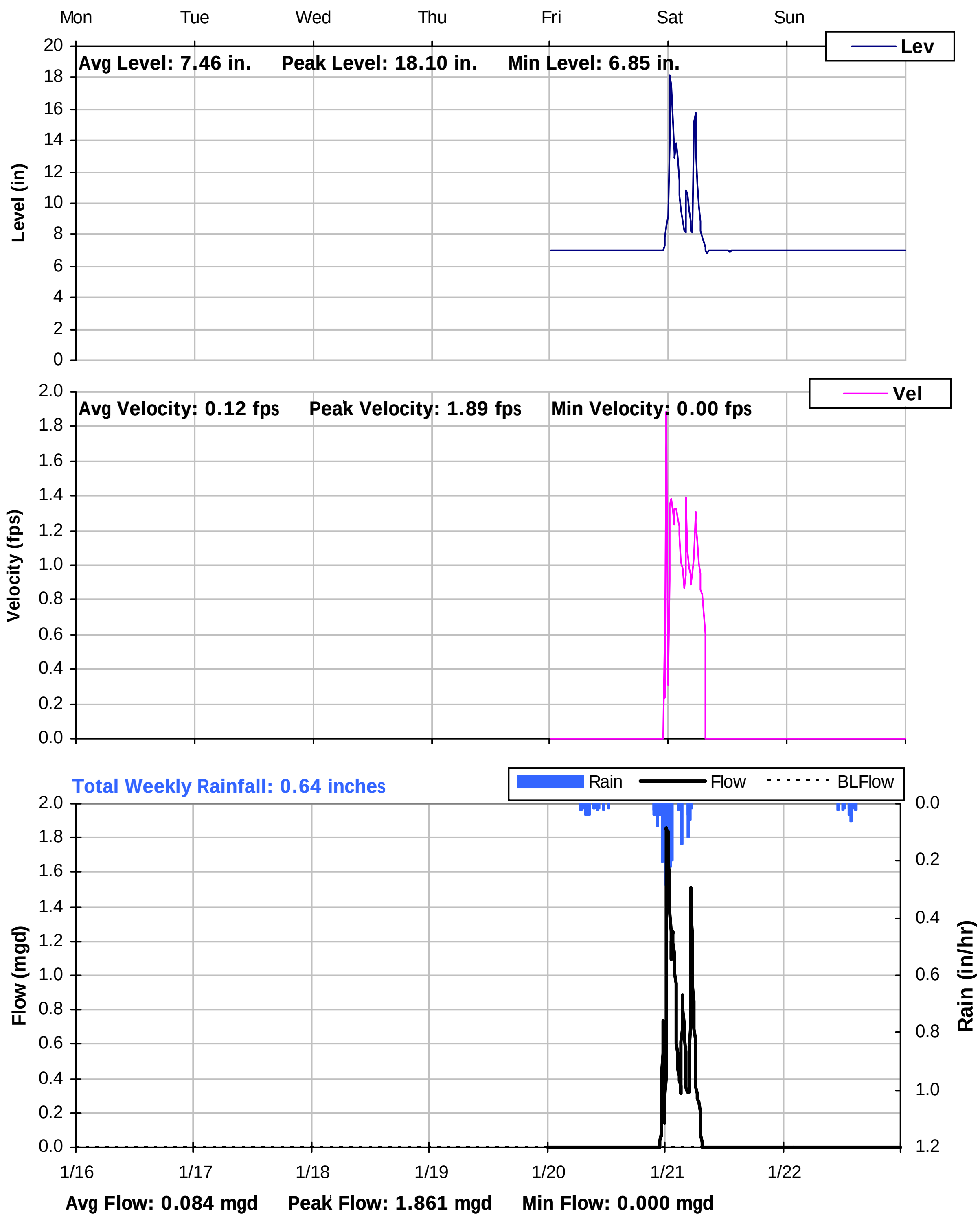
Inflow

Peak I/I Rate: 1.86 *mgd*
Pk I/I:Acre: ,906,093,750 *gpd/acre*
Pk I/I:ADWF: 1859.90

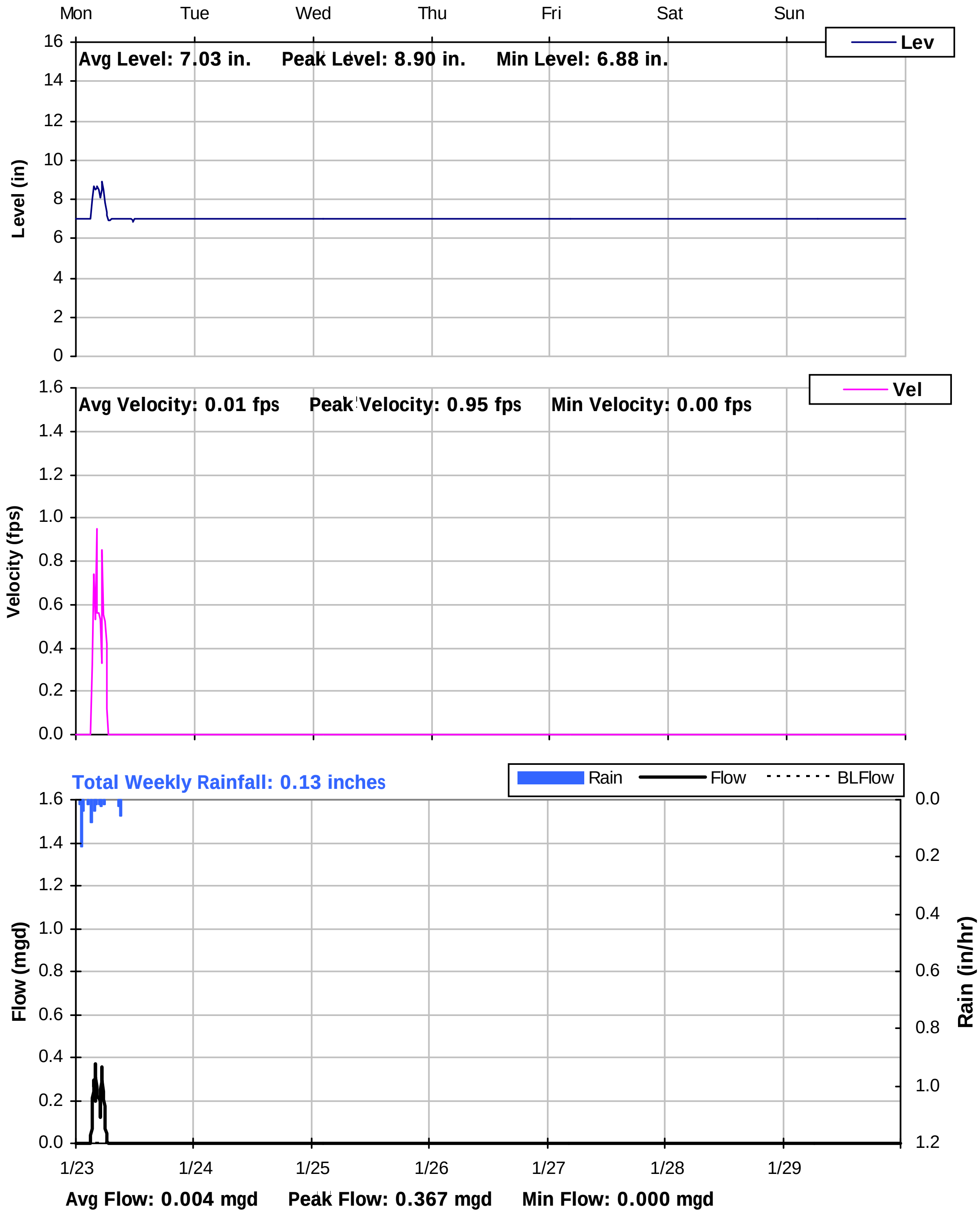
Combined I/I

Total I/I: 275,000 *gallons*
R-Value: 54862.9%
Total I/I:ADWF 358.85 *per in-rain*

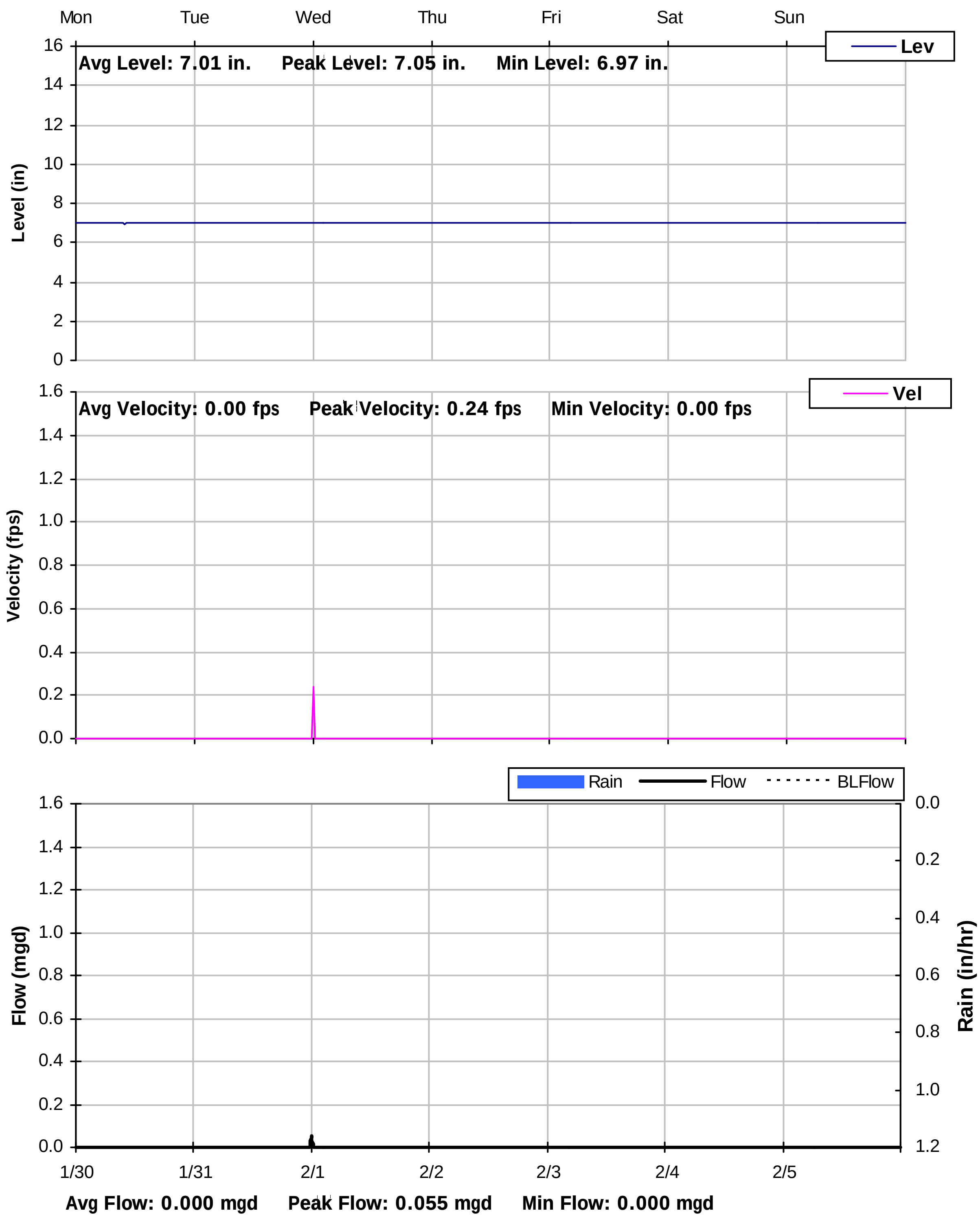
SITE 7
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



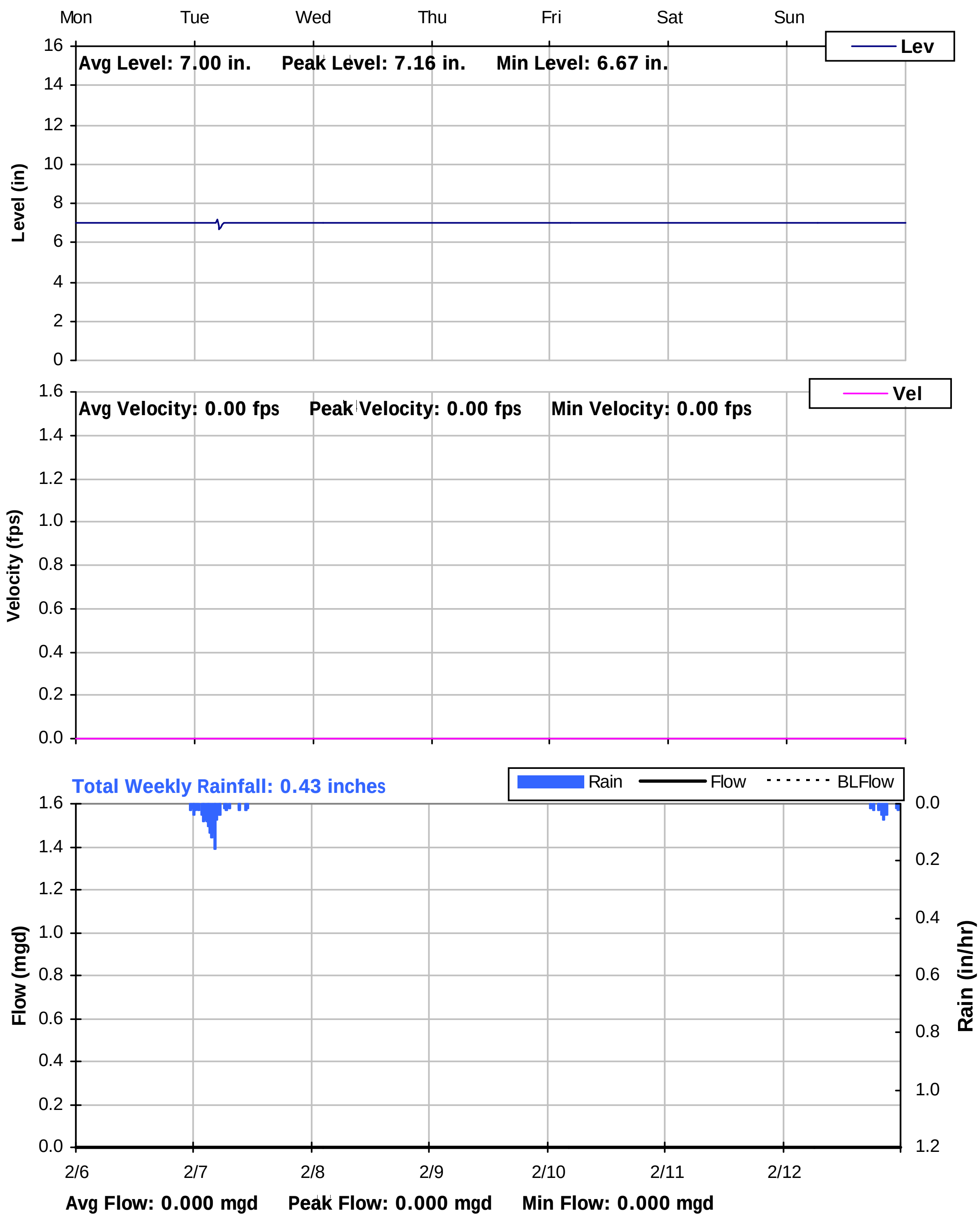
SITE 7
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



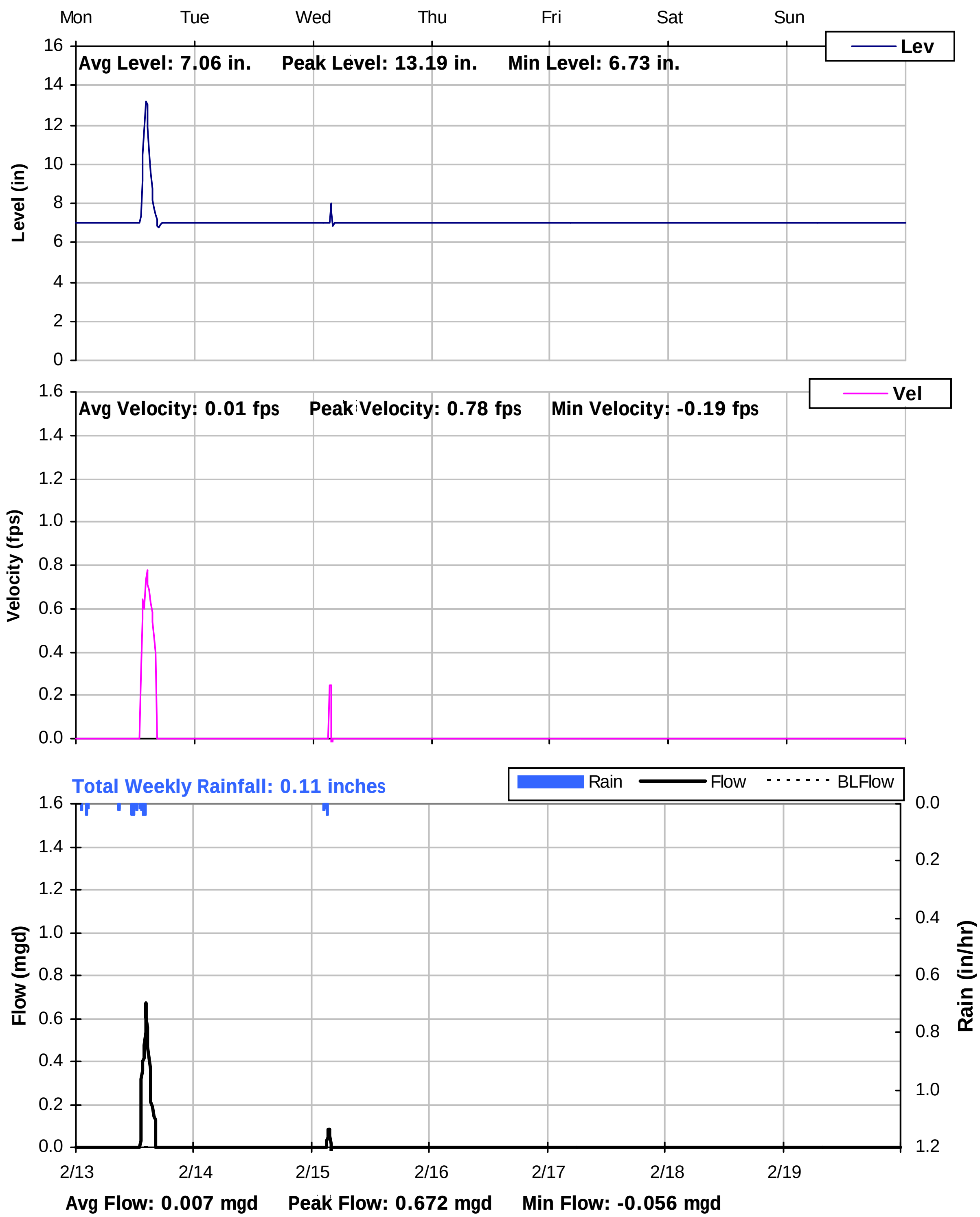
SITE 7
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



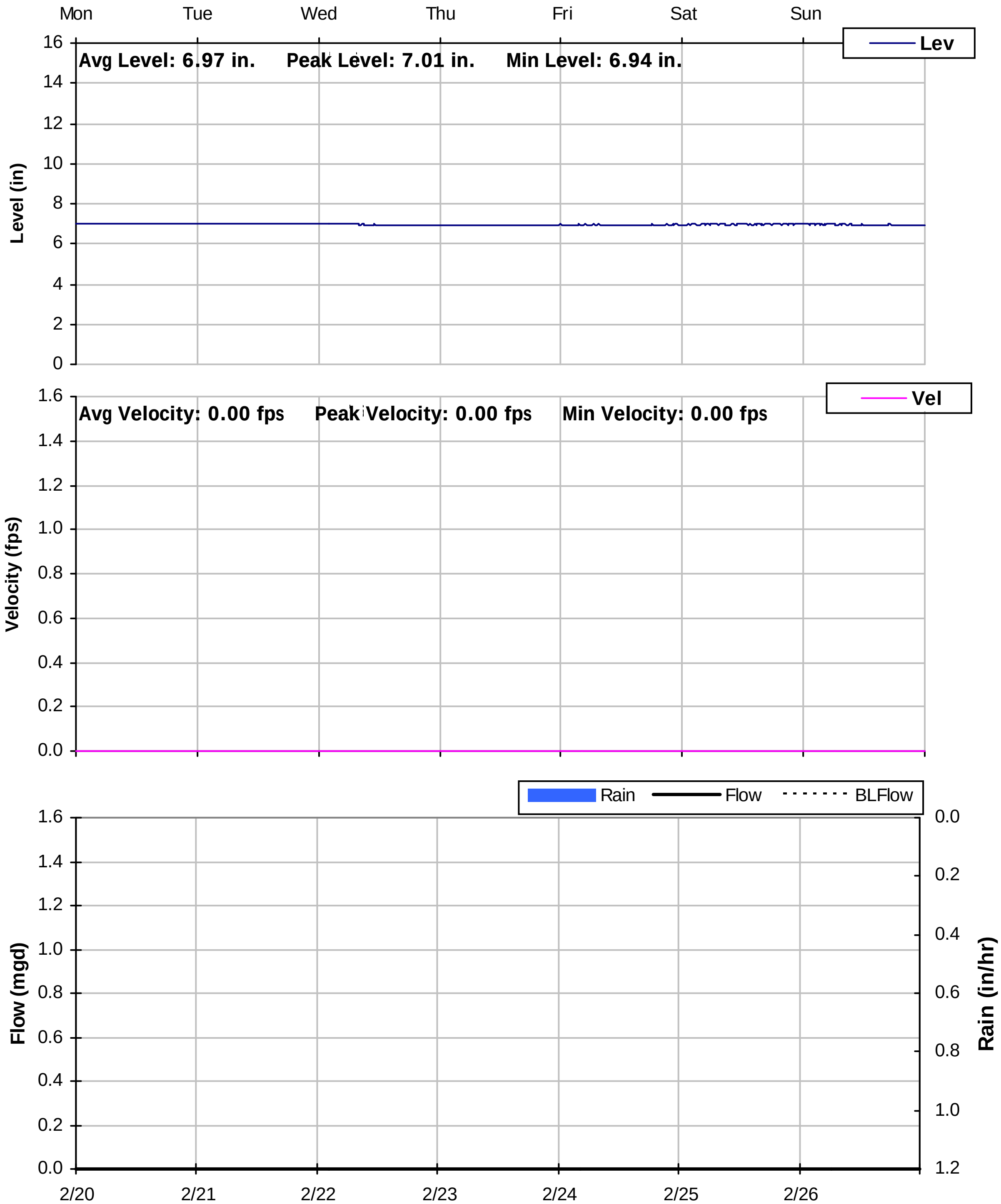
SITE 7
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



SITE 7
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012

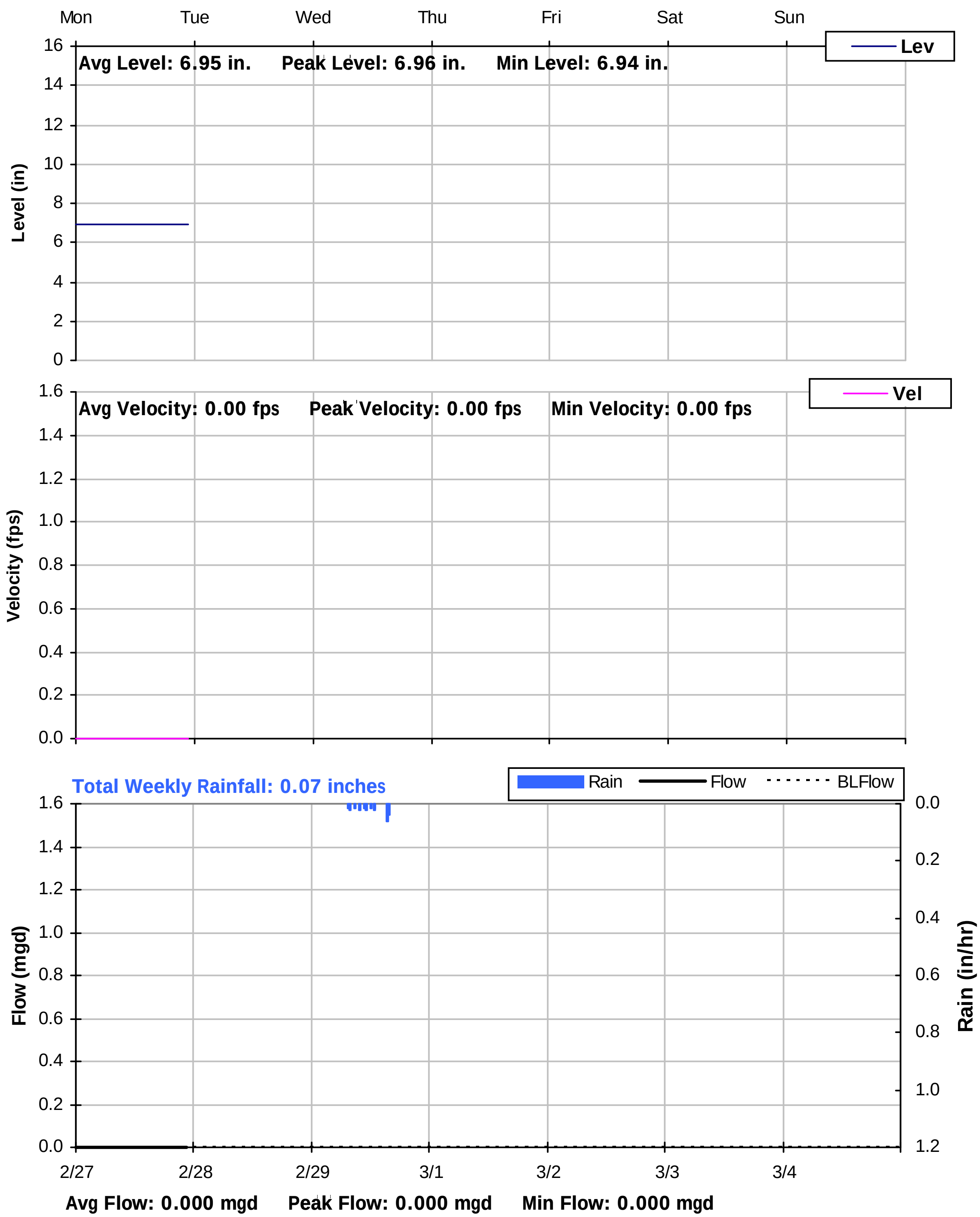


SITE 7
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



Avg Flow: 0.000 mgd **Peak Flow: 0.000 mgd** **Min Flow: 0.000 mgd**

SITE 7
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 8

Location: Intersection of Lander Avenue and F Street

Data Summary Report

Vicinity Map: Site 8

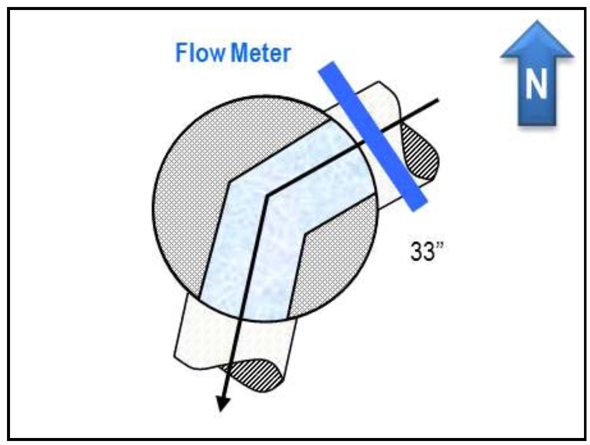
SITE 8

Site Information

Location:	Intersection of Lander Avenue and F Street
Coordinates:	120.8488° W, 37.4822° N
Rim Elevation:	100 feet
Pipe Diameter:	33 inches
Baseline Flow:	1.601 mgd
Peak Measured Flow:	2.951 mgd

Satellite Map

Sewer Map



Flow Sketch

Street View

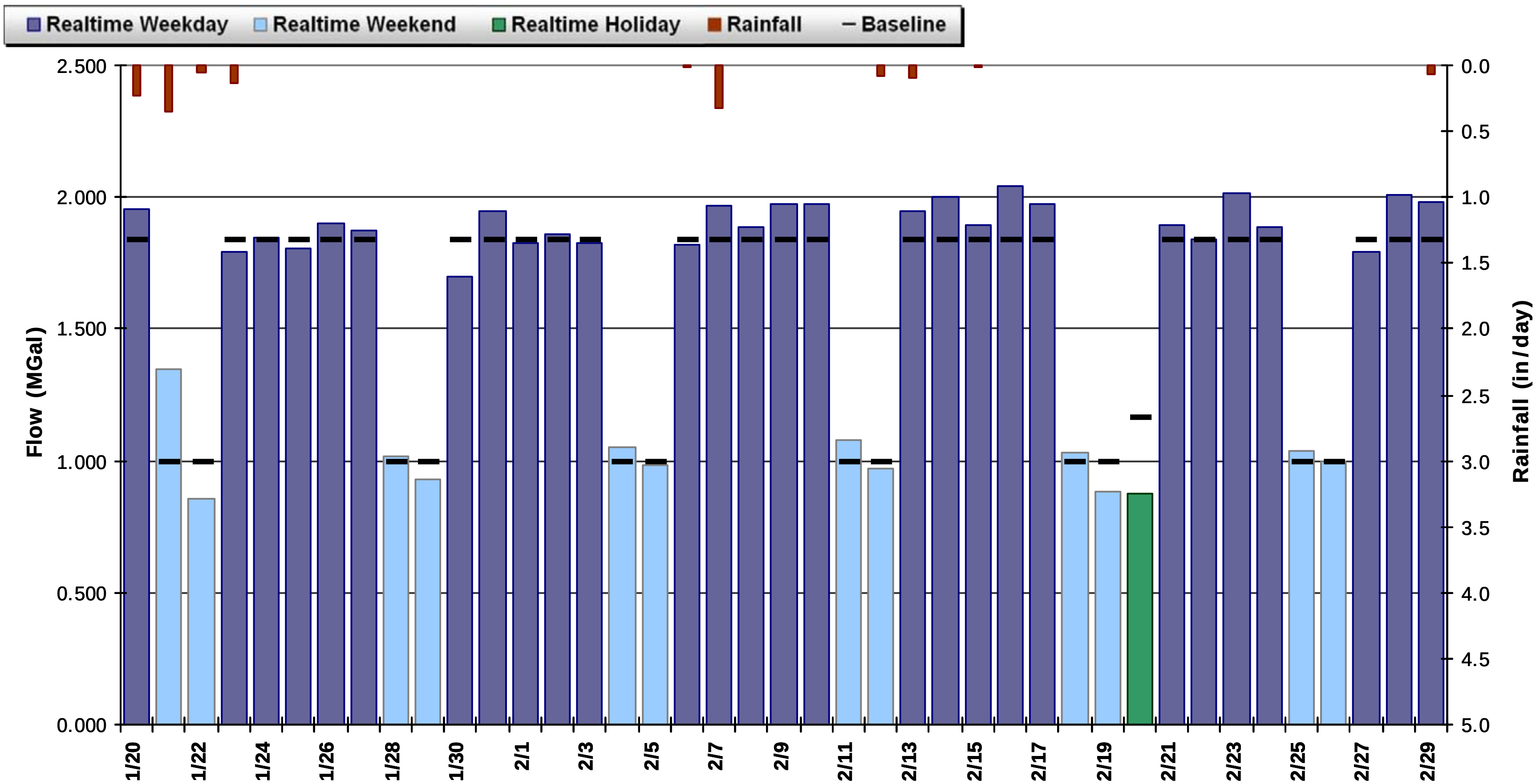
Plan View

SITE 8

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 1.617 MGal **Peak Daily Flow: 2.039 MGal** **Min Daily Flow: 0.858 MGal**

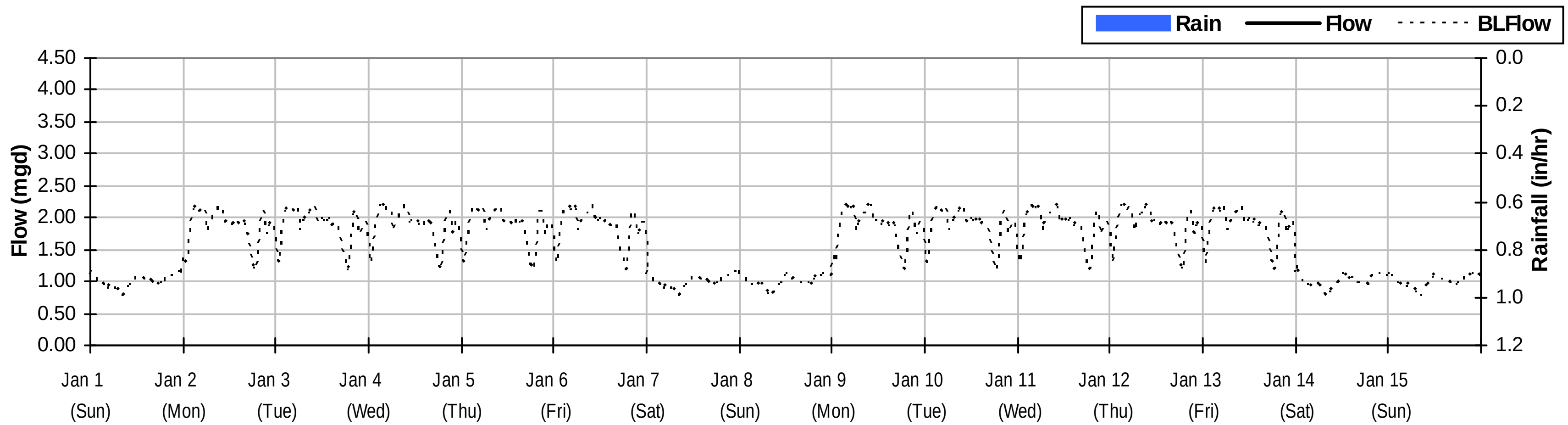
Total Period Rainfall: 1.38 inches

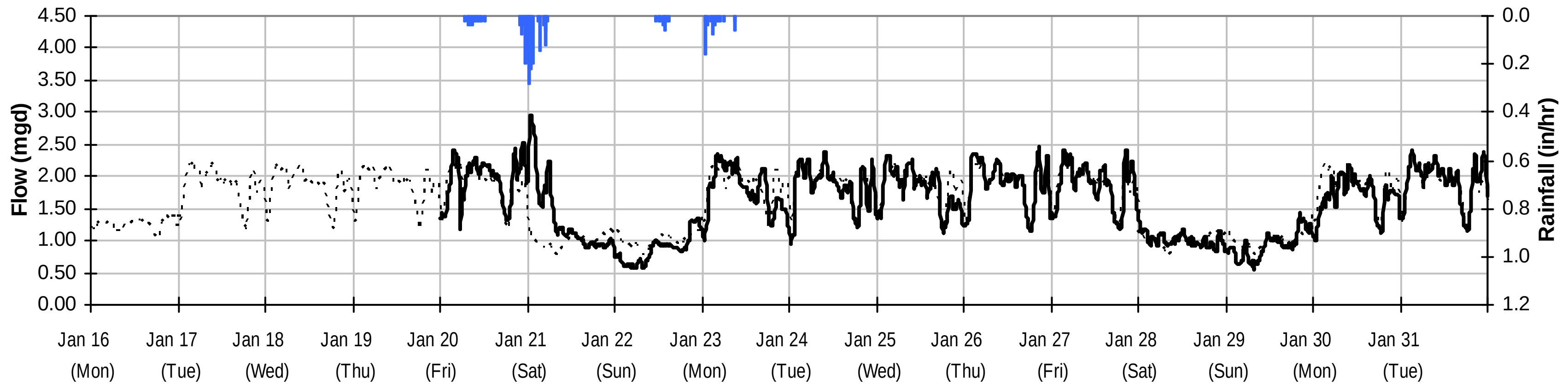


SITE 8

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.77 inches **Avg Flow: 1.581 mgd** **Peak Flow: 2.951 mgd** **Min Flow: 0.534 mgd**

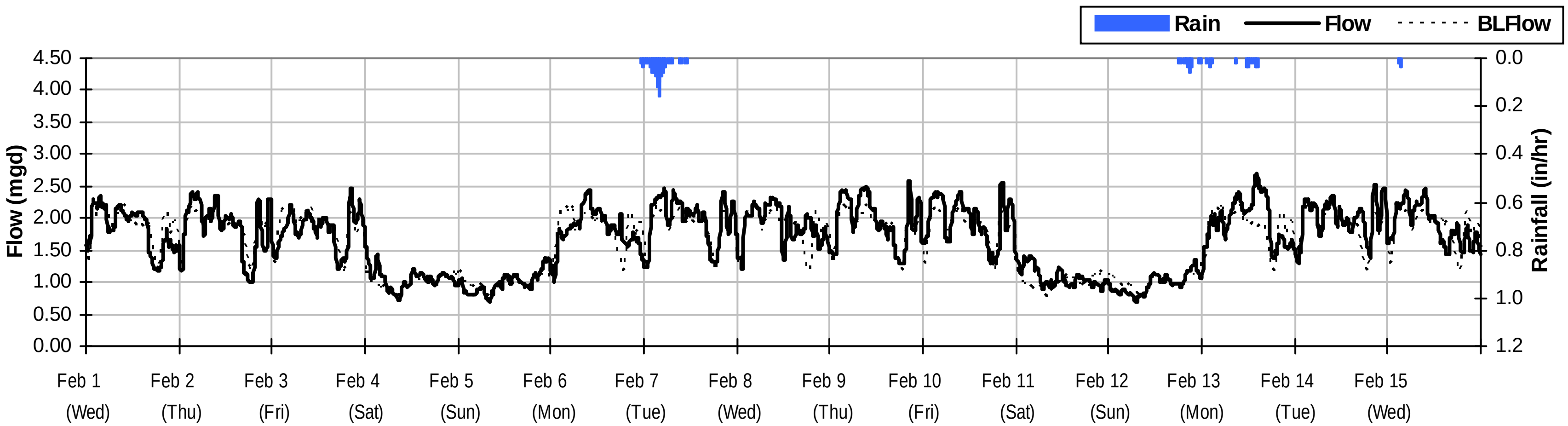


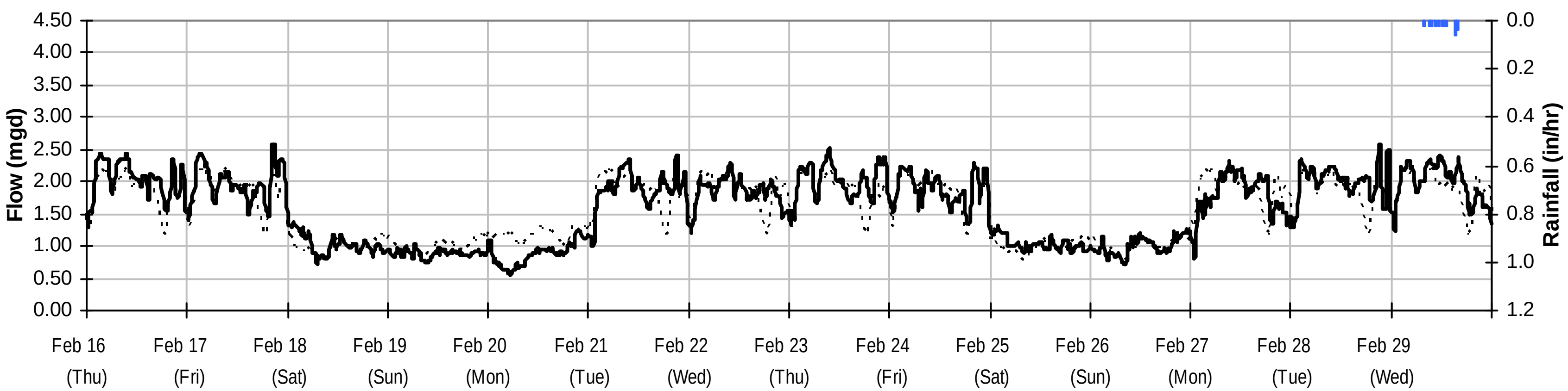


SITE 8

Monthly Flow Summary: February, 2012

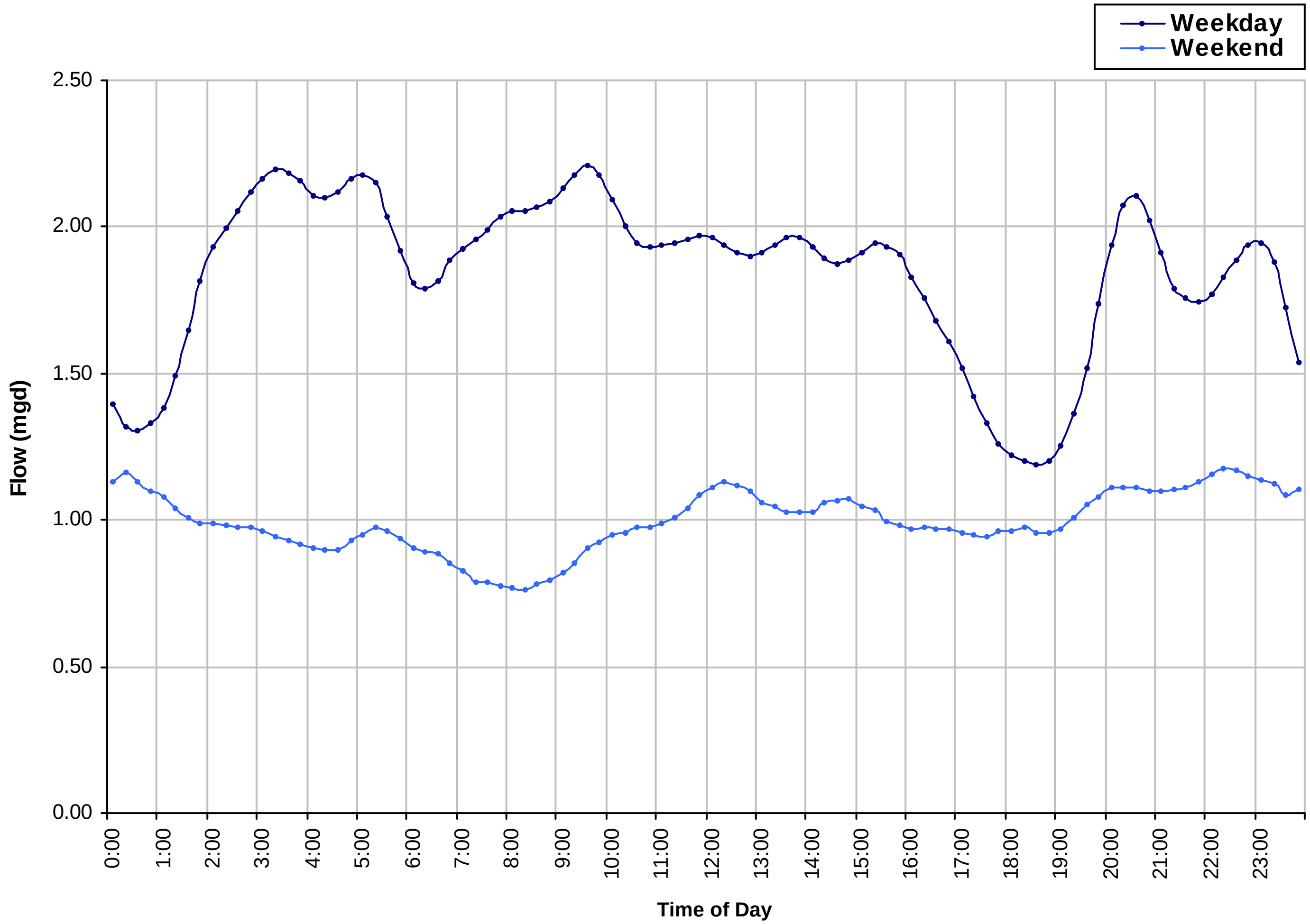
Total Monthly Rainfall: 0.61 inches **Avg Flow: 1.631 mgd** **Peak Flow: 2.699 mgd** **Min Flow: 0.552 mgd**

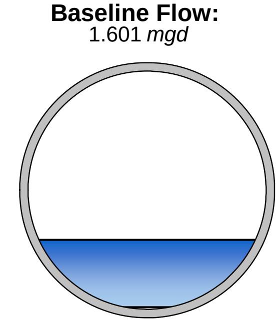




SITE 8

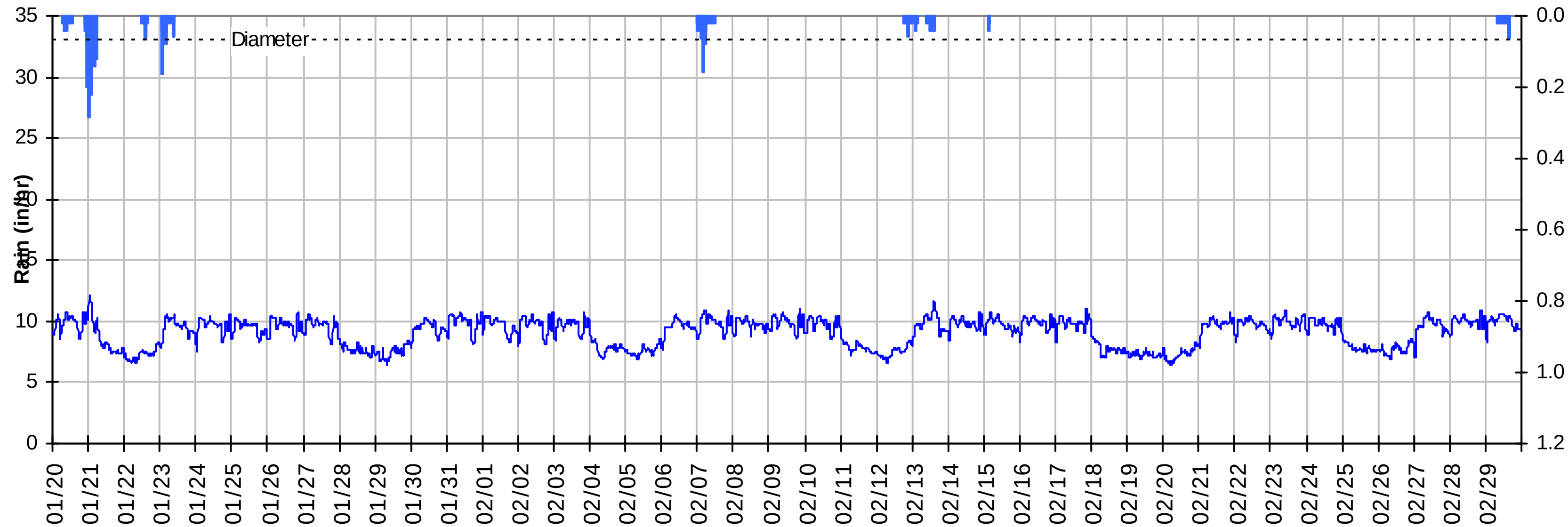
Baseline Flow Hydrographs

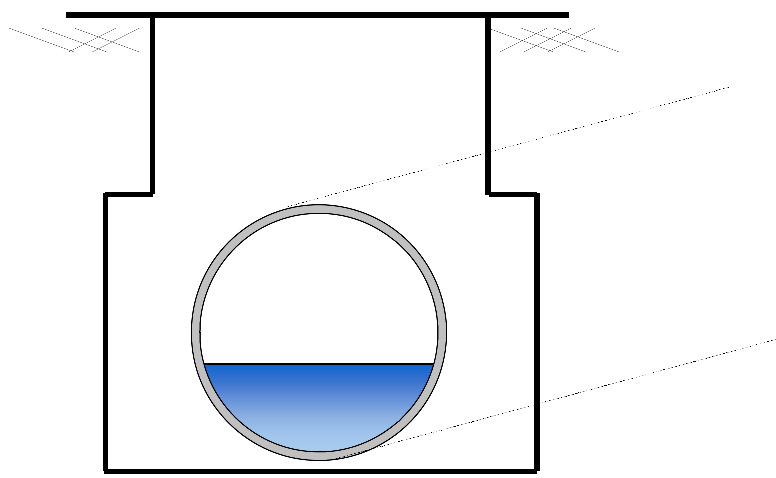




SITE 8
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





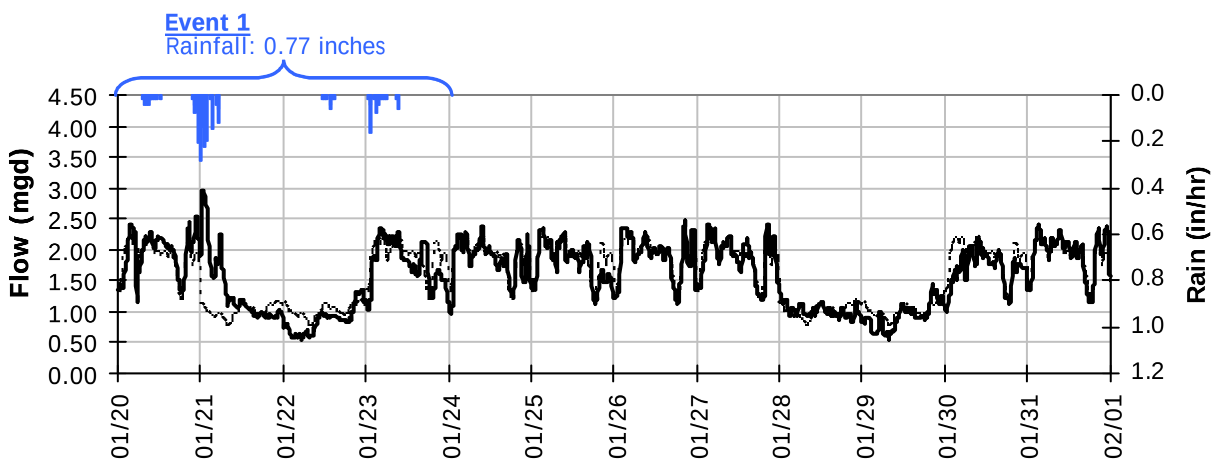
Pipe Diameter: 33 *inches*

Peak Measured Level: 12.1 *inches*

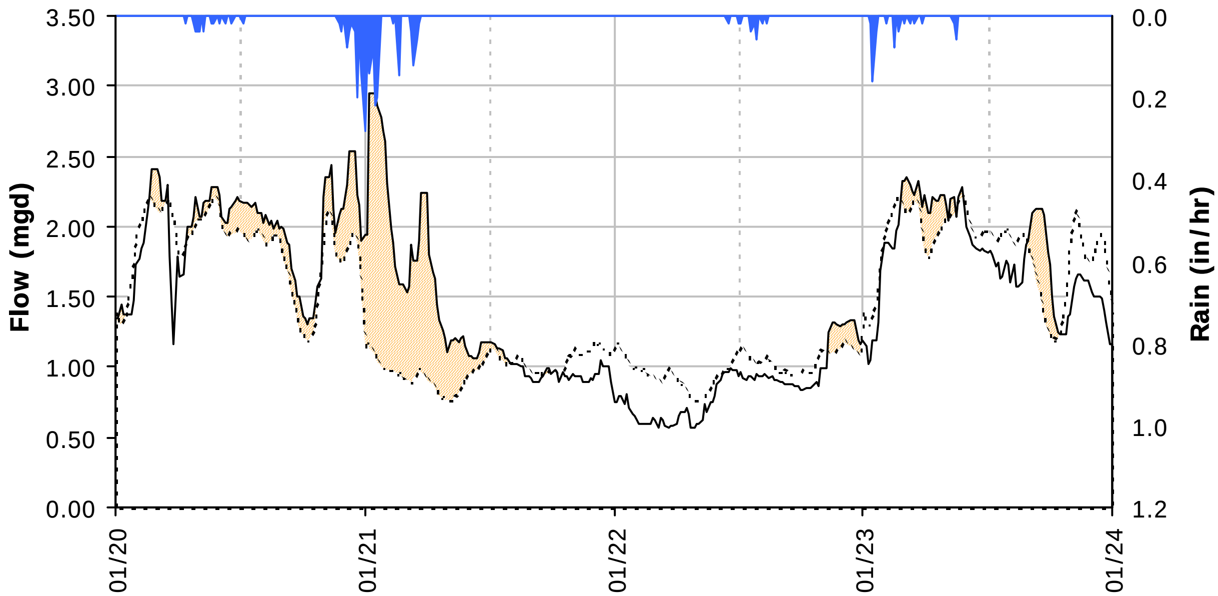
Peak d / D Ratio: 0.37

SITE 8
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph



Storm Event I/I Analysis (Rain = 0.77 inches)

Capacity

Peak Flow: 2.95 *mgd*
PF: 1.84
Peak Level: 12.11 *in*
d/D Ratio: 0.37

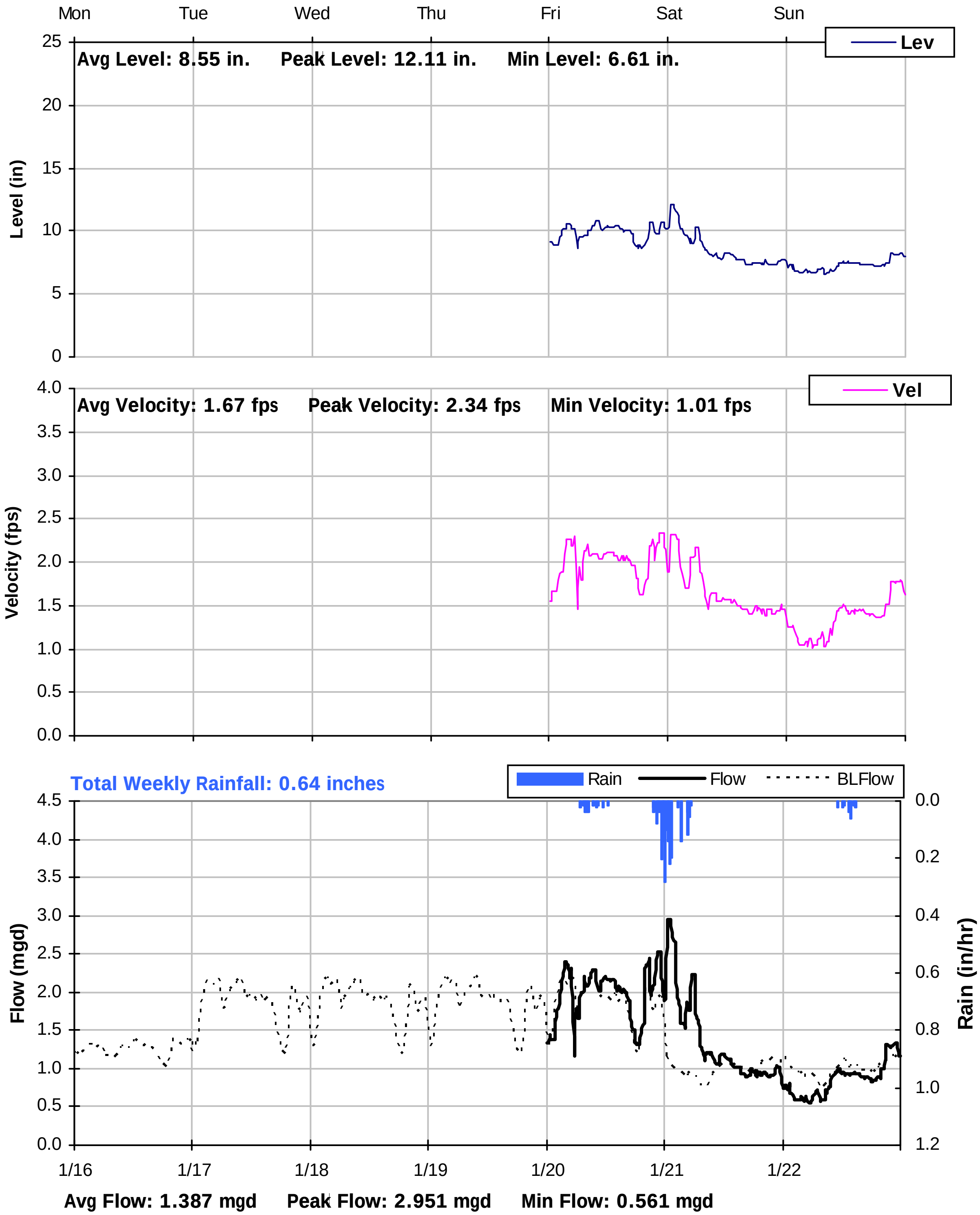
Inflow

Peak I/I Rate: 1.87 *mgd*
Pk I/I:Acre: 1,906 *gpd/acre*
Pk I/I:ADWF: 1.17

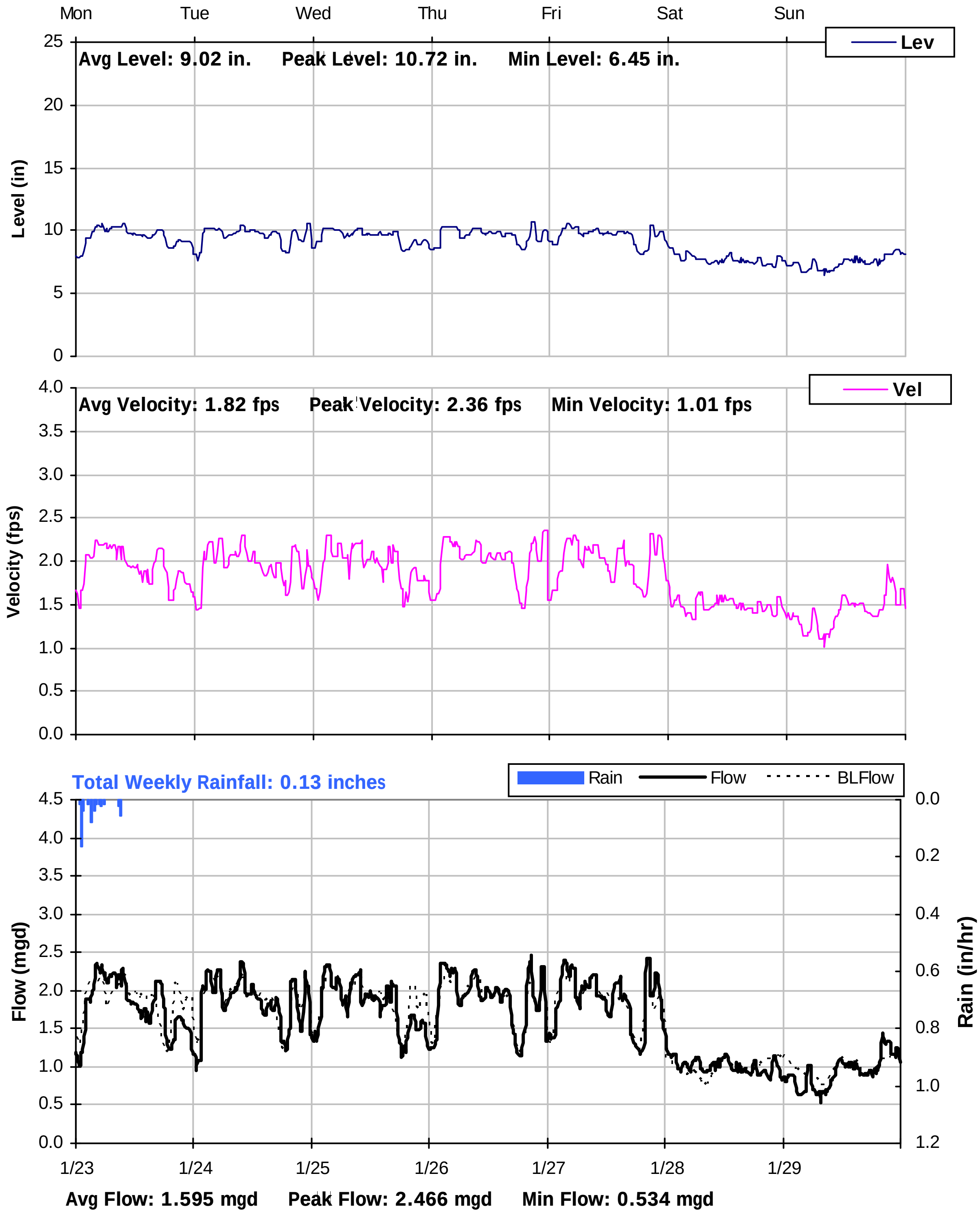
Combined I/I

Total I/I: 293,000 *gallons*
R-Value: 1.4%
Total I/I:ADWF: 0.24 *per in-rain*

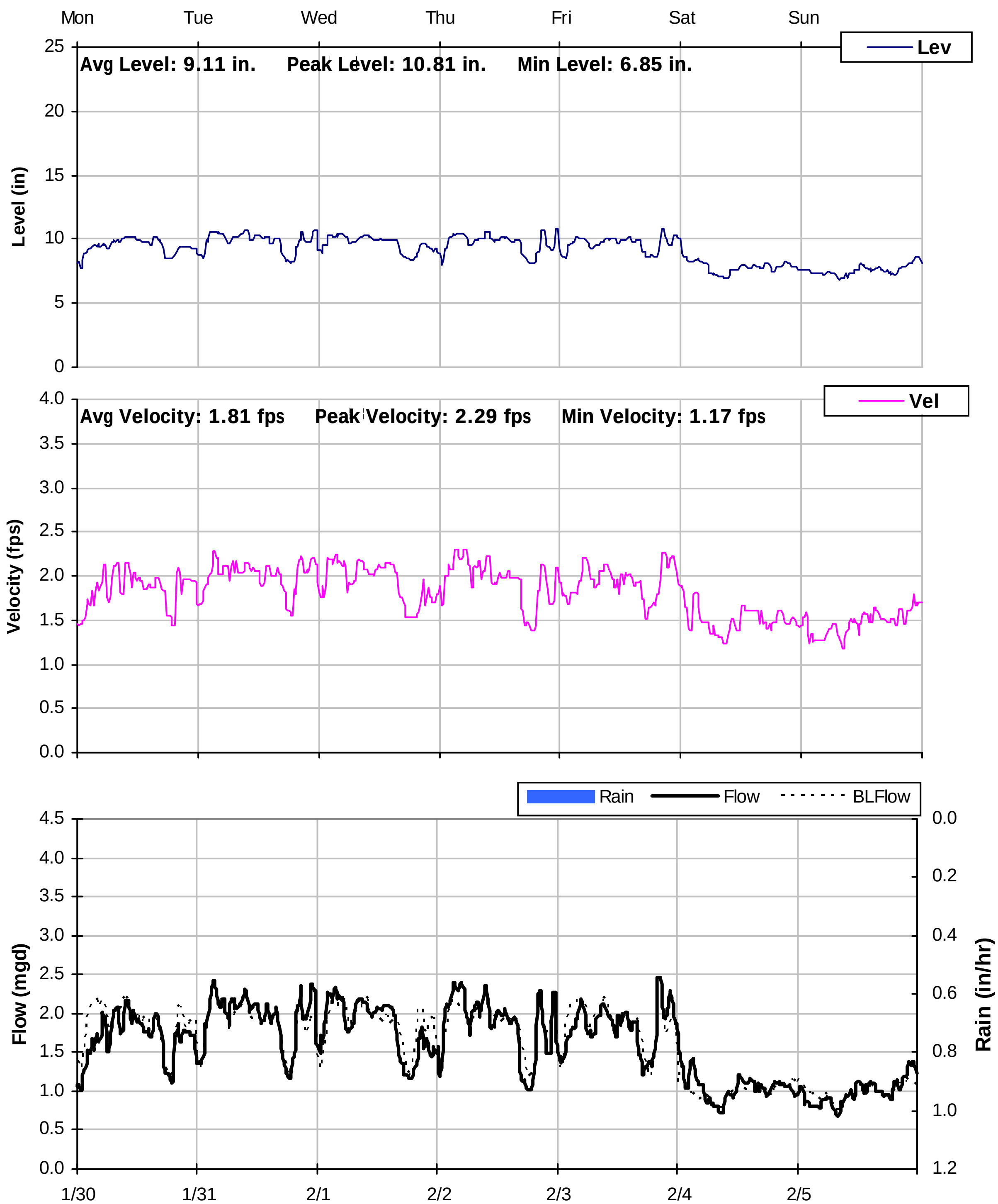
SITE 8
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



SITE 8
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012

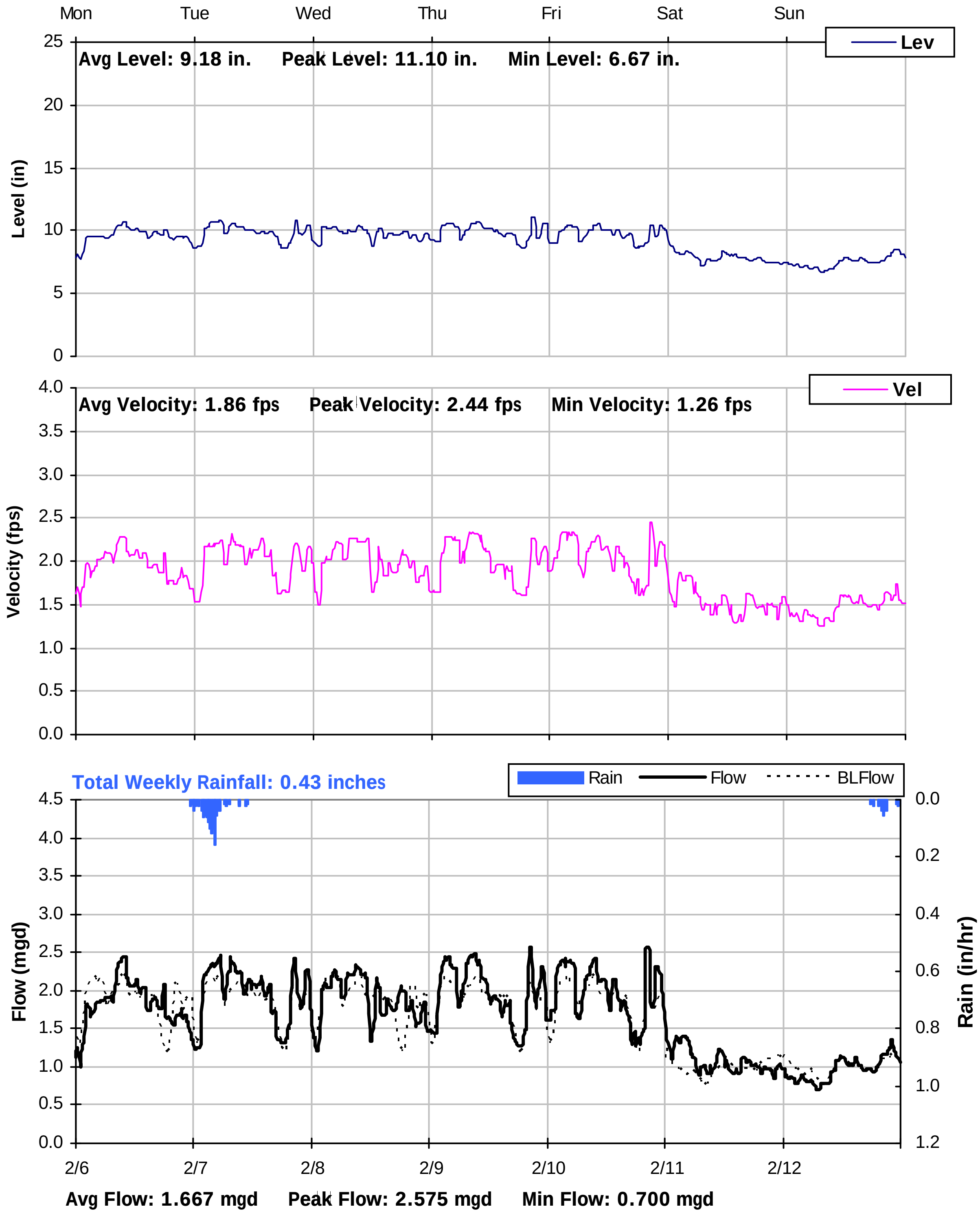


SITE 8
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012

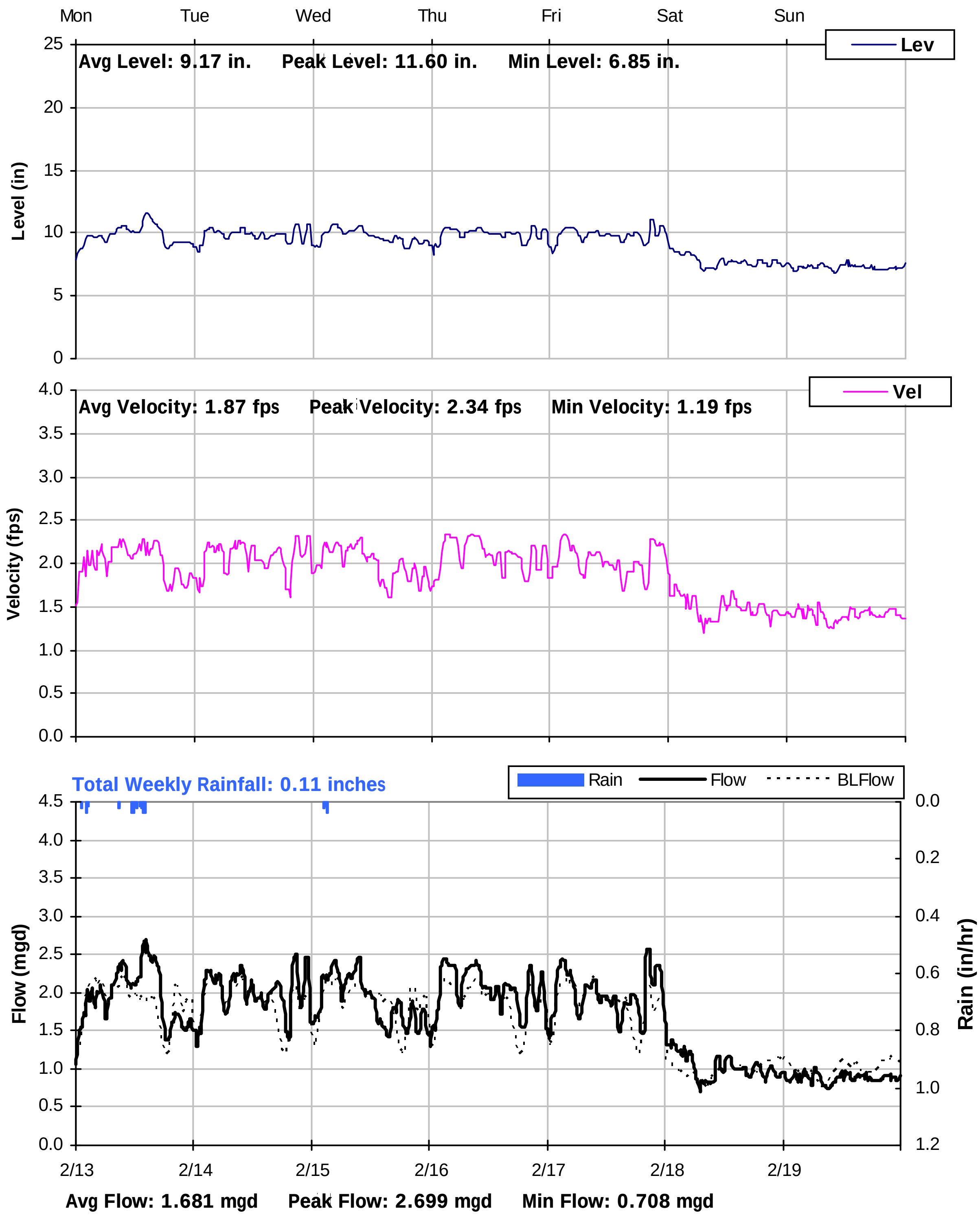


Avg Flow: 1.600 mgd **Peak Flow: 2.473 mgd** **Min Flow: 0.685 mgd**

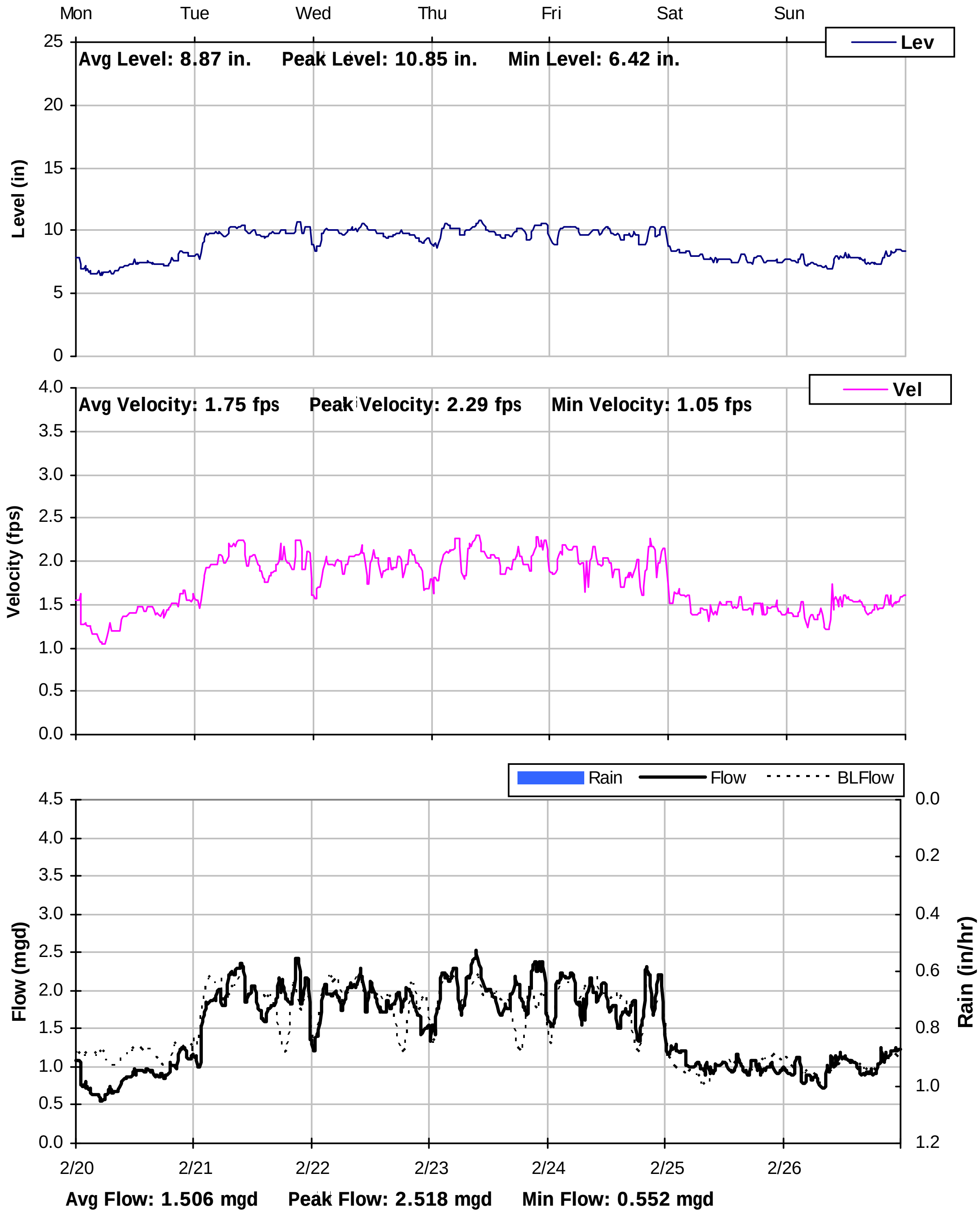
SITE 8
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



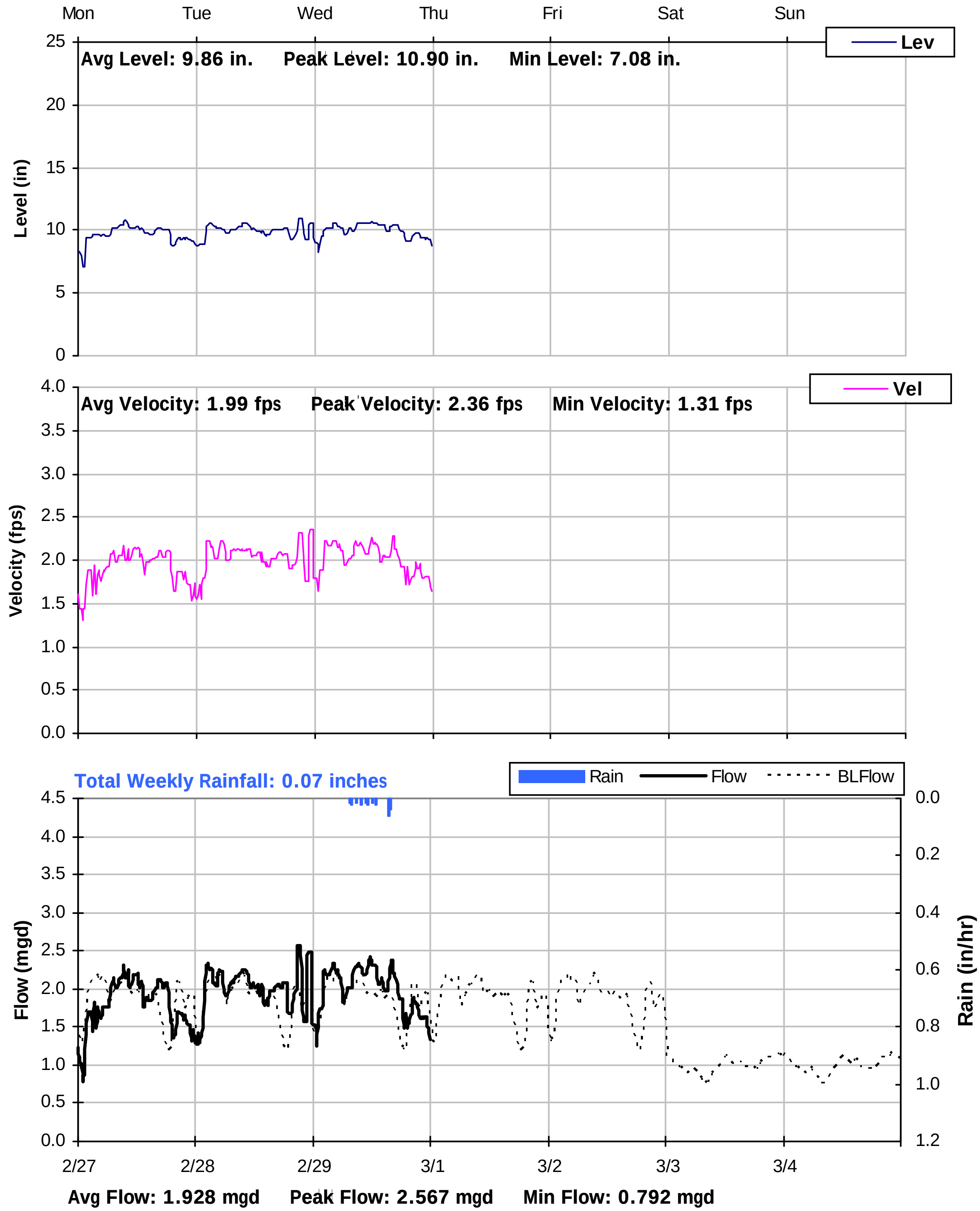
SITE 8
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012



SITE 8
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



SITE 8
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 9

Location: Main Street between Kilroy Road and Walnut Road

Data Summary Report

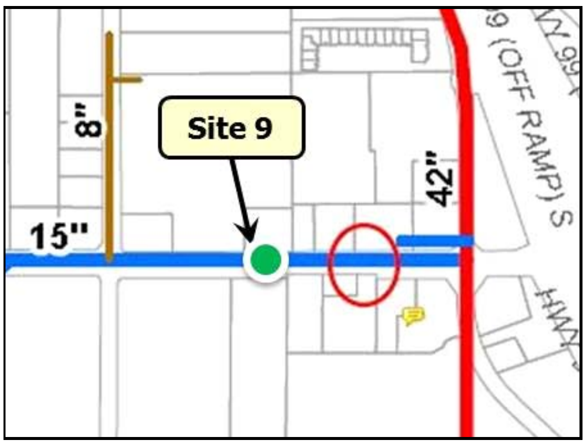
Vicinity Map: Site 9

SITE 9

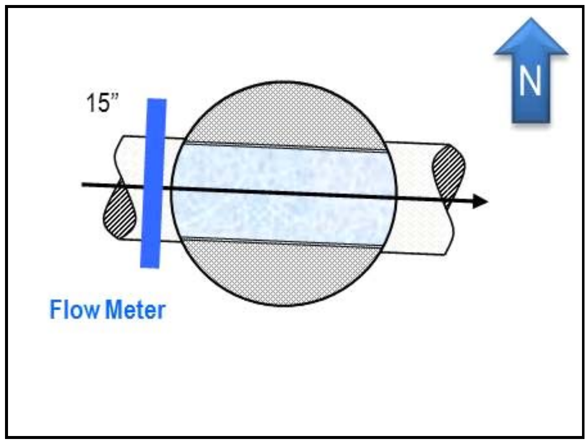
Site Information

Location:	Main Street between Kilroy Road and Walnut Road
Coordinates:	120.8745° W, 37.4928° N
Rim Elevation:	96 feet
Pipe Diameter:	15 inches
Baseline Flow:	0.051 mgd
Peak Measured Flow:	0.320 mgd

Satellite Map



Sewer Map



Flow Sketch

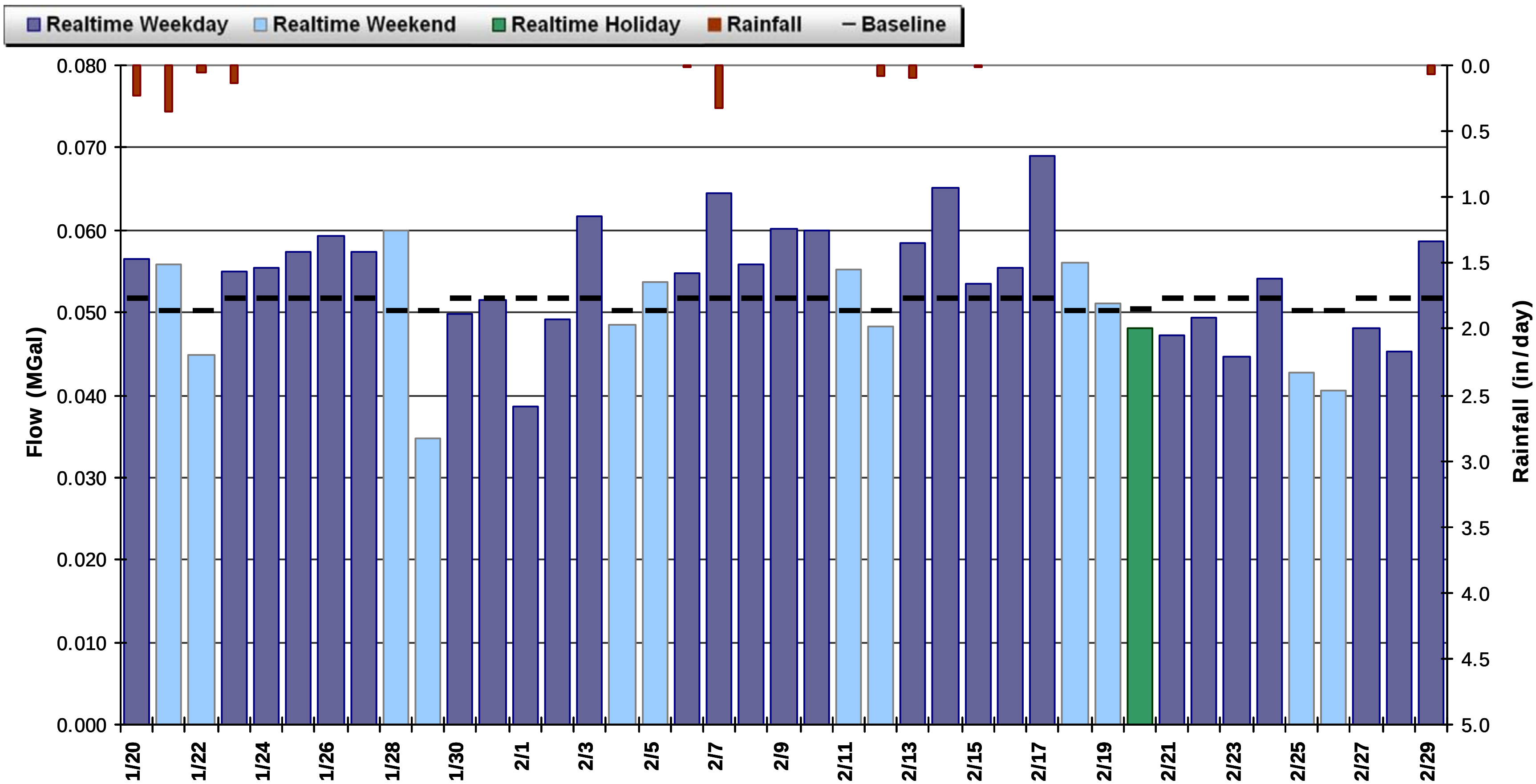
Street View

Plan View

SITE 9
Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.053 MGal **Peak Daily Flow: 0.069 MGal** **Min Daily Flow: 0.035 MGal**

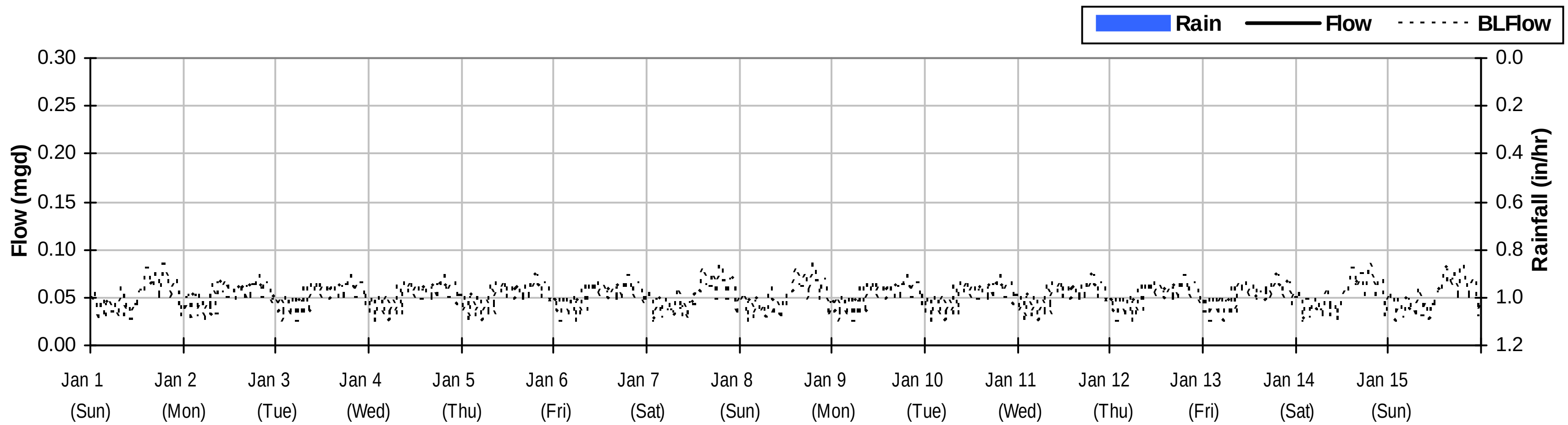
Total Period Rainfall: 1.38 inches

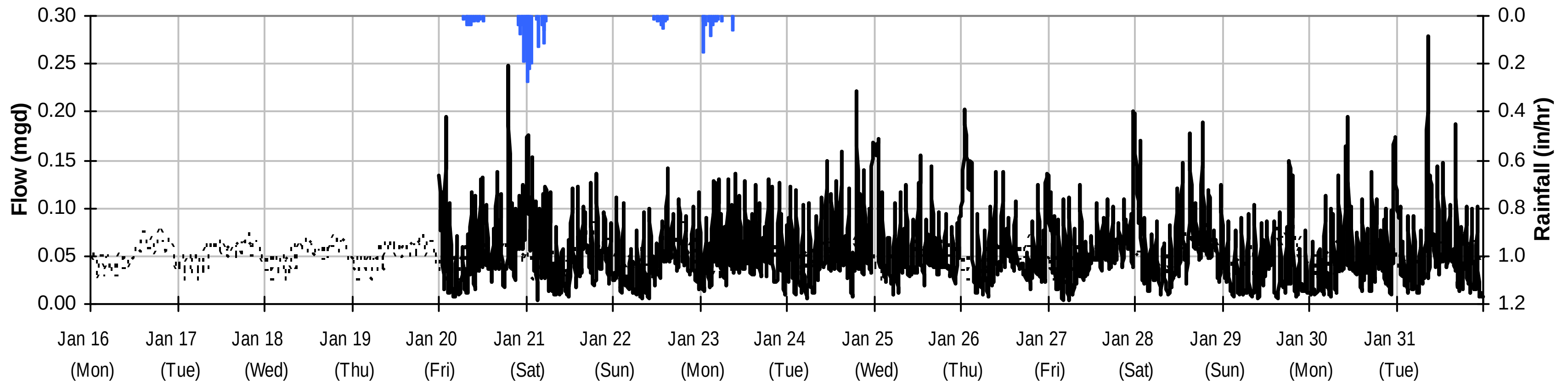


SITE 9

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.76 inches **Avg Flow: 0.053 mgd** **Peak Flow: 0.278 mgd** **Min Flow: 0.003 mgd**

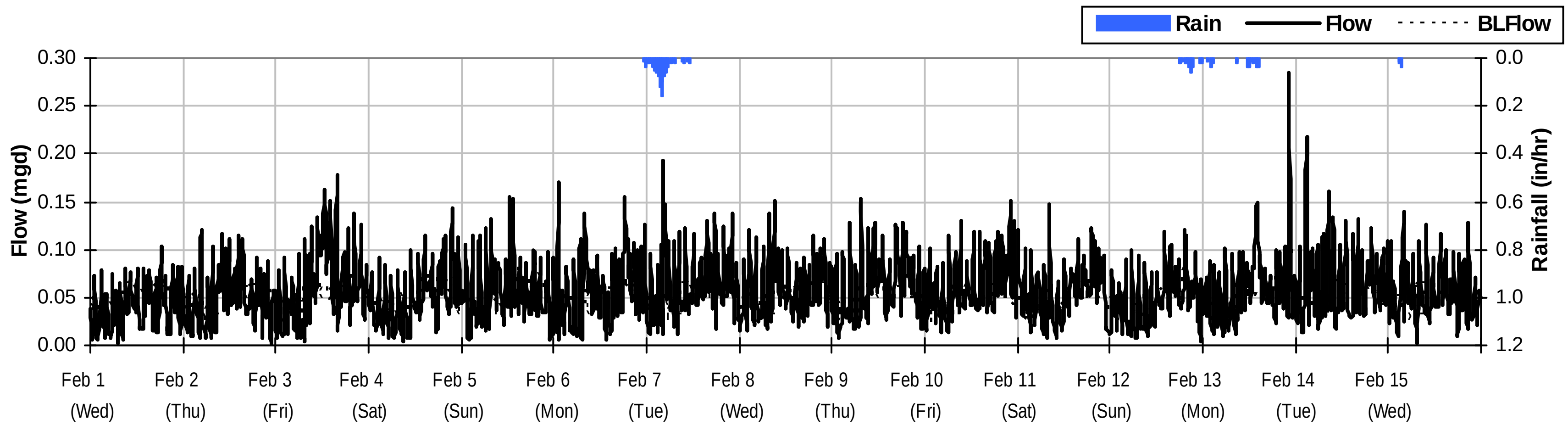


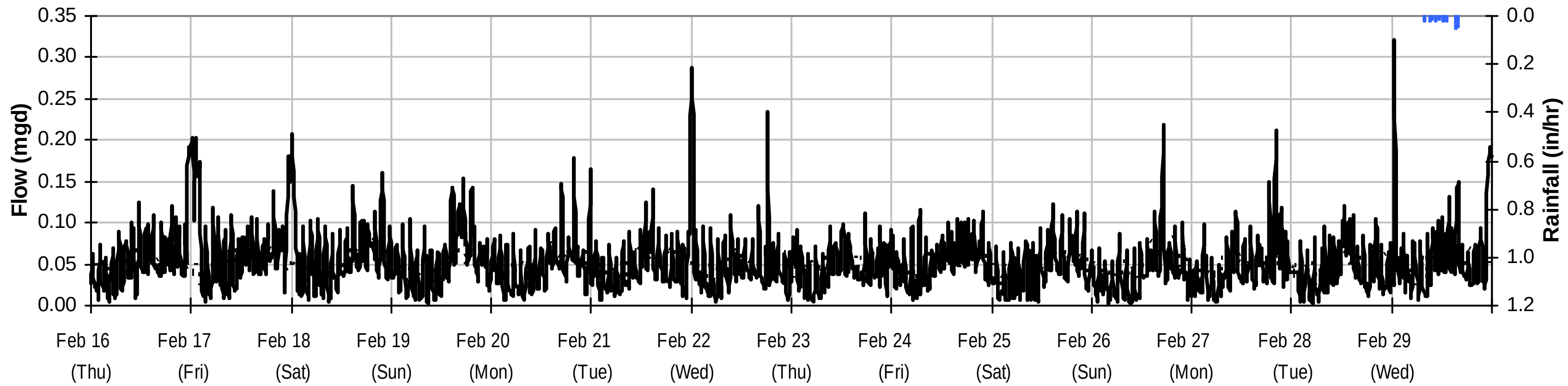


SITE 9

Monthly Flow Summary: February, 2012

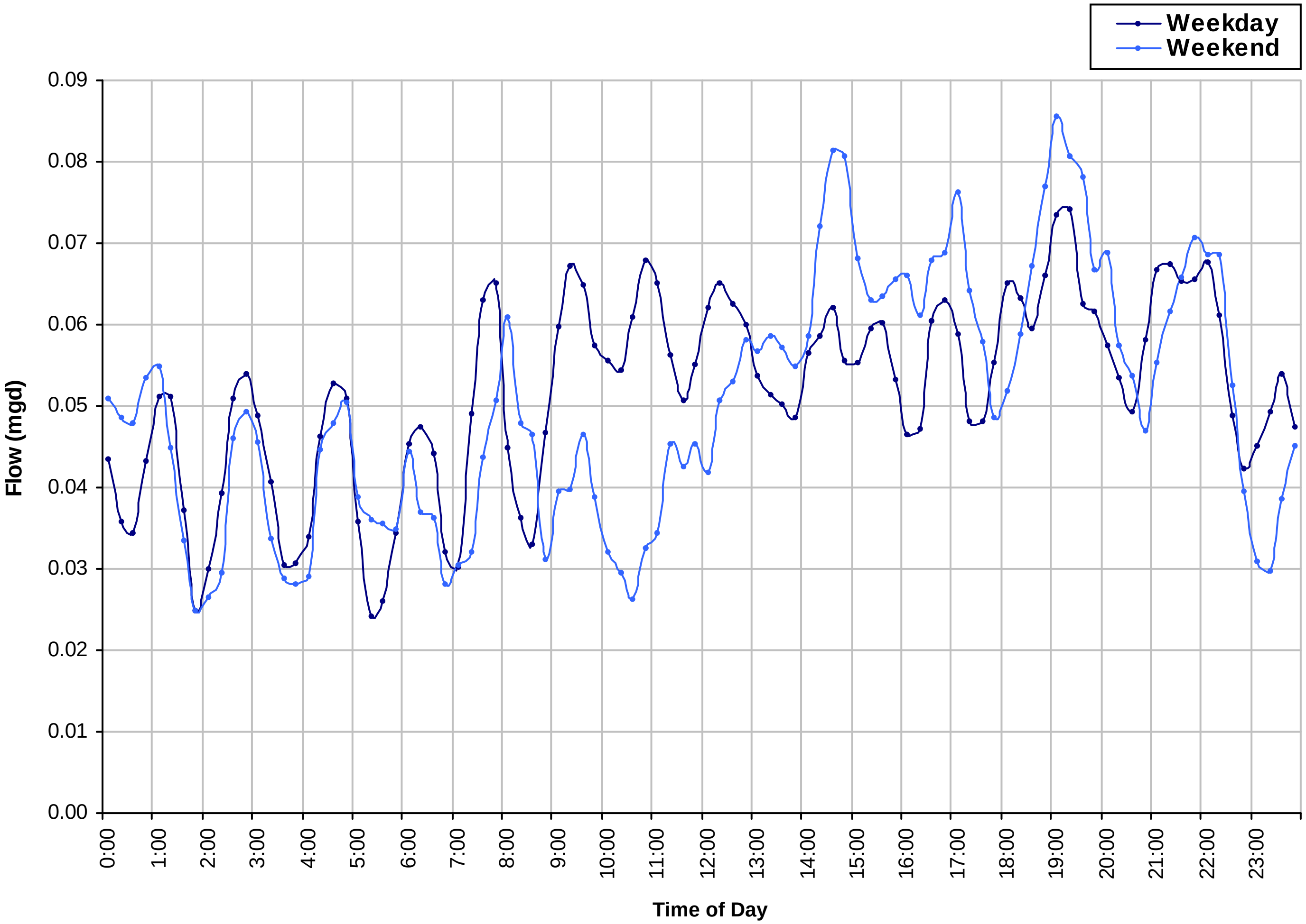
Total Monthly Rainfall: 0.62 inches **Avg Flow: 0.053 mgd** **Peak Flow: 0.320 mgd** **Min Flow: 0.002 mgd**



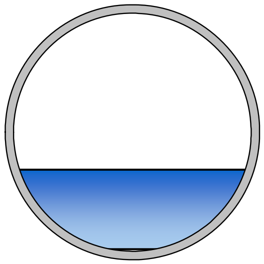


SITE 9

Baseline Flow Hydrographs

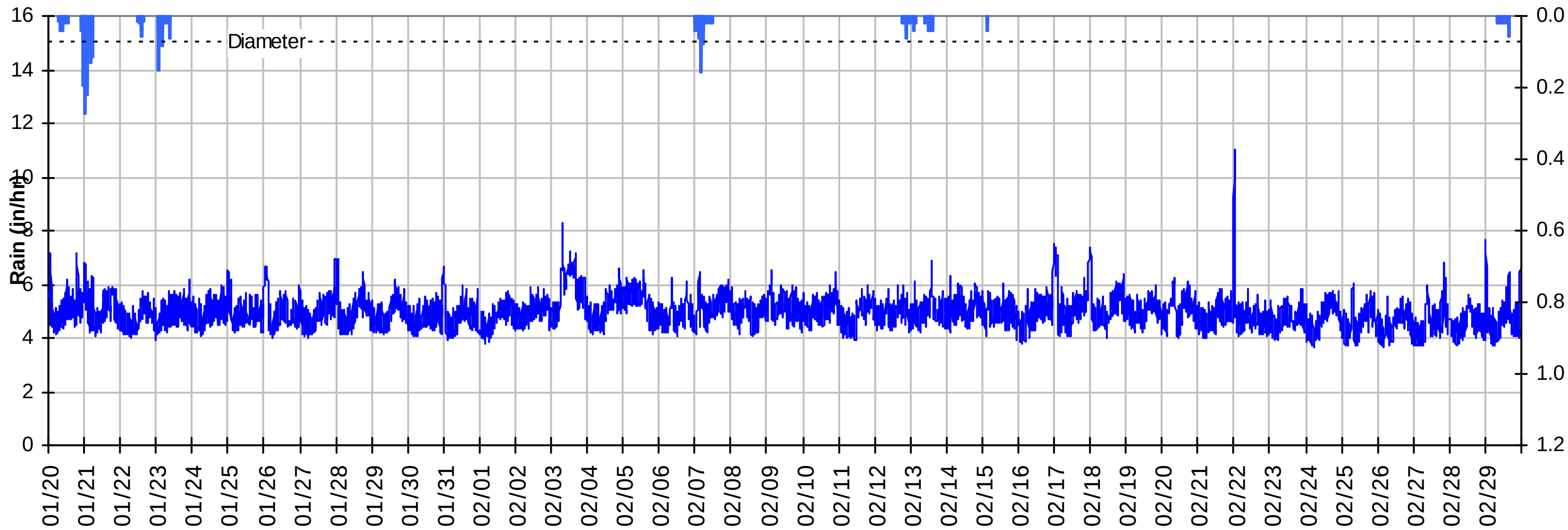


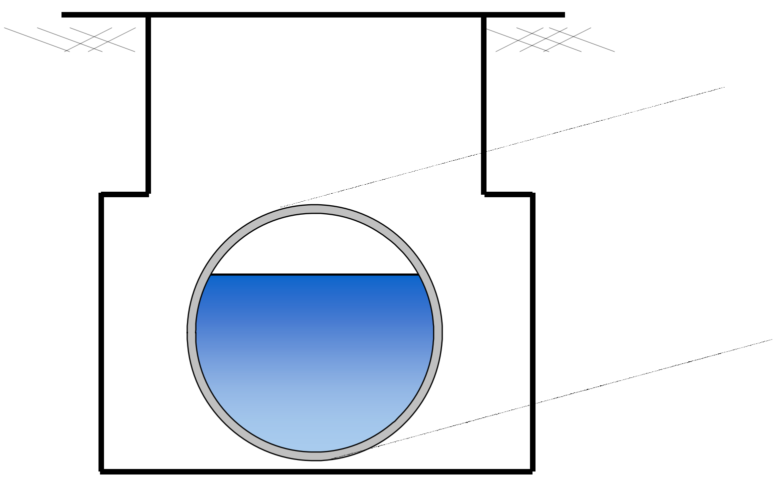
Baseline Flow:
0.051 *mgd*



SITE 9
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

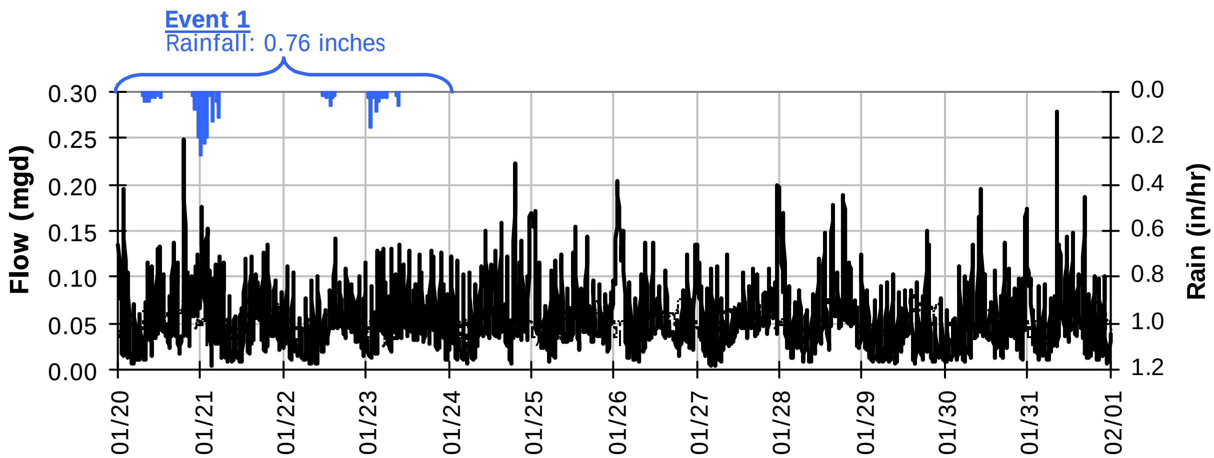




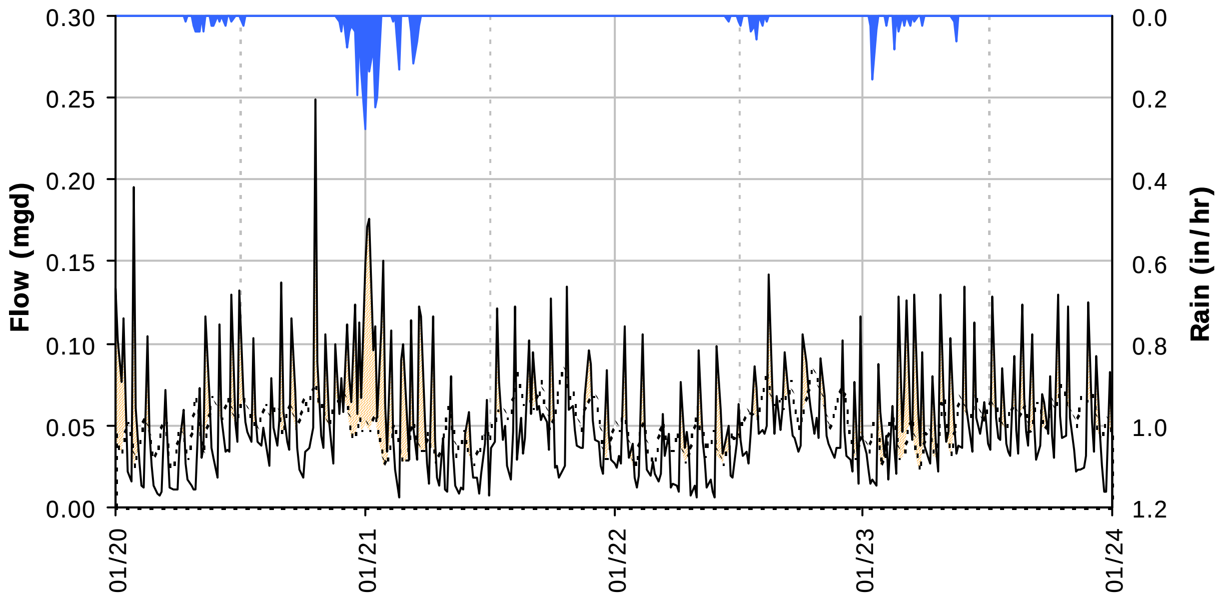
Pipe Diameter:	15	*inches*
Peak Measured Level:	11.0	*inches*
Peak d / D Ratio:	0.74	

SITE 9
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



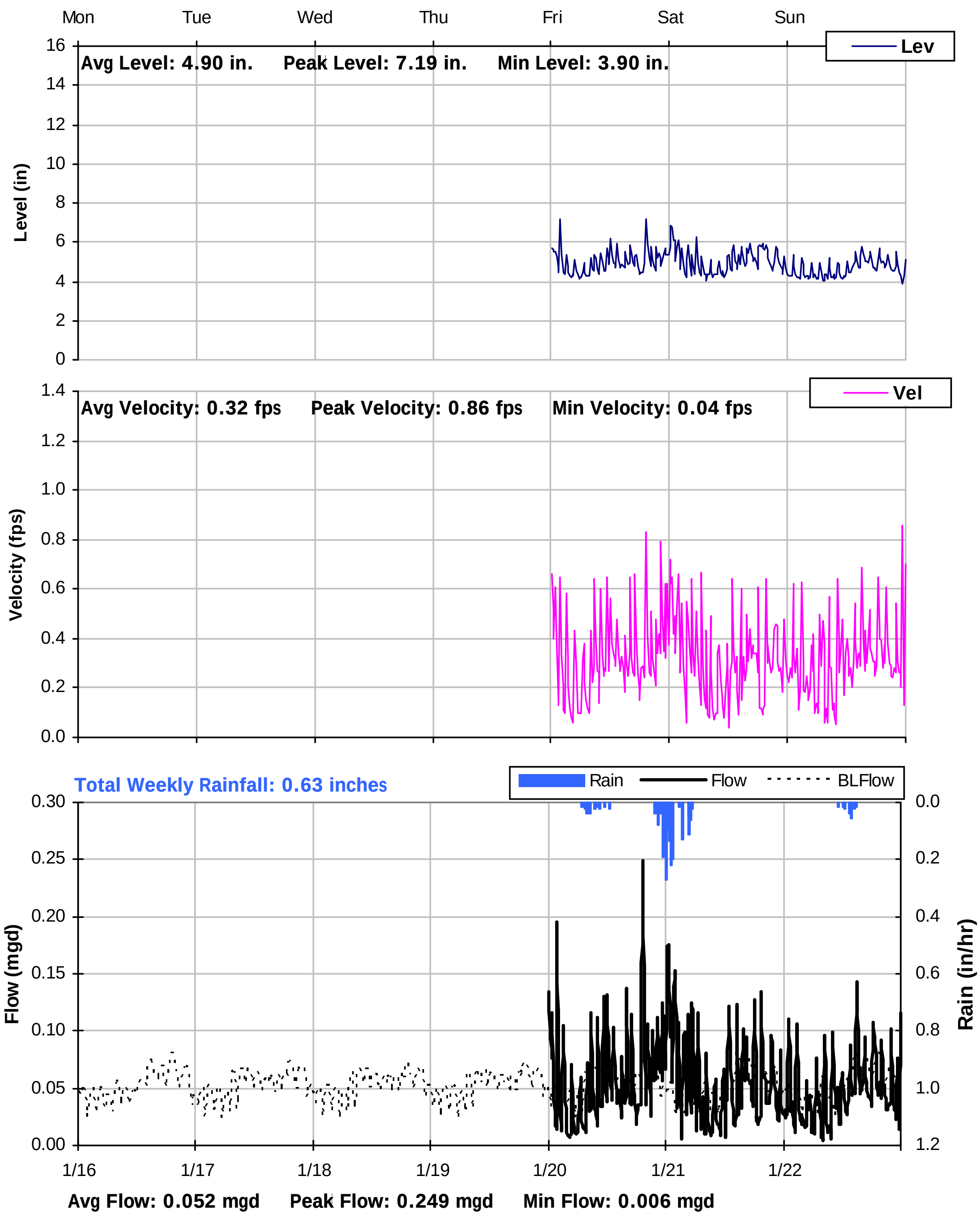
Event 1 Detail Graph



Storm Event I/I Analysis (Rain = 0.76 inches)

Capacity		Inflow		Combined I/I	
Peak Flow:	0.25 *mgd*	**Peak I/I Rate:**	0.17 *mgd*	**Total I/I:**	6,000 *gallons*
PF:	4.85	**Pk I/I:Acre:**	4,105 *gpd/acre*	**R-Value:**	0.7%
		Pk I/I:ADWF:	3.41	**Total I/I:ADWF:**	0.15 *per in-rain*
Peak Level:	7.17 *in*				
d/D Ratio:	0.48				

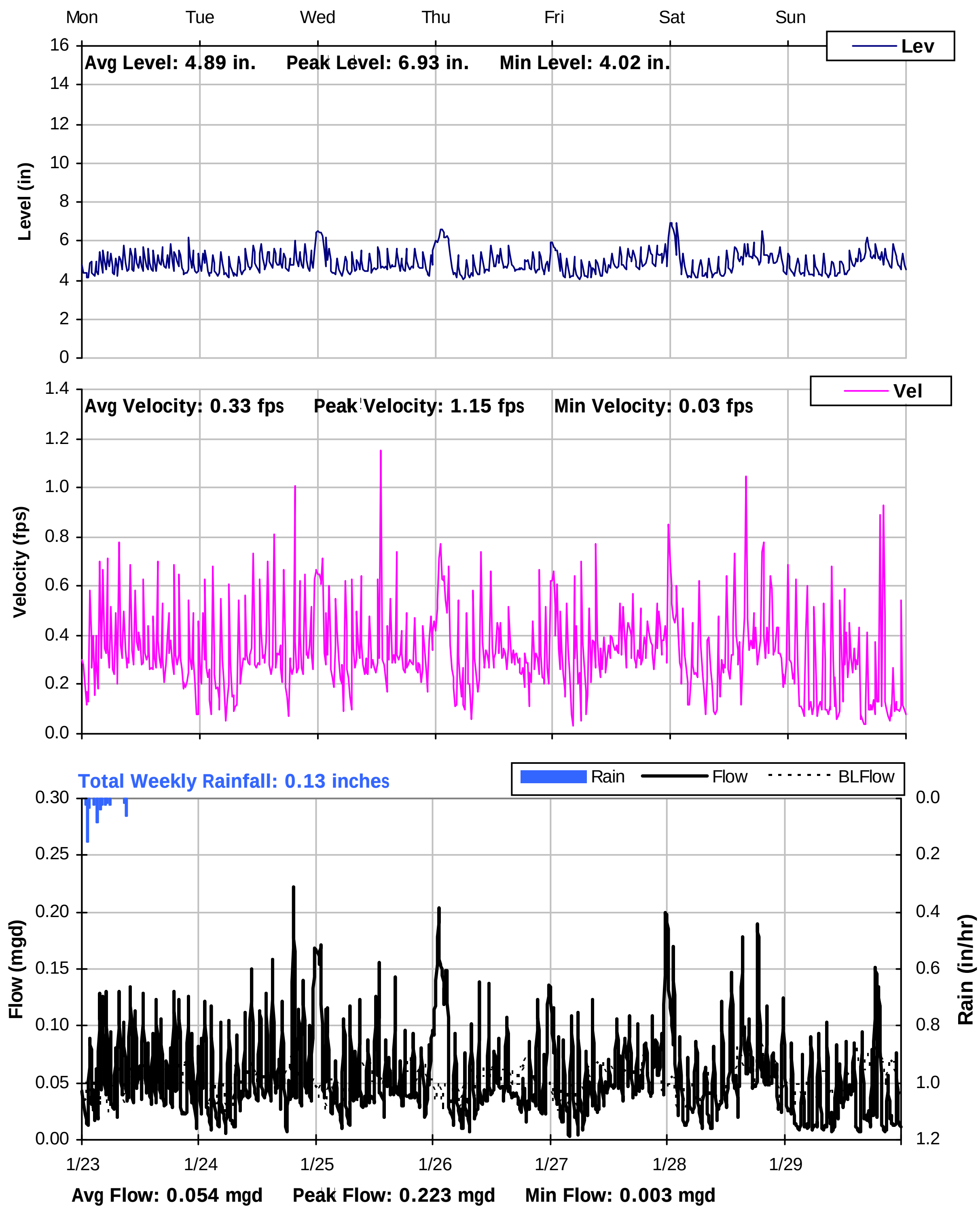
SITE 9
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



SITE 9

Weekly Level, Velocity and Flow Hydrographs

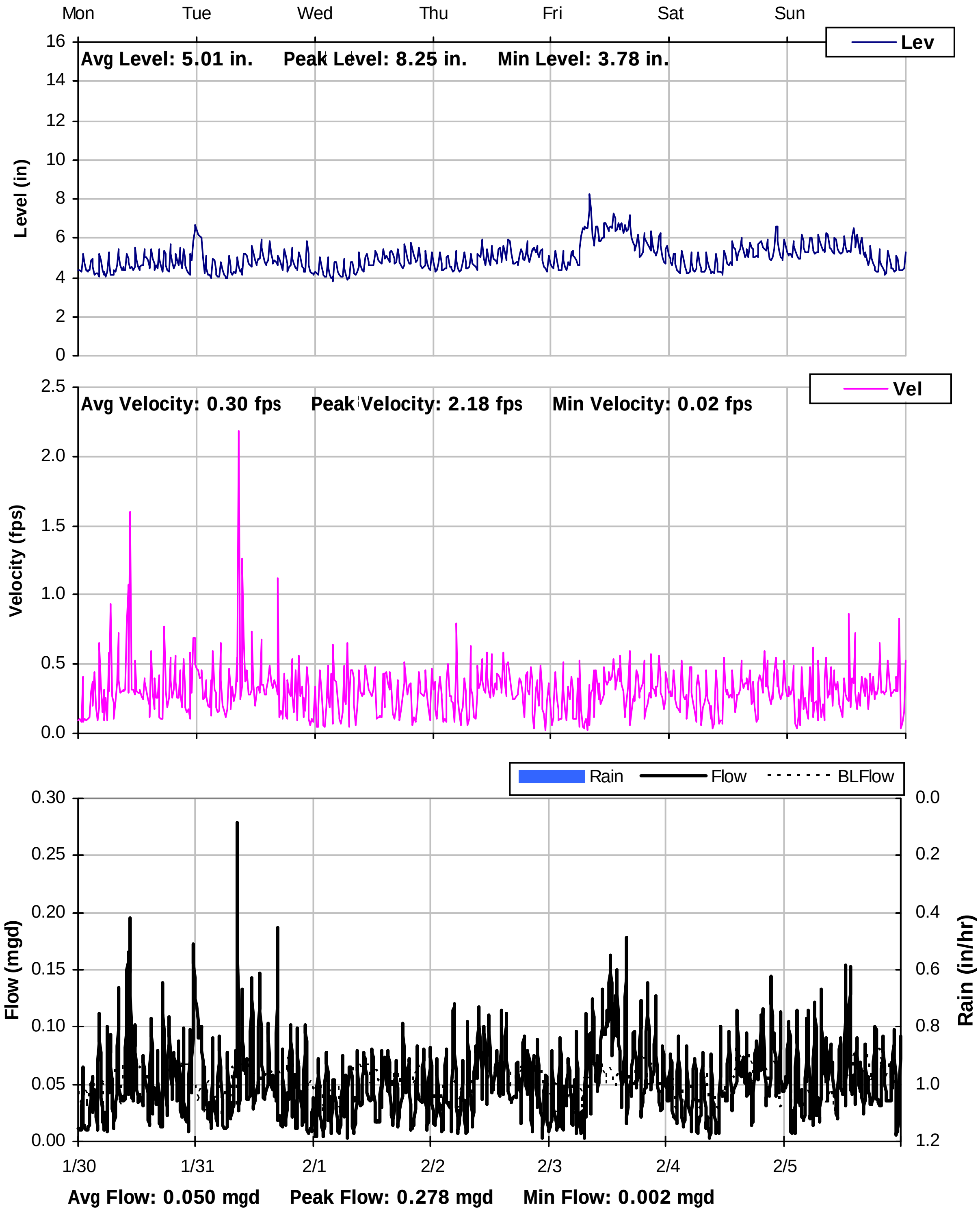
1/23/2012 to 1/30/2012



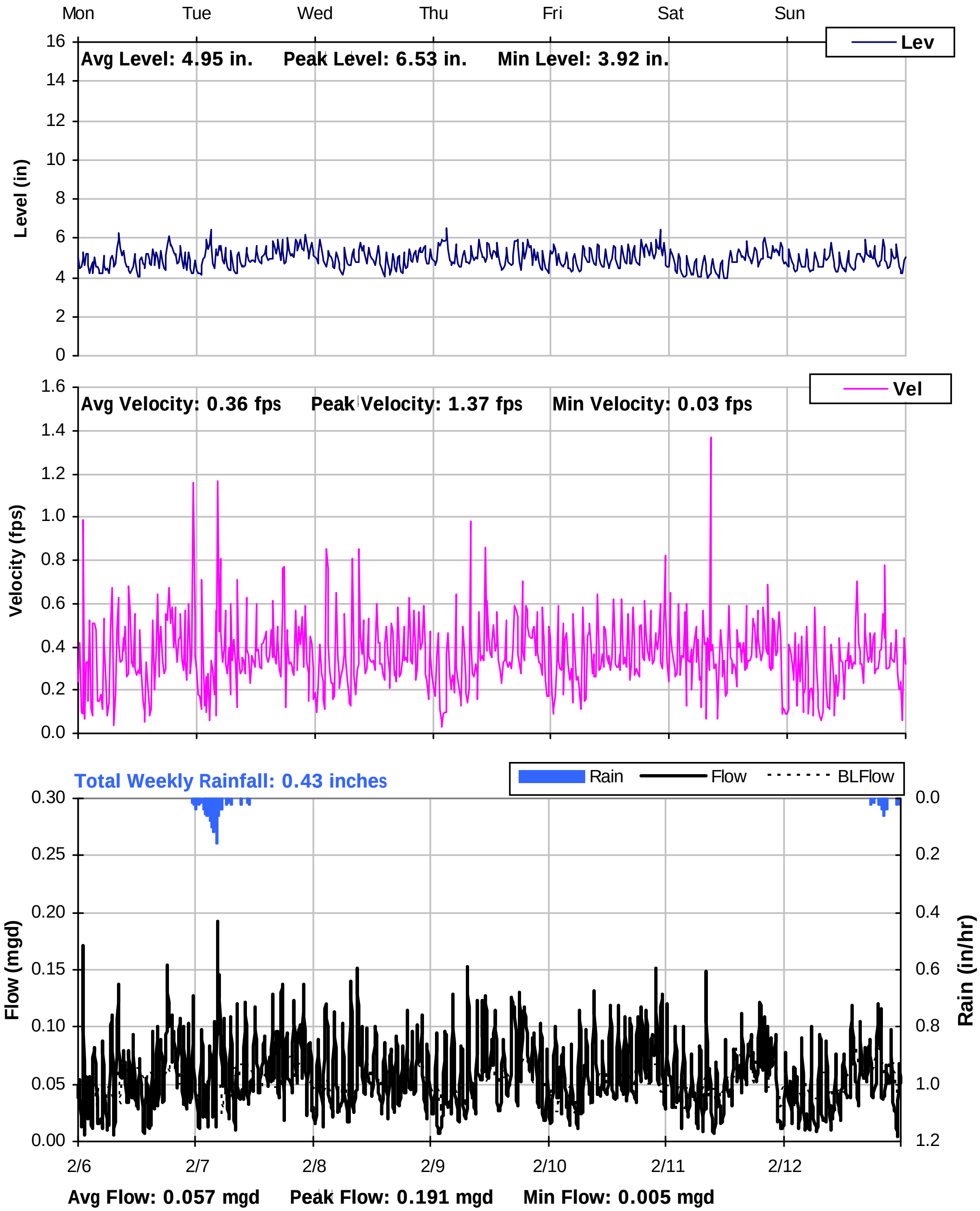
SITE 9

Weekly Level, Velocity and Flow Hydrographs

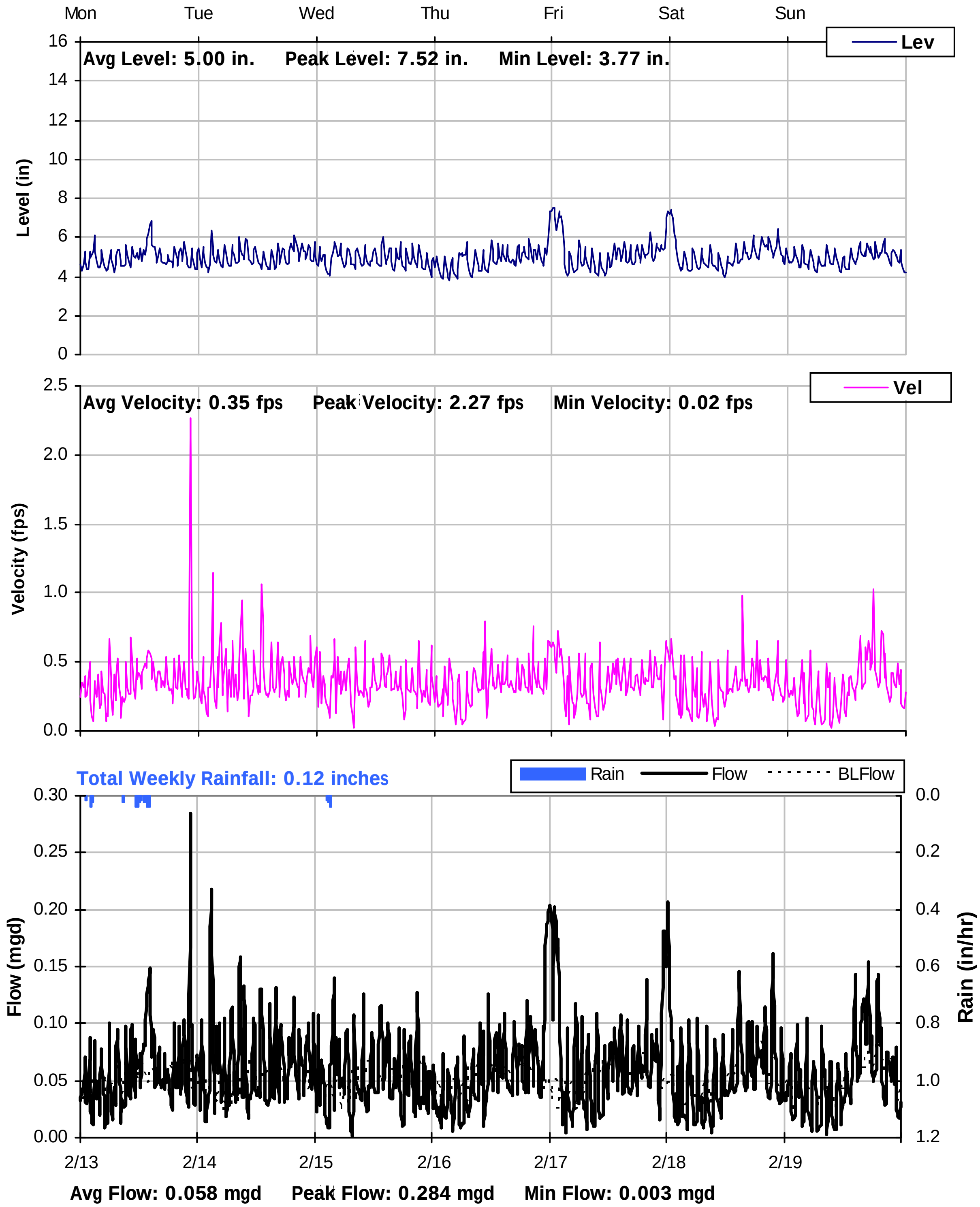
1/30/2012 to 2/6/2012



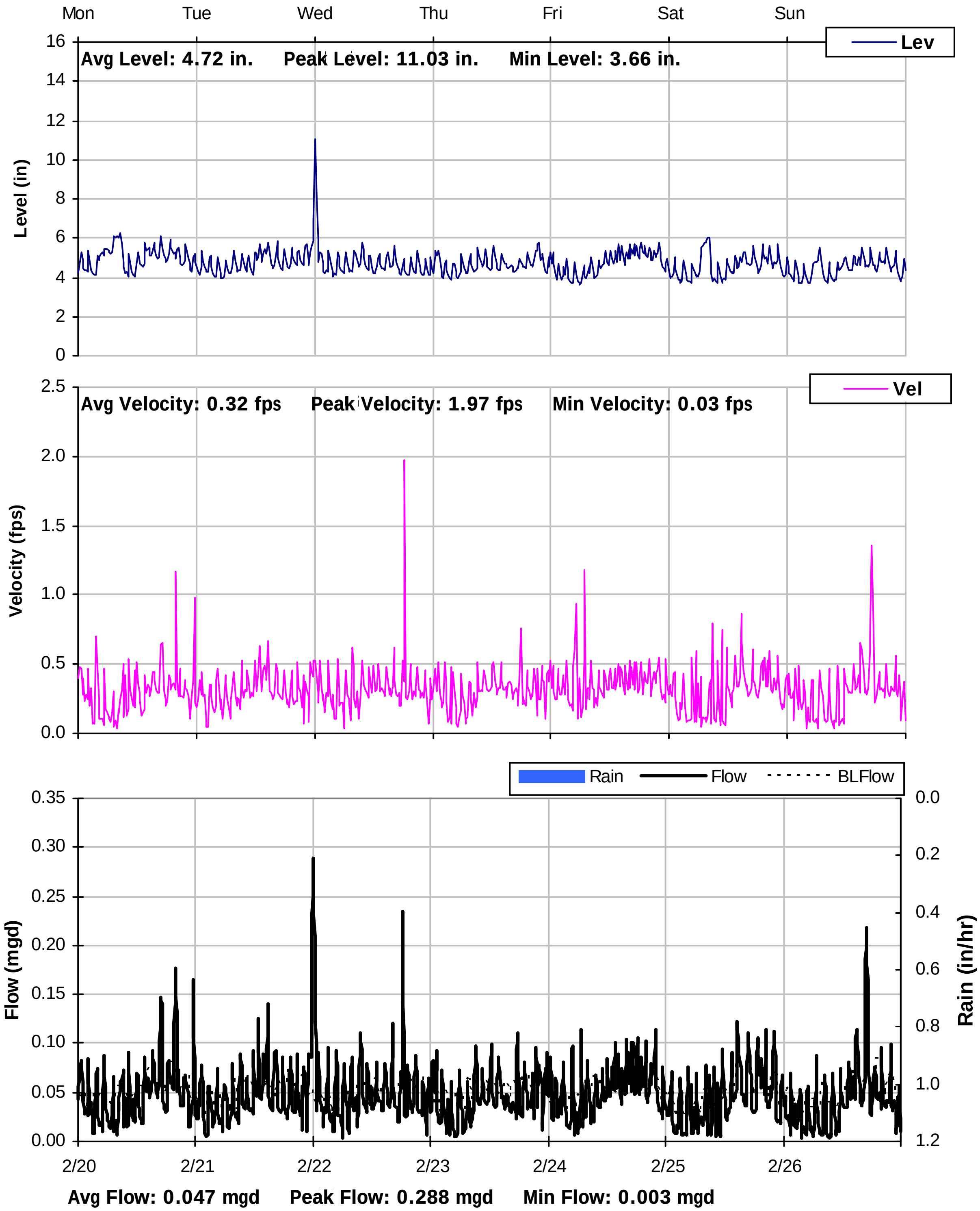
SITE 9
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



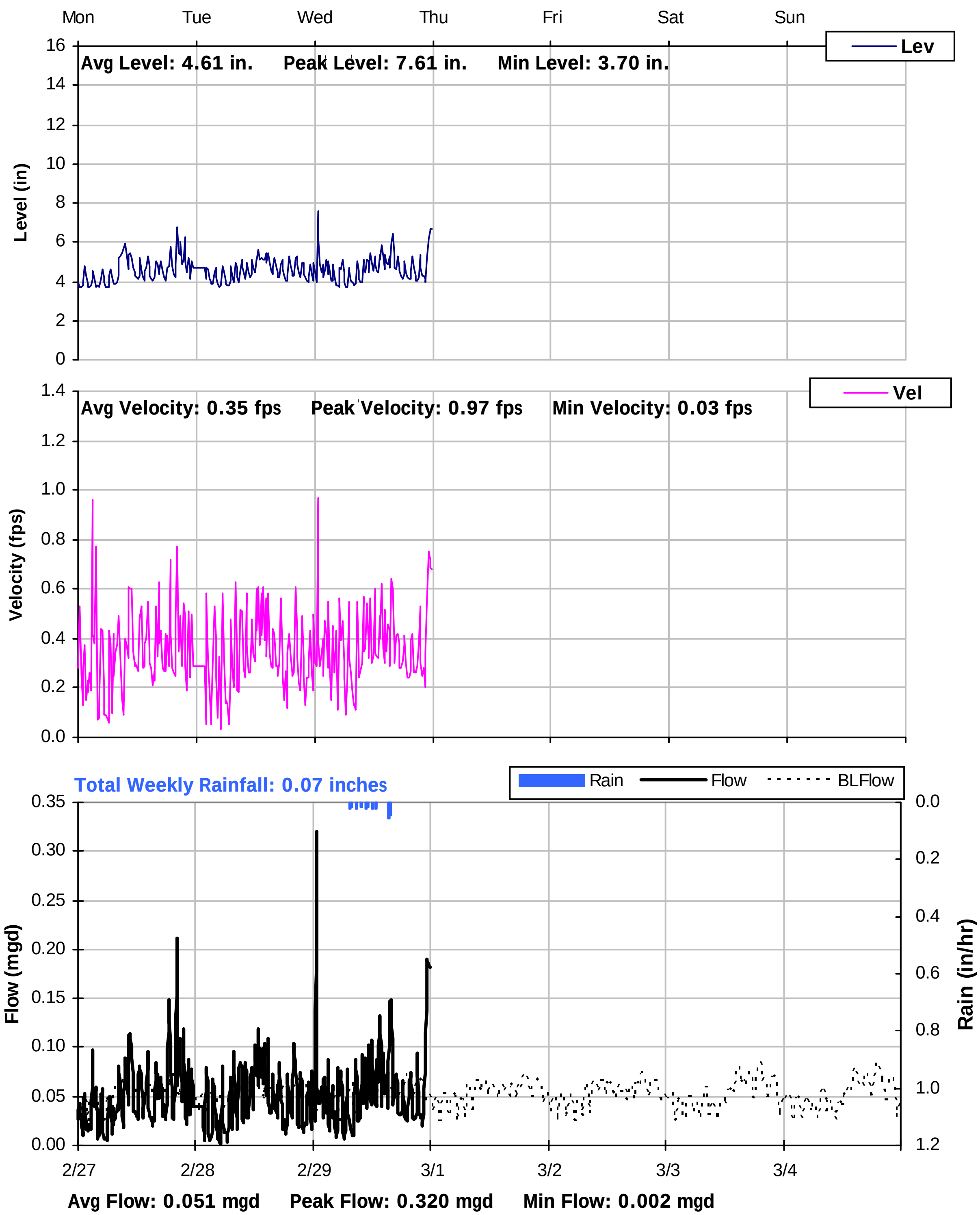
SITE 9
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012



SITE 9
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



SITE 9
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 10

Location: Fulkerth Road between Tully Road and Logan Lane

Data Summary Report

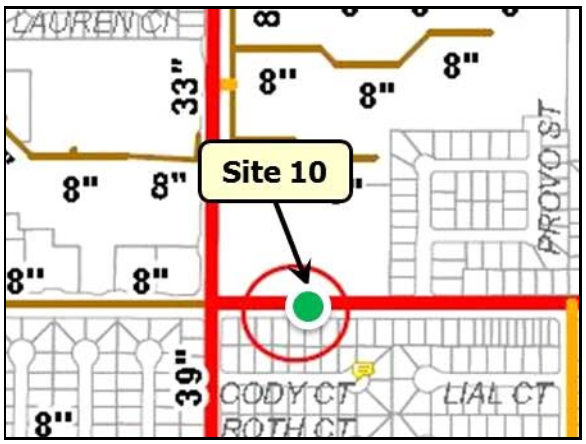
Vicinity Map: Site 10

SITE 10

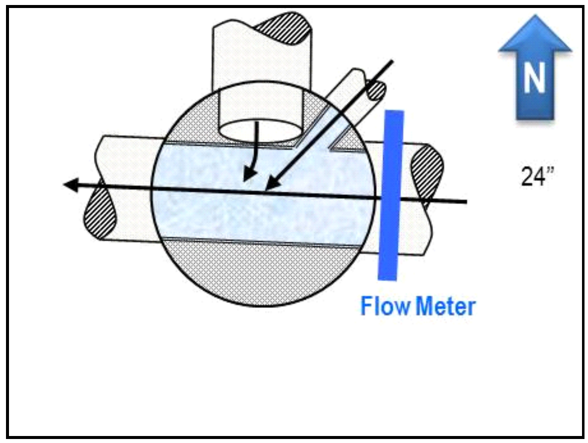
Site Information

Location:	Fulkerth Road between Tully Road and Logan Lane
Coordinates:	120.8705° W, 37.5073° N
Rim Elevation:	99 feet
Pipe Diameter:	24 inches
Baseline Flow:	1.147 mgd
Peak Measured Flow:	1.679 mgd

Satellite Map



Sewer Map



Flow Sketch

Street View

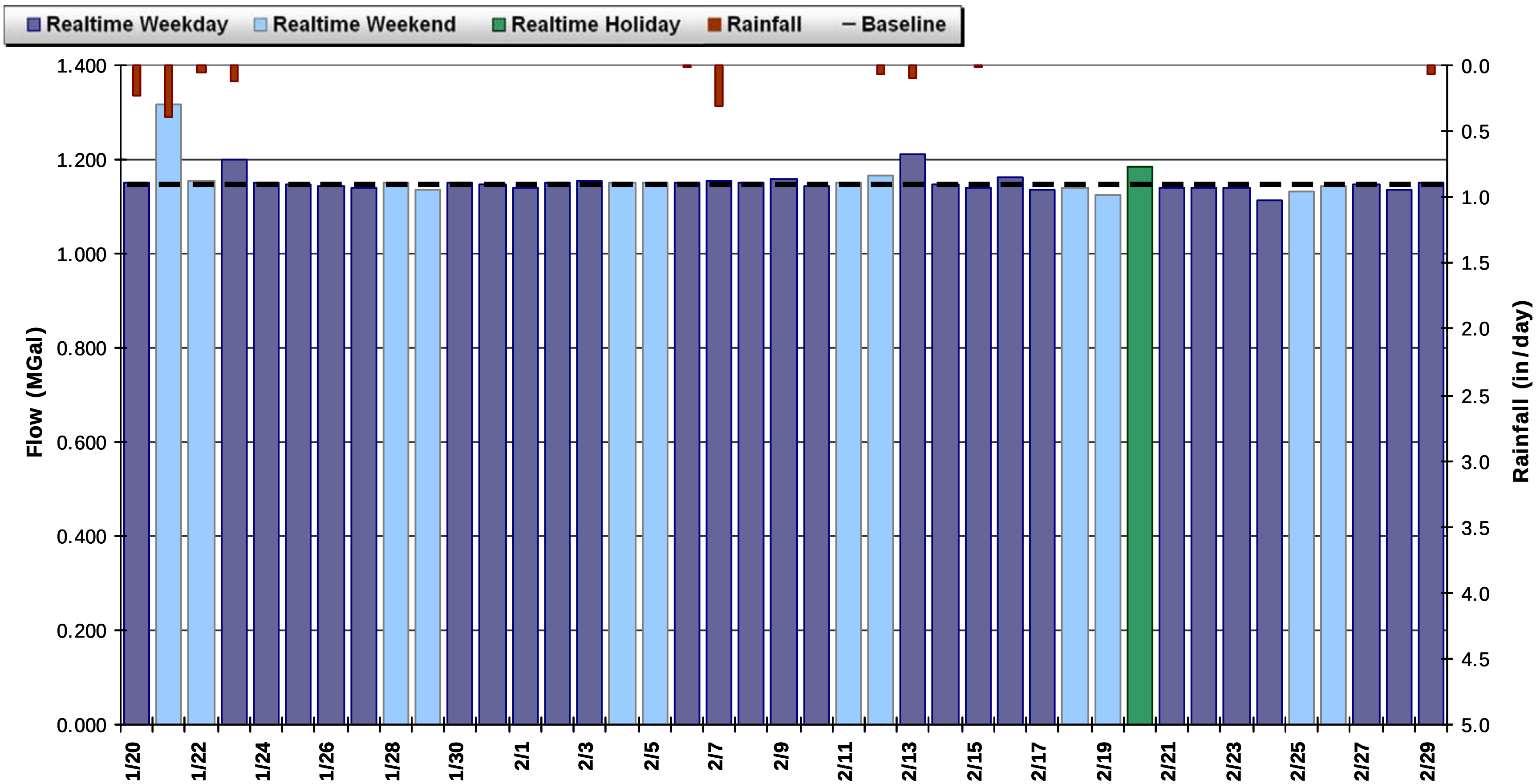
Plan View

SITE 10

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 1.154 MGal **Peak Daily Flow: 1.318 MGal** **Min Daily Flow: 1.111 MGal**

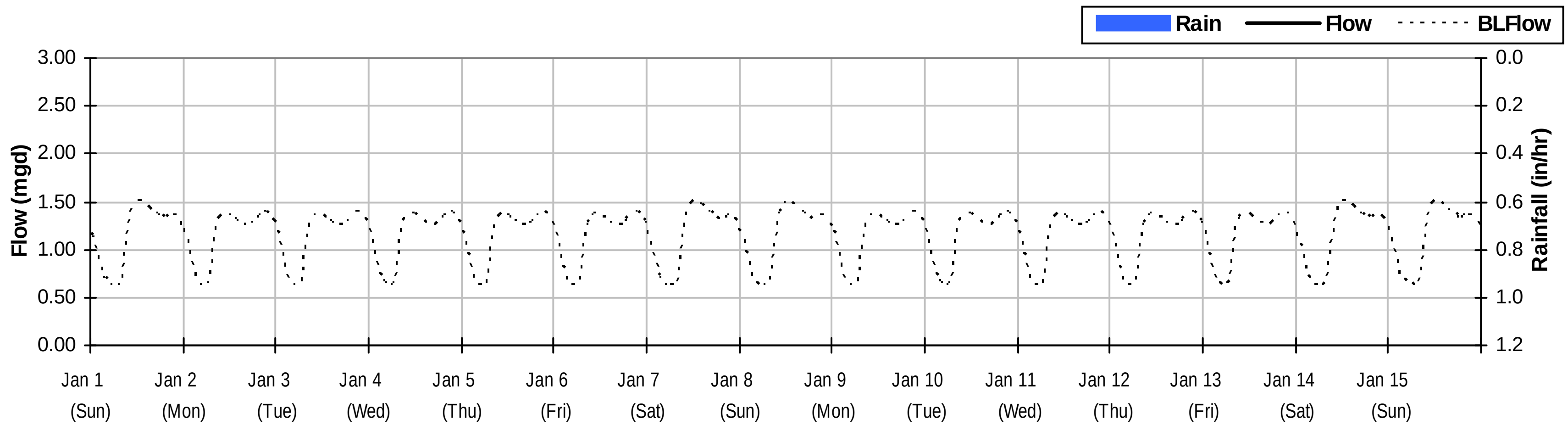
Total Period Rainfall: 1.37 inches

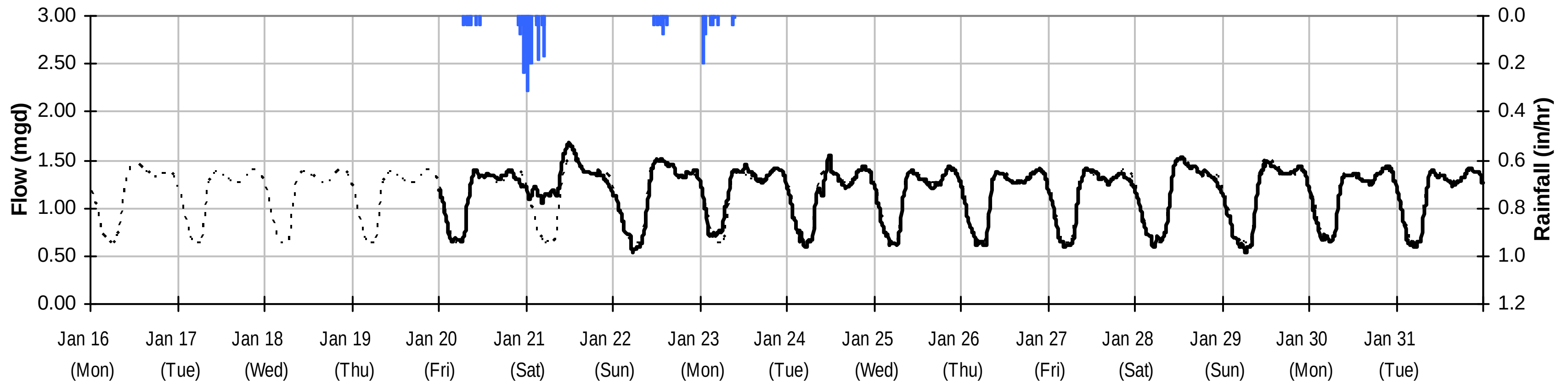


SITE 10

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.8 inches **Avg Flow: 1.165 mgd** **Peak Flow: 1.679 mgd** **Min Flow: 0.535 mgd**

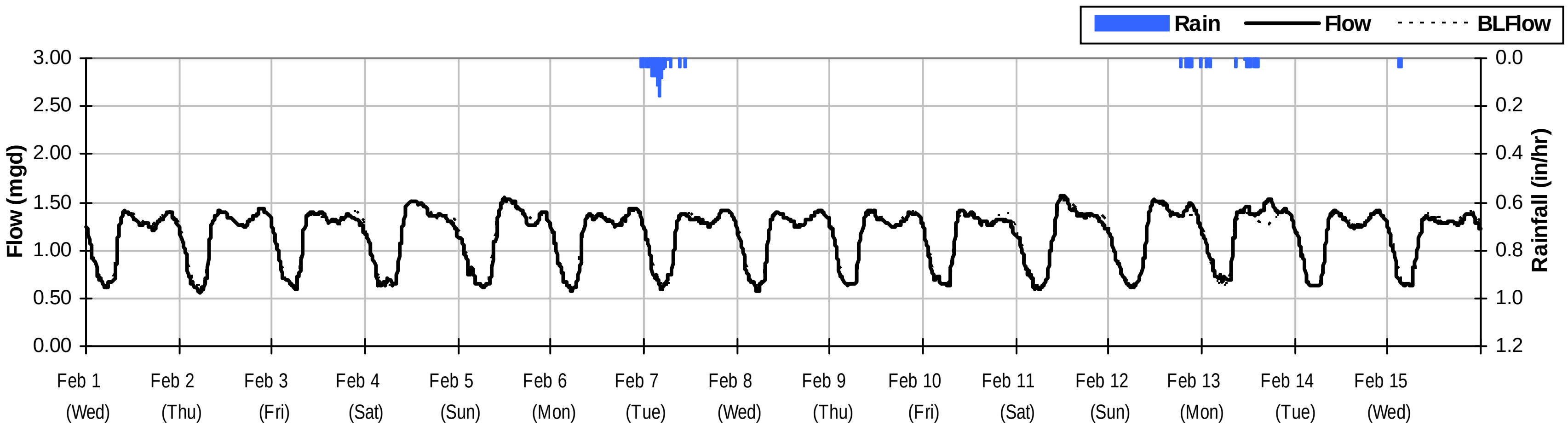


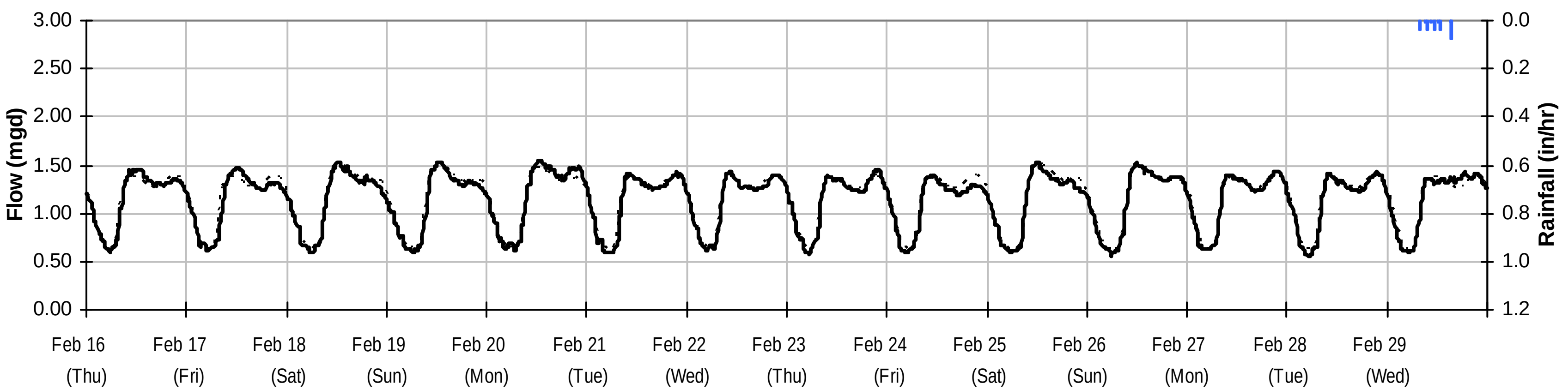


SITE 10

Monthly Flow Summary: February, 2012

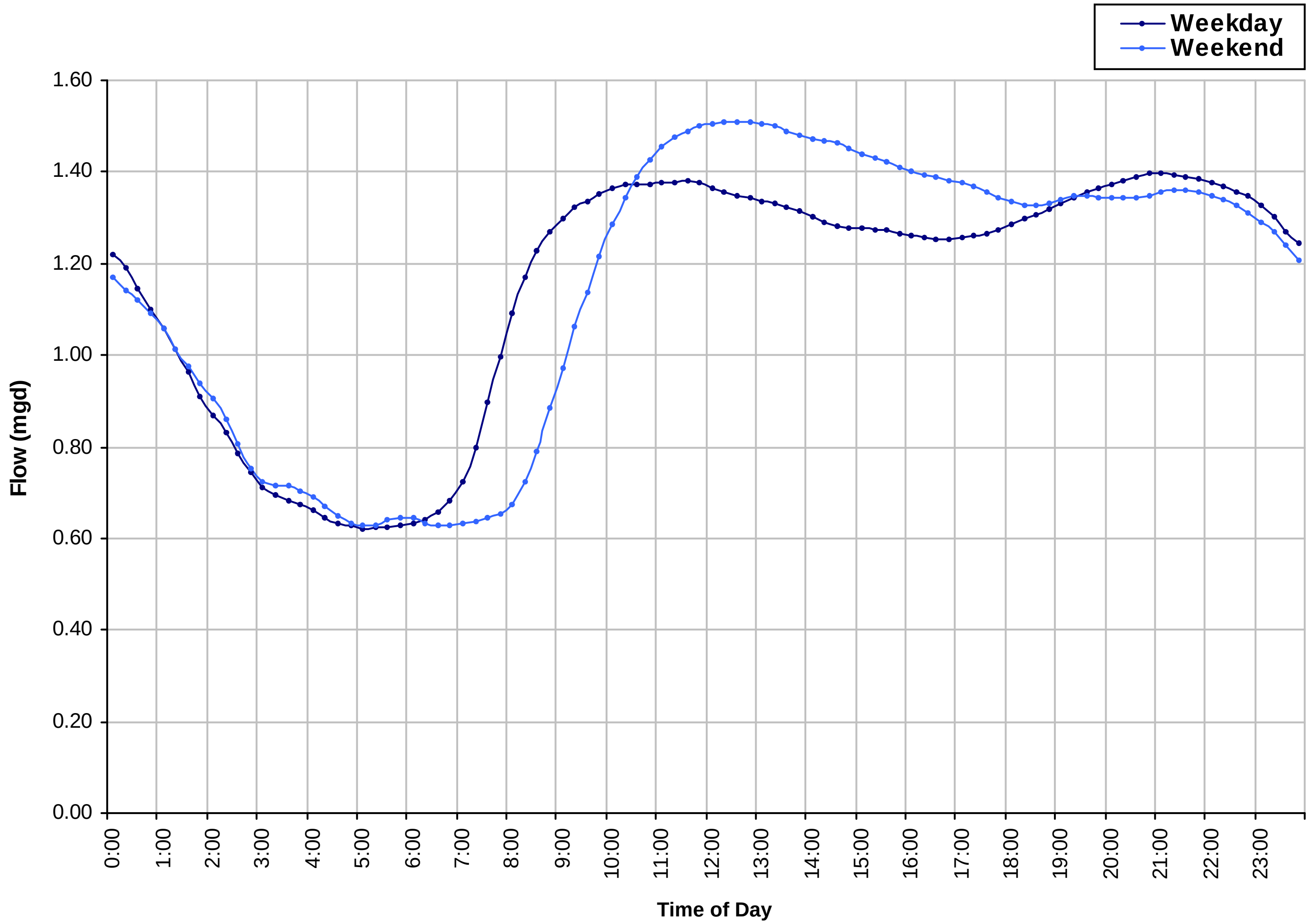
Total Monthly Rainfall: 0.57 inches **Avg Flow: 1.149 mgd** **Peak Flow: 1.568 mgd** **Min Flow: 0.549 mgd**



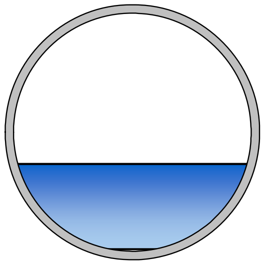


SITE 10

Baseline Flow Hydrographs

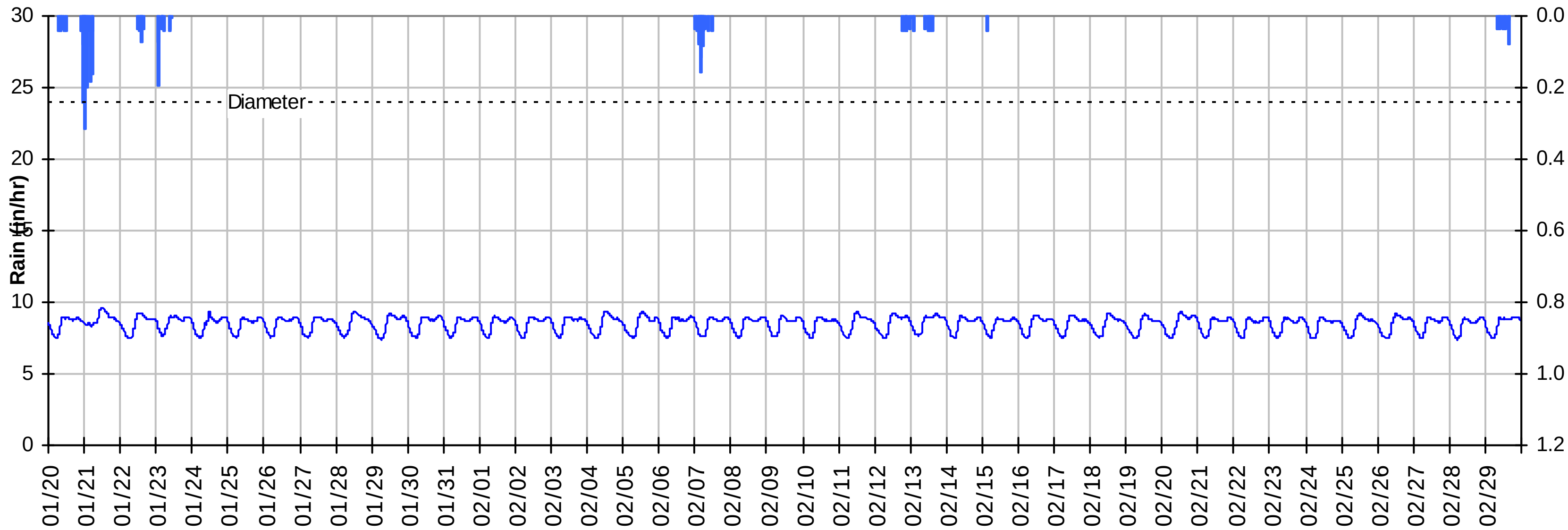


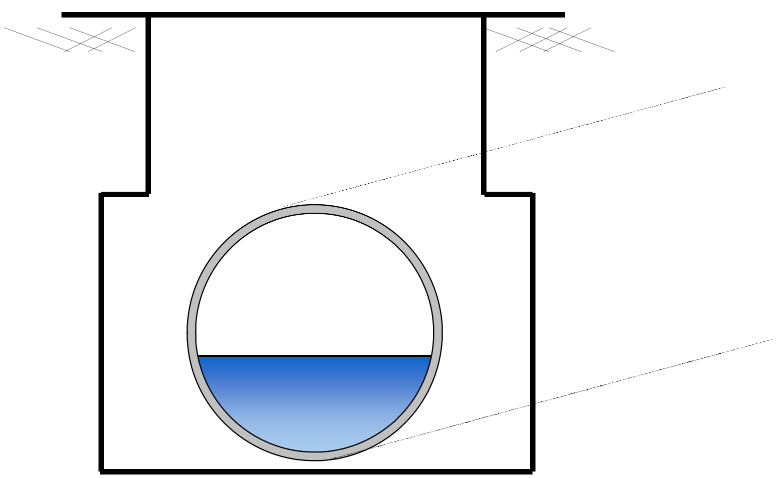
Baseline Flow:
1.147 *mgd*



SITE 10
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period

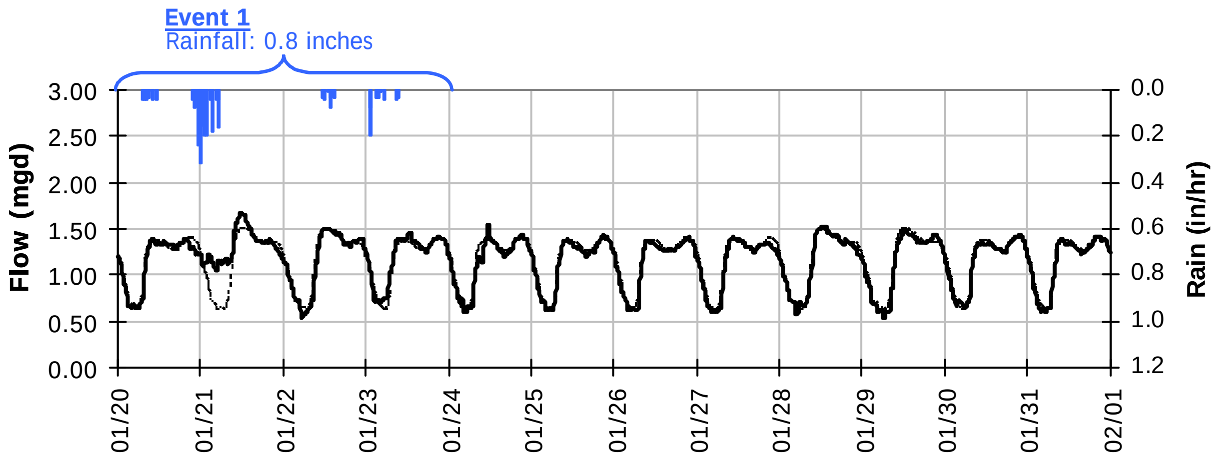




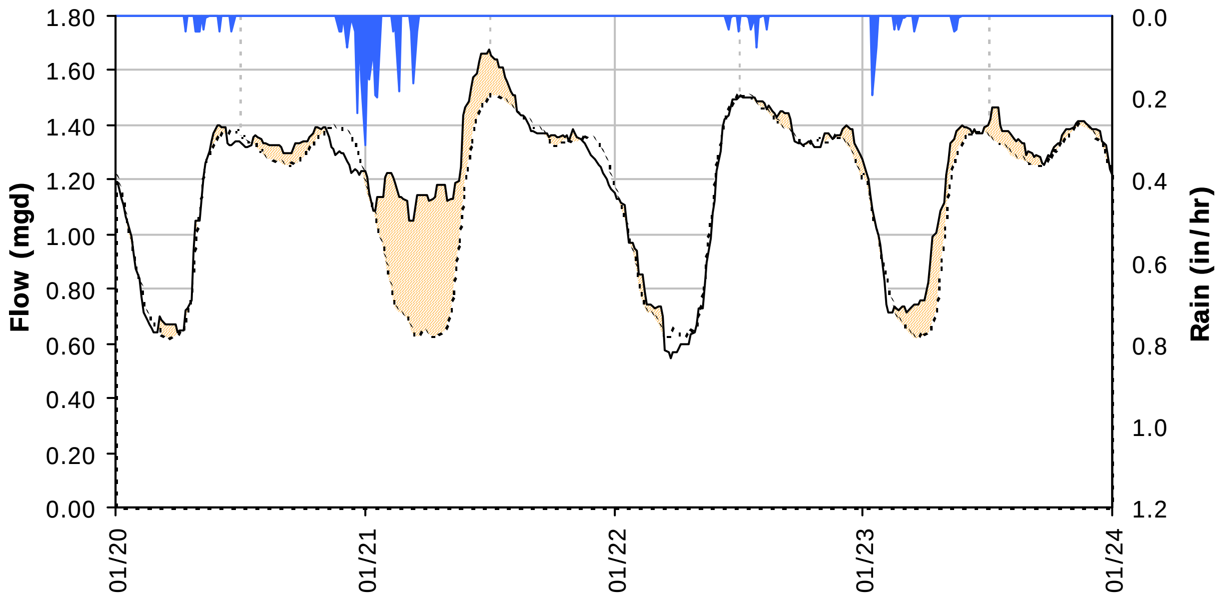
Pipe Diameter:	24	*inches*
Peak Measured Level:	9.58	*inches*
Peak d/D Ratio:	0.40	

SITE 10
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



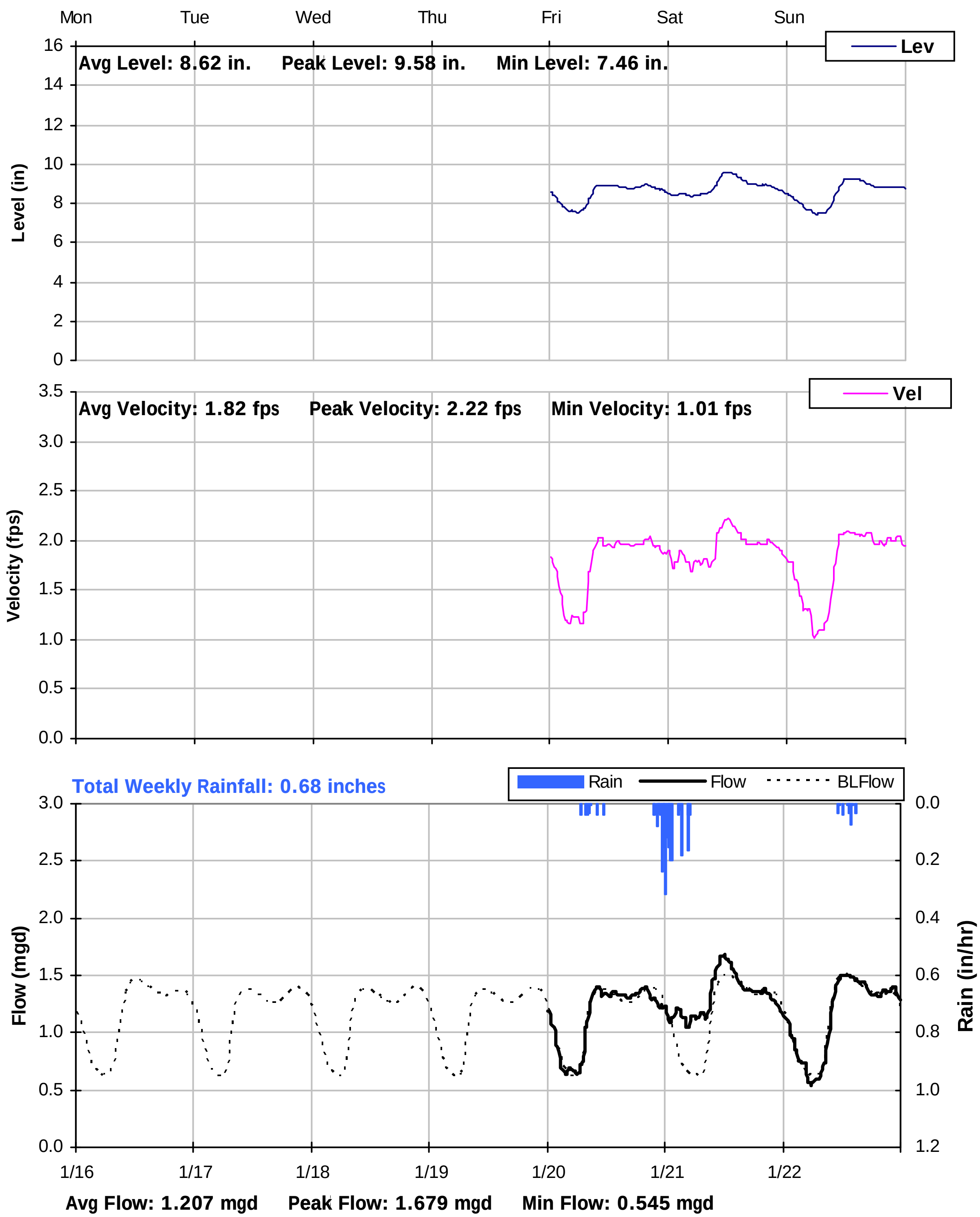
Event 1 Detail Graph



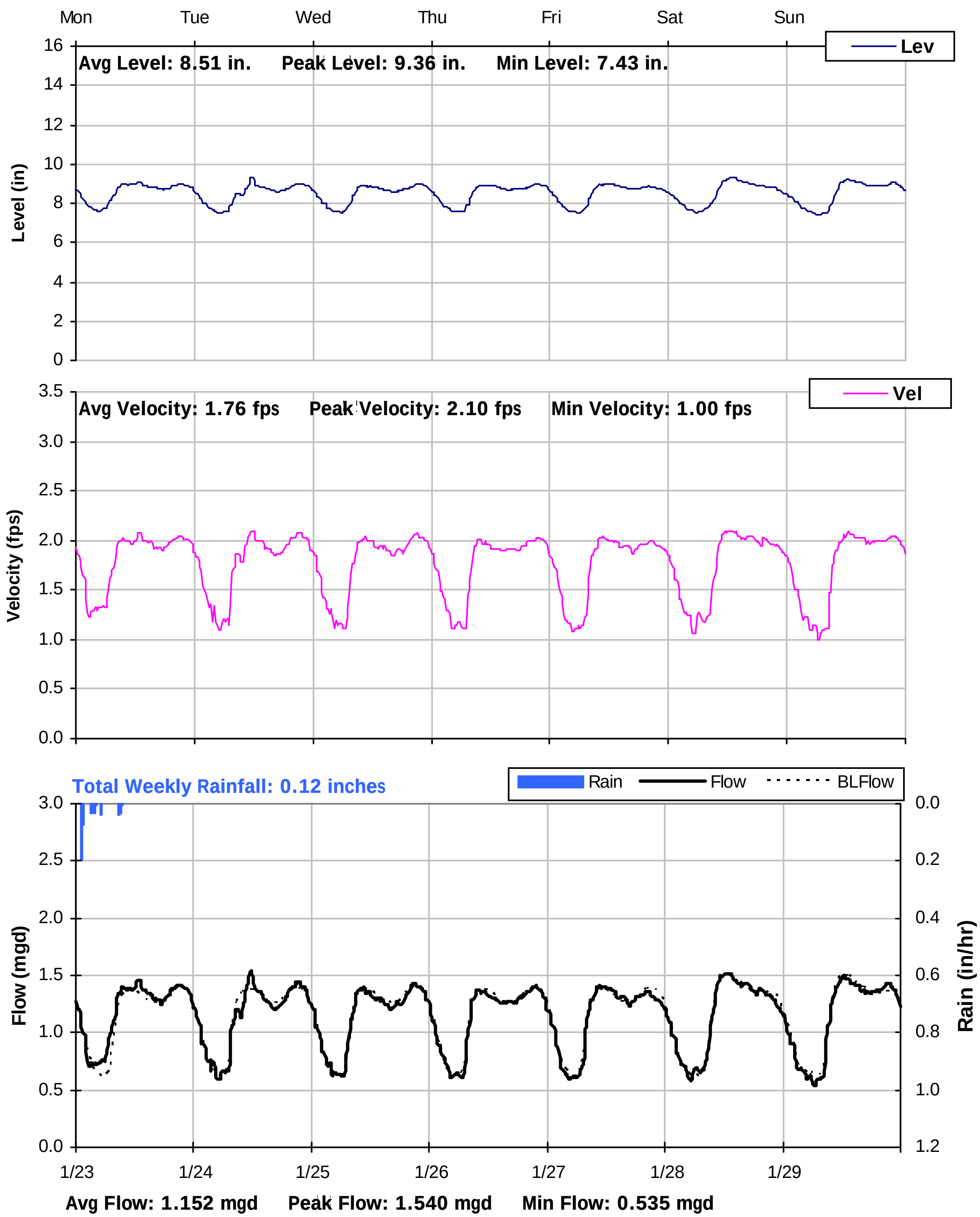
Storm Event I/I Analysis (Rain = 0.80 inches)

Capacity		Inflow		Combined I/I	
Peak Flow:	1.68 *mgd*	**Peak I/I Rate:**	0.55 *mgd*	**Total I/I:**	230,000 *gallons*
PF:	1.46	**Pk I/I:Acre:**	362 *gpd/acre*	**R-Value:**	0.7%
Peak Level:	9.58 *in*	**Pk I/I:ADWF:**	0.48	**Total I/I:ADWF:**	0.25 *per in-rain*
d/D Ratio:	0.40				

SITE 10
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



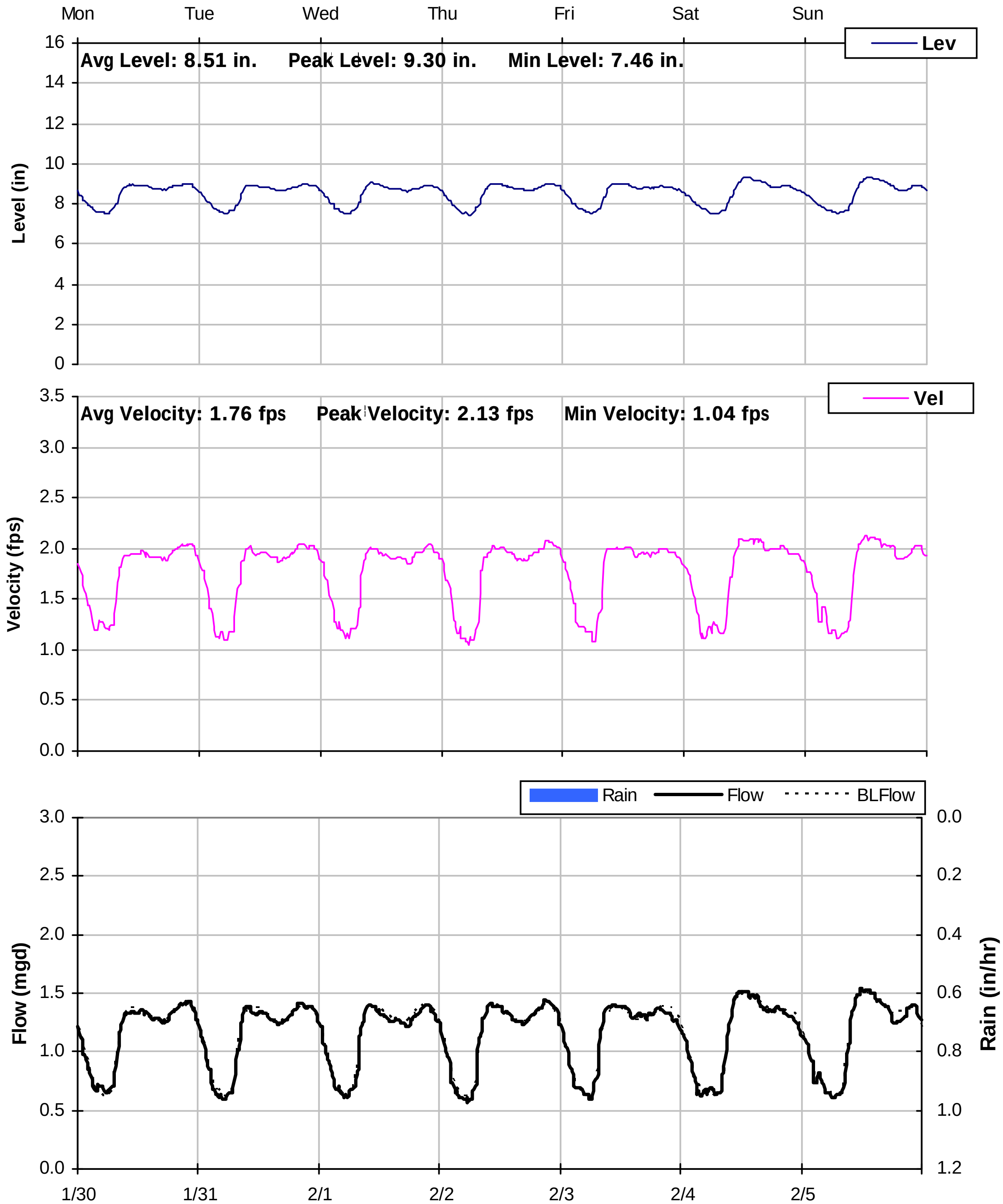
SITE 10
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



SITE 10

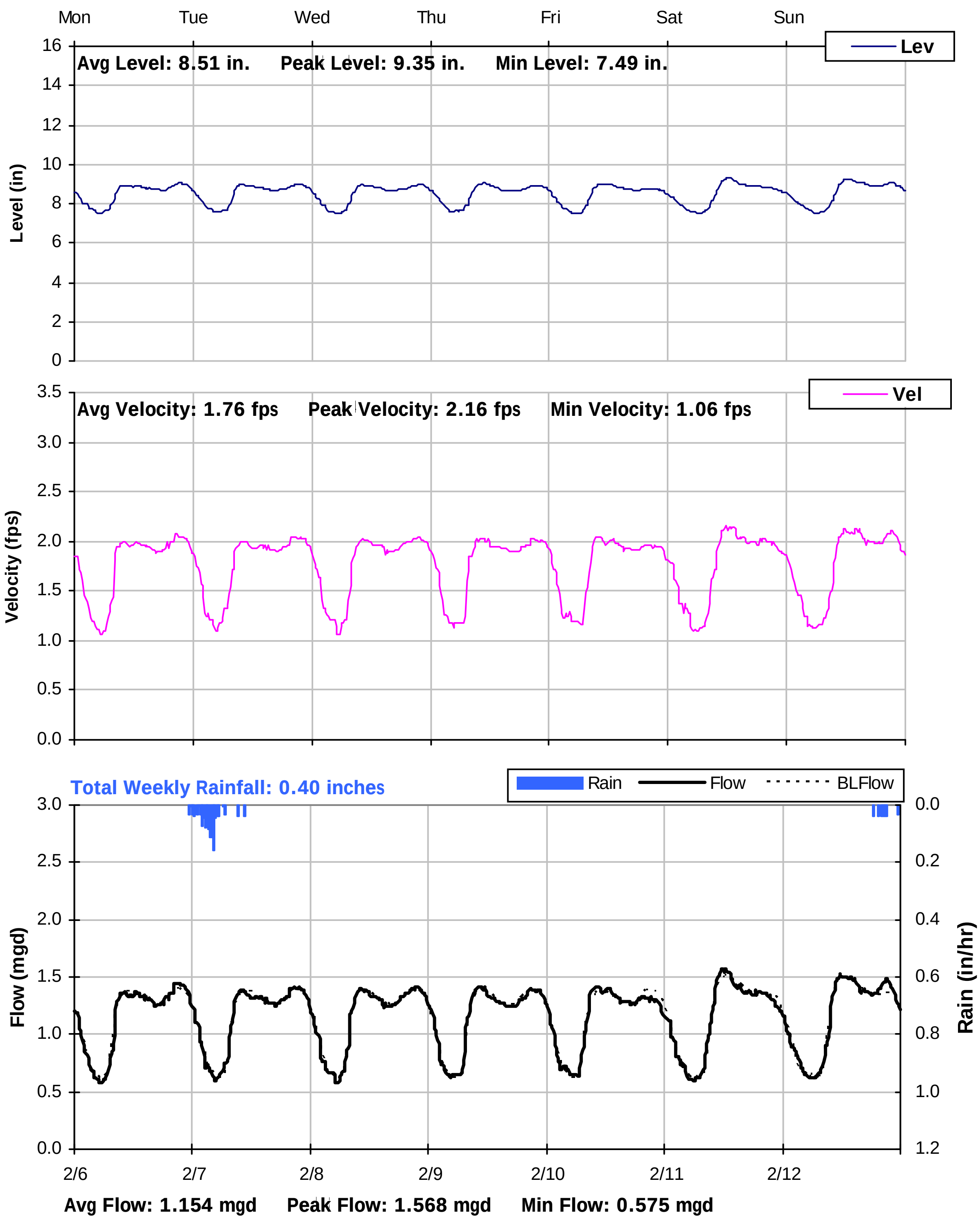
Weekly Level, Velocity and Flow Hydrographs

1/30/2012 to 2/6/2012

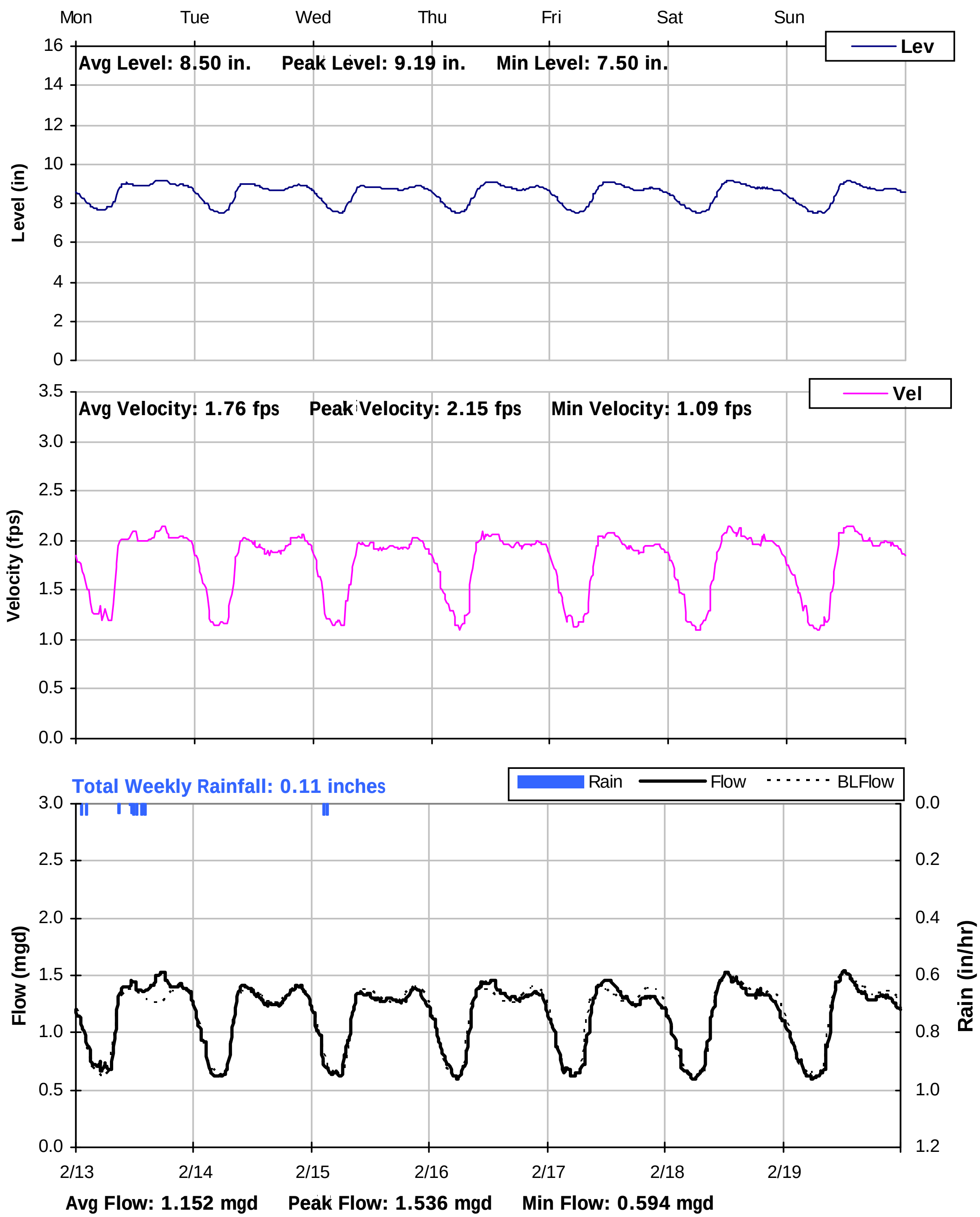


Avg Flow: 1.149 mgd **Peak Flow: 1.548 mgd** **Min Flow: 0.560 mgd**

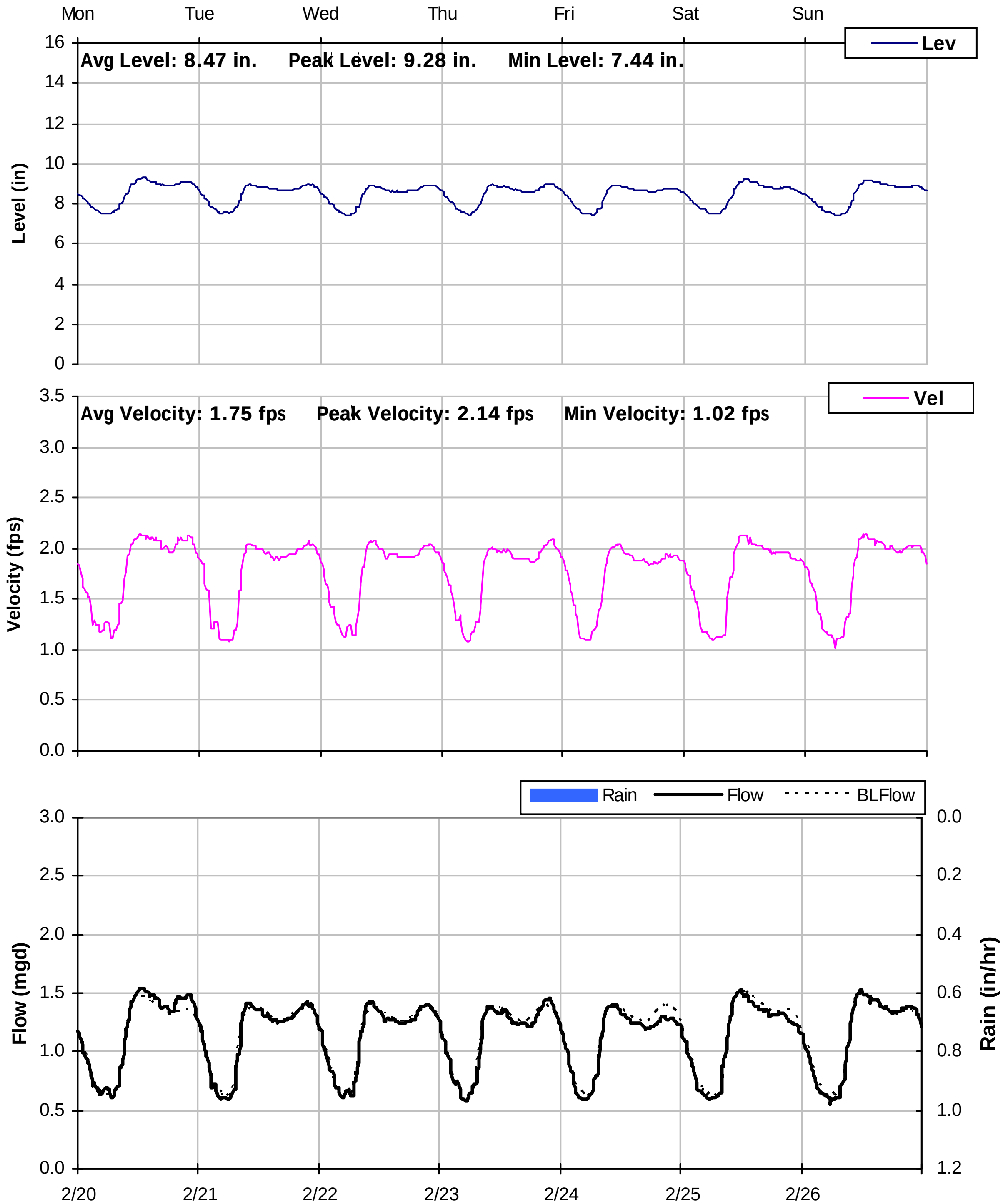
SITE 10
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



SITE 10
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012

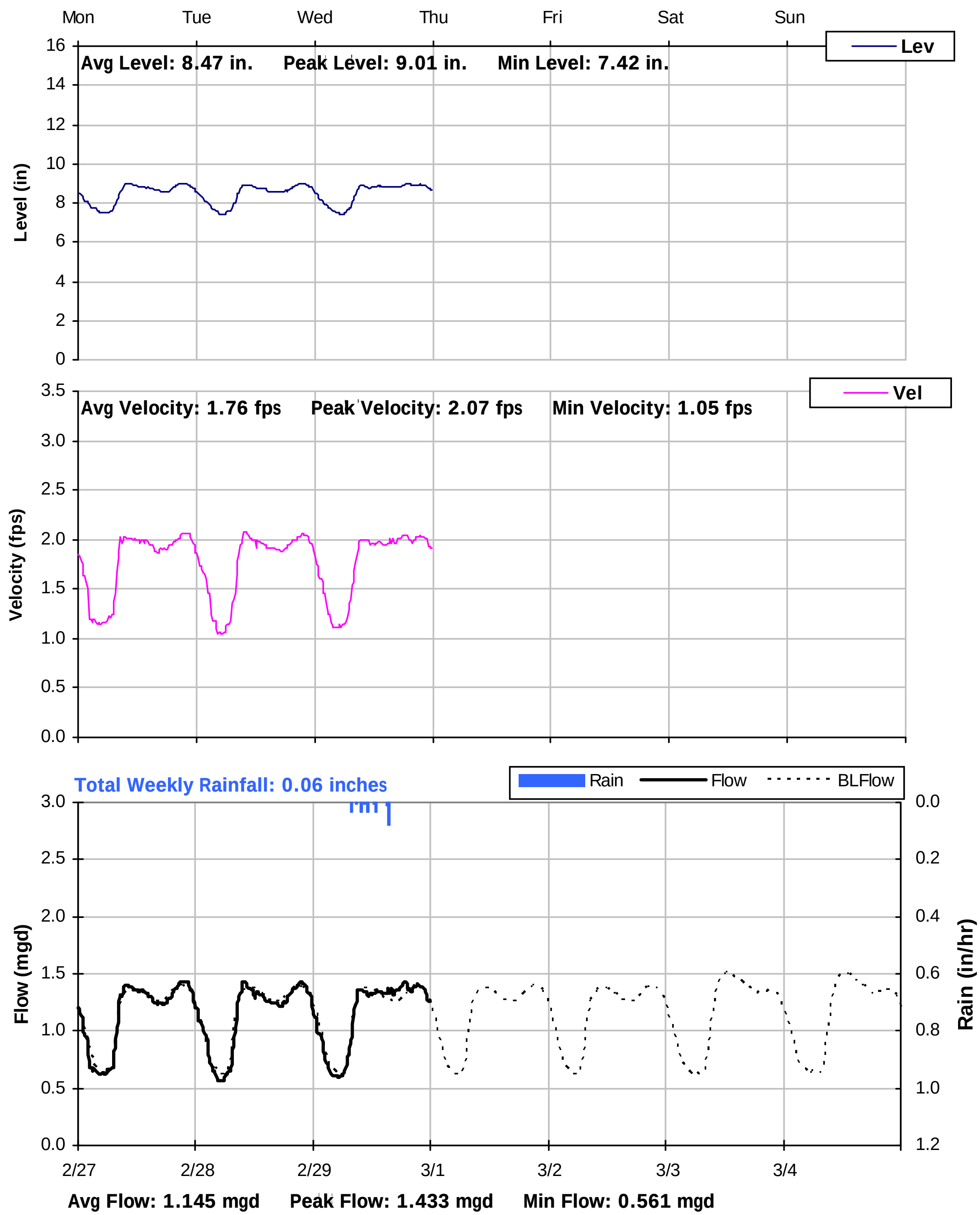


SITE 10
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



Avg Flow: 1.141 mgd **Peak Flow: 1.544 mgd** **Min Flow: 0.549 mgd**

SITE 10
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



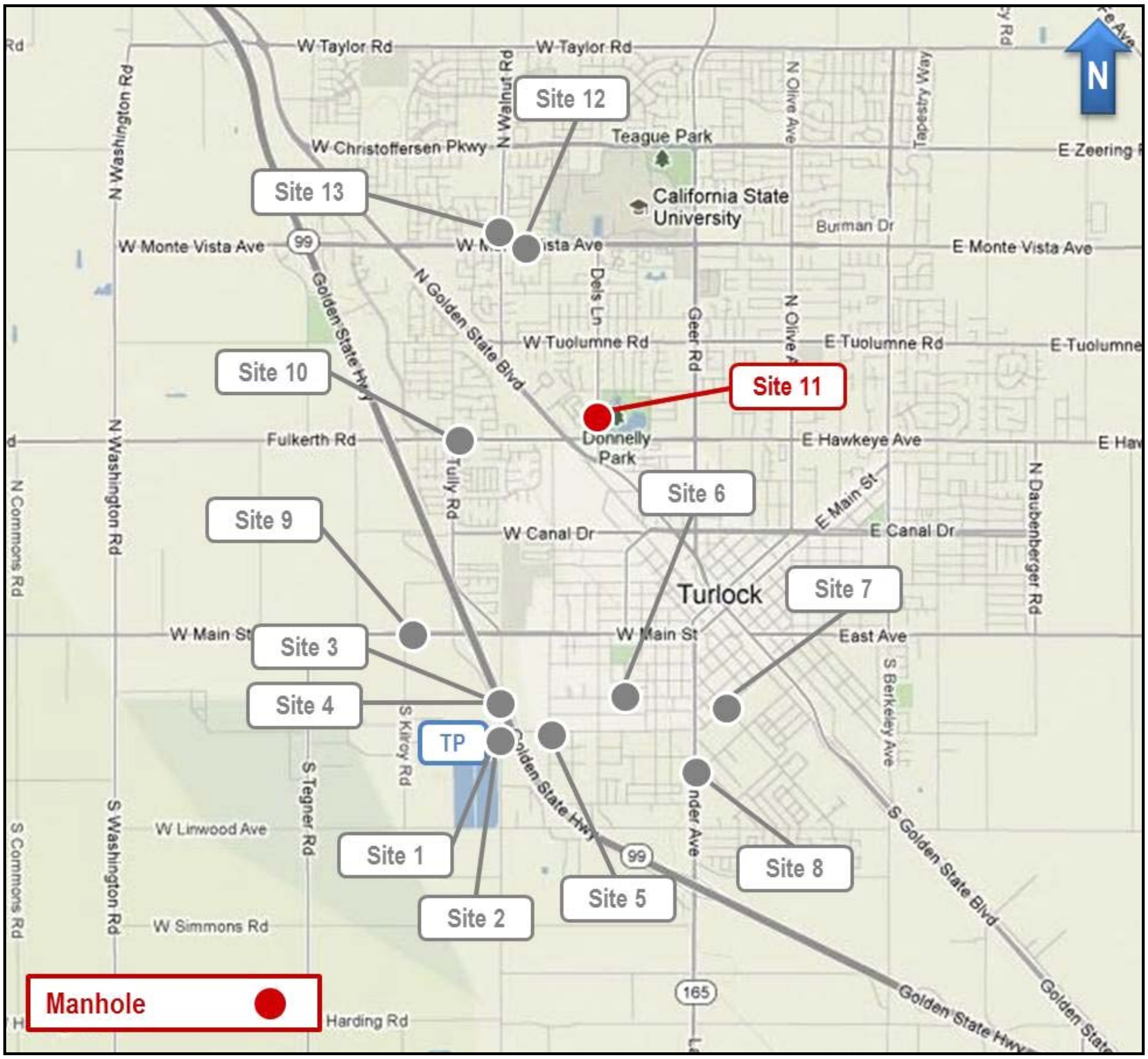
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 11

Location: Dels Lane between Pedras Road and Hawkeye Avenue

Data Summary Report



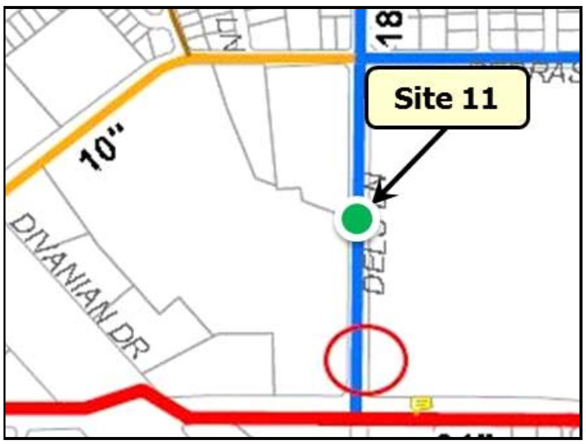
Vicinity Map: Site 11

SITE 11

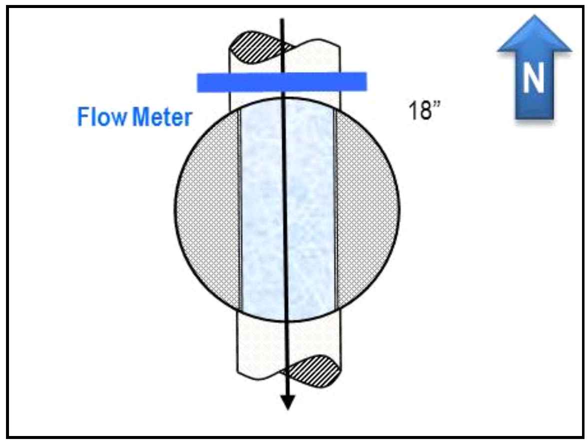
Site Information

Location:	Dels Lane between Pedras Road and Hawkeye Avenue
Coordinates:	120.8581° W, 37.5093° N
Rim Elevation:	103 feet
Pipe Diameter:	18 inches
Baseline Flow:	0.614 mgd
Peak Measured Flow:	1.232 mgd

Satellite Map



Sewer Map



Flow Sketch

Street View

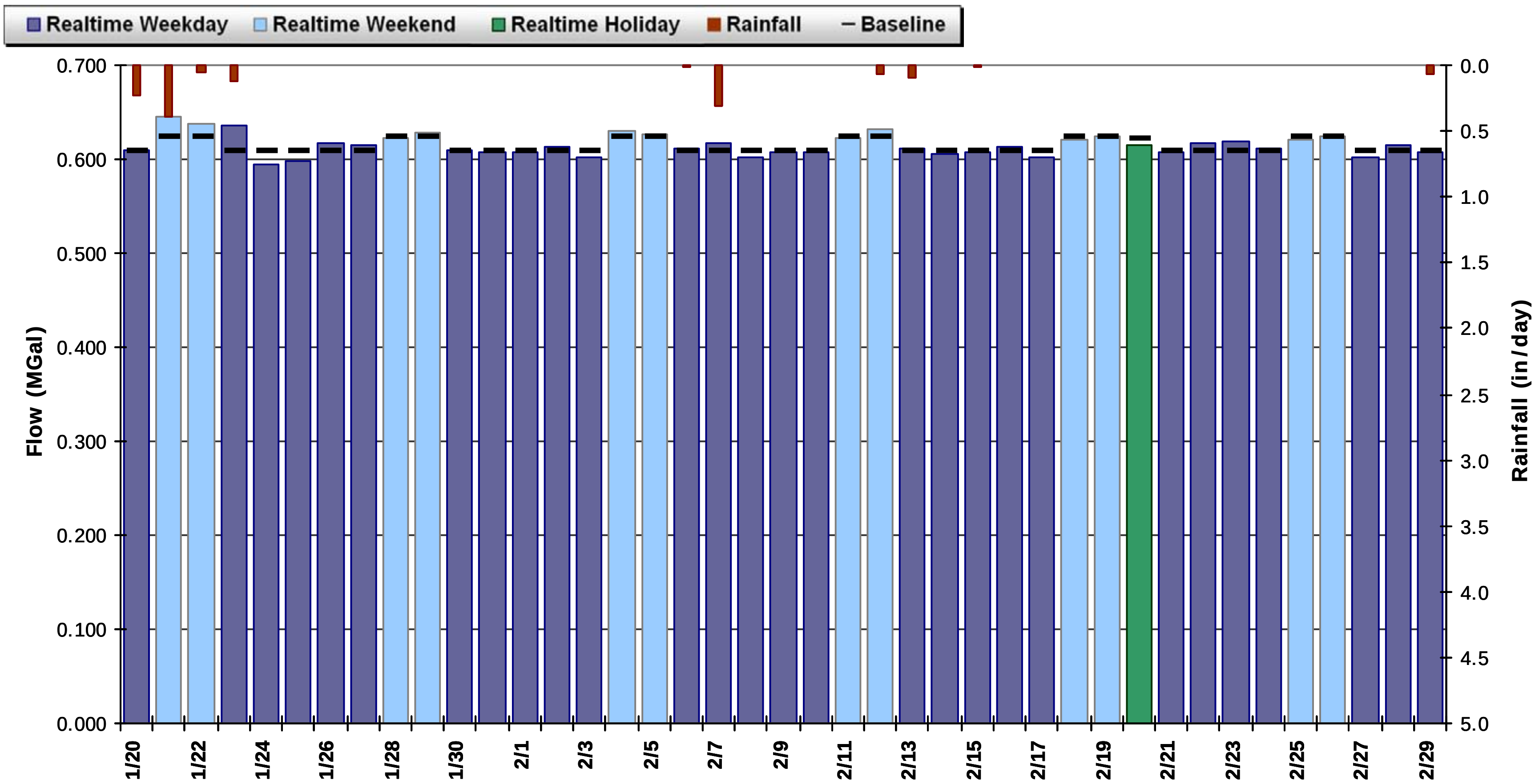
Plan View

SITE 11

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 0.615 MGal   **Peak Daily Flow: 0.644 MGal**   **Min Daily Flow: 0.594 MGal**

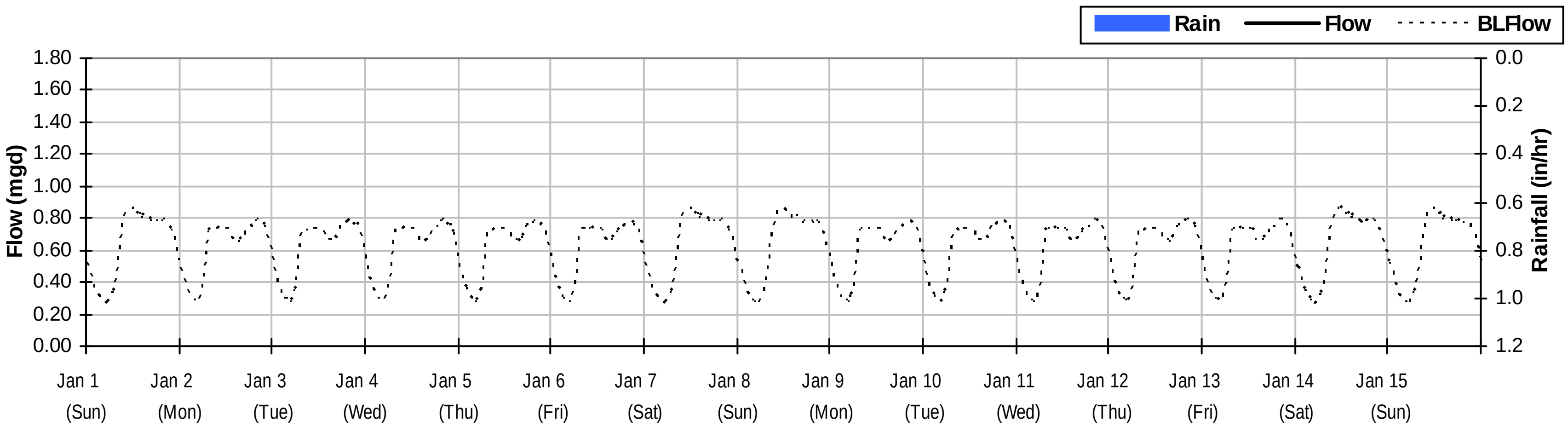
Total Period Rainfall: 1.37 inches

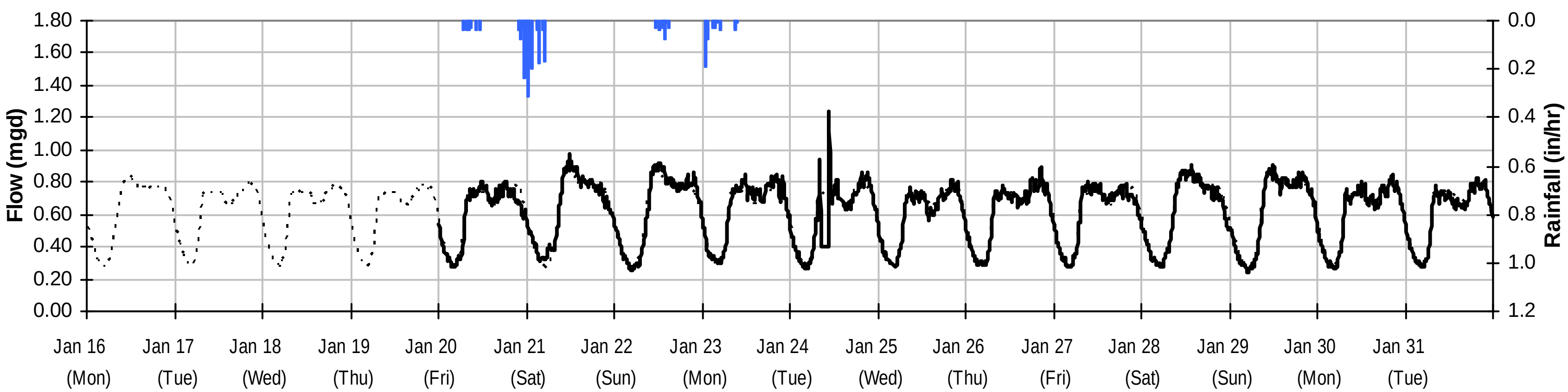


SITE 11

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.8 inches **Avg Flow: 0.619 mgd** **Peak Flow: 1.232 mgd** **Min Flow: 0.245 mgd**

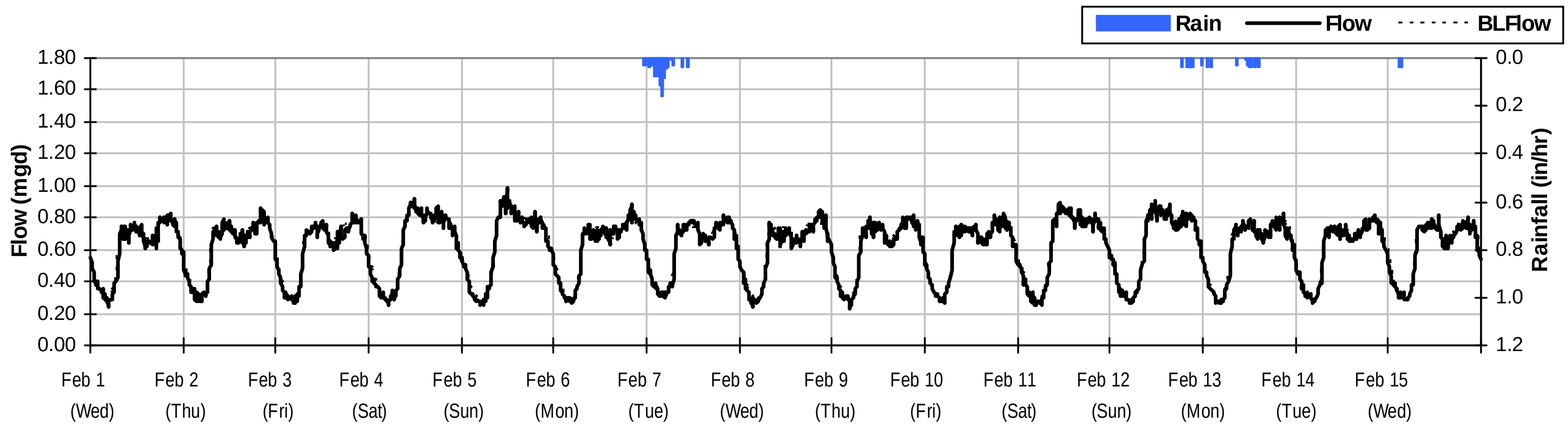


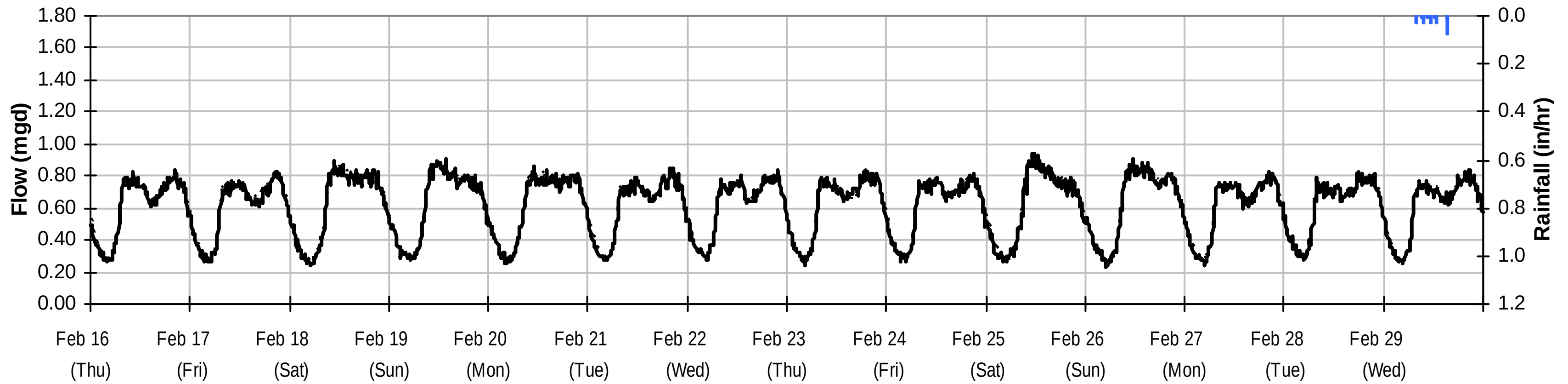


SITE 11

Monthly Flow Summary: February, 2012

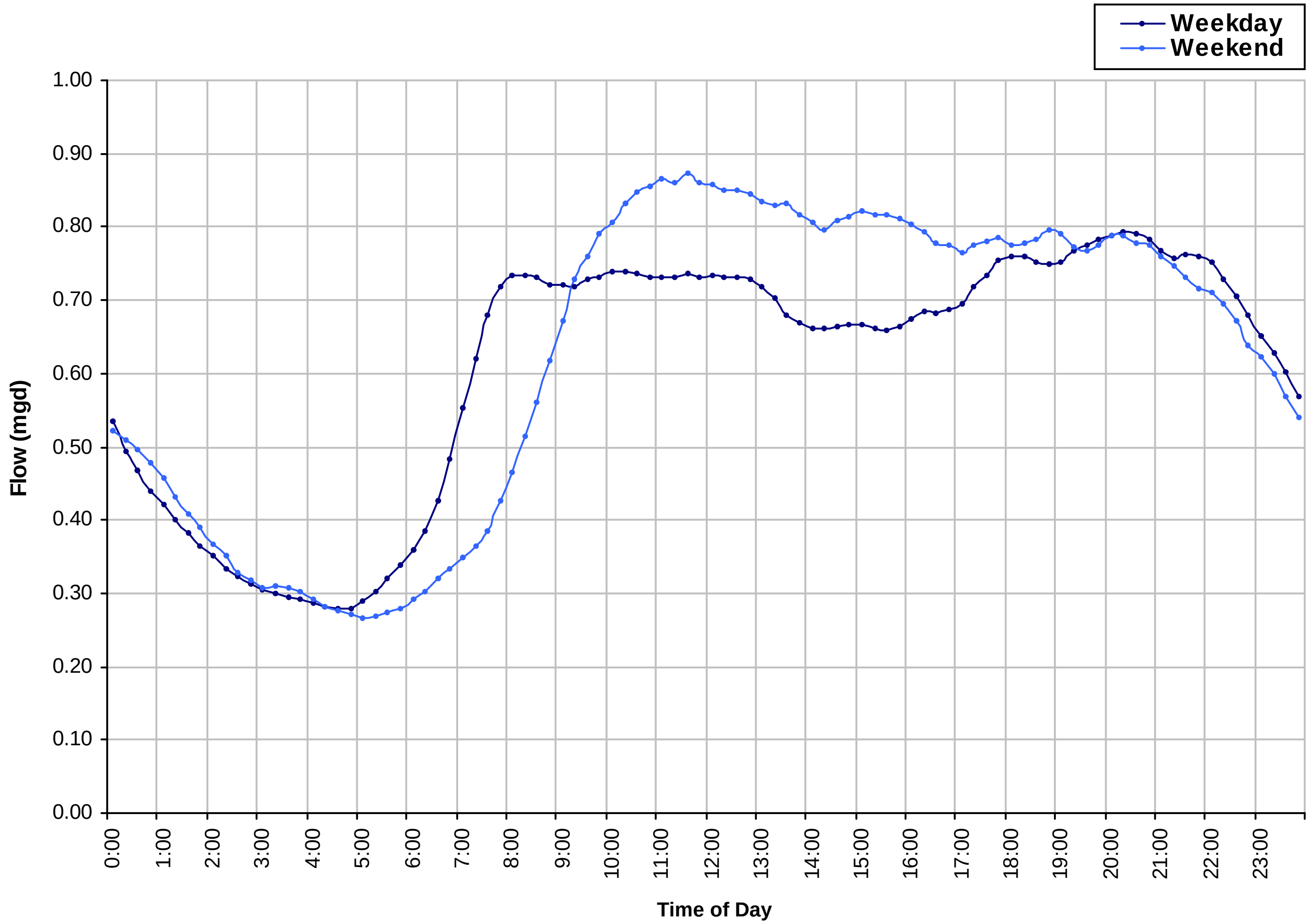
Total Monthly Rainfall: 0.57 inches **Avg Flow: 0.614 mgd** **Peak Flow: 0.991 mgd** **Min Flow: 0.230 mgd**



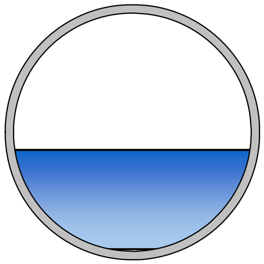


SITE 11

Baseline Flow Hydrographs

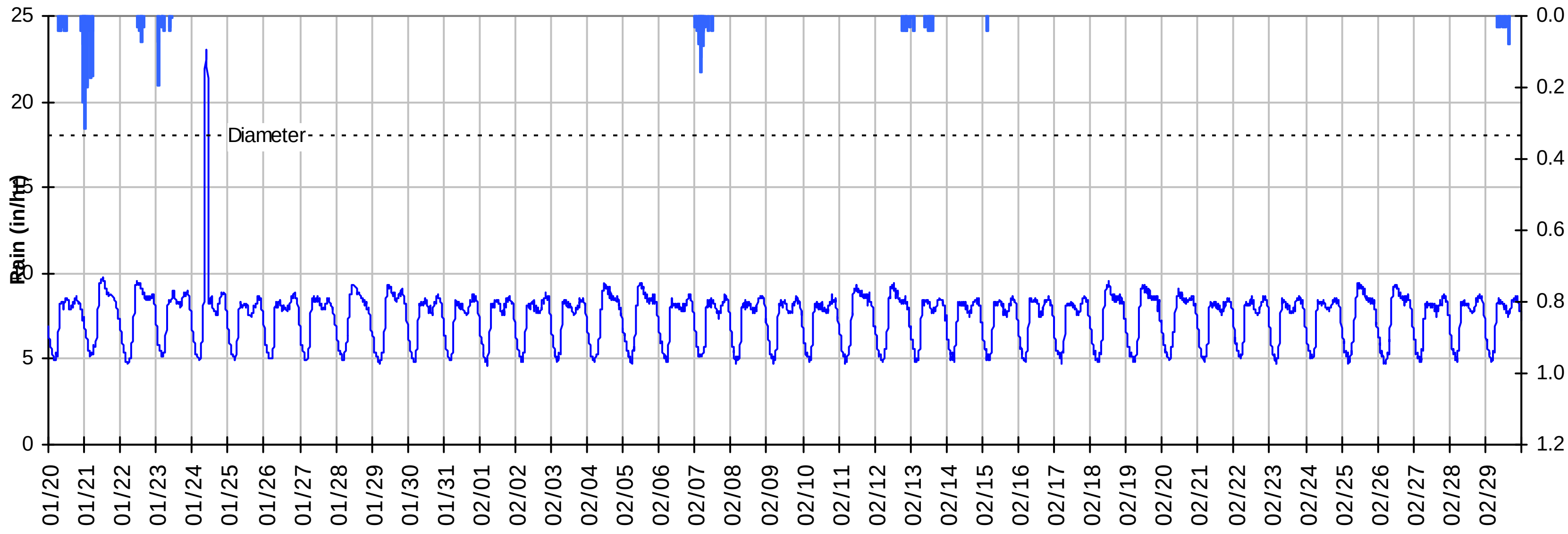


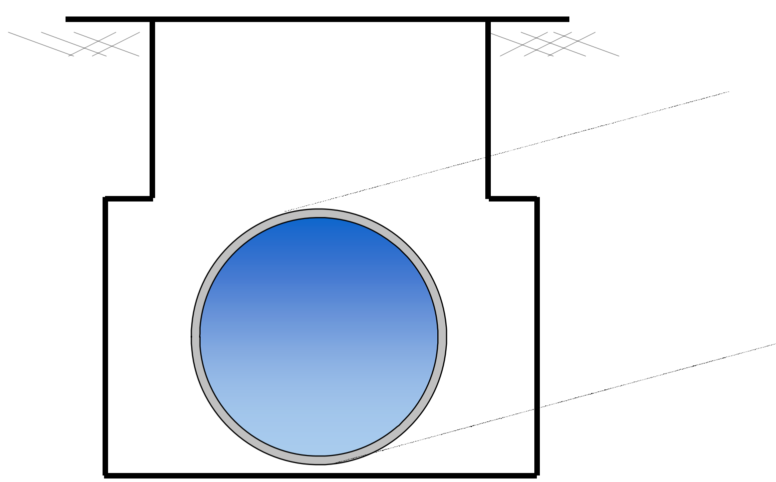
Baseline Flow:
0.614 *mgd*



SITE 11
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





Pipe Diameter: 18 *inches*

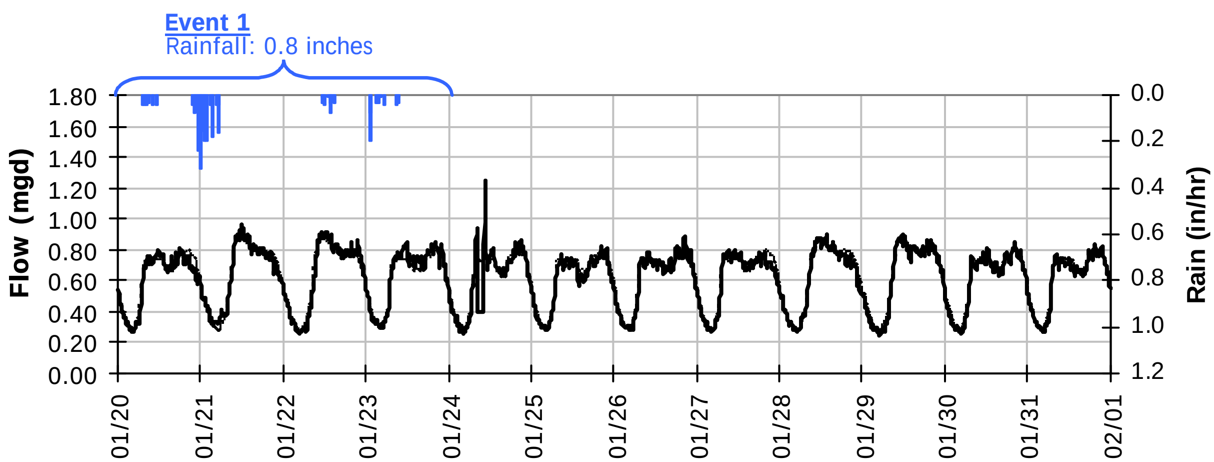
Peak Measured Level: 23.1 *inches*

Peak d/D Ratio: 1.28

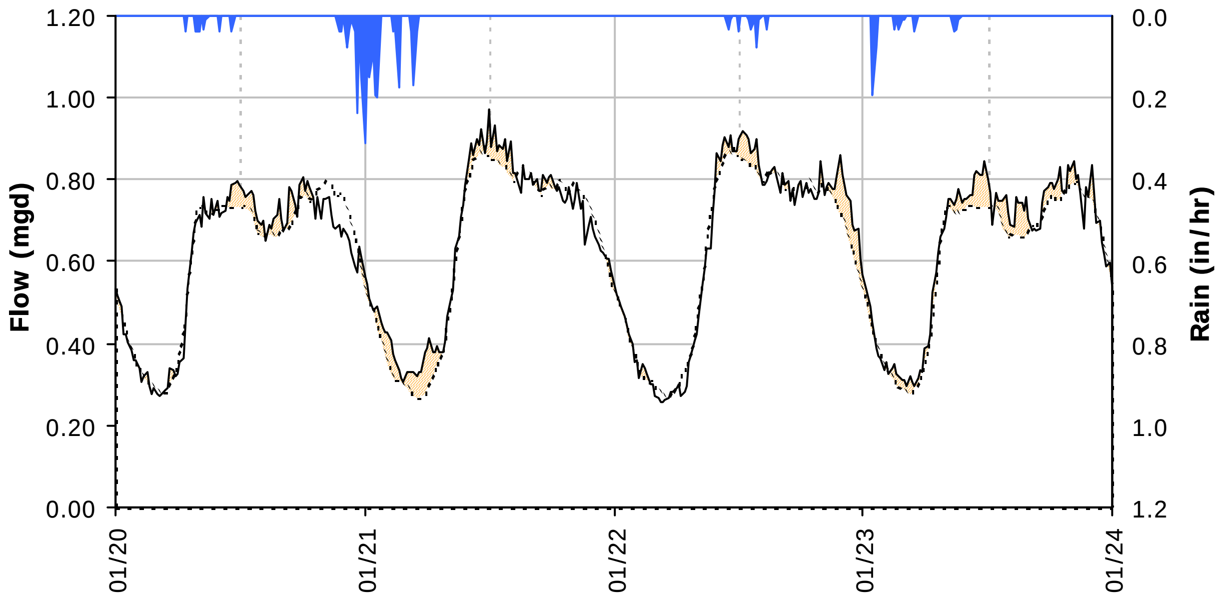
Surcharged 5.1 inches over crown

SITE 11
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



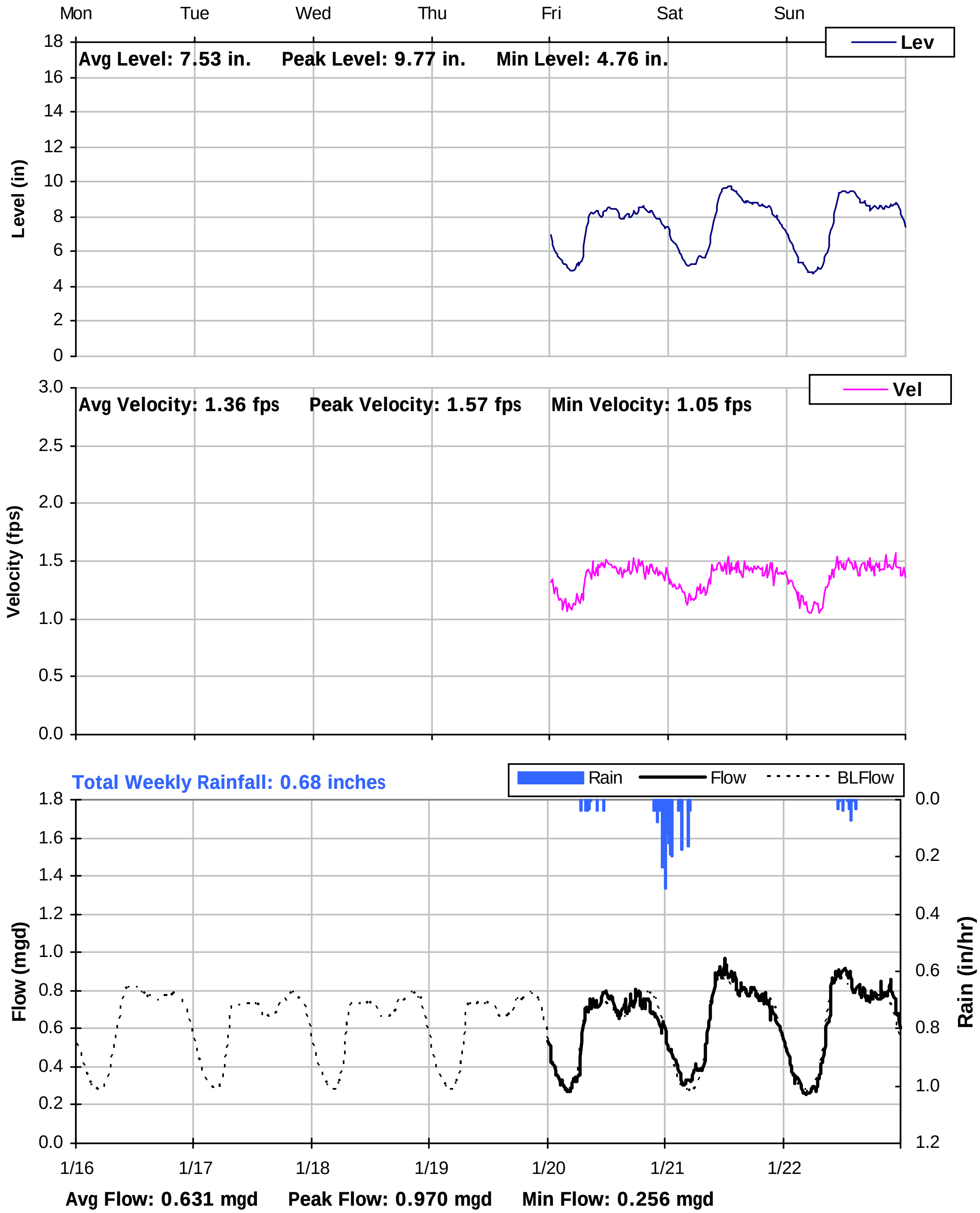
Event 1 Detail Graph



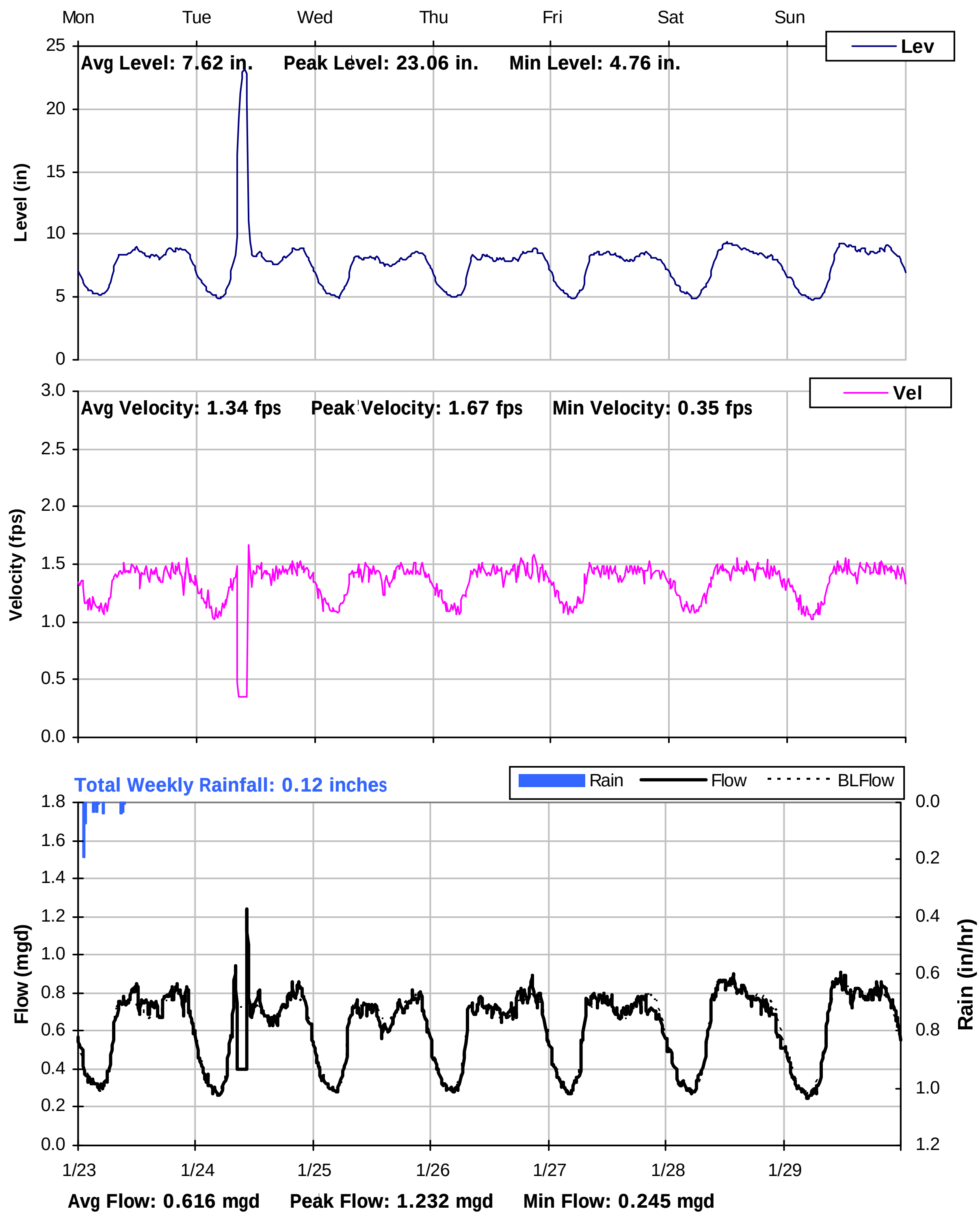
Storm Event I/I Analysis (Rain = 0.80 inches)

Capacity		Inflow		Combined I/I	
Peak Flow:	0.97 *mgd*	**Peak I/I Rate:**	0.15 *mgd*	**Total I/I:**	58,000 *gallons*
PF:	1.58	**Pk I/I:Acre:**	229 *gpd/acre*	**R-Value:**	0.4%
		Pk I/I:ADWF:	0.24	**Total I/I:ADWF:**	0.12 *per in-rain*
Peak Level:	9.77 *in*				
d/D Ratio:	0.54				

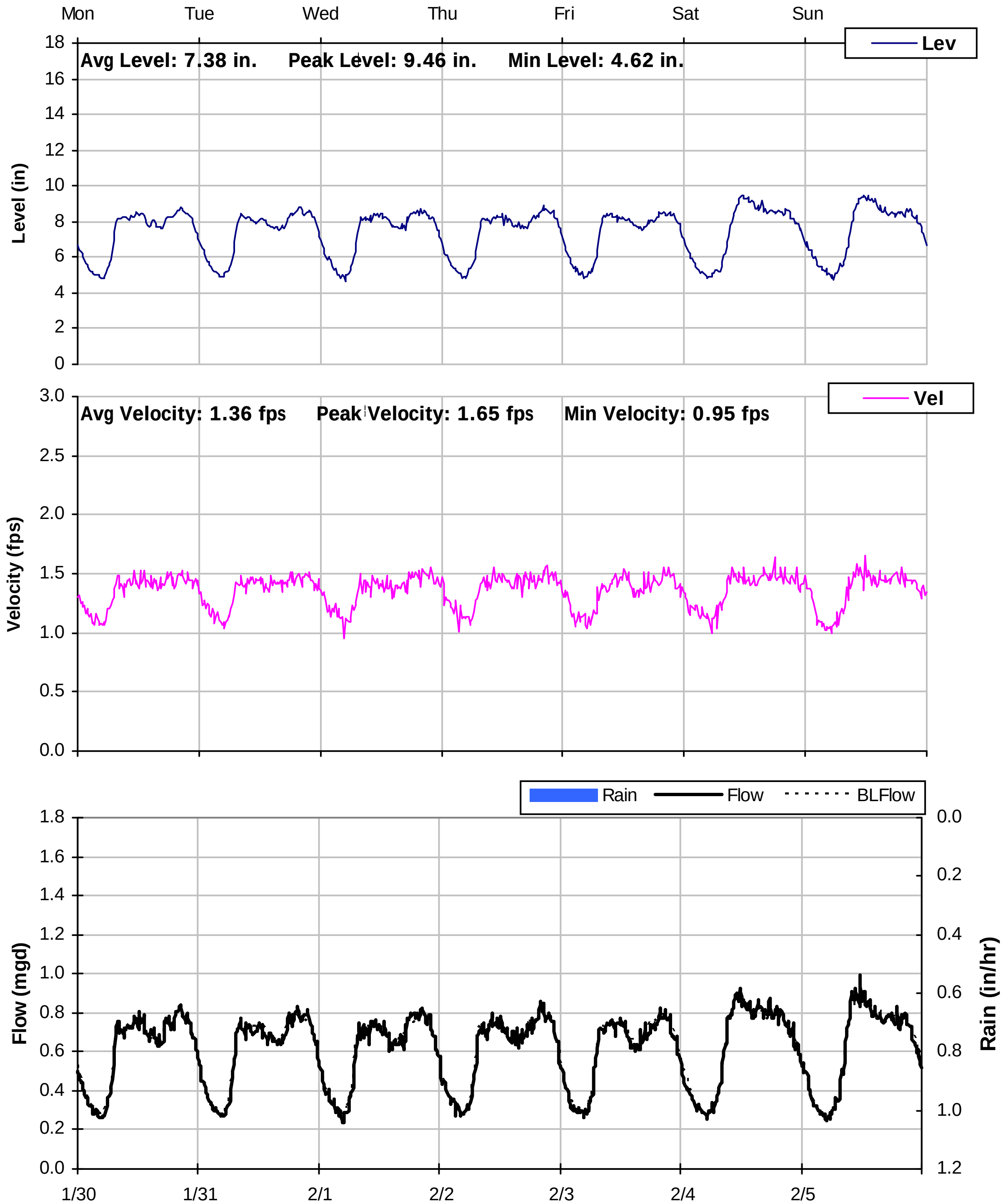
SITE 11
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



SITE 11
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012

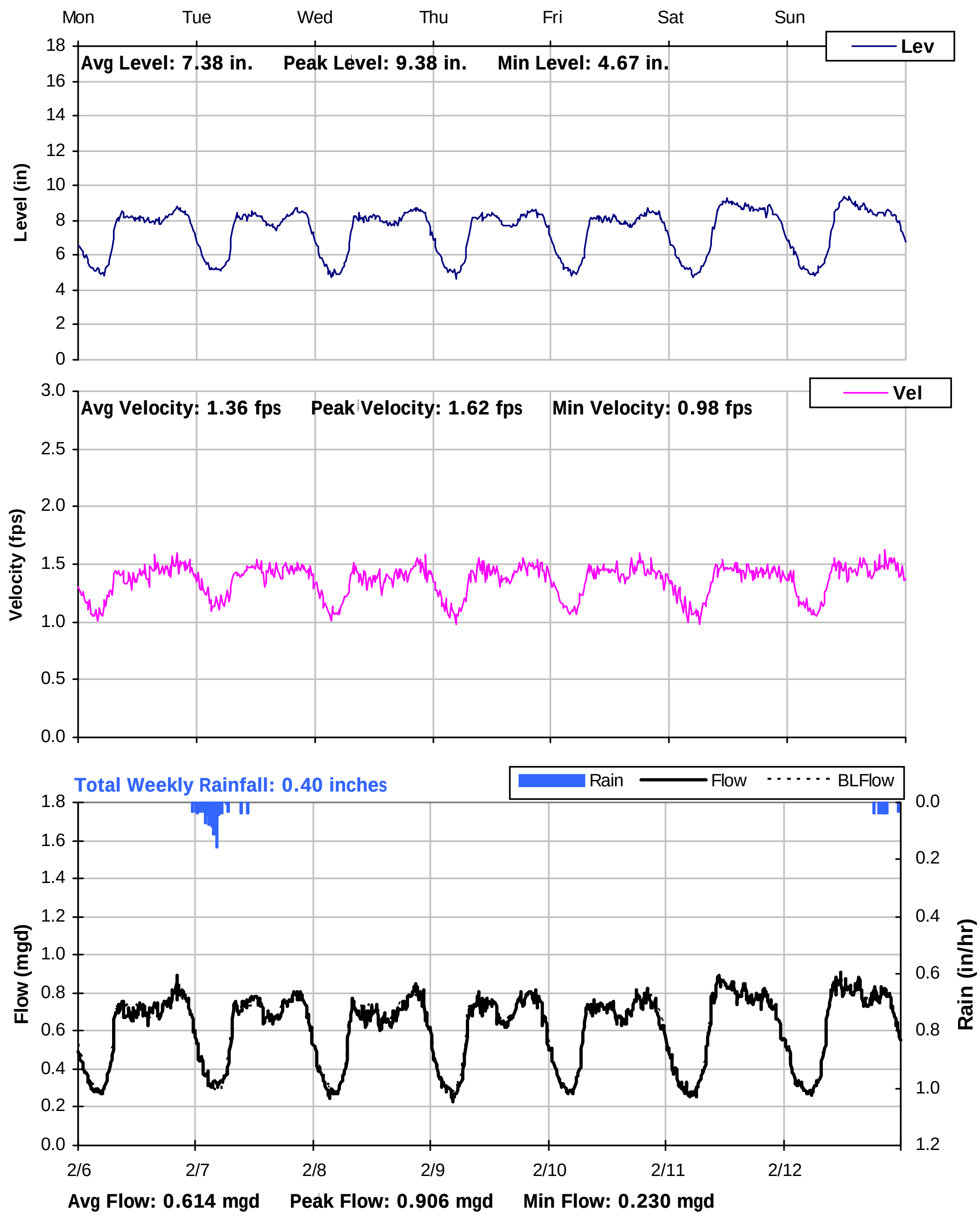


SITE 11
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012

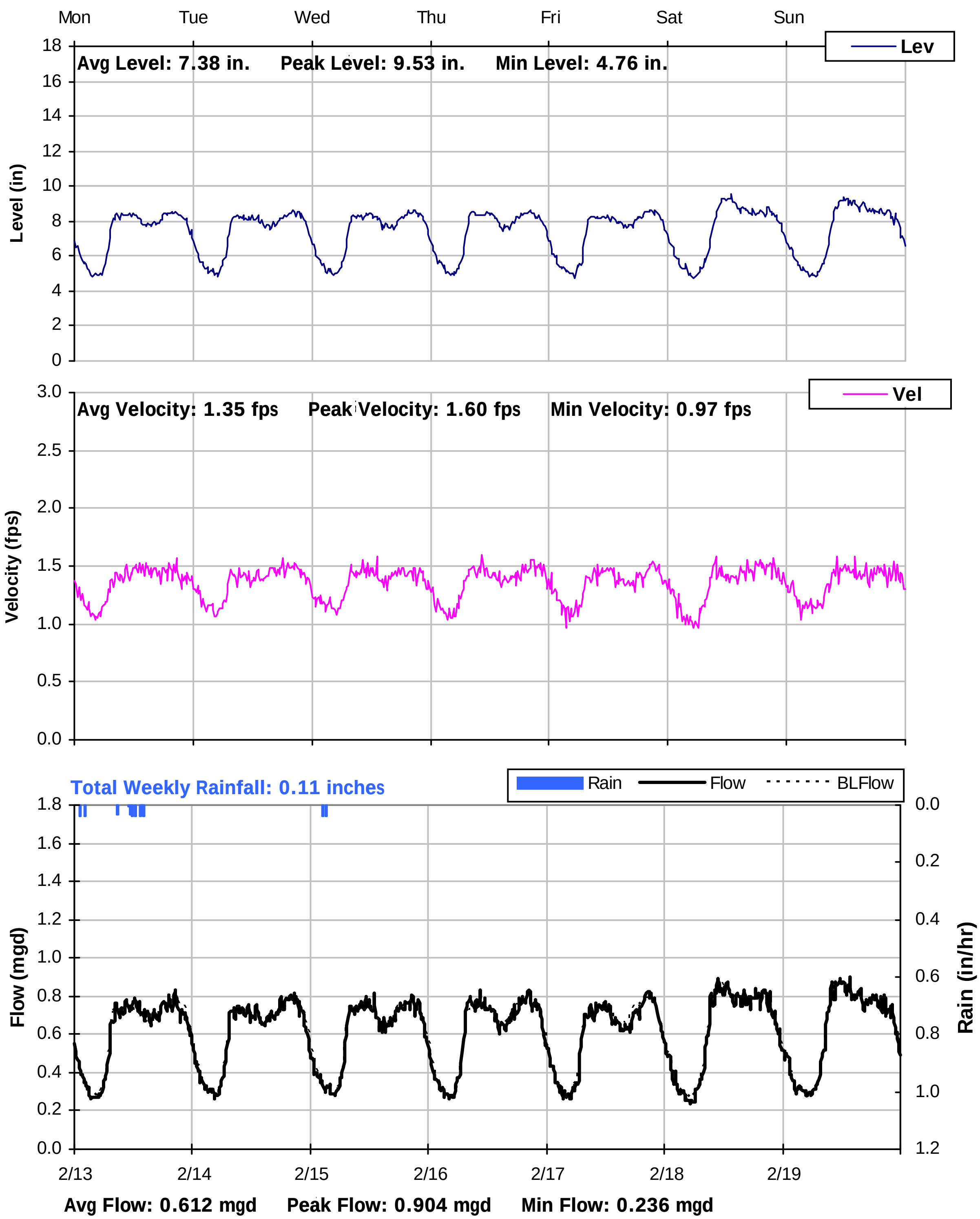


Avg Flow: 0.614 mgd **Peak Flow: 0.991 mgd** **Min Flow: 0.239 mgd**

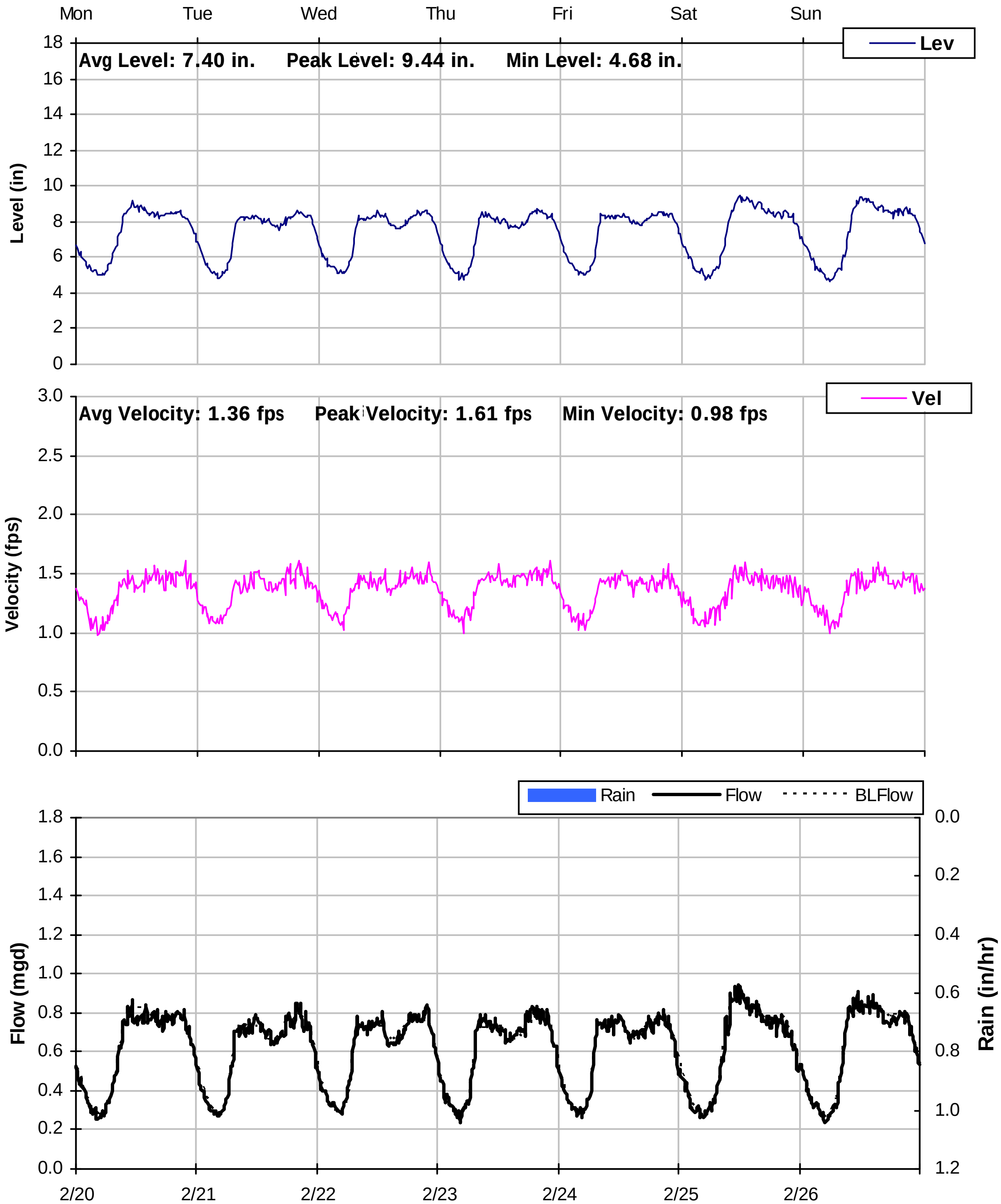
SITE 11
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



SITE 11
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012

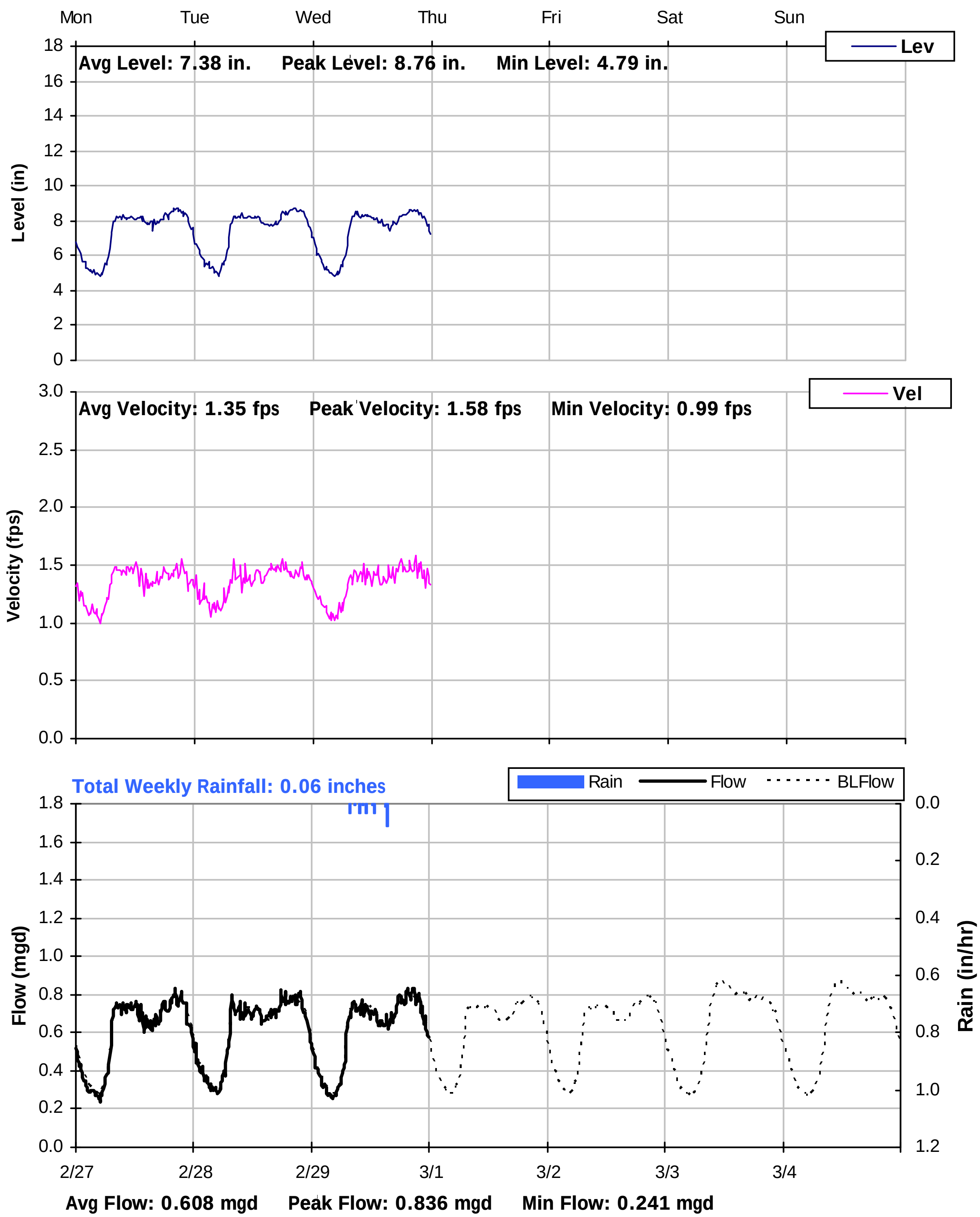


SITE 11
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



Avg Flow: 0.617 mgd **Peak Flow: 0.941 mgd** **Min Flow: 0.234 mgd**

SITE 11
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



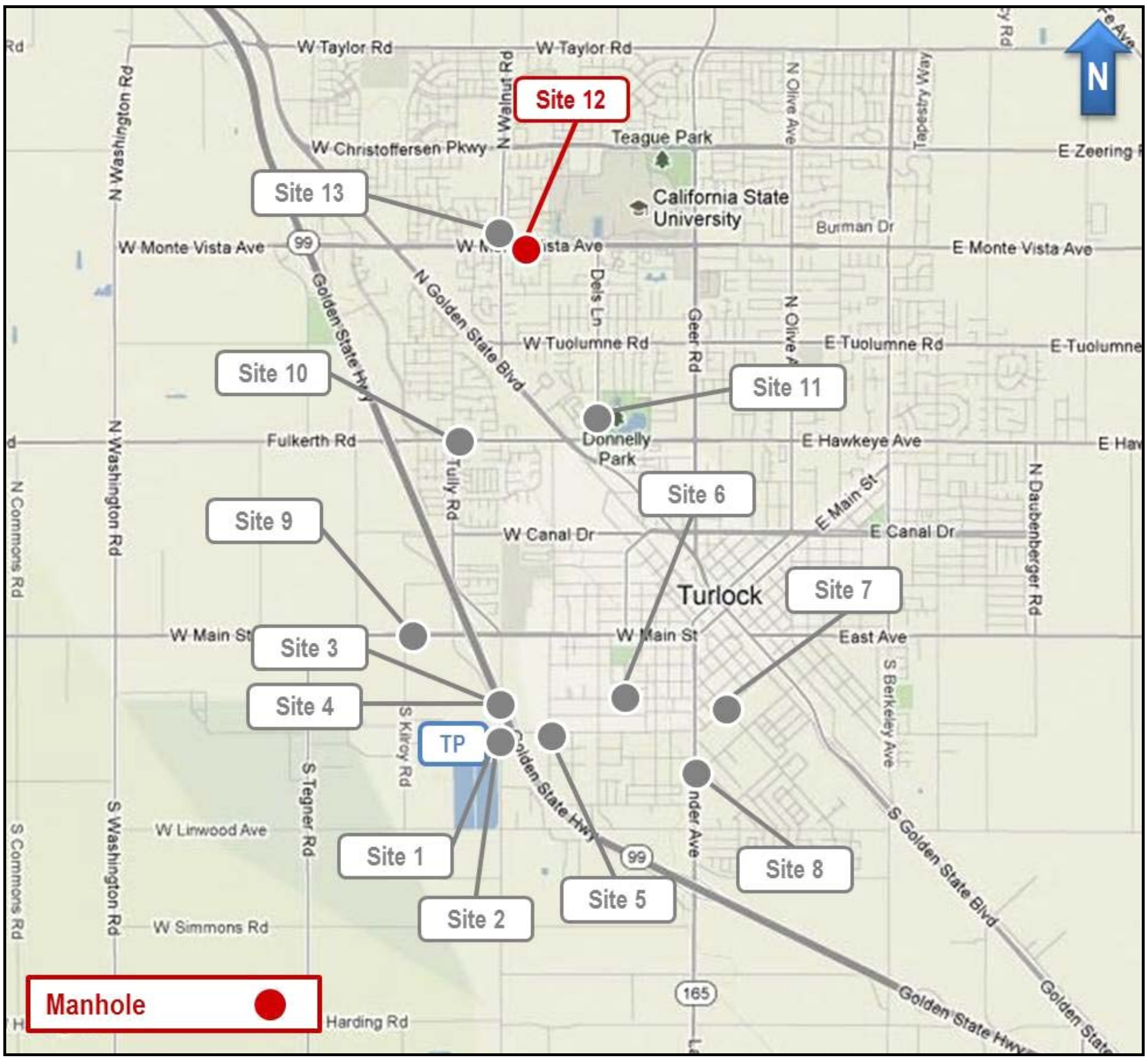
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 12

Location: Intersection of Monte Vista Avenue and Norwich Lane

Data Summary Report



Vicinity Map: Site 12

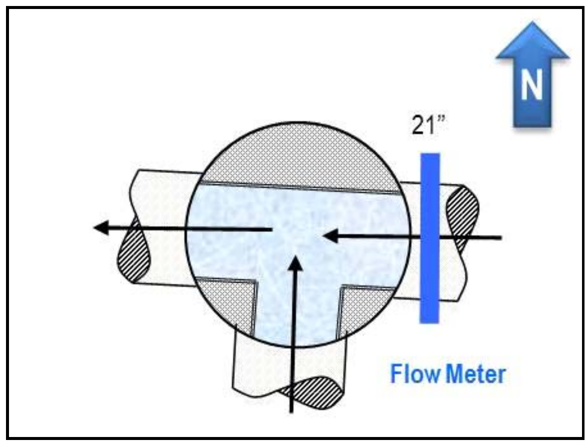
SITE 12

Site Information

Location:	Intersection of Monte Vista Avenue and Norwich Lane
Coordinates:	120.8648° W, 37.5219° N
Rim Elevation:	104 feet
Pipe Diameter:	21 inches
Baseline Flow:	1.182 mgd
Peak Measured Flow:	1.711 mgd

Satellite Map

Sewer Map



Flow Sketch

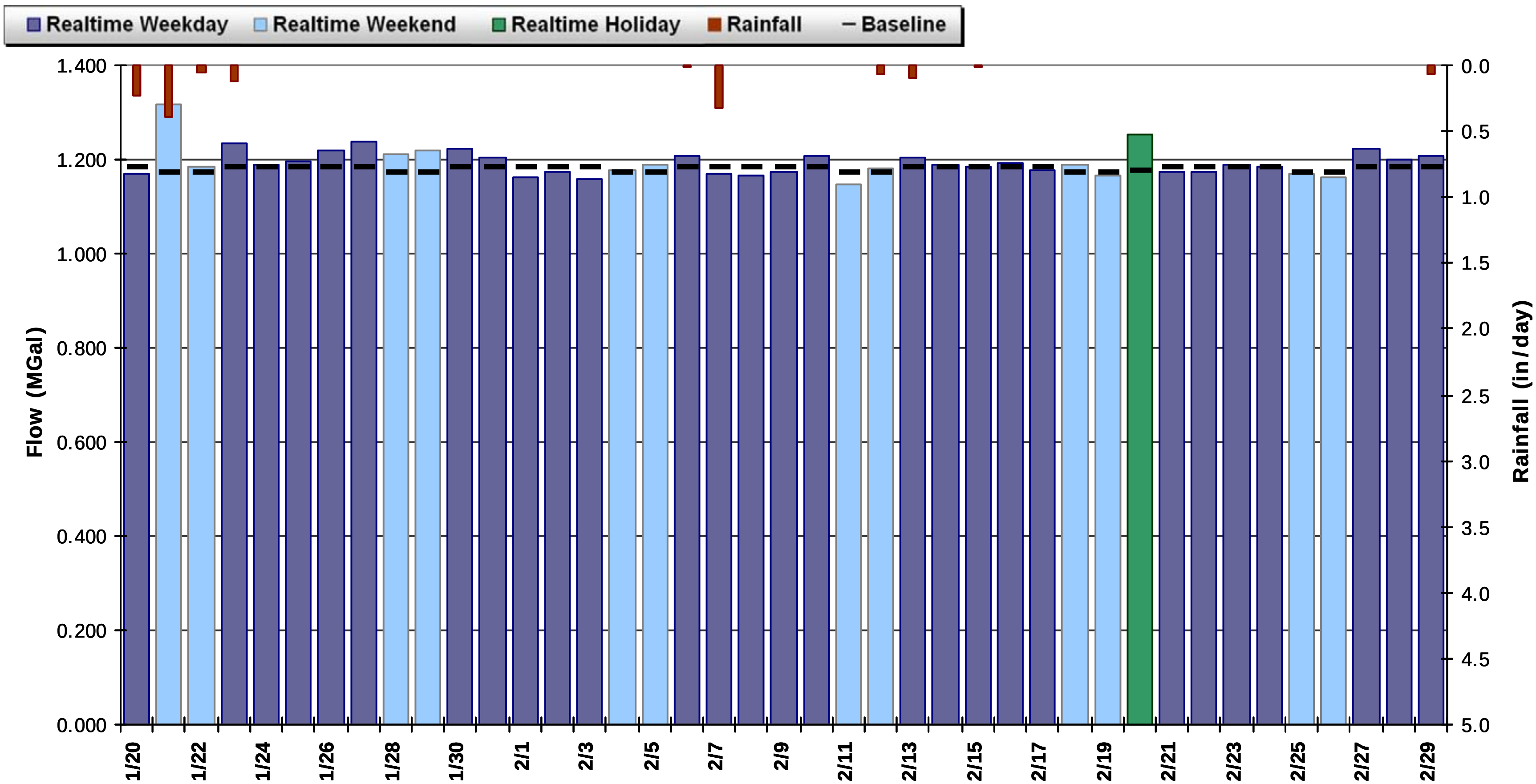
Street View

Plan View

SITE 12
Period Flow Summary: Daily Flow Totals

Avg Period Flow: 1.194 MGal **Peak Daily Flow: 1.318 MGal** **Min Daily Flow: 1.146 MGal**

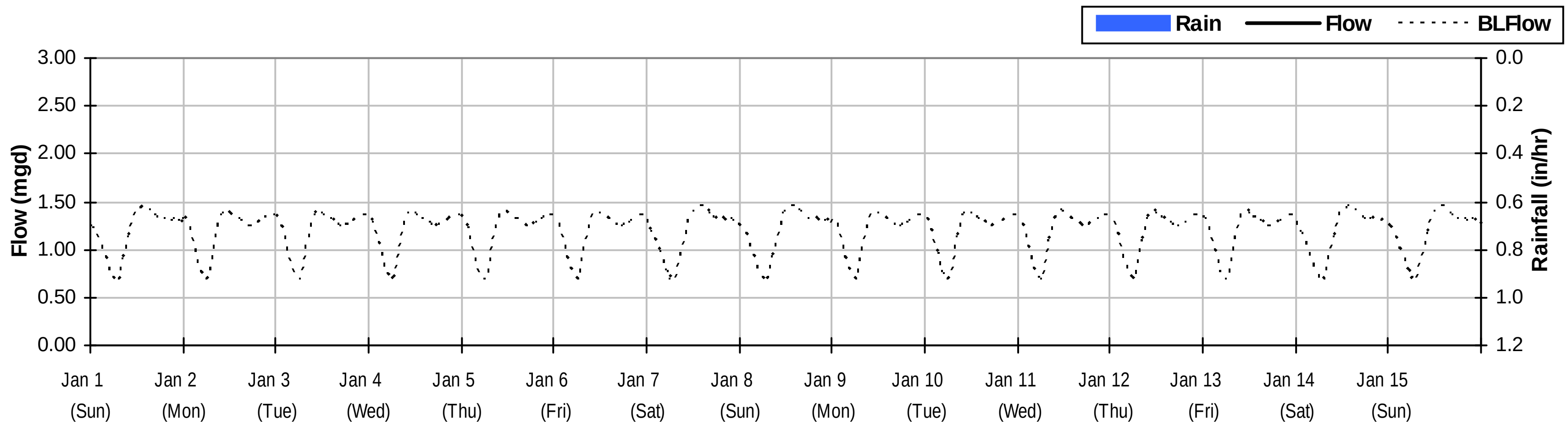
Total Period Rainfall: 1.37 inches

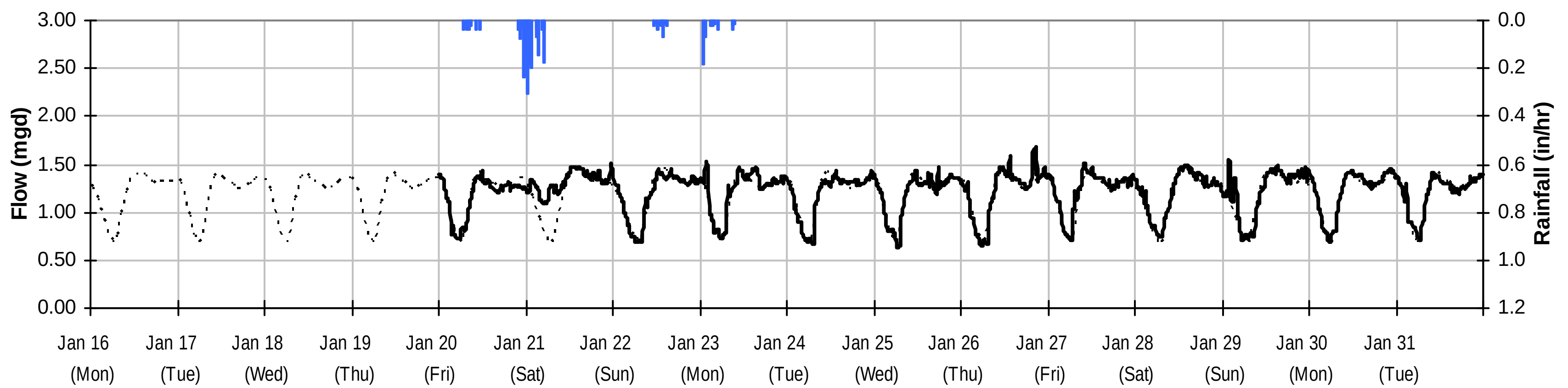


SITE 12

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.79 inches **Avg Flow: 1.217 mgd** **Peak Flow: 1.674 mgd** **Min Flow: 0.624 mgd**

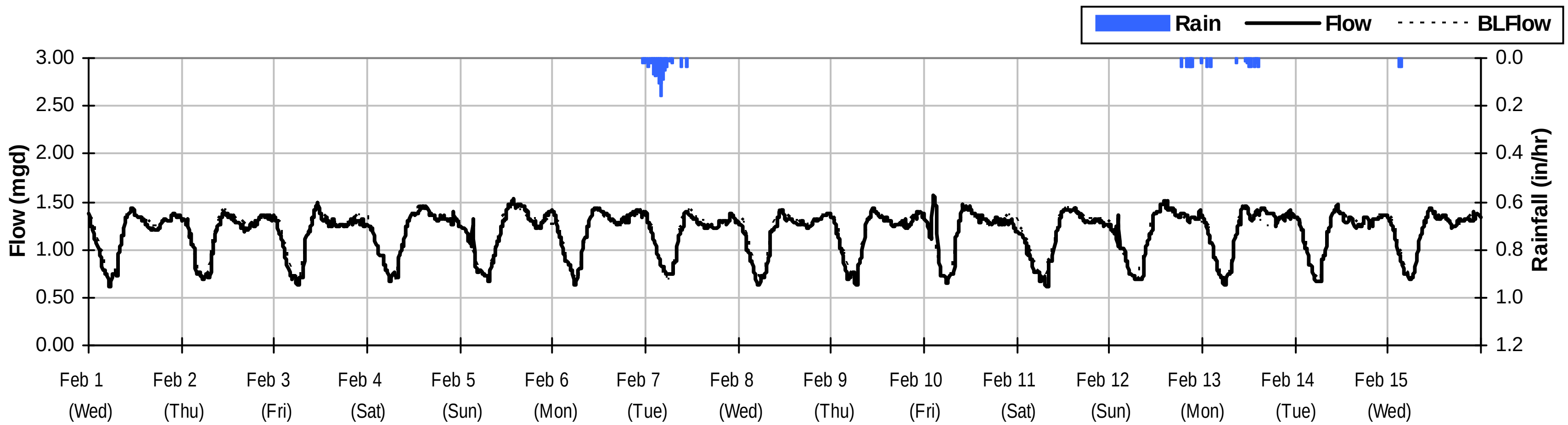


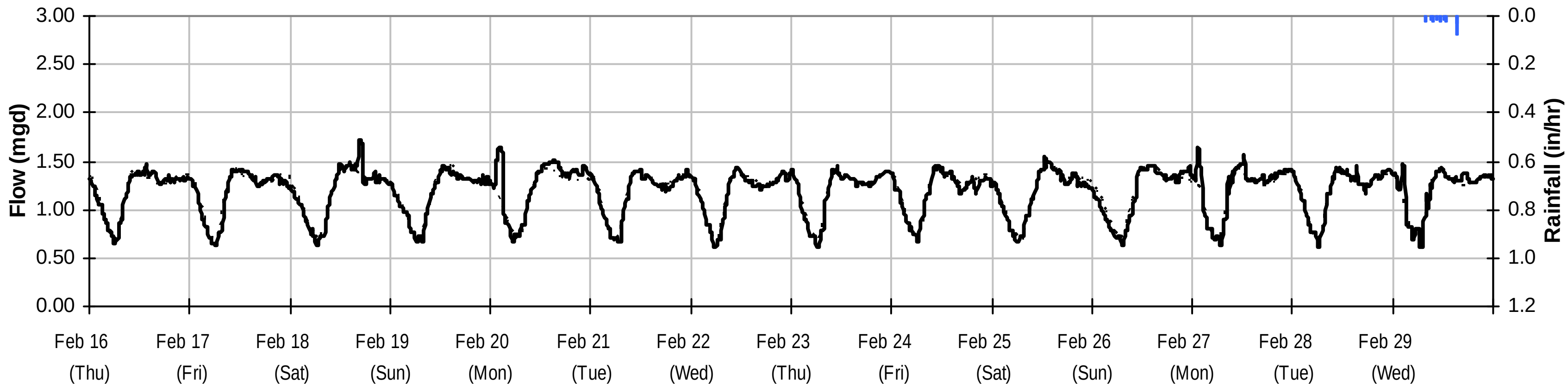


SITE 12

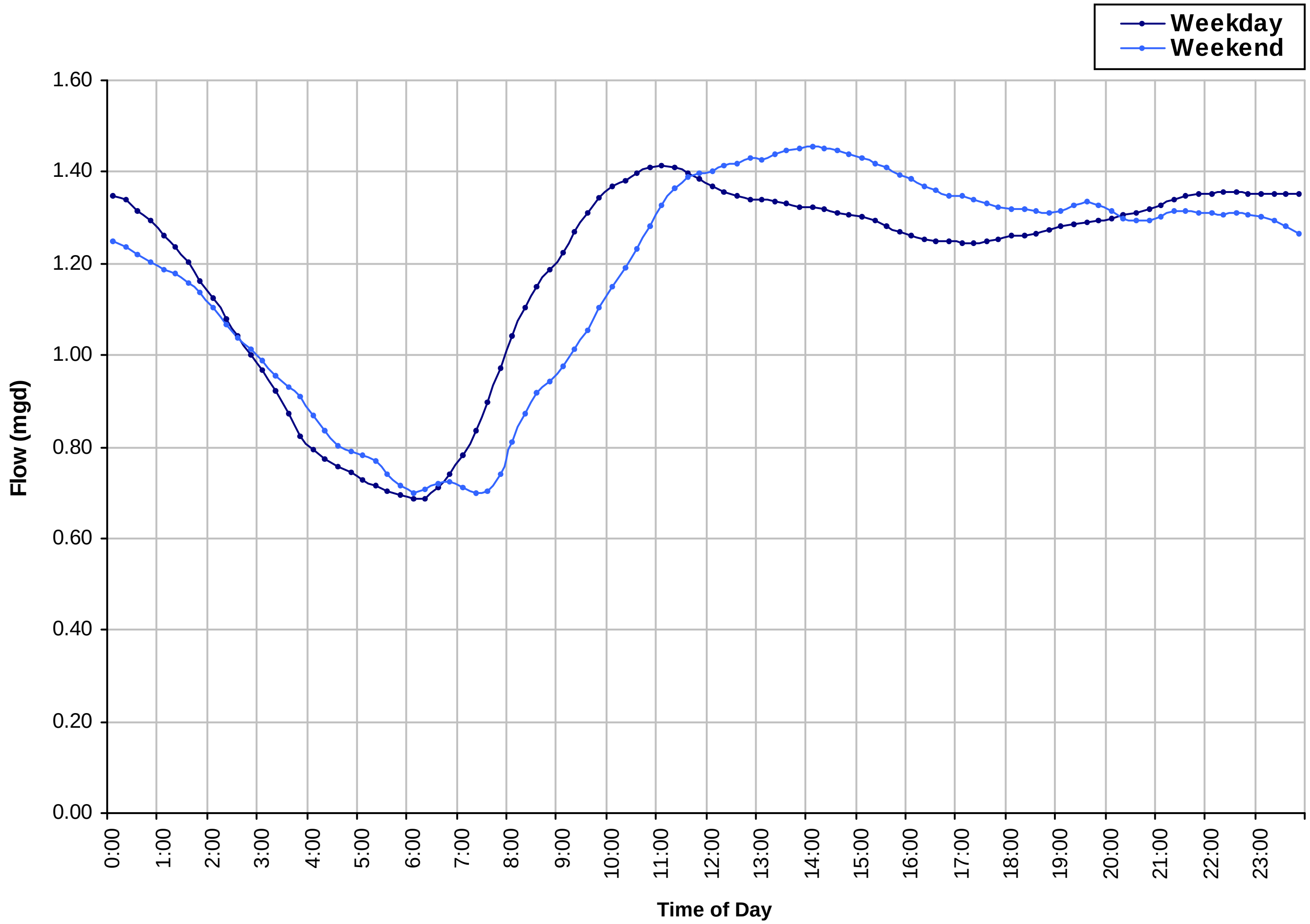
Monthly Flow Summary: February, 2012

Total Monthly Rainfall: 0.58 inches **Avg Flow: 1.184 mgd** **Peak Flow: 1.711 mgd** **Min Flow: 0.603 mgd**

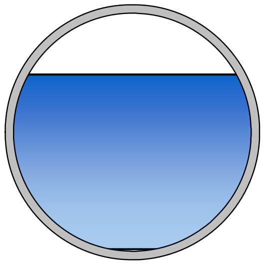




SITE 12
Baseline Flow Hydrographs

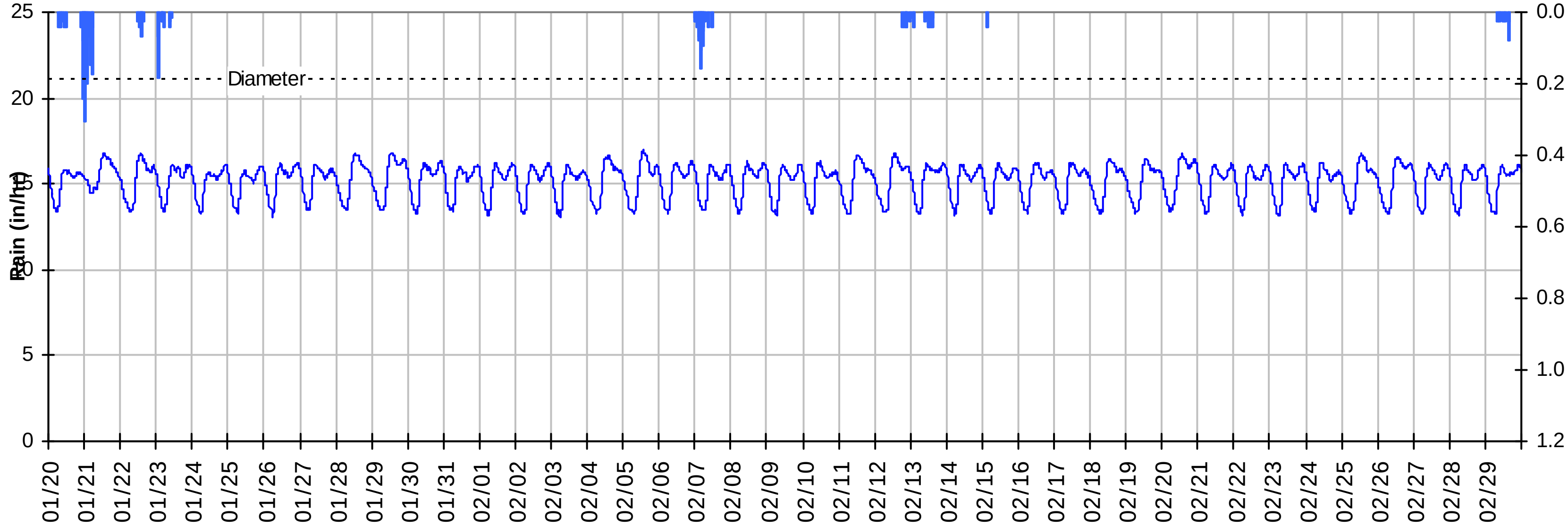


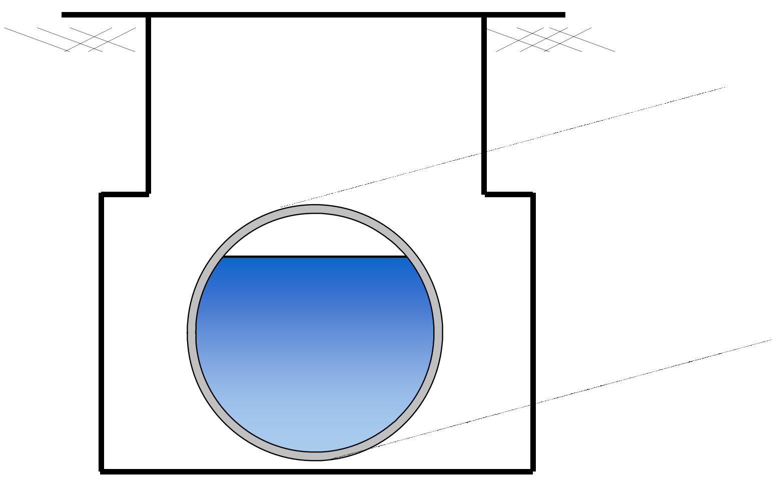
Baseline Flow:
1.182 *mgd*



SITE 12
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





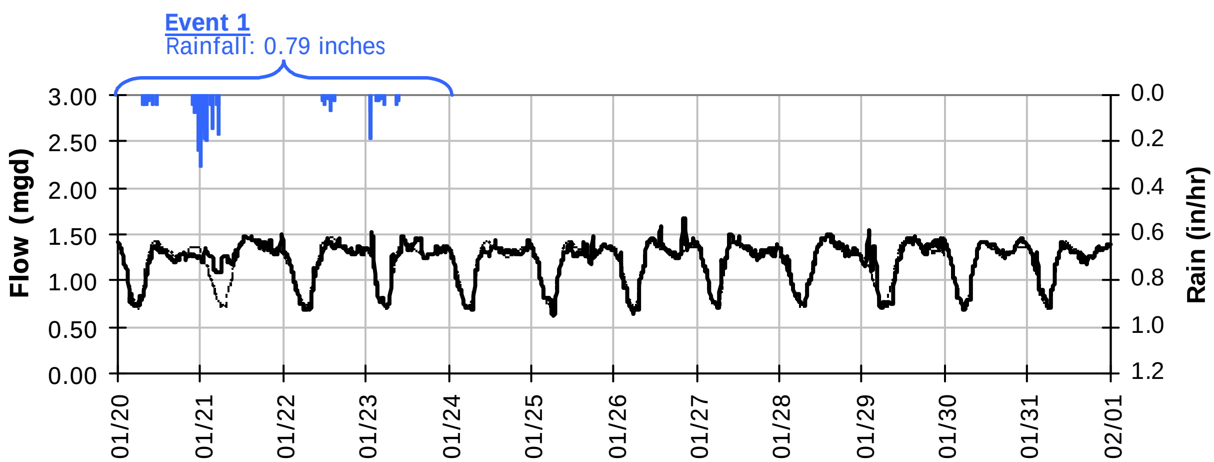
Pipe Diameter: 21 *inches*

Peak Measured Level: 17 *inches*

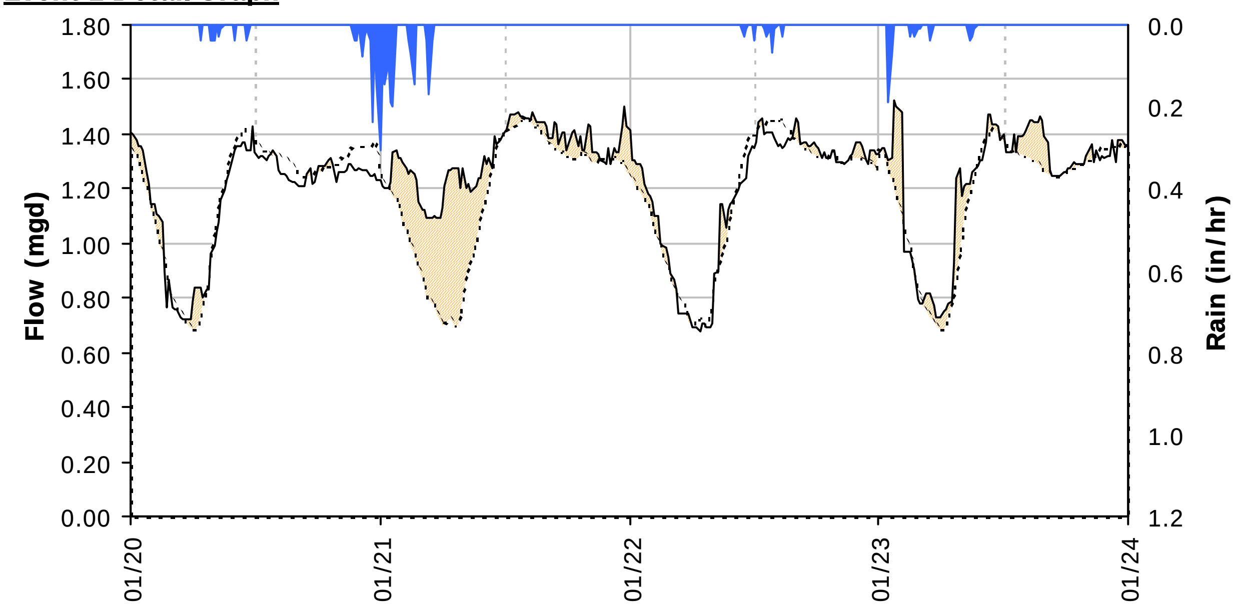
Peak d / D Ratio: 0.81

SITE 12
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



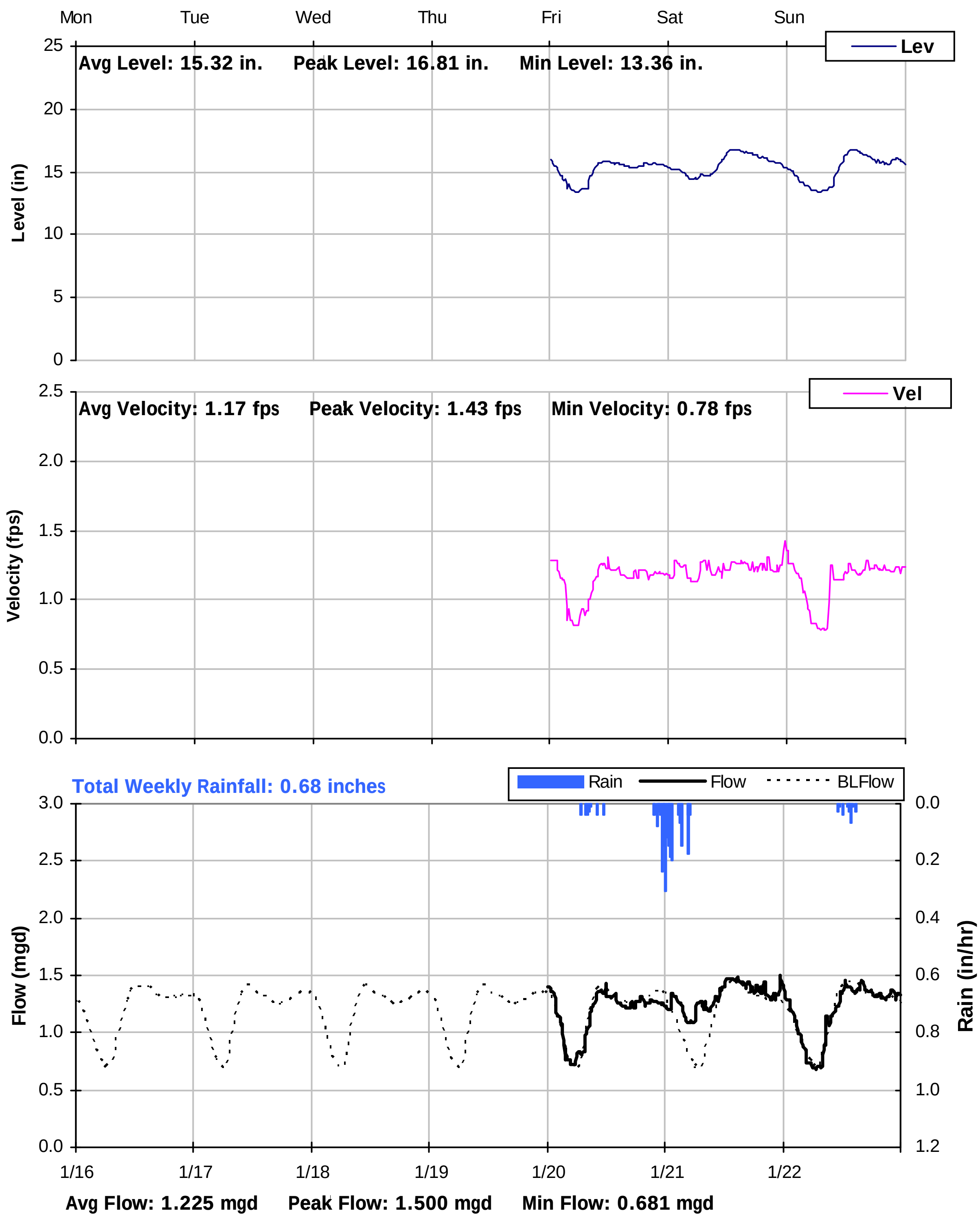
Event 1 Detail Graph



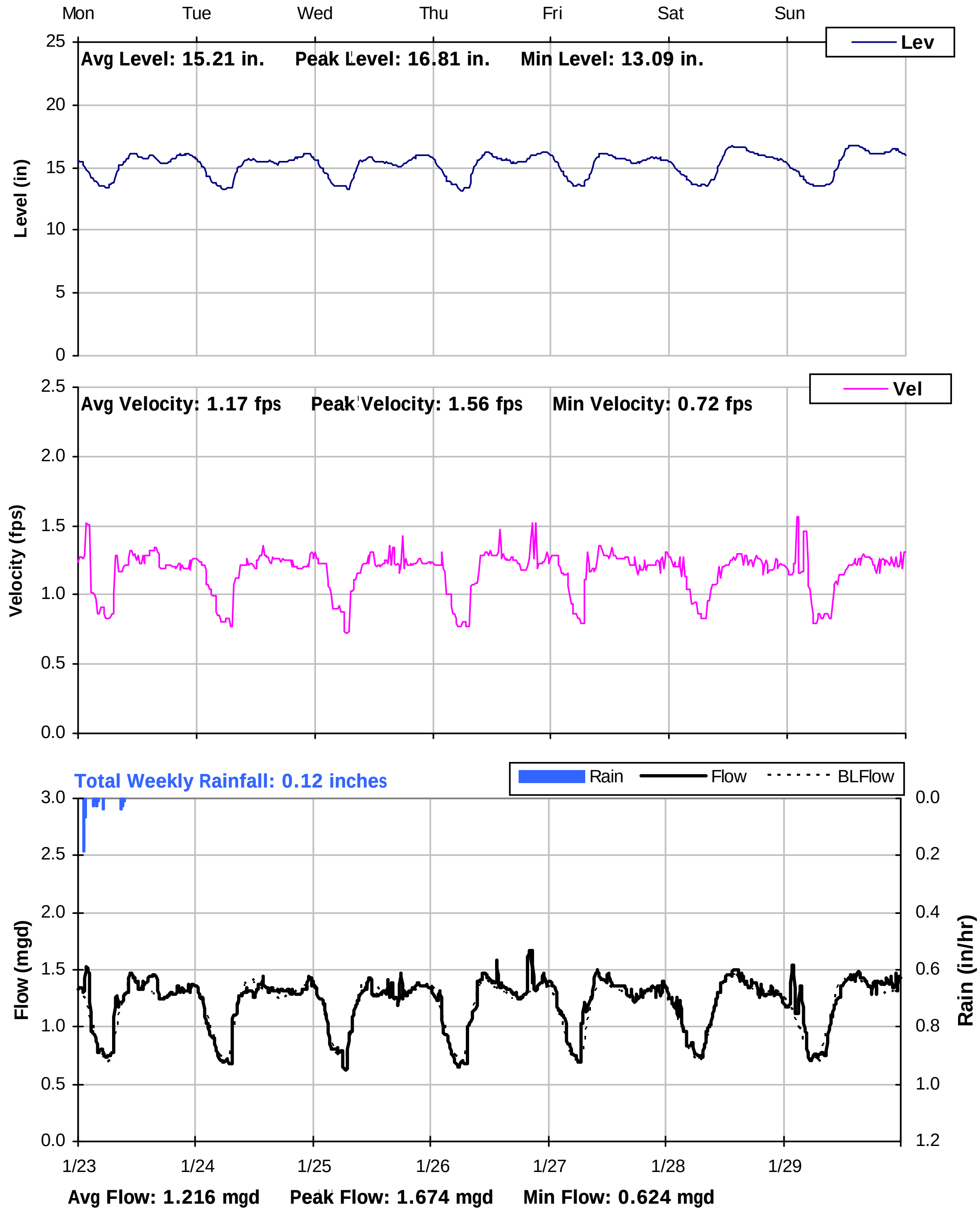
Storm Event I/I Analysis (Rain = 0.79 inches)

Capacity		Inflow		Combined I/I	
Peak Flow:	1.52 *mgd*	**Peak I/I Rate:**	0.58 *mgd*	**Total I/I:**	183,000 *gallons*
PF:	1.29	**Pk I/I:Acre:**	733 *gpd/acre*	**R-Value:**	1.1%
Peak Level:	16.81 *in*	**Pk I/I:ADWF:**	0.49	**Total I/I:ADWF:**	0.19 *per in-rain*
d/D Ratio:	0.80				

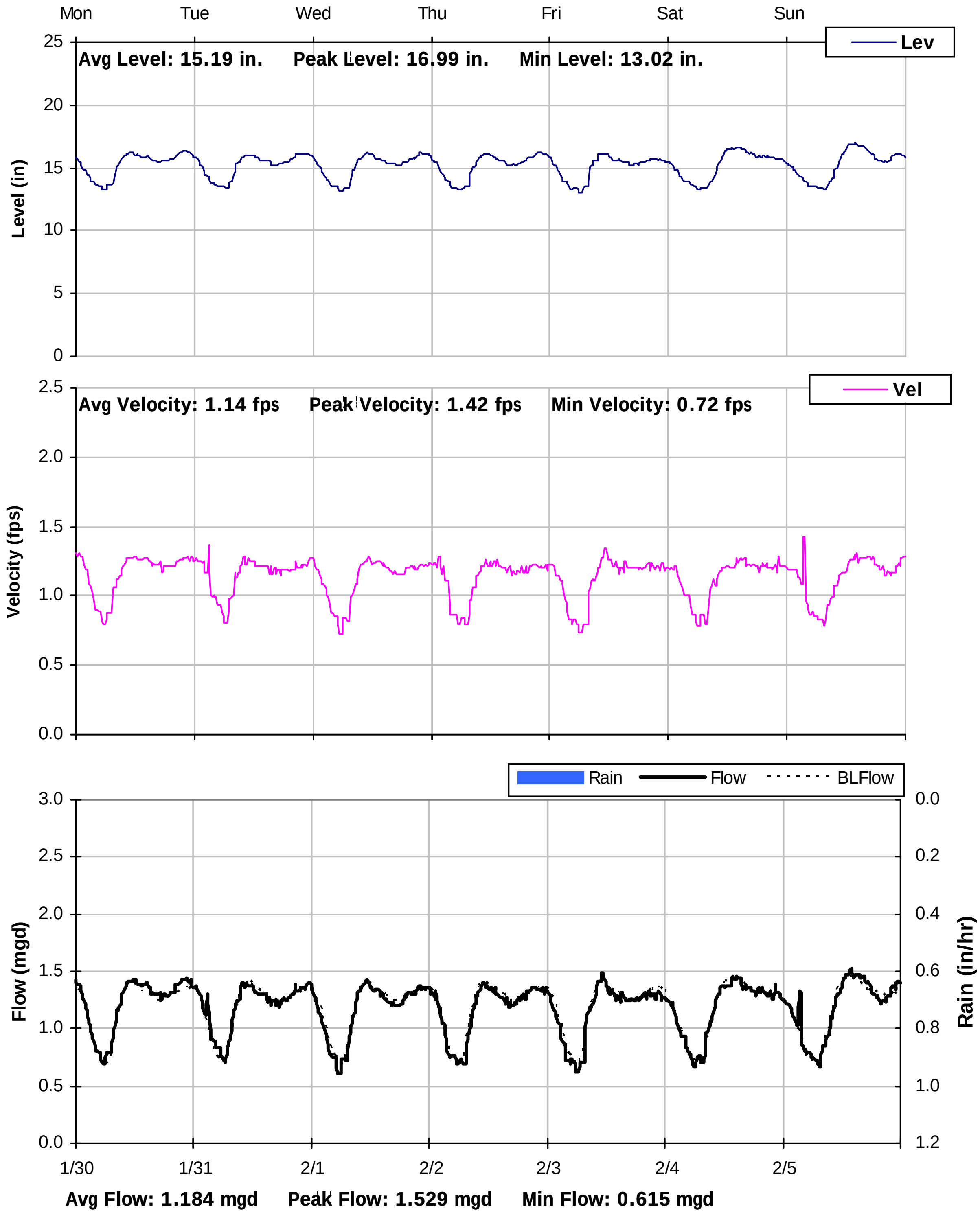
SITE 12
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



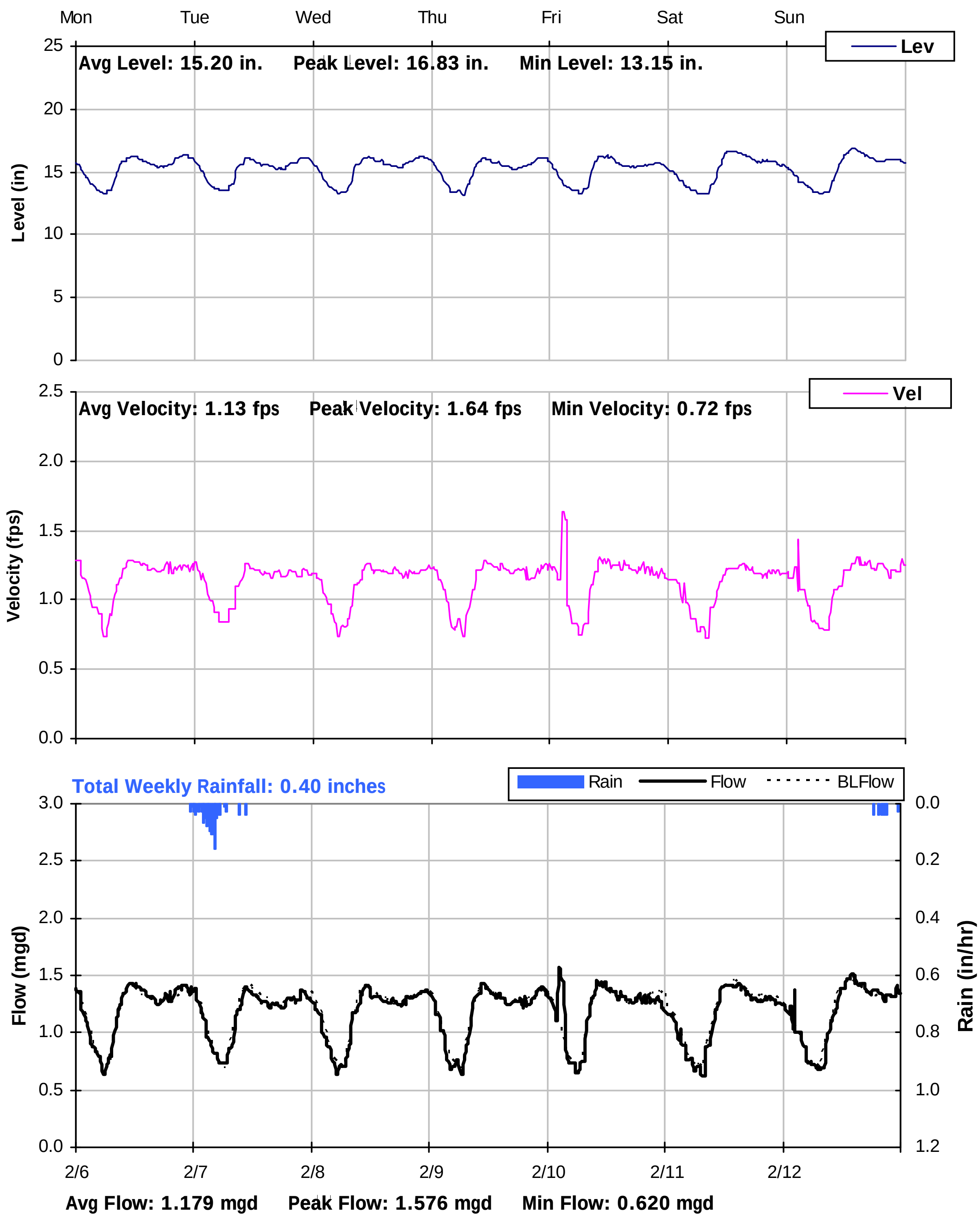
SITE 12
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



SITE 12
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



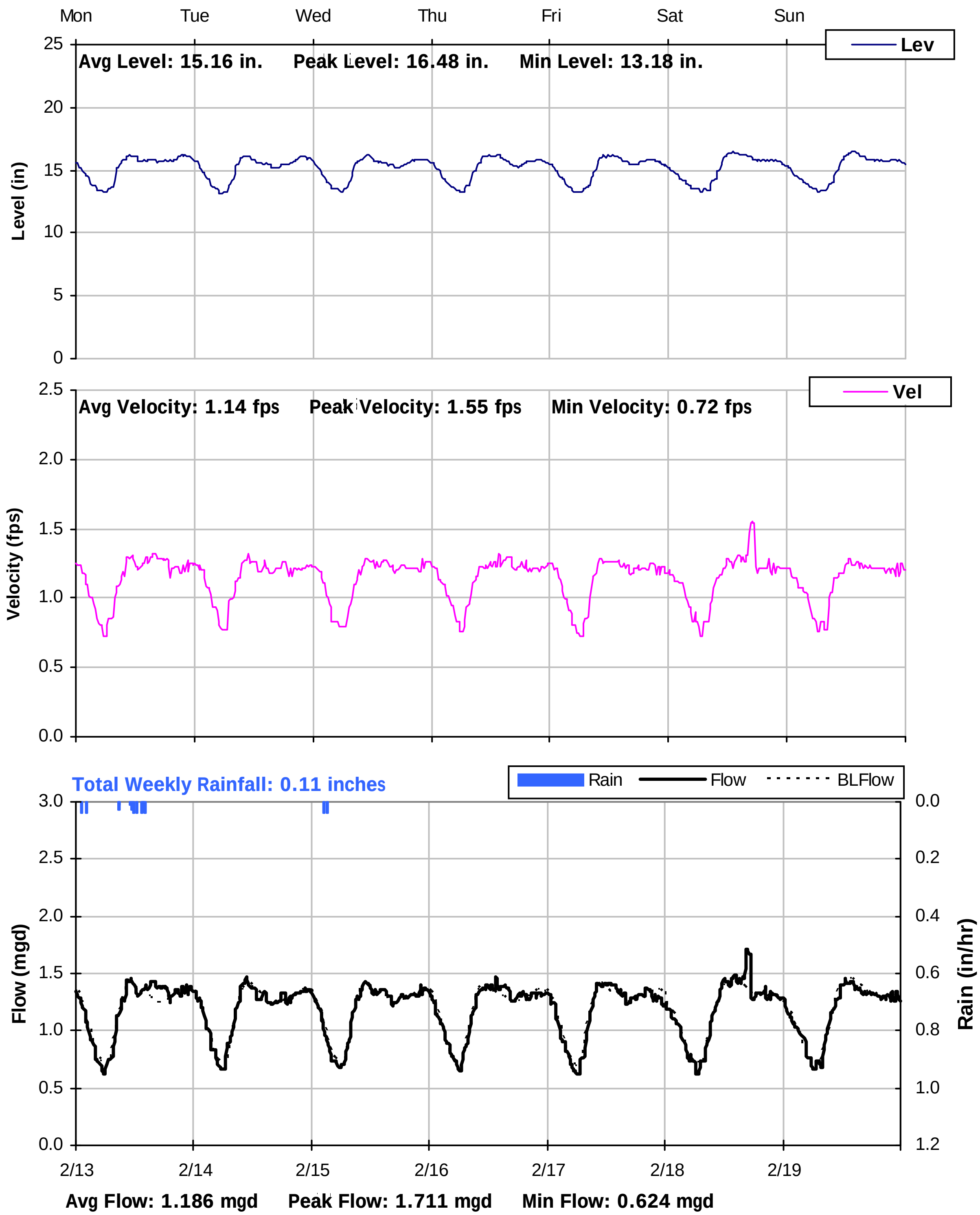
SITE 12
Weekly Level, Velocity and Flow Hydrographs
2/6/2012 to 2/13/2012



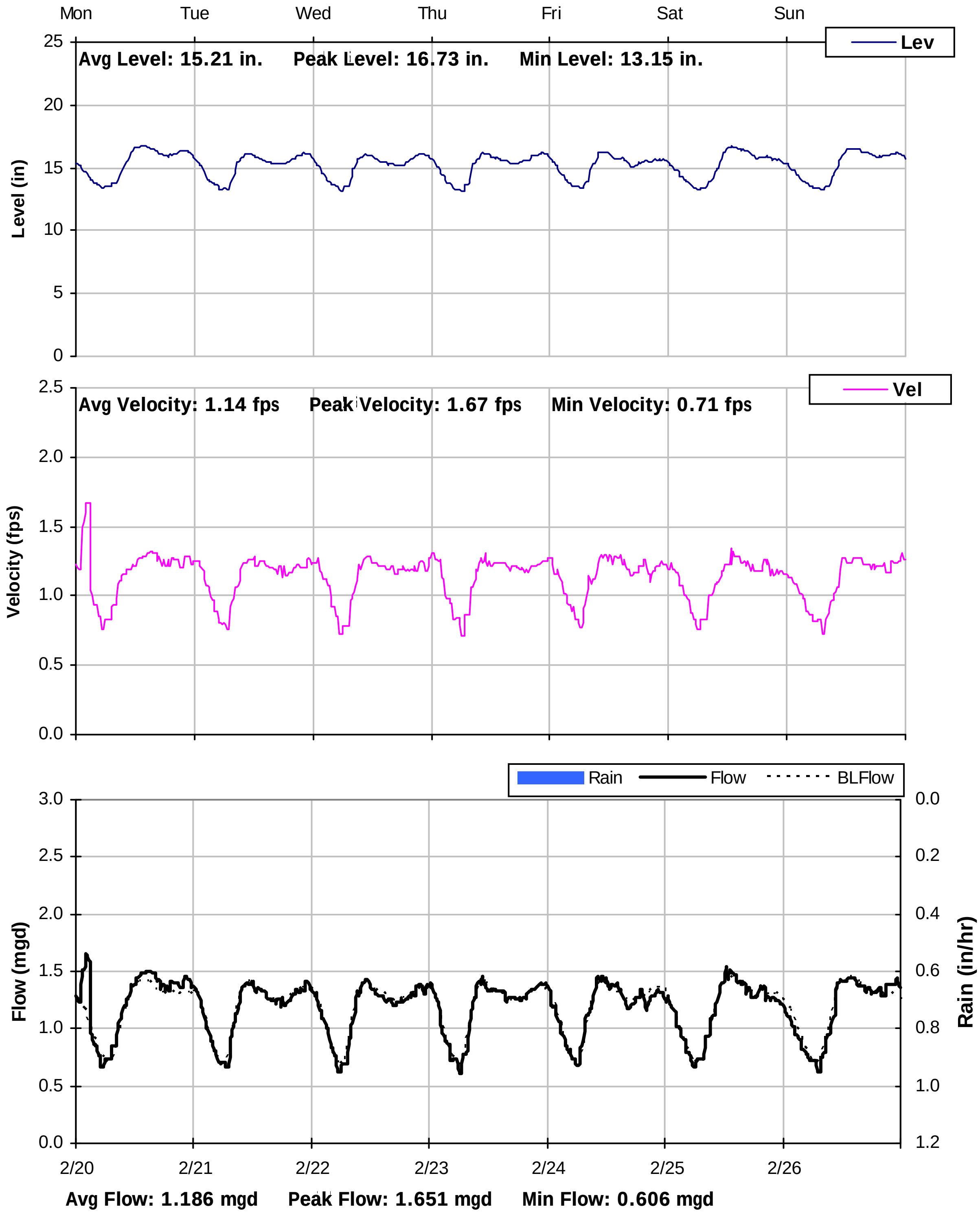
SITE 12

Weekly Level, Velocity and Flow Hydrographs

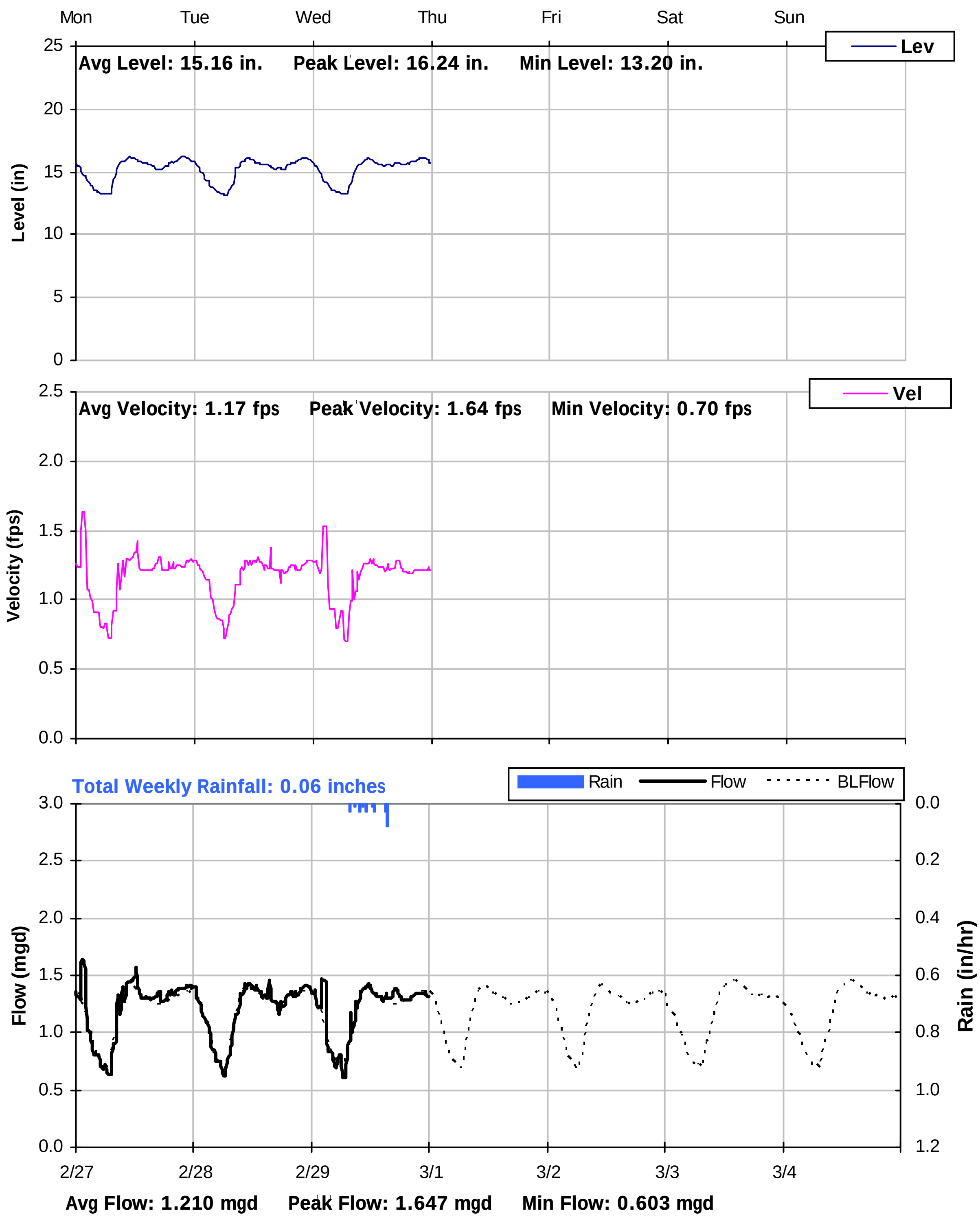
2/13/2012 to 2/20/2012



SITE 12
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012



SITE 12
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



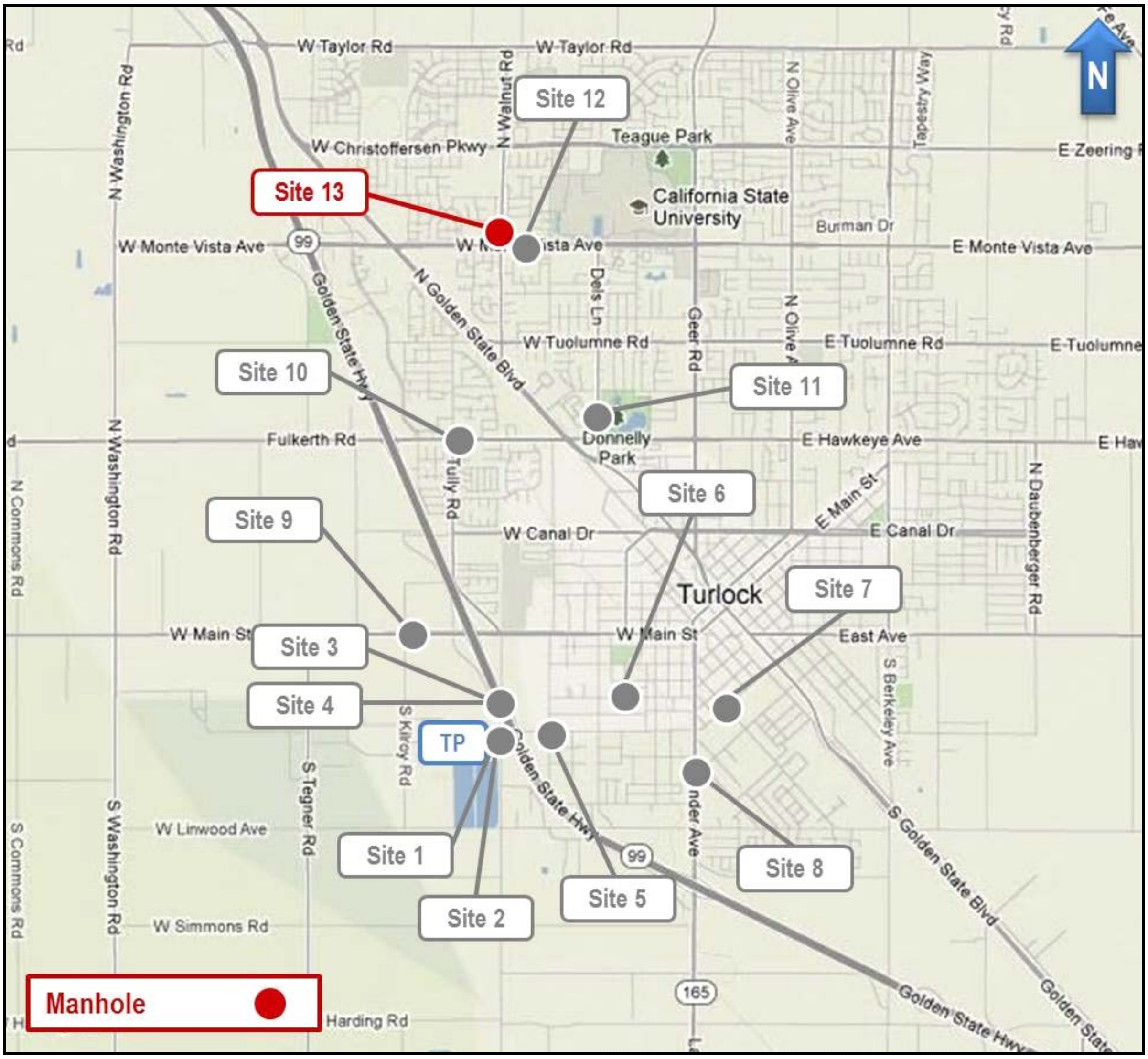
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 13

Location: Walnut Road, North of Monte Vista Avenue

Data Summary Report



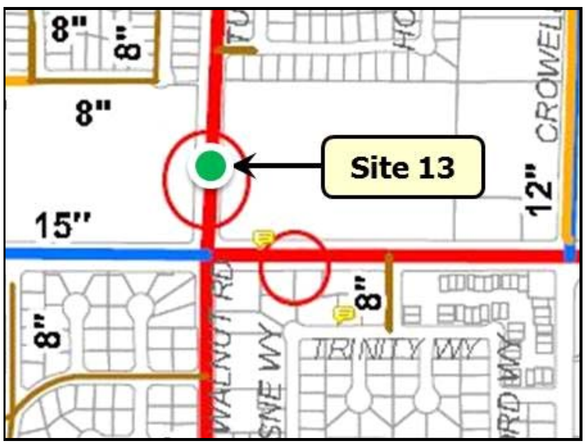
Vicinity Map: Site 13

SITE 13

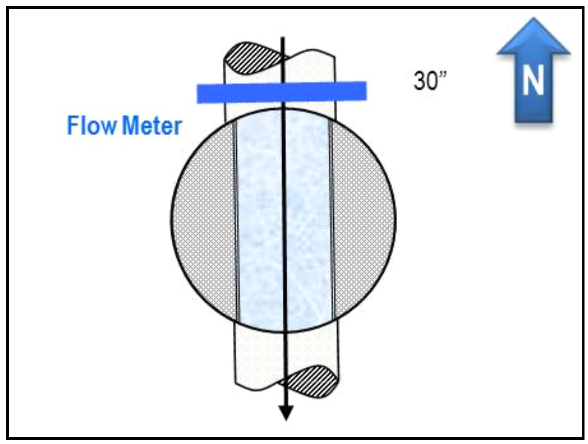
Site Information

Location:	Walnut Road, North of Monte Vista Avenue
Coordinates:	120.8672° W, 37.5230° N
Rim Elevation:	104 feet
Pipe Diameter:	30 inches
Baseline Flow:	1.040 mgd
Peak Measured Flow:	1.977 mgd

Satellite Map



Sewer Map



Flow Sketch


Street View

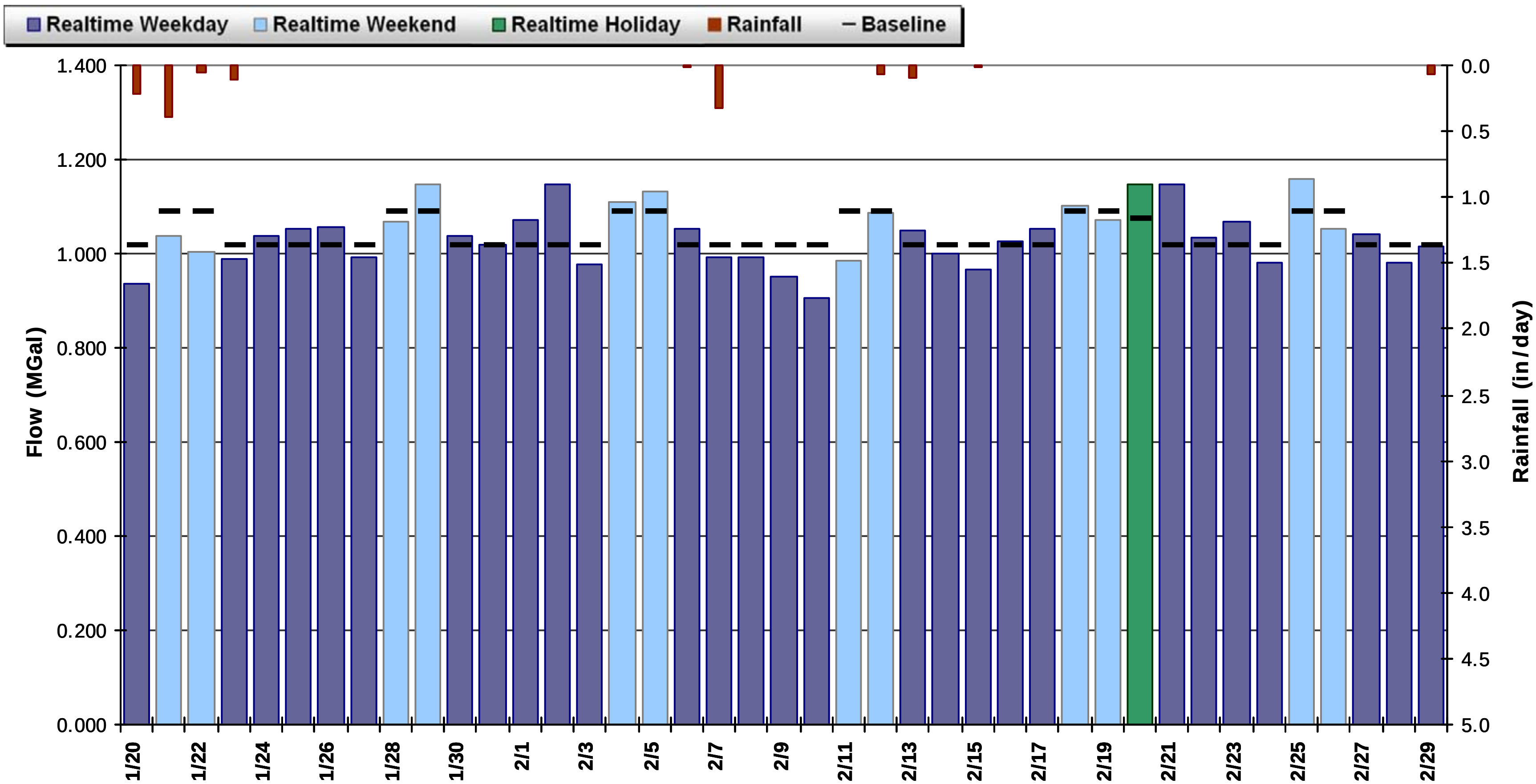

Plan View

SITE 13

Period Flow Summary: Daily Flow Totals

Avg Period Flow: 1.041 MGal **Peak Daily Flow: 1.160 MGal** **Min Daily Flow: 0.907 MGal**

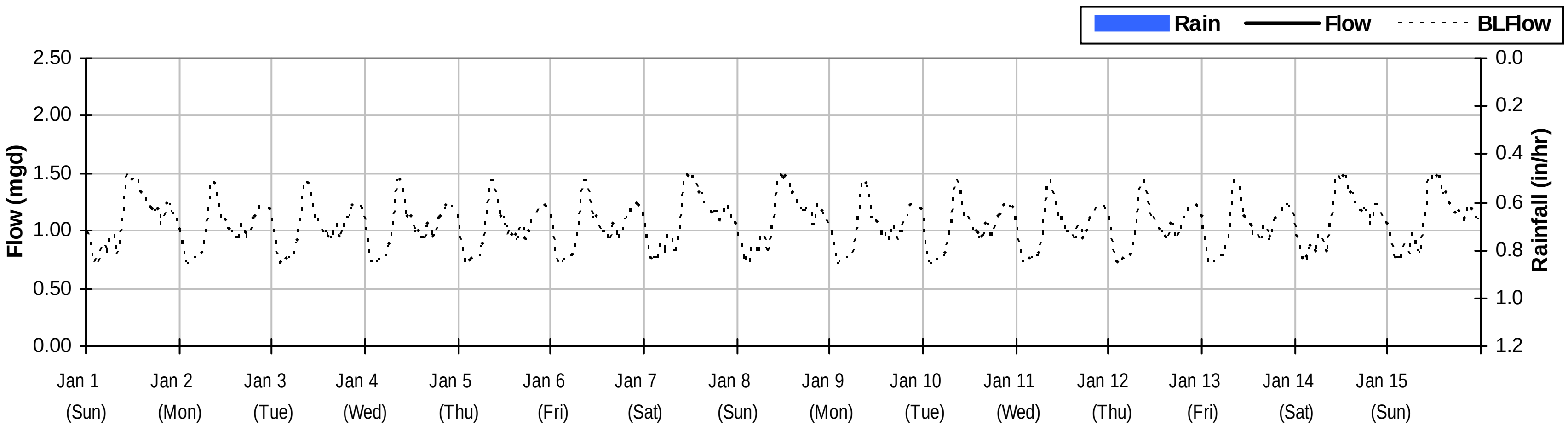
Total Period Rainfall: 1.37 inches

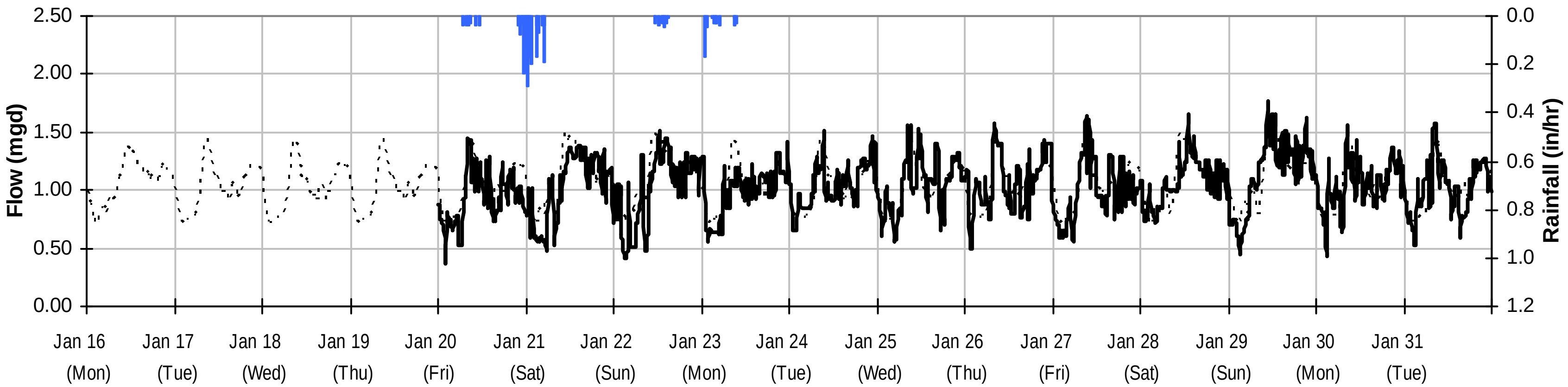


SITE 13

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.78 inches **Avg Flow: 1.032 mgd** **Peak Flow: 1.771 mgd** **Min Flow: 0.359 mgd**

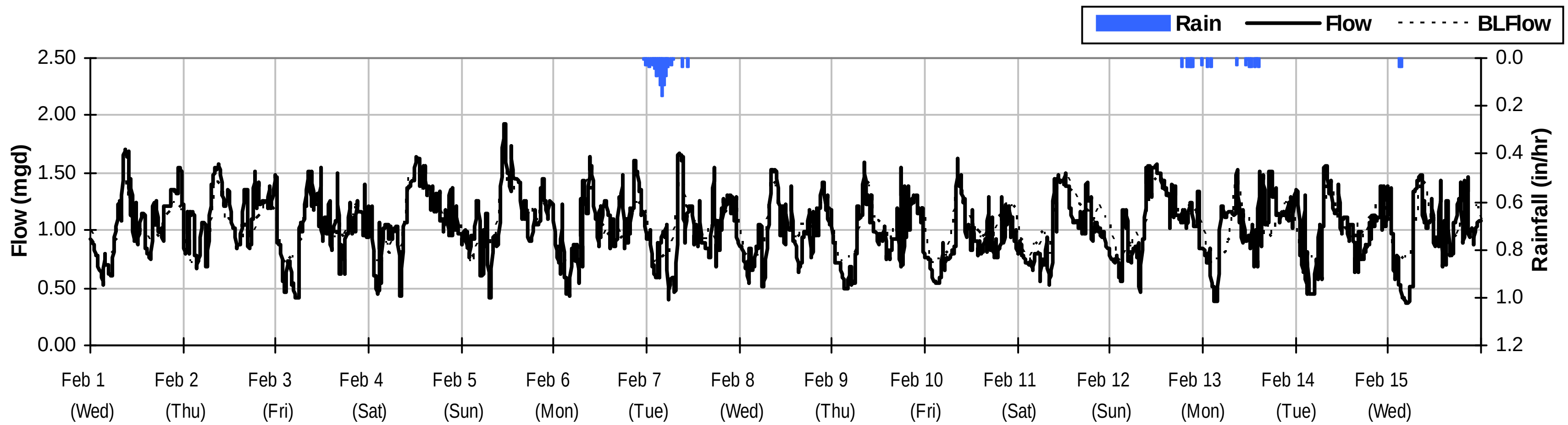


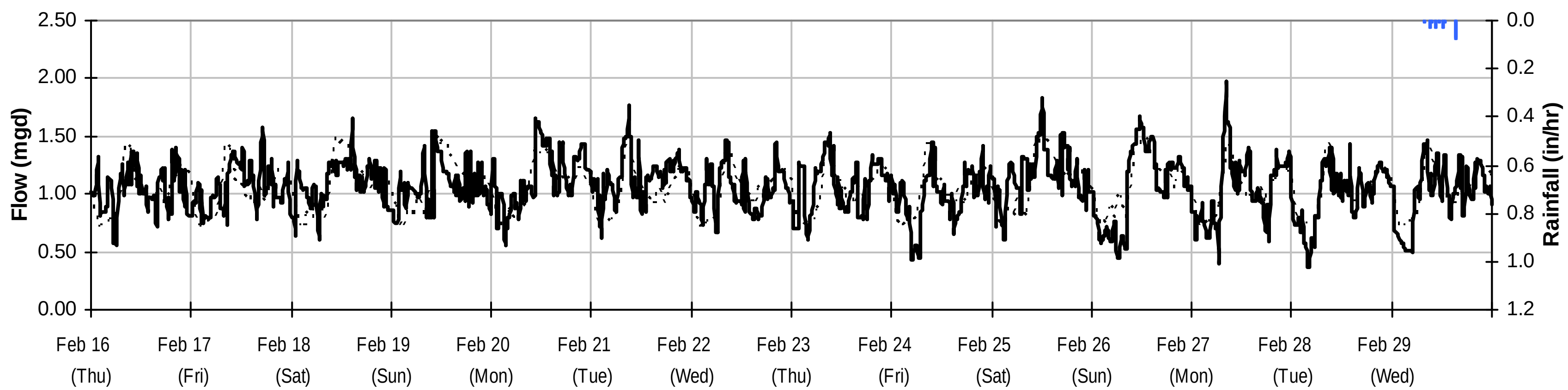


SITE 13

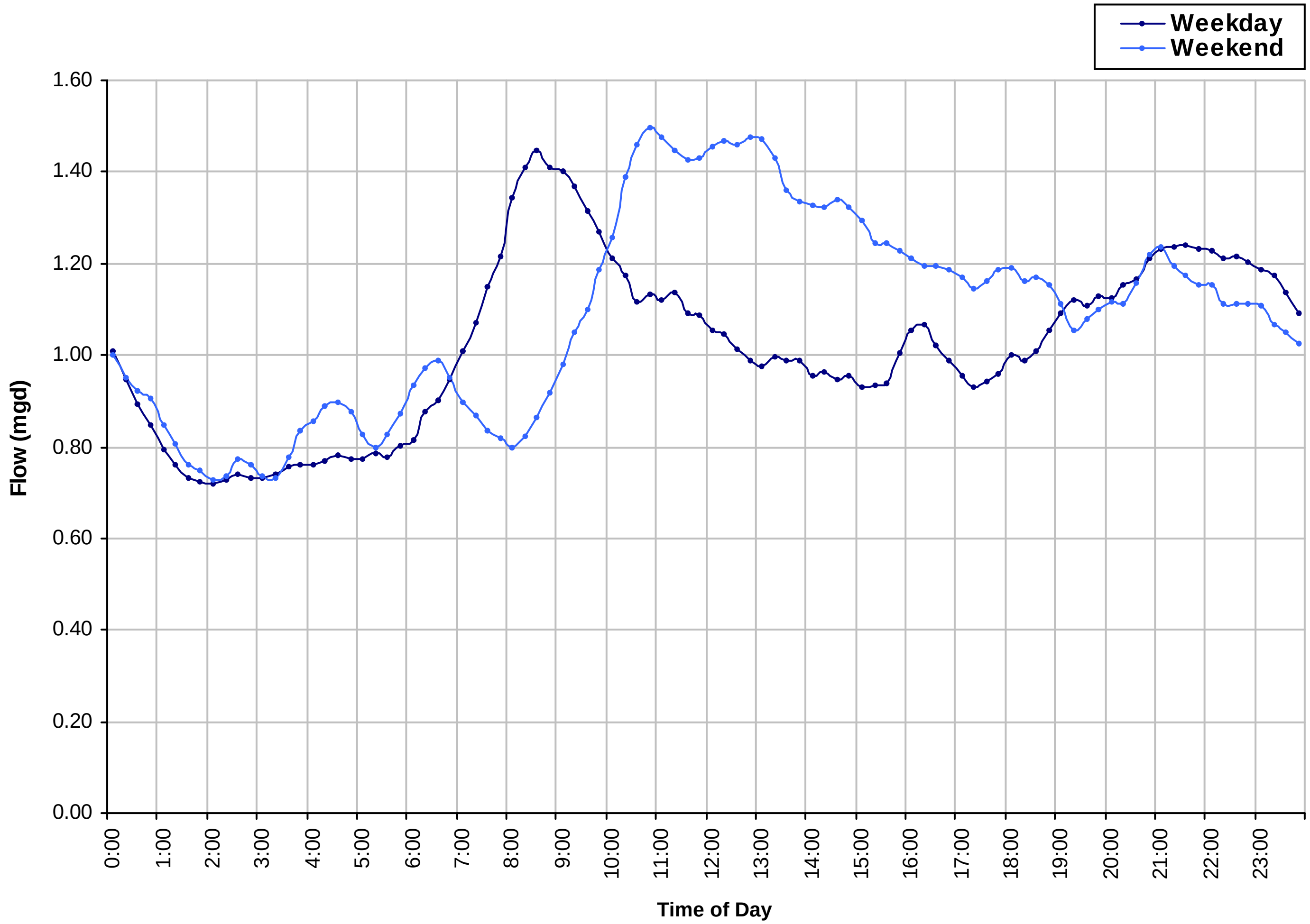
Monthly Flow Summary: February, 2012

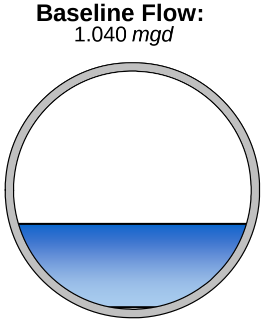
Total Monthly Rainfall: 0.59 inches **Avg Flow: 1.045 mgd** **Peak Flow: 1.977 mgd** **Min Flow: 0.360 mgd**





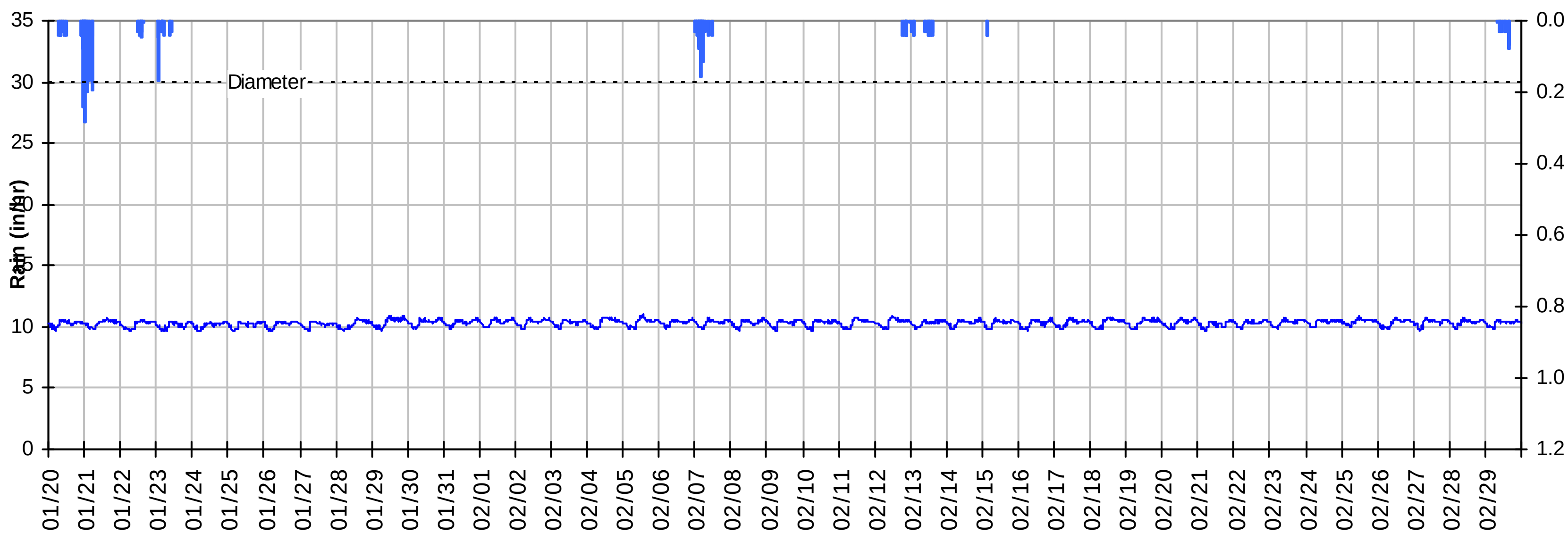
SITE 13
Baseline Flow Hydrographs

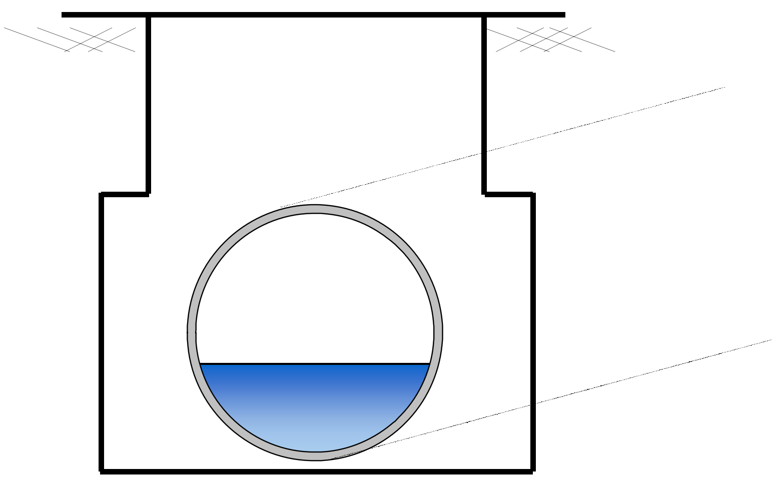




SITE 13
Site Capacity and Surcharge Summary

Realtime Flow Levels with Rainfall Data over Monitoring Period





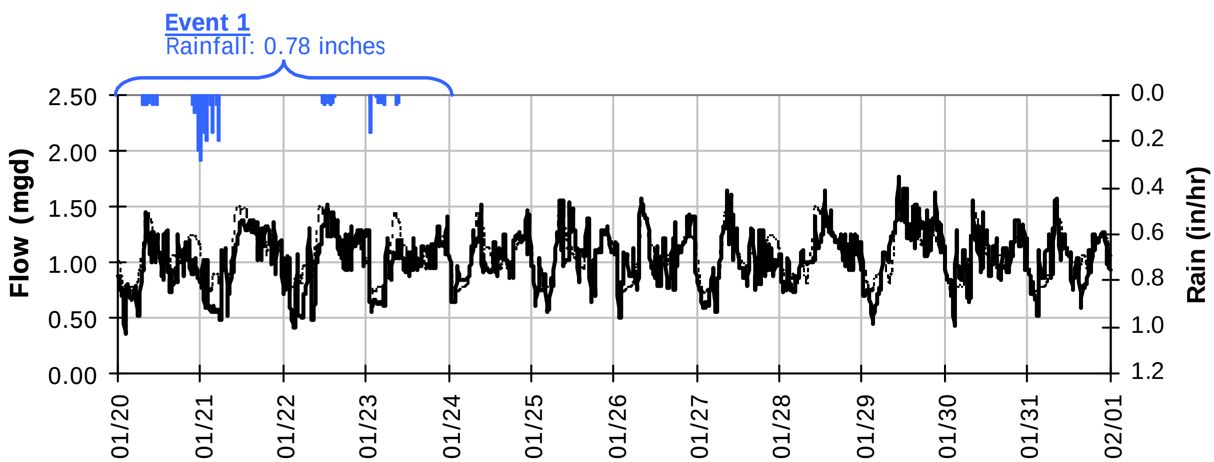
Pipe Diameter: 30 *inches*

Peak Measured Level: 11.0 *inches*

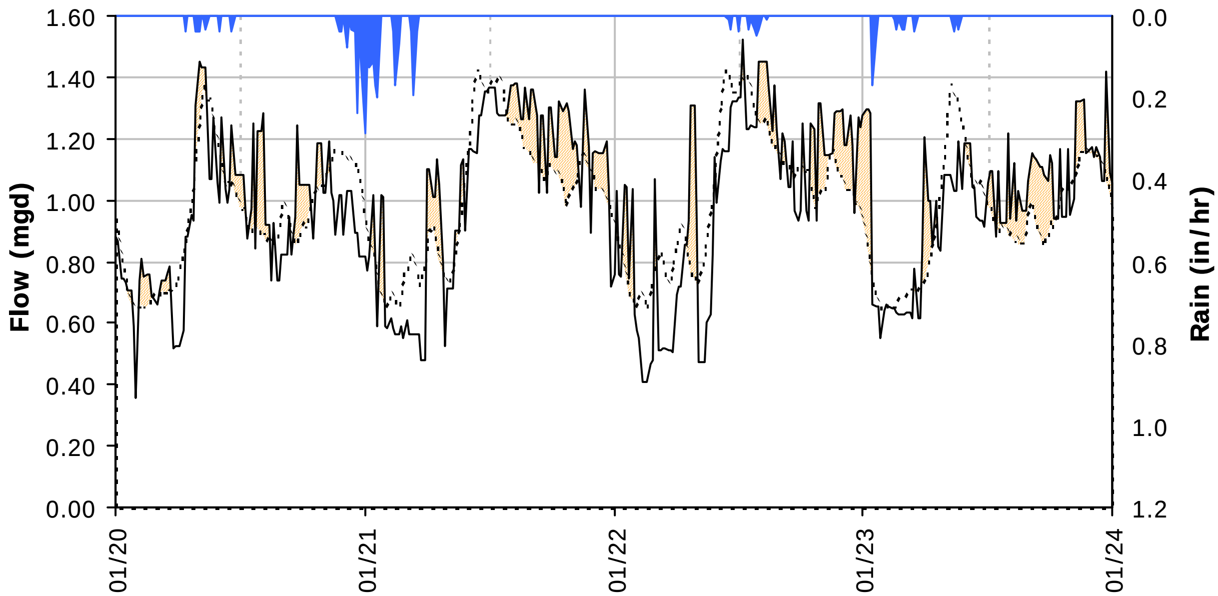
Peak d/D Ratio: 0.37

SITE 13
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



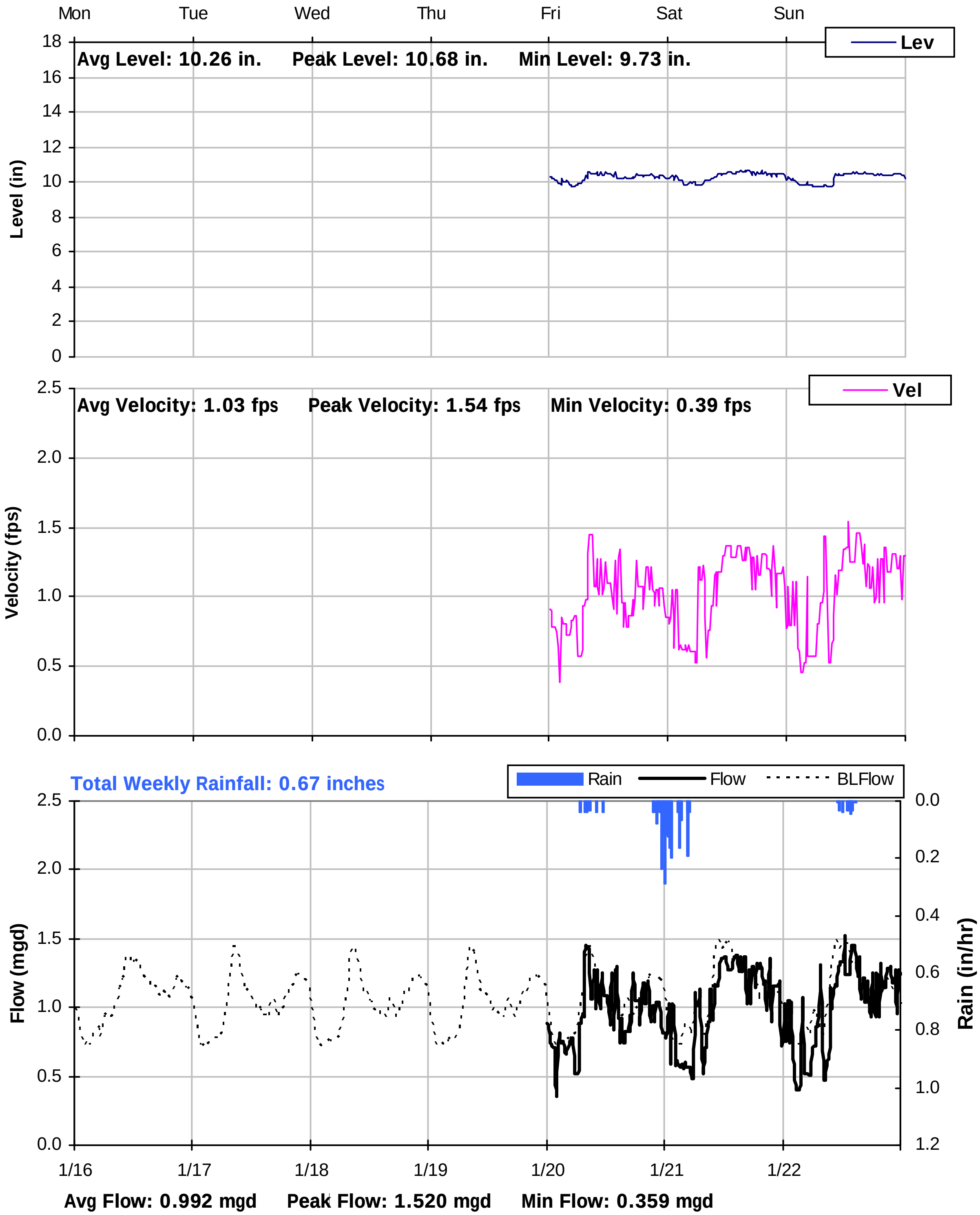
Event 1 Detail Graph



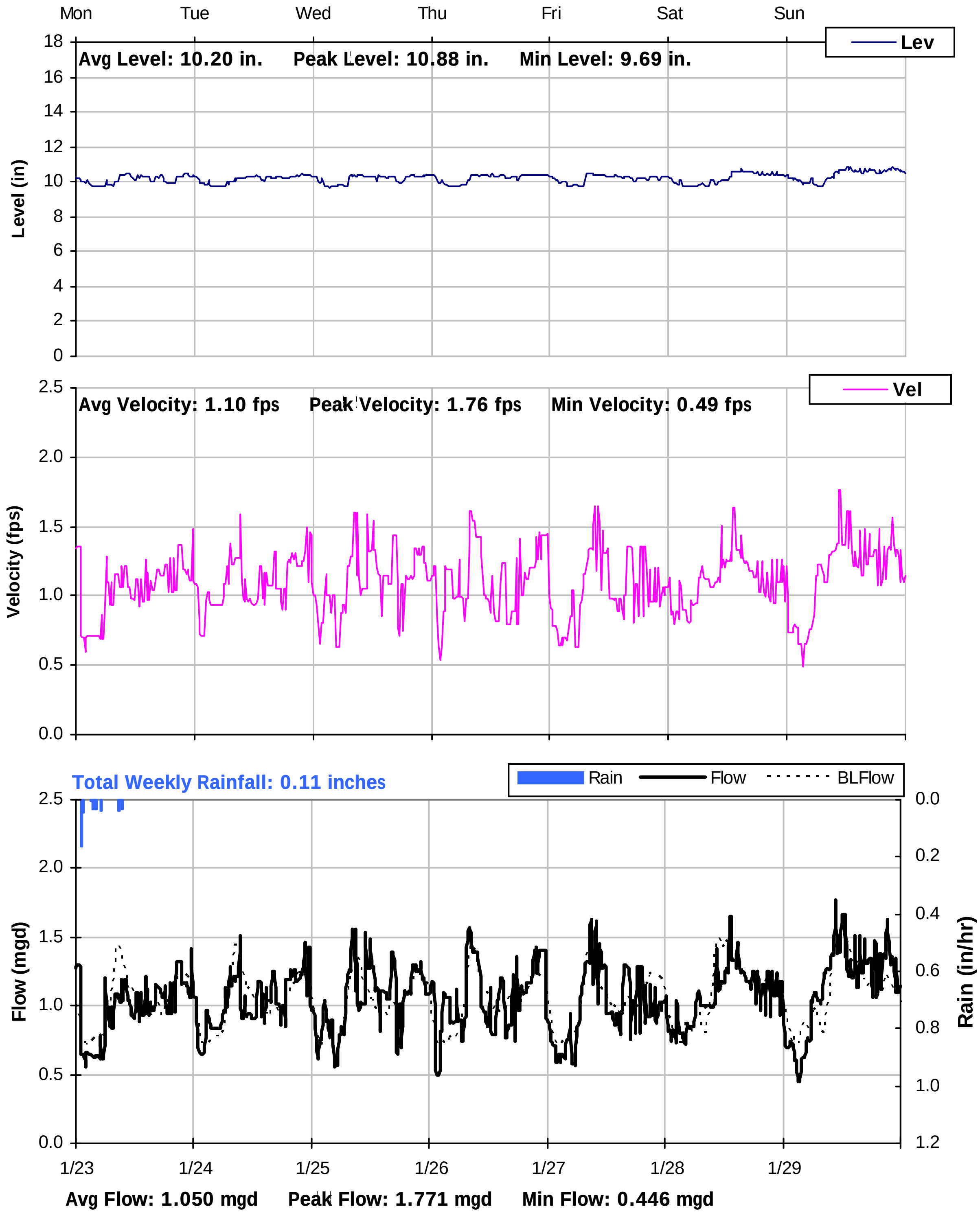
Storm Event I/I Analysis (Rain = 0.78 inches)

Capacity		Inflow		Combined I/I	
Peak Flow:	1.52 *mgd*	**Peak I/I Rate:**	0.49 *mgd*	**Total I/I:**	50,000 *gallons*
PF:	1.46	**Pk I/I:Acre:**	324 *gpd/acre*	**R-Value:**	0.2%
		Pk I/I:ADWF:	0.47	**Total I/I:ADWF:**	0.06 *per in-rain*
Peak Level:	10.68 *in*				
d/D Ratio:	0.36				

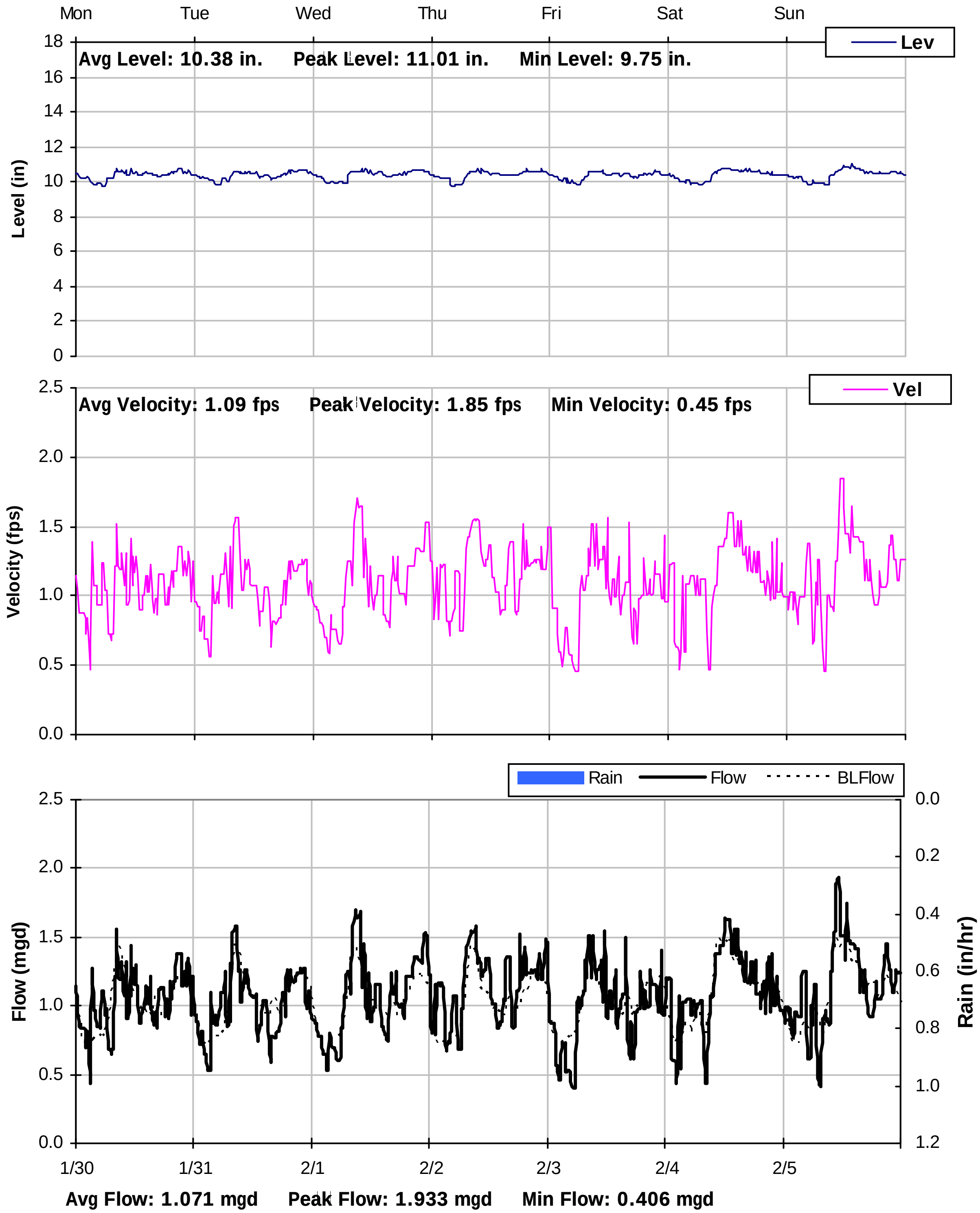
SITE 13
Weekly Level, Velocity and Flow Hydrographs
1/16/2012 to 1/23/2012



SITE 13
Weekly Level, Velocity and Flow Hydrographs
1/23/2012 to 1/30/2012



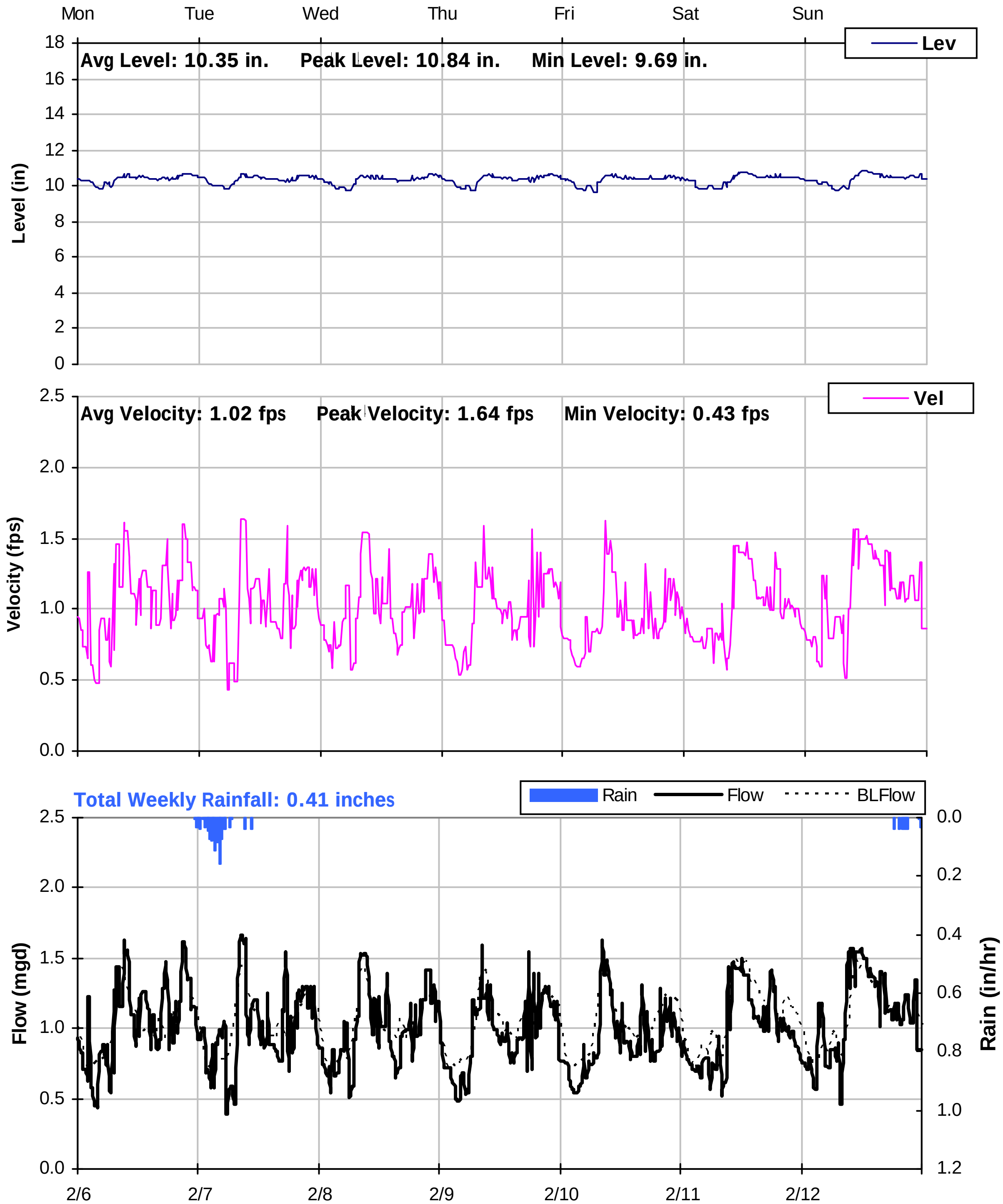
SITE 13
Weekly Level, Velocity and Flow Hydrographs
1/30/2012 to 2/6/2012



SITE 13

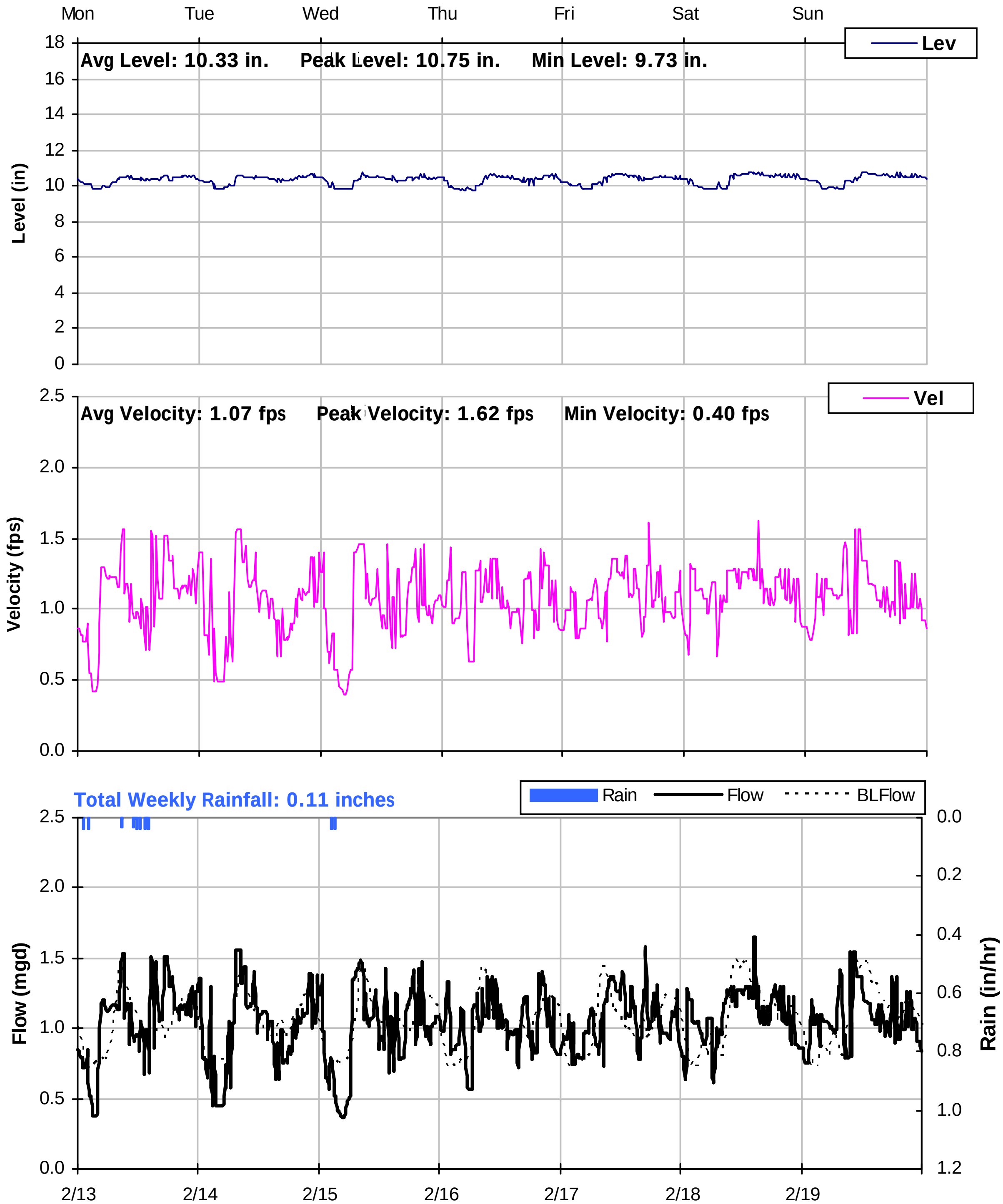
Weekly Level, Velocity and Flow Hydrographs

2/6/2012 to 2/13/2012



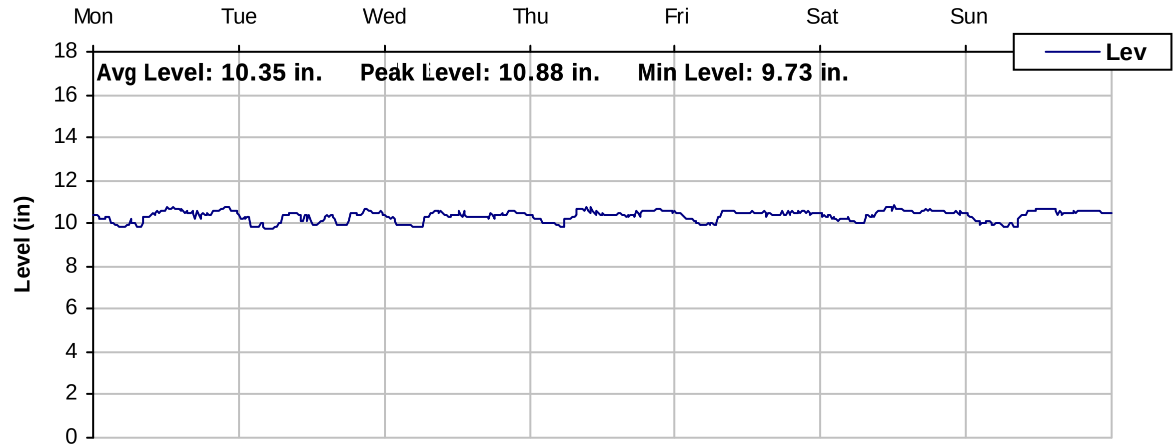
Avg Flow: 0.996 mgd **Peak Flow: 1.665 mgd** **Min Flow: 0.390 mgd**

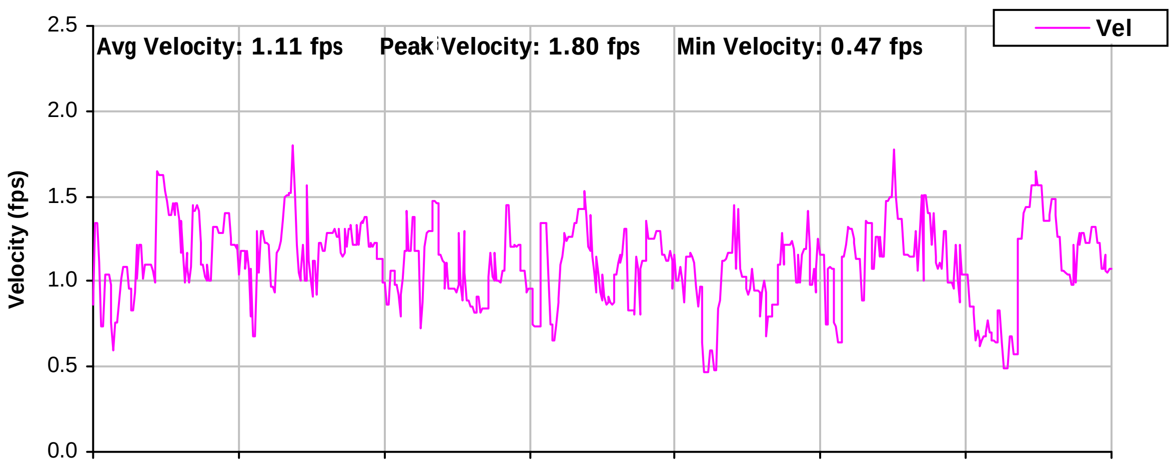
SITE 13
Weekly Level, Velocity and Flow Hydrographs
2/13/2012 to 2/20/2012

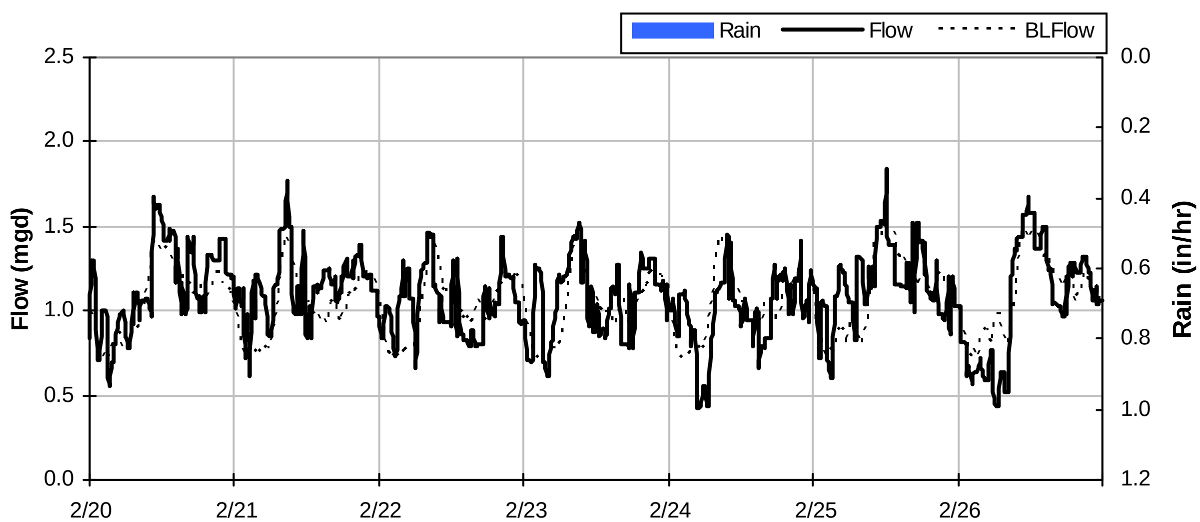


Avg Flow: 1.039 mgd **Peak Flow: 1.651 mgd** **Min Flow: 0.360 mgd**

SITE 13
Weekly Level, Velocity and Flow Hydrographs
2/20/2012 to 2/27/2012

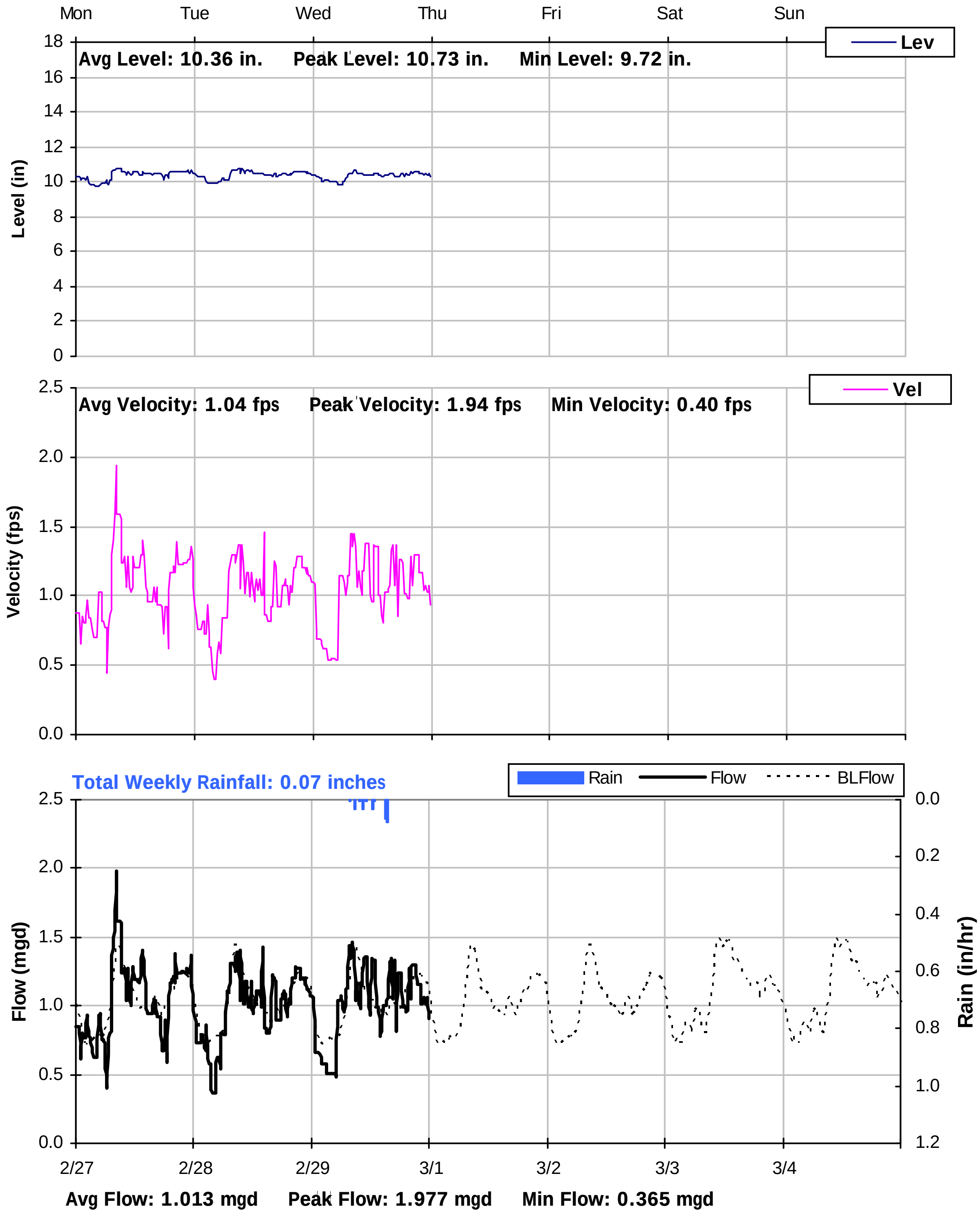






Avg Flow: 1.084 mgd **Peak Flow: 1.838 mgd** **Min Flow: 0.430 mgd**

SITE 13
Weekly Level, Velocity and Flow Hydrographs
2/27/2012 to 3/5/2012



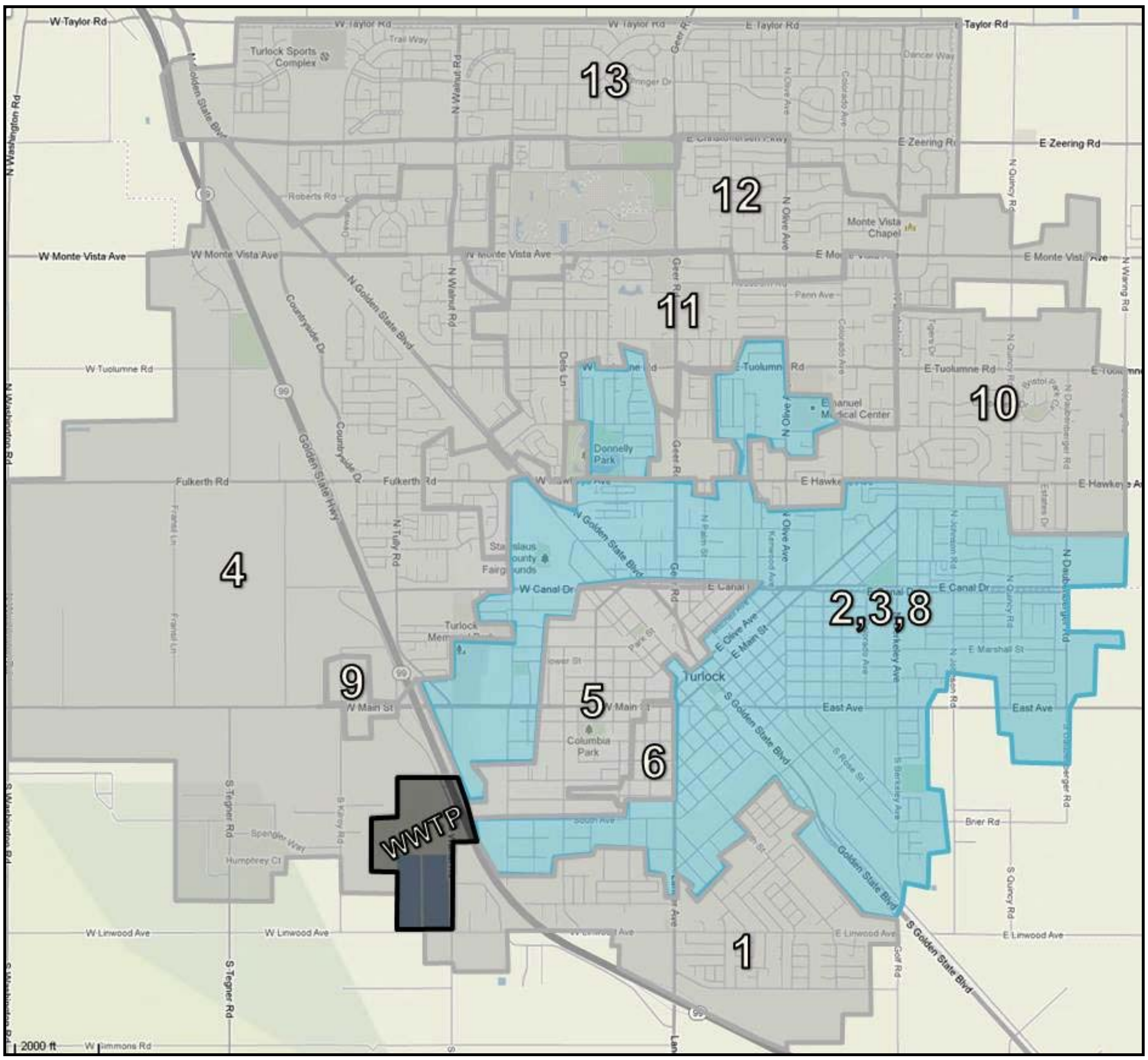
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: Site 2,3,8

Location: Combination of Sites 2, 3 and 8

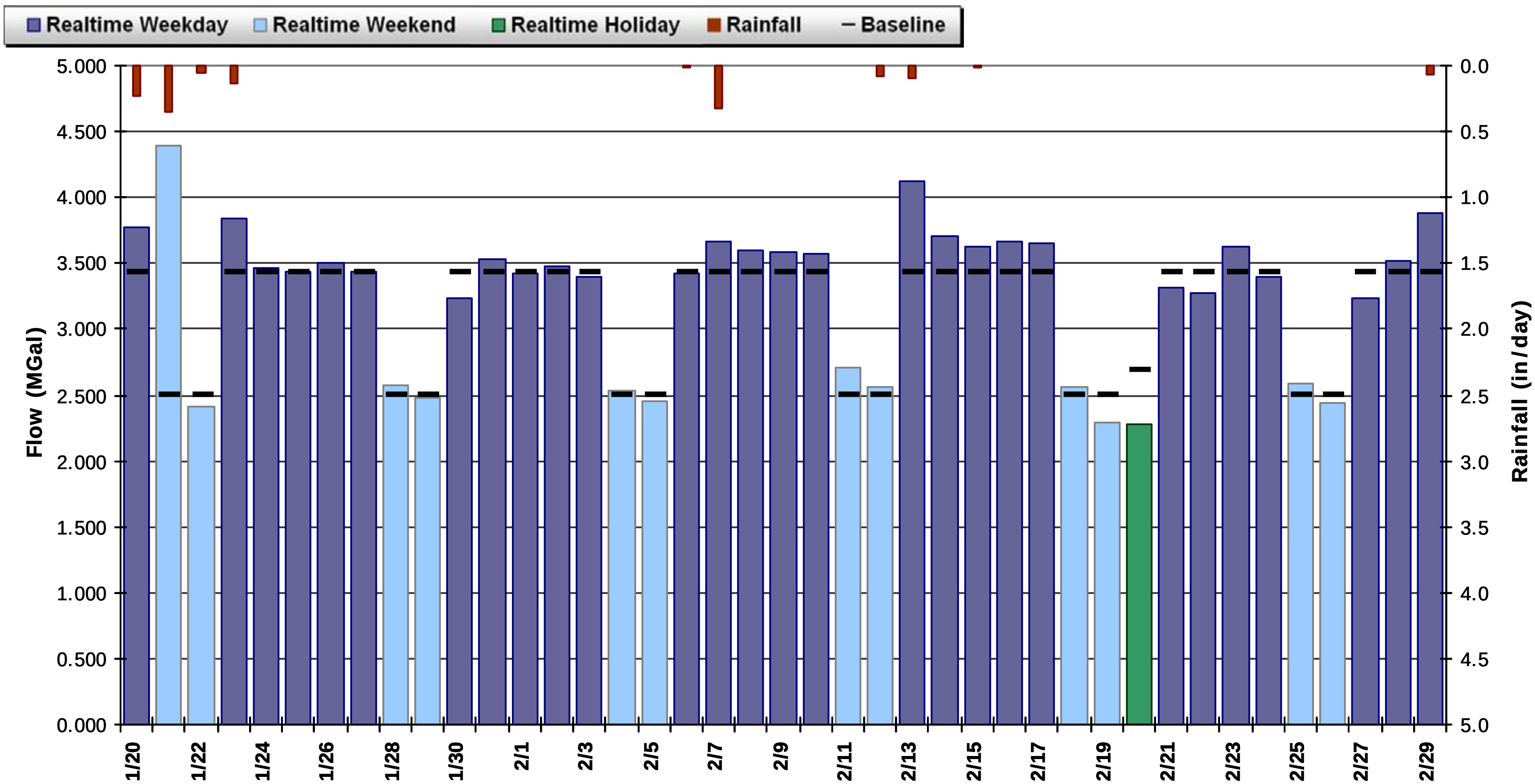
Data Summary Report



Vicinity Map: Site 2,3,8

SITE 2,3,8

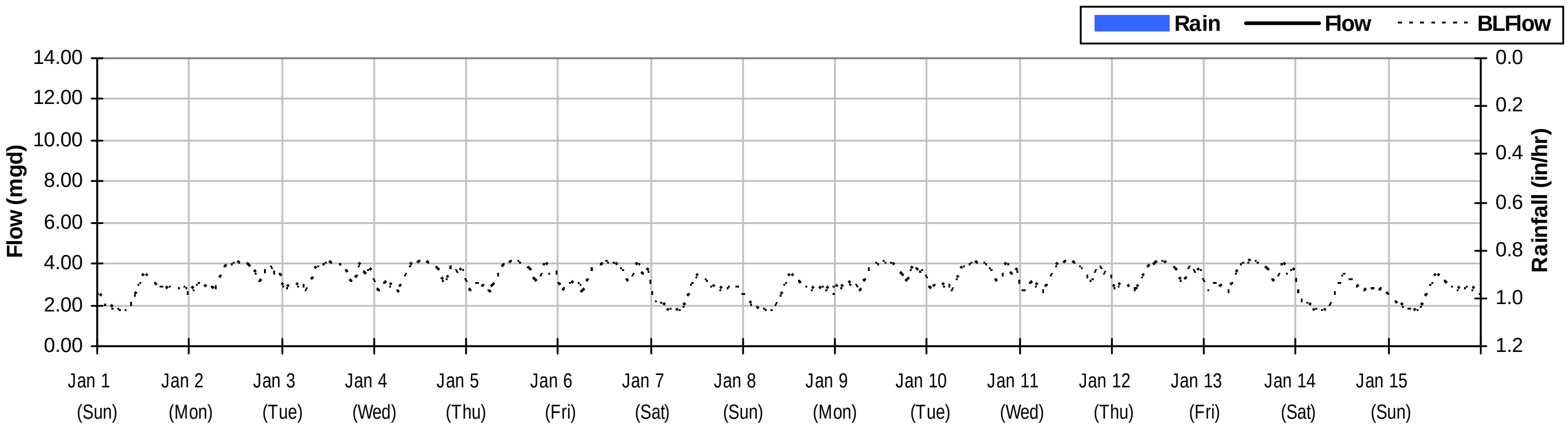
Period Flow Summary: Daily Flow Totals

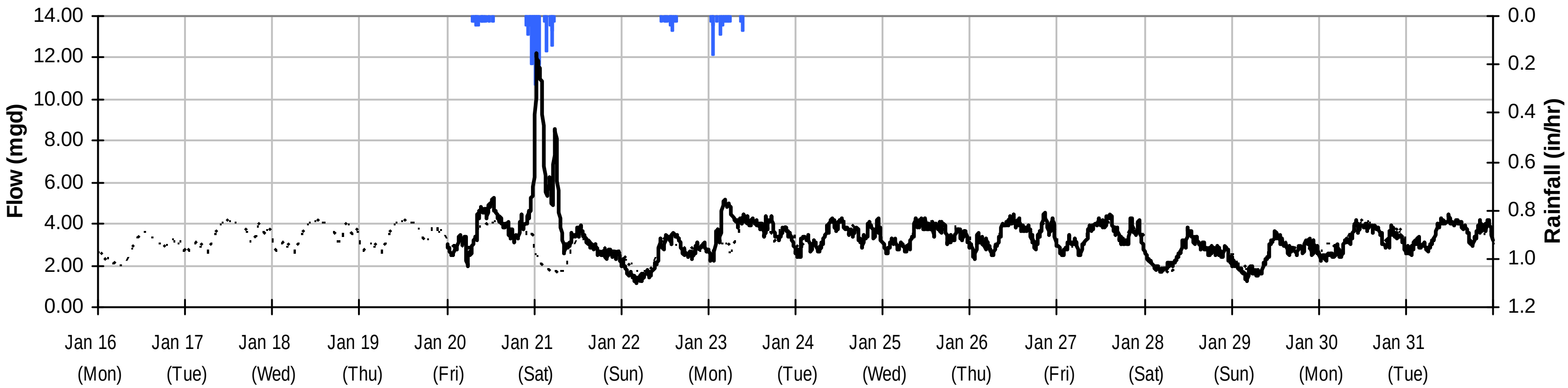


SITE 2,3,8

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.77 inches **Avg Flow: 3.341 mgd** **Peak Flow: 12.259 mgd** **Min Flow: 1.173 mgd**

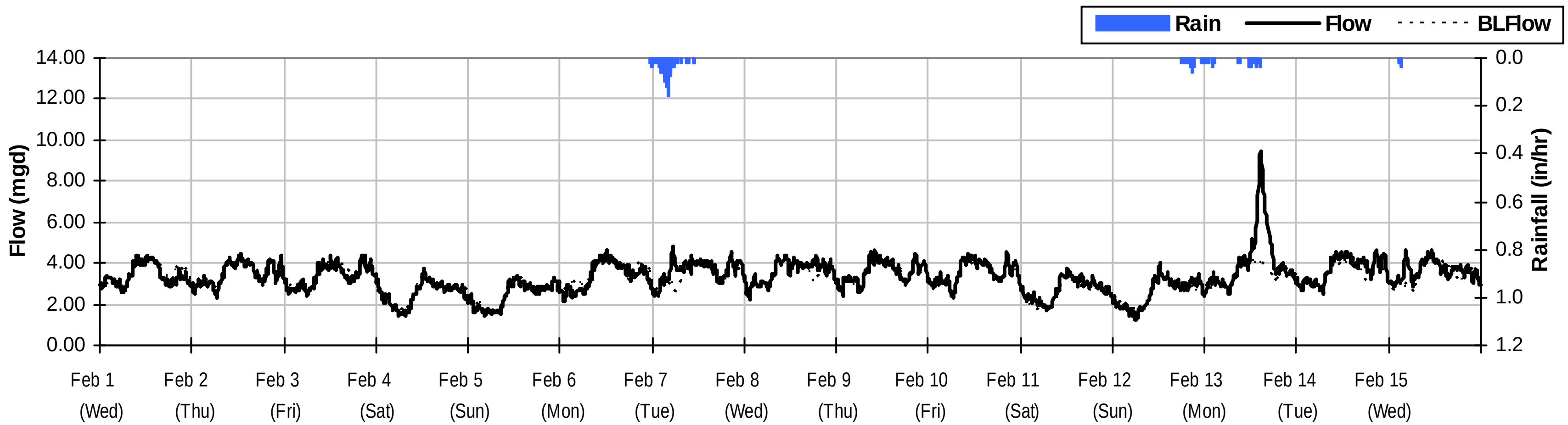


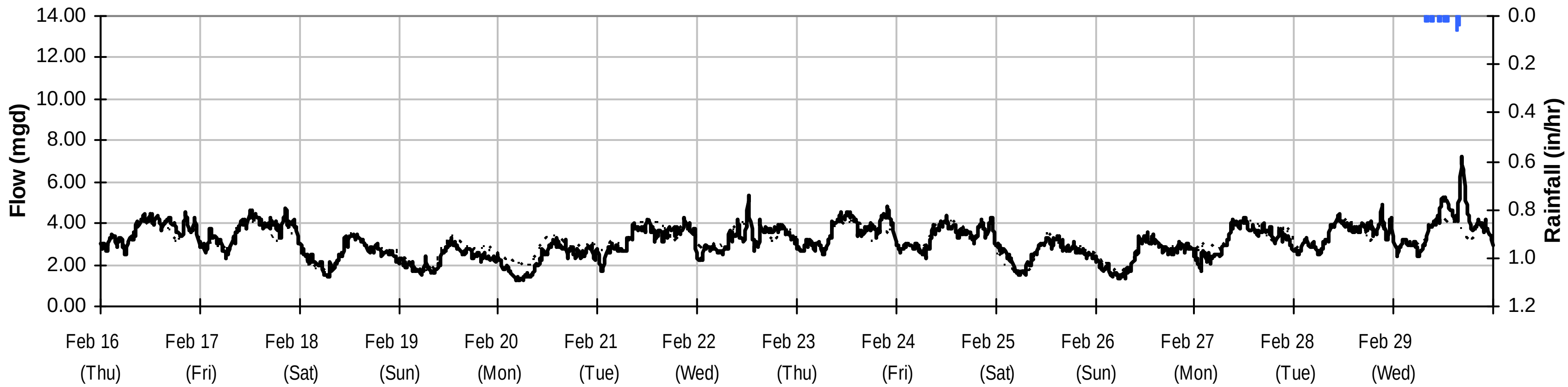


SITE 2,3,8

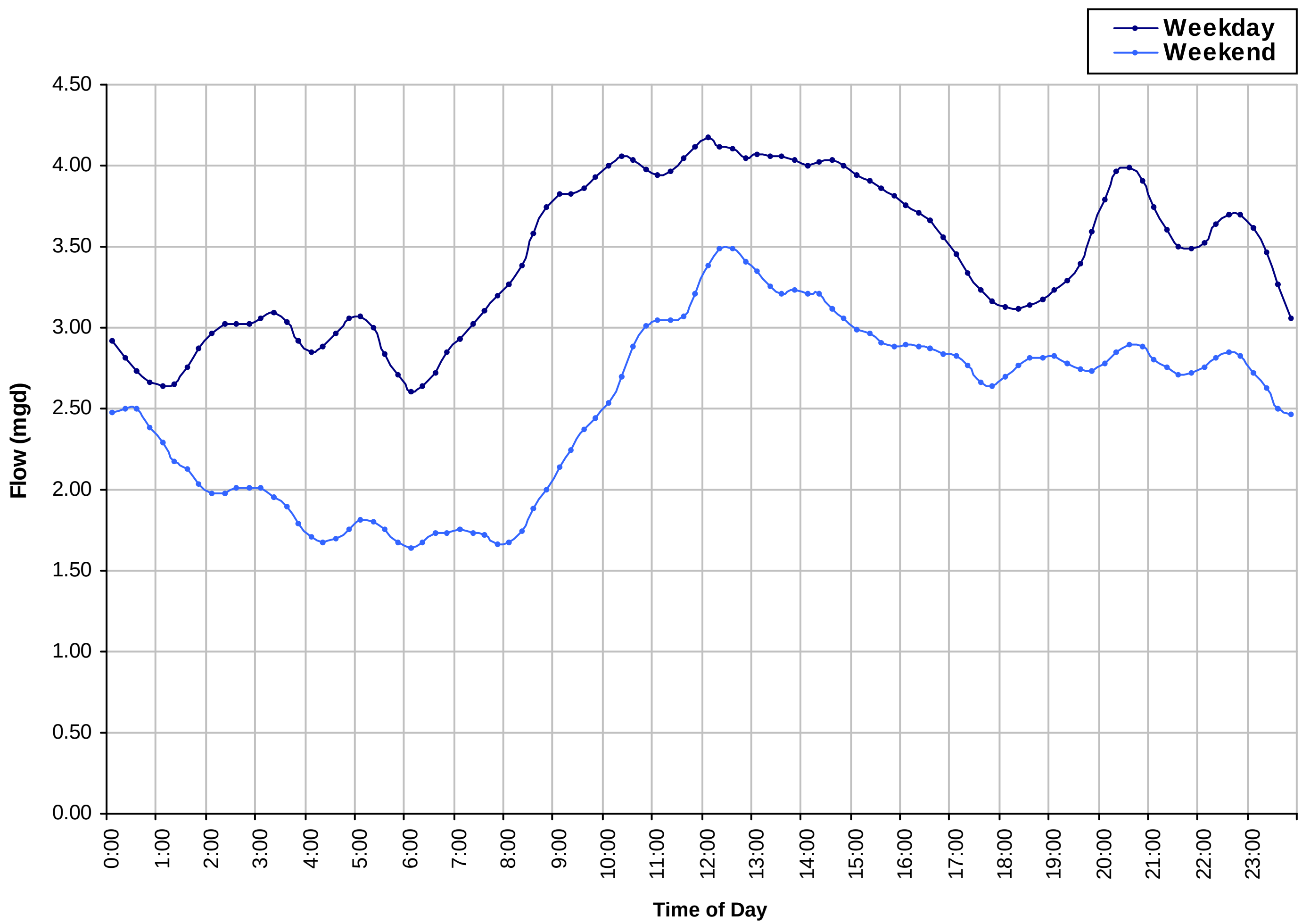
Monthly Flow Summary: February, 2012

Total Monthly Rainfall: 0.61 inches **Avg Flow: 3.227 mgd** **Peak Flow: 9.473 mgd** **Min Flow: 1.226 mgd**

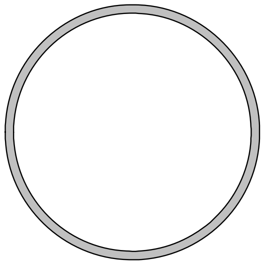




SITE 2,3,8
Baseline Flow Hydrographs

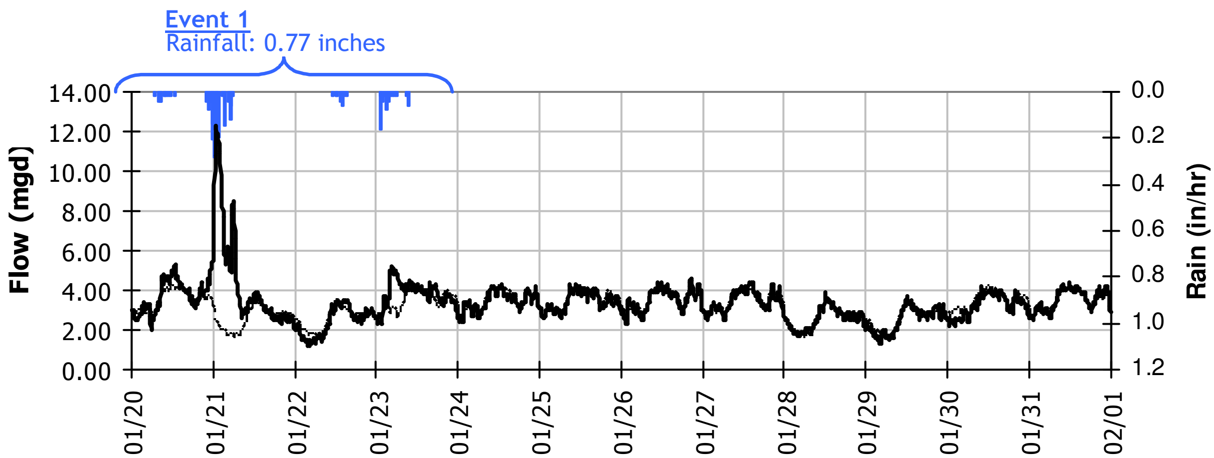


Baseline Flow:
3.176 *mgd*

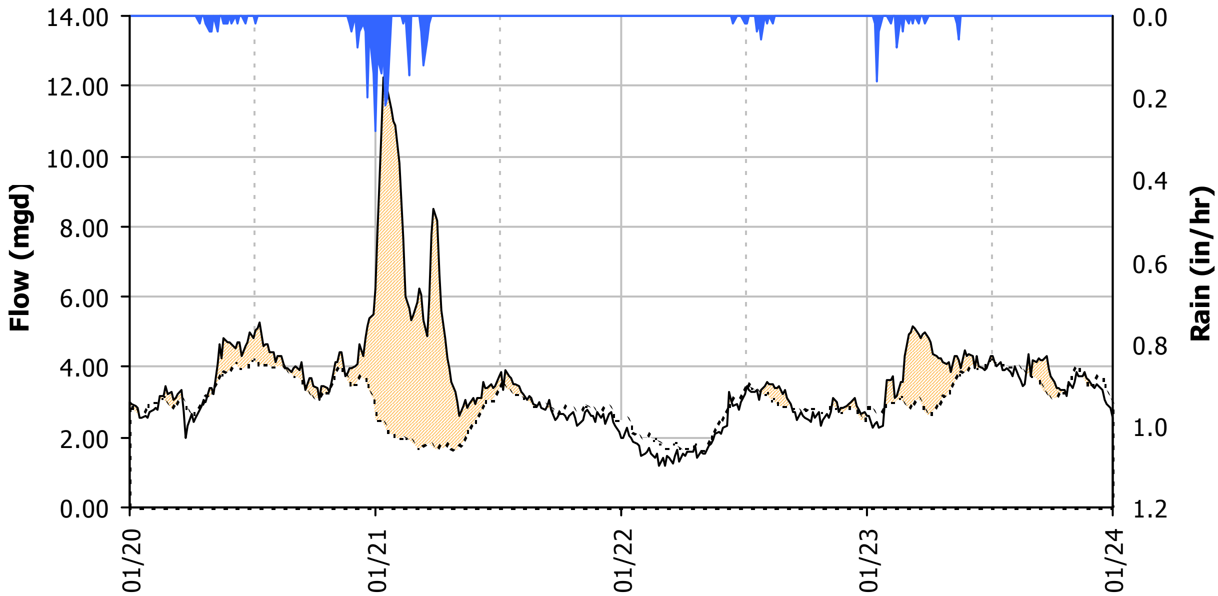


SITE 2,3,8
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period



Event 1 Detail Graph



Storm Event I/I Analysis (Rain = 0.77 inches)

Capacity			Inflow			Combined I/I		
Peak Flow:	12.26	*mgd*	**Peak I/I Rate:**	9.87	*mgd*	**Total I/I:**	2,516,000	*gallons*
PF:	3.86		**Pk I/I:Acre:**	3,426	*gpd/acre*	**R-Value:**	4.2%	
			Pk I/I:ADWF:	3.11		**Total I/I:ADWF:**	1.03	*per in-rain*

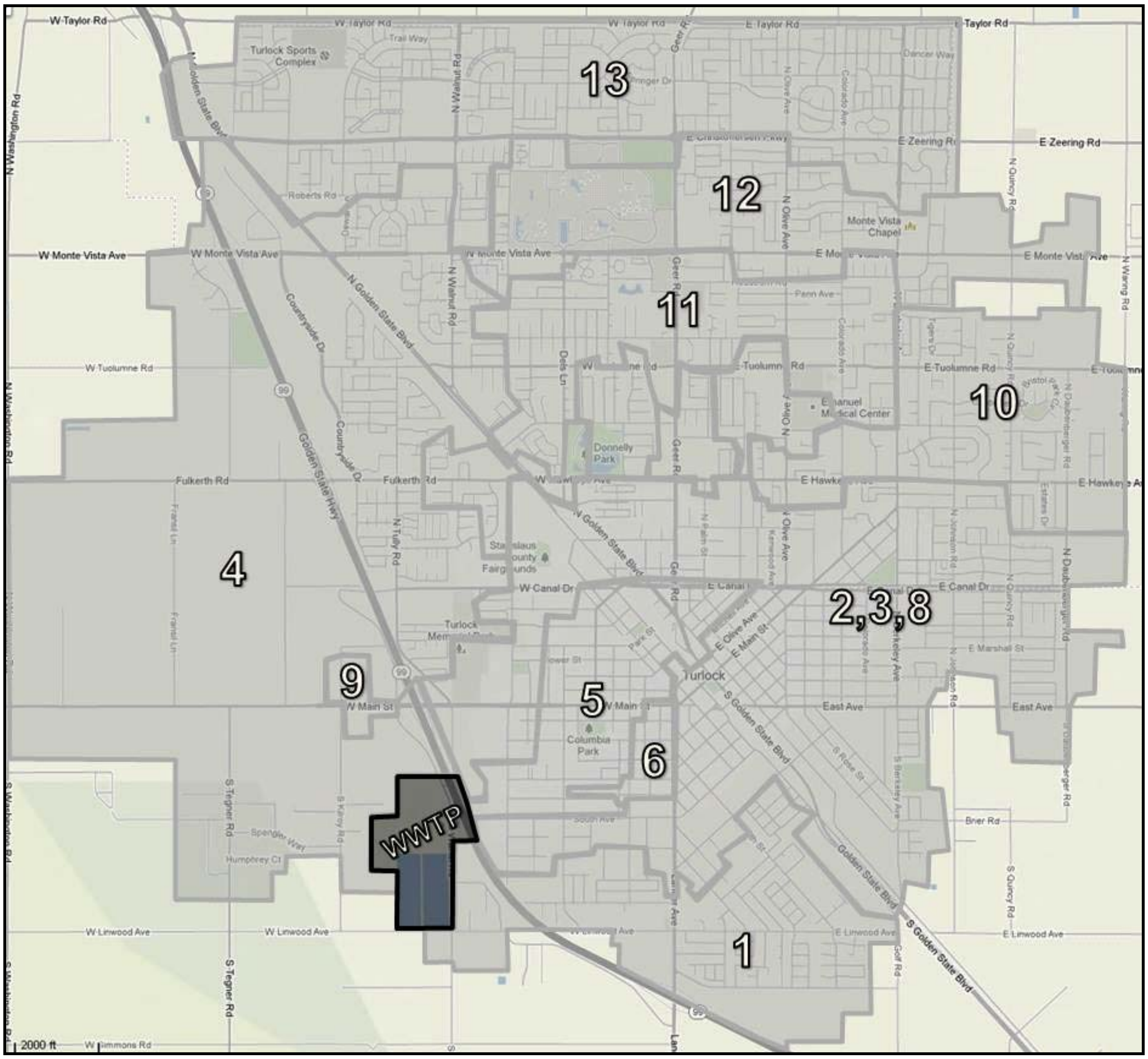
City of Turlock

Sanitary Sewer Flow Monitoring
Year 2012

Monitoring Site: WWTP

Location: Combined flow at the treatment plant

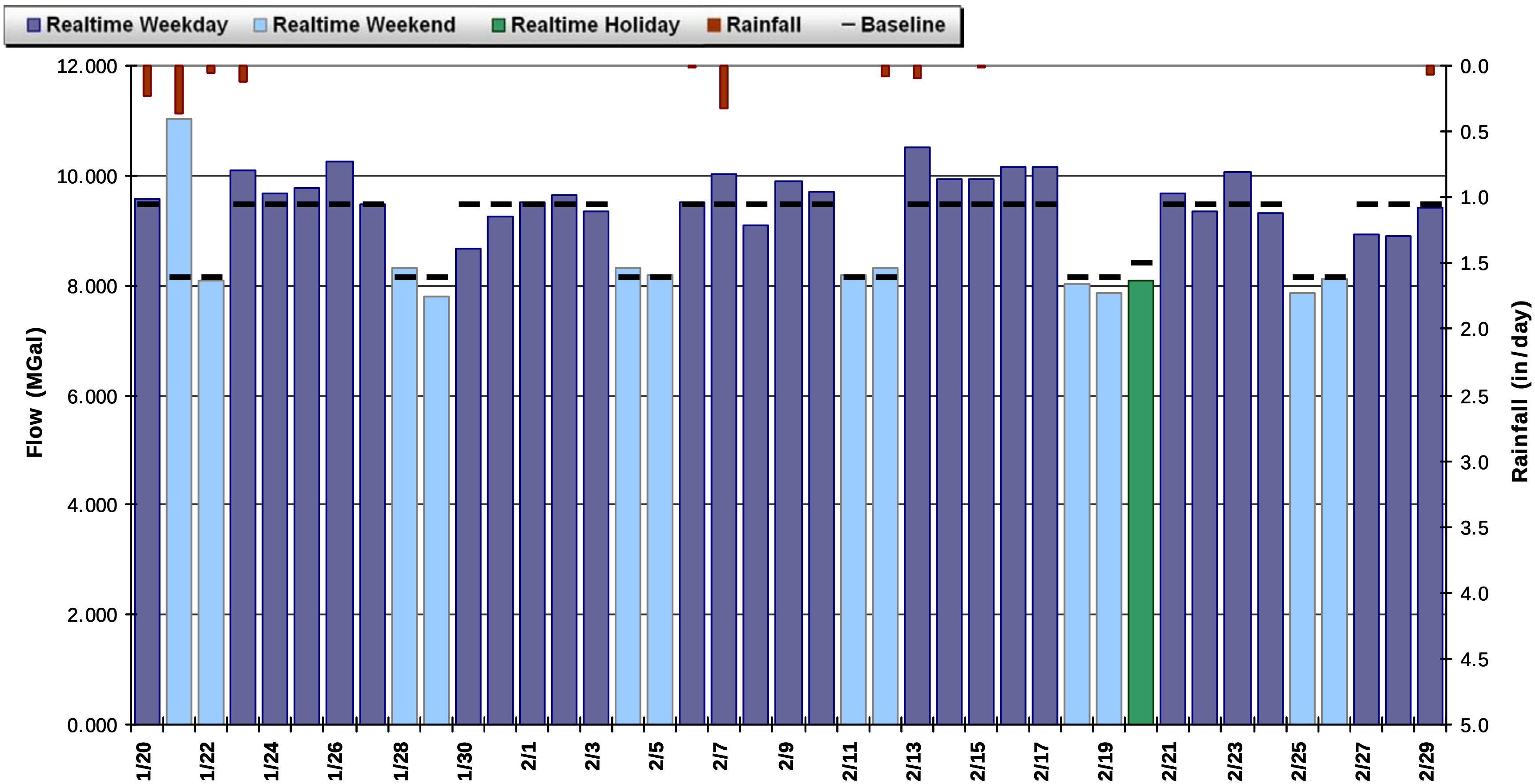
Data Summary Report



Vicinity Map: WWTP

WWTP

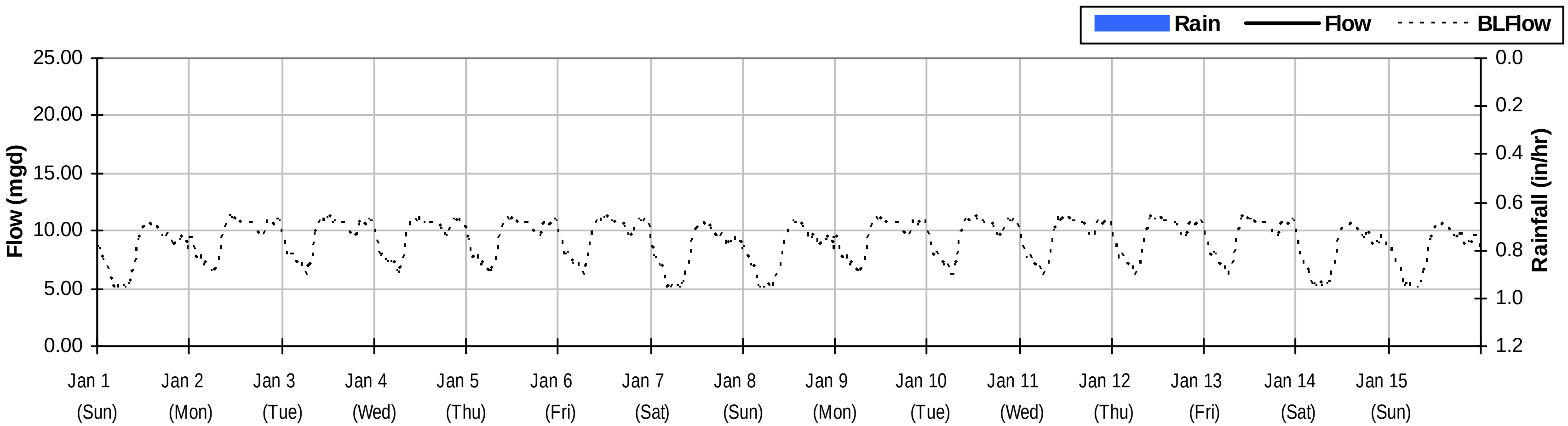
Period Flow Summary: Daily Flow Totals

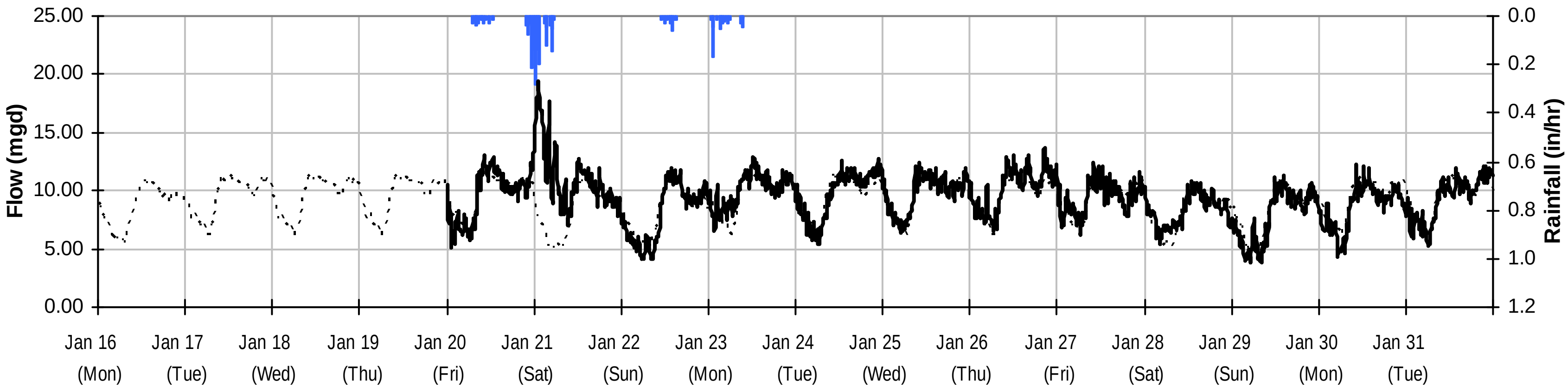


WWTP

Monthly Flow Summary: January, 2012

Total Monthly Rainfall: 0.77 inches **Avg Flow: 9.332 mgd** **Peak Flow: 19.478 mgd** **Min Flow: 3.803 mgd**

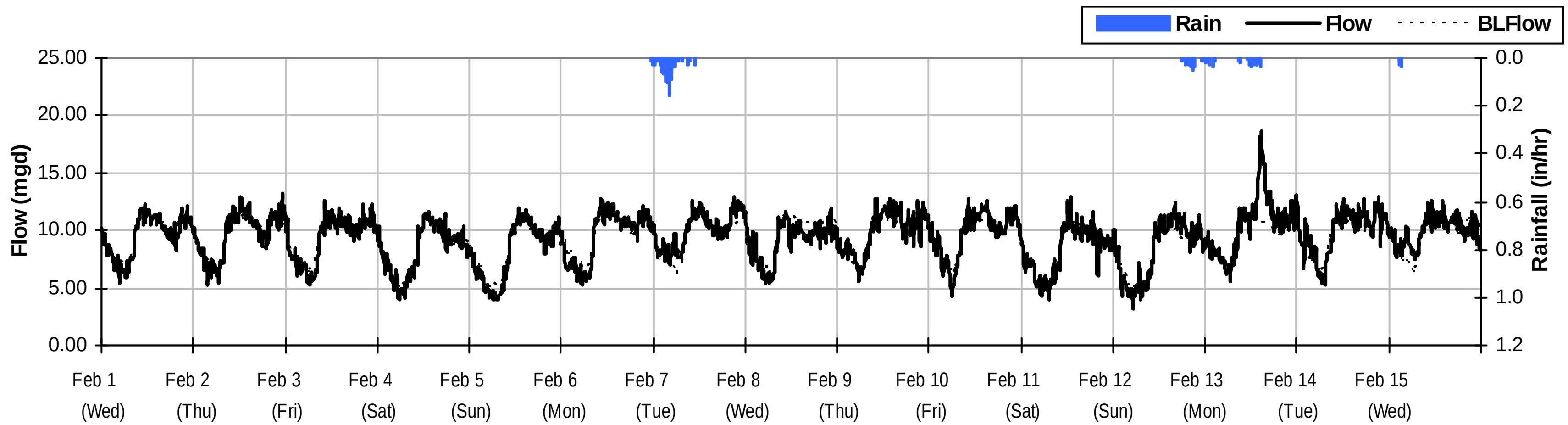


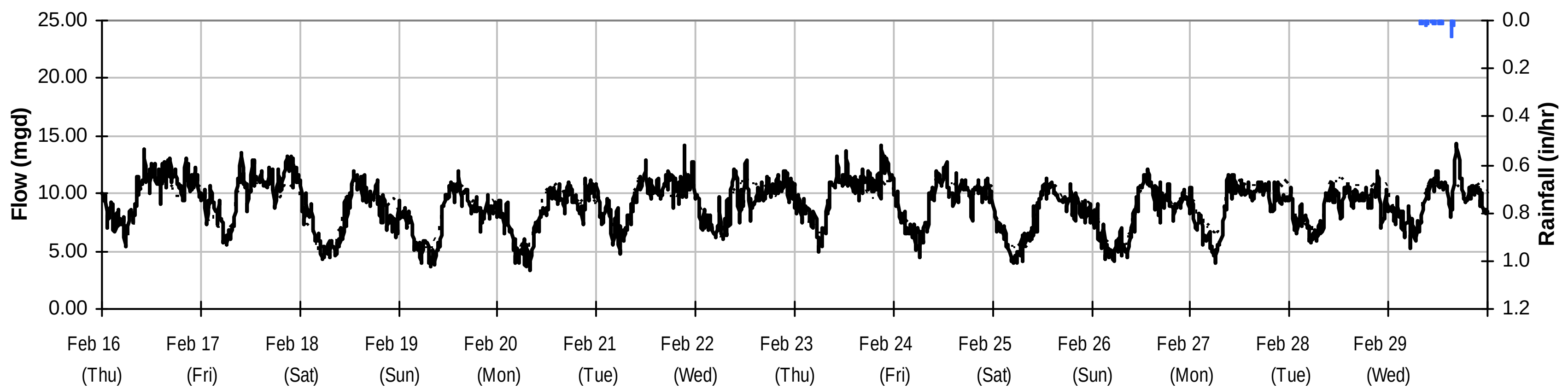


WWTP

Monthly Flow Summary: February, 2012

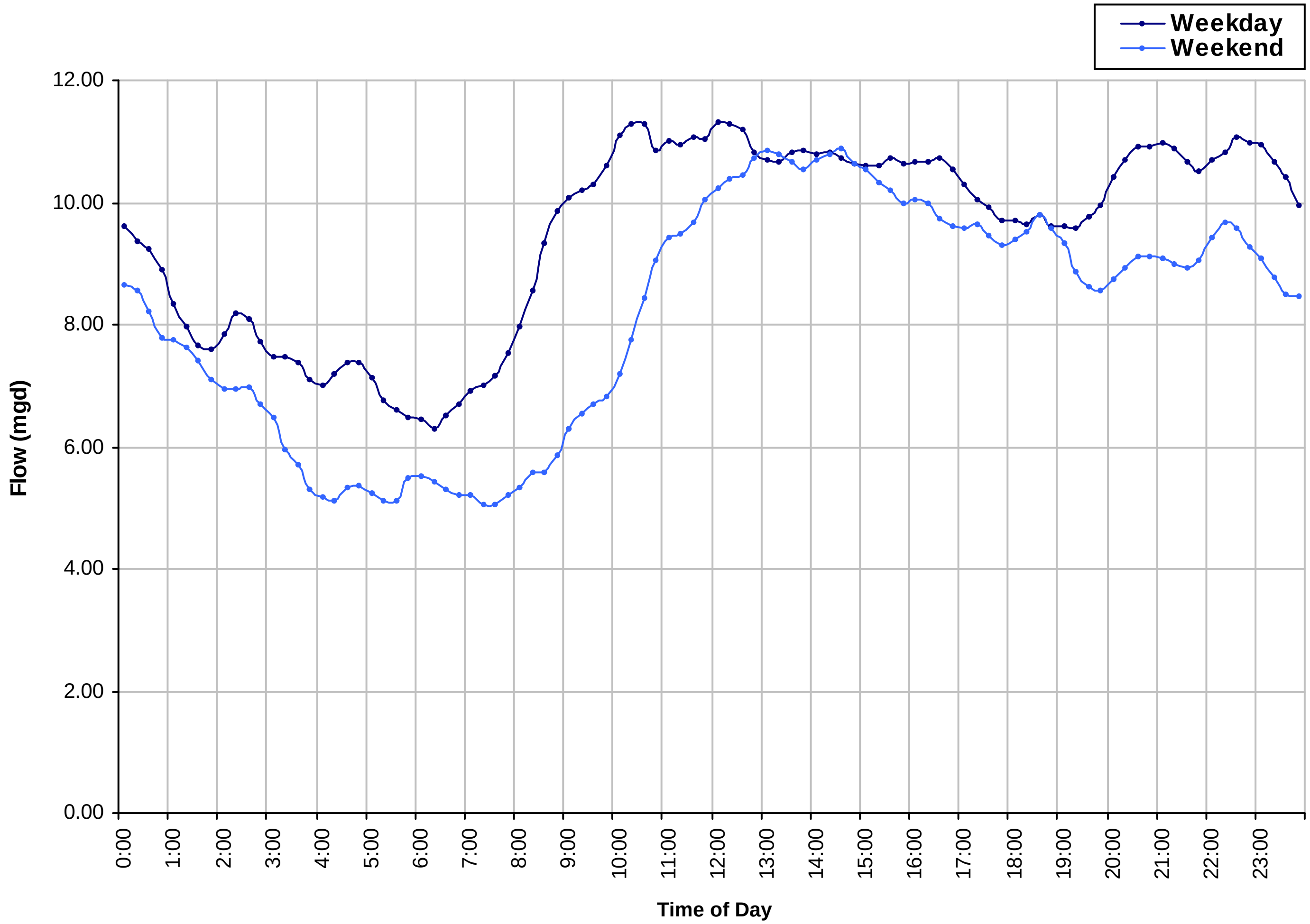
Total Monthly Rainfall: 0.6 inches **Avg Flow: 9.172 mgd** **Peak Flow: 18.554 mgd** **Min Flow: 3.145 mgd**



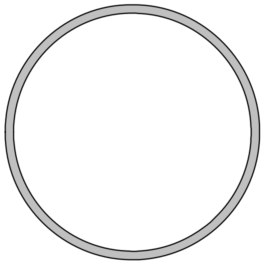


WWTP

Baseline Flow Hydrographs

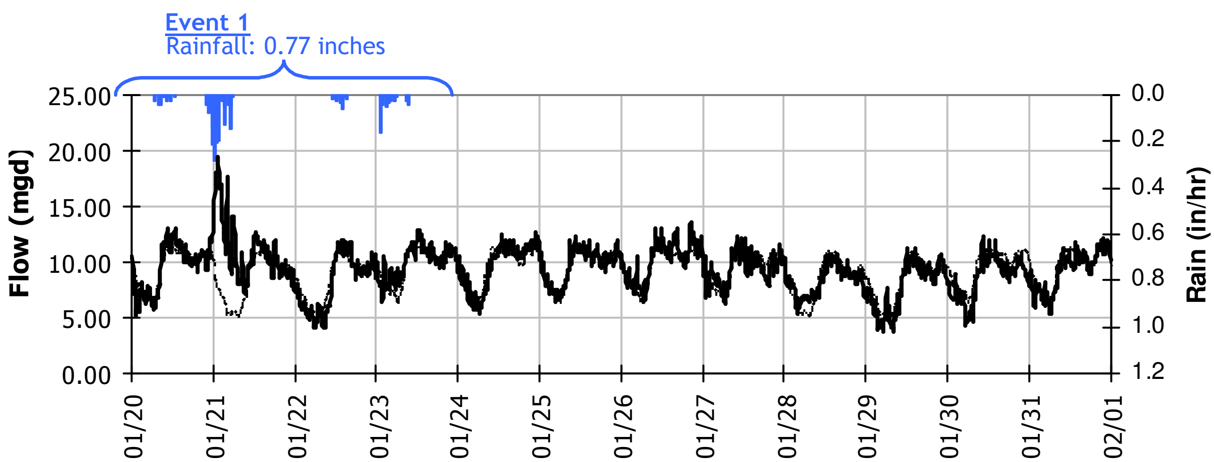


Baseline Flow:
9.106 *mgd*

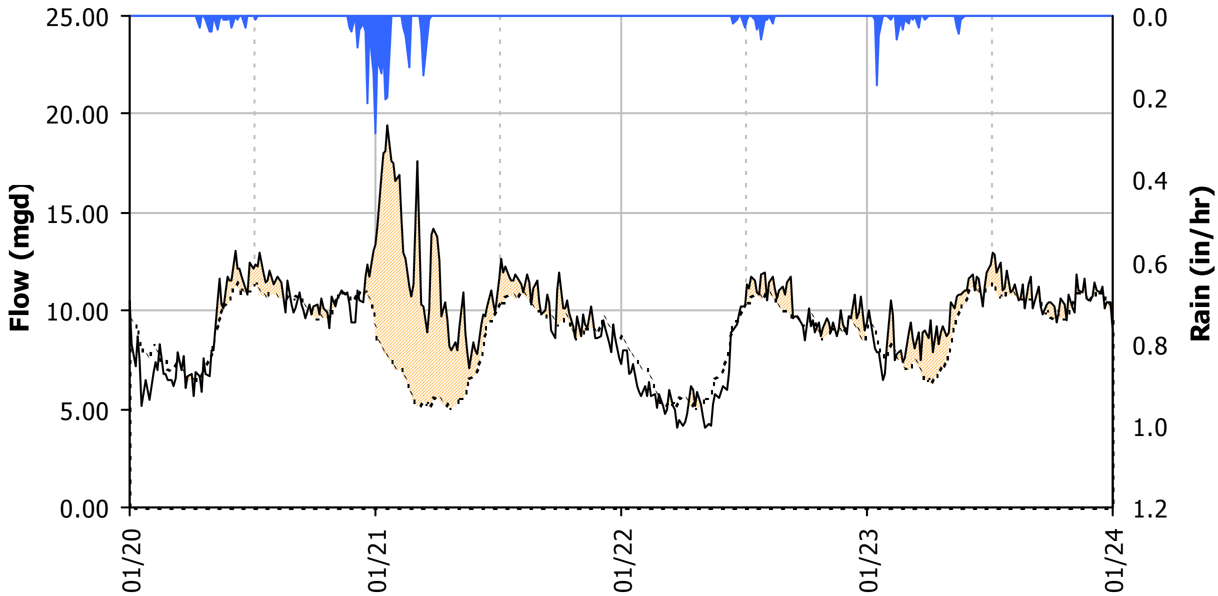


WWTP
I/I Summary: Event 1

Baseline and Realtime Flows with Rainfall Data over Monitoring Period

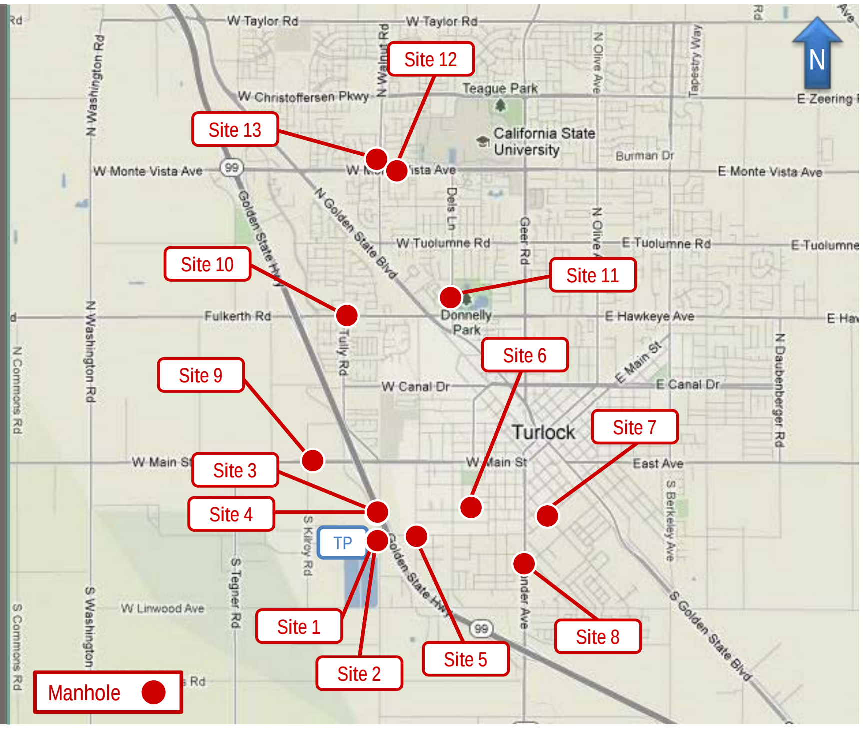


Event 1 Detail Graph



Storm Event I/I Analysis (Rain = 0.77 inches)

Capacity			Inflow			Combined I/I		
Peak Flow:	19.48	*mgd*	**Peak I/I Rate:**	12.42	*mgd*	**Total I/I:**	3,681,000	*gallons*
PF:	2.14		**Pk I/I:Acre:**	1,170	*gpd/acre*	**R-Value:**	1.7%	
			Pk I/I:ADWF:	1.36		**Total I/I:ADWF:**	0.52	*per in-rain*



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Oakland, CA 94612
510.903.6600 **Tel**
510.903.6601 **Fax**

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San Diego, CA 92127
858.576.0226 **Tel**
858.576.0004 **Fax**

Seattle
14900 Interurban Avenue, Suite 268
Seattle, WA 96818
206.674.4560 **Tel**
206.674.4561 **Fax**

Houston
8220 Jones Road, Suite 500
Houston, TX 77065
713.840.6490 **Tel**
713.840.6491 **Fax**

vaengineering.com

APPENDIX C – SIGNIFICANT INDUSTRIAL USER FLOW SUMMARY

Table 1 Average Industrial Wastewater Flow Summary (2009-2011)
Sewer System Master Plan
City of Turlock

Industry Name	Average Annual Flow (mgd) 2009	2010	2011	3-Year Avg.	Assumed Average Flow for Modeling	Notes
Angelica Textiles (Golden State)	0.115	0.068	0.000	0.061	0.000	Appears to have closed
Calif Dairies Inc (SJVD)	0.999	0.974	1.048	1.007	1.007	3-Year Average Flow
Ceres	0.942	0.946	0.946	0.945	0.945	Does Not Flow Through City Collection System
D Street Foods LLC	--	--	0.004	--	0.004	2011 Avearge Flow
Dairy Farmers (Turlock Cheese)	0.170	0.174	0.157	0.167	0.167	3-Year Average Flow
Denair	0.349	0.319	0.318	0.329	0.329	3-Year Average Flow
Foster 2	0.279	0.308	0.272	0.286	0.286	3-Year Average Flow
Foster Truck Wash	0.003	0.004	0.003	0.003	0.003	3-Year Average Flow
Foster Turkey Products C St. Facility (FF1)	0.000	0.000	0.166	0.055	0.000	Only had flow for two months out of three years, when Plant 1 had no flow.
Foster Turkey Products Plant 1 (Butterball)	0.901	0.943	0.828	0.891	0.922	2009/2010 Average. No flow for two months in 2011
Hormel Foods (Valley Fresh)	0.225	0.148	0.003	0.125	0.000	Appears to have closed
Jackson Mitchell	0.013	0.014	0.014	0.014	0.014	3-Year Average Flow
Keyes	0.327	0.308	0.358	0.331	0.331	3-Year Average Flow
Kozy Shack	0.039	0.034	0.027	0.033	0.033	3-Year Average Flow
Lactalis USA	0.000	0.000	0.000	0.000	0.000	Appears to have closed
Mission Linen	0.015	0.000	0.000	0.005	0.005	3-Year Average Flow
Paul Santos Dairy	0.009	0.008	0.008	0.008	0.008	3-Year Average Flow
Real Equitity Investment Group (CFM)	0.034	0.042	0.037	0.038	0.038	3-Year Average Flow
Super Store Industries (Sunnyside Farms)	0.229	0.175	0.187	0.197	0.197	3-Year Average Flow
Supherb	0.091	0.081	0.093	0.088	0.088	3-Year Average Flow

APPENDIX D – DWF CALIBRATION PLOTS

Table 1 Dry Weather Flow Calibration Results
Sewer System Master Plan
City of Turlock

		Weekday Dry Weather Flow												Weekend Dry Weather Flow												Average Dry Weather Flow[4]		
		Measured Data[1]				Modeled Data[2]				Percent Error[3]				Measured Data[1]				Modeled Data[2]				Percent Error[3]						
Meter Number	Pipe Diameter (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Avg. Velocity (%)	Avg. Level (%)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Velocity (ft/s)	Avg. Level (in)	Avg. Flow (%)	Peak Flow (%)	Avg. Velocity (%)	Avg. Level (%)	Measured ADWF (mgd)	Modeled ADWF (mgd)	Percent Difference (%)
1	42	2.290	2.750	1.74	11.3	2.188	2.571	1.52	11.8	-4.5%	-6.5%	-13.0%	4.9%	1.171	1.524	0.99	10.6	1.267	2.028	1.02	10.6	8.2%	33.1%	3.1%	0.8%	1.971	1.925	-2.3%
2	30	0.329	0.472	1.05	4.5	0.342	0.470	1.13	4.5	3.8%	-0.5%	8.4%	-1.7%	0.297	0.460	1.00	4.4	0.276	0.383	1.05	4.0	-7.0%	-16.8%	5.7%	-7.5%	0.320	0.323	0.9%
3	30	1.268	1.715	0.80	15.1	1.298	1.656	0.84	14.5	2.3%	-3.4%	5.8%	-3.5%	1.220	1.866	0.81	14.6	1.315	1.897	0.85	14.5	7.8%	1.7%	5.7%	-0.3%	1.254	1.303	3.8%
4	48	5.600	6.734	1.26	27.2	5.882	6.969	1.32	27.7	5.0%	3.5%	5.2%	1.8%	5.463	7.315	1.24	26.9	5.806	7.497	1.31	27.7	6.3%	2.5%	5.0%	2.8%	5.561	5.861	5.4%
5	16	0.487	0.656	1.00	8.5	0.479	0.647	1.02	8.6	-1.7%	-1.4%	2.1%	1.3%	0.532	0.807	1.04	8.8	0.511	0.771	1.04	8.9	-3.8%	-4.5%	-0.1%	1.0%	0.500	0.488	-2.4%
6	16	0.088	0.122	0.45	4.7	0.088	0.122	0.47	4.6	0.2%	-0.4%	3.6%	-2.2%	0.087	0.125	0.52	4.3	0.087	0.125	0.45	4.7	0.1%	-0.2%	-12.9%	9.5%	0.088	0.088	0.2%
7	24	0.000	0.000	0.00	0.0	0.000	0.000	0.00	0.0	0.0%	0.0%	0.0%	0.0%	0.000	0.000	0.00	0.0	0.000	0.000	0.00	0.0	0.0%	0.0%	0.0%	0.0%	0.000	0.000	0.0%
8	33	1.843	2.175	1.95	9.6	1.820	2.147	1.96	10.4	-1.3%	-1.3%	0.2%	8.2%	0.996	1.163	1.47	7.7	1.020	1.397	1.66	8.1	2.4%	20.2%	12.8%	5.5%	1.601	1.591	-0.6%
9	15	0.052	0.068	0.33	4.9	0.053	0.069	0.27	4.6	1.6%	1.5%	-17.6%	-5.9%	0.050	0.078	0.32	4.9	0.050	0.079	0.27	4.6	0.4%	1.6%	-15.2%	-6.5%	0.051	0.052	1.3%
10	24	1.147	1.391	1.76	8.5	1.134	1.382	1.76	8.4	-1.1%	-0.7%	0.1%	-0.9%	1.148	1.508	1.74	8.5	1.149	1.505	1.76	8.4	0.1%	-0.2%	1.0%	-0.9%	1.147	1.138	-0.8%
11	18	0.610	0.788	1.36	7.4	0.605	0.763	1.44	7.4	-0.8%	-3.2%	6.2%	1.0%	0.625	0.865	1.35	7.5	0.618	0.834	1.44	7.5	-1.1%	-3.5%	6.9%	0.0%	0.614	0.609	-0.9%
12	21	1.185	1.402	1.14	15.2	1.192	1.389	1.05	14.3	0.6%	-0.9%	-8.1%	-5.4%	1.174	1.447	1.12	15.2	1.185	1.450	1.04	14.4	1.0%	0.2%	-7.5%	-5.4%	1.182	1.190	0.7%
13	30	1.021	1.402	1.05	10.3	1.029	1.311	1.07	10.8	0.8%	-6.5%	1.9%	4.5%	1.089	1.465	1.12	10.3	1.097	1.452	1.11	11.0	0.7%	-0.9%	-0.5%	6.3%	1.040	1.049	0.8%

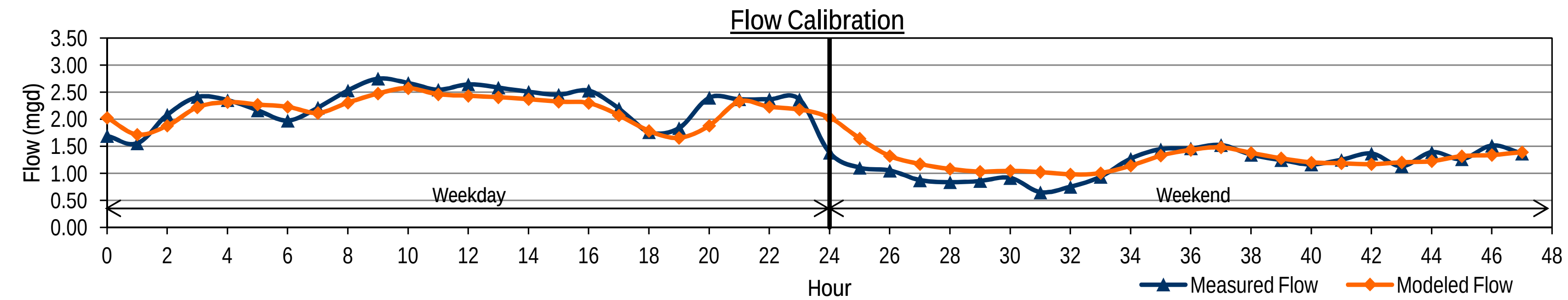
Notes:
1. Source: City of Turlock Temporary Flow Monitoring Program, V&A Consulting Engineers
2. Average flow, level, and velocity are calculated from weekday/weekend dry weather flow monitoring data. Maximum flow values are hourly peaks corresponding to either weekend or weekday confitions, as appropriate.
3. Percent Difference = (Modeled - Measured)/Measured*100.
4. Average Dry Weather Flow = (5*Weekday Dry Weather Flow + 2*Weekend Dry Weather Flow)/7

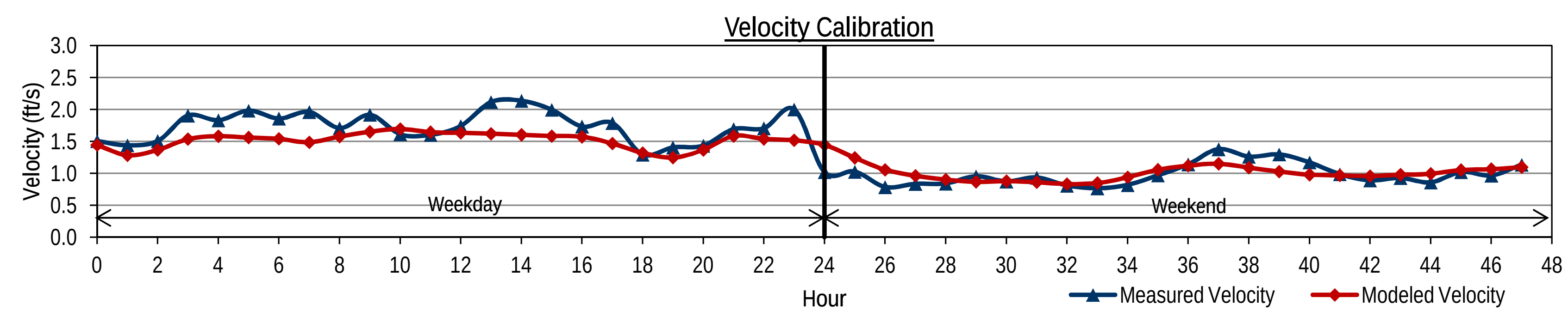
City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 1 DRY WEATHER FLOW CALIBRATION

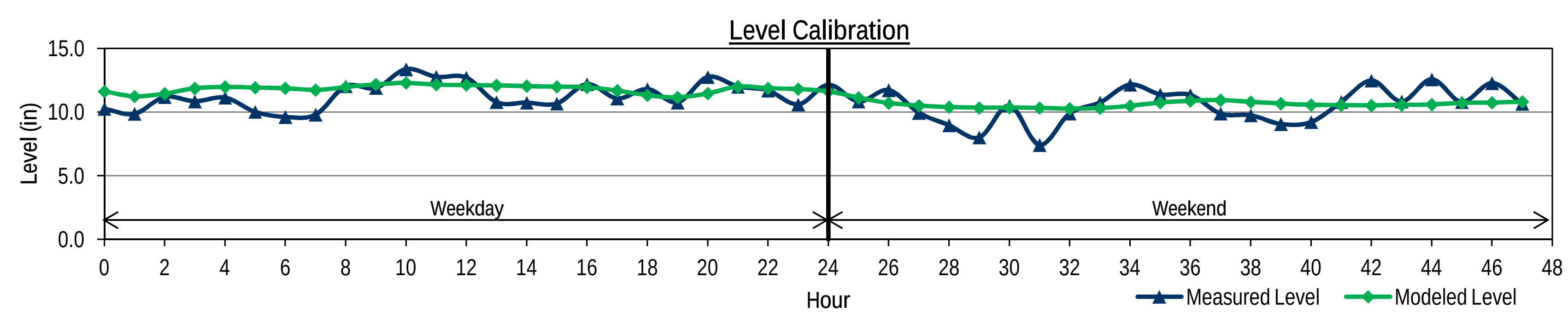
carollo

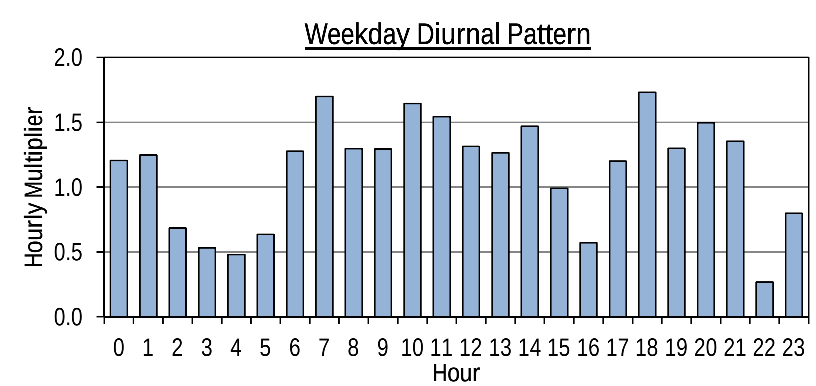
		Measured Data			Modeled Data			Diurnal		
		Flow	Level	Velocity	Flow	Level	Velocity	Initial	Modified	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	Curve	Curve	Diurnal
Weekday	0	1.694	10.3	1.50	2.027	11.6	1.45	0.79	1.20	1.20
	1	1.553	9.9	1.44	1.716	11.2	1.28	1.06	1.25	1.25
	2	2.082	11.2	1.51	1.879	11.4	1.37	1.22	0.69	0.69
	3	2.411	10.9	1.91	2.219	11.9	1.54	1.19	0.53	0.53
	4	2.352	11.1	1.83	2.313	12.0	1.58	1.10	0.48	0.48
	5	2.166	10.0	1.98	2.270	11.9	1.56	1.00	0.64	0.64
	6	1.975	9.6	1.86	2.228	11.9	1.54	1.12	1.28	1.28
	7	2.213	9.8	1.96	2.115	11.7	1.49	1.29	1.70	1.70
	8	2.532	12.0	1.71	2.305	12.0	1.58	1.40	1.30	1.30
	9	2.750	11.9	1.92	2.473	12.2	1.65	1.36	1.29	1.29
	10	2.670	13.4	1.61	2.571	12.3	1.70	1.29	1.65	1.65
	11	2.547	12.8	1.60	2.459	12.2	1.65	1.34	1.54	1.54
	12	2.646	12.7	1.74	2.432	12.1	1.63	1.31	1.31	1.31
	13	2.586	10.8	2.12	2.404	12.1	1.62	1.27	1.27	1.27
	14	2.509	10.7	2.14	2.368	12.1	1.61	1.25	1.47	1.47
	15	2.455	10.7	2.00	2.322	12.0	1.58	1.28	0.99	0.99
	16	2.528	12.2	1.73	2.297	12.0	1.57	1.12	0.57	0.57
	17	2.198	11.1	1.79	2.071	11.7	1.47	0.90	1.20	1.20
	18	1.764	11.8	1.29	1.784	11.3	1.32	0.93	1.73	1.73
	19	1.837	10.8	1.41	1.655	11.2	1.25	1.22	1.30	1.30
	20	2.399	12.8	1.43	1.880	11.5	1.37	1.20	1.50	1.50
	21	2.368	12.0	1.69	2.327	12.0	1.59	1.20	1.35	1.35
	22	2.370	11.7	1.71	2.227	11.9	1.54	1.20	0.27	0.27
	23	2.367	10.6	2.00	2.178	11.8	1.52	0.86	0.80	0.80
Weekend	24	1.380	12.1	1.02	2.028	11.6	1.45	0.56	0.28	0.28
	25	1.104	10.8	1.03	1.643	11.1	1.24	0.53	0.23	0.23
	26	1.053	11.7	0.79	1.321	10.7	1.06	0.44	0.21	0.21
	27	0.874	9.9	0.83	1.173	10.5	0.96	0.42	0.23	0.23
	28	0.837	9.0	0.84	1.082	10.4	0.90	0.44	0.28	0.28
	29	0.859	8.0	0.95	1.032	10.3	0.87	0.46	0.42	0.42
	30	0.915	10.5	0.87	1.047	10.4	0.88	0.33	0.51	0.51
	31	0.651	7.4	0.93	1.024	10.3	0.86	0.38	0.57	0.57
	32	0.752	9.9	0.81	0.983	10.3	0.83	0.48	1.12	1.12
	33	0.936	10.8	0.77	1.006	10.3	0.85	0.65	1.37	1.37
	34	1.271	12.2	0.82	1.141	10.5	0.94	0.73	1.37	1.37
	35	1.447	11.4	0.97	1.328	10.7	1.06	0.74	1.38	1.38
	36	1.463	11.3	1.14	1.433	10.9	1.12	0.77	0.83	0.83
	37	1.524	9.9	1.38	1.481	10.9	1.15	0.68	0.49	0.49
	38	1.346	9.7	1.26	1.378	10.8	1.09	0.63	0.24	0.24
	39	1.245	9.1	1.30	1.279	10.7	1.03	0.59	0.58	0.58
	40	1.163	9.2	1.17	1.202	10.6	0.98	0.63	1.03	1.03
	41	1.250	10.8	0.99	1.187	10.5	0.97	0.69	0.31	0.31
	42	1.366	12.5	0.89	1.170	10.5	0.96	0.57	1.00	1.00
	43	1.131	10.8	0.93	1.203	10.6	0.98	0.71	0.49	0.49
	44	1.392	12.6	0.86	1.225	10.6	1.00	0.64	1.10	1.10
	45	1.262	10.8	1.02	1.318	10.7	1.05	0.77	0.60	0.60
	46	1.513	12.3	0.97	1.340	10.7	1.07	0.69	0.71	0.71
	47	1.366	10.7	1.13	1.392	10.8	1.10	0.70	0.42	0.42
Average										
Weekday		2.290	11.3	1.74	2.188	11.8	1.52	1.16	1.14	1.14
Weekend		1.171	10.6	0.99	1.267	10.6	1.02	0.59	0.66	0.66
ADWF[(1)]		1.971	11.1	1.53	1.925	11.5	1.38	1.00	1.00	1.00
% Error										
Weekday					-4.5%	4.9%	-13.0%			
Weekend					8.2%	0.8%	3.1%			

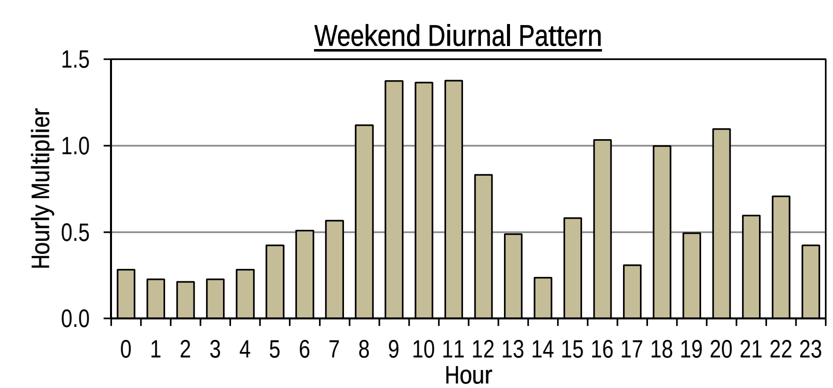
Note:
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











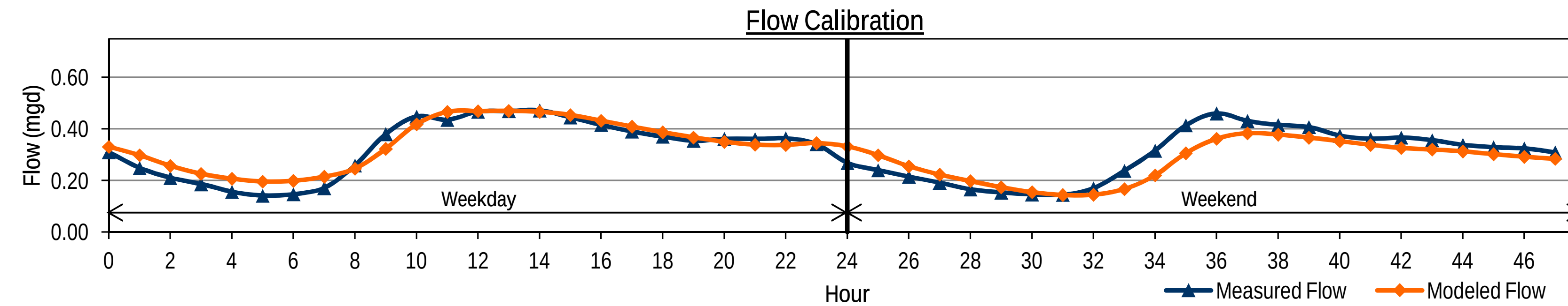
City of Turlock

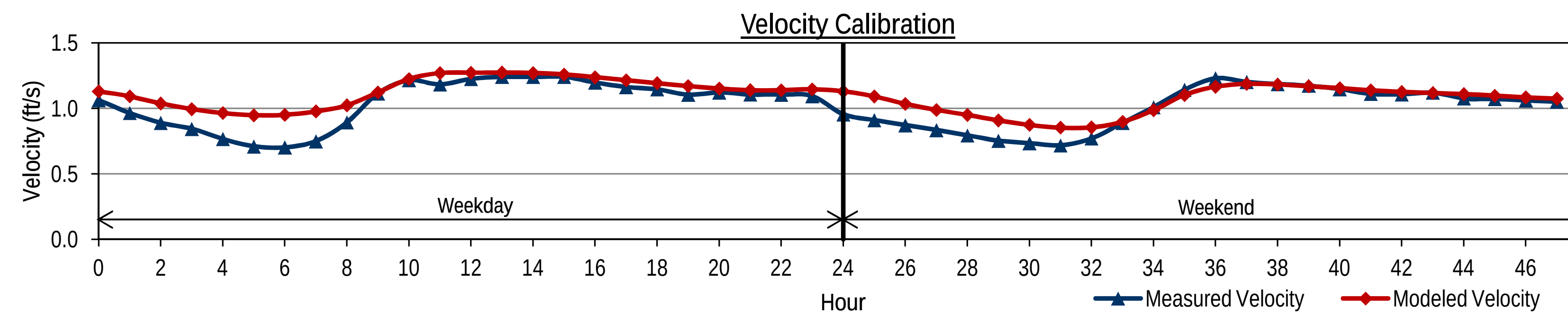
Sewer System Master Plan

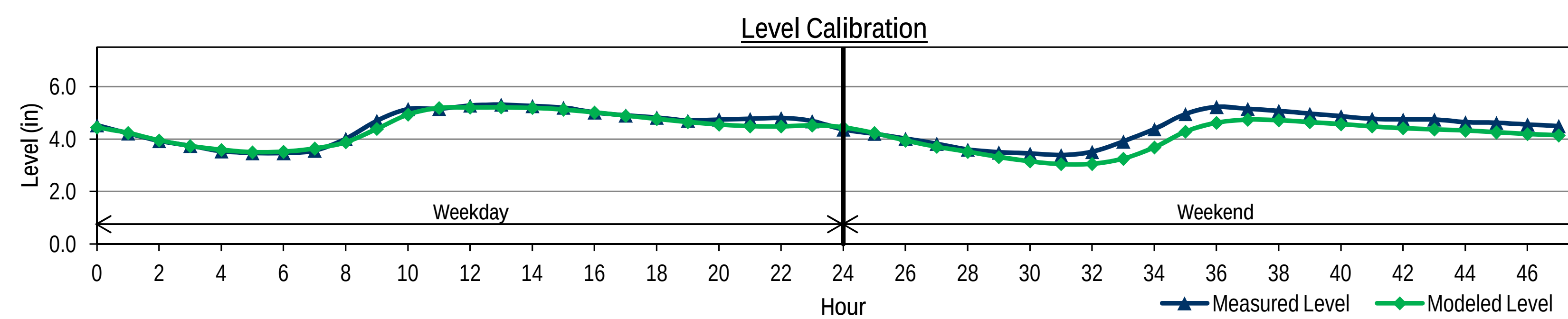
FLOW MONITORING SITE 2 DRY WEATHER FLOW CALIBRATION

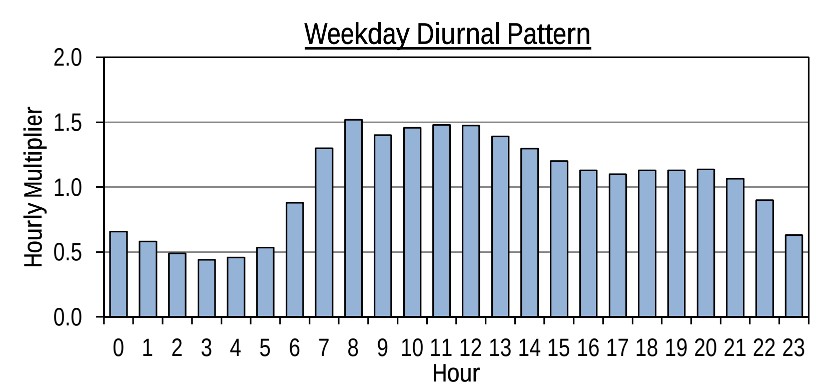
		Measured Data			Modeled Data			Diurnal		
	Hour	Flow (mgd)	Level (in)	Velocity (ft/s)	Flow (mgd)	Level (in)	Velocity (ft/s)	Initial Curve	Modified Curve	Calibrated Diurnal
Weekday	0	0.310	4.5	1.06	0.331	4.4	1.13	0.78	0.66	0.66
	1	0.249	4.2	0.97	0.298	4.2	1.09	0.66	0.58	0.58
	2	0.210	3.9	0.89	0.257	4.0	1.04	0.58	0.49	0.49
	3	0.186	3.7	0.84	0.226	3.7	1.00	0.49	0.44	0.44
	4	0.156	3.5	0.77	0.207	3.6	0.97	0.44	0.46	0.46
	5	0.141	3.5	0.71	0.196	3.5	0.95	0.46	0.53	0.53
	6	0.147	3.5	0.70	0.199	3.5	0.95	0.53	0.88	0.88
	7	0.171	3.6	0.75	0.215	3.6	0.98	0.81	1.30	1.30
	8	0.258	4.0	0.89	0.246	3.9	1.02	1.19	1.52	1.52
	9	0.380	4.7	1.12	0.323	4.4	1.12	1.40	1.40	1.40
	10	0.448	5.1	1.22	0.418	4.9	1.23	1.36	1.46	1.46
	11	0.436	5.1	1.18	0.466	5.2	1.27	1.46	1.48	1.48
	12	0.467	5.3	1.23	0.469	5.2	1.27	1.47	1.47	1.47
	13	0.470	5.3	1.24	0.470	5.2	1.27	1.47	1.39	1.39
	14	0.472	5.3	1.24	0.466	5.2	1.27	1.39	1.30	1.30
	15	0.445	5.2	1.24	0.454	5.1	1.26	1.30	1.20	1.20
	16	0.415	5.0	1.20	0.432	5.0	1.24	1.22	1.13	1.13
	17	0.390	4.9	1.16	0.409	4.9	1.22	1.16	1.10	1.10
	18	0.370	4.8	1.15	0.387	4.8	1.19	1.11	1.13	1.13
	19	0.354	4.7	1.11	0.367	4.7	1.17	1.13	1.13	1.13
	20	0.362	4.8	1.12	0.350	4.6	1.15	1.13	1.14	1.14
	21	0.361	4.8	1.11	0.339	4.5	1.14	1.14	1.06	1.06
	22	0.364	4.8	1.11	0.338	4.5	1.14	1.06	0.90	0.90
	23	0.341	4.7	1.09	0.345	4.5	1.15	0.97	0.63	0.63
Weekend	24	0.268	4.4	0.96	0.332	4.4	1.13	0.75	0.62	0.62
	25	0.240	4.2	0.91	0.298	4.2	1.09	0.67	0.58	0.58
	26	0.215	4.0	0.87	0.255	3.9	1.04	0.60	0.50	0.50
	27	0.191	3.8	0.83	0.223	3.7	0.99	0.52	0.46	0.46
	28	0.165	3.6	0.79	0.198	3.5	0.95	0.48	0.44	0.44
	29	0.154	3.5	0.75	0.174	3.3	0.91	0.46	0.43	0.43
	30	0.146	3.5	0.73	0.155	3.1	0.88	0.45	0.51	0.51
	31	0.145	3.4	0.72	0.144	3.0	0.85	0.53	0.78	0.78
	32	0.170	3.5	0.77	0.145	3.1	0.86	0.74	1.20	1.20
	33	0.237	3.9	0.89	0.167	3.2	0.90	0.99	1.30	1.30
	34	0.316	4.4	1.01	0.220	3.7	0.99	1.29	1.44	1.44
	35	0.414	5.0	1.14	0.306	4.3	1.10	1.44	1.35	1.35
	36	0.460	5.2	1.23	0.362	4.6	1.17	1.35	1.30	1.30
	37	0.432	5.2	1.20	0.383	4.7	1.19	1.30	1.27	1.27
	38	0.416	5.1	1.19	0.378	4.7	1.18	1.27	1.17	1.17
	39	0.407	5.0	1.17	0.366	4.6	1.17	1.17	1.13	1.13
	40	0.374	4.9	1.15	0.353	4.6	1.16	1.13	1.14	1.14
	41	0.362	4.8	1.11	0.338	4.5	1.14	1.14	1.11	1.11
	42	0.367	4.7	1.11	0.326	4.4	1.13	1.11	1.06	1.06
	43	0.357	4.7	1.12	0.320	4.4	1.12	1.06	1.03	1.03
	44	0.338	4.6	1.08	0.313	4.3	1.11	1.03	1.01	1.01
	45	0.329	4.6	1.07	0.302	4.3	1.10	1.01	0.97	0.97
	46	0.324	4.6	1.06	0.292	4.2	1.09	0.97	0.84	0.84
	47	0.309	4.5	1.05	0.284	4.1	1.08	0.84	0.75	0.75
Average										
Weekday		0.329	4.5	1.05	0.342	4.5	1.13	1.03	1.03	1.03
Weekend		0.297	4.4	1.00	0.276	4.0	1.05	0.93	0.93	0.93
ADWF[(1)]		0.320	4.5	1.03	0.323	4.3	1.11	1.00	1.00	1.00
% Error										
Weekday					3.8%	-1.7%	8.4%			
Weekend					-7.0%	-7.5%	5.7%			

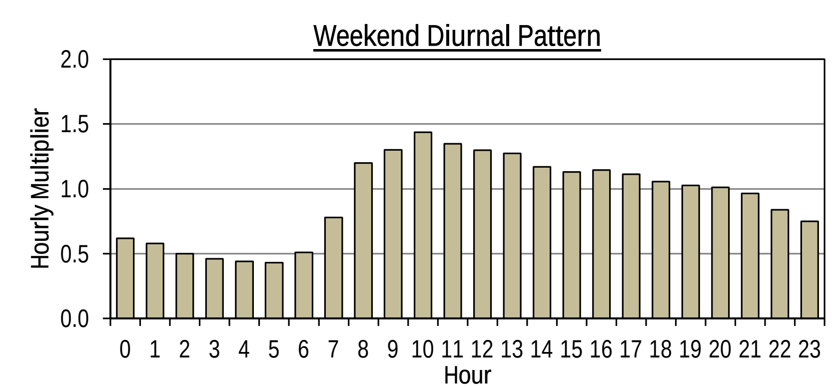
Note:
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Turlock

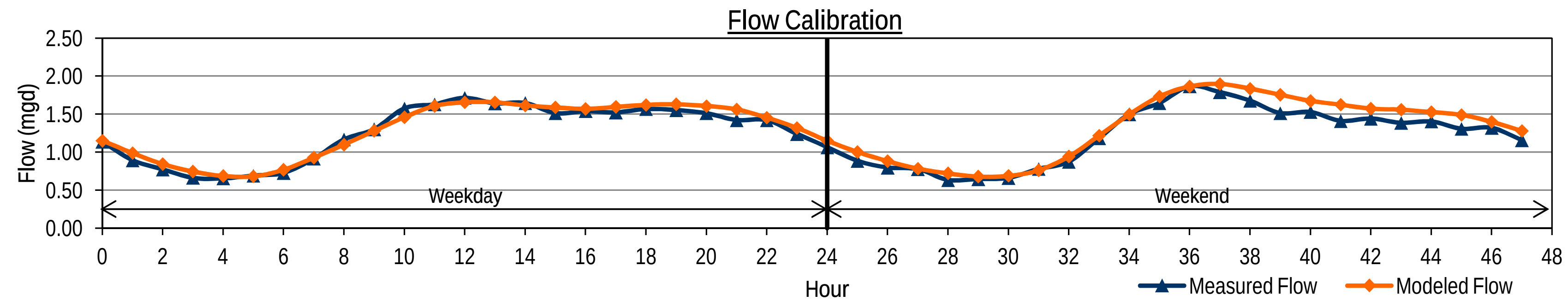
Sewer System Master Plan

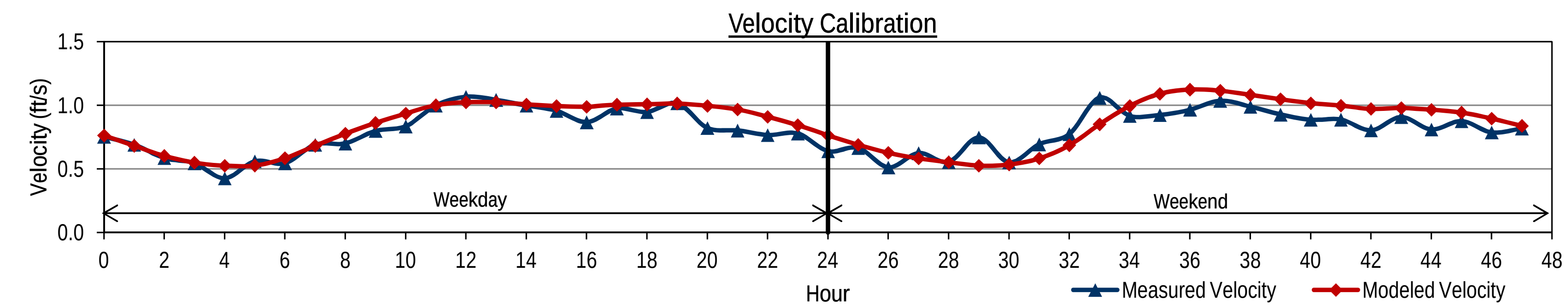
FLOW MONITORING SITE 3 DRY WEATHER FLOW CALIBRATION

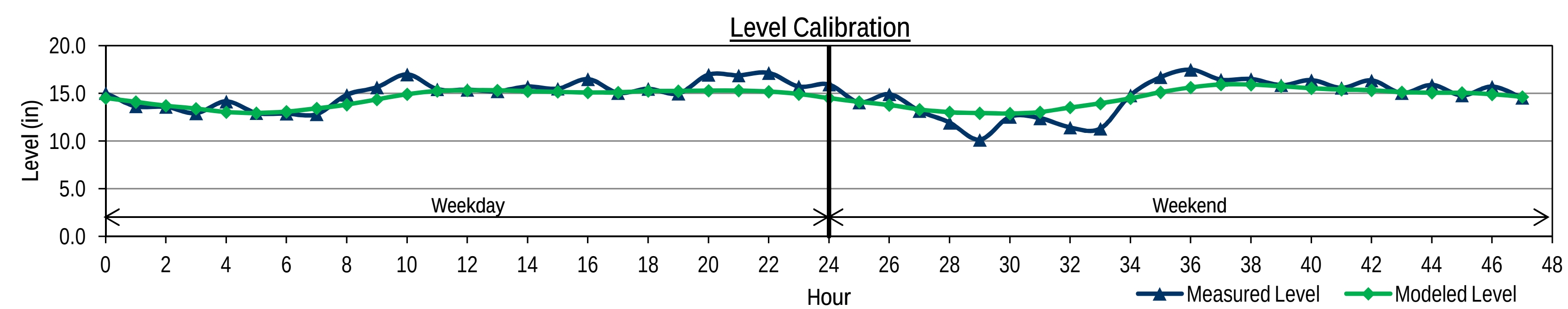
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Diurnal Initial Curve	Diurnal Modified Curve	Diurnal Calibrated Diurnal
Weekday	0	1.138	15.0	0.75	1.151	14.5	0.76	0.71	0.62	0.62
	1	0.895	13.6	0.69	0.990	14.1	0.68	0.62	0.53	0.53
	2	0.775	13.6	0.59	0.845	13.7	0.60	0.53	0.52	0.52
	3	0.663	12.9	0.54	0.747	13.4	0.55	0.52	0.55	0.55
	4	0.656	14.2	0.43	0.689	13.0	0.53	0.55	0.58	0.58
	5	0.692	12.9	0.56	0.684	12.9	0.53	0.58	0.73	0.73
	6	0.728	12.9	0.54	0.771	13.1	0.59	0.73	0.93	0.93
	7	0.916	12.8	0.69	0.930	13.4	0.68	0.93	1.04	1.04
	8	1.168	14.8	0.70	1.100	13.8	0.78	1.04	1.26	1.26
	9	1.303	15.6	0.80	1.282	14.4	0.86	1.26	1.30	1.30
	10	1.576	17.0	0.84	1.461	14.9	0.94	1.30	1.37	1.37
	11	1.630	15.4	1.00	1.609	15.2	1.00	1.37	1.31	1.31
	12	1.715	15.4	1.07	1.656	15.3	1.02	1.31	1.31	1.31
	13	1.641	15.2	1.04	1.656	15.3	1.02	1.31	1.21	1.21
	14	1.647	15.7	1.00	1.615	15.2	1.01	1.21	1.23	1.23
	15	1.512	15.5	0.96	1.590	15.2	1.00	1.23	1.21	1.21
	16	1.540	16.5	0.87	1.570	15.1	0.99	1.21	1.25	1.25
	17	1.523	15.0	0.97	1.597	15.1	1.01	1.25	1.24	1.24
	18	1.568	15.5	0.95	1.621	15.2	1.01	1.24	1.21	1.21
	19	1.554	15.0	1.02	1.631	15.2	1.02	1.21	1.13	1.13
	20	1.512	17.0	0.82	1.606	15.3	1.00	1.13	1.13	1.13
	21	1.423	16.9	0.80	1.564	15.3	0.97	1.13	0.99	0.99
	22	1.421	17.1	0.77	1.455	15.2	0.91	0.99	0.91	0.91
	23	1.240	15.7	0.78	1.320	14.9	0.84	0.91	0.71	0.71
Weekend	24	1.066	15.9	0.64	1.151	14.5	0.76	0.71	0.64	0.64
	25	0.888	14.1	0.66	1.004	14.1	0.69	0.64	0.62	0.62
	26	0.799	14.9	0.51	0.884	13.8	0.63	0.62	0.51	0.51
	27	0.778	13.2	0.62	0.785	13.3	0.58	0.51	0.52	0.52
	28	0.636	11.9	0.56	0.724	13.0	0.55	0.52	0.53	0.53
	29	0.648	10.1	0.75	0.681	12.9	0.53	0.53	0.62	0.62
	30	0.663	12.5	0.55	0.691	12.9	0.54	0.62	0.70	0.70
	31	0.781	12.4	0.69	0.764	13.0	0.58	0.70	0.95	0.95
	32	0.876	11.4	0.77	0.945	13.5	0.69	0.95	1.20	1.20
	33	1.185	11.3	1.06	1.218	13.9	0.85	1.20	1.31	1.31
	34	1.500	14.8	0.92	1.497	14.5	1.00	1.31	1.49	1.49
	35	1.646	16.7	0.92	1.735	15.1	1.09	1.49	1.43	1.43
	36	1.866	17.5	0.97	1.865	15.6	1.12	1.43	1.34	1.34
	37	1.789	16.4	1.04	1.897	15.9	1.12	1.34	1.21	1.21
	38	1.677	16.5	0.99	1.836	15.9	1.08	1.21	1.22	1.22
	39	1.514	15.9	0.93	1.756	15.7	1.05	1.22	1.13	1.13
	40	1.528	16.4	0.89	1.675	15.5	1.02	1.13	1.15	1.15
	41	1.411	15.6	0.89	1.625	15.4	1.00	1.15	1.10	1.10
	42	1.442	16.4	0.80	1.574	15.3	0.97	1.10	1.12	1.12
	43	1.386	15.0	0.91	1.559	15.1	0.98	1.12	1.04	1.04
	44	1.404	15.9	0.81	1.528	15.1	0.97	1.04	1.05	1.05
	45	1.308	14.8	0.88	1.491	15.1	0.94	1.05	0.92	0.92
	46	1.321	15.7	0.79	1.400	14.9	0.90	0.92	0.85	0.85
	47	1.158	14.5	0.82	1.280	14.6	0.84	0.85	0.71	0.71
Average										
	Weekday	1.268	15.1	0.80	1.298	14.5	0.84	1.01	1.01	1.01
	Weekend	1.220	14.6	0.81	1.315	14.5	0.85	0.97	0.97	0.97
	ADWF[1]	1.254	14.9	0.80	1.303	14.5	0.85	1.00	1.00	1.00
% Error										
	Weekday				2.3%	-3.5%	5.8%			
	Weekend				7.8%	-0.3%	5.7%			

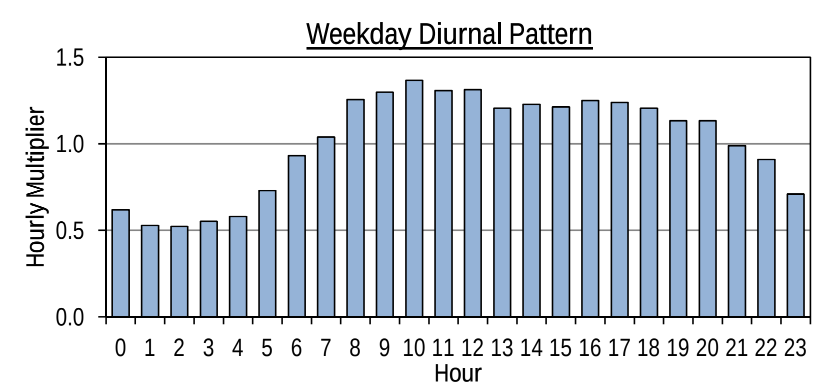
Note:

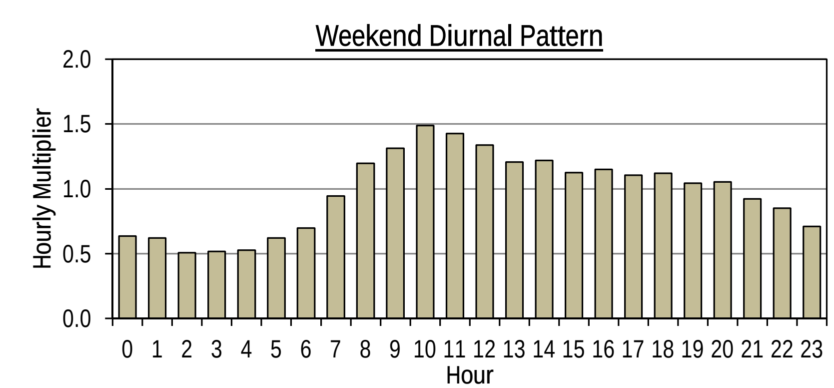
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7







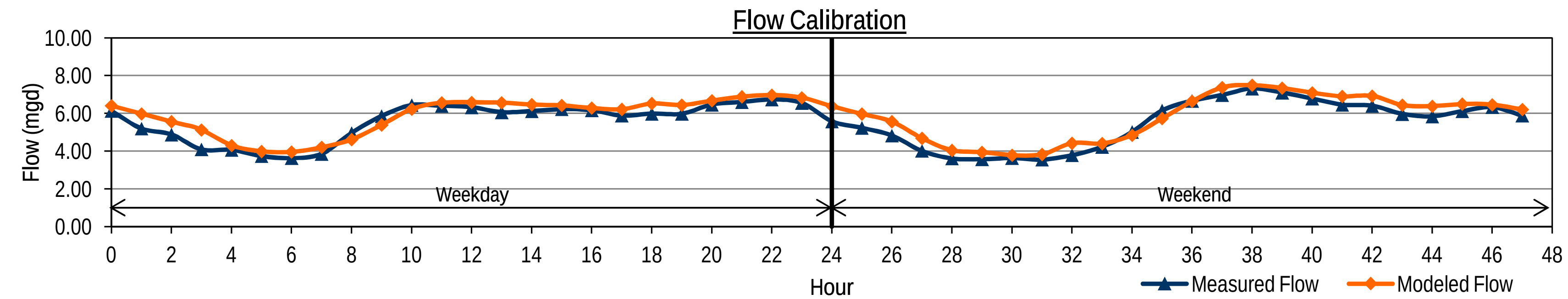


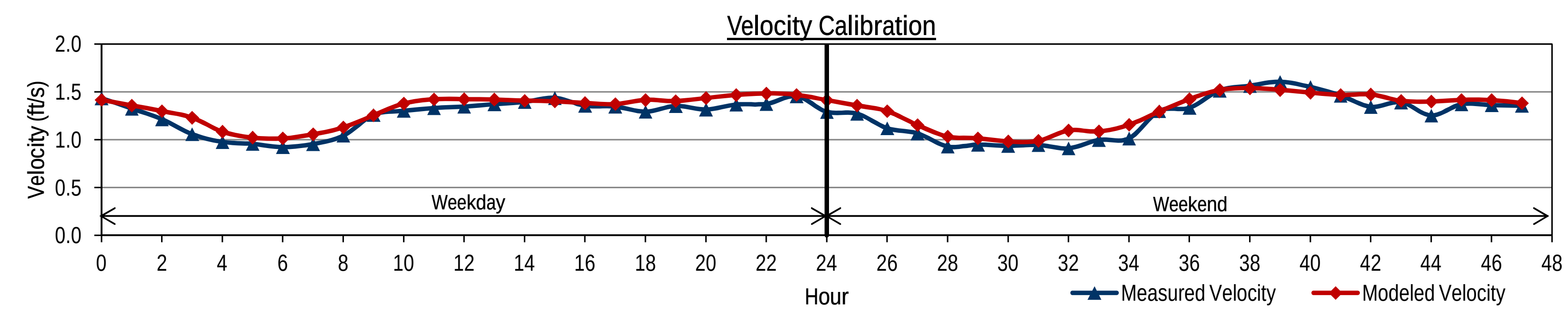


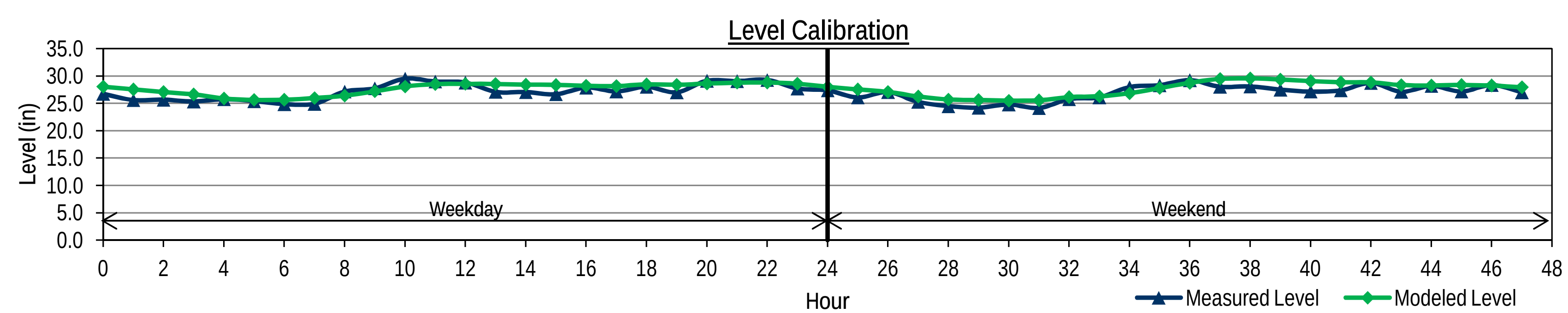
City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 4 DRY WEATHER FLOW CALIBRATION

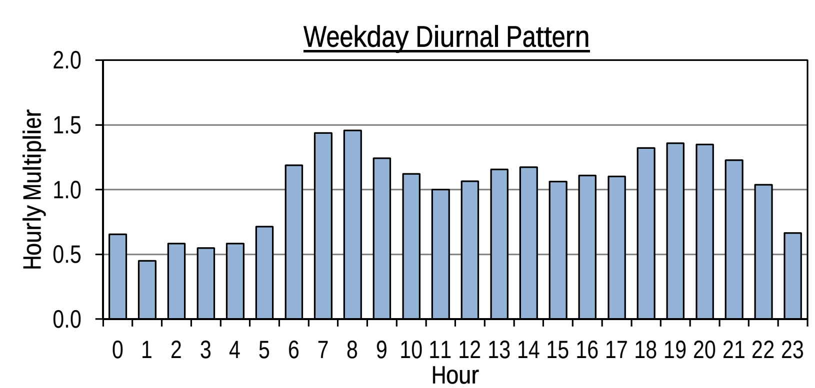
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Diurnal Initial Curve	Diurnal Modified Curve	Diurnal Calibrated Diurnal
Weekday	0	6.134	26.7	1.43	6.403	28.1	1.42	0.94	0.65	0.65
	1	5.200	25.6	1.33	5.978	27.6	1.36	0.88	0.45	0.45
	2	4.886	25.7	1.21	5.564	27.1	1.30	0.74	0.58	0.58
	3	4.097	25.4	1.06	5.127	26.6	1.23	0.73	0.55	0.55
	4	4.079	25.8	0.98	4.302	25.9	1.09	0.67	0.58	0.58
	5	3.743	25.4	0.96	3.984	25.7	1.02	0.65	0.71	0.71
	6	3.637	24.9	0.92	3.957	25.7	1.02	0.69	1.19	1.19
	7	3.859	24.9	0.95	4.206	26.0	1.06	0.89	1.44	1.44
	8	4.969	27.2	1.04	4.617	26.4	1.13	1.05	1.46	1.46
	9	5.861	27.8	1.26	5.392	27.2	1.26	1.16	1.24	1.24
	10	6.439	29.5	1.30	6.227	28.1	1.38	1.15	1.12	1.12
	11	6.401	29.0	1.33	6.566	28.5	1.42	1.14	1.00	1.00
	12	6.325	28.8	1.35	6.583	28.6	1.42	1.09	1.06	1.06
	13	6.064	27.1	1.37	6.565	28.6	1.42	1.10	1.16	1.16
	14	6.124	27.1	1.40	6.465	28.4	1.41	1.12	1.17	1.17
	15	6.221	26.7	1.44	6.423	28.4	1.40	1.11	1.06	1.06
	16	6.164	27.9	1.36	6.284	28.2	1.38	1.06	1.11	1.11
	17	5.881	27.2	1.35	6.216	28.2	1.37	1.08	1.10	1.10
	18	5.986	28.0	1.29	6.523	28.5	1.42	1.08	1.32	1.32
	19	5.982	27.0	1.35	6.443	28.4	1.40	1.16	1.36	1.36
	20	6.465	29.1	1.32	6.672	28.6	1.44	1.19	1.35	1.35
	21	6.602	29.1	1.37	6.880	28.8	1.47	1.21	1.23	1.23
	22	6.734	29.3	1.37	6.969	28.8	1.48	1.18	1.04	1.04
	23	6.549	27.7	1.45	6.831	28.6	1.47	1.10	0.66	0.66
Weekend	24	5.579	27.4	1.29	6.379	28.1	1.41	0.94	0.61	0.61
	25	5.237	26.1	1.27	5.970	27.6	1.36	0.87	0.40	0.40
	26	4.827	27.1	1.12	5.563	27.1	1.30	0.72	0.37	0.37
	27	4.020	25.3	1.07	4.684	26.3	1.15	0.65	0.47	0.47
	28	3.617	24.5	0.93	4.042	25.7	1.03	0.64	0.57	0.57
	29	3.583	24.2	0.95	3.948	25.6	1.02	0.66	0.57	0.57
	30	3.643	24.8	0.94	3.788	25.5	0.98	0.64	0.69	0.69
	31	3.557	24.2	0.94	3.829	25.6	0.99	0.68	0.86	0.86
	32	3.794	25.8	0.91	4.420	26.2	1.10	0.76	1.13	1.13
	33	4.234	26.1	1.00	4.406	26.3	1.09	0.90	1.46	1.46
	34	5.023	28.0	1.01	4.846	26.9	1.16	1.11	1.44	1.44
	35	6.154	28.3	1.30	5.733	27.8	1.30	1.20	1.36	1.36
	36	6.665	29.2	1.33	6.643	28.8	1.42	1.25	1.40	1.40
	37	6.972	28.0	1.51	7.368	29.5	1.52	1.32	1.28	1.28
	38	7.315	28.1	1.56	7.497	29.6	1.54	1.28	1.16	1.16
	39	7.100	27.5	1.61	7.337	29.4	1.52	1.22	1.06	1.06
	40	6.781	27.2	1.55	7.094	29.1	1.49	1.16	1.09	1.09
	41	6.462	27.4	1.46	6.900	28.9	1.47	1.15	0.94	0.94
	42	6.406	28.7	1.34	6.924	28.8	1.47	1.07	0.92	0.92
	43	5.972	27.1	1.39	6.438	28.4	1.41	1.05	1.07	1.07
	44	5.846	28.2	1.25	6.382	28.3	1.40	1.10	1.18	1.18
	45	6.116	27.2	1.37	6.493	28.4	1.42	1.14	0.98	0.98
	46	6.330	28.4	1.36	6.454	28.3	1.42	1.06	0.78	0.78
	47	5.881	27.0	1.36	6.208	28.0	1.38	1.00	0.68	0.68
Average										
Weekday		5.600	27.2	1.26	5.882	27.7	1.32	1.01	1.03	1.03
Weekend		5.463	26.9	1.24	5.806	27.7	1.31	0.98	0.94	0.94
ADWF[(1)]		5.561	27.1	1.25	5.861	27.7	1.32	1.00	1.00	1.00
% Error										
Weekday					5.0%	1.8%	5.2%			
Weekend					6.3%	2.8%	5.0%			

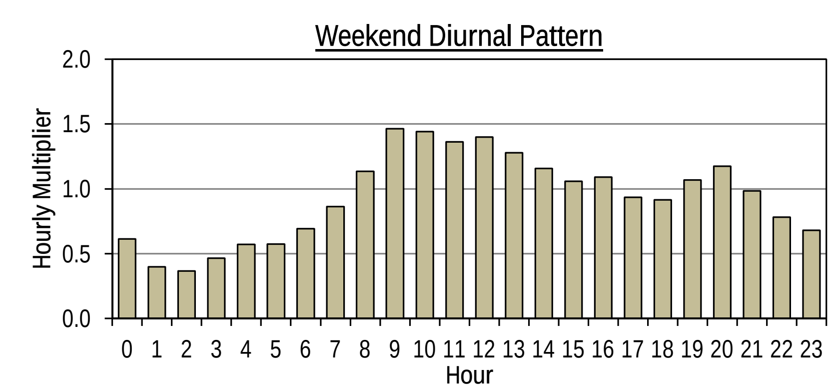
Note:
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Turlock

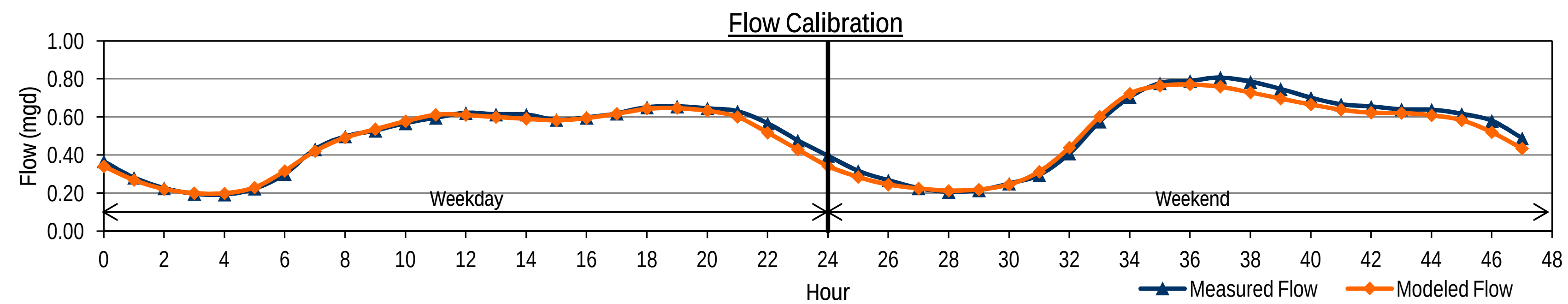
Sewer System Master Plan

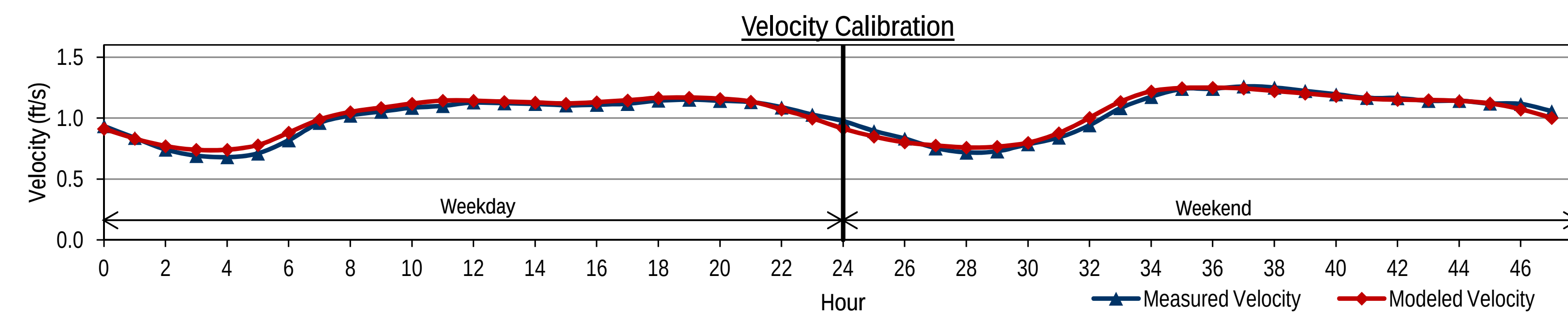
FLOW MONITORING SITE 5 DRY WEATHER FLOW CALIBRATION

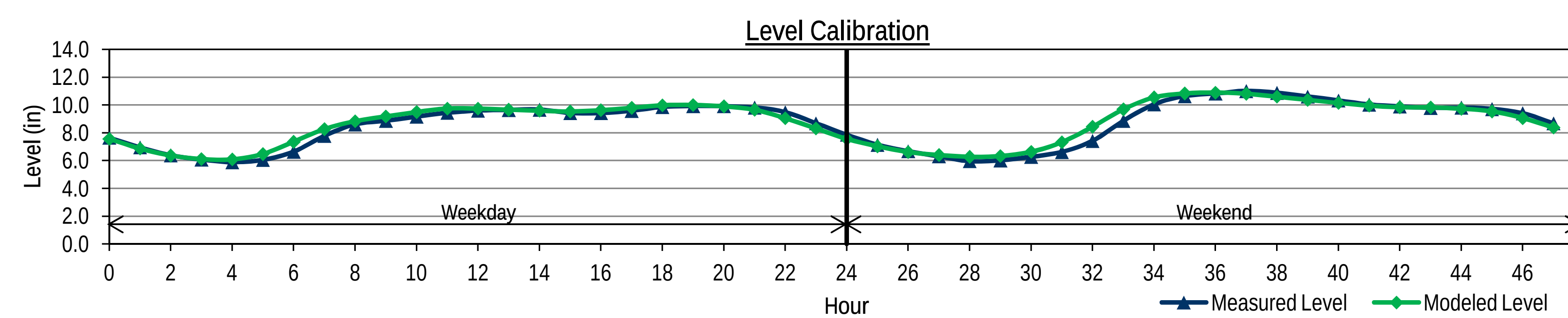
		Measured Data			Modeled Data			Diurnal		
		Flow	Level	Velocity	Flow	Level	Velocity	Initial	Modified	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	Curve	Curve	Diurnal
Weekday	0	0.366	7.6	0.93	0.341	7.6	0.91	0.56	0.45	0.45
	1	0.282	7.0	0.84	0.269	6.9	0.83	0.45	0.39	0.39
	2	0.226	6.4	0.74	0.221	6.4	0.77	0.39	0.39	0.39
	3	0.197	6.1	0.69	0.200	6.1	0.74	0.39	0.45	0.45
	4	0.193	5.9	0.68	0.199	6.1	0.74	0.45	0.60	0.60
	5	0.224	6.1	0.71	0.230	6.5	0.78	0.60	0.86	0.86
	6	0.300	6.6	0.82	0.317	7.4	0.88	0.86	1.00	1.00
	7	0.431	7.8	0.96	0.421	8.3	0.99	1.00	1.06	1.06
	8	0.498	8.6	1.02	0.492	8.8	1.05	1.06	1.14	1.14
	9	0.529	8.9	1.05	0.536	9.2	1.08	1.14	1.19	1.19
	10	0.567	9.2	1.09	0.578	9.5	1.12	1.19	1.24	1.24
	11	0.596	9.4	1.10	0.612	9.7	1.14	1.24	1.23	1.23
	12	0.622	9.6	1.13	0.611	9.7	1.14	1.23	1.23	1.23
	13	0.614	9.6	1.12	0.600	9.7	1.13	1.23	1.17	1.17
	14	0.613	9.7	1.12	0.591	9.6	1.13	1.17	1.19	1.19
	15	0.585	9.4	1.11	0.582	9.5	1.12	1.19	1.24	1.24
	16	0.597	9.4	1.11	0.595	9.6	1.13	1.24	1.30	1.30
	17	0.618	9.6	1.12	0.617	9.8	1.15	1.30	1.31	1.31
	18	0.651	9.9	1.14	0.644	10.0	1.17	1.31	1.29	1.29
	19	0.656	9.9	1.15	0.647	10.0	1.17	1.29	1.26	1.26
	20	0.645	9.9	1.14	0.633	9.9	1.16	1.26	1.13	1.13
	21	0.630	9.8	1.13	0.601	9.7	1.14	1.13	0.95	0.95
	22	0.566	9.5	1.09	0.518	9.1	1.07	0.95	0.73	0.73
	23	0.477	8.7	1.03	0.429	8.3	1.00	0.73	0.56	0.56
Weekend	24	0.396	7.9	0.98	0.342	7.6	0.91	0.63	0.54	0.54
	25	0.317	7.1	0.89	0.285	7.0	0.85	0.54	0.45	0.45
	26	0.268	6.7	0.83	0.245	6.6	0.80	0.45	0.42	0.42
	27	0.227	6.3	0.75	0.225	6.4	0.78	0.42	0.43	0.43
	28	0.207	6.0	0.72	0.213	6.3	0.76	0.43	0.50	0.50
	29	0.216	6.0	0.73	0.219	6.3	0.77	0.50	0.59	0.59
	30	0.250	6.3	0.79	0.245	6.6	0.80	0.59	0.82	0.82
	31	0.296	6.6	0.84	0.313	7.3	0.88	0.82	1.15	1.15
	32	0.408	7.4	0.94	0.440	8.4	1.00	1.15	1.41	1.41
	33	0.576	8.9	1.08	0.602	9.7	1.13	1.41	1.56	1.56
	34	0.704	10.0	1.17	0.723	10.6	1.22	1.56	1.58	1.58
	35	0.777	10.6	1.24	0.764	10.8	1.25	1.58	1.62	1.62
	36	0.790	10.8	1.24	0.771	10.9	1.25	1.62	1.57	1.57
	37	0.807	11.0	1.26	0.760	10.8	1.24	1.57	1.50	1.50
	38	0.785	10.9	1.25	0.729	10.6	1.22	1.50	1.40	1.40
	39	0.747	10.6	1.22	0.697	10.4	1.20	1.40	1.33	1.33
	40	0.701	10.3	1.20	0.666	10.2	1.18	1.33	1.31	1.31
	41	0.666	10.0	1.17	0.639	10.0	1.16	1.31	1.28	1.28
	42	0.655	9.9	1.16	0.623	9.8	1.15	1.28	1.28	1.28
	43	0.640	9.8	1.14	0.621	9.8	1.15	1.28	1.23	1.23
	44	0.638	9.8	1.14	0.609	9.7	1.14	1.23	1.16	1.16
	45	0.616	9.7	1.12	0.583	9.5	1.12	1.16	0.98	0.98
	46	0.580	9.4	1.12	0.520	9.1	1.07	0.98	0.79	0.79
	47	0.489	8.7	1.06	0.435	8.4	1.00	0.79	0.63	0.63
Average										
Weekday		0.487	8.5	1.00	0.479	8.6	1.02	0.97	0.97	0.97
Weekend		0.532	8.8	1.04	0.511	8.9	1.04	1.06	1.06	1.06
ADWF[1]		0.500	8.6	1.01	0.488	8.7	1.03	1.00	1.00	1.00
% Error										
Weekday					-1.7%	1.3%	2.1%			
Weekend					-3.8%	1.0%	-0.1%			

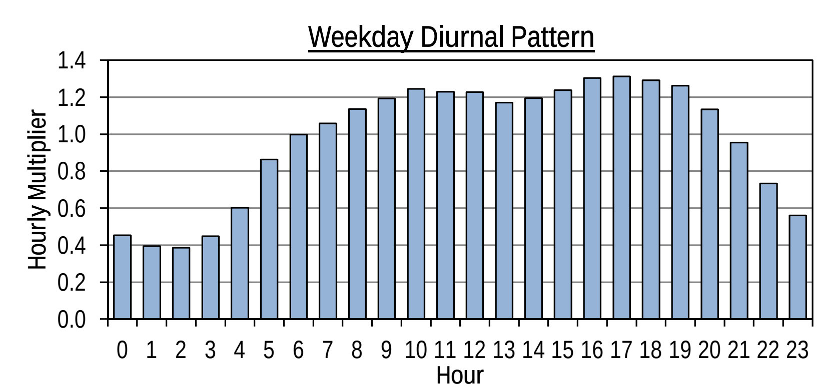
Note:

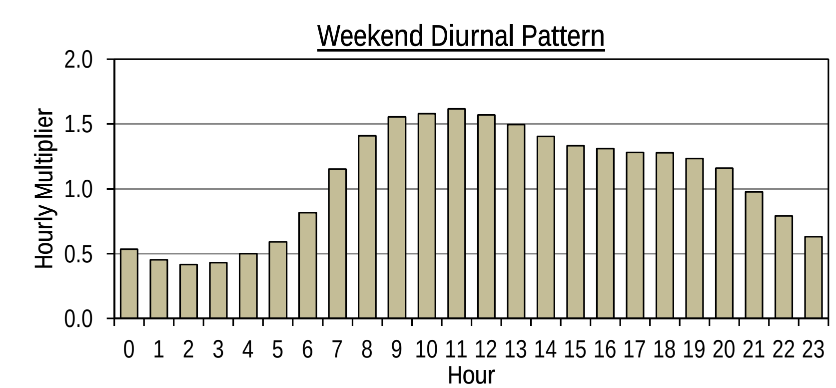
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Turlock

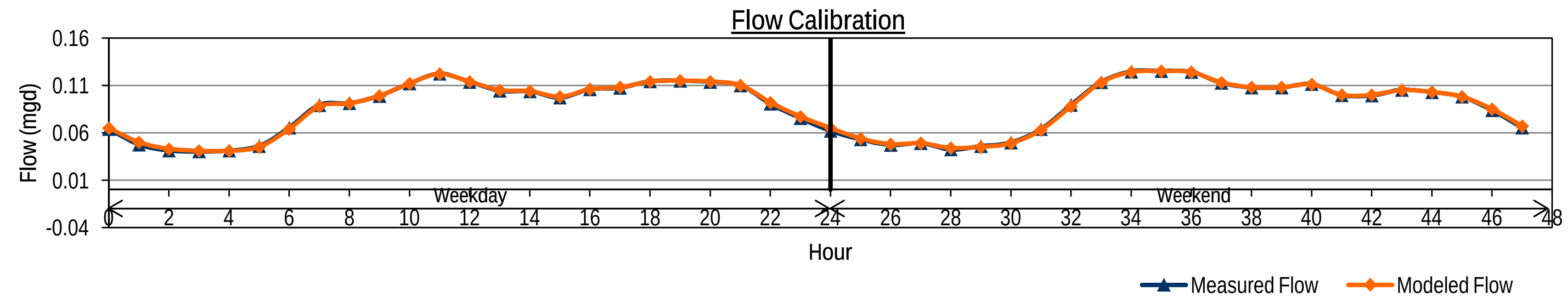
Sewer System Master Plan

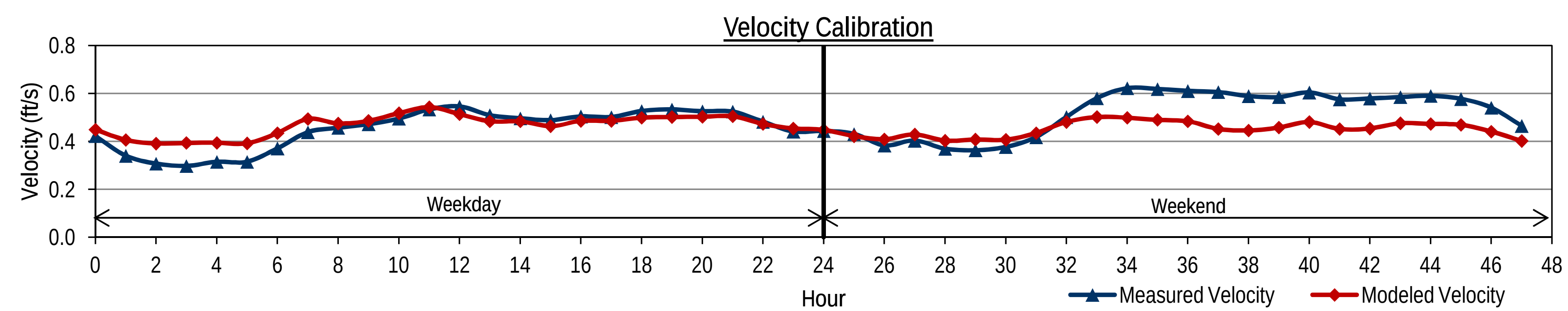
FLOW MONITORING SITE 6 DRY WEATHER FLOW CALIBRATION

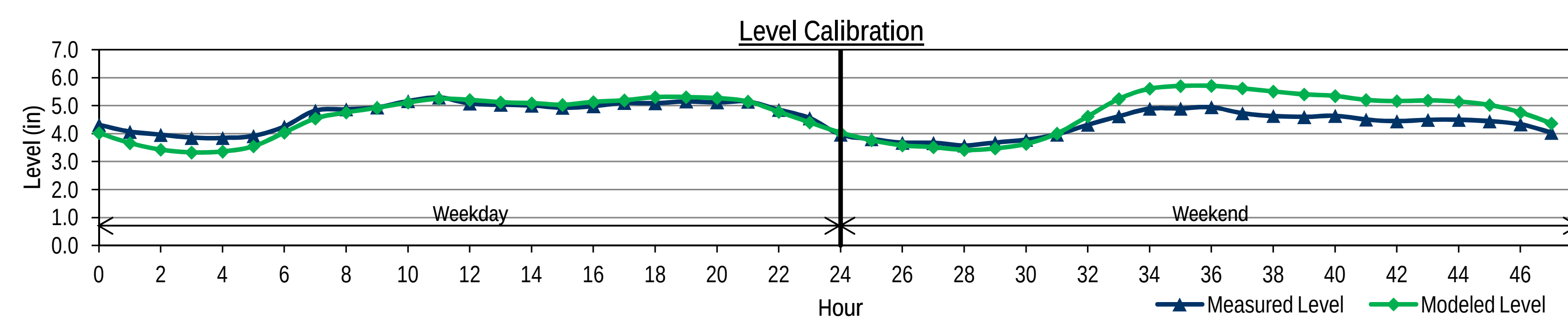
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Diurnal Initial Curve	Diurnal Modified Curve	Diurnal Calibrated Diurnal
Weekday	0	0.064	4.3	0.42	0.065	4.0	0.45	0.54	0.54	0.54
	1	0.048	4.1	0.34	0.050	3.7	0.41	0.47	0.47	0.47
	2	0.041	4.0	0.31	0.043	3.4	0.39	0.46	0.46	0.46
	3	0.040	3.9	0.30	0.041	3.3	0.39	0.47	0.47	0.47
	4	0.042	3.8	0.31	0.041	3.4	0.39	0.53	0.53	0.53
	5	0.046	3.9	0.32	0.045	3.5	0.39	0.75	0.75	0.75
	6	0.066	4.3	0.37	0.064	4.0	0.44	1.02	1.02	1.02
	7	0.089	4.8	0.44	0.088	4.5	0.49	1.04	1.04	1.04
	8	0.091	4.9	0.46	0.091	4.8	0.48	1.13	1.13	1.13
	9	0.099	4.9	0.47	0.099	4.9	0.49	1.28	1.28	1.28
	10	0.112	5.2	0.50	0.112	5.1	0.52	1.40	1.40	1.40
	11	0.122	5.3	0.53	0.122	5.2	0.54	1.30	1.30	1.30
	12	0.114	5.1	0.55	0.114	5.2	0.51	1.19	1.19	1.19
	13	0.104	5.0	0.51	0.105	5.1	0.48	1.18	1.18	1.18
	14	0.104	5.0	0.50	0.104	5.1	0.48	1.11	1.11	1.11
	15	0.097	4.9	0.49	0.098	5.0	0.46	1.21	1.21	1.21
	16	0.106	5.0	0.50	0.106	5.1	0.49	1.23	1.23	1.23
	17	0.108	5.1	0.50	0.108	5.2	0.49	1.30	1.30	1.30
	18	0.114	5.1	0.53	0.114	5.3	0.50	1.31	1.31	1.31
	19	0.115	5.2	0.53	0.115	5.3	0.50	1.30	1.30	1.30
	20	0.114	5.1	0.53	0.114	5.3	0.50	1.26	1.26	1.26
	21	0.110	5.1	0.52	0.110	5.1	0.51	1.03	1.03	1.03
	22	0.091	4.9	0.48	0.092	4.8	0.47	0.86	0.86	0.86
	23	0.076	4.6	0.44	0.077	4.4	0.45	0.73	0.73	0.73
Weekend	24	0.062	4.0	0.44	0.065	4.0	0.45	0.61	0.61	0.61
	25	0.053	3.8	0.43	0.054	3.8	0.42	0.54	0.54	0.54
	26	0.047	3.7	0.38	0.048	3.6	0.41	0.56	0.56	0.56
	27	0.049	3.7	0.40	0.049	3.5	0.43	0.49	0.49	0.49
	28	0.043	3.6	0.37	0.044	3.4	0.40	0.53	0.53	0.53
	29	0.046	3.7	0.36	0.045	3.5	0.41	0.57	0.57	0.57
	30	0.050	3.8	0.38	0.049	3.6	0.41	0.73	0.73	0.73
	31	0.064	4.0	0.42	0.063	4.0	0.44	1.02	1.02	1.02
	32	0.090	4.3	0.50	0.088	4.6	0.48	1.29	1.29	1.29
	33	0.114	4.6	0.58	0.113	5.2	0.50	1.42	1.42	1.42
	34	0.125	4.9	0.62	0.124	5.6	0.50	1.43	1.43	1.43
	35	0.125	4.9	0.62	0.125	5.7	0.49	1.42	1.42	1.42
	36	0.124	4.9	0.61	0.124	5.7	0.48	1.28	1.28	1.28
	37	0.113	4.7	0.61	0.113	5.6	0.45	1.23	1.23	1.23
	38	0.108	4.6	0.59	0.108	5.5	0.45	1.23	1.23	1.23
	39	0.108	4.6	0.59	0.108	5.4	0.46	1.27	1.27	1.27
	40	0.111	4.6	0.60	0.111	5.3	0.48	1.14	1.14	1.14
	41	0.100	4.5	0.58	0.100	5.2	0.45	1.13	1.13	1.13
	42	0.100	4.4	0.58	0.100	5.2	0.45	1.20	1.20	1.20
	43	0.105	4.5	0.59	0.105	5.2	0.48	1.17	1.17	1.17
	44	0.103	4.5	0.59	0.103	5.1	0.47	1.12	1.12	1.12
	45	0.098	4.4	0.58	0.098	5.0	0.47	0.96	0.96	0.96
	46	0.084	4.3	0.54	0.085	4.8	0.44	0.75	0.75	0.75
	47	0.065	4.0	0.47	0.067	4.4	0.40	0.71	0.71	0.71
Average										
Weekday		0.088	4.7	0.45	0.088	4.6	0.47	1.00	1.00	1.00
Weekend		0.087	4.3	0.52	0.087	4.7	0.45	0.99	0.99	0.99
ADWF[1]		0.088	4.6	0.47	0.088	4.6	0.46	1.00	1.00	1.00
% Error										
Weekday					0.2%	-2.2%	3.6%			
Weekend					0.1%	9.5%	-12.9%			

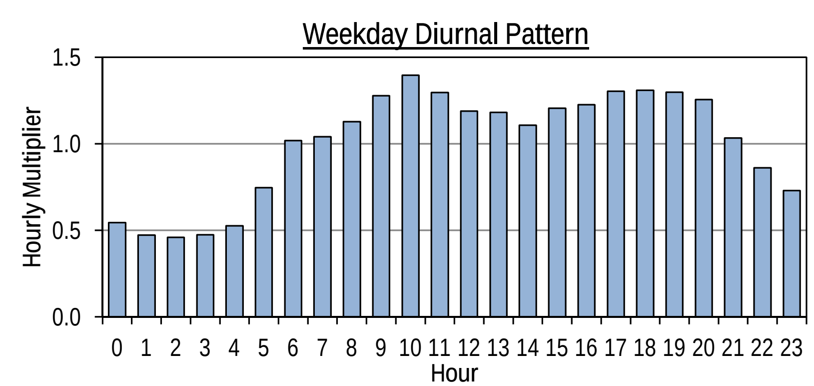
Note:

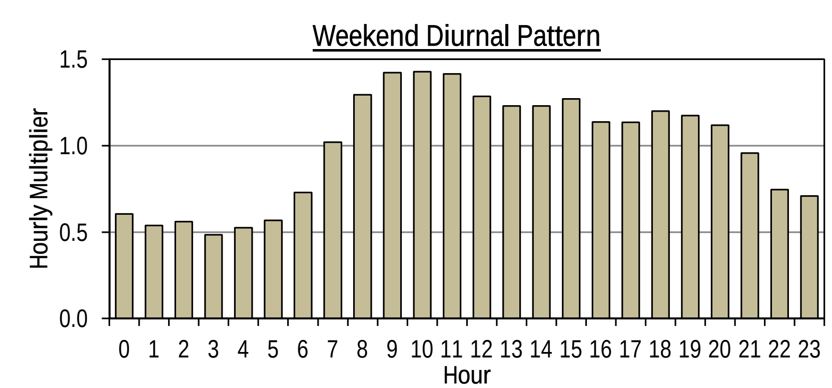
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











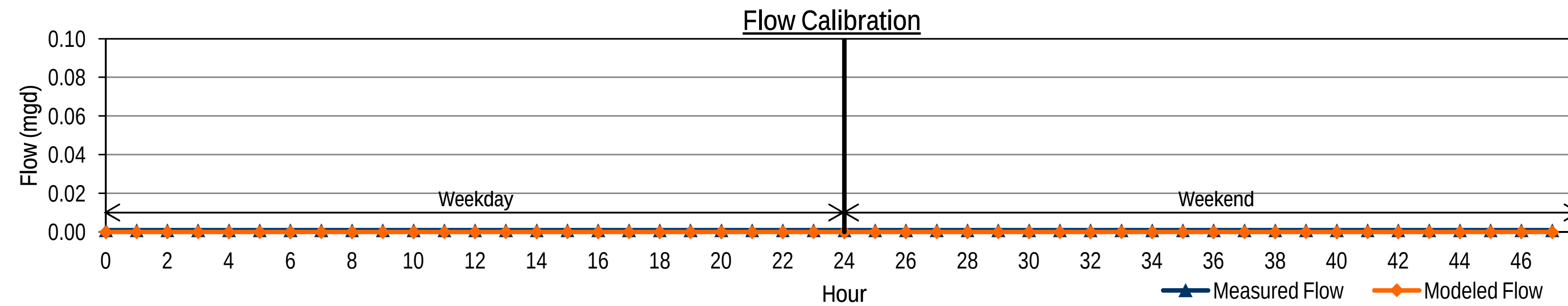
City of Turlock

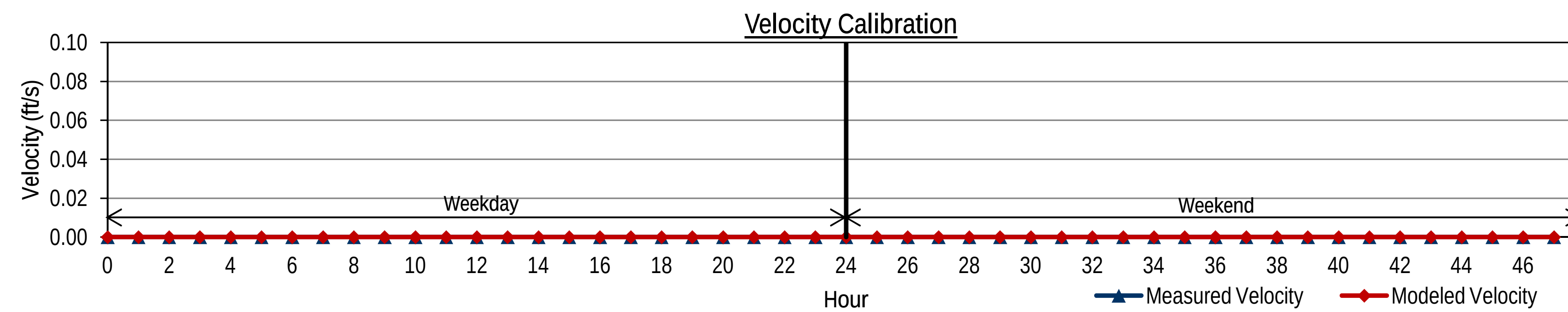
Sewer System Master Plan

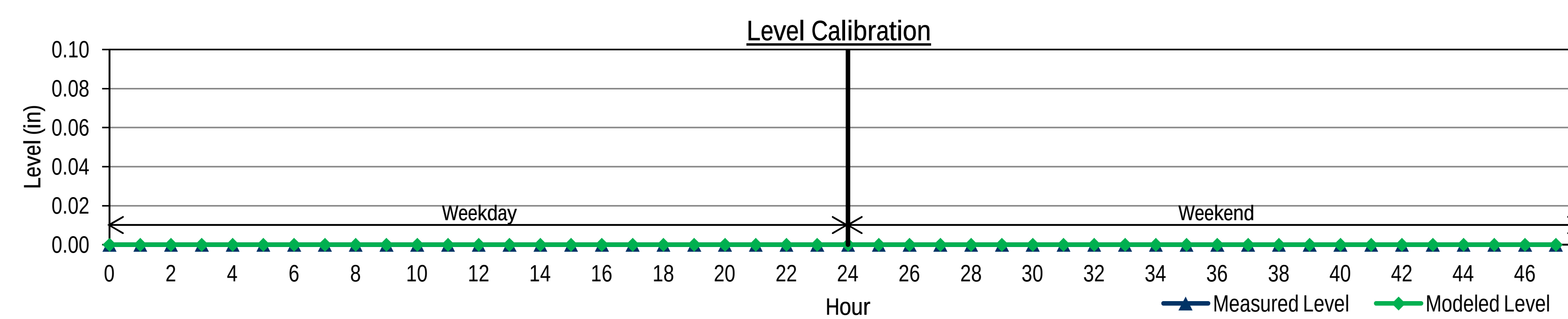
FLOW MONITORING SITE 7 DRY WEATHER FLOW CALIBRATION

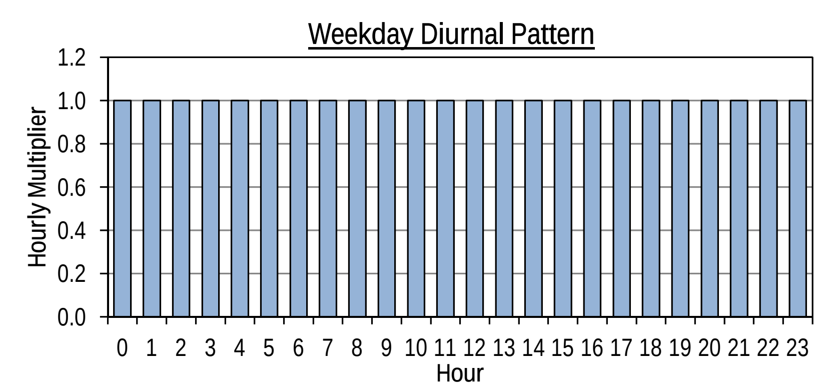
		Measured Data			Modeled Data			Diurnal		
		Flow	Level	Velocity	Flow	Level	Velocity	Initial	Modified	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	Curve	Curve	Diurnal
Weekday	0	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	1	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	2	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	3	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	4	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	5	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	6	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	7	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	8	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	9	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	10	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	11	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	12	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	13	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	14	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	15	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	16	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	17	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	18	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	19	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	20	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	21	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	22	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	23	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
Weekend	24	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	25	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	26	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	27	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	28	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	29	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	30	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	31	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	32	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	33	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	34	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	35	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	36	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	37	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	38	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	39	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	40	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	41	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	42	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	43	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	44	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	45	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	46	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	47	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
Average										
	Weekday	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	Weekend	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
	ADWF[1]	0.001	0.0	0.00	0.000	0.0	0.00	1.00	1.00	1.00
% Error										
	Weekday				-100.0%	#DIV/0!	#DIV/0!			
	Weekend				-100.0%	#DIV/0!	#DIV/0!			

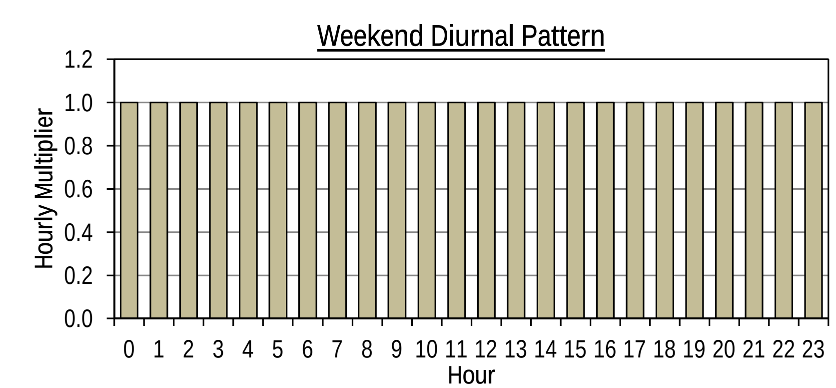
Note:
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7







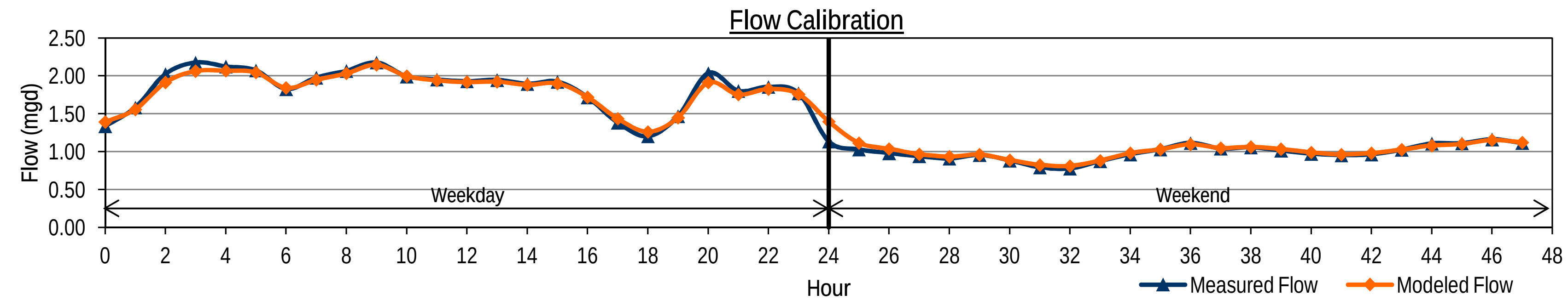


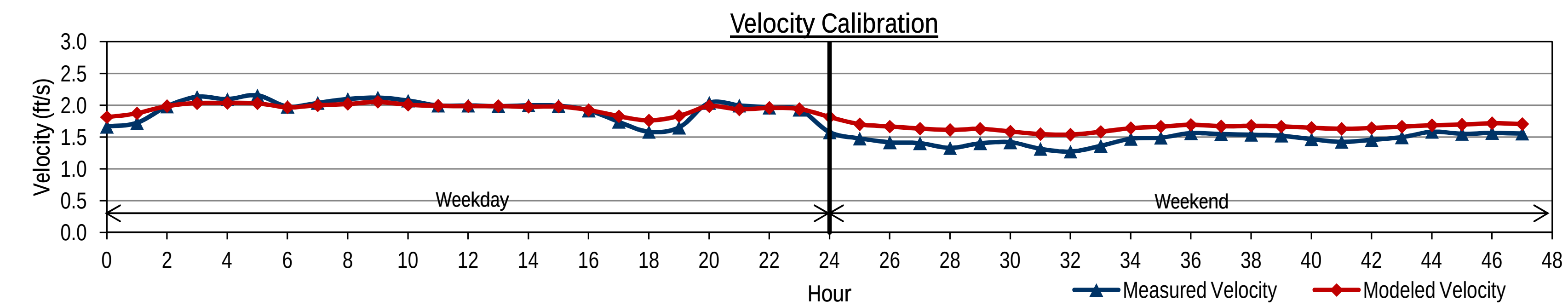


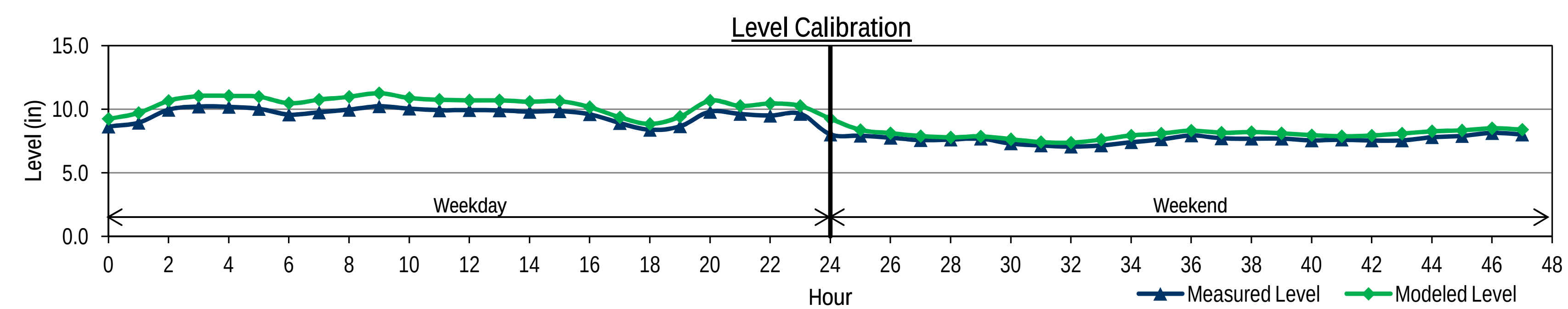
City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 8 DRY WEATHER FLOW CALIBRATION

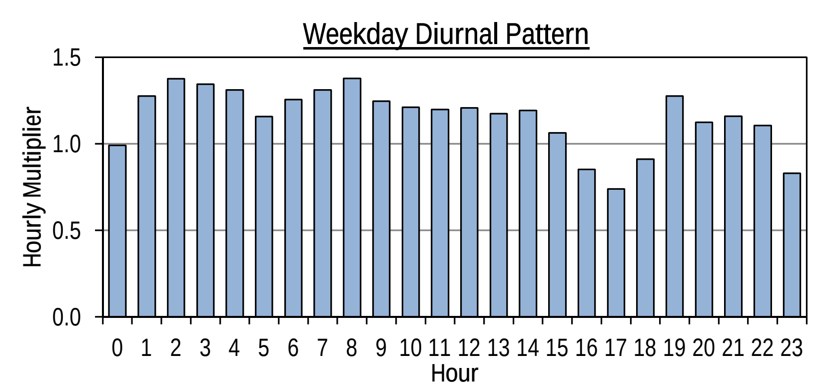
		Measured Data			Modeled Data			Diurnal		
		Flow	Level	Velocity	Flow	Level	Velocity	Initial	Modified	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	Curve	Curve	Diurnal
Weekday	0	1.337	8.6	1.66	1.392	9.3	1.82	0.99	0.99	0.99
	1	1.584	8.9	1.73	1.557	9.7	1.88	1.26	1.28	1.28
	2	2.024	10.0	1.98	1.914	10.7	1.99	1.36	1.38	1.38
	3	2.175	10.2	2.13	2.062	11.0	2.04	1.33	1.34	1.34
	4	2.124	10.2	2.10	2.067	11.1	2.04	1.29	1.31	1.31
	5	2.071	10.0	2.16	2.045	11.0	2.03	1.14	1.16	1.16
	6	1.826	9.6	1.98	1.841	10.5	1.97	1.24	1.26	1.26
	7	1.978	9.8	2.04	1.947	10.8	2.00	1.29	1.31	1.31
	8	2.066	10.0	2.10	2.032	11.0	2.02	1.36	1.38	1.38
	9	2.175	10.2	2.12	2.147	11.3	2.06	1.24	1.25	1.25
	10	1.992	10.0	2.07	1.996	10.9	2.01	1.22	1.21	1.21
	11	1.952	9.9	2.00	1.940	10.8	1.99	1.20	1.20	1.20
	12	1.928	9.9	2.00	1.918	10.7	1.99	1.22	1.21	1.21
	13	1.946	9.9	1.99	1.923	10.7	1.99	1.18	1.18	1.18
	14	1.895	9.8	2.00	1.881	10.6	1.98	1.20	1.19	1.19
	15	1.923	9.9	1.99	1.899	10.6	1.98	1.07	1.06	1.06
	16	1.717	9.6	1.92	1.719	10.2	1.93	0.86	0.85	0.85
	17	1.383	8.9	1.74	1.435	9.4	1.83	0.75	0.74	0.74
	18	1.203	8.4	1.58	1.261	8.9	1.76	0.92	0.91	0.91
	19	1.468	8.7	1.65	1.449	9.4	1.83	1.27	1.28	1.28
	20	2.036	9.8	2.04	1.912	10.7	1.99	1.13	1.13	1.13
	21	1.801	9.6	2.00	1.754	10.3	1.94	1.16	1.16	1.16
	22	1.855	9.5	1.96	1.826	10.5	1.96	1.11	1.11	1.11
	23	1.771	9.6	1.93	1.758	10.3	1.94	0.84	0.83	0.83
Weekend	24	1.133	8.0	1.58	1.397	9.3	1.82	0.64	0.64	0.64
	25	1.028	7.9	1.48	1.114	8.4	1.70	0.61	0.61	0.61
	26	0.980	7.8	1.42	1.036	8.1	1.67	0.59	0.59	0.59
	27	0.939	7.6	1.41	0.967	7.9	1.63	0.57	0.57	0.57
	28	0.908	7.6	1.33	0.934	7.8	1.61	0.60	0.60	0.60
	29	0.956	7.7	1.40	0.961	7.9	1.63	0.55	0.55	0.55
	30	0.884	7.3	1.42	0.890	7.6	1.59	0.50	0.50	0.50
	31	0.793	7.2	1.32	0.825	7.4	1.55	0.49	0.49	0.49
	32	0.777	7.1	1.27	0.812	7.4	1.54	0.55	0.55	0.55
	33	0.875	7.2	1.36	0.882	7.6	1.58	0.60	0.61	0.61
	34	0.965	7.4	1.48	0.982	7.9	1.64	0.64	0.64	0.64
	35	1.032	7.6	1.49	1.030	8.1	1.67	0.70	0.68	0.68
	36	1.115	7.9	1.56	1.097	8.3	1.70	0.65	0.63	0.63
	37	1.041	7.7	1.55	1.047	8.2	1.67	0.66	0.64	0.64
	38	1.058	7.7	1.54	1.062	8.2	1.68	0.63	0.62	0.62
	39	1.014	7.7	1.52	1.034	8.1	1.67	0.61	0.59	0.59
	40	0.972	7.6	1.47	0.990	8.0	1.65	0.60	0.58	0.58
	41	0.954	7.6	1.43	0.963	7.9	1.63	0.60	0.59	0.59
	42	0.964	7.6	1.46	0.981	7.9	1.64	0.64	0.63	0.63
	43	1.026	7.6	1.50	1.027	8.1	1.67	0.69	0.68	0.68
	44	1.107	7.8	1.58	1.081	8.3	1.69	0.69	0.69	0.69
	45	1.111	7.9	1.55	1.101	8.3	1.70	0.73	0.72	0.72
	46	1.163	8.1	1.57	1.153	8.5	1.72	0.70	0.69	0.69
	47	1.114	8.0	1.56	1.121	8.4	1.71	0.71	0.70	0.70
Average										
Weekday		1.843	9.6	1.95	1.820	10.4	1.96	1.15	1.15	1.15
Weekend		0.996	7.7	1.47	1.020	8.1	1.66	0.62	0.62	0.62
ADWF[1]		1.601	9.1	1.82	1.591	9.7	1.87	1.00	1.00	1.00
% Error										
Weekday					-1.3%	8.2%	0.2%			
Weekend					2.4%	5.5%	12.8%			

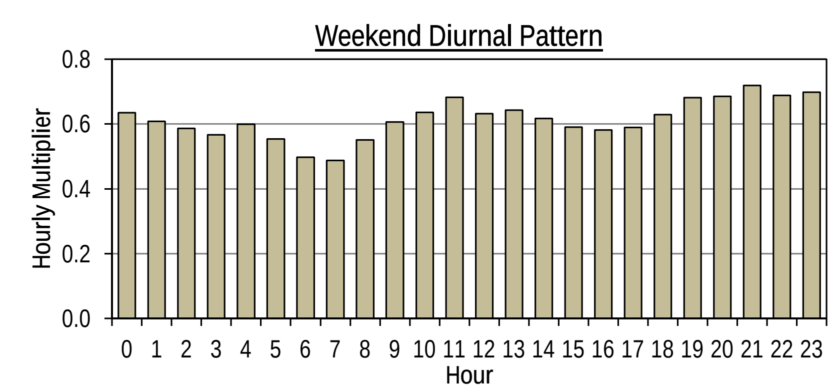
Note:
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











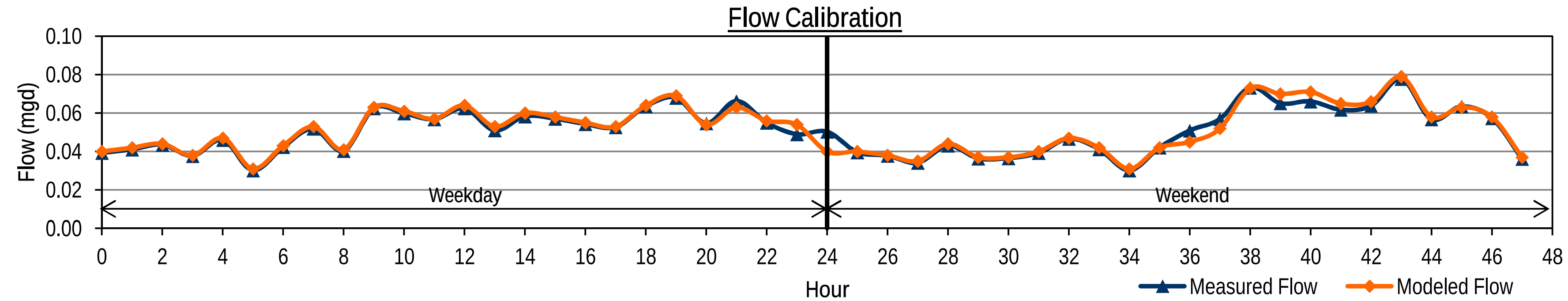
City of Turlock

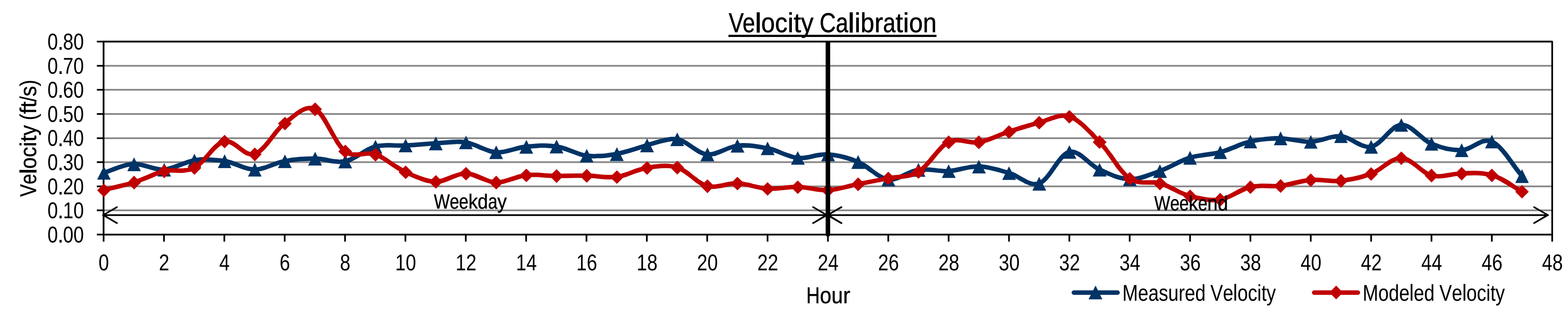
Sewer System Master Plan

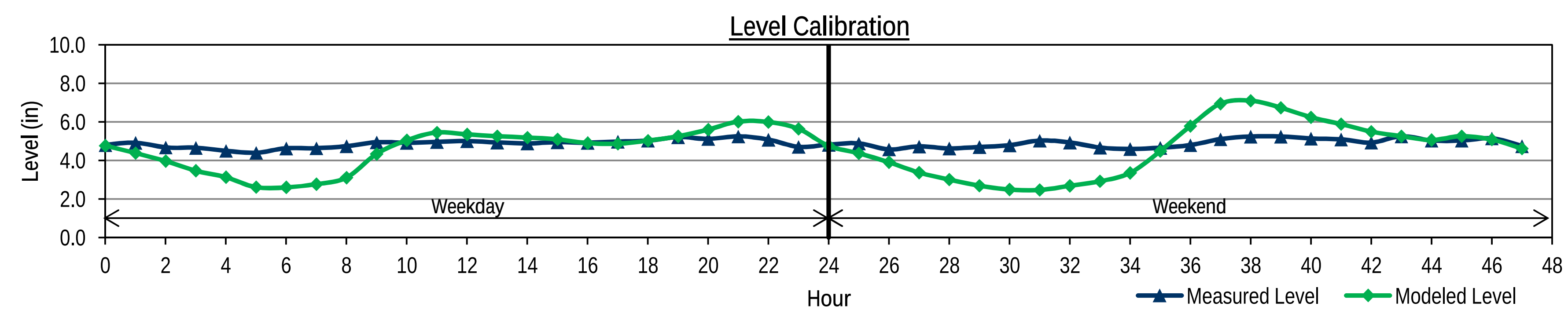
FLOW MONITORING SITE 9 DRY WEATHER FLOW CALIBRATION

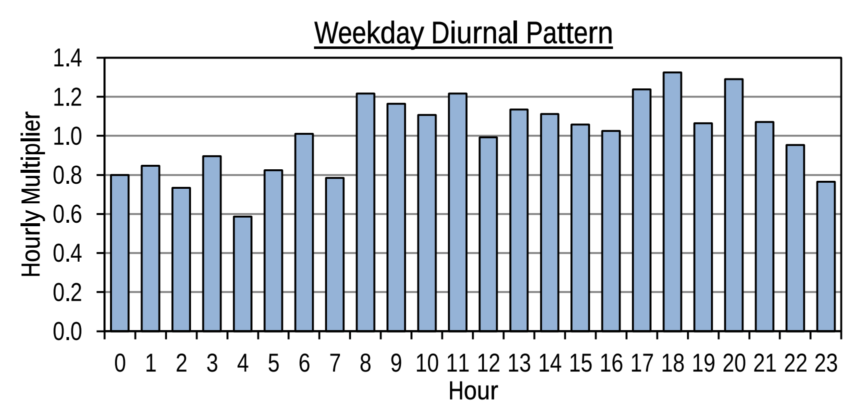
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Diurnal Initial Curve	Diurnal Modified Curve	Diurnal Calibrated Diurnal
Weekday	0	0.039	4.8	0.26	0.040	4.8	0.18	0.80	0.80	0.80
	1	0.041	4.9	0.29	0.042	4.4	0.22	0.85	0.85	0.85
	2	0.044	4.7	0.27	0.044	4.0	0.26	0.73	0.73	0.73
	3	0.038	4.7	0.31	0.038	3.5	0.28	0.90	0.90	0.90
	4	0.046	4.5	0.30	0.047	3.1	0.39	0.59	0.59	0.59
	5	0.030	4.4	0.27	0.031	2.6	0.33	0.82	0.82	0.82
	6	0.042	4.6	0.30	0.043	2.6	0.46	1.01	1.01	1.01
	7	0.052	4.6	0.32	0.053	2.8	0.52	0.78	0.78	0.78
	8	0.040	4.7	0.30	0.041	3.1	0.35	1.22	1.22	1.22
	9	0.062	4.9	0.36	0.063	4.3	0.33	1.16	1.16	1.16
	10	0.060	4.9	0.37	0.061	5.0	0.26	1.11	1.11	1.11
	11	0.057	5.0	0.38	0.057	5.5	0.22	1.22	1.22	1.22
	12	0.062	5.0	0.38	0.064	5.4	0.25	0.99	0.99	0.99
	13	0.051	4.9	0.34	0.053	5.3	0.22	1.13	1.13	1.13
	14	0.058	4.9	0.36	0.060	5.2	0.25	1.11	1.11	1.11
	15	0.057	4.9	0.37	0.058	5.1	0.24	1.06	1.06	1.06
	16	0.054	4.9	0.33	0.055	4.9	0.24	1.02	1.02	1.02
	17	0.053	5.0	0.33	0.053	4.9	0.24	1.24	1.24	1.24
	18	0.064	5.0	0.37	0.064	5.0	0.28	1.32	1.32	1.32
	19	0.068	5.2	0.40	0.069	5.3	0.28	1.06	1.06	1.06
	20	0.055	5.1	0.33	0.054	5.6	0.20	1.29	1.29	1.29
	21	0.066	5.2	0.37	0.063	6.0	0.21	1.07	1.07	1.07
	22	0.055	5.1	0.36	0.056	6.0	0.19	0.95	0.95	0.95
	23	0.049	4.7	0.32	0.054	5.6	0.20	0.76	0.76	0.76
Weekend	24	0.050	4.8	0.33	0.040	4.8	0.18	0.77	0.77	0.77
	25	0.040	4.9	0.30	0.040	4.4	0.21	0.74	0.74	0.74
	26	0.038	4.6	0.23	0.038	3.9	0.23	0.66	0.66	0.66
	27	0.034	4.7	0.27	0.035	3.4	0.26	0.84	0.84	0.84
	28	0.043	4.6	0.26	0.044	3.0	0.38	0.71	0.71	0.71
	29	0.036	4.7	0.28	0.037	2.7	0.38	0.71	0.71	0.71
	30	0.036	4.8	0.26	0.037	2.5	0.43	0.76	0.76	0.76
	31	0.039	5.0	0.21	0.040	2.5	0.46	0.91	0.91	0.91
	32	0.047	4.9	0.34	0.047	2.7	0.49	0.80	0.80	0.80
	33	0.041	4.7	0.27	0.042	2.9	0.38	0.59	0.59	0.59
	34	0.030	4.6	0.23	0.031	3.4	0.23	0.82	0.82	0.82
	35	0.042	4.7	0.26	0.042	4.5	0.21	0.99	0.99	0.99
	36	0.051	4.8	0.32	0.045	5.8	0.16	1.11	1.11	1.11
	37	0.057	5.1	0.34	0.052	7.0	0.15	1.43	1.43	1.43
	38	0.073	5.2	0.39	0.073	7.1	0.20	1.27	1.27	1.27
	39	0.065	5.2	0.40	0.070	6.7	0.20	1.29	1.29	1.29
	40	0.066	5.1	0.39	0.071	6.2	0.23	1.20	1.20	1.20
	41	0.062	5.1	0.41	0.065	5.9	0.22	1.24	1.24	1.24
	42	0.064	4.9	0.36	0.066	5.5	0.25	1.51	1.51	1.51
	43	0.078	5.3	0.46	0.079	5.3	0.32	1.10	1.10	1.10
	44	0.057	5.0	0.38	0.058	5.1	0.25	1.24	1.24	1.24
	45	0.063	5.0	0.35	0.063	5.3	0.25	1.12	1.12	1.12
	46	0.057	5.1	0.39	0.058	5.1	0.25	0.70	0.70	0.70
	47	0.036	4.7	0.24	0.037	4.6	0.18	0.98	0.98	0.98
Average										
Weekday		0.052	4.9	0.33	0.053	4.6	0.27	1.01	1.01	1.01
Weekend		0.050	4.9	0.32	0.050	4.6	0.27	0.98	0.98	0.98
ADWF[1]		0.051	4.9	0.33	0.052	4.6	0.27	1.00	1.00	1.00
% Error										
Weekday					1.6%	-5.9%	-17.6%			
Weekend					0.4%	-6.5%	-15.2%			

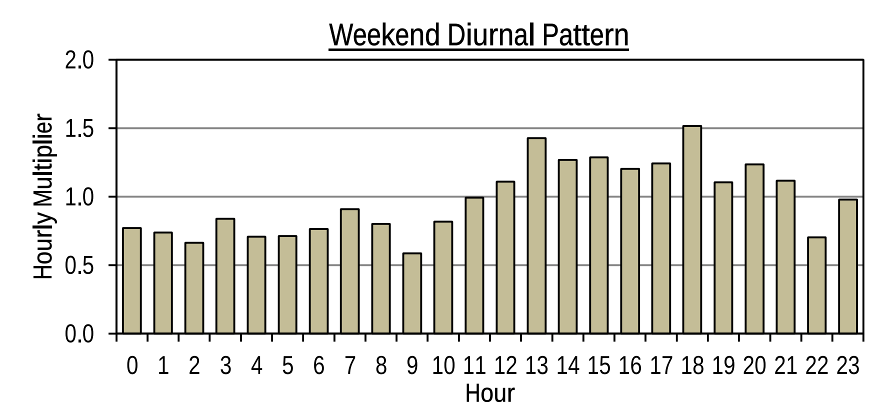
Note:
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Turlock

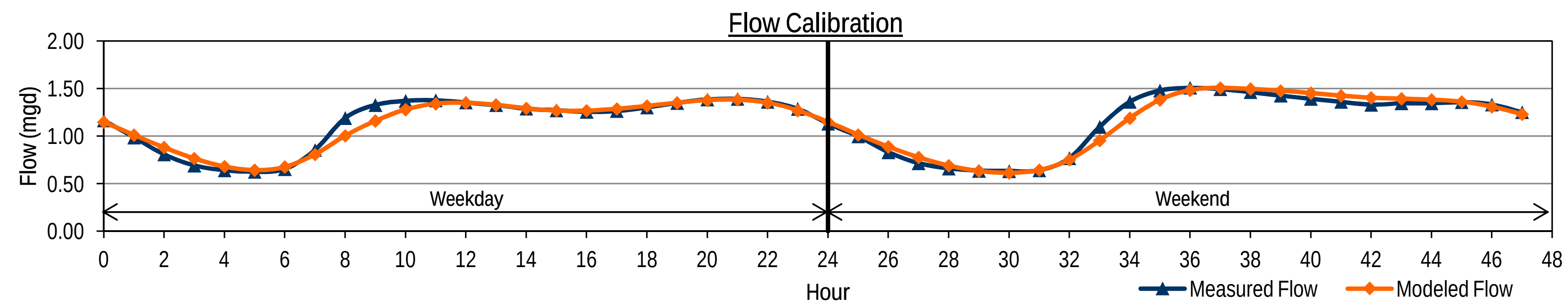
Sewer System Master Plan

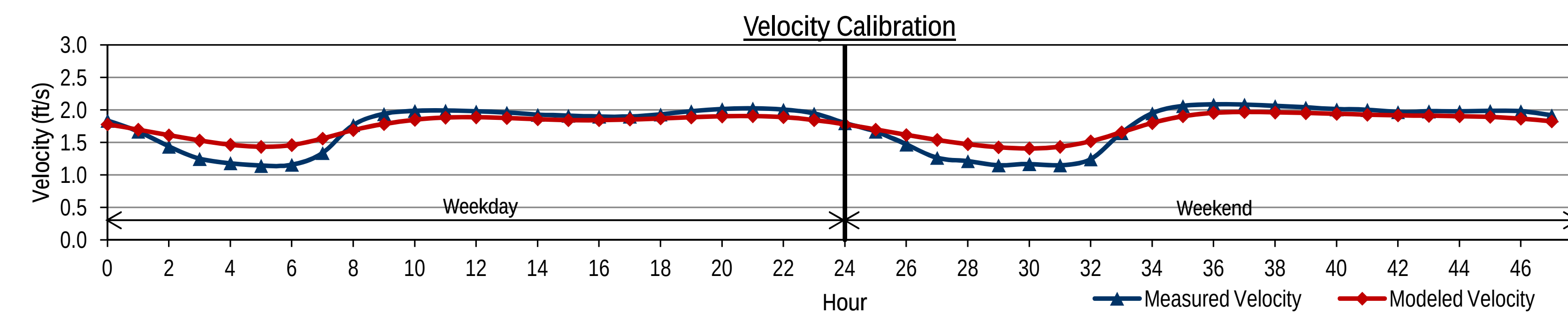
FLOW MONITORING SITE 10 DRY WEATHER FLOW CALIBRATION

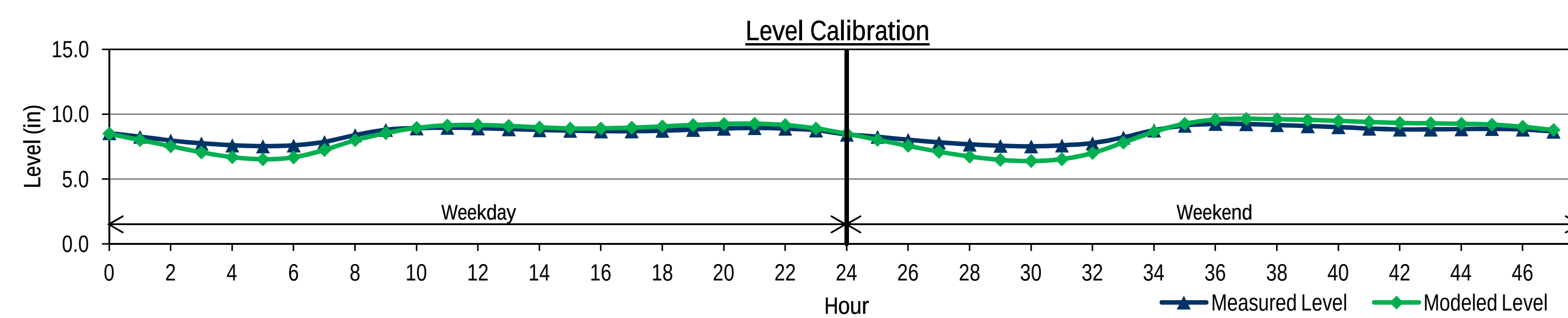
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Diurnal Initial Curve	Diurnal Modified Curve	Diurnal Calibrated Diurnal
Weekday	0	1.164	8.5	1.84	1.147	8.5	1.78	0.86	0.86	0.86
	1	0.986	8.3	1.67	1.010	8.0	1.70	0.70	0.70	0.70
	2	0.807	8.0	1.44	0.880	7.5	1.61	0.60	0.60	0.60
	3	0.691	7.7	1.25	0.764	7.1	1.53	0.56	0.56	0.56
	4	0.642	7.6	1.18	0.680	6.7	1.47	0.54	0.54	0.54
	5	0.625	7.5	1.14	0.642	6.5	1.43	0.57	0.57	0.57
	6	0.653	7.6	1.16	0.675	6.7	1.46	0.75	0.75	0.75
	7	0.855	7.9	1.34	0.808	7.3	1.56	1.04	1.04	1.04
	8	1.190	8.4	1.77	1.003	8.0	1.69	1.16	1.16	1.16
	9	1.328	8.8	1.94	1.159	8.6	1.78	1.19	1.19	1.19
	10	1.370	8.9	1.99	1.278	9.0	1.85	1.20	1.20	1.20
	11	1.377	9.0	1.99	1.339	9.1	1.88	1.18	1.18	1.18
	12	1.353	8.9	1.98	1.348	9.2	1.89	1.16	1.16	1.16
	13	1.326	8.9	1.96	1.327	9.1	1.88	1.12	1.12	1.12
	14	1.288	8.8	1.93	1.291	9.0	1.86	1.11	1.11	1.11
	15	1.272	8.7	1.91	1.266	8.9	1.84	1.09	1.09	1.09
	16	1.256	8.7	1.90	1.266	8.9	1.84	1.10	1.10	1.10
	17	1.264	8.7	1.90	1.285	9.0	1.85	1.14	1.14	1.14
	18	1.302	8.7	1.93	1.316	9.1	1.87	1.18	1.18	1.18
	19	1.349	8.8	1.98	1.348	9.2	1.89	1.21	1.21	1.21
	20	1.385	8.9	2.01	1.376	9.3	1.90	1.21	1.21	1.21
	21	1.391	8.9	2.02	1.382	9.3	1.91	1.19	1.19	1.19
	22	1.362	8.9	2.00	1.349	9.2	1.89	1.12	1.12	1.12
	23	1.286	8.8	1.94	1.268	8.9	1.85	1.01	1.01	1.01
Weekend	24	1.131	8.4	1.80	1.147	8.5	1.78	0.87	0.87	0.87
	25	0.996	8.3	1.67	1.013	8.0	1.70	0.72	0.72	0.72
	26	0.830	8.0	1.47	0.887	7.6	1.62	0.62	0.62	0.62
	27	0.715	7.8	1.26	0.777	7.1	1.54	0.58	0.58	0.58
	28	0.661	7.7	1.21	0.689	6.7	1.47	0.55	0.55	0.55
	29	0.635	7.6	1.15	0.633	6.5	1.43	0.55	0.55	0.55
	30	0.633	7.5	1.17	0.614	6.4	1.41	0.56	0.56	0.56
	31	0.641	7.6	1.15	0.643	6.5	1.43	0.67	0.67	0.67
	32	0.768	7.8	1.24	0.751	7.0	1.52	0.96	0.96	0.96
	33	1.097	8.2	1.65	0.953	7.8	1.66	1.19	1.19	1.19
	34	1.361	8.8	1.95	1.187	8.7	1.80	1.29	1.29	1.29
	35	1.479	9.1	2.06	1.380	9.3	1.90	1.31	1.31	1.31
	36	1.508	9.3	2.08	1.482	9.6	1.96	1.30	1.30	1.30
	37	1.493	9.2	2.08	1.505	9.7	1.97	1.28	1.28	1.28
	38	1.463	9.2	2.06	1.494	9.6	1.96	1.24	1.24	1.24
	39	1.427	9.1	2.04	1.475	9.6	1.95	1.21	1.21	1.21
	40	1.392	9.0	2.01	1.451	9.5	1.94	1.19	1.19	1.19
	41	1.361	8.9	2.00	1.423	9.4	1.93	1.16	1.16	1.16
	42	1.330	8.8	1.97	1.402	9.3	1.92	1.17	1.17	1.17
	43	1.346	8.8	1.98	1.392	9.3	1.91	1.17	1.17	1.17
	44	1.345	8.8	1.98	1.381	9.3	1.91	1.18	1.18	1.18
	45	1.357	8.9	1.99	1.360	9.2	1.89	1.16	1.16	1.16
	46	1.331	8.8	1.98	1.308	9.0	1.87	1.09	1.09	1.09
	47	1.251	8.7	1.92	1.230	8.8	1.82	0.99	0.99	0.99
Average										
Weekday		1.147	8.5	1.76	1.134	8.4	1.76	1.00	1.00	1.00
Weekend		1.148	8.5	1.74	1.149	8.4	1.76	1.00	1.00	1.00
ADWF[1]		1.147	8.5	1.75	1.138	8.4	1.76	1.00	1.00	1.00
% Error										
Weekday					-1.1%	-0.9%	0.1%			
Weekend					0.1%	-0.9%	1.0%			

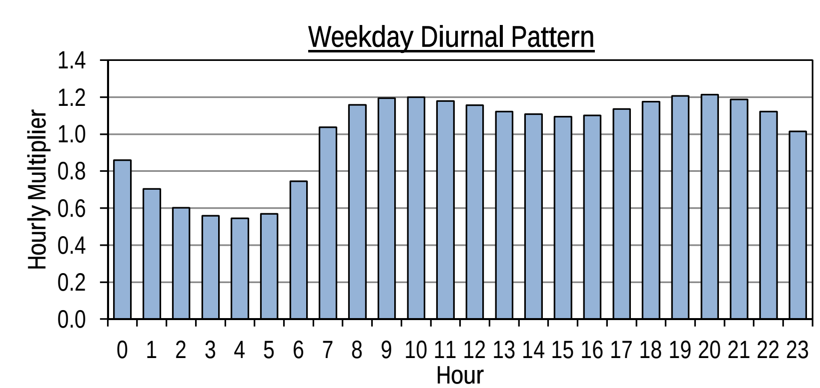
Note:

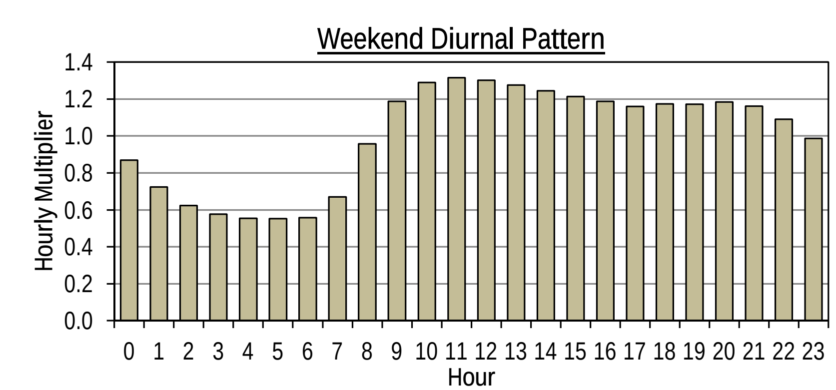
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Turlock

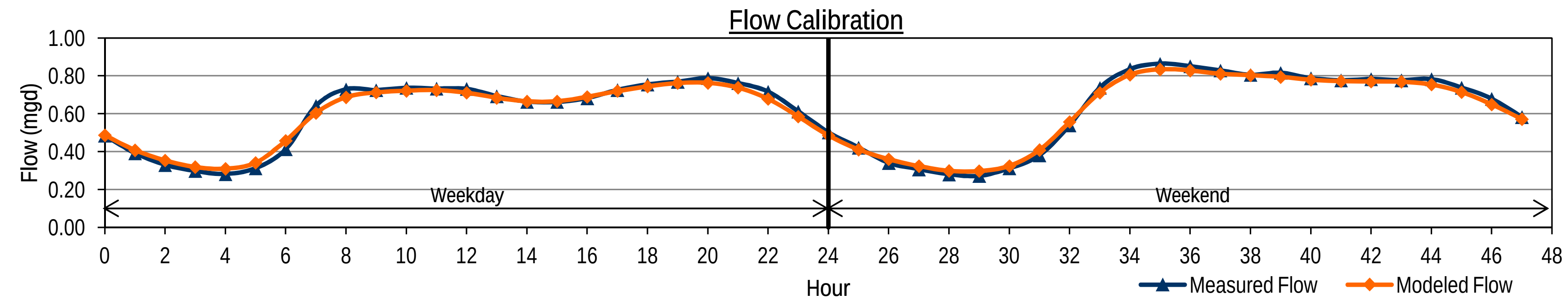
Sewer System Master Plan

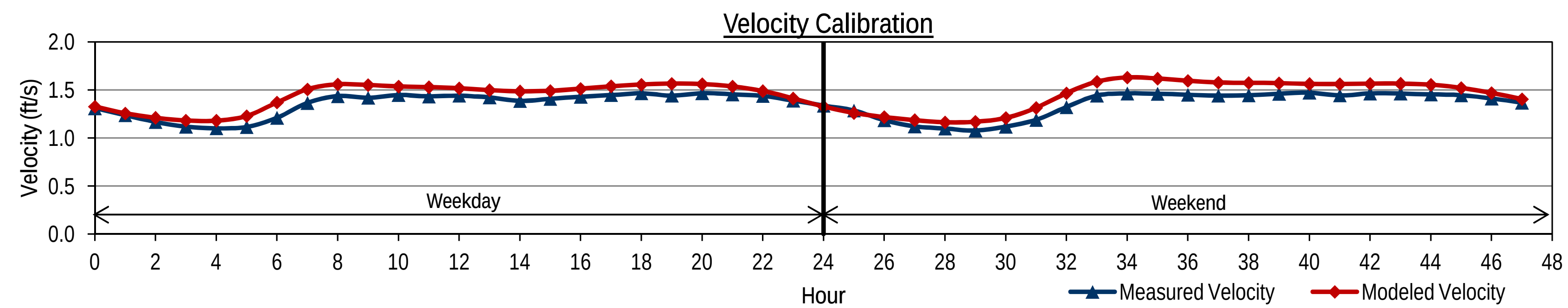
FLOW MONITORING SITE 11 DRY WEATHER FLOW CALIBRATION

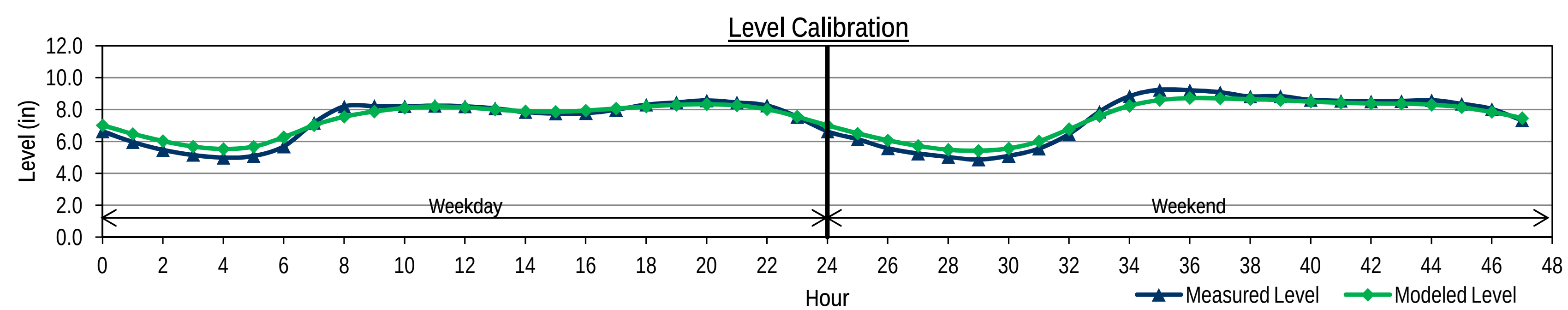
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Diurnal Initial Curve	Diurnal Modified Curve	Diurnal Calibrated Diurnal
Weekday	0	0.484	6.6	1.31	0.487	7.0	1.33	0.64	0.54	0.54
	1	0.392	6.0	1.24	0.408	6.5	1.26	0.54	0.49	0.49
	2	0.330	5.5	1.17	0.354	6.0	1.21	0.49	0.46	0.46
	3	0.298	5.2	1.12	0.319	5.7	1.18	0.46	0.51	0.51
	4	0.282	5.0	1.10	0.310	5.5	1.18	0.51	0.67	0.67
	5	0.313	5.1	1.12	0.342	5.7	1.23	0.67	1.05	1.05
	6	0.413	5.7	1.21	0.458	6.3	1.37	1.05	1.19	1.19
	7	0.642	7.2	1.37	0.604	7.0	1.51	1.19	1.18	1.18
	8	0.730	8.2	1.44	0.687	7.6	1.56	1.18	1.20	1.20
	9	0.725	8.2	1.42	0.712	7.9	1.55	1.20	1.19	1.19
	10	0.737	8.2	1.45	0.721	8.1	1.54	1.19	1.19	1.19
	11	0.733	8.3	1.43	0.724	8.2	1.53	1.19	1.13	1.13
	12	0.731	8.2	1.44	0.711	8.1	1.52	1.13	1.08	1.08
	13	0.693	8.1	1.42	0.684	8.0	1.50	1.08	1.08	1.08
	14	0.664	7.9	1.39	0.665	7.9	1.49	1.08	1.11	1.11
	15	0.663	7.8	1.41	0.666	7.9	1.49	1.11	1.18	1.18
	16	0.682	7.8	1.43	0.689	7.9	1.51	1.18	1.23	1.23
	17	0.726	8.0	1.45	0.720	8.1	1.54	1.23	1.25	1.25
	18	0.755	8.3	1.47	0.744	8.2	1.56	1.25	1.28	1.28
	19	0.769	8.5	1.44	0.762	8.3	1.57	1.28	1.24	1.24
	20	0.788	8.6	1.47	0.763	8.3	1.56	1.24	1.17	1.17
	21	0.762	8.5	1.46	0.738	8.3	1.54	1.17	1.00	1.00
	22	0.717	8.3	1.44	0.678	8.0	1.49	1.00	0.79	0.79
	23	0.612	7.5	1.39	0.585	7.6	1.41	0.79	0.64	0.64
Weekend	24	0.502	6.6	1.34	0.486	7.0	1.33	0.69	0.55	0.55
	25	0.421	6.1	1.29	0.411	6.5	1.26	0.55	0.50	0.50
	26	0.341	5.6	1.19	0.360	6.1	1.22	0.50	0.46	0.46
	27	0.307	5.3	1.12	0.324	5.7	1.19	0.46	0.44	0.44
	28	0.280	5.0	1.10	0.299	5.5	1.16	0.44	0.51	0.51
	29	0.272	4.9	1.08	0.298	5.4	1.17	0.51	0.62	0.62
	30	0.312	5.1	1.12	0.325	5.6	1.21	0.62	0.88	0.88
	31	0.381	5.6	1.19	0.409	6.0	1.31	0.88	1.20	1.20
	32	0.539	6.5	1.32	0.557	6.8	1.47	1.20	1.36	1.36
	33	0.737	7.9	1.44	0.711	7.6	1.59	1.36	1.41	1.41
	34	0.835	8.9	1.47	0.806	8.2	1.63	1.41	1.39	1.39
	35	0.865	9.2	1.46	0.834	8.6	1.62	1.39	1.35	1.35
	36	0.851	9.2	1.45	0.828	8.7	1.60	1.35	1.31	1.31
	37	0.828	9.1	1.44	0.811	8.7	1.58	1.31	1.33	1.33
	38	0.805	8.8	1.45	0.803	8.7	1.57	1.33	1.28	1.28
	39	0.816	8.8	1.46	0.794	8.6	1.57	1.28	1.26	1.26
	40	0.787	8.6	1.47	0.779	8.5	1.56	1.26	1.27	1.27
	41	0.776	8.6	1.44	0.772	8.4	1.56	1.27	1.26	1.26
	42	0.783	8.5	1.47	0.770	8.4	1.57	1.26	1.27	1.27
	43	0.777	8.5	1.46	0.769	8.4	1.57	1.27	1.20	1.20
	44	0.783	8.6	1.45	0.754	8.3	1.56	1.20	1.11	1.11
	45	0.738	8.4	1.45	0.714	8.2	1.52	1.11	0.95	0.95
	46	0.679	8.0	1.41	0.649	7.9	1.47	0.95	0.82	0.82
	47	0.583	7.3	1.37	0.572	7.5	1.41	0.82	0.69	0.69
Average										
	Weekday	0.610	7.4	1.36	0.605	7.4	1.44	0.99	0.99	0.99
	Weekend	0.625	7.5	1.35	0.618	7.5	1.44	1.02	1.02	1.02
	ADWF[(1)]	0.614	7.4	1.36	0.609	7.4	1.44	1.00	1.00	1.00
% Error										
	Weekday				-0.8%	1.0%	6.2%			
	Weekend				-1.1%	0.0%	6.9%			

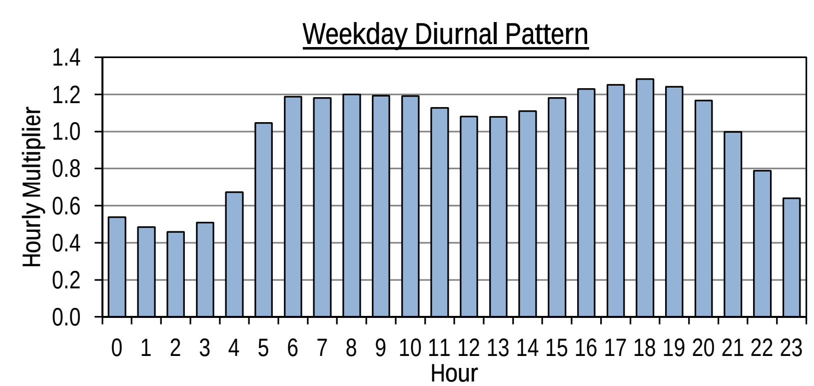
Note:

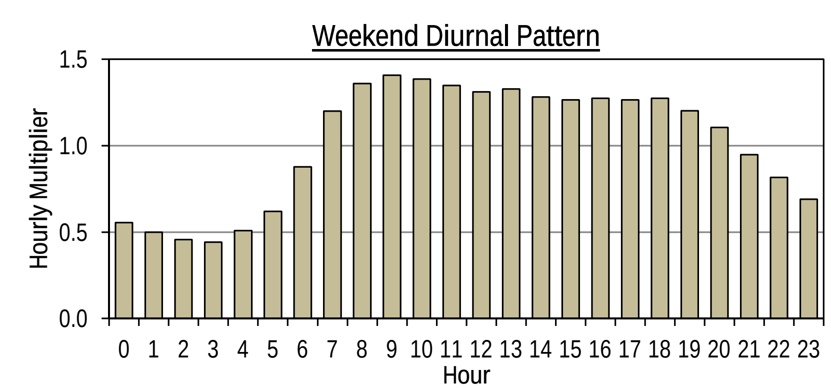
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7







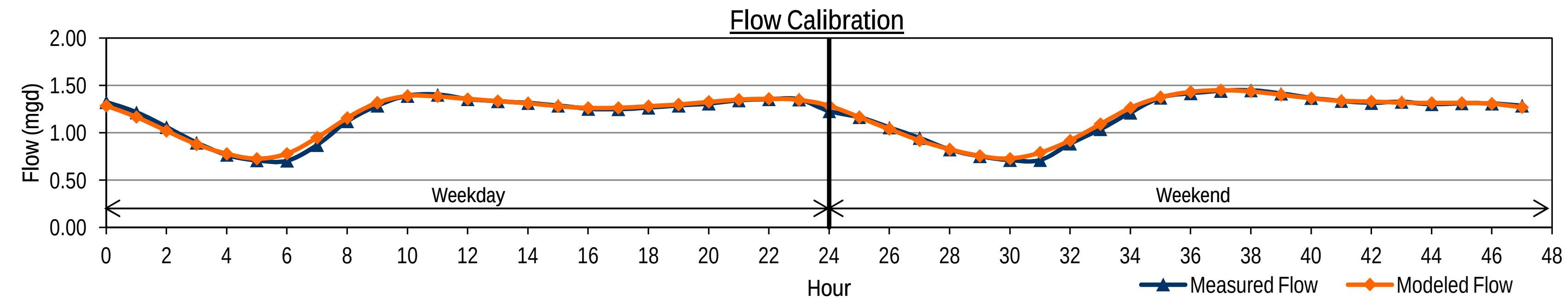


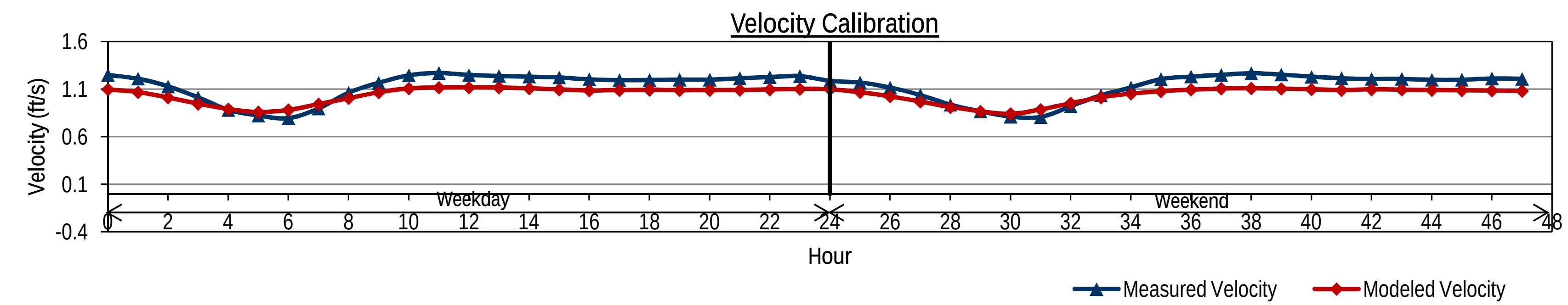


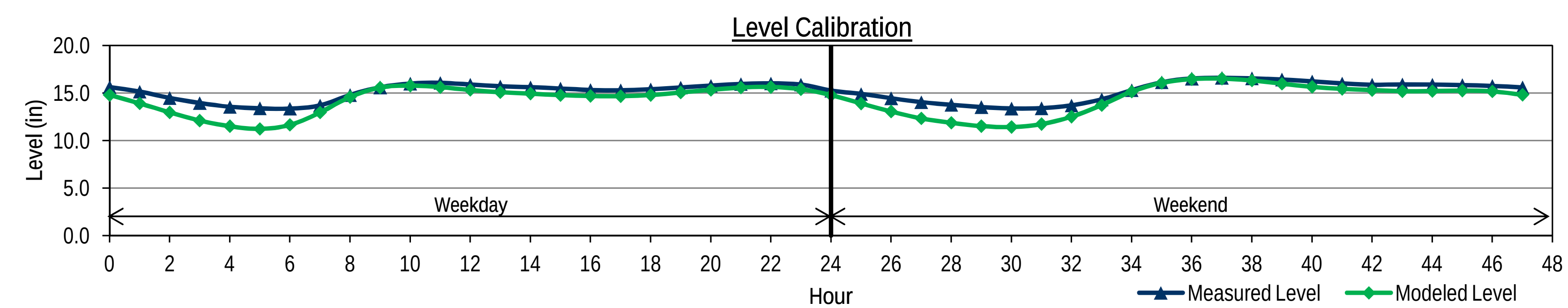
City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 12 DRY WEATHER FLOW CALIBRATION

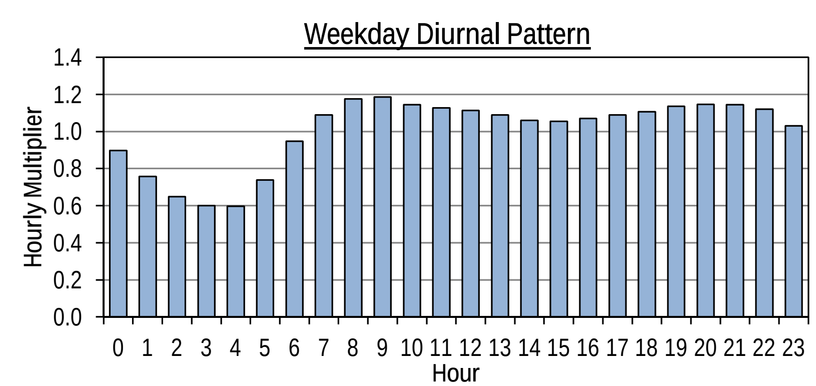
	Hour	Measured Data Flow (mgd)	Measured Data Level (in)	Measured Data Velocity (ft/s)	Modeled Data Flow (mgd)	Modeled Data Level (in)	Modeled Data Velocity (ft/s)	Diurnal Initial Curve	Diurnal Modified Curve	Diurnal Calibrated Diurnal
Weekday	0	1.324	15.6	1.25	1.285	14.8	1.10	1.03	0.90	0.90
	1	1.216	15.2	1.21	1.167	13.9	1.07	0.90	0.76	0.76
	2	1.061	14.5	1.13	1.020	13.0	1.01	0.76	0.65	0.65
	3	0.896	14.0	1.01	0.878	12.1	0.95	0.65	0.60	0.60
	4	0.767	13.6	0.88	0.778	11.5	0.89	0.60	0.60	0.60
	5	0.710	13.4	0.82	0.727	11.2	0.86	0.60	0.74	0.74
	6	0.706	13.4	0.79	0.780	11.7	0.88	0.74	0.95	0.95
	7	0.872	13.7	0.90	0.949	13.0	0.94	0.95	1.09	1.09
	8	1.120	14.8	1.06	1.157	14.6	1.00	1.09	1.18	1.18
	9	1.287	15.6	1.17	1.317	15.6	1.07	1.18	1.19	1.19
	10	1.389	16.0	1.25	1.389	15.8	1.11	1.19	1.15	1.15
	11	1.402	16.1	1.27	1.384	15.6	1.12	1.15	1.13	1.13
	12	1.353	15.9	1.25	1.357	15.3	1.12	1.13	1.11	1.11
	13	1.331	15.7	1.24	1.335	15.1	1.12	1.11	1.09	1.09
	14	1.315	15.6	1.23	1.311	15.0	1.11	1.09	1.06	1.06
	15	1.286	15.5	1.22	1.281	14.8	1.10	1.06	1.06	1.06
	16	1.253	15.3	1.20	1.262	14.7	1.09	1.06	1.07	1.07
	17	1.247	15.3	1.20	1.264	14.7	1.09	1.07	1.09	1.09
	18	1.265	15.4	1.20	1.280	14.8	1.09	1.09	1.11	1.11
	19	1.287	15.6	1.20	1.299	15.1	1.09	1.11	1.14	1.14
	20	1.308	15.8	1.20	1.327	15.3	1.09	1.14	1.15	1.15
	21	1.342	16.0	1.22	1.350	15.6	1.09	1.15	1.14	1.14
	22	1.354	16.0	1.23	1.359	15.6	1.10	1.14	1.12	1.12
	23	1.352	15.9	1.24	1.347	15.4	1.10	1.12	1.03	1.03
Weekend	24	1.227	15.3	1.19	1.285	14.8	1.10	0.99	0.89	0.89
	25	1.165	14.9	1.17	1.165	13.9	1.07	0.89	0.80	0.80
	26	1.056	14.5	1.12	1.041	13.1	1.02	0.80	0.70	0.70
	27	0.946	14.1	1.04	0.919	12.3	0.97	0.70	0.64	0.64
	28	0.825	13.8	0.94	0.825	11.9	0.91	0.64	0.60	0.60
	29	0.752	13.5	0.87	0.757	11.5	0.87	0.60	0.60	0.60
	30	0.713	13.4	0.81	0.727	11.4	0.84	0.60	0.75	0.75
	31	0.713	13.4	0.81	0.792	11.8	0.89	0.75	0.88	0.88
	32	0.886	13.7	0.92	0.919	12.5	0.95	0.88	1.03	1.03
	33	1.037	14.3	1.04	1.092	13.7	1.01	1.03	1.16	1.16
	34	1.213	15.3	1.12	1.263	15.2	1.05	1.16	1.20	1.20
	35	1.371	16.1	1.21	1.376	16.1	1.08	1.20	1.22	1.22
	36	1.417	16.5	1.23	1.431	16.5	1.09	1.22	1.22	1.22
	37	1.441	16.6	1.25	1.450	16.5	1.11	1.22	1.20	1.20
	38	1.447	16.6	1.27	1.437	16.3	1.11	1.20	1.16	1.16
	39	1.413	16.4	1.25	1.402	16.0	1.10	1.16	1.13	1.13
	40	1.366	16.2	1.23	1.365	15.7	1.10	1.13	1.11	1.11
	41	1.335	16.0	1.22	1.336	15.5	1.09	1.11	1.12	1.12
	42	1.315	15.9	1.21	1.331	15.3	1.10	1.12	1.10	1.10
	43	1.326	15.9	1.21	1.319	15.2	1.09	1.10	1.11	1.11
	44	1.301	15.9	1.20	1.315	15.2	1.09	1.11	1.11	1.11
	45	1.311	15.8	1.20	1.316	15.3	1.09	1.11	1.09	1.09
	46	1.309	15.8	1.21	1.307	15.2	1.09	1.09	1.04	1.04
	47	1.286	15.6	1.21	1.269	14.8	1.08	1.04	0.99	0.99
Average										
Weekday		1.185	15.2	1.14	1.192	14.3	1.05	1.00	1.00	1.00
Weekend		1.174	15.2	1.12	1.185	14.4	1.04	0.99	0.99	0.99
ADWF[1]		1.182	15.2	1.14	1.190	14.4	1.04	1.00	1.00	1.00
% Error										
Weekday					0.6%	-5.4%	-8.1%			
Weekend					1.0%	-5.4%	-7.5%			

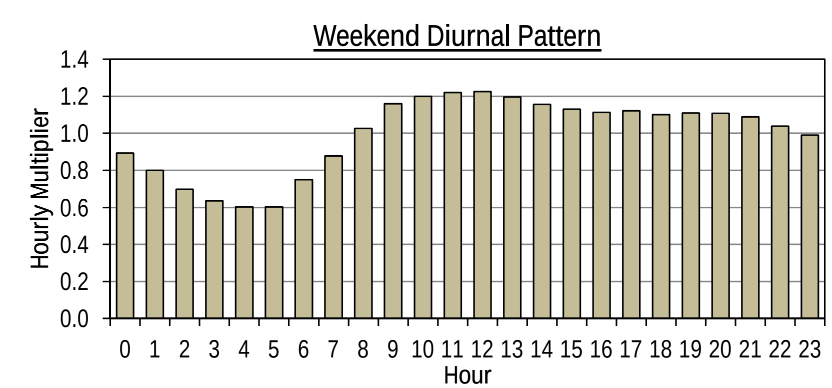
Note:
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7











City of Turlock

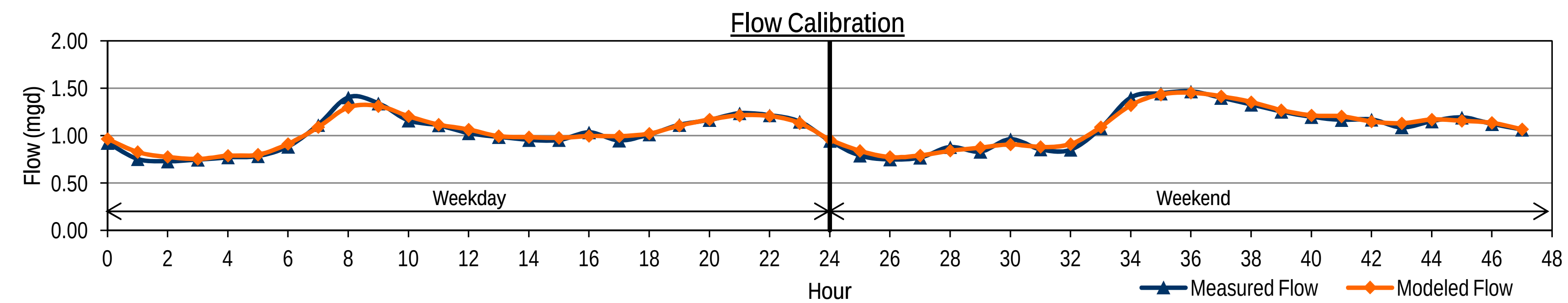
Sewer System Master Plan

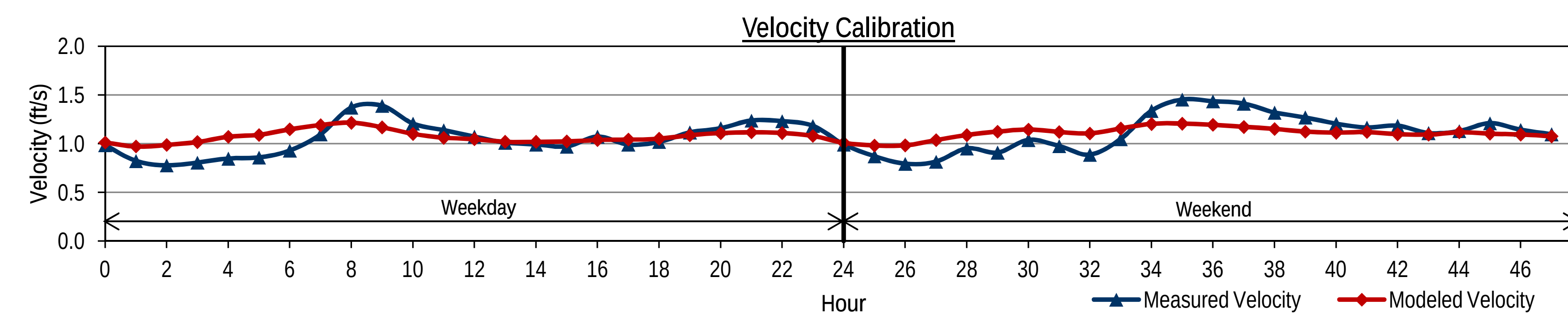
FLOW MONITORING SITE 13 DRY WEATHER FLOW CALIBRATION

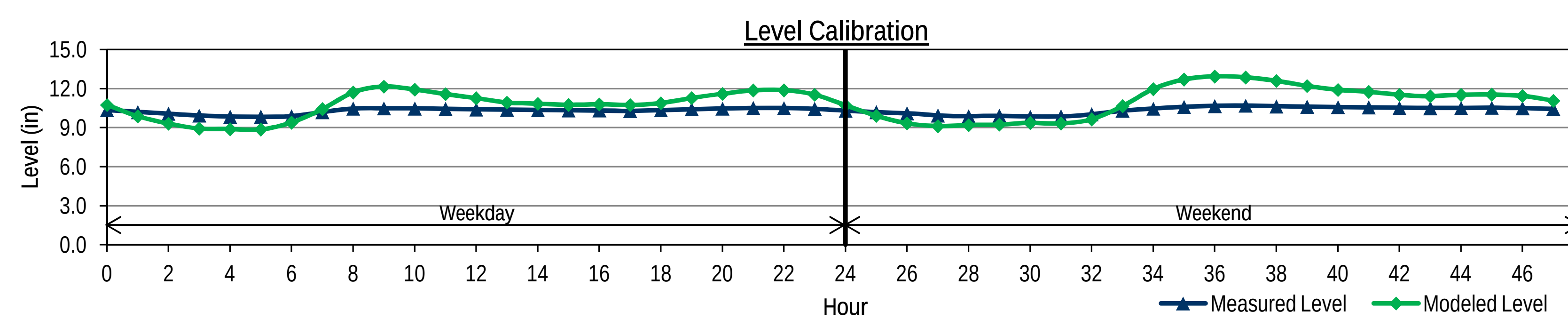
		Measured Data			Modeled Data			Diurnal		
		Flow	Level	Velocity	Flow	Level	Velocity	Initial	Modified	Calibrated
	Hour	(mgd)	(in)	(ft/s)	(mgd)	(in)	(ft/s)	Curve	Curve	Diurnal
Weekday	0	0.924	10.4	0.98	0.965	10.7	1.01	0.72	0.70	0.70
	1	0.753	10.2	0.82	0.827	9.9	0.97	0.70	0.72	0.72
	2	0.729	10.1	0.78	0.776	9.3	0.99	0.72	0.74	0.74
	3	0.747	9.9	0.81	0.755	8.9	1.02	0.74	0.75	0.75
	4	0.771	9.8	0.85	0.789	8.9	1.07	0.75	0.85	0.85
	5	0.784	9.9	0.86	0.800	8.9	1.09	0.85	1.07	1.07
	6	0.884	9.9	0.93	0.913	9.4	1.15	1.07	1.35	1.35
	7	1.112	10.2	1.10	1.089	10.4	1.19	1.35	1.29	1.29
	8	1.402	10.5	1.37	1.298	11.7	1.22	1.29	1.11	1.11
	9	1.339	10.5	1.39	1.311	12.2	1.17	1.11	1.07	1.07
	10	1.159	10.5	1.21	1.204	11.9	1.10	1.07	0.98	0.98
	11	1.109	10.4	1.14	1.116	11.6	1.06	0.98	0.95	0.95
	12	1.025	10.4	1.07	1.064	11.3	1.05	0.95	0.92	0.92
	13	0.986	10.4	1.01	0.995	10.9	1.02	0.92	0.92	0.92
	14	0.955	10.3	0.99	0.984	10.8	1.02	0.92	0.99	0.99
	15	0.953	10.3	0.97	0.977	10.8	1.02	0.99	0.91	0.91
	16	1.033	10.3	1.07	0.996	10.8	1.04	0.91	0.97	0.97
	17	0.948	10.3	0.99	0.994	10.7	1.04	0.97	1.07	1.07
	18	1.012	10.3	1.02	1.021	10.9	1.05	1.07	1.12	1.12
	19	1.113	10.4	1.12	1.105	11.3	1.09	1.12	1.19	1.19
	20	1.164	10.5	1.16	1.170	11.6	1.11	1.19	1.17	1.17
	21	1.235	10.5	1.24	1.213	11.9	1.12	1.17	1.10	1.10
	22	1.213	10.5	1.23	1.207	11.9	1.11	1.10	0.89	0.89
	23	1.147	10.4	1.18	1.132	11.5	1.08	0.89	0.72	0.72
Weekend	24	0.944	10.3	0.99	0.960	10.7	1.01	0.76	0.72	0.72
	25	0.790	10.2	0.87	0.840	9.9	0.98	0.72	0.74	0.74
	26	0.749	10.1	0.79	0.775	9.3	0.98	0.74	0.84	0.84
	27	0.769	9.9	0.82	0.791	9.1	1.04	0.84	0.80	0.80
	28	0.879	9.9	0.95	0.841	9.2	1.09	0.80	0.92	0.92
	29	0.831	9.9	0.91	0.874	9.2	1.12	0.92	0.82	0.82
	30	0.962	9.8	1.04	0.907	9.4	1.15	0.82	0.82	0.82
	31	0.855	9.9	0.98	0.882	9.3	1.12	0.82	1.04	1.04
	32	0.852	10.0	0.89	0.911	9.6	1.11	1.04	1.35	1.35
	33	1.079	10.3	1.05	1.090	10.7	1.16	1.35	1.39	1.39
	34	1.400	10.5	1.34	1.321	12.0	1.20	1.39	1.41	1.41
	35	1.445	10.6	1.45	1.433	12.7	1.21	1.41	1.34	1.34
	36	1.465	10.7	1.44	1.452	12.9	1.19	1.34	1.28	1.28
	37	1.399	10.7	1.41	1.414	12.9	1.17	1.28	1.20	1.20
	38	1.328	10.6	1.32	1.354	12.6	1.15	1.20	1.15	1.15
	39	1.253	10.6	1.27	1.268	12.2	1.12	1.15	1.12	1.12
	40	1.197	10.6	1.21	1.214	11.9	1.11	1.12	1.12	1.12
	41	1.165	10.6	1.17	1.203	11.8	1.12	1.12	1.04	1.04
	42	1.169	10.5	1.18	1.149	11.5	1.10	1.04	1.11	1.11
	43	1.086	10.5	1.11	1.130	11.4	1.09	1.11	1.14	1.14
	44	1.151	10.5	1.13	1.169	11.5	1.12	1.14	1.08	1.08
	45	1.191	10.5	1.21	1.157	11.5	1.10	1.08	1.02	1.02
	46	1.122	10.5	1.14	1.135	11.4	1.10	1.02	0.91	0.91
	47	1.063	10.4	1.10	1.067	11.1	1.08	0.91	0.76	0.76
Average										
Weekday		1.021	10.3	1.05	1.029	10.8	1.07	0.98	0.98	0.98
Weekend		1.089	10.3	1.12	1.097	11.0	1.11	1.05	1.05	1.05
ADWF[1]		1.040	10.3	1.07	1.049	10.8	1.08	1.00	1.00	1.00
% Error										
Weekday					0.8%	4.5%	1.9%			
Weekend					0.7%	6.3%	-0.5%			

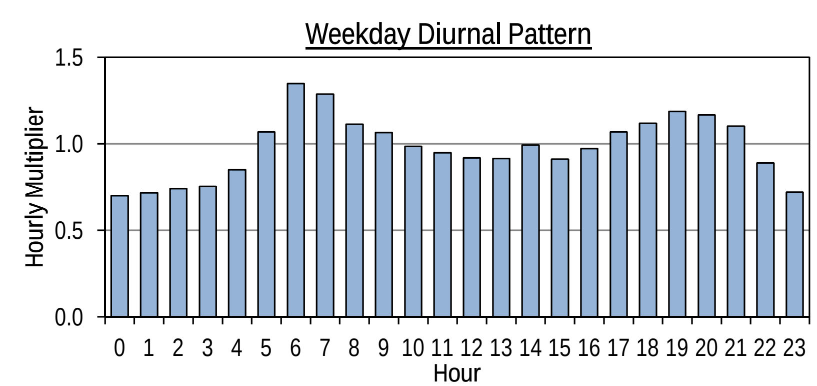
Note:

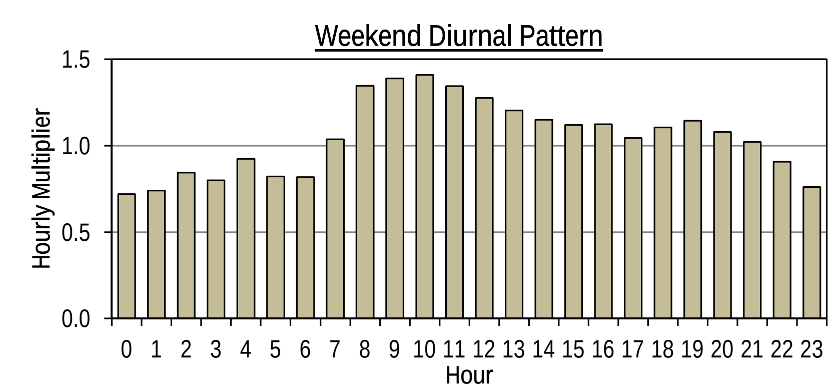
1. ADWF = (5xWeekday Average + 2xWeekend Average)/7







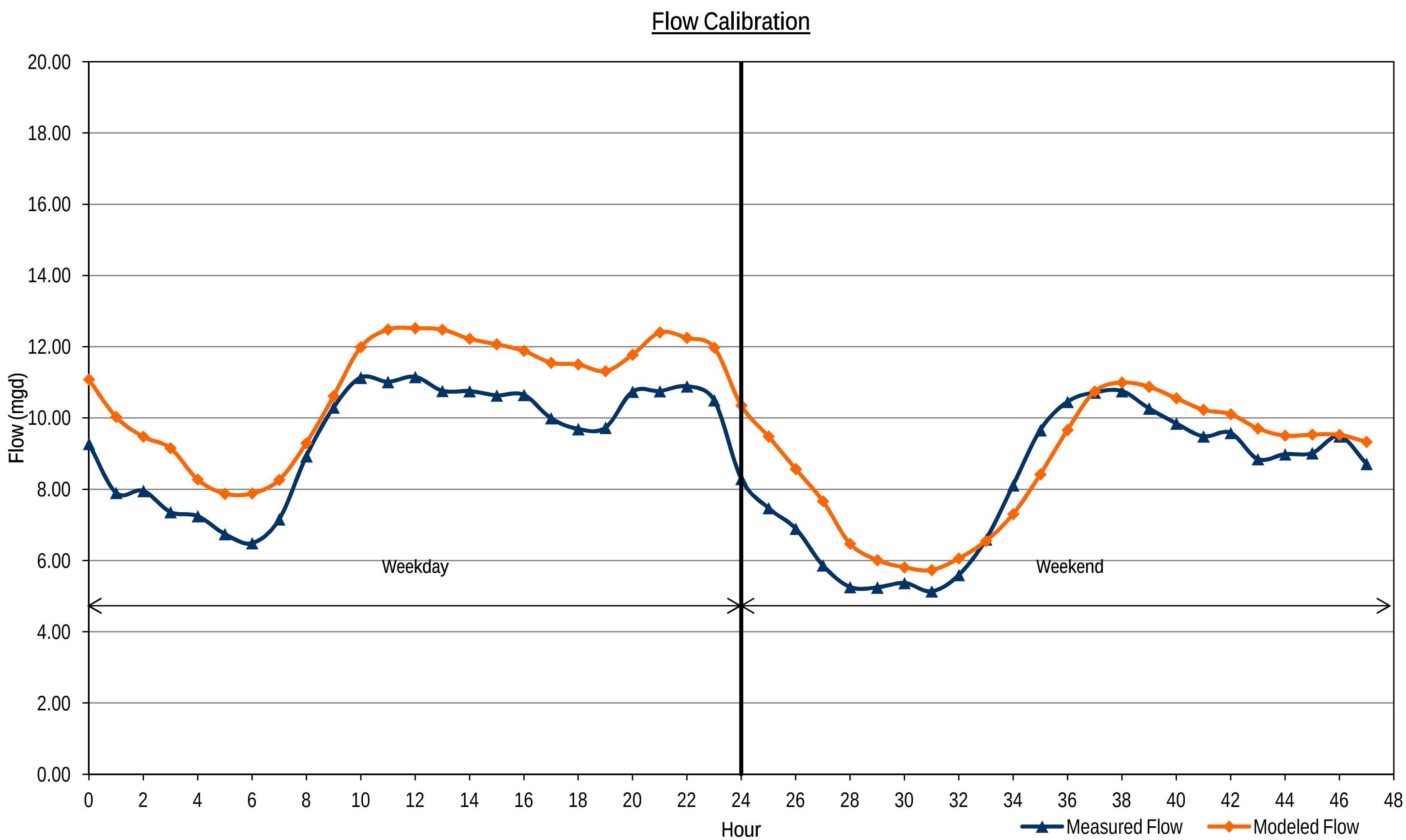




City of Turlock

Sewer System Master Plan

TRWQCF DRY WEATHER FLOW CALIBRATION



APPENDIX E – WWF CALIBRATION PLOTS

Table 2 Wet Weather Flow Calibration Results
Sewer System Master Plan
City of Turlock

Meter Number	Pipe Diameter (in)	Storm 1 (3/13/2012-3/15/2012)					
		Measured Data[1]		Modeled Data[2]		Percent Error[3]	
		Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (mgd)	Peak Flow (mgd)	Avg. Flow (%)	Peak Flow (%)
1	42	1.946	3.859	1.926	4.098	-1.0%	6.2%
2	30	0.409	5.283	0.427	5.566	4.2%	5.4%
3	30	1.288	3.524	1.382	3.947	7.3%	12.0%
4	48	5.590	8.132	5.964	8.216	6.7%	1.0%
5	16	0.509	1.174	0.516	1.293	1.4%	10.1%
6	16	0.099	0.414	0.097	0.532	-1.7%	*28.7%*
7	24	0.011	1.008	0.004	0.851	*-65.2%*	*-15.5%*
8	33	1.560	2.734	1.589	3.187	1.9%	16.6%
9	15	0.052	0.161	0.054	0.144	2.8%	-10.6%
10	24	1.161	1.668	1.169	1.682	0.7%	0.9%
11	18	0.624	0.914	0.622	0.873	-0.3%	-4.5%
12	21	1.204	1.527	1.201	1.578	-0.2%	3.4%
13	30	1.048	1.713	1.070	1.539	2.0%	-10.1%

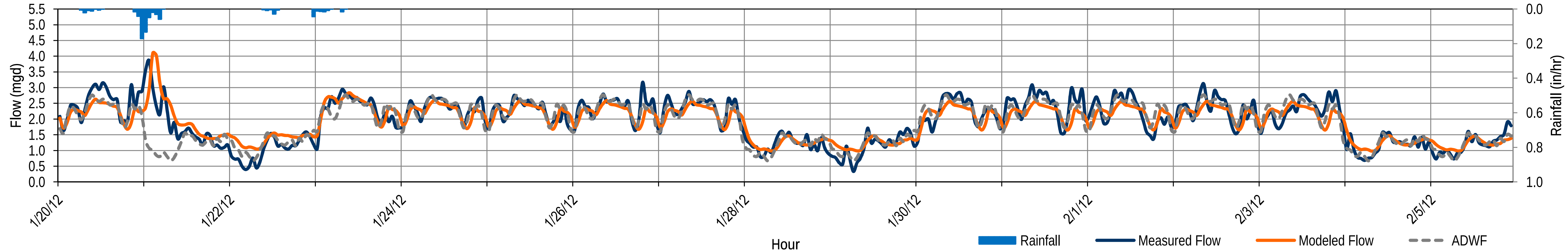
Notes:
1. Source: City of Turlock Temporary Flow Monitoring Program, V&A Consulting Engineers
2. Average flows are calculated from flow monitoring data. Maximum flow values are hourly peaks.
3. Percent Difference = (Modeled - Measured)/Measured*100.

City of Turlock

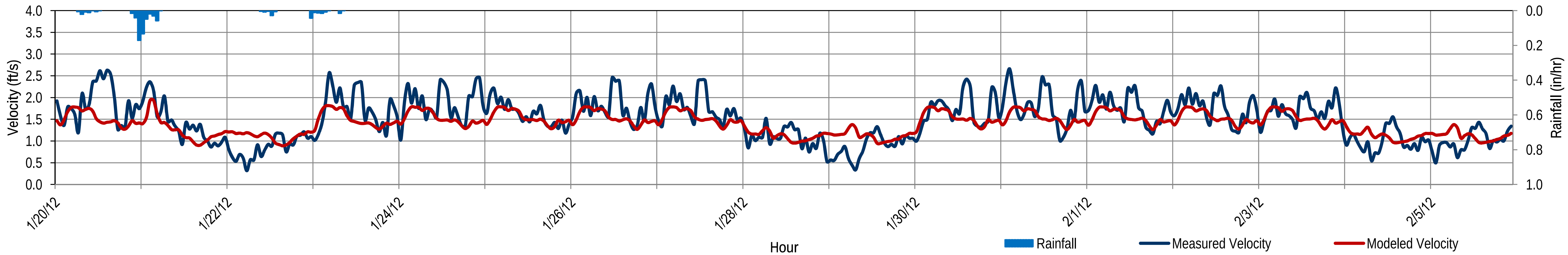
Sewer System Master Plan

FLOW MONITORING SITE 1 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)

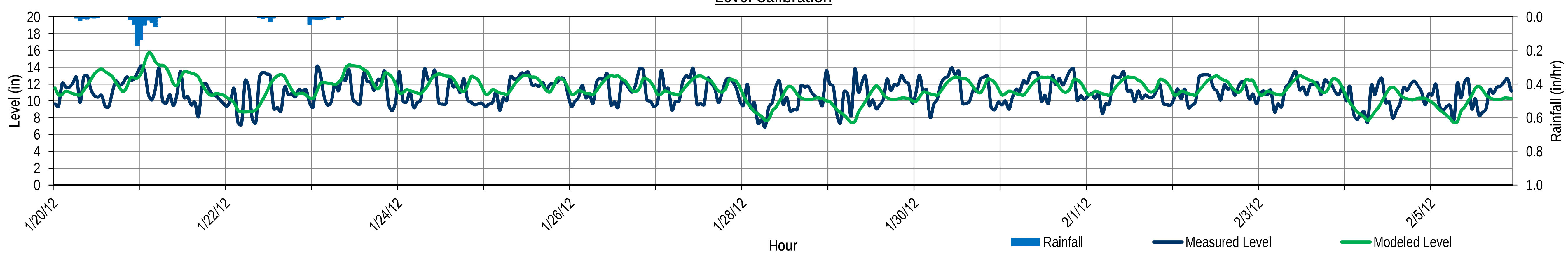
Flow Calibration



Velocity Calibration

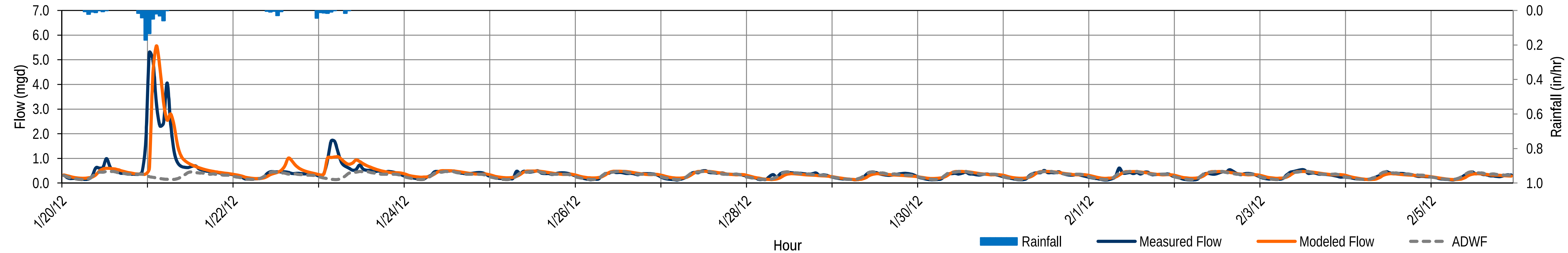


Level Calibration

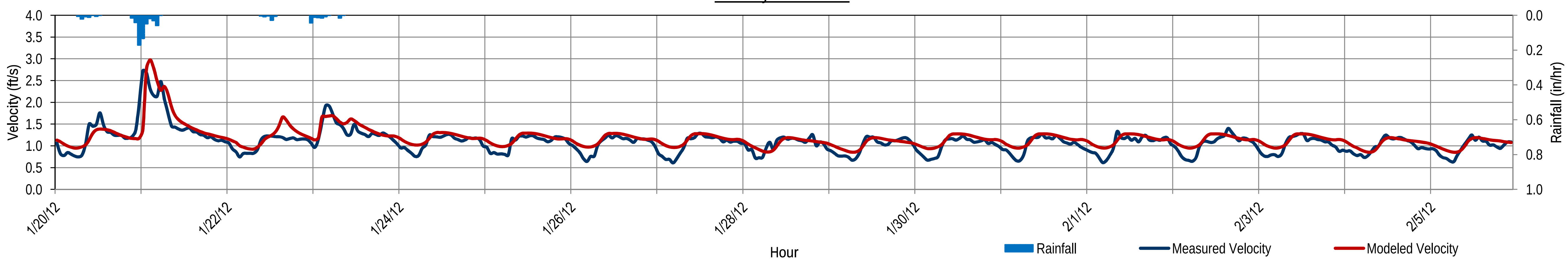


City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 2 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)

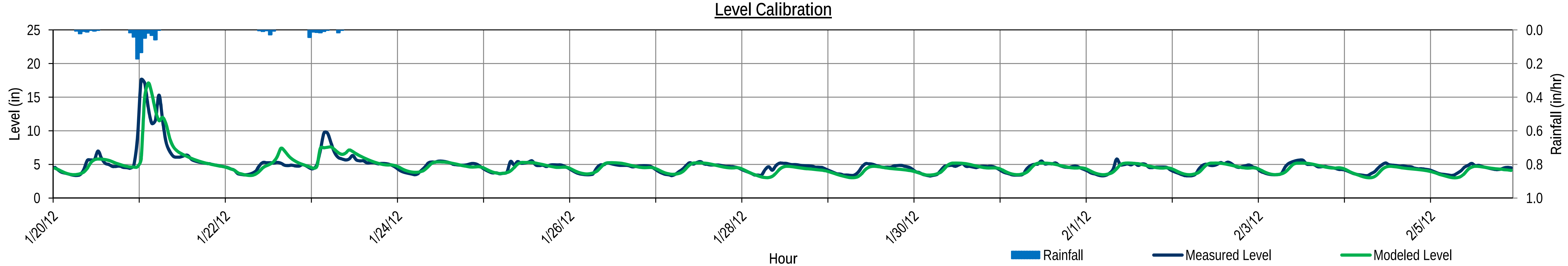
Flow Calibration



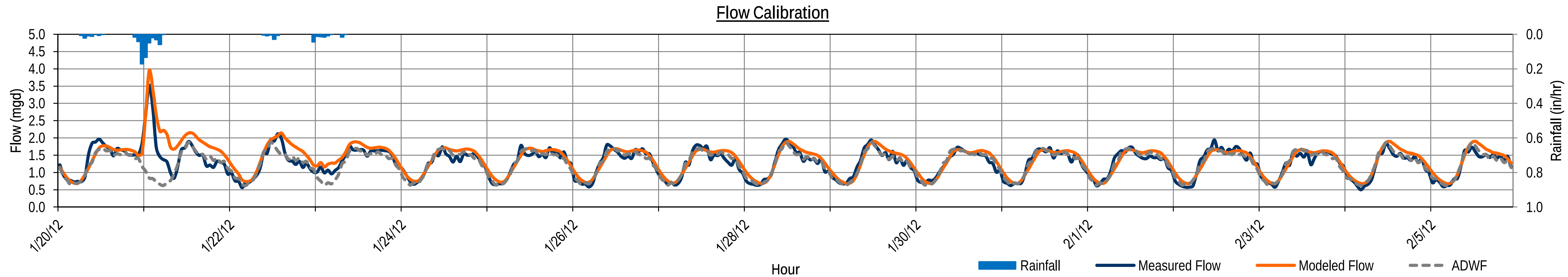
Velocity Calibration

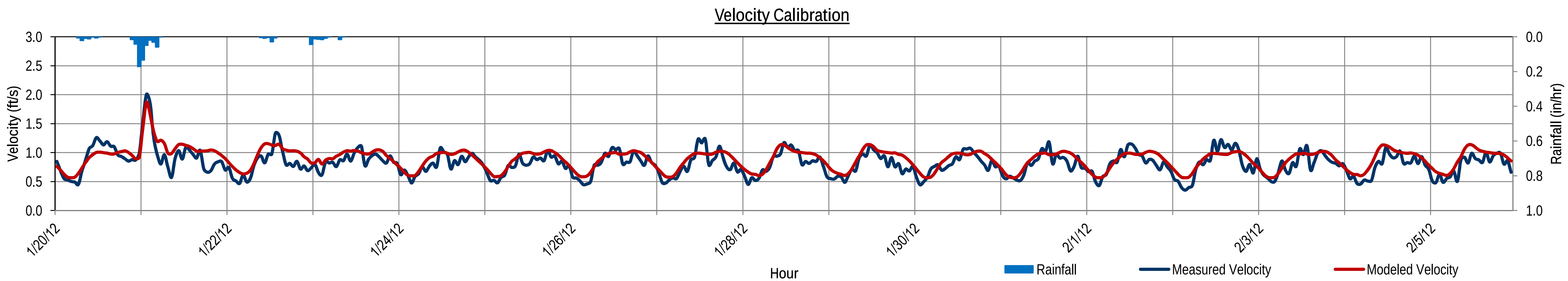


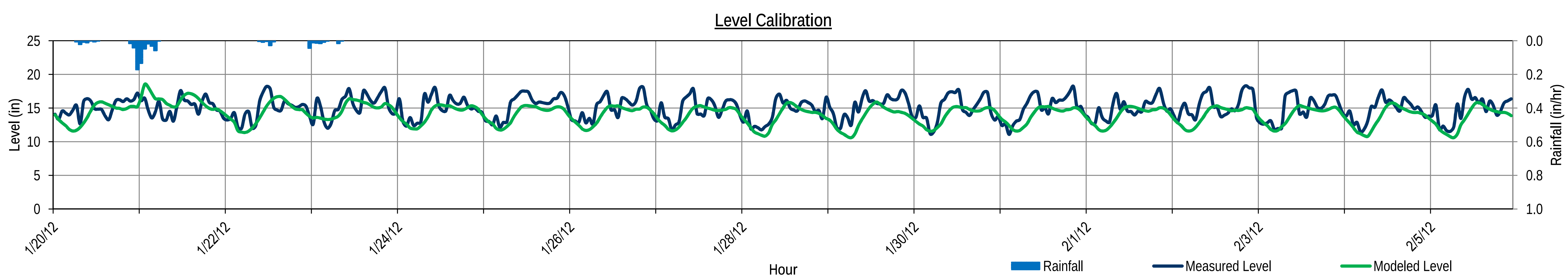
Level Calibration



City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 3 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)



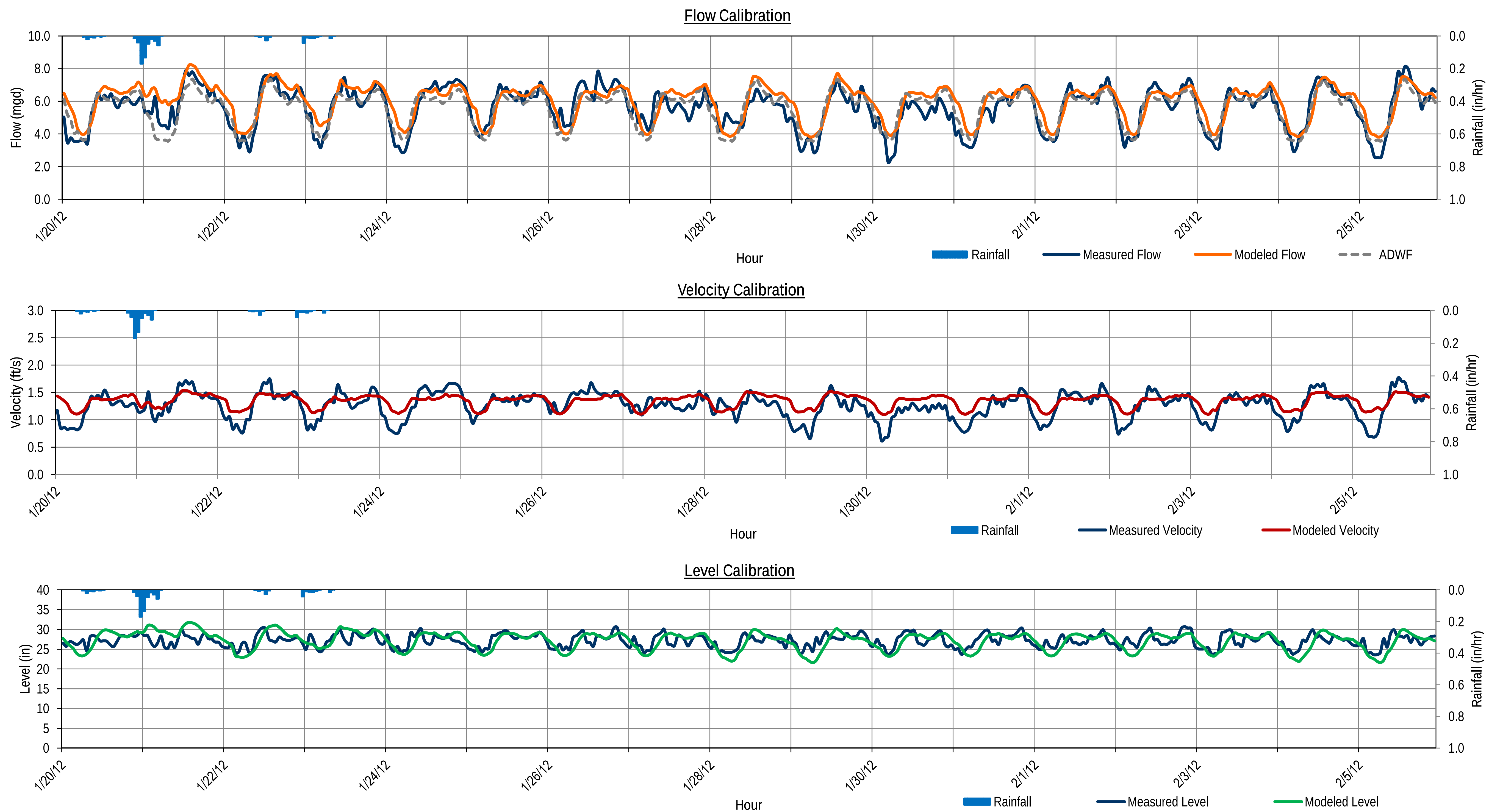




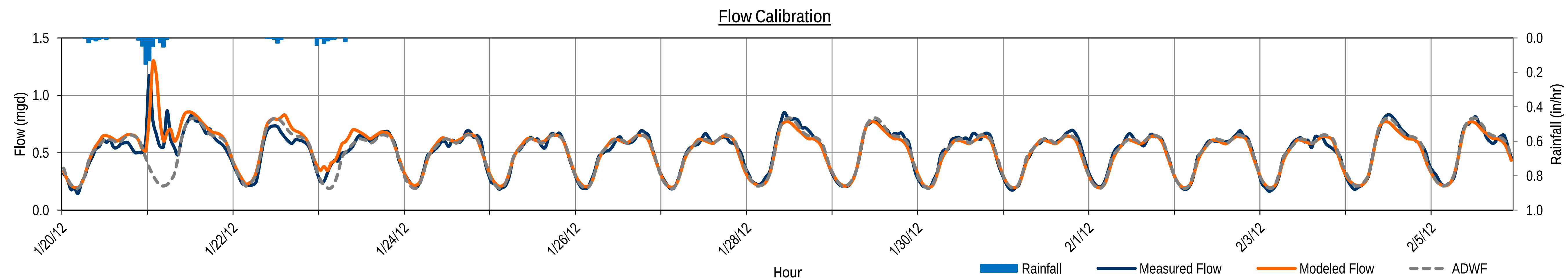
City of Turlock

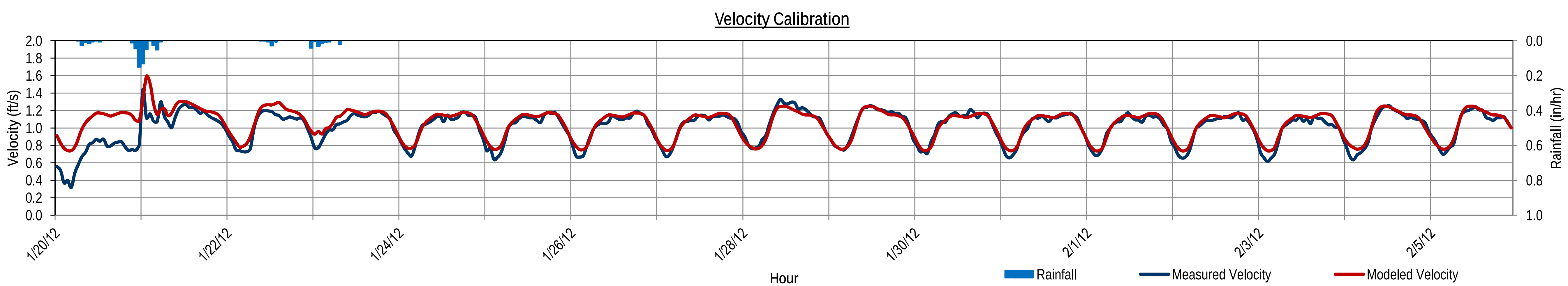
Sewer System Master Plan

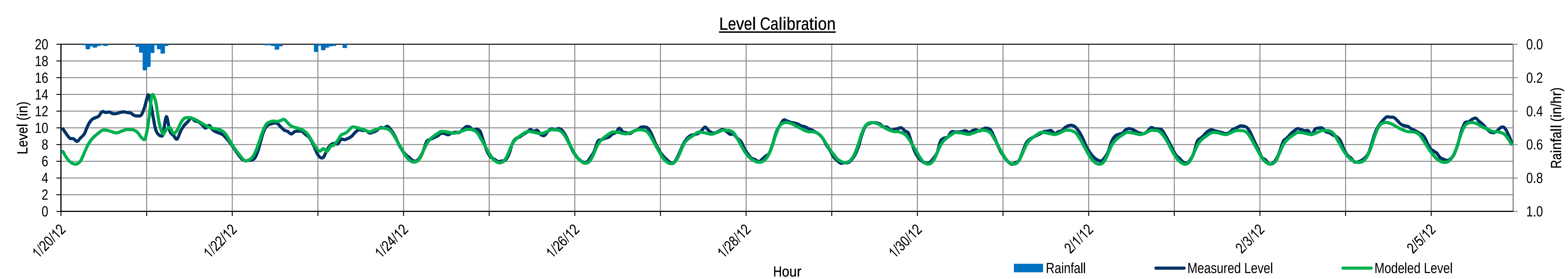
FLOW MONITORING SITE 4 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)



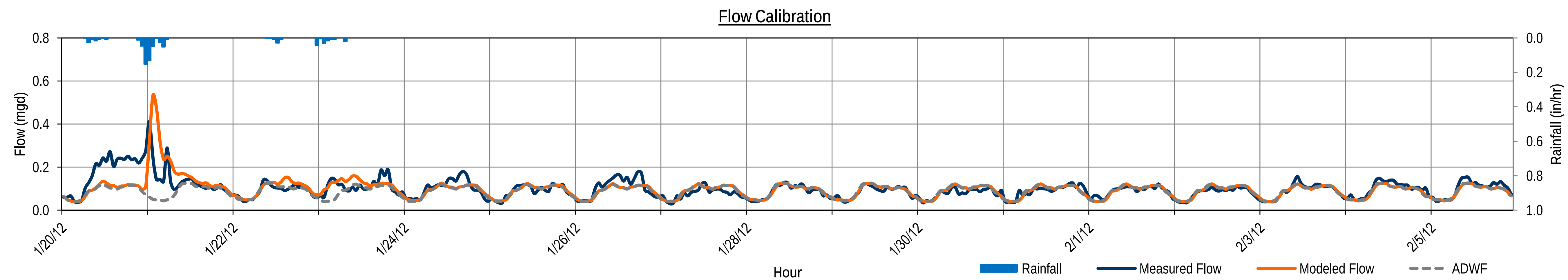
City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 5 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)

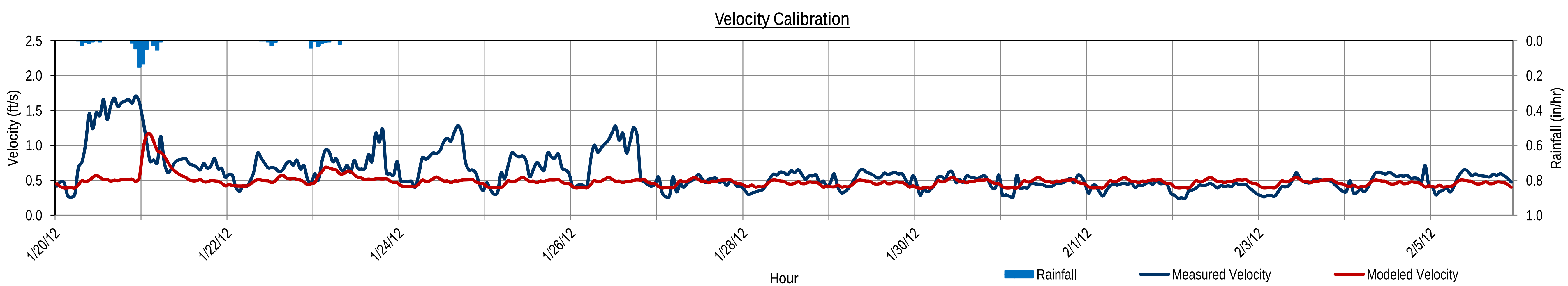


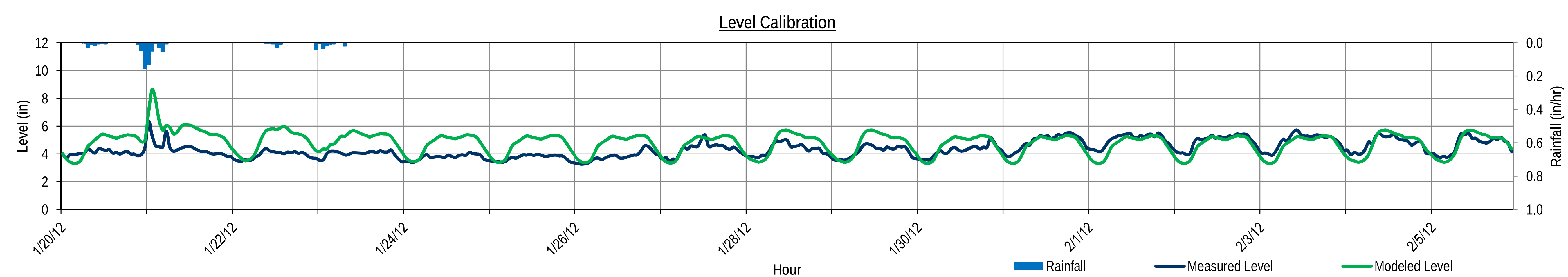




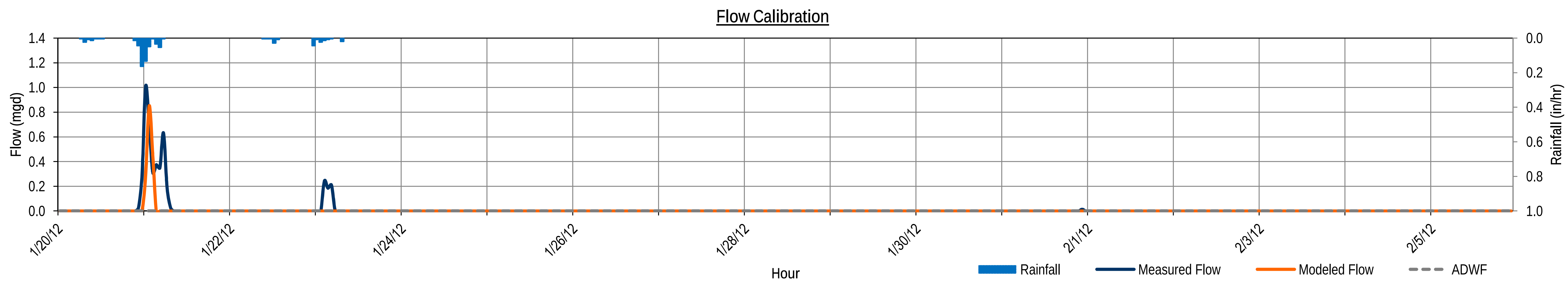
City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 6 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)

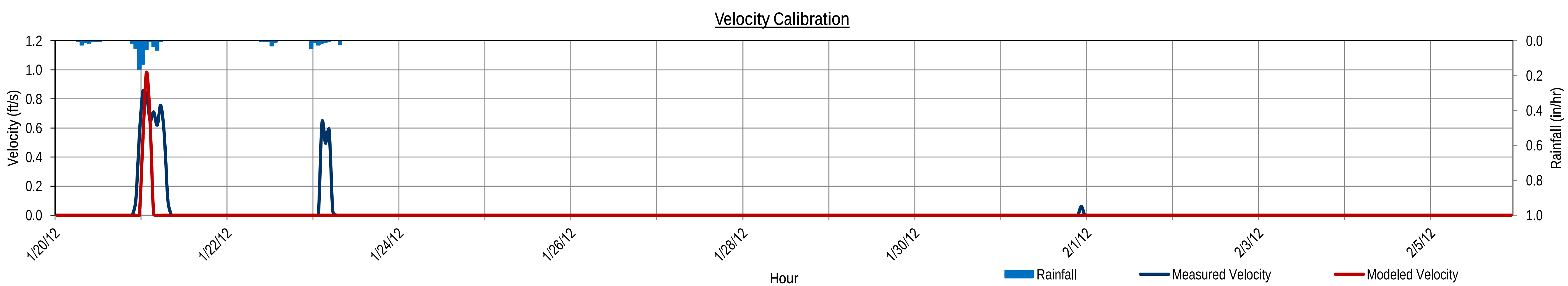


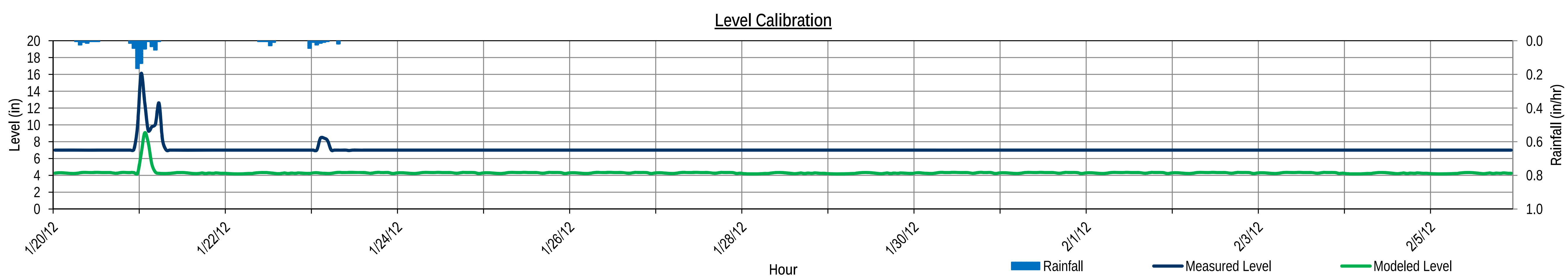




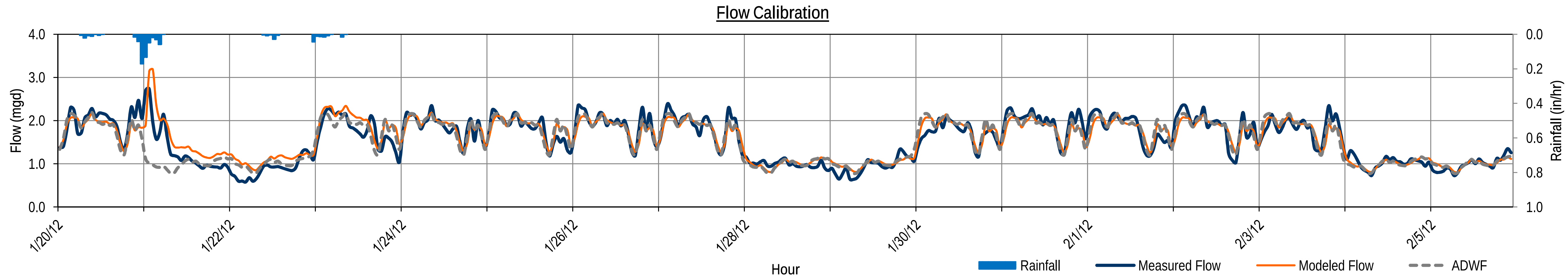
City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 7 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)

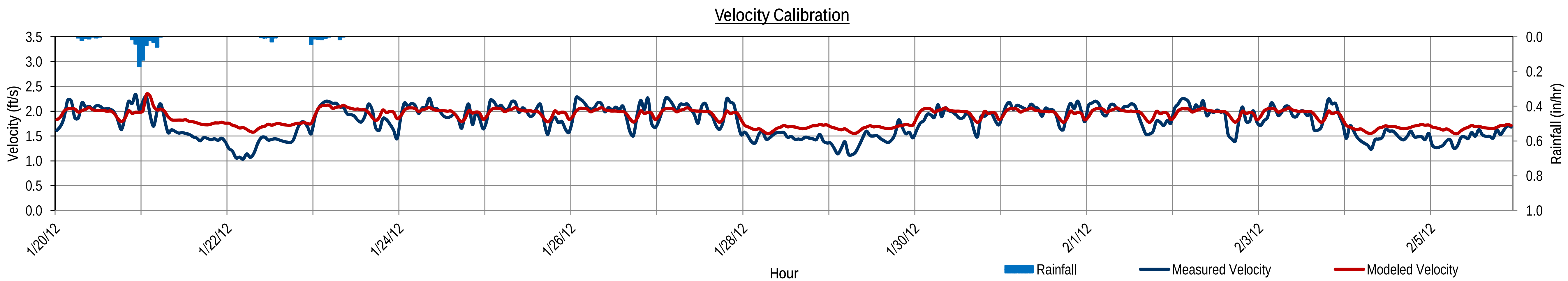


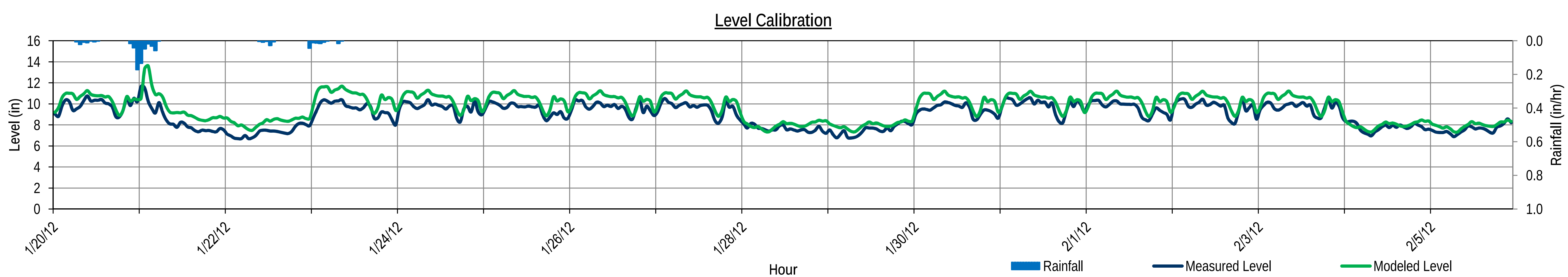




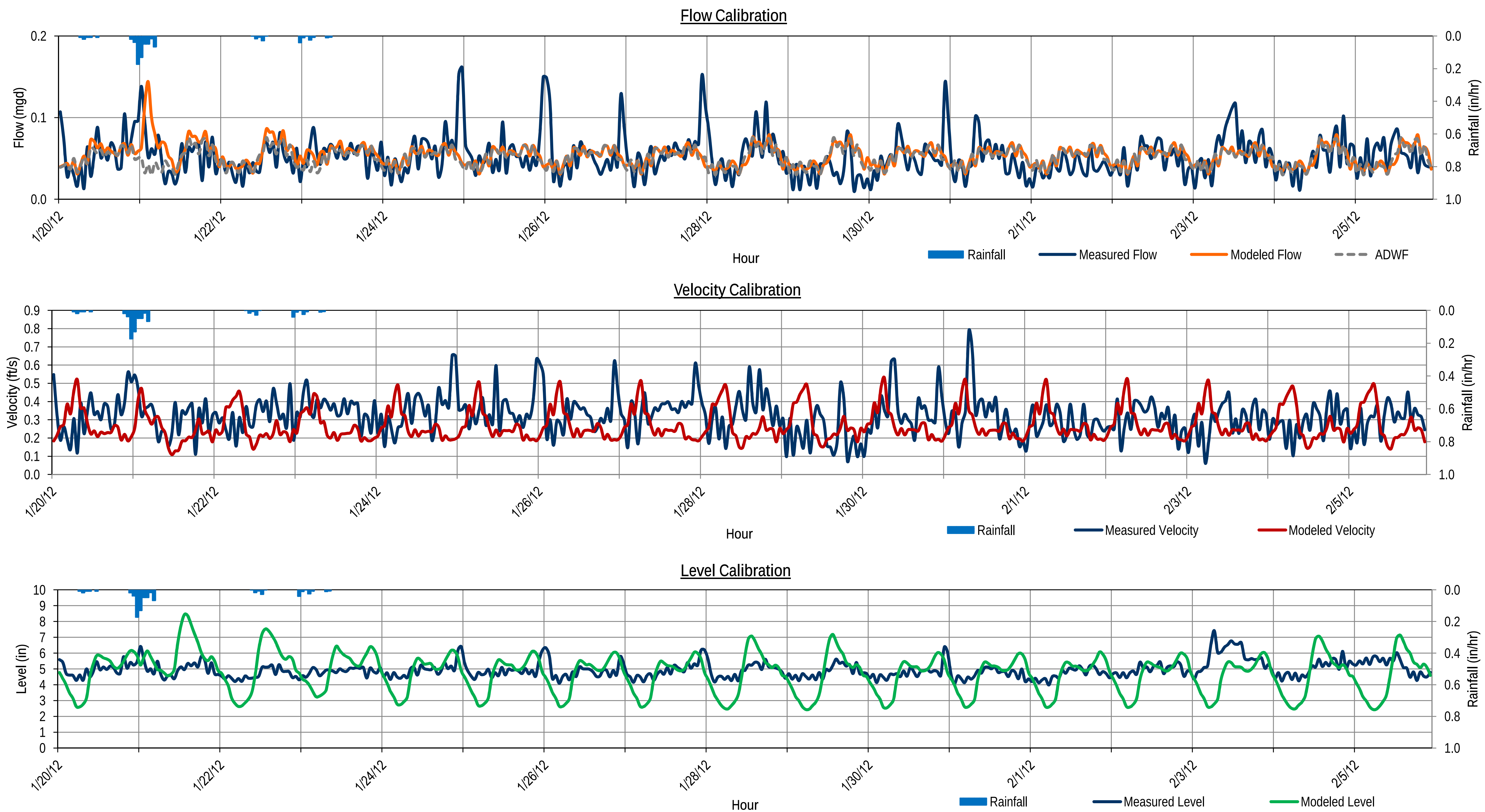
City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 8 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)



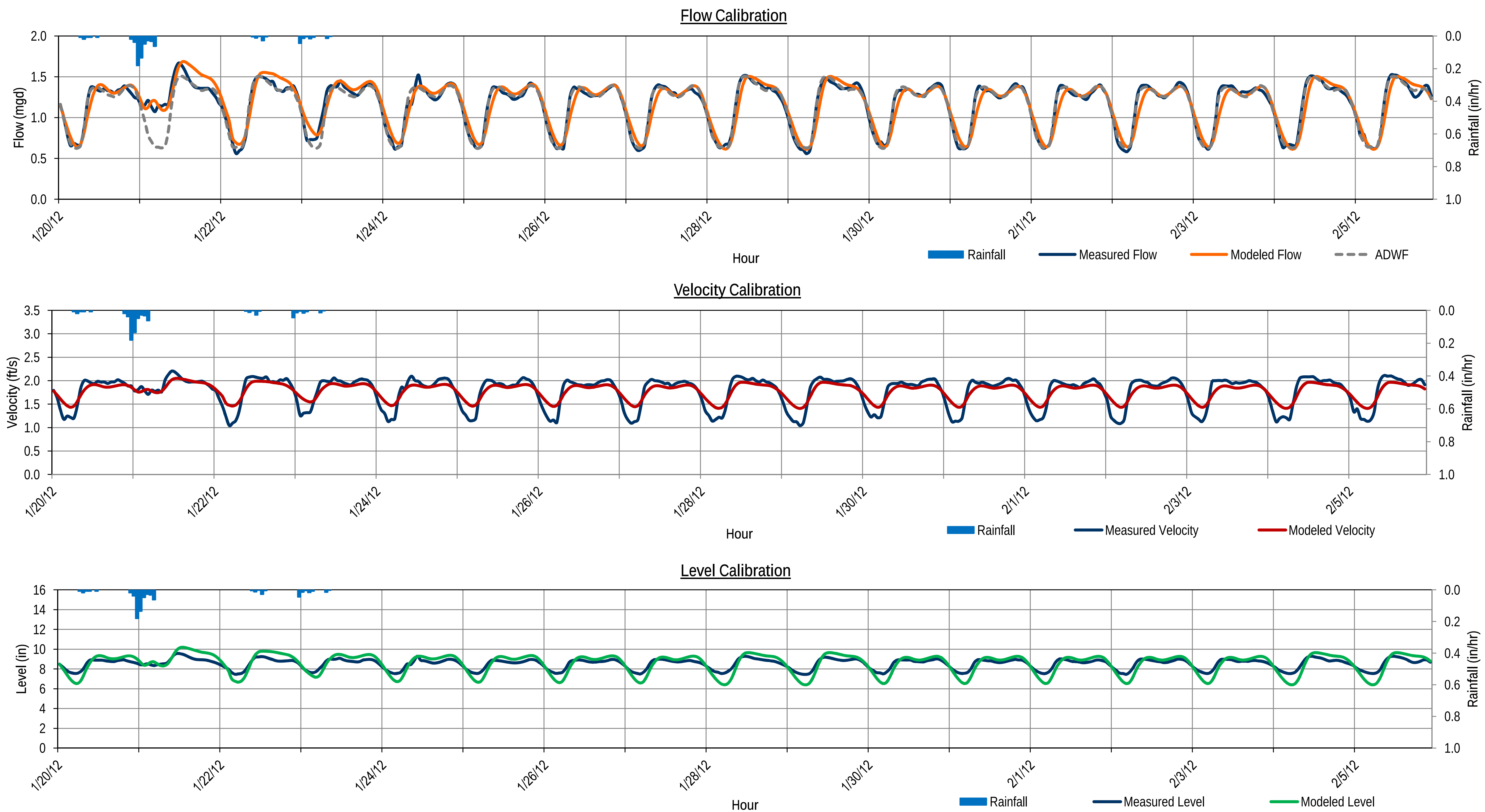




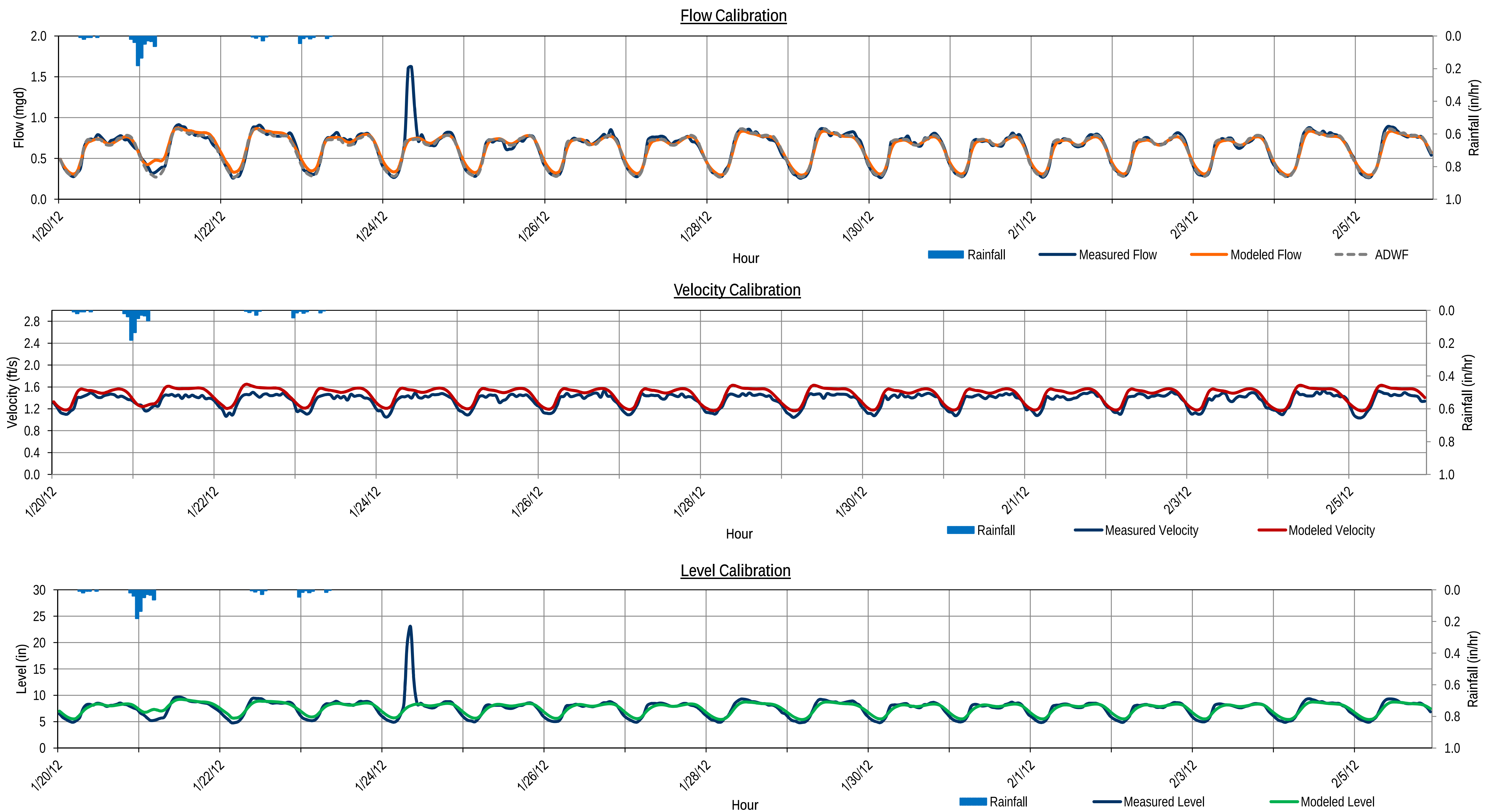
City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 9 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)



City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 10 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)

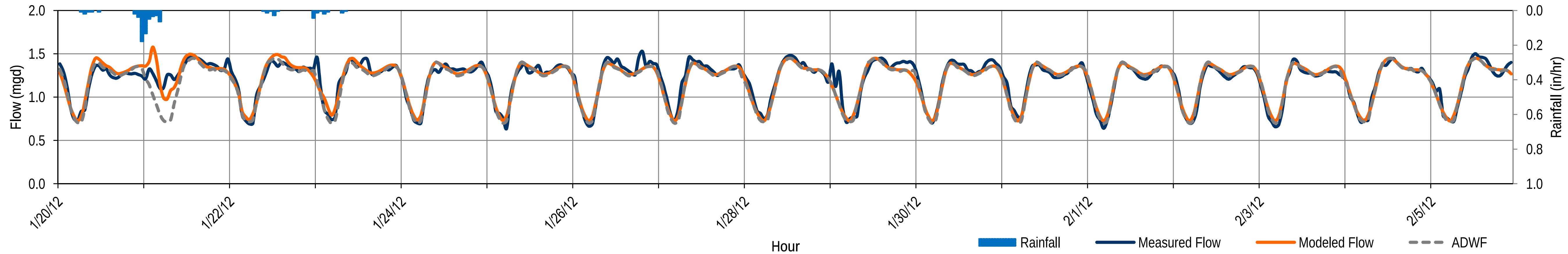


City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 11 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)

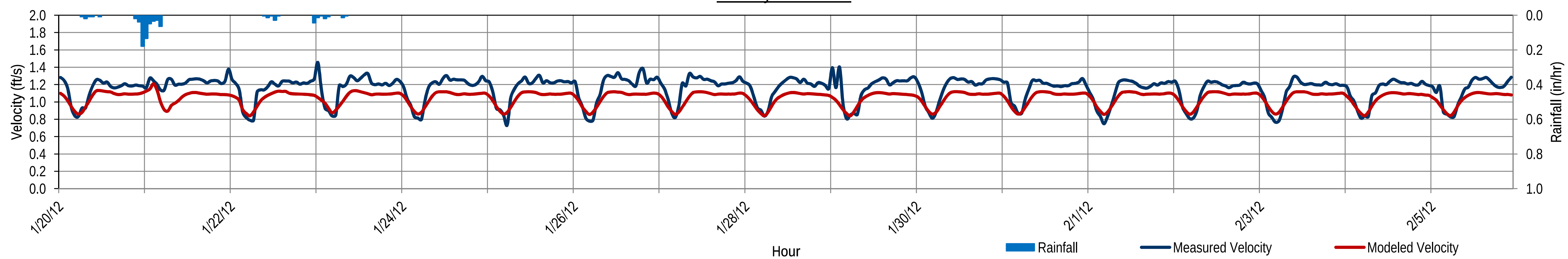


City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 12 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)

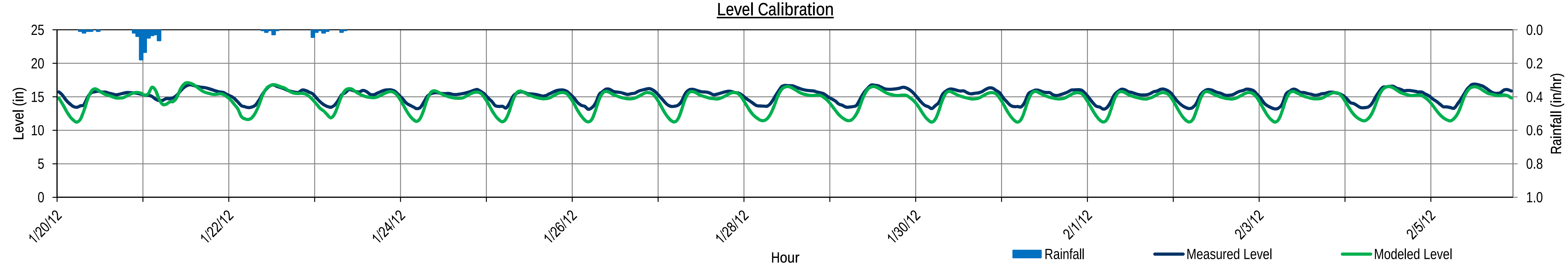
Flow Calibration



Velocity Calibration

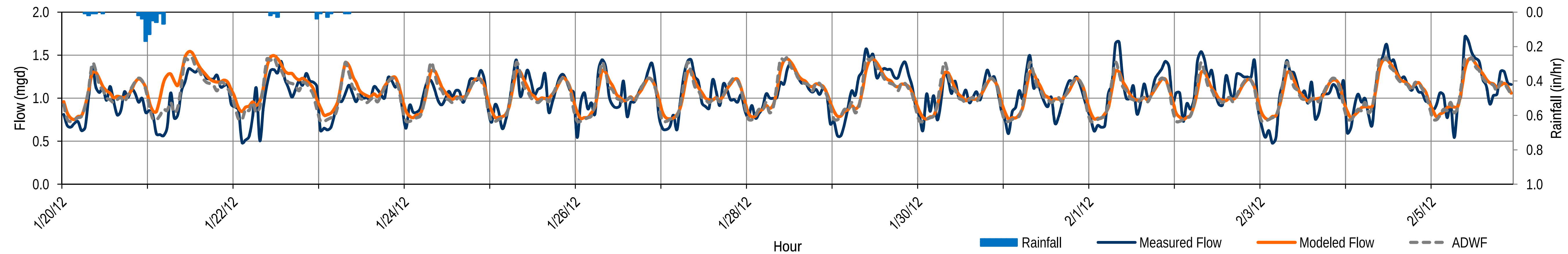


Level Calibration

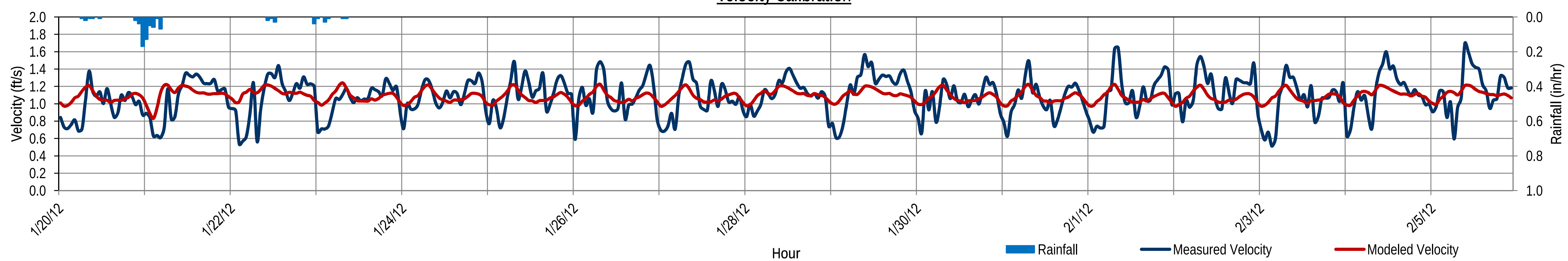


City of Turlock
Sewer System Master Plan
FLOW MONITORING SITE 13 WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)

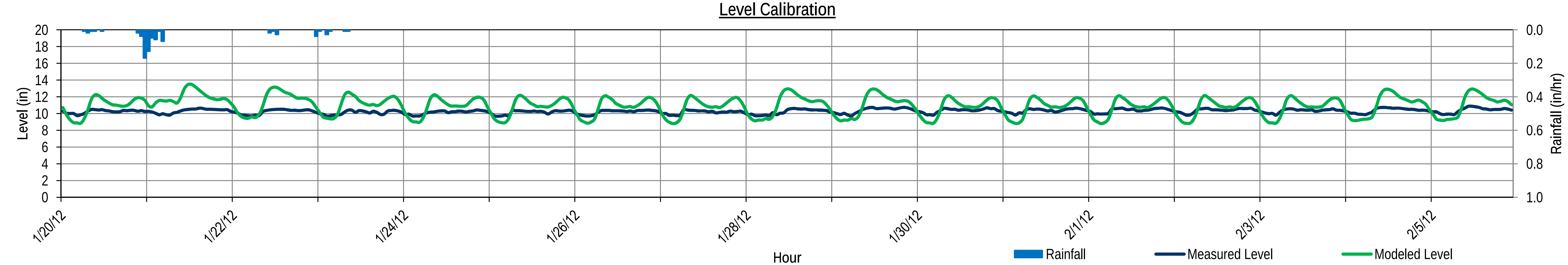
Flow Calibration



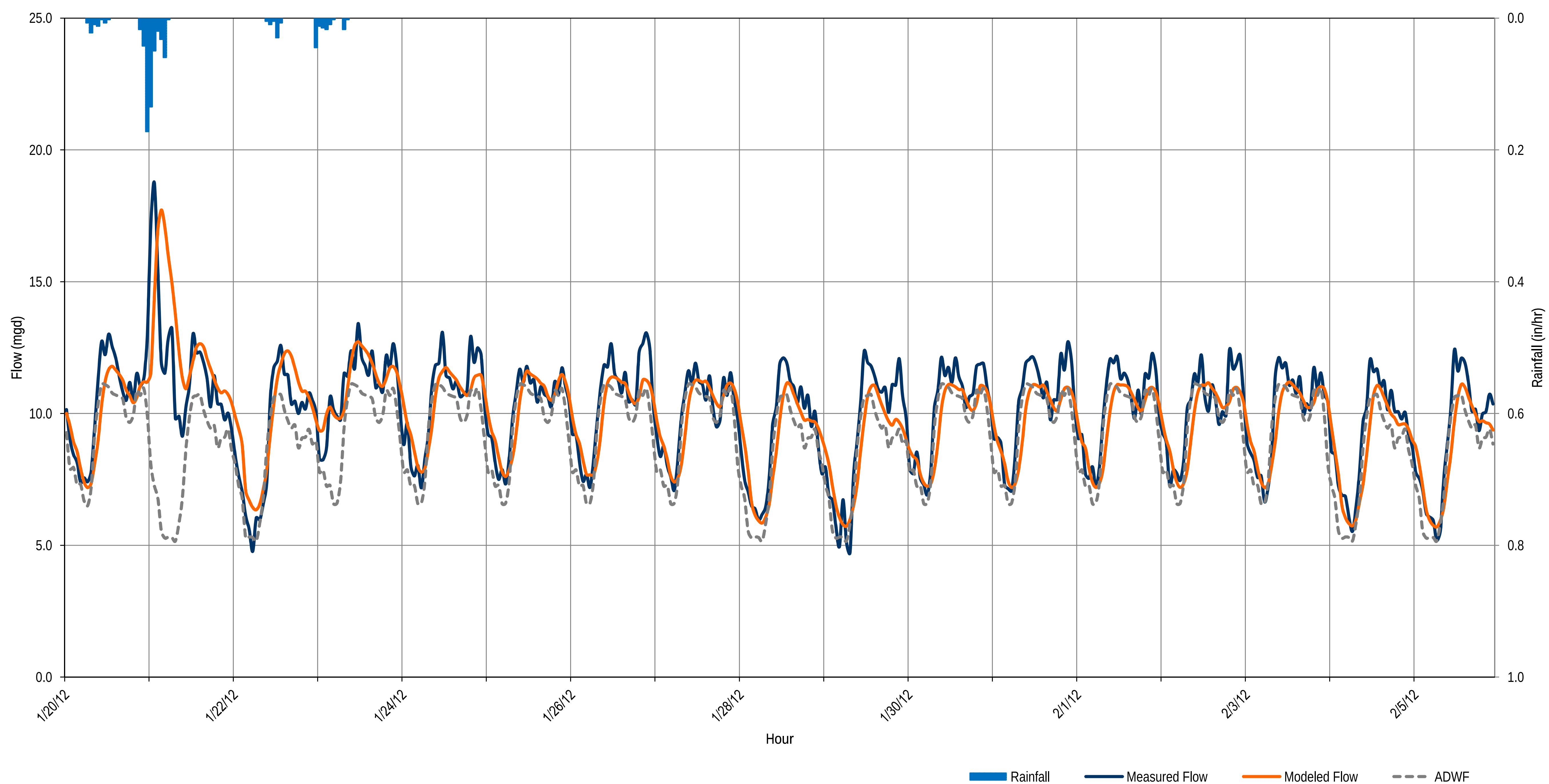
Velocity Calibration



Level Calibration



City of Turlock
Sewer System Master Plan
TRWQCF WET WEATHER FLOW CALIBRATION (1/20/2012-2/29/2012)



City of Turlock
Sewer System Master Plan
WET WEATHER FLOW CALIBRATION AT TRWQCF (OCTOBER 13, 2009 STORM)